Alma Mater Studiorum – Università di Bologna

DOTTORATO DI RICERCA IN

Ingegneria civile, chimica, ambientale e dei materiali

Ciclo XXIX

Settore Concorsuale: **08/A2 ingegneria sanitaria-ambientale, ing. degli idrocarburi e fluidi nel suolo, della sicurezza e protezione in ambito civile**

Settore Scientifico Disciplinare: **ING-IND/29 - Ingegneria delle materie prime**

TITOLO TESI:

ENVIRONMENTAL ASSESSMENT OF BIOMASS POWER PLANTS SYSTEMS AT REGIONAL SCALE: THE CASE OF EMILIA-ROMAGNA REGION (ITA)

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Esame finale anno 2018

Felice, fiero ed orgoglioso
di aver potuto studiare e conseguire il Ph.D
presso la facoltà di Ingegneria dell'Università di Bologna
una delle migliori università del mondo

Grato e riconoscente ad ARPAE per avermi così tanto sostenuto ed incoraggiato

Ringrazio tantissimo i miei professori
Alessandra Bonoli e Paolo Cagnoli

Dedico questo grande risultato
ai miei genitori che da sempre mi aiutano tantissimo
ed ai miei bimbi Erik e Noemi che rendono la mia vita Felice e piena di Gioia

Index - part 1 -

1. MAIN INDEX

2. ABSTRACT

How assess and quantify the environmental impact of the biomass power plants systems (biogas and wood combustion) at territorial/provincial/regional planning level?
To do this we did: 1) We build the biomass GIS land registers for 2015 and 2016; we catalogued them on the base of their technology and productive chains; we did it for wood combustion and biogas plants, not for bioliquid. 2) Using the administrative, planning and environmental territorial cartography we created the GIS regional sensibility maps that show what are the areas adapted to built solid biomass and biogas plants, and what are those where them should not be built, and why. 3) Using GIS forest and roads and agricultural maps and data, we built the GIS regional forest wood potentiality map, to obtain the sustainable forest wood energy budgets and compare them with the relative actual regional/provincial solid biomass combustion plants systems. 4) We implemented in the Simapro 7.3 LCA software 15 different wood combustion and biogas case studies and/or scenarios, including the scenario analysis of a extremely big wood combustion plant of 30 MW electric power actually under construction. 6) We created 4+4 different, theoretical but realistic, standardized unitary wood combustion and biogas power plants with their relative productive chains, so to have the quantitative references and data of what and how much do consume each standardized plant of 1MW electric power that works 8000 hours/year and produce 8000 MWh. electricity/year, so to be able to multiply their unitary LCA Ecoindicator'99 environmental impacts and damages with the correspondent biomass electric power installed ad provincial/regional level in 2015 and 2016. 7) So that, he unitary standardized biomass plants will can be used also to estimate and quantify the environmental impacts of other regions/territories, both starting from their quantitative resources consumptions than starting from their corresponded unitary LCA Econidicator'99 impacts and damages values. 8) We built a DIPSR specific indicators model to assess the regional/provincial territorial planning situation obtaining 7 main indicators judgments; to do this we got 5 environmental/territorial GIS layers, getting from these only the geographic information reputed important overlapping them with the biomass plats GIS land registers 2015 and 2016, so to obtain descriptive numerical indicators suitable to be subtracted from each other that show quantitatively their time trends, which in turn will be used for territorial assessment for territorial planning purposes. 9) At the end of all these processes, we propose some final general conclusions, coming From the above analyzes and acquired knowledge. 10) All the data and tables and GIS layers here presented are available to free download at the following link:

https://drive.google.com/drive/folders/0B_Zr5PU8qrFxV2hUSGJvdlpiSXc?usp=sharing

3. INTRODUCTION

MAIN QUESTION: HOW ASSESS AND QUANTIFY THE ENVIRONMENTAL IMPACT OF THE BIOMASS POWER PLANTS SYSTEMS (BIOGAS AND WOOD COMBUSTION) AT TERRITORIAL/REGIONAL PLANNING LEVEL ?

To evaluate these systems at regional and territorial level we had to:

- Analyze the general regional energy budget.

- Create biomass power plants GIS land register: years 2015 + 2016.

- Divide the GIS land registers in 3 separated type, with their correlated subtypes:
  - Biogas plants;
  - Solid wood combustion plants;
  - Bioliquids (not analyzed in this research).

- Create two GIS territorial sensibility maps: one for biogas plants and one for solid biomass plants, that permit us to define for each single plant of our GIS land register in what type of territory they are located.

- Create a useful forest wood potentiality GIS map indicator, that measures the regional/provincial forest wood potential annual availability, and then calculate the forest wood energy budgets referred to our solid wood combustion plants system.

- Define a group of specific DPSIR indicators calculated through the integration between:
  - GIS territorial cartography and sensibility maps;
  - GIS land registers of biogas and solid wood biomass plants of different years;

  So to be able to overlay them and calculate their geographical pressures/states indicators for the considered time period.

- Estimate the impact of the main biomass plants type groups in terms of LCA impacts/damages, through:
  - Creating realistic hypothetical realistic standardized biomass plants of reference, equal at 1 MW.electric power working for 8000 hours/year and produce 8000 MWh.el per year (and also for solid wood biomass equal to only 2,4 MW.thermal power working 4000 hours/year and produce only 4000 MWh.therm for remote heating without electricity production) for each single subtype of biomass plant, with their correlated productive chains.
  - Implementing the above standardized reference biomass plant in to a LCA software (Simapro 7.3, in our case) applied with one or more LCA reference methods (Ecoindicator’99, in our case), also comparing those with references of energy productions from biogas and wood combustion of Ecoinvent LCA database.
  - Multiplying the impact calculated by the LCA method of 1 MW.el of each different type of biomass plant for their total electrical power (and / or thermal) installed on the regional/provincial territory so to obtain their relative cumulative values of environmental impact calculated in terms of the LCA methodology adopted (Ecoindicator’99).

We can see the conceptual visualization in the following Synthethic frame of DPSIR model used in this research:

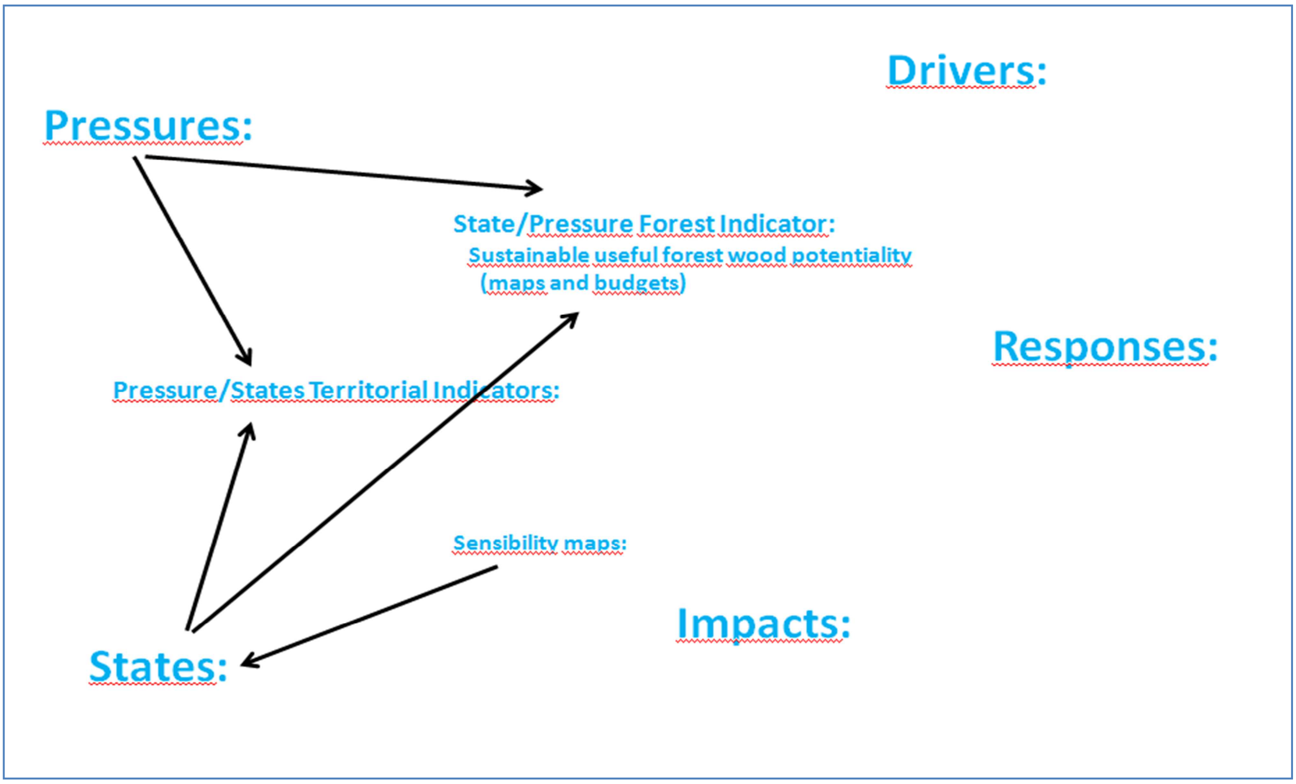


Figura 1- DPSIR conceptual scheme.

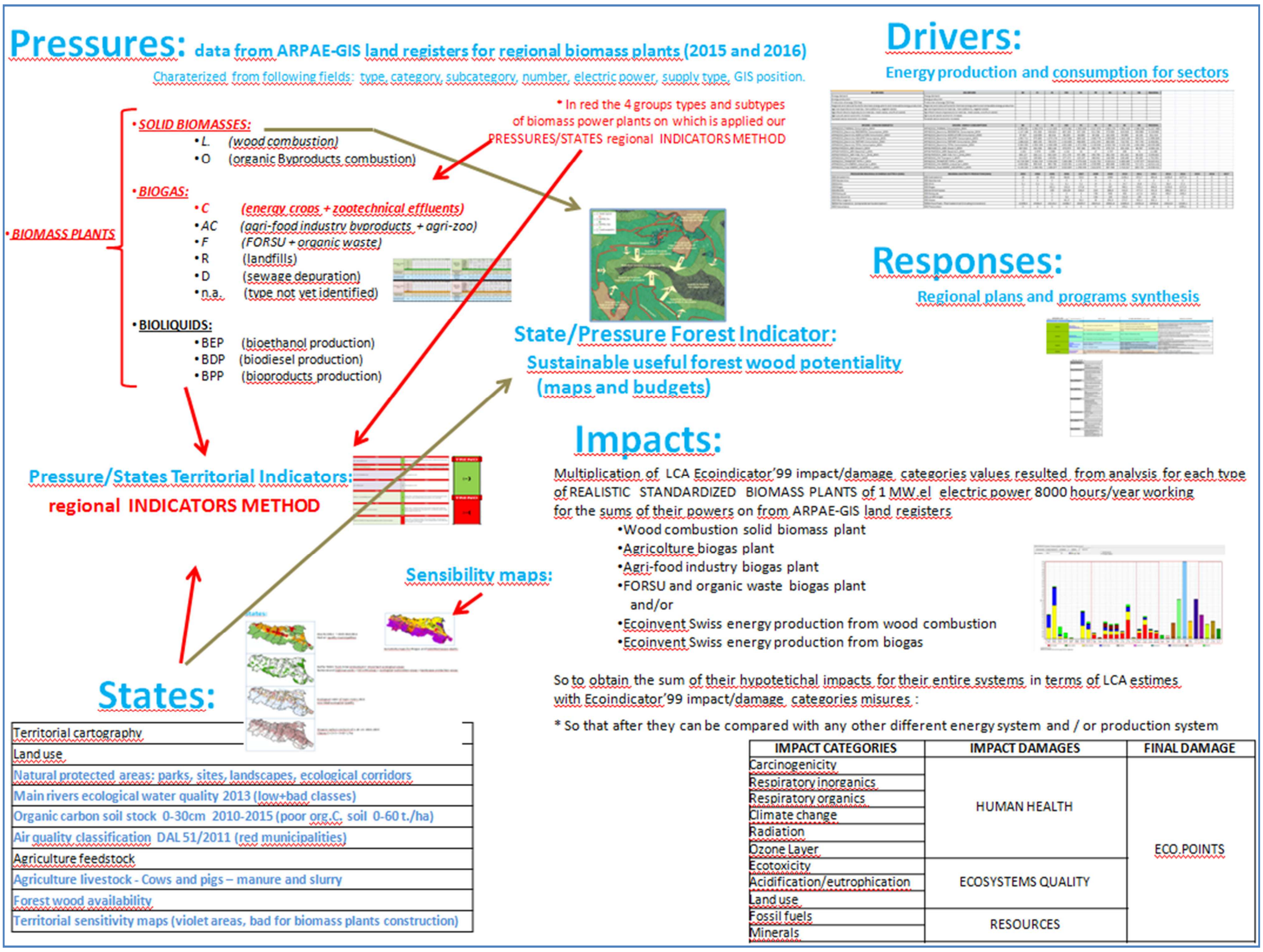


Figura 2- Synthethic frame of DPSIR model used in this research.

Index - part 2.1 -

SUSTAINABLE DEVELOPMENT

1. SUSTAINABLE DEVELOPMENT

Sustainable development is the model of development that "meets the current needs without compromising those of future generations" [Brundtland Report, 1987].

A subsequent definition of sustainable development, which includes a global view, was provided in 1991 by economist Herman Daly that defines sustainable development as "... to develop, remaining within the carrying capacity of ecosystems” and so according to the following terms and conditions concerning the use of natural resources by man: the weight of human impact on natural systems must not exceed the carrying capacity of nature; the rate of use of renewable resources must not exceed their regeneration rate; the placing of pollutants and slags must not exceed the absorption capacity of the environment; the removal of non-renewable resources must be offset by the production of an equal amount of renewable resources, able to replace them.
This definition also introduced the concept of "balance" desirable between man and ecosystem, in which resides the idea of an economy where consumption of a given resource must not exceed its production in the same period.

In 1994, the ICLEI (International Council for Local Environmental Initiatives) provided a further definition of sustainable development: "Development that provides environmental services, basic social and economic services to all members of a community without threatening the operability of natural systems, built and social systems too, from which the supply of these services depends ". This means that the three economic, social and environmental dimensions are closely related, and each programming operation must take into account the mutual interrelationships.
ICLEI, in fact, defines sustainable development as development that provides ecological, social and economic opportunities to all the inhabitants of a community, without creating a threat to the vitality of the natural system, urban and social infrastructure which from these opportunities depend. (...)

Today, the widely accepted definition of sustainable development is the one contained in the Brundtland report, drawn up in 1987 by the World Commission on Environment and Development, and named by the then Norwegian Prime Minister Gro Harlem Brundtland, who chaired this commission: "Sustainable development, far from being a definitive state of harmony, this is rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional changes are made consistent with future needs as well as with the current. (...) Sustainable development requires satisfy the basic needs of all and extending to all the opportunity to implement their aspirations for a better life. (...) The satisfaction of basic needs requires not only a new era of economic growth for nations in which the majority of the inhabitants are poor but also the guarantee that these poor people have their fair share of the resources needed to sustain such growth. This equality should be supported both by political systems that ensure the effective participation of citizens in decision-making, both by greater democracy at the level of international choices"

For these reasons, the sustainability revolves around three fundamental components:
• Economic sustainability: meaning the ability to generate income and employment for the sustenance of the population.
• Social sustainability: meaning the ability to guarantee human welfare conditions (safety, health, education, democracy, participation, justice.) Equally distributed to classes and gender.
• Environmental sustainability: meaning the ability to maintain quality and reproducibility of natural resources.

[Wikipedia, 2015, a.]

Figura 1- Representations of the concept of sustainable development. - [Wikipedia, 2015, a.]

1.1. Ecological Footprint and Biocapacity

The Ecological Footprint can be defined as the total area of land and water ecosystems required to produce the resources that the human population consumes and to absorb the waste that the population itself produces.

The Ecological Footprint is an indicator of environmental pressure internationally recognized, used to evaluate the human consumption of natural resources. It answers the question: "What is the earth's surface to which a person or population needs to satisfy his lifestyle?".

Imagine a city, surrounded by a large area that offers everything the population needs to live (wheat, water, natural resources, etc.); Imagine has built a glass dome over the city, through which light passes, but the material things they can not do to get it to come out; Order for citizens are able to live in it, it is necessary that the dome covers enough land to produce food and energy, to absorb waste and pollution, etc ...; If citizens inside the dome consume many resources the Ecological Footprint of each of them greatly increases; The size of the dome corresponds to the ecological footprint of the city.

Figura 2- Conceptual representation of the dome Ecological Footprint of a city. - [Wikipedia, 2015, a.]

Biocapacity is an indicator that measures the supply of bio-productivity, otherwise the organic production associated to a specific area. In practice it is an indicator of available resources. Expressed in global hectares (gha), is the sum of arable land, pastures, forests, productive marine areas and, in part, of built up areas or degradated areas. It does not depend only on natural conditions, but also on farming and forestry dominant practices, so it can change over time.

[Lenzerini Filippo, 2015, a.]

The "fathers" of the Ecological Footprint are Mathis Wackernagel and William Rees (1996). The ecological footprint is a measure used to assess the human consumption of natural resources in comparison with Earth's capacity to regenerate them.
The ecological footprint measures the area of biologically productive land and sea needed to regenerate the resources consumed by a human population and absorb waste produced. Using the ecological footprint is possible to estimate how many "Planet Earth" would take to support humanity if everybody lived according to a certain lifestyle.
Comparing the footprint of an individual (or region, or state) with the amount of land available per capita (ie the ratio of the total world population and area) you can understand if the level of consumption of the sample is sustainable or not.

To calculate the ecological footprint you relate the amount of each good consumed (eg. wheat, rice, corn, cereals, meat, fruit, vegetables, roots and tubers, legumes, etc.) with a constant performance expressed in kg/ha (kilograms per hectare). The result is a surface quantitatively expressed in hectares.

One can express the ecological footprint also from a point of view of energy, considering the emission of carbon dioxide quantitatively expressed in tonnes, and consequently in terms of the amount of land-forest required to absorb the above tons of CO2.

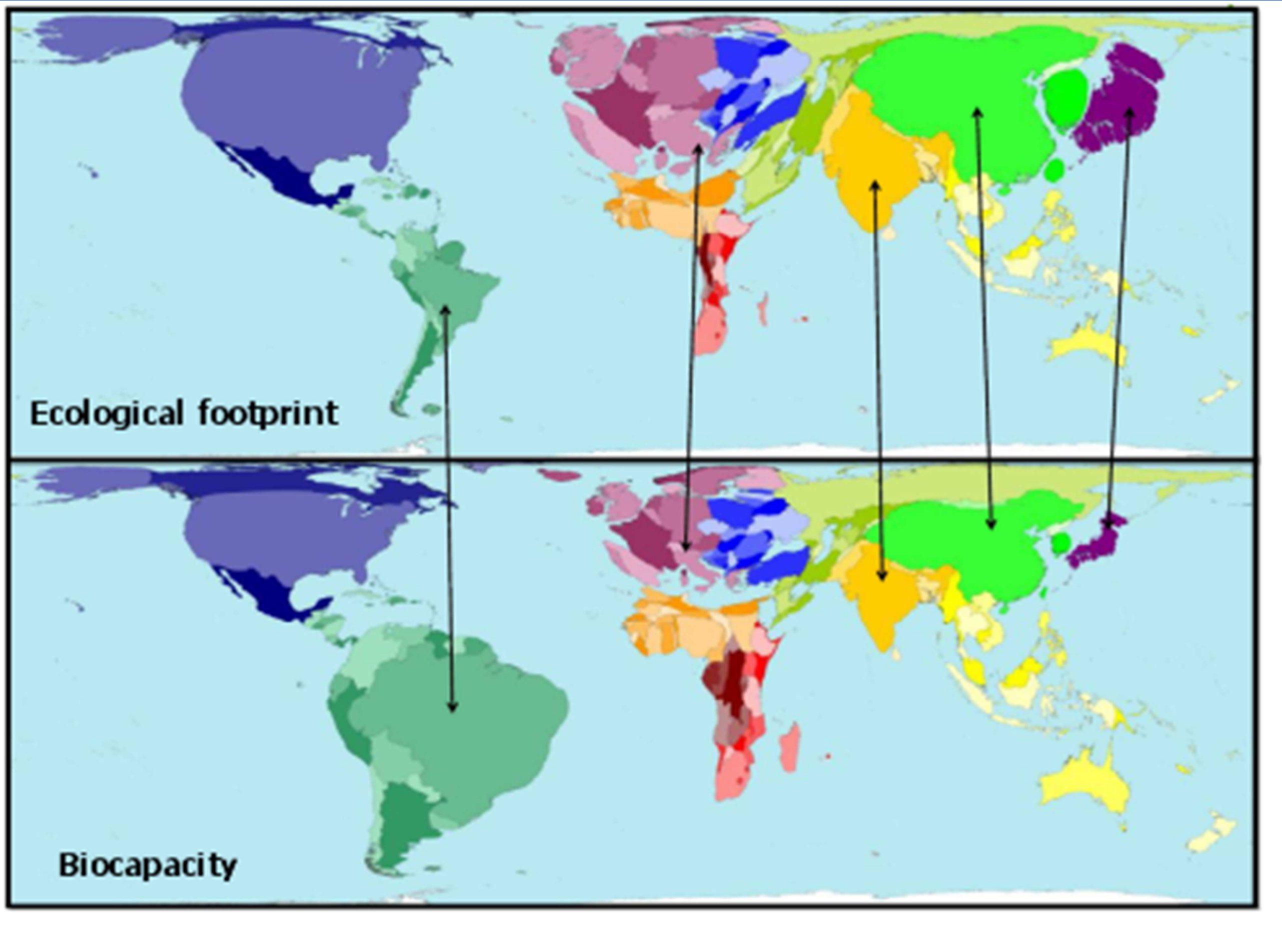


Figura 3- Visual comparison between the domestic consumption of the Ecological Footprint and the natural availability of Biocapacity. - [Wikipedia, 2015, a.]

The ecological footprint is calculated as follows: you consider the use of six major categories of land:

- land for energy: surface area required to absorb the carbon dioxide produced from fossil fuels;
- forests: areas used for timber production;
- built area: space devoted to human settlements, industrial plants, for services and transportation routes;
- agricultural land: arable land used for the production of foods and other goods (jute, tobacco, etc.);
- sea: sea surface dedicated to the growth of fishing resources;
- pastures: surface intended for rearing.

The entire emerged land area of the world is approximately composed of:

- forests and woodlands (34%)
- permanent pastures (23%)
- arable land (10%)
- built earth (2%)
- other soils: glaciers, rocks, deserts, etc. (32%).

The different surfaces are reduced to a common measure, giving each a weight proportional to its global average productivity; thus identifies the "equivalent area" needed to produce the amount of biomass used by a given population (world, national, regional, local), measured in "global hectares" (gha).

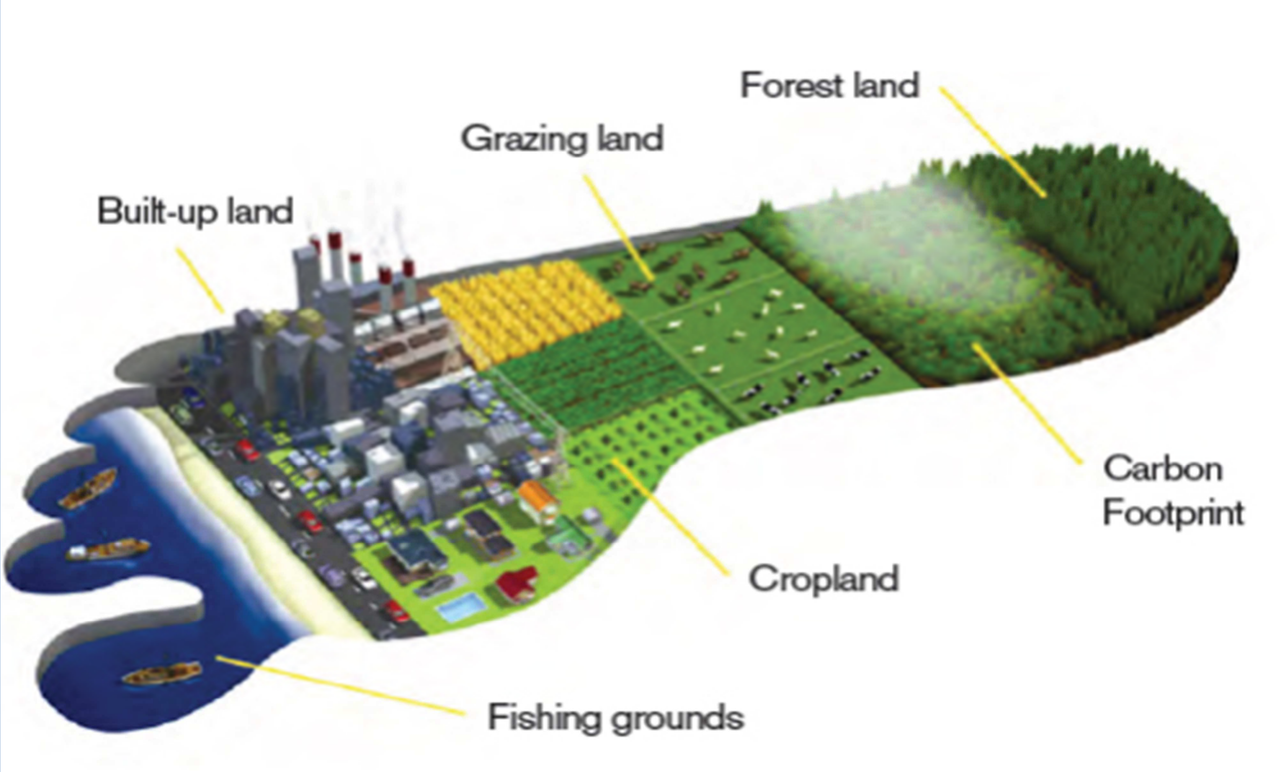


Figura 4- conceptual framework of the Ecological Footprint. - [Wikipedia, 2015, a.]

The ecological footprint F is calculated using the formula:

$$F = \sum_{i=1}^{n} E_i = \sum_{i=1}^{n} C_i q_i$$

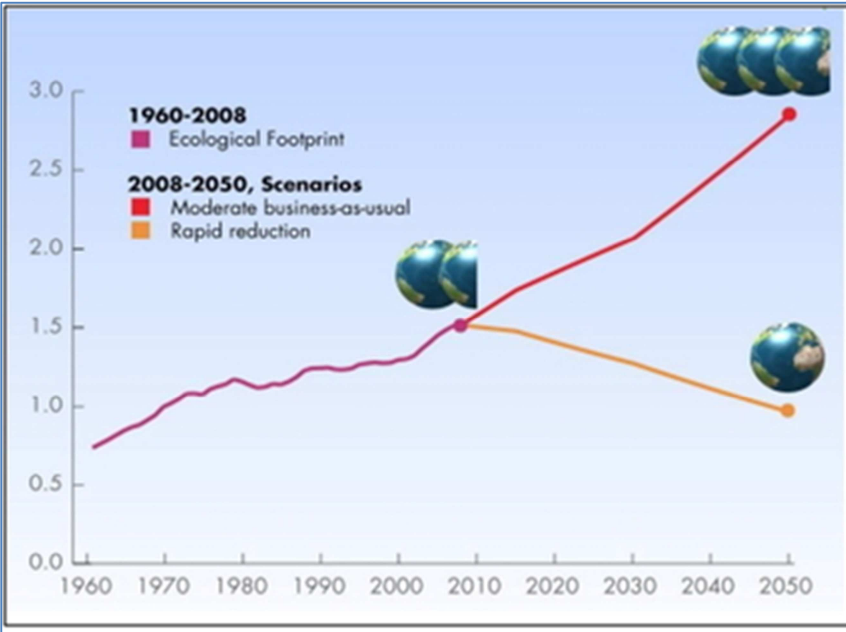
where:

- Ei is the ecological footprint from the consumption;
- Ci is the i-th product;
- qi, expressed in hectares/kilogram, it is the reciprocal of the average productivity for the product i-th;

The ecological footprint per capita f is calculated by dividing for the population N residing in the region concerned:

$$f = \sum_{i=1}^{n} e_i = \sum_{i=1}^{n} \frac{E_i}{N}$$

Many studies carried out on a global scale and some countries show that the global footprint is greater than the world's biologically productive capacity. According to Mathis Wackernagel, in 1961 humanity was using 70% of the global capacity of the biosphere, but in 1999 had increased to 120%. This means that we are consuming resources faster than we could, that we are eroding natural capital and that in the future we can have fewer raw materials for our consumption. Relatively to some states, the data are as follows. For each country is given the footprint per capita. The figure compares with the world average biocapacity that is 1.78 hectares per capita.



	I.E.	I.E. rispetto alla terra
Austria	4,9	-3,12
Stati Uniti	9,6	-7,82
Australia	6,6	-4,82
Svezia	6,1	-4,32
Canada	7,6	-5,82
Francia	5,6	-3,82
Italy	4,2	-2,42
Spagna	5,4	-3,62
Argentina	2,3	-0,52
Cina	1,6	**0,18**
Egitto	4,2	-2,42
Etiopia	0,8	**0,98**
India	0,8	**0,98**
World	**1,78**	**0**

Figura 5- International scenarios and estimates of the Ecological Footprint. - [Wikipedia, 2015, a.]

The ecological footprint has several limitations, recognized by the authors themselves. In the first place it reduces all the values to a single unit of measure, the earth's surface. This distorts the representation of complex and multidimensional problems. It is true that nowadays more and thinks more in terms of CO2 emissions, but in the EF calculation seems to be referred only to this with regard to the energy aspect. We speak to it as carbon footprint, indicator that measures own the impact created by human activities on the environment based on the amount of geenhouse gas injected into the air, measured in units of carbon dioxide equivalent. They are in fact disregarded for example radioactive waste in the context of nuclear energy or the supply that comes from non-renewable sources; There is also problems about the performance estimation. Also with regard to the pollution it is considered only from the point of view of CO2 emissions. From this it follows that:

- the real environmental damage is much greater than the one that shows the ecological footprint, beacause they are not considered many degrading factors;
- the ecological footprint provides useful indications, but it remains a non-definitive tool for the choices of governments: even if one were to achieve equality between consumption and availability this would not solve the environmental problems.

1.2. Greenhouse, Global Warming and Climate Change

Emissions of increasing amounts of CO2 into the atmosphere resulting from the use of fossil fuels for energy production, and other climate-altering greenhouse gases (GHG) such as methane and many others, cause an increase of the GREENHOUSE EFFECT, which in turn generates the GLOBAL WARMING, which in turn causes the GLOBAL CLIMATE CHANGE.
Currently, this latter is currently seen as the greatest danger for the survival of human populations, as well as of all natural ecological systems at all biological levels.

Rising temperatures will cause a rise in sea level, which will also change the current rainfall pattern, thereby modifying the position and size of the climate zones and the global and local meteorological systems, which in turn can induce changes of marine global currents from which the further modification of both global and local meteorological systems, from which then will result consequently the modification of all the natural ecological systems, agricolturali, and therefore also social.

The GREENHOUSE EFFECT is a weather-climate phenomenon that indicates the planet's capability to hold its own atmosphere part of the solar energy coming from the sun.
Therefore it is part of the complex of thermal equilibrium of a planet with gaseous atmosphere, and acts through the presence of certain gases into the atmosphere, said just greenhouse gases, which produce the global effect of mitigating the temperature of Earth's atmosphere by isolating it partially by large fluctuations in temperature or which would be subjected the planet in their absence.

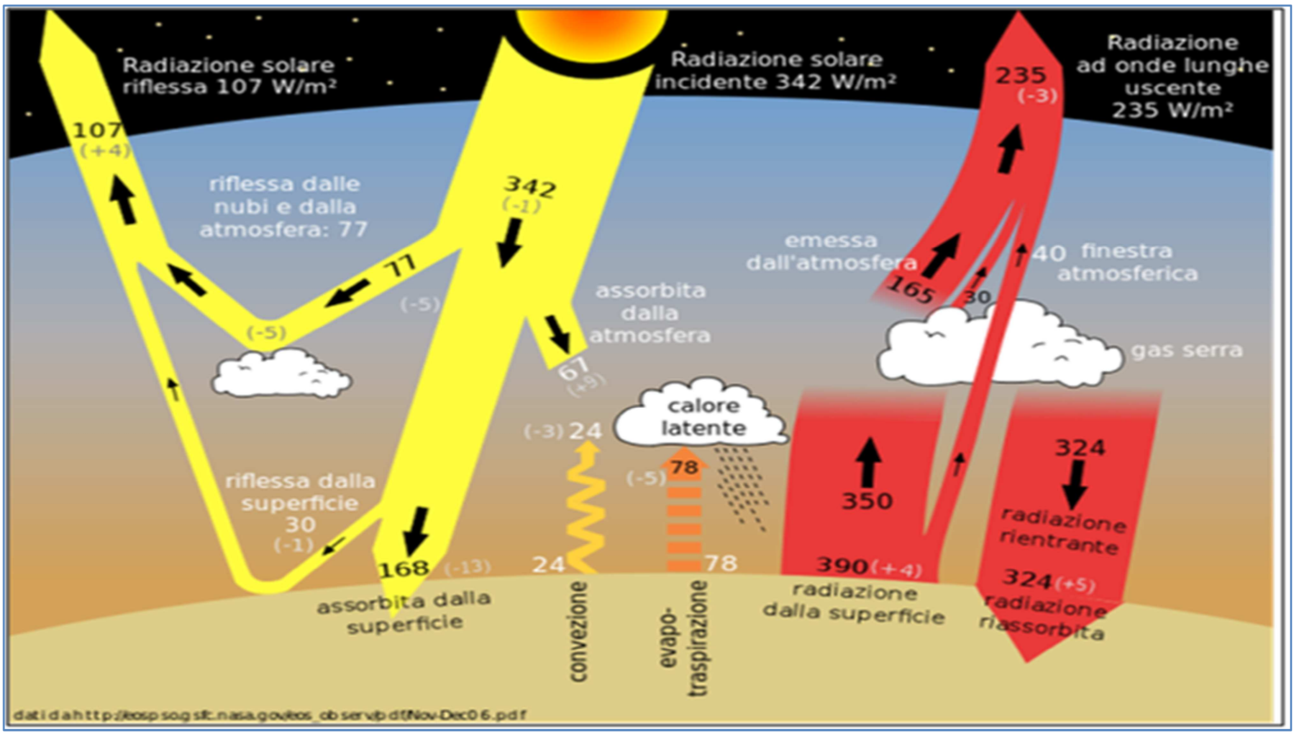


Figura 6- Scheme of radiative exchange and influence of atmospheric greenhouse effect. -

According to the theory of GLOBAL WARMING, the current warming of the Earth's climate both a natural part caused by normal climate variations, than an artificial part due to human action. In fact a large surge in the concentration of atmospheric gases such as CO2 and methane was recorded with the use of fossil fuels, which has affected the carbon geological reserves altering the cycle, and with the majority of methane production due to an explosion of livestock (pigs and cattle) and crops at flooding (eg rice).
It is estimated that by 2052 the average global temperature rise of two degrees Celsius, while by 2080 the warming will reach 2.8 degrees, with potentially dramatic consequences for the environment and for humanity itself. In 2012 it was estimated that the amount of greenhouse gases emitted in a year is double that which can be absorbed by forests and oceans globally.

The main greenhouse gases responsible for global warming and therefore for climate change are as follows:

- Water vapor (H2O)
- Carbon dioxide (CO2)
- Methane (CH4)
- Synthetic chemicals, such as chlorofluorocarbons (CFCs)
- Etc..

Currently it is estimated that the planet today would be able to absorb through photosynthesis and the action of ocean algae, less than half of these emissions, due to deforestation. (...). The burning of fossil fuels produced about 3/4 of the increase of carbon dioxide in the past 20 years. The remainder of the increase is largely due to the use that man has made the Earth's surface (eg. Deforestation). Human activity has reduced the plant biomass that can absorb the CO2 by turning the forests into fields or city. Today deforestation (especially in the Amazon and Indonesia) continues to increase and further aggravates the situation.

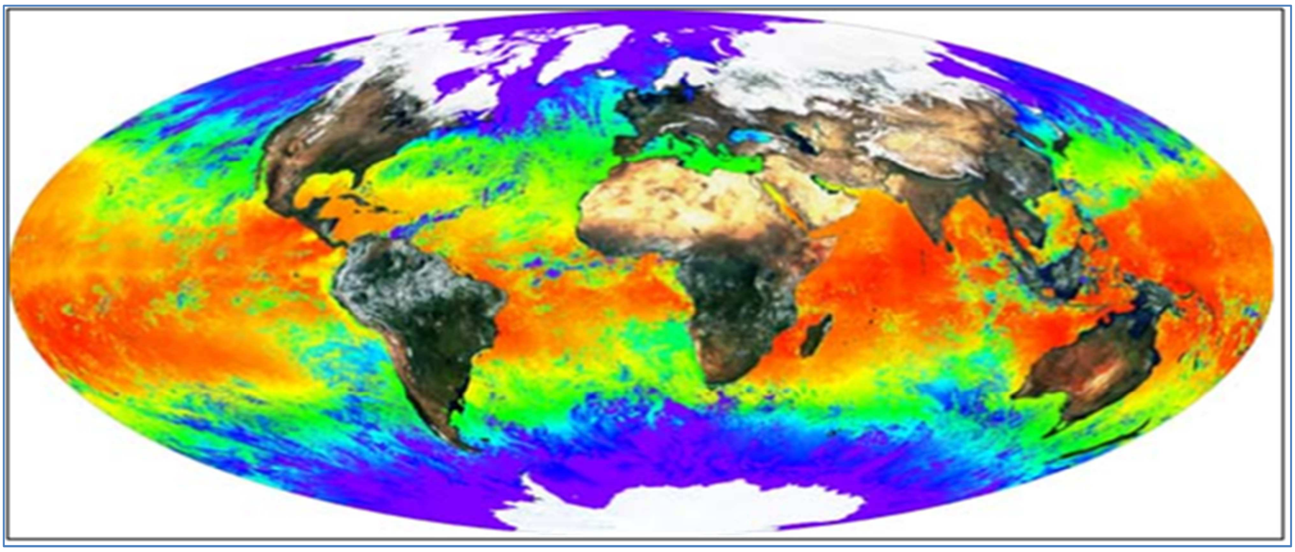


Figura 7- Temperature distribution on the Earth's surface. - [Wikipedia, 2015, a.]

The energy-related emissions constitute the main source of greenhouse gases. In Europe in 2005 they accounted for 80% of total emissions, mainly due to transport and electricity and heat production.
Between 1990 and 2005 the emissions of energy production decreased by 4.4%, mainly due to the lower use of coal and increased use of natural gas. This decrease is still much lower than what was recorded in the sectors "non-energy-related", as agriculture and waste and industrial processes (-19.6% in the 'EU-27). The growth of emissions from transport (+ 26% from 1990 to 2005), however, has vain the reductions achieved in other sectors. Transport is in fact the energy sector in the fastest growing since 1990 and is currently the largest consumer of energy.

We define _ fossil the fuels resulting from the processing (carbogenesis), developed over millions of years, starting from organic matter buried itself below ground during the geological eras, to molecular forms gradually more stable and carbon-rich.
It can be affirmed that fossil fuels represent the accumulation, underground, of energy derived from the sun, directly collected in the biosphere during geological periods, by plants through photosynthesis and water-celled organisms such as protozoa and blue algae or indirectly via the food chain, from animal organisms.

The FOSSIL FUELS are those fuels that are derived from the transformation of organic matter into more stable forms of carbon-rich. These are NOT RENEWABLE ENERGY SOURCES, because their use at current rates affects their availability for future generations. The category of fossil fuels includes:

- Oil and other natural hydrocarbons;
- Coal in all its forms (eg peat and anthracite);
- Natural gas (methane).

[Wikipedia, 2015, e.]

1.3. Energy sources: renewable and not-renewable

1.3.1. Not-renewable energy sources

The non-renewable energy sources are those sources of energy that are derived from resources that tend to be depleted on the human time scale, becoming too expensive or too polluting for the environment, as opposed to renewable ones, that come naturally reintegrated in a period of time relatively short. The non-renewable sources today are those most exploited by humanity because capable of producing the greatest amount of energy with technologically simple installations and tested. Often, the use of these sources brings with it problems of environmental pollution such as the production of greenhouse gases or radioactive waste. They are non-renewable energy sources:

- fossil fuels;
- coal;
- oil;
- natural gas;
- minerals used for the production of nuclear energy, such as uranium and plutonium.

Fossil fuels (also called hydrocarbons) today represent the main energy source of mankind. Because? Basically, because they have a high energy/volume ratio, they are easily transportable and storable and cost relatively little, although it must be emphasized that the price of oil has increased from 11 $/barrel in 1998 to the current 80 $/barrel in 2015 , by more than 700 %. The characteristic of having a low cost has greatly slowed the development of alternative energy (watch video) also due to of the close link between economic and political interests of multinationals and governments.

On the other hand, they have several disvantages:

- They are very polluting;
- They etermine a strong increase of CO2 in the atmosphere, a greenhouse gas non-polluting but that contributes very significantly to global warming;
- They are not renewable, because the fossilization of organic matter process is very long (millions of years) and the amount that becomes fossilized is nothing compared to the energy needs of man.

The OIL is a dense, flammable liquid, which after extraction is subjected to the process of distillation and entered with all its derivatives in the market. The presence of oil and therefore of the oil industry has big social and environmental impacts: the extraction, for example, frequently damages the environment, and offshore exploration and extraction of oil disturbs the surrounding marine environment.
Crude oil and refined oil that spilling out from tanker vessels crashed _, greatly damage the fragile coastal and marine ecosystems. Finally, the burning of massive amounts of oil is among the most responsible for the greenhouse effect.

The COAL is a fossil fuel present in the soil in underground mines or in the open. It 'a ready fuel use, and produces a fourth electricity worldwide. In Italy, the share of energy produced with coal is 17%, but there are countries, like the US, that draw on from coal 50% of its needs. While it is a major source of human energy, the other is also one of the most polluting ways to produce it. From coal is also possible to obtain other types of fuel through gasification and liquefaction processes, with a much lower environmental impact, even if these processes do not affect the relative amount of CO2 emitted into the atmosphere and therefore on their significant contribution to the greenhouse effect and climate change.

The NATURAL GAS (methane, CH4) is a gas produced by the anaerobic decomposition of organic material. It is present, in general, along with the oil, or in own natural gas fields, but also at waste landfills. The main difficulty in the use of natural gas is transportation. The gas pipelines are economical, but because crossing the territories of different states, may occur, mainly due to political problems, the flow interruption when a nation decides to close the taps on its territory. The combustion of gas produces greenhouse gases, even if to a lesser extent than other fossil fuels. The two main negative aspects (in addition to greenhouse gas emissions and pollutants such as carbon monoxide, ozone, nitrogen oxides) are presented from the extraction, which can cause subsidence of the surrounding ground. released into the atmosphere as methane produces a greenhouse effect 4 times greater than CO2.

[EDUCAMBIENTE, 2015, a]

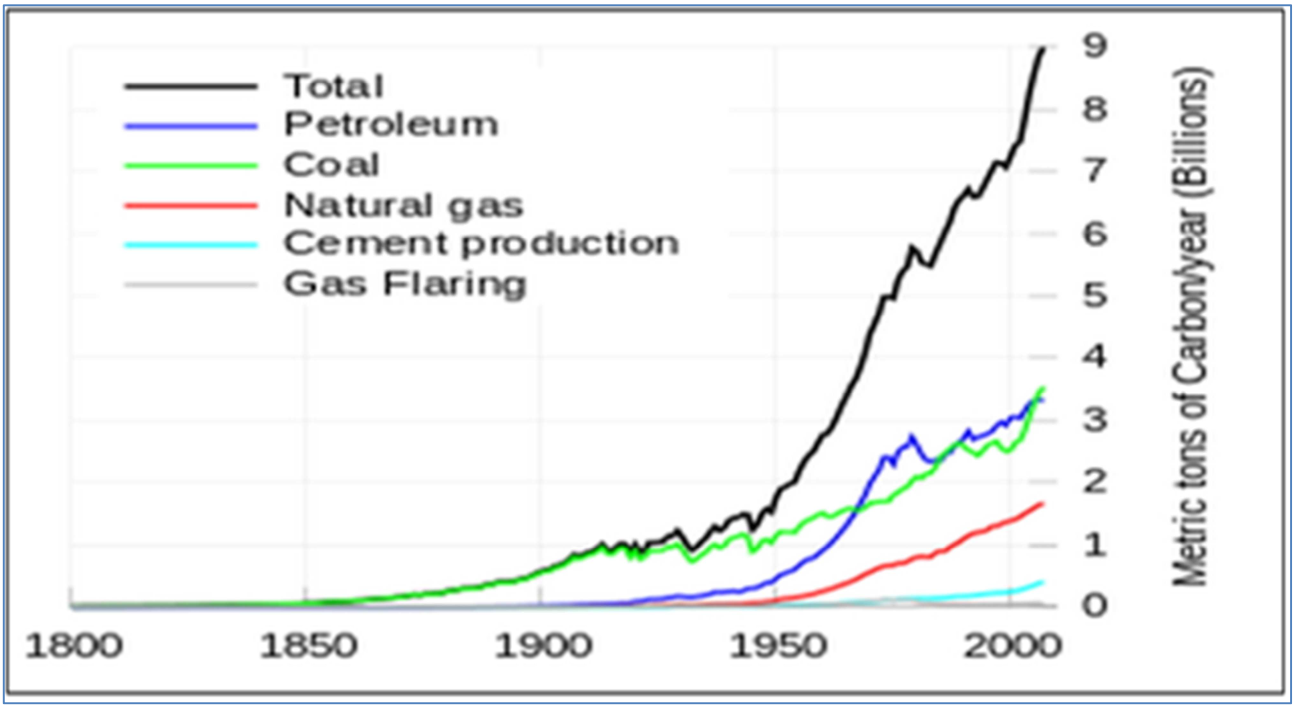


Figura 8- Global carbon emitted as carbon dioxide (CO2) as a result of the use of fossil fuels in the period 1800-2007 . - [Wikipedia, 2015, a]

Combustion is a chemical reaction of oxidation, between a fuel and a comburent (usually oxygen), with development of thermal energy (that is an exothermic reaction). From this reaction are generate new components, the products of combustion. The knowledge of the phenomenon of combustion has an enormous importance both in terms of energy saving and ecological, for air pollution caused by fumes and naturally for CO2 emissions.
The chemical elements contained in fossil fuels react with oxygen, giving rise to exothermic reactions are, mainly, the carbon, hydrogen and sulfur:

$$C + O2 = CO2 + 34.03 \text{ MJ/(kg di C)}$$

$$4H + O2 = 2H2O +144.42 \text{ MJ/(kg di H2)}$$

$$S + O2 = SO2 + 10.88 \text{ MJ/(kg di S)}$$

During the combustion process the mass of each element remains unchanged for which may be performed a mass balance that in the case of the oxidation of the carbon reaction provides:

$$12 \text{ kg C} + 32 \text{ kg O} = 44 \text{ kg CO2}$$

Therefore, 1 kg of pure carbon stoichiometrically for complete combustion requires 32/12 = 2.667 kg of oxygen. Being then the air consists of about 23.2% by mass of oxygen, for the combustion of 1 kg of carbon is required, theoretically, 2.667 / 0.232 = 11.56 kg of air. Proceeding in a similar manner we found that for the combustion of 1 kg of pure hydrogen are required 34.48 kg of air, while for 1 kg of pure sulfur are needed 4.31 kg of air.

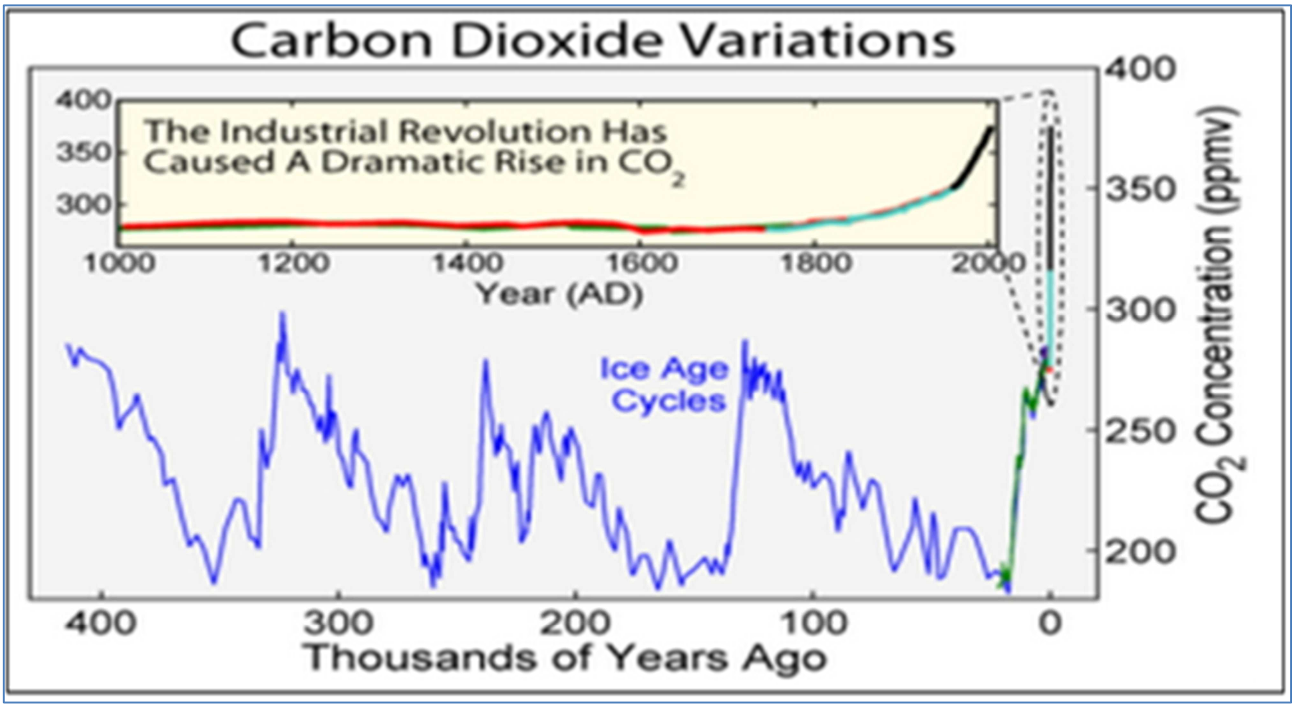


Figura 9- Variations of carbon dioxide concentration in the atmosphere over the last 400,000 years, showing an increase since the Industrial Revolution. - [Wikipedia, 2015, a]

1.3.2. Renewable sources of energy

With the term RENEWABLE ENERGY are intended the forms of energy produced by energy sources deriving from particular natural resources that for their intrinsic feature regenerate themselves at least the same speed with which they are consumed, or otherwise are not "exhaustible" in the time scale of " geological ages "; and whose use does not prejudice the same natural resources for future generations. They are therefore alternative forms of energy to traditional fossil fuels. Many of them also have the peculiarity to be clean energies because they do not introduce into the atmosphere harmful substances and / or climate altering gases such as CO2. They are therefore the basis for the so-called green economy.
A renewable resource, it is also said "SUSTAINABLE", if its regeneration rate is equal to or higher than that of use. This concept implies the need of a rational use of renewable resources and is particularly important for those resources - such as, for example, the Forestry - for which the availability is not indefinite, with respect to the time of evolution of human civilization on Earth, such as instead, for example, the solar or wind sources.

Renewable resources have many advantages, of which the major ones are undoubtedly the absence of polluting emissions during their use (with the exception of biomass) and their inexhaustible. The use of these sources does not affect their availability in the future and they are very precious resources to create energy minimizing the environmental impacts. This will protect the nature in respect of future generations and, moreover, limits the costs of production and distribution of energy.

Renewable energy resources and their utilization technologies are the following:

- solar radiation (solar thermal, photovoltaic, solar thermodynamic);
- wind (wind farms);
- biomass and the organic fraction of the waste (for direct combustion, by fermentation with CH4 methane gas production);
- tides and marine currents generally (marine hydro systems);
- meteoric precipitations (hydrolectric plants);
- geothermal heat (enthalpy systems for terrestrial and underground heat thermal recovery.

Renewable energy sources associated with those resources are then hydropower, solar, wind, geothermal and marine, ie those sources whose current use does not affect their availability in the future.
On the contrary, the energies "non-renewable", both to have long periods of making, much higher than those of current consumption (in particular fossil fuels such as oil, coal, natural gas), both to be present in exhaustible reserves within few hundred human generations.

It is useful to underline that the forms of energy on our planet have almost all solar radiation origin. Exceptions are nuclear energy, geothermal energy and tidal power. Without the Sun there would be not in fact the wind, caused by the uneven heating of air masses, and with it wind power. The energy of biomass is stored solar energy chemically, through the photosynthesis process. Hydropower, which exploits the water falls, would not exist without the water cycle by evaporation to rain, triggered by the sun. Even the fossil fuels (coal, oil, natural gas) are derived from the energy of the sun stored into the biomass million years ago through the photosynthesis process, but are not renewable in human historical times.

If the strict definition of "renewable energy" is the one set out above, are often used as synonyms also the expression "sustainable energy" and "alternative sources of energy." However, there are subtle differences:

- Sustainable energy is a method of production and use of energy which enables a sustainable development: therefore also covers the aspect of efficiency of energy use.
- Alternative sources of energy are generally all those sources of energy "non-fossil", ie other than oil or coal; It is one of them, for example, also nuclear energy, considered alternative to the use of hydrocarbons and coal. They include therefore also renewable energy.

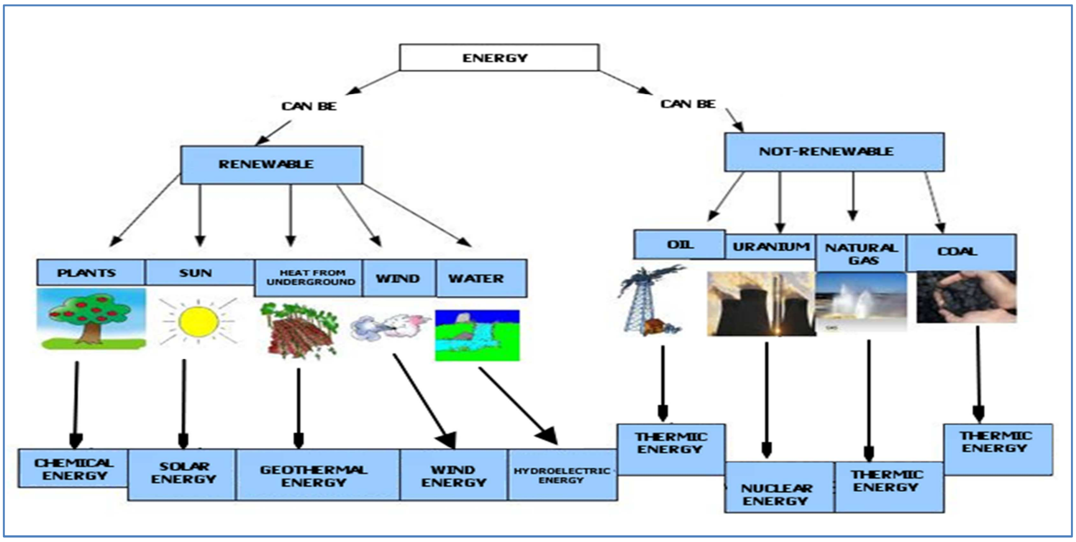


Figura 10- Framework of energy sources. - [Wikipedia, 2015, a.]

European legislation (Directive 2009/28 / EC) has taken steps to make things clear about which sources are actually considered renewable, so as to avoid questionable classifications or unscientific. The Italian law has adopted, through Legislative Decree 28 of 03/03/2011 the content of Directive 2009/28 / EC, including the part relating to the definitions. To all legal effects so even in the Italian renewable energy sources: solar energy, wind energy, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage gas from sewage treatment plant gas and biogases.

Note that, only in Italy, also the energy from waste incineration (thermovalorisation)*, in violation of the European directives on the subject, it is considered a form of renewable energy. The EU instead considers "renewable" only the organic waste (ie biodegradable waste). renewable source, for the EU, therefore means reproducible from the Sun through photosynthesis and the trophic chain.

1.4. Greenhouse gases: CO2, GHG, GWP

1.4.1. GHG: Greenhouse Gases

They are called greenhouse gases (GHG) those gases present in the atmosphere, which are transparent to incoming solar radiation on Earth, but they are able to retain, in a consistent manner, the infrared radiation emitted from the Earth's surface, atmosphere and clouds. Greenhouse gases can be of both natural and anthropogenic origin, and they absorb and emit radiation at specific wavelengths in the spectrum of infrared radiation. This their property causes the phenomenon known as the greenhouse effect.
Water vapor (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and sulfur hexafluoride (SF6) are the main greenhouse gases in Earth's atmosphere.
In addition to these source gases both natural and anthropogenic, there is a wide range of greenhouse gases released into the atmosphere exclusively of anthropogenic origin, as halocarbons, among which the best known are the chlorofluorocarbons (CFCs), and many other molecules containing chlorine and fluorine whose emissions are regulated under the Montreal Protocol. The halogenated gases are emitted in much smaller amounts than CO2, CH4, and N2O and have very low concentrations in the atmosphere but may have a very long life time and a strong effect as radiative forcing, from 3000 to 13000 times higher than that of the dioxide carbon.

1.4.2. GWP: Global Warming Potential

The GWP (Global Warming Potential), represents the combined effect of the residence time of each gas in the atmosphere and its specific effectiveness in the absorption of the infrared radiation emitted by the Earth, expressing the contribution to the greenhouse effect of a gas in terms of CO2 equivalent effect, whose reference potential is equal to 1.
Each GWP value is calculated for a specific time interval (usually 20, 100 or 500 years). This makes it possible to compare different gases between them, when we consider their contribution to the greenhouse effect. Higher is the GWP of a given gas, and greater is its contribution to the greenhouse effect. The "Tonne of CO2 equivalent" is a measure that allows you to weigh different set of greenhouse gas emissions with different climate-altering effects. For example, a tonne of methane (CH4) that has a climate-altering potential GWP 25 times greater than that of CO2, is recorded as 25 tons of CO2 equivalent.

The GWP are calculated and updated regularly by the Intergovernmental Panel on Climate Change and are used as conversion factors to calculate the emissions of all greenhouse gases in terms of CO2 equivalent emissions.

[Wikipedia, 2015, m]

The tons of CO2 equivalents are calculated therefore doing the product of the tons of single gas and its GWP.

tons Gas x GWPgas = tons CO2 equivalent

The GWP of a gas can change depending on the scientific source and year of publication, as can be seen from the following tables.

Tabella 1- GWP potentials from IPCC 2007. [IPCC GHG Protocol, 2007, a] , [Zerosottozero.it, 2015, a]

COMPOST	GWP	NAME
CO2	1	reference
CH4 (methane)	25	hydrocarbon
R12	8500	CFC
R11	4000	CFC
R123	90	HCFC
R134a	1550	HFC
R290	3	hydrocarbon
R407c	1610	mix of R32, R125 e R134a

Tabella 2- GWP potentials from IPCC 1996. [IPCC GHG Protocol, 2007, a] , [Zerosottozero.it, 2015, a]

Table 2: Global Warming Potentials (GWP) and Atmospheric Lifetimes (Years) Used in the Inventory

Gas	Atmospheric Lifetime	100-year GWP[a]	20-year GWP	500-year GWP
Carbon dioxide (CO_2)	50-200	1	1	1
Methane (CH_4)[b]	12±3	21	56	6.5
Nitrous oxide (N_2O)	120	310	280	170
HFC-23	264	11,700	9,100	9,800
HFC-125	32.6	2,800	4,600	920
HFC-134a	14.6	1,300	3,400	420
HFC-143a	48.3	3,800	5,000	1,400
HFC-152a	1.5	140	460	42
HFC-227ea	36.5	2,900	4,300	950
HFC-236fa	209	6,300	5,100	4,700
HFC-4310mee	17.1	1,300	3,000	400
CF_4	50,000	6,500	4,400	10,000
C_2F_6	10,000	9,200	6,200	14,000
C_4F_{10}	2,600	7,000	4,800	10,100
C_6F_{14}	3,200	7,400	5,000	10,700
SF_6	3,200	23,900	16,300	34,900

Source: IPCC (1996)

[a] GWPs used here are calculated over 100 year time horizon

[b] The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

1.4.3. CO2 factor for energy production from italian national mix

In the energy field, in order to make comparisons between CO2 and GHG emissions, of various energy sources (eg. Fossil fuels, coal, oil, natural gas, solar, hydro, wind, biomass, biogas, etc ..) in relation to the Italian national production of thermal and electrical energy, have been defined the following reference emission factors:

Tabella 3- CO2 emission factor for Italian electric and thermal energy mix

Italian ELECTRIC Mix	Coke	Petrolium	Natural gas	Renewable sources
[*Terna 2010]	11,6%	2,9%	44,5%	22,4%
0,440 kg CO2/kWh - electric				
Italian THERMAL Mix	Coke	Petrolium	Natural gas	Renewable sources
[*IEA 2008]	1%	32,6%	61%	2,3%
0,217 kg CO2/kWh - thermal				

[PAEE, 2011, a] , [TERNA, 2010, a] , [IEA, 2008, a]

Index - part 2.2 -

LIFE CYCLE ASSESSMENT

1. LIFE CYCLE ASSESSMENT - LCA -

The Life Cycle Assessment (LCA) is a method that evaluates the set of interactions that a product or a service has with the environment, considering its entire life cycle, which includes the pre-production stages (and therefore also extraction and production of materials), production, distribution, use (and therefore also reuse and maintenance), recycling and final disposal.

[Wikipedia, 2015, h]

According to the SETAC (Society of Environmental Toxicology and Chemistry - www.setac.org) LCA is a process that allows to assess the environmental impacts associated with a product, process or activity by identifying and quantifying material consumption , energy and emissions into the environment, and the identification and evaluation of opportunities to reduce these impacts. The analysis covers the entire life cycle of the product ("from cradle to grave"): from extraction and processing of raw materials, to production, transport and distribution of the product, its use, reuse and maintenance, through to recycling and the final placement of the product after use (SETAC, 1993).

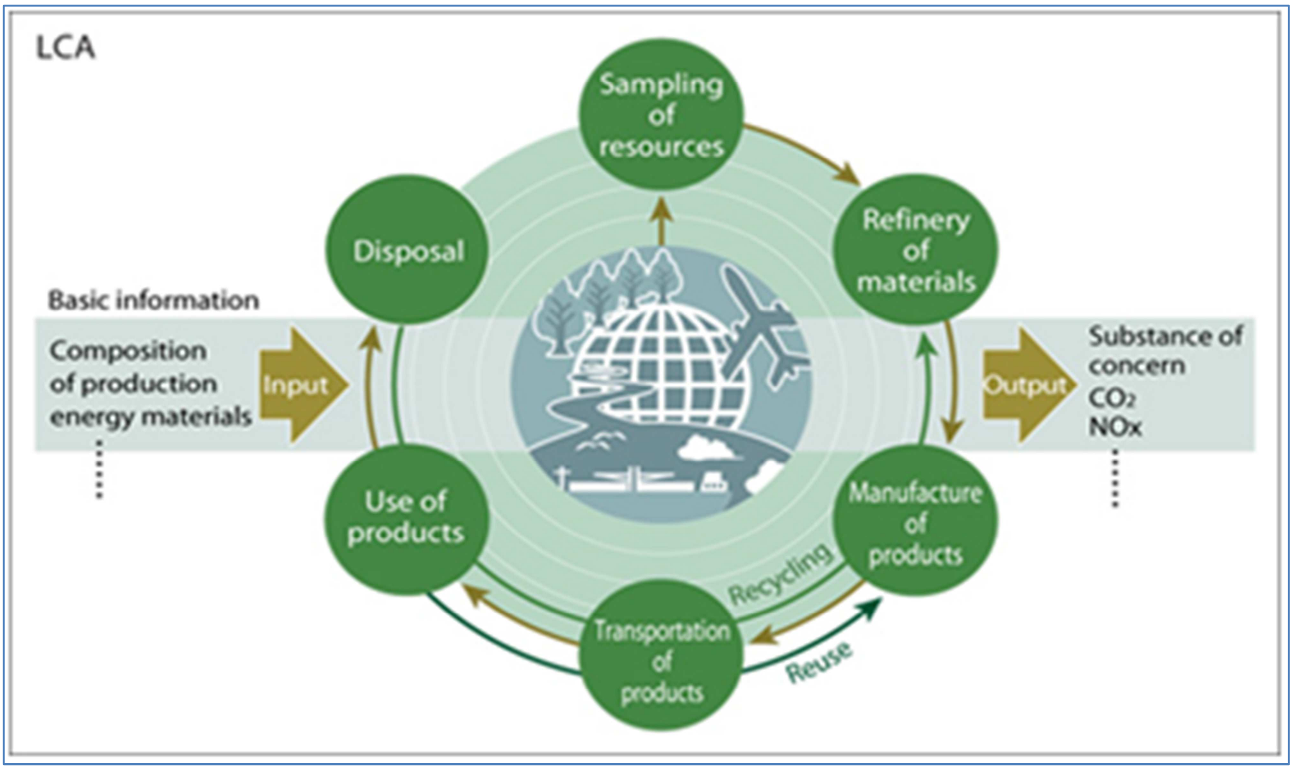


Figura 1- Conceptual visualization of the LCA. - [Toyota, 2015, a]

This methodology allows to determine and quantify the energy and environmental loads, real and potential, present in the various phases of the cycle of production and consumption of bioenergy, considered related and interdependent. Through the LCA, then, we quantify the environmental effects of inflows and outflows from the production system using suitable impact indicators. Applied in the context of renewable energy, it is therefore possible to compare the environmental profile of the various bioenergy with that of fossil fuels that perform similar functions. This comparison provides useful pointers for choosing the technology which best are integrated with the concept of sustainable development.

[Ornella Ronchini, 2010, a]

1.1. Objectives and scope of an LCA

LCA (as defined in ISO 14040) considers the environmental impacts of the event examined respect to human health, ecosystem quality and resource depletion, and whereas the economic and social impacts.
The LCA aims are to establish a complete picture of the interactions with the environment of a product or service, helping to understand the environmental consequences directly or indirectly caused, and then give to those who have decision-making authority (who has the task of define the rules) the information needed to define the behaviors and the environmental effects of activities and to identify opportunities for improvement in order to achieve the best solutions to intervene on environmental conditions.

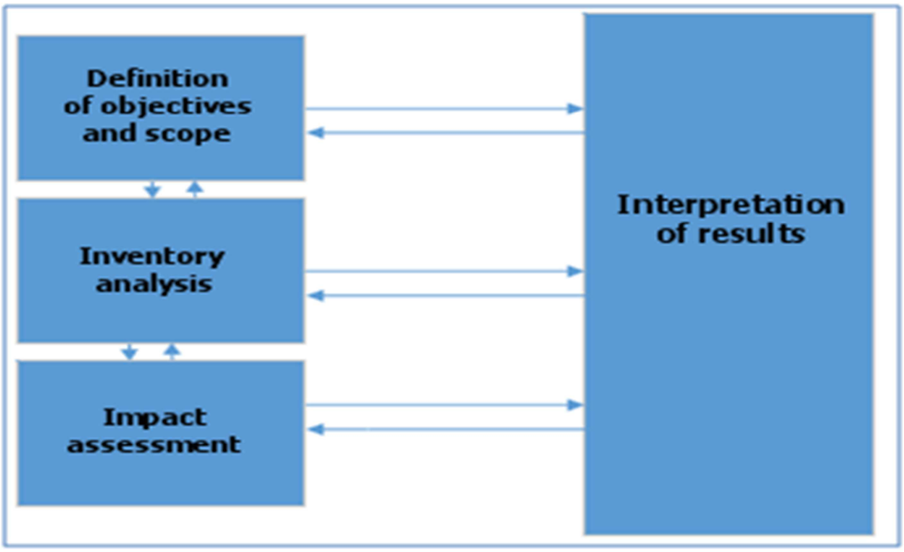


Figura 2- The four phases of the Life Cycle Assessment, in accordance with ISO 14040. - [Ornella Ronchini, 2010, a]

In accordance with the ISO standards 14040 and 14044, the Life Cycle Assessment is divided into five stages of evaluation:

1. Goals and objectives;
2. Inventory of the life cycle;
3. Assessment of the life cycle;
4. Interpretation of data and results;
5. LCA uses and tools;

[Wikipedia, 2015, a]

1.2. The ISO norms for LCA

At present the LCA procedure is standardized internationally by the following ISO standards:

- ISO 14040:2006 - Environmental management — Life cycle assessment — Principles and frame work;
- ISO 14041:1998.E - Environmental management — Life cycle assessment — Goal and scope definition and inventory analysis;
- ISO 14042:2000 - Environmental management — Life cycle assessment — Life cycle impact assessment;
- ISO 14043:2000 - Environmental management — Life cycle assessment — Life cycle interpretation;
- ISO 14044:2006 - Environmental management — Life cycle assessment — Requirements and guidelines;
- ISO 14045:2012 - Environmental management — Ecoefficiency assessment of product systems — Principles, requirements and guidelines;
- ISO 14046:2014 - Environmental management — Water footprint — Principles, requirements and guidelines;
- ISO/TR 14047:2012 Technical Report - Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to impact assessment situations;
- ISO/TS 14048:2002 Techinical Specification - Environmental management — Life cycle assessment — Data documentation format;
- ISO/TR 14049:2012 Technical Report - Environmental management — Life cycle assessment — Illustrative examples on how to apply ISO 14044 to goal and scope definition and inventory analysis;

1.3. General overview of an LCA

The purpose, the boundaries and the level of detail of an LCA depends on the object of the study and the use for which it was prepared; However, although the depth of the survey and the amplitude can vary widely depending on the cases, the schema which reference is made remains the same. On the other hand each valuation technique necessarily has limitations, it is essential to know and take into adequate consideration during the analysis process, in particular:

- models used for inventory analysis or to assess environmental impacts are limited by the assumptions implicitly contained in it;
- the accuracy of an LCA may be limited by accessibility or availability of relevant information and of high quality;
- the absence of a spatial and temporal dimensions in the inventory data used for impact assessment introduces uncertainty in impact results;
- it is not possible an absolute and complete representation of each effect on the environment, since it is based on a scientific model is a simplification of a real physical system.

In general, the information obtained through a LCA study should be used as part of a decision-making process much more complete and used to understand the overall or general exchanges.

Compare the results of different LCA studies is only possible if the assumptions and context of each study are the same. For reasons of transparency, these assumptions should be so explicitly declared.

[Ornella Ronchini, 2010, a]

1.4. Critical issues of the LCA

The investigative techniques based on LCA are still unresolved challenges that limit its use and effectiveness. In particular the two aspects that most affect on the adoption of this tool include:
the absence of a consistent methodology, widely known and accepted internationally, for the evaluation of environmental impacts and the scarcity of data and information necessary for a good understanding of the studied phenomena.

The first problem was addressed by making use of the concept of IMPACT, whose measure is evaluated with the aid of indicators that assume a dependency, linear or nonlinear, between the extent of the release and the potential negative environmental effect.
An alternative approach to this mode of operation resides in the construction of indicators of DAMAGES categories, designed to link the negative effects on a system closer to the actually common experience and more easy to analyze and evaluate, as human health, the quality of ecosystem productivity and the size of the harvest. These retentions have the effect of making more direct the allocation of weights to the different categories of damage and to make more understandable to the public the effects attributed to the studied processes.

As regards the second problem, for both the phase of the standardization, both for the evaluation, the LCA method is based on the threshold values (targets) of environmental impacts relating to particular geographical areas, established by an Authority.

[Ornella Ronchini, 2010, a]

1.5. The structure of an LCA and its 4 phases

From a methodological point of view, the definition of LCA originally proposed by SETAC, later recovered from the ISO 14040 and 14044 standards, is as follows:
"*LCA is an objective process to evaluate the energy and environmental impacts related to a process or activity, conducted through the identification of energy and materials used and wastes released into the environment. The assessment includes the entire life cycle of the process or activity, encompassing extraction and treatment of raw materials, manufacturing, transportation, distribution, use, reuse, recycling and final disposal*".

The specific definition given in ISO 14040 expresses the LCA as a "*compilation and assessment through the entire life cycle of inflows and outflows, and the potential environmental impacts of a product system*".
An LCA applied to an industrial system therefore directs the study of efficiency of the target system toward the preservation of environment and human health as well as to the saving of resources. Fundamental point is the definition of "industrial system", that ISO describes as "product system".

It good to remember, then, that with the industrial system means a set of procedures, whose main function is the production of useful goods: it is separated from the system environment by well-defined physical boundaries and is connected to it through the exchange of input and output. In this perspective the environment is not defined what natural ecology, but it is all that is considered outside of the industrial system.

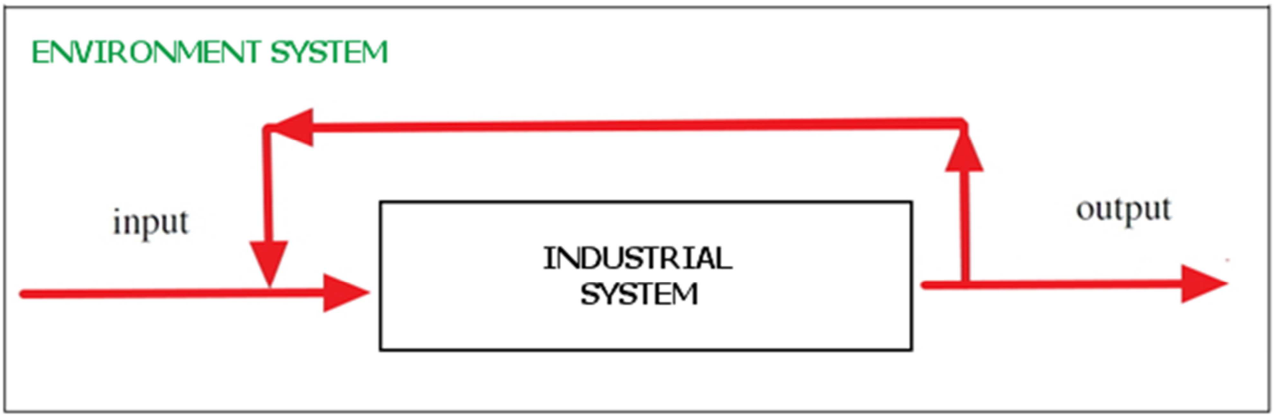


Figura 3- Systems scheme

It is therefore clear how the system input parameters are involved in the debate on resource conservation issues; while the outputs relate to the problems of pollution.
It is understandable that the definition of the system function and the same boundaries represent key operations for the success of an LCA.
So rather than describe the product, an LCA describes the system which generates it or, in other words, the function of the system itself. This is important to clarify, to avoid the risk of identifying the analysis of the life cycle of processes with an analysis of the products life cycle.

The model of the object of investigation system in an LCA is always a simplification of reality, because does not include a complete representation of the interactions with the environment, but only the most significant ones.This type of methodology includes the sphere of production, that of the distribution and that of utilization.so it is legitimate to claim that the success of this technique as an innovative strategic tool at industrial level it began offering a comparison meter between different productions, becoming an image support for production processes with more limited environmental impact.

[Ornella Ronchini, 2010, a]

1.6. The 4 main steps of a LCA

The modern structure of the LCA proposed by ISO 14040 and following can be summarized in four main stages:

1. Definition of goals and objectives and the scope of the study (Goal and scope definition): it is the preliminary step that defines the aims of the study, the functional unit, the boundaries of the system studied, the need and reliability of data, assumptions and limitations;

2. Inventory analysis (Life Cycle Inventory Analysis - LCI): it is the part of the work devoted to the study of the life cycle of the process or activity; the main purpose is to reconstruct the way through which the energy and material flow allows the operation of the production system in question through all the processing and transport processes. Make an inventory of the life cycle means building a model of the real system we intend to study: we then we compiles an inventory of the inputs, ie the materials, energy, natural resources and outputs, ie emissions to air, water and soil;

3. Analysis of impacts (Life Cycle Impact Assessment - LCIA): it is the environmental impact study resulted by the process or activity, which is intended to highlight the magnitude of the changes generated due of releases into the environment and of the calculated resources consumption inventory. It is the phase in which occurs the switch from the objective data calculated during the inventory to the judgment of environmental danger. The calculated impacts are potential, direct and indirect, associated with the input and the output;

4. Interpretation and improvement (Life Cycle Interpretation): This is the final part of a LCA that intendes proposing the changes needed to reduce the environmental impact of the considered processes or activities, evaluating them in order to not carry out actions such as to worsen the state of done. In practice it is the definition of the lines of action.

[Ornella Ronchini, 2010, a]

The description of the conceptual framework of the Life Cycle Analysis is given in the UNI ISO 14040 and related document, and is articulated according to the following scheme:

Tabella 1- Conceptual framework of the UNI ISO 1440 Life Cycle Analysis

Goal and Scope Definition	**Life Cycle Inventory**	**Life Cycle Impact Assessment**	**Life Cycle Interpretation**
ISO 14041	**ISO 14041**	**ISO 14042**	**ISO 14043**
Definition of the objectives of the study	Preparation of data collection and definition of the flow chart	Selection and definition of Impact Categories	Identification of the most significant impacts
Definition of the scope the study application	Data collection	CLASSIFICATION: Assignment one or more impact categories to the data collected in the inventory	Evaluation of the methodology and results (completeness, sensibility, consistency)
Product functions and Function Module Reference Flow	Calculation procedures for input and output streams	CHARACTERIZATION: Quantification of the impact	Sensibility analysis
Initial boundaries of the system	Sensitivity analysis and correction of the system boundaries	STANDARDS: Technical analysis of the significance (optional)	Recurrence of the life cycle in the case that the three previous points are not met
Categories of data	Allocation of flows and releases	ASSESSMENT: Assignment a relative weight to different impact categories (optional)	Conclusions and recommendations
Initial choice of input and output flows	Interpretation of results and uncertainty analysis		Report on the study
Data quality requirements	Report on the study		
Critical revision			

[Ornella Ronchini, 2010, a]

1.6.1. - Phase 1 - definition purposes, objectives and scope (ISO 14041)

An LCA must be preceded by a clear statement of the objectives and aims of the study, and this phase is an important moment of planning.

The ISO 14040 standard as well introduces the topic: "*The objectives of the study and a LCA purposes must be clearly defined and be consistent with the application. The goal of an LCA must establish unambiguously what are the intended application, the motivation for to to conduct the study and the type of audience that is targeted, that is what people intend to communicate the study results*".

It is clear that the purpose of the study greatly affect the choices and working hypothesis because, depending on the motivations of the audience to which it is destined, on the resources available and the expectations, in the results may be very different scenarios. It is possible to cite: the amplitude of the life cycle, the eventual alternatives to consider, the quality and reliability of the available data , the choice of the environmental parameters with which to summarize the results, the level of detail at which to arrive.
It is therefore particularly pleasing to define the frontiers of research and then those of the studied system and express the results in an appropriate manner; in the last analysis the definition of the degree of detail which to push the study.

The preliminary stage of defining of the objective and of the application represents a relevant stage in the development of a study clarifying the main reason why you run the LCA also including the use of the results, describing the studied system and its borders, listing the categories of data to be submitted to the study and identifying the level of detail to be achieved. It provides, in summary, the initial planning to perform an LCA.

Being a critical step, it has a very complex structure within which you must define:

1. **OBJECTIVE OF THE STUDY**: It contains: the reasons that led to carry out the study, the intended application and the recipients of the study, ie the internal or external users of the results obtained.
2. **SCOPE OF THE STUDY**: it must be defined by suitably, in order to ensure that the breadth, the depth and detail of the study are consistent with the established objective and appropriate to achieve it.

For the field of application we consider the following topics:

- **Definition of the system and its functions.**

LCA is defined as_ "system" any set of devices that realize one or more industrial operations that have a specific function; is determined by physical boundaries with respect to the environment and with this has exchange relations characterized by a series of input and output. In the most general case of an industrial system, whose input system consist of raw materials and primary energy and whose output consist of waste (waste heat, emissions into air and water, solid waste) that return to the system environment (the biosphere).
A system, therefore, inside which there are all the processes of transformation: from producers to users, through the final products. Among its outputs do not exist useful pruducts but only wastewater.

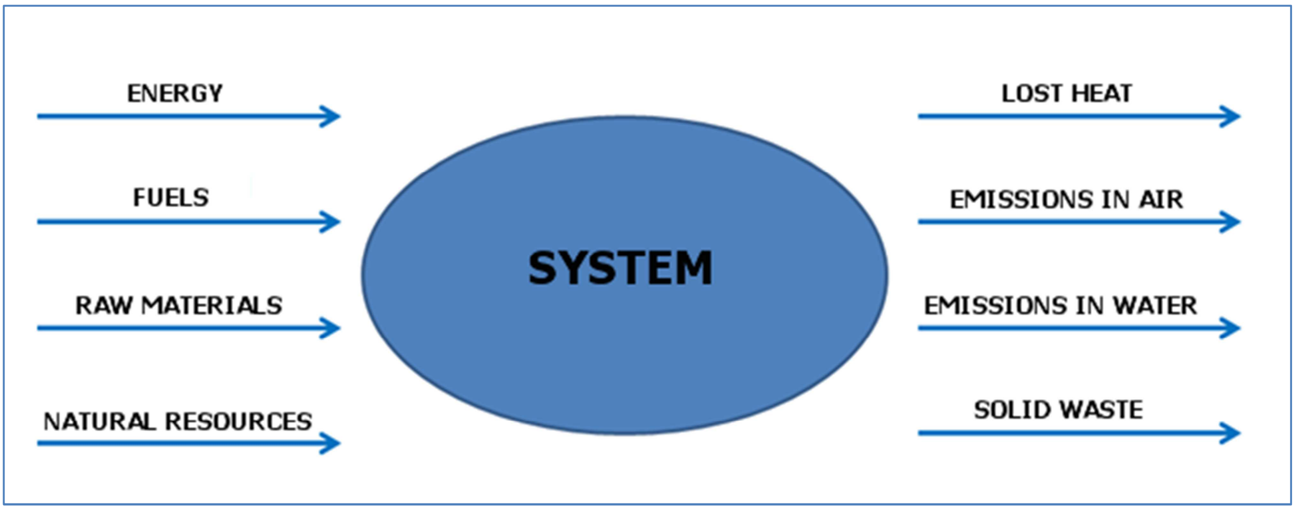


Figura 4- Conceptual description af the system framework of a LCA. - [Toyota, 2015, a]

These systems contain a large number of interconnected transactions,also in a complex way, of flows of materials, energy and finished products.
To make an inventory of life cycle of a system, you must first define the individual transactions that compose it as unitary operations: each of these receives its input from the upstream unit operations, while its output will serve to feed those following, according to the production scheme.

Define the boundaries of the system means determining process units that need to be considered by the study. These units must be explicitly listed by avoiding the comparison of systems that are not comparable.
The functions of the system represent the features and performance of the process and / or of the product.

- **Definition of the functional unit**

We come to the other preliminary operation before proceeding to the inventory. It is in fact important to establish, since the beginning of the study, a unit of measure of reference, called "functional unit", with which to treat and expose the data and the information for the our LCA.
"*The functional unit represents a measure of the performance of the output stream. Its main purpose is to provide a reference to which to tie the incoming and outgoing flows. Such reference is necessary to allow the comparability of LCA results. Such comparability is particularly critical when you evaluate different systems, because you must ensure that comparisons are made on a similar basis. A system may have a large number of possible functions and the option chosen for the study depends on the objective and scope. The corresponding unit of measurement must be defined and measurable*" (ISO 14040).
The functional unit, therefore, is the reference respect to which normalize the data that make up the environmental budget of the examinated system. The functional unit must be representative of a quantifiable and objectively verifiable performance of a product and / or process, in order to allow comparability of LCA results. The choice is that unit is arbitrary and depends primarily on the purpose for which the subsystems and the overall system are designed, and can be meant as an index of the services performed by the system. Its definition is therefore essential for the success of the study.

This unit was also created because the normally used measurement unit, as the mass, the number of parts, the volume etc.. are not always adequate to represent the performance (energy and environment) of a production process, but also because the same results of a study expressed according to different functional units may lead to entirely different conclusions. For example, if the function of a process is the production of packaging, the unit to which to report its performance will be the amount of packaging required to contain a certain volume of product, and not the kilogram of glass or cardboard.

Since the systems studied contain many process units, it is convenient to use functional units of different depending on the considered subsystem process, and then to converge the values using the functional unit chosen as representative of the entire investigated system.

Alongside the functional unit, the ISO 14040 introduces the concept of "reference flow" which is basically the amount of good or service necessary to obtain the functional unit chosen.

- **The system boundaries.**

The boundaries determine the process units that must be included in LCA and their interrelationships; it is often useful to represent them through a flowchart.

To determine, therefore, the frontiers of research they are developed with great care and attention. This definition takes place as a result of a detailed description of the test system and the construction of the production cycle flow chart, performed in order to organize the collection of data and information, delineating the scope of action.

A first delimitation of boundaries will take place in the research of physical environments and production processes that are believed to have to considered for the analysis. Later, you can exclude components that will demonstrate irrelevant or that are too expensive to obtain detailed information, or include other which initially had not given adequate importance.

Is understood, however, that the choice of the boundary of the analysis must be adequately motivated and always reported in the study. It can now reaffirm that every LCA actually contains simplifications and limitations to make it manageable than an LCA of the entire global system that will never be reproducible in whole.

Thus the initial goal of an LCA is to trace back all the productive sectors of the investigated system till the extraction of raw materials as fully as possible and estimate the error we have, disregarding some process units. The ISO is very clear about it: "the criteria used in establishing the boundaries of the system must be identified and justified in the field of application of the study".

Also the reference period is a constraint in the choice of the analysis boundaries.

The data also may represent an average situation of operation of the system, or the best available technology (BAT - Best Avaliable Techniques).

All this information that constitute the foundations on which to set the whole analysis, are grouped according to ISO 14040 in the "scope of the study", which represent a kind of identity card with requirements, limits and initial assumptions.

Experts in the field are investing considerable effort to try to find a code that allows simultaneous use of energetic, environmental and economic quantities. The LCA methodological approach provides only now the employment of energy and environmental data with the intent to link them to economic ones at a later stage and independently.

❖ **Requirements of quality and reliability of the data.**

This step is important to establish the reliability of the study results; often, in fact, if the accuracy of the information has little or nothing, it is necessary to resort to literature.

Both in the case in which an LCA analyst is equipped with a software calculation tool that includes a database from which to draw information, both in the case you have available databases that can be used as a source of information to be included in the own model , it is important to qualify the statistical representativeness of the data, its origin and all the elements required for its reproducibility.

[Ornella Ronchini, 2010]

1.6.2. - Phase 2 - Inventory analysis (ISO 14041)

It is undoubtedly the most delicate phase and expensive in terms of time of a LCA, as it represents the information base onto which the subsequent stages.

Following the definition of ISO 14041, it is in this phase that are "[...] identified and quantified the flows into and out of a system / product, throughout its life [...]". They will therefore be identified and measured the consumption of resources (raw materials, recycled products and water), energy (heat and electricity) and the emissions to air, to water and soil. At the end of the structure it will look like a real environmental balance.

The inventory can be divided into four modules:

1. <u>Process Flow Diagram:</u>

The process flow diagram is a graphical representation and qualitative of all relevant steps and all the processes involved in the life cycle of the analyzed system. It is composed of sequences of processes (boxes), connected by material flows (arrows). Its fundamental characteristic is to divide a system into several subsystems, explicate interconnection actions (the outputs of an upstream subsystem are the inputs of a downstream subsystem) and identify the parts of the process featured of greater importance, especially in terms environmental, to avoid attributing the same degree of attention indiscriminately to all stages;

2. <u>Data collection:</u>

the collection of data requires a very high commitment, in terms of time and resources, due to the considerable amount of information, often difficult to find, necessary to characterize all stages of the production process. The data collected can be divided into three categories:

- primary data from direct measurements;
- secondary data, obtained both from the literature, such as specific software databases (BUWAL, CETIOM, CBS, IVAM) and technical manuals, and by other studies and engineering calculations;
- tertiary data, from estimates and from similar operations, from data relating to tests made in the laboratory, from environmental statistics and by average values.

When you collect the data set you need to check that these are concrete and coherent: a simple assessment method consists of making a budget for each process, taking into account the fact that the amount of input must be equal to the release of the output.

In addition to the impacts related to the process, they must also be defined the data concerning:

- impacts and consumptions relative to electricity imported into the system: it is necessary to clarify the context of reference (regional, national, Community) to perform the assessment of the fuel mixing involved in the production of electrical kWh used, the overall efficiency of the system and its impacts on the environment;
- impacts and consumptions relating to the transport system: the products may be transported by different means, to each of which corresponds a certain impact for the transported product unit.

3. Defining the system boundary conditions:

At this stage they define:

- the boundary between the system studied and the environment; must also be specified the load on the environment , represented by all the extractions and injections that take place during the entire life cycle;
- the boundary between the processes deemed relevant and irrelevant ones: in this phase you decide the extension of the study, by establishing what should be included and what should instead be overlooked. It takes into account the purpose of the study, defined above, and it is based on practical considerations, based on the opportunity to not involve elements which effectively have no substantial significance on the final results.

4. Processing of data:

One time the data have been collected, these are related to all process units that contribute to the chosen functional unit where, for each process units, will determine an appropriate unit of measurement for the reference flow. Subsequently, the data relating to the impact are processed and reported to the unit of product functional, through the definition of a contribution factor that expresses the contribution of each process respect to the production of a functional unit, expressed through the chosen measurement units.

This procedure must be performed for all substances present in each process.

A problem that may occur during this stage concerns the distribution of consumptions and impacts related to different products generated by the same production process. It is evident the importance of knowledge in the detail of the production process in order to be able to assign to each product obtained the relative quota of raw material and energy consumed, therefore the respective impacts in the air, water and solid waste.

When this is not possible, because, for example, in the same process are worked more categories of products, we shall make an allocation of consumption and its impacts through a subdivision that can take into account the following criteria:

- quantities consumed are assigned based on the weight of the different products, ie by weighing;
- based on the economic value of each product;
- depending on the importance of the various products.

[Ornella Ronchini, 2010]

1.6.3. - Phase 3 - Impact Assessment (ISO 14042)

The ISO standard defines "environmental impact any change caused by a given environmental aspect, or any item that can interact with the environment."
An impact is associated with one or more environmental effects: for example the CO2 emitted during the combustion of a certain amount of coal causes an impact that contributes to the greenhouse effect.
Because it is not possible to unambiguously correlate a specific impact to its environmental effects, it will be limited to assert that **the impact is what prelude to an effect, no claim to be able to rigorously quantify the second on the basis of the first.**
While we can get the numeric value of the impacts (or rather, of the pressures) by the results of the phase of inventory analysis, the corresponding environmental effects can be estimated on the basis of assumptions and conventions. The effects due to substances released into the environment occur in the immediate vicinity of the emission point or have a relapse on the entire planet. Therefore, the environmental effects are divided into global effects, regional or local.
Always taking for example the CO2 emissions responsible for the greenhouse: analyzing the residence time in the atmosphere of CO2 it is possible to classify the greenhouse effect as a global effect because it was found that the emission of greenhouse gases in an local point contributes to the effect on the whole planet; For noise emissions instead it is clear that these should only be considered on a local scale.
It is therefore appropriate to highlight that any value judgment on the environmental significance of impacts can concern only the global effects, meaning those that occur at global or regional scale. The the global weight of a given pollutant is the result of numerous contributions often from different geographical areas of the earth, for different periods of time. Therefore the results of the inventory analysis may be used for the evaluation of effects on a global scale. In addition, the substances emitted during transmission can undergo chemical transformations, physical or biological giving origin to other compounds. For example, the formation of photochemical oxidants resulting from the interaction that the sunlight has with hydrocarbons emitted into the atmosphere, leads to the formation of ozone molecules; or if you consider the total SO2 emissions from the inventory results, acid rain, the resulting _ acidification and the eventual loss of biodiversity in a lake are the immediately conceivable consequences. Understanding the phenomenaof the interaction of human activities _ with the environment is an important objective to promote the new culture of industrial production based on the concept of sustainable development. The goal will be to find out as part of the system under test, where and how to intervene to achieve minimization of the impact caused by these processes analyzed.
The impact assessment of the life cycle consists of a technical-quantitative and / or qualitative process for the characterization and evaluation of the environmental impacts of the substances identified in the inventory phase. In this step they are evaluated the effects on health and environment, induced by the process or by the product during the course of its life cycle. The conceptual framework of the impact assessment refers to the ISO 14042 standard that defines and standardizes it in the steps described below:

1. *<u>SELECTION AND DEFINITION OF IMPACT CATEGORIES:</u>*

in this first phase are identified as impact categories produced by the system under test. For the definition of these categories must be observed three characteristics:

- Completeness: include all classes in the short and long term, on which the system could affect;
- Independence: avoid intersections between categories, which would involve multiple counts;
- Practicality: the list formulated will not go to high detail, contemplating an excessive number of categories.

For the choice of categories can be useful to consult the Working Group on the SETAC LCA, within which are proposed and described numerous types of impact, such as:

A. extraction of abiotic resources, in which are included three different types of natural elements:
    - deposits of fossil fuels and minerals, considered as non-renewable resources limited in the short term;
    - resources, such as groundwater, sand and gravel;
    - renewable resources such as surface water, solar, wind, ocean currents;
B. extraction of biotic resources, ie specific types of biomass both harvested in a sustainable manner, both in a non-sustainable;
C. use of the territory, whose bad management leads to a reduction in the number of animal and plant species present, compared to the natural conditions;
D. greenhouse effect, which involves increasing the temperature in the lower atmosphere consequence of the presence of some gases, such as carbon dioxide, methane, nitrogen dioxide, which trap infrared radiation;
E. ecotoxicity, caused by direct emissions of toxic substances such as heavy metals, hydrocarbons, pesticides and substances released during the degradation products, which give rise to impacts on species and ecosystems;
F. photochemical smog, in which you consider all the impacts resulting from the formation of tropospheric ozone, caused by reactions of organic compounds (VOC) in the presence of light and of nitrogen oxides (NOx);
G. human toxicity, attributable to to the presence of chemical and biological substances, and dependent both on the type of exposure, both from the methodology through which the emissions occur in the environment;
H. acidification caused by the release of protons in aquatic and terrestrial ecosystems, mainly through the rain; the effects are evident in the softwood forests, where they manifest themselves in terms of failure to thrive: this phenomenon is particularly present in Scandinavia and in the regions of Central Eastern Europe. In aquatic ecosystems there is a reduction of the pH of the water, deleterious situation for the development of life. The consequences of acidification which indicate, moreover, in buildings, in art and in all buildings usually through the erosion of calcareous stones.
I. nutrient enrichment, caused by an excess of nitrates, phosphates, degradable organic substances and of all those nutrients which lead to an increase in the production of plankton, algae and aquatic plants in general.

2. *CLASSIFICATION:*

It is the assignment phase of the data collected in the inventory to one or more categories of environmental impact, known effects and potential emissions harm to human health, the environment, resource depletion, etc.

At the end of this phase, within each category of impact, it will contain all the inputs and outputs of the life cycle that contribute to the development of various environmental problems. The same substance or material may be contained within multiple categories of impact.

3. *CHARACTERIZATION:*

It stands alongside the step of classification and has the aim to quantify the impact generated. It transforms, through a series of calculations, the substances present in the inventory, and previously classified, in indicators of numeric character , through the definition of the relative contribution of each individual substance emitted or resource used. The operation is carried out by multiplying the weights of the substances emitted, or consumed in the process, for its characterization factors (weight factors), conditions for each impact category. In summary, the characterization factor of measures the intensity of the effect of the substance on the environmental problem considered, and is established by an Authority on the basis of closely scientific considerations.

Listed below are the weight factors for the different impact categories proposed by CML, in October 1992:

- For category ABIOTIC RESOURCE EXTRACTION , the ratio use/reserve Wj , is expressed by the equation:

  $$\mathbf{Wj = Gj / Rj}$$

  where:
  Gj is the current global consumption of the mineral j;
  Rj is the reserve of the mineral j.

- For category BIOTIC RESOURCE EXTRACTION , it has not yet been realized a reliable determination: you might define an indicator based on the rarity of the resource and his regeneration rate.
- For the GREENHOUSE is used the parameter Global Warming Potential (GWP), which defines the potential influence of a substance assessed in relative terms compared to CO2, according to time horizons of 20, 100 and 500 years; this in order to take account of the fact that the various substances decompose and inactivate only in very long periods of time.
- For the DEPLETION OF STRATOSPHERIC OZONE has been introduced parameter Ozone layer Depletion Potential (ODP): the comparison substance for which it assesses the effect of the other is the CFC11.
- For the ECOTOXICITY EFFECT have been introduced the following parameters:
  - AEC (Aquatic Ecotoxicity) [m3 / kg], for the assessment of water toxicity;
  - TEC (EcotoxicityTerrestrial) [m3 / kg], for the evaluation of the toxicity of the soil.
- For the HUMAN TOXICITY have been developed the following indexes:
  - HCTA (Human-toxicological Classification value for Air), classification index for substances emitted into the air;
  - HCTW (Human-toxicological value for Water Classification) classification index for substances emitted into the water;
  - HCTS (Human-toxicological value for Soil Classification) classification index for substances emitted into the ground.

  They provide an indication of maximum and do not claim to be totally accurate and reliable.

- For photochemical smog is used the parameter Photochemical Ozone Creation Potential (POCP), for organic components. This parameter is expressed for the different substances in terms of equivalence with the ethylene (C2H4).
- For ACIDIFICATION category is used the Potential of Acidification factor (AP), estimated for each substance in terms of SO2, or in terms of mole of H+.
- For EUTROPHICATION is used the Potential of Eutrophication (EP) expressed in terms of impoverishment in O2, or in PO4.

The above-mentioned indicators, are, for the most part, the same used within the method of the eco-indicator 99, present within the calculation code sima pro 7.3, used in this study.
The result of the characterization phase is the ***profile environmental***, constituted by a series of environmental impact scores for each category, obtained adding together all the individual contributions previously calculated, that usually is represented visually through a series of histograms or through a network with arrows of different thickness that indicate wich activities implie greater impact.

[Ornella Ronchini, 2010]

4. *NORMALISATION:*

Finished stages of classification and characterization, and obtained the eco-profile, we go to the third step: the normalization. The ISO standards define it like this: "Calculation of amount of the results of category indicator compared with the reference information." In fact, once quantified the different indicators, it is still complex to interpret the effective size of the various impact categories, being expressed in different units of measure.
Normalizing means therefore divide the calculated amount of an impact category to the total quantity of the same category that occurs in a specific time period and in a given area. Are thus obtained synthetic indexes, thanks to which you can effectively understand to what impact category the system contributes most. The normalized results show the environmental problems generated by the life cycle of a product according to their "order of magnitude." Only with the normalization you are able to begin to understand the environmentally critical phases of the test system, or you are able to can begin to make comparisons between products that have upstream different production technologies.
The abovementioned ISO standard defines this stage "optional" for the numerous uncertainties related to the identification of the validity of a limited impact over time and space; uncertainties due primarily by the lack of statistical data. "

[Francesca Cappellaro et alii, ENEA, 2011]

In this phase the values obtained from the characterization are normalized, ie divided by a "reference value" or "normaleffect" which is usually represented by the averages worldwide, European or regional, referred to a given time interval. Through the normalization it can establish the magnitude, ie the extent of the environmental impact of the investigated system, compared with that produced in the specified geographical selected as rfeerment. Table below shows the values relative to a year of world industrial production. The normalization is carried out, for example, by dividing the results of the operation of characterization with those given below.

Tabella 2- Values relative to a year of world industrial production

ENVIRONMENTAL THEMES	UNITS	WORLD VALUES
Depletion of energy sources	$GJ*(year^{-1})*10^9$	235
Greenhouse effect	$kg*(year^{-1})*10^{12}$	37.7
Photochemical oxidants	$kg*(year^{-1})*10^9$	3.74
Acidification	$kg*(year^{-1})*10^9$	286
Human toxicity	$kg*(year^{-1})*10^9$	576
Water ecotoxicity	$m*(year^{-1})*10^{12}$	1160
Spil ecotoxicity	$kg*(year^{-1})*10^9$	1160
Eutrophication	$kg*(year^{-1})*10^9$	74.8

The data in the table are very general, so for more detailed analysis is necessary to use indices for the various geographical areas in which production takes place under consideration. According to ISO standards, the normalization phase is not mandatory for a full LCA.

[Ornella Ronchini, 2010]

5. *<u>WEIGHTING AND EVALUATION:</u>*

The weighting, or weighing, also called evaluation in this case, (weighting across impact categories) is defined by ISO as follows: "The weighting is the process of converting of the indicator results of the different impact categories using numerical factors based on the values chosen. It may include aggregation of the weighted indicator results. "[Matheys J., 2008]

In this phase it is assigned a weight of importance to the different effects caused by the system, so that they can be compared with each other to then make a further aggregation of data. With the weighing is determined to end an absolute index, the so-called eco-indicator, which expresses the environmental performance of the system in a comprehensive manner. This index will be obtained by the following relation:

$$\mathbf{I = \ wi * Fi}$$

where:

Ei is the normalized effect of the generic impact category,

wi is the weight given to the relevant impact category.

[Francesca Cappellaro et alii, ENEA, 2011]

The objective of the weighting / evaluation phase is to be able to express, through a final index, the environmental impact associated with the product throughout its life cycle. The values of normalized effects are therefore multiplied by the "weight factors" of the evaluation, for the various categories of damage, often reported in technical guides, which express the importance intended as criticality, given to each environmental problem. At the base of the calculation of these factors there is the principle of "distance from the purpose": it asserts that how much bigger is the gap between the current status and the ideal one which we tend, greater results the severity of an effect.

It is clear how subjective is the judgment, which can vary by geographical area, sensitivity and different schools of thought. In some cases, use of weight factors all equal to each other, alternatively assume those provided by some databases.
Summing the values of the effects so obtained, we obtain a single dimensionless value, the final environmental index, said eco-indicator, which quantifies the overall environmental impact associated with the product. The phase of impact assessment, unlike the inventory phase which has achieved a good degree of standardization is still characterized by controversial aspects that need further scientific investigation. In addition, the subjectivity linked to the choice of the Impact Assessment methods hardly possible to achieve an international consensus.

[Ornella Ronchini, 2010]

1.6.4. - Phase 4 - Interpretation and improvement (ISO 14043)

Within this phase, through an analysis of sensitivity, they are interpreted and presented the results of the inventory and evaluation phases of the impacts, in order to have an easily usable and understandable perception of the study. To it, almost always is been accompanied by the identification of the LCA phases in which, after identifying the most critical areas, are evaluated and selected the options and improvements acts to reduce the environmantal impacts and loads of the functional unit in the studio. It may, in this section, also represent different scenarios that considered and compare the results gained.
This phase has not yet reached a methodological level equal to that of the previous, however, remains an important moment because it allows, where possible, an improved environmental impact in terms of reduction of energy demand, emissions, use of resources , etc. It is important to note that the LCA, as all methods based on the comparison, does not propose an absolute solution, but it identifies a set of alternatives from which then, the decision maker will choose in his opinion the best. The analysis of the life cycle, in fact, can be used for process improvement, product innovation according to sustainable production standards, the development of environmental policy strategies. Usually this step allows you to identify and make specific changes or to take actions necessary to redesign the entire system, in order to improve the state of fact. The ultimate goal, however, is to seek the maximum eco-efficiency.
The ISO standard defines this phase of LCA ("interpretation and improvement") as the moment in which to realize a valid correlation between the results of the analysis of inventory and of that of the impacts. The standard also strongly recalls the fact that only a clear and understandable, complete and consistent presentation of the results of previous phases is able to provide the information useful to set the possible improvements of the system under test. In particular indicates the operational phases:

- identification of the main aspects highlighted by the results of the previous phases;
- additional control through sensitivity analysis;
- conclusions highlighting the limits, recommendations.

In addition to the inventory results and the assessment of impacts, it should highlight the contribution of the different stages of the process under review by identifying the areas of intervention and improvement. It must be highlighted that the phase of interpretation can be conducted on all or only a part of the environmental indicators, also in relation to the parameters on which it intends to focus its activities. For example, a specific indicator to monitor that could constitute a parameter of improvement on which to focus.

[Ornella Ronchini, 2010]

1.6.5. - Annotation.1 - Transport

Transport accounts a vital element for the majority of industrial production processes and often the amount of energy they tied (and consequent emissions) represents a significant part of the total energy expenditure during the analysis process. They can be considered as a means of transport trucks, trucks, lorries, tractors, equipment consuming fuel like wood chippers, etc.

you can subdivide the energy consumption related to transportation in several contributions, ie:

- the energy content of fuels consumed directly from the vehicle in question, plus the indirect portion necessary to produce the fuel, is usually proportional to the distance and depends on the transport system, the reach of the vehicle, the type of journey etc .;
- the energy needed for the construction and maintenance of the vehicle;
- the energy needed to create the infrastructure to allow the journey and their maintenance.

It is clear, however, that the environmental impact of transport systems, air emissions related to direct phase power consumption emerge as the most important to know and evaluate.

Information relating to energy consumption and emissions of vehicles are available in the form of national statistical data on a certain category of means, or in the form of data provided by the manufacturer of the vehicle itself.

Regarding the units of measurement to be used to express the amounts of energy related to transport, taking into account the carrying capacity of means of transport, you can take the unit of energy per ton x kilometer; or in the case of vehicles which do not perform a full load it is the energy per vehicle x kilometer. For emissions, the unit of mass of emitted substances (for example mg of CO2) is related to the units used for energy.

The road transport system is the system more used for the transport of things and people; It can estimate that about 60% of transportation energy associated with this can be attributed to the consumption of fuel, about 30% to the construction and maintenance and about 10% to the construction of infrastructure. The fuel consumption of trucks depends on several factors: the state of the vehicle, the driving conditions, the type of process, the fuel quality, the weather conditions, etc.

Particular attention must be given to the use of units of measurement adopted. Normally you use ton x kilometer, which recounts the input (fuel) and outputs (emissions) for the transport of one tonne for one kilometer; Here it is always necessary to specify the mass transported and distance traveled, assuming full load trips.

A useful precaution used in a LCA analysis concerns the kilometers with half full or half empty load (cause to collect material it must also do a certain empty path before loading the goods); for this problem the LCA considers an average of the total distance traveled, between vacuum travel and full load travel, to realize the transport path. The average kilometers treaded is multiplied for an experimental factor of 1.7, which implicitly takes into account both the full load trips and those with an empty load. It can be noted, from the studies carried out, that as the size of the vehicles corresponds to a rapid increase in consumption and as the petrol transportation exhibit lower efficiency than diesel.

The use of such a unit could be misleading; therefore we have to express the energy performance more clearly, explaining the energy required to transport a unit of mass for a kilometer, ie dividing the values for the load carried.
The figure below shows the trend in consumption per tonne * km as a function of load carried (and not of the payload). It can be noted how the curve presents the minimum in correspondence of the maximum flow: the energy efficiency is pursued trying to travel with full load means, saturating by weight. Since the energy consumption per kilometer of a little load mean is lower than that the same vehicle full load travel, the not consider it would lead to over-estimate the energy per unit mass transported.

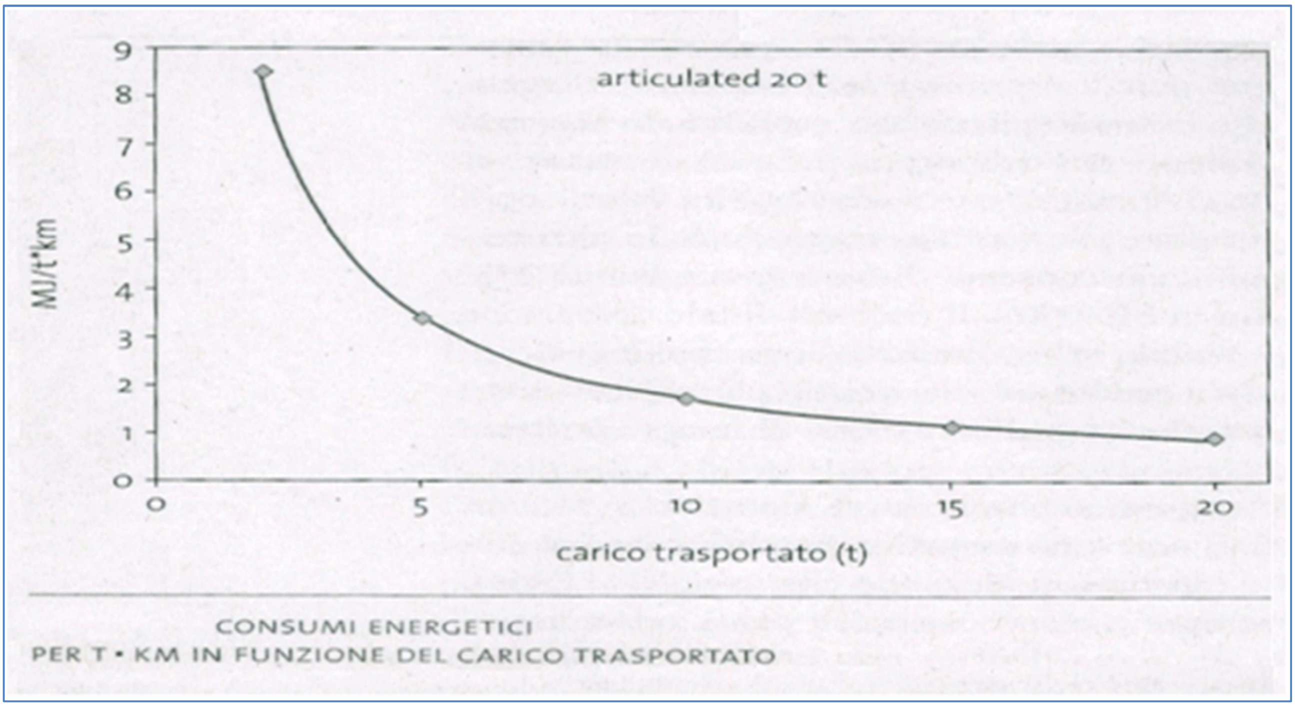


Figura 5- Energy transport consumption, depending on the load carried. - [Ronchini, 2010, a]

Another factor to consider is that related to traffic conditions namely whether the transport takes place mainly in urban or suburban roads. Usually the values provided by the databases refer to situations of extra-urban use, but if you are in urban conditions, the consumption can be increased by 30%.
The databases contained in software programs for the preparation of LCA currently available contain the complete information about all possible means of transport by road, providing detailed information on direct and indirect consumption, thus simplifying the execution of calculations.

[Ornella Ronchini, 2010]

1.6.6. - Annotation.2 - Avoided impacts

Another very important aspect then is what is the quantification of the positive aspects associated with the recovery of certain types of waste.
To assess the benefits of matter or energy recovery _ is usual the methodology of use of the "avoided impacts." Given a system that allows a recovery, through this approach we are subtracted the impacts associated with the production of the flows recovered by the environmental impact generated.

The result of this approach is therefore the assessment of the environmental impacts of a system taking into account, in quantitative terms, the benefits associated with possible recoveries. In this regard it should also be noted as having to perform a subtraction of impacts can cause a negative result. Of course, this data must be interpreted observing that in the presence of negative value, the system produces fewer impacts than the traditional system.

[Ornella Ronchini, 2010]

2. LCA MAIN METHODOLOGIES

As has been said, the LCA method is a standardized procedure that allows you to record, quantify and assess the environmental damages associated with a product, a process or a service, in a very specific context defined in advance.

- First you need to define the purpose and scope of the investigation;
- Next, you need to build the so-called "inventory analysis": in this phase are noted flows of material and energy of the different steps of the procedure in question, in relation to a size that takes into account the benefits (benefit units).
- Once you have completed all budgets, you can start the assessment: this estimate is used to identify and quantify the potential environmental effects of the examined systems and provides essential information for subsequent interpretations.
- At this point the results of the mass and energy balances and the risk assessment are summarized, discussed and evaluated in relation to the objective previously set. You can still consider other contributions that go beyond the pure result obtained; the same is true for subjective elements like moral principles, the technical feasibility and the socio-political and economic aspects.

In summary, the methodologies for impact assessment are systematic calculations used to move from one flow LCI (Life Cycle Inventory), such as carbon dioxide or sulfur dioxide, to the environmental impact that this causes. The results of these calculations typically measure the midpoint effects (impacts) or endpoint (damages).
For example, the following chart illustrates how some endpoint effects are linked to the respective midpoint effects:

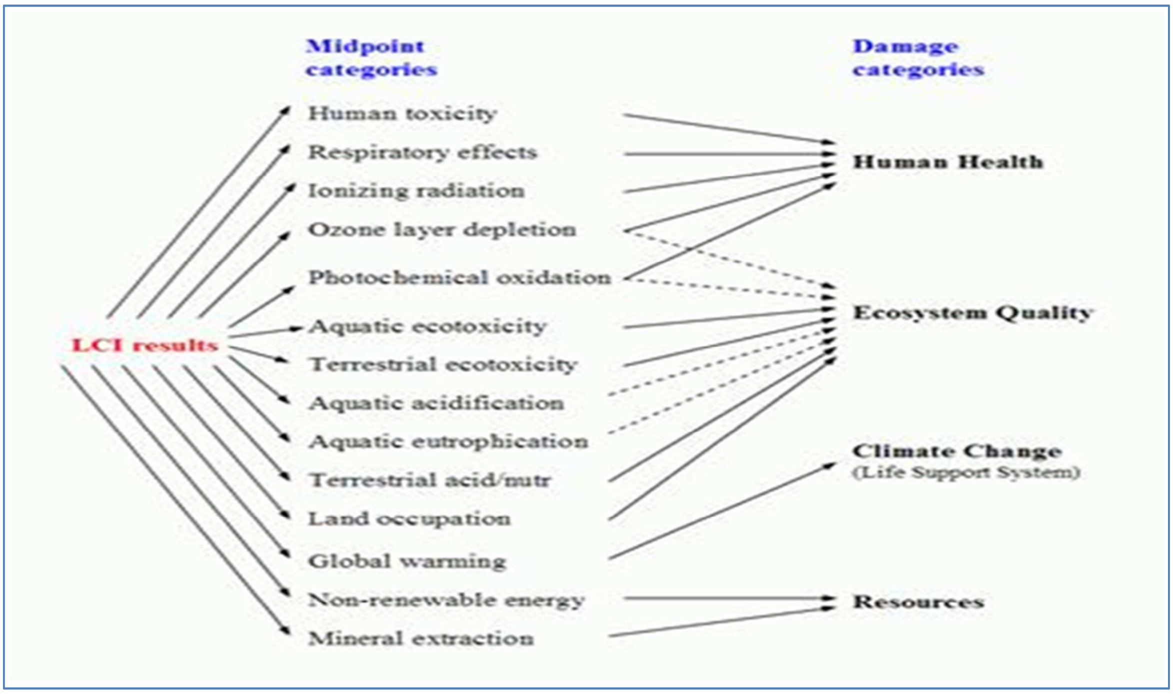


Figura 6- Example correlations between the Life Cycle Inventories, Impacts (midpoint) and damages (endpoint). [Olivia Jolliet, Univ. Of Michigan, 2002] -

Despite the endpoint effects (adverse effects) are the ones we care actually, it can be difficult to measure them directly. For example, how many degrees the increase in global average temperature are caused by the activities of a company? It's really hard to measure such a small effect, so we tend to measure the midpoint effect of greenhouse gas emissions, which lead to the increase in average global temperature. Most of the impact assessment methodologies uses the midpoint measurements.
There are several impact assessment methodologies commonly used in LCIA phases of LCA, and include the classification and characterization, as well as sometimes the normalization and the weighting. Some of these impact assessment methodologies are described below:
[SolidWorks, 2015, a]

2.1. Main methods for LCA analysis

2.1.1. The method of ECO-INDICATORS’99

Eco-indicators’99 (Holland) is a methodology developed by Pré (Product Ecology Consultants) on behalf of the Dutch Ministry of Environment: it is a powerful tool for designers useful to aggregate the results of an LCA into easily understandable and usable quantities or parameters, just called Eco-indicators. [...]
Upstream, the LCA method first of all requires an inventory of all emissions and all resource consumptions attributable to the product / process in its entire life cycle; the result of this inventory is a list of emissions, consumptions of resources and other types of impacts which, once suitably arranged, takes the name of "INVENTORY RESULT". From here, due to the large amount of data, in order to make the procedure more understandable and easily interpretable, it is common practice group the types of impact for categories and calculate a global score, thus referring to the impact categories rather than to the different types of detected impacts.
Downstream, the methodology of eco-indicators aggregates the results of damages in only three main categories.

- Human Health
- Ecosistem Quality
- Resources (resource utilization)

Eco-indicator’99 give a high weight to land use, does not consider the use of water, uses the categories of impact and damage measured as "end point" (the same emission units). The emission of carbon compounds with the greenhouse effect is considered only in relation to human health (Climate Change) and it takes into account the CO2 absorbed ("Carbon dioxide in air" taken with negative characterization factor) and biogenic emissions (CO, CO2 and CH4) resulting from the transformation of the territory ("Carbon dioxide, land transformation").

For the method were developed models that in a scientific weighted manner bind the substances identified in the study of the product life cycle to the types of impact, in turn related to the impact categories, in turn further connected to the above three categories of aggregated damage, thhat have the following units:

- **Human Health: <u>DALY</u>** that measures the years of life lost by the entire European community due of 1 kg of the considered emission .
- **Ecosystem Quality: <u>PDFm2yr</u>** that measures the percentage of damaged plant species in Europe due to 1 kg of the considered emission (Potential Disappeared Fraction), multiplied by the area of Europe (m2) and for the number of years of permanence (yr).
- **Resources: <u>MJ Surplus</u>** that measures the extra energy needed to extract 1 kg of the resource when the request will be 5 times that of 1990.

The **<u>total damage</u>** is expressed in **<u>points (Pt)</u>**

Note: The impact categories (midpoints) have the same units of the categories of damage (endpoints) excluding Ecotoxicity that measures the damage in PAFm2yr, and not in PDFm2yr.

- PAFm2yr measures the percentage of AFFECTED plant species in Europe due 1 kg of considered substance;
- PDFm2yr measures the percentage of DISAPPEARED plant species in Europe due 1 kg of considered substance;

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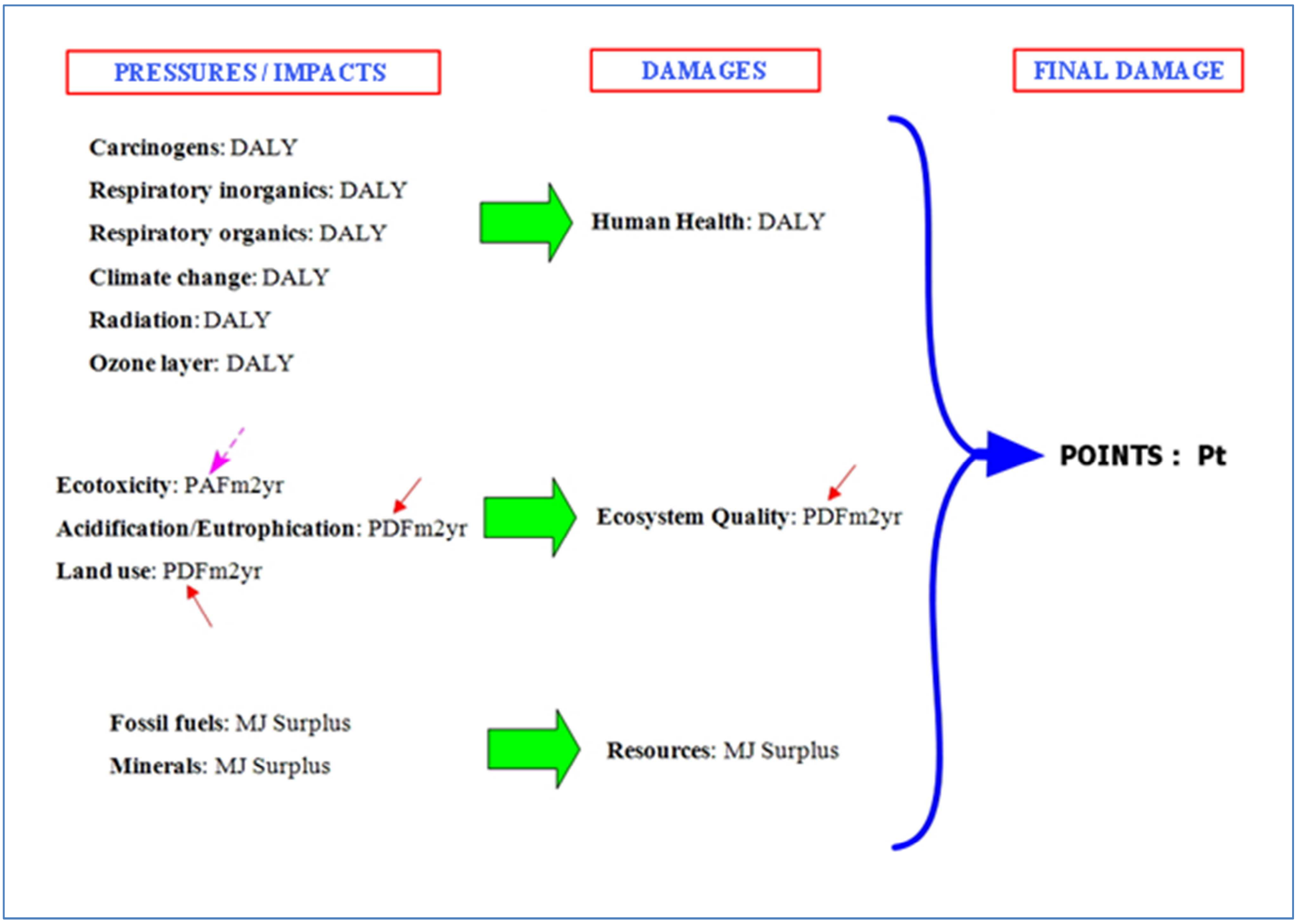

Figura 7- Conceptual scheme of the Ecoindicator'99 LCA method transition from the impact categories to those of damage, until the final measurement of total damage -

With the characterization are characterized (multiplied by the characterization factor) the substances and inserted in the specific impact categories .

The impact categories are then characterized (multiplied by a factor of damage assessment) and included in the categories of damage to which they belong (damage assessment).
The impact category so characterized is normalized by dividing it by a normalization factor that is the damage in the same category due to human activities in Europe in one year and referred to the single European citizen.
The category of damage (and thus that of impact) so normalized, is evaluated (multiplied by the weighting factor, which is 333,333 for all categories of damage.
The total damage is then finally in points (Pt).

[Fortuna, 2009, a]

2.1.2. The method of IMPACT 2002

IMPACT 2002 (Switzerland) does not consider the water and the transformation of the territory, while the emission of carbon compounds with the greenhouse effect is concerned only in Global warming (impact category) and then in Climate change (damage category) without taking into account the CO2 absorbed and biogenic emissions. The impact categories have as unit of measure the quantity of substance equivalent (mid point). The damage categories (except Climate Change which is still measured by the equivalent amount of substance) have as a measure the effect of the damage on humans, the ecosystem quality and resources (endpoints).

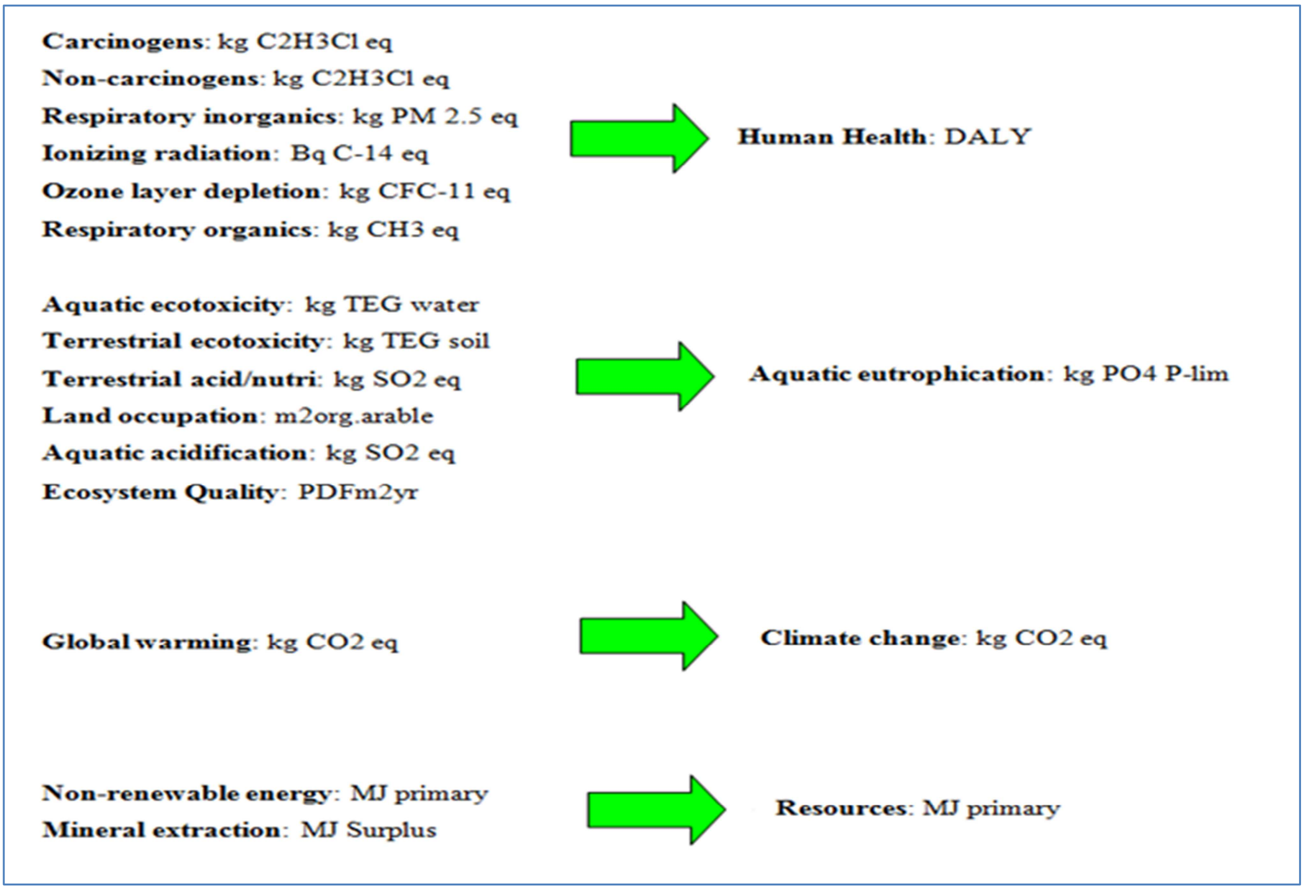

Figura 8- Conceptual scheme of the Impact 2002 LCA method -

With the characterization of the substances are characterized (multiplied by the characterization factor) and then inserted in the individual categories of impact.

The impact categories are then characterized (multiplied by a factor of damage assessment) and included in the categories of damage to which they belong (damage assessment).
The impact category so characterized is normalized by dividing it by a normalization factor that is the damage in the same category due to human activities in Europe in one year and referred to the single European citizen.
The category of damage (and thus that of impact) so normalized, is evaluated through the multiplication by the evaluation factor, which in the case of Impact 2002 is 1 for all categories).
The total damage is expressed in points (Pt).

[Fortune, 2009, a]

2.1.3. The method of EPS-2000

EPS 2000 (Sweden) considers the damage related to the use of water and the production of cereals, wood and meat and fish with a damage category that indicates the production capacity of the ecosystem. In addition consider the damage on human health, biodiversity and on the depletion of resources. The CO2 emission is considered in the human health and the effect on ecosystems, taking into account the biogenic emissions and CO2 absorbed (considered as negative and thus positive for the environment): for this reason in agricultural productions are obtained advantages. It does not consider ionizing radiation, attributes a higher weight to the use of resources. The characterization of the categories of impact is made on the basis of external costs (willingness to pay) and has as a unit of meausure the euro environmental equivalent. The evaluation is equal to 1 for all categories of damage.

The impact categories divided by categories of damage have the following units (end point):

- **Human Health:** The ***PersonYr*** which measures the years of life lost by the entire world community due 1 kg of emissions considered.
- **Ecosystem Production Capacity: kilograms** for all impact categories (excluded Soil acidification that measures the damage in eq H + ions) measures the amount of substance produced or not produced due 1 kg of emission considered).
- **Depletion of reserves: ELU (Environmental Load Unit)** which is the external cost required to compensate the damage due to the depletion of 1 kg of resource considered.
- **Species extinction: NEX** which measures the relationship between the animal and plant world influenced by 1 kg of considered emission and the total species affected in 1 year worldwide.

The damage categories are expressed in ELU that is the external cost required to compensate for the damage produced from 1 kg of emission considered.

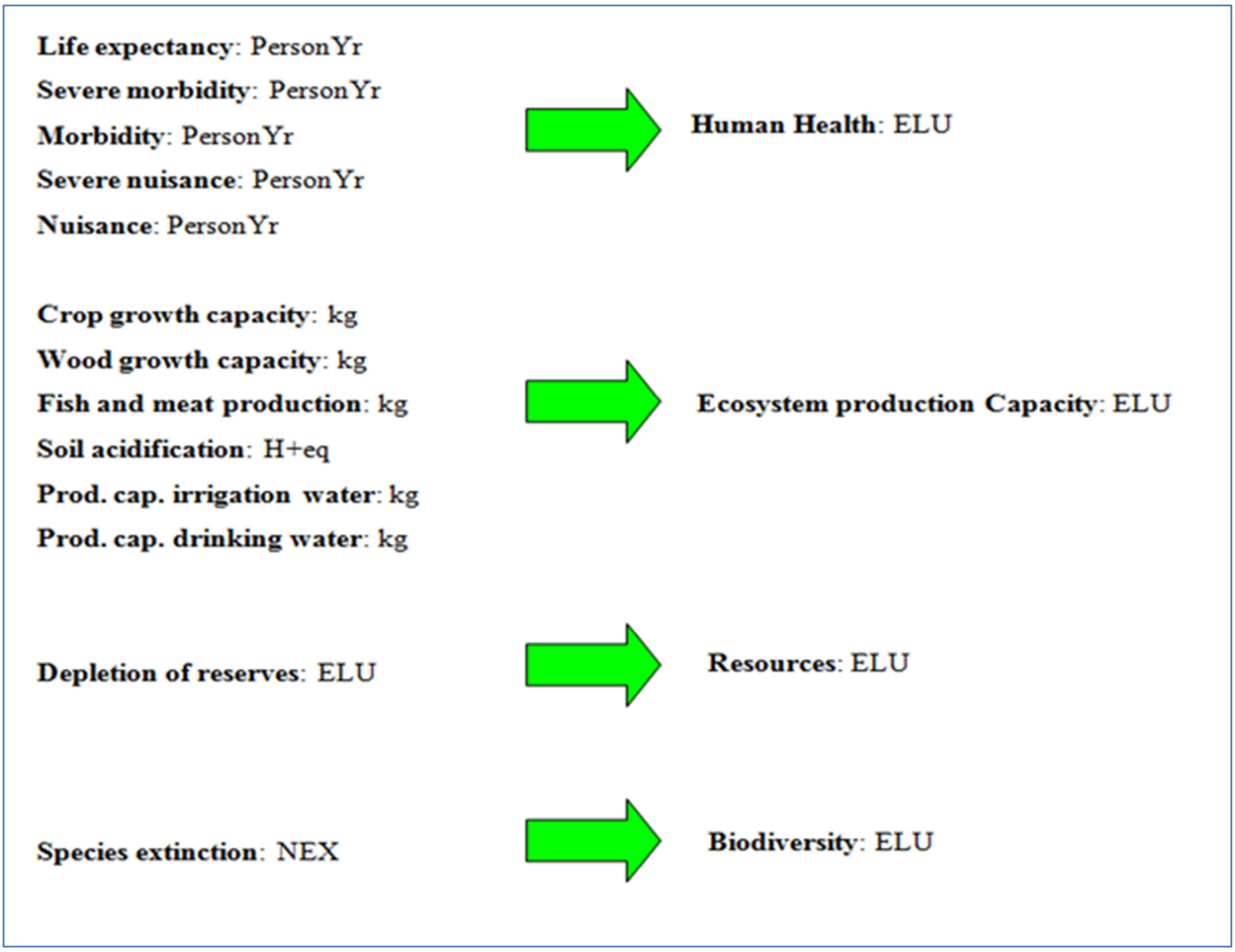

Figura 9- Conceptual scheme of the EPS 2000 LCA method -

With the characterization are characterized (multiplied by the characterization factor) the substances and inserted in the individual categories of impact. The impact categories are then characterized (multiplied by a factor of damage assessment) and included in the categories of damage to which they belong (damage assessment). The impact category, as well characterized, is assessed (multiplied by the weighting factor), which is 1 for all categories of damage excluded Ecosystem production Capacity for which it is 0.1.
The total damage is expressed in points (Pt).

[Fortuna, 2009, a]

2.1.4. The method of EDIP 2003

Edip 2003 (Denmark) does not consider the use of water, the dust emissions and land use. It contains only impact categories, measured as equivalent emission units, as volumes of pollutted air, water and soil. The method also considers the amount of waste products. It attaches a poor weight to use of resources. It takes into account the biogenic emissions but not CO2 absorbed. With the exception to use of resources, it assesses the damage based on the reduction of the damage that the community in the future aims to achieve.
The method uses only the categories of impact that they have as unit of measure the amounts of equivalent substances, areas and volumes damaged by emissions and the waste weights.

Its impact categories are the following:

Tabella 3- EDIP 2003 impact categories

Global warming 100a: kg CO2 eq	**Human toxicity soil**: m3
Ozone depletion: kg CFC11 eq	**Ecotoxicity water chronic**: m3
Ozone formation (Vegetation): m2.ppm.h	**Ecotoxicity water acute**: m3
Ozone formation (Human): person.ppm.h	**Ecotoxicity soil chronic**: m3
Acidification: m2	**Hazardous waste**
Terrestrial eutrophication: m2	**Slag/ashes**: kg
Aquatic eutrophication EP(N): kg N	**Bulk waste**: kg
Aquatic eutrophication EP(P): kg P	**Radioactive waste**: kg
Human toxicity air: m3	**Resources**: kg
Human toxicity water: m3	

With the characterization are characterized (multiplied by the characterization factor) the substances and inserted in the individual categories of of impact. The of impact categories are then characterized (multiplied by a factor of of damage assessment) and included in the categories of damage to which they belong (of damage assessment). The impact category so characterized is normalized by dividing it by a normalization factor that is the damage per person in 1990 (in the world for the two global categories, in Denmark for local categories) in the same category, and per Resources that is the consumption for person in 1990. the impact categories so normalized, are then assessed (multiplied by a weighting factor which is the ratio between the loss per person in 1990 and the damage per person you want to obtain in the future). For Resources the evaluation factor is the ratio between the consumption per person in 1990 and consumption per person in the future.

[Fortuna 2009, a]

2.1.5. The method of IPCC GWP 100a 2007

IPCC 2007 GWP 100a calculates the greenhouse damage relative to a time period of 100 years. It was inserted by the study group the "*Carbon dioxide, land transformation*". For its calculation it considers for carbon dioxide, methane and carbon monoxide, both the fossil emissions that those biogenic (C short cycle). Also it considers the carbon dioxide absorbed by vegetation (which contributes negatively to the greenhouse effect). The only considered impact category is Global warming 100a.

[Fortuna 2009, a]

3. THE BIOMASS AS ENERGY SOURCE

The 20.20.20 Horizon program is a set of measures established by the European Union Directive 2012/27 / EU to combat pollution and greenhouse gases which lead to global climate change: they are rules established after the Kyoto Protocol, has reached its deadline in 2012, which envisage the achievement by the year 2020 of the reduction targets of 20% of greenhouse gas emissions, the reduction of 20% of primary energy consumption and 20% of the increase in production renewable energy.
On one side there is therefore the need to take timely action on reducing greenhouse gas emissions, and reducing the use of fossil fuels such as oil, coal and gas in favor of renewable energy sources such as solar, geothermal, the solar thermal, wind, hydroelectric and biomass power.
On the other there is the need to study the impact that new plants relating to Renewable Energy Sources (RES) have on the environment in order to loss of land and the introduction of substances into the atmosphere.

Among the renewable energy sources are increasing interest the BIOMASS, generally classified into the following three subtypes:

- Solid biomass (woody)
- Bioliquids
- Biogas

Their use at specific installations, allows to produce electricity and thermal energy emitting "almost zero" CO2 (carbon dioxide), which is the most responsible for the greenhouse gases.
By contrast, the combustion of biomass, or their derivatives gaseous, also involves emissions into the atmosphere, of pollutants, such as NOx, SOx, dioxins[1] and particulate matter (PM), responsible for air pollution, or the consumption of agricultural land for energy crops, with their use and consumption of diesel and fertilizers for the cultivation and harvesting, with all the environmental impacts that follow.

In extreme synthesis, the application and use of sustainable energy production systems, such as biomass, sometimes contrasts with those that are the vocations, and the peculiarities of each territory also going to generate conflicts within the local community in order to land consumption, atmospheric emissions of pollutants, noise and visual impact.

[Di Lorenzo, 2015, a]

This research will have as its main aim is to deepen the theme of the use of biomasses for the production of electrical and thermal energy to support the assessment and the energy planning at regional and territorial level.

[1] Dioxins are present only in the case there are Chlorine in the starting biomass or when the combustion doesn't work at right temperature or in in oxygen deficiency. Except in the case of technical combustion problems, therefore, it has no production and emission of dioxins from biomass power plants.

3.1. What is the biomass

Biomass can be defined as any substance of plant or animal used for the production of energy. It can be burned directly as a normal fuel or can be converted into other physical forms of energy (biofuel) from the combustion of which it will obtain thermal energy, and thus then electricity. It includes wood, vegetable waste (including wood waste and bio-energy crop), materials / waste animal, and any other substances of organic origin.
In this context the term "biomass" means "animal organic matter", which may be of vegetable or animal origin. In any case, the animal organic matter derives from the one vegetable: herbivorous animals eat grass and plants, that is vegetable animal organic matter. It is the vegetable world which, through photosynthesis, is capable of converting solar energy and CO_2 in vegetable organic matter, upon which is based the entire food pyramid of living, organic, beings.
Among the different sources of renewable energy (solar, wind, hydro, geothermal, etc ..), biomass is the most sophisticated form of solar energy storage, because through photosynthesis plants convert atmospheric CO_2 into organic matter, thereby fixing the carbon in their biomass with good energy content.
Compared to fossil fuels, that emit the CO_2 absorbed million years ago, the biomass present a "neutral" CO_2 balance _, inasmuch the CO_2 emitted during their combustion is the same as that absorbed and converted during their vegetal growth.
It should be noted, however, that this budget of CO_2, in the case of the use of biomass to produce energy, can not be exactly null, because you have to consider the entire life cycle of biomass fuels, including the cultivation, harvesting, processing, transport, etc .. ie we must add the consumption of energy and raw materials necessary to support these processese of productive chain.
In brief, excluding the chain of processes, required for an energy system with fossil fuels that for one with biomass, while the latter in its combustion system results to have a balance of CO_2 emissions egual to zero, the one based on fossil fuels is instead totally negative (or positive, depending on how you intend to) because all the CO_2 released during combustion of fossil fuels does not belong to the current air-weather-climate system by several hundred million years, thus generating the infamous climate change, which ultimately if pushed to the extreme will lead to a real climatic and ecological upheaval.
The use of biomass for energy purposes instead does not contribute to aggravate the greenhouse effect, because the amount of carbon dioxide emitted into the atmosphere during their decomposition, both it will be done naturally than it happens as a result of energy conversion processes (even if through combustion), is equivalent to that absorbed during the growth of the biomass itself. So if you burn biomass are replaced with new biomass, there is no contribution to the increase of CO_2 concentration in the atmosphere. This happens every time you use biomass, both it has spontaneous natural origin than specifically cultivated (excluding however as mentioned the processese of productive chain consumptions).

[ARPAT, 2015, a. - Modified]

3.1.1. Definition of biomass according to the italian law

Legislative Decree no. 387/2003 "Implementation of Directive 2001/77 / EC on the promotion of electricity produced from renewable energy sources in the internal electricity market, at art. 2 paragraph 1, mirrors the definition of biomass contained in the directive itself ... In particular, biomass means: the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), from forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste .

The subsequent Legislative Decree no. 28/2011 "Implementation of Directive 2009/28 / EC on the promotion of energy from renewable sources, amending and subsequently repealing Directives 2001/77 / EC and 2003/30 / EC widens further the definition: 'Biomass' means the biodegradable fraction of products, waste and residues from biological origin coming from agriculture (including vegetal and animal substances), from forestry and related industries including fisheries and aquaculture, the mowings and prunings from the public and private green, as well as the biodegradable fraction of industrial and municipal waste .

In addition, the Legislative Decree no. 152/2006, as subsequently amended, specifies the types of biomass included among fuels whose use is permitted in the power plants referred to in Title I, specifying the type of tipology and origin conditions:
Biomass fuels identified in Part II, Section 4, at the conditions here foreseen [...]

A. Plant material produced from dedicated crops.
B. Vegetable material produced by exclusively mechanical treatment, water washing or drying of agricultural crops not dedicated.
C. Vegetable material produced by forest operations, from forest maintenance and pruning.
D. Vegetable material produced by exclusively mechanical processing and treatment with air, steam or also superheated water, of virgin wood and consisting bark, sawdust, shavings, chips, refili and virgin wood dowels, pellets and virgin wood waste, pellets and waste of virgin cork, dowels, not contaminated by pollutants.
E. Vegetable material produced by exclusively mechanical treatment, by washing with water and drying of agricultural products.
F. Disoiled olive sansa having the characteristics indicated in the following table, obtained by the treatment of virgin olive residues with n-hexane for oil extraction of sansa intended for human consumption, and subsequent heat treatment, provided that the above mentioned treatments are carried out inside the same manufacturing plant.
G. Black liquor obtained in paper mills by the wood leaching operations and subjected to evaporation in order to increase the solid residue, provided that the production, the treatment and the subsequent combustion are effected in the same paper mill and provided that the use of this product will be an extent to emissions reductions and energy savings identified in the integrated environmental autorization (IEA)."

Lastly, a further definition of which is important to consider, in view of future implementation, is as set out in Directive 2010/75 / EU on industrial emissions (integrated pollution prevention and control), which reads: The term 'biomass 'means:

- products made of vegetable matter from agriculture or forestry which can be used as fuel for recovering its energy content;

- the following wastes:
    - vegetable waste from agriculture and forestry;
    - vegetable waste from the food processing industry, if the heat generated is recovered;
    - fibrous vegetable waste from the production of virgin paper pulp and paper production from pasta, if they are co-incinerated at the place of production and the heat generated is recovered;
    - waste cork;
    - waste wood with the exception of those that may contain halogenated organic compounds or heavy metals as a result of a treatment or coating which includes in particular the wood waste originating from construction and demolition waste. "

Given the definitions set out in above, biomass is defined as all substances that have organic matrix derived directly or indirectly from photosynthesis. We have therefore two types of biomass:

• VEGETABLE Biomass: derives directly from the photosynthesis;
• ANIMAL Biomass: derives indirectly from the photosynthesis, the one that through the food chain of animals, allows the transition from the vegetable world to the animal world.

At the base of the creation of the biomass there is therefore the photosynthesis, which is a chemical process that occurs in the presence of sunlight, thanks to which the green plants and other organisms produce organic substances, mainly carbohydrates, from carbon dioxide and atmospheric metabolic water.

$$6CO_2 + 6H_2O + \text{mineral salts} + \text{solar energy} \longrightarrow C_6H_{12}O_6 + 6O_2 + \text{other substances}$$

The biomass can therefore be properly regarded as a solar energy reservoir, also available to humans to produce energy, through a series of processes of decompositional nature. They have the characteristic of being produced faster than a natural decomposition process and occur through the use of machines and installations with processes of combustion, gasification and other of decompositive type.

3.1.2. Further definitions of national electrical services manager (GSE)

The GSE (Italian National Manager for Electrical Services) in his system to account and pay the incentives for produced electric energy from renewable sources uses following terms:

- ***Biofuels:*** liquid or gaseous fuel for transport produced from biomass (Legislative Decree 28/2011).

- ***Biogas:*** gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass (EU Regulation 147/2013). In particular:
  - landfill gas: biogas produced by the digestion of waste in landfills;
  - gases from sewage sludge: biogas produced from the anaerobic fermentation of sewage sludge;
  - other biogas: biogas produced from the anaerobic fermentation of agricultural products of animal slurries and of wastes in abattoirs, breweries and other agro-food industries.

- ***Biomass:*** the biodegradable fraction of products, waste and residues _ of biological origin coming from agriculture (including vegetal and animal substances) from forestry and related industries including fisheries and aquaculture, the mowings and prunings from the public green and private as well as the biodegradable fraction of industrial and municipal waste (Legislative Decree 28/2011).

- ***Hybrid power plants:*** "plants that produce electricity using both non-renewable sources, both than renewable sources, including the co-combustion plants, ie plants that generate electricity through the combustion of non-renewable and renewable sources (Decree legislative 28/2011). Plants using mainly fossil fuel are not counted in number and power among renewable energy plants. It is taken into account instead of the proportion of electricity generated from renewable sources when calculating the total production from bioenergies.

[GSE, 2014, a]

Index - part 2.3 -

ENVIRONMENTAL PLANNING ASSESSMENT METHODS

1. ENVIRONMENTAL PLANNING ASSESSMENT METHODS

The environmental impact assessment (EIA) is a pre-assessment process, integrated and participated, which concerns the possible significant negative impacts on the environment and cultural heritage caused by the implementation of projects. It aims to protect human health, to contribute with a better environment to the quality of life, ensure the protection of species and to maintain the reproductive capacity of the ecosystem as a basic resource for life. The purpose of an environmental impact study is therefore to determine the effects of a project on the environment through explicating of the advantages and disadvantages of alternative design solutions. In the economic sphere the most popular method for the evaluation of projects is the cost - benefit analysis (CBA), but this is inadequate for the environmental field.

For the EIA have been developed methods of assessment based in the following main categories:

DPSIR analysis that permit us to frame and accounting all the main factors that constitute the environmental system: Drivers, Impacts, Pressures, States and Responses;
Methods to identify and evaluate interactions between project and environment: the coaxial matrix of interaction based on DIPSR model;
Methods that propose to determine the compatibility of a class of projects with the environment in relation to its "sensibility" (intended as the propensity of a framework to be altered, to undergo environmental impacts, due to a specific environmental pressure): maps of territorial / environmental sensibility. [1]
Method of GIS analysis with which for example, starting from the forestall areas and their annual wood increment it is possible calculate the annual sustainable forest wood availability, relating it with the total solid wood combustion plants system and his supply;
Method of LCA approach, where, after had defined some LCA biomass types references (each one of 1 MW.electric power working 8000 hours/year biogas plant) we can multiply their damages/impacts calculated with an LCA method[2] for their overall regional plants systems MW.el powers.

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[1] In the environmental field there is great difference in meaning between the term "sensibility" and the term "sensitivity".
With "sensibility" refers to the propensity of an environment to be changed by a certain cause / factor; this modification, potential or real, can then be measured in different ways.
With the term "sensitivity" instead it refers to the degree of precision / accuracy of a particular measurement method, or tool.
Roughly speaking, with the sensibility analysis we are going to measure the harm that a given environment suffers because of a specific environmental pressure factor; with the sensitivity analysis instead we measure the uncertainty/precision of the method/tool with which we then measure a determined thing.
[2] Ecoindicator'99 in our case.

1.1. Parameters, indicators and indices

PARAMETER: a parameter represents the measurement of some variable such as, without there being any associated further meaning of the context and / or evaluation (eg. average age of a forest).

INDICATOR: The environmental indicators are data, measurements, statistical values and parameters useful for evaluating the environmental conditions (or socio-economic, etc ..) of a system. In practice, an indicator measures a measurable parameter such as ENVIRONMENTAL PARAMETER (eg. the acidity of a lake (pH), the concentration of NO_2 in the air (ug/mc), etc..) or an ENVIRONMENTAL PRESSURE (eg. CO_2 tons emitted, hectares of land urbanized, etc..). It is not uncommon that a parameter coincides conceptually with an indicator. Each environmental indicator may be considered as a significant variable of the system to understand; consequently more complex a system is and more are the indicators needed to describe it.

INDEX: an environmental index measures the STATE ENVIRONMENTAL of a given environment / system (eg. Ecological quality of a river, urban air quality) and it is a numeric or alphanumeric value derived from the aggregation of most environmental indicators.
The air quality index, for example, summarizes in itself, in a single value (eg. as "good") the aggregation of several environmental indicators of air, such as for example, the NO_2 concentration, the PM10 concentration, the O_3 concentration, the number of annual exceedances of the daily limit value of the concentration of PM10, etc..

Also in this case it can happen that a indicator and an index may coincide conceptually and therefore both be represented by the same value.

1.2. Difference between environmental Sensibility and Sensitivity

In the environmental field there is great difference in meaning between the term "sensibility" and the term "sensitivity".
With "***sensibility***" refers to the propensity of an environment to be changed by a certain cause / factor of environmental pressure; this modification, potential or real, can then be measured in different ways.
With the term "***sensitivity***" instead it refers to the degree of precision / accuracy of a particular measurement method, or tool.
Roughly speaking, with the ***sensibility*** analysis we are going to measure the harm that a given environment suffers because of a specific environmental pressure factor; with the ***sensitivity*** analysis instead we measure the uncertainty/precision of the method/tool with which we then measure a determinated thing.

2. The DPSIR model

The definition of indicators and indices that are able to represent a given environmental matrix, both in the context of processes of the same matrix evaluation, both as reporting of environmental state, generally takes place through the use of schemes able to put in relation the pressures exerted on the matrix, the status of the matrix and the answers that already exist or that are conceivable for the future.
In this case, the frame of reference is the one named DPSIR, ie Driving forces, Pressures, States, Impacts and Responses.
The scheme was adopted by the EEA (European Environmental Agency) in order to bring with it a general frame of reference, an integrated approach in reporting processes on the state of the environment, carried out at any European or national level. It allows to represent the set of elements and relationships that characterize any theme or environmental phenomenon, by relating it to the set of policies pursued towards it.

- **Driving forces:**

They are represented by actions, both anthropogenic (human activities and behaviors: industry, agriculture, transport, etc.) and natural, able to determine pressures on the environment;

- **Pressures:**

With pressures is indicated everything that tends to alter the state of the environment (air emissions, noise, electromagnetic fields, waste, industrial waste, urban sprawl (land use), infrastructure construction, de-forestation, forest fires, etc.); if waste can be the same waste production, disposal or recovery, etc.. ;

- **States:**

Physical, chemical, biological and ecological quality of environmental resources (air, water, soils, etc.);

- **Impacts:**

Negative effects on ecosystems, on the health of humans and animals and on the economy. Thus for example soil contamination from leachates, increased greenhouse effect for the emission of gases from landfills and recovery plants, etc.

- **Responses:**

Responses and actions of government, implemented to cope with the pressures and problems manifested on the environment, plans and programs, targets to be reached, etc ..; in the case of waste could be to increase the amount of recovered, regulatory terget, reduction of waste disposed of in landfills, program agreements, etc.

[ARPAT, 2015, d]

The following scheme shows the relationships between the single items of DPSIR:

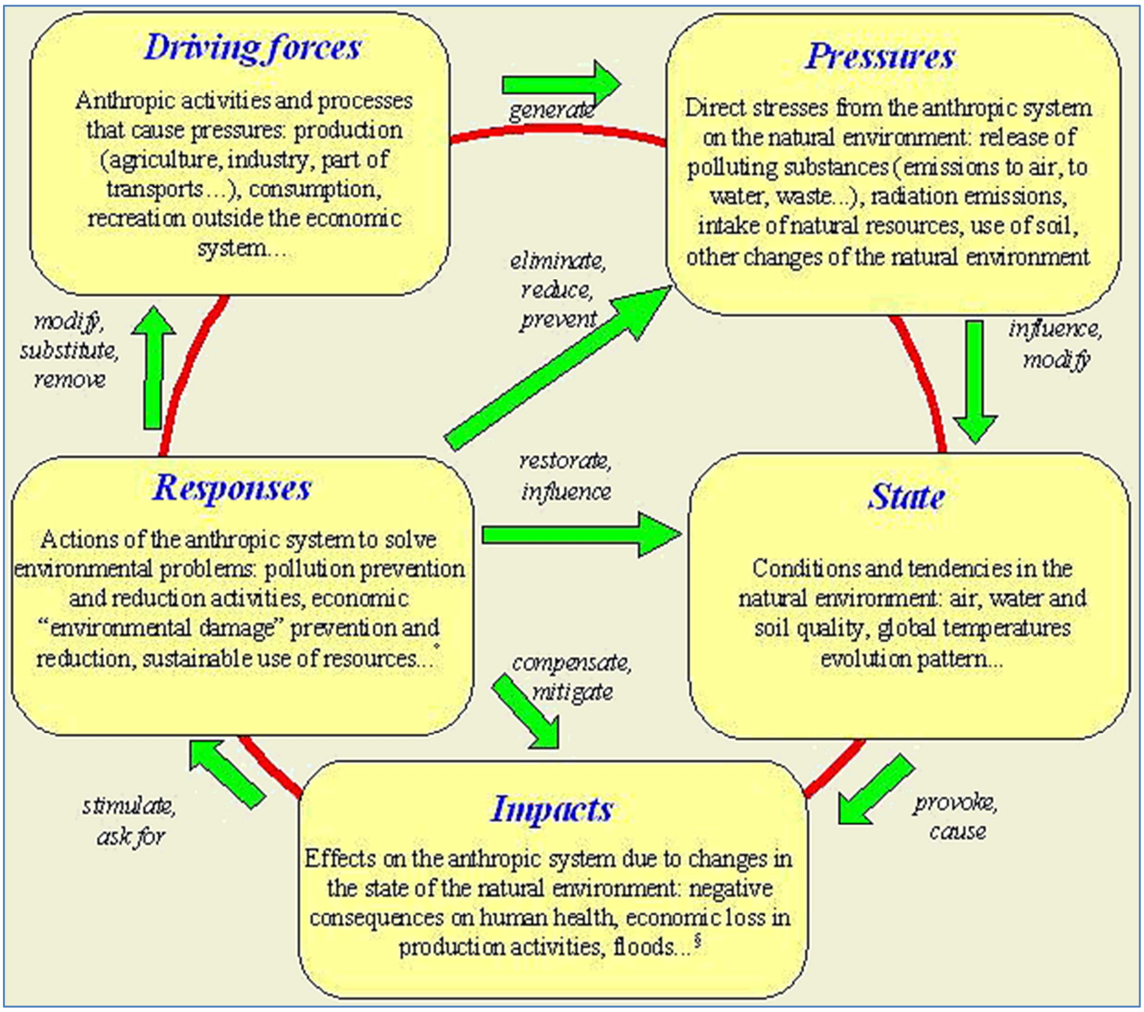


Figura 1– Scheme for the DIPSR impacts assessment methodology [Uni-Kiel.de, 2015, a]

2.1.1. DPSIR coaxial interaction matrix

Among the methods used to identify and evaluate the interactions between the project and the environment we find the interrelation matrices that allows identification of the causal relationships between project activities (construction, operation, etc.) and environmental factors involved.
The evaluation matrices are similar instruments to logic trees, very useful to identify environmental factors influenced by human intervention; in practice are tables in which rows and columns report factors in relation to each other (eg. causes-effects; determinants, pressures, impacts, etc.).
Are known various types of environmental impact matrices, which in the columns show intervention actions (or environmental pressures, such as gas emissions, discharge of effluents, etc.), in the rows they list the altered environmental components (air, water, etc. .) and at intersections indicate the environmental impacts induced by the intervention (damage to air pollution, water, etc.). We can structure different types of evaluation matrix, depending of the interventions and of the factors considered.
Development interventions and human activities cause environmental pressures, emissions, fuel consumption, which in turn cause direct impacts on the environmental components: thus generate cause-effect chains that describe how it is possible alter the environmental components. Building coaxial matrices we can briefly show multiple causal interrelationships between human factors and environmental effects. In practice the coaxial matrices are realized with more matrices that have in common between their rows or columns.

The choice of using the coaxial matrices is useful to represent the high number of influential factors and their intersections.

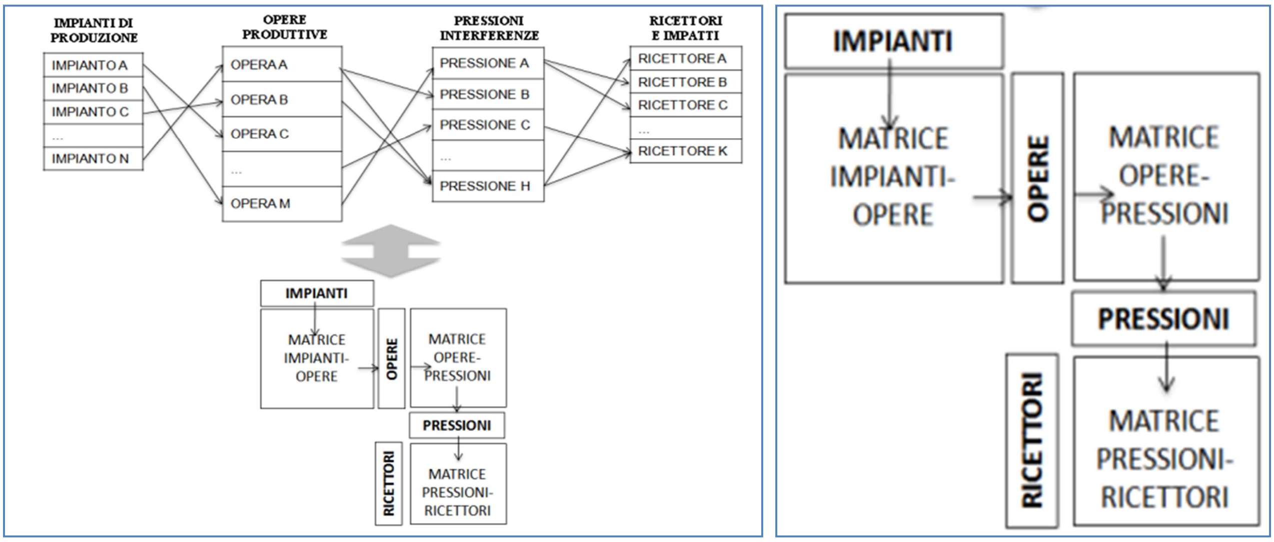


Figura 2- Chain of the environmental effects of productive activities, according to the logic cause-effect, both described by a graph than with three coaxial matrices - [Cagnoli, 2010, a]

The use of a coaxial matrix allows you to set possible mitigative actions, to improve and make "acceptable" a project from the point of view of the impact on the environment. In this analysis for each environmental component you can identify the possible impacts, qualitatively or quantitatively by assigning scores. In practice, the assessment of potential impacts is carried out through the decomposition of the project in different functional phases and through the decomposition of the environment in most parts interfered by the actions of the project.

2.1.2. Environmental impacts Analysis through the coaxial matrix of DPSIR correlation-interrelation

As anticipated, the assessment of potential environmental impacts due to an intervention on the territory,
large or small, such as:

- a single plant;
- a regional financing plan, whatever it may be (eg. Regional operational plan);
- a group of different regional financing plans (eg. Regional operational plan, regional rural, regional plan for air quality, etc ..);
- a type of work (eg. highways, roads, deforestation, reforestation, workshop area, industrial area, biogas power plants, wind power plants, etc ..);
- a specific individual work (eg. a bridge, a railway, highway, industry, an energy solid biomass plant, a hydroelectric power, etc ..);

can be carried through the methodology of DPSIR CORRELATION MATRICES, which can be described and defined according to the following steps:

- break it down of the entity under evaluation in its own main types of works and activities (WORKS and ACTIVITIES) that it requires;

- subsequent correlation of these with the different environmental positive and negative interference voices (PRESSURES);
- further next correlation of the columns of these last with the main environmental components (RECEPTORS), such as for example: air, surface water, groundwater, soil, etc ... ;

Here, to each single relationship, direct and consequential, is assigned a score (or a class of score) of correlation (positive or negative) null, low, medium, high (each with its own color).
In this way, thanks to the correlation colors, the visualization of the correlation / interaction matrices in their entirety and complexity, and at the same time in all their individual cases allows to the decision maker / manager / environmental to manage immediately The display allows you to quickly grasp all the possible criticalities and, consequently, to remedy and / or mitigate them previously, before the implementation of the single project or plan / financial program that is under evaluation.
At the end, the interference / impacts that each activity / work / plant could have on various environmental components can be evaluated in a systematic way through the consultation of the final matrix of environmental impacts (the last one, the lower one).

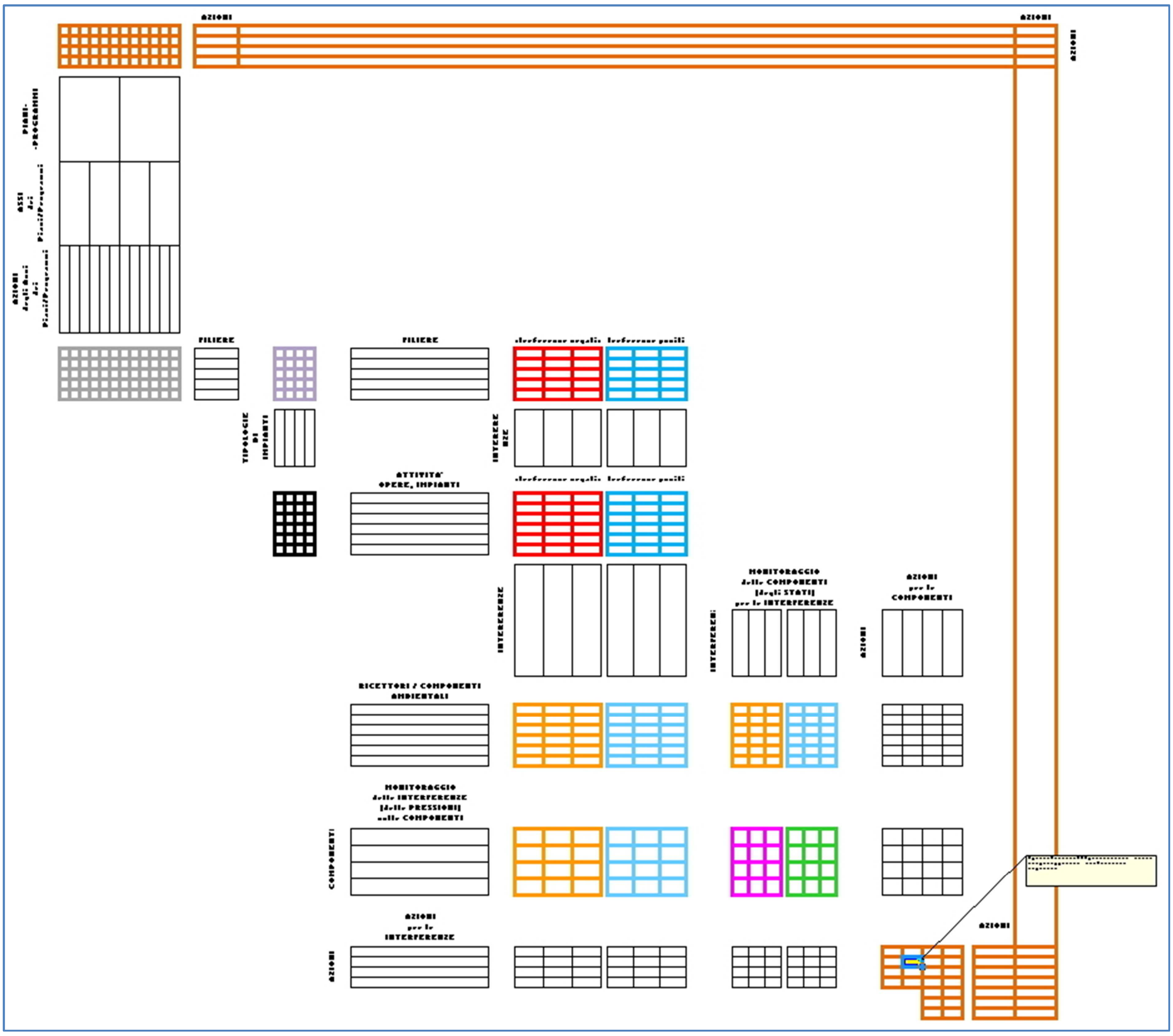


Figura 3– Example of DPSIR coaxial matrices structure.

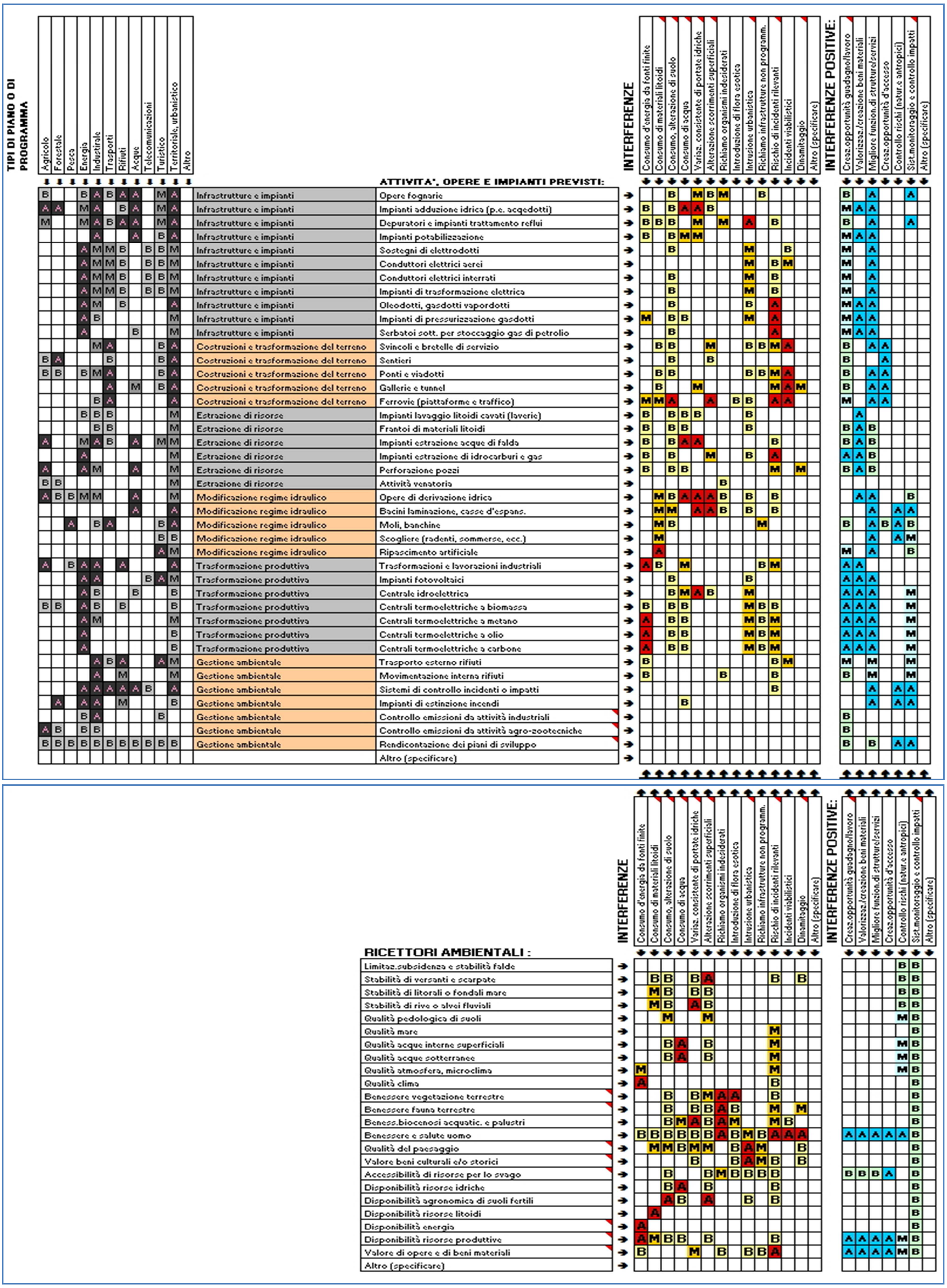


Figura 4- Example, extremely simplified, of a series of coaxial arrays of DPSIR correlation related to a given set of plans / regional programs - [Cagnoli, 2010, a] -

The interferences, and therefore the environmental impacts are assessable by the analysis of the degree of interaction between the activities foreseen for the plant/plan (size and type of induced perturbations) with the sensibilities of the environmental and territorial components, natural, human, socioeconomic and cultural resources.
As mentioned, the impact judgments are expressed with 4 negative judgment classes and other 4 positive judgment. The color shown in the table, in practice, refers to the different level of attention which must be adopted in the assessment both at individual authorization level and at the level of planning bringing back the potential impacts referring to various environmental components involved. For negative interferences colors are used on the red, while for the positive interferences have been adopted colors on blue, always in relation to the incidence degree (high, medium, low, null).

	NEGATIVE INTERFERENCE		
NO INTERFERENCE	LOW INTERFERENCE	MEDIUM INTERFERENCE	HIGHT INTERFERENCE
0	L	M	H

	POSITIVE INTERFERENCE		
NO INTERFERENCE	LOW INTERFERENCE	MEDIUM INTERFERENCE	HIGHT INTERFERENCE
0	L	M	H

In sinthesys, these matrices then enable us to understand what changes will have on the *State* of environmental components (RECEPTORS) due to the *Pressures* (INTERFERENCES) exercised by *Determinants (Driving forces)* (WORKS, ACTIVITIES, PLANT, PLANS, PROGRAMS) and therefore to understand what *Impacts* we will have on the environmental components (RECEPTORS).
The so determined impacts require the Responses, and therefore from this evaluation can be processed subsequent plans, laws and regulations acts to mitigate or eliminate them, following the DPSIR model.

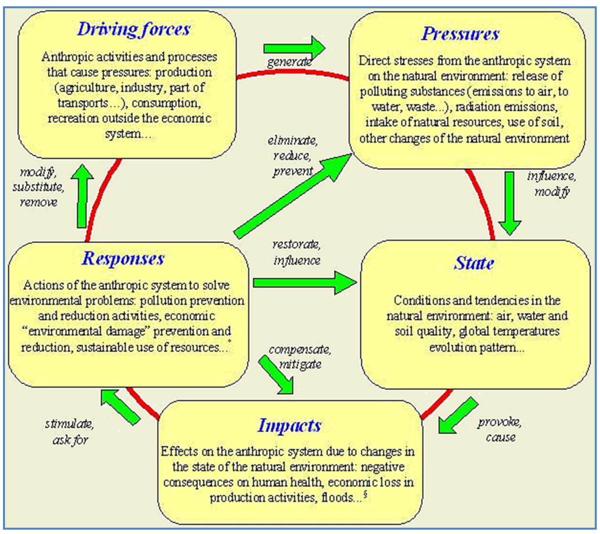


Figura 5- Relationships between the individual components of DPSIR - [uni-kiel.de, 2015, a]

3. SENSIBILITY MAPS method

The methods to determine the "spatial sensibility" are mainly used to select the possible alternatives of localization of projects that have environmental implications not insignificant.
The most widely used method in this class is represented by the overlay mapping methods also known as LSA (Land Suitability Analysis).
The methods in this category are particularly useful in contexts characterized by the presence of particular environmental values, and can be used for:
Determine the optimal location of works such as streets, installations for the production of energy, industrial plants, equipment for recreation in the natural environment, etc.
As support tools such for the assessment of the susceptibility of alternative uses of the sites of a region or a territory.

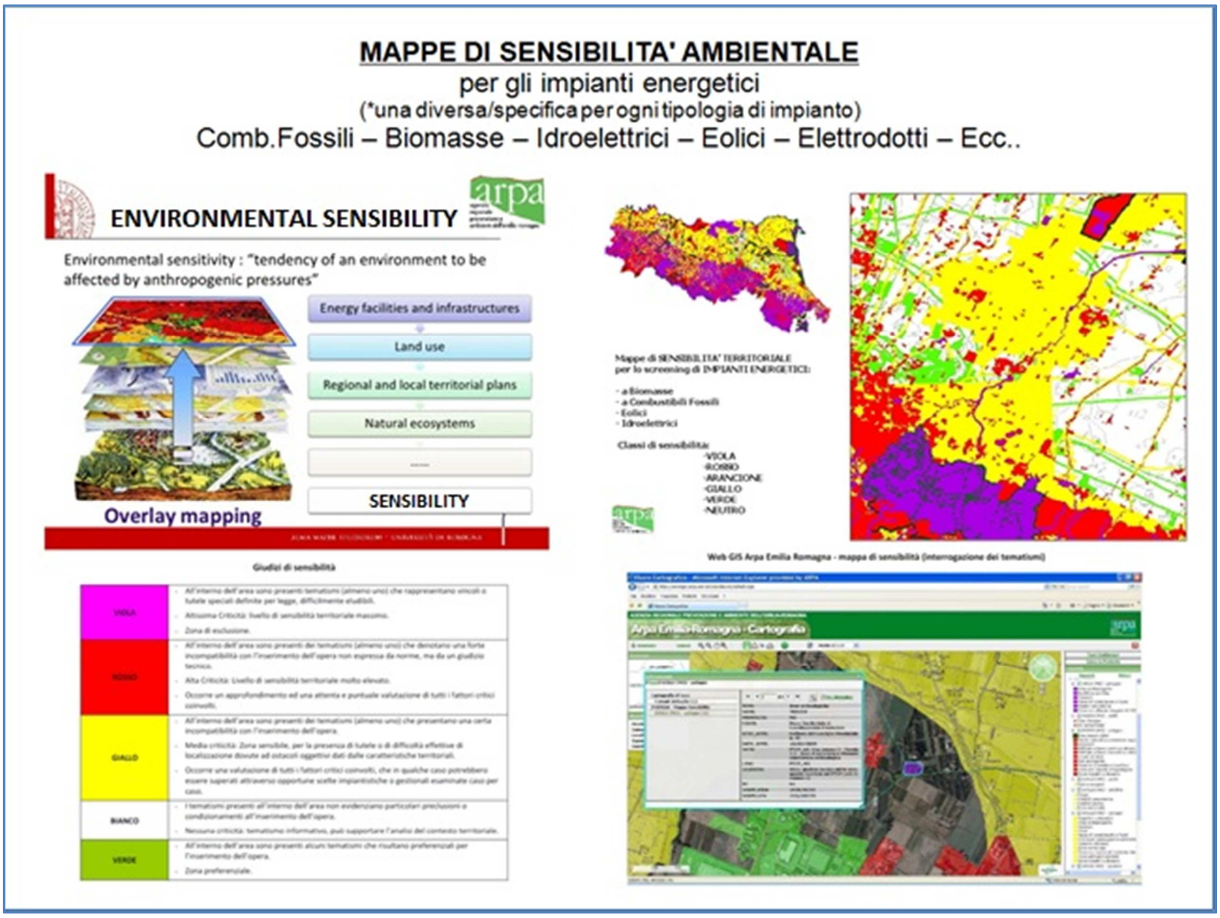


Figura 6- Example framework of enviornmental sensibility maps. – [ARPA, 2015, a]

3.1.1. The McHarg method

One of the most known methods of overlay mapping is the McHarg method. From the technical point of view the method of Mc Hargh and those inspired by it can be distinguished in quantitative and qualitative, which differ between them for the way in which the basic information is organized and processed to obtain the susceptibility evaluation:

In the approach quantity are assigned to each subclass of the scores of each feature of the territory, then these scores are used to calculate an aggregate index of susceptibility relatively to each use of the soil in each of the study area element.
The qualitative approach consists in classify the territory in ecological types for which are applied direct criteria to determine the susceptibility in relation to the specific land uses.

McHarg uses a method in which the quantitative nature of the scores is not directly made explicit, but the scores are expressed in terms of gray (or color tones) assigned to each of the subclasses of a specific characteristic of the territory: the darker tone, is the less suitable use of land considered. For example, if you intend to build a new highway, soils with slopes greater than 10% are associated with a dark gray tone, soils with slopes of between 2.5% and 10% in a light gray tone and soils with slopes of less than 2.5 % to the white color. These choices are coherent with the fact that where the slope is greater, the construction of the road will be more "expensive" not only from the economic point of view, but also for its potential interference with the geological and geomorphological context (risk of instability in the slopes , alteration of the landscape, etc.). For each feature is then drawn a map reporting on a transparent plastic sheet the gray tones appropriate to the different parts of the study area. The sheets for the various characteristics are then overlapped on top of a light table and observed in transparency. The picture that emerges is constructed by a set of light and dark tones that represent qualitative estimates of aggregate susceptibility, that is evaluated with respect to all the characteristics of each element of the study area: how much lighter the image is locally, more the current destination of use of the element considered is susceptible of being transformed into the proposed destination.
The following figures show an example of the maps drawn up by McHarg using three tones of gray for different classes of assessment. By overlaying maps, McHarg obtained a map of synthesis that allowed him to identify two alternative tracks of minimal "cost". In addition to these are shown two maps: a map of the categories of the only social values; and a map obtained from the one total with a simple process of "filtering", where they appear only two classes of susceptibility, which separate the most suitable areas from the less suitable to accommodate the roadways, used to identify two variants of minimum "cost".

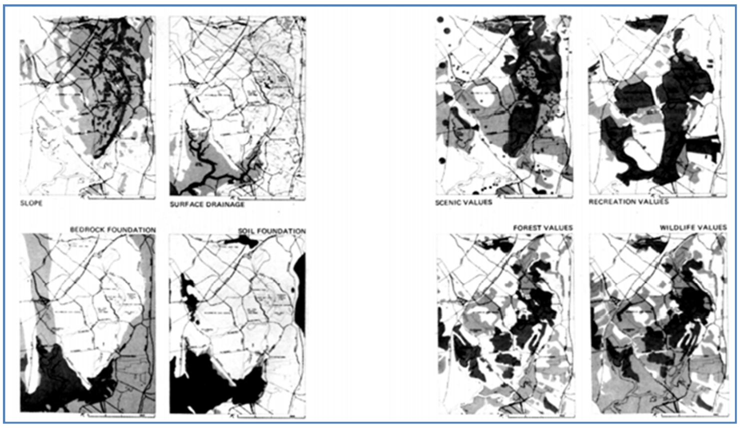


Figura 7- Example of sensibility maps drawn up by McHarg using 3 tones of gray for different classes of assessment - [Cagnoli, 2010, a.] –

3.1.2. Identification and updating of sensible themes interfered from power plants on biogas and solid biomass plants

In the initial phase of the work it is necessary to identify the high impact plants (determinants) and, consequently, a series of "sensible" themes, ie all those elements that are characteristic of the territory/region (natural, landscape, hydrogeological and settlements) that may be affected / altered by the plants under examination. This phase benefits from the work done by Arpae, which led to the definition, in accordance with the Region, of sensible and informative themes to be used for analysis. The identification of a series of sensible themes (ie all those elements characteristic of the region that may influence decisions concerning the need for deepening, for a given system, the analyzes relating to its location, etc ..) is one of the main aspects of this analysis. Their choice is derived from observation and analisys of the territorial planning themes classification approved with provincial and regional laws in the land plans, and in parallel of the intrinsic characteristics of the entire territory of the Emilia-Romagna region, based largely on naturalistic elements, landscaping, environmental, hydrogeological, infrastructure and settlements.
The choice of sensible themes useful for the environmental sensitivity of the model was made at the start, and is therefore not dependent on the availability of the data but from the consideration of all factors and the territorial characteristics that can affect the decision-making stages of a project evaluation.
Starting from the map of sensibility is then possible to frame the criticalities of the geographic areas under examination, according to which we can apply with adequate specificity the coaxial array of DIPSR environmental interferences for the plant concerned and / or the various actions budgeted by a regional plan.

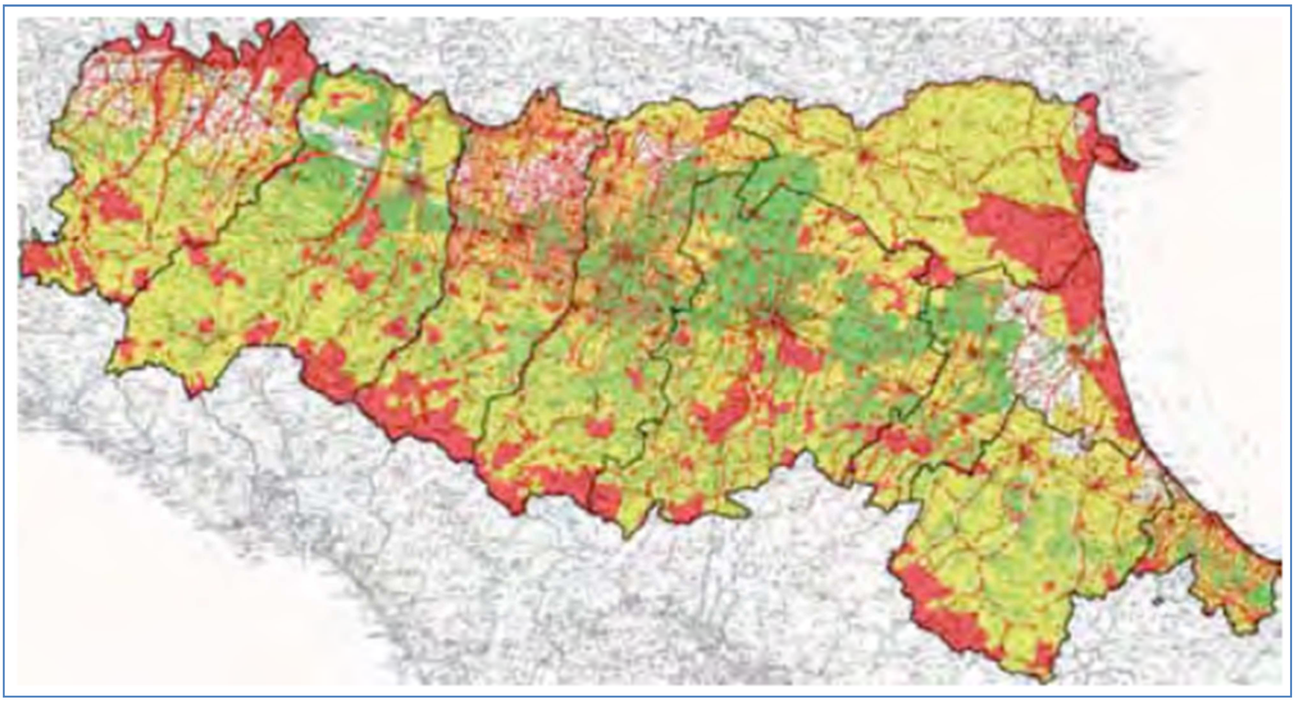


Figura 8- First version of the environmental sensibility map for biomass power plants used in the Strategic Environmental Assessment of the 2008-2010 Regional Energy Plan: in red areas with critical sensibility, in yellow areas with adverse sensibility and uncertain, areas with favorable sensibility in green. – [The evolution of GIS for land management, Cagnoli, 2010, b]

3.1.3. The biomass plants SENSIBILITY MAPS for Emilia-Romagna region

Following the scheme of McHarg, ARPA Emilia-Romagna has developed a GIS[3] expert system for the evaluation of the environmental sensibility of the regional territories, in reference to the introduction of crucial installations (in this case combustion installations of biomass and biogas plants, respectively) that can be analyzed graphically, and therefore territorially, to identify which areas are of particular sensibility toward the construction of these types of plants.
This tool is of fundamental support for the procedures of Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA) and Environmental Incidence Assessment (VINCA in italian) for the realization of projects with significant environmental effects and plans[4].
The expert system is used to create sensibility maps, related to the specific plant we want to realize, or to verify when where it has already been realized.
ARPA has already created the sensibility maps for the following project types:

- wind turbines;
- solid biomass plants
- biogas plants
- works of derivation and equipment for hydroelectric use;
- thermal power plants using fossil sources with power exceeding 50 MW;
- supports for high voltage power lines;
- high voltage aircraft electrical conductors;
- high voltage underground electrical conductors ;
- high and medium voltage electrical transformation installations.

The sensibility maps are decision support systems evolved, able to organize knowledge and speed the search for solutions, and are useful to:
analyze the plan area or project, identify sensible themes and view the related planning informations (screening and scoping);
frame the critical issues in the planning phases (and of the preparation of the environmental report) and in the formulation of plan choices;
obtain maps of areas suitable / unsuitable (adopted by the plans) to support the authorization of works;
support the monitoring: the framework of the critical state on what themes to focus the monitoring (most sensible issues).

The progressive development and updating of these assessment tools allows you to support instructors and decision-making processes. The analysis of environmental / territorial sensibility is in fact a right screening tool in evaluating the territorial plans of individual projects, especially useful in order to increase efficiency and speed of decision making. In summary we can consider suitable tools sensibility maps to highlight the strengths factors and weaknesses with regard to human interventions in the territory.

[3] GIS: Geographic Information System.
[4] Source: ARPA Emilia-Romagna, CTR Energy and Environmental Complex Assessments, 2nd update of the expert system for environmental assessments in Emilia-Romagna, 2010.

The sensibility maps, built with GIS methodology through an "overlay", represent a sort of "semaphore" maps that not only allow us to see graphically what are the most sensible areas compared with these that already exist, but also allow a precise assessment screening for both existing systems (analysis of the current state), and for the individual new plants for which authorization is required (scenario analysis), and for a large scale evaluation of the proposed actions by a spatial plan to about.

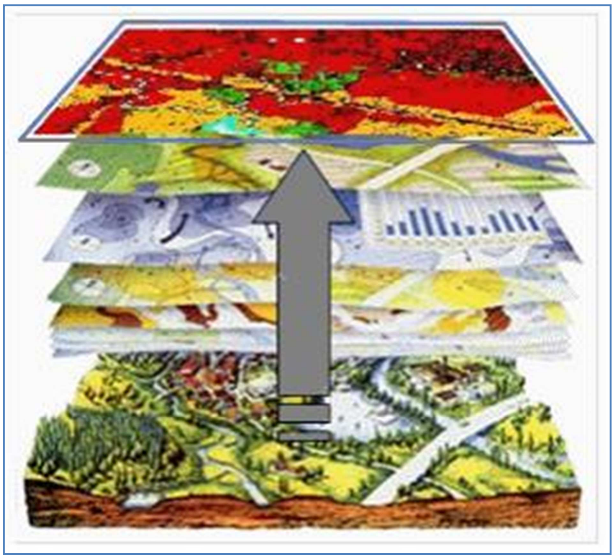


Figura 9- Generation scheme of an environmental sensibility map.

In all cases, the tool allows you to speed up the environmental assessment phase and the decision-making processes especially related to the procedures Enviornmental Impact Assessment -VIA- (preliminary inspections) and Strategic Environmental Assessment -VAS- (context assessment, scenario analysis).
The sensibility map thus becomes a tool integral to coaxial DPSIR matrix described above, because this last provides us with the significance of the impact only related to an overall environmental context, NOT geographical.
Starting from the map of sensibility is now possible to frame the specific issues of the geographical area in question, according to which we can then apply with adequate specificity the coaxial matrix of DIPSR environmental interferences required for the facility and / or the various actions foreseen by a regional plan.

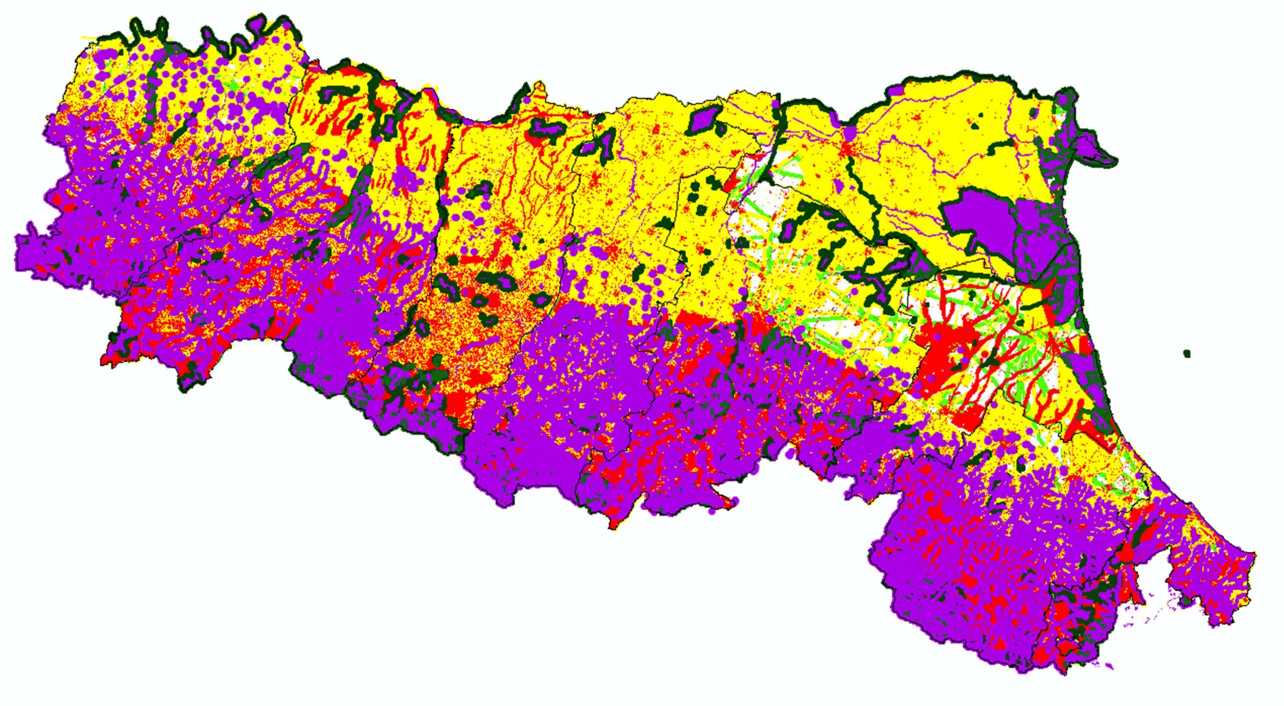


Figura 10- Regional environmental sensibility map for biogas power plants: in red areas with critical sensibility, in yellow areas with adverse sensibility and uncertain, areas with favorable sensibility in green.

Tabella 1- Classes of sensibility legend.

LEGEND	
VIOLET AREA	VIOLET - Exclusion zone
	High Criticality: maximum spatial sensibility level.
	Within the area are present the themes (at least one) that represent constraints or special protections defined by law that much unlikely to be departed
RED AREA	RED - It requires a deepening and a careful and detailed assessment of all the critical factors involved.
	High Criticality: very high spatial sensibility level.
	In the area are present themes which reveal a strong incompatibility with the inclusion of the work, expressed not by rules, but only from a technical opinion
YELLOW AREA	YELLOW - It is necessary an evaluation of all the critical factors involved, which in some cases might be exceeded through suitable equipment or management decisions considered case by case.
	Media criticality: sensitive area, for the presence of safeguards or actual localization difficulties due to objective obstacles arising from territorial characteristics.
	Within the area are present some themes (at least one) that have a certain incompatibility with the work placement.
WHITE AREA	WHITE - Low criticality: low spatial sensibility level
	No automatic decision: we will proceed to the specific assessment of the case.
	The themes present within the area reveal no special exceptions or constraints to the insertion of the work.
GREEN AREA	GREEN - Preferential Zone, where a plant location might be appropriate.
	Within the area there are some themes resulting preferential for the work placement.

Index - part 3.1 -

REGIONAL ELECTRICITY BUDGETS OF EMILIA-ROMAGNA REGION

1. REGIONAL ENERGY BUDGETS

20 20 20 Plan: the 20 20 20 Climate-Energy Package

The “20 20 20 Plan” it is the set of measures designed by the EU for the period after the end of the Kyoto Protocol. The treaty created for fighting climate change that finds its natural end at the end of 2012. The "package" contained in Directive 2009/29 / EC, came into force in June 2009 and will be valid from January 2013 until 2020. In extreme synthesis it plans to: reduce greenhouse gas emissions by 20%, raising to 20% the share of energy produced from renewable sources and increase to 20% energy savings: all by 2020.

1.1. Electric energy production in Emilia-Romagna - GSE/TERNA data

In order to frame the productive territorial energy context and the consumption of emilia-Romagna region, we propose below some reference statistical tables. They summarize the data published by GSE (Electrical Services) in its Statistical bulletin and reports, and by TERNA in its regional balance sheets.

We can see from the following data that in 2014 the target of 20% of electric energy (we don´t consider the thermal) production has been pratically reached.

- **NOTES:**
- *GSE does not monitor the energy production of the fossil fuel plants CF.
- *TERNA does not monitor the number of installations.
- *TERNA classifies the production of the incinerator in CF as thermoelectric.
- *ARPAE acquires energy data (electrical, thermal, fuel, etc ..) from multiple sources, then producing the overall and disaggregated regional energy balances by using appropriate algorithms.
- The ARPAE GIS geographical registers do not coincide with the number of plants published by GSE due to the fact that the latter does not provide any specific reference to the systems by virtue of the law on privacy. Several offices for authorizations instead do not provide the data pointing to a lack of resources to obtain them from the projects and related authorizations granted. Finding (and updating annually) biographical and geographical data of the plants so it is an extremely laborious and difficult work, never perfect, but very important to have the territorial framework of their presence and distribution in the territory.

1.1.1. Gross electric production of italian regions - TERNA Statistical Annuaries 2012 - 2013 - 2014

In order to frame the productive and consumption territorial energy context of the Emilia-Romagna region, we propose below some reference statistical tables.
As of 1 August 2016 they are not yet available TERNA report for the year 2015 and later.

1.1.2. Electric production in Italy and their regions - TERNA data –

Tabella 1- Gross electric production from renewable sources (GWh) in Italy for the years: 2012 - 2013 - 2014 . [TERNA-Sistisan, 2014, a]

Produzione lorda degli impianti da fonti rinnovabili in Italia

Tabella 34

GWh	2007	2008	2009	2010	2011	2012	2013	2014
Idrica	**32.815,2**	**41.623,0**	**49.137,5**	**51.116,8**	**45.822,7**	**41.874,9**	**52.773,4**	**58.545,4**
0 - 1 MW	*1.415,7*	*1.769,7*	*1.960,7*	*2.245,3*	*2.189,9*	*2.084,8*	*2.635,9*	*3.148,3*
1 - 10 MW	*5.684,4*	*7.389,7*	*8.421,7*	*8.711,6*	*7.857,5*	*7.324,5*	*9.350,2*	*10.993,1*
> 10 MW	*25.715,1*	*32.463,6*	*38.755,1*	*40.159,8*	*35.775,2*	*32.465,6*	*40.787,4*	*44.404,0*
Eolica	**4.034,4**	**4.861,3**	**6.542,9**	**9.125,9**	**9.856,4**	**13.407,1**	**14.897,0**	**15.178,3**
Fotovoltaica	**39,0**	**193,0**	**676,5**	**1.905,7**	**10.795,7**	**18.861,7**	**21.588,6**	**22.306,4**
Geotermica	**5.569,1**	**5.520,3**	**5.341,8**	**5.375,9**	**5.654,3**	**5.591,7**	**5.659,2**	**5.916,3**
Bioenergie (1)	**5.441,1**	**5.966,3**	**7.556,7**	**9.440,1**	**10.832,4**	**12.486,9**	**17.090,1**	**18.732,4**
Sola produzione di energia elettrica	3.416,7	3.896,8	5.177,8	6.189,2	6.608,0	7.294,3	9.619,3	9.909,4
Solidi	2.257,2	2.563,5	2.904,0	2.605,3	2.868,4	2.759,7	3.371,2	3.287,5
- rifiuti solidi urbani biodegradabili	*591,0*	*634,8*	*799,7*	*1.062,2*	*1.200,7*	*1.214,7*	*1.239,1*	*1.276,8*
- biomasse solide	*1.666,2*	*1.928,7*	*2.104,3*	*1.543,1*	*1.667,7*	*1.545,0*	*2.132,1*	*2.010,7*
Biogas	1.159,5	1.290,8	1.299,6	1.451,2	1.868,5	2.160,6	3.434,9	3.537,8
- da rifiuti	*1.113,4*	*1.202,0*	*1.177,7*	*1.197,4*	*1.273,5*	*1.210,5*	*1.274,1*	*1.229,7*
- da fanghi	-	*2,4*	*3,3*	*11,6*	*19,3*	*12,2*	*14,5*	*17,6*
- da deiezioni animali	*20,9*	*44,3*	*44,3*	*100,3*	*133,8*	*147,4*	*331,9*	*396,1*
- da attività agricole e forestali	*25,2*	*42,1*	*74,3*	*141,9*	*441,9*	*790,6*	*1.814,4*	*1.894,5*
Bioliquidi	-	42,5	974,2	2.132,7	1.871,2	2.374,0	2.813,3	3.084,2
- oli vegetali grezzi	-	*13,1*	*583,0*	*1.759,1*	*1.709,1*	*2.051,5*	*2.374,2*	*2.579,1*
- altri bioliquidi	-	*29,4*	*391,2*	*373,6*	*162,1*	*322,5*	*439,1*	*505,1*
Produzione combinata di en.el. e calore	2.024,5	2.069,5	2.379,0	3.250,9	4.224,4	5.192,6	7.470,8	8.823,0
Solidi	1.736,8	1.738,8	1.539,9	1.702,2	1.861,8	1.985,8	2.513,5	2.905,4
- rifiuti solidi urbani biodegradabili	*921,5*	*921,4*	*816,5*	*985,7*	*1.017,1*	*961,6*	*981,8*	*1.166,2*
- biomasse solide	*815,3*	*817,4*	*723,4*	*716,5*	*844,7*	*1.024,2*	*1.531,7*	*1.739,2*
Biogas	287,7	308,7	365,4	602,9	1.536,2	2.459,3	4.012,8	4.660,7
- da rifiuti	*133,9*	*153,1*	*195,2*	*217,4*	*254,6*	*276,5*	*347,0*	*408,2*
- da fanghi	*9,0*	*12,4*	*16,8*	*16,6*	*43,2*	*68,3*	*95,6*	*103,4*
- da deiezioni animali	*32,4*	*25,5*	*44,1*	*120,7*	*227,8*	*371,2*	*484,9*	*592,6*
- da attività agricole e forestali	*112,5*	*117,7*	*109,4*	*248,3*	*1.010,7*	*1.743,2*	*3.085,3*	*3.556,5*
Bioliquidi	-	22,0	473,6	945,7	826,3	747,6	944,5	1.256,9
- oli vegetali grezzi	-	*17,0*	*466,6*	*922,5*	*822,1*	*704,5*	*872,8*	*1.142,9*
- altri bioliquidi	-	*5,1*	*7,1*	*23,2*	*4,2*	*43,1*	*71,7*	*114,0*
Totale	**47.898,8**	**58.163,9**	**69.255,4**	**76.964,4**	**82.961,5**	**92.222,4**	**112.008,3**	**120.678,9**

Tabella 2- Gross electric production (GWh) in italian regions for the years: 2012 - 2013 - 2014 . [TERNA-Sistisan, 2014, a]

Produzione di energia elettrica in Italia

Secondo regione

Tabella 26 (*)

	Lorda					
	Produttori		Autoproduttori		Totale	
GWh	2012	2013	2012	2013	2012	2013
Piemonte	23.582,9	24.190,6	1.997,7	2.078,8	25.580,7	26.269,4
Valle d'Aosta	3.092,5	3.571,0	-	-	3.092,5	3.571,0
Lombardia	41.088,0	40.251,2	3.012,9	3.025,4	44.100,9	43.276,6
Trentino Alto Adige	10.345,7	12.470,9	236,0	318,2	10.581,7	12.789,1
Veneto	15.029,4	16.357,4	1.325,6	1.467,7	16.355,0	17.825,2
Friuli Venezia Giulia	9.061,1	8.321,9	1.075,2	1.127,4	10.136,4	9.449,3
Liguria	11.049,9	10.196,9	142,5	141,6	11.192,5	10.338,5
Emilia Romagna	21.533,8	17.758,0	1.356,4	1.480,7	22.890,2	19.238,7
Italia Settentrionale	**134.783,4**	**133.117,9**	**9.146,3**	**9.639,8**	**143.929,8**	**142.757,7**
Toscana	15.666,0	14.586,2	1.096,8	1.092,1	16.762,7	15.678,3
Umbria	2.739,1	3.509,5	34,3	58,5	2.773,5	3.568,1
Marche	3.915,2	2.081,1	218,8	303,5	4.133,9	2.384,6
Lazio	20.216,7	18.723,1	1.006,8	1.027,0	21.223,5	19.750,0
Italia Centrale	**42.537,0**	**38.899,9**	**2.356,7**	**2.481,1**	**44.893,6**	**41.381,0**
Abruzzi	4.098,0	4.058,6	707,4	673,4	4.805,5	4.732,0
Molise	2.733,7	2.849,9	26,6	28,3	2.760,3	2.878,2
Campania	10.889,8	9.680,9	241,7	302,0	11.131,5	9.983,0
Puglia	39.165,6	36.858,2	486,9	523,5	39.652,5	37.381,7
Basilicata	1.932,1	1.956,3	269,8	276,3	2.201,9	2.232,5
Calabria	11.228,6	10.675,1	7,5	26,9	11.236,1	10.702,0
Sicilia	21.937,3	21.681,7	2.192,3	1.708,7	24.129,6	23.390,3
Sardegna	13.914,0	13.954,8	621,2	410,0	14.535,3	14.364,8
Italia Meridionale e Insulare	**105.899,1**	**101.715,3**	**4.553,5**	**3.949,2**	**110.452,6**	**105.664,5**
ITALIA	**283.219,5**	**273.733,1**	**16.056,5**	**16.070,0**	**299.275,9**	**289.803,2**

Produzione di energia elettrica in Italia

Secondo regione

Tabella 26 (*)

	Lorda					
	Produttori		Autoproduttori		Totale	
GWh	2013	2014	2013	2014	2013	2014
Piemonte	24.190,6	21.581,1	2.078,8	1.653,4	26.269,4	23.234,5
Valle d'Aosta	3.571,0	3.469,3	-	-	3.571,0	3.469,3
Lombardia	40.251,2	39.129,0	3.025,4	3.189,3	43.276,6	42.318,3
Trentino Alto Adige	12.470,9	14.734,2	318,2	362,7	12.789,1	15.096,9
Veneto	16.357,4	16.823,3	1.467,7	1.743,1	17.825,2	18.566,4
Friuli Venezia Giulia	8.321,9	8.048,1	1.127,4	1.125,0	9.449,3	9.173,2
Liguria	10.196,9	7.306,3	141,6	146,0	10.338,5	7.452,4
Emilia Romagna	17.758,0	15.958,7	1.480,7	1.261,2	19.238,7	17.219,9
Italia Settentrionale	**133.117,9**	**127.050,1**	**9.639,8**	**9.480,8**	**142.757,7**	**136.530,9**
Toscana	14.586,2	14.158,7	1.092,1	1.150,8	15.678,3	15.309,5
Umbria	3.509,5	3.121,4	58,5	46,7	3.568,1	3.168,1
Marche	2.081,1	2.064,2	303,5	285,1	2.384,6	2.349,3
Lazio	18.723,1	19.146,2	1.027,0	1.110,1	19.750,0	20.256,3
Italia Centrale	**38.899,9**	**38.490,5**	**2.481,1**	**2.592,7**	**41.381,0**	**41.083,2**
Abruzzi	4.058,6	4.240,5	673,4	381,4	4.732,0	4.621,9
Molise	2.849,9	2.367,4	28,3	36,8	2.878,2	2.404,2
Campania	9.680,9	8.468,8	302,0	335,6	9.983,0	8.804,4
Puglia	36.858,2	37.570,3	523,5	532,1	37.381,7	38.102,4
Basilicata	1.956,3	1.982,9	276,3	169,9	2.232,5	2.152,7
Calabria	10.675,1	9.632,2	26,9	24,2	10.702,0	9.656,3
Sicilia	21.681,7	20.664,7	1.708,7	1.871,3	23.390,3	22.536,1
Sardegna	13.954,8	13.619,1	410,0	317,3	14.364,8	13.936,4
Italia Meridionale e Insulare	**101.715,3**	**98.545,9**	**3.949,2**	**3.668,6**	**105.664,5**	**102.214,5**
ITALIA	**273.733,1**	**264.086,5**	**16.070,0**	**15.742,1**	**289.803,2**	**279.828,5**

Tabella 3- Gross electric production from renewable sources (GWh) in Italy for the years: 2013 / 2014 . [TERNA-Sistisan, 2014, a]

Produzione lorda degli impianti da fonti rinnovabili in Italia nel 2013

Secondo regione e fonte

Tabella 35

GWh	Idrica	Eolica	Fotovoltaica	Geotermica	Bioenergie	Totale
Piemonte	8.002,3	25,8	1.596,4	-	1.409,6	11.034,2
Valle d'Aosta	3.534,5	4,1	21,6	-	10,9	3.571,0
Lombardia	11.023,3	0,0	1.932,8	-	3.987,6	16.943,7
Trentino Alto Adige	11.096,5	1,2	406,9	-	256,4	11.761,0
Veneto	4.548,3	10,4	1.728,1	-	1.712,6	7.999,4
Friuli Venezia Giulia	1.778,9	0,0	491,1	-	562,7	2.832,7
Liguria	320,4	121,1	85,6	-	135,4	662,4
Emilia Romagna	1.155,9	26,4	1.979,0	-	2.394,3	5.555,6
Italia Settentrionale	**41.460,0**	**188,9**	**8.241,6**	**-**	**10.469,4**	**60.360,0**
Toscana	1.037,9	187,0	806,6	5.659,2	451,6	8.142,4
Umbria	2.111,0	2,7	519,1	-	152,8	2.785,6
Marche	690,1	0,5	1.214,4	-	175,1	2.080,1
Lazio	1.479,8	88,9	1.529,5	-	637,8	3.736,1
Italia Centrale	**5.318,9**	**279,0**	**4.069,7**	**5.659,2**	**1.417,4**	**16.744,2**
Abruzzi	2.101,4	326,3	822,4	-	134,4	3.384,5
Molise	271,1	683,3	216,8	-	139,8	1.311,1
Campania	853,6	2.043,3	808,9	-	1.002,7	4.708,5
Puglia	4,9	3.909,4	3.714,9	-	1.628,8	9.258,1
Basilicata	467,6	712,6	494,4	-	264,5	1.939,0
Calabria	1.638,6	1.928,8	590,8	-	1.074,0	5.232,2
Sicilia	174,7	3.009,5	1.754,0	-	189,8	5.127,9
Sardegna	482,6	1.815,9	875,1	-	769,3	3.942,9
Italia Meridionale e Insulare	**5.994,5**	**14.429,0**	**9.277,3**	**-**	**5.203,4**	**34.904,1**
ITALIA	**52.773,4**	**14.897,0**	**21.588,6**	**5.659,2**	**17.090,1**	**112.008,3**

Produzione lorda degli impianti da fonti rinnovabili in Italia nel 2014

Secondo regione e fonte

Tabella 35

GWh	Idrica	Eolica	Fotovoltaica	Geotermica	Bioenergie	Totale
Piemonte	8.369,9	26,1	1.646,5	-	1.731,3	11.773,8
Valle d'Aosta	3.431,0	3,7	22,7	-	11,9	3.469,3
Lombardia	13.623,6	0,0	2.046,1	-	4.249,3	19.919,1
Trentino Alto Adige	13.249,3	1,2	407,1	-	340,4	13.998,0
Veneto	5.558,5	17,9	1.784,1	-	1.898,7	9.259,2
Friuli Venezia Giulia	2.524,7	0,0	509,3	-	706,1	3.740,1
Liguria	350,4	117,3	96,1	-	125,5	689,3
Emilia Romagna	1.277,1	27,2	2.093,1	-	2.759,0	6.156,5
Italia Settentrionale	**48.384,5**	**193,4**	**8.605,0**	**-**	**11.822,4**	**69.005,3**
Toscana	1.060,7	220,6	847,8	5.916,3	604,0	8.649,4
Umbria	1.819,1	3,0	526,6	-	223,5	2.572,2
Marche	608,4	1,8	1.243,9	-	186,5	2.040,6
Lazio	1.316,9	87,1	1.572,2	-	704,3	3.680,5
Italia Centrale	**4.805,1**	**312,5**	**4.190,6**	**5.916,3**	**1.718,3**	**16.942,8**
Abruzzi	2.094,9	335,8	861,4	-	161,1	3.453,2
Molise	240,7	681,1	217,9	-	164,8	1.304,6
Campania	673,3	2.046,8	855,8	-	1.028,4	4.604,2
Puglia	4,4	4.297,5	3.612,2	-	1.650,4	9.564,5
Basilicata	314,5	825,6	481,3	-	214,0	1.835,4
Calabria	1.521,0	1.906,3	636,3	-	1.024,3	5.087,8
Sicilia	146,4	2.922,4	1.893,3	-	259,2	5.221,3
Sardegna	360,5	1.657,0	952,5	-	689,6	3.659,6
Italia Meridionale e Insulare	**5.355,8**	**14.672,5**	**9.510,8**	**-**	**5.191,7**	**34.730,8**
ITALIA	**58.545,4**	**15.178,3**	**22.306,4**	**5.916,3**	**18.732,4**	**120.678,9**

1.1.3. Electric energy production in Emilia-Romagna region -GSE/TERNA data-

Numero di impianti	Number of plants		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
IDRO	Hydroelectric	**GSE-Idroelettrico**	**9**	**9**	**13**	**20**	**24**	**29**	74	89	105	112	124	134	118
GEO	Geothermal	**GSE-Geotermica**	0	0	0	0	0	0	0	0	0	0	0	0	0
EOL	Wind	**GSE-Eolica**	1	1	1	1	1	4	3	15	29	42	50	56	29
BM	**Biogas**	**GSE-Biogas**	0	0	13	19	25	19	27	39	72	147	0	176	188
BM	**Solid biomasses**	**GSE-BSolida**	0	0	3	4	5	3	4	5	9	17	0	16	24
BM	**Bioliquids**	**GSE-Bioliquidi**	0	0	0	0	0	9	9	15	25	35	0	43	43
DIS	Landfill biogas	**GSE-Gas discarica**	0	0	0	1	0	19	19	19	20	24	0	22	22
RIF	**Waste**	**GSE-Rifiuti organici**	0	0	0	3	3	3	3	3	4	6	0	3	3
CF	Fossil fuels - Thermoelectrical (including incinerators)	**TERNA-Termoelettrici (comprende termovalorizzatori)**	136	132	134	139	134	145	163	195	352	559	699	806	0

Potenza installata (MW)	Installed electric power (MW)		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
IDRO	Hydroelectric	**GSE-Idroelettrico**	**4.4**	**4.4**	**33.2**	**39.52**	**40.9**	**42**	296.5	298.9	307.7	315	321.4	325.4	0
GEO	Geothermal	**GSE-Geotermica**	0	0	0	0	0	0	0	0	0	0	0	0	0
EOL	Wind	**GSE-Eolica**	0	0	0	0.3	0	14	16.3	17.9	18.1	19	19.1	19.3	22.207
BM	**Biogas**	**GSE-Biogas**	0	0	14.8	21.95	28.2	13	71	24.2	52	118	144.99	144.99	146.12
BM	**Solid biomasses**	**GSE-BSolida**	0	0	27.3	28.31	43.3	41	204	42.8	70	133	122.68	122.68	141.598
BM	**Bioliquids**	**GSE-Bioliquidi**	0	0	0	0	0	104	95	108.6	122	131	138.35	138.35	138.321
DIS	Landfill biogas	**GSE-Gas discarica**	0	0	0	0.8	0	24	24	24.1	25	29	29.06	26.93	28.348
RIF	**Waste**	**GSE-Rifiuti organici**	0	0	0	41.04	41	41	41	41	55	81	53.48	53.48	53.478
CF	Fossil fuels - Thermoelectrical (including incinerators)	**TERNA-Termoelettrici (comprende termovalorizzatori)**	4517	5229.2	5170.9	5655.5	5681.4	6598	6535.5	6568.5	6664.4	6763.2	6634.4	6606.3	0

Energia prodotta (GWh)	Electricity production (GWh)		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
IDRO	Hydroelectric	**GSE-Idroelettrico**	**26**	**26**	**29.8**	**48.92**	**53.5**	**58**	1060	1150.2	872.7	854.8	1155.9	1277.1	**0**
GEO	Geothermal	**GSE-Geotermica**	0	0	0	0	0	0	0	0	0	0	0	0	0
EOL	Wind	**GSE-Eolica**	0.1	0.1	0.1	0.1	0.1	24	21	24.7	19.8	27.2	26.4	27.2	0
BM	**Biogas**	**GSE-Biogas**	0	0	102.1	132.8	174.8	77	287	360.1	545.2	658.9	1130.6	1272.3	0
BM	**Solid biomasses**	**GSE-BSolida**	0	0	195	203.39	326.4	310	369.8	415.4	477.4	441.9	808.1	847.4	0
BM	**Bioliquids**	**GSE-Bioliquidi**	0	0	0	0	0	736	558	530	217.8	328,2	455.7	639.3	0
DIS	Landfill biogas	**GSE-Gas discarica**	0	0	0	0.8	0	156	156	152.9	159	106	0	0	0
RIF	**Waste**	**GSE-Rifiuti organici**	0	0	0	40.17	40.2	40	254.3	274.7	302.4	302.2	0	0	0
CF	Fossil fuels - Thermoelectrical (including incinerators)	**TERNA-Termoelettrici (comprende termovalorizzatori)**	22309.5	24363.4	23219.3	23368.7	25004.7	25541.6	20932.8	23855.5	22051.8	19458.6	15523.9	13264.1	0

Tabella 4- Electric energy production in Emilia-Romagna region with total production -GSE/TERNA data-

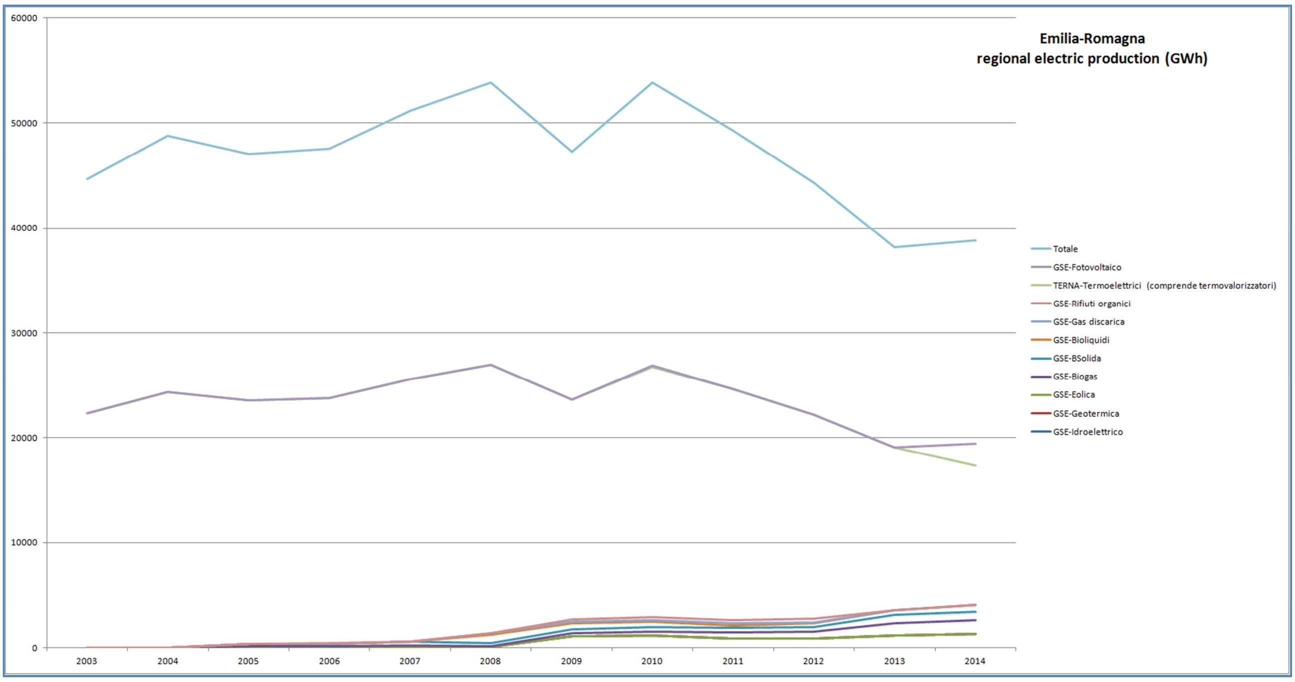


Figura 1- Electric energy production in Emilia-Romagna region with total production -GSE/TERNA data-

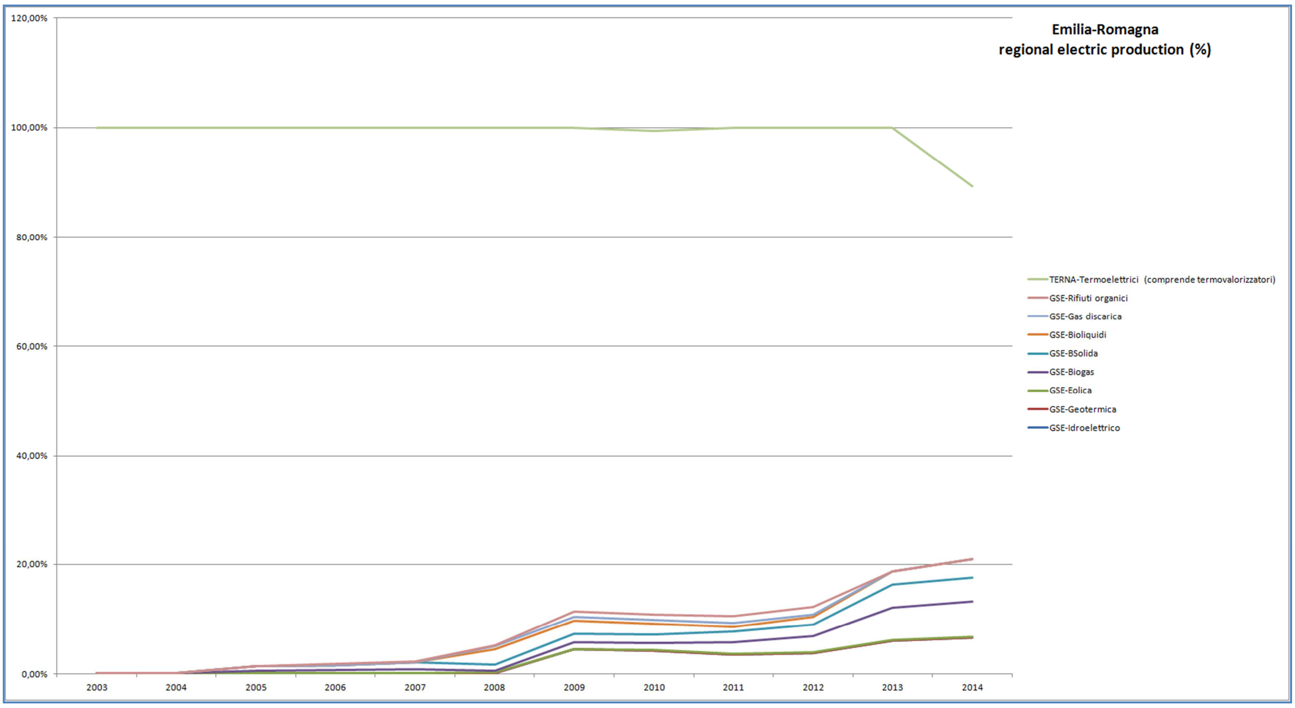
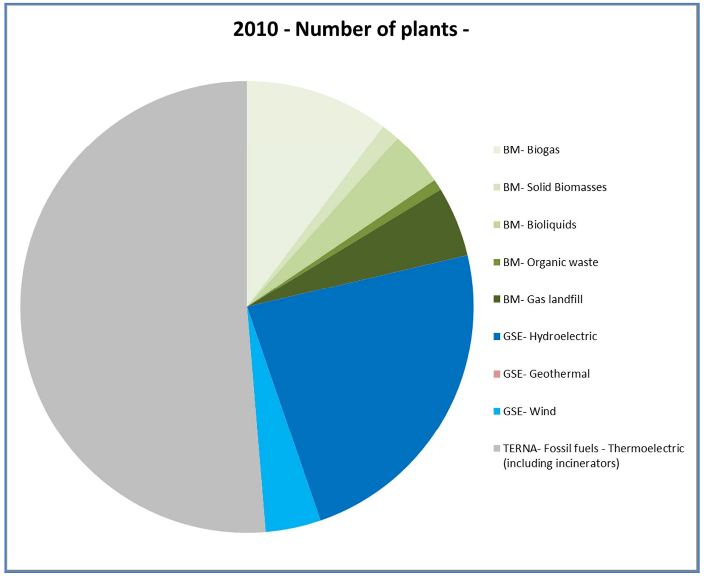
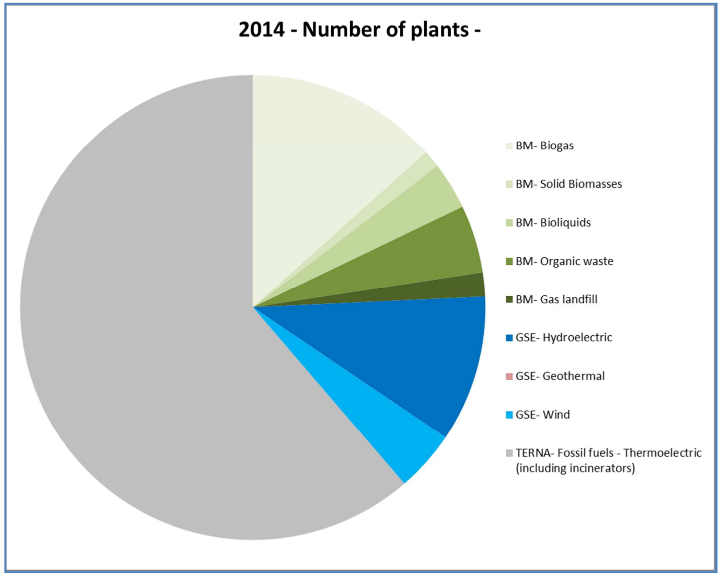


Figura 2- Electric energy production in Emilia-Romagna region without total production -GSE/TERNA data-

1.1.4. Number of electric power plants in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

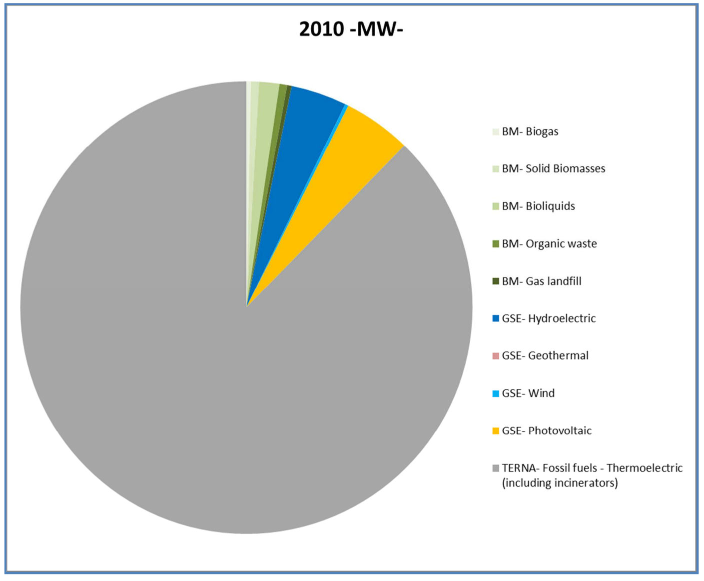
Numero di impianti	Number of plants	2010 - Number of plants -	2010 - %	2014 - Number of plants -	2014 - %
BM- Biogas	BM- Biogas	39	10.26%	176	13.38%
BM- Biomasse solide	BM- Solid Biomasses	5	1.32%	16	1.22%
BM- Bioliquidi	BM- Bioliquids	15	3.95%	43	3.27%
BM- Rifiuti organici	BM- Organic waste	3	0.79%	62	4.71%
BM- Biogas da discarica	BM- Gas landfill	19	5.00%	22	1.67%
GSE- Idroelettrico	GSE- Hydroelectric	89	23.42%	134	10.19%
GSE- Geothermico	GSE- Geothermal	0	0.00%	0	0.00%
GSE- Eolico	GSE- Wind	15	3.95%	56	4.26%
TERNA- Termoelectric Combustibili Fossili (*inclusi i termovalorizzatori)	TERNA- Fossil fuels - Thermoelectric (*including incinerators)	195	51.32%	806	61.29%
~~GSE- Photovoltaic~~	~~GSE- Photovoltaic~~	~~14486~~		~~64214~~	
TOTALE -*no fotovoltaico	TOTAL -*no photovoltaic-	380	100.00%	1315	100.00%

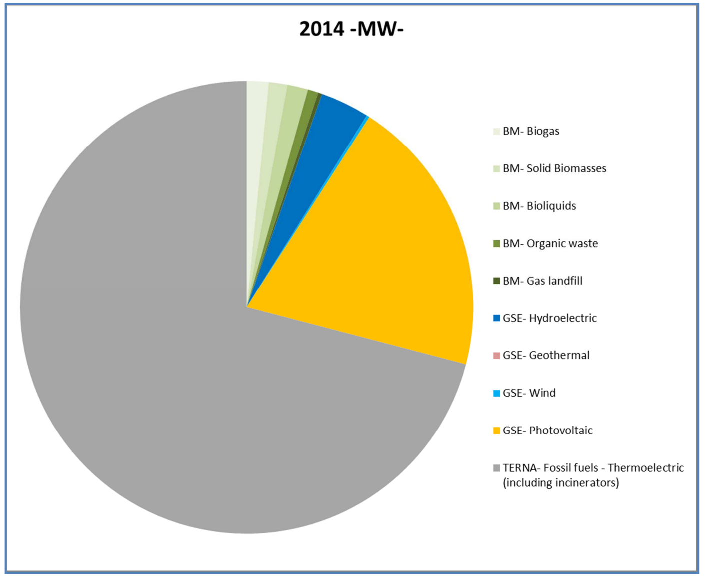




1.1.5. Electric production power in Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

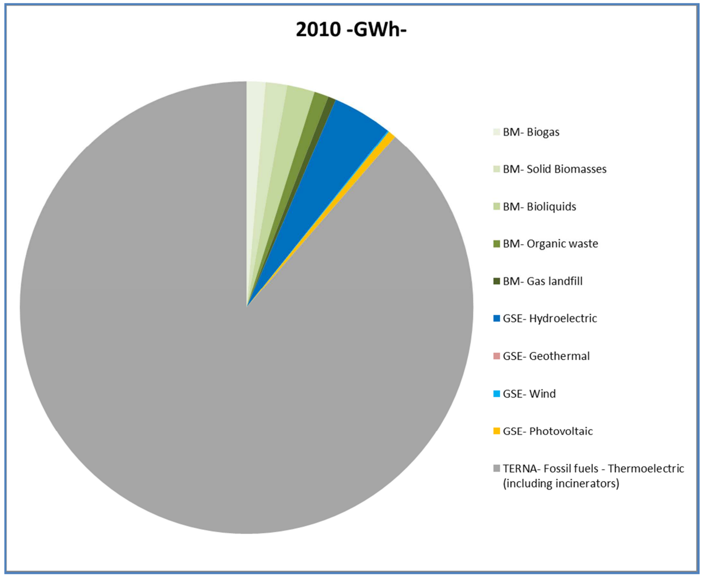
Potenza elettrica	Electric Power	2010 -MW-	2010 - %	2014 -MW-	2014 - %
BM- Biogas	BM- Biogas	24.2	0.32%	144.99	1.56%
BM- Biomasse solide	BM- Solid Biomasses	42.8	0.57%	122.68	1.32%
BM- Bioliquidi	BM- Bioliquids	108.6	1.45%	138.35	1.49%
BM- Rifiuti organici	BM- Organic waste	41	0.55%	70.03	0.75%
BM- Biogas da discarica	BM- Gas landfill	24.1	0.32%	26.93	0.29%
GSE- Idroelettrico	GSE- Hydroelectric	298.9	3.99%	325.4	3.49%
GSE- Geothermico	GSE- Geothermal	0	0.00%	0	0.00%
GSE- Eolico	GSE- Wind	17.9	0.24%	19.3	0.21%
GSE- Fotovoltaico	GSE- Photovoltaic	364	4.86%	1858.8	19.96%
TERNA- Termoelectric Combustibili Fossili (*incluso i termovalorizzatori)	TERNA- Fossil fuels – Thermoelectric (*including incinerators)	6568.5	87.70%	6606.3	70.94%
TOTALE	TOTAL	7490	100.00%	9313	100.00%

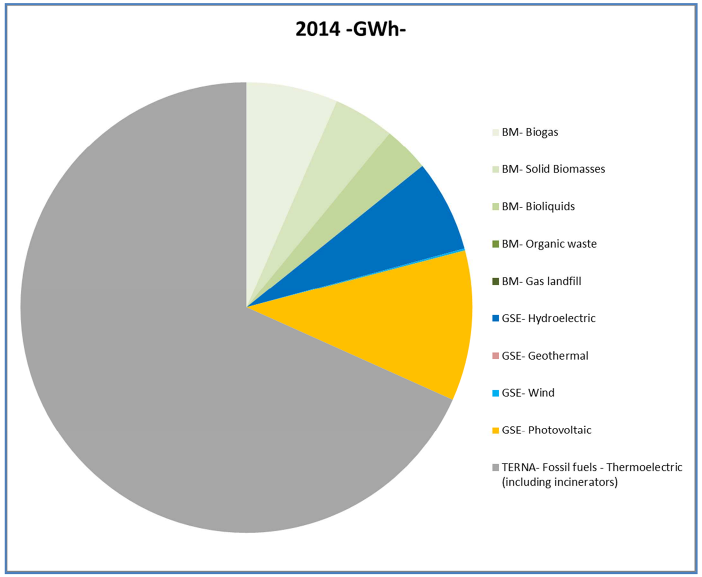




1.1.6. Electric energy production in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

Produzione elettrica	Electric Production	2010 -GWh-	2010 - %	2014 -GWh-	2014 - %
BM- Biogas	BM- Biogas	360.1	1.34%	1272.3	6.55%
BM- Biomasse solide	BM- Solid Biomasses	415.4	1.54%	847.4	4.36%
BM- Bioliquidi	BM- Bioliquids	530	1.97%	639.3	3.29%
BM- Rifiuti organici	BM- Organic waste	274.7	1.02%	0	0.00%
BM- Biogas da discarica	BM- Gas landfill	152.9	0.57%	0	0.00%
GSE- Idroelettrico	GSE- Hydroelectric	1150.2	4.27%	1277.1	6.58%
GSE- Geothermico	GSE- Geothermal	0	0.00%	0	0.00%
GSE- Eolico	GSE- Wind	24.7	0.09%	27.2	0.14%
GSE- Fotovoltaico	GSE- Photovoltaic	153.1	0.57%	2093.1	10.78%
TERNA- Termoelectric Combustibili Fossili (*incluso i termovalorizzatori)	TERNA- Fossil fuels - Thermoelectric (*including incinerators)	23855.5	88.63%	13264.1	68.30%
TOTALE	TOTAL	26917	100.00%	19421	100.00%





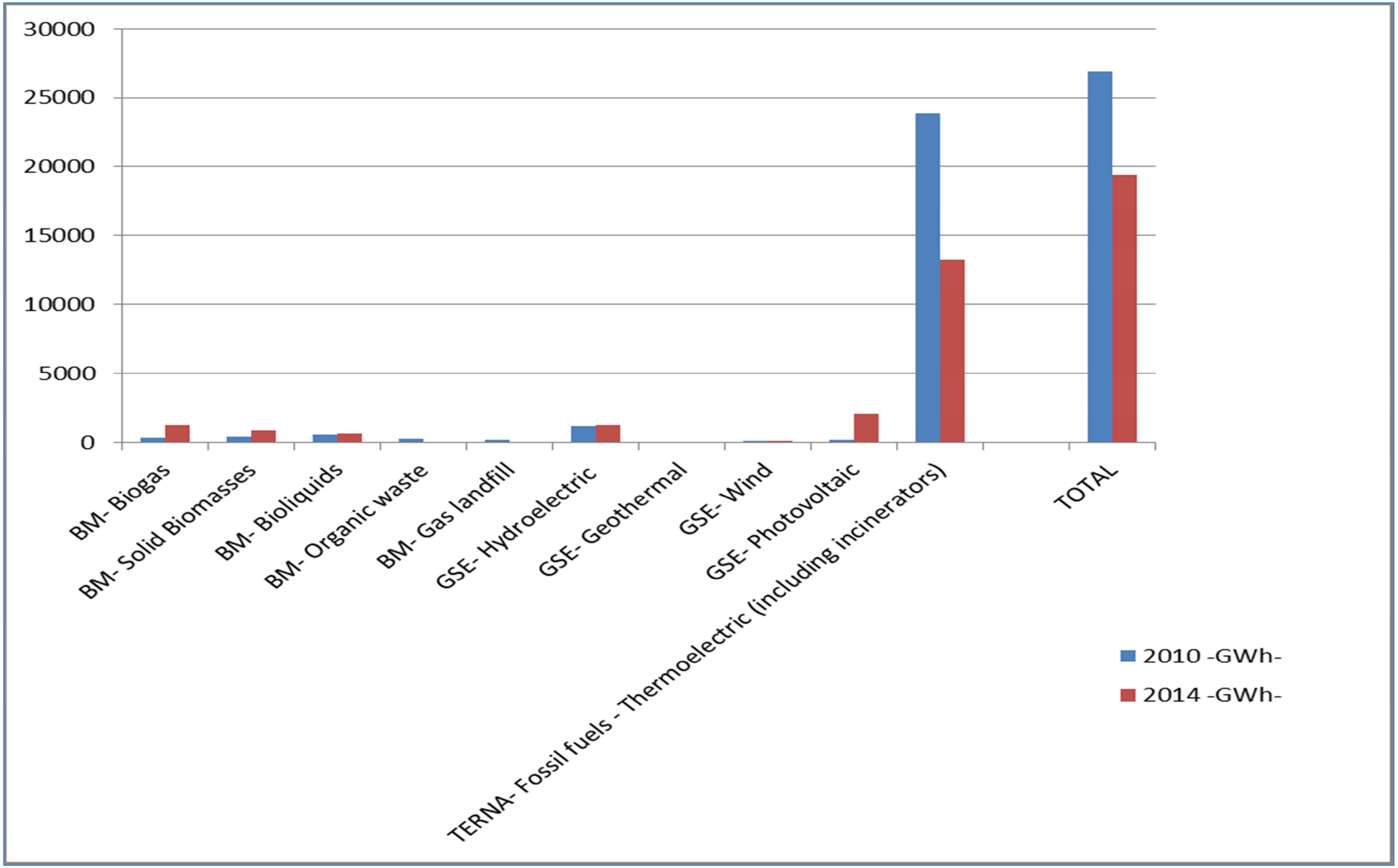
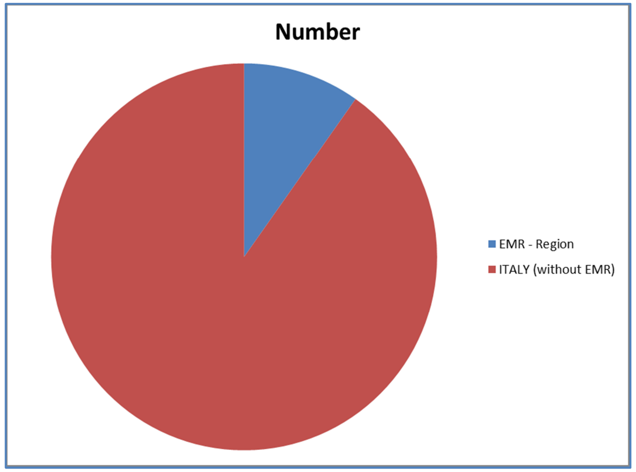
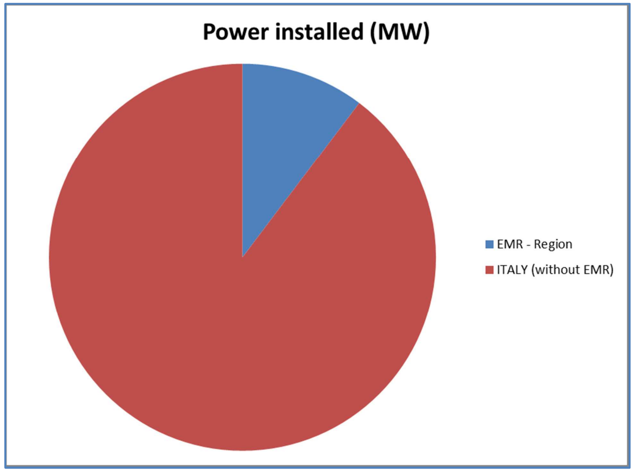


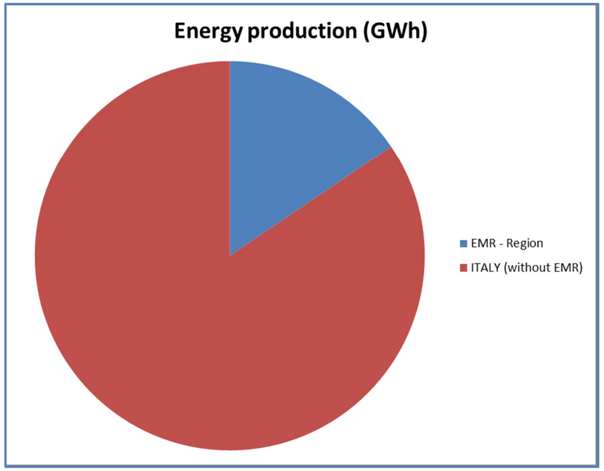
Figura 3- Electric energy production in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

1.1.7. Comparison for ONLY electric BIOGAS sectors of Emilia-Romagna Region and Italy - GSE data - 2014

2014		EMR - Region	ITALY (without EMR)	ITALY	% EMR / ITALY
GSE-Biogas	Number	176	1620	1796	9.8%
GSE-Biogas	Power installed (MW)	144.99	1261	1406	10.3%
GSE-Biogas	Energy production (GWh)	1272.3	6926	8199	15.5%

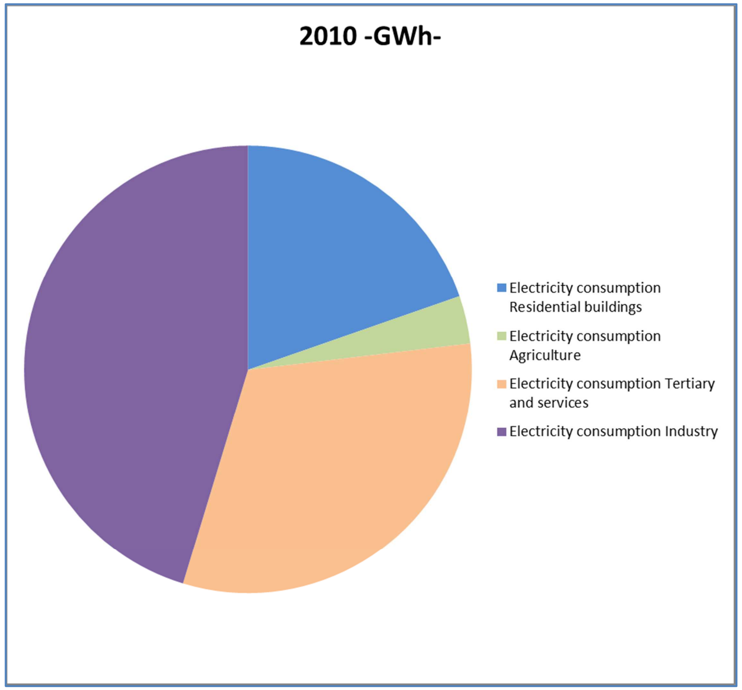


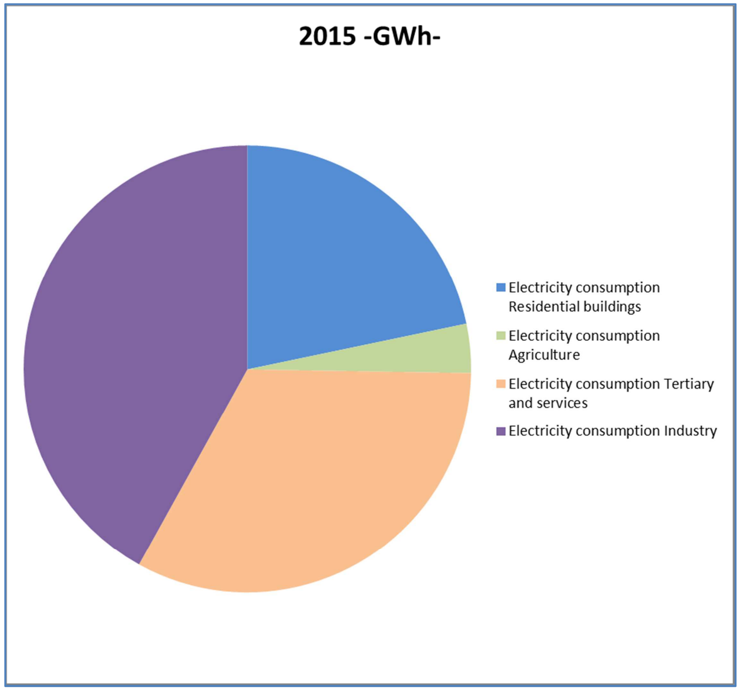




1.1.8. Electricity consumption in Emilia-Romagna - ARPAE data - years 2010 and 2015

Consumi elettrici	Electric energy consumption	2010 -GWh-	2010 - %	2015 -GWh-	2015 - %
Consumi elettrici residenziali	Electricity consumption Residential buildings	5,284	19.68%	6,009	21.73%
Consumi elettrici nell´agricoltura	Electricity consumption Agriculture	924	3.44%	977	3.53%
Consumi elettrici per il terziario ed I servizi	Electricity consumption Tertiary and services	8,474	31.57%	9,065	32.78%
Consumi elettrici industriali	Electricity consumption Industry	12,164	45.31%	11,603	41.96%
TOTALE consumi elettrici	Total electricity consumption	26,846	100.00%	27,654	100.00%





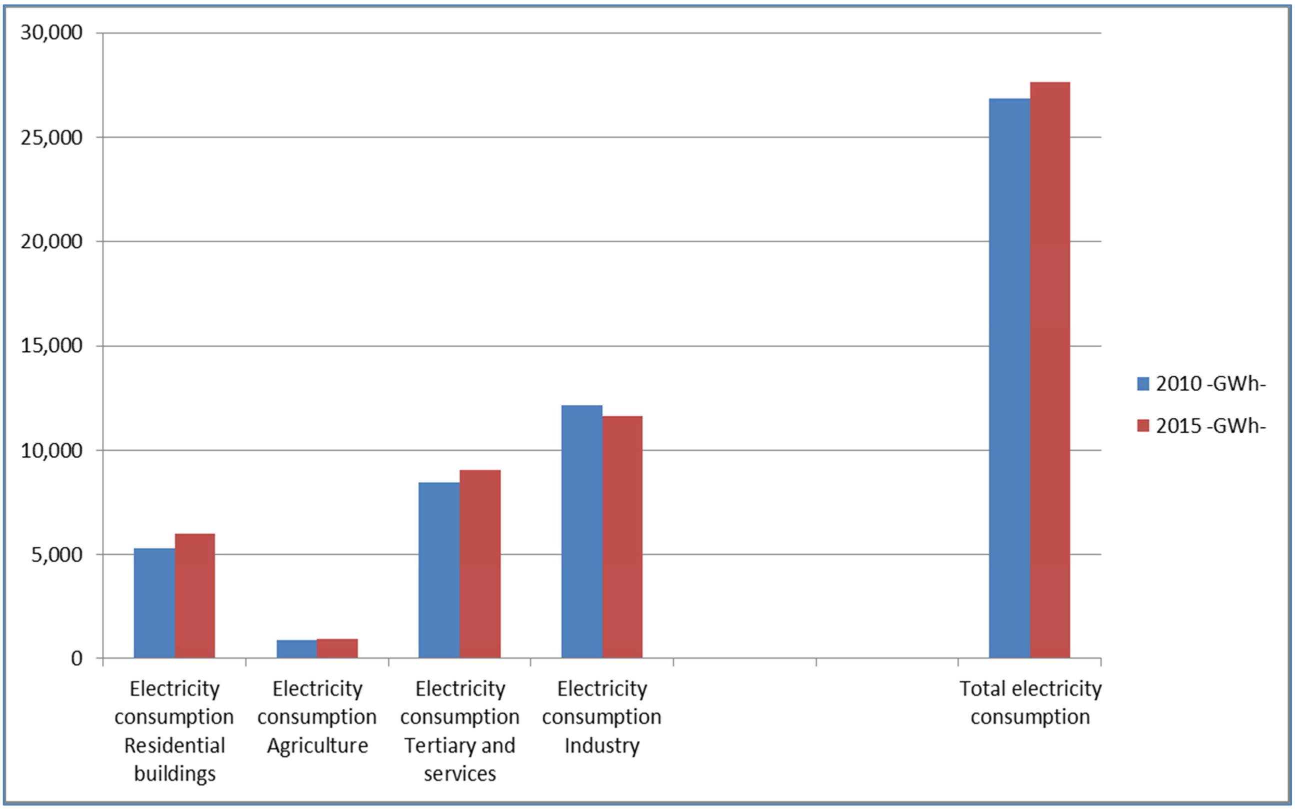


Figura 4- Electric energy consumption in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

1.1.9. Electricity production VS electricity consumption - years 2010 and 2014/15

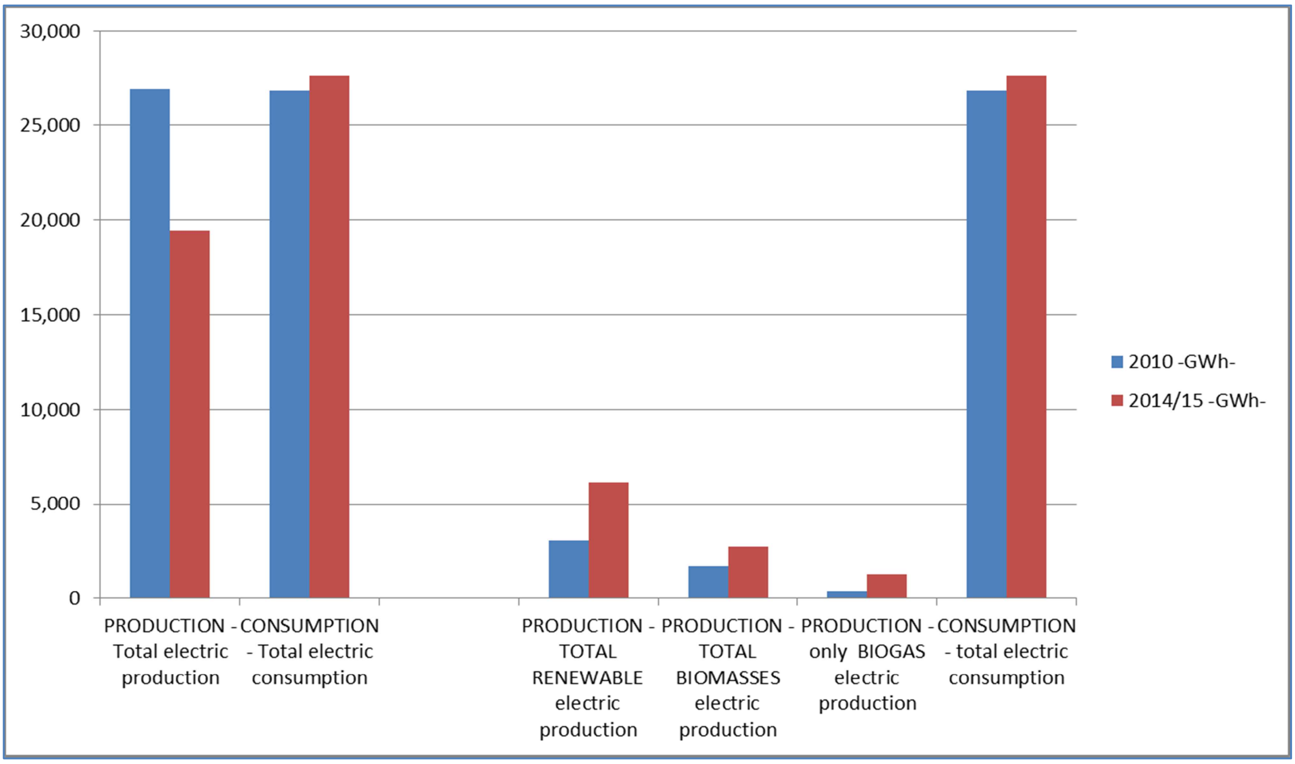


Figura 5- Electric energy production VS consumption in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

Index - part 3.2 -

BIOMASS POWER PLANTS OVERVIEW

1. ENVIRONMENTAL IMPACTS OF THE DIFFERENT ENERGETIC SOURCES

As we mentioned the use of fossil fuels (coal, oil and natural gas) causes increasing amounts CO2 emitted into the atmosphere, which in extreme synthesis is the main cause of the 'greenhouse effect and increase in average temperatures, and thus of global climate change, with everything that goes with it: melting glaciers, rising sea levels, desertification, climate weather imbalances, etc .. which in turn cause the extinction of plant and animal species, famines, metereological disasters , etc ..
That said, it is necessary to be aware that renewable energy sources can create very significant environmental impacts, including also globally. Just think of the massive deforestation of tropical forests to grow palm oil or sugar cane, whose products are used not only in food but also as an energy source for the production of biofuels, such as biodiesel and bioethanol.

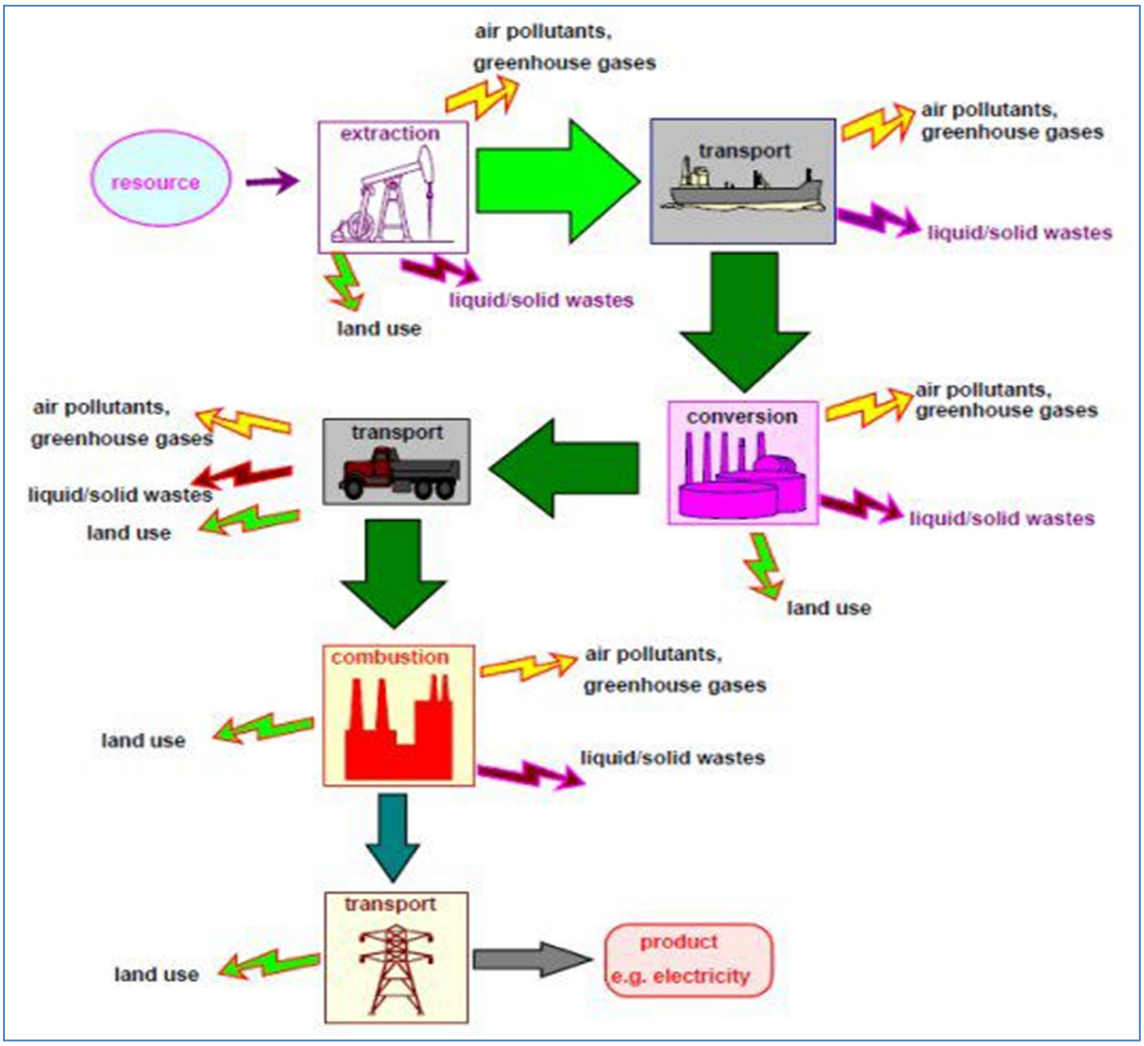


Figura 1- Example of the chain of environmental effects for the energy source of fossil fuel oil; [Research4energy.it, 2015, a] -

Entering into the merits of impacts on local scale , if on one hand it is intuitive that the oil wells with their accidental spills of pollutants, or coal mines, etc .. can cause serious damage to the ecosystem both natural and social, less intuitive is the fact that even here renewable energy can be a source of severe environmental damage locally.
The construction of a hydroelectric plant, for example, can change the whole river system of the territory going to decimate most of the fish species (and not only) who live down of this valley; the construction of a wind farm may instead cause severe impacts from both landscape point of view

which both from hydrogeological, depending on its mode of construction; the establishment of large photovoltaic plants on a land once agricoltural can cause the depletion of agricultural and natural resources, as well as the intensive cultivation of energy crop plants aimed to energy production biomass plants.

In summary, every human activity generates environmental impacts, both locally and globally. These may be very obvious or hidden; often negative, but also positive. Think to he afforestation of hilly mountain slopes aimed at sustainable use of biomass that allow the consolidation of the land, preventing landslides; or to the submerged part of the methane extraction offshore platforms that create new habitats protection and recovery for marine species becoming real hot spots of biological biodiversity, protected by fishermen's nets.

In terms of planning, to make a correct overall assessment of the impacts of different types of energy sources, it is necessary to consider the impacts both globally and locally, both at the level of single supply chain and at one of specific production site, both positive and negative.

The following table summarizes and compares, from a qualitative point of view, the environmental impacts related to the general energy production chain of biomass with those of fossil fuels.

VERY LOW	LL
LOW	L
MEDIUM	M
HIGH	H
VERY HIGH	HH

NEGATIVE	N-
DEPENDS	DEPENDS
NEUTRAL	NEUTRAL
POSITIVE	P+

Tabella 1- Environmental impacts related to the general energy production chain of biomass with those of fossil fuels.

	BIOMASS			FOSSIL FUELS		
ENVIORNOMENTAL COMPONENT	GLOBAL LEVEL	REGIONAL LEVEL	LOCAL LEVEL	GLOBAL LEVEL	REGIONAL LEVEL	LOCAL LEVEL
CONSUMPTION OF NON-RENEWABLE RESOURCES	LL	L	L	HH	H	H
GREENHOUSE EFFECT AND CLIMATE CHANGE	L	L	L	HH	HH	HH
AIR QUALITY	L	L	M	HH	HH	H
SURFACE WATER ENVIRONMENT	LL	L	L	H	H	H
UNDERGROUND WATER ENVIRONMENT	LL	L	L	H	H	H
MARINE ENVIRONMENT	LL	LL	LL	H	H	HH
FLORA AND FAUNA	M	M	H	H	H	HH
POLLUTION SOIL	LL	L	L	H	H	M
POLLUTION OF THE SUBSOIL	LL	L	L	H	H	DEPENDS
CONSUMPTION OF THE SOIL	H	LL	L	LL	LL	LL
USE OF AGRICULTURAL LAND	H	H	H	LL	L	L
WATER CONSUMPTION	M	M	M	H	H	H
FORESTS	H	M	H	L	L	M
ACOUSTIC CLIMATE	LL	LL	L	LL	LL	H
SMELLS	LL	LL	M	LL	M	H
WASTE	P+	P+	P+	H	H	H
TRAFFIC	LL	M	H	HH	H	H
LANDSCAPE	H	H	H	L	M	HH
SOCIAL SYSTEM	P+	P+	H	H	H	H
URBAN SYSTEM	L	L	L	H	H	HH
JOB MARKET	P+	P+	P+	M	N-	N-
LIVELIHOOD OF AGRICULTURE	P+	P+	P+	N-	N-	N-
ENGINEERING AND TECHNOLOGY	P+	M	M	H	M	M
TOURISM	NEUTRAL	M	M	M	H	HH
AVAILABILITY 'LOCAL	P+	P+	P+	P+	M	N-
RISK ACCIDENT	LL	LL	L	H	H	HH
DAMAGE FROM ACCIDENT	LL	LL	L	HH	HH	HH
HUMAN HEALTH	P+	LL	L	HH	HH	HH
PEOPLE AND POPULATIONS	P+	P+	P+	HH	HH	HH

1.1. Local environmental effects of the biomass power plants sites

As mentioned, there are four main types of biomass power plants:

- solid biomass direct combustion (usually of wood chip);
- solid biomass combustion with indirect combustion (through pyro / gasification);
- bioliquids (through production and subsequent combustion of liquid fuels obtained by alcoholic fermentation (bioethanol), or by squeezing of oil seeds and trans-esterification (biodiesel), or from liquid by-products arising from the pyro / gasification processes (synliquids));
- biogas (through anaerobic digestion).

Although all these types of plants have a very low emissive budget of fossil CO2 (due to consumption of fossil fuels for the cultivation, harvesting, processing and transportation of biomass), and therefore in the first approximation they can be defined almost entirely sustainable on a global level, in reality, their construction, presence and activity very often generate real conflicts among the peoples involved, the owners of the plant and the public administration, because at specifically local and territorial level, they are source of significant environmental criticalities, such as for example:

- the consumption of natural resources (eg. forests);
- use of the land (eg. intensive energy crops (eg. maize etc ..))
- the increase of heavy traffic;
- air pollutant emissions and air quality;
- disturbance of the landscape;
- etc..

The environmental and anthropic components potentially subjecedt to impact by biomass plants are the following:

- **Atmosphere**

The parameters to be taken into account for the impacts in the atmosphere are the typical macro-ubiquitarious polluttants, namely:

  - carbon monoxide (CO),
  - nitrogen oxides (NOx, NO and NO2),
  - sulfur dioxide (SO2),
  - particulate matter (PM10)
  - acid substances
  - organic substances

To the emissions of nitrogen oxides (NOx), which is also an important precursor of secondary particulate and ozone formation, contribute both road transport that the real process of combustion aimed at the production of energy. The main contribution to emissions of ammonia (NH3), which is also the precursor of secondary particulate matter, derives from agricultural activities. Also the sulfur dioxide (SO_2), potentially emitted from the anaerobic fermentation even at low concentrations results to be an important precursor of secondary particles.

- **Water environment**

Water resources are affected by the exercise of biomass power stations relatively to the operation of the steam cycle, especially in the cooling of the condenser downstream of the turbine. In general the use of water is quite limited during its operation. With regard to the surrounding water and the ground water these have their own specific characteristics which depend on the area of the plant. They must be made periodic samples of the water to check for any changes.

- **Soil and subsoil**

The use of soil is not particularly relevant, because this is mainly used for the reception, storage and supply of biomass before the combustion system, and only a small portion of the territory is occupied by the buildings and systems.
Different is instead the question regarding the use of the territory when we consider the hectares needed for the cultivation crops of vegetal biomass near the plant, or to the forests exploited for wood, or to areas far from where we are import vegetable oils with great impact as the 'palm oil, etc..

- **Vegetation, flora, fauna and ecosystems**

environmental problems related to the nature matrix, so to say, may be especially in the context of excessive exploitation of forest areas in which the utilization rate of the wood is greater than that of regeneration, and in the case of disturbance of nature within or close to of areas of particular natural value and / or during the reproductive periods of animal species particularly sensitive.

- **Landscape**

In the context of the protection of the landscape, especially in an area so rich in history and culture as the Italian one, the characterization of both the historical and cultural aspects, and those related to the simple visual perception, must explicit the actions of modification and / or disturbance exerted by the single project in relation to environmental quality.
It is therefore necessary analyze the characteristics of the project and identify the characters of the landscape, recognize the relationships, the balances and the quality of the same, in order to capture interactions with study scenarios.

The quality of the landscape is determined by analysis concerning:

- The landscape in its spontaneous dynamics, through the examination of natural components;
- Agricultural activities, residential, manufacturing, tourism, recreational, infrastructural presences, their stratifications and their incidence on the degree of naturalness in the system;
- The natural and human conditions that have generated the evolution of the landscape;
- The strictly visual study of the relationship between subject and environment;
- Characters environmental, archaeological, artistic and historic architecture;
- Etc..

In our case, the possible effects of a biomass power plant are due to the intervention in respect the landscape understood as a sign and trace the historical evolution of the territory according to the perception that "users" have it, whether permanent (the residents around) or occasional, and therefore in relation to the way in which the new structures fit into the context, understood as a perceived environment.

The main factors of disturbance generated by the planned activities that can affect the landscape altering its quality are thus

- the physical presence of means, equipments, manufacturs;
- the emission of unpleasant odors;
- the excessive noise emission;
- changes all'assetto floristic-vegetation;
- changes to the visual landscape;
- changes to the land use in all its complexity.

- **Human health**

Human health is defined by WHO[1] as "a state of physical well-being and not merely the absence of disease." This definition would imply the assessment of impacts on the welfare of the population, ie about the psychological and social components. To the evaluation and characterization of public health thus also contribute all environmental components described above, although measured and related to human health with appropriate functions of evaluation.

[1] World Health Organisation.

1.2. Environmental impacts of biomass p.p. productive chains

As mentioned, the environmental impacts resulting from energy production with biomass must be evaluated necessarily considering the entire production chain, primarily due to the fact that biomass is generated from the territory. These impacts depend both on the structure of the production chain, that on the technology used, that on the sensitivity of territorial context in which the plant is inserted. In general the main impacts at LOCAL-TERRITORIAL level associated with the supply chain of the type of plant and of the types of used biomass, can be summarized as follows:

- **UPSTREAM - PROCUREMENT OF BIOMASS**

	SOURCE OF BIOMASS	ACTIVITY	PRESSURE	EFFECTS
BIOMASS PRODUCTION AIMED TO ENERGY PRODUCTION ***although one can assume that the crops being equally implemented for human food purposes and / or animal husbandry, It assumes that the lands could also be suitable for other, as new forests, natural wetlands, etc ..**	agricultural cultivation	Use of agricultural TERRITORY	TERRITORY consumption	TERRITORY consumption
		Plowing and treatment of TERRITORY	diesel fuel consumption	greenhouse + air pollution
		Sowing	diesel fuel consumption	greenhouse + air pollution
		chemical fertilization	consumption and use of NUTRIENTS	freshwater pollution
				groundwater pollution
				marine pollution
			diesel fuel consumption	greenhouse + air pollution
		organic fertilization	consumption and use of NUTRIENTS	freshwater pollution
				groundwater pollution
				marine pollution
			diesel fuel consumption	greenhouse + air pollution
		pesticide treatments	TOXIC SUBSTANCES diffusion	soil contamination
				freshwater pollution
				groundwater pollution
				marine pollution
			diesel fuel consumption	greenhouse + air pollution
		irrigation	WATER consumption	decrease in water resources
			diesel fuel consumption	greenhouse + air pollution
		harvesting	diesel fuel consumption	greenhouse + air pollution
		treatment	diesel fuel consumption	greenhouse + air pollution
		transport	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
	arboreus cultivations	Use of TERRITORY	TERRITORY consumption	TERRITORY consumption
		planting	diesel fuel consumption	greenhouse + air pollution
		cut	diesel fuel consumption	greenhouse + air pollution
		harvesting	diesel fuel consumption	greenhouse + air pollution
		chopping	diesel fuel consumption	greenhouse + air pollution
		pelletisation	diesel fuel consumption	greenhouse + air pollution
		transport	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
FOREST **BIOMASS** **spontaneous / natural**	forestry forest maintenance	forest management	forest maintenance	P+
		tree cut	diesel fuel consumption	greenhouse + air pollution
		harvesting	diesel fuel consumption	greenhouse + air pollution
		storage for drying	STORAGE manufactures/sites	TERRITORY consumption
		chopping	diesel fuel consumption	greenhouse + air pollution
		pelletisation	diesel fuel consumption	greenhouse + air pollution
		transport	diesel fuel consumption	greenhouse + air pollution
BIOMASS ALREADY PRESENT REGARDLESS OF ENERGY PRODUCTION *** These biomass are produced independently of energy production (eg. the Organic Urban Waste) and therefore should be equally treated / disposed**	agricoltural bypruducts	harvesting	diesel fuel consumption	greenhouse + air pollution
		chopping	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		transport	diesel fuel consumption	greenhouse + air pollution
	zootechnical bypruducts	harvesting	diesel fuel consumption	greenhouse + air pollution
		treatment	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		transport	diesel fuel consumption	greenhouse + air pollution
	food industry bypruducts	harvesting	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		transport	diesel fuel consumption	greenhouse + air pollution
	industrial bypruducts (es. wood)	harvesting	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		transport	diesel fuel consumption	greenhouse + air pollution
	waste: OUW and urban prunings	harvesting	diesel fuel consumption	greenhouse + air pollution
		treatment	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		transport	diesel fuel consumption	greenhouse + air pollution
TREATMENT PLANTS WASTE / WASTEWATER	LANDFILL: (*necessary activities in every case)	waste delivery	diesel fuel consumption	greenhouse + air pollution
		treatment	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		final disposal area	STORAGE manufactures/sites	TERRITORY consumption
		emissions capturing	teli e pompe di aspirazione	**P+ missing methane emissions**
	DEPURATOR: (*necessary activities in every case)	wastewaters reception	sistemi idrici	//
		treatment	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		final disposal area	STORAGE manufactures/sites	TERRITORY consumption
		emissions capturing	teli e pompe di aspirazione	**P+ missing methane emissions**
	INCINERATOR: (*necessary activities in every case)	waste delivery	diesel fuel consumption	greenhouse + air pollution
		treatment	diesel fuel consumption	greenhouse + air pollution
		storage	STORAGE manufactures/sites	TERRITORY consumption
		inceneration site	STORAGE manufactures/sites	TERRITORY consumption
		emissions capturing	teli e pompe di aspirazione	greenhouse + air pollution

- **INTERNAL PHASE OF ENERGY PRODUCTION INSIDE THE PLANT**

TYPE OF PLANT	ACTIVITY	PRESSURE	EFFECTS
SOLID BIOMASS - with DIRECT combustion - with INDIRECT combustion (pyro/gasification)	storage	SMELLS	atmospheric pollution
	DIRECT COMBUSTION	atmospheric polluttant emissions (NOx, PTS, PM10, PM2,5, SO2, ecc..)	atmospheric pollution
		emissions of biogenic CO2	//
		SMELLS	atmospheric pollution
	SYNGAS production	//	**P+ CO2 Reduction - greenhouse effect**
		Syngas leaks (2,5%)	greenhouse + air pollution
	SYNLIQ production	//	**P+ CO2 Reduction - greenhouse effect**
	CHAR production	//	**P+ CO2 Reduction - greenhouse effect**
	COMBUSTION: SYNGAS - SYNLIQ - CHAR	atmospheric polluttant emissions (NOx, PTS, PM10, PM2,5, SO2, ecc..)	atmospheric pollution
		SMELLS	atmospheric pollution
	thermal energy production	//	**P+ CO2 Reduction - greenhouse effect**
	electric energy production	//	**P+ CO2 Reduction - greenhouse effect**
	synfuels sale	diesel fuel consumption + traffic	greenhouse + air pollution

TYPE OF PLANT	ACTIVITY	PRESSURE	EFFECTS
LIQUID BIOMASSES - mechanical pressing - transesterification with intermediate production of: +Biodiesel +Bioethanol	storage	SMELLS	atmospheric pollution
	mechanical pressing process	autoproducted energy consumption	//
		SMELLS	atmospheric pollution
	esterification chemical process	chemical substances consumption	impacts from productive chemical chain (generic)
		SMELLS	atmospheric pollution
	BIODIESEL production	//	**P+ CO2 Reduction - greenhouse effect**
	BIOETHANOL production	//	**P+ CO2 Reduction - greenhouse effect**
	biofuels + residues COMBUSTION	atmospheric polluttant emissions (NOx, PTS, PM10, PM2,5, SO2, ecc..)	atmospheric pollution
		SMELLS	atmospheric pollution
	thermal energy production	//	**P+ CO2 Reduction - greenhouse effect**
	electric energy production	//	**P+ CO2 Reduction - greenhouse effect**
	synfuels sale	diesel fuel consumption + traffic	greenhouse + air pollution

TYPE OF PLANT	ACTIVITY	PRESSURE	EFFECTS
BIOGAS with intermediate production of: +Biogas (CH4+CO2) +BioMethane (CH4)	storage	SMELLS	atmospheric pollution
	ANAEROBIC DIGESTION process	autoproducted energy consumption	//
		SO2 emissions	atmospheric pollution
			rain acidification
		CH4 leaks (1 %)	greenhouse + air pollution
		SMELLS	atmospheric pollution
	biogas COMBUSTION	atmospheric polluttant emissions (NOx, PTS, PM10, PM2,5, SO2, ecc..)	atmospheric pollution
		SMELLS	atmospheric pollution
		CH4 leaks (1,75 %)	greenhouse + air pollution
	thermal energy production	//	**P+ CO2 Reduction - greenhouse effect**
	electric energy production	//	**P+ CO2 Reduction - greenhouse effect**
	biomethane sale	diesel fuel consumption + traffic	greenhouse + air pollution

TYPE OF PLANT	ACTIVITY	PRESSURE	EFFECTS
GAS from **LANDFILLS AND DEPURATORS** with intermediate production of: +Biogas (CH4+CO2) +BioMethane (CH4)	storage	SMELLS	atmospheric pollution
	ANAEROBIC DIGESTION process	autoproducted energy consumption	//
		SO2 emissions	atmospheric pollution
			acidificazione delle pigge
		CH4 leaks (1 % *of the only captured)	greenhouse + air pollution
		SMELLS	atmospheric pollution
	biogas CAPTURING	//	**P+ CH4 Reduction - greenhouse effect**
	biogas COMBUSTION	atmospheric polluttant emissions (NOx, PTS, PM10, PM2,5, SO2, ecc..)	atmospheric pollution
		SMELLS	atmospheric pollution
		CH4 leaks (1,75 %)	greenhouse + air pollution
	thermal energy production	//	**P+ CO2 Reduction - greenhouse effect**
	electric energy production	//	**P+ CO2 Reduction - greenhouse effect**
	biomethane sale	diesel fuel consumption + traffic	greenhouse + air pollution

TYPE OF PLANT	ACTIVITY	PRESSURE	EFFECTS
INCINERATORS	storage	SMELLS	atmospheric pollution
	waste treatment	autoproducted energy consumption	//
		SO2 emission	atmospheric pollution
			acidificazione delle pigge
		SMELLS	atmospheric pollution
	COMBUSTION	emissioni inquinanti atmosferiche (NOx, PTS, PM10, PM2,5, SO2, ecc..)	atmospheric pollution
		DIOXINES emissions	atmospheric pollution
		SMELLS	atmospheric pollution
		CH4 leaks (1,75 %)	greenhouse + air pollution
		not using landfill	**P+ territory use Reduction**
	thermal energy production	//	**P+ CO2 Reduction - greenhouse effect**
	electric energy production	//	**P+ CO2 Reduction - greenhouse effect**

- **DOWNSTREAM – MANAGEMENT OF BYPRODUCTS AND WASTE**

TYPE OF PLANT	ACTIVITY	PRESSURE	EFFECTS
MANAGEMENT OF WASTE AND BYPRUDUCTS	Biofuels sale	diesel fuel consumption	greenhouse + air pollution
	Biomethane sale	pipelines + diesel fuel consumption	greenhouse + air pollution
	DIGESTATE	treatment - autoproducted energy consumption	//
		transportat - fuel consumption + traffic	greenhouse + air pollution
		spreading - diesel fuel consumption	greenhouse + air pollution
			P+ Soustainable soil fertilisation
	ASHES - BIOCHAR	agricoltural TERRITORY fertilisation	**P+ Soustainable soil fertilisation**
		diesel fuel consumption	atmospheric pollution
	POLLUTTED ASHES	landfill disposal	TERRITORY consumption
			water pollution (fresh. ground. marine.)
		diesel fuel consumption	greenhouse + air pollution
	waste from productive activitiy	landfill disposal	pollution from landfill
		disposal in incinerator	pollution from incinerator
		diesel fuel consumption	greenhouse + air pollution

- **BUILDING AND DISPOSAL OF THE PLANT [2]**

	ACTIVITY	PRESSURE	EFFECTS
Every type of plant	**BUILDING AND DISPOSAL OF THE PLANT**	manufactures / buildings / sitesof the PLANT	TERRITORY consumption
			WATER consumption
			RESOURCES consumption
			impact on BIODIVERSITY
		cement	greenhouse + air pollution
		steel	greenhouse + air pollution
		diesel fuel	greenhouse + air pollution
		plastics	greenhouse + air pollution
		traffic	greenhouse + air pollution

[2] The impacts of the physical construction of a plant, and from its ultimate disposal, are comparable to the impacts generated by the construction of a generic production plant of small and medium industry.

2. BIOMASS POWER PLANTS OVERVIEW

2.1. BIOMASS ENERGY PLANTS

Nowadays biomasses, independently of their origin, may be used for multiple applications, including:

- Electric and thermal energy production
- Production of biofuels
- Generation of bio-based products (biodegradable polymers).

A biomass plant is an energy plant that produces energy (electricity and heat) and / or fuels of various types, starting from the initial organic biomass as a raw material, in the quality of fuel input to the system.
Biomass can be used to directly produce energy by direct combustion, or may undergo further processing in order to produce liquid biofuels, bioethanol, biodiesel, or gaseous fuels such as syngas, biogas, methane, etc ..).
The energy biomass plants, depending on their size and characteristics, can meet many types of users, as for example:

- production of electricity to be fed into the national grid;
- crop and livestock farmers utilities: for heating of farms, greenhouses, etc ..
- industrial users (in particular those of the wood and the food industry): for the production of electricity and / or heat;
- local domestic users: for electricity and home heating needs
- public utilities (whole municipalities and districts) for the supply of electricity and heat for district heating.

To obtain bioenergy and biofuels from biomass there are the following types of processes:

- THERMOCHEMICAL = (combustion, gasification, pyrolysis[3]):
    - with the combustion is obtained bioenergy in a direct way: the chemical energy of the biomass is in fact converted into heat energy.
    - by the gasification and pyrolysis are formed intermediate products (gaseous as the Syngas, or liquids such as the bioliq, etc ..) which in turn are combusted to obtain energy, thermal / mechanical / electrical.

- BIOCHEMICAL = (anaerobic digestion, fermentation):
    - through anaerobic digestion is obtained biogas (CH4 mixture, CO2 and other gases), while using the alcoholic fermentation is obtained the liquid bioethanol.

- PHYSICOCHEMICAL = (extraction of oils followed by their transesterification):
    - with production of biodiesel, liquid.

We describe below the main technologies and products in more depth:

[3] Pyrolysis differs from gasification in that the pprima works in the absence of oxygen (often utilizes a hot stream of an inert gas such as nitrogen, by implementing the pyrolysis proper), while the gasification works in the presence of small amounts of oxygen making so even a partial oxidation, representing, in principle, a cross between an incinerator and a pyrolyzer.

2.1.1. Energy from direct combustion / pyrogasification of woody biomasses:

The production of energy through combustion / pyrogasification of solid biomass is very advantageous, both from the economic point of view that environmental, first of all in the wood industry and in those agrifood where, in place of disposing of waste that has a very onerous cost, it can reuse the waste resulting from the processing for the production of energy in support of the production process.
In relation to domestic users, wood biomass is historically the most commonly used: until recently, the entire home heating system was based on biomass stoves, fireplaces or thermocookers powered until to 20-30 kW, with low efficiency, varying from 10% to 15% for the fireplaces, to 40-45% for stoves and thermocookers, and therefore now abandoned in favor of higher returns and greater practicality given by the use of fossil energy sources.
Today, thanks to new technologies, through the use of pellet or chip boilers, which are able to ensure high levels of efficiency (80-90%), it is returning to the use of wood biomass, because the costs are competitive compared to other fuels such as diesel and methane. The latest generation of boilers are designed to obtain an almost perfect combustion of the wood, with emissions lower than those of traditional combustion boilers.

2.1.2. Energy from anaerobic digestion of biomass (BIOGAS):

The process of anaerobic bacterial fermentation of the organic material of plant and animal origin, transforms the organic matter into biogas and digestate. The digestate is a sludge that can be used very positively as a fertilizer material on major crops. Biogas is a gas composed principally of methane (at least 50%) and carbon dioxide, which can be burned to obtain thermal and electric energy.
EU legislation (Dir. 2001/77 / EC) and national (Legislative Decree 387/03) on renewable source explicitly includes among them the "landfill gas, residual gases from purification processes and biogas." In fact all three types of gases indicated are biogas, but their separate listing in the aforementioned legislation highlights the multiplicity of organic matrices from which biogas can be produced: waste to landfill ie fraction organic municipal waste, sewage sludge , animal excreta slaughterhouse waste, agro-industrial organic waste, crop residues, energy crops, etc ..
Mainly the biogas is obtained from anaerobic digestion processes, such as for example those which occur in a controlled manner into the special digesters, or spontaneously in the landfill sites. The biogas has an excellent calorific value given the high methane content, for which lends itself to a direct combustion for energy recovery, implemented in a single boiler for heat production, or in engines coupled with generators to produce electricity alone or for the cogeneration of electricity and heat. Thermoelectric plants fueled by biogas then perform the conversion of thermal energy contained in biogas, into mechanical energy and then into electricity. The biogas can be purified from carbon dioxide and then be sold as methane, which in this case is said bio-methane.

2.1.3. Biofuels

Liquid fuels derived from biomass, called biofuels, belong to biofuels technology: they can be used as fuel for transport and, in some cases, even in biopower technologies. The most common biofuels are bioethanol, synthesized from carbohydrates, and biodiesel, made from fats and oils.
The benefits of using biofuels are:

- possibility of synthesis starting from waste materials of agricultural productions.
- less dependence on fossil fuels;
- reduced greenhouse gas emissions;

- non-toxicity;
- biodegradability (biodiesel is biodegradable in 30 days);
- smaller quantity of sulfur than traditional diesel;

Bioethanol is an organic fuel, produced by fermentation of biomass through reactions mediated by biocatalysts, such as yeast and bacteria. To today, this biofuel, or more likely a derivative called ETBE (EtilTetrioButilEtere) obtained by combining isobutene (a petroleum hydrocarbon) and bioethanoloffers the best compromise between price, availability and performance.
As regards bioethanol, although the one obtained from starches and sugars, it offers a good contribution from the energy and environmental, that one obtained from cellulosic biomass takes on greater importance , ie herbaceous and woody plants, agricultural and forestry residues, and large amount of municipal waste and industrial waste. This is largely due to the availability of the raw material: in fact, while starches and sugars represent a modest quantity of plant material, the cellulose and hemicelluloses, which are also sugar polymers, represent the majority of the biomass.
Biodiesel instead, is a biofuel which is derived from the decomposition of vegetable oils, animal fats or cooking fats and can be used as such or after the esterification or transesterification process, in environmental conditions characterized by low temperature and pressure. It can be obtained from all the rich oil crops of vegetable oils. Biodiesel can be stored in the same fuel tanks and pumped with conventional means (except on cold days in which you have to use tanks heaters and agitators) is completely miscible with diesel fuel, which makes it an excellent additive because, being a oxygenated product, improves the complete combustion and reduces the emissions of pollutants.
One disadvantage of biodiesel regards to the emission of NOx, but research is making good progress thanks to the development of more effective and efficient filtering systems. Moreover, the performance of internal combustion engines that use as fuel pure biodiesel (torque and power) are 8-15% lower because of the different energy content than diesel. To solve the problem, the diesel fuel is conveniently used in a mixture of 20% with traditional diesel.

2.1.4. Bioproducts

Fit into this category many everyday products such as antifreeze, plastics, glue, artificial sweeteners, toothpaste and others. The basic assumption is that any compound synthesized from fossil fuels can be similarly produced from biomass using, inter alia, a lower energy quantity than their counterparts produced from oil. The technological processes at the base of bioproducts technology are three:

- alcoholic fermentation (the same used for the synthesis of biofuels);
- carbon monoxide more hydrogen (are formed in abundance during the heating of the biomass): used for the biosynthesis of plastics and acids indispensable in the production of photographic films, textiles and synthetic fibers;
- pyrolysis oil: this compound is the basis for extracting the phenol compound used to produce adhesives for wood, plastic molds and insulating foam.
-

2.1.5. Conclusion

In summary, the energy contained in vegetal biomass can be converted through thermochemical, biological or physical processes. The final result (with the exception for direct combustion) is an high energy intensive product, usable with more easily and flexibility in successive energy conversion devices. Below you can see a scheme of the different processes usable with vegetal biomasses.

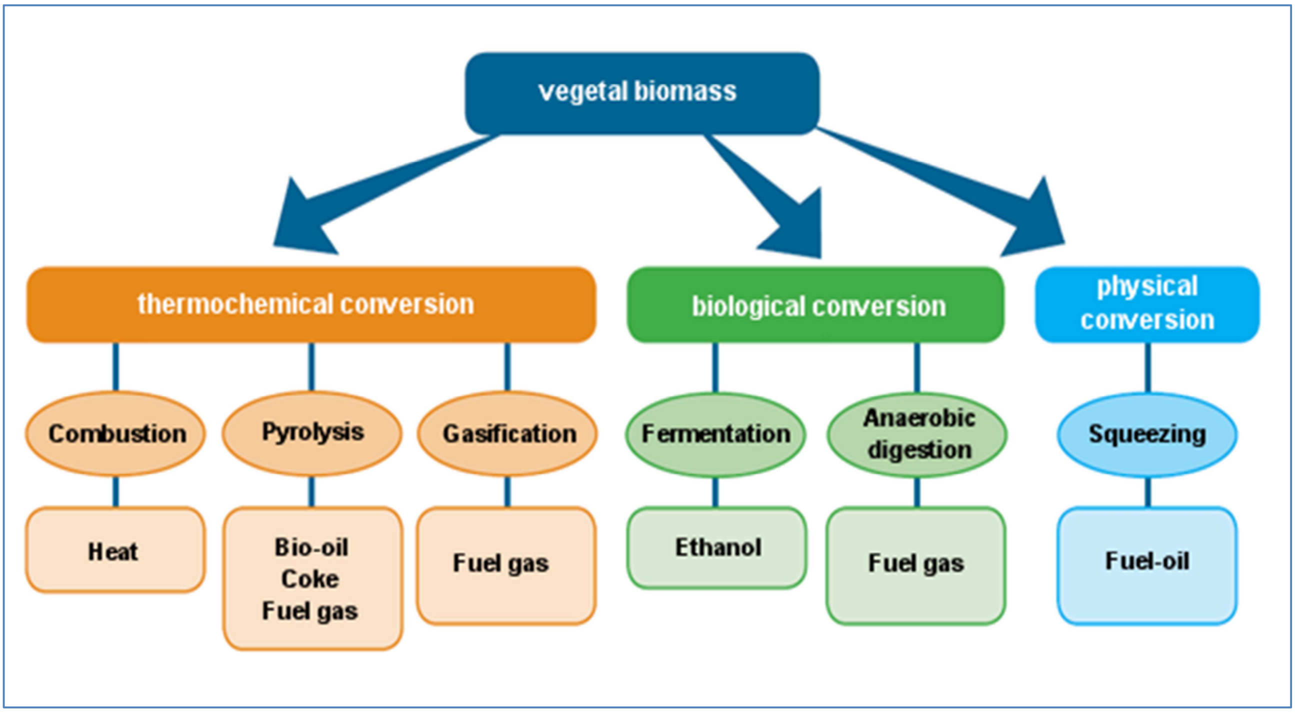


Figura 2- Types of vegetal biomass conversion tecnologies and their energetic products - [CRPA, 2006 a - Candoli, 2006]

The different types of energy conversion presuppose the use of specific biomass to optimize energy yields.The usable biomass can originate either from dedicated crops both companion products. Integrative biomass are an opportunity to re-use and valorisation of byproducts and low cost of purchase materials

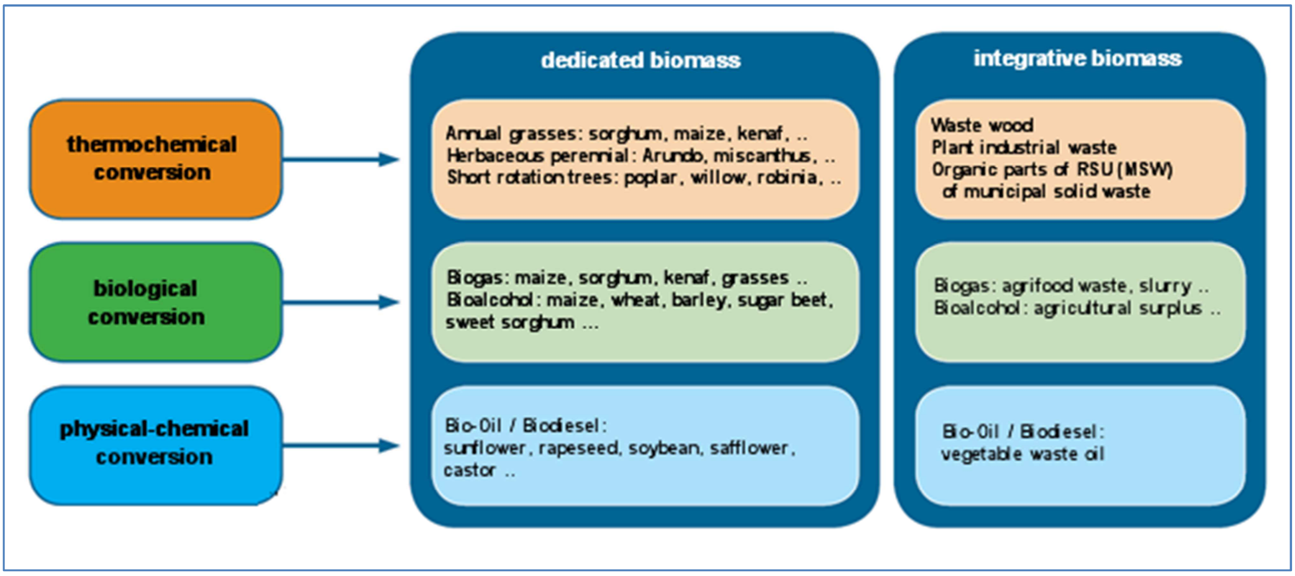


Figura 3- Different types of biomass energy tecnologies need different types of biomass - [CRPA, 2006 a - Candoli, 2006]

2.2. MAIN TYPES OF BIOMASS POWER PLANTS

Despite the many technological variants, we usually divide the biomass plants in the 3 following main types:

- SOLID BIOMASS
- BIOLIQUID
- BIOGAS

- For SOLID BIOMASS plant always we intend a plant that produces energy from a direct or indirect thermochemical combustion (indipendently if it burns wood chips, logs, prunings, sawdust, or any other type of biomass; and/or indipendently if it burns the biomass directly or indirectly after a pyrolysis or a gasification intermediate process). Compared the biomass input the result of the whole process is energy + ashes.

- For BIOLIQUID plant we intend a plant that produces fuel-oil throught a physical conversion like squeezing and transesterification and after it sells his liquid-fuels [4]. Compared the biomass input the result of the whole process is fuel-oils + biomass waste.

- For BIOGAS plant we intend a plant where the biomass where the biomass input (of whatever type it may be) is submitted to a bacterial anaerobic[5] fermentation process from which biogas is obtained (mixture of CH_4 + CO_2 + SO_2 in traces) and digested sludge. The methane is then burned for energy, while the digested sludges are spread on agricultural fields as natural fertilizer. Even here therefore it occurs the step of combustion of the biogas, but conceptually the most significant process, which characterizes the entire energy conversion system, is that of the bacterial fermentation that from the incoming biomass produces biogas fuel + digested sludge.

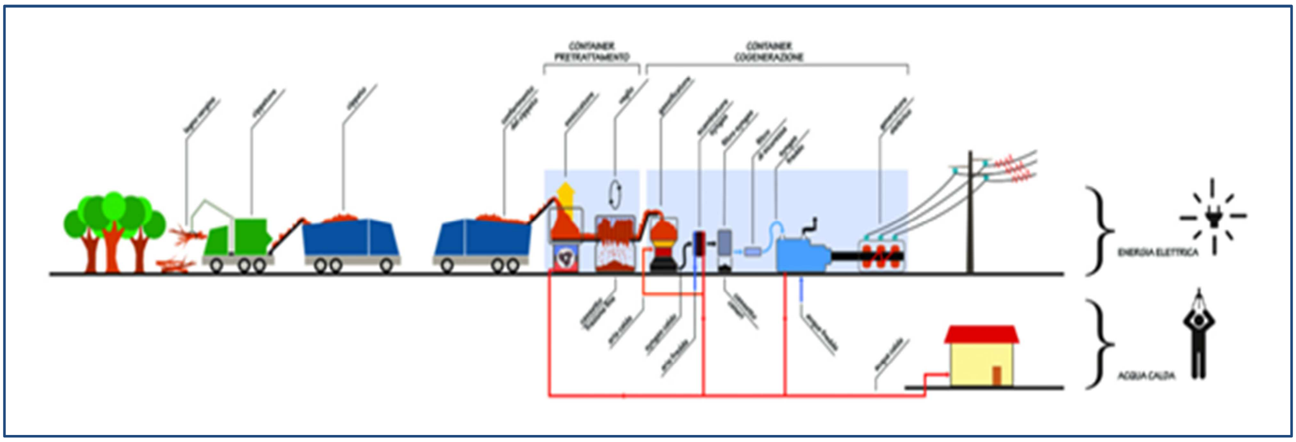


Figura 4- Scheme of a solid biomass gasification power plant - [Poweroilsystem.com, 2015, a]

[4] Liquid-bio-fuels are produced also throught the gasification and pyrolysis process, but in this case the overwhelming majority of the times the liquid-fuels are burned in the same plant, and so, due the fact that liquids are burned there,and due the fact that in any case there is a combustion process, we define this kind of plant a Solid Biomass Plant.

[5] Also from the aerobic fermentation of biomass is obtained biogas fuel containing methane, but while the anaerobic fermentation is used with the primary purpose of producing fuel methane, the aerobic fermentation instead has as its primary purpose that one of the degradation of organic biomass with the aim of transforming it into organic ground of good quality.

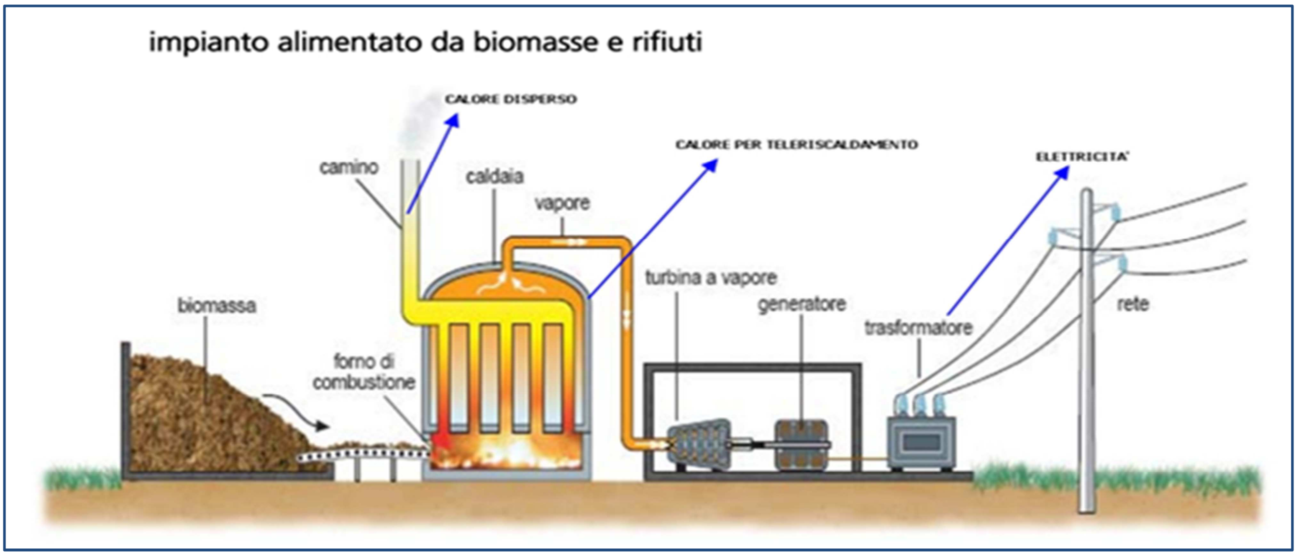


Figura 5- Direct combustion power plant fueled by biomass and organic waste - [GSE, 2008 a]

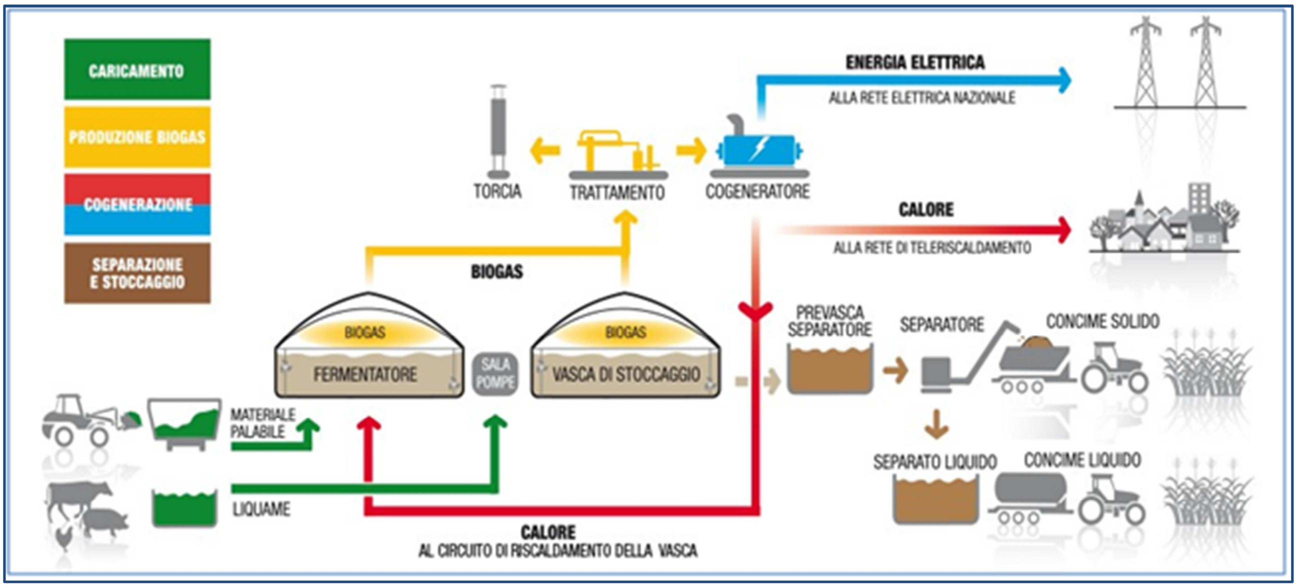


Figura 6- Scheme of a biogas power plant fueled by agro-zootechnical biomasses - [Ies Biogas, 2015, a]

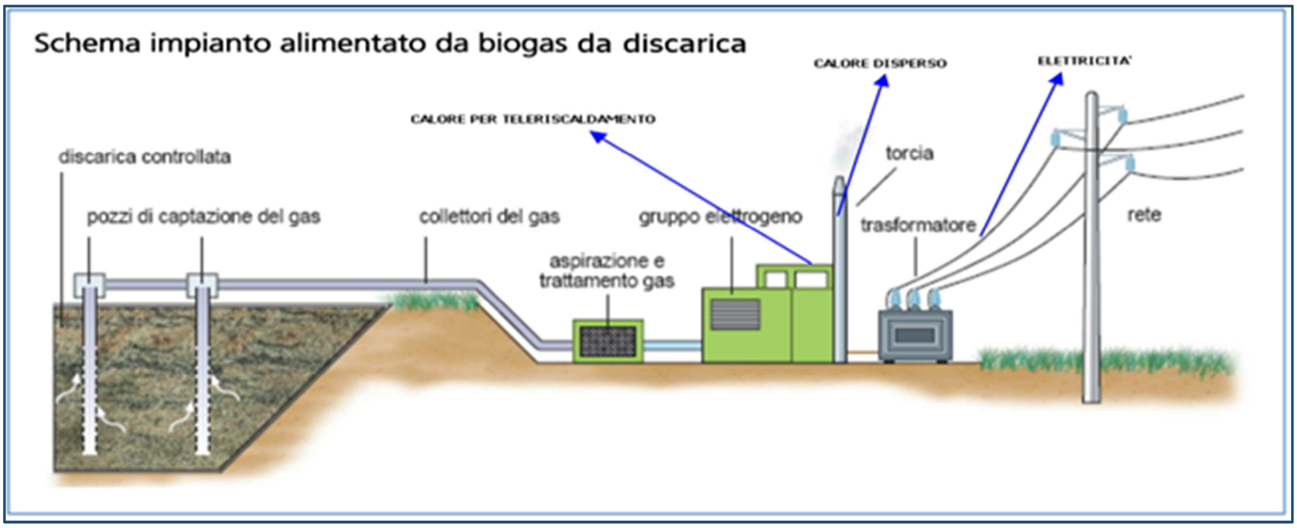


Figura 7- Scheme of a power plant fueled by landfill biogas - [GSE, 2008 a]

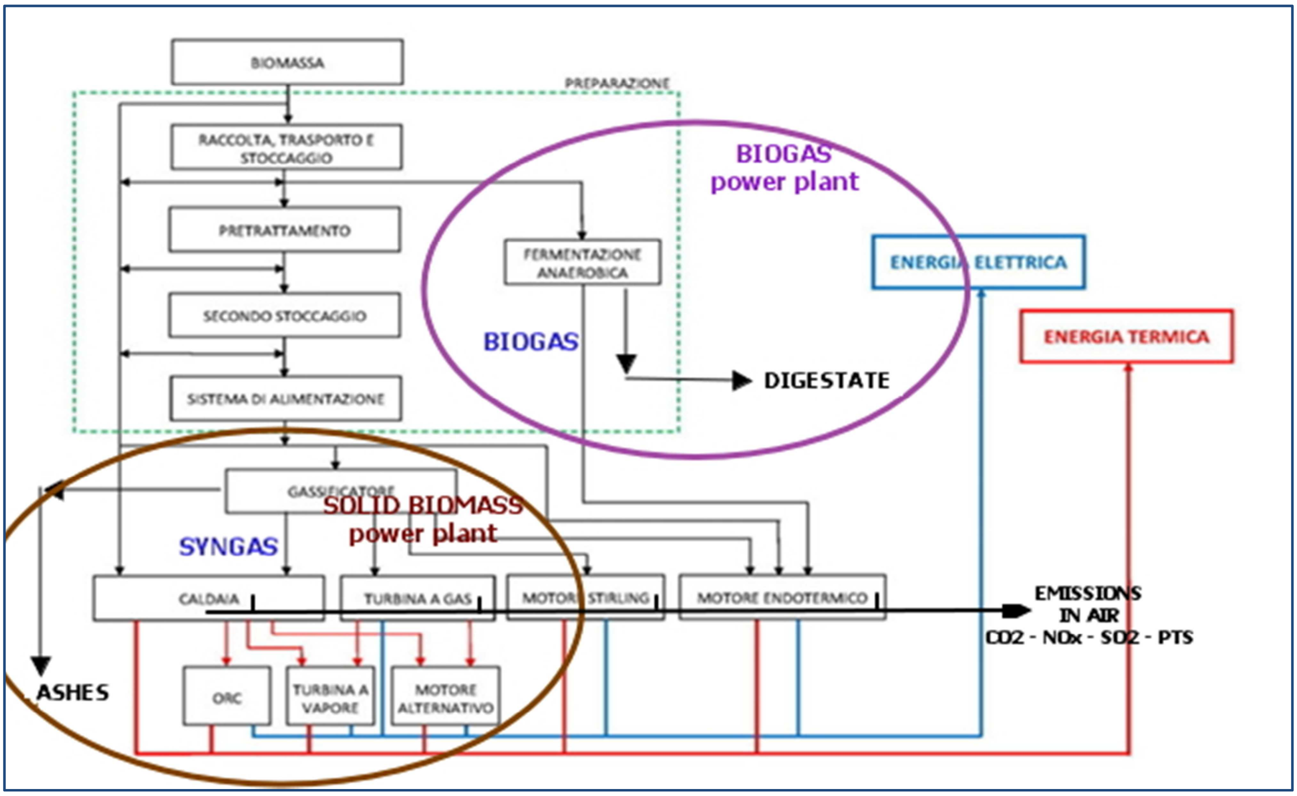


Figura 8- Example of process scheme for a generic biomass power plant : - with anaerobic fermentation technology for biogas installations; - with gasification technology for solid biomass plants. - [M. Tarolli, Itabia, 2015, a. - modified]

We must remeber too that different tecnologies have different efficiencies, even if we don't have forget that each territory has its peculiarities productive in terms of types of biomass available. Below we propose e scheme for energy efficiency productions of different types of energy plants.

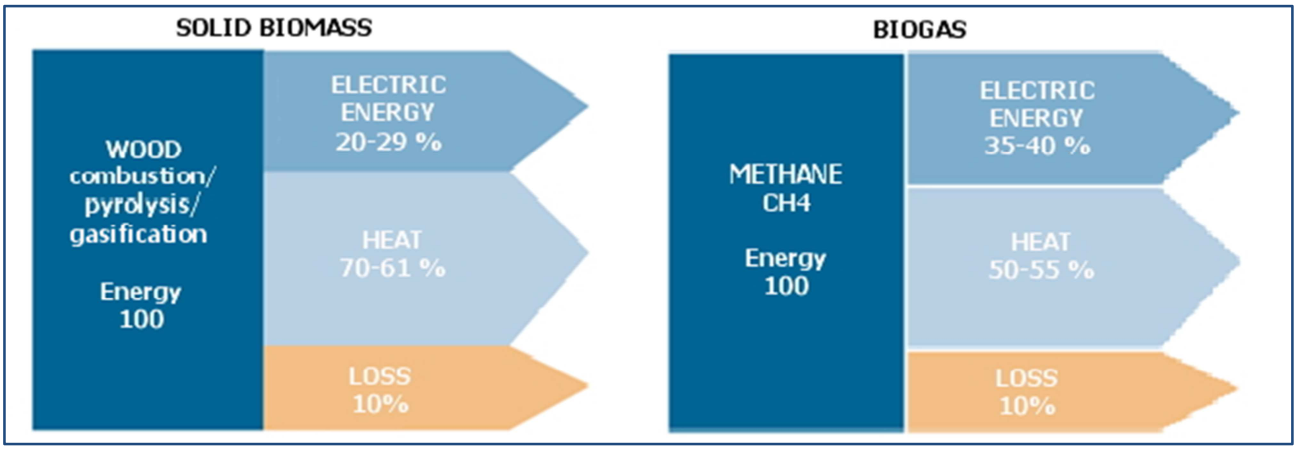


Figura 9- Energy efficiency of a solid biomass plant compared to that one of a biogas plant - [CRPA, 2006 a - Candoli, 2006]

Tabella 2- Table of lower calorific values fuel - [GSE, 2008 a]

COMBUSTIBILI TRADIZIONALI[1]	PCI (kcal/kg)	COMBUSTIBILI RINNOVABILI[2]	PCI SS[3] (kcal/kg)
Lignite	2.500	Paglia da grano, segale e orzo	4.207
Carbon Fossile	7.400	Vinacce	4.266
Carbone di Legna	7.500	Sansa	4.296
Gas Naturale	8.250 kcal/mc	Cedui a rotazione breve	4.398
Olio Combustibile	9.800	Gusci di noci, mandole e pinoli	4.410
Gasolio	10.200	Legno	4.541
Distillati Leggeri	10.400	Corteccia	4.565
GPL	11.000	Residui di potatura	4.577

[1]Fonte BEN
[2]Fonte UNI CEN/TS
[3]PCI SS potere calorifico inferiore della sostanza secca

2.2.1. Biomass plants supply chains

2.2.1.1. The importance of the different supply productive chains of biomass plants

In the context of the biomass power plants, the most significant environmental impact depends very little by the plant itself, but rather stems from the entire production chain connected to it: this both upstream of the system for the supply of biomass needed (eg . cultivation of biomass, collection and transport to the plant), both downstream of the plant, in reference to the phases of destination , transport and processing of byproducts and waste derived from the processes performed within the plant energy.

In general we can schematize the production chains for biomass plants as it follows:

Tabella 3- Table scheme for production chains of biomass power plants.

GROUP	PHASE	SUBPHASE	ACTIVITIES
UPSTREAM	PROCUREMENT OF BIOMASS	full cultivation	plowing, sowing, watering, harrowing, etc ..
		harvesting	tractor, truck, harvester, etc..
		primary treatment	shredding, chipping, etc..
	TRANSPORT	transport of biomass	trucks, lorries
SYSTEM	PRODUCTIVE PROCESS INSIDE THE PLANT	- production of electric energy - production of heat energy - production of bio-fuels	
PRODUCTS	TRANSPORT OF PRODUCTS	electricity lines gas pipelines tank trucks	
	USE OF PRODUCTS	combustion	
DOWNSTREAM	TRANSPORT	transport of byproducts	trukcs, lorries, etc..
	DESTINATION OF BYPRODUCTS AND WASTE	agricultural fields forests landfill composting reuse etc..	spreading in agricoltural fields spreading in the forest etc..

- PROCUREMENT

First, there is the procurement (made up of the sub-steps of: planting, cultivation, harvesting, etc ..) of the initial biomass needed for system operation. Internal to the phase of procurement also we consider the phase of pre-treatment (preparation) that the INITIAL BIOMASS undergoes in order to be able to be conferred operatively in the power plant.

- INBOUND TRANSPORT

Then, of course, there is the transport phase of the biomass harvest to the energy plant; Now, except for any additional pre-specific treatments, in the moment in which the biomass is conferred within the plant gates it represents the real 1° FUEL with which the system is fueled.

- ENERGY PRODUCTION

At this point we enter the phase of ENERGY PRODUCTION: the 1° fuel is sent, to one of the following two process steps, (A) or (B), characterizing the single specific plant:

(A) The 1° fuel is burned directly, going to generate the DIRECT ENERGY PRODUCTION (Electricity + Thermal Energy), via a cogeneration engine, a boiler or other mechanism, with the consequent emission of CO_2 in the atmosphere (in addition to Particulate Matter , NO_x and other gaseous molecules to be purified) together with the production of ash to be disposed.

(B) Or the 1° fuel undergoes a biochemical treatment and / or physico-chemical aimed at its transformation in 2° FUEL, which may be:

of GASEOUS type, such as for example:

- Biogas containing CH_4 (coming from anaerobic fermentation process);
- Syngas fuel (coming from gasificastion or pyrolysis process);

of LIQUID type, which for example:

- Bioethano (produced by squeezing and fermentation with specific bacteria);
- Biodiesel (coming from squeezing and transestherification process);
- Bioliq (coming from gasificastion or pyrolysis process);

Afterwards the 2° fuel (gaseous or liquid it be) is burned to obtain electricity and heat.
In the case of 2° fuel _ "gaseous" there will be CO_2 emissions, together with NO_x, and other gaseous molecules, to be purified, but not of fine dust.
In the case of 2° fuel _ "liquid" there will be emissions into the atmosphere even fine particles (but in much smaller quantities than the direct combustion of biomass as in the case (A)).

- PRODUCTION EMISSIONS, WASTE and BYPRODUCTS

Accompanied to the production of energy from the production / combustion of 1° or 2° fuel, we must to consider also the "compartments" associated with it the consequent EMISSIONS (CO_2, NO_x, CO, PTS, etc ..) and producing of BYPRODUCTS / or WASTE (such as, respectively, the digestate of biogas plants spreadable in agricultural fields as fertilizer, or the ash from combustion plants for solid biomass with which to fertilize agricultural fields or to be disposed in landfills).

- OUTBOUND TRANSPORT

Consequently by-products and / or the generated waste must be transported to their places of reuse or disposal defined.

- REUSE and / or DISPOSAL

In the final, as anticipated, by-products are reused (eg. digestate in agricultural fields), while the waste are disposed (eg. Ineligible ashes).

2.2.2. Structural analysis between different biomass plants

2.2.2.1. Hypothesis of scheme for a structural analysis between different biomass plants

*Tabella 4- Hypothesis of scheme for a structural analysis between different biomass plants - (*Invented data).*

		Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant N-nth
TYPOLOGY		solid biomass (direct combustion)	solid biomass (pyrolysis)	bioliquid (biodiesel sale)	bioliquid (bioethanol sale)	biogas	biogas	/
Phase of	Plant construction	/	/	/	/	/	/	/
FUEL	1° Fuel	woodchips	wood sawdust + + woodchips	oilseed rape	agri-food industry residues	shredded maize	agro-zootechnic mixture: eg. Shredded maize + + manure and cattle slurry	/
FUEL	2° Fuel	woodchips	syngas from pyrolysis	biodiesel from transesterification	bioethanol from alcoholic fermentation	biogas from anaerobic digestion	CH4 from Biogas puriefed from anaerobic digestion	/
Phase of	PROCUREMENT	from woodland maintenance (Cutting + handling with cable car + + handling tractor + chipping + etc ..)	woodworking byproducts + + from woodland maintenance	agricultural dedicated crops oilseed rape (sowing, plowing, irrigation, harvesting, etc ..)	wineries residues (grape marces, grape mustes, etc ..)	agricultural dedicated maize crops	cattle manurse + shredded maize + etc ..	/
Phase of	INBOUND TRANSPORT	trucks	conveyor belt from adjacent sawmill + + trucks from woodland warehouse	trucks	pipe	trucks	conduits + cochlea + trucks	/
Phase of	PREPARATION	none	pyrolysys	squeezing + trans.esterification	alcholic fermentation	anaerobic digestion	anaerobic digestion	/
Phase of	ENERGY TRANSFORMATION (energy production)	electric energy + heat (cogeneration)	electric energy	electric energy + heat (cogeneration)	bioethanol sale	electric energy + heat (cogeneration)	biomethane sale	/
TYPOLOGY	TYPOLOGY	solid biomass (direct combustion)	solid biomass (pyrolysis)	bioliquid (biodiesel sale)	bioliquid (bioethanol sale)	biogas	biogas	/
TECHNOLOGY	Energy Transformation	Stirling external	internal combustion	steam boiler	/	Stirling external	/	/

	System / Engine	combustion engine	engine			combustion engine		
ELECTRIC POWER	MW el.	0,45	0,5	/	/	/	0,99	/
HEAT POWER	MW th.	0,4	0,4	/	/	/	0,85	/
SOLD VOLUMES	cube meters (gaseous or liquid)	/	/	7500 mc of biodiesel	3000 mc of bioethanol	/	15000 mc of Biomethane	/
AIR EMISSIONS	AIR EMISSIONS	CO2, CO, NOx, FineDust	CO2, CO, NOx.	CO2, CO, NOx, FineDust, etc..	/	CO2, CO, Nox	/	/
RESIDUES	BYPRODUCTS	clean ashes	/	/	alcholic digestate	organic digestate	organic digestate	/
WASTE	WASTE	/	polluted ashes + polluted oils	/	/	/	/	/
WASTEWATER	WASTEWATER	/	/	/	/	/	/	/
Phase of	OUTBOUND TRANSPORT	trucks	trucks	tank trucks	tank trucks	tank trucks	tank trucks	/
Phase of	BYPRODUCTS DESTINATION	agriculture and forestry spreading	/	/	composting plant	agriculture spreading	agriculture spreading	/
Phase of	WASTE DESTINATION	ashes disposed in landfill	ashes disposed in landfill	/	/	/	/	/
Phase of	Plant dismission	/	/	/	/	/	/	/
NOTE	NOTE	notes by the compiler	/	notes by the compiler	/	notes by the compiler	/	/

2.2.3. Types of inbound biomass

2.2.3.1. Types of inbound biomass

The types of biomass used in power plants can be divided into the following groups [6]:

VEGETAL: Ligno-cellulosic: fuel of vegetable origin classified in the following categories:
- Wood from trees specially cultivated;
- Wood from forest maintenance;
- Wood from maintenance of road and similar trees (branches and tops, peels, stumps, etc ..);
- Wood charcoal ;
- Split logs (only for fireplaces and home stoves, ovens for restaurants, etc ..)
- Wood in the form of wood chips;
- Wood in the form of pellets;
- Wood residues from craft / industrial processes of wood (sawdust, shavings, scarf joints, etc .. from sawmills and furniture factories, packaging, etc ..) not contaminated by pollutants;
- Ligno-cellulosic residues of agro-industrial tree crops (residues of pruning of fruit trees, wine grapes, olives, citrus, peach, apricot, plum, apple, etc ..);
- Lignocellulosic agro-industrial residues of herbaceous crops (eg. straws, soft and durum wheat, barley, oats, rice, grain maize, soybean, sunflower, etc ..);
- Residues from some sort of food-grade fruits, such as nutshells, fruit pits, citrus peels, etc ..;
- Residual oil industries such as vegetation water-residue and sanse;
- Agro-industrial residues (sanse, stalks, rice husks, pomace, grape must, pulp, etc ..);

VEGETAL: Starchy: fuel of vegetable origin derived from the following ceral and food crops specially cultivated, such as:
- Wheat;
- Corn;
- Triticale;
- Grain sorghum;
- Potato;
- Rice;

VEGETAL: Sugar: fuel of vegetable origin classified in categories:
- Sugar beet: processing waste / by-products (molasses, pulp, etc ..);
- Sugar cane: processing residues / byproducts (bagasse, etc ..);

VEGETABLE: oleaginous: fuel of vegetable origin classified in the categories
- Soy;
- Rapeseed;
- Sunflower;

ANIMAL: Livestock: animal combustible residue of livestock activities, such as:

[6] Some primary fuels can also appear in multiple categories, such as the fruit stones, shells, etc .. which fall both in lignocellulosic than in the agricultural-livestock-industrial.

- Livestock waste (slurry, manure, manure, etc ..);
- Milk whey;
- Various animal by-products (ABP);

MIXED: Agro-livestock: arising from agro-livestock products not subjected to industrial processes;

MIXED: Agro-livestock-industry: of different types, resulting from complex food chains and / or integrated, such as:

- Residues from the industrial food chain (fruit stones, shells, etc ..);

MIXED: Urban-organic: from separate specific collection of the fraction of the urban organic waste (FORSU) [7]:

- urban organic waste (obtained from the specific differentiated collection

MIXED: Mixture "personalized": available from organic sources, specially selected and blended.

[7] In reality, often the organic fraction od urban waste are delivered to composting systems for the production of compost (a mixture of humified substances) used as a soil amendment, for agronomic uses or for floriculture; also sometimes ROUF may be mixed with twigs and pruning residues of vegetable and horticulture;

2.3. SOLID COMBUSTION BIOMASS POWER PLANTS

2.3.1. Solid biomass power plants

Power plants fueled by solid or liquid biomass perform the conversion of thermal energy contained in the biomass fuel into mechanical energy and then into electricity. The central sizes can range from medium-sized thermal power plants fueled by solid biomass, usually of wood chips, up to small generators powered by liquid biofuels. Beyond a preliminary stage of treatment of the biomass, thermal power plants fueled by biomass can also be quite similar to those fed with traditional fuels, and as for these it is possible to obtain different thermal cycles. The most diffused types of plant are the following:

- Traditional plants with furnace of combustion of solid biomass , boiler that feeds a steam turbine coupled to a generator;
- Plants with gas turbine driven by the syngas obtained from the gasification of biomass;
- Combined cycle plants with steam turbine and gas turbine;
- Hybrid thermal power plants that use biomass and conventional sources (the most frequent case is the co-combustion of biomass and conventional sources in the same furnace);
- Plants, powered by liquid biomass (vegetable oils, biodiesel), made up of engines coupled to generators (generator sets).

Figura 10- Example of wood combustion biomass power plant. [Greenplanner, 2015, a]

The following table shows the lower calorific value of traditional fuels and renewable fuels. The calorific value is the energy that a fuel realases during the combustion process. We talk about HSV the higher calorific value (PCS in italian), when we consider all the energy produced by the fuel; we talk about LCV the lower calorific value (PCI in italian) if it is not considered that fraction of energy produced by the combustion, consumed for the evaporation of water in the fuel.

Tabella 5- Lower calorific values of most common fuels. [GSE, 2008 a].

COMBUSTIBILI TRADIZIONALI[1]	PCI (kcal/kg)	COMBUSTIBILI RINNOVABILI[2]	PCI SS[3] (kcal/kg)
Lignite	2.500	Paglia da grano, segale e orzo	4.207
Carbon Fossile	7.400	Vinacce	4.266
Carbone di Legna	7.500	Sansa	4.296
Gas Naturale	8.250 kcal/mc	Cedui a rotazione breve	4.398
Olio Combustibile	9.800	Gusci di noci, mandole e pinoli	4.410
Gasolio	10.200	Legno	4.541
Distillati Leggeri	10.400	Corteccia	4.565
GPL	11.000	Residui di potatura	4.577

[1]Fonte BEN
[2]Fonte UNI CEN/TS
[3]PCI SS potere calorifico inferiore della sostanza secca

Under EU legislation (Dir. 2009/28 / EC) on the promotion of energy from renewable sources, with the term "biomass" shall mean "the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and crop water, as well as the biodegradable fraction of industrial and municipal waste ". From any solid organic (biomass) is possible to obtain heat and consequently mechanical energy with these systems:

- direct combustion;
- gasification;
- pyrolysis;

This definition covers a very wide range of materials, virgin or residual of agricultural and industrial processes, which may occur in different physical states, with a wide range of calorific values. Depending on the type of biomass and therefore the most appropriate technology for its energy valorisation, as well as depending on the size of interest and on the end-uses of the energy produced, thermal and / or electrical, is possible to adopt a plurality of plant engineering solutions.

- The **direct combustion** of biomass, in special furnaces, implies its total oxidation at high temperature. It can be carried out according to different technologies: in suspension, on fixed or moving grate furnaces, on fluid bed. Direct combustion of biomass takes place in specially constructed furnaces to burn organic material (fuel), together with environment air (combustion air). The two elements, brought to a certain temperature (ignition temperature), burning, leading to oxidation and direct mineralization of the biomass without any intermediate steps. Actually this is considered an obsolete technology, more polluting than others.
- **Gasification, pyrolysis and carbonization** are processes that instead involve a partial oxidation of the biomass, so as to obtain solid byproducts, liquid and gaseous, more pure compared to the original source, which can then be completely combusted in a subsequent step. Particularly interesting appears gasification because the syngas (synthesis gas) obtained has the advantage of being versatile, ensuring high combustion efficiency and low emissions.
    - The **pyrolysis** occurs in the absence of oxygen and produces liquid oils, solid coals and Syngas; this last has a better PCI compared to that produced in gasification,

because in the pyrolysis is not consumed oxygen and then in its Syngas are not present all the gases produced in the gasification.
- The **gasification** takes place in special reactors with oxygen deficiency: it forms a syngas that is used in engines for power generation. Gasification also enters into direct combustion after the pyrolysis.

In this regard we think to the feeding of a **classic direct combustion** furnace:
Biomass, just enter the room, given the enormous temperature, begins a thermochemical reaction that is not combustion (totally lacking oxygen) but pyrolysis. In fact the flame which then wraps the biomass in this area is blue.
Subsequently, the biomass starts to find oxygen in small parts and the pyrolysis process evolves in the gasification process. The flame changes color from blue to orange.
When finally the biomass enters into area rich in oxygen, gasification becomes direct combustion and the flame becomes pale red-orange.

❖ Pyrolysis

Pyrolysis is a thermochemical process of decomposition of organic materials, obtained by the application of heat, typically between 400°C and 800°C, and in the complete absence of an oxidizing agent (normally oxygen). From the pyrolysis we obtain gaseous products, liquids and solids, in proportion to the used method that can be fast, slow and conventional pyrolysis, also in function of other reaction parameters.

Tabella 6- Summary scheme for pyrolysis technologies.

Tipology	Features	Liquid	Char	Gas
Slow pyrolysis	Low temperatures, very long endurance times	35%	35%	35%
intermediate pyrolysis	Average temperatures, moderate endurance times	50%	25%	25%
Fast pyrolysis, and Flash	Average temperatures, shorter endurance times	75%	12%	13%

Fast Pyrolysis at short endurance times, is performed at temperatures comprised between 500 and 650 ° C: the reactions take place quickly and with short contact times of less than 2 seconds in order to reduce the formation of intermediate compounds to promote the production of liquid substance as much as 70-80% by weight of the biomass used.
The "flash pyrolysis" is a fast pyrolysis at very low residence times: it takes place at temperatures exceeding 700 ° C and with contact times of less than 1 second. This allows to produce a liquid fraction at around 80% of the incoming biomass. The main product obtained from the fast and flash pyrolysis process is the bio-oil (about 80%) and in minor amounts is obtained char and gas.
The use of bio-oil is a replacement of the fuel oil in many applications, such as boilers, furnaces, engines and turbines for electricity generation. From it also can be extracted chemical substances.
At the conclusion of the above, through the pyrolysis, the biomass input is transformed into other products (in different percentages depending on the process used). They are:

- GAS: "Gaseous" fraction containing CO, CO2, light hydrocarbons (CH4, C2H2, C3H6) and H2.
- TAR Topping Atmospheric Residue: liquid-oil fraction containing water vapor and compounds in vapor form (aldehydes, acids, ketones, alcohols, heavy hydrocarbons) condensable at temperatures below 200-100 ° C.
- CHAR: Solid carbonaceous fraction consisting of mainly carbon.
- ASH: Ashes.

❖ Gasification

It consists in the partial oxidation of a solid or liquid substance which occurs at high temperatures with the final purpose of producing a gaseous fuel.
"The UNI 9254 standard defines gasification the thermochemical conversion process of a solid fuel in the fuel gas."
Unlike pyrolyzzators, which implement the pyrolysis in the strict sense, or in the total absence of oxygen, gasifiers operate instead in the presence of small amounts of oxygen, also producing a partial oxidation. In relation to the type of process used, gasifiers may be considered as an intermediate technology between incineration and pyrolysis itself.

The fuel that is obtained is a mixture of gases (CO, H2, CO2) named "syngas", composed of carbon monoxide and hydrogen. Also you get a solid part called "char" residual (usually coal) and a compound of aromatic hydrocarbons of tarry type, carbon dioxide and nanoparticulate, totally unnecessary for the combustion and harmful for the plants.

Tabella 7- Summary scheme for gasification technology.

Tipology	Features	Liquid	Char	Gas
Gasification	High temperatures, long endurance times	5%	10%	85%

The gasification process depends on the temperature, which characterizes it in the following three phases:

- 100 ° C - Drying of the biomass through the vaporization of humidity in order to achieve the humidity level required by the gasifier;
- between 200 and 700 ° C - Pyrolysis, through which occurs the thermal decomposition of solid biomass into gas, tar and char;
- between 700 and 1000 ° C - Reforming, substantially the gasification phase in which, through the oxidation-reduction, it takes place the transformation of the gas, char and tar, in the synthesis gas "syngas."

The syngas produced is used as alternative source of energy in plants for the production of electric energy, thermal or cogeneration: it is a source of clean and renewable energy because, during the combustion, it oxidizes itself, producing water vapor and carbon dioxide (CO2).
The gasifiers require an extremely precise characterization of the biomass in terms of quality, size and relative humidity, with considerable increases of costs for fuel preparation compared to other uses of the raw material.
The syngas can be used for the production of heat in normal boiler or to directly feed alternative engines or gas turbines. It can also be synthesized for the production of biofuels, turning it into methyl alcohol or methanol. The biomass gasification technologies are considered promising because both they can immediately be combined to the current power generation technologies, particularly in combined-cycle gas plants, either because they can be combined with any future power plants with fuel- cell, in particular MCFC and SOFC, in which gas composed of hydrogen and carbon are optimal.
The gasification can contribute to the disposal of urban solid waste and / or the use of fuel from waste, as from the gasification of solid urban waste is obtained syngas that could feed the gas turbine in combined cycle plants. This with the following main objectives:

- remove the remaining barriers on the application of USW (Urban Solid Waste) gasification technologies;
- favor the diffusion of the combined cycle gas which remain one of the most environmentally more valuable technologies for the production of electricity;
- expand the use of renewable sources (the rate of renewability of USW is currently indicated in 66%);
- avoid recourse to the conferment in of solid urban waste landfill.

❖ **Combustion**

It is the traditional process of energy production. It consists in the complete oxidation of a substance that burns in the presence of oxygen contained in the air, which acts as comburent. It is an exothermic reaction (heat transfer from the system to the environment) during which the chemical energy contained in the fuel is released in the form of heat.

Combustion applies to all types of fuel: liquid, solid, gaseous.

The combustion of waste wood can be implemented with good returns when using fuels rich substances such as cellulose and lignin and with water content lower than 35%. For example, the energy produced by the combustion of 1 kg of dry wood is about 12.5 MJ.

If, however, we start from a product with 10% dry matter, we can estimate that to evaporate 9 kg of water we need about 22 MJ. From this it follows that the combustion process is usable only if we start from products having the lowest possible degree of humidity. The reduction the content of water in general, is obtained by drying the products to the sun, so as to make the process economically viable.

In Italy there are about 40 large plants for the production of energy from the combustion of woody biomass, for a total electric power of about 330 MW.

These systems are of cogenerative type, in the sense that the final energy is given by heat and electrical energy. Part of heat is in fact used to produce steam that is used to feed the turbines connected with electrical generators. The part of the remaining heat can be used for industrial or residential users.

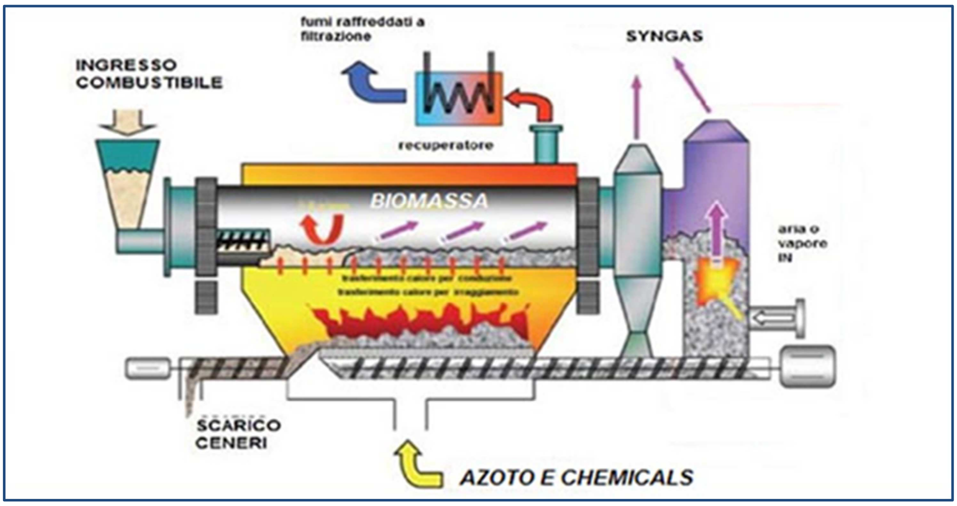


Figura 11- Operation scheme of a pyrogasifier. [Tecnologiemarconi.it, 2015, a]

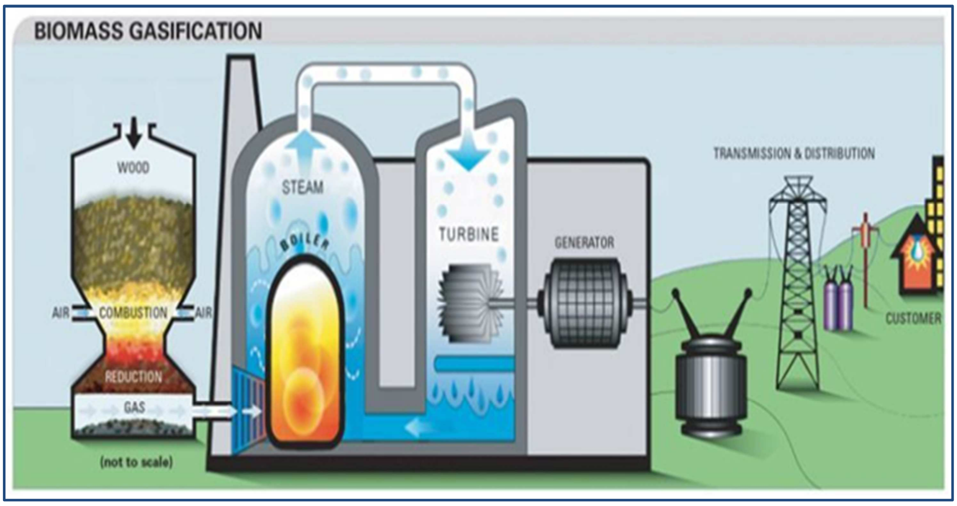


Figura 12- Gasification plant scheme. [fotovoltaicosulweb.it, 2015, a]

2.3.2. Ashes produced from solid wood gasification combustion plants

In addition to their energy products (Electricity, thermal energy, biofuels and biomethane) the biomass power plants also produce air emissions, waste and / or by-products.

The Ashes deriving from biomass combustion plants can be classified as non-hazardous waste (cod. CER 10:01:01 -Ashes and charcoal- "Bottom ash, slag and boiler dust", or cod. CER 10:01:03 - Ashes and Dust- "fly ash from untreated wood") or as a by-product available for the production of fertilizers and for agricultural spreading.
Their composition is substantially constituted by inert and unburned substances, such as silica, aluminum oxides, potassium, calcium, magnesium, sodium, other trace metals and carbonaceous agglomerates.

Actually for ashes resulting from a biomass plant the waste legislation offers the following possibilities:

1) landfill disposal,
2) recovery in cement plants and in the brick industry,
3) production of fertilizers,
4) authorization to the spreading for agricultural purposes.

The first two points concern the ashes that are considered waste. Points 3 and 4 instead define the ashes as by-products. Usually the ashes resulting from direct combustion of biomass are considered as waste. The indirect fired systems through pyro / gasification instead can produce ash classifiable as a byproduct, which can be used as fertilizer for the land.

❖ **BIOCHAR: ashes produced by gasification of biomass**

The ashes with specific chemical characteristics can be classified as "biochar": these features have been normed with DM 22 June 2015 the Ministry of Agriculture and Food and Forestry "Updating Annexes 2, 6 and 7 to Legislative Decree no. 75 of the April 29, 2010 "Reorganisation and revision of the legislation on fertilizers, in accordance with Article 13 of the law 7 July 2009, n. 88" (Official Journal General Series No. 186 of 12.08.2015) "the Biochar was added the list of soil (fertilizers that improve the soil characteristics).
The characteristics that are indicated in the Ministerial Decree relatively to the modes of preparation are the following: *"Process of carbonization of products and residues of plant origin from agriculture and forestry, as well as from olive residues, marc, bran, kernels and shells of fruit, untreated waste from the production of wood, as byproducts of the related activities. - The carbonization process is the loss of hydrogen, oxygen and nitrogen from organic matter as a result of application of heat in the absence or reduced presence of oxidizing agent, typically oxygen. To this thermochemical decomposition is given the name of pyrolysis or pyroscission. the gasification involves an additional redox process charged to the coal produced by pyrolysis."* The new legislation[8] authorizes marketing of the ash regulating the production and use by farmers.
The Biochar is a porous charcoal produced by the combustion of plant material in the absence of oxygen (pyrolysis, gasification). The definition biochar was chosen dall'IBI (International Biochar Initiative) specifying that it is the material that find application in agriculture and in the environmental protection [IBI, 2015 a].

[8] The approval of the Ministerial Decree has come in the year of Expo 2015 in which, at the "Italian Pavilion", a series of events were organized on the Biochar characteristics to make known the potential of this technology.

Essentially a vegetal coal consists mainly of carbon atoms that were contained in atmospheric CO2 and were fixed by plants through photosynthesis.

Thanks to its resistance to degradation the Biochar allows to fix permanently a part of atmospheric CO2 and, if incorporated into the soil, improves the its characteristics increasing agricultural production yields.
When a vegetal biomass is incorporated in the soil, as in the case of the compost or other amendments, this goes to a meeting soon mineralization process, resulting in the release of CO2 into the atmosphere. The structure of Biochar instead ensures that the product is not degraded by soil microorganisms, with the result of store carbon in the soil rather than return it to the atmosphere. This makes it a crucial element in the fight against climate change, because its use at offsetting emissions can generate carbon credits and revenues or savings for those who will use it.
The Biochar contains between 80 and 90% of carbon: each ton of Biochar is generated by a quantity of carbon dioxide (CO2) Atmospheric equal to about three times its weight. If we put in the ground a tonne of Biochar we subtract three tons of CO2 from the atmosphere. The Option Biochar, if practiced on a large scale, would reduce 9% of European CO2 emissions (Glaser et other, Nature, 2009). If only 3.2% of Italian agricultural waste was turned into Biochar, Italy would achieve the target set by the Kyoto Protocol.

The Biochar can be be a solution for developing countries because its benefits are numerous:

- of health order, because by using gasification instead of combustion for cooking the foods you eliminate the toxic fumes considered today the fourth leading cause of human death globally;
- of environmental order because it can help recover degraded land and deprived of fertility and encourage a reduction in deforestation through improved energy efficiency;
- of social order because it reduces the time spent collecting fuel and saves the purchase of fuel, because the gasification does not necessarily require wood, which is expensive, but can be obtained from any type of vegetal residue.

The Biochar can be a sustainable and environmentally friendly solution for the following resons:

- manage the residues of agricultural crops, often considered more a problem than a resource;
- improve the properties and soil fertility, decrease the leaching of nutrients and increase the yields of many agricultural crops;
- increasing soil fertility and reduce the use of synthetic fertilizers with lower costs for farmers, less impact on the environment, lower consumption of resources and energy;
- immobilize carbon in the soil for long periods, "eliminating" from the atmosphere.

2.4. BIOGAS POWER PLANTS

2.4.1. Biogas power plants

Anaerobic digestion is a biological process through which, in the absence of oxygen, the organic substance is transformed into biogas that mainly consists of methane and carbon dioxide. The process of an anaerobic digestion system can be described as follows:

Figura 13- Example of a biogas power plant- [Biofermenergy.com, 2015, a]

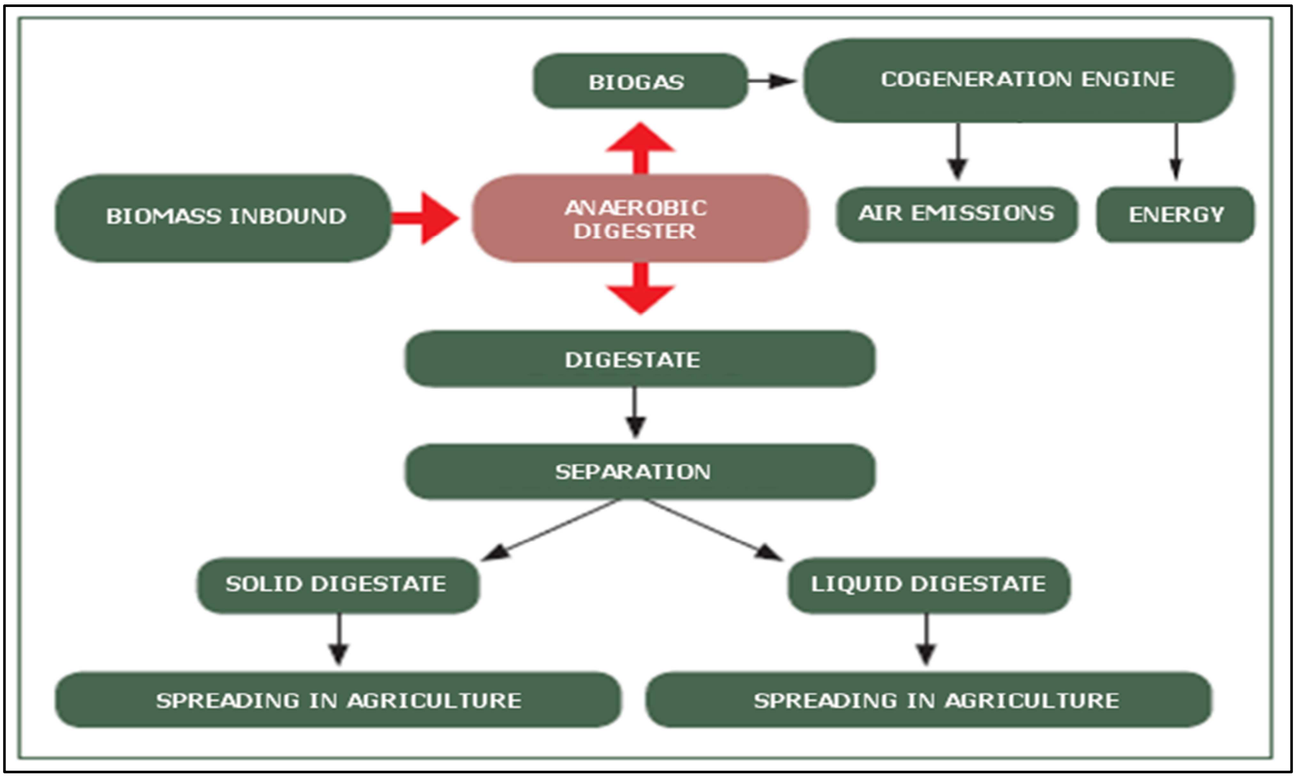


Figura 14- Block diagram of the functioning of a biogas power plant- [ARPA EMR, 2014, a]

The biomasses entering the plant (silage, waste from agro-food industries, livestock manure etc.), undergo a process of degradation in an oxygen-free environment in a fully closed anaerobic

biodigester. Specific microorganisms degrade complex molecules such as sugars, starches, proteins etc.. first into simpler molecules (glucose, amino acids etc.) and then break them down further, to obtain a gaseous mixture composed mainly of methane (CH_4) and carbon dioxide (CO_2): the biogas.
The biogas, after purification, is sent to to the generator for the production of electricity and heat (cogeneration); while the electrical energy is almost entirely fed into the grid, the heat produced by cogeneration in part is used in the production cycle (heating the digesters) and in part may be recovered and used for heating of buildings, stables, working environments or for production requirements (eg. drying of fodder).
In addition to biogas, digestate is produced, which is spreaded in agriculture like fertiliser.

[ARPA EMR, 2014, a]

2.4.2. Biogas

Biogas is a mixture of methane (CH_4) and carbon dioxide (CO_2) in variable percentages depending on the matter from which they derive. In this mixture there are small amounts of other gases, such as hydrogen sulfide (H_2S), ammonia (NH_3), carbon monoxide (CO) and others gases in traces. The "useful part" is obviously methane, other gases are useless or harmful both for the machines than for human health, and must be eliminated.
Biogas is produced by the decomposition of organic matter by bacteria that live in the absence of oxygen (anaerobic bacteria). These bacteria are very common in nature, for example, live in the intestines of many animals (ruminants, cattle and sheep), in septic tanks and are also formed in the organic household waste when we leave them for more than a few hours in a closed environment (the bucket or bag for example).
One of the problems in nature is just that, however, anaerobic digestion produces large amounts of methane, which is a gas with greenhouse gas with an effect 21 times more potent than carbon dioxide. From this thereby whwne we produce and collect biogas from organic waste we get two results: we broke down the greenhouse effect and produce energy.
Returning to the biogas through anaerobic digestion, we merely represent the essence of the natural process that takes place. In a first phase the large organic molecules, formed by Carbon, Hydrogen and Oxygen + other (N, S, etc.) are broken (ie made simpler). This phase (hydrolysis) is accompanied by a phase of acidification (acidogenesis) with the formation of volatile fatty acids, ketones and alcohols. Afterwards in the second phase (acetogenesis) are formed groups of molecules of acetic acid, formic acid, carbon dioxide, hydrogen. Finally the third and final phase (methanogenesis) leads to the formation of methane. Obviously the involved bacteria take the name of the phases, for which intervene before the bacteria hydrolytic and fermentative bacteria, then the acetogenic bacteria, and finally bacteria acetoclastic and idrogenofilic. This is only an illustrative step ladder of a standard process, in reality intervene other reactions, some of which also lead to harmful and hazardous compounds. In summary, the methane is formed

from the reduction of carbon of CO_2:

$$\mathbf{(CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O)}$$

or from acetate

$$\mathbf{(CH_3C00H \rightarrow CH_4 + CO_2).}$$

[AICCRE, 2008 a]

And the reactions that happen in an anaerobic digestor of a biogas power plant are the same that happen inside the digestive system of a cow, how we can see in the next figure.

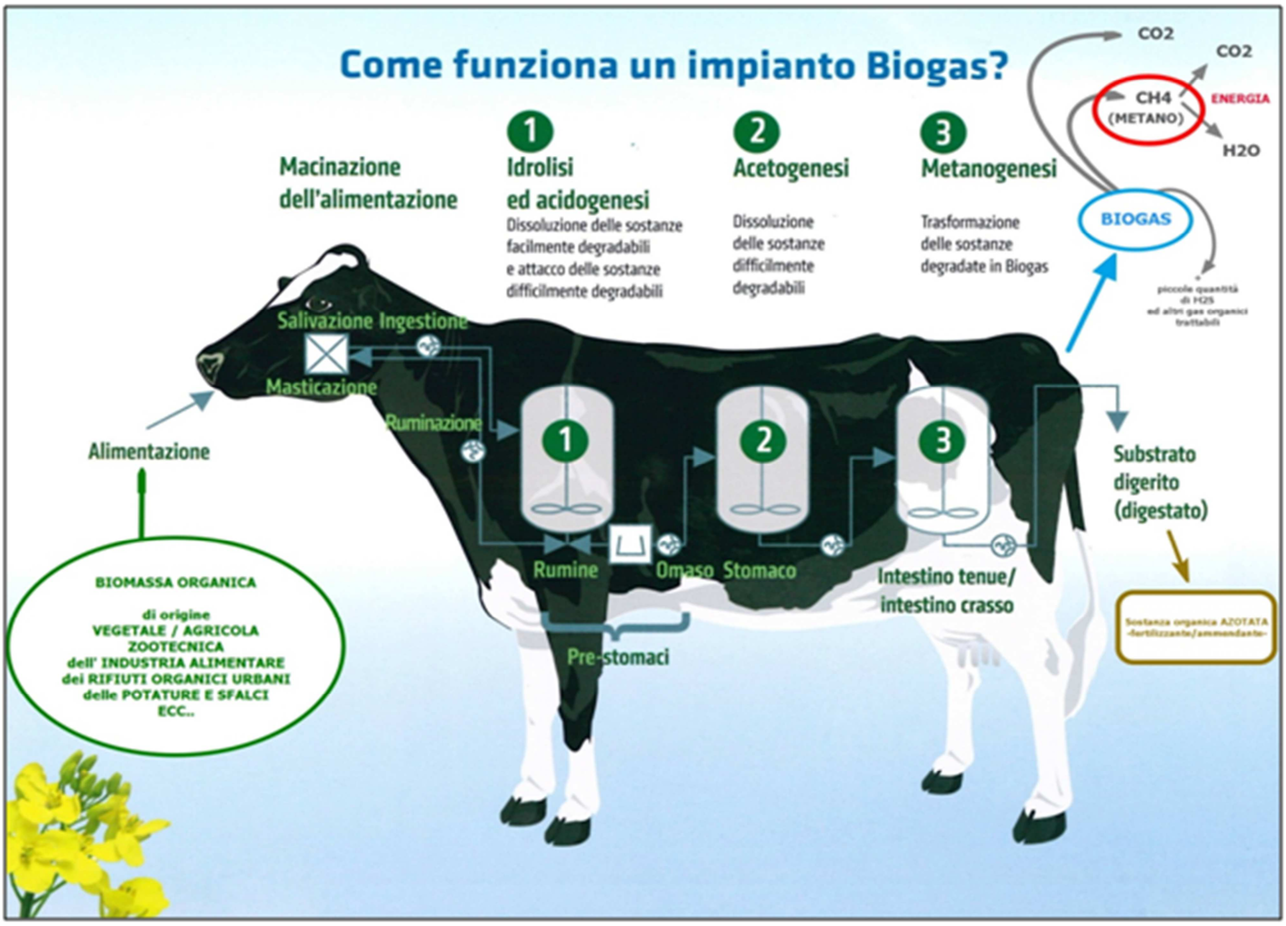


Figura 15- Scheme of the digestive system of cattle and correlated methane production[Solvay Bicarz, 2015, a. -modified]

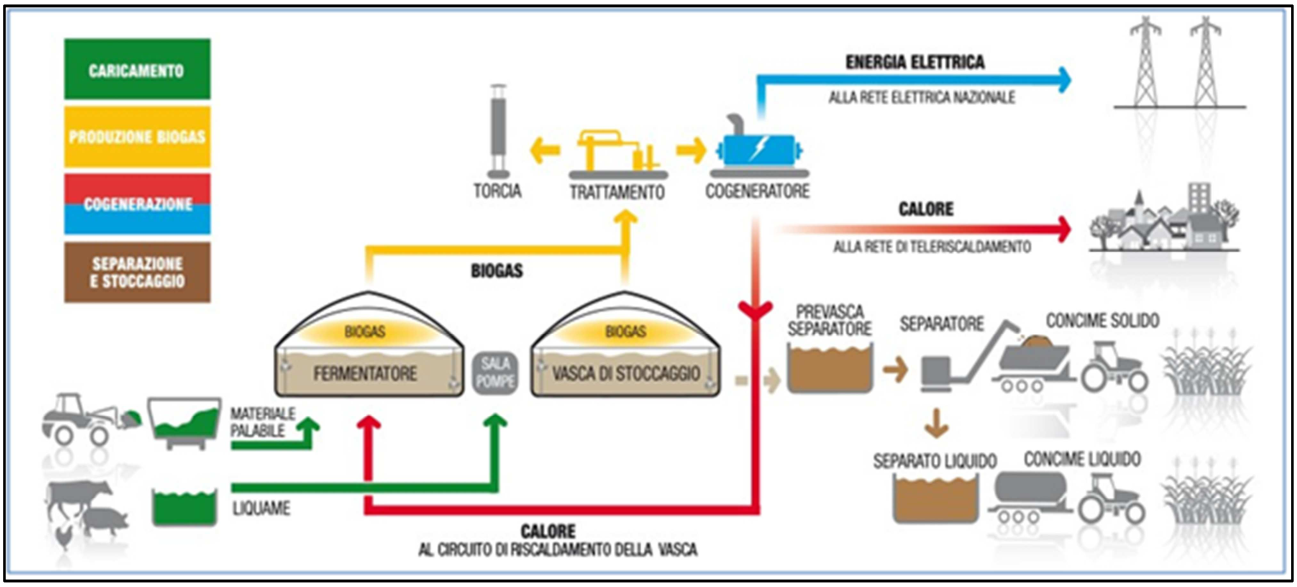


Figura 16- Scheme of a productive chain a biogas power plant fueled with agro-zootechnical biomasses [Ies Biogas, 2015, a]

2.4.3. LEGISLATIVE elements for the phases of biogas plants

We can summarize the main internal phases of a biogas plant in the following list:

- Biomass inbound (external phase)
- Silage storage
- Storage of agricultural and food-byproducts
- Biomass movimentation
- Biomass digester units (closed unit)
- Cogeneration unit
- Management of electric energy and heat
- Treatment of air emissions
- Treatment and storage of digestate
- Digestate storage as such and/or of the solid fractions and clarified
- Spreading and agronomic use of the digestate
- Wastewater collection and treatment systems
- Management of waste
- Aspects relating to the protection of the health and safety of workers

Every one of these points must be deepened in the law context of the project for the authorisation and for the subsequent monitoring for environmental and health and safety. These law aspects are under responsability of ARPA (Regional Agency for Environmental Protection) and AUSL (Local Health Agency).

[ARPA EMR, 2014, a]

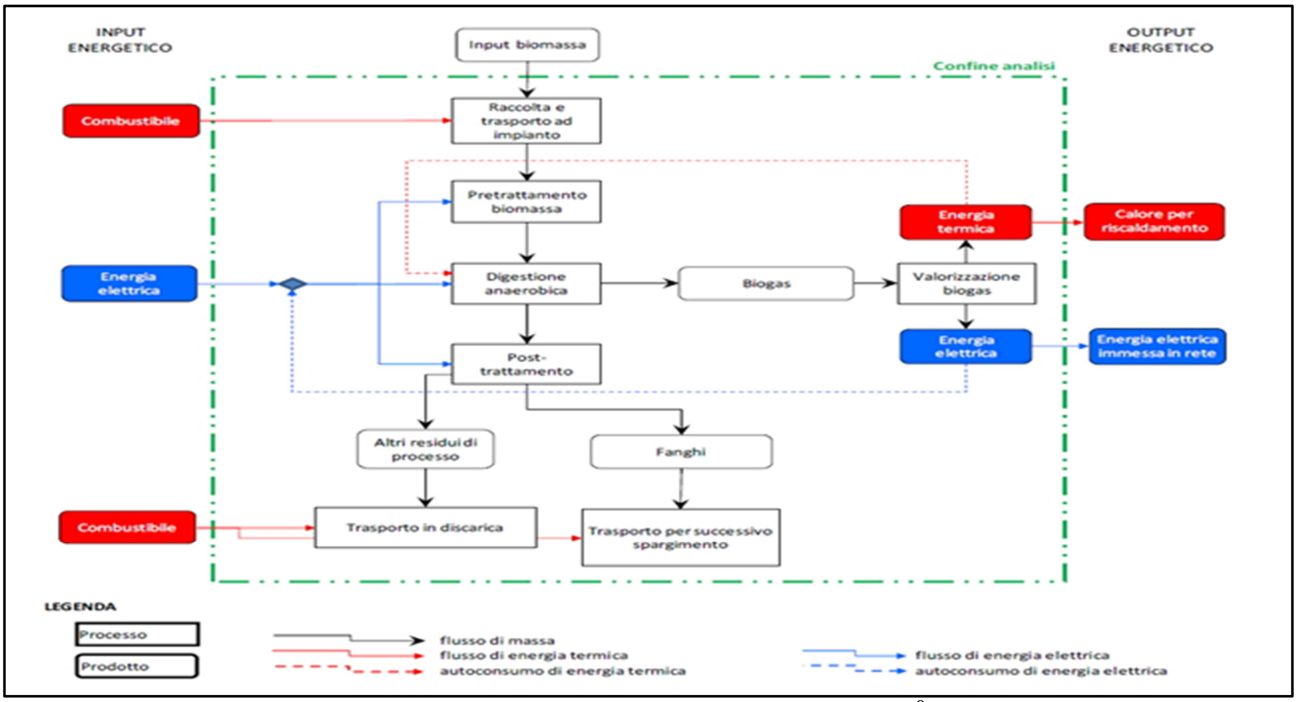


Figura 17- Block diagram of the functioning of a biogas power plant- [TIS, 2011, a] [9]

[9] Notes the legislative framework relating to the main stages of a biogas plant.

❖ Silage storage

The term of silage means those agricultural crops called "energy crops" such as maize, sorghum, triticale and rye grass, stored by silage technique.
The silage is a preservation technique of fodder which is achieved by acidification of surface vegetation thanks to the work of anaerobic microorganisms and its purpose to prevent the proliferation of spoilage microorganisms and potentially toxic, that would lead to the loss of the nutritional value of plant mass , and the development of unhealthy substances.
The ensilage consists in the vegetable mass storage in outdoor silos, consisting of concrete platforms equipped with containment walls called "trenches". In silos the chopped forage is compacted and finally sealed by a plastic sheet that acts as a cover. The silos, isolating the mass from the outside environment, preventing the intake of atmospheric oxygen, while that which is naturally present within the mass, is consumed in the earlier period of the silage maturation, by the aerobic bacteria, present in the vegetable mass.
In the first few days, in fact, it has an acetic fermentation aerobic which lowers the pH to 4.5-5. The acidification of the environment of the silo leads to the development of lactic acid bacteria, that will operate the lactic fermentation, bringing the pH to values even lower than 4, thus ensuring the correct preservation of the stored material.
For storage you should refer to the technical / design criteria dictated by the Regional Council Regulation pursuant to Article 1 of 28/10/2011. 8 of the Regional Law n. 4 of 06/03/2007 and criteria of Good Agricultural Practices dictated by D.M. 19.04.1999 - Ministry of Agriculture and consolidated for this type of process.

❖ Storage of agricultural and food-byproducts

For the storage of agri-food by-products, they must be provided for individual installation devices and more or less pushed management, in relation to the peculiarities of the biomass and its odorigenous potential.
As provided by DGR 1495/2011, it must be stored in closed or covered containers to prevent leakage both of Volatile Organic Compounds (VOCs) and particulate matter.
If the dry matter content of the incoming biomass is less than 60%, or in the case of biomass not shoveled manure as source of extra business, sugary sauces, agro-industrial byproducts, conservation, waiting for loading, must be done in tanks / sealingly closed containers (silos, tanks, etc.), except for a minimum opening vents that must be appropriately treated. Typically, treatment principals of the vents of the silos, are represented by dry filters such as: activated carbon filters, multilayer and multireagents filters, etc ..
From this context, they are excluded animal slurries of business origin, sent directly to the phase of anaerobic digestion. If the storage takes place in a closed dedicated areas and / or blankets, the floor must be waterproofed and shaped so as to facilitate the rapid draining of any leachates, which should be sent directly to the digester or, alternatively, stored in sealed containers. Storage of animal origin by-products (ABP) must take place in accordance with the recommendations by DGR 1495/2011 and the veterinary sector Regulation (CE1069 / 2009 Regulations).
Finally, please note that when maize is used in energy use, with a level of aflatoxins exceeding the legal limits unfit for human consumption, the workers involved in the handling and milling of maize grain, will be equipped with proper devices of personal protection and that the storage site, the corn grain, will officially communicated to the Province.
As regards transport, in order to avoid the dispersion into the environment and on the road of sediment, grain and corn powders, the load must be suitably protected. The means of transport used may contain corn for the food chain without prior decontamination.

❖ **Biomass handling**

With regard to material handling inside the perimeter of the plant and the management of stocks, the Council Resolution 1495/11 RER (DGR) provides that:

- during the phases of transport, of incoming and outgoing from the plant the shovelable materials, the vehicles used (trucks, mechanical shovels, forklift trucks, etc.), the construction must not give rise to soiling of the squares for solid material losses or leachate;
- transport and load silage, for supply to the system, takes place through a special bucket / shearing silage;
- in the case of discharge to tankers, the liquid has be placed in the container, below the free surface or by using a closed circuit;
- the storage of incoming materials to the system, with the dry matter content <60%, excluding silage, should be of short duration, not more than 72 hours, in order to prevent phenomena of anaerobiosis, which are the primary source of emissions malodorous.

❖ **Cogeneration unit**

The outbound biogas produced in the digester is sent to the cogeneration unit for its conversion into electricity and heat. Biogas must conform to the provisions of Annex X with Part V of Legislative Decree no. 152/06 and subsequent amendments, as indicated in point 2 of point 4.36 of DGR 1496/11.

From the cogenerator originates an emission whose main pollutants, defined by law, are: Volatile organic compounds (VOC), nitrogen oxides, sulfur oxides, carbon monoxide, dusts, and and chlorine compounds, expressed as hydrochloric acid. The maximum allowable concentrations for each pollutant are specified under point 4.36 of DGR 1496/11.

To guarantee the respect of the limits the cogenerator is interlocked with abatement systems for nitrogen oxides and carbon monoxide [10]. A criticality bind to these emissions, is the high temperature (about 500 - 600 °C) from where the combustion gases exit, factor this latter, which also affects the sampling and control activities[11].

The DGR 1496/11, imposes the kept of a special register where jotting down the date, the time, the results of measurements and the operating characteristics of the cogenerator during the sampling phase.

The register must be completed in its entirety and the same information must be given on analytical certificates concerning the checks carried out on emissions. Annual emissions data must be transmitted to the Province and to the Control Authority.

The manager, however, will have to take all the technical and / or management measures, specified in the DGR 1495/11 concerning:

- the formation of diffuse emissions and in particular of those odorigenous;
- the monitoring of the unit.

Another critical issue that is associated to the cogeneration group, derives from the noise, generated from the thermal power plant and from the chimneys of the exhaust gases.

For this reason in the construction of these plants the DGR 1495/11 provides structural precautions such as:

- cogeneration modules placed within a engine room, made of masonry or container, constructed so as to contain adequately the noise impact;
- silencer on the chimney of exhaust gases.

[10] In any case the abatement equipments must be able to bring back within the limits also the other parameters where there may be exceedances.

[11] Often in the authorization phase or prescription it is useful to adopt a control device of the combustion parameters, oxygen content and temperature.

In the design of a biogas plant it is necessary to consider the obligation, to equip the plant of the same safety devices for the combustion of biogaswhen the latter is not initiated to final consumption. Such a system must be constituted by a torch, or by any alternative device, such as to ensure the same level of security. The system must be dimensioned to allow the possible rapid emptying of all the stocks (5 - 6 hours).
The excess of biogas or that emitted in periods of stop of the motors, must always be sent to the torch, with pilot, able to ensure the 99% minimum efficiency of combustion expressed as $CO2$ / ($CO2$ + CO). During system start-up, when the biogas produced has not sufficient methane content to be sent to the cogenerator, it is necessary to provide a system which avoids its release into the atmosphere, such as, for example, the use of supplemental fuels to support the torch, and avoid free biogas spills.

- ***The three next points about the digestate are briefly treated in the next charapter about digestate legislation***
    - ***Treatment and storage of digestate***
    - ***Digestate storage as such and / or the solid fractions and clarified***
    - ***Spreading and agronomic use of the digestate***

- **Wastewater collection and treatment systems**

From anaerobic digestion plants originate the following drains:

- Rainwater run-off of the squares, characterized by a high organic load, which will have to be conveyed, before discharge to a suitable treatment system (first rain tank), or alternatively, can be collected and recovered with reintroduction in the head the anaerobic digester;
- Domestic waste water coming from service areas and not connected to the sewerage system, must be treated before discharge into surface water body, through effective purification system.

In order to avoid environmental problems, arising from the mismanagement of the artifacts installed for the collection and treatment of water, it will need to provide for appropriate verification operations, control and maintenance of all devices.

- **Waste management**

The anaerobic digestion process generates the following types of waste:

- Waste arising from the cogenerator maintenance operations such as: Waste hydraulic oils and waste engine, identified by EWC code (European Waste Catalogue) (CER in Italy): 130111 - 1300113 - 130207 - 130208;
- Waste arising from other activities such as, plastic sheets of roofing of the trenches, identified by CER code 020104;

All waste generated by the activity, will be stored in temporary storage in closed containers. In the case of liquid waste, these will have to be managed within a containment basin, in order to avoid accidental spills on the ground. The storage area must be properly marked and the waste identified with a sign indicating its EWC code. For the management of movements and disposal of waste, reference is made to what is stated by the D.L.gs 152/06.

- **Aspects relating to the protection of the health and safety of workers**

Being understood any requirements of the appropriate Provincial Command of the Fire Department, the holder of the Company is held at the time of project execution, to produce the Settlement Notice in accordance with art. 67 of Legislative Decree 9 April 2008, n. 81, amended by Decree 3 August 2009. No. 106.

The content of the notification will concern the method for managing, a detailed description of the personal interactions involved in individual operations and system control, as well as the operations of scheduled and extraordinary maintenance .
The Decree of the Ministry of Environment May 29, 2008 and the D.P.C.M. July 8, 2003 provides, in the presence of processing and power lines cabins, the estimation of the "distance of first approximation " in places where the presence of people or workers is more than 4 hours per day. The evaluation of the "distance of first approximation ", is provided, both during the phase of authorization of the installations, which during the vigilance.

[ARPA EMR, 2014, a]

2.4.4. Biogas plant byproducts: the digestate

2.4.4.1. Biogas plant byproducts: the digestate

Beyond to energy products (Electricity, thermal energy, biofuels and biomethane) the biomass power plants also produce air emissions and by-products.

The main by-product of anaerobic digestion plants is the DIGESTATE.

The digestate is the byproduct of the anaerobic digestion process and can be used as a fertilizer material on the major agricultural crops. The anaerobic digestion, in fact, causes a reduction of the organic substance less stable, but does not reduce the presence of nitrogen, phosphorus and potassium of the loaded biomass in the digester.
In particular, during the anaerobic digestion process we see the mineralization of organic nitrogen into ammonia nitrogen, with an apportionment that strictly depends on the initial characteristics of the biomass; it is clear that the type of biomass also affects the amount of other nutrients which are found in the digestate.

The table below shows the main chemical characteristics of some digestates of different origin; the dry matter content is generally variable between 2% and 10% depending on the loaded matrices (highest where they are used silages) and the nitrogen content can arrive to values of 5-7 kg per tonne.

In the digestates resulting from zootechnic effluents nitrogen the increased proportion of nitrogen is in ammoniacal form, whereas for those deriving from plant biomass can still prevail the type of organic nitrogen (calculable as the portion of total nitrogen that is not ammoniacal).

[CRPA, 2012, a]

Tabella 8- Average characteristics of some digestates. [CRPA, 2012, a]

Tab. 1 - Caratteristiche medie di alcuni digestati

Matrici caricate all'impianto	Sostanza secca (%)	Sostanza organica (% s.s.)	Azoto totale (kg/t)	Azoto ammoniacale (% N totale)	Fosforo (kg di P_2O_5/t)	Potassio (kg di K_2O/t)
Liquame suino[1]	2-4	40-60	2-5	70-85	0,5-4	1,5-5
Liquame bovino o liquame bovino più colture energetiche	4-8	65-80	2,5-4,5	40-65	1-2,2	2,5-6
Colture energetiche più sottoprodotti agro-industriali	5-10	65-80	3,5-7	30-65	1-2	3-8

[1] Nel caso di liquame suino sottoposto a flottazione il tenore di sostanza secca e di nutrienti (fosforo in particolare) risulta più elevato.
Fonte: Banca dati CRPA

Figura 18- Storage tank and removal of the digestate. [CRPA, 2012, a.]

Figura 19- Digestate shovelable. [Biosuino, 2015, a.]

Figura 20- Spreading digestate clarified. [ARGAV, 2015, a.]

In most of biogas installations the digestate is subjected to solid-liquid separation with the production of two fractions, the one shovelable and the one clarified (acqueous). The reasons for this are different: we remember, among the principal, the possibility to re-circulate the liquid fraction, the absence of surface crusting in storage, better management of the two fractions during their agronomic use. In biogas plants built in agricoltural farms and zootechnical the solid-liquid separation is usually implemented with helical compression separators or with opposed rolls, while it is more rare the presence of centrifuges or belt presses. The two fractions that are generated have the chemical compositions indicated in following tables.
Knowing that for the use agronomic it is necessary periodically characterizing the digestate and his fractions to know the real fertilising, in summary it can be observed that:

- shoveled fractions have a higher organic content and volatile solids, an allocation of nitrogen essentially under organic form and an N / P ratio shifted in favor of phosphorus;
- clarified fractions have lower organic content, a nitrogen allocation represented by more than 45-50% of ammonia nitrogen and a ratio N / P shifted in favor of nitrogen.

The use of the digestate on soils for the purpose fertilizer is the natural closing of a cycle that, starting from plant organisms, that passes or not through the animal breeding and biogas plant, to exploit as much as possible the nutritional and energy content of the biomass. As amply has been demonstrated by several studies, the digestate, in fact, provides a valid fertilizer effect on major crops. Not only that, it was verified that it can ensure complete fertilization without integration with mineral fertilizers.

[CRPA, 2012, a]

Tabella 9- Composition of solid and clarified fraction of different digestate types. - [CRPA, 2012, a]

Tab. 2 - Composizione delle frazioni solide

Matrici caricate all'impianto	Sostanza secca (%)	Sostanza organica (% s.s.)	Azoto totale (kg/t)	Azoto ammoniacale (% N totale)	Fosforo (kg di P_2O_5/t)	Potassio (kg di K_2O/t)
Liquame suino	20-30	65-90	5-10	15-45	5-15	1,5-5
Liquame bovino o liquame bovino più colture energetiche	14-26	80-90	3-7	20-40	2-8	2-5
Colture energetiche più sottoprodotti agro-industriali	20-30	85-90	4-12	15-45	2-8	3-7

Tab. 3 - Composizione delle frazioni chiarificate

Matrici caricate all'impianto	Sostanza secca (%)	Sostanza organica (% s.s.)	Azoto totale (kg/t)	Azoto ammoniacale (% N totale)	Fosforo (kg di P_2O_5/t)	Potassio (kg di K_2O/t)
Liquame suino	1,5-3,5	30-50	2-4,5	75-90	0,3-3	1,5-5
Liquame bovino o liquame bovino più colture energetiche	2,5-6	55-75	2-4	45-70	1,2-2	2,5-5
Colture energetiche più sottoprodotti agro-industriali	4-8	60-75	3,5-7	35-70	0,7-1,7	3-8

Fonte: Banca dati CRPA

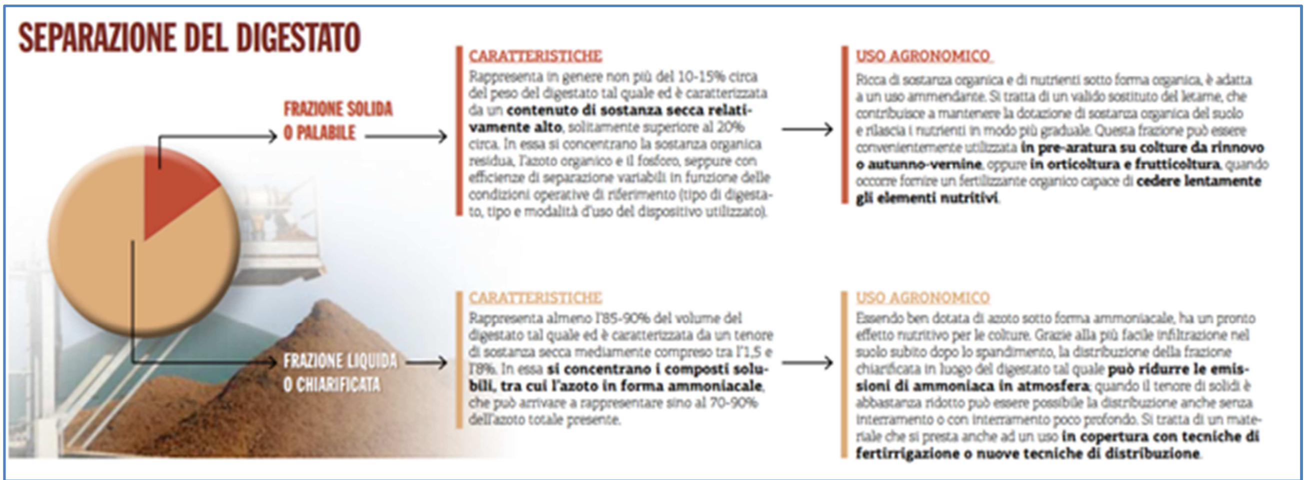


Figura 21- Characteristics and uses of different digestate fractions.- [CRPA, 2012, a]

In practice the benefits of the agronomic use of digestates are:

- Supply of organic substance stabilized in agricultural soils;
- Supply of NPK (in substitution of chemical fertilizers);
- significant reduction in greenhouse gas emissions through 'carbon sink'.

To maximize its agronomic use and maximize the real fertilizing power it is essential that operators know and evaluate adequately the differences between the two fractions of the digestate, in order to choose the correct time and mode of agronomic use of the two materials. About this assumes great importance to know the use efficiency of nitrogen that it provides with digestate, which is closely related to technical and time of distribution. In general, the efficiency of an organic fertilization depends on the ability of the contributions to coincide with the phases of greater nitrogen uptake by crops and of increased activity of the soil microflora. For further details on the best methods and techniques for using the digestate, please refer to the source of the information:

[CRPA, 2012, a].

We report here following an illustrative chart of the average amount of nitrogen characteristics of the different types of agro-zootechnical biomass and their digestates:

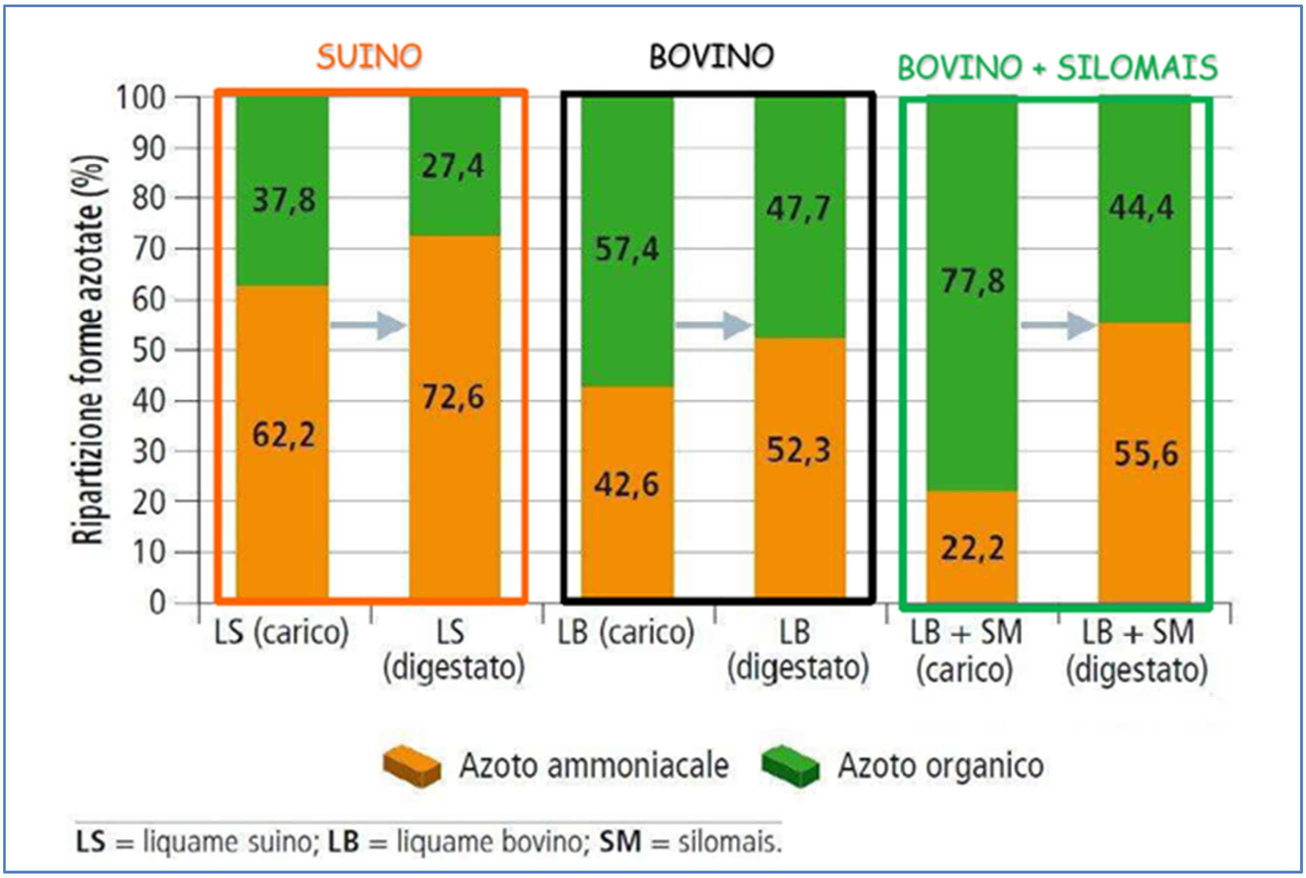


Figura 22- Average characteristics of different biomasses and their digestates. [CRPA, 2014, a]

It is important also we mention some possible problems related to the use of digestate agronomic, ie:

- Nitrate losses into water (in case of application at an inopportune periods and in excess doses) [12].
- Ammonia emissions into the atmosphere (if it is not distributed with the Best Available Techniques) [13].

[12] To this end it is necessary to refer to what is defined in R.R.2016 and subsequent updates, regarding the calculation of nitrogen and spreading mode of digestate, reported in the following chapters.

[13] In the context of diffuse emissions, the BAT (Best Available Techniques) are prescribed primarily for Plants subject to development consent regime IEA (Integrated Environmental Authorisation). However, usually the biogas plants are under threshold asseveration to IEA regime and therefore they are not obliged to act in accordance with BAT).

2.4.5. LEGISLATION for biogas digestate utilisation

2.4.5.1. National legislation about the digestate

The February 25, 2016 was signed the Decree of the Ministry of agricultural food and forestry policies, which updates the rules and criteria for agronomic use of animal manure and waste water (defined by decree April 7, 2006, which is now repealed) and digestate from anaerobic digestion plants. The Regions and Autonomous Provinces have 180 days from the entry into force of the decree to regulate the use of agricultural activities or adapt existing rules in accordance with the general criteria laid down by decree (Ie by 25 August 2016).

As regards the digestate, the new rule reaffirms that it can be excluded from the waste legislation - and thus considered a by-product - only if it fulfills certain conditions:

- It is produced in authorized anaerobic digestion plants - corporate and intercompany - and fed with manure and a range of materials including vegetable scraps and some agro-industry waste (art. 22);
- There is certainty of its agronomic use;
- It can be used directly, without further treatments different from normal industry practices such dehydration, sedimentation, clarification, centrifugation and drying, filtration, solid-liquid separation, stripping, nitrification denitrification, phytodepuration;
- It satisfies the quality requirements specified in Annex IX, as well as sanitary regulations and environmental protection in any case applicable.

It then forbidden the agronomic use of the digestate produced from crops that come from contaminated sites or contaminated material. This material, considered to be waste, following a specific operation of drying, will have to be booted, preferably, to incineration (Art. 23).
According to inflows, the digestate is distinguished into:

- agro-zootechnical, ie produced with straw, grass cuttings, prunings, agricultural material derived from crops, livestock manure, agricultural and forestry equipment not destined for human consumption;
- agro-industrial, ie produced from waste water, residues of agricultural and food activities, vegetable water of the crushers and humid olive residues, animal by-products.

Who produces or those who uses the digestate is obliged, among other things, to present the communication agronomic utilization (art. 4) to the competent technical department of the municipality (SUAP in italian); certain types of companies are also obliged to prepare also the agronomic use plan - PUA (art. 5).
The norm finally face the use the agronomic in areas vulnerable to nitrates regulating prohibitions, storage modes and agronomic use well as inspections and monitoring necessary for the verification of the concentration of nitrates in the waters and evaluation of trophic status.
The Decree regulates therefore the digested, together with other types of effluent from farming, for its direct use in agriculture.
We Remind you that in the field of digestate was already intervened last year a norm (Decree of the Ministry of Agricultural Food and Forestry Policies of 26 May 2015), which had inserted between the fertilizers the dry digestate , ie from drying of the resulting digestate obtained by conversion of dedicated crops, crop residues, agro-industrial vegetal by-products in biogas .
The decree than a year ago allows the placing on the market of a registered fertilizer that can be sold without the buyer must justify their use: in this case the control over regularity of the product is awarded exclusively to the Ministry for Agricultural Policies through the Institute for quality control and the manufacturers must register themselves in advance at the same Ministry.

[ARPAT, 2016, a]

2.4.5.2. Regional legislation about use of digestate

In Emilia-Romagna the modalities of use of the digestate are defined by the **R.R.2016: "Regional regulation under Article 8 of the Regional Law 6 March 2007, n. 4. - Provisions on the agronomic use of animal manure and wastewater from agriculture companies and small agro-food companies. "**
According to this legislation the management of digestate from biogas plants requires the drafting and subsequent approval of the PAU (Plan Of Agronomic Use) that, very briefly, with regard to this report, are listed in its Annex 1, section 8 to page 61, where it is defined that:
The nitrogen supply with organic fertilizers (Fo)

- in NVZ (Nitrogen vulnerable zones) can not exceed 170 kg / ha / year.
- in ZNVN (Zone NOT Vulnerable to nitrogen) can not exceed 340 kg / ha / year.

8.1 Features
The characteristics of the digested depend on those of the input materials. The anaerobic digestion process, in which the materials are subjected, alone or in mixture between them, does not change their nature. rather determines a physical chemical action of biodegradation of the organic matter contained in them, with positive effects on: i) fertilizing propherties; ii) odouros-smelling impact; iii) sanitary issues; iv) environmental protection.

8.2 Calculation of weight, volume and of nitrogen content of the digestate
The weight of the digestate is obtained by subtracting to the weight of the biomass load the one of produced biogas, according to the following equation:

$$\textbf{Weight.}_{\textbf{DIGESTATE}} = \textbf{Weight.}_{\textbf{BIOMASS}} - (\textbf{Volume.}_{\textbf{BIOGAS}} \times \textbf{Density.}_{\textbf{BIOGAS}})$$

The amount of nitrogen to the field of digestate is defined as the sum of the zootechnical nitrogen calculated according to the values of table 1 of Annex I, and of the nitrogen content in the other biomass inbound to the plant. The nitrogen quota from other biomass is reduced by 20% to take account of emissions into the atmosphere during storage.

$$\textbf{N.}_{\textbf{IN FIELD FROM DIGESTATE}} = \textbf{N.}_{\textbf{ZOOTECHNIC}} + (\textbf{N.}_{\textbf{OTHER BIOMASSES}} \times \textbf{0.8})$$

where:

Tabella 10- Quote of nitrogen from other vegetal biomass

TILLING ... Examples from law table ...	content of nitrogen in % for whole plant
	[%]
Aglio	1,08
Asparago verde	2,56
sugar beet	0,31
Basilico	0,37
[illegible]	[illegible]
grain maize	2,27
sweet maize	1,42
shredded maize	0,39
[illegible]	[illegible]

2.4.5.3. Management of atmospheric emissions originating from digestate

- **Treatment and storage of digestate**

The digestate output, can be used as such or subjected to treatment of separation into two fractions. If this separation operation is carried out with machines with high efficiency and energy use, it may represent a potential source of odors; in these cases, the Regional Executive Decision (DGR) 1495/11 provides structural interventions consisting of environments totally closed and depressed, including aspiration and treatment of the exhaust air, before it is released into the atmosphere, through suitable abatement system: a biofilter. As indicated by the same from the regional norm, at the exit of the treatment plant, the guide values which refer for the odor emissions are:

- Odor concentration expressed as odorimetric units: 400 uo E / Nm3 measured with dynamic olfactometry according to UNI EN 13725/2004;
- Reduced nitrogen compounds, expressed as: NH4: 5 mg / Nm3.

- **Digestate storage as such and / or the solid fractions and clarified**

As indicated by Regional Executive Decision (DGR) 1495/11, the digestate storage and / or solid and clarified fraction resulting from any separation treatment, must guarantee containment of emissions, in accordance with the recommendations of the Regional Council Regulation 28/10/2011 num.1, in accordance with Article. 8 of L.R. n. 4 of 06/03/2007, provides:

that the capacity of the containers, to be used for storage, is calculated in relation to the amount of treated materials from the plant. The volume of further tanks / containers, may not be lower than the digestate volume, as such or clarified, produced in 180 days for spreading on land in nitrate vulnerable zones (NVZ), and 120 days for spreading on land into ordinary areas (NNVZ not nitrogen vulnerable zones).

As regards the possible fraction shovelable, the Regional Executive Decision (DGR) 1495/2011, refers to a storage time of 90 days; for that fraction it is also compulsory the coverage of the storage area.

[ARPA EMR, 2014, a]

- **Spreading and agronomic use of the digestate**

Directive 91/676 / EEC, identifies for the agricultural sector, the technical rules concerning fertilization and management of of livestock manure. In Emilia-Romagna is in force the R.R. 1/2016: "Regional regulation in accordance with Article 8 of Regional Law 6 March 2007, n. 4. - Provisions on agronomic use of animal manure and wastewater from agriculture companies and small agro-food companies "which provides operational guidelines for the use of the main agronomic nitrogen fertilizers, including the digestate [14].

In order to limit emissions in the atmosphere of nitrogen and ammonia odors, pursuant to the aforementioned Regulation, the solid digestate spreading / liquid must be made according to the following ways:

- The solid digestate must be incorporated into the soil within 24 hours of their distribution;
- Liquid digestate must be distributed directly via injection into the ground, or through surface spreading at low pressure followed by burying within 24 hours. On field crops in coverage, it is provided to grazing spreading in bands, while on grassland crops it is provided grazing on ground.

[14] Every year the region provides to issue an update of the regulation, where, for example, updates the areas classified as vulnerable to nitrogen and non-vulnerable.

The spreading will have still guarantee compliance with the minimum distances provided by the Regional Regulation (50 metres from residential and productive buidings and 100 m from urban areas).
Into consideration of the risk of nitrogen release from soil to water, the distribution of the digestate is prohibited, from November 1 to January 31 of each year, except eventual exemptions granted by the Province (this until 31/12/2015, date of removal of the Province authorities).

2.5. BIOGAS PLANTS FROM LANDFILL

2.5.1. Biogas plants from landfill

In the case of plants using biogas produced from managed landfills for urban waste, the main parts of the system are as follows:

- the landfill biogas extraction section (catchment wells, transportation lines, grouping collectors);
- the suction side and conditioning of landfill biogas (general collector, condensate separators, filters, vacuums);
- the power generation section (gensets) and torch (safety device to burn the eventual unburnt biogas).

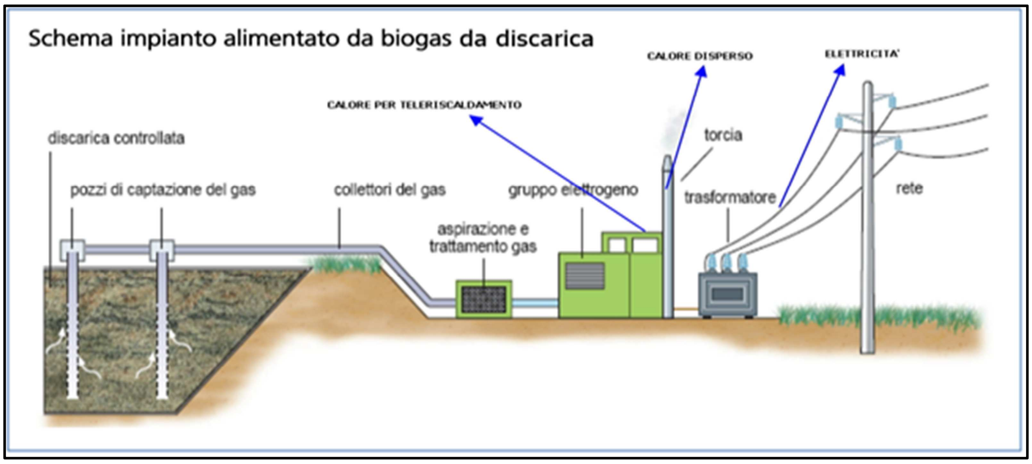


Figura 23- Scheme of a power plant fueled by landfill biogas. [GSE, 2008 a]

Relative to a standard landfill, the following chart shows the difference between the theoretically producible biogas and biogas effectively tappable. The first is the one obtainable under the best conditions. The reality, however, shows that not all the material decomposes and that the reactions are also aerobic. For this literature has established that the effective captation, is equal to 50% of the previous.

The landfill biogas production has a distinctive bell-shaped trend that depends (for amplitude, maximum and inflections) by the amount of waste deposited in landfill annually. As a medium-sized landifill works for about 20 years, its life cycle is around 30 years.

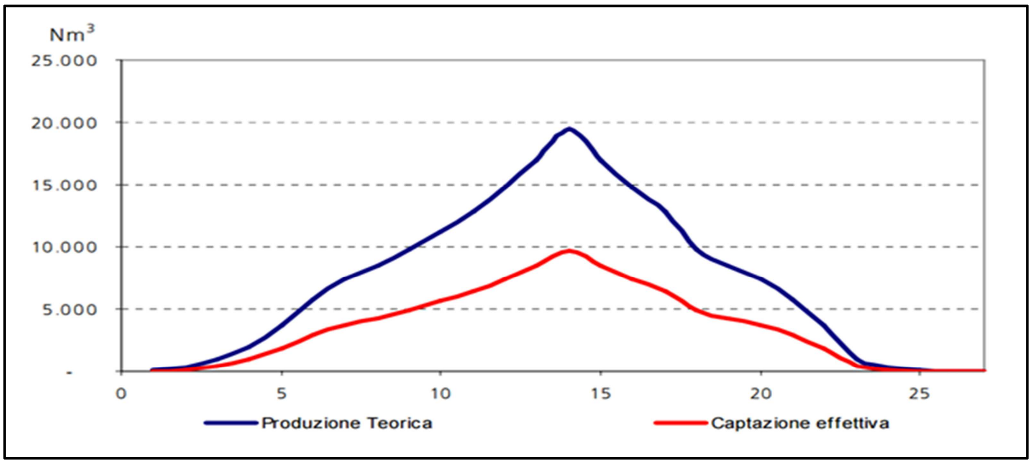


Figura 24- Typical trend of landfill biogas collection. [GSE, 2008 a]

2.6. ATMSPHERIC EMISSION FROM BIOGAS PLANTS

[ARPA EMR BO, 2011, a]

2.6.1. Emitted pollutants

The biogas from the anaerobic digestion of biomass, consisting mainly of methane (50-75%), feeds a cogenerator constituted by an internal combustion engine (Diesel, Eight cycle or modified gas turbine), coupled to an alternator and to one heat exchanger for heat recovery. The principle on which works a cogenerator is based on the oxidation of methane by burning, from which it follows a natural gas transformation mainly into CO_2 and H_2O, and other pollutants that can result from incomplete combustion.

Tabella 11- Composition of the biogas from anaerobic digestion. [ARPA EMR BO, 2011, a]

Methane	50-75%
Carbon dioxide (CO_2)	25-45%
Hydrogen (H_2)	1-10%
Nitrogen (N_2)	0,5-3,0%
Carbon monoxide (CO)	0,1%
Hydrogen sulphide (H_2S)	0,02-0,2%
Water (H_2O)	saturazione
Calorific Value (P.C.I.)	18,8 -21,6 MJ/Nm3

2.6.2. Characteristic pollutants of biogas plants

Not for all the pollutants, which may occur on plants of this type are provided limits of law. Legislative Decree 152/06, Part III of Annex I Section 1.3 provides limits for the pollutants specified below. In the table are also inserted its abatement systems authorized for plants in the Province of Bologna.

Tabella 12- Reference limits

Pollutants in emission	**Reference law values (mg/m3)**	**Abatement systems used in projects authorized in Bologna Province**
TOC [15] (Total Organic Carbon)	150	-
CO Carbon monoxide	800	Lean burn like LEANOX
NOx Nitrogen oxides	500	The removal of nitrogen oxides (NOx) is performed for selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR).
Cl* Chlorine compounds	10	-

In the TOC parameter are included all polluted arising from the incomplete combustion of natural

[15] Value expressed as COTNM total non-methane organic carbon.

gas (formaldehyde, hydrocarbons, benzene). The TOC corresponds to the total sum of these but there isn´t a specific limit of each of these.

- **Formaldehyde**

The formaldehyde is the main pollutant, among the compounds of carbon, which is formed in the methane combustion processes (about 60%) in an internal combustion engine for incomplete combustion of methane.
German legislation (TA-LUFT 2002) for a gas-powered spark engines imposes a limit for formaldehyde of 60 mg / Nm (5% O2)., while in Italy the Legislative Decree 152/2006 Annex I to Part Five part II of Schedule D Class II, provides: output value 20 mg / Nm3 (expressed as concentration).

- **Hydrocarbons and benzene**

These may also be present, but in lesser quantities than the Formaldehyde, for incomplete combustion of methane.

- **Dioxins**

Dioxins are formed in trace amounts in every combustion process (200-450 ° c) in the presence of chlorine and organic substances (carbon, oxygen, hydrogen).
The biomass containing chlorine in trace amounts (% by weight variable up to a maximum value of 0.3% for grain).

Tabella 13- Chemical composition of some biomasses. [Phenomenology of biomass combustion (T.Faravelli et al), 2013, a].

	Carbon	**Hydrogen**	**Nitrogen**	**Sulphur**	**Chlorine**	**Oxigen**
Sawdust	46.9	5.2	0.1	0.04	0.2	41.7
Grain	49.4	5.6	0.6	0.1	0.3	42.5
Poplar	48.4	5.9	0.4	0.01	nd	39.6
Wheat straw	42.8	5.5	0.07	-	1.5	35.5
Alfalfa	45.4	5.8	2.1	0.09	nd	36.5
Sugar cane waste	44.8	5.4	0.4	0.001	nd	39.6
Sunflower	47.4	5.8	1.4	0.05	0.1	41.3
Bark	53.9	5.8	0.4	0.03	0.15	38.3

Consequently, the biogas from biomass, in contrast to the biogas from landfill where the chlorine is derived mainly from the degradation of plastic and vinyl materials, has a TOTAL CHLORINE content nil or very low, therefore we exclude the presence of dioxins in amounts analytically detectable.

Tabella 14- Chemical composition of biogas: Comparison between biogas from biomasses and biogas from landfills. [International Energy Agency (IEA Bioenergy), 2013, a]

Parameters	Unit of measure	Biogas from landfill	Biogas from Anaerobic Digestion	Natural gas North Sea
Calorific power	Mj/Nm3	16	23	40
Methane	vol %	45	63	87
Hydrocarbons sup.	vol %	0	0	12
Hydrogen	% vol	0-3	0	0
Carbon monoxide	% vol	0	0	0
CO2	% vol	40	47	1,2
Nitrogen	% vol	15	0,2	0,3
Oxygen	% vol	1	0	0
H2S	ppm	≤100	≤10000	1-2
Ammonia	Ppm	5	≤100	0
Total chlorine	Mg/Nm3	20-200	0-5	0

- **Dust and PM10**

The possible formation of fine particles (PM10 and PM2.5) is due to the combustion of the biogas in the CHP.
The combustion of methane is a less significant process for the production of fine particles compared to direct combustion of biomass, in particular of so-called chipped wood, and is in fact on the latter type of systems that have been performed many specific studies for the analysis of the problem and there is a considerable body of literature data.
As regards the production of fine dust by co-generators of biogas plants, in addition to not being provided reference regulatory limits, at the time (2011) there are no studies and literature data. To give an example on the emission factors from the combustion of methane we can report a table that shows the difference between those arising from natural gas, fuel oil and from those demonstrating that their ratio of concentration, for the total PM10, is 1:10.

Tabella 15- Emission factors for methane combustion. [Chemistry and Energy, 2012, "Emission from combinated cycle centrals" by Fraternali/Oliveti Selmi]

Emission factors of pollutants from the combustion of methane in gas turbines				
Fuel	CH4 - Natural gas (in turbogas)		Burning oil	
Polluttants	*Emission factors*		*Emission factors*	
	lb/MMBTU	g/GJ	lb/10^{-3} Gal	g/GJ
CO2	110	47.332	25.000	71.761
NOx	-	23,0	a	116
CO	-	23,0	a	2,9075

CH4 + N2O	0,012	4,99	0,39	1,12
SO2	0,003	1,46	94,20	270,40
TOC	0,011	4,73	1,04	2,99
Reactive hydrocarbons	0,001	0,43	0,04	0,12
PM10 totale	0,007	2,84	8,50	24,40
Source: US-EPA – Compilation of emission factors – AP42, Cap 3.1 External Combustion Sources – Stationary Gas Turbines + Cap 1.3 External Combustion Sources – Fuel Oil combustion				

Taking as a reference another cogeneration plant of equal heat capacity, that works with biogas resulting from the anaerobic digestion of municipal solid waste, the range of values of Dusts which on average was observed in the last 10 years corresponds to: 0.06 to 7.5 mg / Nm3 .

2.6.3. Odorous emissions and mitigation measures

Most of the odorous impacts of a plant in Anaerobic Digestion is originated by the steps of:

- Receipt and storage of organic biomass waiting for their loading in the plant
- Biogas energy conversion
- Digestate treatment and storage

Generally, the negative impacts are reflected in correspondence with:

- insufficient design or construction
- inadequate facilities management

and they can be effectively prevented or greatly mitigated by the adoption of special design arrangements, appropriate abatement devices of pollutants and with a correct management practice.

2.6.3.1. Receipt and storage of organic biomass waiting for their loading in the plant

One of the most important steps for the possible odor, is constituted by the MANAGEMENT of Storages of incoming biomasses.
The storage systems required vary greatly depending on the type of biomass and the degree of fermentability of this. In particular it is possible distinguish two large categories: silage: storage on plateau as established agricultural practice for this type of process;

- agri-food products: they must be provided of management and plant measures that will reduce the potential odorigenous impact.

2.6.3.2. Plant requirements for the storage of by-products

- Storage must be in closed tanks / containers and sealed (generally for solid biomass all projects planned underground tanks)
- Tanks and containers are enslaved by appropriate exhaust air treatment; in the case of silos for not shoveled (manure biomass, molasses, etc.) is expected to adopt, on the vents, treatment filters' (eg. activated carbon filters)

- Storage areas must be equipped with floor or surface waterproofed, shaped so as to facilitate the rapid draining of any leachates, even these sources of odor.

2.6.4. Management requirements for the storage of by-products

- With the exception of silage, it is necessary to limit the storage time of the waiting material loading them to the digester (maximum 72 hours), in order to prevent phenomena of anaerobiosis, the primary source of malodorous emissions.
- Avoid contamination of the squares for solid material losses or leachate.
- In all phases of transport, loading, unloading, and use pumps to test pipes of absolute tightness.

2.6.5. Biogas energy conversion

In the energy conversion of methane, the phase of the boot can be a critical phase for odor emissions, if they are not adopted some measures system engineering and management. In this phase, in fact, the biogas produced has not sufficient methane content to be sent to the co-generator or to be burned in the emergency flashlight. To avoid that this biogas as it is without undergoing appropriate treatment is released into the atmosphere, the following requirements are identified:

- Use additional fuels (eg LPG, mains gas) to support the torch;
- Treat abatement plant emissions before they are discharged into the atmosphere (eg. cartridges with activated carbon filters).

When fully operational, the cogenerator is subject to compliance with the limits set by Legislative Decree 152/2006 (see Table 2) with the obligation of a control at least annually fireplace. Are also provided for semi / annual inspections to check the effectiveness of the abatement equipment (in particular the biofilter, used in these own equipments to reduce odorous emissions) for which are defined values of operating parameters and limits to odors, even if the national legislation did not provide to date (2011) any legal limit.

2.6.6. Separation and storage of digestate

The storage of the digestate and / or of the solid fractions and clarified resulting from a possible separation treatment normally takes place in a tank. Some plant requirements were identified:

- The tank must be covered and the volume of air present between the surface of the liquid and coverage, must be extracted; the intake air can be fed back to the plant for the energy use or can be piped to a treatment plant (biofilter with setting limits to smells and to ammonia concentration);
- For shovelable fraction of the digestate storage it is mandatory the coverage of the area with shed equipped with side cladding.

In the case in which is provided a treatment of the digestate separation into two fractions (solid and clarified) with strong centrifugal efficiency, this operation must be performed in fully closed environments and in the depression, with the intake and exhaust air treatment plant to a biofiltration system (also in this case with the fixation limits to odors and ammonia).
The solid digestate heaps must be of adequate size to avoid anaerobic conditions within them, just possibly causing odor at the time of their loading and distribution on the ground.

3. EMISSION FACTORS FOR AIR EMISSION INVENTORY

3.1. AIR EMISSIONS FACTORS FOR BIOMASS PLANTS

Both the combustion of the biogas produced from power plants based on anaerobic digestion of biomass, that the one deriving from direct combustion and/or gasification/pyrolysis of solid biomasses, independently of the CO2 released in neutral budget, generate polluting air emissions, particularly NOx and Particulate Matter.
In addition to this, in the context of anaerobic digestion plants, also the storage of the inbound biomass as well as the spreading of digestate produce _ pollutant air emissions , especially of ammonia and methane. _ These emissions however must be counted in reference to the fact that these would be greater if the biomass was disposed / spreaded as such without first being digested anaerobically. [IPCC, 2006, a] + [INEMAR Emilia-Romagna, 2015, c] + [EMEP/EEA, 2015, a]
From the cogenerator come out air emissions whose main pollutants, defined by current legislation, are: Volatile organic compounds (VOC), nitrogen oxides, sulfur oxides, carbon monoxide and dust. The maximum allowable concentrations for each pollutant are specified in item 4.36 of Emilia-Romagna Regional Executive Decision (DGR) 1496/11. And to guarantee the respect of the limits the cogenerator is enslaved from abatement systems for nitrogen oxides and carbon monoxide.

3.1.1. Air emissions resulting from the internal combustion of biomass plants (solid biomass and biogas plants)

In the present study regarding the pollutants emissions from the operation of the system we have used the emission factors published by INEMAR ARPA Emilia-Romagna.
The emission factors for power plants are referred to the energetic GJ corresponding to total annual biomass inbound to the system.

[INEMAR Emilia-Romagna, 2015, c]

Tabella 16-Emission factors for power plants. [INEMAR Emilia-Romagna, 2015, c]

Sector	Power	Fuel	Air Pollutant	Emission Factor	Emission Factors Unit	Reference Unit
Production of electricity	Boilers with a heat output <50 MW	biogas	CH4	203,907426	g	GJ
Production of electricity	Boilers with a heat output <50 MW	biogas	CO2 lorda	74,366238	kg	GJ
Production of electricity	Boilers with a heat output <50 MW	biogas	NOx	118,517622	g	GJ
Production of electricity	Boilers with a heat output <50 MW	biogas	PTS	0,951949	g	GJ
Production of electricity	Boilers with a heat output <50 MW	biogas	SO2	1,846781	g	GJ
Production of electricity	Boilers with a heat output <50 MW	wood and similars	CO2 lorda	124,9	kg	GJ
Production of electricity	Boilers with a heat output <50 MW	wood and similars	NOx	180	g	GJ
Production of electricity	Boilers with a heat output <50 MW	wood and similars	PM10	6	g	GJ
District heating	Boilers with a heat output <50 MW	wood and similars	CH4	18	g	GJ
District heating	Boilers with a heat output <50 MW	wood and similars	CO2 lorda	124,9	kg	GJ
District heating	Boilers with a heat output <50 MW	wood and similars	NOx	200	g	GJ
District heating	Boilers with a heat output <50 MW	wood and similars	PTS	12	g	GJ
District heating	Boilers with a heat output <50 MW	wood and similars	SO2	11	g	GJ
Production of electricity	Boilers with a heat output <50 MW	methane	CH4	2,5	g	GJ
Production of electricity	Boilers with a heat output <50 MW	methane	CO2	55,83	kg	GJ
Production of electricity	Boilers with a heat output <50 MW	methane	CO2 lorda	55,83	kg	GJ
Production of electricity	Boilers with a heat output <50 MW	methane	NOx	60	g	GJ
Production of electricity	Boilers with a heat output <50 MW	methane	PTS	0,2	g	GJ
Production of electricity	Boilers with a heat output <50 MW	methane	SO2	0,24	g	GJ
Production of electricity	Boilers with a heat output <50 MW	fossil oil fuel	CH4	3	g	GJ
Production of electricity	Boilers with a heat output <50 MW	fossil oil fuel	CO2	74,66	kg	GJ
Production of electricity	Boilers with a heat output <50 MW	fossil oil fuel	CO2 lorda	74,66	kg	GJ
Production of electricity	Boilers with a heat output <50 MW	fossil oil fuel	NOx	130	g	GJ
Production of electricity	Boilers with a heat output <50 MW	fossil oil fuel	PTS	20	g	GJ
Production of electricity	Boilers with a heat output <50 MW	fossil oil fuel	SO2	926,83	g	GJ
			* in this table the comma represents the decimal divisor			

3.1.2. Air emissions resulting from transports

For the estimation of emissions from transports (agricoltural and road) we have used both INEMAR emission factors of ARPA Emilia-Romagna than those INEMAR of ARPA Lombardia. In both cases the emissions factors are related to the kilometers traveled.

Tabella 17- Emission factors for transport from INEMAR ARPA Emilia-Romagna, 2012 –

Settore	Combustibile	Tipo legislativo	COV	NH3	NOx	PM10	SO2
AUTOMOBILI	benzina	Euro II - 94/12/EC	211	169	305	29	6
		Euro III - 98/69/EC Stage 2000	47	16	73	28	6
		Euro IV - 98/69/EC Stage 2005	41	16	33	28	6
		Euro V	20	6	47	28	7
		Euro VI – futuro	18	10	14	28	7
	Diesel	Euro II - 94/12/EC	61	1	680	85	6
		Euro III - 98/69/EC Stage 2000	26	1	748	66	6
		Euro IV - 98/69/EC Stage 2005	9	1	548	64	6
		Euro V	5	1	371	28	6
		Euro VI – futuro	5	1	129	28	6
	GPL	Euro II - 94/12/EC	47	0	122	27	0
		Euro III - 98/69/EC Stage 2000	36	0	83	27	0
		Euro IV - 98/69/EC Stage 2005	5	0	43	27	0
		Euro V	1	0	28	27	0
	metano	Euro II - 94/12/EC	43	0	118	27	0
		Euro III - 98/69/EC Stage 2000	31	0	79	27	0
		Euro IV - 98/69/EC Stage 2005	5	0	43	27	0
		Euro V	3	0	41	27	0
COMMERCIALI LEGGERI	benzina	Euro III - 98/69/EC Stage 2000	57	7	62	39	12
		Euro IV - 98/69/EC Stage 2005	41	6	22	39	13
		Euro V	11	3	36	39	12
		Euro VI-.futuro	11	3	36	39	12
	diesel	Euro III - 98/69/EC Stage 2000	107	1	992	105	8
		Euro IV - 98/69/EC Stage 2005	41	1	807	73	8
		Euro V	32	1	619	39	8
		Euro VI-.futuro	31	1	411	39	8
COMMERCIALI PESANTI	diesel	Euro III - 1999/96/EC	320	3	7035	306	25
		Euro IV - COM(1998) 776	17	3	4391	178	24
		Euro V - COM(1998) 776	19	3	2763	181	26
		Euro VI - futuro	18	3	1408	158	26

Fattori di emissione in mg/km utilizzati per la valutazione delle misure sui trasporti stradali (Fonte INEMAR).

Tabella 18- Emission factors for transport from [INEMAR ARPA Lombardia, 2012]

Tipo di veicolo	SO_2	NO_x	COV	CH_4	CO	CO_2
	mg/km	mg/km	mg/km	mg/km	mg/km	g/km
Automobili	1,0	434	40	9,3	552	172
Veicoli leggeri < 3.5 t	1,5	843	69	2,6	562	236
Veicoli pesanti > 3.5 t e autobus	**4,1**	**5.420**	**307**	**58**	**1.185**	**635**
Ciclomotori (< 50 cm3)	0,4	142	3.651	78	6.535	65
Motocicli (> 50 cm3)	0,6	161	1.206	98	5.984	97
Veicoli a benzina - Emissioni evaporative			138			

Tipo di veicolo	N_2O	NH_3	PM2.5	PM10	PTS	CO_2eq	Precurs. O_3	Tot. acidif. (H+)
	mg/km	mg/km	mg/km	mg/km	mg/km	g/km	mg/km	g/km
Automobili	6,0	15	30	41	54	174	630	10
Veicoli leggeri < 3.5 t	7,9	2,6	63	81	97	238	1.159	19
Veicoli pesanti > 3.5 t e autobus	**20**	**3,0**	**190**	**240**	**298**	**642**	**7.051**	**118**
Ciclomotori (< 50 cm3)	1,0	1,0	69	75	81	67	4.544	3,2
Motocicli (> 50 cm3)	2,0	2,0	28	34	40	99	2.062	3,6
Veicoli a benzina - Emissioni evaporative							138	

Apart from these, in the case of only CO_2 from road diesel fuel it was also used as a reference the emission factor = 2650 g CO_2 / liter diesel

$$1 \text{ liter of diesel} \rightarrow 2.65 \text{ kg } CO_2$$

[QuattroRuote, 2015, a]

3.1.3. CO2 resulting from energy produced by national mix

As anticipated, in terms of emissions of greenhouse gases, a detailed analysis of the environmental effects related to the exercise of a biomass plant must take into account not only the well-known CO_2 produced in the process of biomass/biogas combustion, accountable as neutral budget because of plant / animal origin, but it must also account the emissions from cultivation, harvesting and transport of both the inbound biomass than of outgoing byproducts (ex. ashes, digestate). In particular, it must take into account the CO_2, methane (CH_4) and nitrous oxide (N_2O).
In addition to this, of course, to make a correct comparison in terms of environmental impact and sustainability from the point of view of CO_2 and GHG emissions, we must keep in consideration the Italian national factors referred to the production of thermal and electrical energy, defined in the the following table:

<table>
<tr><td rowspan="2">Italian ELECTRIC mix [*Terna 2010]</td><td>Coke</td><td>Petrolium</td><td>Natural gas</td><td>Renewable sources</td></tr>
<tr><td>11,6%</td><td>2,9%</td><td>44,5%</td><td>22,4%</td></tr>
<tr><td colspan="5">0,440 kg CO2/kWh - for Electric energy</td></tr>
<tr><td rowspan="2">Italian THERMAL mix [*IEA 2008]</td><td>Coke</td><td>Petrolium</td><td>Natural gas</td><td>Renewable sources</td></tr>
<tr><td>1%</td><td>32,6%</td><td>61%</td><td>2,3%</td></tr>
<tr><td colspan="5">0,217 kg CO2/kWh - for Thermal energy</td></tr>
</table>

3.1.4. Emissions from biogas plant’s digestate

As indicated by Regional Executive Decision (DGR) 1495/11, the digestate storage and / or solid and clarified fraction resulting from any separation treatment, must guarantee containment of emissions. This argument will be deeped in the next charapter about digestate legislation.

3.1.5. CO2 emissions from biogas plant construction

The climate-altering gas emissions during the construction of the biogas plant are mainly due to the use (and therefore to their production) of steel and concrete.

The biogas plant components are primarily:

- the fermenter with the power system and / or the pre-storage;
- the post digester;
- the storage tank of digestate;
- the cogeneration unit.

Since an exact calculation of the type and quantity of materials used for construction of the plant would be somewhat challenging, we used data from the literature using the data shown in a study of Plöchl 2006 "Ecological assessment of the production and of biogas exploitation" calculated with the help of the GEMIS software (Globalen Emissions Modell Integrierter Systeme). [16]

- for used cement → 117 tons. CO2eq / MW total power (electricity + heat + lost)
- for used steel → 27 tons. CO2eq / MW total power (electricity + heat + lost)
- for the cogenerator (small plant size) → 29 g. CO2eq / electric kWh
- for the cogenerator (medium plant size) → 42 g. CO2eq / electric kWh

[TIS, 2011, a]

[16] Assuming a period of useful life of 15 years and 7500 operating hours per year.

4. REGIONAL PLANS AND PROGRAMS FOR BIOENERGIES

4.1. Plans and regional funding programs regarding bioenergy and energy biomass plants.

Here we propose you the references of regional energy plans for 2007 - 2011 - 2013 - 2017, together with those of funding and programming plans prior to 2015 to be connected to other sectors of bioenergy and biomass plants. Of these were carried out the analysis and synthesis, which we propose the summary diagrams. In subsequent chapters of these schemes will be integrated to research environmental analysis model along with the results of the LCA analysis performed on 11 biomass plants analyzed as cases of baseline study.

Web link to the REP Regional Energy Plans of Emilia-Romagna Region:

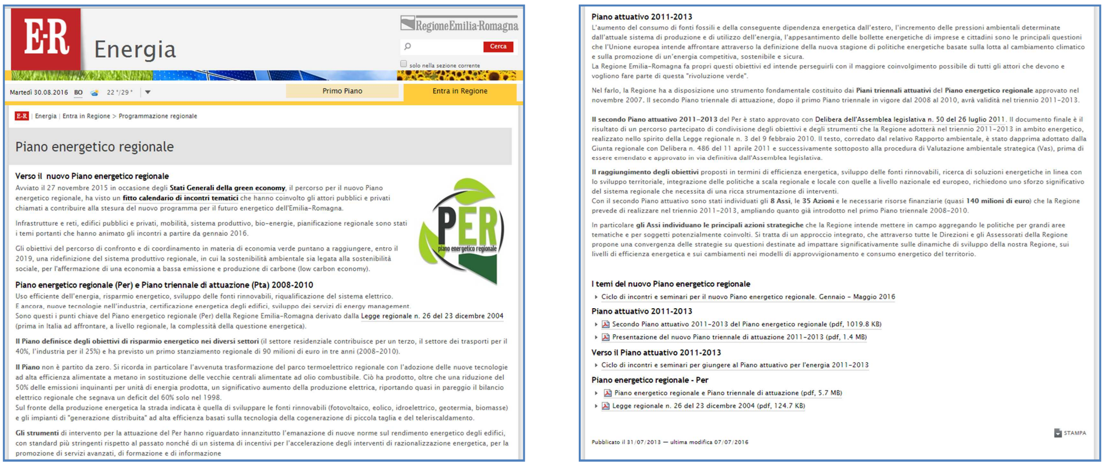


Figura 25- Web link to the Regional Energy Plans of Emilia-Romagna: 2007 - 2011 - 2013

Figura 26- Web link to the new Regional Energy Plan of Emilia-Romagna: 2016-2030 + Triennial Implementation Plan 2017-2019

4.2. Synthesis of various regional plans/programs prior to 2015 related to bioenergy and biomass plants:

Tabella 19- Synthesis of various regional plans/programs prior to 2015 related to bioenergy and biomass plants: - PER 2011-2013 , PRSR 2007-2013 , PAIR2020 , POR-Fesr 2014-2020 .

TERRITORIAL LEVEL *planes and programs previous to 2015	PLANS AND PROGRAMS (p/p)	AXLES of p/p	ACTIONS AND MISURES of axles	FORECAST ACTIVITIES
REGIONAL	PER 2011-2013 Regional Energetic Plan (PTA Technical Actuative Plan)	Axle 3 - Development and energetic qualification of agricolture sector	ACTION 3.1 - Supporting to the production of agro-energy	A) Investments for the energy production from renewable sources, included those finalized to biomass production B) Incentives for innovative systems of biomass combustion with the minimum environmental impact
			ACTION 3.2 - Supporting to projects of energy qualification for agro-farm	A) Diversifications in not agricultural activties B) Realization of intervents for the construction of plants that are turned to the production and distribution of bioenergies C) Regional Plan for the development of agro-energies
		Axle 6 - Regulamentation of the agricultural sector	ACTION 6.3 - Discipline for the geographic localisation of plants fueled with renewable sources	Elaboration and indication of areas and sites that are not idoneus for the installation of plants fueled by renewable sources
	PRSR 2007-2013 Agricultural development plan	Axle 1 – Emprovement of the competity of the agro-forestal sector	ACTION 2 - MISURE 121 - Modernisation of farms	The misure consist in a support to the farms throught the financing of material and/or immatirial investments, that be: - destinated to improve the global return of the farm; - conform to the comunitary norms that are applicable to the investment definited; -finalized to increase the competitivity of the farm, with particular regard to the businness needs of technology innovation; - referred to the productive chains that are identified in the axle strategies.
		ASSE 3 - Quality of life in rural areas and diversification of rural economy	MISURE 311 - Diversification in not agricultural activities	Aims: - integration of the farmer's income; - increasing of the actrattivity of the rural environment as seat of investments and residence; - realization of in interventions for the construction of plants finalized to the production and distribution of bioenergies.

	PAIR2020 Integrated Plan for the Air Quality (*published inl 2013)	SECTION III - MISURES FOR PRODUCTIVE ACTIVITIES	Article 19 - Prescriptions and other conditions for the authorizations	Article 19 - Prescriptions and other conditions for the authorizations
			Article 20 - Balance Zero	Article 20 - Balance Zero
		SECTION IV - AGRICOLTURE	Article 21 - Misures of promotion for good agricoltural practices	Article 21 - Promotion misures of good agricultural practices
		SEZIONE V SUSTAINABLE USE OF ENERGY	Article 23 - Misures of promotion for the enviornmenta sustainablity of public buildings and of the electric power plants throught the use of not emissive renewable energy sources	Article 23 - Promotion misures for the environmental sustainability of public buildings and of electric energy plant throught the use of not emitting renewable energy sources
			Article 26 - Regulatory of the combustion apparatus destinated to domestic heating	Article 26 - Regulatory of the combustion apparatus destinated to domestic heating
			Article 31 - Monitoring	Article 31 - Monitoring
	POR-Fesr 2014-2020 Programma operativo regionale	Axle 3 - Competitivity and actractivity of the productive system	Actions - All - Economic support for the companies	Actions - All - Economic support for the companies
		Axle 4 - Promozione della low carbon economy nei territori e nel sistema produttivo - Promotion of low carbon economy in the territories and in the productive system	Action 4.1.2 - Installation of production systems from renewable energy sources	Action 4.1.2 - Installation of production systems from renewable energy sources
			Azione 4.2.1 - Incentives finalized to the riduction of energy consumes and of greenhouse gasses	Azione 4.2.1 - Incentives finalized to the riduction of energy consumes and of greenhouse gasses

4.3. Synthesis of Tecnichal Implementation Plan 2017-2019 of Regional Energy Plan 2017-2030

Tabella 20- Synthesis of Tecnichal Implementation Plan 2017-2019 of REP 2017-2030 [17]

Axis 1. Development of regional system of research, innovation and training	
	Support to the network of High Technology research laboratories
	Support for innovative research projects promoted by institutions, enterprises, associations
	Reorganization of the system of professional qualifications
Axis 2. Development of green economy and green jobs	
	Training actions in the field of green economy
	Support for the green economy sector projects
	Support for the development of new businesses in the green economy
	Facilitated finance for the development of guarantee for green economy
	Strengthening Greener Observatory
	Development of protocols, agreements, conventions with third parties
Axis 3. Qualification of companies (industry, services and agriculture)	
	Support for energy efficiency projects to companies (local area networks, energy management, etc.).
	Qualification, energetic and environmental, of productive areas
	Support for the production of agro-energy
	Support for qualifying energy projects of agricultural enterprises
Axis 4. Requalification building, urban and regional	
	Energy qualification for construction and public assets
	Urban and regional energetic requalification
	RES support (self-production, cogeneration)
	Smart grid development
	Private building energy qualification
	Development of energy certification procedures for buildings
Axis 5. Development of sustainable mobility	
	Support for carrying PUMS
	Support to infomobility
	Local public transport development
	Interventions for modal interchange
	Promotion of infrastructures for bicycle and pedestrian mobility
	Integrated transport planning and mobility indicators database
	Support measures aimed at dissemination of low emission vehicles
	Support for incentive measures on train transport of goods and people
Axis 6. Regulation of the sector	
	Update L.R. n. 26/2004
	Updating Regulation by localization systems for electricity generation RES
	Simplification and coordination for the regulation of the sector
	New Regional Law on Territorial and Urban Planning
Axis 7. Support the role of local authorities	
	Support for preparation and monitoring of SEAP / PAESC
	Support for the implementation of the SEAP / PAESC

[17] Web link to the new Regional Energy Plan of Emilia-Romagna: 2016-2030 + Triennial Implementation Plan 2017-2019

	Support for development of energy function in the municipalities and unions of municipalities
	Support for local authorities programming, desks for energy and territorial energy agencies
Axis 8. Information, communication and technical assistance	
	Development of regional energy desks
	Relationships with schools and universities
	Information and guidance
	Management of the Regional Energy Plan
	Information System and Regional Energy Observatory
	Monitoring and evaluation of interventions

5. Appendix: REGIONAL AIR EMISSION INVENTORY 2010

- Source: Arpae-Inemar-2010 -

Tabella 27- Regional emission inventory summary 2010 of Emilia-Romagna

	CO tonn	%	COV tonn	%	NOx tonn	%	SO_2 tonn	%	PM_{10} tonn	%	NH_3 tonn	%	CH_4 tonn	%	CO_2 ktonn	%	N_2O tonn	%
M 1: Combustione - Energia	6.003	3	1.534	2	9.482	9	430	2	86	1	0	0	4.135	2	9.956	25	79	1
M 2: Combustione - non industriale	83.256	47	28.309	29	8.729	8	1.194	7	5.395	40	154	0	5.479	3	10.093	26	956	11
M 3: Combustione - industria	4.501	3	1.770	2	12.207	11	9.773	56	993	7	0	0	358	0	6.468	17	391	4
M 4: Processi produttivi	8.333	5	7.645	8	3.077	3	4.540	26	617	5	1.106	2	868	1	3.920	10	30	0
M 5: Estraz. Distribuz. combustibili fossili	0	0	5.187	5	0	0	0	0	0	0	0	0	40.319	24	0	0		0
M 6: Uso solventi	0	0	39.883	40	15	0	2	0	4	0	1	0	0	0	0	0		0
M 7: Trasporti stradali	68.266	39	12.498	13	60.675	57	371	2	4.593	34	832	2	1.138	1	12.697	32	356	4
M 8: Altre sorgenti mobili	6.231	4	2.055	2	11.300	11	1.005	6	1.524	11	2	0	48	0	934	2	306	3
M 9: Trattamento e smaltimento rifiuti	255	0	62	0	622	1	183	1	6	0	128	0	53.351	31	550	1	156	2
M 10: Agricoltura	0	0	59	0	637	1	0	0	418	3	49.299	96	63.680	38	0	0	6.785	75
M 11: Altre sorgenti di emissione ed assorbimenti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5.455	-14	0	0
Totale	176.846	100	99.002	100	106.745	100	17.499	100	13.637	100	51.522	100	169.377	100	39.163	100	9.059	100

Tabella 28- Regional emission inventory summary 2010 of Emilia-Romagna

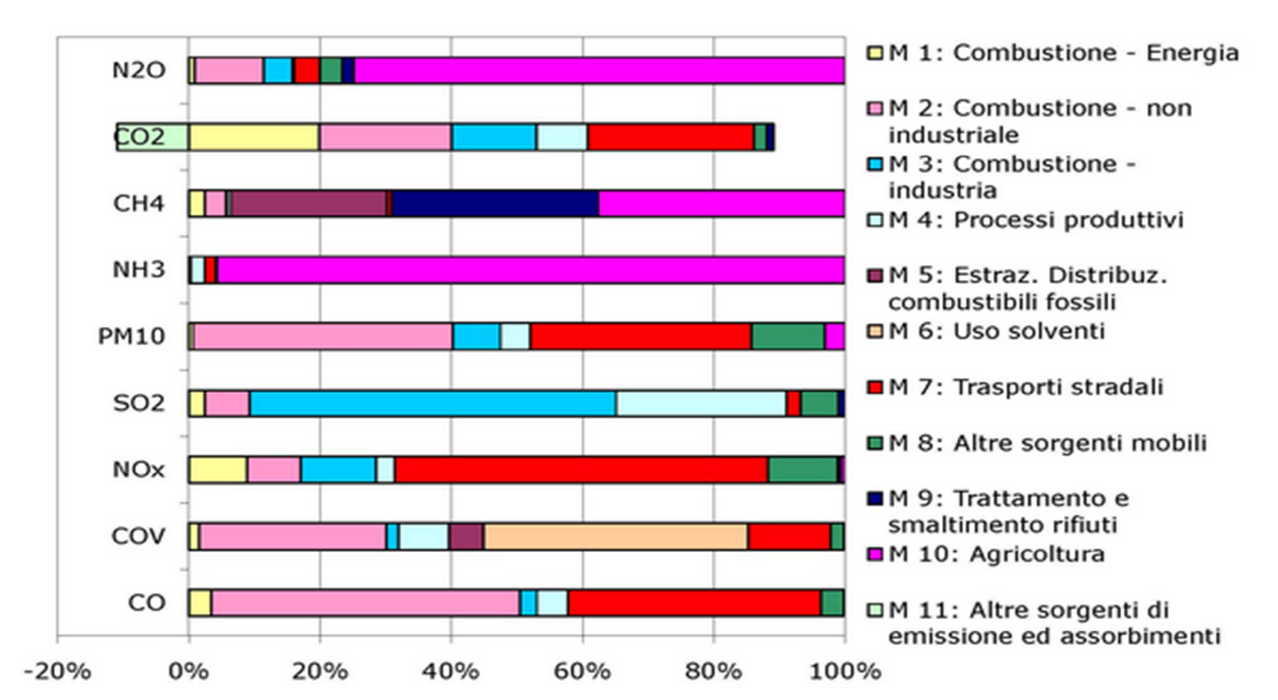


Tabella 29- Regional emission inventory summary 2010 of Emilia-Romagna - part 1 - [INEMAR, 2010, a]

1	SETTORI	Sum CO	%	Sum SO2	%	Sum COV	%	Sum CH4	%	Sum NOx	%
2	**Agricoltura**	**0**		**0**		**58**	0.06%	**63,680**	37.60%	**638**	0.60%
3	Coltivazioni con fertilizzanti	0		0		0		0		638	0.60%
4	Coltivazioni senza fertilizzanti	0		0		0		0		0	
5	Emissioni di particolato dagli allevamenti	0		0		0		0		0	
6	Fermentazione enterica	0		0		0		47,491	28.04%	0	
7	Gestione reflui riferita ai composti azotati	0		0		0		0		0	
8	Gestione reflui riferita ai composti organici	0		0		58	0.06%	16,189	9.56%	0	
9	**Altre sorgenti e assorbimenti**	**0**		**0**		**0**		**0**		**0**	
10	Foreste - assorbimenti	0		0		0		0		0	
11	**Altre sorgenti mobili e macchinari**	**6,230**		**1,005**		**2,055**		**47**		**11,300**	
12	Agricoltura	5,803	3.28%	141	0.81%	1,846	1.86%	47	0.03%	10,103	9.46%
13	Attività marittime	0		828		72		0		914	
14	Traffico aereo	427		36		137		0		283	
15	**Combustione nell'industria**	**4,501**		**9,774**		**1,770**		**357**		**12,208**	
16	Combustione nelle caldaie turbine e motori a combustione interna	1,256		2,456		230		265		6,658	
17	Forni di processo senza contatto	28		125		7		7		400	
18	Processi di combustione con contatto	3,217		7,193		1,533		85		5,150	
19	**Combustione non industriale**	**83,256**		**1,195**		**28,308**		**5,480**		**8,730**	
20	Impianti commerciali ed istituzionali	6		0		1		1		10	
21	Impianti residenziali	83,250		1,195		28,307		5,479		8,720	
22	**Estrazione e distribuzione combustibili**	**0**		**0**		**5,187**		**40,318**		**0**	
23	Distribuzione di benzine	0		0		3,966		0		0	
24	Reti di distribuzione di gas	0		0		1,221		40,318		0	
25	**Processi produttivi**	**8,333**		**4,541**		**7,646**		**867**		**3,077**	
26	Processi nelle industrie chimiche inorganiche	580		3,338		560		806		2,482	
27	Processi nelle industrie chimiche organiche	0		0		1,553		0		44	
28	Processi nelle industrie del ferro e dell'acciaio e nelle miniere di carbone	7,579		17		350		61		344	
29	Processi nelle industrie di metalli non ferrosi	173		9		0		0		16	
30	Processi nell'industria del legno pasta per la carta alimenti bevande e altro	1		1,177		5,183		0		191	
31	**Produzione energia e trasformazione combustibili**	**6,003**		**430**		**1,534**		**4,135**		**9,482**	
32	Miniere di carbone - estrazione oli/gas - compressori per tubazioni	89		0		130		1,731		37	
33	Produzione di energia elettrica	5,383	3.04%	424	2.42%	1,337	1.35%	2,337	1.38%	6,784	6.36%
34	Raffinerie	3		0		0		0		17	
35	Teleriscaldamento	528		6		67		67		2,644	
36	**Trasporto su strada**	**68,268**		**372**		**12,496**		**1,139**		**60,673**	
37	Automobili	27,568		192		1,970		492		15,087	
38	Ciclomotori (< 50 cm3)	2,278		0		1,837		30		78	
39	Motocicli (> 50 cm3)	19,811		8		3,387		240		308	
40	Veicoli a benzina - Emissioni evaporative	0		0		2,038		0		0	
41	Veicoli leggeri < 3.5 t	9,319		53		1,012		66		6,663	
42	Veicoli pesanti > 3.5 t e autobus	9,292		119		2,252		311		38,537	
43	**Trattamento e smaltimento rifiuti**	**253**		**183**		**60**		**53,350**		**621**	
44	Altri trattamenti di rifiuti	0		0		0		23		0	
45	Incenerimento rifiuti	62		179		29		0		458	
46	Interramento di rifiuti solidi	191		4		31		53,327		163	
47	**Uso di solventi**	**0**		**2**		**39,886**		**0**		**15**	
48	Altro uso di solventi e relative attività	0		0		14,827		0		0	
49	Produzione o lavorazione di prodotti chimici	0		2		4,643		0		15	
50	Sgrassaggio pulitura a secco e componentistica elettronica	0		0		124		0		0	
51	Verniciatura	0		0		20,292		0		0	
52	TOTALE	176,844		17,502		99,000		169,373		106,744	

Tabella 30- Regional emission inventory summary 2010 of Emilia- Romagna - part2 - [INEMAR, 2010, a]

1	SETTORI	Sum PTS	%	Sum CO2*	%	Sum N2O	%	Sum NH3	%	Sum PM10	%
2	**Agricoltura**	597	3.69%	0		6,785	74.95%	49,296	95.69%	418	3.07%
3	Coltivazioni con fertilizzanti	0		0		1,943	21.46%	11,641	22.60%	0	
4	Coltivazioni senza fertilizzanti	0		0		997	11.01%	1,245	2.42%	0	
5	Emissioni di particolato dagli allevamenti	597	3.69%	0		0		0		418	3.07%
6	Fermentazione enterica	0		0		0		0		0	
7	Gestione reflui riferita ai composti azotati	0		0		3,845	42.47%	36,410	70.68%	0	
8	Gestione reflui riferita ai composti organici	0		0		0		0		0	
9	**Altre sorgenti e assorbimenti**	0		-5,456		0		0		0	
10	Foreste - assorbimenti	0		-5,456		0		0		0	
11	**Altre sorgenti mobili e macchinari**	1,716		933		305		0		1,524	
12	Agricoltura	1,600	9.90%	802	2.05%	305	3.37%	0	0.00%	1,520	11.15%
13	Attività marittime	112		49		0		0		0	
14	Traffico aereo	4		82		0		0		4	
15	**Combustione nell'industria**	1,410		6,465		389		0		990	
16	Combustione nelle caldaie turbine e motori a combustione interna	279		4,562		300		0		222	
17	Forni di processo senza contatto	36		38		2		0		1	
18	Processi di combustione con contatto	1,095		1,865		87		0		767	
19	**Combustione non industriale**	5,646		10,094		956		153		5,395	
20	Impianti commerciali ed istituzionali	0		14		1		0		0	
21	Impianti residenziali	5,646		10,080		955		153		5,395	
22	**Estrazione e distribuzione combustibili**	0		0		0		0		0	
23	Distribuzione di benzine	0		0		0		0		0	
24	Reti di distribuzione di gas	0		0		0		0		0	
25	**Processi produttivi**	984		3,922		30		1,105		616	
26	Processi nelle industrie chimiche inorganiche	329		776		0		1,104		217	
27	Processi nelle industrie chimiche organiche	116		0		0		0		106	
28	Processi nelle industrie del ferro e dell'acciaio e nelle miniere di carbone	181		302		30		0		6	
29	Processi nelle industrie di metalli non ferrosi	20		57		0		1		19	
30	Processi nell'industria del legno pasta per la carta alimenti bevande e altro	338		2,787		0		0		268	
31	**Produzione energia e trasformazione combustibili**	96		9,956		78		0		86	
32	Miniere di carbone - estrazione oli/gas - compressori per tubazioni	0		383		12		0		0	
33	Produzione di energia elettrica	91	0.56%	8,887	22.69%	63	0.70%	0	0.00%	81	0.59%
34	Raffinerie	0		27		1		0		0	
35	Teleriscaldamento	5		659		2		0		5	
36	**Trasporto su strada**	5,703		12,696		353		830		4,596	
37	Automobili	2,397		7,154		235		774		1,844	
38	Ciclomotori (< 50 cm3)	47		24		0		0		43	
39	Motocicli (> 50 cm3)	84		220		4		4		73	
40	Veicoli a benzina - Emissioni evaporative	0		0		0		0		0	
41	Veicoli leggeri < 3.5 t	947		1,630		37		38		824	
42	Veicoli pesanti > 3.5 t e autobus	2,228		3,668		77		14		1,812	
43	**Trattamento e smaltimento rifiuti**	4		550		157		129		3	
44	Altri trattamenti di rifiuti	0		0		0		118		0	
45	Incenerimento rifiuti	4		442		151		11		3	
46	Interramento di rifiuti solidi	0		108		6		0		0	
47	**Uso di solventi**	4		0		0		1		3	
48	Altro uso di solventi e relative attivita	0		0		0		0		0	
49	Produzione o lavorazione di prodotti chimici	4		0		0		1		3	
50	Sgrassaggio pulitura a secco e componentistica elettronica	0		0		0		0		0	
51	Verniciatura	0		0		0		0		0	
52	**TOTALE**	16,160		39,160		9,053		51,514		13,631	

Index - part 3.3 -

LEGISLATION FOR AUTHORIZATION

1. BIOMASS POWER PLANTS LEGISLATION FOR AUTHORISATION

1.1. Basic LEGISLATION for authorization to the construction of solid biomass or biogas power plants

1.1.1. General overview

The European Union with the Directive 2001/77 / EC and subsequent amendments by 2006/108 / EC and 2009/28 / EC on the promotion of electricity produced from renewable energy sources in the internal electricity market, asked, among other things, to the Member States to simplify and facilitate the construction of power plants, in order to facilitate development of the offer of energy from renewable sources (RES).
In implementation of these mentioned Directives the framework of the authorization regimes for RES systems has been regulated at national level in Italy, first with the Legislative Decree num. 387 of 29 December 2003, and then with the Legislative Decree num. 28 of 3 March 2011.

[Energy and Citizens, 2015, in - November 4, 2013]

1.1.2. National legislation

1.1.2.1. - D.Lgs. 387/2003 - Legislative Decree of 29 December 2003 n. 387: Implementation of Directive 2001/77 / EC concerning the promotion of electricity produced from renewable energy sources in the internal electricity market.

This contains specific provisions relating to individual energy sources, to simplify rules and streamlining of authorization procedures, the provision of a campaign of information and communication in favor of the aforementioned sources, as well as the inclusion of waste among the energy sources eligible to benefit from the economic regime reserved for renewable sources. The Decree in brief provides:

- The increase in the minimum rate of 2% of energy from renewable sources to be introduced into the electricity grid, as per art. 11, D.Lgs. N. 79/99 (art. 4, c. 1) from the year 2004 until 2006;
- The guarantee of origin of electricity produced from renewable sources issued by GRTN (operator of the national electricity grid) in the presence of annual production, or rather attributable production, not less than 100 MWh;
- The simplification of authorization procedures for plants using renewable energy sources and the single authorization granting by the region or other institutional body delegated by it, for the construction and operation of the power plants fueled by renewable sources; for the conduct of the proceedings must be approved the guidelines for the Joint Conference, at the proposal of the Minister of Production Activities, in agreement with the Minister of Environment and Protection of Natural Resources and the Minister for Heritage and cultural activities;
- Regulations on green certificates.

In accordance with Directive 2001/77 / ECthe article 2 of Legislative Decree n. 387 called "renewable energy sources" shall mean renewable non-fossil sources: wind, solar, geothermal, wave, tidal, hydropower, landfill gas, the residual gases from purification processes and biogas, biomass (ie the biodegradable fraction of products, waste and residues from agriculture - including vegetal and animal substances - from forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste).
The definition introduced by Legislative Decree corresponds to that of renewable sources in Article 2, letters a) and b) of Directive 2001/77 / EC.
For "electricity produced from renewable energy sources" means - under the same Article 2 entitled "Definitions" - that one produced by plants using only renewable energy sources, the production attributable to renewable energy sources in hybrid plants (ie produce energy using and renewable sources, and non-renewable sources) as well as electricity from renewable sources used for filling storage systems, but excludes electricity produced as a result of storage systems.

To stimulate the construction of new plants fueled by renewable energy, art. 12 "Streamlining and simplification of authorization procedures" of the Legislative Decree n. 387 under consideration, in implementing the provisions of Article 6 of Directive 2001/77 / EC, it intervenes on discipline for authorization to construct and operate plants powered by renewable energy, in order to make it more simple and certain, arranging the release regional single authorization for the construction of plants powered by renewable sources, as well as for the realization of works connected and declares those works of public utility, can not be postponed and that are urgent.
This Article reaffirms in fact that the works for the construction of plants powered by renewable sources, as well as the works connected and the infrastructures necessary to the construction and operation of these plants, are works of public utility and urgent that can not be postponed, establishing that the construction and operation of plants for the production of electricity using renewable sources, the editing operations, upgrading, total or partial reconstruction and reactivation, as well as the works connected and the infrastructures necessary for construction and operation of the plant, are subject to an authorization only issued by the region or other institutional body delegated by this, in compliance with the regulations relating to the landscape and the historical and artistic heritage and environmental protection.
This authorization is issued following a single procedure (lasting a maximum of 180 days), with the participation of all relevant government departments. The granting of authorization is entitled to build and exercise the plant in accordance with the approved project.
In the Unified Conference, proposed by the Minister of Productive Activities jointly with the Minister of Environment and Land Protection and the Minister of Heritage and Culture, are approved guidelines for the conduct of the single procedure: these guidelines must be aimed, in particular, to ensure the correct insertion of the plants in the landscape, with specific regard to wind farms. In implementing these guidelines, the regions can indicate areas and sites unsuitable for the construction of specific types of plants.

The article also allows to locate these plants even in the areas classified as agricultural by the current urban plans, The article also allows to locate these plants even in the agricultural areas classified by the current urban plans, although it should take into account the provisions relating to support in the agricultural sector, with particular reference to the promotion of local food traditions, the protection of biodiversity, as well as the cultural heritage and the rural landscape.

The plants of electricity generation with a total power of not more than 3 MW thermal, located within the waste disposal landfill, fueled by landfill gas, residual gases from purification processes and biogas are also considered as minor air pollution and their exercise does not require authorization [1].

The article 12 of Legislative Decree 387/03 specifies that the construction, operation, modification, upgrading, renovation and reactivation of plants producing energy from renewable sources, including the re-pristine as a result of the divestiture:

A. they are subject to Single Authorization or to simplified certificates of permission for minor plants;
B. according to the norms on environmental protection, landscape, historical and artistic heritage;
C. the single procedure is substantially held in the form of conference services with the participation of all relevant government departments (called up by law to express acts of assent to the installation) which evaluates primarily the observance of this protective legislation;
D. for the agricultural area it is stated that:
    - you do not need the urban variant or law because RES systems are compatible with the agricultural use;
    - in these spheres must be taken into account for the single authorization / SCIA / release of HPs, of the provisions relating to support in agriculture, agri-food traditions and biodiversity protection, cultural heritage, the rural landscape;
E. are there national guidelines (LLGGNAZ), concerning:
    - the conduct of the single procedure;
    - criteria for the correct spatial placement of implants in the landscape (in particular those wind);
    - indications to the regions for the definition of the areas and sites not suitable;
F. the regions:
    - they can proceed to the indication of areas and sites not suitable, in implementing the guidelines
    - adapt its rules on the conduct of the single procedure within 90 days,spent uselessly this period, we apply the rules of national guidelines.

1.1.2.2. - D.Lgs 152/2006 - Legislative Decree of 3 April 2006 n. 152 - "Environmental Regulations"

Legislative Decree 152/2006, and subsequent amendments, contains in Part V the "Rules on air protection and reduction of atmospheric emissions," Title III "fuels".
The rules governing air emissions orient their limitations and requirements in function of the thermal nominal power of the plant, and not of the delivered power.
Article 293 of Legislative Decree 152/2006 (permitted fuels) states that "*in the installations covered by Title I and Title II of Part Five, including civilians thermal plants of thermal power lower than threshold value, may be used only the planned fuel for these categories of plants by the Annex X at part Five, under the conditions specified therein. The materials and substances listed in Annex X, at fifth part of this Decree, can not be used as fuel within the meaning of of this title if it is waste within the meaning of Part IV of this decree.*"
Annex X at the part V lists in Part One of the permitted fuels, for industrial plants (section 1) and heating systems (section 2), in both cases there are firewood and biomass fuels. Legislative Decree 152/2006, at last, defines the national emission limits for plants powered by biomass fuels. These are indicated in Annex I to Part V of the said Decree, whose Part III establishes the "emission values for specific types of plants."

[1] In practice, only plants using gas not coming from waste can enter into the ordinary authorization system.

Legislative Decree 152/2006 also defines the national emission limits for plants using biomass fuels. These are indicated in Annex I to Part V of the said Decree, whose Part III establishes the "emission values for specific types of systems."

1.1.2.3. - DM 10/09/2010 - Decree of the Ministry of Economic Development September 10, 2010 - "Guidelines for the authorization of plants fueled by renewable sources"

The Ministerial Decree 201/09/10, in implementation of Legislative Decree 387/03, have been approved the National Guidelines for the authorization of plants powered by renewable sources, while respecting the autonomy and competences of local governments, They were enacted in order to harmonize regional procedural processes for the authorization of electricity generation plants using renewable energy sources (RES).
In particular, the D.M. It provides that the regions can put restrictions and prohibitions proceedings of programmatic or planning type for the installation of specific types of plants.
Specifically, these guidelines state:

- source by source, and types of plants and modalities of installation that allow the access to the simplified authorization procedures;
- content of applications, how to start and conduct of the single authorization procedure;
- the criteria and procedures for plant placement in the landscape and territory, particularly with regard to wind farms.

(* The Region of Emilia Romagna approved the locational criteria with the Legislative Assembly Resolutions no. 28 of 6 December 2010 and no. 51 of 26 July 2011, the first one relating to photovoltaic plants, and the second one relating to wind farms, biogas , biomass and hydro power.)

1.1.2.4. - D.Lgs 28/2011 - Legislative Decree of 3 March 2011 n. 28 ("Renewable Decree") - Implementation of Directive 2009/28 / EC on the promotion of energy from renewable sources amending and subsequently repealing Directives 2001/77 / EC and 2003/30 / EC.

D.Lgs 28/2011 "Renewable Decree" has added additional simplification and rationalization of administrative procedures for the construction of RES plants (Renewable Energy Sources), both for electricity generation and for the production of thermal energy.
In particular it has been introduced the so-called simplified enabler procedure (SEP) (PAS in Italy) which has replaced the SAR (Start Activity Report) (DIA in Italy), and RCAS (Reporting Certified Activity Start) (SCIA in Italy) to authorize plants with different performance depending on the type of source used, leaving the Regions the opportunity to raise the power thresholds for PAS to 1 MWe and thresholds for communication up to 50 kWe.

The PAS introduces important new features compared to previous legislation: particularly relevant the fact that now the municipalities are required to make timely and / or to acquire in all cases the "acts of agreement" eventually required (for environmental restrictions, landscape, historical, artistic, etc.), in all cases where these are not attached to the declaration. In addition, in paragraph 9 of Article 6, the Decree provides that the regions (and Autonomous Provinces) can extend the simplified enabler procedure to the nominal electric power plants up to 1 MW electric.
Anyway, in the absence of specific regional requirements, the reference thresholds below which it is sufficient PAS remain those of Table A attached to Legislative Decree 387/2003 and resumed by

National Guidelines. But perhaps the truly innovative aspect of PAS is that the authorization regulation for the construction of small renewable energy plants is disconnected from building industry (Presidential Decree 380/2001: Unique Act about Building), at which until yesterday it had been "assimilated."

Instead of the Communication of Start Works to the Municipality, sufficient in some cases instead of PAS, it is not in any way changed by the D.lgs 28/2011 and therefore continues to maintain the assimilation to the interventions of "free building activities", as well as regulated by the Unique Law Act about Building.
In summary the authorization procedures are planned depending on the type of renewable energy, on operating modalities of installation mode and of installed power, and they are divided into:

- COMMUNICATION → Competent Authority: Municipality;
- PAS → Simplified Enabler Procedure: Competent Authority: Municipality;
- AU → Unique Authorization: Competent Authority: Province / Region.

Tabella 1-Authorization procedures for biomass plants (by direct combustion) [2]

OPERATING MODE / INSTALLATION	POWER electric KW	AUTHORIZATION REGIME
Micro-cogeneration plants	0-50	**Comunication to the Municipality** (art.27 c.20, L. n. 99/2009)
Plants buid in existing buildings provided they do not alter the volumes and surfaces, do not involve changes to the use destination, do not affect the structural parts of the building, do not result in increase in the number of building units and do not involve increase in urban parameters	0-200	**Comunication to the Municipality** (art. 6 c. 2, lettera a) DPR 380/01)
Small cogeneration plants not falling in the previous cases	50-1000	**PAS from Municipality**
Plants up to 200 kWe and not falling in the previous cases	0-200	**PAS from Municipality**
Different plants respect the previous cases	≤ 50 MW thermic	**AU from Province**
	> 50 MW thermic	**AU from Region**

[2] The indirect combustion plants are those using pyro/gasification.

Tabella 2-Authorization procedures for biogas plants.

TECHNOLGY / SOURCE	OPERATING MODE / INSTALLATION	POWER electric KW	AUTHORIZATION REGIME
Biogas	**Micro-cogeneration plants**	0-50	**Comunication to the Municipality** (art.27 c.20, L. n. 99/2009)
	Plants buid in existing buildings provided they do not alter the volumes and surfaces, do not involve changes to the use destination, do not affect the structural parts of the building, do not result in increase in the number of building units and do not involve increase in urban parameters	0-200	**Comunication to the Municipality** (art. 6 c.2, lettera a) DPR 380/01)
	Small cogeneration plants not falling in the previous cases	50-1000	**PAS from Municipality**
	Plants up to 250 kWe and not falling in the previous cases	0-250	**PAS from Municipality**
	Different plants respect the previous cases	≤ 50 MW thermic	**AU from Province**
		> 50 MW thermic	**AU from Region**

1.1.3. Regional regulatory for Emilia-Romagna

1.1.3.1. - D.A.L. 51/2011 - Deliberation of the Legislative Assembly of 26 July 2011, n. 51 "Identification of areas and sites for the installation of electricity generation plants using renewable energy sources, wind energy, biogas, biomass and hydro power

The Emilia-Romagna Region, in implementation of the National Guidelines, has given indications about the areas for the installation of plants using renewable sources. As for wind power plants, biogas, biomass and hydropower with DAL num. 51 of 26 July 2011, the Region has identified areas and sites for their installation distinguishing between:

- areas unsuitable for installation of the systems;
- suitable areas but on the condition that the plants have determined maximum power and / or respect certain construction conditions;
- suitable areas, without special conditions for the plants.

In the deliberation are listed for each type of plant (wind, biogas, biomass, hydro) the special protection areas landscaping, as classified and perimetrate in PTPR or Regional Landscape Territorial Plan. In this thesis, in relevance to its content, we will cover only paragraphs 3 and 4 of D.A.L. 51/2011 related to:

1.1.3.2. - CASE A - "ENERGY FROM BIOGAS AND PRODUCTION OF BIO-METHANE" for bio methane production plants to be fed in and biogas energy are defined as those fueled by biomass under article 2 c.1, letter e of the D. Lgs 28/2011.

A. They are considered **unsuitable** to the installation of plants producing energy from biogas and biomethane production the following areas:
   1. the special lanscape protection areas listed below , as perimetrated in regional spatial plan Landscape (PTPR) or in the provincial and municipal levels which had implemented in its execution:
      1.1. Areas of nature conservation (article 25 PTPR)
      1.2. Areas of coastal protection and of beach (Art.15 PTPR)
      1.3. Reservoirs and river beds of lakes, basins and waterways (article 18 PTPR)
      1.4. Ridges (art.20 c.1, letter a) PTPR)
      1.5. Gullies (art.20 C.3 PTPR)
      1.6. Archaeological complexes (c.2 art.21, letter a) and b1) PTPR)
   2. Areas covered by fire (Law 353/2000)
   3. Zones A and B of the Parks (Law 394/1991 and LR 6/2005)
   4. Natural Reserves (Law 394/1991 and LR 6/2005)

B. It is considered **unsuitable**:
   the area of production of Parmigiano-Reggiano cheese, except in cases where the plants do not use corn silo and digestate spreading occurs outside the area.

C. They are considered **eligible** areas:
   the cultivation areas of meadowland falling in nature conservation areas (article 25 TCP), provided they are livestock farms and do not use corn silage.

D. They are considered **eligible** areas:
   areas of the system of ridges and hill system at heights over 1,200 m, provided that the applicant is established and in of self-production regime.

E. They are considered **eligible** areas:
   special protection areas the SPA and SCI sites of Community importance, provided that the applicant is established at the date of August 5, 2011.

F. They are considered **eligible** areas:
   agricultural areas (outside of the cases referred to in points A, B, C, D, E) and productive areas.

In DAL 51/2011 are also shown all the technical requirements for this type of plant, and it is specified that the municipalities can be identified in its RUE (the Building planning rules) additional minimum distances for the location of these plants.

1.1.3.3. - CASE B - "ENERGY FROM DIRECT BIOMASS COMBUSTION " for biomass plants are defined as those that use the materials indicated art.2 c.1, letter e of the D.lgs 28/2011.

A. They are considered **unsuitable** to the installation of plants producing energy from biomass combustion the following areas:
   1. the special lanscape protection areas listed below , as perimetrated in regional spatial plan Landscape (PTPR) or in the provincial and municipal levels which had implemented in its execution:
      1.1. Areas of nature conservation (article 25 PTPR)
      1.2. Areas of coastal protection and of beach (Art.15 PTPR)
      1.3. Reservoirs and river beds of lakes, basins and waterways (article 18 PTPR)

1.4. Ridges (art.20 c.1, letter a) PTPR)
1.5. Gullies (art.20 C.3 PTPR)
1.6. Archaeological complexes (c.2 art.21, letter a) and b1) PTPR)
2. Areas covered by fire (Law 353/2000)
3. Zones A and B of the Parks (Law 394/1991 and LR 6/2005)
4. Natural Reserves (Law 394/1991 and LR 6/2005)

B. They are considered **eligible** areas:
areas of the system of ridges and hill system at heights over 1,200 m, provided that the applicant is established and in of self-production regime.

C. They are considered **eligible** areas:
special protection areas the SPA and SCI sites of Community importance, provided that the applicant is established at the date of August 5, 2011.

D. They are considered **eligible** areas:
agricultural areas (outside of the cases referred to in points A, B, C) and productive areas.

In DAL 51/2011 are also shown all the technical requirements for this type of plant, and it is specified that the municipalities can be identified in its RUE (the Building planning rules) additional minimum distances for the location of these plants.

1.1.3.4. DGR 362/12 - Regional Council Deliberation of 26 March 2012 n. 362: "Implementation of D.A.L. 51 of 26 July 2011 - Approval of the criteria for the elaboration of emission computation for biomass power plants"

With DGR 362/12in implementation of previous D.A.L. num. 51/11 laying down general location criteria for the installation of power plants through the use of renewable energy sources (wind, hydro, biogas and biomass burning), the Region has aimed at promote the adoption of the best technology, to enhance the short chain within 70 km and to assess the cumulative effect that may result from the concentration of more plants in the territory.

In addition to this it defined the criteria for the emission calculation of biomass power plants.

As regards the plants for the production of energy from biomass having nominal thermal power exceeding 250 kW thermal, shall apply the following general criteria:

- on the whole regional territory installations must use the best available techniques.
- in the areas of exceedance (**RED**) and at risk of exceeding (**ORANGE** and **YELLOW**) of cartography below about the air quality standards (EQS) it is possible locate plants only on condition that they replace existing emission sources, and it is ensured a overall balance of at least egual to zero emissions of PM10 and NO2 in the atmosphere.

It is also foreseen that in these areas can be installed new plants in the case where:

- they replace old existing plants;
- they are accompanied by actions capable to guarantee the simultaneous reduction of pollution in the territory (cogeneration and trigeneration, use of heat, district heating, energy efficiency, cycle tracks and pedestrian, etc.).

These conditions must be proven by any specific report to be submitted to the plant application for authorization that certify the balance emission of the plant.

The EMISSION COMPUTATION consists in demonstrating that emissions into the atmosphere, generated by the new plant, to be compensated by the shutdown or reduction of existing emission sources, using the following formula:

Balance Emissive Emissions =
new plant emissions – turned off or reduced emissions $\leq$ 0

This assessment among other things must also take account of:

- reference timeframe for achieving the objective as well as the possible compensation with other emission sources;
- use of a plant layout in cogeneration or regeneration regime;
- conclusion of agreements that ensure the realization of the conditions of compatibility of the same, which can among other things foresee the use, even in the longer time, the thermal energy produced by the plant for different uses, as agreed with the local authorities territorially competent.

In other areas (GREEN) it must employ a precautionary criteria to maintain acceptable air quality.
The current law requires interventions to maintain good air quality in the areas where they are not needed remediation.
To this end, ARPA has prepared a voluntary instrument, the online software ABACO, aimed at a preliminary assessment of the at risk of exceeding about the air quality standards required by law (annual average of 40 micrograms / m3 NO2 and PM10 and 35 days year exceeded the daily limit of 50 ug / m3 PM10), to be applied in areas identified as "green."

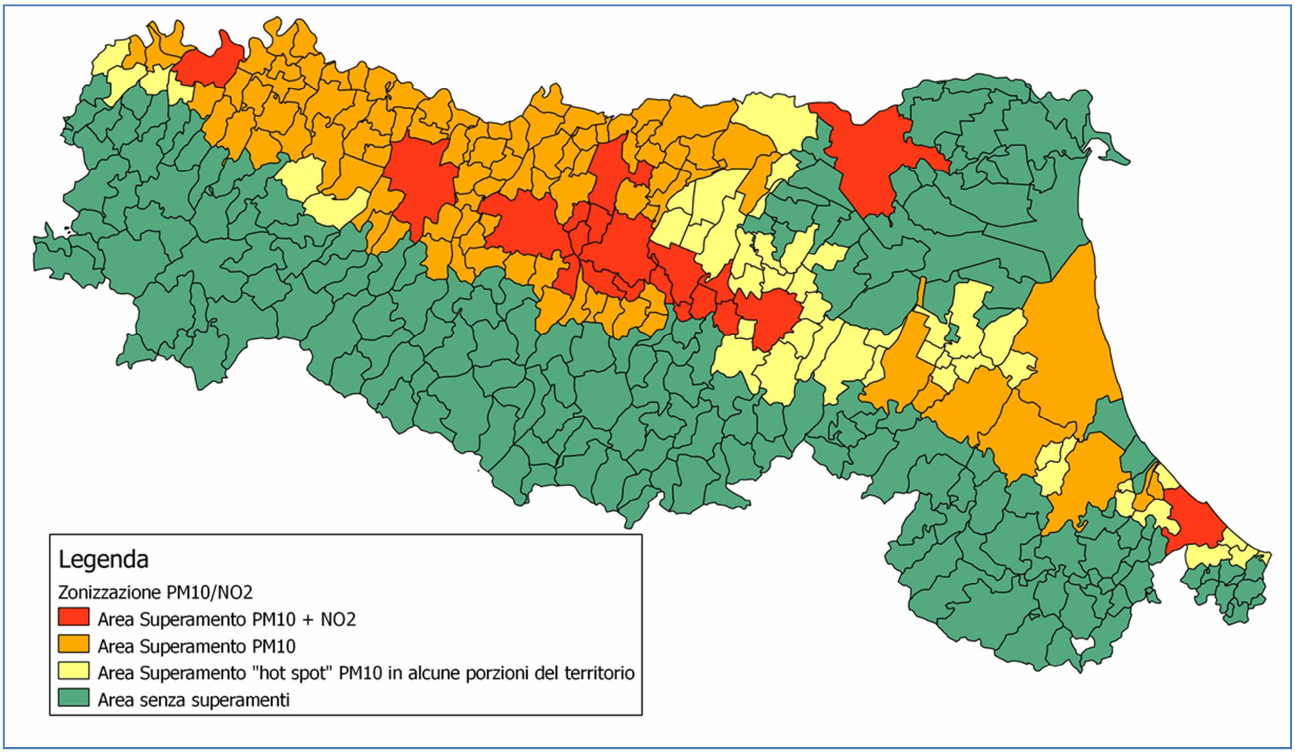


Figura 1- Zoning PM10 / NO2 annexed to DAL 51 of 26 July 2011.

To facilitate and standardize the regional emissions calculations together with the evaluation of integration actions which may be indicated by the offeror, ARPA and Emilia-Romagna have created a simplified method by making available an on-line program for the calculation of the **Balance Emissive Emissions**, that can be used by accessing the website:
http://service.arpa.emr.it/biomasse/ComputoSaldoEmissivo.aspx .

The online software automatically select the application to be followed according to the municipality where we want to evaluate the opportunity to put into operation a biomass plant:

- " **ZERO BALANCE COMPUTATION**" for Municipalities classified with red, orange or yellow color.
- "**ABACO**" for Municipalities classified with green color.

See following chapters for further explanations:

1. *The certification and the calculation of the zero balance computation for biomass plants located in red, orange or yellow zone*

In accordance to the Legislative Assembly Resolution no. 51/2011, the applicant must attach to the application and to the project a document, prepared by a qualified technician, certifying the balance emission of the plant (Certification of emission balance). This document consists of:

- A technical report describing:
  - the characteristics of the plant,
  - the atmospheric emissions generated by energy conversion processes,
  - the emissions from transportation of biomass, if not already described in the project documents contained in the application for authorization to construct and operate the plant;
  - the emission sources that will be extinguished or reduced with the entry into operation of the plant,
  - the intergrate the measures for the calculation of the emission balance and consequently reduced emissions;
  - the emissive balance assessment for PM10 and NO2;
  - the path for the realization of integrated actions and the time period to referring,
  - the possible existence of agreements with municipal and provincial authorities or other public or private entities.
- copy the outcome of emission computation performed through the application available on the site: www.biomasse-emissionizero.emilia-romagna.it ;
- copy of any agreements with municipal and provincial authorities or other public or private entities;

The attestation of the document of emission balance, including any agreements signed to ensure the realization of the compatibility conditions of the plant, shall be attached the authorization.

The EMISSION COMPUTATION consists in demonstrating that emissions into the atmosphere, generated by the new plant, to be compensated by the shutdown or reduction of existing emission sources, using the following formula:

Balance Emissive Emissions =
new plant emissions – turned off or reduced emissions $\leq$ 0

In the assessment of the total emission balance must therefore be counted existing emission sources to be "off" or reduced with the entry into operation of the plant.
They are configured in particular two possible cases:

- Replacement of emissions from existing plants;

- Installation of new plants with a simultaneous reduction of total emissions in the territory through the creation of compensatory measures, localized as a priority in the same town or area, depending on the location, falling in the contiguous areas of other municipalities, to be defined with competent authorities also through possible agreements.

To define the emission balance of the plant must therefore be quantified 3 components:

1. **Emissions generated by the installation to be undertaken including those arising from the transport of biomass;**
2. **Emissions from any plants that are replaced by the plant biomass;**
3. **Emissions saved through the implementation of compensatory measures identified in the reference area.**

For this purpose we should also take into account:

- the reference time period to achieve the objective as well as the possible compensation with other emission sources.
- the use of a plant configuration in cogeneration or regeneration regime
- the signing of agreements that ensure the realization of the same compatibility conditions, which can among other things foresee the use, even in the longer time, the thermal energy produced by the plant for different uses, as agreed with the local authorities territorially competent.

2. ***Estimate of the emissions generated by the new biomass plant***

For the calculation of pollutant emissions from the new plant must be considered the contributions of all the emission processes and the overall emissions of the pollutant i-th and must be calculated using the following methodology:

$$\mathbf{Ei = P\ (Nm3 / h) \times conc\ (mg / Nm3) \times h}$$

Where:
Ei (mg / y) = the emission of the pollutant;
P (Nm3 / h) = flow of smoke;
conc (mg / Nm3) = concentration of pollutants;
h (h / a) = operating hours per year.

The parameters used are those typical the plant and of the production process in question defined in the design phase, and it must be documented their provenance and reliability for the specific case.
For PM10 parameter must be used a conversion factor with respect to the concentration of total dust, which in the case of installations for the combustion of biomass is assumed equal to 0.7, on the basis of measurements made in Emilia Romagna and the of existing technical literature of matter.

Atmospheric emissions determined from biomass transport must be considered as part of the emission computation if the length of the path from the point of biomass production to the plant exceed 70 km.

For the emission factors (FE) to be used for the transport of biomass is referenced to the concerted instrument at Padanian level of INEMAR Basin (Air Emissions Inventory), that estimates the level of emissions on the basis of specific FE for passenger cars and commercial vehicles (Source Corinair) and distances traveled by each vehicle. The following table shows the classification of vehicles according to the registration classes under current legislation.

Tabella 3-Veicles classification in function of matriculation class

Tabella 2 - Classificazione dei veicoli secondo le classi di immatricolazione

Veicoli a benzina	
Pre EURO	Veicoli immatricolati fino al 1992
EURO I (91/441/EC)	Veicoli immatricolati dal 1992 al 1996
EURO II (94/12/EC)	Veicoli immatricolati dal 1997 al 2000
EURO III (98/69/EC)	Veicoli immatricolati dal 2000 al 2005
EURO IV (98/69/EC)	Veicoli immatricolati dopo l' 1/1/2006
Veicoli diesel	
Conventional	Veicoli immatricolati fino al 1992
EURO I (91/441/EC)	Veicoli immatricolati dal 1993 al 1996
EURO II (94/12/EC)	Veicoli immatricolati dal 1997 al 2000
EURO III (98/69/EC)	Veicoli immatricolati dal 2000 al 2005
EURO IV (98/69/EC)	Veicoli immatricolati dopo l' 1/1/2006
Autocarri diesel e benzina (<3,5 t)	
Conventional	Veicoli immatricolati fino al 1992
EURO I (91/441/EC)	Veicoli immatricolati dal 1993 al 1996
EURO II (94/12/EC)	Veicoli immatricolati dal 1997 al 2000
EURO III (98/69/EC)	Veicoli immatricolati dal 2000 al 2006
EURO IV (98/69/EC)	Veicoli immatricolati dopo l' 1/1/2007
Autocarri pesanti diesel (>3,5 t)	
Conventional	Veicoli immatricolati fino al 1992
91/542/EEC (Stage I)	Veicoli immatricolati dal 1992 al 1995
91/542/EEC (Stage II)	Veicoli immatricolati dal 1995 al 2000
EURO III (99/96/EC)	Veicoli immatricolati dal 2000 al 2005
EURO IV (99/96/EC)	Veicoli immatricolati dal 2006 al 2008
Motocicli >50cc	
Conventional	Veicoli immatricolati fino al 17/6/99
Euro I (97/24/EC)	Veicoli immatricolati dopo il 17/6/99

For each pollutant, the estimation of emissions from transport of biomass is based on data relating to the fleet of commercial vehicles used and to the length of the path within the region, through the following formula:

$$\mathbf{Ei = \sum iNi \times Li \times FEi}$$

Where:
N = number of vehicles used for the type of material transport vehicle;
L = length of the actual trip [km] from the points of supply of biomass that has impact on the areas where the zero balance is required;
FE = emission factor for vehicle type [g / km].

The emission factors of the main road transport vehicles are given in Annex II. These factors were calculated from data estimated Inventory of emissions INEMAR 2007 and the ongoing updates will be made available on site www.biomasse-emissionizero.emiliaromagna.it .

3. *Estimate of emissions from existing plants*

To calculate the emissions of existing plants replaced by the plant for which authorization is requested is used the same methodology described in the previous paragraph.

In this case the estimation of emissions from power plants must be based on emissions data "measured" through regular programs of analytical tests and self-controls or resulting from the monitoring systems of the emissions automatically (EMS).0

In case of unavailability of such data, the proponent will have to agree with the competent authority the methodology for estimation to be used. For the purposes of emission calculation, are considered as existing also decommissioned plants which fall within the categories described in paragraph c) number 2 of the resolution passed by the Legislative n. 51 of 26 July 2011.

In the case of existing plants intended for self own consumption, for already authorized changes, even if unrealized, involving the increase of the thermal capacity of the plant, the emission calculation takes into account the emissions avoided for loss of use of other fuels. The possible sobstitution of vehicles of transport for the supply of biomasses with less polluting vehicles should be quantified using the methodology described in the preceding paragraph and shall be considered in calculating emission as "reduced source."

4. *integrated measures for the calculation of the computation of the emission balance*

To check the emission balance of the biomass plant, specifications can be identified and accounted for measures involving the reduction of PM10 and NOx emissions in the reference area, located on basis at a priority in the same municipal area, to be determined with the competent authorities through some agreements.

In order to identify these measures in relation to different territorial situations, you can refer to the Inventory regional atmospheric emissions (INEMAR), briefly described in Annex IV and available in full version with detail on a municipal scale on the website http://www.smr.arpa.emr.it/inemar/webdata/main.seam .

As example only, the web site on www.biomasse-emissionizero.emilia-romagna.it also contains some possible actions and the related methodology for estimating the emissions of PM10 and NO2 saved, already shared with provincial governments during the environmental balance of the Restructuring Plan for air quality, relative to:

- realization remote heating installations for the replacement of systems fed with traditional fuels;
- interventions to increase the energy efficiency of buildings;
- replacement of local public transport vehicles with less polluting vehicles;
- construction of cycle and pedestrian paths.

1	**Stima emissioni risparmiate con l'utilizzo di nuove reti energetiche per la cogenerazione e il teleriscaldamento (t)**

Dati INPUT

Sup. riscaldate (mq) per titpologia di combustibile che verranno servite da teleriscaldamento

Metodologia di calcolo

Si stima il risparmio in termini di consumo di combustibile (e di conseguenza in termini di emissioni) come differenza tra il combustibile consumato nella rete di teleriscaldamento e il consumo che si avrebbe se la sup. riscaldata dal teleriscaldamento fosse stata riscaldata in modo tradizionale.

Dai dati di consumo complessivi di metano in Regione e i dati di superficie riscaldati a metano (input dell'inventario delle emissioni Regione Emilia-Romagna 2007) si ricava un consumo medio per m2 di superficie riscaldata è pari a 34 m3/mq (1,17 Gj/mq).

Pertanto sulla base del dato di superficie riscaldata con teleriscaldamento (dato INPUT) si stimano le emissioni evitate applicando un FE (mg/Gj) specifico per tipologia di combustibile al consumo di combustibile calcolato come sopra..

3	**Efficienza energetica degli edifici**

Dati INPUT

- Superficie (mq) dell'edificio oggetto dell'azione di efficientamento, relativa classe energetica e tipologia di combustibile utilizzato per il riscaldamento (colonna A per tipo di combustibile)
- Classe energetica obiettivo a seguito dell'intervento di efficientamento, espressa come superficie (mq) complessiva (colonna B per tipo di combustibile)

Metodologia di calcolo

La valutazione delle emissioni risparmiate avviene stimando il risparmio in termini di consumo energetico a seguito del cambio classe applicando opportuni FE (g/Gj) specifici per tipologia di combustibile.

CLASSE ENERGETICA	VALORE MEDIO EPtot PER CLASSE [kWh/(m2 x anno)]
A+	12,5
A	32,5
B	50
C	75
D	110
E	150
F	190
G	250

Il consumo di combustibile viene stimato sulla base della superficie dell'edificio interessato dall'intervento e l'indice di prestazione energetica per classe.

$$\Delta E = \sum_{I=1}^{n} FE_I (Canteoperam_I - Cpostoperam_I)$$

I = tipo combustibile
Canteoperam = consumo prima dell'intervento di efficientamento
Cpostoperam = consumo prima dell'intervento di efficientamento

2	Variazione di emissioni da TPL associate alla sostituzione dei mezzi (t/anno)
Dati INPUT	
Veicoli km percorsi dai mezzi TPL per tipologia di alimentazione e categoria ambientale sia prima della sostituzione dei mezzi (Situazione attuale) che come previsto dall'azione (Azione prevista)	
Metodologia di calcolo	
I veicoli km è un parametro che permette di quantificare i chilometri complessivamente percorsi dalle unità veicolari e si calcolano come $Veickm = \sum_{i=1}^{n} [N°veicoli_i \times km/anno]$ i = cat. Legislativa veicolare Le emissioni sono calcolate attraverso i fattori di emissione dipendenti dalla tipologia di combustibile e dalla classe di omologazione. $Em = \sum_{i=1}^{n} [[veickm/anno] \times FE_i]$ i = cat. veicolare Corinair I veicoli elettrici sono stati considerati ad emissione nulla, sebbene la produzione di energia elettrica comporti comunque un impatto in termini di emissioni atmosfera. Per quanto riguarda i filobus si è ipotizzato che una quota di veicoli km percorsi (pari al 10%) avvenga con motore alimentato a diesel.	

4	Piste ciclabili
Dati INPUT	
• Km di pista ciclabile che si intende realizzare • sviluppo complessivo della rete stradale del comune (km)	
Metodologia di calcolo	
La valutazione delle emissioni risparmiate avviene stimando le emissioni complessive da trasporto degli autoveicoli in ambito urbano (sulla base dei veickm per tipo di veicolo). Sulla base dell'hp che la realizzazione di una pista ciclabile porti ad una riduzione del 15% del traffico autoveicolare dell'arteria stradale a cui è affiancata si stima il risparmio andando ad applicare tale riduzione alla quota di emissioni da traffico autoveicolare in ambito urbano pari al rapporto tra i km di pista ciclabili realizzate e i km di strada urbana complessivi. $\Delta E = \sum_{I=1}^{n} E_{stradaurbana\_I} (1 - 15\% * kmpistaciclabile / kmstradaurbana)$ I = tipo autoveicolo	

Figura 2- Screenshots of formulas to use for transport emission budgets. [ARPA, 2013, a]

More integrated measures for the calculation of the emission balance can be identified by the applicant in agreement with the competent authorities, without prejudice to the need to make explicit the estimation methodology and the emission factors used.
The list of actions mentioned above will be updated with more integrated actions (such as agricultural supply chain practices that lead to the reduction of PM10 and NO2 emissions) when they become available related estimation methods and emission factors used.

The annexes related to the criteria for establishing the emission calculation and the user manual for the calculation of emission computation relating to the integrated actions help the user for the proper completion of Form for the calculation of emissions from the plant and of the integration measures that the applicant must attach to the application. The user can login to complete the form to the information contained in the Inventory of atmospheric emissions of the Emilia-Romagna Region.

On the website of ARPA Emilia-Romagna are available:

- The criteria for the elaboration of emission calculation
- The instruction handbook for the calculation of emission calculation
- The module for the calculation of emissions from the plant and of the integration measures that the applicant must accompany the application for authorization.

Are shown below of the sample images relating to the application ZERO EMISSIVE BALANCE:

Risultato

Emissioni Totali	NO_x (t/anno)	PM_{10} (t/anno)
Emissioni impianto	0	0
Emissioni trasporti	0	0
Emissioni complessive impianto	0	0

Risultati delle azioni	NO_x (t/anno)	PM_{10} (t/anno)
Nuove reti energetiche per il teleriscaldamento	0	0
Miglioramento dell'efficienza energetica degli edifici	0	0
Miglioramento dell'efficienza del parco mezzi adibiti al trasporto pubblico	0	0
Realizzazione di piste ciclabili	0	0
Sostituzione impianto esistente	0	0
Ulteriori azioni integrative	0	0

	NO_x (t/anno)	PM_{10} (t/anno)
Saldo emissivo	0	0

Figura 3-Screenshot of software for emission calculation. – [ARPA, 2013, a]

5. ***Preliminary assessment impact on the quality of the air with "ABACO"***

The preliminary assessment "ABACO" is planned by the regional regulation D.A.L. 51/2011 for facilities that have more power to 250 kWt and that fall into areas of color "GREEN" according to figure of the aforementioned D.A.L. The purpose of the evaluation is to ensure the conservation of good air quality even in areas where they are not required remediation efforts.
"Abaco" is a online-software-methodology able to preliminarily evaluate the potential for deterioration in air quality after you install biomass plants for the production of energy from renewable sources, going to assess the risk of exceeding the limits of law required by law (annual average of 40 micrograms / m3 NO2 and PM10 and 35 days year of exceeding of the daily average value of 50 ug / m3 of PM10).
An operational manual for the use of the Abaco describes the criteria used in the creation of the abacus and the method of use, that are also listed briefly in the notes attached to the Abaco.
The Abaco allows, through the introduction of limited information, to make a first evaluation of the impact on air quality in the construction area of the new plant (1 km2) and in the neighboring area (4 km2): the evaluation it is performed on the basis of calculation criteria that refer to simulations carried out on predefined cases through the identification of the basic types and situation types, constituted by the undermentioned cases.

- Plants with different treatment of biomass:
    - biogas production and combustion,
    - woody biomass combustion,
    - liquid biomass combustion.
- Three different powers of installation for each type of treatment, with values between 0.25 and 10 MWt.
- Different topographic localization of the plant (plains, valleys, ridge).

For each type of system have been applied emission limits provided for by Legislative Decree 152/2006 reduced by 25%, the following table shows the case studies considered in the preparation of the Abaco:

Tabella 4- case studies considered in the preparation of the Abaco. [ARPA, 2013, a]

caratteristiche impianto	impianto a biogas		combustione biomassa solida		combustione biomassa liquida	
	0,25 - 1 MWt	1 - 10 MWt	0,25 - 1 MWt	1 - 10 MWt	0,25 - 1 MWt	1 - 10 MWt
altezza camino (m)	5	7	6	8	5	7
diametro camino (m)	0,2	0,35	0,3	0,6	0,2	0,35
portata fumi (Nmc/sec)	0,36	1,1	0,2	5	0,36	1,1
temperatura fumi (°C)	450 (*)	450 (*)	80	120 (§)	450 (*)	450 (*)
polveri totali (mg/mc)	10	10	30	10	30	30
% PM10 (%)	90	90	70	70	70	70
NO2 (mg/mc)	500	450	450	200	500	500

The impact of the plant, or of the plants in case they are more of a plant in the same area, is evaluated by considering the emissions of the plant and of the related vehicular traffic necessary for the transport of the biomass and of the consequent waste. These values are added to the air quality in the area (basic values) and constitute reason to risk as much as the basic values are close to regulatory limits.

The modeling study executable with the online application of the "Abaco", allows:

- to evaluate the increase in the average annual values of PM10 and NO2 on areas around the plant with surface of 1 km2 and 4 km2, and both relating to the construction of the plant that the transport of the biomass (the minimum area of fallout of the plant has been evaluated equal to 1 Km2, because it is the surface that constitute the unit element of the reference paper of air quality).
- Calculate the risk of exceeding the 35 days allowed by law with a PM10 daily average value upper to 50 micrograms / cubic meter (Processing the data of the regional air quality monitoring network has been observed that the threshold of 35 days per year of exceeding the daily average values of PM10 allowed corresponds to the average annual value of 28.3 micrograms / cubic meter PM10, calculated value on data from 2006 to 2010).
- Evaluate the risk of deterioration of air quality in the municipality concerned to the construction of the plant in relation to the regional grid of annual average concentration values of PM10 and NO2 (with a mesh of 1 km2).

The information that the software requests are:

- the Municipalitie wher we want locate the plant and metrics or geographical coordinates of the point;
- the topographic location (mountains, hills, lowland);
- the type of plant (biogas, solid fuel, liquid combustion);
- the number of plants in the area, and the total power;
- the annual number of trips for the transport of the biomass.

Once you have entered the information and the list of existing plants you can run the model, thus obtaining the result of its processing.

In case the scenario described does not cause an exceeding of the limits will appear the information "NOT exceeded limits"; on the contrary they will be represented in mapping the areas of exceedance with different color in relationship to the pollutant that resulted in overcoming (PM10, NO2, both).

The following table shows some sample images relating to the application of ABACO:

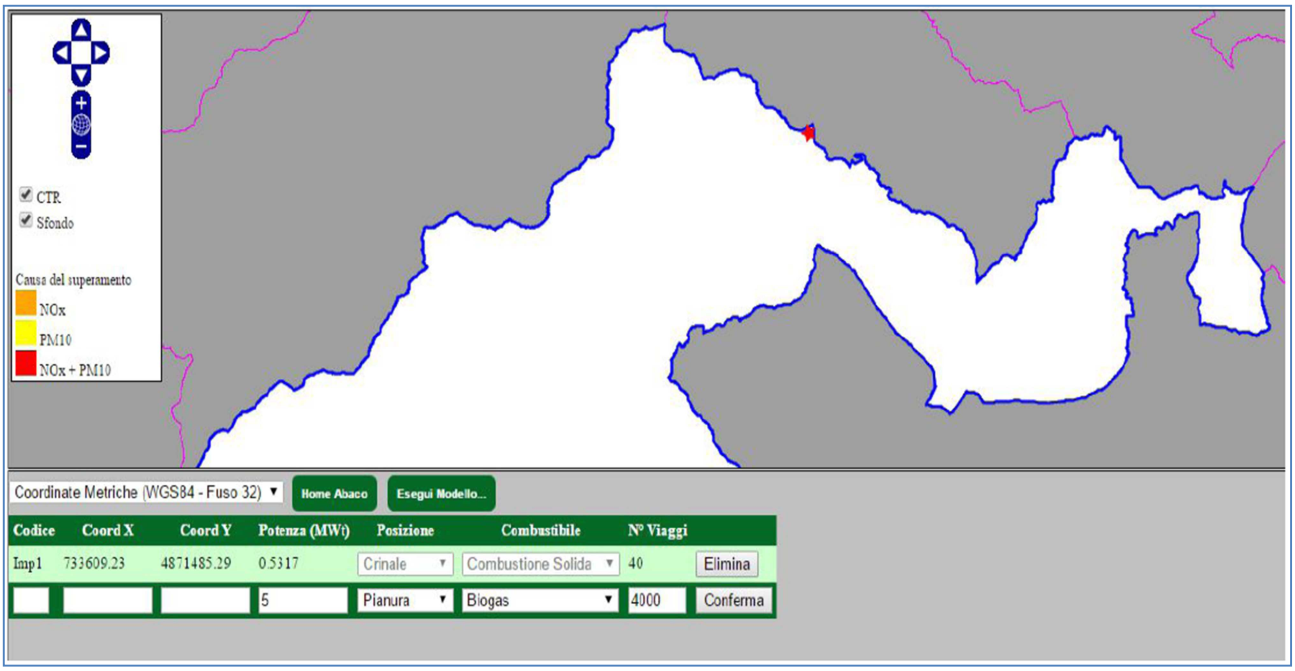


Figura 4- Screenshot of example of data entered. [ARPA, 2013, a]

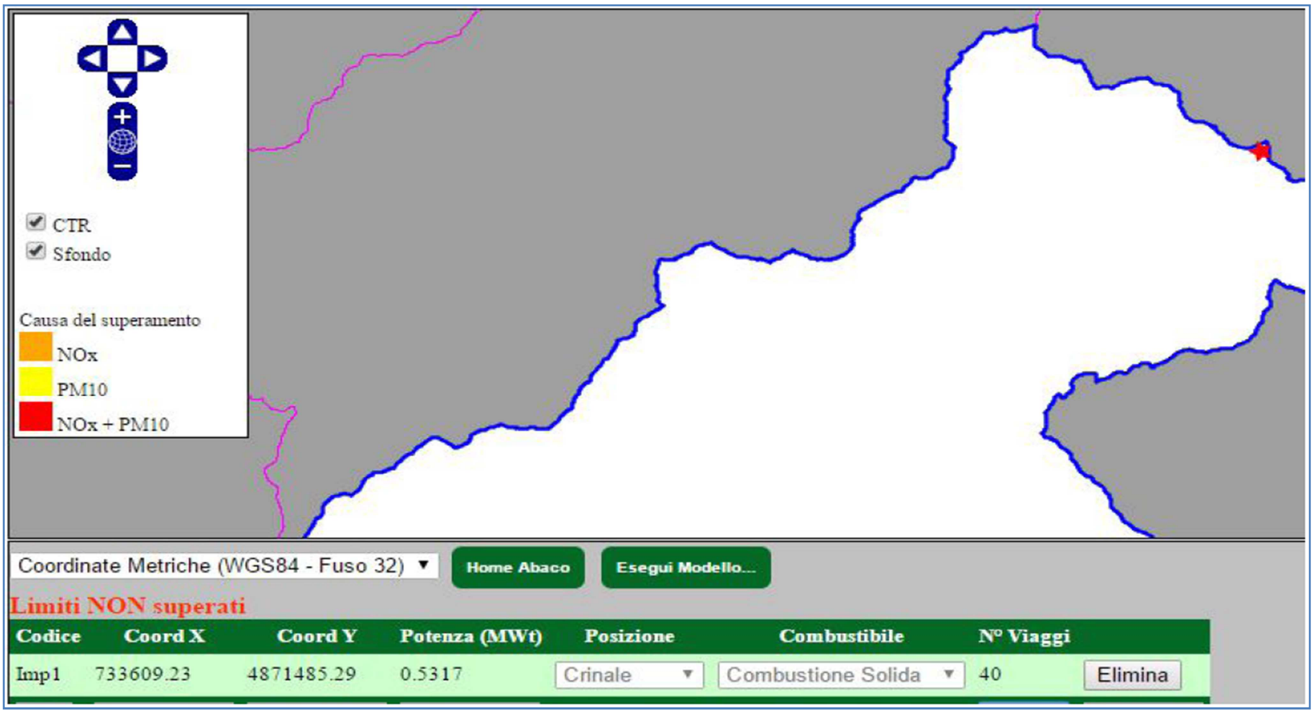


Figura 5- Screenshot of data processing (processing shows that the limits are not exceeded) -*

1.1.3.5. - CASE C - "THE SPECIAL CASE OF INDIRECT COMBUSTION SOLID BIOMASS PLANTS"

Pyro/gasification plants are not completely comparable to the plants with direct combustion, so they are applied to the limits and operating conditions provided the limits for biogas plants, or the limits referred to DGR 1496 of 24/10/11, related to "plant indirect combustion of biomass that are not completely equivalent to those direct combustion".

In Legislative Decree 152/2006, where are definited the characteristics of biomass fuels and their conditions of use (Annex X, Part 2, Section 4, Part V), it is stated that the conversion of biomass into energy can be carried out through direct combustion, or upon pyrolysis or gasification. The regulation therefore also foresees the indirect combustion of biomass, in accordance with the same operating conditions and characteristics of the direct combustion.

In the Part V of Legislative Decree 152/06 they are declared that the plants and / or channeled emissions for which there is no requirement for prior authorization to the emissions into the atmosphere (AEA) (AEA in italy) issued under the Unique Environmental Authorisation (UEA) (AUA in Italy).

The activity relating to biomass plants operating with pyro / gasification technology is on the list of Annex IV Part I, in combination disposed with the Annex X, Part II, Section IV, point 2, in accordance with art. 272, paragraph 1 of Legislative Decree 152/06, therefore is subject to the authorization to atmospheric emissions, if the nominal thermal power exceeds 3MW (cit. Norm: [...] combustion plants, including power generators and generators of cogeneration units, powered by biogas in Annex X to part Five of this decree, nominal heat output lower or equal to 3 MW).
Plants with nominal power lower 3 MW are not subject to prior authorization because activity of "little relevance" for effects of air pollution. However, even if not subject to authorization for atmospheric emissions are anyway required to respect the limits set by current regulations.

Pyro/gasification plants are not completely comparable to the plants with direct combustion, so they are applied to the limits and operating conditions provided the limits for biogas plants present in to DGR 1496 of 24/10/11, or the limits of the DGR 855/2012 for energy plants with direct burning of solid biomass. This option depends from the evaluation of the authority authorization during the phase of deepening of the project.

During the transformation and energy production process it is necessary to treat and emit the exhaust fumes through the use of emission points conveyed. In this regard, we must remember that the true and proper gasification process does not include emission points, as with regard to the pyrolysis process takes place inside a closed structure and under anaerobic conditions, while the oxidizing agent during the gasification is supplied from the outside without that there is an escape of fumes. Even the insertion of wood chips / pellets in the gasifier takes place through a system that does not foresee the emission of fumes (there are different types of gasifiers and for feeding of the biomass, that varies depending the gasifier, is provided a system of valves which allow to introduce the material avoiding escape of fumes present within the reactor during the thermochemical process). The emission points depend on the technology that is used: usually are at least two for all plants, namely that one relating to the "Cogenerator" and the "Emergency Torch.[3]" In the case that

[3] As regards the emergency torch must be said that the same is activated only in case of emergency (maintenance or cogenerators failure) or to eject the first syngas that is still crude, and is not appropriate to add it in the cogeneration engine. It has a unique safety function and in accordance with point 16 of the DGR 1496/2011 and the limits listed in table at point 7 are applicable, because in the case of the torch, due to its occasional use and reduced in time, they are not requested specific analysis regarding the emissions into the atmosphere.

the biomass is wood chips there is another point of emission for _ fumes of drying. Additionally there may be other points such as the start up of the gasifier, the one of the emergency cogeneration and also others.

1.1.3.6. PG / 2012/92428 of 12/04/2012 on the application of DAL 51/2011, issued by the Emilia-Romagna Region

Given the absence of a specific regulation for "indirect combustion", the Emilia Romagna Region has dealt with the issue on energy conversion (direct and indirect) of biomass with opinion PG / 2012/92428 of 12/04/2012, concerning the application of the DAL 51/2011 in relation to the fact that the same discipline in paragraph 4 "plants with direct combustion of biomass" but does not expressly regulate "the biomass plants with indirect combustion."

That advice has established that:

- To the indirect fired biomass plants can be applied by analogy, its own rules of biomass plant (paragraph 4 DAL 51/2011) or of biogas (paragraph 3 DAL 51/2011), depending on the characteristics of harmful emissions assessed during the authorization process, in particular as regards the possible odor emissions and to those of pollutants.
- As regards the remaining requirements and the regime of ineligible or eligible areas, is evident that the DAL 51/2011 does not foresee significant differences between the two types of plants, except for the provisions related to the themes of the adverse effects on the milk of cattle in context of quality production as that of the district of parmesan cheese.

The enunciation of the opinion anyway leaves some uncertainties in terms of practical application, and from time to time we must assess the specific case and then decide whether to apply the rules relating to "direct combustion", or those relating to "biogas."
In both cases it is not taken account of the "Syngas" which is derived from a thermochemical gasification process that is different from the direct combustion and from the production of biogas which occurs with biochemical processes of digestion.

Referring to general plants in pyro / gasification of biomass which process can be represented in the following phases:

- phase conversion of biomass (wood chips) into synthesis gas (syngas production via pyrogasification);
- phase of the synthesis gas combustion in the co-generator (after treatment / filtration of the syngas);
- eventual usage phase of the combustion fumes for drying the fresh biomass in new entry.

these are not fully comparable to the direct combustion plants, so they are applied to the limits and operating conditions provided for biogas plants, or the limits referred to DGR 1496 of 24/10/11, and already mentioned in section . 1.2. e) point 2) relating to "Plant indirect combustion of biomass not completely equivalent to those with direct combustion".

1.1.3.7. ARPA Emilia Romagna GUIDELINES LG/DT

About this uncertainty ARPA Emilia Romagna has issued guidelines LG19 / DT "*Technical evaluation on limits and requirements to apply to indirect biomass combustion plants for the production of electricity*.". The above guidelines governing the following three cases:

1. **Indirect combustion plants considered simply as equal to those biomass direct combustion.**

They are those in which the process is divided into two phases of the same plant: primary gasification chamber and secondary oxidation chamber. In the gasification chamber is obtained the Syngas, while in the oxidation it is completely combusted. The hot combustion gases are used for energy recovery (eg in heat exchangers connected to the steam turbine or organic fluids). To these plants shall apply the arrangements provided for the direct combustion of biomass, including that relating to the "balance of zero-emission" (paragraph 4 DAL 51/2011); in relation to emissions in the atmosphere, it is stated that there is no uniformity of values between those provided by national legislation for solid fuels (Legislative Decree 152/06, Part III of Annex 1 in paragraph 1.1) and those provided by the Regional legislation (DGR 855/2012) , in this case they will apply the more restrictive ones, that is those Regional, also reported in the following table:

Tabella 5- Indirect combustion plants considered simply as equal to those biomass direct combustion. [ARPA EMR, 2013, b]

Combustione Diretta (Ossigeno di riferimento 11%)	Biomasse di cui alla DGR 855/2012		RER DGA 4606/99 §4.12.20	Dlgs 152/06 e s.m.i. Allegato 1 Parte III § 1.1 — Biomasse diverse da quelle della DGR 855/2012			
Potenzialita'	***≤ 1MWt***	***> 1MWt ≤ 10MWt***	< 50 MWt	>0,15MWt ≤ 3MWt	> 3MWt ≤ 6MWt	> 6MWt ≤20MWt	>20MWt
NOX mg/Nm3 (come NO2)	***450 (NOx + NH3)***	***200 (NOx + NH3)***	650	500 (200) °	500 (200) °	400 (300)*	400 (200) *
SOx mg/Nm3 (come SO2)	***100***	***100***	2000	200	200	200	200
Polveri mg/Nm3 (polveri totali)	***30***	***10***	50	100 (200)**	30	30	30
Carbonio Organico Totale COT mg/Nmc	***30***	***30***	50	----	-----	30	20 (10) *
CO mg/Nm3	***250***	***150***	250	350 (150) °	300 (150) °	250 (150)*	200 (100) *
HCl mg/Nm3 (acido cloridrico)	***30 ******	***10***	100	30 ***	30 ***	30 ***	30 ***

(*) Tra parentesi è indicato il valore medio giornaliero.
(**) Agli impianti di potenza termica nominale superiore a 0,035MWt e non superiore a 0,15MWt si applica un valore di emissione di 200mg/Nm3
(***) Valore limite riportato in All.1 parte II della parte V del DLgs152/06
(°) Tra parentesi è indicato il valore limite riportato nel parere del Ministero Sanità n.408/8.AG/535 del 30/04/1997 per impianti adibiti a produzione di energia elettrica.

2. **Indirect combustion plants biomass not completely equivalent to those direct combustion.**

They are those in which the process is divided into two phases of different plants: the production plant of Syngas and the plant of the combustion (eg. Engine cogeneration).

The combustion takes place in a separate device but fed from the syngas produced in the first plant. At these plants, unlike those above that are similar to the direct combustion, we apply the limits established for Biogas plants, for which there is no uniformity of values between those provided by the national legislation for gaseous fuels (Legislative Decree 152/06, Part III of Annex 1 in paragraph 1.3 letter a) related to engines, and letter b) relative to gas turbines) and those forseen by the Regional legislation (DGR 1496/2011), in which case we will apply the most restrictive, the regional ones, reported in the follow table, where even for these types of plants the Guidelines establish that it is considered appropriate to apply the obligation to ensure, in exceeded areas and in areas at risk of exceeding of the PM10 and NO2 the respect for the "zero-emission balance" referred to DAL 51/2011 and DGR 362/2012.

Tabella 6- Indirect combustion plants biomass not completely equivalent to those direct combustion. - [ARPA EMR, 2013, b]

MOTORI (Ossigeno di riferimento 5%)	RER DGR 1496/2011			RER DGA 4606/99 (**) <50 MW		Dlgs 152/06 e s.m.i. Allegato 1, parte III § 1.3 a	
Potenzialita'	*≤0,25MW*	*>0,25MWt ≤ 3MWt*	*>3MWt*	Diesel § 4.12.17	Otto §4.12.18	≤3MWt	>3MWt
NOX mg/Nm3 (come NO2)	***500 (°°)***	***450 (°°)***	***200 (°°)***	4000	800	500	450
CO mg/Nm3	***650***	***500***	***250***	100	650	800	650
SOx mg/Nm3 (come SO2)	***350***	***350***	***150***	500	500	500 *	500 *
Carbonio Organico Totale COT mg/Nmc	***150(°)***	***150(°)***	***100(°)***	50	----	150	100
HCl mg/Nm3 (acido cloridrico)	***10***	***10***	***5***	----	----	10	10
Polveri mg/Nm3 (polveri totali)	***10***	***10***	***10***	130	----	50 *	50 *
Formaldeide	***20 ****	***20 ****	***10***	----	----	20 *	20 *

(*) Valori limite riportati in All.1 parte II della parte V del DLgs152/06
(**) Nella DGA 4606/99, per i motori fissi a combustione interna non viene menzionato il combustibile.
(°) escluso il metano
(°°) somma di NOx e NH3 espressi come NO2, nel caso di utilizzo di sistema di abbattimento degli ossidi di azoto con urea o ammoniaca.

TURBINE A GAS (Ossigeno di riferimento 15%)	Dlgs 152/06 e s.m.i. Allegato 1 § 1.3 b)			RER DGA 4606/99 § 4.12.16 (°)
Potenzialita'	*≤ 8MWt*	*8 < MWt ≤ 15MWt*	*15 < MWt ≤ 50MWt*	< 50 MWt
NOX mg/Nm3 (come NO2)	***150***	***80***	***80***	600
CO mg/Nm3	***100***	***80***	***60***	100
SOx mg/Nm3 (come SO2)	***500 ****	***500 ****	***500 ****	500
Carbonio Organico Totale COT mg/Nmc	----	----	***50***	50
HCl mg/Nm3 (acido cloridrico)	***5***	***5***	***5***	----
Polveri mg/Nm3 (polveri totali)	***50 ****	***50 ****	***50 ****	50

(°) Nella DGA 4606/99 vengono indicate genericamente turbine a gas senza specificare il combustibile.
(*) Valori limite riportati in All.1 parte II della parte V del DLgs152/06

1. **Indirect combustion plants of biomass in which the fumes are used for drying of incoming biomass.**

They are those in which the fumes generated by the combustion (direct or indirect) are used in the drying process of biomass. The used fumes resulting from combustion and _ must respect the parameters in the preceding two points with the corresponding oxygen contents, while those typical of the drying concern the emission of only dust and an oxygen content of 17% (Legislative Decree 152 / 2006 and the sme. Annex 1, part III section 2).

$$E_{ess.} = [(21 — O2_{ess.}) / (21 — O2_{combustione})] \times E_{combustione}$$

$E_{ess.}$ = Concentrazione Limite Uscita Essiccatore (riferita al 17% di O2)
$O2_{ess}$ = Ossigeno di riferimento per impianti essiccamento (pari al 17% di O2)
$O2_{combustione}$ = Ossigeno di riferimento impianti di combustione (motori endotermici 5%, turbine a gas 15%, impianti a focolare 11%)
$E_{combustione}$ = Concentrazione Limite di NOx, SOx, CO, HCl impianti di combustione.

[ARPA EMR, 2013, b]

1.1.3.8. ABACO Classification of regional air quality of municipalities

As we previously reported [4], the Emilia-Romagna has proceeded to classify the air quality of his municipalities through the zoning map of PM10 / NO2 attached to DAL 51 of 26 July 2011 [5] . This sets out the general location criteria for the installation of plants producing energy through the use of renewable energy sources like wind power, biogas, biomass and hydro power.
This map has been defined on the basis of the number and type of exceedances of air pollutants PM10 and NO2 measured in 2009. The allocation criteria of the classes of air quality in brief, were the following [6] .
In the areas of exceedance and the areas at risk of exceeding the air quality standards can be realized biomass plants provided it is ensured an emission balance equal to or less than zero for pollutants PM10 and NO2, taking into account a period of reference time to achieve the objective as well as the possible compensation with other emission sources.
To this end, the Regional Board approved the criteria for individuation of emission calculation for the plants with Thermal power bigger then 250 kWt (Del. Giunta Emilia-Romagna 362/2012), in relation to the criticality of the different areas and the consequent identification of localization conditions.
In exceeded areas and in areas at risk of exceeding identified with red, orange and yellow in the map of Zoning PM10 / NO2 attached to Resolution A.L. 51 of 26 July 2011, it is necessary to undertake an evaluation of the balance emissive system and any integrated action envisaged.
The class color of the municipality has been given with the following criteria on 2009 detected data from the ARPAE air quality net monitoring system (and modelling elaboration):

- RED: exceeded the annual average of 40 micrograms / m3 both of NO2 than PM10.
- ORANGE: for more 35 days/year exceeded the concentration daily limit of 50 ug / m3 of PM10 , but no exceeded for NO2 the annual average limit of 40 ug/m3 .

[4] http://www.arpae.it/dettaglio_generale.asp?id=2087&idlivello=1454 .
[5] http://enerweb.casaccia.enea.it/enearegioni/UserFiles/Emilia%20Romagna/2011_151_dal_rer.pdf .
[6] http://www.arpae.it/cms3/documenti/_cerca_doc/energia/biomasse/zonizzazione_biomasse.pdf .

- YELLOW: for more 35 days/year exceeded the daily limit of 50 ug / m3 of only PM10 , but occurred only in some portions of the municipality area, so scientists can define it: “municipality with hot-spot exceedances”.
- GREEN: zero exceedances for both parameters limit values during all the year

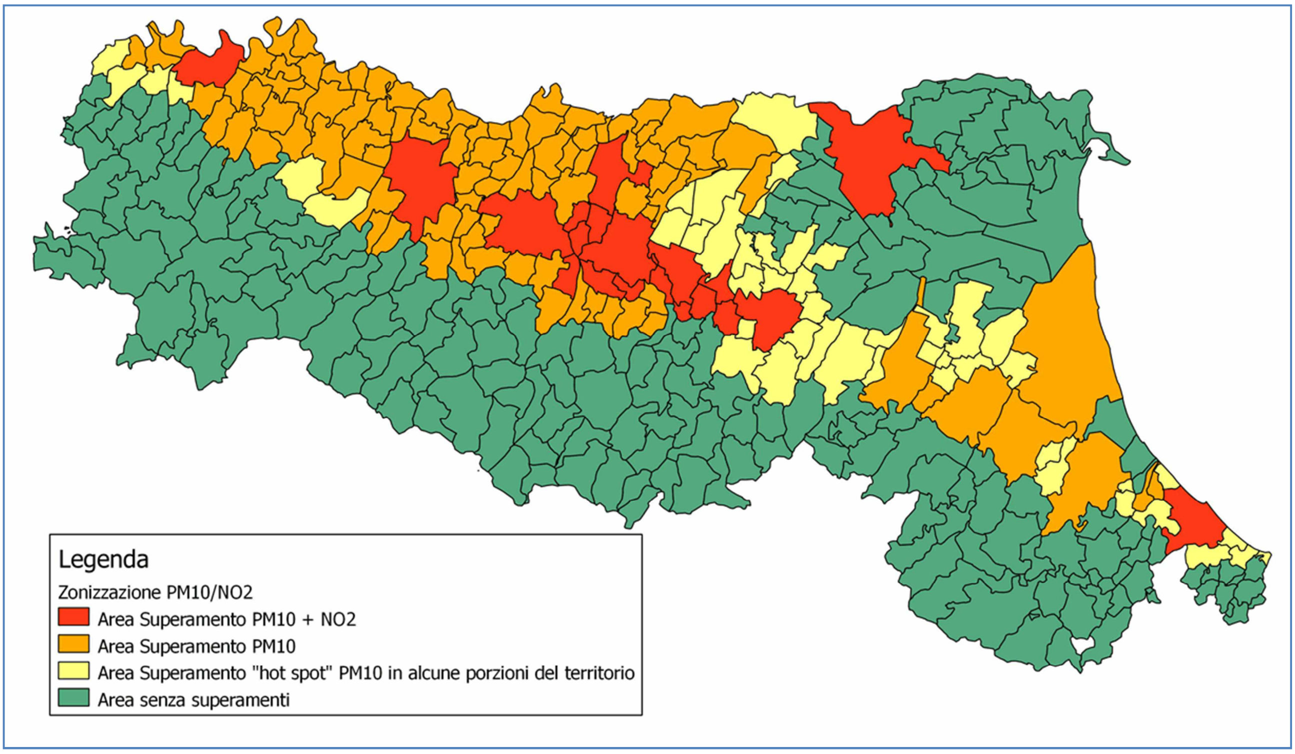


Figura 6- Zoning PM10 / NO2 annexed to DAL 51 of 26 July 2011. -

1.2. SUMMARY OF ESSENTIAL NORMS FOR AUTHORISATIONS

The plants for energy production from renewable sources are subject to regulations that govern the technical, management requirements, monitoring and emission limits.
The combustion installations for BIOMASS and BIOGAS are subject to Title I of Part V of Legislative Decree 152/06 and therefore must in any case meet at least the limit values specifically specifically designed for the use of such fuels in Part III of Annex I to Part V of this Decree or the emission limit values and the requirements specifically provided for in the plans and programs or regional air quality regulations.
For this reason, to these systems shall be applied firstly requirements relating to the type of fuel and the emission limit values laid down by regional standards regulated by DGR 2236/2009 (art. 272 c.2 - General authorization (GA)) and subsequent amendments.
The DAL 51/2011 introduces the obligation to ensure a balance of ZERO AT LEAST in municipal red, orange and yellow areas for PM10 and NOx, or a preliminary assessment through ABACO software in the other (green) areas.
The obligation of emission ZERO balance exists for the biomass power plants exceeding 250 kWt.

The list of the essential rules referred to in this chapter is as follows:

- DIR 2001/77/CE;
- DIR 2006/108/CE;
- DIR 2009/28/CE;
- DL n. 387 december 29, 2003;
- DLgs 152/2006: Framework law on environment;
- DGR 2236/2009; General authorization;
- DM 2010/09/10: Guide lines for renewable plants authorizations;
- DL n. 28 march 3, 2011;
- DLgs 28/2011: Renewable Decree (instit. Simplified Enabler Procedure (PES/PAS));
- DAL 51/2011: Identification of areas suitable for the installation of electricity generation plants using renewable sources;
- DGR 1496/2011: Biogas combustion engines (<10 MW);
- DGR 335/2011: Liquid biomass combustion engines (<10MW);
- DGR 855/2012: (Solid) Biomass combustion plants (<10MW);
- DGR 362/2012: Implementation of D.A.L. 51 of July 26, 2011 - Approval of the criteria for the calculation of the emissive bill for biomass energy production plants.
- PG/2012/92428 del 12/04/2012, about application of DAL 51/2011;
- GUIDELINES ARPA LG19/DT.

Index - part 4 -

REGIONAL POWER PLANTS GIS LAND REGISTERS

1. REGIONAL POWER PLANTS GIS LAND REGISTERS

During the 3 years of Ph.D. We produced, and updated, the following registers of power plants. The GIS land registers are available online at ARPAE page:
http://www.arpae.it/dettaglio_generale.asp?id=1549&idlivello=1207

1.1. GIS fossil fuels thermoelectric plants and remote heating networks land register 2016

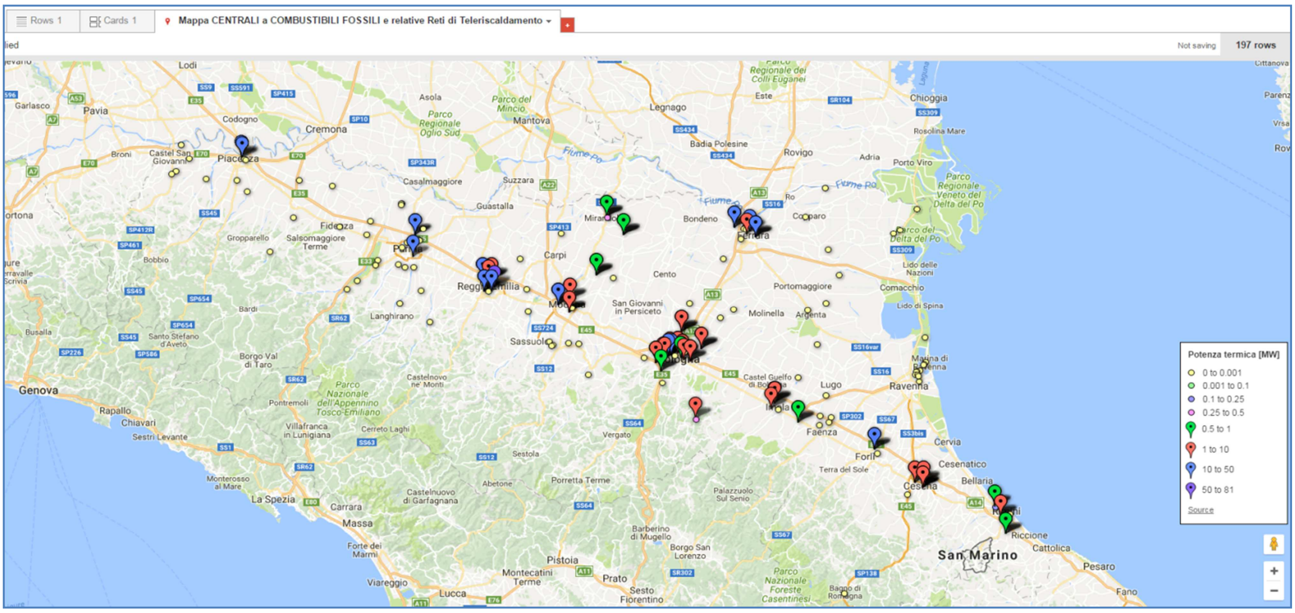


Figura 1- GIS fossil fuels thermoelectric plants land register 2016.

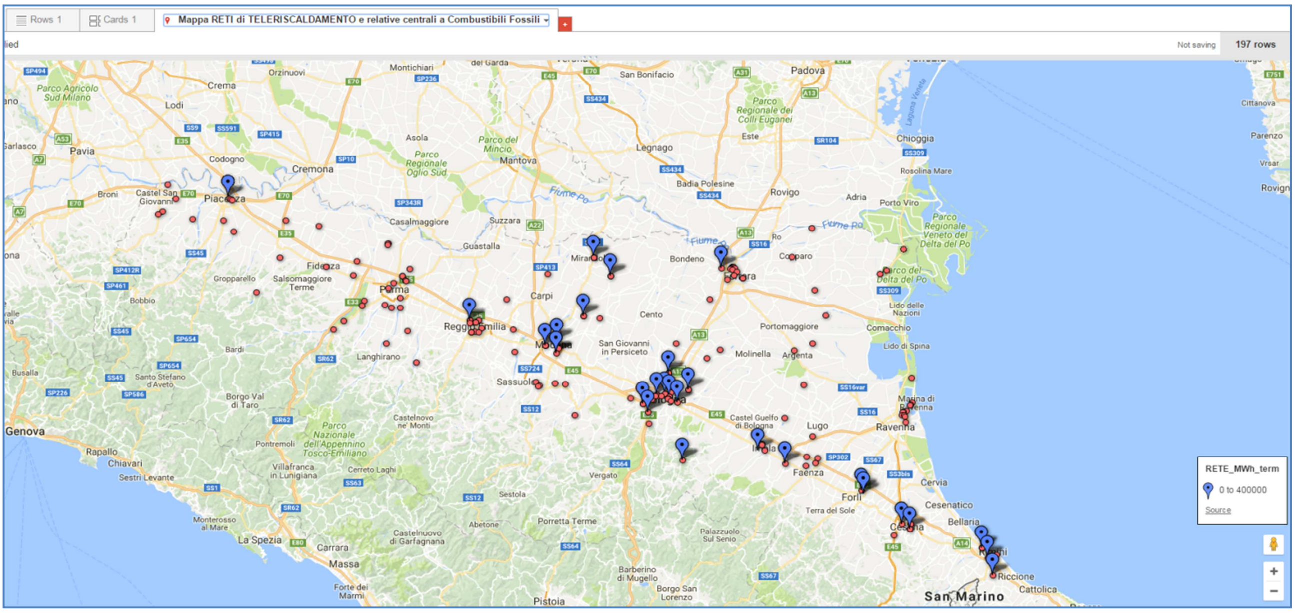


Figura 2- GIS remote heating networks land register 2016.

Tabella 1- GIS fossil fuels thermoelectric plants land register 2016.

PROVINCE	Number of fossil fuels plants	Thermal power [MW]
BOLOGNA	45	2,779
FORLI-CESENA	13	697
FERRARA	26	1,340
MODENA	28	530
PIACENZA	14	200
PARMA	25	1,360
RAVENNA	20	32
REGGIO EMILIA	18	1,397
RIMINI	8	158
Totale complessivo	197	8,494

Tabella 2- GIS remote heating networks land register 2016.

REMOTE HEATING NETWORKS	Number of RHN	Thermal energy production [MWh]
BO	**10**	**2,776**
Cogen - Barca	1	597
Ecocity	1	240
Fossolo	1	33
Navile - sede unica Comune di Bologna	1	23
Rete Castel Maggiore	1	55
Rete di teleriscaldamento di Monterenzio	1	8
Rete di teleriscaldamento urbana - IMOLA	1	1,042
San Biagio	1	40
Sede - San Giacomo	1	258
TeleFrullo	1	481
(vuoto)		0
FC	**5**	**446**
Bagno di Romagna	1	0
Centro Logistico	1	0
Cesena Bufalini	1	134
Rete CittÃ di Cesena	1	136
Rete Iper - Fiera di Forli	1	176
(vuoto)		0
FE	**1**	**1,496**
Termodotto	1	1,496
(vuoto)		0
MO	**6**	**483**
Comparto ex mercato	1	16
Quartiere 3Â° PEEP	1	70
Quartiere Giardino	1	248
Rete di teleriscaldamento Bomporto-1	1	62
Rete Mirandola-1	1	57
Rete San Felice-1	1	31
(vuoto)		0
PC	**1**	**289**
Rete di teleriscaldamento di Piacenza	1	289
(vuoto)		0

PR	**1**	**1,553**
Toscana-Farnese	1	1,553
(vuoto)		0
RA	**1**	**24**
Rete di Castel Bolognese	1	24
(vuoto)		0
RE	**1**	**3,779**
Rete di Teleriscaldamento di Reggio Emilia	1	3,779
(vuoto)		0
RN	**3**	**113**
P.E.E.P. Gaiofana	1	27
P.E.E.P. Marecchiese	1	37
P.E.E.P. Viserba	1	49
(vuoto)		0
TOTAL	**29**	**10,959**

1.2. GIS wind plants land register 2013.

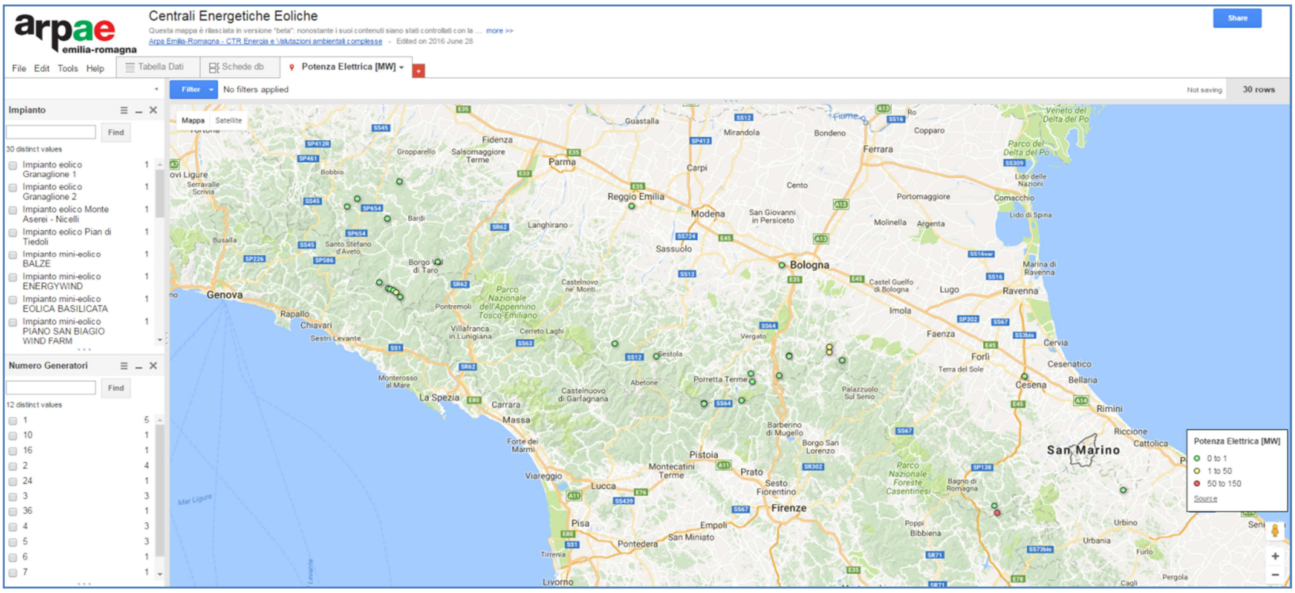


Figura 3- GIS wind plants land register 2013.

Tabella 3- GIS wind plants land register 2013.

PROVINCE	Number of wind parks	Number of wind plants	Electric power [MW]
BOLOGNA	12	63	2.45
FORLI-CESENA	3	36	122.4
MODENA	2	6	0.27
PIACENZA	4	11	0.59
PARMA	7	29	2.18
REGGIO EMILIA	1	0	0
RIMINI	1	3	0.12
TOTAL	**30**	**148**	**128.01**

1.3. GIS geothermal plants land register 2015.

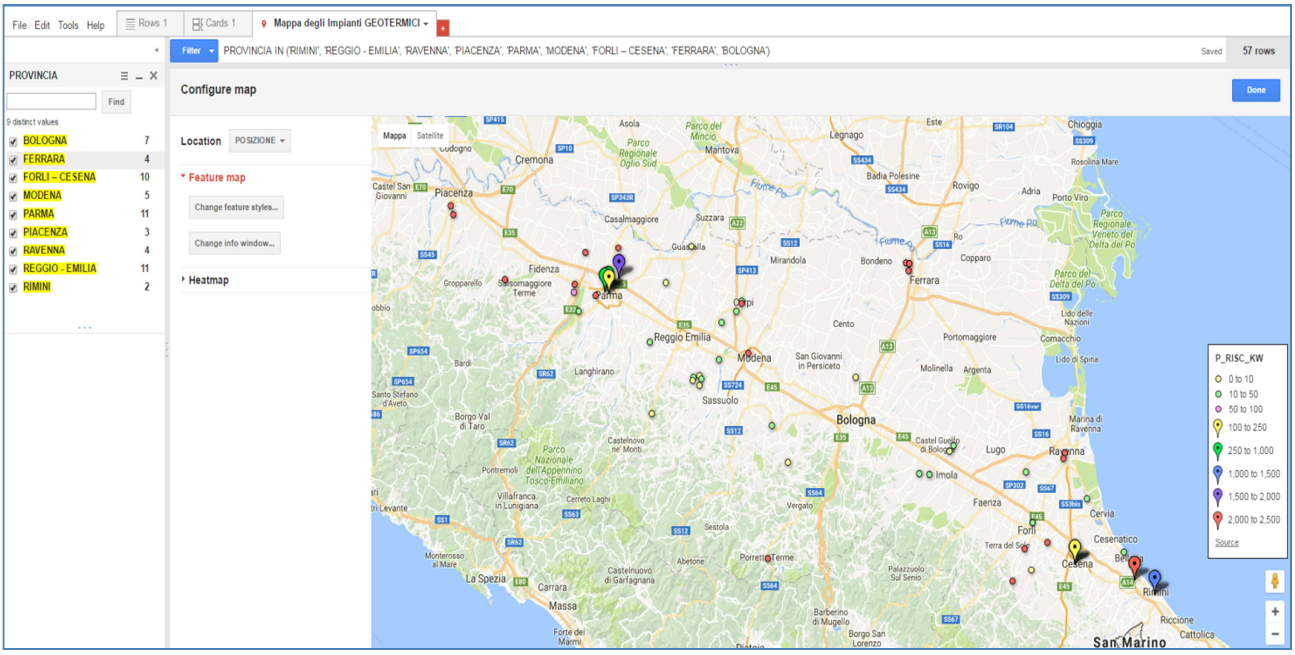


Figura 4- GIS geothermal plants land register 2015.

Tabella 4- GIS geothermal plants land register 2015.

	Number of geothermal plants	**Heating power [MW]**	**Cooling power [MW]**
BOLOGNA	7	0.1	0.1
FERRARA	4	0.0	0.0
FORLI-CESENA	10	0.8	0.0
MODENA	5	0.1	0.0
PARMA	11	2.7	2.7
PIACENZA	3	0.0	0.0
RAVENNA	4	0.0	0.0
REGGIO-EMILIA	11	0.2	10.0
RIMINI	2	3.5	2.9
TOTAL	**57**	**7.2**	**15.7**

1.4. GIS hydroelectric plants land register 2013.

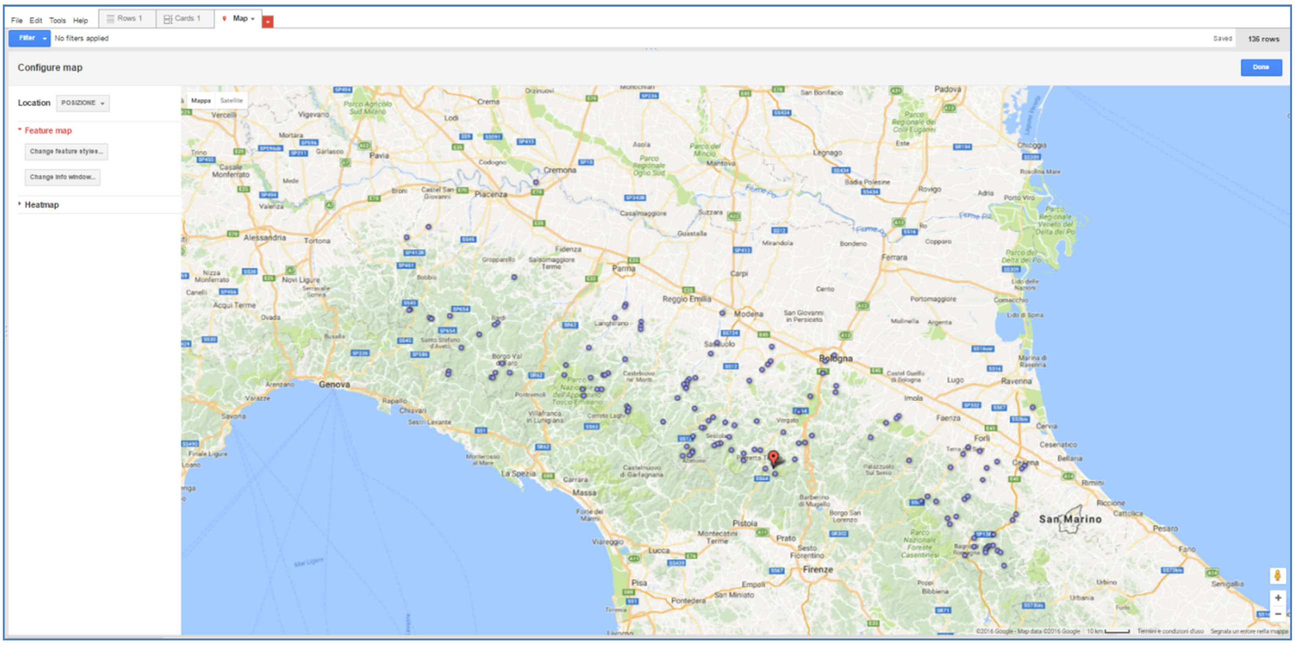


Figura 5- GIS hydroelectric plants land register 2013.

Tabella 5- GIS hydroelectric plants land register 2013.

PROVINCE	Number of hydroelectric plants	Nominal electrical power [MW]
BOLOGNA	26	343,532 [1]
FORLI-CESENA	31	11,507
MODENA	28	16,438
PIACENZA	10	72,008
PARMA	24	18,596
RAVENNA	2	372
REGGIO EMILIA	14	30,736
RIMINI	1	203
TOTAL	**136**	**493,392**

[1] The hydroelectric Bargi Basin of Suviana-Brasimone (BO), has a gross efficient capacity of 330,000 kW, uses, in addition to the waters of of Suviana basin, even those of the Pavana basin, which the lake is connected through the big pipes. In seventy years then, Enel has built a new power station upstream, which is also fed by the waters of the nearby reservoir and the overlying Brasimone basin, which is connected to Lake Suviana from a pipeline that takes advantage of the difference in height between the two reservoirs (about 380 m). This central overnight performs the pumping of waters upstream so as to generate electricity during the day when the electricity demand (and the sale price) is greater..

1.5. GIS land register of hydrocarbon wheels, concessions and productions 2015.

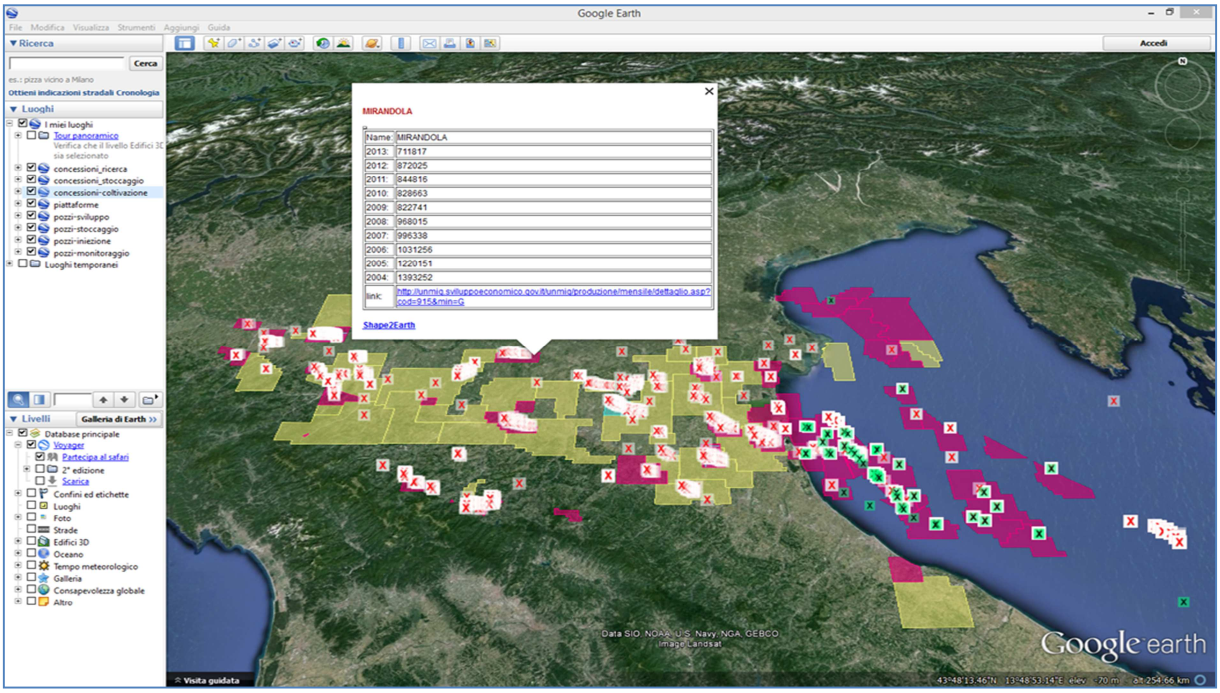


Figura 6- GIS land register of hydrocarbon wheels, concessions and productions 2015.

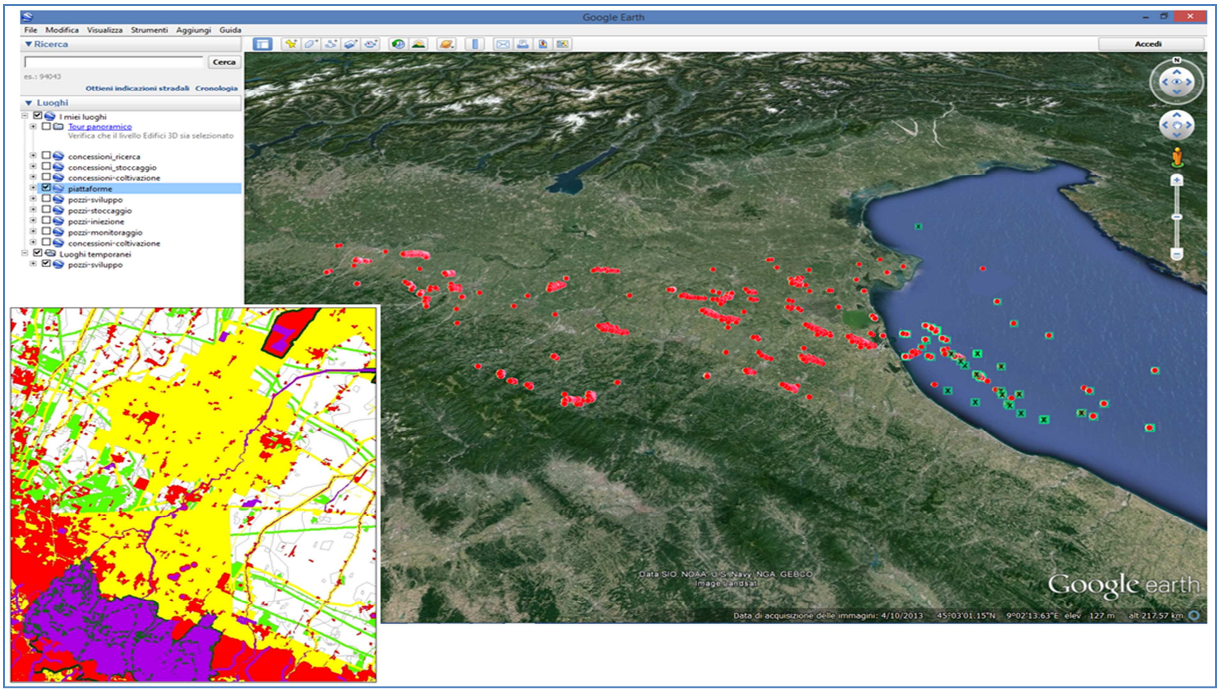


Figura 7- GIS land register of hydrocarbon wheels 2015.

Tabella 6- Historical series of the regional fossil hydrocarbons production/estraction[2] .

ANNO	CH4_Smc	OLIO_GREGGIO_kg	GASOLINA_kg
2008	190.089.804	33.975.030	1.857.251
2009	157.829.126	28.869.969	1.466.864
2010	148.726.029	29.075.670	1.210.108
2011	202.995.263	29.662.806	1.026.730
2012	290.932.154	30.623.599	770.219
2013	277.396.867	25.602.449	907.916
2014	225.059.617	22.926.671	912.003
2015	167.998.447	23.994.713	658.472

1.6. GIS incinerators land register 2016.

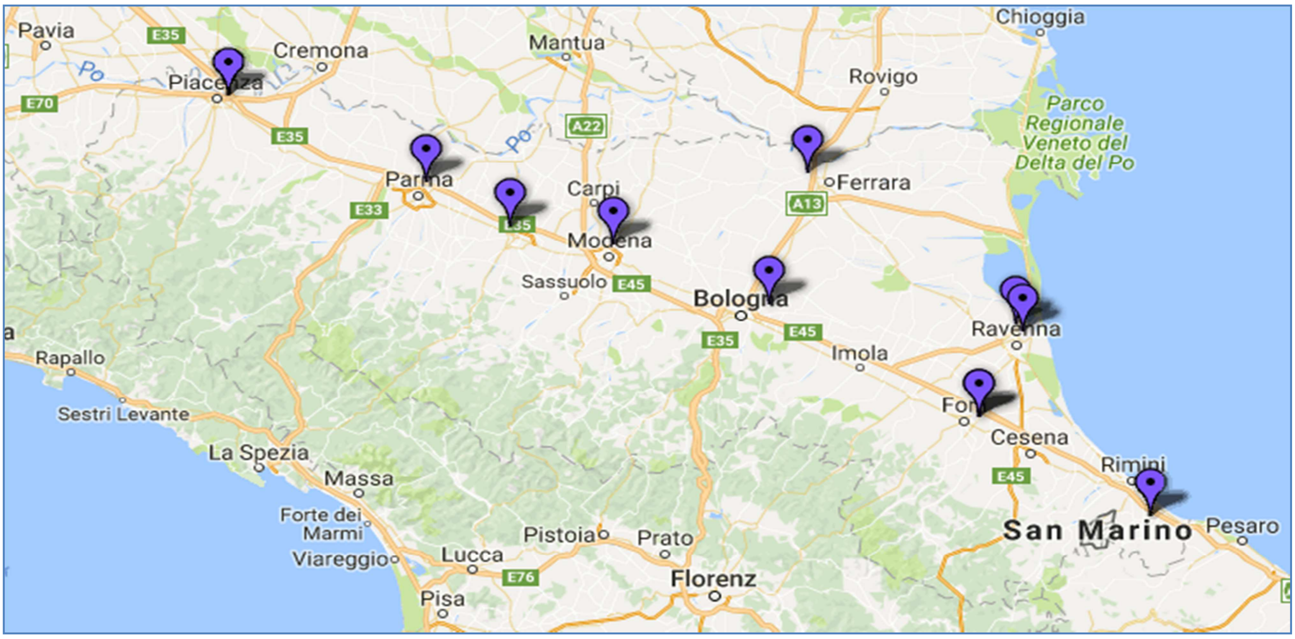


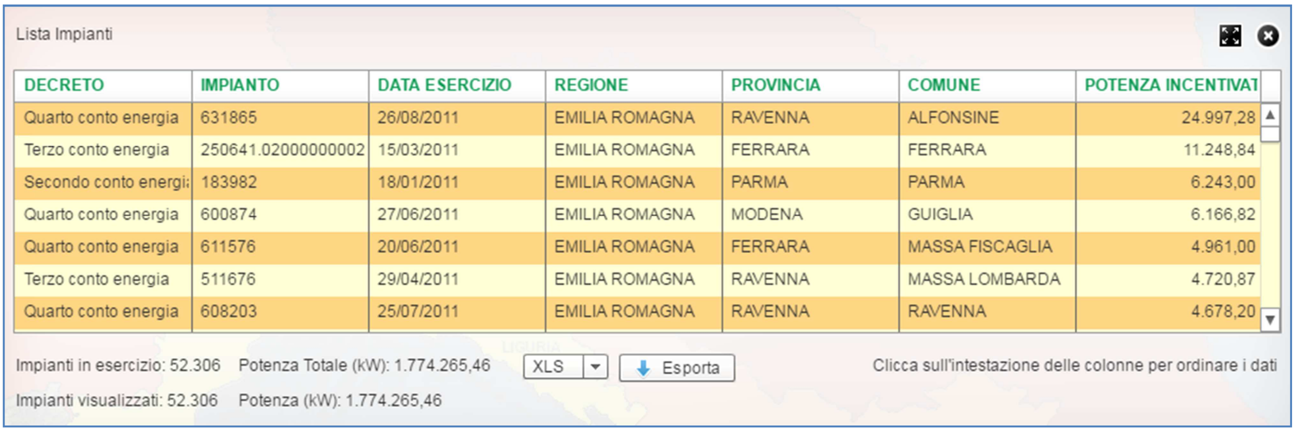
Figura 8- GIS incinerators land register 2016.

Tabella 7- GIS incinerators land register 2016.

PROVINCE	Number	Electric power [MW]	Thermal power [MW]
BOLOGNA	1	11,0	13,9
FERRARA	1	13,0	25,0
FORLI' - CESENA	2	21,0	20,0
MODENA	1	19,0	40,0
PARMA	1	8,9	20,0
PIACENZA	1	12,0	0,0
RAVENNA	2	10,4	0,0
REGGIO EMILIA *cessata attivita´	~~1~~	~~0,0~~	~~0,0~~
RIMINI	1	10,5	20,0
TOTALE	**11**	**105,8**	**138,9**

[2] *Fonte: Produzione nazionale di idrocarburi - Ministero dello sviluppo economico - DGS-UNMIG - http://unmig.sviluppoeconomico.gov.it/unmig/produzione/produzione.asp

1.7. Atlasole GSE photovoltaic plants land register 2016.



Lista Impianti

DECRETO	IMPIANTO	DATA ESERCIZIO	REGIONE	PROVINCIA	COMUNE	POTENZA INCENTIVAT
Quarto conto energia	631865	26/08/2011	EMILIA ROMAGNA	RAVENNA	ALFONSINE	24.997,28
Terzo conto energia	250641.02000000002	15/03/2011	EMILIA ROMAGNA	FERRARA	FERRARA	11.248,84
Secondo conto energi	183982	18/01/2011	EMILIA ROMAGNA	PARMA	PARMA	6.243,00
Quarto conto energia	600874	27/06/2011	EMILIA ROMAGNA	MODENA	GUIGLIA	6.166,82
Quarto conto energia	611576	20/06/2011	EMILIA ROMAGNA	FERRARA	MASSA FISCAGLIA	4.961,00
Terzo conto energia	511676	29/04/2011	EMILIA ROMAGNA	RAVENNA	MASSA LOMBARDA	4.720,87
Quarto conto energia	608203	25/07/2011	EMILIA ROMAGNA	RAVENNA	RAVENNA	4.678,20

Impianti in esercizio: 52.306 Potenza Totale (kW): 1.774.265,46 XLS Esporta Clicca sull'intestazione delle colonne per ordinare i dati

Impianti visualizzati: 52.306 Potenza (kW): 1.774.265,46

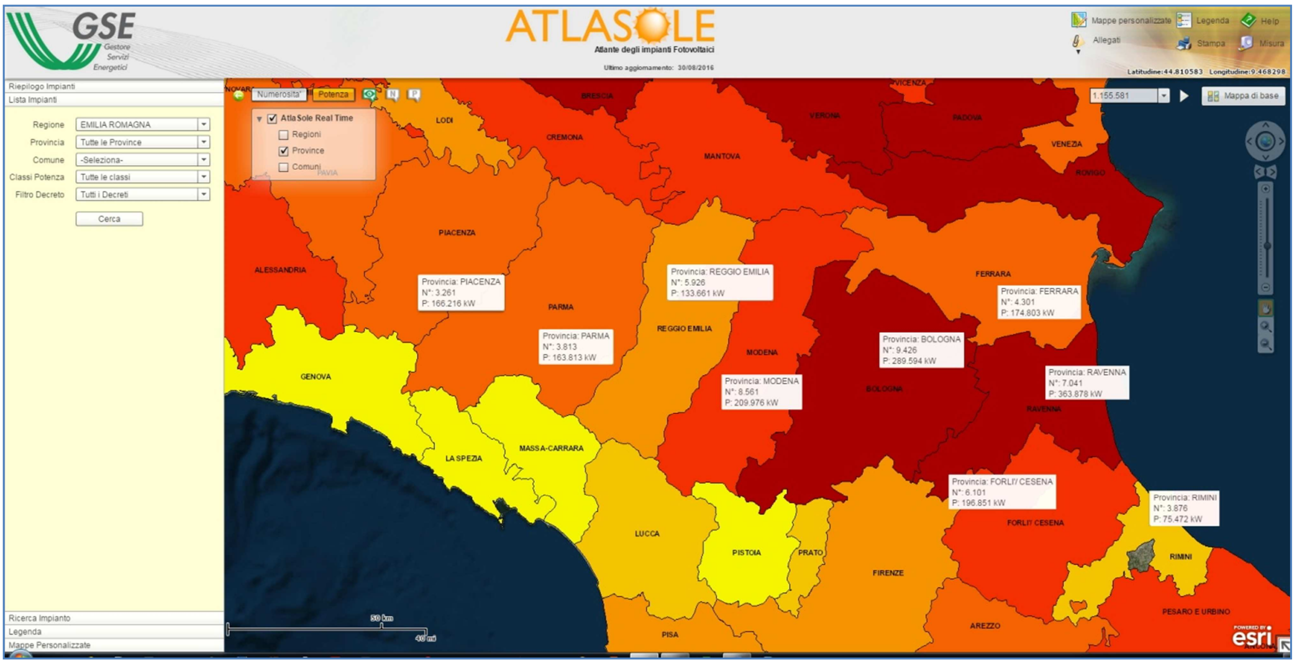


Figura 9- Number and power of photovoltaic plants. - [http://atlasole.gse.it/atlasole/] – al 30/08/2016.

Tabella 8- Number and power of photovoltaic plants. - [http://atlasole.gse.it/atlasole/] – al 30/08/2016.

PROVINCE	Number of plants	Electric power [kW]
PIACENZA	3,261	166,216
PARMA	3,813	163,813
REGGIO EMILIA	5,926	133,661
MODENA	8,561	209,976
BOLOGNA	9,426	289,594
FERRARA	4,301	174,803
RAVENNA	7,041	363,878
FORLI-CESENA	6,101	196,851
RIMINI	3,876	75,472
TOTAL	**52,306**	**1,774,265 kW**

1.8. GIS BIOMASS power plants land register 2016

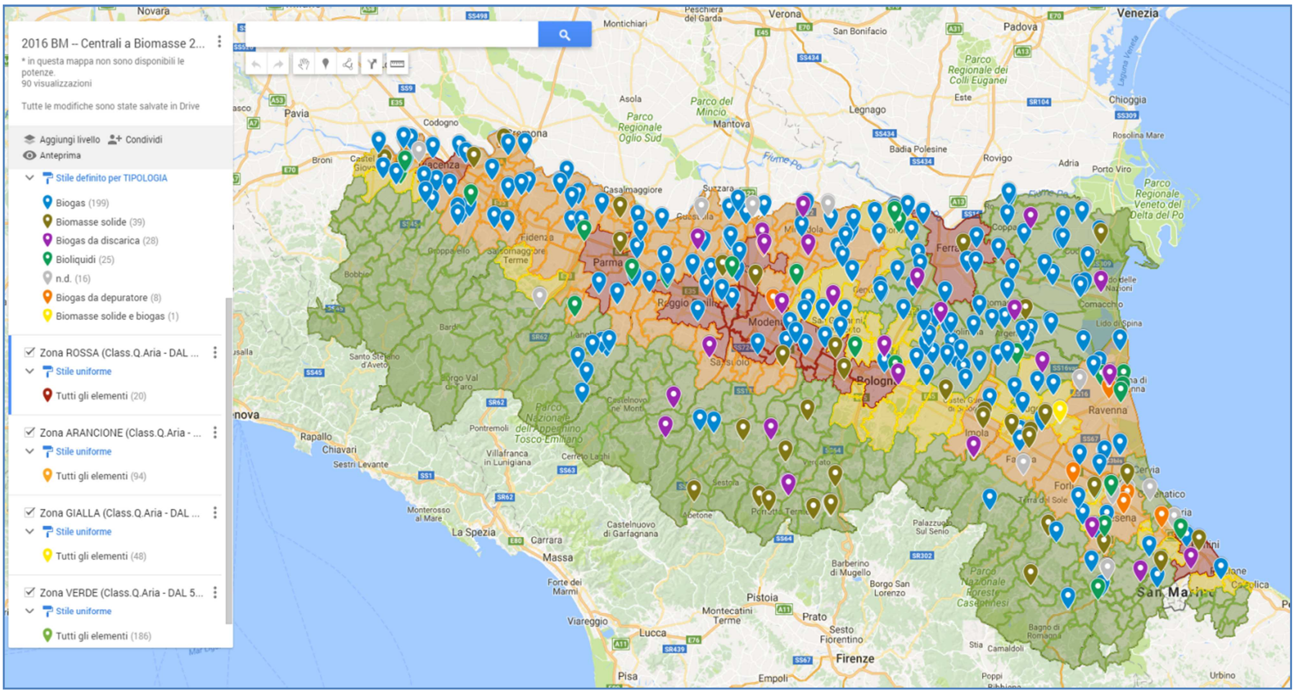


Figura 10- Biomasses power plants GIS land register - 2016 -: total.

Tabella 9- Biomasses power plants GIS land register - 2016 -: summary table

TIPOLOGY	Number of plants	Electric power (MW)
Biogas	196	135.54
Biogas from depurator	8	3.56
Biogas from landfill	26	22.13
Bioliquids	23	93.35
Solid biomasses	27	70.95
Solid biomasses and biogas	1	13.70
Waste	16	1.80
n.d.	19	13.19
TOTAL	**316**	**354.22**

Tabella 10- Biomasses power plants GIS land register - 2016 -: summary table

TIPOLOGY	SECTOR	Number
Biogas	Agricultural-Livestock	158
	Agri-Livestock industry seawage	5
	FORSU - urban organic waste	1
	FORSU - urban organic waste + Depuration sludges	1
	(nd)	31
Biogas TOTAL		**196**
Biogas from depurator	Rif. Depuration sludges	4
	(nd)	4
Biogas from depurator TOTAL		**8**
Biogas from landfill	Waste	15
	FORSU - urban organic waste	1
	FORSU - urban organic waste + Fanghi depurazione + scarti ligneo cellulosici	1

	(nd)	9
Biogas from landfill TOTAL		**26**
Bioliquids	Agricultural-Livestock	1
	(nd)	22
Bioliquids TOTAL		**23**
Solid biomasses	Forestal wood	1
	Agri-Livestock industry seawage	3
	(nd)	23
Solid biomasses TOTAL		**27**
Solid biomasses e biogas	(nd)	1
Solid biomasses e biogas TOTAL		**1**
n.d.	Agricultural-Livestock	2
	Agri-Livestock industry seawage	1
	(nd)	16
n.d. TOTAL		**19**
Waste	(nd)	16
Waste TOTAL		**16**
TOTAL		**316**

Tabella 11- Biomasses power plants GIS land register - 2016 -: summary table

PROVINCE	TIPOLOGY	Number of plants	Electric power (MW)
BOLOGNA	Biogas	35	28.38
	Biogas from depurator	1	2.38
	Biogas from landfill	8	4.65
	Bioliquids	2	1.68
	Solid biomasses	9	1.13
	n.d.	3	1.24
	Waste	4	0.00
BOLOGNA TOTAL		**62**	**39.46**
FERRARA	Biogas	42	36.76
	Biogas from landfill	3	1.75
	Bioliquids	2	0.95
	Solid biomasses	2	13.10
	Waste	2	0.00
FERRARA TOTAL		**51**	**52.56**
FORLI' - CESENA	Biogas	10	3.23
	Biogas from depurator	4	0.97
	Biogas from landfill	2	3.46
	Bioliquids	3	1.43
	Solid biomasses	8	5.76
	n.d.	6	8.92
	Waste	1	0.00
FORLI' - CESENA TOTAL		**34**	**23.77**
MODENA	Biogas	19	9.53
	Biogas from depurator	2	0.21
	Biogas from landfill	7	3.82
	Bioliquids	1	0.62
	Solid biomasses	3	0.50
	n.d.	2	0.00

	Waste	1	0.00
MODENA TOTAL		**35**	**14.68**
PARMA	Biogas	23	8.52
	Bioliquids	3	2.30
	Solid biomasses	1	0.00
	Waste	2	0.00
PARMA TOTAL		**29**	**10.82**
PIACENZA	Biogas	23	12.51
	Bioliquids	3	2.28
	Solid biomasses	1	0.06
	n.d.	4	2.33
	Waste	2	1.80
PIACENZA TOTAL		**33**	**18.97**
RAVENNA	Biogas	21	21.56
	Biogas from depurator	1	0.00
	Biogas from landfill	2	1.86
	Bioliquids	5	81.69
	Solid biomasses	2	49.90
	Solid biomasses e biogas	1	13.70
	n.d.	2	0.60
	Waste	2	0.00
RAVENNA TOTAL		**36**	**169.31**
REGGIO EMILIA	Biogas	20	12.78
	Biogas from landfill	3	5.60
	Bioliquids	2	0.95
	Solid biomasses	1	0.50
	n.d.	2	0.10
REGGIO EMILIA TOTAL		**28**	**19.93**
RIMINI	Biogas	3	2.27
	Biogas from landfill	1	1.00
	Bioliquids	2	1.45
	Waste	2	0.00
RIMINI TOTAL		**8**	**4.72**
TOTAL		**316**	**354.22**

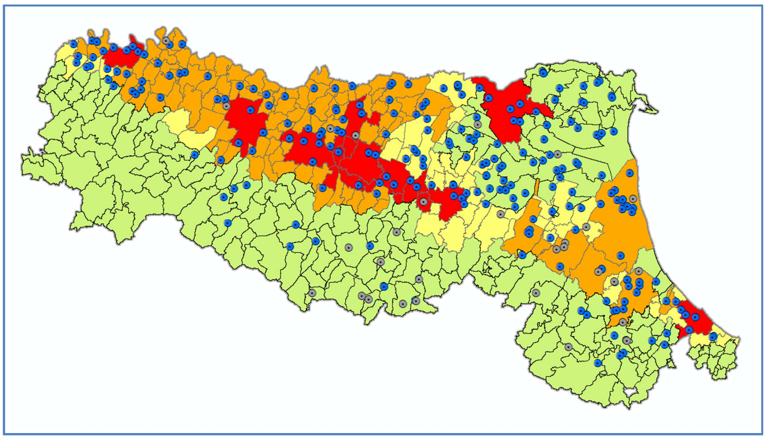


*Figura 11- Biomass power plants 2016 and their zoning on regional law DAL number 51, 26 july 2011 for PM10 and NO2 - *ABACO -.*

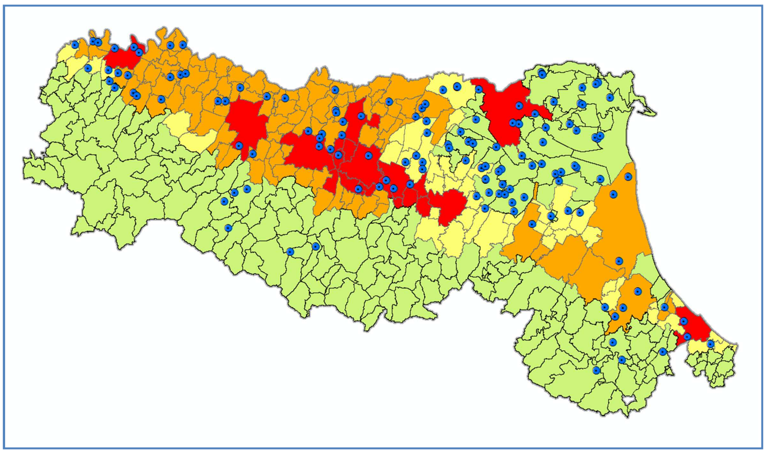


*Figura 12- Biogas power plants 2016 and their zoning on regional law DAL number 51, 26 july 2011 for PM10 and NO2 - *ABACO -.*

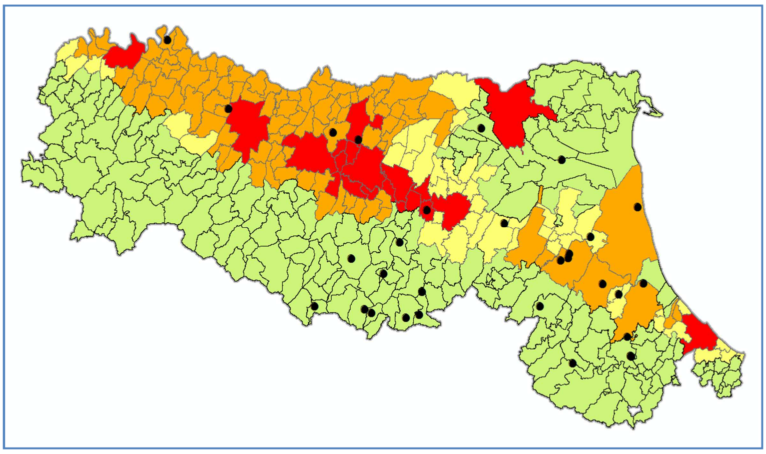


*Figura 13- Solid biomass power plants 2016 and their zoning on regional law DAL number 51, 26 july 2011 for PM10 and NO2 - *ABACO.*

Index - part 5 -

ASSESSMENT FRAMEWORK FOR THE REGIONAL BIOMASS POWE PLANT SYSTEM

1. ASSESSMENT FRAMEWORK OF THE REGIONAL BIOMASS PLANTS SYSTEM

MAIN QUESTION: HOW ASSESS THE ENVIRONMENTAL IMPACT OF THE BIOMASS POWER PLANTS SYSTEMS (BIOGAS AND WOOD COMBUSTION) AT TERRITORIAL/REGIONAL PLANNING LEVEL ?

To evaluate these systems at regional and territorial level we had to:

Analyze the general regional energy budget.

Create biomass power plants GIS land register: years 2015 + 2016.

Divide the GIS land registers in 3 separated type, with their correlated subtypes:

- Biogas plants;
- Solid wood combustion plants;
- Bioliquids (not analyzed in this research).

Create two GIS territorial sensibility maps: one for biogas plants and one for solid biomass plants, that permit us to define for each single plant of our GIS land register in what type of territory they are located.

Create a useful forest wood potentiality GIS map indicator, that measures the regional/provincial forest wood potential annual availability, and then calculate the forest wood energy budgets referred to our solid wood combustion plants system.

Define a group of specific DPSIR indicators calculated through the integration between:

- GIS territorial cartography and sensibility maps;
- GIS land registers of biogas and solid wood biomass plants of different years;

So to be able to overlay them and calculate their geographical pressures/states indicators for the considered time period.

Estimate the impact of the main biomass plants type groups in terms of LCA impacts/damages, through:

- Creating realistic hypothetical realistic standardized biomass plants of reference, equal at 1 MW.electric power working for 8000 hours/year and produce 8000 MWh.el per year (and also for solid wood biomass equal to only 2,4 MW.thermal power working 4000 hours/year and produce only 4000 MWh.therm for remote heating without electricity production) for each single subtype of biomass plant, with their correlated productive chains.
- Implementing the above standardized reference biomass plant in to a LCA software (Simapro 7.3, in our case) applied with one or more LCA reference methods (Ecoindicator’99, in our case), also comparing those with references of energy productions from biogas and wood combustion of Ecoinvent LCA database.
- Multiplying the impact calculated by the LCA method of 1 MW.el of each different type of biomass plant for their total electrical power (and / or thermal) installed on the regional/provincial territory so to obtain their relative cumulative values of environmental impact calculated in terms of the LCA methodology adopted (Ecoindicator’99).

We can see the conceptual visualization in the following Synthethic frame of DPSIR model used in this research:

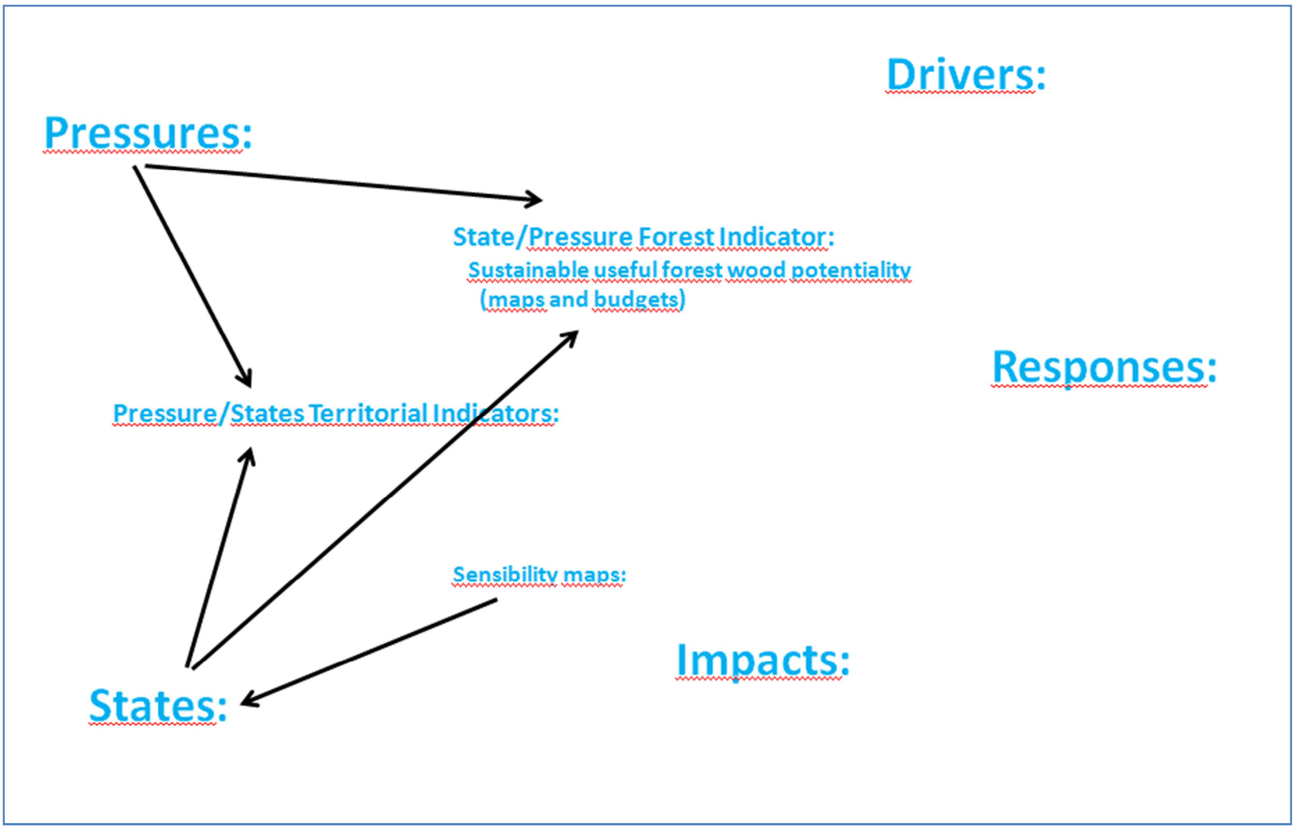


Figura 1- DPSIR conceptual scheme.

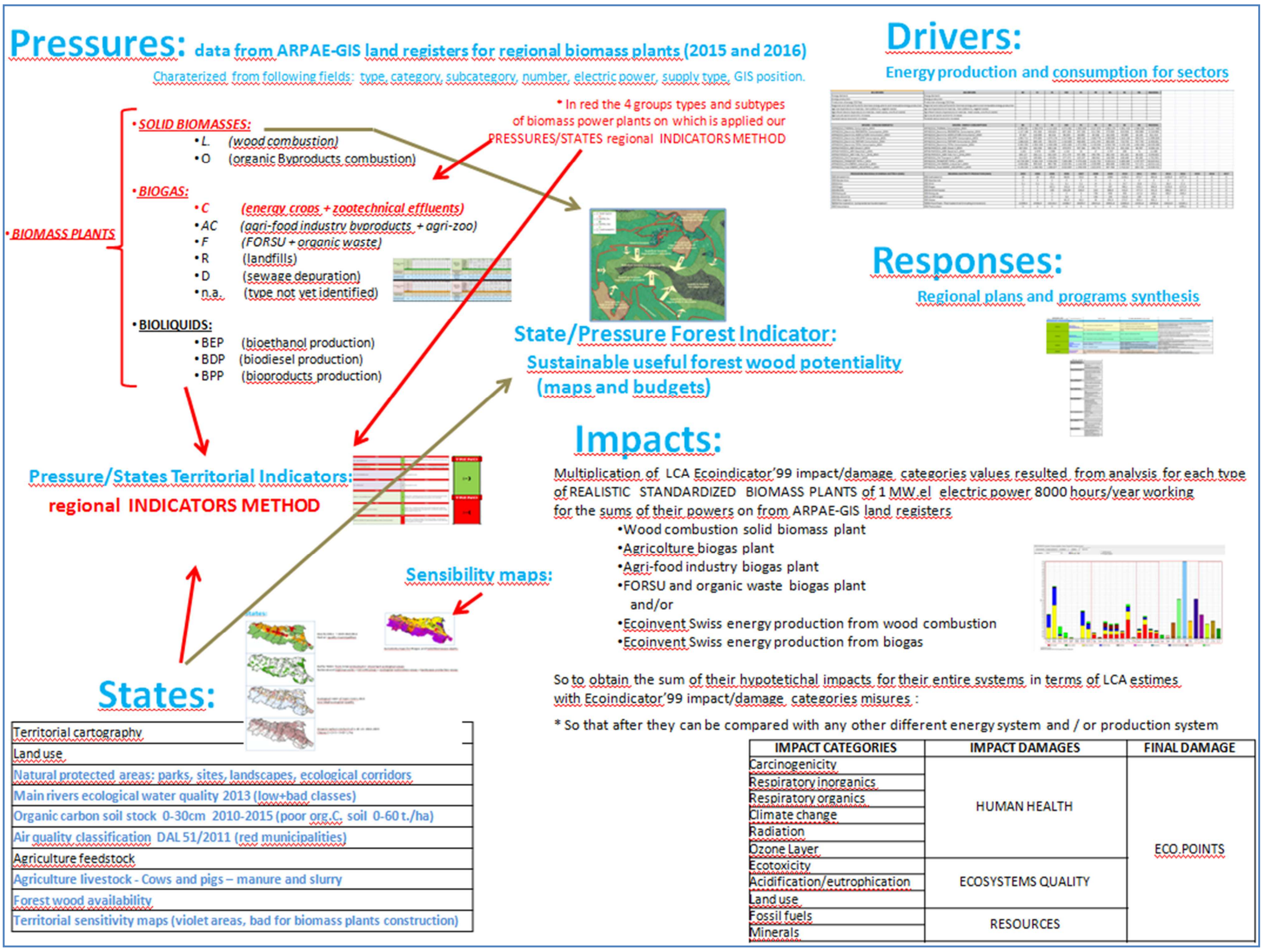


Figura 2- Synthethic frame of DPSIR model used in this research.

Index - part 6 -

BIOMASS POWER PLANTS SENSIBILITY MAPS FOR EMILIA-ROMAGNA REGION

1. SENSIBILITY MAPS FOR BIOGAS AND SOLID BIOMASS POWER PLANTS

As mentioned above, the sensibility[1] map is a tool integral to the coaxial DPSIR matrix that shows geographically the degree of environmental sensitivity of the territories in function of the specific type of plant.

Starting from the map of sensibility is now possible to frame the criticalities of the geographic areas under examination, according to which we can apply with adequate specificity the coaxial array of DIPSR environmental interferences for the plant concerned and / or the various actions budgeted by a regional plan.

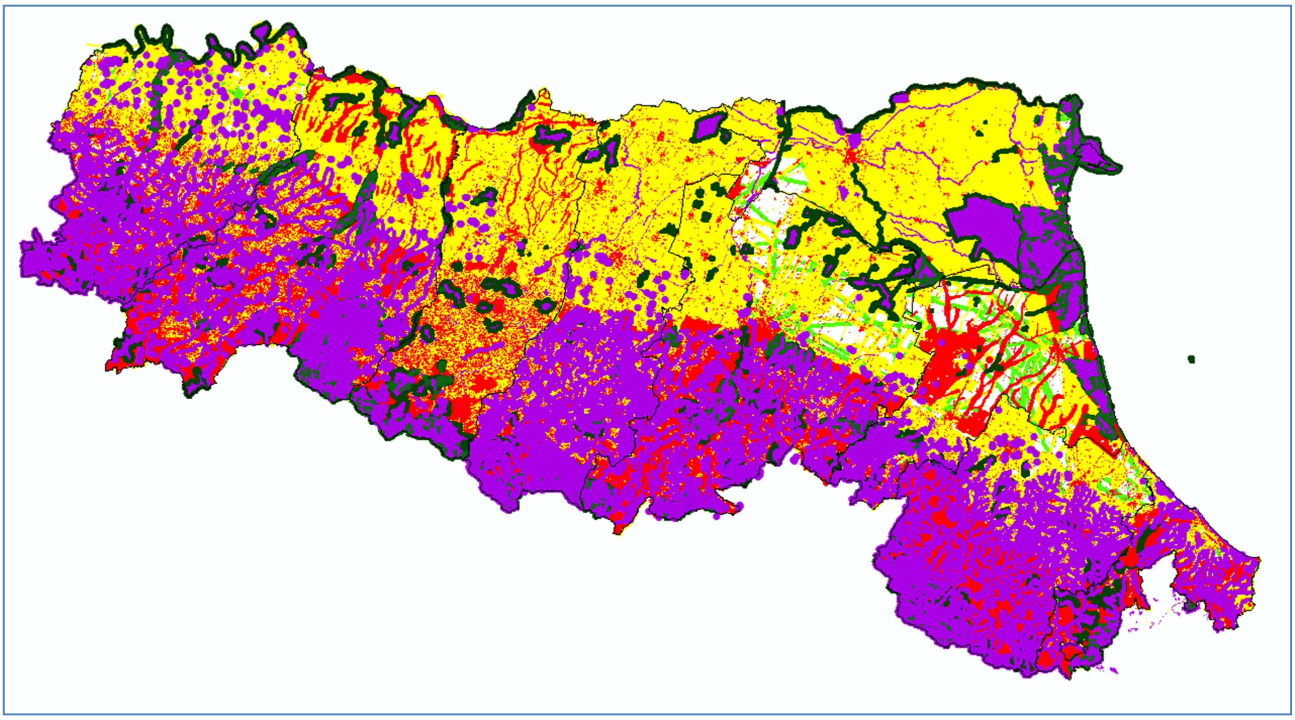


Figura 1- First version of the environmental sensibility map for biomass power plants: in red areas with critical sensibility, in yellow areas with adverse sensibility and uncertain, areas with favorable sensibility in green.

[1] In the environmental field there is great difference in meaning between the term "sensibility" and the term "sensitivity".
With "sensibility" refers to the propensity of an environment to be changed by a certain cause / factor; this modification, potential or real, can then be measured in different ways.
With the term "sensitivity" instead it refers to the degree of precision / accuracy of a particular measurement method, or tool.
Roughly speaking, with the sensibility analysis we are going to measure the harm that a given environment suffers because of a specific environmental pressure factor; with the sensitivity analysis instead we measure the uncertainty/precision of the method/tool with which we then measure a determinated thing.

Tabella 1- Classes of sensibility legend for biogas and solid wood combustion plants

LEGEND	
VIOLET AREA	VIOLET - Exclusion zone
	High Criticality: maximum spatial sensibility level.
	Within the area are present the themes (at least one) that represent constraints or special protections defined by law that much unlikely to be departed
RED AREA	RED - It requires a deepening and a careful and detailed assessment of all the critical factors involved.
	High Criticality: very high spatial sensibility level.
	In the area are present themes which reveal a strong incompatibility with the inclusion of the work, expressed not by rules, but only from a technical opinion
YELLOW AREA	YELLOW - It is necessary an evaluation of all the critical factors involved, which in some cases might be exceeded through suitable equipment or management decisions considered case by case.
	Media criticality: sensitive area, for the presence of safeguards or actual localization difficulties due to objective obstacles arising from territorial characteristics.
	Within the area are present some themes (at least one) that have a certain incompatibility with the work placement.
WHITE AREA	WHITE - Low criticality: low spatial sensibility level
	No automatic decision: we will proceed to the specific assessment of the case.
	The themes present within the area reveal no special exceptions or constraints to the insertion of the work.
GREEN AREA	GREEN - Preferential Zone, where a plant location might be appropriate.
	Within the area there are some themes resulting preferential for the work placement.

1.1. Identification and updating of sensible themes interfered from power plants on biogas and biomass plants

In the initial phase of the work it is necessary to identify the high impact plants (determinants) and, consequently, a series of "sensible" themes, ie all those elements that are characteristic of the territory/region (natural, landscape, hydrogeological and settlements) that may be affected / altered by the plants under examination.
This phase benefits from the work done by Arpae, which led to the definition, in accordance with the Region, of sensible and informative themes to be used for analysis.
The identification of a series of sensible themes (ie all those elements characteristic of the region that may influence decisions concerning the need for deepening, for a given system, the analyzes relating to its location, etc ..) is one of the main aspects of this analysis.

Their choice is derived from observation and analisys of the territorial planning themes classification approved with provincial and regional laws in the land plans, and in parallel of the intrinsic characteristics of the entire territory of the Emilia-Romagna region, based largely on naturalistic elements, landscaping, environmental, hydrogeological, infrastructure and settlements.

The choice of sensible themes useful for the environmental sensitivity of the model was made at the start, and is therefore not dependent on the availability of the data but from the consideration of all factors and the territorial characteristics that can affect the decision-making stages of a project evaluation.

For the realization of the model is therefore necessary to carry out a research work and organization of the information actually available and then later update them, in case some of them are missing.

In our case,

- We have updated the assessment of sensibility of the territories, In function of regional resolution DAL 51/2011
- and we have built and added to the sensibility system the two themes [2] of:
  - Woodly forestal potential

- We have compiled the updates for all the 9 provinces of Emilia-Romagna region:

PIACENZA - PARMA - REGGIO.EMILIA [3] - MODENA - BOLOGNA - FERRARA - RAVENNA - RIMINI

And from these, through GIS processing with the following levels of overlay prioritization:

VIOLET > RED > YELLOW > GREEN > WHITE

obtaining the spatial sensibility maps for biomass combustion plants and biogas plants, which the following is a zoom.

[2] They will be explained in later chapters
[3] Reggio Emilia Province sensibility map is very different from the others because in its time, when it did its territorial planning, it used an independent different classification respect the other Provinces, so now his coloured sensibility map is very different from the others.

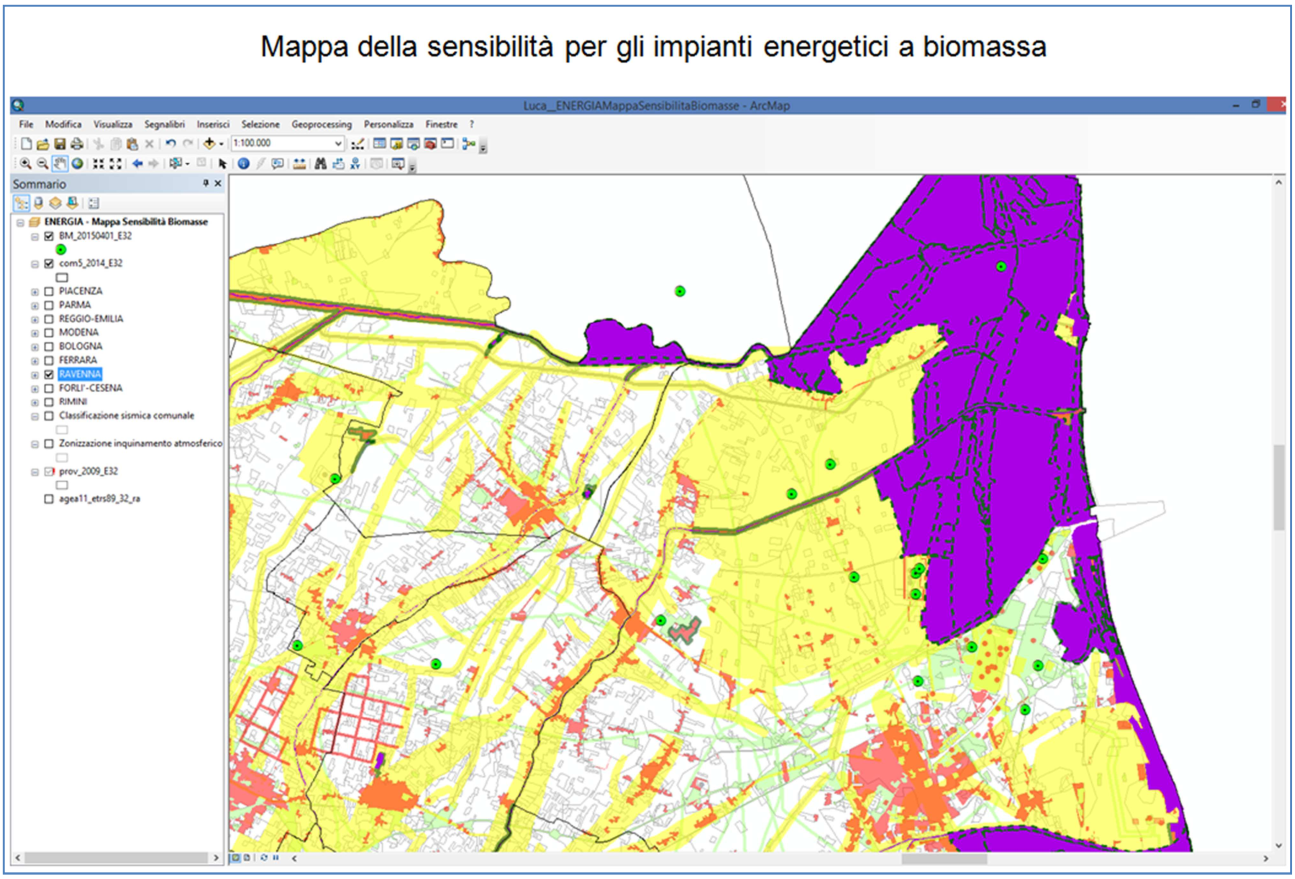


Figura 2- Example: sensibility map for solid biomass plants related to an area of Province of Ravenna.

Tabella 2- General list of the classified areas by the Provinces of Emilia-Romagna region

N°	SENSIBLE THEMS
1	airports
2	archaeological sites (type c)
3	archaeological sites (type a and type b)
4	areas of military interest
5	regional cultural landscapes (Colonie, Colonie Town)
6	state cultural landscape Heritage
7	historical reclamation
8	badlands
9	ridges
10	hillocks
11	continuously inhabited urban built
12	village discontinuous urban built
13	power lines
14	Bands of protection basins and rivers
15	springs and sources
16	reservoirs and river beds
17	pipelines
18	natural parks Regional Protection
19	national parks, state nature reserves
20	Natura 2000 network (SCI, SPA)
21	hilly
22	Forestry and forest system
23	contaminated sites
24	panoramic roads
25	historic roads
44	Attitudes to building transformations (units subject to verification - appropriate units or with little limitations to urban use)
45	zoning perimetrate areas
46	ridges system
47	burned areas
48	buidings and areas of significant public interest
49	production area of Parimgiano-Reggiano cheese
	INFORMATIVE THEMES
50	floodable areas
51	pipelines, steam pipelines
52	migratory routes of the avifauna
53	areas with high noise pollution
54	areas with hydrogeological restrictions
55	DOC / DOCG / IGP / DOP areas for quality food production
56	panoramic areas
57	wood forest potentiality map
	NEUTRAL INFORMATIVE THEMES
58	open areas with sparse or no vegetation
59	water Environment
60	wooded areas
61	mining areas
62	port areas
63	artificial green areas non-agricultural

26	centuriate areas	64	Municipal seismic classification
27	areas with heights> 1200 metres	65	permanent crops
28	areas with risks of a major accident	67	significant hydrography
29	coastal protection zones	68	power plants
30	nature conservation areas	69	waste disposal plants
31	landscaped areas of environmental interest	70	meadowland
32	habitable building zones	71	ARPAE air monitoring networks
33	industrial areas	72	Arable crops
34	unstable areas and disruption	73	subsidence map
35	unstable and instability zones - active landslide	74	shrubs and / or herbaceous
36	windy areas	75	Heterogeneous agricultural areas
37	vulnerable aquifers	76	wetlands
38	water wells	77	zoning air pollution
39	protection of catchment works - the absolute protection zones	78	ARPAE surface water monitoring networks
40	protection of catchment works - buffer zones	79	significant hydrography
41	ecological network		
42	areas at risk of landslides		
43	attitudes to building transformations (not suitable for urban use units)		

In the next paraghraph we will show the compilated table for the Province of Bologna, and the two related sensibility maps for wood combustion plants and for biogas plants. Then this work has been done for all 9 Provinces of Emilia-Romagna region.

1.2. The regional environmental sensibility map for wood biomass and biogas plants

We propose below the two regional-scale photographs of the environmental sensibility maps developed for wood combustion biomass energy plants and for biogas energy plants. They are very similar but not identical. The difference is very minimal and this is due to the fact that the voice/theme number 1 - Airports - is classified in a different way from the law of 4 February 1963, like also the number 49 - Area of Parmigiano-Reggiano cheese production - in reference of DGR 51/2011 (All. I parte 3A).
Below we propose the table of the territorial classification we adopted [4]. It's important to remember that these maps are an important immediate screening tool for preliminary environmental assessments to the authorization processes and / or planning, but they certainly cannot replace the final evaluation of the responsible professional for the specific final evaluations, because the sensitivity maps can contain implicitly some inaccuracies caused from the starting cartography that is updated independently by the provinces or by other delegated institutions for planning and / or land management. For example, the fact that there are the green zones within the historic center of the city of Bologna derives from its territorial not updated classification to that effect. Another example of a very obvious irregularities, as already mentioned, and represented by the territory of the Province of Reggio Emilia which is colored in a manner significantly different than the other provinces; This occurs because of the different regional planning classes that several years ago were adopted by the Provincial Authority during the construction of its PTCP, which remains yet completely valid, and wich it was used for the GIS construction of its environmental sensibility map.

[4] Reggio Emilia Province sensibility map is very different from the others because in its time, when it did its territorial planning, it used an independent different classification respect the other Provinces, so now his coloured sensibility map is very different from the others.

At the end of process we will account the number and the electric power that are situated in violet areas, and we will use those values in the DPSIR pressures/states INDICATORS analysis.

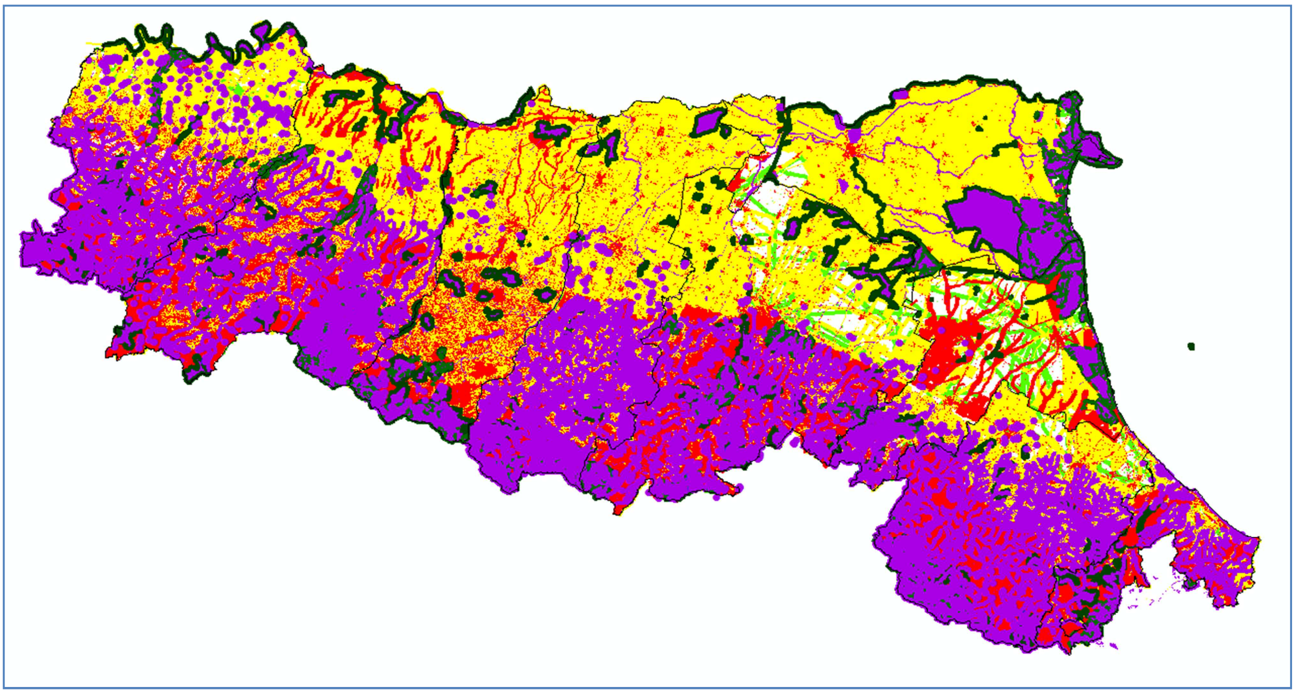


Figura 3- Regional map of the environmental sensibility for SOLID COMBUSTION biomass plants.

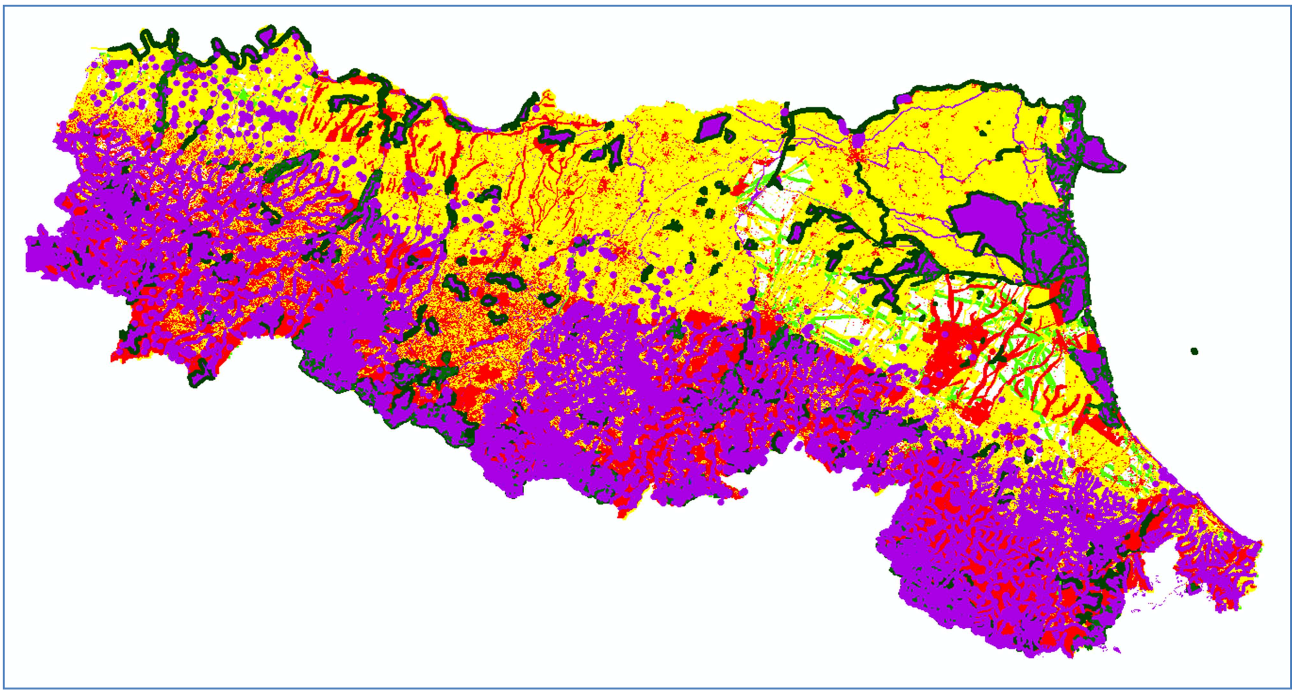


Figura 4- Regional map of the environmental sensibility for BIOGAS plants.

1.3. Environmental sensibility classification adopted for combustion biomass and biogas plants for the territory of Emilia-Romagna region

Tabella 3- Environmental sensibility classification for combustion biomass and biogas plants for the territory of Emilia-Romagna region

N°	SENSIBILITY THEMES	BIOMASSE COMBUSTION PLANT	BIOGAS / BIOMETHANE PLANTS	Laws planning sources	Laws planning article	Reference article from PTCP of BO	Reference TABLE from PTCP of BO	Judgment notes and considerations
SENSIBLE THEMES								
1	airports	R	G	Carta dell'uso del suolo della RER		L 4 feb 1963		Viola: giudizio tecnico Arpae basato su Legge 4 feb 1963 Rosso e giallo: giudizio tecnico Arpae
2	archaeological sites (type c)	G	G	PTCP Prov. Bologna	21	8.2	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP (art.8.2 comma 5)
3	archaeological sites (type a and type b)	Vio	Vio	PTCP Prov. Bologna	21	8.2	Tavola I	Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A, 5A) e nel PTCP (art.8.2 comma 5).
4	areas of military interest	R	R	Piani Urbanistici Comunali				Rosso: giudizio tecnico Arpae
5	regional cultural landscapes (Colonie, Colonie Town)			PTCP, PTPR	16, 8 App.			Non presente nel PTCP di BO
6	state cultural landscape Heritage							Non normati nel PTCP di Bologna
7	historical reclamation	G	G	PTCP Prov. Bologna	23	8.4	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP (art.8.4 comma 3)
8	badlands	Vio	Vio	PTCP Prov. Bologna	20	7.6	Tavola I	Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A, 5A). Rosso: giudizio tecnico Arpae basato su PTCP (art.7.6 comma 5)
9	ridges	Vio	Vio	PTCP, PTPR	9	7.1 - 7.6	Tavola I	Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A, 5A). Giallo: giudizio tecnico Arpae basato su PTCP (art. 7.1 comma 3 e 4; art. 7.6 comma 4) Rosso: giudizio tecnico Arpae basato su PTCP (art. 7.1 - art. 7.6)
10	hillocks	R	R	PTCP Prov. Bologna	20	7.6	Tavola I	Rosso: giudizio tecnico Arpae basato su PTCP (comma 8) Giallo: giudizio tecnico Arpae
11	built continuously inhabited urban	R	R	Carta dell'uso del suolo della RER				Giudizio tecnico Arpae
12	built village discontinuous urban	R	R	Carta dell'uso del suolo della RER				Giudizio tecnico Arpae

13	power lines	V	V	Rielaborazione dati forniti dal gestore (TERNA, ENEL, …)				Verde: giudizio tecnico Arpae
14	bands of protection for basins and rivers	G	G	PTCP Prov. Bologna	17	4.3	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP (art. 4.3, comma 5 e 6) Rosso: giudizio tecnico Arpae basato sul PTCP (art. 4.3)
15	springs and sources	Vio	Vio	PTCP Prov. Bologna	28	5.3	Tavola II	Viola: giudizio tecnico Arpae basato su PTCP art. 5.3 comma 9
16	reservoirs and river beds	Vio	Vio	PTCP, PTPR	18	4.2	Tavola I	Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A). Giallo: giudizio tecnico Arpae basato su PTCP (art.4.2 comma 5) Rosso: giudizio tecnico Arpae basato su PTCP (art.4.2)
17	pipelines	V	V	Rielaborazione dati forniti dal gestore (SNAM Rete Gas)				Giudizio tecnico Arpae
18	natural parks Regional Protection	Vio	Vio	Servizio Parchi e Risorse Forestali della RER				Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A, 5A). Rosso: giudizio tecnico Arpae
19	national parks, state nature reserves	Vio	Vio	Servizio Parchi e Risorse Forestali della RER				Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A, 5A). Rosso: giudizio tecnico Arpae
20	Natura 2000 network (SCI, SPA)	Vio	Vio	Servizio Parchi e Risorse Forestali della RER		DGR 1224/2008		Viola: giudizio tecnico Arpae basato su DGR N. 1224 del 28.7.08 sulle misure di conservazione delle ZPS (All 3 punto 1) Rosso: giudizio tecnico Arpae anche se non esplicitato da DGR 1224/08 Stessi giudizi applicati ai SIC in una logica conservativa
21	hilly	G	G	PTCP Prov. Bologna	9	7.1	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP (art. 7.1, comma 3 e 4)
22	forestry and forest system	R	R	PTPR, PTCP	10	7.2	Tavola I	Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 5A). Giallo: giudizio tecnico Arpae basato su PTCP (art. 7.2 comma 5) Rosso: giudizio tecnico Arpae basato su PTCP (art. 7.2)
23	contaminated sites	R	R	ARPA				Giudizio tecnico Arpae
24	scenic roads	G	G	PTCP	24	7.7		Giallo: giudizio tecnico Arpae anche se non esplicitato da PTCP NB: il tematismo non è cartografato
25	historic roads	G	G	PTCP Prov. Bologna	24	8.5	Tavola I	Giallo: giudizio tecnico Arpae anche se non esplicitato da PTCP
26	centuriate areas	G	G	PTCP Prov. Bologna	21c, 21d	8.2d1-8.2d2	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP (art.8.2 comma 8 e 9)

27	areas with heights> 1200metri	G	G	ARPA (rielaborazione Modello Digitale del Terreno RER)	9			Viola: giudizio tecnico Arpae basato su DAL 51/2011 (All. I parte 5A). Rosso e giallo: giudizio tecnico Arpae basato su PTPR (art. 9)
28	areas with risks of a major accident	G	G	ARPA				Giudizio tecnico Arpae
29	coastal protection zone			PTCP, PTPR	13, 14, 15			Non presente nel PTCP di BO
30	areas of nature conservation	Vio	Vio	PTCP, PTPR	25	7.5	Tavola I	Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A, 4A, 5A). Rosso: giudizio tecnico Arpae basato su PTCP art. 7.5
31	landscaped areas of environmental interest	G	G	PTCP Prov. Bologna	19	7.3	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP art. 7.3
32	habitable building zones	G	G	PRG				Giudizio tecnico Arpae
33	industrial areas	V	V	Carta dell'uso del suolo della RER				Giudizio tecnico Arpae
34	unstable areas and disruption	G	G	Carta del dissesto della RER				Giudizio tecnico Arpae
35	unstable and instability zones - active landslide	R	R	Carta del dissesto della RER				Viola: giudizio tecnico Arpae basato su DAL 51/2011 (All. I parte 2A). Rosso: giudizio tecnico Arpae
36	windy areas			Atlante Eolico Italiano CESI				Giudizio tecnico Arpae
37	aquifers vulnerable	G	G	PTCP		28		Tematismo normato ma non cartografato
38	water wells	Vio	Vio	PTCP		5.3	Tavola II	Aree di rispetto 10 e 200m Viola: giudizio tecnico Arpae basato su PTCP art. 5.3 comma 9 - (pozzi d'acqua a tutela idropotabile)
39	protection of catchment works - the absolute protection zones	Vio	Vio	PTCP		5.3	Tavola II	Viola: giudizio tecnico Arpae basato su PTCP art. 5.3 comma 9
40	protection of catchment works - buffer zones	R	R	PTCP		5.3	Tavola II	Rosso: giudizio tecnico Arpae basato su PTCP art. 5.3 comma 9
41	ecological network	G	G	PTCP		3.4 - 3.5 - 3.6	Tavola I	Giallo: giudizio tecnico Arpae basato su PTCP (art. 3.4 - 3.5 - 3.6) Rosso: giudizio tecnico Arpae basato su PTCP (art. 3.4 - 3.5 - 3.6)
42	areas at risk of landslides	R	R	PTCP		6.8	Tavola II	Rosso: giudizio tecnico Arpae basato su PTCP (art. 6.8)
43	attitudes to building transformations (not suitable for urban use units)	R	R	PTCP		6.9	Tavola II	Rosso: giudizio tecnico Arpae basato su PTCP art. 6.9 comma 2
44	attitudes to building traasformazioni (units subject to verification - appropriate units with little or limitations to urban use)	G	G	PTCP		6.9	Tavola II	Giallo: giudizio tecnico Arpae basato su PTCP art. 6.9 comma 6 e comma 7
45	zoning perimetrate areas	Vio	Vio	PTCP		6.3 6.4 6.5	Tavola II	Viola: giudizio tecnico Arpae basato su PTCP art. 6.3 - 6.4 - 6.5

46	the ridges system	R	R	PTCP	9	3.2-7.1	Tavola I	Rosso: giudizio tecnico Arpae basato su PTCP art.7.1
47	burned areas	Vio	Vio	Regione Emilia-Romagna + CFS 2014		-		Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A).
48	areas of property and significant public interest	R	R			-		Viola: giudizio tecnico Arpae basato su DAL 28/2010 (All. I) e 51/2011 (All. I parte 2A) Rosso: giudizio tecnico Arpae
49	area of Parmigiano-Reggiano cheese production		G			-		Giallo: giudizio tecnico Arpae basato su DGR 51/2011 (All. I parte 3A).
INFORMATIVE THEMES								
50	floodable areas	G	G	Autorità di Bacino, PTCP	17			Giudizio tecnico Arpae basato su PTPR art. 17
51	pipelines, steam pipelines	G	G	Cartografie ARPA				
52	migratory routes of the avifauna			n.d.				
53	areas with high noise pollution	G	G	Cartografie ARPA				
54	areas with hydrogeological restrictions	G	G	Cartografie ARPA				
55	DOC / DOCG / IGP / DOP areas for quality food production	R	R	Cartografie Provinciali separate				Giudizio LV
56	panoramic areas	G	G	da elaborare a cura di RER				Giudizio LV Da riformulare e/o eliminare ad esempio buffer attorno ai crinali o mappe di sovrintendenze
57	wood forest potentiality map	G	G	Elaborazione con Servizio Forestale Regionale				Costruzione e giudizio LV + Servizio Forestale Regionale
NEUTRAL INFORMATIVE THEMES								
58	open areas with sparse or no vegetation			Carta dell'uso del suolo della RER				
59	water environment	R	R	Carta dell'uso del suolo della RER				Giudizio LV
60	wooded areas			Carta dell'uso del suolo della RER				
61	mining areas			PIAE				
62	port areas			Carta dell'uso del suolo della RER				
63	artificial green areas non-agricultural			Carta dell'uso del suolo della RER				

64	Municipal seismic classification			Servizio Geologico, Sismico e dei Suoli, RER				
65	permanent crops			Carta dell'uso del suolo della RER				
67	significant hydrography	R	R	PTA				Giudizio LV
68	power plants			ARPA				
69	waste disposal plants	R	V	ARPA				Giudizio LV
70	meadowland		V	Carta dell'uso del suolo della RER				DAL 51/2011 C) Sono considerati idonei: le zone di coltivazione dei prati stabili ricadenti nelle aree di tutela naturalistica (art.25 PTCP), a condizione che siano aziende agricole zootecniche e non si utilizzi silomais. Non citato per gli impianti a combustione diretta di biomasse.
71	ARPAE air monitoring networks	V	V	Carta dell'uso del suolo della RER				DAL 51/2011
72	Arable crops			ARPA				
73	subsidence map			Carta dell'uso del suolo della RER				
74	shrubs and / or herbaceous			Carta dell'uso del suolo della RER				
75	Heterogeneous agricultural areas	Vio	Vio	Carta dell'uso del suolo della RER				DIR 92/43/CEE: Direttiva Habitat
76	wetlands	G	G	Carta della zonizzazione della qualità dell’aria della RER				DGR 362/12 - computo emissivo a saldo zero per impianti in zone ROSSE-ARANCIONI-GIALLE - valutazione ABACO per impianti in zone VERDI
77	zoning air pollution			ARPA				
78	ARPAE surface water monitoring networks			ARPA				
79	ARPAE groundwater monitoring networks			ARPA				

1.3.1. Example: Environmental sensitivity map for solid biomass combustion systems for the province of Bologna.

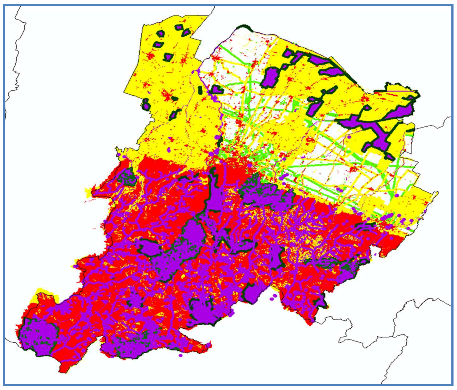


Figura 5- Environmental sensibility map about the SOLID COMBUSTION biomass plants for the Bologna Province.

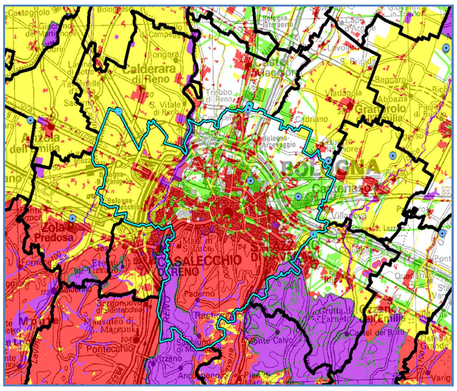


Figura 6- Environmental sensibility map about the SOLID COMBUSTION biomass plants for the Casalecchio di Reno (BO) Municipality and other nearby municipalities.

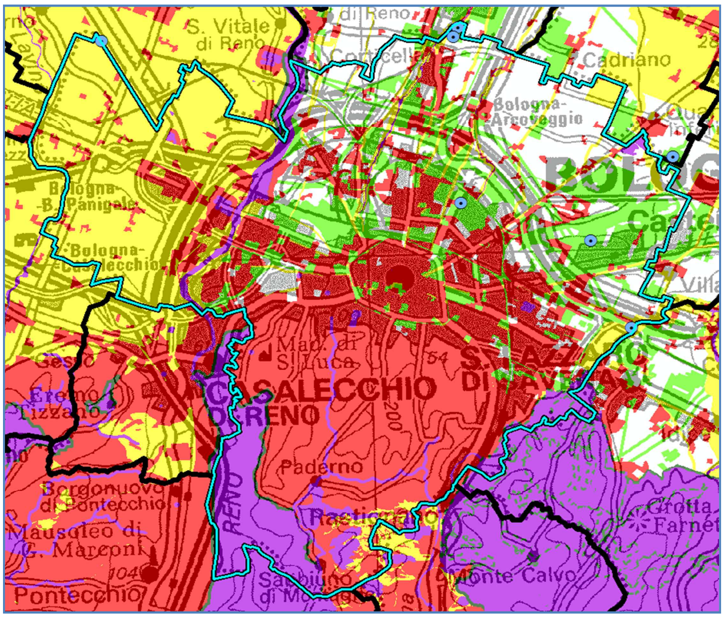


Figura 7- Environmental sensibility map about the SOLID COMBUSTION biomass plants for the Casalecchio di Reno (BO) Municipality.

1.3.2. Example: Environmental sensitivity map for solid biomass combustion systems for the province of Bologna.

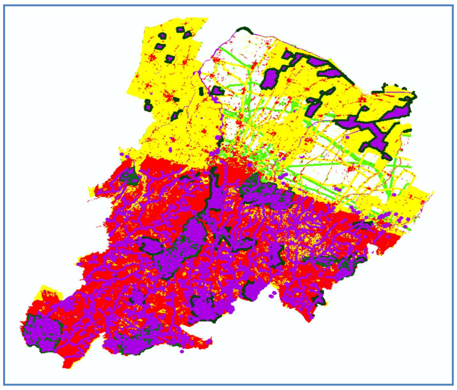


Figura 8- Environmental sensibility map about the BIOGAS plants for the Bologna Province.

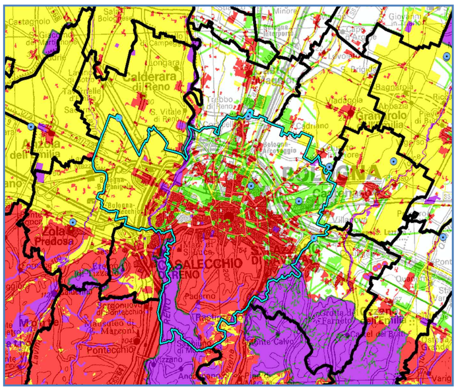


Figura 9- Environmental sensibility map about the BIOGAS plants for the Casalecchio di Reno (BO) Municipality and other nearby municipalities.

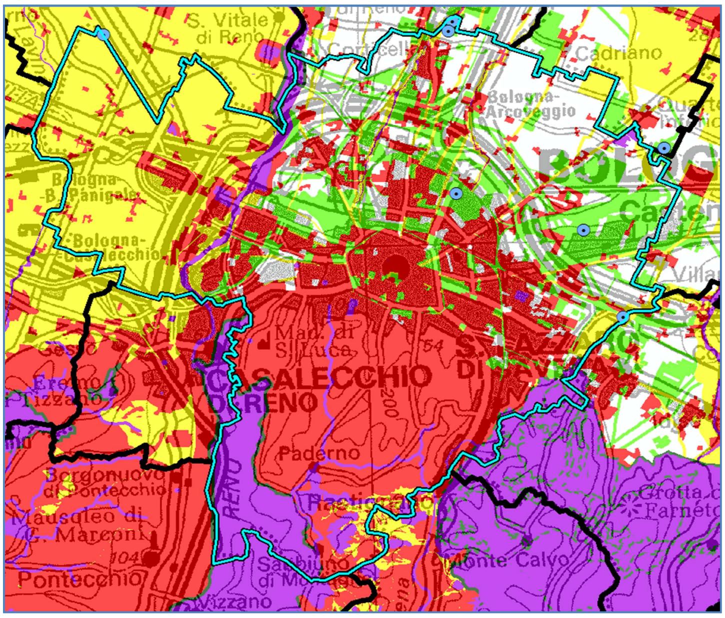


Figura 10- Environmental sensibility map about the BIOGAS plants for the Casalecchio di Reno (BO) Municipality.

1.3.1. The comprehensive table of territorial sensibility map analysis 2015-2016 both for provinces than region .

In the following tables you can find the numerical results synthesis of the biomass GIS land registers overlaid on the sensibility map.

Tabella 4- The comprehensive table of territorial sensibility analysis 2015

2015 - ARPAE GIS land registers data	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
2015 - BIOMASS.Num.plants (Num.)	**46**	**30**	**45**	**26**	**28**	**18**	**25**	**21**	**8**	**247**
2015 - BIOMASS.electric.power (MW.el)	**31,849**	**25,153**	**66,914**	**13,202**	**17,997**	**7,771**	**191,861**	**16,966**	**4,719**	**376,432**
2015 - Number of biomass plants located in violet areas of sensitivity territorial maps	5	5	4	0	1	3	1	0	0	19
2015 - Electric power of biomass plants located in violet areas of sensitivity territorial maps	0,999	5,304	28,638	0	0,34	1,019	0,999	0	0	37,299
2015 - SOLID BIOMASS.Num.plants (Num.)	**13**	**6**	**3**	**4**	**3**	**1**	**5**	0	**2**	**37**
2015 - SOLID BIOMASS.electric.power (MW.el)	**1,13**	**3,264**	**27,199**	**0,5**	**1,859**	0	**72,728**	0	0	**106,68**
2015 - Number of solid biomass plants located in violet areas of sensitivity territorial maps	4	1	1	0	0	0	0	0	0	6
2015 - Electric power of solid biomass plants located in violet areas of sensitivity territorial maps	0	0,18	27,199	0	0	0	0	0	0	27,379
2015- BIOGAS.Num.plants (Num.)	**30**	**13**	**39**	**20**	**21**	**13**	**13**	**17**	**4**	**170**
2015- BIOGAS.electric.power (MW.el)	**28,674**	**9,193**	**36,816**	**12,086**	**12,863**	**5,47**	**35,019**	**14,435**	**3,266**	**157,822**
2015 - Number of biogas plants located in violet areas of sensitivity territorial maps	1	2	2	0	1	1	1	0	0	8
2015 - Electric power of biogas plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	0,999	0	0	3,767
2015 - BIOGAS-AGRI-ZOOTECHNICAL num.plants (Num.)	**12**	**5**	**22**	**4**	**16**	**10**	**6**	**11**	**2**	**88**
2015 - BIOGAS-AGRI-ZOOTECHNICAL electric power (MW.el)	**10,416**	**2,009**	**19,481**	**0,995**	**9,344**	**3,472**	**5,242**	**7,006**	**1,998**	**59,963**
2015 - Number of BIOGAS-AGRI-ZOOTECHNICAL . plants located in violet areas of sensitivity territorial maps	1	1	2	0	1	1	1	0	0	7
2015 - Electric power of BIOGAS-AGRI-ZOOTECHNICAL . plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	0,999	0	0	3,767

Tabella 5- The comprehensive table of territorial sensibility analysis 2016

2016 - ARPAE GIS land registers data	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**
2016 - BIOMASS.Num.plants (Num.)	**62**	**34**	**51**	**35**	**33**	**29**	**36**	**28**	**8**	**316**
2016 - BIOMASS.electric.power (MW.el)	**39,46**	**23,765**	**52,564**	**14,678**	**18,973**	**10,821**	**169,313**	**19,93**	**4,717**	**354,221**
2016 - Number of biomass plants located in violet areas of sensitivity territorial maps	5	6	4	0	1	3	2	0	0	21
2016 - Electric power of biomass plants located in violet areas of sensitivity territorial maps	0,999	3,8	14,539	0	0,34	1,019	1,998	0	0	22,695
2016 - SOLID BIOMASS.Num.plants (Num.)	**13**	**6**	**4**	**4**	**3**	**2**	**5**	**1**	**2**	**40**
2016 - SOLID BIOMASS.electric.power (MW.el)	**1,13**	**3,269**	**13,1**	**0,5**	**1,86**	0	**63,6**	**0,5**	0	**83,959**
2016 - Number of solid biomass plants located in violet areas of sensitivity territorial maps	4	1	1	0	0	0	0	0	0	6
2016 - Electric power of solid biomass plants located in violet areas of sensitivity territorial maps	0	0,18	13,1	0	0	0	0	0	0	13,28
2016- BIOGAS.Num.plants (Num.)	**46**	**17**	**44**	**29**	**25**	**23**	**24**	**23**	**4**	**235**
2016- BIOGAS.electric.power (MW.el)	**36,28**	**8,258**	**37,515**	**13,558**	**12,836**	**8,522**	**23,423**	**18,38**	**3,267**	**162,039**
2016 - Number of biogas plants located in violet areas of sensitivity territorial maps	1	3	2	0	1	1	2	0	0	10
2016 - Electric power of biogas plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	1,998	0	0	4,766
2016 - BIOGAS-AGRI-ZOOTECHNICAL num.plants (Num.)	**19**	**8**	**24**	**10**	**18**	**16**	**12**	**12**	**2**	**121**
2016 - BIOGAS-AGRI-ZOOTECHNICAL electric power (MW.el)	**16,556**	**3,008**	**21,529**	**5,345**	**9,274**	**5,605**	**11,259**	**7,357**	**1,998**	**81,931**
2016 - Number of BIOGAS-AGRI-ZOOTECHNICAL . plants located in violet areas of sensitivity territorial maps	1	2	2	0	1	1	1	0	0	8
2016 - Electric power of BIOGAS-AGRI-ZOOTECHNICAL . plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	0,999	0	0	3,767

Index - part 7 -

FOREST WOOD POTENTIALITY GIS ANALYSIS AND ENERGY BUDGETS

1. FOREST WOOD AVAILABILITY MAP AND WOOD ENERGY BUDGETS

1.1. Introduction: Woods and forests

[Pividori, 2005, a]

In general, the forest is a large, unpaved area where natural vegetation, mainly made up of tall trees, grows and spontaneously spreads. We talk about wood when the extension of the forest is limited.

- The **forest** is defined as a surface of uncultivated land, not controlled by man and much larger than that of a forest, where vegetation grows spontaneously and is made up of herbaceous plants, bushes and in particular from tall trees. According to the FAO [1] nomenclature, its size must be at least 1 hectare or 10,000 sq. M. It must be characterized by a tree cover of more than 10% determined by species capable of reaching 5 m in height at maturity in situ.
- Italian law defines a **wood** [2], differentiating it from a masting, an orchard or similar plantations, in the following terms: a forest consists of a large surface of soil covered by arboreal vegetation, ie trees, predominantly tall; For this purpose, it shall have a minimum extension of 2,000 m², with an average tree height of at least 5 m, a soil coverage of at least 20% and a minimum width of at least 25 m.

The woods exploited by man can be distinguished in cedus and fustaies:

- ***Cedu*** is a periodically cut wood (usually every 10/30 years), which after being cut off regenerates thanks to the suckling of breeds. The forest therefore regenerates mainly vegetative or agamic, that is, through branches or roots.
- ***Fustaia*** (or " high pit wood ") is a forest that is cut at intervals of at least 40/100 years and in such a way that, after cutting, the forest itself is renewed through the emergence of new seedlings (plantule), born from the seeds of pre-existing trees or left after the cut ("stockseeds trees" or "reserves"). The forest is therefore regenerated especially for sexuata or gamic way.

The management of the high-pit wood, allowing cutting only at very spaced intervals, suits the great properties (which are mostly public), where it is possible to cut into staggered lots over time (forest settlement). In small properties, the need to obtain timber every year pushes the owner of the forest into a cedar management. In addition, usually, firewood is obtained mainly from firewood or, in particular, in the case of chestnut, piles; The fustaies provide lumber for every type of workmanship.

- With the term "**woody arboriculture**" we mean "the cultivation of a simple set of forest trees constituting a temporary or transient artificial system, which may also evolve towards a forest ecosystem, in order to obtain more or less short timber products in high quantity and specific quality, in relation to different phyto-climatic regions, and to environmental and socio-economic conditions. " [3].

The concept of **short-term woody arboriculture** means a plant with a production cycle of up to 8 years (Buresti Lattes and Mori 2005) and usually an arboriculture destined to quantity. The purpose

[1] FAO: Food and Agriculture Organization of the United Nations.
[2] Parameters adopted by ISAFA - TN for the first national forest inventory - IFN1 - 1983-1985.
[3] For woody arboriculture, we intend the applied science that study the temporary cultivation of individual trees or a set of trees in order to produce wood with specific characteristics; In the light of this, arboriculture can be classified according to the productive objective or to the energy supply provided from the outside (Mori, 1996).

of this type is to provide large amounts of wood in a short time without paying too much attention to the technological and qualitative characteristics of each single tree.
They are often used in fast-growing species, which have, compared to other, the characteristic of achieving, at the same time and available ecological factors, higher dimensional parameters (height, diameter and volume). The aim is to produce wood mass, minimizing costs, limiting field interventions except those strictly necessary. Spesso The plants are monospecific or even monoclonal, the cutting is practiced in a single solution. The material used is usually used for low value assortments: particle boards, energy production, packaging materials, cellulose pulp, low-grade sawn and more (Mori, 1996).

Long-lasting woody arboriculture, with a production cycle of more than 20 years (Buresti Lattes and Mori 2005) and normally less than 40-60, can also be termed as quality or quality arboriculture. Made using valuable wood species with different purposes, in which the aim of this is important: production of quality timber for the production of roundwood, sawn timber (carpentry and earthenware) [4] , High-quality cut veneers, leafy plants, aesthetic or naturalistic plants.
Each plant assumes a particular value that needs to be maximized. In these systems the individual is a fundamental element. The species used generally have high edacial needs to obtain medium-fast growths. In this type of arboriculture the production cycle is subordinated to the dimensional, aesthetic and technological characteristics of the production that is to be obtained (for example, if you want to produce walnut wood with a dark color it is not advisable to stimulate the plant to a rapid growth, To avoid a clearer coloration) (Buresti E., Frattegiani M., 1995).
The plants can be pure or mixed, cutting operations can be carried out in multiple solutions, depending on the species and individual subjects that have reached the desired or economically most desirable characteristics. The choice in making a short-cycle plant or a long cycle is determined by various factors (stational, business organizational, time), not least the possibility of investment and economic objective.

The term **extensive arboriculture** usually coincides with that of a quantity of arboriculture. The external energy supply is usually reduced to the essentials, it is usually the plant, the compensation of the pests, the localization for the first years. This type of arboriculture is suitable for species suitable for the station and widely experimented.
Semi-extensive arboriculture consists of a low energy input as well as the strictly necessary; Both quantity and quality arboriculture can be semi-extensive. The minimum allowances in this case are: soil work, pruning, thinning, defense against biotic and abiotic agents.
Intensive arboriculture provides a high energy input in addition to what is needed for good plant performance. The result is usually an arboriculture that aims to produce quality except for the production of biomass for energy (short rotation). It consists of energy delivery under the most varied forms of plant care: different soil treatments, fertilizers, irrigation ... (Mori, 1996).
Diversification of plants reduces the risks of biotic and abiotic agents and the resulting economic risks; The term diversification refers to the preference for mixed plants compared to pure ones, with main plants of several species, in order to obtain distributed production at different times and to diversify the economic risk; moreover, diversification means preferring monoclonal respect pluriclonal implants, thus increasing the level of biodiversity and reducing the risks of biotic disadvantages (pathogenic or abiotic disadvantages) (frost, droughts, floods ...).
On the basis of the principle of *complementarity*, the plant, in addition to its production functions, provides services, positive externalities (a positive externality manifests itself in cases where a benefit is provided to someone outside the production or consumption of a Merchandise) to the

[4] In reality, quality arboriculture can also provide a high percentage of low-grade wood products for dimensions or technological and aesthetic features that are inadequate to the most profitable transformations (shreds, scraps, or drums with defects).

community:

- Landscape improvement;
- Reduction of eutrophication of watercourses;
- Improvement of the habitat for wildlife;
- Increasing biological diversity compared to agricultural crops (especially if plants are mixed).

In addition, there are advantages to the manufacturer (additional benefits: maximized without affecting the production target in any way) that can help ease the running costs (eg robinia: honey and firewood).

According to the principle of *ecological compatibility*, the plant and all its related operations should be carried out with the least environmental impact (environmental, genetic, invasion of the species adopted), limiting external inputs through a high degree of self- facility.

The term **short rotation forestry (SRF)** refers to short tree shrubs ranging from 2-3 to 7-8 years, with a high density of 2,000 to 20,000 plants per hectare. Generally the purpose is to produce wood biomass for cellulose, panels and energy uses. At present, the development and diffusion of this kind of arboriculture depend to a large extent on the interest of the world community in the use of alternative fuels for fossil fuels for the production of energy (thermal, electrical, etc.) and in reducing emissions of CO2.

The most suitable soils for energy crops are the uninitiated, according to the indications of Community Agricultural Policy, according to American studies there are also three other types of soil suitable for the production of biomass:

- Land with problems of strong erosion (not very high gradient, since soil acitivity is a limitation to mechanization);
- Wetlands reclaimed and converted to agricultural use;
- Marginal agricultural land.

The most commonly used species in this area are the rapidly growing broadleaf, while the less common is the use of conifers. In Italy, potentially more suitable species are poplars and willows on the plains of the North and the Center, robinia in hilly terrain, eucalyptus in the Center and in the South. Other interesting species could be robinia, plantain, oak and elm Siberian. In Sweden, where this system has been used for some years, the species used are willow and birch.

There are two crop models: the American and the Swedish models; The first involves lower plant density and higher woody quality production than the second, shifts are usually between 5 and 7 years; The Swedish Module provides for the colonial government, with shifts no higher than 3 years, plant density between 8,000 and 15,000 plants per hectare (Bisoffi S., Facciotto G., 2000).

By means of SRC: Short Rotation Coppice it is possible to obtain small material in short time and to exploit the polloniferous capacity of the species used. All operations from the plant to collection are mechanized to reduce crop costs.

In 2005 in Italy, the research was directed towards the Swedish system. The cultivation model is of intensive type, therefore requires considerable energy inputs and a whole series of operations that often in other plantations can be sporadic or limited:

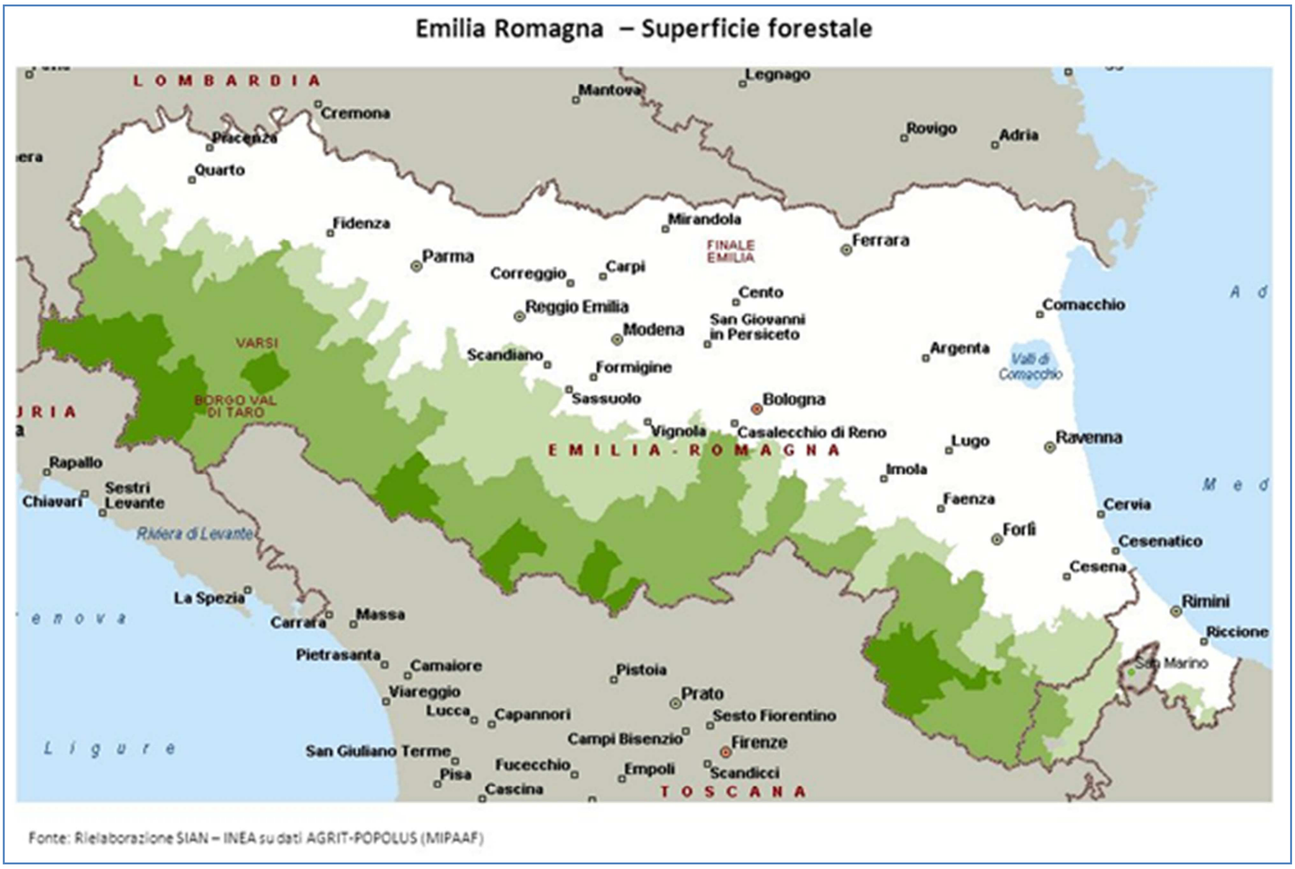
- Use of selected clones or varieties, in the form of woody cuttings with low production cost, great ability to grind and easy handling;
- Soil preparation, by means of a medium-depth plow;
- Post-plant weed control and subsequent land-based mechanical processing;
- Fertilization in order to compensate for the loss of nutrients resulting from the removal of biomass;
- Phytosanitary defense;
- Summer irrigation;
- Use by direct chopping.

In general, from the reading of the international bibliography in a Short Rotation Forestry

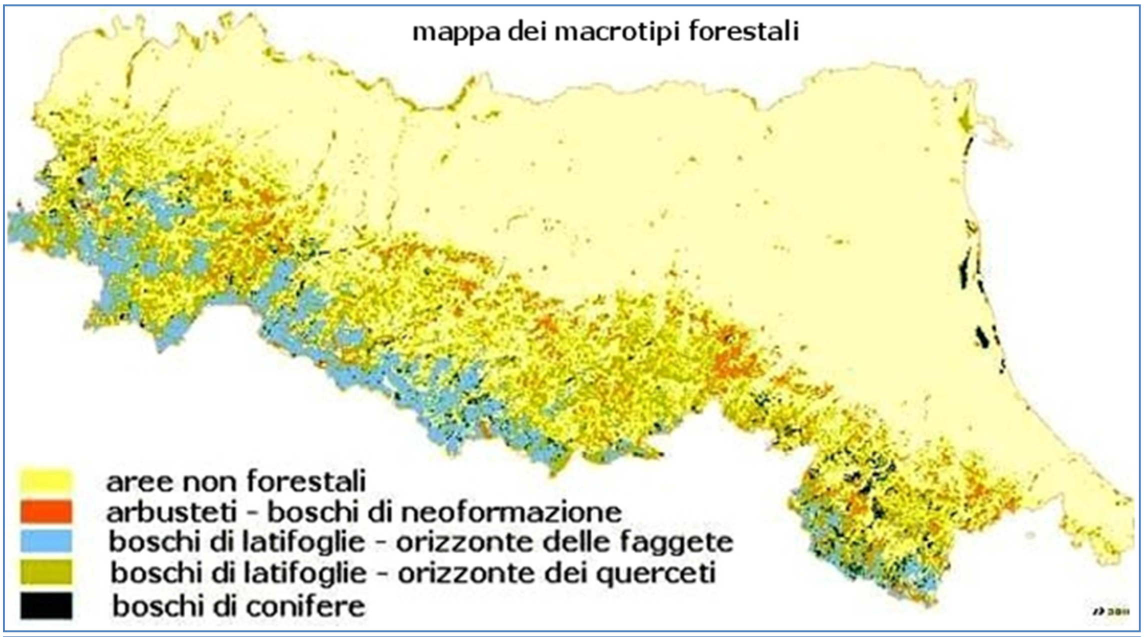
conducted in a rational way (energy input by irrigation, fertilization, etc.), average dry matter productivity ranges from 10 to 20 tonnes per hectare. Year, corresponding to about 15 to 30 tonnes of fresh substance (Bisoffi and Facciotto, 2000), naturally depending on soil fertility, cultivated species and seasonal climatic trends. In the case of poor energy inputs, plant productivity tends to decrease sharply with productions that can be estimated at around 10 tonnes per hectare. Year of fresh substance, comparable to that of the natural forest formations with good feracity.
Of course, one of the most controversial topics is the duration of the production cycle. A very short cycle (up to three years) implies more dense plants and a production of bark rich material and hence with lower calorific power, but allows some ease in mechanization of the harvest; A longer production cycle with lower plant density allows to harvest material with lower bark percentages, but larger sizes that today are poorly crafted to a mechanized harvest.
In addition, in short cycles, woody material collection is necessarily limited to the vegetative rest period (up to six months), as a summer harvest would greatly affect productivity, without thinking of the problems associated with extinction of planters, which would tend to emit a new generation of suckerings during the same season, with serious risk for their survival in the following winter due to poor lignification of the tissues. In longer cycle installations, any seasonal productivity loss would be distributed over several years.
Another aspect of the SRF is related to the storage of the harvested material: in the case of small material (very short cycle), cluster storage is difficult due to the size they would have to take due to the presence of empty blanks, Inside of the same. Under these conditions, it is advisable to immediately pick up the material, but once it is packed, if it is not used in a short time, it starts to ferment with a loss of 30% of the calorific value.
The appearance of the vitality of the plant material (cuttings, seedlings) and the vitality of the planters (the number of shifts before the production collapse and the need for a new plant) are still not well defined and are heavily linked to costs.
In order to obtain economically sustainable wood biomass production it is necessary to cultivate species that have rapid growth, which can easily be propagated vegetatively (through the cuttings), and easily recover after each cession (Facciotto and Schenone, 1998).
Plants with these characteristics, generally in the Emilia-Romagna plain, **poplar (Populus L.)** is one of the most suitable. *Populus Alba* and *Populus Lombardo*, for example, in favorable conditions can reach 24 meters in height over 20 years.
With regard to the density of the plant, decreasing the number of plants per unit area also decreases the fraction of wood in the stem and increases the amount of leaves, branches and bark, for this reason the plant density is rather high, variable Between 1000 and 10,000 plants per hectare, larger densities are hardly tolerated by poplar. Cuttings can be arranged on single or twin files; The latter have several advantages from the economic and technical point of view, making the density of the system high, without compromising the accessibility of interfaces by complex mechanical means, such as self-propelled chippers, and also reduces labor and machines. The choice of shift, which depends on the species, station fertility and initial density, must be made in order to obtain the highest yields possible at low cost, given the scarce quality of the timber, the production costs (a high number of Plants per hectare) and transport have a significant impact on the financial balance of plants. Usually the shifts do not exceed 2-4 years, the maximum diameter to use current self-propelled chippers is 10 cm.

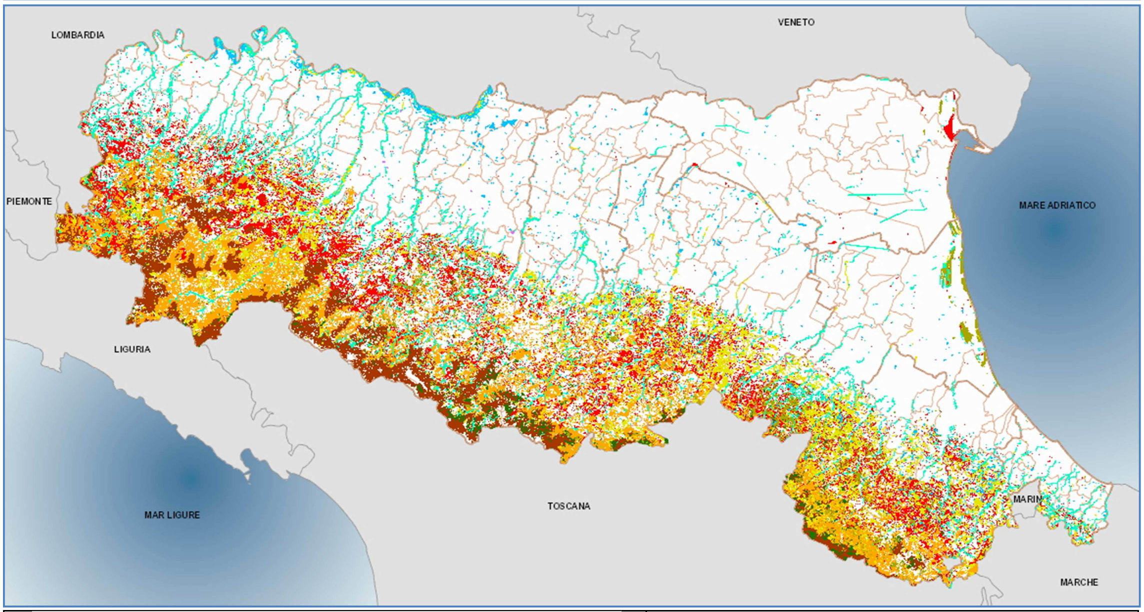
1.2. Emilia-Romagna regional forest context

The Emilia-Romagna region has a total extension of 22,451 sq km, or 2,245,100 hectares. The north-west-south-east pedecular line divides the region into two parts with almost equivalent extents: the northern part (47.8% of the total area) is flat, while the hills (27.1% Territory) and the mountains (25.1%) are located in the southern region of the region.
Protected Areas are represented by Parks, Nature Reserves, Ecological Equilibrium Areas, Protected Natural and Semi-Natural Landscapes and, together with Natura 2000 sites, protect an area of 16% of the regional territory.
Forest areas in the region occupy a total area of about 612,600 hectares, of which 88.8% (543,000 ha) are forests, while 11.2% (68,000 ha) are forests.



[RER.SIAN-INEA, 2016, a]





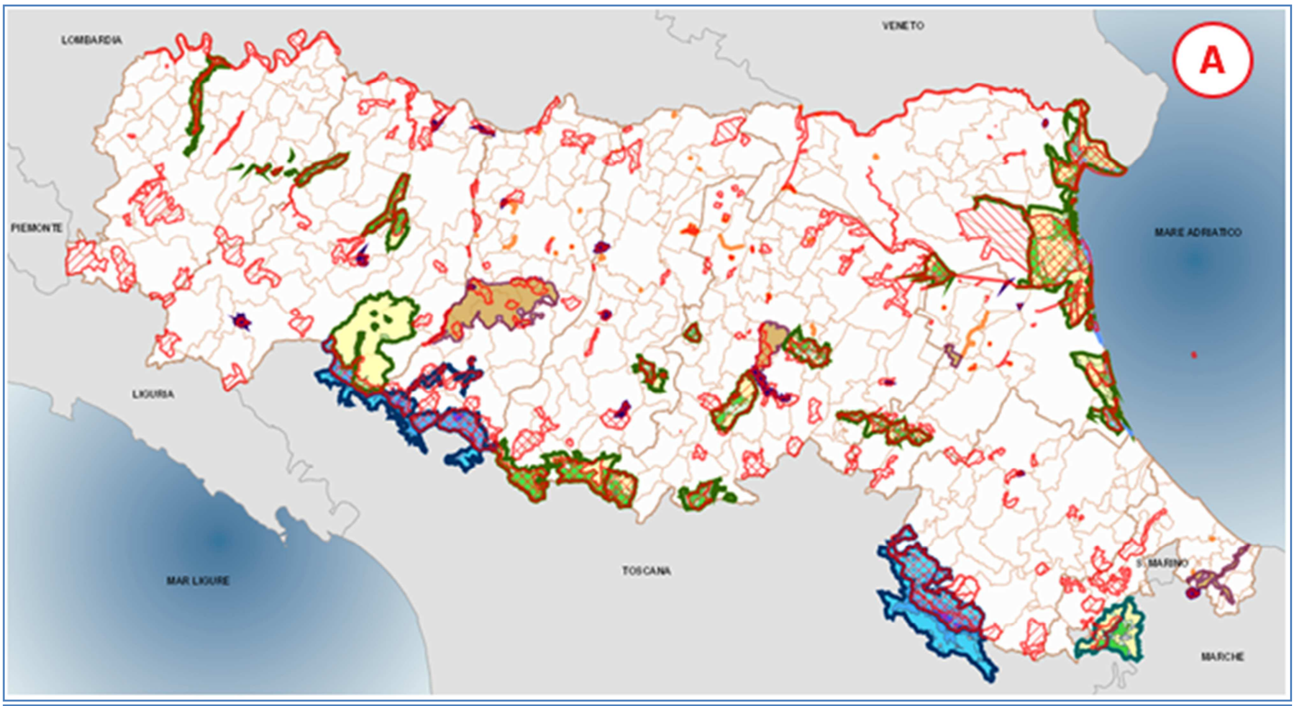
Carta forestale dell'Emilia-Romagna
Tipi forestali

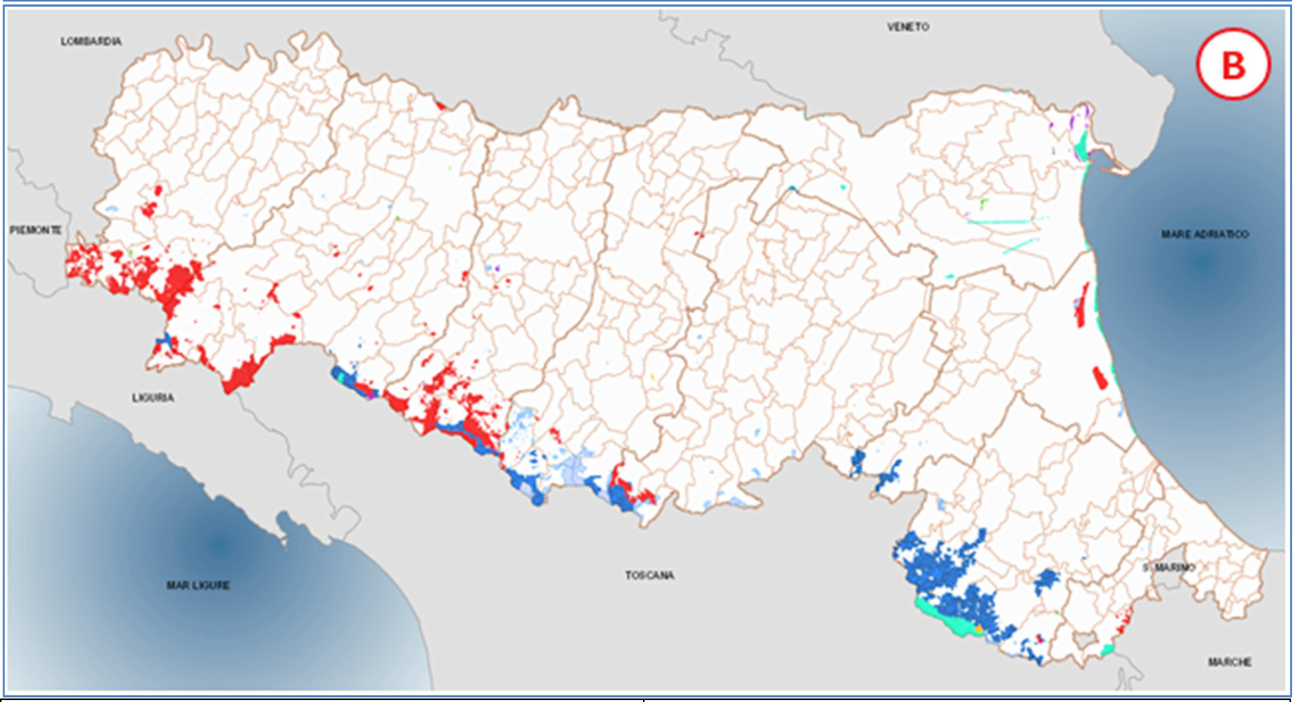
abetine, popolamenti a conifere montane	6.900 ha
pinete, conifere da litorali a submontane	31.200 ha
Pioppeti colturali e arboricoltura da legno	19.900 ha
Boschi ripariali	37.300 ha
Arbusteti (escluse praterie arbustate)	36.000 ha
Querceti misti submesofili e castagneti	278.000 ha
Querceti xerofili di Roverella e sclerofille	98.300 ha
Faggete	105.000 ha
totale aree forestali dalla carta forestale	*612.600 ha*

Maps of:
Forest macro-types
and Forest types [5]
(*updating 2006)

[RER.SAPFSM.IFRER, 2016, b]

[5] Processing obtained from the regional forest map database by assigning to each polygon a provisional forest code on the basis of the two main species and the forest of government and treatment..





(A) Map of protected areas and Rete Natura 2000

Aree protette e Rete Natura 2000
- SIC e ZPS regionali
  - SIC
  - SIC-ZPS
  - ZPS
- Parchi e Riserve (limiti)
  - TIPOLOGIA
  - Parco nazionale
  - Parco interregionale
  - Parco regionale
  - Riserva regionale
  - Riserva statale
- Parchi e Riserve (zone)
- Paesaggi protetti
- Aree riequilibrio ecologico

(B) Public Property Charter and Forestry Interest

Proprietà pubbliche e collettive di interesse forestale
- Proprietà pubbliche e Assetti Fondiari Collettivi
  - Demanio statale
  - Patrimonio forestale indisponibile
  - Proprietà regionali
  - Proprietà provinciali
  - Comuni e Unioni
  - Enti Parco
  - Usi civici

[RER.SAPFSM.IFRER, 2016, b]

1.3. Forest legislation

National and European Norms

- D. Lgs. 18 maggio 2001, n. 227 “Modernizzazione del settore Foreste”
- Piano di Azione dell’Unione Europea per la gestione sostenibile delle foreste (15 giugno 2006)

Regional norms

- Legge Regionale 4 settembre 1981, n. 30 "Incentivi per lo sviluppo e la valorizzazione delle risorse Foresti, con particolare riferimento al territorio montano. Modifiche ed integrazioni alle Leggi Regionali 25 maggio 1974, n. 18 e 24 gennaio 1975, n. 6"
- Legge Regionale 6 luglio 2007, n. 10 "Norme sulla produzione e commercializzazione delle piante Foresti e dei relativi materiali di moltiplicazione"
- Legge Regionale 17 febbraio 2005, n. 6 "Disciplina della formazione e della gestione del sistema regionale delle aree naturali protette e dei siti della Rete Natura 2000"
- Art. 47 della Legge Regionale 14 aprile 2004, n. 7 "Integrazione alla legge regionale n. 25 del 1999" con cui viene riconosciuta la necessità di assegnare specifici fondi per attività finalizzate alla manutenzione ordinaria del territorio montano e al mantenimento della funzionalità degli elementi territoriali sia naturali sia di origine antropica
- Art. 63 della Legge Regionale 6 luglio 2009, n. 6 "Definizione di bosco" (ai soli fini dell'individuazione dei territori coperti da boschi negli strumenti di pianificazione territoriale e urbanistica e della delimitazione dei territori assoggettati a vincolo paesaggistico)
- Art. 34 della Legge Regionale 22 dicembre 2011, n. 21 "Norme transitorie in materia di trasformazione di aree boschive e oneri compensativi"
- Art. 24 della Legge Regionale 26 luglio 2012, n. 9 "Modifiche all'articolo 34 della Legge regionale n. 21 del 2011"

Additional regulatory acts are available on the website of the Protected Areas, Forests and Mountain Development of Emilia-Romagna: [RER.SAPFSM, 2016, d.].

1.4. National and regional forest and carbon reservoires inventory INFC 2005

I valori del bosco sono molteplici: valori d'uso diretto, che derivano dai prodotti che esso offre, valori d'uso indiretto rappresentati dalle funzioni ecologiche da esso svolte. Appartengono a quest'ultima categoria le funzioni di protezione idrogeologica, di aumento della fertilità dei suoli, di riduzione dell'inquinamento atmosferico e attenuazione dei fenomeni legati ai cambiamenti climatici, di salvaguardia della qualità delle acque, di conservazione della biodiversità, sia vegetale che animale, di benessere psicofisico attraverso tutte quelle attività di cui ognuno può fare esperienza all'interno di una foresta. L'Inventario Foreste Nazionale con le sue rilevazioni indaga e fornisce risposte utili a tutto questo sistema di valori. In Italia il primo Inventario Foreste Nazionale, basato su tecniche campionarie con metodo adeguato dal punto di vista scientifico, è stato realizzato nel 1985 (IFNI 1985). A realizzarlo è stato il Corpo Foreste dello Stato con la collaborazione tecnica e scientifica dell'Istituto Sperimentale per l'Assestamento Foreste e per l'Alpicoltura di Trento. Successivamente, nel 2005, per rispondere agli adempimenti del Protocollo di Kyoto, strumento della Convenzione ONU sui cambiamenti climatici, l'Italia si è dotata di un nuovo inventario Foreste nazionale, per stimare le superfici verdi del Paese e la loro capacità di stoccare anidride carbonica, sottratta dall'atmosfera, ha redatto il 2° INVENTARIO NAZIONALE DELLE FORESTE E DEI SERBATOI DI CARBONIO 2005[6] (IFNC 2005)[7]. Un compito importante per i boschi, anche perché l'Italia, nell'ambito del Protocollo di Kyoto (art. 3.4), ha inserito la "gestione Foreste" tra le azioni mirate a contenere le emissioni di gas a effetto serra, per un valore assegnato pari a 10,2 milioni di tonnellate nel quinquennio 2008-2012. [INFC, 2005, a]

1.4.1.1. Extension and composition of Italian and and regional forests

Nel 2005 la superficie Foreste nazionale totale è stata stimata in 10.467.533 ha. Essa si ripartisce in Bosco e Altre terre boscate secondo un rapporto percentuale rispettivamente di 83.7% e 16.3% .
A livello nazionale il coefficiente di boscosità, calcolato con riferimento alla superficie Foreste totale nazionale, è pari a 34.7% .

BOSCO E ALTRE TERRE BOSCATE (SECONDO FRA2000)

Distretto territoriale	**Bosco** superficie (ha)	**Altre terre boscate** superficie (ha)	**Superficie Foreste totale** superficie (ha)	**Superficie territoriale** (ha)
Emilia Romagna	563 263	45 555	608 818	2 212 309
TOTALE NAZIONALE	**8 759 200** *(83.7%)*	**1 708 333** *(16.3%)*	**10 467 533** *(34.7%)*	**30 132 845**

Riguardo alla composizione in categorie inventariali del Bosco, oltre il 98% è rappresentato da **Boschi Alti**, le cui categorie più diffuse a livello nazionale sono i *Boschi di rovere, roverella e farnia, le Faggete e i Boschi di cerro, farnetto, fragno e vallonea*, che superano ciascuna il milione

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[6] In passato non venivano rilevati lo stato fitosanitario del bosco, la sua importanza naturalistica, l'aspetto di ambiente di protezione e di sviluppo della fauna selvatica, la funzione turistico ricreativa e la già citata funzione di assorbimento e immagazzinamento del carbonio atmosferico. Oggi questi elementi costituiscono aspetti importanti del nuovo disegno inventariale. Il risultato dell'Inventario va ben aldilà di una fotografia delle risorse Foresti del Paese, è più simile a un film, in cui scorrono in parallelo le immagini di tutte le componenti dinamiche del bosco, osservate anche attraverso le rispettive interazioni.
[7] Il 3° Inventario Nazionale delle Foreste e del Carbonio, realizzato nel 2015, non è ancora disponibile al 01/06/2016.

di ettari[8]. Tra i boschi di conifere, predominano quelli di abete *rosso*. Gli Impianti di arboricoltura sono costituiti prevalentemente da *Pioppeti artificiali*. Le Piantagioni *di altre latifoglie* sono costituite in misura uguale da piantagioni di eucalipti e da altre latifoglie.

1.4.1.2. Composition for coniferous and deciduous

I Boschi Alti italiani risultano essere costituiti per circa il 68% da popolamenti a prevalenza di latifoglie. La predominanza dei boschi di latifoglie è comune a tutto il panorama regionale italiano, ad eccezione di alcuni contesti alpini rappresentati dalla Valle d'Aosta, dal Trentino e dall'Alto Adige. In quasi tutte le regioni la classe di mescolanza più rappresentata occupa più del 50% dei Boschi alti, ad eccezione del Veneto dove i boschi di latifoglie prevalgono con il 46% del totale. Anche per gli Impianti di arboricoltura da legno i dati evidenziano la prevalenza delle latifoglie; l'84% della superficie è occupata da specie di latifoglie coltivate in purezza.

BOSCO, RIPARTITO PER GRADO DI MESCOLANZA DEL SOPRASSUOLO					
Distretto territoriale	**Puro di conifere** superficie (ha)	**Puro di latifoglie** superficie (ha)	**Misto di conifere e latifoglie** superficie (ha)	**Superficie non classificata per il grado di mescolanza** superficie (ha)	**Totale Bosco** Superficie (ha)
Emilia Romagna	21 700	487 914	27 204	26 446	563 263
TOTALE NAZIONALE	**1 172 806** *(13.3%)*	**5 942 912** *(67.8%)*	**840 883** *(9.6%)*	**802 600** *(9.2%)*	**8 759 200**

1.4.1.3. Property

Complessivamente il 63.5% della superficie Foreste (Bosco e Altre terre boscate) risulta di proprietà privata, il 32.4% è di proprietà pubblica, mentre quasi il 4% della superficie non è stata classificata per tale carattere (tabella a/b). Una simile ripartizione fra boschi privati e pubblici si riscontra anche se si considera solo la macrocategoria Bosco, ma in questo caso la prevalenza della proprietà privata è ancora più accentuata (66.2%). Per le Altre terre boscate la percentuale di boschi privati scende al 49.7%, ma si segnala che per questa macrocategoria l'aliquota di superficie non classificata per il carattere della proprietà è piuttosto elevata (23.3%).
A livello di singoli distretti, le percentuali più elevate di superficie Foreste di proprietà privata si riscontrano in Liguria (82.3%), in **Emilia-Romagna** (82.0%) e in Toscana (80.0%). (tabella a).
Esaminando la ripartizione del Bosco per tipo di proprietà a livello nazionale, si osserva che, nell'ambito delle forme di proprietà privata, quella individuale è di gran lunga prevalente (oltre il 79%), mentre i restanti boschi privati appartengono per il 6.2% a società e imprese e per il 4.5% ad altri enti privati. Occorre specificare che il 10% circa dei boschi privati non è stato classificato per il tipo di proprietà ed è confluito nella voce residua di "proprietà privata non definita o non nota".
Riguardo alla proprietà pubblica, prevalgono le proprietà di Comuni e Province (65.5%), seguite da quelle del Demanio statale e regionale (23.7%), mentre solo l'8.3% delle superfici appartiene ad altri enti pubblici. In questo caso, i boschi non classificati per tipo di proprietà rappresentano il 2.4% della superficie di proprietà pubblica. Una distribuzione simile dei tipi di proprietà si riscontra anche per le Altre terre boscate, per le quali a livello nazionale prevalgono la proprietà individuale

[8] Per una valutazione sulla frequenza delle singole specie sul territorio nazionale si dovrebbe comunque considerare che si confrontano categorie Foresti caratterizzate da un diverso grado di eterogeneità specifica.

(74.3%) per la proprietà privata e le proprietà comunali e provinciali (67.3%) per la proprietà pubblica. In questo caso l'aliquota di superficie non classificata per il tipo di proprietà è sensibilmente superiore ed è pari al 17.2% delle aree di proprietà privata e al 5.7% di quelle di proprietà pubblica.
A livello di singoli distretti territoriali, la prevalenza della proprietà individuale è confermata per tutte le Regioni, eccetto che per la Valle d'Aosta e il Friuli Venezia Giulia dove però una parte consistente del Bosco di proprietà privata non è stato classificato per il tipo di proprietà.
Riguardo al Bosco di proprietà pubblica, la ripartizione per tipo di proprietà varia molto fra le diverse Regioni; in confronto al dato nazionale molte Regioni dell'Italia centrale (**Emilia-Romagna**, Toscana, Umbria e Marche) e la Sicilia si distinguono per una minore presenza di proprietà comunali e provinciali a favore di proprietà statali, ad eccezione dell'Umbria, dove prevalgono le proprietà di altri enti pubblici. Questi ultimi risultano notevolmente più rappresentati rispetto alla media italiana anche in Alto Adige e Trentino.

BOSCO RIPARTITO PER CARATTERE DI PROPRIETA' (tab a)

Distretto territoriale	**Proprietà privata** superficie (ha)	**Proprietà pubblica** superficie (ha)	**Superficie non classificata per il carattere della proprietà** superficie (ha)	**Totale Bosco** superficie (ha)
Emilia Romagna	476 888	85 271	1 103	563 263
TOTALE NAZIONALE	**5 797 715** *(66.2%)*	**2 931 688** *(33.4%)*	**29 798** *(0.3%)*	**8 759 200**

ALTRE TERRE BOSCATE RIPARTITE PER CARATTERE DI PROPRIETA' (tab b)

Distretto territoriale	**Proprietà privata** Superficie (ha)	**Proprietà pubblica** superficie (ha)	**Superficie non classificata per il carattere della proprietà** superficie (ha)	**Totale Altre terre boscate** superficie (ha)
Emilia Romagna	22 042	2 207	21 307	45 555
TOTALE NAZIONALE	**848 570** *(49.7%)*	**461 669** *(27%)*	**398 095** *(23.3%)*	**1 708 333**

1.4.1.4. Forest planning, constraints and protected areas

Oltre l'86.6% della superficie Foreste nazionale è regolamentata da almeno una tra le tre forme di pianificazione considerate (regolamentazione derivante da Prescrizioni di Massima e di Polizia Foreste; presenza di pianificazione di orientamento; presenza di pianificazione di dettaglio).
Se si considera soltanto la macrocategoria Bosco, tale aliquota arriva a superare il 93% a livello nazionale, mentre in alcune regioni, come la Toscana, la Liguria e la Basilicata, sfiora addirittura il 100%. Se osserviamo la macrocategoria delle Altre terre boscate, le superfici regolamentate da forme di pianificazione sono pari a circa il 52% del totale.

BOSCO RIPARTITO PER STATO DELLA PIANIFICAZIONE FORESTE				
Distretto territoriale	**Pianificazione presente** superficie (ha)	**Pianificazione assente** superficie (ha)	**Superficie non classificata per lo stato della pianificazione Foreste** superficie (ha)	**Totale Bosco** superficie (ha)
Emilia Romagna	533 223	28 937	1 103	563 263
TOTALE NAZIONALE	**8 170 435** *(93%)*	**558 967** *(6.3%)*	**29 798** *(0.3%)*	**8 759 200**

ALTRE TERRE BOSCATE RIPARTITE PER STATO DELLA PIANIFICAZIONE FORESTE				
Distretto territoriale	**Pianificazione presente** superficie (ha)	**Pianificazione assente** superficie (ha)	**Superficie non classificata per lo stato della pianificazione Foreste** superficie (ha)	**Totale altre terre boscate** superficie (ha)
Emilia Romagna	23 145	1 103	21 307	45 555
TOTALE NAZIONALE	**895 276** *(52%)*	**414 963** *(24%)*	**398 095** *(23%)*	**1 708 333**

BOSCO RIPARTITO PER PRESENZA DI VINCOLO IDROGEOLOGICO				
Distretto territoriale	**Con vincolo idrogeologico** superficie (ha)	**Senza vincolo idrogeologico** superficie (ha)	**Superficie non classificata per presenza del vincolo idrogeologico** superficie (ha)	**Totale Bosco** superficie (ha)
Emilia Romagna	497 639	64 520	1 103	563 263
TOTALE NAZIONALE	**7 628 082** *(87%)*	**1 101 320** *(12.6%)*	**29 798** *(0.3%)*	**8 759 200**

ALTRE TERRE BOSCATE RIPARTITE PER PRESENZA DI VINCOLO IDROGEOLOGICO				
Distretto territoriale	**Con vincolo idrogeologico** superficie (ha)	**Senza vincolo idrogeologico** superficie (ha)	**Superficie non classificata per presenza del vincolo idrogeologico** superficie (ha)	**Totale altre terre boscate** superficie (ha)
Emilia Romagna	22 409	1 839	21 307	45 555
TOTALE NAZIONALE	**841 169** *(49.2%)*	**469 070** *(27.5%)*	**398 095** *(23.3%)*	**1 708 333**

BOSCO RIPARTITO PER PRESENZA DI VINCOLO NATURALISTICO				
Distretto territoriale	**Con vincoli di tipo naturalistico** superficie (ha)	**Senza vincoli di tipo naturalistico** superficie (ha)	**Superficie non classificata per presenza di vincoli di tipo naturalistico** superficie (ha)	**Totale Bosco** superficie (ha)
Emilia Romagna	116 029	446 130	1 103	563 263
TOTALE NAZIONALE	**2 495 409** *(28.5%)*	**6 233 993** *(71%)*	**29 798** *(0.3%)*	**8 759 200**

ALTRE TERRE BOSCATE RIPARTITE PER PRESENZA DI VINCOLO NATURALISTICO				
Distretto territoriale	**Con vincoli di tipo naturalistico** superficie (ha)	**Senza vincoli di tipo naturalistico** superficie (ha)	**Superficie non classificata per presenza di vincoli di tipo naturalistico** superficie (ha)	**Totale Altre terre boscate** superficie (ha)
Emilia Romagna	4 414	19 835	21 307	45 555
TOTALE NAZIONALE	**381 042** *(22.3%)*	**929 197** *(54%)*	**398 095** *(23.3%)*	**1 708 333**

1.4.1.5. Availability for woody picking

A livello nazionale l'81.3% della superficie Foreste totale risulta disponibile al prelievo legnoso[9]. Per i singoli distretti territoriali l'aliquota di superficie Foreste potenzialmente utilizzabile per la produzione di legname è sempre superiore al 50%, con i valori più bassi in Friuli (55.1%) e Valle d'Aosta (62.5%) e i più elevati in Umbria e Marche (per entrambe maggiori del 94%). La minore disponibilità al prelievo legnoso in alcune regioni si spiega quasi interamente con una maggiore aliquota di superfici inaccessibili, come ad esempio in Valle d'Aosta, Campania e Calabria.
Osservando separatamente le due macrocategorie, per il Bosco l'aliquota di superficie disponibile al prelievo legnoso (88.4%) è molto superiore a quella delle Altre terre boscate, dove solo il 45.1% della superficie risulta disponibile. A livello di categorie inventariali, gli Impianti di arboricoltura da legno risultano ovviamente tutti disponibili al prelievo legnoso, mentre tra le Altre terre boscate sono gli Arbusteti la categoria che risulta disponibile con minore frequenza (57.4%).

BOSCO RIPARTITO PER DISPONIBILITA' AL PRELIEVO LEGNOSO				
Distretto territoriale	**Superficie disponibile per il prelievo legnoso** superficie (ha)	**Superficie non disponibile per il prelievo legnoso** superficie (ha)	**Superficie non classificata per il prelievo legnoso** superficie (ha)	**Totale Bosco** superficie (ha)
Emilia Romagna	508 484	52 204	2 575	563 263
TOTALE NAZIONALE	**7 741 176** *(88.4%)*	**912 017** *(10.4%)*	**106 007** *(1.2%)*	**8 759 200**

ALTRE TERRE BOSCATE RIPARTITE PER DISPONIBILITA' AL PRELIEVO LEGNOSO				
Distretto territoriale	**Superficie disponibile per il prelievo legnoso** superficie (ha)	**Superficie non disponibile per il prelievo legnoso** superficie (ha)	**Superficie non classificata per il prelievo legnoso** superficie (ha)	**Totale Altre superfici Boscate** superficie (ha)
Emilia Romagna	8 827	15 421	21 307	45 555
TOTALE NAZIONALE	**769 922** *(45%)*	**536 248** *(31.4%)*	**402 163** *(23.5%)*	**1 708 333**

1.4.1.6. Accessibility of forest areas

Nella macrocategoria Bosco il 91.5% della superficie risulta accessibile. Il dato non varia molto nei diversi distretti territoriali: quelli con la minore accessibilità sono risultati la Campania (84.5%) e la Basilicata (80.3%); quelli con la più elevata accessibilità la Puglia (99.5%), l'Umbria (96.6%) e la Liguria (96.2%).

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[9] Per disponibile al prelievo si intende una superficie Foreste non soggetta a limitazioni significative delle attività selvicolturali dovute a norme o vincoli (es. riserve integrali) o a cause di tipo fisico (aree inaccessibili). La FAO infatti considera come non disponibili al prelievo legnoso le foreste in cui i vincoli e le restrizioni derivanti dalla normativa in vigore o da decisioni politiche escludono o limitano severamente il prelievo per esigenze di tutela ambientale o di conservazione di siti di particolare interesse scientifico, storico, culturale o spirituale, così come le foreste in cui la produttività o il valore del legname sono troppo bassi per rendere conveniente il prelievo di legname, fatta eccezione per il taglio occasionale per consumo interno (FAO, 2000). Sono considerati disponibili perciò anche soprassuoli non più utilizzati da lungo tempo per abbandono della gestione, purché l'utilizzazione abbia ancora una certa convenienza economica, così come quelli trattati con turni molto lunghi.

Nella macrocategoria Altre terre boscate il dato scende sensibilmente, anche per le motivazioni sopra riportate, attestandosi a livello nazionale sul 66.9% di aree accessibili, con significative differenze fra i diversi distretti territoriali. E' più interessante però osservare le percentuali relative alle singole categorie inventariali delle Altre terre boscate, poiché la presenza di una categoria denominata "aree inaccessibili" condiziona fortemente i risultati a livello di macrocategoria.
Se si escludono le Boscaglie, accessibili soltanto per il 69.4%, la percentuale di superficie accessibile per le altre categorie si aggira intorno all'80% (78.2% per i Boschi bassi, 85.1% per i Boschi radi e 81.6% per gli Arbusteti). La categoria delle Aree boscate non classificate o inaccessibili comprende un 19.8% di aree accessibili, benché non classificate.

1.4.1.7. Forest health state

I risultati esposti nel presente documento si riferiscono esclusivamente ad una prima stima quantitativa delle superfici interessate da danni evidenti e non forniscono indicazioni sull'intensità del danno e sulle eventuali conseguenze in termini di vitalità degli ecosistemi Foresti.

BOSCO RIPARTITO PER PRESENZA DI DANNI O PATOLOGIE EVIDENTI 1

Distretto territoriale	Selvaggina o pascolo superficie (ha)	Parassiti superficie (ha)	Eventi meteorici o climatici intensi superficie (ha)	Incendio soprassuolo (ha)	Incendio sottobosco (ha)
Emilia Romagna	4 781	67 307	67 586	2 575	2 942
TOTALE NAZIONALE	**284 606** *(3.2%)*	**789 918** *(9%)*	**488 326** *(5.6%)*	**205 402** *(2.3%)*	**95 677**

BOSCO RIPARTITO PER PRESENZA DI DANNI O PATOLOGIE EVIDENTI 2 /2

Distretto territoriale	Interventi selvicolturali superficie (ha)	Inquinamento superficie (ha)	Cause complesse o ignote superficie (ha)	Assenza di danni o patologie evidenti superficie (ha)	Superficie non classificata superficie (ha)	Totale altre terre boscate superficie (ha)
Emilia Romagna	0 -	0 -	368	16 170	24 604	45 555
TOTALE NAZIONALE	**2 239** *(0,1%)*	**740** *(0,04%)*	**10 943** *(0,6%)*	**777 822** *(45%)*	**648 101** *(38%)*	**1 708 333**

1.4.1.8. Margins of the forest

Per margini del bosco si intendono le linee di contatto tra le aree boscate e gli altri usi del suolo. La conoscenza della densità e dello sviluppo dei margini del bosco è alla base della caratterizzazione ecologica del paesaggio Foreste e possono fornire informazioni utili sulla frammentazione del bosco.
A livello nazionale, la presenza di margini è stata riscontrata sul 19.2% della superficie del Bosco; per le Altre terre boscate è stato ottenuto un risultato molto simile, ma una parte consistente della superficie di queste ultime non è stata classificata (23.4%).
Nell'ambito della macrocategoria del Bosco, una frequenza maggiore dei margini è stata osservata negli Impianti di arboricoltura da legno (36.7%), mentre la percentuale stimata per i Boschi alti si discosta di poco da quella riferita all'intero macrogruppo.
Esaminando la distribuzione a livello di distretti, il paesaggio Foreste italiano appare molto diversificato. Piuttosto elevata, pari a circa il 30% della superficie regionale occupata dalle due grandi macrocategorie, è anche l'incidenza dei margini in **Emilia-Romagna**. Valori molto bassi,

inferiori o intorno al 10%, sono stati invece stimati per alcune regioni alpine (Trentino, Alto Adige, Veneto, Friuli Venezia Giulia, Liguria).

A livello nazionale, più del 70% della superficie Foreste totale si trova ad una quota inferiore a 1.000 m. Nonostante i limiti insiti nelle possibilità di confrontare l'inventario attuale con quello del 1985, si può evidenziare che la distribuzione appare molto simile a quella riscontrata nel primo inventario e non sembra che ci siano stati cambiamenti concentrati in determinate fasce di quota: a quote inferiori a 500 m si riscontra infatti il 35.4% delle aree boscate (nel 1985 era risultato il 35.3%), fra 500 e 1 000 m il 34.7% (nel 1985 il 37.4%), fra 1 000 e 1 500 m il 17.4% (rispetto al 18.1% del vecchio inventario) e oltre i 1 500 m l'8.5% (il 9.2% nel precedente inventario 1985).

1.4.1.9. Phenomena of disruption

Su base nazionale, nella macrocategoria Bosco, la gran parte dei soprassuoli (76.9%) non è risultata interessata da tali fenomeni. Il più diffuso tra quelli considerati è risultato la "caduta o rotolamento di pietre" (6%), seguito dai fenomeni alluvionali (4.3%), dalle frane e smottamenti (3.3%) e infine dalle slavine e valanghe (0.5%). A livello regionale alcuni fenomeni possono talora assumere proporzioni più significative; ad esempio in **Emilia Romagna le frane e gli smottamenti interessano il 13.7% della superficie**, in Umbria l'erosione idrica e i fenomeni alluvionali l' 8.7%, mentre in Valle d'Aosta la caduta e il rotolamento di pietre riguardano il 14.9% dei boschi.

BOSCO RIPARTITO PER PRESENZA DI FENOMENI DI DISSESTO

Distretto territoriale	**Assenza di fenomeni di dissesto** superficie (ha)	**Frane, smotta-menti** superficie (ha)	**Erosione idrica, fenomeni alluvionali** superficie (ha)	**Caduta o rotolamento pietre** superficie (ha)	**Slavine, valan-ghe** superficie (ha)	**Superfici non classificate per presenza di fenomeni di dissesto** superficie (ha)	**Totale bosco** superficie (ha)
Emilia Romagna	414 758	77 192	32 708	13 241	0 -	25 365	563 263
TOTALE NAZIONALE	**6 739 492** *(76.9%)*	**289 931** *(3.3%)*	**379 866** *(4.3%)*	**526 384** *(6%)*	**47 372** *(0,5%)*	**776 156** *(8.8%)*	**8 759 200**

ALTRE TERRE BOSCATE RIPARTITE PER PRESENZA DI FENOMENI DI

Distretto territoriale	**Assenza di fenomeni di dissesto** superficie (ha)	**Frane, smotta-menti** superficie (ha)	**Erosione idrica, fenomeni alluvionali** superficie (ha)	**Caduta o rotolamento pietre** superficie (ha)	**Slavine, valan-ghe** superficie (ha)	**Superfici non classificate per presenza di fenomeni di dissesto** superficie (ha)	**Totale altre terre boscate** superficie (ha)
Emilia Romagna	8 827	5 872	4 781	1 471	0 -	24 604	45 555
TOTALE NAZIONALE	**865 310** *(50.6%)*	**28 587** *(1,6%)*	**53 109** *(3,1%)*	**96 236** *(5.6%)*	**20 358** *(1.2%)*	**644 733** *(37.3%)*	**1 708 333**

1.4.1.10. Infrastructures

Oltre a rilevare la presenza di elementi a valenza positiva per la biodiversità delle aree Foresti, i microhabitat, durante i rilevi di seconda fase è stata registrata anche la presenza di fonti di possibile impatto negativo per l'ambiente e per le popolazioni animali che occupano gli ambienti Foresti. Complessivamente la superficie Foreste interessata dalla presenza di infrastrutture è pari a 1 854 659 ha, corrispondente al 17.7%. La presenza di infrastrutture è sensibilmente superiore nel Bosco (19.2%) rispetto alle Altre terre boscate (10.1%), macrocategoria quest'ultima che include molte formazioni a elevato grado di naturalità e interessate in misura minore dall'impatto delle attività antropiche. A livello di distretti territoriali non si evidenziano grandi differenze, se non per alcune regioni dove la frequenza delle infrastrutture nei boschi risulta leggermente più elevata (Alto Adige, **Emilia-Romagna** e Toscana) o più bassa (Abruzzo, Campania, Puglia e Basilicata) rispetto al valore nazionale.

1.4.1.11. Provisional carbon estimates fixed by the forests

I boschi, oltre ad essere tra i principali serbatoi di biodiversità animale e vegetale del pianeta, rappresentano un serbatoio dove il carbonio atmosferico, sottratto all'atmosfera mediante il processo di fotosintesi, viene stoccato in grandi quantità. La crescita continua dei soprassuoli Foresti richiede periodici inventari al fine di quantificare la biomassa vegetale presente. In Italia la quantità di legname che viene tagliato ogni anno è inferiore alla capacità di accrescimento dei boschi e questo permette di aumentare progressivamente, anno dopo anno, la quantità di carbonio che il patrimonio Foreste è in grado di conservare. Si tratta di un effetto molto importante, non solo dal punto di vista ecologico, ma anche da quello economico. In sede degli accordi di Kyoto, infatti, l'Italia, ha eletto la "gestione Foreste" tra le attività che possono concorrere all'adempimento degli impegni presi nella riduzione dei gas a effetto serra. Questa attività è quantificabile fino ad un massimo di 2.78 Mt di Carbonio all'anno (circa 10 milioni di t di CO_2).
Per quanto detto sopra, grazie all'azione delle foreste, si profila per l'Italia un risparmio che va da 750 milioni al miliardo di euro in cinque anni (2008-2012 periodo di impegno del Protocollo di Kyoto – al valore attuale di borsa del Carbonio a tonnellata). Le stime che seguono sono relative alla parte epigea e sono provvisorie; i dati definitivi prodotti dall'inventario Foreste saranno disponibili alla fine della terza fase dell'INFC[10].

Figura 1- Provisional estimates on carbon set by the woods

STIME PROVVISORIE SUL CARBONIO FISSATO DAL BOSCO			
Regione	**Massa arborea secca (Mg o tonnellate)**	**Carbonio (Mg o tonnellate)**	**Carbonio per ettaro ($Mg*ha^{-1}$ o tonnellate per ha)**
Emilia Romagna	60 272 000	30 136 000	54
TOTALE NAZIONALE	**972 037 000**	**486 018 500**	**55**
486 018 500 (tonnellate) **di Carbonio** → *corrispondenti a* → **1 782 068 000 Mg** (tonnellate) **di CO_2**			

[INFC, 2005, a]

[10] Mg = Megagrammo = Tonnellata

1.5. Forest analysis summary at regional and provincial scale INFC 2005

[RER.SAPFM, 2016, a]
[Servizio Aree Protette Foreste e Sviluppo della Montagna della Regione Emilia-Romagna.]

Tabella 1- Suddivisione delle aree Foresti per Provincia -anno 2015-

Superficie dei boschi per Provincia	ettari in Provincia	% su superficie totale della Provincia
Piacenza	86.871	34%
Parma	141.730	41%
Reggio Emilia	56.632	25%
Modena	58.848	22%
Bologna	80.766	22%
Ferrara	2.512	1%
Ravenna	16.786	9%
Forli'-Cesena	81.393	34%
Rimini	18.033	21%
Totale Regione	**543.572**	**24,00%**

Non vengono conteggiati gli arbusteti, i castagneti da frutto, i pioppeti ed altra arboricoltura da legno -*dati 2015-.

Tabella 2- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: BOLOGNA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	1.910	1%
Faggete	6.798	2%
Querceti misti submesofili e castagneti	31.176	8%
Pinete, conifere da litorali a submontane	1.786	0%
Queceti xerofili di Roverella e sclerofille	37.052	10%
Boschi ripariali	3.585	1%
Arbusteti (escluse praterie arbustate < 40%)	10.704	3%
Pioppeti colturali e arboricoltura da legno	1.460	0,4%

Tabella 3- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: FERRARA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Pinete, conifere da litorali a submontane	256	0,1%
Queceti xerofili di Roverella e sclerofille	1.793	1%
Boschi ripariali	463	0,2%
Pioppeti colturali e arboricoltura da legno	2.297	1%

Tabella 4- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: FORLI-CESENA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	2.314	1%
Faggete	9.272	4%
Querceti misti submesofili e castagneti	24.340	10%
Pinete, conifere da litorali a submontane	10.147	4%
Queceti xerofili di Roverella e sclerofille	33.105	14%
Boschi ripariali	2.976	1%
Arbusteti (escluse praterie arbustate < 40%)	14.742	6%
Pioppeti colturali e arboricoltura da legno	1.301	1%

Tabella 5- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: MODENA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	2.657	1%
Faggete	18.168	7%
Querceti misti submesofili e castagneti	22.614	8%
Pinete, conifere da litorali a submontane	1.107	0,4%
Queceti xerofili di Roverella e sclerofille	11.989	4%
Boschi ripariali	2.603	1%
Arbusteti (escluse praterie arbustate < 40%)	5.103	2%
Pioppeti colturali e arboricoltura da legno	777	0,3%

Tabella 6- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: PARMA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	1.092	0,3%
Faggete	36.616	11%
Querceti misti submesofili e castagneti	56.879	17%
Pinete, conifere da litorali a submontane	2.952	1%
Queceti xerofili di Roverella e sclerofille	39.637	11%
Boschi ripariali	4.625	1%
Arbusteti (escluse praterie arbustate < 40%)	9.593	3%
Pioppeti colturali e arboricoltura da legno	2.460	1%

Tabella 7- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: PIACENZA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	338	0,1%
Faggete	13.445	5%
Querceti misti submesofili e castagneti	33.100	13%
Pinete, conifere da litorali a submontane	1.968	1%
Queceti xerofili di Roverella e sclerofille	30.632	12%
Boschi ripariali	7.491	3%
Arbusteti (escluse praterie arbustate < 40%)	3.929	2%
Pioppeti colturali e arboricoltura da legno	1.958	1%

Tabella 8- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: RAVENNA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	57	0,03%
Querceti misti submesofili e castagneti	1.587	1%
Pinete, conifere da litorali a submontane	4.283	2%
Queceti xerofili di Roverella e sclerofille	8.747	5%
Boschi ripariali	2.491	1%
Arbusteti (escluse praterie arbustate < 40%)	2.023	1%
Pioppeti colturali e arboricoltura da legno	441	0,2%

Tabella 9- Riepiloghi delle aree Foresti suddivise per tipologia Foreste la provincia di: REGGIO EMILIA

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	761	0,3%
Faggete	16.190	7%
Querceti misti submesofili e castagneti	19.364	8%
Pinete, conifere da litorali a submontane	2.854	1%
Queceti xerofili di Roverella e sclerofille	14.475	6%
Boschi ripariali	3.198	1%
Arbusteti (escluse praterie arbustate < 40%)	1.554	1%
Pioppeti colturali e arboricoltura da legno	2.257	1%

Tabella 10- Riepiloghi delle aree Foresti suddivise per tipologia Foreste per la provincia di: RIMINI

Superfici suddivise per tipologia forestale	ettari in Provincia	% su superficie totale della Provincia
Abetine, popolamenti a conifere montane	32	0,04%
Faggete	642	1%
Querceti misti submesofili e castagneti	5.659	7%
Pinete, conifere da litorali a submontane	653	1%
Queceti xerofili di Roverella e sclerofille	9.033	10%
Boschi ripariali	2.051	2%
Arbusteti (escluse praterie arbustate < 40%)	3.133	4%
Pioppeti colturali e arboricoltura da legno	382	0,40%

2. THE REGIONAL MAP OF THE FOREST WOODY ENERGY POTENTIALITY (MRPELFU)

2.1. Introduction

In a very general but extremly important way we have to account the ecologica values of forest, that are not considered in this research:

- Forestry areas play important key functions, such as:
- Woody production (from work, fire, biomass, etc.);
- Protection of biodiversity (habitats and wild animal and plant species);
- CO2 storage;
- Hydrogeological maintenance (soil protection);
- Water protection (water resources storage);
- Tourist-recreational function (undergrowth, hiking, etc.);
- Aesthetic-landscaping;
- Excellent food productions (mushrooms and truffles, hunting activities, ...);
- etc..

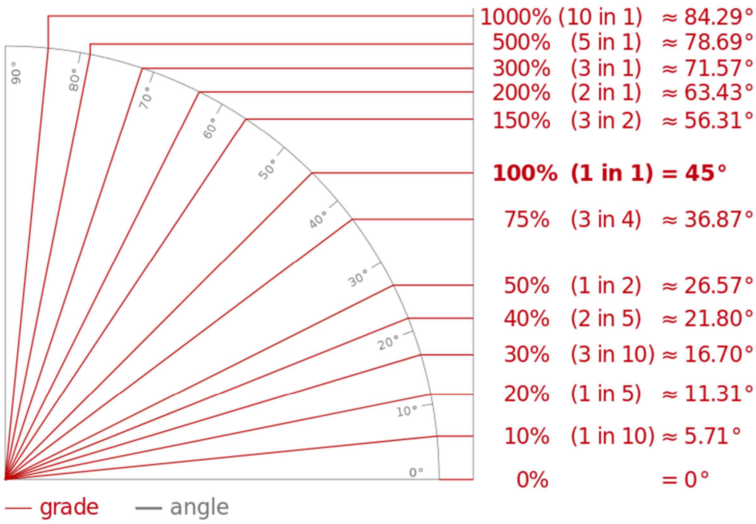
1. The forests and forests of Emilia-Romagna are poorly suited to the supply of wood for furniture, boards, etc .. only 7% of forest areas are Fustaie [11].
2. The Emilia-Romagna Region estimates that 70% of wood harvested by forest is sold and used as a fire in traditional fireplaces and stoves, while only 30% is potentially available for sale to wood combustion plants. [Informal datum, [RER.SAPFSM, 2015, b].
3. The firewood market for fireplaces and domestic stoves (including commercial pizza ovens such as pizzerias, etc.) allows the sale of the product in knots at prices around 10 to 17 euros / quintal (average = 13,5 euro / q.le);
   The wood market for biomass combustion power plants, on the other hand, allows the sale of wood harvested at prices around 2 to 3 euros/quintal (average = 2.5 euros / q.le). [Informal datum, [RER.SAPFSM, 2015, b], while the Borgo Val di Taro hospital in the province of Parma burns wood pulp from 60 to 85 euros / ton. (Average = 7.25 euro / q.le) [RER.DG Agriculture, 2016,a].
4. The domestic heating implemented using fireplaces / domestic stoves, if one part is characterized by a low energy efficiency and a considerable emission of particulate matter and pollutants, on the other hand allows the personalized management of combustion for periods of time segmented (eg. 10 hours on 24), while the management of the combustion of a biomass energy plant, with the sole aim of producing only thermal energy, runs 24 hours a day for about

[11] Man-made woods can be distinguished in cedars and cloaks:
- Cedu is a periodically cut wood (usually every 10/30 years), which after the cut is regenerated thanks to the pollen, that is to say, of recaptures from the plundering. The forest therefore regenerates mainly vegetative or agamic, that is, through branches or roots.
- Fustaia (or "tall wood forests") is a forest that is cut at intervals of at least 40/100 years and in such a way that, after cutting, the forest itself is renewed through the emergence of new seedlings (plantule) Born from the seeds of the pre-existing trees or left after the cut ("trees portasemi" or "reserves"). The forest is therefore regenerated especially for sexuata or gamic.
- The management of the high-pit wood, allowing cutting only at very spaced intervals, suits the great properties (which are mostly public), where it is possible to cut into staggered lots over time (forest settlement). In small properties, the need to obtain timber every year pushes the owner of the forest into a cedar management. In addition, usually, firewood is obtained mainly from firewood or, in particular, in the case of chestnut, piles; The crates provide lumber for every type of workmanship.

1500 hours / year).

5. Firewood requires significant minor workings compared to chips and / or pellets, and therefore implies far less fuel consumption of fossil fuels for pulping and / or pelletising from which less fossil CO2 emissions per unit of product.
6. **Taking out a sustainable forestry forest should not only consider the rate of forest growth (average value = 4.4 mc / ha * year), but it must also take account of the fact that such levies can only be made in the forestry Around 75-150 meters from the forest roads because over these distances the conferment to the truck would be too expensive in terms of logistics convenience.**
7. It should also be borne in mind that the slopes of the woodland based on the shifting technologies used: the operator can, on the one hand, climb up the slope to cut trees and transport them to the road due to gravity, on the other side if Must go down the slope to supply the wood, and then retrieve it up to the truck in the street must necessarily use appropriate mechanical systems that consume much fuel / energy and thus significantly affect the procurement costs. In general, it can be estimated that the maximum gradient acceptable for woodworks and wood harvesting is 30%.
8. Wood procurement, whatever its destination, must take into account that 50% of the regional forest areas are owned by private individuals, which may therefore pay for (or refuse) the forest exploitation of their properties; 30% of the woods in the Region are within farms; The remaining 20% of forest areas are publicly owned (14.8% state ownership and 5.2% regional ownership).
9. Within energy calculations, it is important to keep in mind the values of lower and higher calorific value (the fresh water content may be equal to that of the dry substance), in addition to the fact that very often in this field, with reference to the density and woody volumes, it doesn't use the unit of measure of the linear meter, but those of the stacked steric meters (msa) or of stems steric in bulk (msr).

NOTE: The slope term is used to indicate the degree of steepness or inclination of a road or a stretch of path. The slope of a road is indicated by vertical signage with danger signs pointing to the gradient with a percentage. The same definition of slope as a trigonometric tangent of an angle should make it clear that slope, as a trigonometric function, is not a linear function. In other words, a road with a 10% slope is not 10 times less sloping than a 100% gradient road: the 10% inclination angle is 5.7 °, that of a 100% Is 45 °.



[Wikipedia, 2015, o]

2.2. Regional map of useful woody forest potentiality (MRPELFU)

Thanks to the support of the Emilia-Romagna Region - Forest Protected Areas and Mountain Development [RER.SAPFSM, 2015, b.], All the information in the previous paragraphs has been elaborated and the " REGIONAL MAP OF HELPFUL WOODY FOREST POTENTIALITY " from which the numerical values of forest energy potential for woody biomasses are used in the firewood market and in the field of energy-efficient combustion plants of solid wood biomass.

2.3. GIS map construction procedure

1) The Emilia-Romagna regional forest map 2014 [12] has been cleared of all areas classified as "shrubs" and "pine forests" and the regional forest map of the forests and high forests (CFRBFAF) has been obtained.
2) 2) Regional Cartwrights of Road Traffic (CVO) and Forestry (CVF) Cartographies have been integrated into the Cartography of Agricultural Areas (CAAs) by getting the Road Map and Agriculture (CVA) map. At the Forest map CFRBFAF è stata sovrapposta la carta della viabilità ed agricoltura CVA.
3) Subsequently, the CVA portion contained within the CRBFAF was extracted, obtaining the road map and useful forestry areas (CVAUAF).
4) At this point, the 2 mappings of BUFFER 75 meters and 150 meters from the road lines and the agricultural polygons have been derived according to the fact that the removal of forestry wood can be done preferably 75 meters away (and most of the distance Of 150 meters) from the roads and agricultural areas, thus obtaining the 2 cards of the gross forest areas for the 75 m wood picking. And at 150 m. (CFUL75 and CFUL150).
5) From the initial high-forest forest logs (CFRBFAF), the forest areas belonging to the two above-mentioned buffers were extracted again to obtain their respective net worth forestry logs (CZFUN75 and CZFUN150).
6) The slopes of the reliefs were not considered as being too complex from the point of view of cartographic elaborations; This simplification has been considered acceptable since, on the one hand, the downhill to the road where timber loads can make it easier to move (thanks to gravity in favor), on the other hand an uphill slope would require excessive effort (both from the Logistical point of view, than that of handling machinery, rather than that of fuel consumption) due to the opposite force of gravity.
7) No elaborations have been made regarding the state of ownership of the forest areas; Then keep in mind that many forestry owners may not be willing to give their woody areas for woody exploitation.

Here is a clear picture of a forestry supply area extracted from the net forestry use cards for wood picking (CZFUN75 and CZFUN150).
This CZFUN cartography is very useful for energy and forest planning since it allows geographically to determine with a good degree of reliability the localization and extension of the forest areas that are realistically available to be used for the supply of wood biomass.
Then associating a medium woody growth rate (comparable to an equal rate of sustainable woody biomass removal) is therefore possible to derive an estimate of the amount of wood available to be exploited without affecting negatively the basic forest stock.

[12] [RER.SAPFSM.IFRER, 2016, b.]

The correction factors due to the loss of humidity required by the different uses must then be applied to the values of the above quantity.

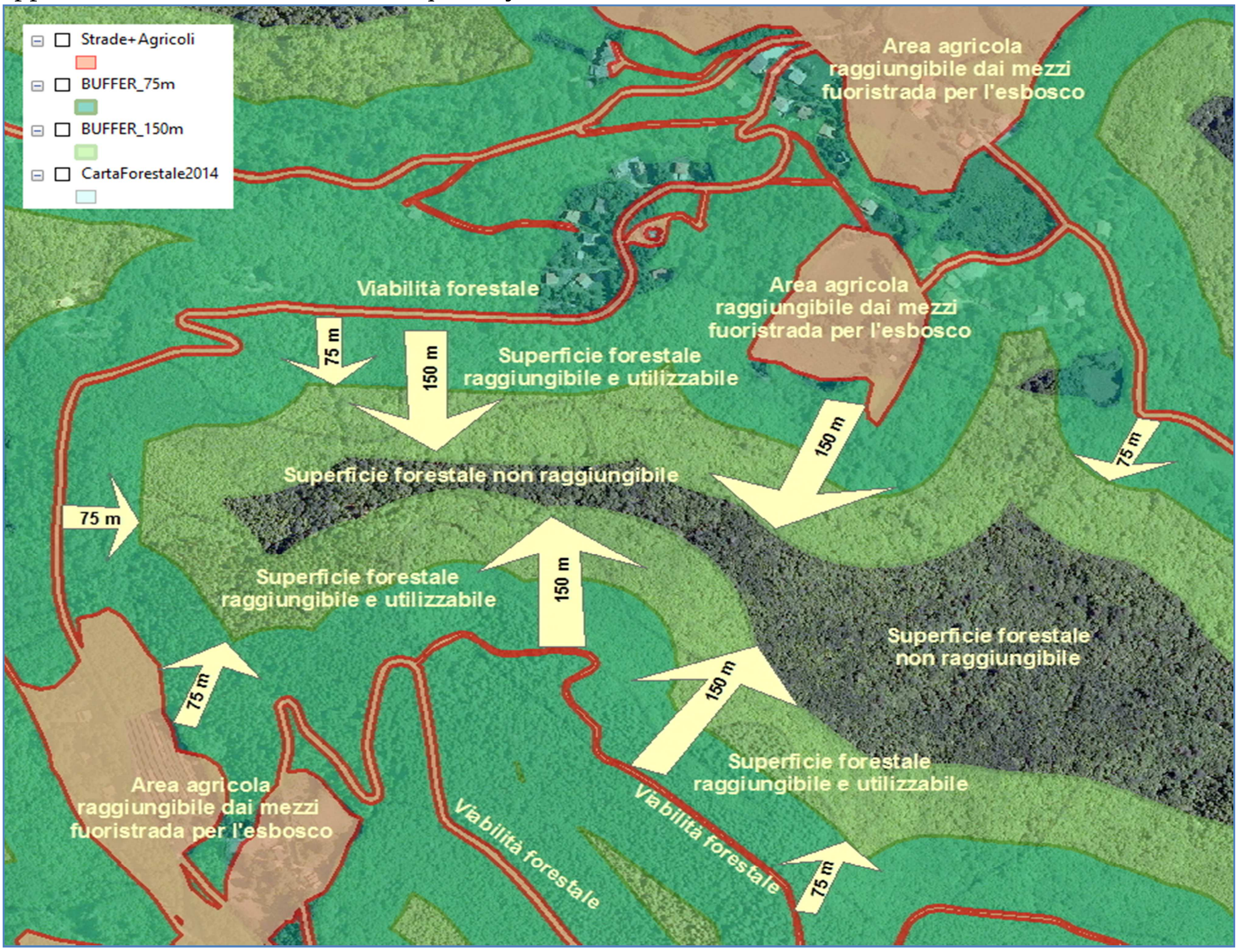


Figura 2- Visualization of useful areas where it is possible collect forest wood.

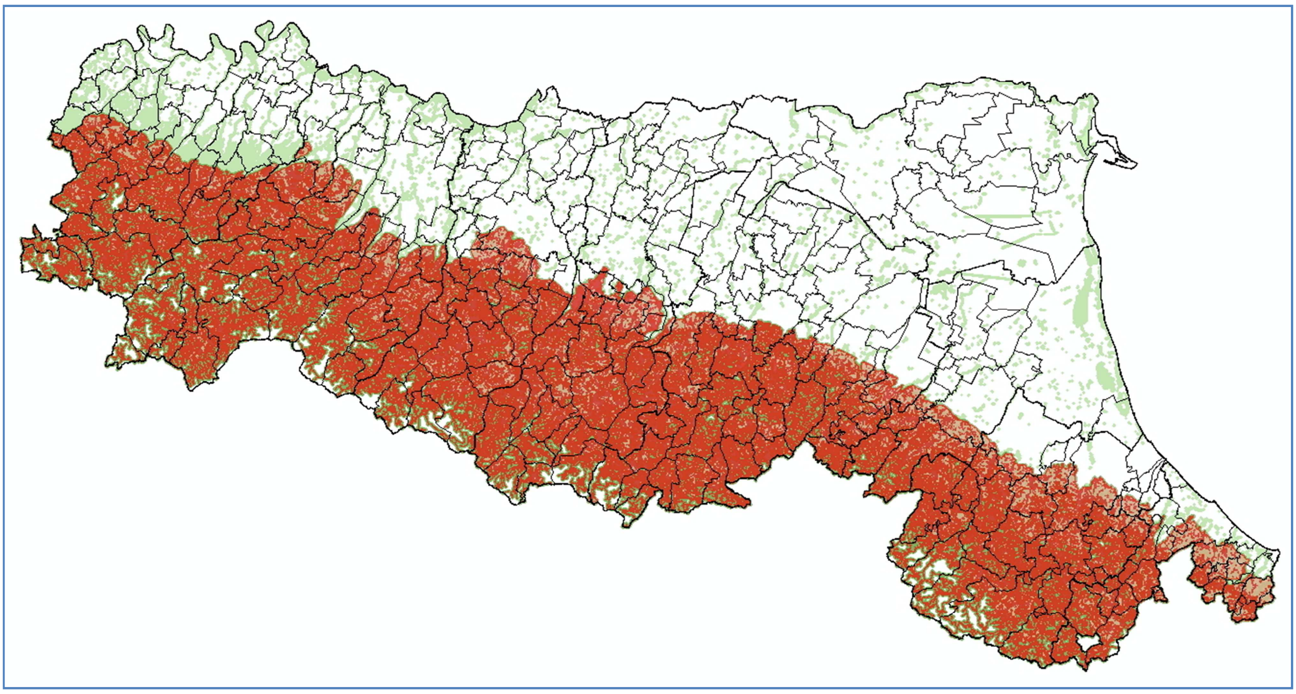


Figura 3- Visualization at regional scale of useful areas where it is possible collect forest wood.

Figura 4- Detail of ortophoto AGEA 2008

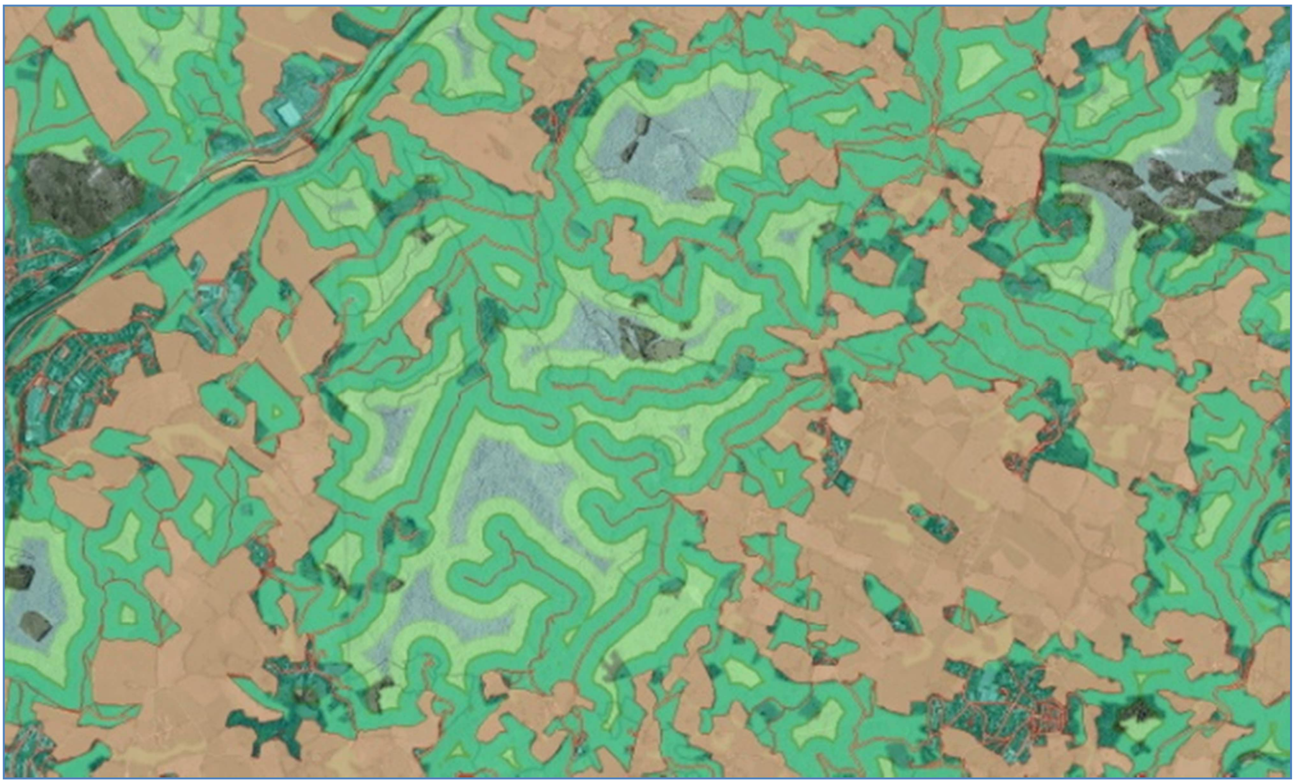


Figura 5- Relative map of the useful forest wood potentiality (MPELFU)

2.4. Forest wood availability

With a total forest area of 612,600 hectares (update RER 2006) and the subsequent elimination of shrubby areas and shrubby pine forests according to SAPFSM [13] cartography updated to 2014, the Emilia-Romagna Region has 546,928 hectares of land high-wood available [14] to supply wood biomass.
According to the INFC-2005 [15], this forest extension consists of 72,338,122 cubic meters of wood, with an average woody increase of 2,379,879 cubic meters per year.

The overall data, *in hectares*, derived from the forestry map of Emilia-Romagna region, INFC 2005 updated 2006, are as follows:

Tabella 11- Overall data, in hectares, derived from the forestry map of Emilia-Romagna region 2006

FOREST TYPES (updated 2006)	FOREST AREAS (ha)
abetine, popolamenti a conifere montane	6.900*
pinete, conifere da litorali a submontane	31.200
pioppeti colturali e arboricoltura da legno	19.900*
boschi ripariali	37.300
arbusteti (escluse praterie arbustate)	36.000*
querceti misti submesofili e castagneti	278.000
querceti xerofili di roverella e sclerofite	98.300
faggete	105.000
TOTAL FORSTALL AREAS -2006-	612.600
TOTAL FORSTALL AREAS USEFUL FOR FOREST COLLECTION -2006-	549.800

FOREST TYPES (updated 2014)	RER -2014- FOREST AREA (ha)	INFC 2005 Average increment (mc/year) for all regional forest	INFC 2005 Average increment (mc/ha) For single hectare
Boschi alti CEDUI	390.568		
Boschi alti A FUSTAIE	156.360		
TOTAL FOREST AREAS -2014-	**546.928**	**2.379.879**	**4,4**

[13] Protected Areas for Forestry and Mountain Office of the Emilia-Romagna Region.
[14] Although patchy forests should also be excluded from the counts of the available areas to supply timber as it is impossible to collect them systematically with the usual forest machinery, it was considered appropriate to count them equally as in the vast majority of the time the timber recovered from maintenance Repairs are given, together with agricultural and urban potato, to generic energy use.
[15] - 2nd National Inventory of Forests and Carbon Tanks 2005.

The overall data, *__in cubed meters__*, derived from the forestry map of Emilia-Romagna region, INFC 2005, are as follows:

Tabella 12- Overall data, in cubed meters, derived from the forestry map of Emilia-Romagna region 2006

	Tipology	Actual increment (mc/ha)	Actual increment (mc/ha)
WOOD ARBORICULTURE	pioppeti artificiali	87.569	11,0
	piantagioni di altre latifoglie	7.965	5,6
	piantagioni di conifere	9.029	24,6
	TOTALE IMPIANTI di ARBORICOLTURA DA LEGNO	104.563	10,7
AREAS TEMPORARILY WITHOUT TOPSOIL	Aree temporaneamente prive di soprassuolo	21	0,0
	TOTALE AREE TEMPORANEAMENTE PRIVE SOPRASSUOLO	21	0,0
HIGH FORESTS	larice e cembro	0	0,0
	abete rosso	53.279	13,2
	abete bianco	36.410	12,4
	pino silvestre e montano	15.772	3,9
	pino nero, laricio e loricato	104.101	6,3
	pinete di pini mediterranei	12.196	4,3
	conifere pure o miste	14.014	4,8
	faggete	627.498	6,2
	rovere, roverella e farnia	166.082	2,2
	cerrete, farnetto, fragno e vallonea	463.170	4,7
	castagneti	223.458	5,3
	ostrieti, carpineti	331.595	3,2
	boschi igrofili	83.328	3,4
	altri boschi caducifogli	244.652	3,4
	leccete	3.825	5,2
	sugherete	0	0,0
	altri boschi sempreverdi	0	0,0
	TOTALE BOSCHI ALTI	2.379.879	4,3

Tabella 13- Synthesis of overall data, in cubed meters, derived from the forestry map of Emilia-Romagna region 2006

General tipology	Actual increment (mc/ha)	Actual increment (mc/ha)
Boschi alti	2.379.879	4,3
Arboricoltura da legno	104.563	10,7
Aree temporaneamente prive di soprassuolo	21	0,0
TOTALE	2.484.463	4,4
TOTALE AREE AD ALTO FUSTO (Boschi+Arboricoltura)-(INFC *2005)	2.484.442	4,4

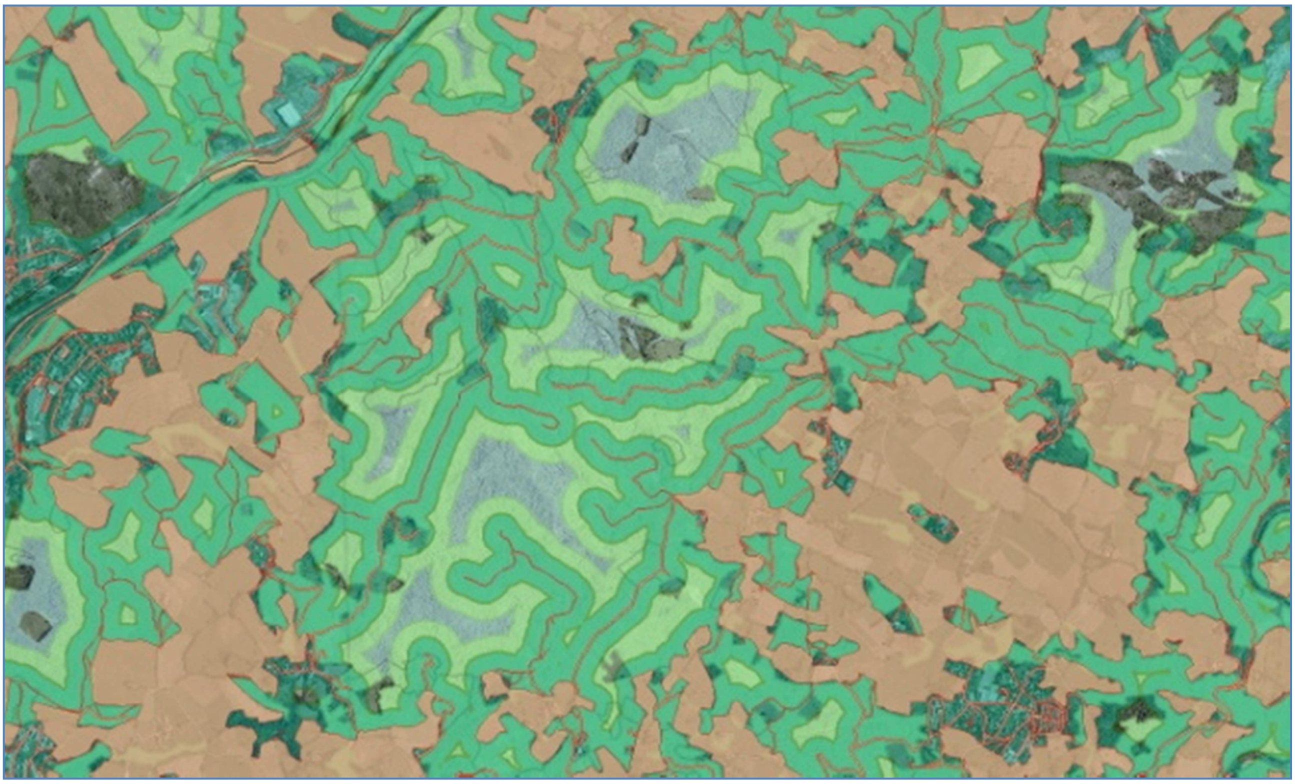


Figura 6- Zoom of the map of useful forest woody energetic potentiality (MPELFU)

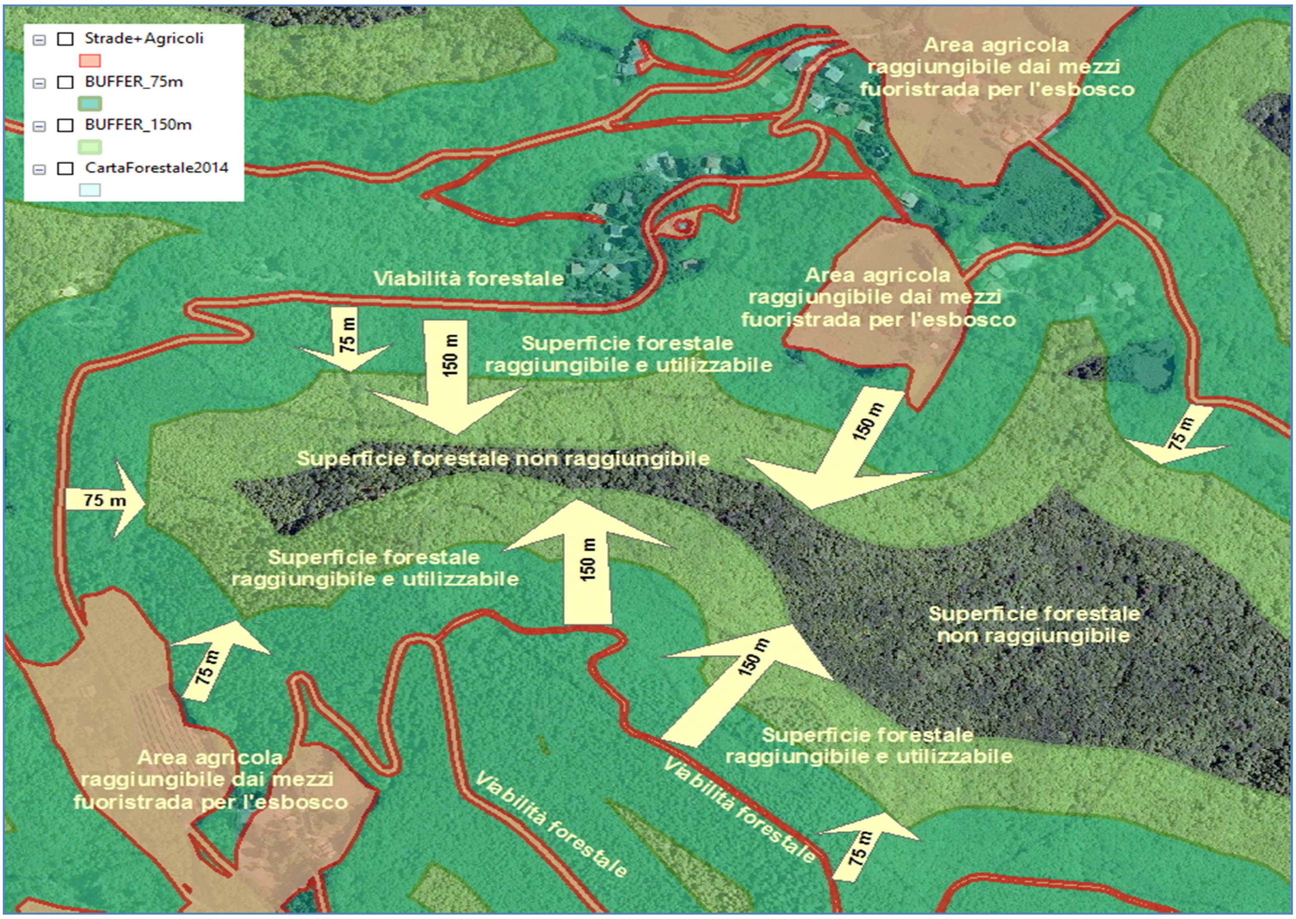


Figura 7- Particular of the map of useful forest woody energetic potentiality(MPELFU)

2.5. Forest wood useful availability budget

In relation to only forest areas at high altitudes, the following table can be adopted by supplementing the above data:

Tabella 14- Synthesis of overall regional data, in cubed meters and in tonnes, derived from the forestry map of Emilia-Romagna region 2006

*Fonte: RER.SAPFSM *2014.*	*Fonte: INFC *2005*				
Superficie delle formazioni a Boschi alti (ha)	**Stock esistente (mc)**	**Disponibilità volumica areale unitaria medio corrente (mc/ha)**	**Peso specifico medio della legna stagionata (ton/mc)**	**Stock esistente di legname -stagionato- (ton.)**	**Disponibilità massiva medio corrente (ton/anno/ha)**
546.928	**72.338.122**	**132,3**	**0,60**	**43.402.873**	**79,36**
Superficie delle formazioni a Boschi alti (ha)	**Incremento volumico medio corrente (mc/anno)**	**Incremento volumico areale unitario medio corrente (mc/anno/ha)**	**Peso specifico medio della legna stagionata (ton/mc)**	**Incremento massivo di legname stagionato (ton.)**	**Incremento massico medio corrente (ton/anno/ha)**
546.928	**2.379.879**	**4,35**	**0,60**	**1.427.927**	**2,61**

At this point, as explained just recently, the map of only forests of high trees from which were eliminated the "shrubs" and "pinete" (CFRBFAF) areas, was mapped for high forest forests Included within the buffer of 150 meters from the CZFUN150 forest and agricultural road traffic, from which the area values, volume and weight values for the timber that can be collected annually in a sustainable way, or in quantities equal to the annual increase Current average, from the only wooded areas reachable by the exhumation means (150 meters from viable and agricultural areas).

Note that although 78.69% of the high-wooded wooded area is reachable, due to the fact that the specific types of forestry polygons are associated with their specific yearly increase in volume and specific weight of seasoned wood, the values percentages of mass and volume increases are different, that is, 75.17% and 79.59% respectively.

Tabella 15- Synthesis of the amounts in hectares of annual available forest wood productive areas, in function of the destinations of the two kind of wood: HQ firewood and LQ wood energy plants

[TOTALE] Aree Foresti	**Superficie delle formazioni a Boschi alti (ha)**	**Incremento volumico medio corrente (mc/anno)**	**Incremento volumico areale unitario medio corrente (mc/anno/ha)**	**Peso specifico medio della legna stagionata (ton/mc)**	**Tonnellate di legname stagionato (ton.)**	**Incremento massico medio corrente (ton/anno/ha)**
PRELIEVO MAX TEORICAMENTE SOSTENIBILE	**546.928 = 100%**	**2.379.879**	**4,35**	**0,60**	**1.427.927**	**2,61**
Destinazione: PRELIEVI MAX PER LEGNA DA ARDERE	**431.624 = 78,9 %**					
Destinazione: PRELIEVI MAX PER IMPIANTI ENERGETICI	**115.304 = 21,1 %**					

Tabella 16- Synthesis of the amounts, in hectares and in tonnes, of annual useful available forest wood productive areas, in function of the destinations of the buffer of 150 m. from agricultural fields and from roads, reachable by the woodsmen, calculated through operations of mathematical averages and weights

[RAGGIUNGIBILI] Buffer 150 metri dalla viabilità Foreste ed agricola	Superficie delle formazioni a Boschi alti (ha)	Incremento volumico medio corrente (mc/anno)	Incremento volumico areale unitario medio corrente (mc/anno/ha)	Peso specifico medio della legna stagionata (ton/mc)	Tonnellate di legname stagionato (ton.)	Incremento massico medio corrente (ton/anno/ha)
PRELIEVO SOSTENIBILE REALIZZABILE ALL'INTERNO DEL BUFFER DI 150 metri	**430.379**	**1.765.203**	**4,10**	**0,64**	**1.136.490**	**2,64**
% rispetto al totale delle superfici Foresti RER	**78,69 %**	**75,17 %**			**79,59 %**	
				LQ Energy plants wood 30%	**340.947**	
				HQ Firewood 70%	**795.543**	

According to the estimates of the Regional Forest Service[16] about 70% of the volume of wood that can be picked is destined for the firewood market (high quality timber, such as beech, oak, hornbeam, robinia) with an average selling price of 13.5 euro, while only about 30% is lighter wood (coming from conifers, chestnut, riparian, poplar, willow shrubs) available to be launched on the market of biomass combustion energy plants at an average price that oscillates from 2.5 euro / quintals for the whole wood whitewash up to 7.5 euro / quintals for chips.

According to this reasoning, the following table can be calculated, always bearing in mind that % percentages are not homogeneous because there is no exact correspondence between areas, volumes and masses due to the different forest types of the individual polygons.

[16] Fonte: RER.SAPFSM, 2016, a.

Tabella 17- Synthesis of the amounts, in hectares and in tonnes, of annual useful available forest wood productive areas, in function of the destinations of the buffer of 150 m. from agricultural fields and from roads, reachable by the woodsmen, calculated through GIS coverage operations

[RAGGIUNGIBILI] Buffer 150 metri dalla viabilità Foreste ed agricola	Superficie delle formazioni a Boschi alti (ha)	Incremento volumico medio corrente (mc/anno)	Incremento volumico areale unitario medio corrente (mc/ha/anno)	Peso specifico medio della legna stagionata (ton/mc)	Tonnellate di legname stagionato (ton.)	Incremento massico medio corrente (ton./ha/anno)
HQ **LEGNA DA ARDERE** faggio, quercia, carpino, robinia	331.383	1.250.916	3,77	0,7	874.690	2,64
%	77,00%	70,87%			76,96%	
LQ **LEGNA PER IMPIANTI ENERGETICI** pioppi,salici, conifere, castagno	98.996	514.287	5,2	0,51	261.800	2,64
%	23,00%	29,13%			23,04%	

3. COMPARISON BETWEEN ELECTRIC+THERMAL AND ONLY THERMAL PLANTS

3.1. Hypothesis and calculations

At this point, in order to analyze the aforementioned data on the availability of wood biomass for energy plants, it is first and foremost necessary to consider the difference between a biomass combustion energy plant for district heating only (4,000 hours per year) and one destined First of all to the production of electricity (active 8,000 hours / year). [17]

- **<u>Caso 0 – CC.AA.OO [18] PLANT DEDICATED TO ELECTRIC + THERMAL ENERGY</u>**

Starting from a study case, using the CA.FF.OO plant for the production of electricity and heat (heating in district heating 1 school + 1 gym + 1 swimming pool) we can use the following reference data:

Impianto esistente: CA.FF.OO **<u>original start data</u>**: 35 kWel x 6.000 ore

- Quantità annuale di legna fresca richiesta (50% pioppo + 50% robinia) = 812,2 ton./anno
- Umidità eliminata tramite stagionatura per 12 mesi = 45% di acqua
- Quantità di cippato legnoso secco utilizzato annualmente = X_{CAFO} = 450 ton./anno
- Funzionamento dell'impianto = 6.000 ore/anno = 250 giorni/anno = 8,3 mesi/anno
- Potenza elettrica (17,5%) = 35 kWe
- Energia elettrica prodotta = 210 MWh.el
- Potenza termica (70%) = 140 kWt
- Energia termica erogata in teleriscaldamento = 840 MWh.t
- Potenza persa (12,5%) = 25 kW
- Energia persa = 150 MWh
- Potere calorifico desunto (1.200.000 kWh / 450.000 kg cippato) = 2,67 kWh/kg
- Consumo (450.000 kg cippato / 6.000 ore) = 75 kg/ora = 1.800 kg/giorno
- **$X_{CFE.35kW.6000ore}$ → 450 ton. di cippato (6.000 ore)**

Caso 0: CA.FF.OO: **<u>equiparated</u>** to 1 MWel. x 6.000 e x 8.000 ore

- 35 kWel : 450 ton./anno cippato = 1000 kWel : X ton. cippato
- **$X_{CFE.1MW.6000}$ → 12.857 ton. di cippato (6.000 ore)**
- Energia elettrica prodotta = 1 MW x 6.000 ore = 6.000 MWh.el
- Energia termica utile = 2,4 MW x 6.000 ore = 24.000 MWh.t
- **$X_{CFE.1MW.8000}$ → 17.143 ton. di cippato (8.000 ore)**
- Energia elettrica prodotta = 1 MW x 8.000 ore = 8.000 MWh.el
- Energia termica utile = 2,4 MW x 8.000 ore = 32.000 MWh.t

[17] Such installations should then be compared to a residential environment heated directly with firewood through stoves and / or domestic fireplaces.
[18] CC.AA.OO i san acronymum, for privacy norms.

So, we can assume these two reference case:

- **Caso 1 - IMPIANTO DESTINATO ALLA PRODUZIONE DI ELETTRICITA' + ENERGIA TERMICA PER RETE DI TELERISCALDAMENTO**

IMPIANTO IPOTETICO ELETTRICO+TERMICO: 1 MWel + 2,4 MW.term x 8.000 ore

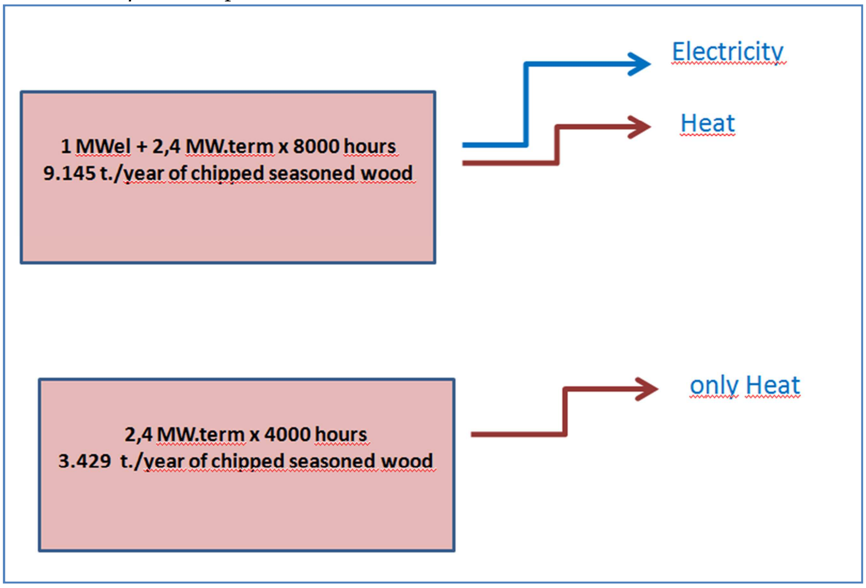
- Funzionamento dell'impianto = 8.000 ore/anno = 333 giorni/anno = 11 mesi/anno
- Potenza elettrica (25%) = 1 MWel
- Energia elettrica prodotta = 8.000 MWh.el
- Potenza termica (60%) = 2,4 MWt
- Energia termica erogata in teleriscaldamento = 19.200 MWh.t
- Potenza persa (15%) = 0,6 MW
- Energia persa = 4.800 MWh
- Potere calorifico del cippato (W30%) = 3,5 kWh/kg
- Energia totale in entrata = 8.000+19.200+4.800 = 32.000 MWh = 32.000.000 kWh
- Cippato richiesto in entrata = 32.000.000 kWh / 3,5 kWh/kg = 9.142.857 kg di cippato
- **$X_{IME.1MW.8000ore}$ → 9.145 t./anno di cippato**

- **Caso 2 - IMPIANTO DESTINATO ALLA SOLA PRODUZIONE DI ENERGIA TERMICA PER RETE DI TELERISCALDAMENTO**

IMPIANTO IPOTETICO solo TERMICO: 2,4 MWt x 4.000 ore

- Funzionamento dell'impianto = 4.000 ore/anno = 166,7 giorni/anno = 5,5 mesi/anno
- Potenza termica (80%) = 2,4 MWt
- Energia termica erogata in teleriscaldamento = 2,4 MWt x 40000 ore = 9.600 MWh.t
- Potenza persa (20%) = 0,6 MW
- Energia persa = 2.400 MWh
- Potere calorifico del cippato (W30%) = 3,5 kWh/kg
- Energia totale in entrata = 9.600+2.400 = 12.000 MWh = 12.000.000 kWh
- Cippato richiesto in entrata = 12.000.000 kWh / 3,5 kWh/kg = 3.428.571 kg di cippato
- **$X_{IT.2,4MW.4000ore}$ → 3.429 t./anno di cippato**

Figura 8- Conceptual scheme of the comparison



3.2. Preliminary conclusions

In the light of the above mentioned cases we can therefore assume that a wood-powered biomass co -energetic power plant of 1 MWel, operating for 8,000 hours / year, requires consumption[19] of seasoned wood chips (W = 30%) between 9,000 and 13,000 ton./anno.

Tabella 18- Data comparison

	Impianto 1 MWel x 8.000 ore	Impianto 2,4 MWt x 4.000 ore
Consumo cippato stagionato	13.000 ton./anno	3.429 ton./anno
Ore di funzionamento	8.000	4.000
Potere calorifico del cippato	3,5 kWh/kg	3,5 kWh/kg
Efficienza elettrica	25%	/
Potenza elettrica (eff. 25%)	1 MWel	/
Energia elettrica prodotta	8.000 MWh.el	/
Efficienza termica (eff. %)	60%	80%
Potenza termica	2,4 MWt	2,4 MWt
Energia termica utilizzabile	19.200 MWh.t	9.600 MWh.t

Ultimately, we can approximate the concept that from the point of view of the consumption of wood biomass (and therefore the use and management of energy, together with its polluting emissions (PM10, PM2,5, NOX, etc ..) Re-entering biogenic CO2 in the atmosphere, number 1 electric power plant 1 MW and 2.4 MW wood-powered biomass heaters operating for 8,000 hours / year has about the same impact of 3.7 thermal power plants of equal thermal power Woody biomass running 4,000 hours / year each.

Without prejudice to all case-cases, for information purposes only, for the same consumption of wood biomass 13.000 t./year of wood and therefore for the use of wooded areas and relative biogenic CO2 balance, it is considered correct to hypothesize the following two limit cases:

- Construction of a power plant + thermal by a private subject, which requires an average consumption of 13,000 tons. Of seasoned wood biomass taken from the land / woods of public ownership, or the entire community of the territory, which will be paid to the consortium of foresters 7.5 euro / quintal, and whose revenues will be obtained from the sale with incentives of electricity to State (Public Body) and the sale of district heating energy to Public Structures and private individuals located nearby at a certain price;

- Equivalent construction of 3.7 exclusive thermal power plants by Public Spatial Bodies which, in respect of the same purchase price of chips from forestry consortia, will cover the winter heat demand to the Community of neighboring territories by selling heat to Reduced prices, compensating for the exploitation of forests.

Of course, we reiterate, these are only two hypothetical extreme and opposing limit cases useful only to facilitate any planning and / or management reasoning.

[19] Average value between the two highest reported consumption: [9,000 - 17,000] tons / year .

4. MAXIMUM SUSTAINABLE NUMBER OF ENERGY WOOD PLANTS AT REGIONAL LEVEL

At the end of this chapter, we propose a wood availability budget below which generally quantifies how many biomass wood power plants can be genuinely sustainably fueled by the Emilia-Romagna forests. *Tabella 19- Regional forest energy wood budget*

	Superficie delle formazioni a Boschi alti (ha)	Incremento volumico medio corrente (mc/anno)	Incremento volumico areale unitario medio corrente (mc/anno*ha)	Peso specifico medio della legna stagionata (ton/mc)	Tonnellate di legname stagionato (ton.)	Incremento massico medio corrente (ton/anno*ha)	Num. Impianti 1.MW ELETTRICO (11.000 ton/anno) 8.000 ore/anno	Num. Impianti 1.MW ELETTRICO (13.000 ton/anno) 8.000 ore/anno	Num. Impianti 2,4.MW TERMICO (3.500 ton/anno) [20] 4.000 ore anno
LEGNA PER IMPIANTI ENERGETICI pioppi,salici, conifere, castagno	98.996	514.287	5,2	0,51	261.800	2,64	24	20	75
%	23,00%	29,13%			23,04%				

The conclusion is that the regional forest of Emilia-Romagna are able to supply 24 wood combustion plants of 1 MW.electric that needs 11000 t./year of seasoned wood, while if all wood plants would produce only thermal energy for remote heating, only for 4000 hours/year, the forest could support 75 plants of 2,4 MW.thermal each one.

4.1. Regional scale synthesis

Tabella 20- Reference synthesis at regional scale

	Superfice Foreste idonea (ha)	Superfice di esbosco potenziale (150 m da viabilità)	%	Stima prelievo sostenibile (mc)	Peso specifico MEDIO della legna stagionata TOTALE (ton./mc)	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)
Legna totale disponibile	546.928	430.379	100,00%	1.765.203	0,64	1.136.490	3.523.119
Legna da ardere	431.624	331.383	76,96%	1.250.916	0,7	874.690	2.711.539
Legna per impianti energetici	115.304	98.996	23,04%	514.287	0,51	261.800	811.580
Num. Impianti 1.MW ELETTRICO (11.000 ton/anno) 8000 ore/anno	24						
Num. Impianti 1.MW ELETTRICO (13.000 ton/anno) 8000 ore/anno	20						
Num. Impianti 2,4.MW TERMICO (3.500 ton/anno) 4000 ore/anno	75						

[20] Per ragioni di semplificazione il valore delle 3.429 ton./anno è stato approssimato per eccesso a 3.500 ton./anno .

4.2. Provincial scale synthesis

Tabella 21- Synthesis for Province total biomass takeble overall for all kind of use

Provincia	Superfice Foreste idonea (ha)	Superfice di esbosco potenziale (150 m da viabilità)	% effettiva selvicoltura	Stima prelievo sostenibile (mc)	Peso specifico MEDIO della legna stagionata TOTALE (ton./mc)	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)
Piacenza	86.974	70.420		275.697	0,65	179.239	555.642
Parma	141.799	102.503		435.733	0,66	289.110	896.241
Reggio Emilia	56.826	45.230		195.771	0,64	126.160	391.096
Modena	59.139	48.925		235.865	0,63	148.811	461.315
Bologna	82.308	69.914		264.922	0,63	166.356	515.703
Ferrara	2476	2476		6.767	0,62	4.202	13.026
Ravenna	17.175	15.584		57.637	0,58	33.539	103.969
Forli'-Cesena	82.158	59.792		241.248	0,63	151.750	470.426
Rimini	18.070	15.533		51.565	0,65	33.618	104.217
Totale	**546.928**	**430.379**		**1.765.203**	**0,64**	**1.136.490**	**3.523.119**

Tabella 22- Synthesis for Province of theretical taking of firewood

Provincia	Superficie Foreste idonea (ha)	Superficie di esbosco potenziale (150 m da viabilità)	% effettiva selvicoltura	Stima prelievo sostenibile (mc)	Peso specifico MEDIO della legna stagionata DA ARDERE (ton./mc)	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO = =(CA.FF.OO+Bibliografia)/2) = = [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)
Piacenza	68.824	54.418	79%	206.954	0,7	144.868	449.090
Parma	121.556	87.023	72%	356.218	0,7	249.353	772.993
Reggio Emilia	44.737	34.503	77%	141.373	0,7	98.961	306.779
Modena	44.221	35.349	80%	154.394	0,7	108.076	335.035
Bologna	61.626	52.304	85%	169.474	0,7	118.632	367.759
Ferrara	1.757	1.757	100%	4.092	0,7	2.864	8.880
Ravenna	9.263	8.203	89%	23.600	0,7	16.520	51.212
Forli'-Cesena	64.763	45.395	70%	155.632	0,7	108.942	337.721
Rimini	14.875	12.431	84%	39.179	0,7	27.425	85.018
Totale	**431.624**	**331.383**		**1.250.916**	**0,70**	**874.690**	**2.711.539**

Tabella 23- Synthesis for Province of theretical taking for energy plants

Provincia	Superficie Foreste idonea (ha)	Superficie di esbosco potenziale (150 m da viabilità)	% effettiva selvicoltura	Stima prelievo sostenibile (mc)	Peso specifico MEDIO della legna stagionata PER IMPIANTI ENERGETICI (ton./mc)	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO = =(CA.FF.OO+Bibliografia)/2) = = [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)
Piacenza	18.150	16.002	88%	68.743	0,5	34.372	106.552
Parma	20.243	15.480	76%	79.515	0,5	39.758	123.248
Reggio Emilia	12.089	10.727	89%	54.398	0,5	27.199	84.317
Modena	14.918	13.576	91%	81.471	0,5	40.736	126.280
Bologna	20.682	17.610	85%	95.448	0,5	47.724	147.944
Ferrara	719	719	100%	2.675	0,5	1.338	4.146
Ravenna	7.912	7.381	93%	34.037	0,5	17.019	52.757
Forli'-Cesena	17.395	14.397	83%	85.616	0,5	42.808	132.705
Rimini	3.195	3.102	97%	12.386	0,5	6.193	19.198
Totale	**115.304**	**98.996**		**514.287**	**0,51**	**261.800**	**811.580**

Tabella 24- Synthesis for Province of maximum sustainable number of wood combustion plants

Provincia	Tonnellate prelievo sostenibile (ton.)	Numero di impianti energetici da 1 MW ELETTRICO approvvigionabili (11.000 ton./anno) per 8.000 ore/anno	Numero di impianti energetici da 1 MW ELETTRICO approvvigionabili (13.000 ton./anno) per 8.000 ore/anno	Numero di impianti energetici da 2,4 MW TERMICI approvvigionabili (3.500 ton./anno) per 4.000 ore/anno
Piacenza	34.372	3,1	2,6	9,8
Parma	39.758	3,6	3,1	11,4
Reggio Emilia	27.199	2,5	2,1	7,8
Modena	40.736	3,7	3,1	11,6
Bologna	47.724	4,3	3,7	13,6
Ferrara	1.338	0,1	0,1	0,4
Ravenna	17.019	1,5	1,3	4,9
Forli'-Cesena	42.808	3,9	3,3	12,2
Rimini	6.193	0,6	0,5	1,8
Totale	**261.800**	**23,8 → 24**	**20,1 → 20**	**74,8 → 75**

Tabella 25- Synthesis for Province of energy availability from forest wood

	LEGNA DA ARDERE		LEGNA PER IMPIANTI ENERGETICI		NUMERO di impianti energetici equivalenti	NUMERO di impianti energetici equivalenti	NUMERO di impianti energetici equivalenti
Provincia	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)	da 1 MW ELETTRICO approvvigionabili (11.000 ton./anno) per 8.000 ore/anno	da 1 MW ELETTRICO approvvigionabili (13.00 ton./anno) per 8.000 ore/anno	da 2,4 MW TERMICI approvvigionabili (3.500 ton./anno) per 4.000 ore/anno
Piacenza	144.868	449.090	34.372	106.552	3,1	2,6	9,8
Parma	249.353	772.993	39.758	123.248	3,6	3,1	11,4
Reggio Emilia	98.961	306.779	27.199	84.317	2,5	2,1	7,8
Modena	108.076	335.035	40.736	126.280	3,7	3,1	11,6
Bologna	118.632	367.759	47.724	147.944	4,3	3,7	13,6
Ferrara	2.864	8.880	1.338	4.146	0,1	0,1	0,4
Ravenna	16.520	51.212	17.019	52.757	1,5	1,3	4,9
Forli'-Cesena	108.942	337.721	42.808	132.705	3,9	3,3	12,2
Rimini	27.425	85.018	6.193	19.198	0,6	0,5	1,8
Totale	**874.690**	**2.711.539**	**261.800**	**811.580**	**23,8**	**20,1**	**74,8**

4.3. Appendix – technical elements of deeping for the different woody trees species

Tabella 26- Technical elements of deeping for the different woody tree species

ELEMENTI TECNICI DI UTILIZZO *Fonte:* RER.SAPFSM *2014	**Incremento corrente (mc/ha) = prelievo medio annuo massimo "sostenibile"**	**Impiego commerciale prevalente**	**Impiego commerciale alternativo**	**Fattore di conversione da metri cubi a tonnellate (con corteccia)**	**MW termici ricavati da ogni metro cubo di biomassa legnosa (* da impianti termici con rendimento = 0,85)**
Faggio (cedui, fustaie, non governati)	6,2	legna da ardere	tondame da sega	0,7	0,182
Cerro (cedui, fustaie, non governati)	4,7	legna da ardere		0,7	0,182
Roverella e altre querce (cedui fustaie non governati)	2,2	legna da ardere		0,7	0,182
Carpino n. Orniello Robinia (cedui fustaie non governati)	3,2	legna da ardere		0,7	0,182
Castagno (cedui, fustaie, castagneti, non governati)	5,3	**energia da biomassa**	tondame da sega, paleria	0,5	0,13
Ripariali	3,4	**energia da biomassa**		0,4	0,104
Altre latifoglie - cedui e fustaie	3,2	legna da ardere		0,6	0,156
Altre latifoglie - boschi non governati	3,2	**energia da biomassa**		0,6	0,156
Abete bianco	12,4	**energia da biomassa**	tondame da sega	0,45	0,117
Abete rosso	13,2	**energia da biomassa**	tondame da sega	0,45	0,117
Pini montani	6,3	**energia da biomassa**		0,6	0,156
Pini mediterranei	4,3	**energia da biomassa**		0,65	0,169
Altre conifere	4,8	**energia da biomassa**	tondame da sega	0,6	0,156
Conifere in impianti specializzati (arboricoltura)	24,6	**energia da biomassa**	tondame da sega	0,6	0,156
Pioppeti - DATO NON ELABORATO	11,0	altri impieghi - dato non eleaborato		0,4	0,104
Altre latifoglie in impianti arboricoltura - DATO NON ELABORATO	5,6	altri impieghi - dato non eleaborato		0,6	0,156
Arbusteti - DATO NON ELABORATO	0,0	dato non eleaborato		0	0
Parchi e giardini - DATO NON ELABORATO	0,0	dato non eleaborato		0	0

5. REGIONAL FOREST WOOD ENERGY POWER BUDGET

If we assume that all the solid biomass energy plants would be of the wood combustion plants type, and that they would have energy yields similar at those standardized we created, where to produce 8000 MWh/year of electricity it needs 12766 tons./year of fresh wood, that is 7660 tons./year of seasoned wood, we estimate that actually:

- If all the forest wood sustainable production (HQ High Quality firewood + LQ Low Quality wood for energy plants) would be used to supply the whole actual solid biomass power plants system of 141,6 MW electric power at all (as it would be all composed by forest wood combustion plants), the whole regional forest could supply 1,048 actual system.

- If it would be used only LQ wood, the regional forest could supply only 0,314 forest wood combustion systems.

- In the special case study analised of PWCP (the solid wood combustion plant of 30 MW.electric power authorized and actually in costruction in the province of Ravenna, that should be supplied with wood coming from 8000 hectares of Populus L. arboriculture) the calculation show that if it would be supplied only with only LQ forest wood, the regional forest would be able to supply at all 1,48 plants like this one; while if it would be used both HQ+LQ forest wood, the regional forest could supply 4,95 plants like this one.

You can see the data calculation in the following tables.

Tabella 27- Reference table for calculation of wood biomass input needed by a 1 MW.el WOOD COMBUSTION plant.

TAB (C5) for calculation of wood biomass input needed by a 1 MW.el WOOD COMBUSTION plant								
IMPIANTO STANDARD C.LEGNOSA DI 1 MW.el	MW	%	ore/anno	MWh/anno				
STANDARD WOOD PLANT OF 1 MW.el	MW	%	hours/year	MWh/year				
Electric power	1,0	22%	8.000	8.000				
Thermal power	3,0	67%	8.000	24.000				
Lost power	0,5	11%	8.000	4.000				
Total power	4,5	100%	8.000	36.000				
ENRGIA LEGNOSA RICHIESTA DALL'IMPIANTO STANDARD	Energia richiesta in input	Pci legno stagionato (cippato)	Tonnellate di legno stagionato necessarie per 1.MW.el di input	Acqua %	Tonnellate di legno fresco necessarie	Peso specifico legno stagionato	Peso specifico legno fresco	PSst/PSfr
WOOD ENERGY NEEDED BY THE STANDARD PLANT	Energy request for starting input	inferior Calorific Power of seasoned wood	Tons of seasoned wood needed by a 1 MW.el standard plant	Water %	Tons. Of fresh wood needed by a 1 MW.el standard plant	Specific weight of seasoned wood	Specifica weight of fresh wood	SWsw / SW fw
	MWh/year	kWh/kg	t./anno	%	t./anno	t./m3	t./m3	%
Populus L. arboriculture	36.000	4,70	7.660	40%	12.766	0,45	0,75	60%
Forest: general mix	36.000	4,70	7.660	40%	12.766	0,64	1,07	60%
Forest: firewood (High Quality)	36.000	4,70	7.660	40%	12.766	0,70	1,17	60%
Forest: wood for energy plants (Low Quality)	36.000	4,70	7.660	40%	12.766	0,51	0,85	60%

Tabella 28- Reference table (part a) for calculation of wood biomass productivity of forest/arboriculture.

TAB (C6) for calculation of wood biomass productivity of forest/arboricolture								
RESE LEGNOSE	Energia richiesta in input	Incremento massivo medio di legno stagionato nelle foreste dell'Emilia-Romagna / pioppicoltura	Incremento volumico medio di legno stagionato nelle foreste dell'Emilia-Romagna / pioppicoltura	Ettari necessari per 1.MW.el di legna stagionata di input	Incremento massivo medio di legno fresco nelle foreste dell'Emilia-Romagna / pioppicoltura	incremento volumico medio di legno fresco nelle foreste dell'Emilia-Romagna / pioppicoltura	Ettari necessari per 1.MW.el di legna fresca di input	
WOOD YIELDS	Energy request for starting input	Average mass increment of seasoned wood in the forest of region / arboricolture	Average volumic increment of seasoned wood in the forest of region / arboricolture	Needed hectares for seasoned wood forest/arboricolture for 1 MW.el standard plant	Average mass increment of fresh wood in the forest of region / arboricolture	Average volumic increment of fresh wood in the forest of region / arboricolture	Needed hectares for fresh wood forest/arboricolture for 1 MW.el standard plant	
	MWh/year	t./ha/year	m3/ha/year	ha/year	t./ha/year	m3/ha/year	ha/year	
Populus L. arboriculture	36.000	18,00	40,00	426	30,00	40,00	426	
Forest: general mix	36.000	2,62	4,10	2.919	4,77	4,47	2.676	
Forest: firewood (High Quality)	36.000	2,65	3,79	2.888	4,75	4,00	2.688	
Forest: wood for energy plants (Low Quality)	36.000	2,64	5,17	2.902	4,80	5,00	2.661	

Tabella 29- Reference table (part b) for calculation of wood biomass productivity of forest/arboriculture.

CARATTERISTICHE FORESTALI REGIONALI (dati dall'ufficio forestale regionale + Arpae)	Ettari forestali totali regionale	Disponibilità totale ettari forestali raggiungibili (buffer 150 m.)	% Ettari di tipologia forestali	Ettari di tipologia di foreste disponibili	Tonnellate totali di legna stagionata disponibile	% tipologie tonnellate di legna forestale stagionata disponibile	Tonnellate di legna forestale stagionata disponibile per tipologia	Incremento massivo
REGIONAL FOREST CHARCTERISTICS (data from RER Forest Office + Arpae)	Total regional forest hectares	Total regional forest hectares available (buffer 150 m.)	% of forest typologies	Hectares of forest typologies available	Total tons. of seasoned wood available	% of tons. of seasoned forest wood for thipology	Tons. of seasoned forest wood for thipology	Mass increment
	ha	ha	%	ha	t./year	%	t./year	t./ha/year
Populus L. arboriculture	/	/	/	/	/	/	/	/
Forest: general mix	546.928	430.379	100%	430.379	1.136.490	100%	1.136.490	2,64
Forest: firewood (High Quality)	546.928	430.379	77%	331.392	1.136.490	70%	795.543	2,40
Forest: wood for energy plants (Low Quality)	546.928	430.379	23%	98.987	1.136.490	30%	340.947	3,44

*Tabella 30- Reference table for calculation comparison between the regional solid (*wood combustion) biomass plants system and the forest wood availability*

TAB (C7) for calculation comparison between the regional solid (*wood combustion) biomass plants system and the forest wood availability

SISTEMA REGIONALE DEGLI IMPIANTI A BIOMASSE SOLIDE (assumendo che tutti gli impianti a biomasse solide siano a combustione di BM legnose) - (dati GSE 2015)	Potenza elettrica MW.el installata nell'attuale intero sistema regionale di imp. a biomasse solide installata in esercizio 2015	Num. Imp. da 1 MW.el sostenibili dagli ettari di foresta	Num. Imp. 1 MW.el sostenibili dalle tonnellate di legna forestale stagionata	Ettari richiesti dal sistema esistente di imp.BS a seconda della tipologia di legna forestale disponibile	Tonnellate di legna stagionata richieste dal sistema esistente di imp.BS	Tonnellate di legna fresca richieste dal sistema esistente di imp.BS	Disponibilità residua ettari forestali	Disponibilità residua tonnellate legna forestale stagionata	Numero di attuali sistemi regionali sostenibili dalgli ettari forestali	Numero di attuali sistemi regionali sostenibili dalle produzioni (TON.) di legna forestale stagionata
REGIONAL SYSTEM OF BIOMASS SOLID PLANTS (assuming that all solid biomass plants burn wood biomass) - (GSE 2015 data)	Electrical power installed of actual whole regional system of solid biomass plants 2015	Number of plants that are sustainable from the available useful forest	Number of plants that are sustainable from the available useful tons of forest wood	Hectars of forest needed by the whole sb plants regional system	tons of seasoned wood needed by the whole sb plants regional system	tons of seasoned fresh needed by the whole sb plants regional system	Residual availability of forest hectares	Residual availability of tons. Of seasoned forest wood	Number of actual systems sustainable from regional forest calculating with forest hectares	Number of actual systems sustainable from regional forest calculating with tons. of seasoned forest wood
	MW.el	num.	num.	ha	t.	t.	ha	t.	num.	num.
Populus L. arboriculture	141,6	/	/	60.255	1.084.596	1.807.660	/	/	/	/
Forest: general mix	141,6	147	148	413.337	1.084.596	1.807.660	17.042	51.894	1,041	1,048
Forest: firewood (High Quality)	141,6	115	104	408.973	1.084.596	1.807.660	-77.581	-289.053	0,810	0,733
Forest: wood for energy plants (Low Quality)	141,6	34	45	410.987	1.084.596	1.807.660	-312.000	-743.649	0,241	0,314

Tabella 31- Reference table for for calculation comparison between the PWCP wood combustion plant and the forest/arboricolture wood availability

TAB (C8) for calculation comparison between the PWCP wood combustion plant and the forest/arboricolture wood availability

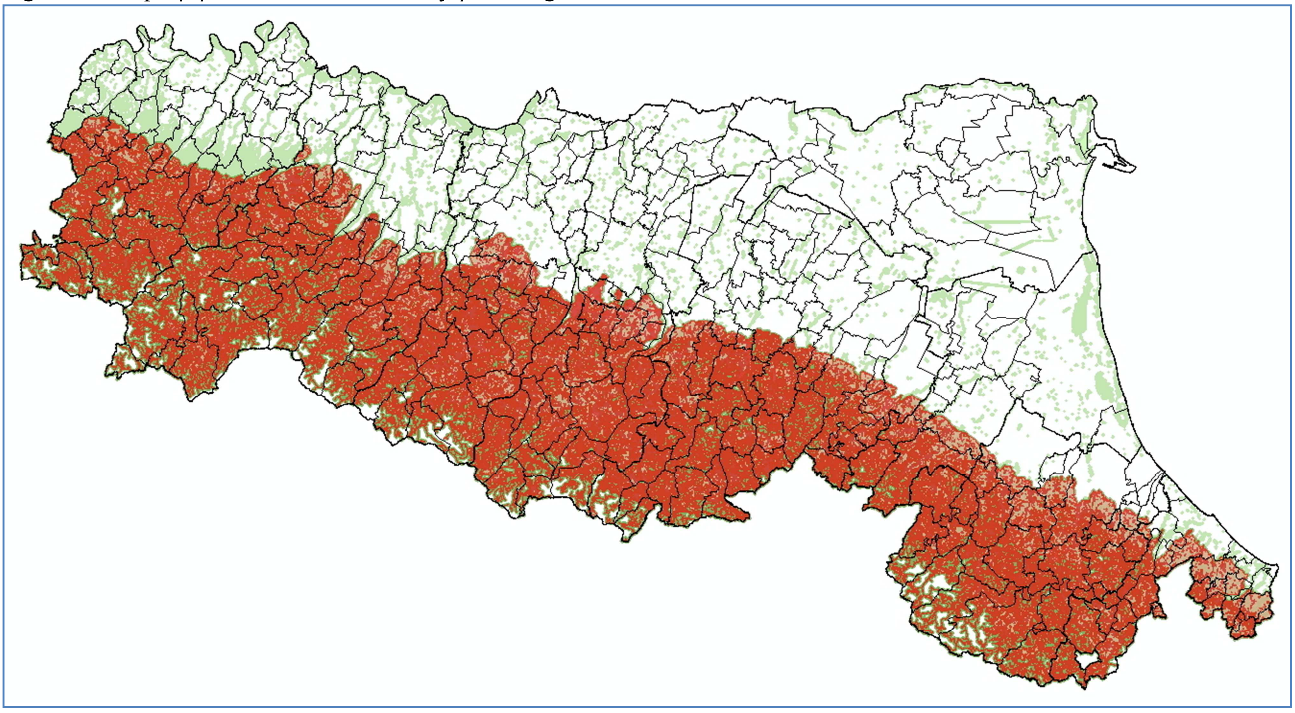
PWCP (30 MW.el)	Potenza elettrica dell'impianto PWCP	Ettari necessari a POWERCROP a seconda della tipologia di legna forestale disponibile	Tonnellate di legna stagionata necessarie a POWERCROP	Tonnellate di legna fresca richieste dall'attuale sistema regionale esistente di imp.BS	Num imp. PWCP sostenibili a livello regionale in base agli ettari forestali disponibili	Num imp. PWCP sostenibili in base alle tonnellate di legna forestal stagionata disponibile
PWCP (30 MW.el)	Electriacal power of PWCP plant	Needed hectares to supplys PWCP in function of different forest/arboricolture wood available	Needed tons of seasoned wood by PWCP plant	Tons, of freash wood neede by actual regional sb plants system	Number of PWCP plants sustainable from available hectares of forest	Number of PWCP plants sustainable from available tons. f forest wood
	MW.el	ha	t.	t.	num.	num.
Populus L. arboriculture	30	12.766	229.787	382.979	/	/
Forest: general mix	30	87.571	229.787	382.979	4,91	4,95
Forest: firewood (High Quality)	30	86.647	229.787	382.979	3,82	3,46
Forest: wood for energy plants (Low Quality)	30	87.074	229.787	382.979	1,14	1,48

6. CONCLUSION: REGIONAL POWER AND FOREST WOOD ENERGY AVAILABILITY

Tabella 32- Synthesis for Province and Region of the energy availability from forest woody biomasses

	LEGNA DA ARDERE		LEGNA PER IMPIANTI ENERGETICI		NUMERO di impianti energetici equivalenti	NUMERO di impianti energetici equivalenti	NUMERO di impianti energetici equivalenti
Provincia	**Tonnellate prelievo sostenibile (ton.)**	**MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)**	**Tonnellate prelievo sostenibile (ton.)**	**MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)**	**da 1 MW ELETTRICO approvvigionabili (11.000 ton./anno) per 8.000 ore/anno**	**da 1 MW ELETTRICO approvvigionabili (13.00 ton./anno) per 8.000 ore/anno**	**da 2,4 MW TERMICI approvvigionabili (3.500 ton./anno) per 4.000 ore/anno**
Piacenza	144.868	449.090	34.372	106.552	3,1	2,6	9,8
Parma	249.353	772.993	39.758	123.248	3,6	3,1	11,4
Reggio Emilia	98.961	306.779	27.199	84.317	2,5	2,1	7,8
Modena	108.076	335.035	40.736	126.280	3,7	3,1	11,6
Bologna	118.632	367.759	47.724	147.944	4,3	3,7	13,6
Ferrara	2.864	8.880	1.338	4.146	0,1	0,1	0,4
Ravenna	16.520	51.212	17.019	52.757	1,5	1,3	4,9
Forli'-Cesena	108.942	337.721	42.808	132.705	3,9	3,3	12,2
Rimini	27.425	85.018	6.193	19.198	0,6	0,5	1,8
REGION	**874.690**	**2.711.539**	**261.800**	**811.580**	**23,8**	**20,1**	**74,8**

Figura 9- Map of forest wood availability for energetic uses



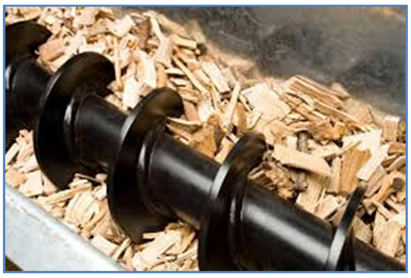
7. Appendix - Technical elements of wood for energy uses

[ENEA, 2009, a. Francescato V.] - [AIEL, 2008, b. Antonini E., Francescato V.]

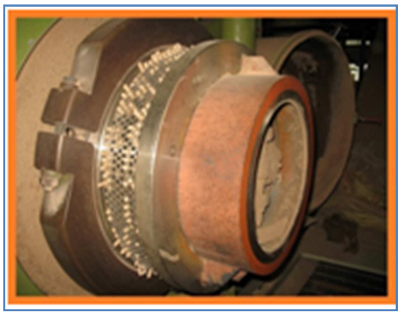
7.1.1.1. The main types of wood energy products

WOOD

WOODCHIPS



PELLETS



7.1.1.2. Carbon and CO2 content of wood biomass

Wood is composed of 50% carbon (C). 1 cubic meter of wood weighs an average of 500 kg and then contains 250 kg of C. If carbon is converted into CO_2 (oxidized), 1 kg of C is about 3.67 kilograms of CO_2. 250 kg of C then generate 917 kg of CO_2, or about 1 ton. Of CO_2 per cubic meter of wood.

$$250 \text{ kg C/m}^3 \text{ legno} \times 3{,}67 \text{ kg } CO_2 = 917{,}5 \text{ kg } CO_2$$

[Frühwald, 2015, a]

7.1.1.3. Specific weight and mass volume

The ratio of wood fuel to bulk and its volume can be expressed by three different and distinct units of measure:

SPECIFIC WEIGHT: (not dimensional value) refers to the woody substance of cellular walls (cellulose, hemicellulose, lignin, etc.) with which the woody body is structured. The woody substance (mainly cellulose, hemicellulose and lignin) has a specific weight of 1.5 which does not vary for different woody species.

MASS VOLUME (MV): It refers to the weight and volume of the woody body (porous body) or the single piece of dense fuel (pellets and bristles); Consisting of a set of substances and voids (vascular snow, etc.) filled with air and / or water. Often, the bulk density is indicated as an apparent specific weight or even as a specific weight. It is expressed in gr / cm3 or kg / m3.

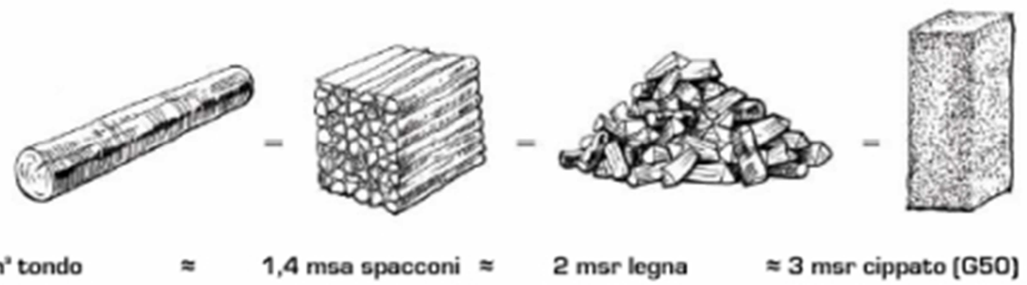
STERIC MASS VOLUME (Ms): It is used for clusters of wood fuel such as firewood, chips and pellets, which have empty spaces inside more or less large depending on their size and shape. It is expressed by weight (kg or tonne) per steric volume unit: stacked steric volume mass (SSVM) and spilled steric volume mass (SPSVM).

[ENEA, 2009, a. Francescato V.]

Rapporti di conversione legno-legna-cippato tra i più comuni assortimenti riportati in allegato alle norme austriache ÖNORM M7132 e M7133

Assortimento	Legno tondo	Spacconi	Legna spaccata corta		Cippato	
			accatastata	riversata	fino (G30)	medio (G50)
	m^3	msa	msa	msr	msr	msr
1 m^3 tondo	1	1,4	1,2	2,0	2,5	3,0
1 msa spacconi 1 m	0,7	1	0,8	1,4	(1,75)	(2,1)
1 msa legna spaccata corta	0,85	1,2	1	1,7		
1 msr legna spaccata corta	0,5	0,7	0,6	1		
1 msr cippato di bosco fino (G30)	0,4	(0,55)			1	1,2
1 msr cippato di bosco medio (G50)	0,33	(0,5)			0,8	1

Nota: una tonnellata di cippato G30 con M 35% corrispondono a circa 4 msr di cippato di abete rosso e a circa 3 msr di cippato di faggio.



[ENEA, 2009, a. Francescato V.]

Il metro cubo (m^3) fa riferimento al volume interamente occupato dal legno.

Unità di misura		(il volume sterico)	
tonnellata	chilogrammo	metro stero accatastato	metro stero riversato
t	kg	msa	msr
Legna da ardere Cippato Pellet e Briquettes		Legna da ardere	Legna da ardere Cippato

[ENEA, 2009, a. Francescato V.]

7.1.1.4. Energy content of woody fuels:

CALORIFIC POWER (P.C.): Quantity of thermal energy that can be gained (that is freed) by the complete combustion per unit of weight.
It is generally expressed in MJ / kg or kWh / kg. It is almost always referred to the lower calorific power.

HIGHER CALORIFIC POWER -PCS- (ΔcHs^{o}) It is the amount of heat that is available due to full combustion at constant pressure of the unitary fuel mass when combustion products are brought back to the initial fuel and combustion temperature. In practice, it corresponds to the energy released during the burning of the wood containing water, which, therefore, when it evaporates, when it burns, steals heat to become a vapor phase. For each kg of water vapor in the fumes, about 2.44 MJ per latent vaporization heat at 100 ° C.

LOWER CALORIFIC POWER -PCI- (ΔcHi^{o}) It is the higher calorific value decreased by the condensation heat of the water vapor during combustion.
This is the value that is usually referred to when it comes to calorific power of a fuel and the performance of a thermal machine.[21]

ENERGY DENSITY (E): It is the ratio between the energy content of wood and the steric volume in which it is included. (CIPPATO vs. PELLET) It is generally expressed in MJ / ms or kWh / ms. Thanks to this measure, the correct dimensioning of wood storage facilities for energy purposes can be carried out.

[21] In modern condensing boilers, you can recover part of the latent heat of the water vapor. This fact makes it possible to derive from a kilogram of fuel a greater amount of heat than the lower calorific value, thus with a nominal yield of 100%, even though a portion of theoretically available heat (higher calorific power) continues to be dispersed with the fumes.

If referred to the unit of weight, the calorific value of wood in different species, with the same moisture, varies very little. However, it is commonly known that hardwood has an anhydrous calorific value slightly lower than that of conifers [22].

- p.c. Conifers = 18,9 MJ/kg
- p.c. Hardwood = 18,5 MJ/kg

- **Variables that affect the energy content of wood**

The WATER CONTENT (M%): Wood, due to its chemical and histological structure and architecture, has a double porosity:

- macroporousness consisting of cavities of conductive vessels and parenchymal cells;
- microporousity of the actual woody substance (cellulose, hemicellulose and lignin).

Wood biomass is normally not in anhydrous state, but has a fairly variable water content.

To indicate wood humidity, generally speaking in percentage terms, there are two criteria:

1. Humidity on dry (anhydrous) → u%

$$u = \frac{M_u - M_a}{M_a} * 100[\%]$$

2. Water content (as such)→ M%

$$w = \frac{M_u - M_a}{M_u} * 100[\%]$$

The formula for calculating P.C.I. Of a general wood to a certain water content (M) is as follows: (reported in HARTMAN):

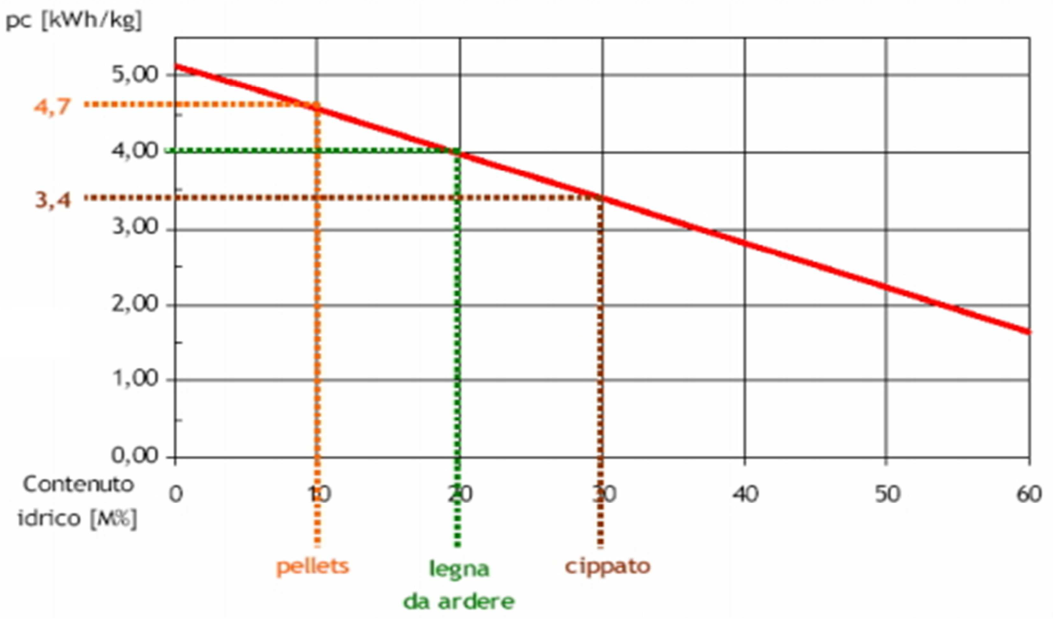
$$P.C.I._M = \frac{18{,}5 * (100 - M) - 2{,}44 * M}{100} * 0{,}278[kWh/kg]$$

In the anhydrous state, wood has an average calorific power of 5.2 kWh / kg = 19 MJ / kg

[AIEL, 2008, b. Antonini E., Francescato V.]

[22] Conifers possess a high content of lignin, resins, waxes and oils.

Variazione del pc (con pc_0= 5,14 kWh/kg) in funzione di M.



La formula per il calcolo del potere calorifico del legno (MJ/kg) con un dato contenuto idrico (M%) è la seguente:

$$pc_M = \frac{pc_0 x(100-M)-2{,}44xM}{100}$$

Variazione del P.C.I. del legno in funzione dell'epoca di taglio

Stato del legno	w (%)	Potere calorifico
Fresco di taglio	50-60	2,0 kWh/kg = 7,2 MJ/kg
Una stagione estiva	25-35	3.4 kWh/kg = 12,2 MJ/kg
Più stagioni estive	15-25	4,0 kWh/kg = 14,4 MJ/kg

[ENEA, 2009, a. Francescato V.]

PRIMARY ENERGY	1 kWh = 3,6 MJ ----- 1 MJ = 0,277 777 777 8 kWh
1 liter of diesel [23] = 10 kWh	10 kWh = 2,5 kg legno (M.20%)
1 mc of methane [24] = 10 kWh	10 kWh = 2,94 kg cippato (M.30%)

[ENEA, 2009, a. Francescato V.]

[23] Diesel density = 0,85 kg/liter
[24] MEthane density = 0,72 kg/mc

Figura 4.7.2 Andamento di M per varie specie[3]

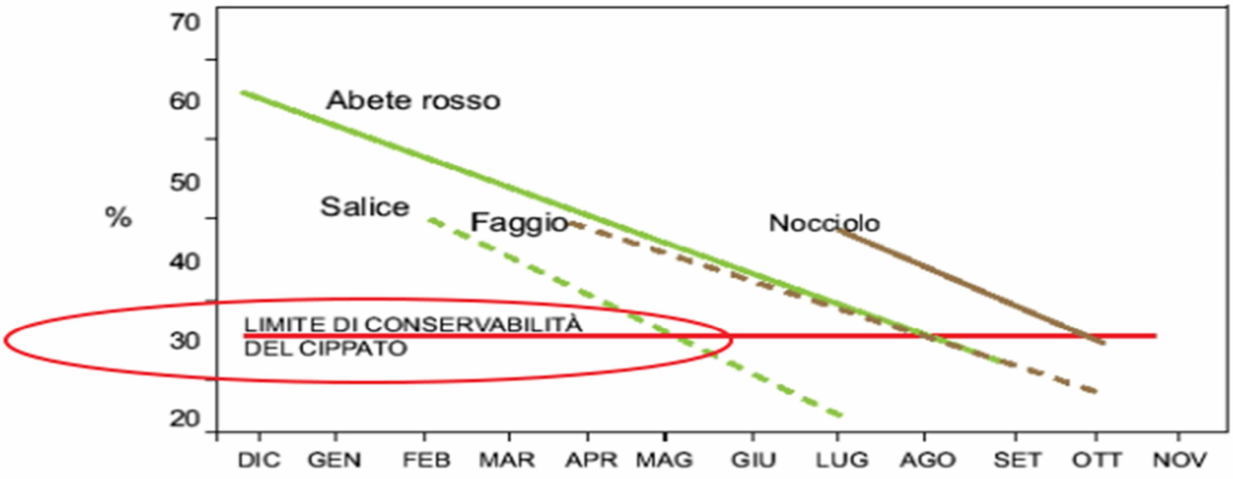


Figura 4.6.1 Andamento del contenuto idrico nella legna spaccata e accatastata di faggio e abete, stagionata all'aria e coperta[4]

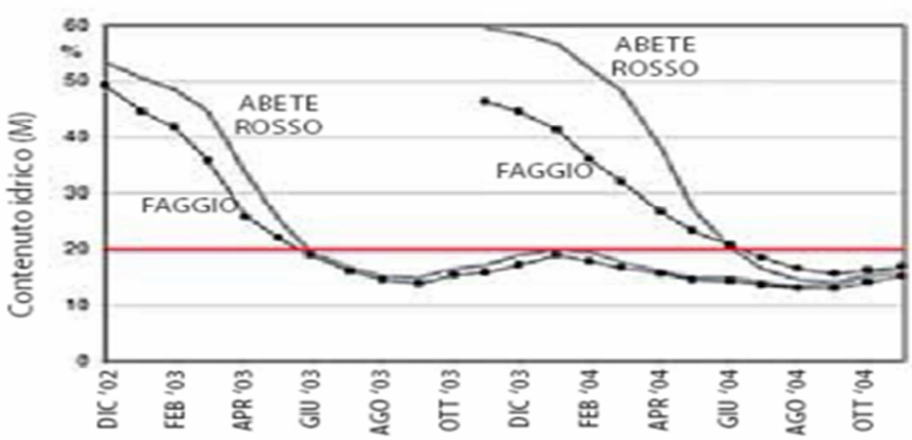
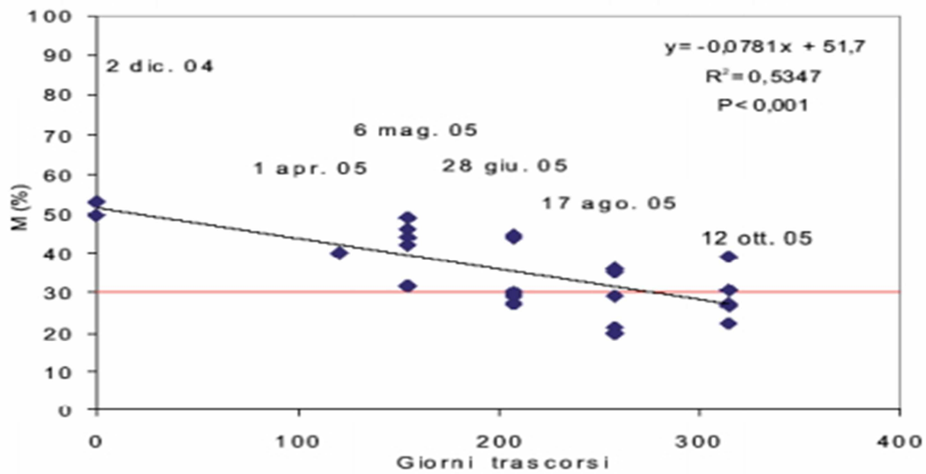


Figura 4.8.3 Il legno (platano) tagliato in dicembre e cippato fresco raggiunge M30 dopo 9 mesi[15]



[ENEA, 2009, a. Francescato V.]

Nella pratica si impiegano i seguenti valori medi per i combustibili legnosi

pc_0 = 18,5 MJ/kg = 5,14 kWh/kg	LEGNO ANIDRO	(M 0%)
pc_{10} = 17,0 MJ/kg = 4,7 kWh/kg	PELLET	(M 10%)
pc_{20} = 14,4 MJ/kg = 4 kWh/kg	LEGNA DA ARDERE	(M 20%)
pc_{30} = 12,2 MJ/kg = 3,4 kWh/kg	CIPPATO	(M 30%)

Densità energetica sterica (DS)

Esprime il rapporto tra il contenuto energetico del combustibile e il volume sterico che occupa. Si esprime in: MJ/ms o kWh/ms.

Tabella 2.9.1 - Densità energetica sterica in funzione del contenuto idrico [2].

Combustibile	Quantità	Contenuto idrico	Massa	Potere calorifico	**Densità energetica**(*)		
		M%	kg	MJ/kg	in MJ	in kWh	in litri di gasolio eq.
Legna accatastata							
Faggio 33 cm	1 msa	15	445	15,3	6 797	1 888	189
Faggio 33 cm	1 msa	30	495	12,1	6 018	1 672	167
Abete r. 33 cm	1 msa	15	304	15,6	4 753	1 320	132
Abete r. 33 cm	1 msa	30	349	12,4	4 339	1 205	121
Cippato							
Faggio	1 msr	15	295	15,3	4 505	1 251	125
Faggio	1 msr	30	328	12,1	3 987	1 107	111
Abete r.	1 msr	15	194	15,6	3 032	842	84
Abete r.	1 msr	30	223	12,4	2 768	769	77
Pellet di legno	1 msr	8	650	17,1	11 115	3 088	309

(*) Nell'intervallo M 0-23% è stato applicato il rispettivo fattore di correzione volumetrico.

[ENEA, 2009, a. Francescato V.]

Perdita di sostanza legnosa

Tabella 4.5.1

Materiale/tipo di stoccaggio	Perdita annua di ss (%)
Cippato forestale fine, fresco, scoperto	20 fino a >35
Cippato forestale fine, stagionato, coperto	2-4
Cippato forestale grossolano (7-15 cm), fresco, coperto	4
Corteccia, fresca, scoperta	15-22
Legna da ardere (faggio, abete) dopo due anni, coperta	2,5
Legna da ardere (faggio, abete) dopo due anni, scoperta	5-6
Stangame (abete, pini) fresco, scoperto	1-3
Giovani piante intere (pioppi, salici) fresche, scoperte	6-15

[ENEA, 2009, a. Francescato V.]

LEGNA DA ARDERE

Parametri energetici indicativi

	Unità di misura	Valori
Massa volumica	kg/m³	400 – 850
Contenuto idrico (M)	%	20
Potere calorifico inferiore	kWh/kg	4
Densità energetica	kWh/msa (spacconi)	1600 – 2529
	kWh/msa (da stufa)	2000 - 3071
Densità energetica	kWh/msr (da stufa)	1275 - 1806
Ceneri	% (in peso)	0,2 - 0,5

CIPPATO di LEGNO

Parametri energetici indicativi

	Unità di misura	Valori
Massa sterica	kg/msr	220 - 320
Contenuto idrico (M)	%	**30**
Potere calorifico inferiore	kWh/kg	**3,4**
Densità energetica	kWh/msr	748 - 1088
Ceneri	% (in peso)	1 - 3

PELLET

Parametri energetici indicativi

	Unità di misura	Valore
Lunghezza	mm	10-50
Diametro	mm	6-10
Massa volumica	kg/m³	1150-1400
Massa sterica	kg/msr	600 - 650
Contenuto idrico (M)	%	8-12
Potere calorifico inferiore	kWh/kg	4,7-5
Ceneri	% (in peso)	0,3 - <1

[AIEL, 2008, b. Antonini E., Francescato V.]

POTERE CALORIFICO

Variazione del potere calorifico inferiore in funzione del contenuto idrico sul secco (u) e sul tal quale (M) – (Fonte: HELLRIGL)

U %	0	12	18	25	35	50	75	100	150
M %	0	10.7	15.3	20	25.9	33.3	42.9	50	60
P.C.I. (MJ/kg)	18.5	16.3	15.3	14.3	13.7	11.5	9.53	8.03	5.94
P.C.I. (kWh/kg	5.14	4.53	4.25	3.98	3.81	3.20	2.65	2.23	1.65

Il calo del contenuto idrico dal 50%, facilmente riscontrabile nei legni leggeri allo stato fresco, al 20% (valore medio per la legna ben stagionata in legnaia) fa AUMENTARE il potere calorifico dell'78 % .

DATI

Stato del legno	M (%)	Potere calorifico
Fresco di taglio	50-60	2,0 kWh/kg = 7,2 MJ/kg
Una stagione estiva	25-35	3.4 kWh/kg = 12,2 MJ/kg
Più stagioni estive	15-25	4,0 kWh/kg = 14,4 MJ/kg

Potere calorifico inferiore di alcuni combustibili – *(Effective thermal value)*

Legno **Anidro**	18,5 – 21,0 MJ/kg 5.14 – 5.83 kWh/kg	Carbone	23,3 – 24,0 MJ/kg
Torba anidra	20,0 – 21, 0 MJ/kg	Olio combustibile	40,0 – 42,3 MJ/kg
Idrogeno	10,75 MJ/m^3	Metano	38 - 35,87 MJ/m^3
Gasolio	43,1 MJ/kg	Nafta	41 MJ/kg

1 MJ = 0,278 kWh/kg

[AIEL, 2008, b. Antonini E., Francescato V.]

Specie legnose e masse volumiche

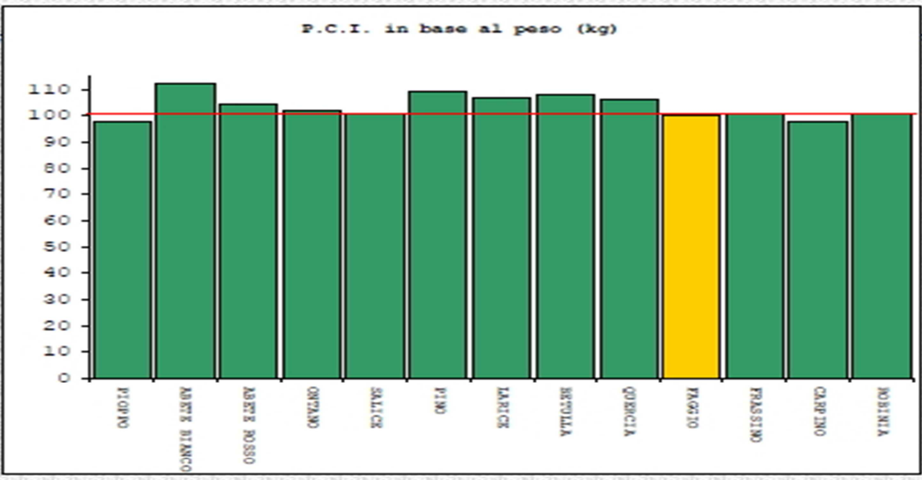
- I legni hanno diverse masse volumiche (kg/m³) e quindi masse steriche (kg/ms).

Abete r. 410 (430)	Quercia 670	Nocciolo 560
Abete b. 410	Cerro 740	Ontano 490
Pino sil. 510	Faggio 680 (650)	Robinia 730
Pino nero 560	Carpino b. 750	Betulla 640
Larice 550	Olmo 640	Tiglio 520
Douglasia 470	Frassino 670	Pioppo ss.pp. 410
P. Cembro 400	Acero 590	Salice 520
		Pioppo tremulo 450

Poteri calorifici inferiori al contenuto idrico (M) 13% (Fonte: HOLZ)

POTERI CALORIFICI	SPECIE LEGNOSE
4,0 kWh/kg	Faggio
4,1 kWh/kg	Pioppo, Acero, Robinia, Olmo
4,2 kWh/kg	Frassino, Quercia
4,3 kWh/kg	Larice
4,4 kWh/kg	Pino, Douglasia
4,5 kWh/kg	Picea, Abete

PCI relativi alle specie



Posto uguale a 100 il faggio

Legno (w=20%) = 4.0 kWh/kg = 14.4 MJ/kg = 3440 kcal/kg

[AIEL, 2008, b. Antonini E., Francescato V.]

7.1.1.5. Firewood

REQUISITI QUALITATIVI E NORME DI RIFERIMENTO

La classificazione qualitativa dei biocombustibili solidi è definita a livello europeo dalla specifica tecnica CEN/TS 14961 (*Solid biofuels, fuel specification and classes*, 2005), sulla base della quale nel 2007 è stata pubblicata in Italia la specifica tecnica UNI/TS 11264 "Caratterizzazione di legna da ardere, brichette e cippato".

Tabella 4.1.1

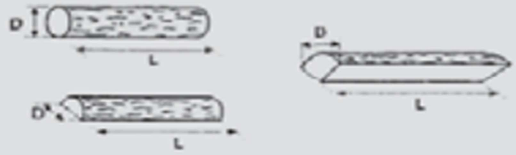
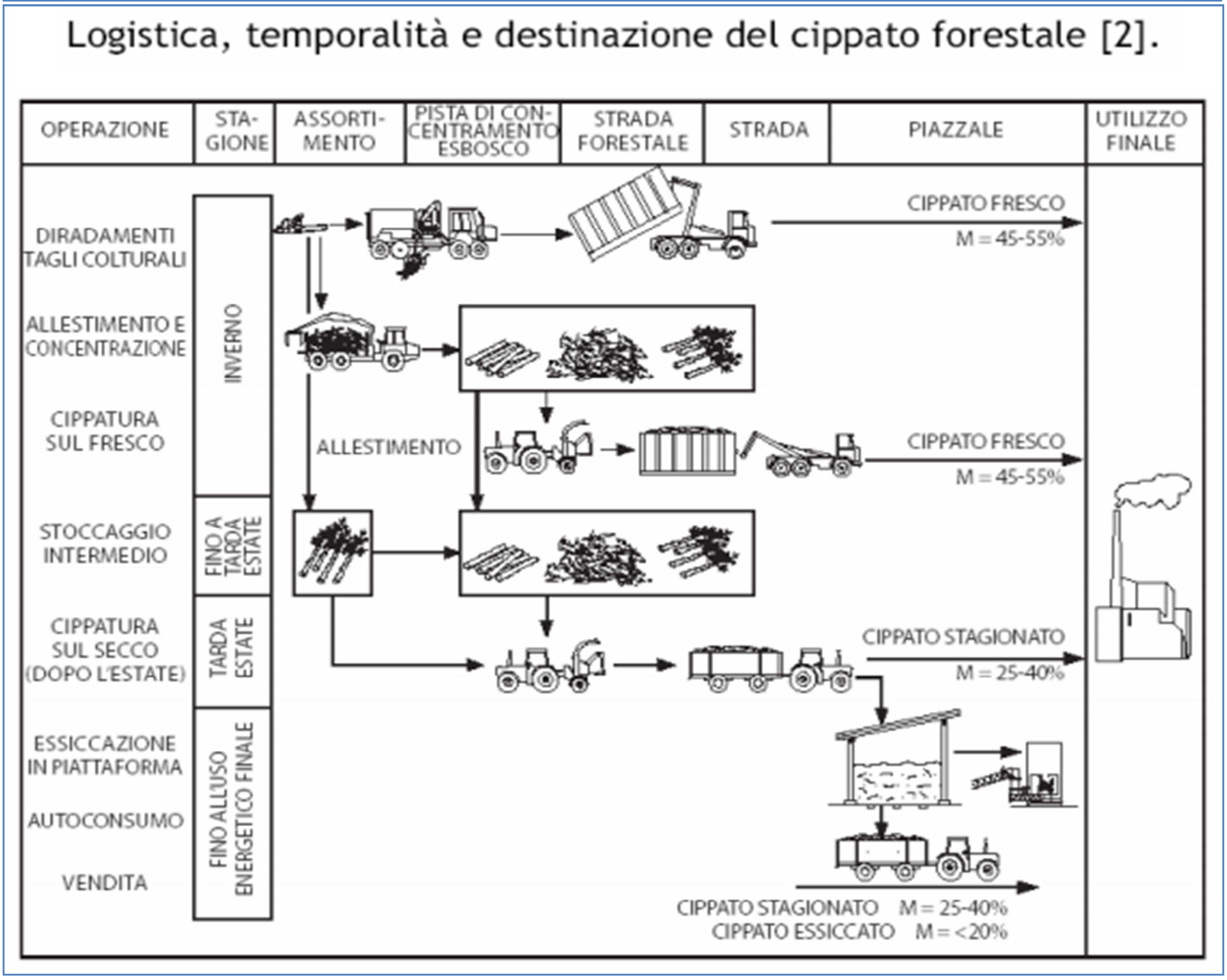
	Origine e provenienza	Tronchi di conifera e latifoglia (1.1.2.1, 1.1.2.2, 1.1.2.3)
	Tipologia commerciale	**LEGNA DA ARDERE**
NORMATIVA	**Dimensione** o **Pezzatura** Lunghezza (L) Spessore (D) (diametro massimo del singolo pezzo)	
	P200– P200 P250 P330 P500 P1000 P1000+	L < 200 e D < 20 (legnetti da accensione) L = 200 ± 20 e 40 ≤ D ≤ 150 mm L = 250 ± 20 e 40 ≤ D ≤ 150 mm L = 330 ± 20 e 40 ≤ D ≤ 160 mm L = 500 ± 40 e 60 ≤ D ≤ 250 mm L = 1000 ± 50 e 60 ≤ D ≤ 350 mm L > 1000 (indicare lunghezza e diametro reale)
	Contenuto idrico (M) M20 ≤ 20% M30 ≤ 30% M40 ≤ 40% M65 ≤ 65%	 pronta all'uso stagionata al coperto stagionata in bosco legno fresco, appena tagliato in bosco
	Tipo di legno (composizione) Indicare la specie legnosa o se si tratta di legno di latifoglie o di conifere o miscuglio delle due	

Tabella 4.1.2

	Origine e provenienza		Biomassa legnosa non contaminata (1.1.1, 1.1.2, 1.1.3, 1.1.4, 1.1.6, 1.2.1.1, 1.2.1.2, 1.2.1.4)	
	Tipologia commerciale		LEGNO CIPPATO 	
NORMATIVA	**Dimensioni** o **Pezzatura**	Frazione principale >80% (massa)	Frazione fine <5%	Frazione grossa <1%
	P 16	3,15 mm ≤ P ≤ 16 mm	< 1 mm	> 45 mm, tutto < 85 mm
	P 45	3,15 mm ≤ P ≤ 45 mm	< 1 mm	> 63 mm
	P 63	3,15 mm ≤ P ≤ 63 mm	< 1 mm	> 100 mm
	P 100	3,15 mm ≤ P ≤ 100 mm	< 1 mm	> 200 mm
	Contenuto idrico (M)			
	M20	≤ 20% essiccato		
	M30	≤ 30% stagionato all'aria e adatto ad essere stoccato nel silo		
	M40	≤ 40% non stagionato e non adatto ad essere stoccato nel silo		
	M55	≤ 55%		
	M65	≤ 65%		
	Contenuto di cenere (%ss)			
	A0.7	≤ 0,7%		
	A1.5	≤ 1,5%		
	A3.0	≤ 3,0%		
	A6.0	≤ 6,0%		
	A10	≤ 10,0%		

[ENEA, 2009, a. Francescato V.]

7.1.1.6. Woodchips

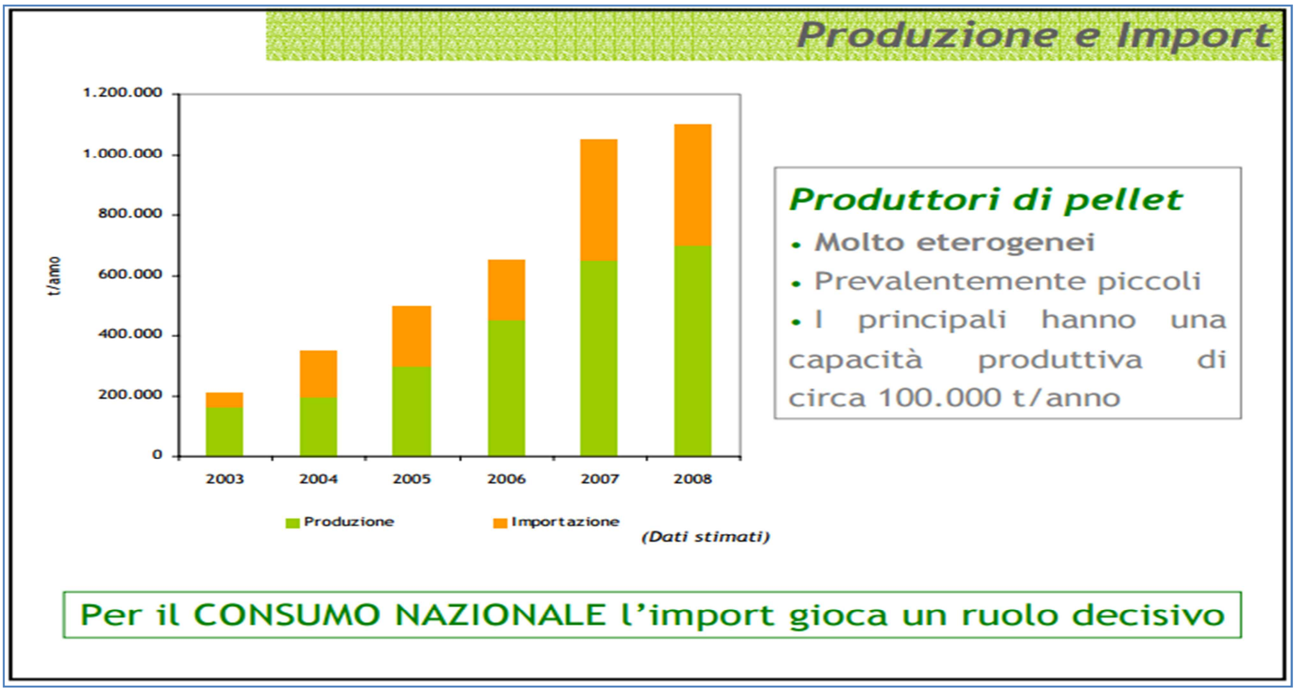


[ENEA, 2009, a. Francescato V.]

[ENEA, 2009, a. Francescato V.]

[ENEA, 2009, a. Francescato V.]

7.1.1.7. Pellets



Limiti di accettabilità

Parametro	U.M.	LIMITI AIEL	Grado di tolleranza
Contenuto idrico (tal quale)	%su	< 10	-
Ceneri	%ss	≤ 1	+ 0,05
PCI	MJ/kg	≥ 16,9	- 0,2
Azoto - (N)	%ss	≤ 0,3	-
Cloro - (Cl)	%ss	< 0,03	-
Zolfo - (S)	%ss	< 0,05	-
Piombo - (Pb)	mg/kg	< 10	La concentrazione totale dei 4 metalli deve essere ≤ 20 mg/kg t.q. (vd. UNI/TS 11263)
Mercurio - (Hg)	mg/kg	< 0,05	
Cadmio - (Cd)	mg/kg	< 0,5	
Cromo - (Cr)	mg/kg	< 8	
Massa sterica	kg/m³	> 600	-
Durabilità meccanica	%	≥ 97,7	-
Formaldeide (HCHO)	mg/100g	≤ 1,5	+ 0,5
Radioattività	Bq/kg	< 6	-
Agenti leganti	< 2%	Indicare valore	-

Parametro	U.M.	LIMITI AIEL	Grado di tolleranza
Rame - (Cu)	mg/kg	< 5	+ 5
Arsenico - (As)	mg/kg	< 0,8	+ 0,2
Zinco - (Zn)	mg/kg	< 100	-
Sodio - (Na)	%ss	< 0,03	-

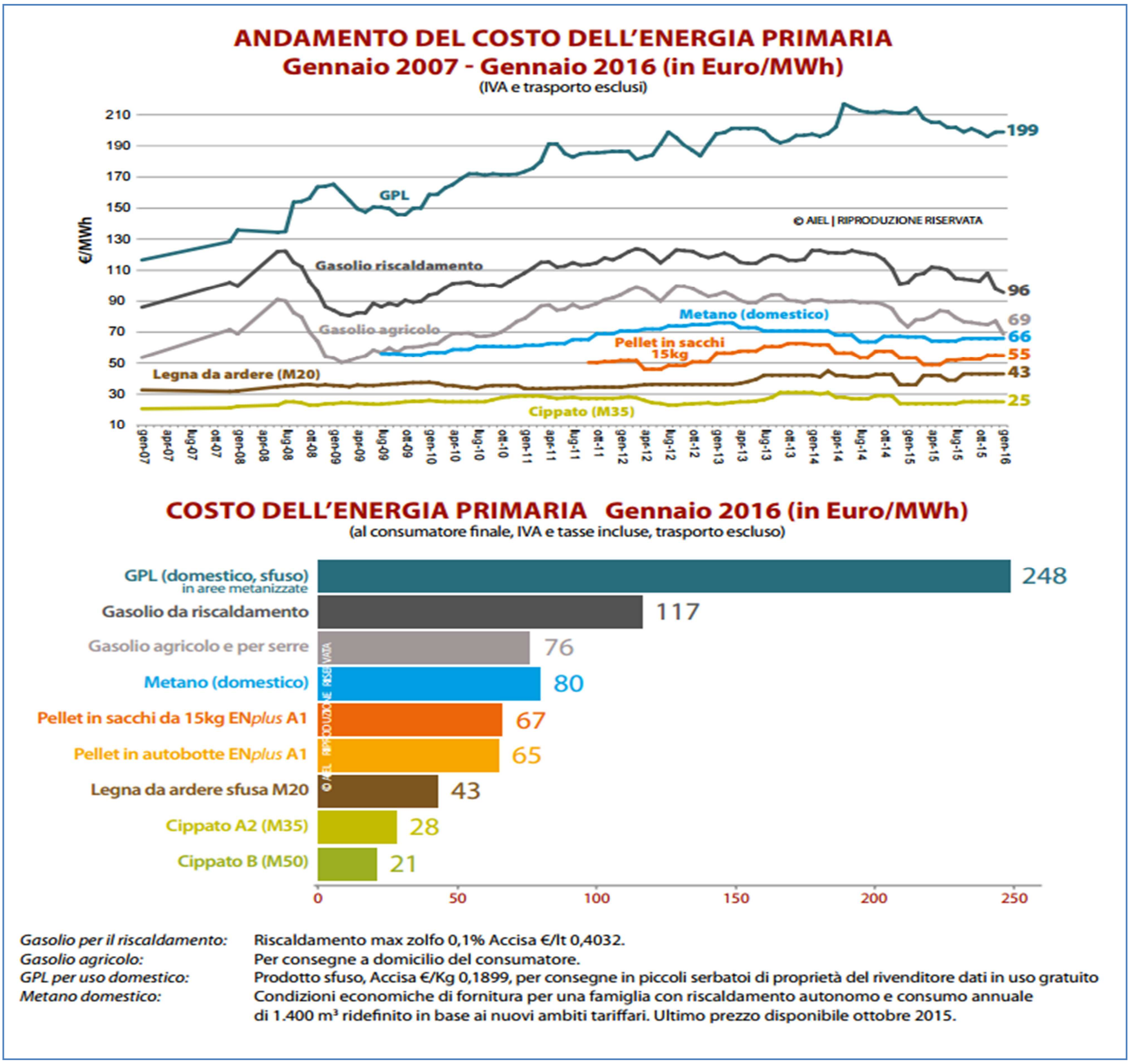
[ENEA, 2009, a. Francescato V.]

8. Appendix - Wood energy products prices references

In the light of the informal estimates of the average selling prices of wood by forestry producers proposed by the Protected Areas, Forests and Mountain Development of the Emilia-Romagna Region [RER.SAPFSM, 2015, a.] they correspond around to :

- Firewood in firewood: 13.5 euro / quintal;
- Wood for energy from biomass: 2.5 euro / quintal;
- Chip for biomass energy: 7.25 euro / quintal;

For information, please see below, some final consumer prices for wood energy products from the magazine AIEL AGRIFORENERGIA - supplement markets & prices no. 1/2016.



[AIEL.AGRIFORENERGY, 2016, a.]

PREZZI DEI COMBUSTIBILI LEGNOSI

CIPPATO Ottobre-Dicembre 2015 (Franco partenza, IVA esclusa)

Rilevazioni riferite a 68 operatori del Gruppo Produttori Professionali di Biomassa. Valori minimi e massimi si riferiscono al valore mediano del 1° e 3° quartile.

Materia prima	Classe di qualità (contenuto idrico)	PREZZO franco partenza		
		€/MWh	€/t	(range min-max)
CIPPATO DI BOSCO				
Stanghe, tronchi sramati di conifere e latifoglie, refili	A1Plus (M10)	37	169	150-180
	A1 (M25)	29	107	99-139
	A2 (M35)	25	79	62-96
Cimali, tronchi conifere con rami e ramaglia, manutenzione del verde	B (M50)	19	43	37-63
ALTRE TIPOLOGIE DI CIPPATO				
Cippatino	M10	42	190	180-200
Cippato da industria del legno	M45	26	57	45-65
Cippato agricolo (potature di vite, olivo, frutteti)	M 20-25	22	81	80-85
Cippato agricolo (potature di vite, olivo, frutteti)	M 30-35	21	65	55-70
Cippato agricolo (potature di vite, olivo, frutteti)	M 40-50	22	50	40-60
DENSIFICATI				
Bricchetti agricoli	M 25	34	160	155 - 165
Pellet agricolo	M 25	40	190	180 - 200

Costo del trasporto: al prezzo franco partenza vanno aggiunti, a seconda della logistica e della qualità del prodotto, 10-15 €/ton per conferimenti entro 50 km con autotreno da 90 mc.

LEGNA DA ARDERE Ottobre-Dicembre 2015 (Franco partenza, IVA esclusa)

Rilevazioni riferite a 21 operatori del Gruppo Produttori Professionali di Biomassa

Tipologia	Pezzatura	Contenuto idrico (M)	PREZZO franco partenza			
			€/MWh	€/t	range min-max	€/msa
Legna dura	25 cm	20-25	34	126	120-127	57
		30-35	37	116	100-150	53
		40-50	49	110	100-125	50
	35 cm	20-25	43	158	120-160	72
		30-35	39	122	100-155	56
		40-50	43	96	90-110	44
	50 cm	20-25	38	141	127-150	64
		30-35	36	113	100-150	51
		40-50	47	104	100-108	47

PELLET EN*plus* in sacchi da 15kg - Gennaio 2016 (Franco partenza, IVA esclusa)

		€/MWh	€/t	range min-max
EN*plus* A1	Ingrosso	46	214	200 - 228
	Dettaglio	55	258	225 - 300
EN*plus* A2	Ingrosso	36	170	167 - 210
	Dettaglio	50	234	215 - 245

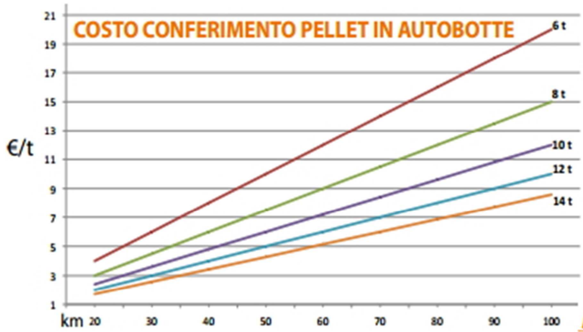
Le rilevazioni si riferiscono a 36 operatori del Gruppo Produttori Distributori EN*plus*. L'area geografica servita e la provenienza del pellet influiscono la determinazione dei prezzi. Prezzo all'ingrosso riferito franco partenza da centro di distribuzione italiano. Costo del trasporto pellet in sacchi: 20€/t per consegne entro 30km. Valori minimi e massimi si riferiscono al valore mediano del 1° e 3° quartile.

[AIEL.AGRIFORENERGY, 2016, a.]

PELLET EN*plus* sfuso, distribuito in autobotte - Gennaio 2016 (Franco partenza, IVA esclusa)

		€/MWh	€/t	range min-max
EN*plus* A1	Autobotte	53	247	217 - 280

Le rilevazioni si riferiscono a 11 operatori del Gruppo Produttori Distributori EN*plus*. Il prezzo è franco partenza (0km inclusi), al fine di rendere le rilevazioni confrontabili internamente e con le altre categorie di combustibili. La determinazione dei prezzi è influenzata dall'area geografica servita e dalla sua ampiezza, dalla capacità dell'autobotte e dalla quantità ordinata. Valori minimi e massimi si riferiscono al valore mediano del 1° e 3° quartile.



TARIFFE DI VENDITA DEL CALORE CON CIPPATO: FORMULA DEL CONTRACTING

Il contracting è un modello economico-commerciale attraverso il quale viene venduta energia contabilizzata. La tariffa viene espressa in €/MWh ed è definita tra le parti sulla base dei servizi offerti all'utenza, che vanno dalla sola fornitura del combustibile (caso 1), all'inclusione dei costi di gestione ordinaria e/o straordinaria dell'impianto (caso 2) fino all'ammortamento totale o parziale dell'investimento iniziale dell'impianto (caso 3). Di seguito vengono descritte le 3 casistiche tipo riscontrabili nella vendita dell'energia con formula del contracting.

CASO 1 Contracting cippato: tariffa che considera il costo di approvvigionamento del cippato e del rendimento dell'impianto (tanto più basso è il rendimento dell'impianto e tanto più elevato sarà il prezzo di vendita dell'energia a parità di condizioni del cippato usato per l'approvvigionamento)

$$\frac{\text{Costo totale approvvigionamento } (€/anno)}{\text{Energia utile annua erogata } (MWh)}$$

CASO 2 Contracting gestione: tariffa che tiene conto dei costi di approvvigionamento, dei costi di gestione e manutenzione dell'impianto e del rendimento.

$$\frac{\text{Costo totale approvvigionamento} + \text{Costo manutenzione e gestione } (€/anno)}{\text{Energia utile annua erogata } (MWh)}$$

CASO 3 Contracting puro: tariffa che tiene conto dei costi di approvvigionamento, dei costi di gestione e manutenzione dell'impianto, della quota di ammortamento della parte dell'investimento sostenuto dal fornitore (ripartita per la durata del contratto) e del rendimento dell'impianto.

$$\frac{\text{Costo totale approvvigionamento} + \text{Costo manutenzione e gestione} + \text{Ammortamento } (€/anno)}{\text{Energia utile annua erogata } (MWh)}$$

Di seguito si riportano i valori delle tariffe base di vendita dell'energia, sulla base delle casistiche sopra elencate. Per omogeneità delle rilevazioni e a titolo esemplificativo, le quotazioni fanno riferimento alle tariffe base previste per un impianto con potenza di 540 kWt, funzionante a pieno regime per 1.500 ore/anno, approvvigionato con cippato di classe qualitativa A2 norma ISO 17225-4 (vedi quotazioni dell'ultimo periodo di rilevamento riportate nella presente rubrica mercato e prezzi) e efficienza complessiva dell'impianto pari al 75%. Il costo di realizzazione dell'impianto è stimato senza incentivi in 270.600 € e il costo annuo di gestione (escluso approvvigionamento) in 10.000 €. Prezzi IVA inclusa.

VALORI DI PREZZO RIFERITI A OTTOBRE-DICEMBRE 2015

Impianto a cippato da 540 kWt con minirete di teleriscaldamento e rendimento di impianto del 75%, IVA inclusa. **Il prezzo €/MWh si riferisce all'energia utile.**

CASO 1 Contracting cippato (solo combustibile)	37 €/MWh		
CASO 2 Contracting gestione (Combustibile e gestione/manutenzione impianto)	50 €/MWh		
durata del contratto (anni)	10	15	20
CASO 3 Contracting puro (Investimento, combustibile e gestione/manutenzione impianto)	97 €/MWh	86 €/MWh	80 €/MWh

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[AIEL.AGRIFORENERGY, 2016, a.]

5. COSTI DELL'ENERGIA, ANDAMENTI E CONFRONTI

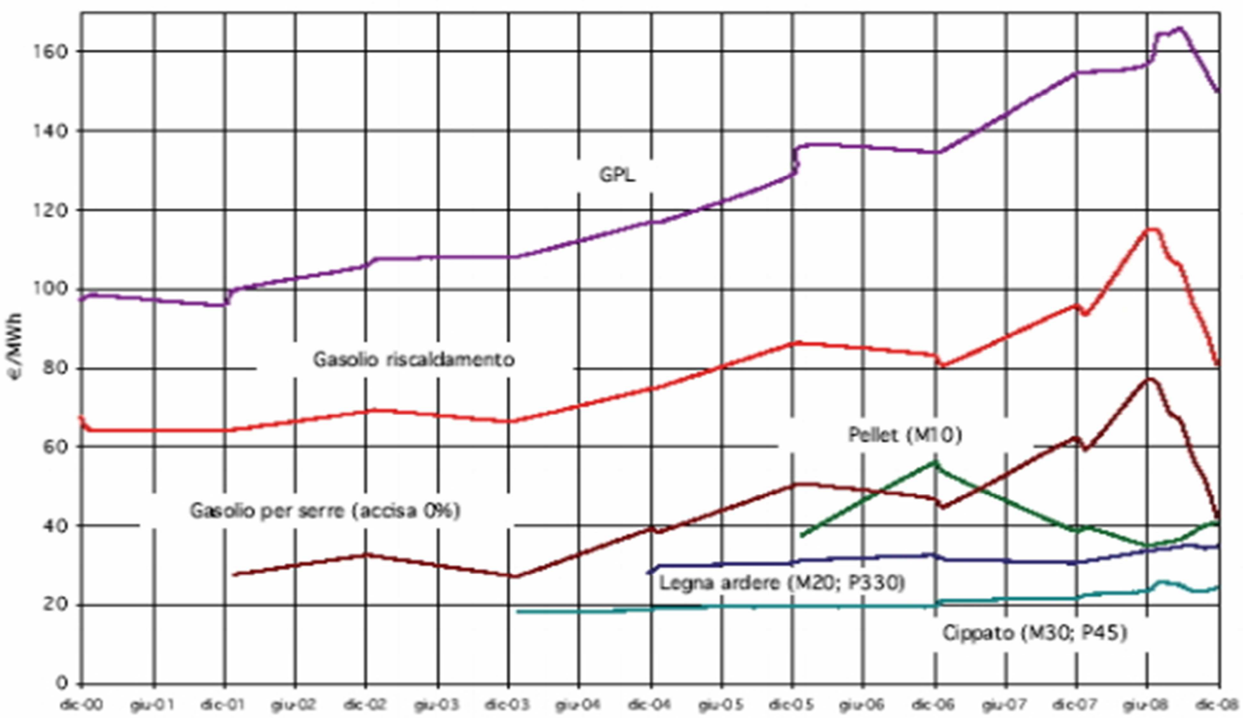
Tabella 5.1 Costi dell'energia primaria a confronto rispetto al cippato (prezzi IVA esclusa*)

	MWh	Prezzo €	Prezzo energia €/MWh	Rapporto
1 t cippato (M30, P45)	3,40	**68**	**20,00**	1,00
1 t cippato (M40, P45)	2,81	**56**	**20,00**	1,00
1 t legna (M20, P330)	3,98	130	32,66	1,63
1 t Pellet (M10) sfuso	4,70	150	31,91	1,60
1 t Pellet (M10) sacchi 15 kg	4,70	180	38,30	1,91
100 mc Metano "servito"	1,00	70	70,00	3,50
1 t Gasolio per serre	11,7	448	38,39	1,92
1 t Gasolio da riscaldamento	11,7	863	73,95	3,70
1000 l GPL (bombola proprietà)	6,82	1020	149,56	7,48

	MWh	Prezzo €	Prezzo energia €/MWh	Rapporto
1 t cippato (M30, P45)	3,40	**85**	**25,00**	1,00
1 t cippato (M40, P45)	2,81	**70**	**25,00**	1,00
1 t legna (M20, P330)	3,98	130	32,66	1,31
1 t Pellet (M10) sfuso	4,70	150	31,91	1,28
1 t Pellet (M10) sacchi 15 kg	4,70	180	38,30	1,53
100 mc Metano "servito"	1,00	70	70,00	2,80
1 t Gasolio per serre	11,7	448	38,39	1,54
1 t Gasolio da riscaldamento	11,7	863	73,95	2,96
1000 l GPL (bombola proprietà)	6,82	1020	149,56	5,98

[ENEA, 2009, a. Francescato V.]

Grafico 5.2.1 Costi dell'energia nel periodo 2001-2008 (IVA escl.)



[ENEA, 2009, a. Francescato V.]

5.4 Compravendita della legna e del cippato

Esempio 5.4.1 – Calcolo del costo dell'energia della legna da ardere

Si supponga di dover acquistare la legna per alimentare la propria moderna caldaia per l'intera stagione termica e di dover valutare il miglior prezzo offerto. Il produttore vi propone un prezzo a volume sterico per spacconi da 1 m (P1000) differenziato per specie:

faggio 62 €/msa

abete rosso 46 €/msa

Si ha la necessità quindi di ricercare il miglior prezzo attraverso il calcolo del costo dell'energia

1) calcolo la massa sterica della legna M20, P1000 per le due specie utilizzando le tabelle 1.7.2 e 1.7.3

faggio → 453 x 0,81 = 367 kg/msa

abete → 315 x 0,86 = 271 kg/msa

2) calcolo il costo dell'energia della legna M20 con pc_{20} = 4 kWh/kg

faggio → 62:[(367x4):1.000] = **42,2 €/MWh** (11,7 €/GJ)

abete → 46:[(271x4):1.000] = **42,4 €/MWh** (11,8 €/GJ)

Con questo livello di prezzi proposti e tipo d'uso finale della legna i due prodotti dal punto di vista del costo dell'energia risultano equivalenti.

[ENEA, 2009, a. Francescato V.]

A4. Esempio di listino prezzi per la vendita professionale della legna da ardere

Prezzi franco partenza, IVA inclusa.

LEGNA DA ARDERE DI FAGGIO E ABETE ROSSO – PRONTA ALL'USO (M20)

→ Prezzi per metro stero accatastato (msa) e metro stero riversato (msr), 1 msa ~ 1,4 msr

→ Potere calorifico inferiore (pc_{20} = 4 kWh/kg)

→ ~ 450 kg faggio ~ 300 kg abete rosso con M20 = 1 msa P330 (L = 33 cm)

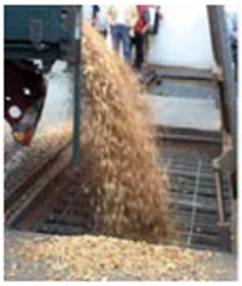
Faggio (con una quota di altre sp. pesanti) **1 msa = 450 kg 1 msr = 320 kg**	Lunghezza (L)	fino a 7 msr	fino a 5 msa	oltre 5 msa sconto 5%
	100 cm (P1000)	-	79,00 €	75,05 €
	50 cm (P500)	-	84,00 €	79,80 €
	33 cm (P330)	59,70 €	84,00 €	79,80 €
	25 cm (P250)	63,30 €	89,00 €	84,55 €
Abete rosso (con una quota di larice/pino) **1 msa = 300 kg 1 msr = 215 kg**	Lunghezza (L)	fino a 7 msr	fino a 5 msa	oltre 5 msa sconto 5%
	100 cm (P1000)	-	69,00 €	65,55 €
	50 cm (P500)	-	74,00 €	70,30 €
	33 cm (P330)	53,00 €	74,00 €	70,30 €
	25 cm (P250)	56,60 €	79,00 €	75,05 €

[ENEA, 2009, a. Francescato V.]

5.4 Compravendita della legna e del cippato

Tabella 5.4.1 **Prezzi ponderali del cippato per classi di contenuto idrico al costo dell'energia di 25 €/MWh**

Classi di contenuto idrico	M (%)	€/t	
		IVA escl.	IVA incl.
M 20	≤ 20	103	114
M 25	≤ 25	95	105
M 30	≤ 30	88	97
M 35	≤ 35	81	89
M 40	≤ 40	73	81
M 50	≤ 50	62	69
M 60	≤ 60	48	53



A1. Esempio di contratto per la compravendita di cippato a contenuto energetico

(cfr. CEN/TS 14961:2005 e UNI/TS 11264:2007)

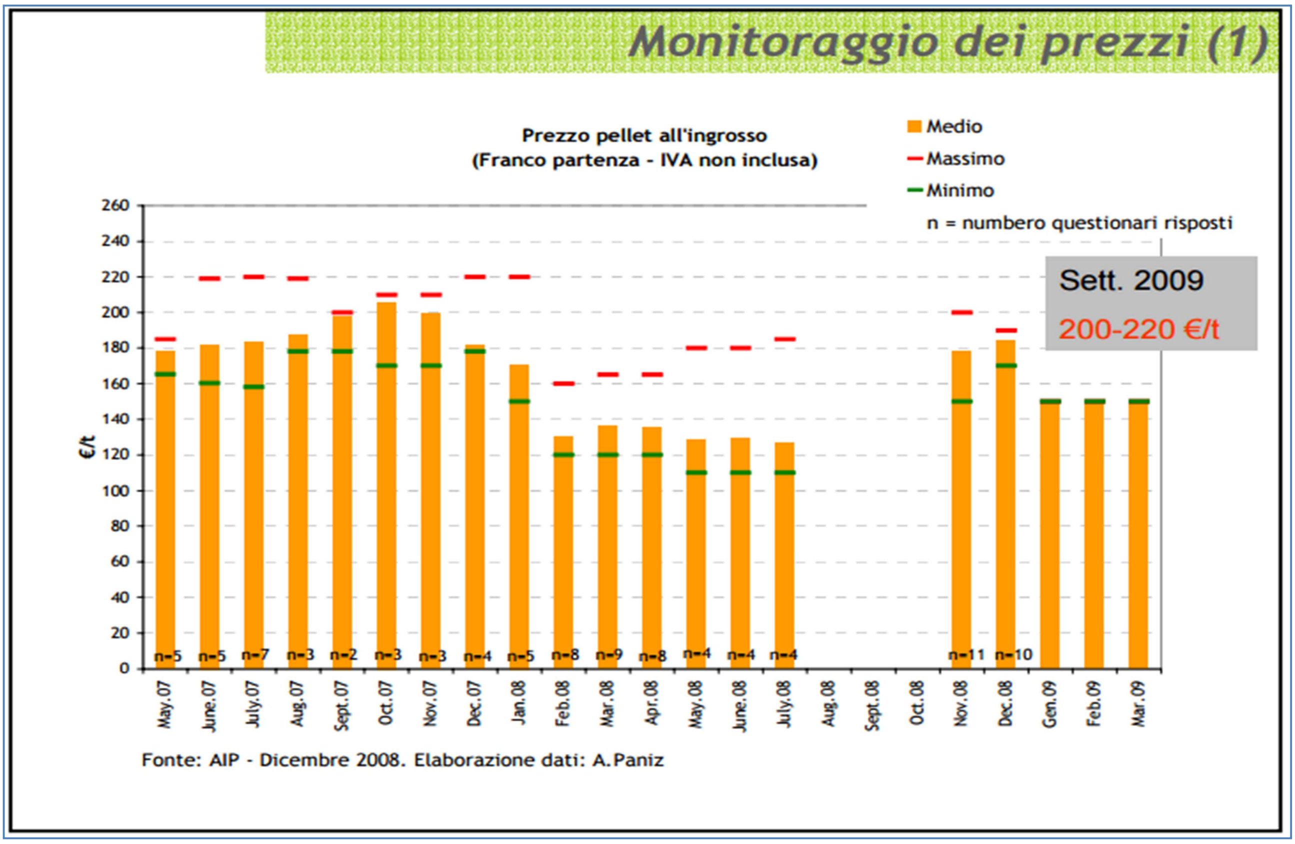
[ENEA, 2009, a. Francescato V.]

[ENEA, 2009, a. Francescato V.]

[ENEA, 2009, a. Francescato V.]

[ENEA, 2009, a. Francescato V.]

[ENEA, 2009, a. Francescato V.]



[ENEA, 2009, a. Francescato V.]

9. Appendix - POWERCROP - Ravenna (RA)

ASSESSMENT OF SUPPLY SCENARIOS
OF THE BUILDING WOOD BIOMASS COMBUSTION
POWER PLANT OF POWERCROP OF RUSSI (RA)

VALUTAZIONE DI SCENARI DI APPROVVIGIONAMENTO
DELL'IMPIANTO IN COSTRUZIONE
A BIOMASSE SOLIDE LEGNOSE DI POWERCROP DI RUSSI (RA)

arpae
agenzia prevenzione ambiente energia emilia-romagna

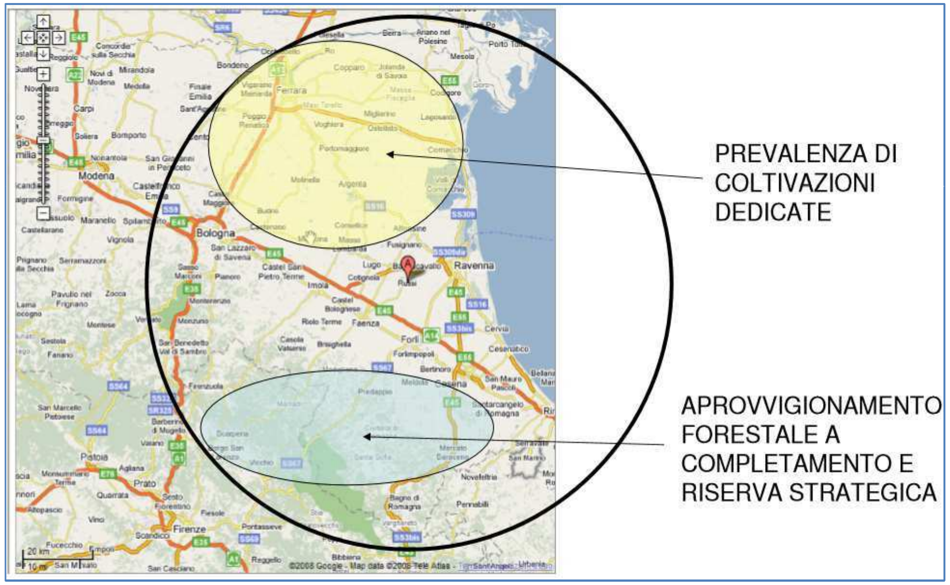
RUSSI (RA)
11/03/2017

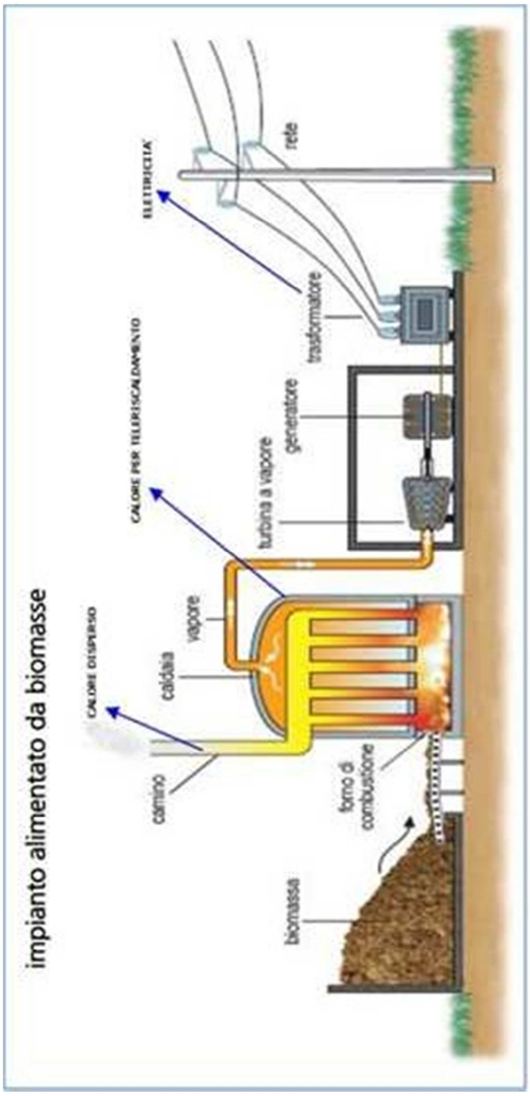
Alessia Castellucci
CdL in scienze ambientali
Tesi di laurea in energie rinnovabili
e gestione dell'energia

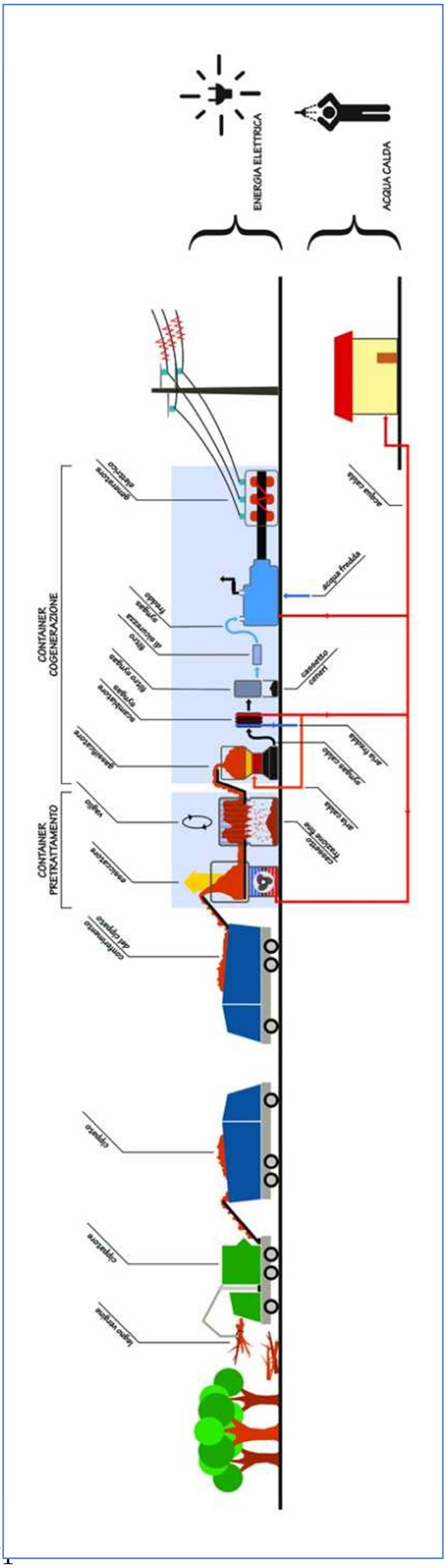
Arpae
Ctr energia e valutazioni
ambientali complesse
lucavignoli@arpae.it

L'analisi che costituisce il lavoro di tesi è stata elaborata basandosi sui dati dichiarati da Powercrop stessa, recepiti dalla Valutazione di impatto ambientale deliberata dalla Giunta regionale nell'anno 2011 e dagli Allegati annessi.
In particolare l'Allegato 1 – Rapporto ambientale e l'Allegato 2 – Complemento di Provincia AIA sono scaricabili dal sito del Bollettino Ufficiale della Regione Emilia-Romagna: Valutazione di impatto ambientale e autorizzazione unica relativa al progetto per la realizzazione di un polo per le energie rinnovabili sito in Via Carrarone n. 3 nel comune di Russi (RA).
L'impianto in esame sarà costruito sul terreno di Eridania Sadam Spa a Russi (RA), mettendo in atto la riconversione di uno zuccherificio in un impianto a biomasse lignocellulosiche.
Il progetto, avanzato da PowerCrop (Gruppo Maccaferri), si prefissa i seguenti obiettivi:
Dare un nuovo impulso al comparto agricolo attraverso le coltivazioni "no food";
Salvaguardare l'occupazione della maestranze;
Contribuire all'utilizzo di fonti energetiche rinnovabili nel pieno rispetto della compatibilità ambientale dei nuovi impianti sul territorio.
I diversi passaggi burocratici e giudiziari hanno comportato alcune modifiche al progetto iniziale. Ridimensionato nell'estensione e arricchito con alcune prescrizioni riguardo alle compensazioni, la centrale a biomasse sarà costruita nel Comune di Russi entro giugno 2018.

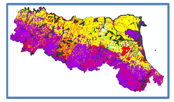
POWERCROP		Impianto a biomasse solide	Impianto a biogas	Impianto fotovoltaico	Caldaia ausiliaria	Potenza termica utilizzabile prevista per il teleriscaldamento
Ore lavorative	ore/anno	8.000	8.000			
Potenza elettrica	MW.el	30	0,99	0,29		
Potenza termica	MW.term	92,9	2,7		1,5	20
Biomassa	ton.	270.880	44.280			



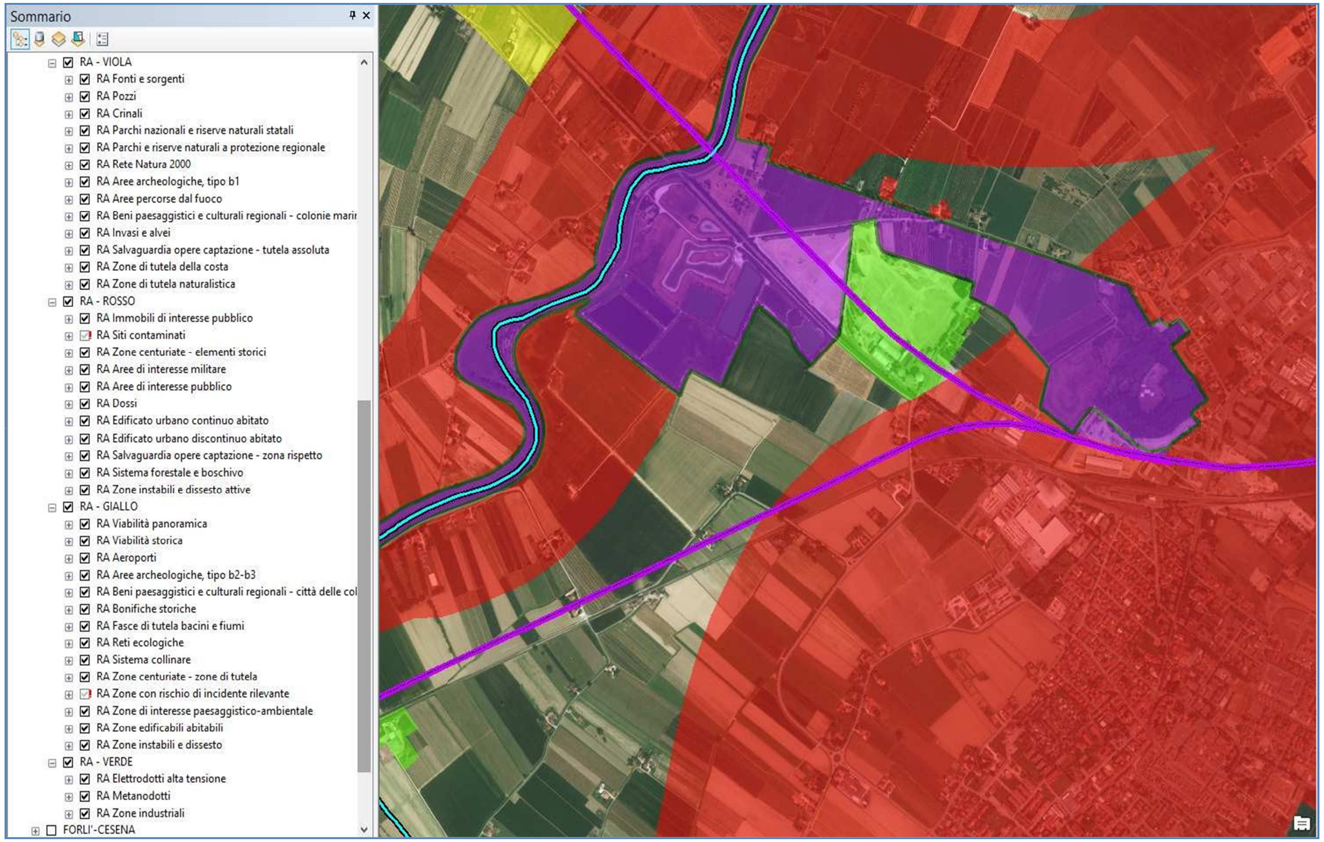

impianto alimentato da biomasse
biomasse
camino
forno di combustione
caldaia
vapore
turbina a vapore
generatore
trasformatore
rete

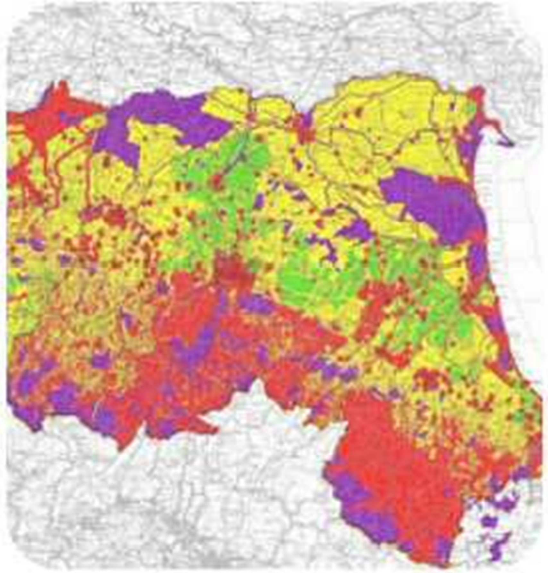

ENERGIA ELETTRICA
ACQUA CALDA
CONTAINER COGENERAZIONE
CONTAINER PRETRATTAMENTO

Mappe di sensibilità territoriale ambientale per la localizzazione degli impianti energetici



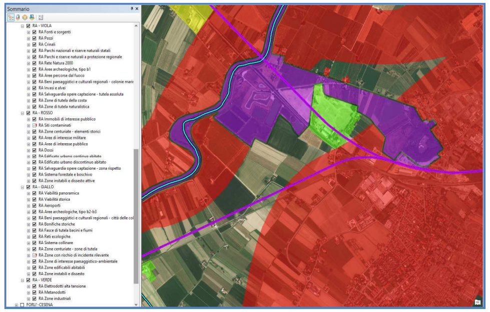
L'impianto Powercrop è situate in zona verde



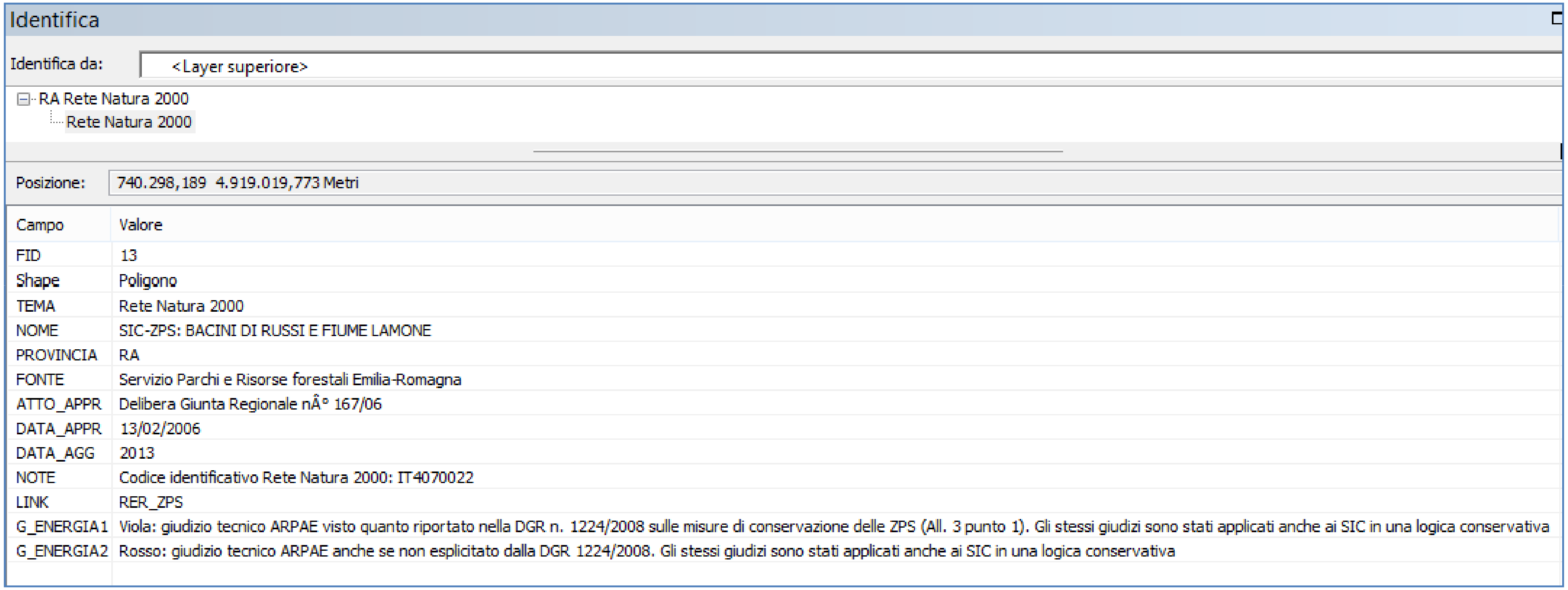


https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031

* Utilizzare browser Firefox con plugin silverlight attivato



Descrizione dei territori di colore VIOLA



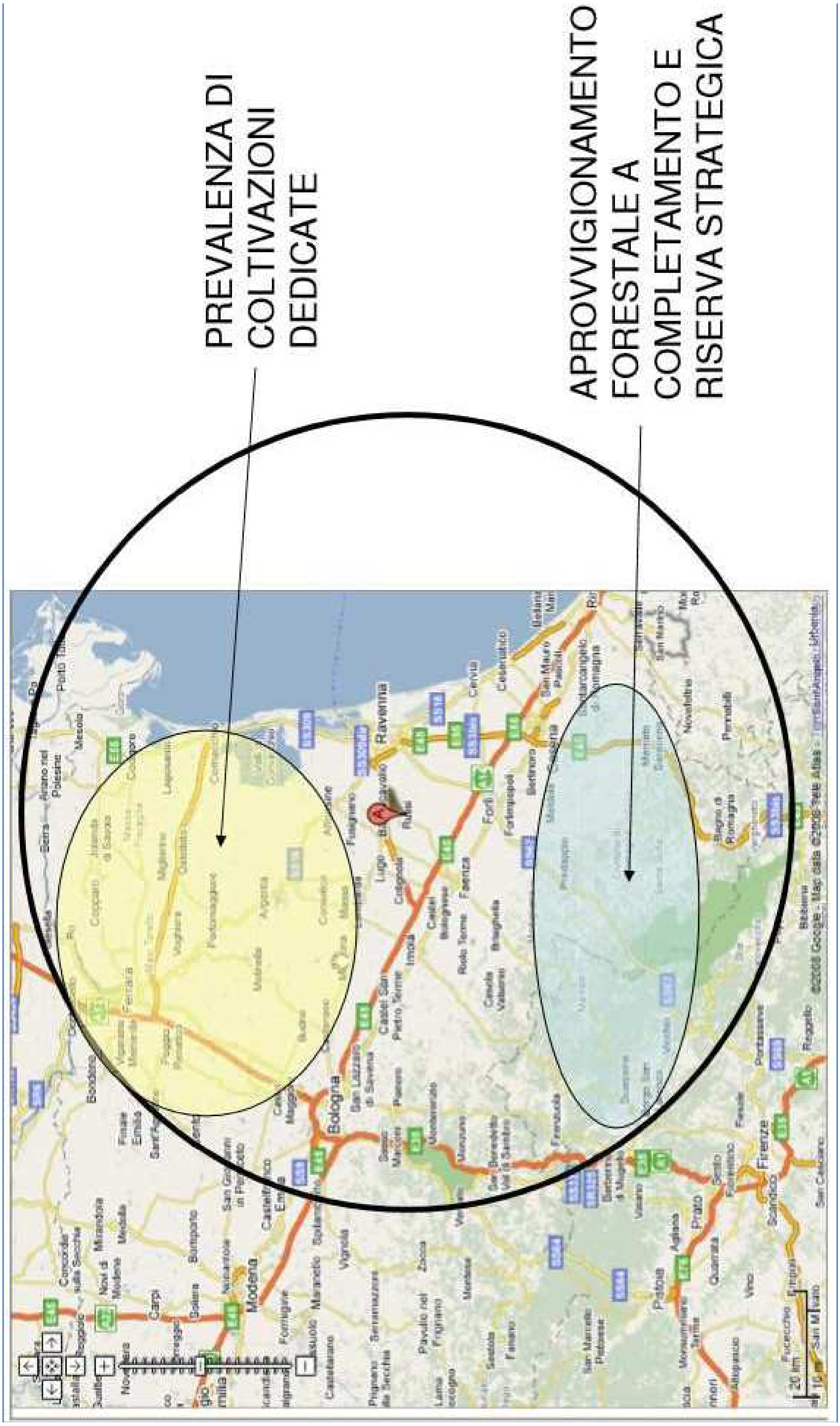
Identifica

Identifica da: <Layer superiore>

RA Rete Natura 2000
Rete Natura 2000

Posizione: 740.298,189 4.919.019,773 Metri

Campo	Valore
FID	13
Shape	Poligono
TEMA	Rete Natura 2000
NOME	SIC-ZPS: BACINI DI RUSSI E FIUME LAMONE
PROVINCIA	RA
FONTE	Servizio Parchi e Risorse forestali Emilia-Romagna
ATTO_APPR	Delibera Giunta Regionale nÂ° 167/06
DATA_APPR	13/02/2006
DATA_AGG	2013
NOTE	Codice identificativo Rete Natura 2000: IT4070022
LINK	RER_ZPS
G_ENERGIA1	Viola: giudizio tecnico ARPAE visto quanto riportato nella DGR n. 1224/2008 sulle misure di conservazione delle ZPS (All. 3 punto 1). Gli stessi giudizi sono stati applicati anche ai SIC in una logica conservativa
G_ENERGIA2	Rosso: giudizio tecnico ARPAE anche se non esplicitato dalla DGR 1224/2008. Gli stessi giudizi sono stati applicati anche ai SIC in una logica conservativa

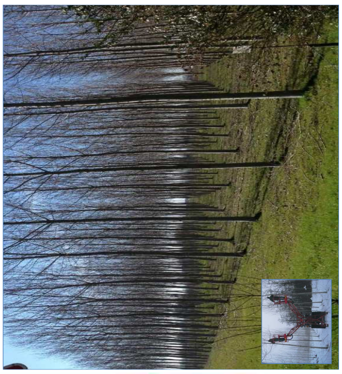

PREVALENZA DI COLTIVAZIONI DEDICATE
APROVVIGIONAMENTO FORESTALE A COMPLETAMENTO E RISERVA STRATEGICA

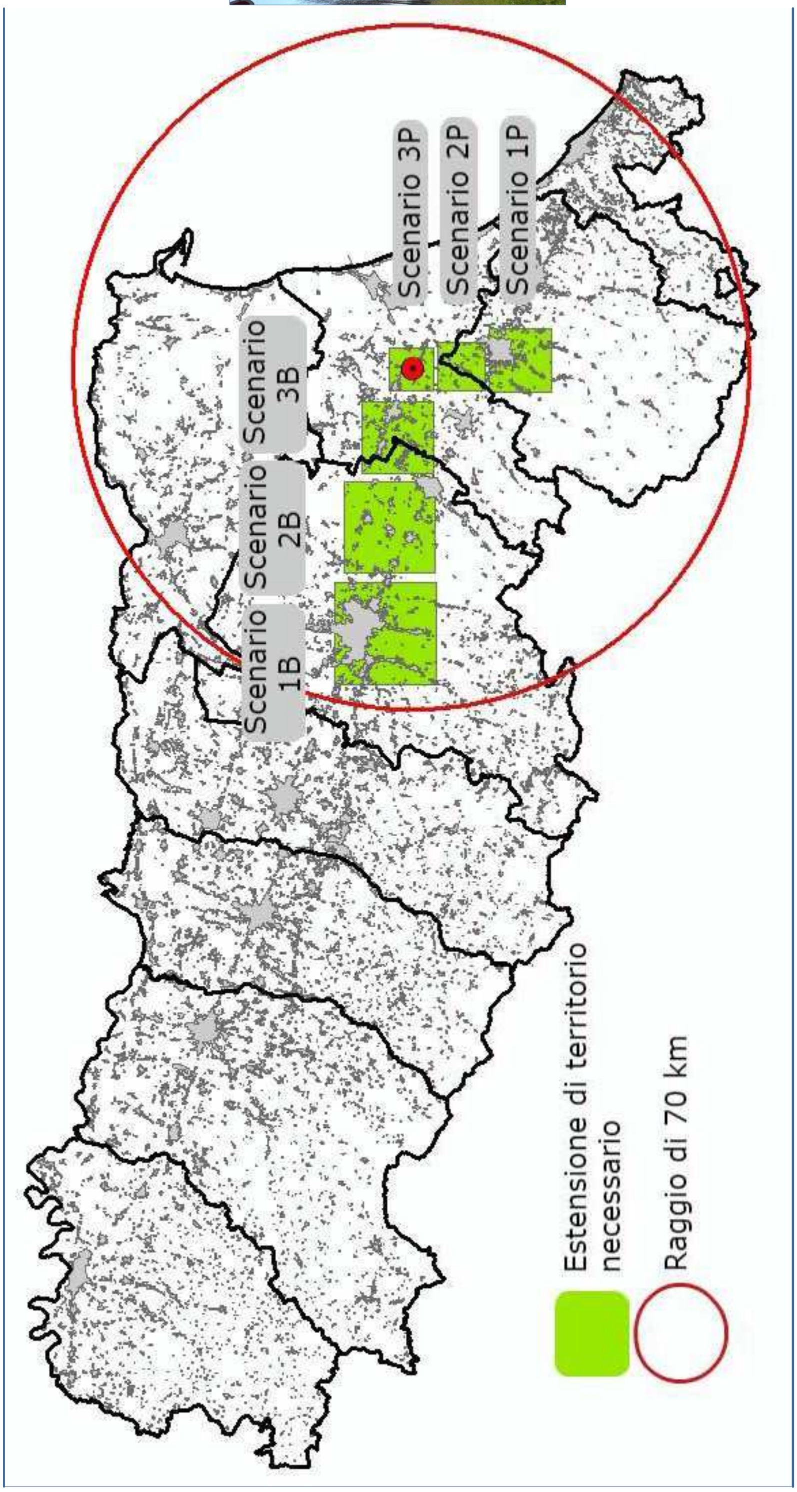
SCENARI di PIOPPICOLTURA

POWERCROP	Scenari	Energia necessaria MWh	Quantità legna fresca ton/anno	Umidità del legno %	Quantità legna stagionata ton/anno	Pci desunto kWh/ton
Produzione minima	1P	1.265.208,89	492.509	45	270.880	4,67
Produzione massima	2P	1.265.208,89	492.509	45	270.880	4,67
Territorio di 8000 ha	3P	1.265.209,89	492.509	45	270.880	4,67
	Scenari	Densità d'impianto piante/ha	Incremento massiccio fresco ton/ha/anno	Incremento massiccio stagionato ton/ha/anno	Ciclo colturale anni	**Estensione territorio necessario ha**
Produzione minima	1P	5.700	30	16,5	12	**16.417**
Produzione massima	2P	5.700	50	27,5	12	**9.850**
Territorio di 8000 ha	3P	5.700	62	33,9	12	**8.000**

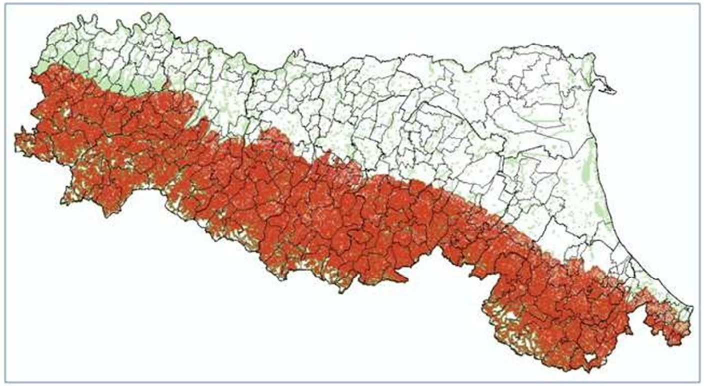
BIBLIOGRAFIA	Scenari	Quantità legna fresca ton/anno	Quantità legna stagionata richiesta ton/anno	Densità d'impianto piante/ha	Ciclo colturale anni	Incremento volumico areale fresco m^3/ha	Peso specifico legna fresca ton/m^3
Produzione massima lombarda	1B	492.509	270.880	330	10	30	0,76
Produzione minima lombarda	2B	492.509	270.880	200	10	15	0,76
Produzione Pianura Padana	3B	492.509	270.880	317	10	18,7	0,76
	Scenari	Incremento massivo fresco	Umidità del legno fresco	Incremento massivo stagionato		**Estensione territorio necessario**	
				Desunto	Dichiarato da Regiona Lombardia	Dal legno fresco e dal legno stagionato desunto	**Dal legno stagionato dichiarato**
		ton/ha/anno	%	ton/ha/anno	ton/ha/anno	ha/anno	**ha/anno**
Produzione massima lombarda	1B	22,8	45	12,54	12,4	21.601	**21.845**
Produzione minima lombarda	2B	11.4	45	6,27	6,27	43.203	**43.202**

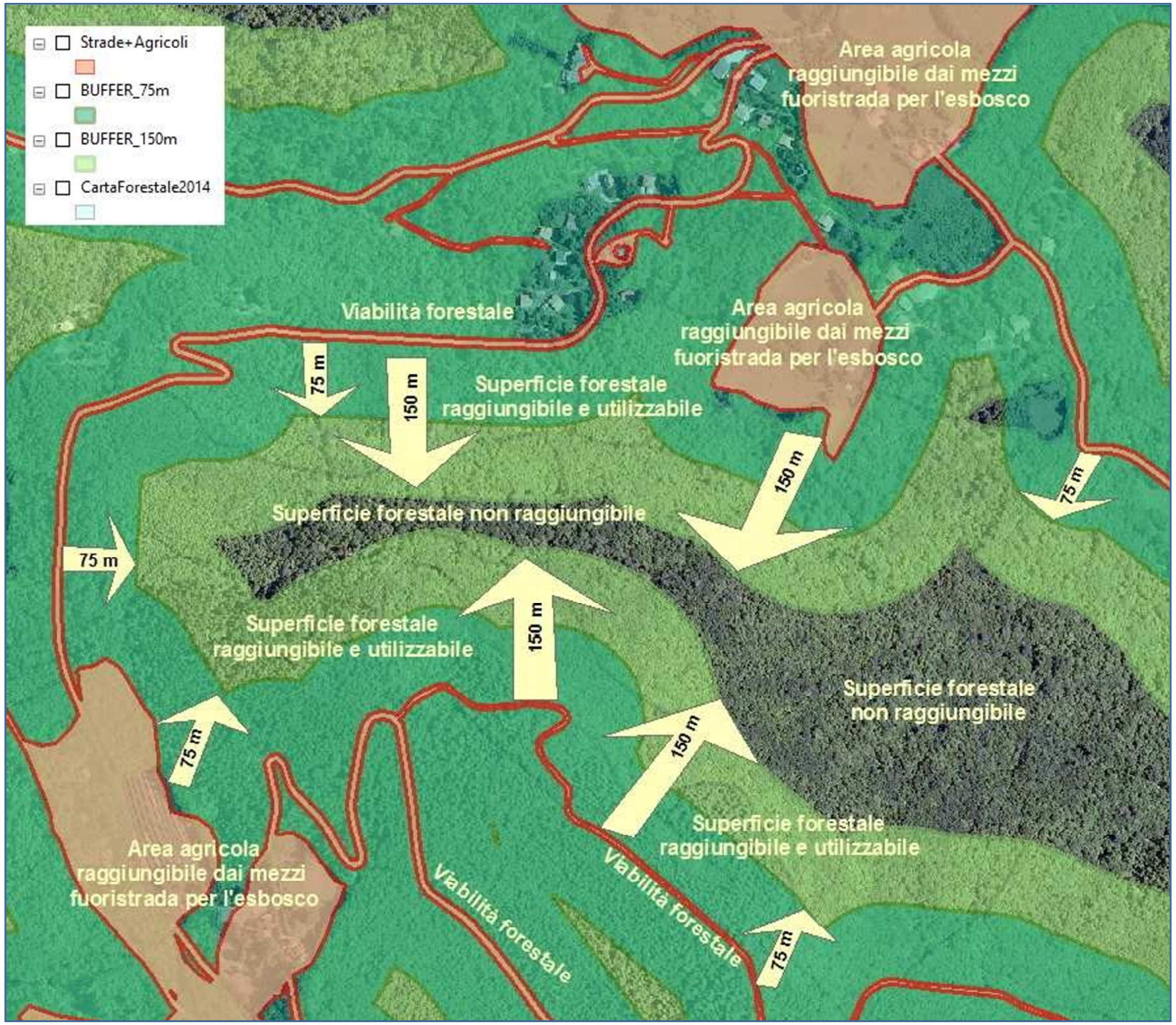
Produzione Pianura Padana	3B	14,21	45	7,82	7,1	34.659	**38.152**




Scenario 3P
Scenario 2P
Scenario 1P
Scenario 3B
Scenario 2B
Scenario 1B
Estensione di territorio necessario
Raggio di 70 km

SCENARI DI APPROVVIGIONAMENTO FORESTE

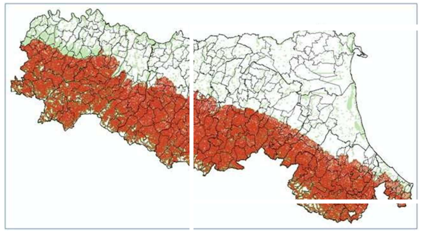




Mappa regionale della potenzialità energetica legnosa Foreste raggiungibile/utile

		LEGNA DA ARDERE -di maggior qualità- (70%) - 13,5 euro/q.le		LEGNA PER IMPIANTI ENERGETICI -di minor qualità- (30%) - 3,5 euro/q.le		NUMERO di impianti energetici equivalenti alimentabili con sola legna di minore qualità	
UdM		tonnellate	MWh	tonnellate	MWh		
Produzione energetica	MWe					1	0
	MWt					2,4	2,4
Caratteristiche degli impianti	ton/anno					13.000	3.500
	ore/anno					8.000	4.000
Piacenza		144.868	449.090	34.372	106.552	2,6	9,8
Parma		249.353	772.993	39.758	123.248	3,1	11,4
Reggio Emilia		98.961	306.779	27.199	84.317	2,1	7,8
Modena		108.076	335.035	40.736	126.280	3,1	11,6
Bologna		118.632	367.759	47.724	147.944	3,7	13,6
Ferrara		2.864	8.880	1.338	4.146	0,1	0,4
Ravenna		16.520	51.212	17.019	52.757	1,3	4,9
Forli'-Cesena		108.942	337.721	42.808	132.705	3,3	12,2
Rimini		27.425	85.018	6.193	19.198	0,5	1,8
Totale		874.690	2.711.539	261.800	811.580	20,1	74,8

SCENARI DI APPROVVIGIONAMENTO FORESTE



	Scenario	Estensione Foreste raggiungibile ha/anno	Produttività Foreste legno stagionato ton/ha	Quantità legna stagionata da foreste ton/anno	Quantità di legna stagionata in input a POWERCROP ton/anno	Numero di impianti POWERCROP alimentabili
Legna di minore qualità destinata ad imp. energetici	1F	98.996	3,44	340.947	270.880	1,26
Legna di maggiore qualità destinata a legna da ardere	2F	331.383	2,40	795.543	270.880	2,94
Totale	3F	430.379	2,64	1.136.490	270.880	4,20

RER BMs system EQUIVALENT PLANTS	Pot.Elettrica MW.el richiesta dall'intero sistema regionale di imp. a biomasse solide (NEL CASO TEORICO SIANO TUTTI IMP: A COMB.BM.LEGNOSE) installata in esercizio in RER 2015 (GSE)	Num. Imp. da 1 MW.el sostenibili dagli ettari di foresta	Num. Imp. 1 MW.el sostenibili dalle tonnellate di legna forestale stagionata	Ettari richiesti dal sistema esistente di imp.BS a seconda della tipologia di legna forestale disponibile	Tonnellate di legna stagionata richieste dal sistema esistente di imp.BS a seconda della tipologia di legna forestale stagionata disponibile
	MW.el	num.	num.	ha	t.
Populus L. arboriculture	141,6	/	/	62.933	1.132.800
Forest: general mix	141,6	141	142	431.707	1.132.800
Forest: firewood (HQ)	141,6	110	99	427.149	1.132.800
Forest: wood for energy plants (LQ)	141,6	33	43	429.254	1.132.800

Tonnellate di legna fresca richieste dal sistema esistente di imp.BS a seconda della tipologia di legna forestale stagionata disponibile	Disponibilità residua ettari forestali	Disponibilità residua tonnellate legna forestale stagionata	Numero di attuali sistemi regionali sostenibili dalgli ettari forestali	Numero di attuali sistemi regionali sostenibili dalle produzioni (TON.) di legna forestale stagionata
t.	ha	t.	num.	num.
1.888.000	/	/	/	/
1.888.000	-1.328	3.690	0,997	1,003
1.888.000	-95.757	-337.257	0,776	0,702
1.888.000	-330.266	-791.853	0,231	0,301

SCENARI DI APPROVVIGIONAMENTO CON RIFIUTI VERDI

	Energia necessaria in input MWh	Quantità fresco ton	Pci medio kWh/kg	Energia ricavabile MWh	Numero di impianti POWERCROP alimentabili
Provincia RA	1.265.209	50.790	4,56	231.602	0,18
Emilia Romagna	1.265.209	418.890	4,56	1.910.138	1,51

Tipologie di biomasse	Potere calorifico kcal/kg	MJ/kg	kWh/kg
Ramaglie cedue di valore	4100	17,15	4,77
Ramaglie cedui dolci	4000	16,74	4,65
Altri cedui: tutta la produzione	4000	16,74	4,65
Scarti da fustaie resinose	4200	17,57	4,88
Scarti da fustaie latifoglie	4100	17,15	4,77
Residui tagli fustaie varie	4100	17,15	4,77
Ripulitura cesse linee elettriche	4200	17,57	4,88
Cure forestali castagneti	4000	16,74	4,65
Materiale risulta vigneti	4300	17,99	5,00
Materiale risulta oliveti	4200	17,57	4,88
Materiale risulta frutteti	4300	17,99	5,00
Materiale risulta vivai	4300	17,99	5,00
Recupero paglia	3950	16,53	4,59
Biorifiuti - potature	3950	16,53	4,59
Biorifiuti - erba fresca	575	2,41	0,67
Biorifiuti - foglie secche	4337	18,15	5,04
Scarti lavorazione legno	4100	17,15	4,77
MEDIA	**3924**	**16,42**	**4,56**

CONCLUSIONI

Tra gli scenari di approvvigionamento mediante legna da pioppicoltura, quello dichiarato nella documentazione da Powercrop è caratterizzato dal tasso di produzione legnosa di pioppo più elevato (62 ton/ha/anno) ed implica l'estensione di terreno più piccola, pari 8000 ha.
Lo scenario calcolato con il minor tasso di incremento legnoso da pioppo è della Regione Lombardia (14 ton/ha) ed implica l'utilizzo di un'estensione di terreno molto maggiore, cioè 43.203 ha.
Tra i due scenari vi è una differenza di 35.202 ha, ovvero di 5,4 volte,.

Nell'ambito degli scenari di approvvigionamento per la legna Foreste disponibile entro un buffer di 150 m dalle strade e dai campi agricoli, con l'intero ammontare di produzione regionale della sola legna di minor qualità (30%), vendibile intorno ai 3,5 euro/q.le , si potrebbero alimentare 1,26 impianti Powercrop.
Se invece si utilizzasse anche tutta la produzione annuale disponibile di legna da ardere di elevata qualità (70%), vendibile intorno ai 13,5 euro/q.le , sarebbe possibile alimentare 4,04 impianti uguali a quello di Powercrop.

Ipotizzando, infine, che l'impianto Powercrop venga alimentato unicamente con rifiuti vegetali verdi, si è calcolato che l'intera Provincia di Ravenna potrebbe alimentare solo il 18% del suddetto impianto, mentre utilizzando l'intera produzione di rifiuti verdi di tutta la regione Emilia-Romagna si potrebbero complessivamente alimentare annualmente 1,51 centrali Powercrop.

Nel 2016 in Emilia-Romagna il GSE ha dichiarato attivi 16 impianti a biomasse solide di tutte le tipologie (sia legnose che non legnose) con una potenza elettrica installata totale pari a 141,6 MW.el [GSE, 2017].
Nell'ipotesi, del tutto teorica, che siano tutti alimentati a legna Foreste, l'intero complesso Foreste RER con la sola legna di bassa qualità potrebbe sostenere 0,3 sistemi a biomasse solide come quello attuale, mentre ne potrebbe alimentare 1,003 utilizzando tutta la legna di bassa qualità e di alta qualità.

L'impianto a biomasse legnose Powercrop non è ancora stato censito tra gli impianti in esercizio registrati dal GSE, in quanto è ancora in fase di costruzione. Con i suoi 30 MW.el di potenza elettrica, Powercrop aumenterebbe di circa il 25% la richiesta regionale totale di biomassa solida legnosa.

Riguardo la sostenibilità economica dell'impianto Powercrop, è importante considerare anche il fatto che, una volta che l'impianto sarà a regime, nell'intorno dell'impianto la domanda di legname subirà un significativo aumento, e di conseguenza è possibile che anche i prezzi di compravendita di tutti i tipi di legna, sia di pioppo che Foresti, sia per uso energetico che per uso domestico, possano aumentare significativamente, sia per l'alimentazione dell'impianto Powercrop che per il semplice utilizzo domestico.

Index - part 8.1 -

LCA QUANTITATIVE ENVIRONMENTAL IMPACT ANALYSIS -MATERIALS AND METHODS-

1. INTRODUCTION

We present this study on LCA environmental impacts in two different part:
The first part show you the method and the complete database used for the assessment. The second part is constituted by a scientific article that should be published in a scientific book focused on "Life Cycle Assessment and Energy" edited by the Italian Lyfe Cycle Analysis Association in 2018 with Springer edition. We propose it to you in the original format of the complete scientific article, and it represents the description of the application of the quantitative LCA assessment method. As well as the results and the conclusions it reports also the bibliography of all the specific parameters and their range used.

2. HOW ESTIMATE AND QUANTIFY THE ENVIRONMENTAL IMPACT AT REGIONAL LEVEL WITH AN LCA APPROACH

After collecting and structuring the data of 15 biomass plants acquired as real case studies [1] (and their specific inlet and output supply chains), the data were implemented in the software for LCA Simapro.7.3 with the help of databases Ecoinvent, thus obtaining results according to the Ecoindicator'99 method, or measured in numerical terms in Ecopoints for the following categories of environmental impact/damage [2]:

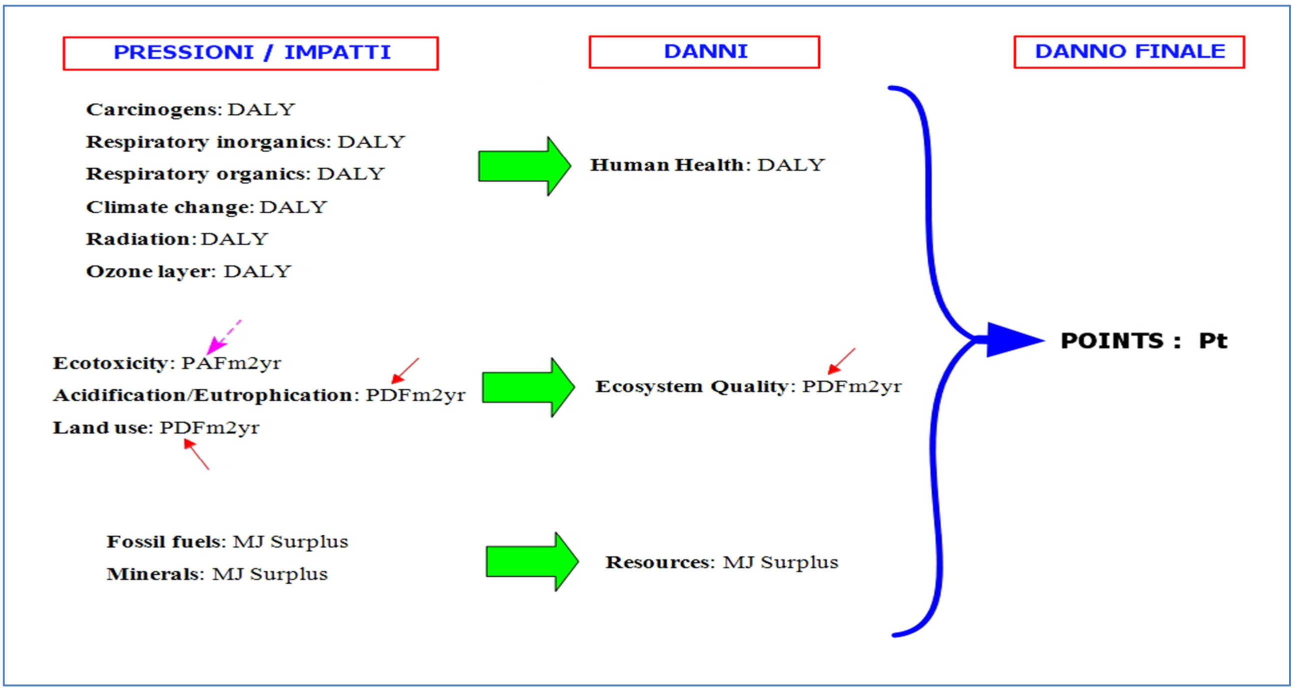


Figura 1- Conceptual diagram of the transition from the impact to the damage categories, to the measurement of the total final environmental damage, according to the LCA Ecoindicator'99 methodology.

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1 The description of real case study facilities is presented in the following paragraph.
2 NOTE: This research does not carry out in-depth LCA analyzes, but only LCA-based analysis that only uses basic plant / productive chain data, as the target remains the impact assessment and of sustainability in terms of territorial planning, and not of in-depth analysis.

Once the results in terms of environmental impacts / damage are obtained for the aforementioned single plants and related production lines, it is therefore possible to compare them with each other and with other plants and / or productive activities of any kind, Provided that these have been implemented on the software and processed using the same analytical methodology used, which in this research is Ecoindicator'99 [3].

Now, due to the fact that it is not possible to find all the plant and supply data of the entire Emilia-Romagna biomass regional energy system (316 plants in 2016, totaling 354.2 MW.el electric power) to implement them in the LCA software, in order to calculate its overall environmental impact / damage, it was decided to construct at the table the theoretical but realistic profiles of the main typologies of the plant and their chains, all referring to an electrical power of 1 MW .el so that they can then multiply their unitary impact [4] for the sum of the installed power in the region and cataloged in the GIS regional scale of the biomass plants reported in the previous chapters, depending on the type.

For simplicity, we will call these STANDARD PLANTS, although technically speaking, using this name may be improper, depending on the reader.

The operational comparison with the LCA approach between case studies and standard installations allows us to verify the reliability of these.

The multiplication of the impacts / damage of the standard 1 MW power plants for electric power installed at the regional level of the relevant typology, using the Ecoindicator'99 methodology, allows us to estimate its overall environmental impacts / damage at regional level, quantifying them numerically: both in terms of the pressure / impact measures of the 11 environmental categories (Carcinogens, Respiratory Inorganics, etc.), and in terms of the extent of damage to the major category (Human Health, Quality of the Ecosystem, Consumed Resources) both in terms of EcoPoints of total final damage [5] .

Below we propose the list of realistic reference STANDARD PLANTS of electrical power of 1 MW.el operating for 8000 hours / year, or thermal power of 2.4 MW.term operating for 4000 hours per year, which were created In this research and then implemented in the LCA software.

- -MAIZE- = BIOGAS - 1 MW.el - MAIS 100% = 100% supplied with silage maize [6];
- -EC- = BIOGAS - 1 MW.el - AGRO-LIVESTOCK = supplied with cattle and pork manure&slurry (84,4%) with a silage maize fraction (16,6%);

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3 Once the data on Simapro software is implemented, however, it is always possible to carry out in-depth analysis and comparison using other methodologies other than ecoindicator'99, such as: IMPACT 2002, EPS 2000, EDIP 2003, IPCC GWP 100a 2007, etc. (For more information, read the introductory chapter on the Life Cycle Assessment of this research).

4 The unit reference value useful for comparing and calculating the overall impact / environmental damage is calculated using the Ecoindicator'99 methodology as a function of the 1 MW functional unit * 8000 hours of work = 8000 MWh. Or 2.4 MW.term thermal * 4000 hours of work - cold weather = 9600 MWh.term. It is important to keep in mind that wood burning biomass combustion plants destined for the production of thermal energy for district heating in this research have been considered / modeled only for the cold period, equal to 4000 hours / year of operation; While all other plants primarily intended for the production of electricity have been modeled for 8000 operating hours per year as they operate throughout the year.

5 Clearly, due to the fact that they were all implemented in the Simapro software, it is possible to carry out calculations and estimates of environmental damage / impact even with other methods other than Ecoindicator'99, but this comparison is not within the scope of the Present research.

6 Corn silage is used in all types of biogas plant as it has the property of stabilizing and improving all the fermentation processes that take place within anaerobic reactors from which biogas is obtained.

- -AC- = BIOGAS - 1 MW.el – AGRO-FOOD INDUSTRY = supplied with byproducts af food and ortofrutta industry (84,4%) with a silage maize fraction (16,6%);
- -F- = BIOGAS - 1 MW.el – ORGANIC WASTE URBAN FRACTION (FORSU) = supplied with the organic fraction of urban waste collecting (80%) with a silage maize fraction (20%);
- -W- = WOOD SOLID BIOMASS - 1 MW.el - POPLAR CULTIVATION = 100% supplied with wood biomass coming from polar cultivation;
- -W- = WOOD SOLID BIOMASS - 2,4 MW.term - POPLAR CULTIVATION = 100% supplied with wood biomass coming from polar cultivation;
- -W- = WOOD SOLID BIOMASS - 1 MW.el - WITH FORESTAL WOOD = 100% supplied with wood coming from forest exploitation;
- -W- = WOOD SOLID BIOMASS - 2,4 MW.term - WITH FORESTAL WOOD = 100% supplied with wood coming from forest exploitation;

The main functional units of reference will therefore be:

- Electrical power 1 MW.el * 8000 hours / year of work = 8000 MWh.el
- Thermal power 2.4 MW.term * 4000 hours / year of work = 9600 MWh.term

- k.Ecopoint of environmental damage / 8.000 MWh elettricity [7] per year
- k.Ecopoint of environmental damage / 9.600 MWh thermal [8] per year

3. THE -15- LCA CASE STUDIES:

Parallel to territorial research, several case studies of biomass energy plants of different types and sizes have been studied.
After collecting and structuring the plant data and their specific inbound and outbound supply chains, the data were implemented in LCA SIMAPRO.7.3 software with the help of ECOINVENT databases, thus to obtain results in terms of measurement of overall environmental impact, human health, quality of the ecosystem, and resources, by measuring them in ecoPoints according to the ECOINDICATOR'99 methodology.

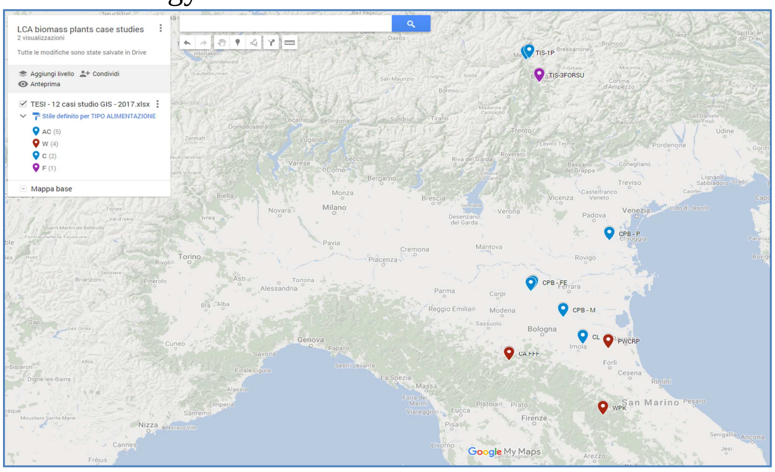

Figura 2- The analyzed biomass plants:

7 Unità funzionale di confronto: Potenza elettrica 1 MW.el * 8000 ore/anno di lavoro = 8000 MWh.el .
8 Unità funzionale di confronto: Potenza termica 2,4 MW.term * 4000 ore/anno di lavoro = 9600 MWh.term .

The analyzed biomass plants are following:

1. **CX:** biogas plant located in the MODENA province powered by maize silage power = 249 kWe; (AIR Q.DAL.52 / 2011 ORANGE AREA).
2. **CL:** Biogas plant located in the province of BOLOGNA fed by scraps of the agri-food industry of bovine and swine slaughter + pig slurry + maize silage, electrical power = 834 kW; (AIR Q. DAL.52 / 2011 GREEN AREA).
3. **CRPB-M:** biogas plant located in the province of BOLOGNA fed to by-products of sugar syrup + maize silage, with electric power = 999 kW; (AIR Q.DAL.52 / 2011 YELLOW AREA).
4. **CRPB-FE:** biogas plant located in the province of MODENA fed to by-products of sugar syrup + maize silage, with electric power = 999 kW; (AIR Q.DAL.52 / 2011 YELLOW AREA).
5. **CRPB-P:** biogas plant located in the province of PADOVA fed to by-products of sugar syrup + maize silage, with electrical power = 999 kW; (OUTSIDE REGION).
6. **TIS-1P:** small-scale biogas plant located in the province of BOLZANO fed to bovine electrical power losses = 18,5 kW; (OUTSIDE REGION).
7. **TIS-2M:** medium size consortium located in the province of BOLZANO fed to slurry and bovines of electrical power = 380 kW; (OUTSIDE REGION).
8. **TIS-3FORSU:** biogas plant located in the Province of BOLZANO powered by FORSU of electric power = 900 kW; (OUTSIDE REGION).
9. **CAFO-1:** wood biomass gasification plant supplied with ONLY FOREST WOOD CHIPS, located in CASTEL D'AIANO (BO) on the BOLOGNESE APPENNINO of electrical power = 35 kWe + 140 kWt; (AIR Q. DAL.52 / 2011 RED AREA).
10. **CAFO-2:** wood biomass gasification plant supplied with FOREST WOOD CHIPS + SAWDUST FROM A SAWMILL, located in CASTEL D'AIANO (BO) on the APPLENNINO BOLOGNESE electric power = 35 kWe + 140 kWt; (AIR Q. DAL.52 / 2011 RED AREA).
11. **PCPP:** gasification plant for wood biomass located in RAVENNA province of electrical power = 30 MW.el. + 92.4 MW.term (AIR Q. DAL.52 / 2011 GREEN AREA). With 4 different scenario cases with SEASONED annual WOOD productivity from:
    - FROM ARBORICOLTURE (Popolus) = 34 t./ha/year
    - FROM ARBORICOLTURE (Popolus) = 12,4 t./ha/year
    - FROM ARBORICOLTURE (Popolus) = 6,27 t./ha/year
    - FROM FOREST = 2,64 t./ha/year
12. **WPK:** wood biomass gasification plant located in SAN PIERO IN BAGNO (FC) on the APPENNINE of Forlì-Cesena province of electrical power = 200 kW.el + 200 kW.therm (AIR Q. DAL.52 / 2011 RED AREA).

The main reference functional units will be those of the Ecoindicator'99 method:
:

- Environmental impact ecoPoints / 1 MWh.el elettric produced
- Environmental impact ecoPoints / 8.000 MWh.el elettric produced

Tabella 1- Synthesis of the case studies

PLANT	Latitude	Longitude	POSITION	SENSIBILITY MAP	AIR QUALITY ZONE DAL.52.2011	PLANT TYPE	SUPPLY CODE	SUPPLY	Electric Power (kW.el) (kW)
CA.FFF	44.2825073392	10.9920852471	44.2825073392 10.9920852471	RED	GREEN	Solid biomass: Wood combustion	W	Forest wood chips	35
CA.OOO	44.2825073392	10.9920852471	44.2825073392 10.9920852471	RED	GREEN	Solid biomass: Wood combustion	W	Forest wood chips (70%) + sawmill waste (30%)	35
CPB - M	44.632368	11.554261	44.632368 11.554261	YELLOW	YELLOW	Biogas	AC	Pulp and molasses from sugar (87%) + silated maize (13%)	999
CPB - FE	44.852009	11.239809	44.852009 11.239809	YELLOW	ORANGE	Biogas	AC	Pulp and molasses from sugar (87%) + silated maize (13%)	999
CPB - P	45.243555	12.031042	45.243555 12.031042	Out region	Out region	Biogas	AC	Pulp and molasses from sugar (87%) + silated maize (13%)	999
TIS-1P	46.666873	11.165117	46.666873 11.165117	Out region	Out region	Biogas	C	Agro-zootechnical mix	13
TIS-2M	46.678534	11.200066	46.678534 11.200066	Out region	Out region	Biogas	C	Agro-zootechnical mix	380
TIS-3FORSU	46.495008	11.303494	46.495008 11.303494	Out region	Out region	Biogas	F	Urban waste organic fraction	870
CL	44.419074	11.757383	44.419074 11.757383	GREEN	ORANGE	Biogas	AC	Agro-zootechnical + meat.food.industry mix	888
CX	44.839785	11.217557	44.839785 11.217557	YELLOW	ORANGE	Biogas	AC	Silated maize (98%) + grape must (2%)	249
WPK	43.838140	11.965167	43.838140 11.965167	RED	GREEN	Solid biomass: Wood combustion	W	Forest wood chips	200
PWCRP	44.383132	12.020172	44.383132 12.020172	GREEN	YELLOW	Solid biomass: Wood combustion	W	Arboricolture + forest wood chips	30000

PLANT	Thermal useful power deliverable (kW.term)	Lost power (kW.lost)	Total power (el+therm+lost) (kW.tot) (kW)	% electric power	% thermal useful power	% Lost power	Cogeneration (YES/NO)	Remote heating	Work hours/year (ore/anno)	Electric production (MWh.el/year)
CA.FFF	140	25	200,0	17,5%	70,0%	12,5%	YES	YES	6000	210000
CA.OOO	140	25	200,0	17,5%	70,0%	12,5%	YES	YES	6000	210000
CPB - M	1024	426	2448,5	40,8%	41,8%	17,4%	YES	IN LITTLE PART	8000	7992000
CPB - FE	1024	426	2448,5	40,8%	41,8%	17,4%	YES	IN LITTLE PART	8000	7992000
CPB - P	1024	426	2448,5	40,8%	41,8%	17,4%	YES	IN LITTLE PART	8000	7992000
TIS-1P	19	16	47,3	27,5%	39,7%	32,8%	YES	YES	8000	104000
TIS-2M	414	221	1015,0	37,4%	40,8%	21,7%	YES	YES	4635	1761300
TIS-3FORSU	945	862	2676,9	32,5%	35,3%	32,2%	YES	NO	8000	6960000
CL	914	515	2317,0	38,3%	39,4%	22,2%	YES	YES	8000	7104000
CX	262	144	655,0	38,0%	40,0%	22,0%	NO	NO	8000	1992000
WPK	200	100	500,0	40,0%	40,0%	20,0%	YES	YES	8000	1600000
PWCRP	92900	15000	137900	21,8%	67,4%	10,9%	YES	YES	8000	240000000

4. DESCRIPTION OF THE 15 BIOMASS PLANTS CASE STUDIES ANALYZED

4.1. Description of the 15 biomass plants case studies analyzed

We propose below the detailed descriptions of the biomass energy systems examined. Although most of the data shown here have been declared by the companies, so it was not for some diesel consumption values and linear kilometers; Such consumption and distances were then estimated through basic factors derived from the literature and then mathematically operated with other stated data in order to put the reader under the condition of having to have an idea of the quantities in play that, if necessary, replace the different Basic values that he believes to be more realistic.
The analysis / LCA comparison approach, however, was conducted by implementing the consumption of the stages of cultivation, exploitation and transport in terms of the unit of measure in kgkm (or tonkm) associated with the use of the types of means of trucks and agricultural machines present In the European database for LCA Ecoinvent.
The estimated values in terms of km and liters of diesel will can be used to calculate a specific deepening on air emissions by lecturers, if they like. At level of this research, this should be done using the INEMAR Emission Factors of Emilia-Romagna and Lombardia regions (see previous chapters).

4.1.1. BIOGAS plants

MODULE	FIELDS	CX	CL	CPB - FE	CPB - MB	CPB - PL	TIS-1P	TIS-2M	TIS-3FORSU
ANAGRAFIC	Arpae ID Code	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Arpae reference links	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Arpae compilator	Luca Vignoli	Luca Vignoli	Luca Vignoli	Luca Vignoli	Luca Vignoli	Luca Vignoli	Luca Vignoli	Luca Vignoli
	Identification code of the data source	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Info source	CISA, 2014, a	CLAI, 2015, a	CPB	CPB	CPB	TIS, 2011, a	TIS, 2011, a	TIS, 2011, a
	Updating	2014	2016	2015	2015	2015	2011	2010	2006
	Business name	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Fiscal code	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Manager	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Address	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Municipality	Finale Emilia	Imola	Finale Emilia	Minerbio	Pontelongo	Province di Bolzano	Province di Bolzano	Province di Bolzano
	Province	MO	BO	MO	BO	PD	BZ	BZ	BZ
	Telephone	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	E-mail	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Website	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Start activity	nd	nd	2012	2012	2012	nd	nd	2006
	End incentives	nd	nd	nd	nd	nd	nd	nd	nd

FRAMEWORK	Local unit (Unique reference name)	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Authorisation	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Status of activity	in esercizio	in esercizio	in esercizio	in esercizio	in esercizio	in esercizio	in esercizio	in esercizio
	Latitude	44.842.335	44.419.074	44.852009	44.632368	45.243555	46.666873	46.678534	46.495008
	Longitude	11.339.525	11.757.383	11.239809	11.554261	12.031042	11.165117	11.200066	11.303494
	Type of plant	BIOGAS	BIOGAS	BIOGAS	BIOGAS	BIOGAS	BIOGAS	BIOGAS	BIOGAS
	Arpae sensitivity map zone	ORANGE	GREEN	YELLOW	YELLOW	Out of region	Out of region	Out of region	Out of region
	Air quality zone (DAL 51.2011)	ORANGE	ORANGE	YELLOW	ORANGE	Out of region	Out of region	Out of region	Out of region
	Authorized Electric Power (kW)	249,0	888,0	999,0	999,0	999,0	13,0	380,0	870,0
	Useful / dissiptable thermal power (kW)	262,0	914,0	1.023,5	1.023,5	1.023,5	18,8	414,4	945,0
	Lost Power (kW)	144,0	515,0	426,0	426,0	426,0	15,5	220,6	862,0
	Total power (el + therm + lost) (kW)	655,0	2.317,0	2.448,5	2.448,5	2.448,5	47,3	1.015,0	2.676,9
	% electric power	38,0%	38,3%	40,8%	40,8%	40,8%	27,5%	37,4%	32,5%
	% Useful thermal power	40,0%	39,4%	41,8%	41,8%	41,8%	39,7%	40,8%	35,3%
	% Lost power	22,0%	22,2%	17,4%	17,4%	17,4%	32,8%	21,7%	32,2%
	Cogeneration (YES / NO)	NO	YES	YES	YES	YES	YES	YES	YES
	District heating (YES / NO - IN SMALL PORTION)	NO	YES	IN SMALL PORTION	IN SMALL PORTION	IN SMALL PORTION	YES	YES	NO
	Operating hours per year (hours / year)	8.000	8.000	8.000	8.000	8.000	4.500	4.635	8.000
DESCRIPTION	Description	BIOGAS: Private biogas plant powered by -5000 tons. Maize silage -100 tons. Grape must	BIOGAS: Private biogas plant powered by - Spills in the agri-food industry for bovine and porcine slaughter: 562 tons. Pig fat for food use 2916 t. Full pouch 556 tons. Content of bovine rumine - Pigs: 5830 tons of pig slurry - 4059 tons. Maize silage (triticale or sorghum)	BIOGAS : Enhancement of biotechnology Electric Power 999 kW -3.300 tons. Maize silage; -21,000 tons. Sugared surplus sugars; -990 tons. Sugar molasses. (Supply to Minerbio sugar factory: 100 km AR)	BIOGAS : Enhancement of biotechnology Pot. Electric 999 kW -3.300 tons. Maize silage; -21,000 tons. Sugared surplus sugars; -990 tons. Sugar molasses. (Adjacent sugar factory supply: dist.1 km AR)	BIOGAS : Enhancement of biotechnology Pot. Electric 999 kW -3.300 tons. Maize silage; -21,000 tons. Sugared surplus sugars; -990 tons. Sugar molasses. (Adjacent sugar factory supply: dist.1 km AR)	BIOGAS: by anaerobic digestion of slurry and bovines: + maize silage (+ small amount of vegetable waste) A family-run livestock farm 15.2 tons. Maize silage 13.8 tons. Co-substrates 935.5 t. Bovine slurry 16.4 tons. Bovine manure	BIOGAS: anaerobic digestion of slurry and bark (+ small amount of vegetable waste) Cooperative of 48 agro-zootechnical companies 540 tons. Co-substrates 10,017 tons. Bovine slurry 5,008 tons. Bovine manure	BIOGAS: FORSU anaerobic digestion (Organic Solid Waste Urban Fraction) There are 37 towns in the upper Tirol HIGH ENERGY CONSUMPTION IS DUE TO THE FACT THAT THE PLANT INCLUDES ALL THE DIFFERENT COLLECTION OF FORSU AND ITS PRELIMINARY TREATMENT IN THE FIELD OF THE ANAEROBIC DIGESTION PROCESS For waste preparation 2.7 tons are needed. Of water / t. Of organic waste Approximately 22.5% of incoming waste is separated and sent to other treatment facilities. Then another 10% is separated by a grid / disseller, which is disposed in a landfill and does not enter the anaerobic digestion process. Part of the incoming biomass (Suspended Solids = Dry Substance) is then disposed of as process water, while about 15% is converted into biogas. 9534 t. FORSU 12,206 tons. FORSU entry -> 9,534 tons. BM useful

	Supply	AC = Agricultural activities + By-products of the agro-food industry	AC = Agricultural activities +Sewage sludge +By-products of the food agro-food industry of meat	AC = Agricultural activities +By-products of the agro-food sughar industry	AC = Agricultural activities +By-products of the agro-food sughar industry	AC = Agricultural activities +By-products of the agro-food sughar industry	C = Agricultural activities + Sewage sludge + Small part of plant and animal waste	C: Sewage sludge + Small part of plant and animal waste	F = BIOGAS DA FORSU Organic fraction urban soil waste
	Supply type code	AC	AC	AC	AC	AC	C	C	F
	Organic fraction urban waste (t./year)	0	0	0	0	0	0	0	9.534
	Seasoned wood from forest/arboricolture (t./year)	0	0	0	0	0	0	0	0
	Seasoned wood byproducts (t./year)	0	0	0	0	0	0	0	0
INPUT	Silated maize (t./year)	5.000	1.500	3.300	3.300	3.300	15	0	0
	Silated sorghum (t./year)	0	1.500	0	0	0	0	0	0
	Silated tritical (t./year)	0	1.000	0	0	0	0	0	0
	Cow manure (t./year)	0	0	0	0	0	16	5.009	0
	Cow slurry (t./year)	0	0	0	0	0	936	10.017	0
	Pork slurry (t./year)	0	5.830	0	0	0	0	0	0
	Vegetal co-substrates (t./year)	0	0	0	0	0	14	540	0
	Surpressed sugar pulps (t./year)	0	0	21.000	21.000	21.000	0	0	0
	Sugary melass (t./year)	0	0	990	990	990	0	0	0
	Must of grapes (t./year)	100	0	0	0	0	0	0	0
	Pig fat for food use (t./year)	0	562	0	0	0	0	0	0
	Pork pouch (t./year)	0	2.916	0	0	0	0	0	0
	Bovine rumen content (t./year)	0	556	0	0	0	0	0	0
	Total quantity of biomass ready in entry (t./year)	5100	13.923	25.290	25.290	25.290	981	15.565	9.534

SUPPLY CARACHTERSTICS	Silated maize needed (t./year)	5000	4000	3300	3300	3300	15,2	0	0
	Agricultural maize productivity - regional average.agri.statistics = 40 t./ha/year	40	40	47	50	60	30,4	0	0
	Fresh wood productivity (t./ha/year)	0	0	0	0	0	0	0	0
	Seasoned wood productivity (t./ha/year)	0	0	0	0	0	0	0	0
	Forest-seasoning site truck type	0	0	0	0	0	0	0	0
	Main truck type	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U
	Main truck load capacity (t./truck)	20	20	20	20	20	20	20	20
	Unitary diesel consumption road truck transport (liters / km) = 0.333 liters / km	0,333	0,333	0,333	0,333	0,333	0,333	0,333	0,333
	Linear kilometers for field machining 1 pass = 5 km / ha	5	5	5	5	5	5	0	0
	Linear consumption unit tractor: 12.5 liters / hour for 15 km / hour = 0.85 liters / km	0,85	0,85	0,85	0,85	0,85	0,85	0,85	0,85
	Number of roundtrips (agricultural, livestock or forestry) of the truck (specific formulas for each one) (num.)	250	494	165	165	165	49	778	0
	Number of roundtrips (industrial or urban) of the truck (specific formulas for each one) (num.)	5	0	1.100	1.100	1.100	1	0	477
	SAU - agricultural cultivated used land (ha / year)	125	100	70	66	55	0,5	0	0
	SFUC - forest/arboricolture used land (ha / year))	0	0	0	0	0	0	0	0
	SU- coltivated/used total surface = SAU+ SFUC (ha/year)	125	100	70	66	55	1	0	0
	Animal units used (txt)	0	nd	0	0	0	42 UBA - unità bovine adulte	779 UBA - unità bovine adulte	0
	Population served for organic waste collecting (eq.inhab)	0	0	0	0	0	0	0	nd
	Territorial cover served (txt)	//	//	//	//	//	//	//	37 comuni dell'Alto Adige
	Medium roundtrip distance for agro-zoo-forest (km)	12	15	10	2	10	2	50	0
	Medium roundtrip distance for industrial-urban (km)	40	1	100	1	1	1	0	75

	Declared diesel agricultural unitary consumption for agricoltural cultivation+collection or for forestry (liters / ha)	120	120	120	113	120	63	0	0
	Mediated ENAMA diesel agricultural unitary consumption for agricoltural cultivation+collecting or for forestry (liters / ha)	400	400	400	400	400	400	400	0
INPUT ::: CONSUME FOR SUPPLY AGRO-ZOO-FOREST = COLTIVATION/COLLECTING + TRANSPORT	Declared total diesel consumption for agricoltural cultivation+collecting (liters/year)	10.375	8.000	8.400	7.458	6.600	0	0	0
	Mediated ENAMA total diesel consumption for agricoltural cultivation+collecting (liters/year)	50.000	40.000	28.085	26.400	22.000	200	0	0
	USED diesel CONSUMPTION: AVERAGE - Total diesel consumption for agricoltural-zoo-forest CULTIVATION/EXPLOITATION (liters / year)	30.188	24.000	18.243	16.929	14.300	100	0	0
	USED diesel CONSUMPTION: Calculated total diesel consumption for industrial-urban TRANSPORT (liters / year)	67	0	36.613	366	366	0	0	11.906
	Declared total diesel consumption for transport (liters/year)	137	0	1190	224	748	0	9145	0
	Calculated total diesel consumption for agri-zoo-forest transport (liters/year)	624	500	351	330	275	2	0	0
	Calculated/Declared total diesel consumption for industrial-urban transport (liters/year)	67	0	36.613	366	366	0	0	11.906
INPUT ::: LINEAR KM FOR SUPPLY AGRO-ZOO-FOREST = COLTIVATION/COLLECTING + TRANSPORT	(A) - Total agricoltural linear kilometers considering 2 trip/ha (cultivation+collecting) (km/year)	1.250	1.000	702	660	550	5	0	0
	(B) - Total agricoltural linear kilometers considering 4 trip/ha (preparation+working+cultivation+collecting) (km/year)	2.500	2.000	1.404	1.320	1.100	10	0	0
	NOTE: from the above 2 string you can under stand why consumption per hectare of ENAMA are = 400 liters / ha , while the consumption calculated according to the data provided is around 113-120 liters / ha								
	Total agri-zoo-forest linear km for cultivation-collecting [(A+B)/2] - (km/year)	1.875	1.500	1.053	990	825	8	0	0
	Total industrial-urban linear km for collecting - (km/year)	200	0	109.950	1.100	1.100	1	0	35.753
	Total transport km - (km/year)	3.200	7.417	111.600	1.430	2.750	99	38.913	35.753

INSIDE PLANT CONSUMPTION AND KM INTERNI ALL'IMPIANTO	Electric energy taken from the national electricity grid (kWh / year)	0	0	0	0	0	1.980	26.700	134.750
	Diesel internal consumption (liters/year)	4288	0	12.000	12.000	12.000	0	0	8.500
	Total linear treaded kilometers inside plant (km/year)	1428	0	30.000	30.000	30.000	0	0	0
PRIMARY ENERGY OUTPUT	Total electric energy production (kWh/year)	1.992.000	7.104.000	7.992.000	7.992.000	7.992.000	58.500	1.761.300	6.960.000
	Electricity autoconsumption (%)	11%	10%	7%	7%	7%	20%	15%	15%
	Electricity supplied in grid (kWh / year)	1.772.880	6.393.600	7.432.560	7.432.560	7.432.560	46.800	1.497.105	5.916.000
	Electricity autoconsumed (kwh / year)	219.120	710.400	559.440	559.440	559.440	11.700	264.195	1.044.000
	Total thermal useful energy produced (kWh / year)	2.096.000	7.312.000	8.188.000	8.188.000	8.188.000	84.600	1.920.777	7.559.631
	% thermal energy supplied in remote heating grid (%)	0,0%	0,0%	7,0%	7,0%	7,0%	15,0%	35,0%	33,0%
	% thermal energy autoconsumed (%)	0,0%	25,0%	10,0%	10,0%	10,0%	65,5%	38,5%	25,0%
	% thermal energy not used (%)	100,0%	75,0%	83,0%	83,0%	83,0%	19,5%	26,5%	42,0%
	% thermal energy supplied in remote heating grid (kWh / year)	0	0	573.160	573.160	573.160	12.690	672.272	2.494.678
	% thermal energy autoconsumed (kWh / year)	0	1.828.000	820.000	820.000	820.000	55.411	739.526	1.889.908
	% thermal energy not used (kWh / year)	2096000	5484000	6.794.840	6.794.840	6.794.840	16.499	508.979	3.175.045
	Thermodinamicaly lost energy (kWh / year)	1.152.000	4.120.000	3.408.000	3.408.000	3.408.000	69.750	1.022.250	6.895.754
	Total energy input with starting biomass (=electricity+thermal+lost) (kWh / year)	5.240.000	18.536.000	19.588.000	19.588.000	19.588.000	212.850	4.704.327	21.415.385
PRIMARY OUTPUT BIOGAS/CH4	Biogas production (t. /year)	1660	3.124	4.690	4.690	4.690	52	1.113	nd
	CH4 production (t. /year)	747	2.030	1.272	1.272	1.272	29	338	nd
	% CH4 content inside biogas (5)	45,0%	65,0%	27,1%	27,1%	27,1%	56,0%	30,3%	nd
	Apparatus for purification of CH4 for direct sells (YES/NO)	NO	NO	NO	NO	NO	NO	NO	NO

OUTPUT 2° ::: DIGESTATE	% Digestate production respect starting input biomass (%)	67,45%	14%	81%	81%	81%	85%	93%	21%
	Digestate production (t. /year)	3440	1.896	20.600	20.600	20.600	830	14.452	1.962
	Digestate destination (agricolture spreading, composting, ..)	Spandimento agricolo	Spandimento agricolo	Spandimento agricolo	Spandimento agricolo	Spandimento agricolo	Spandimento agricolo	Spandimento agricolo	Compostaggio
	Digestate DB Ecoinvent reference	Digested matter, application in agriculture/CH U	Digested matter, application in agriculture/CH U	Digested matter, application in agriculture/CH U	Digested matter, application in agriculture/CH U	Digested matter, application in agriculture/CH U	Digested matter, application in agriculture/CH U	Digested matter, application in agriculture/CH U	0
	Agticoltural hectares needed to digestate spreading (not vulnerable zone) (ha)	32	362	293	300	417	30	170	0
	Agticoltural hectares needed to digestate spreading (vulnerable zone) (ha)	0	0	0	0	0	0	0	0
OUTPUT 2° ::: DIGESTATE ::: CONSUMPTION AND KM	Average roundtrip distance plant-spreading fields (km)	12	20	26	15,5	40	1	//	170
	Unitary diesel consumption for digestate spreading in to agricoltural fields (liters/ha)	40	55	55	55	55	63	60	0
	Main truck type	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U
	Tractor for digestate spreading type	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U
	Total diesel consumption for digestate transport (liters / year)	702	632	10.547	6.361	16.480	0	357	4.533
	Total diesel consumption for digestate spreading (liters / year)	1280	723	16.104	16.500	22.955	1.877	10.200	0
	Total kilometers for digestate transport (liters / year)	3440	1.896	13.184	7.952	20.600	0	850	13.589
	Total kilometers for digestate spreading (liters / year)	162	1.808	1.464	1.500	2.087	3.754	850	0
OUTPUT 2° ::: WASTE AND ASH	Poduced waste - main types and wuantities (txt)	nd	15,000 t. H2O discharged into the sewage treatment plant + 0.015 tons. KIT (cod.CER = 160605) to incinerator + 1 t. Engine oil (code CER = 130205) to incinerator	nd	nd	nd	0	0	* Biomass to be directly landfilled (808 t / a);* Biomass to be conferred to other treatment facilities (1.174 tons); * Biomass as to confer on sewage depurator (690 t / yr);** Consumption and km counted in incoming consumption / supply **Grilled to be handed over to landfill (647 t / year)+Sand to be landfilled (698 t / year)
	% Wood ash respect starting input wood biomass (%)	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
	Wood ash (t. / year)	0	0	0	0	0	0	0	0
OUTPUT 2° ::: WASTE AND ASH ::: CONSUMPTION AND KM	Destination for wood ashes	nd	depuratore + inceneritore	nd	nd	nd	nd	nd	discarica+depuratore+altri impianti
	Average roundtrip distance for waste and/or ashes	nd	240	nd	nd	nd	0	0	60
	Total diesel consumption for waste disposal or ash destination (liters / year)	0	24	0	0	0	0	0	1.050
	Total kilometers consumption for waste disposal or ash destination (km / year)	0	240	0	0	0	0	0	4.200

SINTHESYS CONSUMPTION AND KM ::: INPUT+INTERNAL+OUTPUT	Total INPUT diesel consumption (liters / year)	30.254	24.000	54.856	17.295	14.666	100	0	11.906
	Total INPUT kilometers treaded (km / year)	5.275	8.917	222.603	3.519	4.674	107	38.913	71.505
	Total INTERNAL diesel consumption (liters / year)	4.288	0	12.000	12.000	12.000	0	0	8.500
	Total INTERNAL kilometers treaded (km / year)	1.428	0	30.000	30.000	30.000	0	0	0
	Total OUTPUT diesel consumption (liters / year)	1.982	1.379	26.651	22.861	39.435	1.877	10.557	5.583
	Total OUTPUT kilometers treaded (km / year)	3.602	3.944	14.648	9.452	22.687	3.754	1.700	17.789
TOTAL TOTAL CONSUMPTION + KM	TOTAL DIESEL CONSUMPTION (liters/year)	36.524	25.379	93.507	52.156	66.101	1.977	10.557	25.989
	TOTAL KILOMETERS TREADED (km/year)	10.305	12.861	267.251	42.971	57.361	3.861	40.613	89.294

4.1.2. SOLID WOOD COMBUSTION biomass plants

MODULE	FIELDS	CA.FFF	CA.OOO	PCPP_P-8000	PCPP_P-21601	PCPP_P-43203	PCPP_F-102606	WPK
ANAGRAFIC	Arpae ID Code	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Arpae reference links	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Arpae compilator	Luca Vignoli	Luca Vignoli	Luca vignoli	Luca vignoli	Luca vignoli	Luca vignoli	Luca vignoli
	Identification code of the data source	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Info source	Ronchini, 2010, a	Ronchini, 2010, a	PWCP, 2016, a.	PWCP, 2016, a.	PWCP, 2016, a.	PWCP, 2016, a.	WPK, 2016, a.
	Updating	2010	2010	2016	2016	2016	2016	2016
	Business name	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Fiscal code	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Manager	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Address	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Municipality	Castel d'Aiano	Castel d'Aiano	Russi	Russi	Russi	Russi	San Piero in Bagno
	Province	BO	BO	RA	RA	RA	RA	FC
	Telephone	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	E-mail	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Website	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Start activity	2010	2010	nd	nd	nd	nd	nd
	End incentives	nd	nd	nd	nd	nd	nd	nd
FRAMEWORK	Local unit (Unique reference name)	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Authorisation	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy	Privacy
	Status of activity	in esercizio	in esercizio	in costruzione	in costruzione	in costruzione	in costruzione	in progetto
	Latitude	44.2825073392	44.2825073392	44.384525	44.384525	44.384525	44.384525	43.838140
	Longitude	10.9920852471	10.9920852471	12.018342	12.018342	12.018342	12.018342	11.965167
	Type of plant	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa	BIOMASSE SOLIDE: gassificazione e successiva combustione di biomassa legnosa
	Arpae sensitivity map zone	ROSSA	ROSSA	GREEN	GREEN	GREEN	GREEN	ROSSA
	Air quality zone (DAL.51.2011)	GREEN	GREEN	YELLOW	YELLOW	YELLOW	YELLOW	GREEN
	Authorized Electric Power (kW)	35,0	35,0	30.000,0	30.000,0	30.000,0	30.000,0	200,0
	Useful / dissiptable thermal power (kW)	140,0	140,0	92.900,0	92.900,0	92.900,0	92.900,0	200,0
	Lost Power (kW)	25,0	25,0	15.000,0	15.000,0	15.000,0	15.000,0	100,0
	Total power (el + therm + lost) (kW)	200,0	200,0	137.900,0	137.900,0	137.900,0	137.900,0	500,0
	% electric power	17,5%	17,5%	21,8%	21,8%	21,8%	21,8%	40,0%
	% Useful thermal power	70,0%	70,0%	67,4%	67,4%	67,4%	67,4%	40,0%
	% Lost power	12,5%	12,5%	10,9%	10,9%	10,9%	10,9%	20,0%
	Cogeneration (YES / NO)	YES	YES	YES	YES	YES	YES	YES
	District heating (YES / NO - IN SMALL PORTION)	YES	YES	YES	YES	YES	YES	YES
	Operating hours per year (hours / year)	6.000	6.000	8.000	8.000	8.000	8.000	8.000

DESCRIPTION	Description	WOOD BIOMASSES: In addition to producing electricity, it provides heat in district heating A school, a communal pool, and a gym. SCENARIO -FFF- Distance 7.5 km for 100% wood The incoming wood biomass reported here is seasoned. The consumption for cutting, exhumation and picking are coming to the incoming transport 818.2 tons. Fresh wood = Fresh wood (50% robinia, 50% poplar): 818.2 tonnes / year from forest maintenance. ... which, after maturation, lose 45% of water -> = Dried forestwood chips: total 450 tons. /year	WOOD BIOMASSES: In addition to producing electricity, it provides heat in district heating A school, a communal pool, and a gym. SCENARIO -OOO- Distance 61 km for 70% wood + 135 tons. SEGHERIA SHOES for 30% wood The incoming wood biomass reported here is seasoned. Cutting consumables, exhumation and cuttings are similar to inbound transport 527.7 tons. Fresh wood + 135 t. Seasoned sawdust waste = Fresh wood (50% robinia, 50% poplar): 572.7 tonnes / year from forest maintenance Which then thanks to the seasoning Lose 45% of water -> = 315 tons. Dried chips + Sawdust waste = 135 t / year = Dried wood chips From forest maintenance: In total 450 tons. /year	WOOD BIOMASSES: Plant powered by -woody chips obtained from poplar cultivation 492,509 tons. Fresh wood = 270880 t. Seasoned wood	WOOD BIOMASSES: Plant powered by -woody chips obtained from poplar cultivation 492,509 tons. Fresh wood = 270880 t. Seasoned wood	WOOD BIOMASSES: Plant powered by -woody chips obtained from poplar cultivation 492,509 tons. Fresh wood = 270880 t. Seasoned wood	WOOD BIOMASSES: Plant powered by -woody chips obtained from forest exploitation 492,509 tons. Fresh wood = 270880 t. Seasoned wood	WOOD BIOMASSES: Plant powered by -woody chips obtained from forest exploitation 6800 t. fresh wood = 4000 t. Seasoned wood

INPUT	Supply	W = Wood burning combustion forest	W = Wood burning combustion forest + Scraps of non-food sawmill industry	W = Wood burning firewood from arboriculture (Poplar)	W = Wood burning firewood from arboriculture (Poplar)	W = Wood burning firewood from arboriculture (Poplar)	W = Wood burning firewood from forestry exploitation	W = Wood burning firewood from forestry exploitation
	Supply type code	W	W	W	W	W	W	W
	Organic fraction urban waste (t./year)	0	0	0	0	0	0	0
	Seasoned wood from forest/arboricolture (t./year)	450	315	270.880	270.880	270.880	270.880	4.000
	Seasoned wood byproducts (t./year)	0	135	0	0	0	0	0
	Silated maize (t./year)	0	0	0	0	0	0	0
	Silated sorghum (t./year)	0	0	0	0	0	0	0
	Silated tritical (t./year)	0	0	0	0	0	0	0
	Cow manure (t./year)	0	0	0	0	0	0	0
	Cow slurry (t./year)	0	0	0	0	0	0	0
	Pork slurry (t./year)	0	0	0	0	0	0	0
	Vegetal co-substrates (t./year)	0	0	0	0	0	0	0
	Surpressed sugar pulps (t./year)	0	0	0	0	0	0	0
	Sugary melass (t./year)	0	0	0	0	0	0	0
	Must of grapes (t./year)	0	0	0	0	0	0	0
	Pig fat for food use (t./year)	0	0	0	0	0	0	0
	Pork pouch (t./year)	0	0	0	0	0	0	0
	Bovine rumen content (t./year)	0	0	0	0	0	0	0
	Total quantity of biomass ready in entry (t./year)	450	450	270.880	270.880	270.880	270.880	4.000

	Silated maize needed (t./year)	0	0	0	0	0	0	0
	Agricultural maize productivity - regional average.agri.statistics = 40 t./ha/year	0	0	0	0	0	0	0
	Fresh wood productivity (t./ha/year)	4,80	4,80	62,00	22,80	11,40	4,80	
	Seasoned wood productivity (t./ha/year)	2,64	2,64	34,00	12,54	6,27	2,64	
	Forest-seasoning site truck type	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U	Transport, tractor and trailer/CH U
	Main truck type	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U
	Main truck load capacity (t./truck)	20	20	35	35	35	35	20
	Unitary diesel consumption road truck transport (liters / km) = 0.333 liters / km	0,333	0,333	0,333	0,333	0,333	0,333	0,333
	Linear kilometers for field machining 1 pass = 5 km / ha	5	5	5	5	5	5	5
	Linear consumption unit tractor: 12.5 liters / hour for 15 km / hour = 0.85 liters / km	0,85	0,85	0,85	0,85	0,85	0,85	0,85
	Number of roundtrips (agricultural, livestock or forestry) of the truck (specific formulas for each one) (num.)	23	16	7.739	7.739	7.739	7.739	200
	Number of roundtrips (industrial or urban) of the truck (specific formulas for each one) (num.)	0	7	0	0	0	0	0
SUPPLY CARACHTERSTICS	SAU - agricultural cultivated used land (ha / year)	0	0	0	0	0	0	0
	SFUC - forest/arboricolture used land (ha / year))	170	119	8.000	21.601	43.203	102.606	1.515
	SU- coltivated/used total surface = SAU+ SFUC (ha/year)	170	119	8.000	21.601	43.203	102.606	1.515
	Animal units used (txt)	0	0	0	0	0	0	0
	Population served for organic waste collecting (eq.inhab)	0	0					0
	Territorial cover served (txt)	//	//					0
	Medium roundtrip distance for agro-zoo-forest (km)	15	121,6	100	100	100	100	45
	Medium roundtrip distance for industrial-urban (km)	0	1	0	0	0	0	0

	Declared diesel agricultural unitary consumption for agricoltural cultivation+collection or for forestry (liters / ha)	0	0	1,42	1,42	1,42	1,42	1,42
	Mediated ENAMA diesel agricultural unitary consumption for agricoltural cultivation+collecting or for forestry (liters / ha)	0	0	1,42	1,42	1,42	1,42	1,42
INPUT ::: CONSUME FOR SUPPLY AGRO-ZOO-FOREST = COLTIVATION/COLLECTING + TRANSPORT	Declared total diesel consumption for agricoltural cultivation+collecting (liters/year)	4.775	3.828	11.322	30.571	61.142	145.213	58.100
	Mediated ENAMA total diesel consumption for agricoltural cultivation+collecting (liters/year)	0	0	11.322	30.571	61.142	145.213	2.144
	USED diesel CONSUMPTION: AVERAGE - Total diesel consumption for agricoltural-zoo-forest CULTIVATION/EXPLOITATION (liters / year)	2.387	1.914	11.322	30.571	61.142	145.213	30.122
	USED diesel CONSUMPTION: Calculated total diesel consumption for industrial-urban TRANSPORT (liters / year)	0	2	0	0	0	0	0
	Declared total diesel consumption for transport (liters/year)	459	594	nd	nd	nd	nd	nd
	Calculated total diesel consumption for agri-zoo-forest transport (liters/year)	284	199	13.320	35.966	71.932	170.839	2.522
	Calculated/Declared total diesel consumption for industrial-urban transport (liters/year)	0	2	0	0	0	0	0
INPUT ::: LINEAR KM FOR SUPPLY AGRO-ZOO-FOREST = COLTIVATION/COLLECTING + TRANSPORT	(A) - Total agricoltural linear kilometers considering 2 trip/ha (cultivation+collecting) (km/year)	0	0	80.000	216.013	432.026	1.026.061	15.150
	(B) - Total agricoltural linear kilometers considering 4 trip/ha (preparation+working+cultivation+collecting) (km/year)	0	0	160.000	432.026	864.051	2.052.121	30.300
	NOTE: from the above 2 string you can under stand why consumption per hectare of ENAMA are = 400 liters / ha , while the consumption calculated according to the data provided is around 113-120 liters / ha							
	Total agri-zoo-forest linear km for cultivation-collecting [(A+B)/2] - (km/year)	852	597	40.000	108.006	216.013	513.030	7.575
	Total industrial-urban linear km for collecting - (km/year)	0	7	0	0	0	0	0
	Total transport km - (km/year)	338	1.922	773.943	773.943	773.943	773.943	14.800

INSIDE PLANT CONSUMPTION AND KM INTERNI ALL'IMPIANTO	Electric energy taken from the national electricity grid (kWh / year)	0	0	0	0	0	0	0
	Diesel internal consumption (liters/year)	0	0	0	0	0	0	0
	Total linear treaded kilometers inside plant (km/year)	0	0	0	0	0	0	0
PRIMARY ENERGY OUTPUT	Total electric energy production (kWh/year)	210.000	210.000	240.000.000	240.000.000	240.000.000	240.000.000	1.600.000
	Electricity autoconsumption (%)	15%	15%	10%	10%	10%	10%	15%
	Electricity supplied in grid (kWh / year)	178.500	178.500	216.000.000	216.000.000	216.000.000	216.000.000	1.360.000
	Electricity autoconsumed (kwh / year)	31.500	31.500	24.000.000	24.000.000	24.000.000	24.000.000	240.000
	Total thermal useful energy produced (kWh / year)	840.000	840.000	743.200.000	743.200.000	743.200.000	743.200.000	1.600.000
	% thermal energy supplied in remote heating grid (%)	65,0%	65,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	% thermal energy autoconsumed (%)	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
	% thermal energy not used (%)	35,0%	35,0%	100,0%	100,0%	100,0%	100,0%	100,0%
	% thermal energy supplied in remote heating grid (kWh / year)	546.000	546.000	0	0	0	0	0
	% thermal energy autoconsumed (kWh / year)	0	0	0	0	0	0	0
	% thermal energy not used (kWh / year)	294.000	294.000	743.200.000	743.200.000	743.200.000	743.200.000	1.600.000
	Thermodinamicaly lost energy (kWh / year)	150.000	150.000	120.000.000	120.000.000	120.000.000	120.000.000	800.000
	Total energy input with starting biomass (=electricity+thermal+lost) (kWh / year)	1.200.000	1.200.000	1.103.200.000	1.103.200.000	1.103.200.000	1.103.200.000	4.000.000
PRIMARY OUTPUT BIOGAS/CH4	Biogas production (t. /year)	//	//	//	//	//	//	//
	CH4 production (t. /year)	//	//	//	//	//	//	//
	% CH4 content inside biogas (5)	//	//	//	//	//	//	//
	Apparatus for purification of CH4 for direct sells (YES/NO)	//	//	//	//	//	//	//

OUTPUT 2° ::: DIGESTATE	% Digestate production respect starting input biomass (%)	#	#	#	#	#	#	#
	Digestate production (t. /year)	#	#	#	#	#	#	#
	Digestate destination (agricolture spreading, composting, ..)	#	#	#	#	#	#	#
	Digestate DB Ecoinvent reference	#	#	#	#	#	#	#
	Agticoltural hectares needed to digestate spreading (not vulnerable zone) (ha)	#	#	#	#	#	#	#
	Agticoltural hectares needed to digestate spreading (vulnerable zone) (ha)	#	#	#	#	#	#	#
OUTPUT 2° ::: DIGESTATE ::: CONSUMPTION AND KM	Average roundtrip distance plant-spreading fields (km)	#	#	#	#	#	#	#
	Unitary diesel consumption for digestate spreading in to agricoltural fields (liters/ha)	#	#	#	#	#	#	#
	Main truck type	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U	Transport, lorry 16-32t, EURO4/RER U
	Tractor for digestate spreading type	0	0	0	0	0	0	0
	Total diesel consumption for digestate transport (liters / year)	0	0	0	0	0	0	0
	Total diesel consumption for digestate spreading (liters / year)	0	0	0	0	0	0	0
	Total kilometers for digestate transport (liters / year)	0	0	0	0	0	0	0
	Total kilometers for digestate spreading (liters / year)	0	0	0	0	0	0	0
OUTPUT 2° ::: WASTE AND ASH	Poduced waste - main types and wuantities (txt)	wood ash: 13,5 t./anno	Wood ash: 13,5 t./anno	wood ash 5% of seasoned wood chips input / year	wood ash 5% of seasoned wood chips input / year	wood ash 5% of seasoned wood chips input / year	wood ash 5% of seasoned wood chips input / year	wood ash 5% of 4000 tons. seasoned wood chips input / year
	% Wood ash respect starting input wood biomass (%)	3,00%	3,00%	5,00%	5,00%	5,00%	5,00%	5,00%
	Wood ash (t. / year)	14	14	13.544	13.544	13.544	13.544	200
OUTPUT 2° ::: WASTE AND ASH ::: CONSUMPTION AND KM	Destination for wood ashes	Discarica	Discarica	Fertilizzazione	Fertilizzazione	Fertilizzazione	Fertilizzazione	Fertilizzazione boschiva
	Average roundtrip distance for waste and/or ashes	332	332	100	100	100	100	50
	Total diesel consumption for waste disposal or ash destination (liters / year)	1.953	1.953	12.886	12.886	12.886	12.886	167
	Total kilometers consumption for waste disposal or ash destination (km / year)	664	664	38.697	38.697	38.697	38.697	500

SINTHESYS CONSUMPTION AND KM ::: INPUT+INTERNAL+OUTPUT	Total INPUT diesel consumption (liters / year)	2.387	1.916	11.322	30.571	61.142	145.213	30.122
	Total INPUT kilometers treaded (km / year)	1.190	2.525	813.943	881.949	989.956	1.286.973	22.375
	Total INTERNAL diesel consumption (liters / year)	0	0	0	0	0	0	0
	Total INTERNAL kilometers treaded (km / year)	0	0	0	0	0	0	0
	Total OUTPUT diesel consumption (liters / year)	1.953	1.953	12.886	12.886	12.886	12.886	167
	Total OUTPUT kilometers treaded (km / year)	664	664	38.697	38.697	38.697	38.697	500
TOTAL TOTAL CONSUMPTION + KM	TOTAL DIESEL CONSUMPTION (liters/year)	4.340	3.869	24.208	43.457	74.029	158.099	30.289
	TOTAL KILOMETERS TREADED (km/year)	1.854	3.189	852.640	920.646	1.028.653	1.325.670	22.875

5. BIOGAS: STANDARD PLANTS AND SUPPLIES

To create standard supplies we have create a dynamic formulas table where it is possible write the main variables (yellow cells) to obtain the needed quantities of each biomass types to make work a standard biogas plant of 1 MW.el power for 8000 hours.

- Before all we have used data from CRPA, Piemonte Region Agricolture Office and LaboratorioBiomasse.it bibliography to create a formula table to calculate yields of different biomass (like such, or like volatile solids). For this see tab. A.
- Then we created another formula table where is possible obtain the needed quantities of each biomass types to make work a standard plant of 1MW.el power for 8000 hours. For this see tab. B.
- Then we created specific formula table for calculation of biomass input needed by a 1 MW.el biogas plant supplied for the STANDARD PLANTS with mix of supplies that represent a realistic mix input of different types of biomass input.
- Then we created the relative profiles of the related standard biogas plants productive chains, so to implement their data in to the LCA software.
- Like for case studies the implementation on LCA software has been done with truck and tractor types of Ecoinvent database, misured in kgkm (t.km).

- So, at the end, we will can multiply the different LCA-Ecoindicators'99 impacts/damages results for the electric biogas plants regional main systems power and/or energy production to obtain his overall ESTIMED impact in terms of LCA environmental values.

To create standard supplies we have create a dynamic formulas table where it is possible write the main variables (yellow cells) to obtain the needed quantities of each biomass types to make work:

NOTE: in the cases of organic waste and agro-food / orto-fruit byproducts productions we have used the productivity value of 1.000.000,000 t./ha/year , so to make practically null the correlated land use needed hectares, because their production is not correlated to agricultural field areas; In this way the mathematical formulas inside the table work good and don't shows numeric errors.

5.1. Formulas used to estimate standard biogas plants supplies

5.1.1. Biogas formulas

TAB (A) for methan yield from biomass as it is input

.	BM tal quale (t.)	ST %	H2O %	ST (t.)	SV/ST - %
BiomassaCH4: f (SV)	1,0	14,60%	85,40%	0,15	86,30%
BiomassaCH4: f (BM)	1,0				. --> . --> . -->

	C (% su ST)	N (% su ST)	N-NH4 (% su ST)	..-->-->-->	Contenuto di C (t. / t. BM)
Nutrienti presenti: f (ST)	46,30%	1,60%			0,463

.	SV (t.)	SV/BM %	SV Resa in metano CH4 m3/t. SV	Metano prodotto CH4 (m3)	Resa in CH4 della BM tal quale	
BiomassaCH4: f (SV)	0,13	12,60%	360,4	45,4	45,41	http://www.crea.it/media/documents/crea_www/Settori/Ambiente/Download/Archivi…
BiomassaCH4: f (BM)				75,0	75,0	http://www.laboratoriobiomasse.it/media/docs/downloads/103-1.pdf
	Contenuto di N (t. / t. BM)	Contenuto di N-NH4 (t. / t. BM)				
Nutrienti presenti: f (ST)	0,016	0				http://www.regione.piemonte.it/agri/comunicazione/quaderni/num77/dwd/Agricoltur…

TAB (B) for calculation of biomass input for biogas plants with an installed electric power = 1 MW.el * 8.000 hours

BM only 1 type , as it is	BM as it is : YIELD in methane m3 CH4 /t. biomass as it is	kWh / m3 CH4	kWh tot	MWh tot	Plant electric YIELD	MWh.elettric produced / t. biomass as it is	MW.el Electric power plant installed	Work hours	MWh.el produced from 1 MW.el * X = MWh.el prod	Tons. of biomass needed a plant of 1 Mw.el installed that works for X hours	http://www.laboratoriobiomasse.it/media/docs/downloads/103-1.pdf
SILAGE MAIZE	**75**	**9,91**	**743,25**	**0,74**	**40%**	**0,30**	**1,00**	**8.000**	**8.000**	**26.909**	
SILAGE SORGHUM	**70**	**9,91**	**693,7**	**0,69**	**40%**	**0,28**	**1,00**	**8.000**	**8.000**	**28.831**	
ORTO-FRUIT WASTE	**30**	**9,91**	**297,3**	**0,30**	**40%**	**0,12**	**1,00**	**8.000**	**8.000**	**67.272**	
AGRI-FOOD IND.BYPRODUCTS	**125**	**9,91**	**1238,75**	**1,24**	**40%**	**0,50**	**1,00**	**8.000**	**8.000**	**16.145**	
Residues from processing of fruit juices	100	9,91	991,0	0,99	40%	0,40	1,00	8.000	8.000	20.182	
Waste processing fruit and vegetables	30	9,91	297,3	0,30	40%	0,12	1,00	8.000	8.000	67.272	
Molasses	150	9,91	1.486,5	1,49	40%	0,59	1,00	8.000	8.000	13.454	
Residues of potato processing residues	17,5	9,91	173,4	0,17	40%	0,07	1,00	8.000	8.000	115.324	
Hulls tomato	50	9,91	495,5	0,50	40%	0,20	1,00	8.000	8.000	40.363	
Residues from the distillation of cereals	15	9,91	148,7	0,15	40%	0,06	1,00	8.000	8.000	134.544	
Brewers grains	30	9,91	297,3	0,30	40%	0,12	1,00	8.000	8.000	67.272	
Serum	10	9,91	99,1	0,10	40%	0,04	1,00	8.000	8.000	201.816	
Cellulose pulp	30	9,91	297,3	0,30	40%	0,12	1,00	8.000	8.000	67.272	
Straw	200	9,91	1.982,0	1,98	40%	0,79	1,00	8.000	8.000	10.091	
Vegetation water	6,5	9,91	64,4	0,06	40%	0,03	1,00	8.000	8.000	310.487	
ORGANIC WASTE	**100**	**9,91**	**991**	**0,99**	**40%**	**0,40**	**1,00**	**8.000**	**8.000**	**20.182**	
FORSU: organic fraction of municipal solid waste	**75**	9,91	743,3	0,74	40%	**0,30**	1,00	8.000	8.000	26.909	
Catering waste	**100**	9,91	991,0	0,99	40%	**0,40**	1,00	8.000	8.000	20.182	
Pig stomach contents	**50**	9,91	495,5	0,50	40%	**0,20**	1,00	8.000	8.000	40.363	
Rumen contents	**75**	9,91	743,3	0,74	40%	**0,30**	1,00	8.000	8.000	26.909	
Pig blood	**50**	9,91	495,5	0,50	40%	**0,20**	1,00	8.000	8.000	40.363	
In hatchery waste	**75**	9,91	743,3	0,74	40%	**0,30**	1,00	8.000	8.000	26.909	
Broken eggs	**100**	9,91	991,0	0,99	40%	**0,40**	1,00	8.000	8.000	20.182	
COW SLURRRY	**25**	**9,91**	**247,75**	**0,25**	**40%**	**0,10**	**1,00**	**8.000**	**8.000**	**80.727**	
COW MANURE	**25**	**9,91**	**247,75**	**0,25**	**40%**	**0,10**	**1,00**	**8.000**	**8.000**	**80.727**	
PIG SLURRY	**15**	**9,91**	**148,65**	**0,15**	**40%**	**0,06**	**1,00**	**8.000**	**8.000**	**134.544**	

	Manure&Slurry productivity:	Number of Animals needed for 8000 MWh.electricity
cows slurry	10	8.073
cows manure	13	6.210
pigs slurry	3	44.848

5.1.2. Biogas standard plants supplies

TAB (C1) for calculation of biomass input needed by a 1 MW.el biogas plant supplied with SILAGE MAIZE 100%							
	tons. of INPUTs	% tons. of INPUTs	MWh.electricity produced	% MWh.el produced	- 10 % plant autoconsumption = MWh.el erogated		
SILAGE MAIZE	26.909	100,0%	8.000	100,0%	7.200		
TOTAL	26.909	100,0%	8.000	100,0%	7.200		

TAB (C2) for calculation of biomass input needed by a AGRICULTURAL C.E.CE. 1 MW.el biogas plant supplied with different types of agriculture biomasses							
	tons. of INPUTs	% tons. of INPUTs	MWh.electricity produced	% MWh.el produced	- 10 % plant autoconsumption = MWh.el erogated	*remeber that a single cow produces: slurry+manure so the number of cows is the same !!! We make a rounded average:	
SILAGE MAIZE	5.500	8,3%	1.635	20,4%	1.472		
SILAGE SORGHUM	5.500	8,3%	1.526	19,0%	1.374		
ORTO-FRUIT WASTE	0	0,0%	0	0,0%	0	Number of animals needed for each animal quantity of these single lines of manure&slurry	Average numbers of animals
AGRI-FOOD IND.BYPRODUCTS	0	0,0%	0	0,0%	0		
ORGANIC WASTE	0	0,0%	0	0,0%	0		
COW SLURRRY	20.000	30,3%	1.982	24,7%	1.784	2.000	1.769
COW MANURE	20.000	30,3%	1.982	24,7%	1.784	1.538	
PIG SLURRY	15.000	22,7%	892	11,1%	803	5.000	5.000
TOTAL	66.000	100,0%	8.017	100,0%	7.215		

TAB (C3) for calculation of biomass input needed by a 1 MW.el biogas plant supplied with AGRI-FOOD INDUSTRY BYPRODUCTS + ORTO-FRUIT WASTE							
	tons. of INPUTs	% tons. of INPUTs	MWh.electricity produced	% MWh.el produced	- 10 % plant autoconsumption = MWh.el erogated	*remeber that a single cow produces: slurry+manure so the number of cows is the same !!! We make a rounded average:	
SILAGE MAIZE	2.500	8,3%	743	9,1%	669		
SILAGE SORGHUM	2.500	8,3%	694	8,5%	624		
ORTO-FRUIT WASTE	15.000	50,0%	1.784	21,8%	1.605	Number of animals needed for each animal quantity of these single lines of manure&slurry	Average numbers of animals
AGRI-FOOD IND.BYPRODUCTS	10.000	33,3%	4.955	60,6%	4.460		
ORGANIC WASTE	0	0,0%	0	0,0%	0		
COW SLURRRY	0	0,0%	0	0,0%	0	0	0
COW MANURE	0	0,0%	0	0,0%	0	0	
PIG SLURRY	0	0,0%	0	0,0%	0	0	0
TOTAL	30.000	100,0%	8.176	100,0%	7.358		

TAB (C4) for calculation of biomass input needed by a 1 MW.el biogas plant supplied with ORGANIC WASTE							
	tons. of INPUTs	**% tons. of INPUTs**	**MWh.electricity produced**	**% MWh.el produced**	**- 10 % plant autoconsumption = MWh.el erogated**	*remeber that a single cow produces: slurry+manure so the number of cows is the same !!! We make a rounded average:	
SILAGE MAIZE	**2.500**	10,0%	**743**	**9,3%**	**669**		
SILAGE SORGHUM	**2.500**	10,0%	**694**	**8,7%**	**624**		
ORTO-FRUIT WASTE	**5.000**	20,0%	**595**	**7,5%**	**535**	**Number of animals needed for each animal quantity of these single lines of manure&slurry**	**Average numbers of animals**
AGRI-FOOD IND.BYPRODUCTS	**0**	0,0%	**0**	**0,0%**	**0**		
ORGANIC WASTE	**15.000**	60,0%	**5.946**	**74,5%**	**5.351**		
COW SLURRRY	**0**	0,0%	**0**	**0,0%**	**0**	**0**	**0**
COW MANURE	**0**	0,0%	**0**	**0,0%**	**0**	**0**	
PIG SLURRY	**0**	0,0%	**0**	**0,0%**	**0**	**0**	**0**
TOTAL	**25.000**	100,0%	**7.978**	**100,0%**	**7.180**		

5.1.3. Biogas standard plants productive chains

TAB (K1) impianti a biogas realistici standardizzati: produzione di c.a. 8000 MWh.el/anno					
		MAIZE 100%	AGRICOLTURE manure&slurry + silage maize	AGRO-FOOD INDUSTRY + ortofruit byproducts	ORGANIC WASTE
BIOGAS PLANT	Electric power installed (MW.el)	1,0	1,0	1,0	1,0
	Thermal power (MW.t)	1,0	1,0	1,0	1,0
	Lost power (MW.lost)	0,5	0,5	0,5	0,5
	Total power (MW)	2,5	2,5	2,5	2,5
	% El.p	40,0%	40,0%	40,0%	40,0%
	%.Term.p	40,0%	40,0%	40,0%	40,0%
	%Lost.p	20,0%	20,0%	20,0%	20,0%
	Work hours	8.000	8.000	8.000	8.000
	Electric energy production (MWh.el/year)	8.017	8.017	8.176	7.978
	• Electric autoconsume = 10% --> Electric energy erogated (MWh.el/year)	7.200	7.215	7.358	7.180
	Silage maize (t./year)	26.909	5.500	2.500	2.500
	Silage sorghum (t./year)	0	5.500	2.500	2.500
	Vegetal orto-fruit waste (t./year)	0	0	15.000	5.000
	Agro-food industry byproducts (t.year)	0	0	10.000	0
	Organic waste (t./year)	0	0	0	15.000
	Cow slurry (t./year)	0	20.000	0	0
	Cow manure (t./year)	0	20.000	0	0
	Pig slurry (t./year)	0	15.000	0	0
	Total biomass input (t./year)	26.909	66.000	30.000	25.000

ENERGY CROPS CULTIVATION	S.Maize Productivity (t./ha/year)	50	50	50	50
	S.Maize Hectares cultivation (ha/year)	538	110	50	50
	S.Maize Cultivation: diesel consume (liters/ha/year)	50	50	50	50
	Average tractor linear km for cultivation (km/ha/year)	25	25	25	25
	Tractor field consumption (diesel liters/km)	2,0	2,0	2,0	2,0
	S.Maize Total linear km for cultivation (km/year)	13.454	2.750	1.250	1.250
	S.Maize Total diesel consume for cultivation	26.909	5.500	2.500	2.500
	***S.Maize CultivationBIBLIOGRAFY : diesel consume (liters/ha/year)	400,0	400,0	400,0	400,0
	S.Sorghum Productivity (t./ha/year)	50	50	50	50
	S.Sorghum Hectares of s.sorghum cultivation (ha/year)	0	110	50	50
	S.Sorghum Cultivation: diesel consume (liters/ha/year)	50	50	50	50
	Average tractor linear km for cultivation (km/ha/year)	25	25	25	25
	Tractor field consumption (diesel liters/km)	2,0	2,0	2,0	2,0
	S.Sorghum Total linear km for cultivation (km/year)	0	2.750	1.250	1.250
	S.Sorghum Total diesel consume for cultivation	0	5.500	2.500	2.500
	***S.Maize CultivationBIBLIOGRAFY : diesel consume (liters/ha/year)	400,0	400,0	400,0	400,0
ORTO-FRUIT WASTE	Orto-Fruit waste Productivity (t./ha/year)	~~1.000.000,000~~	~~1.000.000,000~~	~~1.000.000,000~~	~~1.000.000,000~~
	Orto-Fruit waste cultivation (ha/year)	0	0	0	0
	Orto-Fruit waste production: diesel consume	50	50	50	50
	Average tractor linear km for cultivation (km/ha/year)	25	25	25	25
	Tractor field consumption (diesel liters/km)	2,0	2,0	2,0	2,0
	Orto-Fruit waste Total linear km for production	0	0	0	0
	Orto-Fruit waste Total diesel consume for production (liters/year)	0	0	1	0
AGRO-FOOD BYPRODUCTS	Agro-Food ind. byproducts Productivity (t./ha/year)	~~1.000.000,000~~	~~1.000.000,000~~	~~1.000.000,000~~	~~1.000.000,000~~
	Agro-Food ind. byproducts cultivation (ha/year)	0	0	0	0
	Agro-food industry byproducts production: diesel consume (liters/ha/year)	50	50	50	50
	Average tractor linear km for cultivation (km/ha/year)	25	25	25	25
	Tractor field consumption (diesel liters/km)	2,0	2,0	2,0	2,0
	Agro-Food ind. byproducts Total linear km for production (km/year)	0	0	0	0
	Agro-Food ind. byproducts Total diesel consume for production (liters/year)	0	0	1	0
ORGANIC WASTE	Organic waste Productivity (t./ha/year)	~~1.000.000,000~~	~~1.000.000,000~~	~~1.000.000,000~~	~~1.000.000,000~~
	Organic waste cultivation (ha/year)	0	0	0	0
	Organic waste production: diesel consume	50	50	50	50
	Average tractor linear km for cultivation (km/ha/year)	25	25	25	25
	Tractor field consumption (diesel liters/km)	2,0	2,0	2,0	2,0
	Organic waste Total linear km for production	0	0	0	0
	Organic waste Total diesel consume for production (liters/year)	0	0	0	1

COWS + PORKS	Cow slurry input (t./year)	0	20.000	0	0
	Cow manure input (t./year)	0	20.000	0	0
	Pig slurry input (t.year)	0	15.000	0	0
	Cow slurry production (t./animal/year)	10,0	10,0	10,0	10,0
	Cow manure production (t.animal/year)	13,0	13,0	13,0	13,0
	Pig slurry production (t./animal/year)	3,0	3,0	3,0	3,0
	Cows (number/MW.el)	0	1.769	0	0
	Pig (number/MW.el)	0	5.000	0	0
CULTIVATION CONSUMPTION	Total hectares needed for cultivation (ha)	538	220	100	100
	Total linear km done in fields for cultivation (km)	13.454	5.500	2.501	2.501
	Total diesel consume for cultivation (liters)	26.909	11.000	5.001	5.001
TRANSPORT DISTANCES	Medium distance from s.maize crops fields (km)	10	10	10	10
	Medium distance from s.sorghum crops fields (km)	10	10	10	10
	Medium distance from vegetal orto-fruit waste (km)	10	10	10	10
	Medium distance from agro-food industry (km)	1	1	1	1
	Medium distance from organic waste point (km)	1	1	1	1
	Medium distance from livestocks (km)	10	10	10	10
TRANSPORT CONSUMPTION	Lorry capacity for biomass input transport (t.)	20	20	20	20
	S.Maize transport trips (number)	1.345	275	125	125
	S.Sorghum transport trips (number)	0	275	125	125
	Vegetable org-fruit waste trips (number)	0	0	750	250
	Agro-food industry byproducts trips (number)	0	0	500	0
	Organic waste trips (number)	0	0	0	750
	Manure&slurry trips (number)	0	2.750	0	0
	S.Maize total km for transport roundtrip (km)	26.909	5.500	2.500	2.500
	S.Sorghum total km for transport roundtrip (km)	0	5.500	2.500	2.500
	Vegetable orto-fruit waste total km for transport roundtrip (km)	0	0	15.000	5.000
	Agro-food industry byproducts transport roundtrip (km)	0	0	10.000	0
	Organic waste transport roundtrip (km)	0	0	0	15.000
	Manure&slurry total km for transport rountrip (km)	0	55.000	0	0
	Transport INPUT diesel consumption (liters/km)	0,25	0,25	0,25	0,25
	S.Maize total diesel liters for transport roundtrip	6.727	1.375	625	625
	S.Sorghum total diesel liters for transport roundtrip	0	1.375	625	625
	Vegetable orto-fruit waste total diesel liters for transport roundtrip (liters)	0	0	3.750	1.250
	Agro-food industry byproducts (liters)	0	0	2.500	0
	Organic waste (liters)	0	0	0	3.750
	Manure&slurry total diesel liters for transport rountrip (liters)	0	13.750	0	0
TRANSPORT CONSUMPTION SUMMARY	Transport input KM	26.909	66.000	30.000	25.000
	Transport input LITERS	6.727	16.500	7.500	6.250

DIGESTATE	Digestate production rate (t./t. biomass input)	0,75	0,75	0,75	0,75
	Digestate production (t./year)	20.182	49.500	22.500	18.750
INTERNAL CONSUMPTION	Total moved mass: Input biomass + output digestate (t./year)	47.090	115.500	52.500	43.750
	Internal diesel consumption (liters/ t. of moved mass)	0,25	0,25	0,25	0,25
	Internal diesel consumption (km/liter)	0,25	0,25	0,25	0,25
	Total internal diesel consumption (liters/year)	11.773	28.875	13.125	10.938
	Total internal consumption km done within plants	47.090	115.500	52.500	43.750
DIG.TRANSPORT CONSUMPTION	Medium distance from fields where spread digestate	10	10	10	10
	Lorry capacity for digestate output transport (t.)	20	20	20	20
	Transport OUTPUT diesel consumption (liters/km)	0,25	0,25	0,25	0,25
	Digestate transport trips to spreading fields (number/year)	1.009	2.475	1.125	938
	Digestate transport total km (km/year)	20.182	49.500	22.500	18.750
	Digestate transport diesel consumption (liters/year)	5.045	12.375	5.625	4.688

CRPA, 2012, a. Digestate from energy crops and agro-industrial byproducts : [3.5 - 7] kg total N / t. digestate solid fraction: [4 - 12] clarified fraction: [3.5 - 7]	Digestate: Total N kg total N / t. digestate	7,0	7,0	7,0	7,0
CRPA, 2012, a. Digestate from energy crops and agro-industrial byproducts : [30% - 65%] Ammonia N / total N solid fraction: [15% - 45%] clarified fraction: [35% - 70%]	Digestate: % Ammonia N / total N = 50 % kg Ammonia N / t. digestate	3,5	3,5	3,5	3,5
CRPA, 2012, a. Digestate from energy crops and agro-industrial byproducts : [1 - 2] kg P2O5 / t. digestate solid fraction: [2 - 8] clarified fraction: [0.7 - 1.7]	Digestate: Total Phosphate P2O5 kg P2O5 / t. digestate	1,5	1,5	1,5	1,5
CRPA, 2012, a. Digestate from energy crops and agro-industrial byproducts : [3 - 8] kg K2O / t. digestate solid fraction: [3 - 7] clarified fraction: [3 - 8]	Digestate: Potassium K2O kg K2O / t. digestate	5,0	5,0	5,0	5,0
N - NH4 - P2O5 - K2O	Total N within digestate (kg)	141.271	346.500	157.500	131.250
	Ammonia N within digestate (kg)	70.636	173.250	78.750	65.625
	Total Phosphate P2O5 within digestate (kg)	30.272	74.250	33.750	28.125
	Total Potassium K2O within digestate (kg)	100.908	247.500	112.500	93.750
DIGESTATE SPREADING HECTARES	Total N maximum contribution to field (kg N/ha/year)	340	340	340	340
	Hectares of fields to spread digestate (ha/year()	416	1.019	463	386
DIG.SPREADING CONSUMPTION	Liters of diesel to spread digestate into fields	50	50	50	50
	Linear km to spread digestate into fields (km/ha)	5	5	5	5
	Total diesel used to spread digestate (liters/year)	20.775	50.956	23.162	19.301
	Total linear km done to spread digestate (km/year)	2.078	5.096	2.316	1.930

SUMMARY CONSUMPTION	Only CROPS km supply ** cultivation + transport input	40.363	16.500	7.501	7.501
	Entity of only crops km supply (km-%)	100,00%	23,08%	23,08%	27,27%
	TOTAL KM SUPPLY cultivation + transport input - (km)	40.363	71.500	32.501	27.501
	TOTAL KM INTERNAL moving BM - (km)	47.090	115.500	52.500	43.750
	TOTAL KM OUTPUT digestate transport + spreading -	22.259	54.596	24.816	20.680
	Only CROPS liters supply ** cultivation + transport input (liters)	33.636	13.750	6.251	6.251
	Entity of only crops liters supply (liters-%)	100,00%	50,00%	50,00%	55,56%
	TOTAL diesel liters SUPPLY cultivation + transport input - (liters)	33.636	27.500	12.501	11.251
	TOTAL diesel liters INTERNAL moving BM - (liters)	11.773	28.875	13.125	10.938
	TOTAL diesel liters OUTPUT digestate transport + spreading - (liters)	25.821	63.331	28.787	23.989
	Hectars of cultivation (ha)	538	220	100	100
	Hectars to spresd digestate (ha)	416	1.019	463	386

5.1.4. Biogas standard plants productive chains sinthesys

SINTESYS					
		MAIZE 100%	AGRICOLTURE manure&slurry + silage maize	AGRO-FOOD INDUSTRY + ortofruit byproducts	ORGANIC WASTE
BIOGAS PLANT	Electric power installed (MW.el)	1,0	1,0	1,0	1,0
	Thermal power (MW.t)	1,0	1,0	1,0	1,0
	Lost power (MW.lost)	0,5	0,5	0,5	0,5
	Total power (MW)	2,5	2,5	2,5	2,5
	% El.p	40%	40%	40%	40%
	%.Term.p	40%	40%	40%	40%
	%Lost.p	20%	20%	20%	20%
	Work hours	8.000	8.000	8.000	8.000
	Electric energy production (MWh.el/year)	8.017	8.017	8.176	7.978
BIOMASS SUPPLY	Silage maize (t./year)	26.909	5.500	2.500	2.500
	Silage sorghum (t./year)	0	5.500	2.500	2.500
	Vegetal orto-fruit waste (t./year)	0	0	15.000	5.000
	Agro-food industry byproducts (t.year)	0	0	10.000	0
	Organic waste (t./year)	0	0	0	15.000
	Cow slurry (t./year)	0	20.000	0	0
	Cow manure (t./year)	0	20.000	0	0
	Pig slurry (t./year)	0	15.000	0	0
	Total biomass input (t./year)	26.909	66.000	30.000	25.000
	Digestate production (t./year)	20.182	49.500	22.500	18.750
	Hectars of cultivation (ha)	538	220	100	100
	Hectars to spresd digestate (ha)	416	1.019	463	386
TOTAL KM	TOTAL KM SUPPLY cultivation + transport input - (km)	40.363	71.500	32.501	27.501
	TOTAL KM INTERNAL moving BM - (km)	47.090	115.500	52.500	43.750
	TOTAL KM OUTPUT digestate transport + spreading - (km)	22.259	54.596	24.816	20.680
TOTAL DIESEL LITERS	TOTAL diesel liters SUPPLY cultivation + transport input - (liters)	33.636	27.500	12.501	11.251
	TOTAL diesel liters INTERNAL moving BM - (liters)	11.773	28.875	13.125	10.938
	TOTAL diesel liters OUTPUT digestate transport + spreading - (liters)	25.821	63.331	28.787	23.989

6. WOOD COMBUSTION: STANDARD PLANTS AND SUPPLIES

6.1. Formulas used to estimate standard wood combustion plants supplies

- Before all we have created a basic realistic standard wood combustion plant of 1 MW.el electrical power + 2,4 MW.therm thermal power. For this see tab. C5.
- Then we have used data from Regional Forest Office of Emilia-Romagna and INFC 2005 bibliography to define the needed quantities of the different types of forest/arboriculture wood For this see tab. C6.
- After we have resumed the data of our previous chapter describing the forest wood useful potentiality to correlate with the four standard plants. For this see tab. C6.
- Afterwards we did the comparison between the regional solid biomass plants system (*assuming that all they burn wood to produce energy) and the forest wood availability. For this see tab. C7.
- Afterwards we did the comparison between the regional solid biomass plants system (*assuming that all they burn wood to produce energy) and the forest wood availability. This to estimate the impact of the actual system on the forest wood productivity/availability/sustainability. For this see tab. C7.
- At the end we did the comparison between the very big wood combustion PWCP plant of 30,00 MW.el electric power that is actually in construction (see previous chapters) and the forest wood availability. This to estimate the impact of this single big plant on the forest wood productivity/availability/sustainability. For this see tab. C8.
- Then we created the 4 different productive chain profiles of the related standard WOOD COMBUSTION plants, so to implement their data in to the LCA software.
- Like for case studies the implementation on LCA software has been done with truck and tractor types of Ecoinvent database, measured in kgkm (t.km).
- So, at the end, we will can multiply the different LCA-Ecoindicators'99 impacts/damages results for the electric solid biomass plants regional system power and/or energy production to obtain his overall ESTIMED impact in terms of LCA environmental values.

To create standard supplies we have create a dynamic formulas table (see tab. C9) where it is possible write the main variables (yellow cells) to obtain the needed quantities of each biomass types to make work:

1. a **standard wood combustion plant of 1 MW.el + 2,4 MW.therm power** supplied with seasoned wood from arboriculture (Populus. L.) working 8.000 hours/year;

2. a **standard wood combustion plant of only 2,4 MW.therm power** for 8000 hours supplied with seasoned wood from arboriculture (Populus. L.) working 4.000 hours/year = 5,5 winter months;

3. a **standard wood combustion plant of 1 MW.el + 2,4 MW.therm power** supplied with seasoned forest wood (wood general mix) working 8.000 hours/year;

4. a **standard wood combustion plant of only 2,4 MW.therm power** supplied with seasoned forest wood (wood general mix) working 4.000 hours/year = 5,5 winter months;

6.1.1. Wood combustion standard plants supplies

TAB (C5) for calculation of wood biomass input needed by a 1 MW.el WOOD COMBUSTION plant				
IMPIANTO STANDARD C.LEGNOSA DI 1 MW.el	MW	%	ore/anno	MWh/anno
STANDARD WOOD PLANT OF 1 MW.el	MW	%	hours/year	MWh/year
Electric power	1,0	22%	8.000	8.000
Thermal power	3,0	67%	8.000	24.000
Lost power	0,5	11%	8.000	4.000
Total power	4,5	100%	8.000	36.000

ENRGIA LEGNOSA RICHIESTA DALL'IMPIANTO STANDARD	Energia richiesta in input	Pci legno stagionato (cippato)	Tonnellate di legno stagionato necessarie per 1.MW.el di input	Acqua %	Tonnellate di legno fresco necessarie	Peso specifico legno stagionato	Peso specifico legno fresco	PSst/PSfr
WOOD ENERGY NEEDED BY THE STANDARD PLANT	Energy request for starting input	inferior Calorific Power of seasoned wood	Tons of seasoned wood needed by a 1 MW.el standard plant	Water %	Tons. Of fresh wood needed by a 1 MW.el standard plant	Specific weight of seasoned wood	Specifica weight of fresh wood	SWsw / SW fw
	MWh/year	kWh/kg	t./anno	%	t./anno	t./m3	t./m3	%
Populus L. arboriculture	36.000	4,70	7.660	40%	12.766	0,45	0,75	60%
Forest: general mix	36.000	4,70	7.660	40%	12.766	0,64	1,07	60%
Forest: firewood (High Quality)	36.000	4,70	7.660	40%	12.766	0,70	1,17	60%
Forest: wood for energy plants (Low Quality)	36.000	4,70	7.660	40%	12.766	0,51	0,85	60%

TAB (C6) for calculation of wood biomass productivity of forest/arboricolture							
RESE LEGNOSE	Energia richiesta in input	Incremento massivo medio di legno stagionato nelle foreste dell'Emilia-Romagna / pioppicoltura	Incremento volumico medio di legno stagionato nelle foreste dell'Emilia-Romagna / pioppicoltura	Ettari necessari per 1.MW.el di legna stagionata di input	Incremento massivo medio di legno fresco nelle foreste dell'Emilia-Romagna / pioppicoltura	incremento volumico medio di legno fresco nelle foreste dell'Emilia-Romagna / pioppicoltura	Ettari necessari per 1.MW.el di legna fresca di input
WOOD YIELDS	Energy request for starting input	Average mass increment of seasoned wood in the forest of region / arboricolture	Average volumic increment of seasoned wood in the forest of region / arboricolture	Needed hectares for seasoned wood forest/arboricolture for 1 MW.el standard plant	Average mass increment of fresh wood in the forest of region / arboricolture	Average volumic increment of fresh wood in the forest of region / arboricolture	Needed hectares for fresh wood forest/arboricolture for 1 MW.el standard plant
	MWh/year	t./ha/year	m3/ha/year	ha/year	t./ha/year	m3/ha/year	ha/year
Populus L. arboriculture	36.000	18,00	40,00	426	30,00	40,00	426
Forest: general mix	36.000	2,62	4,10	2.919	4,77	4,47	2.676
Forest: firewood (High Quality)	36.000	2,65	3,79	2.888	4,75	4,00	2.688
Forest: wood for energy plants (Low Quality)	36.000	2,64	5,17	2.902	4,80	5,00	2.661

CARATTERISTICHE FORESTALI REGIONALI (dati dall'ufficio forestale regionale + Arpae)	Ettari forestali totali regionale	Disponibilità totale ettari forestali raggiungibili (buffer 150 m.)	% Ettari di tipologia forestali	Ettari di tipologia di foreste disponibili	Tonnellate totali di legna stagionata disponibile	% tipologie tonnellate di legna forestale stagionata disponibile	Tonnellate di legna forestale stagionata disponibile per tipologia	Incremento massivo
REGIONAL FOREST CHARCTERISTICS (data from RER Forest Office + Arpae)	Total regional forest hectares	Total regional forest hectares available (buffer 150 m.)	% of forest typologies	Hectares of forest typologies available	Total tons. of seasoned wood available	% of tons. of seasoned forest wood for thipology	Tons. of seasoned forest wood for thipology	Mass increment
	ha	ha	%	ha	t./year	%	t./year	t./ha/year
Populus L. arboriculture	/	/	/	/	/	/	/	/
Forest: general mix	546.928	430.379	100%	430.379	1.136.490	100%	1.136.490	2,64
Forest: firewood (High Quality)	546.928	430.379	77%	331.392	1.136.490	70%	795.543	2,40
Forest: wood for energy plants (Low Quality)	546.928	430.379	23%	98.987	1.136.490	30%	340.947	3,44

TAB (C7) for calculation comparison between the regional solid (*wood combustion) biomass plants system and the forest wood availability

SISTEMA REGIONALE DEGLI IMPIANTI A BIOMASSE SOLIDE (assumendo che tutti gli impianti a biomasse solide siano a combustione di BM legnose) - (dati GSE 2015)	Potenza elettrica MW.el installata nell'attuale intero sistema regionale di imp. a biomasse solide installata in esercizio 2015	Num. Imp. da 1 MW.el sostenibili dagli ettari di foresta	Num. Imp. 1 MW.el sostenibili dalle tonnellate di legna forestale stagionata	Ettari richiesti dal sistema esistente di imp.BS a seconda della tipologia di legna forestale disponibile	Tonnellate di legna stagionata richieste dal sistema esistente di imp.BS	Tonnellate di legna fresca richieste dal sistema esistente di imp.BS	Disponibilità residua ettari forestali	Disponibilità residua tonnellate legna forestale stagionata	Numero di attuali sistemi regionali sostenibili dalgli ettari forestali	Numero di attuali sistemi regionali sostenibili dalle produzioni (TON.) di legna forestale stagionata
REGIONAL SYSTEM OF BIOMASS SOLID PLANTS (assuming that all solid biomass plants burn wood biomass) - (GSE 2015 data)	Electrical power installed of actual whole regional system of solid biomass plants 2015	Number of plants that are sustainable from the available useful forest	Number of plants that are sustainable from the available useful tons of forest wood	Hectars of forest needed by the whole sb plants regional system	tons of seasoned wood needed by the whole sb plants regional system	tons of seasoned fresh needed by the whole sb plants regional system	Residual availability of forest hectares	Residual availability of tons. Of seasoned forest wood	Number of actual systems sustainable from regional forest calculating with forest hectares	Number of actual systems sustainable from regional forest calculating with tons. of seasoned forest wood
	MW.el	num.	num.	ha	t.	t.	ha	t.	num.	num.
Populus L. arboriculture	141,6	/	/	60.255	1.084.596	1.807.660	/	/	/	/
Forest: general mix	141,6	147	148	413.337	1.084.596	1.807.660	17.042	51.894	1,041	1,048
Forest: firewood (High Quality)	141,6	115	104	408.973	1.084.596	1.807.660	-77.581	-289.053	0,810	0,733
Forest: wood for energy plants (Low Quality)	141,6	34	45	410.987	1.084.596	1.807.660	-312.000	-743.649	0,241	0,314

TAB (C8) for calculation comparison between the PWCP wood combustion plant and the forest/arboricolture wood availability

PWCP (30 MW.el)	Potenza elettrica dell'impianto PWCP	Ettari necessari a POWERCROP a seconda della tipologia di legna forestale disponibile	Tonnellate di legna stagionata necessarie a POWERCROP	Tonnellate di legna fresca richieste dall'attuale sistema regionale esistente di imp.BS	Num imp. PWCP sostenibili a livello regionale in base agli ettari forestali disponibili	Num imp. PWCP sostenibili in base alle tonnellate di legna forestal stagionata disponibile
PWCP (30 MW.el)	Electriacal power of PWCP plant	Needed hectares to supplys PWCP in function of different forest/arboricolture wood available	Needed tons of seasoned wood by PWCP plant	Tons, of freash wood neede by actual regional sb plants system	Number of PWCP plants sustainable from available hectares of forest	Number of PWCP plants sustainable from available tons. f forest wood
	MW.el	ha	t.	t.	num.	num.
Populus L. arboriculture	30	12.766	229.787	382.979	/	/
Forest: general mix	30	87.571	229.787	382.979	4,91	4,95
Forest: firewood (High Quality)	30	86.647	229.787	382.979	3,82	3,46
Forest: wood for energy plants (Low Quality)	30	87.074	229.787	382.979	1,14	1,48

6.1.2. Wood combustion standard plants productive chains

TAB (C9) for calculation of wood combustion STANDARD PLANT and PRODUCTIVE CHAIN input needed by a 1 MW.el - or by a 2,4 MW.term - WOOD COMBUSTION plant					
	FIELDS	EL+THERM POPULUS L. arboriculture	only HEAT POPULUS.L. arboricolture	EL+THERM FOREST general mix	only HEAT FOREST general mix
BIOMASS COMBUSTION PLANT	Electric power installed (MW.el)	1,0	0,0	1,0	0,0
	Thermal power (MW.t)	3,0	2,4	3,0	2,4
	Lost power (MW.lost)	0,5	0,4	0,5	0,4
	Total power (MW)	4,5	2,8	4,5	2,8
	% Electric power	22,2%	0,0%	22,2%	0,0%
	% Thermal power	66,7%	85,7%	66,7%	85,7%
	% Lost power	11,1%	14,3%	11,1%	14,3%
	Work hours	8.000	4.000	8.000	4.000
	Work months	12	5,5	12	5,5
	Remote heating (%)	20%	80%	20%	80%
	Remote heating (MWh)	4.800	7.680	4.800	7.680
	Electric energy production (MWh.el/year)	8.000	0	8.000	0
	Thermal energy production (MWh.el/year)	24.000	9.600	24.000	9.600
	Lost energy (MWh.el/year)	4.000	1.600	4.000	1.600
	Total energy input (MWh/year)	36.000	11.200	36.000	11.200
	% of energy input (%)	100%	31%	100%	31%

TONS and HECTARES	Fresh wood (t./year)	12.766	3.972	12.766	3.972
	Seasoned wood (t./year)	7.660	2.383	7.660	2.383
	% Ashes on seasoned wood (%)	7,5%	7,5%	7,5%	7,5%
	Ashes (t/year)	574	179	574	179
	Type of cultivation/exploitation	Cycle of 10 years in the same area We get 1 tree per 10 each one and then we reseed	Cycle of 10 years in the same area We get 1 tree per 10 each one and then we reseed	Cycle of 10 years with rotation of forest areas Each area is cutted one time per 10 years	Cycle of 10 years with rotation of forest areas Each area is cutted one time per 10 years
	Fresh wood productivity (t./ha/year)	30,00	30,00	4,77	4,77
	Seasoned wood productivity (t./ha/year)	18,00	18,00	2,62	2,62
	Cycle (years)	1	1	10	10
	Annual hectares (ha/year)	426	132	2.919	908
	Hectars occuped per cycle (ha/cycle)	426	132	29.190	9.081
CULTIVATION, SUPPLY and CHOPPING	Diesel cultivation consumption (liters/ha)	25	25	0	0
	Cultivation trees consumption (liters/year)	10.638	3.310	0	0
	Work hours	1.328	413	1.328	413
	Harvaster consumption (liters/hour)	15	15	15	15
	Forwarder consumption (liters/hour)	14	14	14	14
	Chopping consumption (liters/hour)	6	6	6	6
	Diesel consumption (liters/year)	46.480	14.460	46.480	14.460
	Lubrificant Harvaster consumption (liters/hour)	0,35	0,35	0,35	0,35
	Lubrificant Forwarder consumption (liters/hour)	0,35	0,35	0,35	0,35
	Lubrificant Chopping consumption (liters/hour)	0,24	0,24	0,24	0,24
	Lubrificant consumption (liters/year)	1.248	388	1.248	388
TRANSPORT DISTANCES	Medium distance from trees to seasoning site (km)	2,5	2,5	5	5
	Medium distance from seasoning site to combustion plant (km)	35	35	20	20
	Medium distance to ashes destination (km)	25	25	10	10

IN-OUT TRANSPORT	Seasoning - Lorry capacity transport (t.)	20	20	10	10
	To plant - Lorry capacity transport (t.)	20	20	20	20
	Ashes - Lorry capacity transport (t.)	10	10	10	10
	Seasoning - Number of roundtrips (trips)	638	199	1.277	397
	To plant - Number of roundtrips (trips)	383	119	383	119
	Ashes - Number of roundtrips (trips)	57	18	57	18
	Seasoning - total roundtrip kilometers (km)	3.191	993	12.766	3.972
	To plant - total roundtrip kilometers (km)	26.809	8.340	15.319	4.766
	Ashes - total roundtrip kilometers (km)	2.872	894	1.149	357
	Seasoning - Transport diesel consumption (liters/km)	0,25	0,25	0,25	0,25
	To plant - Transport diesel consumption (liters/km)	0,25	0,25	0,25	0,25
	Ashes -Transport diesel consumption (liters/km)	0,25	0,25	0,25	0,25
	Seasoning transport (liters)	798	248	3.191	993
	To Plant transport (liters)	6.702	2.085	3.830	1.191
	Ashes transport (liters)	718	223	287	89
TOTAL TRANSPORT	TOTAL TRANSPORT consumption (km)	32.872	10.227	29.234	9.095
	TOTAL TRANSPORT consumption (liters)	8.218	2.557	7.309	2.274

6.1.3. Wood combustion standard plants productive chains sinthesys

SINTESYS					
		EL+THERM POPULUS L. arboriculture	only HEAT POPULUS.L. arboricolture	EL+THERM FOREST general mix	only HEAT FOREST general mix
WOOD BIOMASS PLANT	Electric power installed (MW.el)	1,0	0,0	1,0	0,0
	Thermal power (MW.t)	3,0	2,4	3,0	2,4
	Lost power (MW.lost)	0,5	0,4	0,5	0,4
	Total power (MW)	4,5	2,8	4,5	2,8
	% Electric power	22,2%	0,0%	22,2%	0,0%
	% Thermal power	66,7%	85,7%	66,7%	85,7%
	% Lost power	11,1%	14,3%	11,1%	14,3%
	Work hours	8.000	4.000	8.000	4.000
	Work months	12	5,5	12	5,5
	Remote heating (%)	20%	80%	20%	80%
	Remote heating (MWh)	4.800	7.680	4.800	7.680
	Electric energy production (MWh.el/year)	8.000	0	8.000	0
	Thermal energy production (MWh.el/year)	24.000	9.600	24.000	9.600
	Lost energy (MWh.el/year)	4.000	1.600	4.000	1.600
	Total energy input (MWh/year)	36.000	11.200	36.000	11.200
	% of energy input (%)	100%	31%	100%	31%

PRODUCTIVE CHAIN	Fresh wood (t./year)	12.766	3.972	12.766	3.972
	Seasoned wood (t./year)	7.660	2.383	7.660	2.383
	% Ashes on seasoned wood (%)	0,075	0,075	0,075	0,075
	Ashes (t/year)	574	179	574	179
	Fresh wood productivity (t./ha/year)	30	30	5	5
	Seasoned wood productivity (t./ha/year)	18	18	3	3
	Cycle (years)	1	1	10	10
	Annual hectares (ha/year)	426	132	2.919	908
	Hectars occuped per cycle (ha/cycle)	426	132	29.190	9.081
	Cultivation trees consumption (liters/year)	10.638	3.310	0	0
	Diesel consumption (liters/year)	46.480	14.460	46.480	14.460
	Lubrificant consumption (liters/year)	1.248	388	1.248	388
	Seasoning transport (liters)	798	248	3.191	993
	To Plant transport (liters)	6.702	2.085	3.830	1.191
	Ashes transport (liters)	718	223	287	89
	TOTAL TRANSPORT consumption (liters)	8.218	2.557	7.309	2.274
	Seasoning - total roundtrip kilometers (km)	3.191	993	12.766	3.972
	To plant - total roundtrip kilometers (km)	26.809	8.340	15.319	4.766
	Ashes - total roundtrip kilometers (km)	2.872	894	1.149	357
	TOTAL TRANSPORT consumption (liters)	8.218	2.557	7.309	2.274

7. BIBLIOGRAPHIC REFERENCE PARAMETERS FOR STANDARD BIOMASS PLANTS

7.1. Parameters used

7.2. Reference bibliography

References of all parameters values we used are available together their bibliographic range in the next chapter.

*This chapter represents a scientific article that should be published in 2018 the first book of Italian LCA Net association http://www.reteitalianalca.it/ with title: "Life Cycle Assessment in the Energy System and Sustainable Technologies Sector: Italian experiences". Here it is presented exactly how it has been sent to the final revision.

TITLE:

Estimation of environmental impacts of biomass power plants system at regional scale: the case study of Emilia Romagna (ITA): methodology, data and results.

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Acknowledgments

My dearest thanks to Sinead O'Keeffe of Deutsches Biomasseforschungszentrum of Leipzig (DE)

Index

1. ABSTRACT

How estimate the environmental impacts of a green energy sector like biomass power plants systems at regional scale?
The biomass power plants GIS land register of Emilia-Romagna region (ITA) is constituted by 316 plants in 2016 with an electric power installed of 210 MW_{el}, constituted of different types of supply chains: wood, only agricultural, agricultural and livestock biogas, agro-food industry biogas, organic waste biogas. Knowing data on their supply productive chain type, geographic position and electric power installed, our objective has been that one to measure their environmental impacts at regional scale, in a way it would be possible compare them with other different productive systems.
To assess their environmental impacts with numerical values we adopted a LCA approach implementing our data in Simapro 7.3 software and working with Ecoinvent references and Ecoindicator ’99 1000y method.
We created 8 different realistic theoretical standardized (not average) biomass plants, with their related weighted productive supply chains, all calculated for a 1 MW electric power producing 8000 MWh. electricity per year.
We implemented all the data in the Simapro 7.3 software, along with indicators of other 15 real case studies of different real biomass plants and the data references of Swiss Ecoinvent LCA database, about wood combustion and biogas power plants. This is useful to obtain the related environmental impacts calculated with Ecoindicator’99 LCA method, and to measure both impact categories values and macro-catogories damages.
Comparing these results we found that, at general level the results of standardized plants result comparable and agree with the Swiss Ecoinvent references; moreover if we consider productive chains Simapro 7.3 results can be used in future for other different more specific impacts and damages evaluations.
So it was possible multiply their corresponded 1 MW.el – 8000 MWh/year unitary Ecoindicator’99 numerical result values with the correlated electric energy power installed at regional level, and obtain a measured LCA assessment of environmental impacts and damages caused by the biomass plants system at regional scale in 2016 in terms of Ecoindicator’99 LCA method.
In this research we propose all the fundamental starting data for each single standardized unitary 1MW.el – 8000 MWh_{el}./year biomass plant type. After this we propose their correspondent unitary Ecoinvent’99 numerical results measured in terms of Ecoindicator 99 impacts and damages categories and at final the results at regional scale.
If required the reader could improve the standardized data base, to make similar calculations for different territories, or to compare impacts in different regions, or to reproduce impact indices with other LCA methods, and so on.

Keywords: energy,
biomass, biogas, wood combustion power plant,
environmental impact, LCA, assessment, regional scale,
Emilia-Romagna

2. INTRODUCTION

In Emilia-Romagna region (ITA) in 2000 there were 26 biomass power plants with an installed electric power of 89 MW_{el}, in 2016 there are 316 plants with an installed electric power of 210 MWel [1]. They exist many different types of biomass power plants: solid combustion, wood combustion, biogas from agriculture, biogas from food industries, bioliquids plants producing bioethanol or biodiesel, and other; and all these types of plants have different productive chains and technologies to work and produce energy.
At planning level, at territorial and regional scale, it would be extremely important to have the possibility to measure and quantify the environmental impact produced by all these power plants that work in our territory so to plan at best their evolution on the territory, but actually it is impossible have all the process data of all single plants, and so it is impossible to calculate their precise environmental impact, and even if they was available, what methodology should we use to elaborate them?
We have tried to respond to this need using an LCA approach calculating with simapro 7.3 [2] and adopting Ecoindicator’99 method [3] their environmental impacts the construction of a realistic unitary standardized plants of 1 MW_{el} electric power and 8000 MWh_{el}./year production for each main type of biomass plants (biogas from agriculture, food industries, waste and of forest and arboriculture wood combustion plants). In addiction we compared them with Swiss Ecoinvent references for biogas electricity production and for wood combustion. After this we have multiplied their unitary impacts and damages for the related electric powers installed in Emilia-Romagna region in 2016, so obtaining their respective regional values and being able to compare with each other and, in future, with other completely different productive regional systems like for example that one of wind energy plants or, even, that one of the tile manufacturing industries.

2.1 METHODOLOGY

2.2 The ISO 14040 framework

The ISO 14040 framework within it has moved this study can be resumed like it follows:

- Objective: to estimate numerically the environmental impacts caused by the biomass energy plants at regional scale, in specific for Emilia-Romagna region (ITA), in such a way that it can technically comparable with other different productive systems.
- Field of application: The methodology and the results will be used to a better environmental planning at regional/territorial scale by regional and national authorities and agencies.
- Boundaries of studied system: the analysis methodology is based on:
  - The availability of the GIS regional land register 2016 of the biomass plants with their related supply chains typology.
  - The data to describe and implement 15 case studies and scenarios of biogas and wood combustion plants;
  - The construction of 8 different realistic unitary standardized biomass plants of 1 MW_{el} power and a production of 8000 MWh_{el}/year with the related weighted supply chains, in way to be implemented together and compared with these case studies data and with the Swiss Ecoinvent energy and bioenergy references.
  - The main functional unit is a biomass plant of 1 MW_{el} electricity power that produces 8000 MWh_{el}/year of electricity. This permits to compare each biomass plant types with other and with Swiss Ecoinvent references for energy production from biogas and wood combustion.
  - In addition to these plants we built also two only thermal unitary wood combustion plants that consumes forest and arboriculture wood only to produce heat for remote heating systems only for the 6 cold months of the year, representing a important information in territorial planning, because they have a wood consumption that is half of one year and their efficiency is better in terms of useful heat producible and deliverable. These two case have been calculated for a thermal production of 9600 MWh_{therm}/year each one.
  - The unitary standardized plants have been built looking data and parameters got by bibliography and case studies, and then adopting the best reputed realistic values internal to their bibliographic range both in terms of scientific then of simplicity and commodity. All the data, the sources and the range are available in the tables here presented.
  - After implemented data have been applied the Ecoindicator'99 100y method.
- This studio is produced by ARPAE (Regional Agency for Environment Protection and Energy) and is intended to be helpful both for the regional energy planning than for university and research.
- The inventory data are all here presented, and represent the best choice within the bibliographic range founded for each parameter. The here adopted parameters are believed to be best possible to model biomass plants and their supply chains.

2.3 Creation of the unitary standardized biomass plants

Through bibliographic research and using the starting data of 15 real case studies, looking their productive chains and burning systems, we created the following hypothetical but realistic standardized unitary biomass plants of 1 MW_{el}. referring the production of 8000 MWh_{el}./year .

To built these different unitary standardized plants we created theoretical numerical models using values of bibliography for each parameter of the productive chains and plants. We got from bibliography the main parameters, with their interval of confidence, and then we chosen realistic values to build the hypothetical standardized main types of plants. We use the adjective *standardized* to represent the fact that these plants (and their related supply chains) are not real or average, but they were built on the table, adopting the best values available by bibliography in terms of scientific value and for reasons of utility, practicality and ease of use. All the reference are presented in the tables. We used also the adjective *unitary* because we built our plants using a useful main functional unit, that is the fact that the plants models are calculated for the value of 1 MW_{el} of electric power installed, that works for 8000 hours/year and produce 8000 MWh.el/year of electricity; So this three unitary quantities of reference are very useful in terms energy and environmental planning at regional and territorial scale.

It is clear that the limit of this method stays inside the fact that the reality of the regional biomass plant situation cannot be resumed in a planning sustainability model like or similar to that one here proposed, because in the sector of biomass energies each plant is specifically different and works on his specific territorial situation where it is located, with a big diversity between each plant. So the methodology adopted and his results here proposed certainly don't represent the averaged or the exactly sum of the biomass energy system environmental impact. The unitary standardized models here presented represent a *"realistic possible average structure of a biomass energy system constructed with a good reliability of the bibliographic parameters, that were selected on the base of their scientific and practicality of use"*.

In addition to these plants we built also two only thermal unitary wood combustion plants that consumes the quantities of forest and arboriculture wood only to produce heat for remote heating systems only for the 6 cold months of the year, representing a important information in territorial planning, because they have a wood consumption that is half of one year and their efficiency is better in terms of useful heat producible and deliverable.

We implemented their data in Simapro 7.3 using Ecoinvent database as much possible, so to elaborate them with Ecoindicator'99 method and to measure their environmental impacts to a production of 8000 MWh/year of electricity, that correspond to a single standardized biomass plant of 1 MW_{el} power; in the case of the only thermal plants we implemented a useful production of only thermal energy of 9600 MWh.th cause the better only thermal efficiency.

First we created the following unitary standardized plants.

BIOGAS:

- **BG1 s.maize**: biogas plant supplied 100 % silage maize[1];
- **BG2 agro-zoo**: biogas supplied by agricultural and livestock byproducts;
- **BG3 food.ind**: biogas supplied by agro-food industry byproducts;
- **BG4 org.waste**: biogas supplied with organic waste;

WOOD COMBUSTION:

- **WP1 el.th**: wood combustion plant supplied with seasoned Populus L. arboriculture wood;
- **WP2 th***: only thermal wood combustion plant supplied with seasoned PopulusL. arboriculture wood;
- **WF3 el.th**: wood combustion plant supplied with seasoned forest wood;
- **WF4 th***: only thermal wood combustion plant supplied with seasoned forest wood;

Tabella 1 – Features of modelled unitary standardized biogas plants

BIOGAS unitary standard plant		GX-s.maize	GX-agrozoo	GX-agrofood.ind	GX-org.waste		
		MAIZE 100%	AGRO-ZOO	FOOD INDUSTRY	ORGANIC WASTE	BIBLIOGRAPHIC RANGE	BIBLIOGRAPHIC REFERENCES
BIOGAS PLANT	Electric power installed (MWel.)	1.0	1.0	1.0	1.0	/	/
	Thermal power (MW.t)	1.0	1.0	1.0	1.0	/	/
	Lost power (MW.lost)	0.5	0.5	0.5	0.5	/	/
	Total power (MW)	2.5	2.5	2.5	2.5	/	/
	% El.p	40.0%	40.0%	40.0%	40.0%	/	/
	% Term.p	40.0%	40.0%	40.0%	40.0%	/	/
	% Lost.p	20.0%	20.0%	20.0%	20.0%	/	/
	Work hours	8,000	8,000	8,000	8,000	/	/
	Electric energy production (MWhel./year)	8,017	8,017	8,176	7,978	/	/
	Electric energy erogated (MWhel./year) *autoconsume = 10%	7,200	7,215	7,358	7,180	/	/
	Silage maize (t./year)	26,909	5,500	2,500	2,500	/	/
	Silage sorghum (t./year)	0	5,500	2,500	2,500	/	/
	Vegetal orto-fruit waste (t./year)	0	0	15,000	5,000	/	/
	Agro-food industry byproducts (t.year)	0	0	10,000	0	/	/
	Organic waste (t./year)	0	0	0	15,000	/	/
	Cow slurry (t./year)	0	20,000	0	0	/	/
	Cow manure (t./year)	0	20,000	0	0	/	/
	Pig slurry (t./year)	0	15,000	0	0	/	/
	Total biomass input (t./year)	26,909	66,000	30,000	25,000	/	/
CH4 PRODUCTION	CH4 production from Silage Maize, as it is. (CH4 m3/t.)	75	75	75	75	[32.0 - 115.3]	[4]–[7]
	CH4 production from Silage Sorghum, as it is. (CH4 m3/t.)	75	75	75	75	[46 - 123]	[4]–[7]
	CH4 production from agro-industrial byproducts. (CH4 m3/t.)	125	125	125	125	[5 - 242]	[4]–[7]
	CH4 production from organic waste (FORSU) . (CH4 m3/t.)	100	100	100	100	[20 - 169]	[4]–[7]
	CH4 production from Cow Manure, as it is. (CH4 m3/t.)	25	25	25	25	[9.0 - 48.2]	[4]–[7]
	CH4 production from Cow Slurry, as it is. (CH4 m3/t.)	25	25	25	25	[9.0 - 45]	[4], [5]
	CH4 production from Pig Slurry, as it is. (CH4 m3/t.)	15	15	15	15	[3 - 44.6]	[4], [5]
FIELD CONSUMPTION	Average tractor linear km for cultivation (km/ha/year)	25	25	25	25	Declared	[8]
	Tractor field consumption (diesel liters/km)	2,0	2,0	2,0	2,0	[1.5 - 2.0]	[9]
ENERGY CROPS CULTIVATION	S.Maize Productivity (t./ha/year)	50	50	50	50	[30 - 80]	[10]–[15]
	S.Maize Hectares cultivation (ha/year)	538	110	50	50	calculation	calculation
	S.Maize Cultivation: diesel consume (liters/ha/year)	50	50	50	50	50	[10]
	S.Sorghum Productivity (t./ha/year)	50	50	50	50	[35.6 - 96.8]	[16], [17]
	S.Sorghum Hectares of s.sorghum cultivation (ha/year)	0	110	50	50	calculation	calculation
	S.Sorghum Cultivation: diesel consume (liters/ha/year)	50	50	50	50	calculation	calculation
COWS + PORKS	Cow slurry input (t./year)	0	20,000	0	0	/	/
	Cow manure input (t./year)	0	20,000	0	0	/	/
	Pig slurry input (t./year)	0	15,000	0	0	/	/
	Cow slurry production (t./animal/year)	10.0	10.0	10.0	10.0	[3.9 - 22.2]	[18], [19]
	Cow manure production (t.animal/year)	13.0	13.0	13.0	13.0	[1.2 - 15.7]	[18], [19]
	Pig slurry production (t./animal/year)	3.0	3.0	3.0	3.0	3.0	[18], [19]
TRANSPORT DISTANCES TRANSPORT CONSUMPTION	Medium distance from s.maize crops fields (km)	10	10	10	10	/	/
	Medium distance from s.sorghum crops fields (km)	10	10	10	10	/	/
	Medium distance from vegetal orto-fruit waste (km)	10	10	10	10	/	/
	Medium distance from agro-food industry (km)	1	1	1	1	/	/
	Medium distance from organic waste point (km)	1	1	1	1	/	/
	Medium distance from livestocks (km)	10	10	10	10	/	/
	Lorry capacity for biomass input transport (t.)	20	20	20	20	/	/
	Transport INPUT diesel consumption (liters/km)	0.25	0.25	0.25	0.25	0.25	[20]
DIGESTATE	Digestate production rate (t./t. biomass input)	0.75	0.75	0.75	0.75	[13.62 - 142.73]	[10]
INTERNAL CONSUMPTION	Internal diesel consumption (liters/ t. of moved mass)	0.25	0.25	0.25	0.25	0.25	[10]
	Internal diesel consumption (liter/km)	0.25	0.25	0.25	0.25	0.25	[10]
DIGESTATE TRANSPORT CONSUMPTION	Medium distance from fields where spread digestate (km)	10	10	10	10	/	/
	Lorry capacity for digestate output transport (t.)	20	20	20	20	/	/
	Transport OUTPUT diesel consumption (liters/km)	0.25	0.25	0.25	0.25	0.25	[20]
DIGESTATE CONTENT	Digestate: Total N (kg total N / t. digestate)	7.0	7.0	7.0	7.0	[3.5 - 7]	[21]
	Digestate: % Ammonia N/ total N (kg Ammonia N/t. digestate)	3.5	3.5	3.5	3.5	[30% - 65%]	[21]

[1] Silage maize is used like stabilizer in anaerobic digestion mixing. It avoids pH problems and other.

	Digestate: Total Phosphate P2O5 (kg P2O5 / t. digestate)	1.5	1.5	1.5	1.5	[1 - 2]	[21]
	Digestate: Potassium K2O (kg K2O / t. digestate)	5.0	5.0	5.0	5.0	[3 - 8]	[21]
DIGESTATE SPREADING HECTARES	Total N maximum contribution to field in sensitive areas (kg N/ha/year)	170	170	170	170	170	[22]
	Total N maximum contribution to field in not sensitive areas (kg N/ha/year)	340	340	340	340	340	[22]
DIGESTATE SPREADING CONSUMPTION	Tractor field diesel consumption (liters/km)	1.5	1.5	1.5	1.5	1.5	[9]
	Liters of diesel to spread digestate into fields (liters/ha)	50	50	50	50	50	[10]
	Average linear km to spread digestate into fields (km/ha)	5	5	5	5	/	/
CONSTRUCTION CO2 EMISSION TISS,2011, a. - emission factors	ton. CO2eq / MW Emission factor CEMENT used (ton.CO2eq /MW/year)	117	117	117	117	117	[23]
	ton. CO2eq / MW Emission factor STEEL used (ton.CO2eq /MW/year)	27	27	27	27	27	[23]
	g. CO2eq /kWh el. Emission factor kWh elettricity produced (g.CO2eq /kWh.el/year)	42	42	42	42	42	[23]

Tabella 2 – Features of modelled unitary standardized wood combustion plants

WOOD COMBUSTION Unitary standard plant		LX.P.el EL+THERM POPULUS L. arboriculture	*LX.P.ht only HEAT POPULUS.L. arboricolture	LX.P.rF EL+THERM FOREST general mix	*LX.P.rF only HEAT FOREST general mix	BIBLIOGRAPHIC RANGE	BIBLIOGRAPHIC REFERENCES
BIOMASS COMBUSTION PLANT	Electric power installed (MWel.)	1.0	0.0	1.0	0.0	/	/
	Thermal power (MW.t)	3.0	2.4	3.0	2.4	/	/
	Lost power (MW.lost)	0.5	0.4	0.5	0.4	/	/
	Total power (MW)	4.5	2.8	4.5	2.8	/	/
	% Electric power	22.2%	0.0%	22.2%	0.0%	/	/
	% Thermal power	66.7%	85.7%	66.7%	85.7%	/	/
	% Lost power	11.1%	14.3%	11.1%	14.3%	/	/
	Work hours	8,000	4,000	8,000	4,000	/	/
	Work months	12	5.5	12	5.5	/	/
	Remote heating (%)	20%	80%	20%	80%	/	/
	Remote heating (MWh)	4,800	7,680	4,800	7,680	/	/
	Electric energy production (MWhel./year)	8,000	0	8,000	0	/	/
	Thermal energy production (MWhel./year)	24,000	9,600	24,000	9,600	/	/
	Lost energy (MWhel./year)	4,000	1,600	4,000	1,600	/	/
	Total energy input (MWh/year)	36,000	11,200	36,000	11,200	/	/
	% of energy input (%)	100%	31%	100%	31%	/	/
TONS and HECTARES	Fresh wood (t./year)	12,766	3,972	12,766	3,972	Calculation	Calculation
	Seasoned wood (t./year)	7,660	2,383	7,660	2,383	Calculation	Calculation
	% Ashes on seasoned wood (%)	7.5%	7.5%	7.5%	7.5%	/	/
	Ashes (t/year)	574	179	574	179	Calculation	Calculation
	Fresh wood productivity (t./ha/year)	30.00	30.00	4.77	4.77	[18.7 - 80.9] [m3/ha/year] 4.77 [t./ha/year]	[24], [25], [26] [27]–[29]
	Seasoned wood productivity (t./ha/year)	18.00	18.00	2.62	2.62	[6.27 - 33.9] [m3/ha/year] 2.62 [t./ha/year]	[25], [26] [27]–[29]
	Cycle (years)	1	1	10	10	/	/
CULTIVATION, SUPPLY and CHOPPING	Diesel cultivation consumption (liters/ha/year)	25	25	0	0	Declared	[8]
	Harvaster consumption (liters/hour)	15	15	15	15	Declared	[8]
	Forwarder consumption (liters/hour)	14	14	14	14	Declared	[8]
	Chopping consumption (liters/hour)	6	6	6	6	Declared	[8]
	Lubrificant Harvaster consumption (liters/hour)	0.35	0.35	0.35	0.35	Declared	[8]
	Lubrificant Forwarder consumption (liters/hour)	0.35	0.35	0.35	0.35	Declared	[8]
	Lubrificant Chopping consumption (liters/hour)	0.24	0.24	0.24	0.24	Declared	[8]
TRANSPORT DISTANCES	Medium distance from trees to seasoning site (km)	2.5	2.5	5	5	/	/
	Medium distance from seasoning site to combustion plant (km)	35	35	20	20	/	/
	Medium distance to ashes destination (km)	25	25	10	10	/	/
IN-OUT TRANSPORT	Seasoning - Lorry capacity transport (t.)	20	20	10	10	/	/
	To plant - Lorry capacity transport (t.)	20	20	20	20	/	/
	Ashes - Lorry capacity transport (t.)	10	10	10	10	/	/
	Seasoning - Transport diesel consumption (liters/km)	0.25	0.25	0.25	0.25	0.25	[20]
	To plant - Transport diesel consumption (liters/km)	0.25	0.25	0.25	0.25	0.25	[20]
	Ashes -Transport diesel consumption (liters/km)	0.25	0.25	0.25	0.25	0.25	[20]
ECOINVENT TRANSPORT	Transport, tractor and trailer/CH U	/	/	/	/	Ecoinvent db	[30]
	Transport, lorry 16-32t, EURO4/RER U	/	/	/	/	Ecoinvent db	[31]
POPULUS L WOOD FROM ARBORICULTURE	Popolus L. arboriculture: SW specific weight of fresh wood (t./m3)	0.75	0.75	/	/	0.76	[25], [26]
	Popolus L. arboriculture: SW specific weight of seasoned wood (t./m3)	0.45	0.45	/	/	[0.42 - 0.45]	[25], [26]
	Popolus L. arboriculture: Volume increase of fresh wood (m3/ha/year)	30	30	/	/	[18.7 - 80.9]	[25], [26]
	Popolus L. arboriculture: Massive increase of fresh wood (t./ha/year)	30	30	/	/	[11.4 - 61.5]	[25], [26]
	Populus L. arboriculture: Massive increase of seasoned wood (t./ha/year)	18.00	18.00	/	/	[6.27 - 33.9]	[25], [26]
	Popolus L. arboriculture: PCI internal calorific power seasoned wood (kWh/kg)	4.5	4.5	/	/	[4.50 - 4.67]	[25], [26]
FOREST WOOD	Forest wood gen.mix : SW specific weight of fresh wood (t./m3)	/	/	1.00	1.00	1.07	[27]–[29]
	Forest wood gen.mix : SW specific weight of seasoned wood (t./m3)	/	/	0.65	0.65	0.64	[27]–[29]
	Forest wood gen.mix : Volume increase of fresh wood (m3/ha/year)	/	/	4.47	4.47	[4.10 - 4.47]	[27]–[29]
	Forest wood gen.mix : Massive increase of fresh wood (t./ha/year)	/	/	4.77	4.77	4.77	[27]–[29]
	Forest wood: Massive increase of seasoned wood (t./ha/year)	/	/	2.62	2.62	2.62	[27]–[29]
	Forest wood gen.mix : PCI internal calorific power seasoned wood (kWh/kg)	/	/	4.50	4.50	4.50	[27]–[29]

The unitary standard plants have been implemented in the Simapro 7.3 software, also in addiction to other 15 real case studies of biogas and wood combustion plants and scenarios, and also with some Ecoinvent references for other different types of energetic sources, like that one of national Italian electricity production mix and other sources including the Swiss Ecoinvent biogas and wood combustion references.
All these standardized plants have been compared through Ecoindicator'99 LCA method; the resulted values of Ecoindicator'99 represent the annual impacts/damages associated to each type plant, standardized for unitary power and 8000 MWh_{el}./year of electricity production. The following graph and data tables sums up the results of this comparison.
To simplify the exposure plants are divided into five groups: I) Other sources (including *Swiss Ecoinvent* biogas and wood combustion references); II) Biogas case studies; III) Biogas unitary standard plants; IV) Wood combustion case studies; V) Wood combustion unitary standardized plants[2]. Note that infrastructure process and long term emissions are included in the Ecoindicator'99 calculations.

Tabella 3 – List of the plants implemented in the Simapro 7.3 LCA software applying Ecoindicator'99 method, for a production of 8000 MWh_{el}: Ecoinvent references, case studies and unitary standardized biomass plants.

GROUP	PLANT CODE	STARTING FEATURES OF PLANT	ENERGY PRODUCTION implemented in Simapro 7.3 for Ecoindicator'99 comparison
ECOINVENT references	**e01**	**Electricity, production mix IT/IT U**	**8000 MWhel./year**
	e02	**Electricity, oil, at power plant/IT U**	**8000 MWhel./year**
	e03	**Electricity, production mix photovoltaic, at plant/IT U**	**8000 MWhel./year**
	e04	**Electricity, at wind power plant/RER U**	**8000 MWhel./year**
	e05	**Electricity, hydropower, at power plant/IT U**	**8000 MWhel./year**
	e06	**Dummy_Electricity, geothermal, unspecified/US**	**8000 MWhel./year**
	SG.e07	**Electricity, at cogen 6400kWth, wood, emission control, allocation energy/CH U**	**8000 MWhel./year**
	SW.e08	**Electricity, at cogen, biogas agricultural mix, allocation exergy/CH U**	**8000 MWhel./year**
BIOGAS case studies	B1	249 kW.el -Silage maize 98%	8000 MWhel./year
	B2	888 kW.el -Meat food industry + agro-zoo	8000 MWhel./year
	B3	999 kW.el -Sugar industry + agriculture	8000 MWhel./year
	B4	999 kW.el -Sugar industry + agriculture	8000 MWhel./year
	B5	999 kW.el -Sugar industry + agriculture	8000 MWhel./year
	B6	130 kW.el -Agro-zoothecnical	8000 MWhel./year
	B7	380 kW.el -Agro-zootechnical	8000 MWhel./year
	B8	870 kW.el -Urban organic waste	8000 MWhel./year
BIOGAS *unitary standard* plants	**BG1 - silage maize 100%**	**1000 kW.el -Agricultural energy crops**	**8000 MWhel./year**
	BG2 - agro-zoothecnical	**1000 kW.el -Agricultural + livestock**	**8000 MWhel./year**
	BG3 - food industry	**1000 kW.el -Food industry**	**8000 MWhel./year**
	BG4 - org.waste	**1000 kW.el -Organic waste**	**8000 MWhel./year**
WOOD COMBUSTION case studies	W1	35 kW.el -Forest wood	8000 MWhel./year
	W2	35 kW.el -Forest wood	8000 MWhel./year
	W3	30000 kW.el -Populus L. Arboriculture	8000 MWhel./year
	W4	30000 kW.el -Populus L. Arboriculture	8000 MWhel./year
	W5	30000 kW.el -Populus L. Arboriculture	8000 MWhel./year
	W.6	30000 kW.el -Forest wood	8000 MWhel./year
	W7	200 kW.el -Forest wood	8000 MWhel./year
WOOD COMBUSTION *unitary standard* plants	**WP1 - arboriculture**	**1000 kW.el + 2400 kW.th -Populus L. Arboriculture**	**8000 MWhel./year**
	WP2 - arboriculture	**2400 kW.th -Populus L. Arboriculture**	***9600 MWh.thermal/year**
	WF3 - forest wood	**1000 kW.el + 2400 kW.th -Forest wood**	**8000 MWhel./year**
	WF4 - forest wood	**2400 kW.th -Forest wood**	***9600 MWh.thermal/year**

[2] In the Vth group only 2,4 MW thermal wood combustion standardized plants are considered, working only for 4000 hours/year.

3. RESULTS

3.1 The comparison of the Ecoindicator'99 application results

Running the software Simapro 7.3, using Ecoinvent references, with the Ecoindicator'99 LCA method we obtained the following results, we propose you in form of graphs (see fig. 1, 2 3,4) and data sheets (see tab. 4, 5, 6).

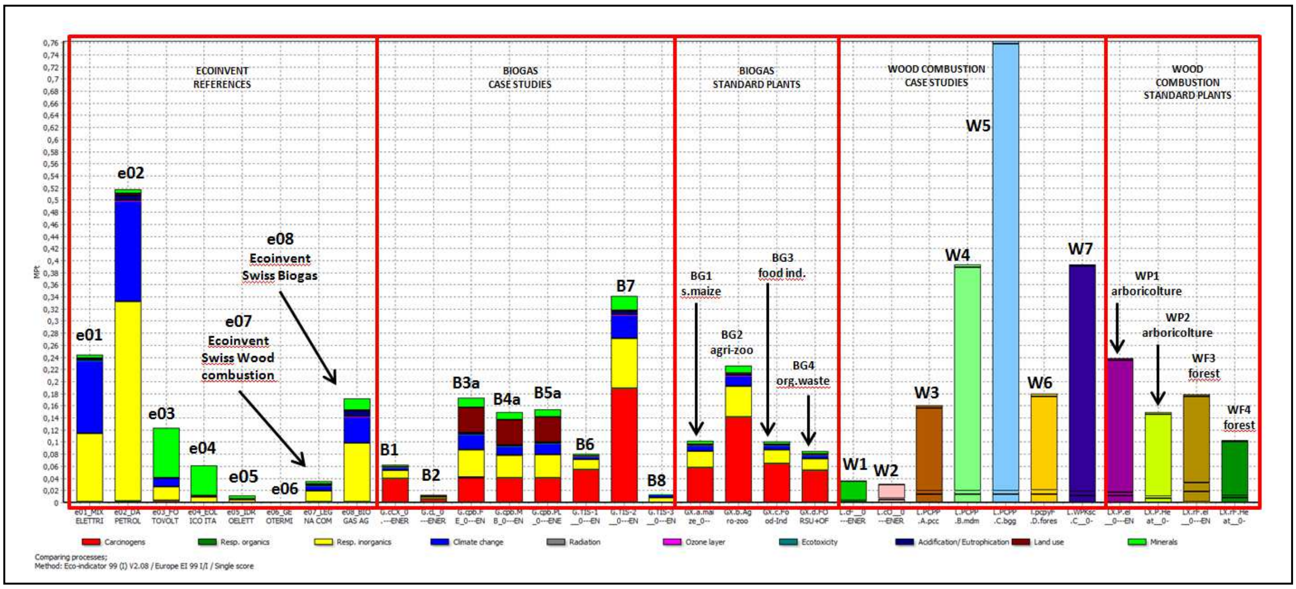

Figura 1 – Overall results of the weighted comparison for 8000 MWh. electricity production with the different energy source systems, in terms of impacts categories measured with Ecoindicator'99 LCA method [3].

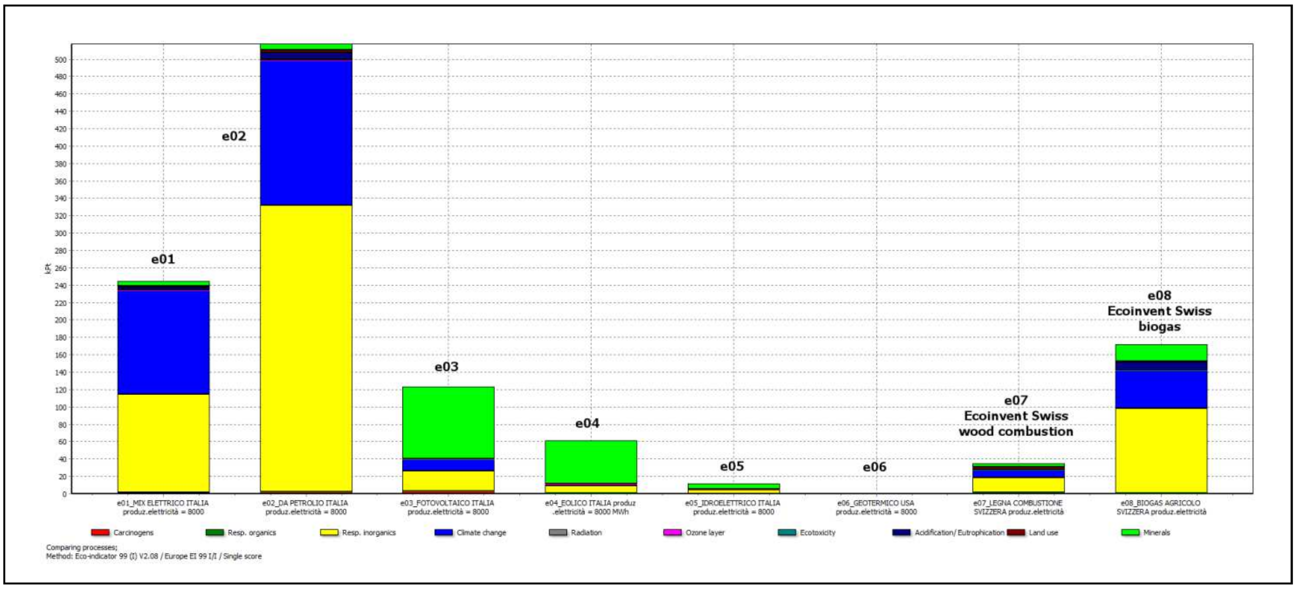

Figura 2 – Overall results of the weighted comparison for 8000 MWh. electricity production with Ecoinvent energy sources references, in terms of impacts categories measured with Ecoindicator'99 LCA method.

[3] Unfortunately, cause the hight number of implemented plants, Simapro 7.3 software was not able to show correctly in the graph the colors of wood combustion case studies plants and standard. Looking the data you would see that they are almost entirely colored of brown, due the extremely high land use resulted values. For reason of space we cannot publish other colored graphs.

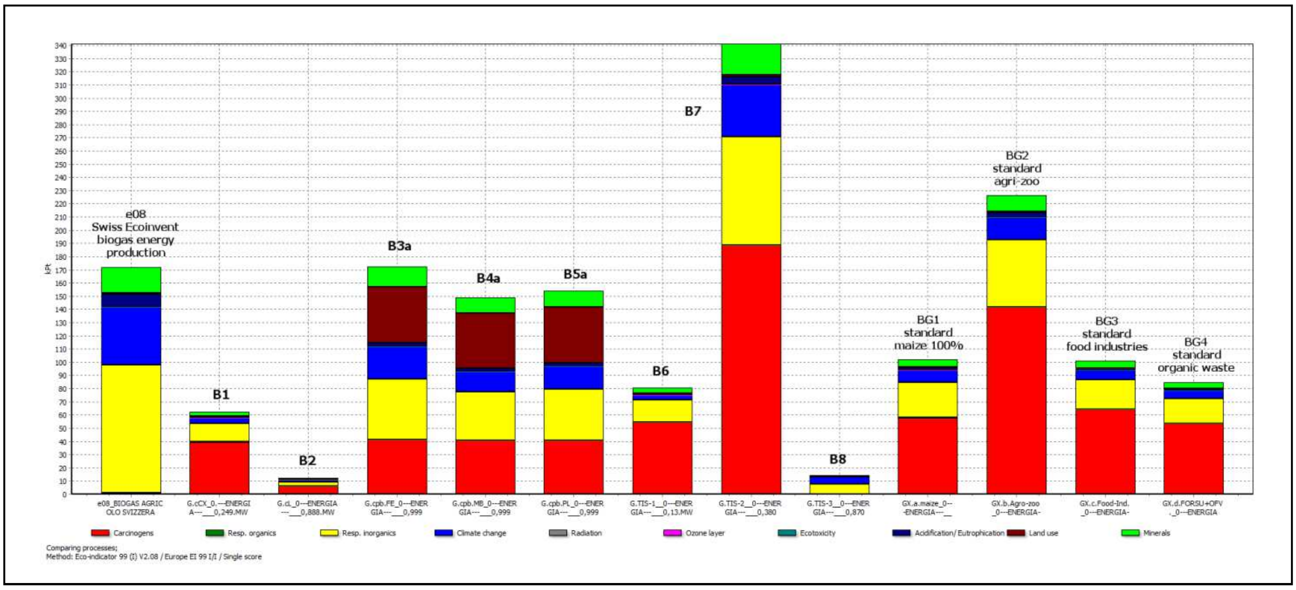

Figura 3 – Overall results of the weighted comparison for 8000 MWh. electricity production with biogas plants, in terms of impacts categories measured with Ecoindicator'99 LCA method.

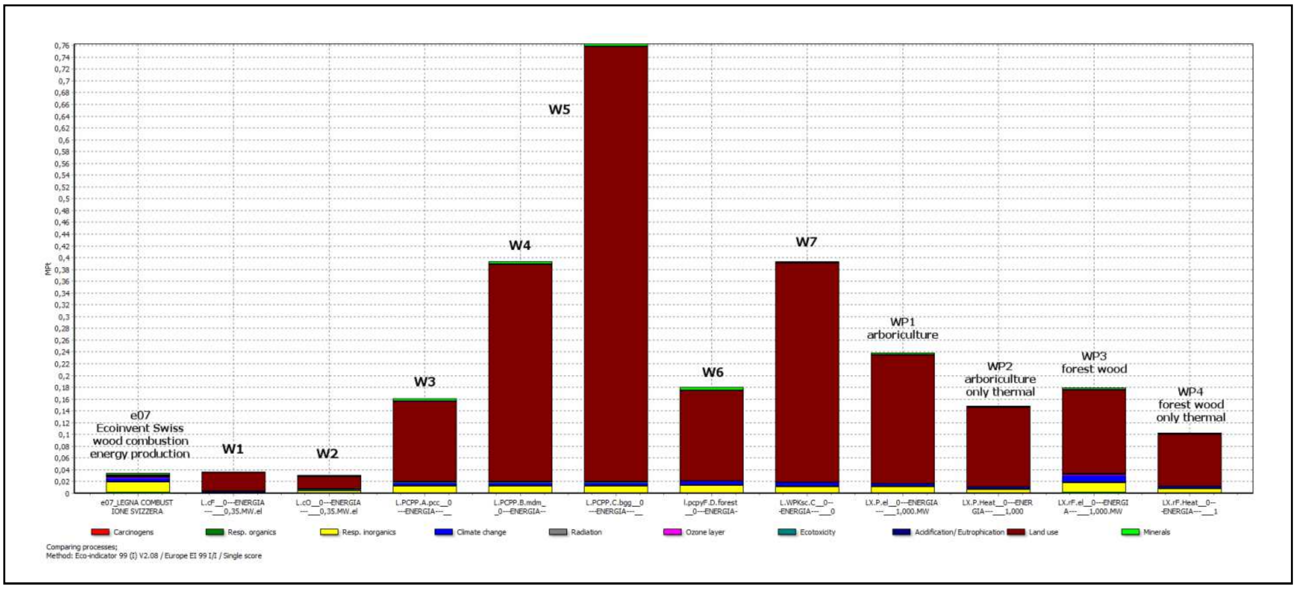

Figura 4 – Overall results of the weighted comparison for 8000 MWh. electricity production with wood combustion plants, in terms of impacts categories measured with Ecoindicator'99 LCA method.

Tabella 4 - Final values of the comparison for the different energy source systems for a production of 8000 MWhel., in terms of IMPACTS categories measured with Ecoindicator'99 LCA method.

Impact category	Unit	e01	e02	e03	e04	e05	e06	e07	e08
Total	Pt	244372.3731	517405.0398	122766.3529	61173.21369	11695.89091	0	34728.03345	171840.5391
Minerals	Pt	5535.270168	7022.783593	82380.29178	49581.21843	5956.577456	0	3761.73022	19341.45055
Land use	Pt	1328.015959	2918.513396	338.1240171	253.595952	92.83897283	0	2980.535815	839.3246261
Acidification/ Eutrophication	Pt	3375.445083	8156.280521	391.1433977	64.10720486	33.98206123	0	896.1490539	9864.013671
Ecotoxicity	Pt	224.902544	1134.297048	192.2256199	64.58127344	7.959542808	0	337.6551521	57.20496804
Ozone layer	Pt	40.67953681	83.13495352	10.68610439	0.492690037	0.225357634	0	0.968848144	5.250433019
Radiation	Pt	9.628159116	13.02885268	15.97887866	1.534055725	0.685388368	0	2.34095628	17.14805049
Climate change	Pt	119523.8658	166491.1185	12912.09476	2128.86365	936.7880184	0	7935.257154	43842.92734
Resp. inorganics	Pt	113005.7375	329191.4224	23112.06865	8564.543779	4574.273937	0	17319.38812	97052.86926
Resp. organics	Pt	242.8776579	380.3428524	93.71495542	7.373017784	3.142302829	0	54.61723904	157.0872263
Carcinogens	Pt	1085.950711	2014.117737	3320.024719	506.9036424	89.41787674	0	1439.39089	663.2630186
Impact category	**Unit**	**B1**	**B2**	**B3a**	**B4a**	**B5a**	**B6**	**B7**	**B8**
Total	Pt	62447.18927	12109.32508	172308.2304	148804.3402	153937.6789	80488.78616	341065.2074	14034.92728
Minerals	Pt	3397.090659	888.5356559	15340.0185	11650.12514	12458.67809	3884.110993	23401.41156	1014.328673
Land use	Pt	192.0935336	65.20608593	42133.98825	41835.49669	41900.17634	165.0935767	1354.909862	133.0310483
Acidification/ Eutrophication	Pt	980.0646204	206.2724939	3109.09852	2564.535869	2683.726309	1230.111388	5743.873652	344.9450839
Ecotoxicity	Pt	52.76288535	20.02561206	214.9065851	94.03354183	120.5244113	46.34811953	490.4880345	36.68185501
Ozone layer	Pt	3.84486901	1.398722301	12.93216217	6.575625547	7.947282929	2.903492981	26.60849217	3.551237144
Radiation	Pt	1.857260374	0.685923542	25.87284443	22.00286579	22.84878144	1.61054907	16.05059727	1.330279896
Climate change	Pt	4379.581055	1630.404258	24517.44287	15062.6277	17131.79783	3834.296293	39392.78234	4959.534043
Resp. inorganics	Pt	13912.24259	3138.822397	45592.0546	36678.08557	38618.21154	16666.42603	81917.33076	7337.156228
Resp. organics	Pt	39.87046296	12.59762168	131.1612657	72.57793696	85.33600035	38.42875357	300.5764015	73.33766097
Carcinogens	Pt	39487.78133	6145.37631	41230.75484	40818.27925	40908.43227	54619.45697	188421.1757	131.0311668
Impact category	**Unit**	**BG1**	**BG2**	**BG3**	**BG4**				
Total	Pt	102190.7883	226506.7889	101017.6109	84611.92075				
Minerals	Pt	5890.063808	12622.28654	5432.760374	4565.106445				
Land use	Pt	572.3470717	719.962698	302.6330143	263.3835465				
Acidification/ Eutrophication	Pt	1609.572028	3577.157487	1581.024837	1324.637626				
Ecotoxicity	Pt	106.1495549	203.8362519	82.67327183	70.08370183				
Ozone layer	Pt	13.53556591	14.41363374	6.02746318	5.325192662				
Radiation	Pt	4.310832805	7.113365179	2.913898004	2.491349239				
Climate change	Pt	9557.238583	16829.26121	6869.138094	5850.531273				
Resp. inorganics	Pt	26482.85639	50849.92239	22378.03345	18886.72885				
Resp. organics	Pt	96.52039203	149.4920558	63.11650959	54.08100496				
Carcinogens	Pt	57858.1941	141533.3433	64299.29001	53589.55176				
Impact category	**Unit**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	
Total	Pt	36361.46917	31007.77234	160721.2469	393257.6578	762567.4035	179755.8321	393001.0544	
Minerals	Pt	782.6661377	2191.900776	4562.43	4562.429922	4562.429922	4917.295589	2289.148043	
Land use	Pt	31893.09194	22399.45303	136917.5045	369453.9169	738763.6626	153967.3087	372152.8339	
Acidification/ Eutrophication	Pt	98.63636522	152.0495087	538.9873924	538.9873728	538.9873728	584.3749756	383.3089463	
Ecotoxicity	Pt	5.439811157	15.05013567	38.38708353	38.38708122	38.38708122	41.74622263	67.50168408	
Ozone layer	Pt	0.931147754	1.356102056	3.434540893	3.434539515	3.434539515	3.736418966	12.5884247	
Radiation	Pt	0.2865457	1.15940042	1.586618475	1.58661827	1.58661827	1.713980099	3.343625932	
Climate change	Pt	967.0429921	1914.657242	5641.954693	5641.954339	5641.954339	6119.979856	6818.304627	
Resp. inorganics	Pt	2563.12434	4170.200239	12731.9977	12731.99674	12731.99674	13813.19116	10849.53446	
Resp. organics	Pt	10.00876402	15.75611643	50.95380985	50.95380398	50.95380398	55.30219549	75.13201745	
Carcinogens	Pt	40.24112724	146.1897944	234.0105191	234.0104968	234.0104968	251.1829387	349.3587064	
Impact category	**Unit**	**WP1**	**WP2**	**WF3**	**WF4**				
Total	Pt	238755.9872	148572.0732	178936.0104	102772.0745				
Minerals	Pt	3878.34111	2413.245032	3658.787979	2331.181191				
Land use	Pt	218380.0366	135893.0783	142535.6119	88720.06895				
Acidification/ Eutrophication	Pt	463.9930415	288.7317023	1367.019842	294.411355				
Ecotoxicity	Pt	33.43312406	20.80606241	35.31909867	21.03010506				
Ozone layer	Pt	2.971623617	1.84920812	4.553031598	3.828197897				
Radiation	Pt	1.372128578	0.853884136	1.561695668	1.118737938				
Climate change	Pt	4860.203034	3024.395375	13000.54137	3300.618687				
Resp. inorganics	Pt	10891.3238	6777.08266	17554.66257	7919.854055				
Resp. organics	Pt	43.8918751	27.31285305	88.29446942	34.7710056				
Carcinogens	Pt	200.4209378	124.7181642	689.6584207	145.1921883				

Tabella 5 - Results of the comparison for the different energy source systems for a production of 8000 MWhel., in terms of DAMAGES categories measured with Ecoindicator'99 LCA method.

Damage category	Unit	e01	e02	e03	e04	e05	e06	e07	e08
Total	Pt	244372.3731	517405.0398	122766.3529	61173.21369	11695.89091	0	34728.03345	171840.5391
Resources	Pt	5535.270168	7022.783593	82380.29178	49581.21843	5956.577456	0	3761.73022	19341.45055
Ecosystem Quality	Pt	4928.363585	12209.09097	921.4930347	382.2844303	134.7805769	0	4214.340021	10760.54327
Human Health	Pt	233908.7394	498173.1653	39464.56808	11209.71084	5604.532881	0	26751.96321	141738.5453
Damage category	**Unit**	**B1**	**B2**	**B3a**	**B4a**	**B5a**	**B6**	**B7**	**B8**
Total	Pt	62447.18927	12109.32508	172308.2304	148804.3402	153937.6789	80488.78616	341065.2074	14034.92728
Resources	Pt	3397.090659	888.5356559	15340.0185	11650.12514	12458.67809	3884.110993	23401.41156	1014.328673
Ecosystem Quality	Pt	1224.921039	291.5041919	45457.99335	44494.06611	44704.42706	1441.553084	7589.271549	514.6579873
Human Health	Pt	57825.17757	10929.28523	111510.2186	92660.14895	96774.57371	75163.12208	310074.5243	12505.94062
Damage category	**Unit**	**BG1**	**BG2**	**BG3**	**BG4**				
Total	Pt	102190.7883	226506.7889	101017.6109	84611.92075				
Resources	Pt	5890.063808	12622.28654	5432.760374	4565.106445				
Ecosystem Quality	Pt	2288.068655	4500.956437	1966.331123	1658.104874				
Human Health	Pt	94012.65586	209383.5459	93618.51943	78388.70943				
Damage category	**Unit**	**W1**	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	
Total	Pt	36361.46917	31007.77234	160721.2469	393257.6578	762567.4035	179755.8321	393001.0544	
Resources	Pt	782.6661377	2191.900776	4562.43	4562.429922	4562.429922	4917.295589	2289.148043	
Ecosystem Quality	Pt	31997.16811	22566.55267	137494.879	370031.2913	739341.0371	154593.4299	372603.6445	
Human Health	Pt	3581.634917	6249.318894	18663.93788	18663.93654	18663.93654	20245.10655	18108.26186	
Damage category	**Unit**	**WP1**	**WP2**	**WF3**	**WF4**				
Total	Pt	238755.9872	148572.0732	178936.0104	102772.0745				
Resources	Pt	3878.34111	2413.245032	3658.787979	2331.181191				
Ecosystem Quality	Pt	218877.4627	136202.616	143937.9509	89035.51041				
Human Health	Pt	16000.1834	9956.212145	31339.27156	11405.38287				

Tabella 6 - Synthesis of the IMPACT categories and DAMAGE macro.categories for 8000 MWhel production.

Ecoindicator'99 results 1 MWel. power 8000 MWhel./year		**BIOGAS**					**WOOD COMBUSTION**	
		e08 Ecoinvent Swiss biogas ref.	BG1 Standard only crops	BG2 Standard agro-zoo	BG3 Standard food industries	BG4 Standard organic waste	e07 Ecoinvent Swiss wood combustion ref.	WF3 Standard Forest wood combustion
• **IMPACTS**								
Total	**Pt**	**171841**	**102191**	**226507**	**101018**	**84612**	**34728**	**178936**
Carcinogens	Pt	663	57858	141533	64299	4565	3762	690
Resp. organics	Pt	157	97	149	63	263	2980	88
Resp. inorganics	Pt	97053	26483	50850	22378	1325	896	17555
Climate change	Pt	43843	9557	16829	6869	70	337	13001
Radiation	Pt	17	4	7	3	5	1	2
Ozone layer	Pt	5	14	14	6	2	2	5
Ecotoxicity	Pt	57	106	204	83	5851	7935	35
Acidification/ Eutrophication	Pt	9864	1610	3577	1581	18887	17319	1367
Land use	Pt	839	572	720	303	54	55	142536
Minerals	Pt	19341	5890	12622	5433	53590	1440	3659
• **DAMAGES**								
Total	**Pt**	**171841**	**102191**	**226507**	**101018**	84612	**34728**	**178936**
Human Health	Pt	141739	94013	209384	93619	456	3762	31339
Ecosystem Quality	Pt	10761	2288	4501	1966	1658	4214	143938
Resources	Pt	19341	5890	12622	5433	78389	26751	3659

4. ASSESSMENT OF THE REGIONAL BIOMASS PLANTS SYSTEM

4.1 The impacts of biomass plants system of Emilia-Romagna in terms of Ecoindicator'99

To estimate the regional biomass power plants system environmental impacts we have multiplied each one standard plant type value referring the unitary 1 MW_{el} power, quantified in Pt/MW.el from Ecoindicator'99 elaboration, with the real biomass electric power value stored in the regional biomas p.plants GIS[4] land register 2016 [1].
We have also estimate these impacts calculating them with the unitary 8000 MW_{el} /year Ecoinvent Swiss biogas and wood combustion electricity values, and we have also assessed both the sum of the three biogas standardized types (only crops + agri-zoo + food industries) than the single value for wood combustion type. Follow here the electric power installed provincial and regional data, and their results and graph in terms of final Econidicators'99 impacts and damages.

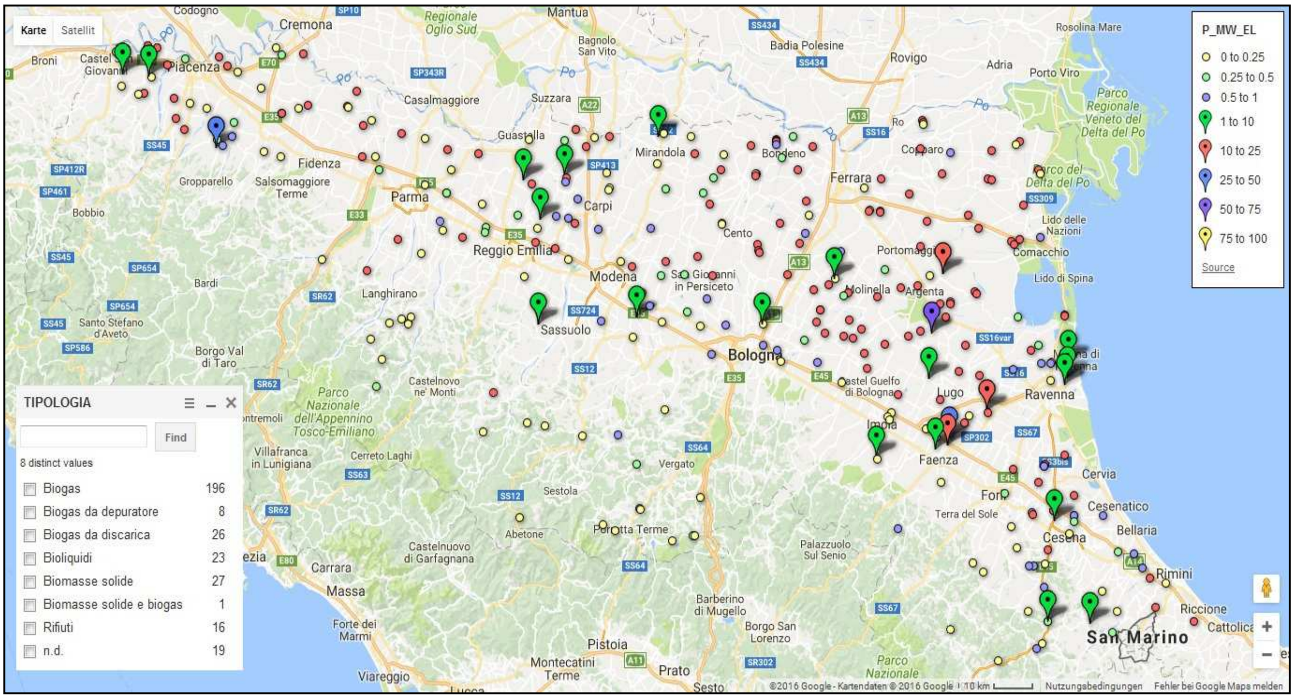

Figura 5 – Emilia-Romagna region biomass power plants; view from regional GIS - 2016.

Tabella 7- Synthesis for different types of biomass plants systems, in terms of sum of electric power installed in different provinces and total for Emilia-Romagna[5].

MWel. power	BO	FC	FE	MO	PC	PR	RA	RE	RN	Region
Biogas Only energy crops	11.85	3.92	15.29	2.00	2.87	4.00	3.87	1.00	1.00	**45.78**
Biogas Agri-zoo farm	4.71	3.01	6.24	3.35	7.41	1.61	7.99	6.36	1.00	**41.67**
Biogas Food.industry	12.07	0.19	7.24	2.60	0.00	2.62	10.30	2.13	0.00	**37.15**
Biogas Organic waste	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	**n.d.**
Solid wood biomass	1.13	3.27	14.10	0.50	1.86	0.00	63.60	0.50	0.00	**84.96**

Tabella 8 - Synthesis of IMPACT categories and DAMAGE macro.categories Ecoindicator'99 result values, in MegaPoints, of the single and summed different regional biomass power plants systems.

Ecoindicator'99 impacts/damages MPoints/year amounts		BIOGAS					WOOD COMBUSTION	
		Ecoinvent	Standard's SUM	Standard			Ecoinvent	Standard
		e08 Ecoinvent Swiss biogas ref.	SUM BG1+BG2+BG3	BG1 Standard only crops	BG2 Standard agro-zoo	BG3 Standard food industries	e07 Ecoinvent Swiss wood combustion ref.	WF3 Standard Forest wood combustion
Regional Biomass electric installed power	MW el.	**124.6**	**124.6**	**45.78**	**41.67**	**37.15**	**84.96**	**84.96**
IMPACTS								
Total	**Mpt**	**21.4**	**17.6**	**10.4**	**4.2**	**3.0**	**3.0**	**15.2**
Carcinogens	Mpt	0.1	9.3	6.5	2.7	0.2	0.3	0.1

[4] We didn't accounted biogas from landfill and sewage depuration, and bioliquids plants.
[5] We had not good information about types of solid biomass is used by each single solid biomass plants, so we assumed that all solid biomass plants are wood combustion type.

Resp. organics	Mpt	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Resp. inorganics	Mpt	12.1	3.3	2.3	0.9	0.0	0.1	1.5
Climate change	Mpt	5.5	1.1	0.8	0.3	0.0	0.0	1.1
Radiation	Mpt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ozone layer	Mpt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ecotoxicity	Mpt	0.0	0.2	0.0	0.0	0.2	0.7	0.0
Acidification/Eutrophication	Mpt	1.2	0.9	0.2	0.1	0.7	1.5	0.1
Land use	Mpt	0.1	0.0	0.0	0.0	0.0	0.0	12.1
Minerals	Mpt	2.4	2.8	0.6	0.2	2.0	0.1	0.3
DAMAGES								
Total	**Mpt**	**21.4**	**12.7**	**10.4**	**4.2**	**3.1**	**3.0**	**15.2**
Human Health	Mpt	17.7	13.5	9.6	3.9	0.0	0.3	2.7
Ecosystem Quality	Mpt	1.3	0.3	0.2	0.1	0.1	0.4	12.2
Resources	Mpt	2.4	3.7	0.6	0.2	2.9	2.3	0.3

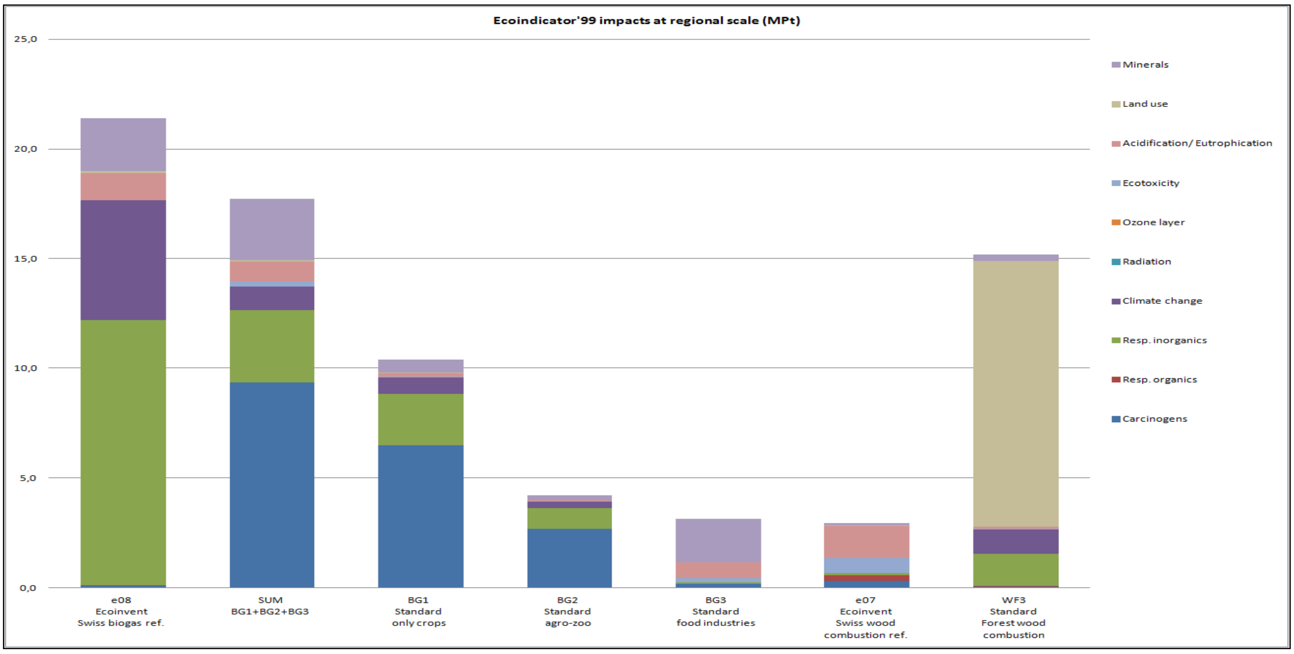

Figura 6 - Synthesis of impact categories Ecoindicator'99 result values, in MegaPoints, of the single and summed different regional biomass power plants systems.

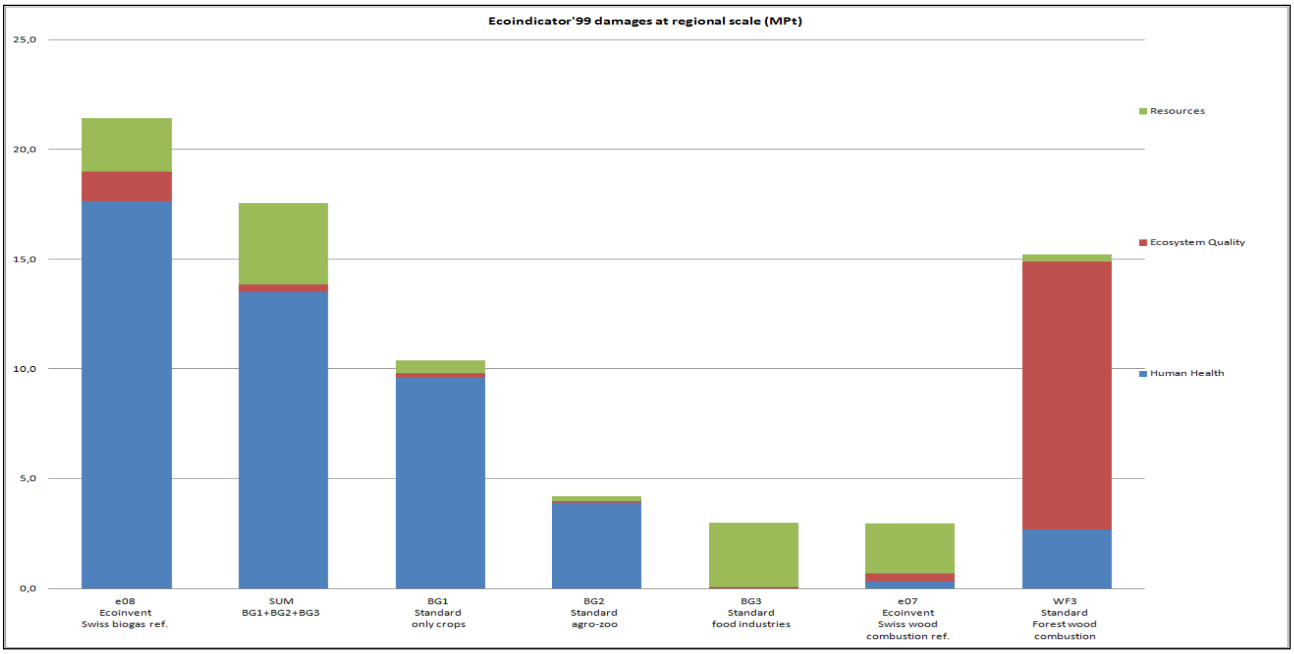

Figura 7 - Synthesis of damage macro.categories Ecoindicator'99 result values, in MegaPoints, of the single and summed different regional biomass power plants systems.

5. DISCUSSION

- The unitary damages of the considered cases vary between 0 and 0.763 MPt. Case studies will be analyzed more in depth. The values are comparable, even if the impacts categories are very different between the different groups of plants. Ecoinvent'99 methodology show that impacts are mostly blue for climate change, yellow for respiratory inorganic (dust) and green for respiratory organic substances, while all the biogas plants (both study cases and standardized) present a greater impact differentiation: red for carginogens prevails, brown of land use in addition to yellow and blue; and while in the group of wood combustion brown for land use prevails a lot[6]. Obviously results depend on the original structure both of the present research and of the Ecoinvent. The amber of brown color indicates that data about land use are not accounted in Ecoinvent energy sources productions.
- Comparing *e08.Ecoinvent.Swiss.Biogas* (171.8 kP) with other case studies and unitary standardized biogas plants, *energy crop BG1* could be underestimated (because of diesel consumption for cultivation parameter; we used a factor of 50 liters/ha declared in the data project [10], while we could use a 400 liters/ha proposed by ENAMA [32]).
  Agri-zoo BG2 appears to be enough comparable with e08, and so it is acceptable. Also food industry (BG3), even if shows practically the same impacts of *energy crop BG1*, can be considered acceptable because there are very few kilometers of input transport from byproduct production site and the anaerobic digestor.
  Also *organic waste (BG4)* has impacts very similar to food industry BG3, this is due to the fact that this biomass is waste that in every case has to be collected and disposed somewhere; so we have not implemented the input transport; and under this condition food byproducts and organic waste could be conceptually associated, and so they are numerically equivalent.
  In synthesis we think that while *energy crops BG1* standard underestimates significantly the diesel consumption for cultivation and it must be corrected; the other three standardized plants *agro-zoo BG2*, *food industry BG3* and *organic waste BG4* can be used like in-depth references, both as base productive chain and as unitary quantification, with Ecoindicator'99 impact and damage values.
- Comparing the *e07.Ecoinvent.Swiss.Woodcombustion* (34.7 kP) with other case studies and standardized wood combustion plants, first we see that it is almost 5 times more little of *W3.arboriculture* case study, of *W6.forest* case study and *WF3.forest standard* plants. Also in this case the impacts of our case studies and standardized plants are not based on blue and yellow color categories, like the case of *e07.Ecoinvent.swc*, but they are brown (land use); this depends, how in the previous case, on the original structure both of the present research and of the Ecoinvent.
  The standardized wood combustion plant *WF3.forest*, that collect wood from forest at the sustainable rate of 4.80 t/ha/year, has the same impact of *W6.forest* case study that use the same increment, and produces the same impact of *W3.arboriculture* case study, taking on a growth rate of 30 t/ha/year of fresh Populus L. wood. This can mean either that the implementing method used overestimates land use or that the Ecoinvent swiss impact references for energy produced from wood combustion is underestimated. On this we can only say that the rate of growth used by us of 30 t/ha/year of fresh wood for arboriculture exploitation [25] and that one of 4.80 t/ha/year for forest [27], [28], for which the consequent estimates needed areas are reliable, and are the cause of the related whole impact magnitudes. Is better to use the standardized reference plants respect the Ecoinvent swiss reference, because it is more conservative, in terms of environmental impacts and damages.
  We can justify the extremely high impacts of *W5* and *W4* used land by the extremely wide areas needed for Populus L. arboriculture, considering the annual massive increment of fresh wood productivity (22.8 t./ha/year and 11.4 respectively, reported by CRA-PF [24]); while the Ecoinvent swiss reference propose so low impacts values probably because of the wood combustion systems in Switzerland are much more efficient; Switzerland has always been a technological culture for the woody exploitation of alpine forests, both for the electricity and for the heat, also because land use is not implemented in its Ecoinvent references.
- Analyzing the multiplication of Ecoindicator'99 impacts and damages to installed electric powers, at regional scale we can see that:
  the sum of the impacts/damages produced by the three different standardized biogas plants *(BG1+BG2+BG3* = 17.6 Mpts) is less (-17.9%) than the related Ecoinvent Swiss biogas reference (*e08* = 21.4 Mpts); we also note that Ecoinvent swiss reference shows impacts associated mainly to respiratory inorganics substances (green) and climate change (violet), while the sum of three standard results mainly associated to carcinogens substances. Clearly this result depends on the method adopted, creating standardized dataset; note that in the standard plants we have considered the diesel consumption for cultivation as it is declared in the official documents of our case studies (50 liters/ha/year), and not 400 liters/ha/year as it is present in bibliography.
  We consider the three standard plants a good instrument to assess with more accuracy different biogas plants, and their productive chains, because with them it is possible to consider and to assess the diesel consumption associated to cultivation, transports and agronomic spread of digestate.
  About wood combustion the comparison between Ecoinvent swiss-reference and standard plants, clearly the results

[6] Unfortunately, cause the hight number of implemented plants, Simapro 7.3 software was not able to show correctly in the graph the colors of wood combustion case studies plants and standard. Looking the data you would see that they are almost entirely colored of brown, due the extremely high land use resulted values. For reason of space we cannot publish other colored graphs.

of unitary assessment are exactly proportional to the results of real installed electric power. The Ecoinvent impacts/damages (3.0 Mpts) is only the 19.4 % of those calculated with the standardized forest wood combustion plants (15,2 Mpts) that show a very high impact about land use impact category. This depends on the implementation logic we adopted for the wood combustion standard plant, where the forest area of exploitation in Simparo 7.3 was been implemented like "*Occupation, forest, extensive*" while we don't know how it would be implemented in Ecoinvent swiss references. From our point of view the "*Occupation, forest, extensive*" implementation is correct because we never have to forget that forest is not only a spontaneous trees cultivation, but it is a real ecosystem, where trees permits to live to all other life forms, that are very disturbed, especially in the reproductive periods, by forest exploitation, even if it is done in a sustainable way.

6. CONCLUSION

We repute the values of impact/damage associated to unitary standard plants can represent a good way and assessment instrument to quantify the environmental impact/damage of a regional biogas and wood combustion energy systems, both for Emilia-Romagna and for similar territories.
How the reader prefers he can easily choose and take in account both the Ecoinvent Swiss than the unitary standardized references we presented to multiply them for the biomass electric power installed on his territory to calculate directly related Ecoindicator'99 impacts/damages. The reader can also modify the starting data of standardized plants, with their productive chains, and so after implement them as he likes in a LCA software so to recalculate new unitary standardized plants and elaborate them with Ecoindicator'99 or other LCA methodologies.
This is a good starting point to improve correlated research, planning, sustainability balances, etc.. Unitary values here tested and presented can be an excellent fast screening instrument for regional assessments, especially why the environmental planner needs to know only the electric power installed values to obtain the quantitative estimation of the impacts/damages at regional scale with Ecoindicator'99 method, under the consideration that it can be a good realistic estimation even if it cannot be absolutely considered like an average.

The limit of this method, and of his opportunities, stays inside the fact that the reality of the regional biomass plant situation cannot be resumed in a planning sustainability model like or similar to that one here proposed, because in the sector of biomass energies each plant is specifically different and works on his specific territorial situation where it is located, with a big diversity between each plant. So the methodology adopted and his results here proposed certainly don't represent the averaged or the exactly sum of the biomass energy system environmental impact. The unitary models here presented represent a *"realistic possible average structure of a biomass energy system constructed with a good reliability of the bibliographic parameters, that were selected on the base of their scientific and practicality of use"*. The big difference between Swiss Ecoinvent solid combustion energy and the unitary standardized plants depends by the implementation of the land and forest use, very important parameter that cannot be forgot in all the environmental models. In conclusion, at first at the view of the good comparability with Swiss Ecoinvent references for bioenergy production, we repute the methodology, data and results here presented can be very useful instrument to be able to get a realistically possible quantitative estimation of the impact of biomass system and/or his subsystems at regional scale, simply multiplying the unitary values here proposed with the biomass electric power installed in your region. Equally useful is to be able to take this model and restructure it in a further better way and/or elaborate it with different LCA methodologies. So to arrive to a always better results, in turn comparable with those here presented and others.

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Index - part 9 -
DPSIR TERRITORIAL PLANNING ANALYSIS

1. DPSIR ANALYSIS

1.1. MAIN QUESTION:

How assess the environmental impact of a territorial system of woody solid biomass and biogas power plants including their related productive chains, with a DPSIR model?

- **OVERALL QUESTION:**

How can we assess, and monitor over time, environmental impacts, benefits and burdens related to the development of woody solid biomass and biogas plants at a territorial/regional level, or in a given area, through a DPSIR model, so as to support in a simple and effective way both the territorial planning activities that the related information at all levels?

- **SOLID WOOD COMBUSTION QUESTIONS:**

1. What are the real useful sustainable annual forest woody potentialities of the provincial/regional forest?
2. What are the equivalent thermal and electric energy amounts?
3. What are the best types of wood combustion plants (only thermal or only electric+thermal) to built?
4. Actually how many wood combustion plants systems the provincial/regional forests are able to supply according to a sustainable utilization?
5. How estimate the best wood biomass electric potential power that can be installed in a determinate territory?
6. What is the energy impact on the forest due to a standardized unitary wood plant of 1 MW.electric, and of an equivalent 2,4 MW.thermal power?

- **BIOGAS QUESTIONS:**

7. What are the main different kinds of biogas plants systems and productive chains?
8. What are the quantities of resources used by standardized unitary biogas plant of 1 MW.electric, for every type of different biogas productive chains?
9. What are the critical points that should be prevented (or considered with particular attention) by the energy planning regulations, and by the prescription of required actions of authorization entities for a biogas plant projected and his supply chain.
10. How can we localize the best and the more critical places where to build biogas power plants?
11. How can we identify the biogas plants that are localized in the most critical areas, and so that should be monitored more carefully?

- **SOLID WOOD BIOMASS AND BIOGAS QUESTIONS:**

12. How can we monitor over time environmental and territorial benefits and burdens of growing development of woody solid biomass and biogas plants, through the use of DPSIR model?
13. What are the main environmental (and socio-economic) benefits and burdens of producing energy with woody solid biomass and biogas plants?
14. How can evaluate/measure the environmental overall impact of the whole different system of woody solid biomass and biogas plants of a territory, so it would be possible compare it with other completely different productive systems?

    → LCA of the different unitary standardized woody solid biomass and biogas productive chains, and of their references on LCA Ecoinvent databases, that after are multiplied for their entire regional power systems.
15. How give an overall judgment of the entire and subclassified types of regional/territorial biomass systems?

- **TARGET**

Create an excel DPSIR tool that allows the updating, viewing and immediate assessment of the biogas plants territorial situation

2. THE BIOMASS DPSIR MODEL

To be able to assess, and monitor over time, overall environmental situation and impacts, benefits and burdens related to the development of the biomass plants system/s in a given area, through a DPSIR model, we can start from the situation showed on the following figure and then imagine to have to compile the remaining part of the lists that complete the DPSIR voices. While a significant amount of data have been calculated in the previous chapters, other significant data are here presented for first time. Our DPSIR model uses both groups of data.

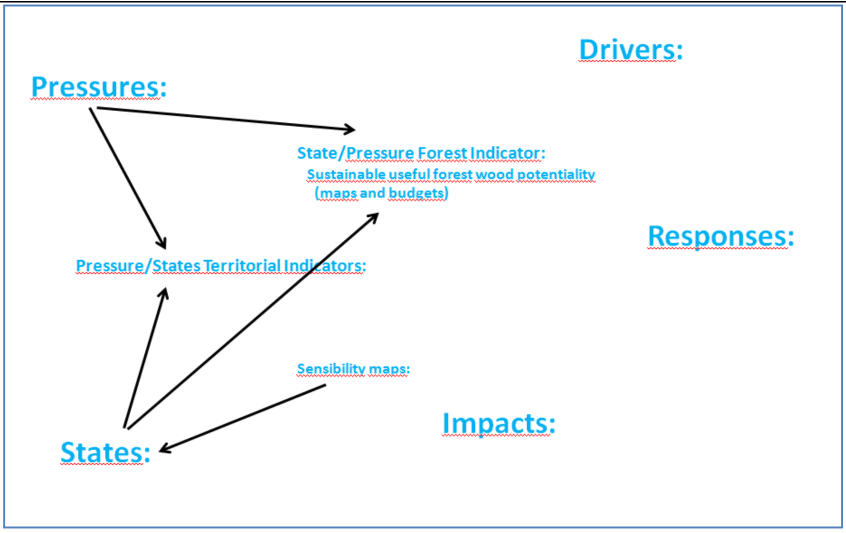


Figura 1- DPSIR conceptual scheme.

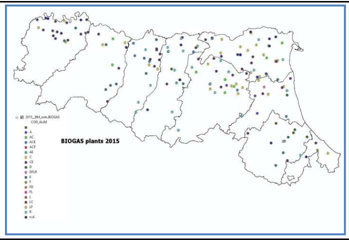


Figura 2- Biomass plants 2015

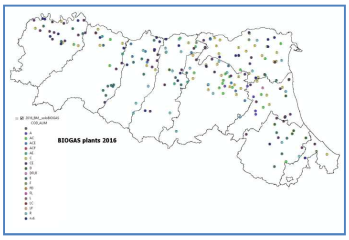


Figura 3- Biomass plants 2016

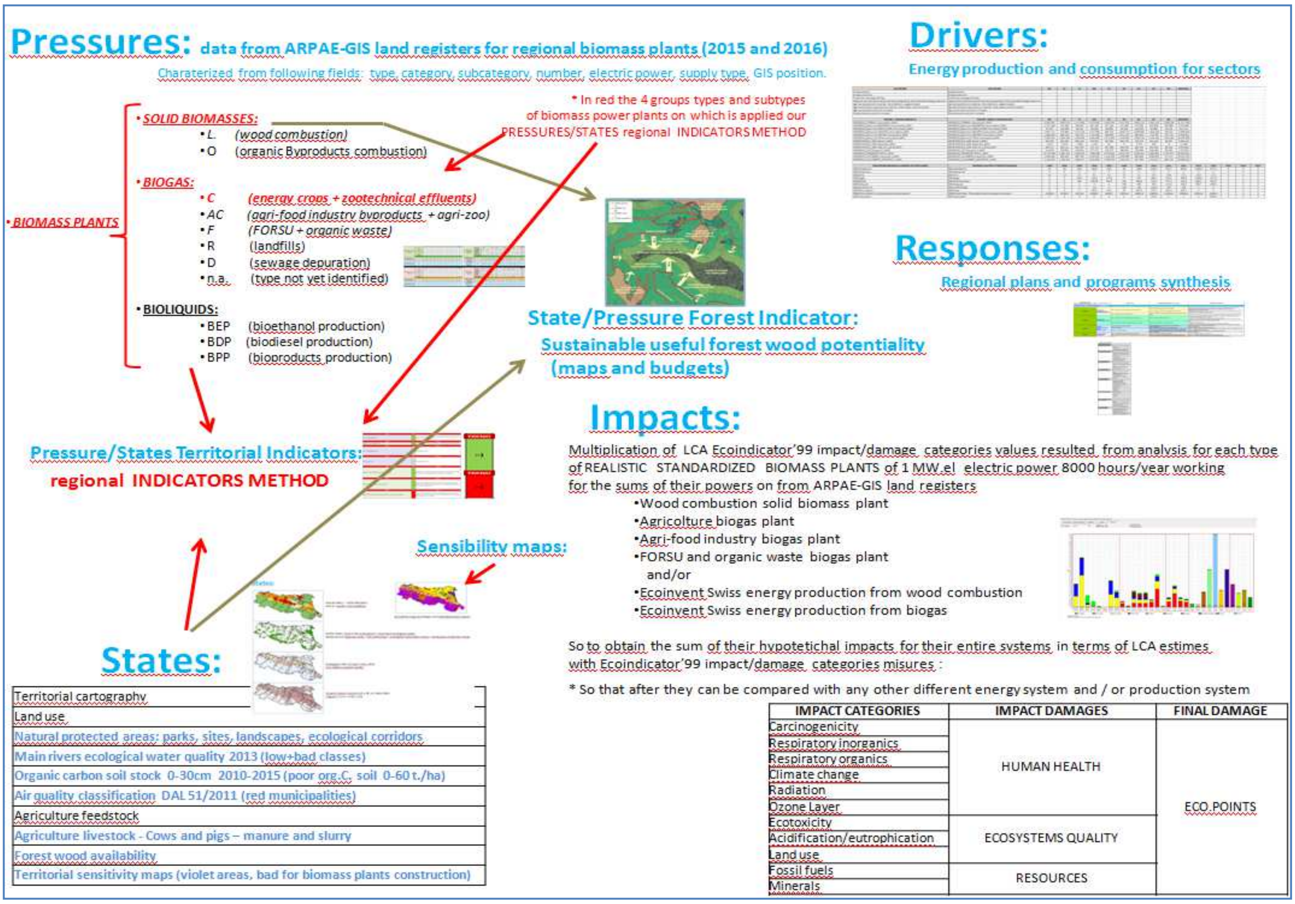


Figura 4- Synthethic frame of DPSIR model used in this research.

3. THE DPSIR JUDGMENT INDICATORS METHOD

3.1.1. The DPSIR judgment indicators method

To conclude the planning analysis of the regional biomass power plants system we have created the following method, based on pressure/state indicators, where we use different state values, derived from the data of ARPAE GIS land registers for biomass plants, from the regional consumption and production data, and from the values extracted from the previous parts of this research in which we have elaborated and/or calculated the maximum sustainable annual amount of forest wood available to supplies the regional/provincial solid wood combustion biomass plants system, or also the violet areas of sensibility maps, or also the red air quality municipalities defined by DAL 52/2011.

Practically we have applied the following steps:

1. To contextualize the DPSIR model, first of all we have schematized the RESPONSES, producing a scheme of the economic funds deriving by national/regional plans and programs that were active in the past years until 2015, and those that are been activated with the new operating regional energy plan 2017-2020 internal to the global regional energy plan 2017-2030.

2. Then, always to contextualize the DPSIR model, we have schematized and proposed the main DRIVERS, that we have identified in the regional and provincial data of energy consumption per sector of activities. We have also identified and show other data about the overall situation about different fields of activity, that were available only at regional scale.

3. Then we have identified the biomass power plants GIS land register 2015 and 2016 like PRESSURES data, and for each year we have grouped plants in the following groups on the basis of their productive chain:

			PRODUCTIVE CHAIN
TOTAL BIOMASS PLANTS	BIOGAS PLANTS	C	Energy crops and/or livestocks effluents
		AC	Agri-Food industry with part of Energy crops and/or lifestocks effients
		A	Agri-Food industry
		D	Sewage depuration
		F	Organic urban waste
		R	Landfill
		n.d.	Unknown
	SOLID BIOMASS PLANTS	L	Wood combustion (assumed all like forestal wood)
		~~O~~	~~Organic waste combustion~~
	~~BIOLIQUIDS~~	~~BEP~~	~~Bioethanol production~~
		~~BDP~~	~~Biodiesel production~~
		~~BPP~~	~~Bioproducts production~~
		~~n.d.~~	~~Unknown~~

4. After we have decided to apply our DPSIR model/assessment method only to the four red colored PRESSURE groups, that is: the three main bigger groups (Biomass plants, Biogas plants and solid wood biomass combustion plants) and to the most impactful sub-group type C (biogas plants supplied with energy crops and/or livestock manure and slurry).
This due the few available time, and for the fact that we repute C the most impactful biogas productive chain, we have decided to analyze with DPSIR method only the C sub-group, and

not the others sub-groups. This on the basis of reasoning that the other sub-groups reflect the need to treat the byproducts and organic waste that come out from their main processes, that are not primarily carried out to produce energy but other products, on the opposite of C group that has for main primary goal to cultivate energy crops to produce electric energy. In synthesis the reasoning is that: the crops cultivation to produce energy produce environmental impacts, while on the opposite way the treating of waste and/or byproducts coming out from other kind of activities is necessary and decreases their impacts.
We assumed that all the solid biomass plants are of the unique type of solid forestall wood combustion plants.
We didn’t analyze bioliquids plants because we had not good data about them.

5. Then, we have chosen the better STATES GIS layers, that have permitted us to overlap with the locations and values of our biomass GIS land registers. In particular we used the following GIS informative layers:

    - PRESSURE/STATE: hystorical trend (difference) about the number and electric power of our four main biomass group systems.

    - BURDEN: Natural parks and protected areas and their external buffer of 500 meters far from their boundaries.
      The reasoning is that the impacts produced from a biomass plant can create bigger environmental damages if they are located near the natural protected areas.

    - BURDEN: xternal buffer of 500 meters far from the segments of the rivers that in the ARPAE freshwater quality report 2010-2013 were classified with a low and bad ecological class.
      The reasoning is that the impacts produced from a biomass plant can create bigger environmental damages if they are located near rivers, and overall if they are located near portions of rivers that already have clear ecological quality problems.

    - BENEFIT: Areas where the organic Carbon content, in the first 30 cm of soil, are minor of 60 t./hectare (GIS layer dated 2010-2015).
      The reasoning is that spreading digestate or biochar improve the organic Carbon content, and these areas need to be enriched of organic Carbon.

    - BURDEN: Areas that are indicated with violet color in the sensibility maps.
      The reasoning is that in these area should not be built biomass energy power plants. So understand if they was built new plants there is important, to see the trend, to be able examine better specifically every single case and choose those that need a better and deeper monitoring activities.

6. After this, for each of the four groups, in a separated way for 2015 and for 2016 year, we have calculated the following 11 pressure/state indicators, both at provincial than regional scale:
   To better explain, here we propose the basis list of the indicators, for both years, only for Total biomass plants. In reality we have calculated these indicator for each ones of 4 biomass groups of plants, and for both years 2016 and 2015. Further on, in the right deepening chapter, we will show you all the list for both years of each of the four plants groups.

    - NOTE: In a first time we thought to misure how many plants there would be near 500 m. far from centers inhabited, but immediately it resulted that practically all plants are located within a their buffer, so we didn’t use this indicator.

Tabella 1- The basis list of the 11 adopted indicators for the Total biomass plants group (2015).

2015 - BIOMASS.Num.plants (Num.)
2015 - BIOMASS.electric.power (MW.el)
2015 - Number of biomass plants located within TPAB.500m [1]
2015 - Electric power of biomass plants located within TPAB.500m
2015 - % Electric power of biomass plants located within TPAB.500m respect total biomass plants
2015 - Number of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013
2015 - Electric power of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013
2015 - Number of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015
2015 - Electric power of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015
2015 - Number of biomass plants located in violet areas of sensitivity territorial maps
2015 - Electric power of biomass plants located in violet areas of sensitivity territorial maps

Tabella 2- The basis list of the 11 adopted indicators for the Total biomass plants group (2016).

2016 - BIOMASS.Num.plants (Num.)
2016 - BIOMASS.electric.power (MW.el)
2016 - Number of biomass plants located within TPAB.500m
2016 - Electric power of biomass plants located within TPAB.500m
2016 - % Electric power of biomass plants located within TPAB.500m respect total biomass plants
2016 - Number of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013
2016 - Electric power of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013
2016 - Number of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2016
2016 - Electric power of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2016
2016 - Number of biomass plants located in violet areas of sensitivity territorial maps
2016 - Electric power of biomass plants located in violet areas of sensitivity territorial maps

7. At this point we have calculated the difference values between each 2016 values and his corresponded 2015 values, so to obtain the values of differences.

8. So, analyzing the obtained difference values we were able to express a judgment about each single indicator. Both at provincial level that at regional level.
   In this research we propose the conclusions only for the analysis at regional scale, for lengthens reasons, but in appendix you will can find all the indicator values that, if you are interested, you can use to calculate and give them your judgments.

9. Each judgment consist of:
   - A trend indicator value (2016-2015);
   - A related explicative emoji (negative ☹ red, neutral :-I grey, positive ☺ green)
   - An explanation for the judgment;

10. In final, the 11 indicators table was been reassumed in a brief clear table of 7 themes, that describe the overall situation from these 7 points of view. Also each of these 7 themes are characterized from a final new judgment, also this described from a negative/neutral/positive emoji and related explanation.

[1] TPAB500m = located within the distance of 500 m. from the natural parks and areas.

3.2. DRIVERS

Figura 5- Drivers reference for the DPSIR model.

3.2.1. DRIVERS: Energy data 2010 + 2014 and others

We have identified these global big drivers:

Tabella 3- General drivers.

GENERAL DRIVERS
Energy consumption
Energy production
Production of energy CO2 free
Agricutural sector economic increase
Forestal sector economic increase

Inside these group we propose the disaggregated data for energy consumption and production, as it follows:

Tabella 4- Driver/States: Energy consumptions 2010.

DRIVER: consumption	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
ARPAE2010_THERMAL.Consumption_MWh	6.300.052	2.992.978	2.114.835	4.573.082	1.953.849	3.527.679	2.883.179	4.901.419	2.080.396	31.327.469
ARPAE2010_Electricity.RESIDENTIAL.Consumption_MWh	1.147.186	441.500	440.824	807.100	347.200	511.780	473.900	619.500	430.969	5.219.959
ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	97.827	218.000	85.516	96.200	66.800	64.536	161.500	94.900	26.135	911.414
ARPAE2010_Electricity.INDUSTRY.Consumption_MWh	1.952.712	575.800	1.073.176	2.317.900	669.100	1.560.776	1.599.800	1.810.100	436.241	11.995.605
ARPAE2010_Electricity.TERTIARY.Consumption_MWh	1.866.628	669.100	780.579	1.410.600	488.800	1.012.444	693.500	718.700	767.740	8.408.091
ARPAE2010_Electricity.TOTAL.Consumption_MWh	5.064.353	1.904.400	2.380.095	4.631.800	1.571.900	3.149.536	2.928.700	3.243.200	1.661.084	26.535.069
ARPAE-PAIR2014_AGRI.Diesel.C_MWh	387.925	253.435	500.138	370.970	407.362	348.778	379.724	301.326	88.457	3.038.115
ARPAE-PAIR2014_AGRI.Gasoline.C_MWh	2.201	2.676	2.366	1.210	32	17	2.707	206	71	11.486
ARPAE-PAIR2014_AGRI.FUEL.Tot.C_(D+G)_MWh	390.127	256.111	502.504	372.179	407.395	348.795	382.430	301.532	88.529	3.049.602
ARPAE2010_CH4.Transport.C_MWh	414.523	139.604	149.654	277.472	125.237	198.942	148.390	208.466	90.263	1.752.551
ARPAE2010_TRANSPORT.TOTAL.C_MWh	10.729.594	4.662.420	4.456.040	7.509.398	4.475.835	6.202.753	4.535.911	5.800.884	2.447.977	50.820.811
ARPAE2010_CH4.ENERGY_Industrial.C_MWh	4.640.660	959.619	963.796	3.529.391	1.218.359	2.539.995	863.886	3.080.945	727.471	18.524.122
ARPAE2010_Total.ENERGY_INDUSTRIAL.C_MWh	5.135.025	1.063.481	1.066.877	3.910.804	1.348.546	2.810.678	957.469	3.410.817	805.725	20.509.422

Tabella 5- Driver/States: Historical trend for electric energy production.

DRIVER: Electricity production	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Hydroelectric	26	26	29,8	48,92	53,5	58	1060	1150,2	872,7	854,8	1155,9	1277,1
Geothermal	0	0	0	0	0	0	0	0	0	0	0	0
Wind	0,1	0,1	0,1	0,1	0,1	24	21	24,7	19,8	27,2	26,4	27,2
Biogas	0	0	102,1	132,8	174,8	77	287	360,1	545,2	658,9	1130,6	1272,3
Solid biomasses	0	0	195	203,39	326,4	310	369,8	415,4	477,4	441,9	808,1	847,4
Bioliquids	0	0	0	0	0	736	558	530	217,8	328,2	455,7	639,3
Landfill biogas	0	0	0	0,8	0	156	156	152,9	159	106	0	0
Waste	0	0	0	40,17	40,2	40	254,3	274,7	302,4	302,2	0	0
Fossil fuels - Thermoelectrical (including incinerators)	22309,5	24363,4	23219,3	23368,7	25004,7	25541,6	20932,8	23855,5	22051,8	19458,6	15523,9	13264,1
Photovoltaic	0	0	0	0	0	0	0	153,1	0	0	0	2093,1

3.3. PRESSURES

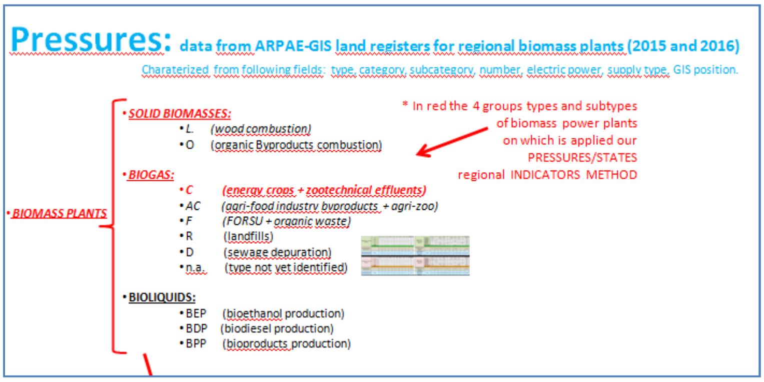


Figura 6- Pressures reference for the DPSIR model.

Starting from ARPAE GIS land registers 2015 + 2016 we have classified and grouped the biomass plants in the groups showed a sit follows, and then we have elaborated the data of only the red coloured groups:

- All biomass plants;
- All solid biomass plants (*assumed all burning forest wood);
- All biogas plants;
- (C) - Only biogas plants supplied with only agricultural matters and specially energy crops;

As well as analyzing the three big categories of biomass plants (total biomass, solid biomass, biogas plants) we have decide to give priority and analyze only the biogas plants supplied with only agricultural matters, because while byproducts coming from agro-food industries (or also from not-food industries like sawmills) that necessarily must be treated in a way or in an other, while instead it can be possible avoid to cultivate specifically energy crops that involve directly fossil fuels, water, fertilizers and pesticedes to grow. Consuming resources to treat waste and/or byproducts is a need and it is better if we produce energy from this treatments, while on the contrary practice cultivations and consume resources specifically to produce energy is a non-sense.

Tabella 6- Classification of biomass plants derived from starting GIS land registers. (in red the groups of energy plants analyzed).

			PRODUCTIVE CHAIN
BIOMASS PLANTS	BIOGAS PLANTS	C	Energy crops and/or livestock effluents
		AC	Agri-Food industry with part of Energy crops and/or lifestocks effluents
		A	Agri-Food industry
		D	Sewage depuration
		F	Organic urban waste
		R	Landfill
		n.d.	Unknown
	SOLID BIOMASS PLANTS	L	Wood combustion
		O	Organic waste combustion
	BIOLIQUIDS	BEP	Bioethanol production
		BDP	Biodiesel production
		BPP	Bioproducts production
		n.d.	Unknown

3.3.1. PRESSURES: ARPAE GIS land register for only biomass power plants 2015 + 2016:

Tabella 7- Biomass plants GIS land register disaggregated per type and Provinces. (Green 2015 + Rose 2016).

		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2015 -Number of plants-	C	12	2	20	3	13	6	6	8	3	73
	AC	6	0	6	3	0	2	1	3	0	21
	A	1	0	0	0	0	0	2	0	0	3
	D	1	4	0	2	0	0	1	0	0	8
	F	0	4	2	1	3	4	1	3	0	18
	R	9	2	3	7	0	0	2	3	0	26
	Other	1	1	8	4	5	1	0	0	1	21
	Tot Biogas plants	30	13	39	20	21	13	13	17	4	170
SOLID BIOMASS 2015 - Number of plants-	L	13	6	3	4	3	1	5	0	2	37
TOTAL BIOMASS PLANTS 2015 -Number of plants-	TOTAL	43	19	42	24	24	14	18	17	6	207

		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2015 - Electric power (MW.el)-	C_MW.el	7,484	0	8,991	1,298	0	1,998	27,917	1,129	0	48,817
	AC_MW.el	10,416	0,79	18,232	2,175	8,889	3,352	5,242	6,299	1,998	57,393
	A_MW.el	2,38	0,97	0	0,21	0	0	0	0	0	3,56
	D_MW.el	0	0	0	0	0	0	0,999	0	0	0,999
	F_MW.el	0	2,469	1,249	0,12	0,455	0,12	0	0,707	0,998	6,118
	R_MW.el	0	0	5,994	4,01	3,519	0	0	0	0,27	13,793
	Other_MW.el	8,394	4,964	2,35	4,273	0	0	0,861	6,3	0	27,142
	Total_MW.el	28,674	9,193	36,816	12,086	12,863	5,47	35,019	14,435	3,266	157,822
SOLID BIOMASS 2015 - Electric power (MW.el)-	L	1,13	3,264	27,199	0,5	1,859	0	72,728	0	0	106,68
TOTAL BIOMASS PLANTS 2015 -Electric power (MW.el)-	TOTAL	29,804	12,457	64,015	12,586	14,722	5,47	107,747	14,435	3,266	264,502

		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2016 -Number of plants-	C	19	8	24	10	18	16	12	12	2	121
	AC	14	1	8	4	1	5	4	4	0	41
	A	1	0	0	0	0	0	4	0	0	5
	D	1	4	0	2	0	0	1	0	0	8
	F	0	1	1	1	0	0	1	0	1	5
	R	9	2	3	7	0	0	2	3	0	26
	Other	2	1	8	5	6	2	0	4	1	29
	Tot Biogas plants	46	17	44	29	25	23	24	23	4	235
SOLID BIOMASS 2016 - Number of plants-	L	13	6	4	4	3	2	5	1	2	40
TOTAL BIOMASS PLANTS 2016 -Number of plants-	TOTAL	59	23	48	33	28	25	29	24	6	275

		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2016 - Electric power (MW.el)-	C_MW.el	11,436	0,19	7,243	1,299	0	2,318	10,305	2,128	0	34,919
	AC_MW.el	16,506	1,789	20,28	6,276	8,574	5,705	11,259	6,307	1,998	78,694
	A_MW.el	2,38	0,97	0	0,21	0	0	0	0	0	3,56
	D_MW.el	0	0,63	0	0	0	0	0	0	0	0,63
	F_MW.el	0,31	1,219	2,248	0,369	0,7	0,2	0,999	1,05	0,999	8,094
	R_MW.el	0,999	0	5,994	1,585	3,562	0,299	0	3,296	0,27	16,005
	Other_MW.el	4,649	3,46	1,75	3,819	0	0	0,86	5,599	0	20,137
	Total_MW.el	36,28	8,258	37,515	13,558	12,836	8,522	23,423	18,38	3,267	162,039
SOLID BIOMASS 2016 - Electric power (MW.el)-	L	1,13	3,269	13,1	0,5	1,86	0	63,6	0,5	0	83,959
TOTAL BIOMASS PLANTS 2016 -Electric power (MW.el)-	TOTAL	37,41	11,527	50,615	14,058	14,696	8,522	87,023	18,88	3,267	245,998

3.4. STATES

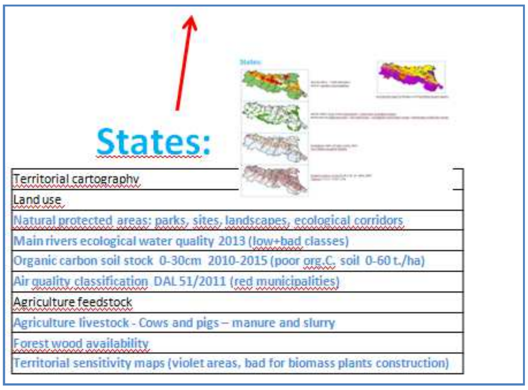


Figura 7- States reference for the DPSIR model.

Geographicaly we have choosen 5 territorial GIS layers on which to overlap our two biomass plants GIS land registers (2015+2016) and so elaborate the helpful indicators that we will show a little bit further on.

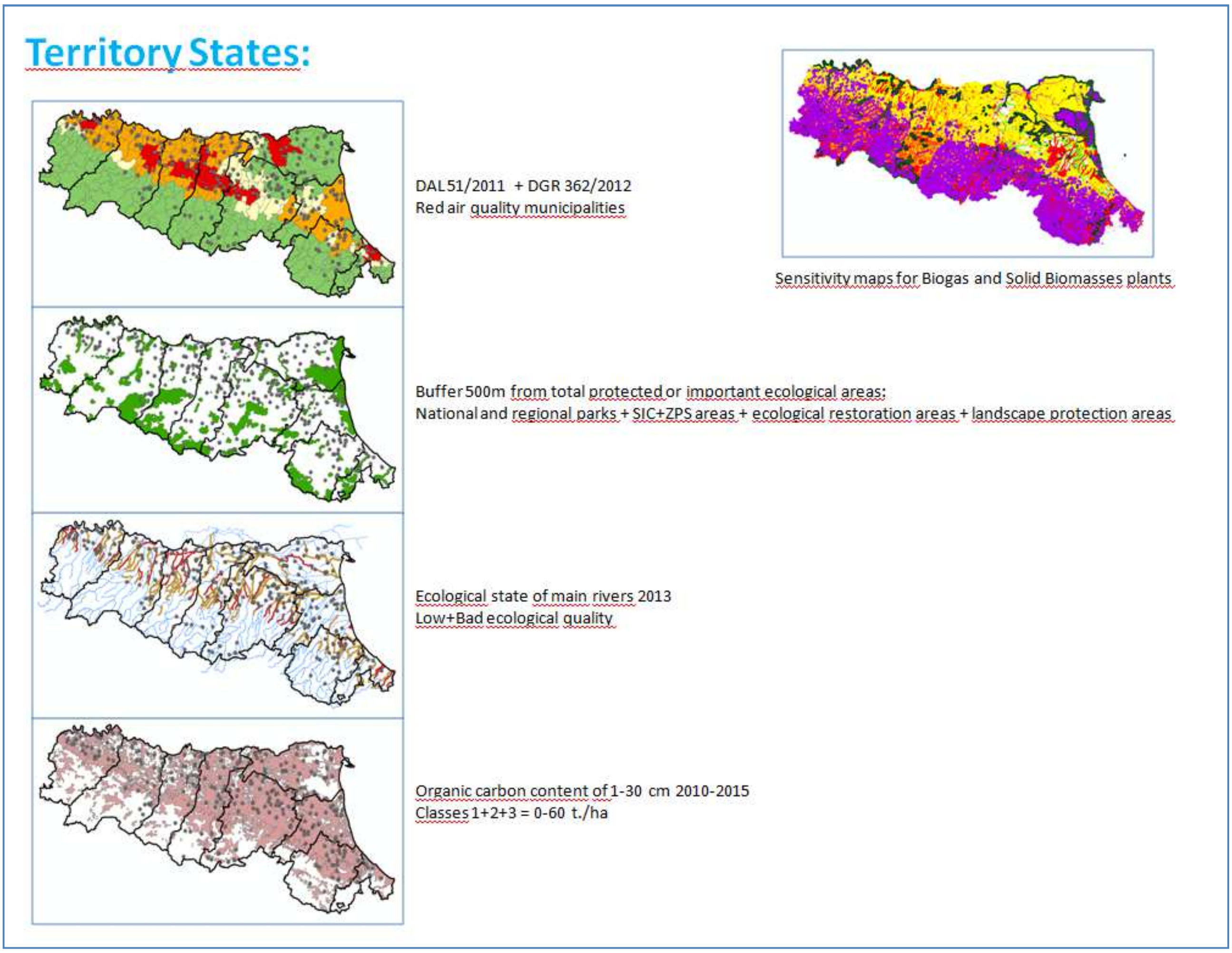


Figura 8- States: The 5 GIS layers used like informative states to elaborate the indicators of the DPSIR model.

3.4.1. STATES: GIS layers used for informative/numerical states values

Tabella 8- The 5 GIS layers used like informative/numerical states to elaborate the indicators of the DPSIR model

ORIGINAL STARTING GIS LAYER STATES[2]	INDICATORS	BENEFIT/BURDENS
Pressure/State: Biomass power plants GIS land registers 2015+2016	Pressure/State: - Increment/decrement of number, electric power, location of the 4 different groups of biomass plants systems.	PRESSURE/STATE
Land use: Natural parks and protected areas: - Areas of natural parks and protected areas.	Land use: - Biomass plants situated within protected areas or within the buffer of 500 m. from them.	BURDEN
Water: Ecological quality 2010-2013: - Km of main rivers classified with good and sufficient ecological quality. - Km of main rivers with bad and low ecological quality.	Water: - Biomass plants situated close 500 m. from river segments with low/bad ecological quality index.	BURDEN
Soil: superficial organic carbon content (0-30 cm) of soil: - poor organic carbon soil (0-60 org.C t./ha). - sufficient+rich organic carbon soil (60-270 org.C t./ha).	Soil: - Biomass plants situated on poor organic carbon soil (0-60 org.C t./ha).	BENEFIT [3]
Land use: Sensibility maps: - Areas (VIOLET) where it should not built biomass energy plants. - Areas (red, yellow, green, white) where it should not built biomass energy plants.	Sensibility maps: - Biomass plants situated within violet areas where it should not built biomass energy plants.	BURDEN
Air: DAL 51/2011: - Bad (red) quality air municipalities. - Not bad (orange, yellow, green) quality air municipalities.	Air: - Biomass plants situated MW.electric power inside bad (red) municipalities.	BURDEN

[2] In a first time we thought to misure how many plants there would be near 500 m. far from centers inhabited, but immediately it resulted that practically all plants are located within a their buffer, so we didn't use this indicator.
[3] The spreading of digestate or biochar on soil enrich his content of organic Carbon, so where the soil is poor of org. Carbon the presence of biomass plants (and overall biogas) that produce and spreading digestate is seen like a benefit for environment

3.4.2. STATES: GIS layers bibliography

Tabella 9- Bibliographyc references for the considered States data sources.

SECTOR	DATA TYPE	STATE THEME	SOURCE	WEB
Land use	GIS	Emilia-Romagna region Land Use GIS Map: vector covers of land use - year 2008 with 2011 updated edition: • Urban land • Agricultural land • Forest land • Wetland • Water areas	Emilia-Romagna Region	http://geoportale.regione.emilia-romagna.it/it/catalogo/dati-cartografici/pianificazione-e-catasto/uso-del-suolo/2008-coperture-vettoriali-delluso-del-suolo-edizione-2011
Land use	GIS	Emilia-Romagna region main urbanised localities and cities GIS Map	ARPAE	http://arpae.it
Natural Protected Areas	GIS	Emilia-Romagna region Natural Protected Areas: • National and Regional Parks	Emilia-Romagna Region	http://ambiente.regione.emilia-romagna.it/parchi-natura2000/consultazione/dati
Natural Protected Areas	GIS	Emilia-Romagna region Natural Protected Areas: • Nature 2000 Net SIC-ZPS protected areas	Emilia-Romagna Region	http://ambiente.regione.emilia-romagna.it/parchi-natura2000/consultazione/dati
Territorial cartography	GIS	Emilia-Romagna region low/high lands: • Low land areas	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=1177&idlivello=1527
Ecological water quality	GIS	Ecological state quality of water bodies 2010-2013: • Bad+Low ecological quality • High+Good+Sufficient ecological quality	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=1177&idlivello=1527
Organic carbon soil stock	GIS	Stock of 0-30 cm soil organic carbon (t./hectare): • Soil C class 1+2+3 = 0-60 C.org • Soil C class 4+5+6+7 = 60-315 C.org	Emilia-Romagna Region	http://ambiente.regione.emilia-romagna.it/geologia/temi/suoli/carbonio-organico
Air quality classification	Data	Air quality regional municipalities classification for biomass/biogas plants assessment by the Regional Assembly Resolution DAL 51 26/07/2011: • Red area • Orange area • Yellow area • Green area	ARPAE	https://www.arpae.it/cms3/documenti/_cerca_doc/energia/biomasse/zonizzazione_biomasse.pdf
Energy demand	Data	Total energy (Electric+Thermal) demand (MWh)	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031
Energy demand	Data	Total electric energy demand (MWh)	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031
Energy demand	Data	Agricultural electric demand (MWh)	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031
Energy demand	Data	Agricultural transport energy demand (MWh)	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031
Energy demand	Data	Only CH4 of total transport fuel demand (MWh)	ARPAE	https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031
Agriculture feedstocks	Data	National agricultural census 2010: Hectars and types of sowing fields (ha)	Regione Emilia-Romagna - ISTAT	http://statistica.regione.emilia-romagna.it/servizi-online/censimenti/6b0-censimento-dellagricoltura-2010/dati-al-24-ottobre-2010/copy_of_dinamiche/utilizzazione-dei-terreni
Agriculture livestocks	Data	National agricultural census 2010: Number of cows and pigs and animals bred (Num.)	Regione Emilia-Romagna - ISTAT	http://statistica.regione.emilia-romagna.it/servizi-online/censimenti/6b0-censimento-dellagricoltura-2010
Energy: biogas plants	Data	GSE Annual bulletins: Biogas plants 2014	GSE – national manager of renewable energy agency	http://www.gse.it/it/Dati%20e%20Bilanci/bollettino%20infomativo%20sull%20energia%20da%20fonti%20rinnovabili/Pagine/default.aspx
Energy: biogas plants	Data	GSE Annual bulletins: Biogas installed electric power 2014	GSE – national manager of renewable energy agency	http://www.gse.it/it/Dati%20e%20Bilanci/bollettino%20infomativo%20sull%20energia%20da%20fonti%20rinnovabili/Pagine/default.aspx
Energy: biogas plants	Data	GSE Annual statistical reports: Biogas electric production 2014	GSE – national manager of renewable energy agency	http://www.gse.it/it/Statistiche/Pages/default.aspx

3.4.3. STATES: Other fundamental regional/provincial data values

Tabella 10- Other states/drivers values data.

DATA	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
Regional AREA.2015.km2	3702	2379	2633	2689	2588	3447	1859	2290	864	22451
Regional AREA.2015.hectares	370238	237860	263269	268891	258768	344718	185920	229048	86385	2245097
Population 2015	1004323	395897	354073	702364	288013	445394	391997	533248	335199	4450508
ARPAE2010_THERMAL.Consumption_MWh	6300052	2992978	2114835	4573082	1953849	3527679	2883179	4901419	2080396	31327469
ARPAE2010_Electricity.RESIDENTIAL.Consumption_MWh	1147186	441500	440824	807100	347200	511780	473900	619500	430969	5219959
ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	97827	218000	85516	96200	66800	64536	161500	94900	26135	911414
ARPAE2010_Electricity.INDUSTRY.Consumption_MWh	1952712	575800	1073176	2317900	669100	1560776	1599800	1810100	436241	11995605
ARPAE2010_Electricity.TERTIARY.Consumption_MWh	1866628	669100	780579	1410600	488800	1012444	693500	718700	767740	8408091
ARPAE2010_Electricity.TOTAL.Consumption_MWh	5064353	1904400	2380095	4631800	1571900	3149536	2928700	3243200	1661084	26535069
ARPAE-PAIR2014_AGRI.Diesel.C_MWh	387925	253435	500138	370970	407362	348778	379724	301326	88457	3038115
ARPAE-PAIR2014_AGRI.Gasoline.C_MWh	2201	2676	2366	1210	32	17	2707	206	71	11486
ARPAE-PAIR2014_AGRI.FUEL.Tot.C_(D+G)_MWh	390127	256111	502504	372179	407395	348795	382430	301532	88529	3049602
ARPAE2010_CH4.Transport.C_MWh	414523	139604	149654	277472	125237	198942	148390	208466	90263	1752551
ARPAE2010_TRANSPORT.TOTAL.C_MWh	10729594	4662420	4456040	7509398	4475835	6202753	4535911	5800884	2447977	50820811
ARPAE2010_CH4.ENERGY_Industrial.C_MWh	4640660	959619	963796	3529391	1218359	2539995	863886	3080945	727471	18524122
ARPAE2010_Total.ENERGY_INDUSTRIAL.C_MWh	5135025	1063481	1066877	3910804	1348546	2810678	957469	3410817	805725	20509422
MUN-AgriC2010_SOWING_Hectares	141235	55004	160876	94739	97422	101850	75910	75843	27693	830571
MUN-AgriC2010_COWS	33180	19450	21742	94857	79760	150122	8850	140163	9107	557231
MUN-AgriC2010_PIGS	75340	149918	46917	338238	120074	111889	58439	332168	14477	1247460
MUN-AgriC2010_SHEEPS	9342	17136	7378	4231	3332	4264	2804	6054	8740	63281
MUN-AgriC2010_POULTRY	3997783	13863889	1384743	889259	414765	318718	5215960	1619682	542091	28246890
PROV.SMAIL-ER2014_AGRIworkers	15921	15891	13952	1408	9074	9984	15432	10989	4527	97178
PROV.SMAIL-ER2014_INDUSTRYworkers	103008	42267	26096	101331	26431	52201	34584	74722	21504	482144
PROV.SMAIL-ER2014_TERTIARYworkers	149134	47795	33927	80758	34192	57414	57752	5403	6746	473121
PROV.SMAIL-ER2014_BUILDINGworkers	28239	13624	8888	2356	8711	15425	12858	2007	10567	102675
PROV.SMAIL-ER2014_COMMERCEworkers	67548	27576	19388	42704	1816	26312	23529	29682	25067	263622
PROV.SMAIL-ER2014_TOTALworkers	363850	147153	102251	228557	80224	161336	144155	122803	68411	1418740
GSEBoll2015-Biogas.EL.power	30,9	9,0	33,2	14,4	15,2	9,2	22,0	8,4	3,8	146,1
GSEBoll2015-Biogas.Num.plants	33	13	33	23	25	20	21	16	4	188
GSERappStat2015-Biogas.elecrticenergy.production	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1272,3

3.4.1. STATES: Other general regional data values of state

Tabella 11- Other general regional context values of State.

ITA	WEB-SOURCE	CATEGORY	PARAMETER	MISURE UNIT	VALUE	%	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Area totale	http://dati.istat.it	Territorial CONTEXT	Total area	km2	22452,78	100,00%														
Pianura	http://dati.istat.it	Territorial CONTEXT	Pianura area	km2	10732,43	47,80%														
Collina	http://dati.istat.it	Territorial CONTEXT	Hill area	km2	6084,70	27,10%														
Monatagna	http://dati.istat.it	Territorial CONTEXT	Mountain area	km2	5635,65	25,10%														
Popolazione residente	http://sasweb.regior	POPULATION	Resident population	Inhabitants					4151335					4395606					4457115	
Totale lavoratori (in migliaia)	http://dati.istat.it//I	JOB	Total employees	Employees (values rounded to thousands)								1950		1906			1 904		1918	
Agricoltura, silvicoltura e pesca	http://dati.istat.it//I	JOB	Agriculture, forestry and fishing	Employees (values rounded to thousands)								74		74			65		66	
Totale industria (b-f)	http://dati.istat.it//I	JOB	Industry	Employees (values rounded to thousands)								666		641			619		629	
Totale industria escluse costruzioni (b-e)	http://dati.istat.it//I	JOB	Industry excluding construction (b-e)	Employees (values rounded to thousands)								516		510			497		522	
Totale servizi (g-u)	http://dati.istat.it//I	JOB	Services	Employees (values rounded to thousands)								1209		1192			1220		1224	
Aziende agricole	http://agri.istat.it/sa	AGRI - ECONOMIC- Agricultural companies: economic results	Agricultural companies	Number											73466	73309	66473			
Aziende con fatturato uguale o sup. a 15.000 euro	http://agri.istat.it/sa	AGRI - ECONOMIC- Agricultural companies: economic results	Companies with turnover of egual or greater € 15,000	Number											37310	36987	33150			
Produzione (milioni di euro)	http://agri.istat.it/sa	AGRI - ECONOMIC- Agricultural companies: economic results	Production (million euro)	Milions of euro											4344	4808	5083			
Valore aggiunto (milioni di euro)	http://agri.istat.it/sa	AGRI - ECONOMIC- Agricultural companies: economic results	Value added (million euro)	Milions of euro											2184	2258	2479			
ULA (unità di lavoro)	http://agri.istat.it/sa	AGRI - ECONOMIC- Agricultural companies: economic results	ULA (work units)	ULA											75475	76503	76665			
ULA dipendenti (unità di lavoro)	http://agri.istat.it/sa	AGRI - ECONOMIC- Agricultural companies: economic results	ULA employees (work units)	ULA											10937	13984	17182			
Consumi energetici totali	http://www.arpae.it	ENERGY - CONSUMPTION	Total energy consumption	MWh										236.387.705						
Consumi elettrici totali	http://www.arpae.it	ENERGY - ELECTRICITY CONSUMPTION	Total electricity consumption	MWh										26845699					26845699	
Consumi elettrici Edifici residenziali	http://www.arpae.it	ENERGY - ELECTRICITY CONSUMPTION	Electricity consumption Residential buildings	MWh										5283700					5283700	
Consumi elettrici Agricoltura	http://www.arpae.it	ENERGY - ELECTRICITY CONSUMPTION	Electricity consumption Agriculture	MWh										924499					924499	
Consumi elettrici Terziario e servizi	http://www.arpae.it	ENERGY - ELECTRICITY CONSUMPTION	Electricity consumption Tertiary and services	MWh										8473900					8473900	
Consumi elettrici Industriali	http://www.arpae.it	ENERGY - ELECTRICITY CONSUMPTION	Electricity consumption Industry	MWh										12163600					12163600	
Industriale Diffuso - TOTALE complessivo	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial TOTAL overall	MWh										20509421						
Industriale Diffuso - Carbone di legna	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Wood charcoal	MWh										22909						
Industriale Diffuso - Carbone coke	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Coal coke	MWh										39800						
Industriale Diffuso - Coke di petrolio	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Petroleum coke	MWh										19532						
Industriale Diffuso - Diesel (Gasolio)	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Diesel	MWh										284824						
Industriale Diffuso - Gas liquido (GPL)	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Liquid gas (LPG)	MWh										2641636						
Industriale Diffuso - Kerosene e altri liquidi	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Kerosene and other liquid	MWh										29570						
Industriale Diffuso - Gas naturale	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Natural gas	MWh										18524122						
Industriale Diffuso - Olio da riscaldamento	http://www.arpae.it	ENERGY - CONSUMPTION	Widespread industrial - Heating oil	MWh										1324498						
Trasporti - Consumo trasporti TOTALE complessivo	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - transport overall consumption TOTAL	MWh										50820810						
Trasporti - Consumo stradale Benzina	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - road Gasoline Consumption	MWh										12531109						
Trasporti - Consumo stradale Diesel	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - road Diesel Consumption	MWh										31900677						
Trasporti - Consumo stradale GPL	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - road LPG consumption	MWh										1572803						
Trasporti - Consumo stradale Gas Naturale	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - road Natural Gas Consumption	MWh										1752551						
Trasporti - Consumo stradale TOTALE	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - road consumption TOTAL	MWh										47757141						
Trasporti - Consumo off-road Benzina	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - off-road Gasoline Consumption	MWh										11539						
Trasporti - Consumo off-road Diesel	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - off-road diesel consumption	MWh										3052132						
Trasporti - Consumo off-road TOTALE	http://www.arpae.it	ENERGY - CONSUMPTION	Transport - off-road consumption TOTAL	MWh										3063669						
Consumo Residenziale - Consumo termico Residenziale	http://www.arpae.it	ENERGY - CONSUMPTION	Residential consumption - heat consumption Residential	MWh										31713080						
Consumi Terziario - TOTALE	http://www.arpae.it	ENERGY - CONSUMPTION	Tertiary consumption - TOTAL	MWh										22419872						
Consumi Terziario - Gas liquido (GPL)	http://www.arpae.it	ENERGY - CONSUMPTION	Tertiary consumption - Liquefied gas (LPG)	MWh										379104						
Consumi Terziario - Gas naturale	http://www.arpae.it	ENERGY - CONSUMPTION	Tertiary consumption - Natural gas	MWh										21670059						
Consumi Terziario - Gasolio	http://www.arpae.it	ENERGY - CONSUMPTION	Tertiary consumption - Oil	MWh										370709						

Agricoltura - SAU	http://statistica.regi	AGRICOLTURE	Agriculture - SAU	Hectares					1030322		1065572			1064449			1034364			
AGRI - FOT Frutta arborea TOTALI - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - OFT - Orchard fruit TOTAL - Quintals collected	Quintals										22804730			22133953	22376332		
AGRI - FOT Frutta arborea TOTALI - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - OFT - Orchard fruit TOTAL - Total hectares	Hectares										133013			120739	119716		
AGRI - FOT Frutta arborea TOTALI - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - OFT - Orchard fruit TOTAL - Yield (quintals / ha)	Quintals / ha										192,15			206,81	209,24		
AGRI - LGT Legumi da granella TOTALI - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - GLT - Grain legumes TOTAL - Quintals collected	Quintals										140812			64455	93163		
AGRI - LGT Legumi da granella TOTALI - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - GLT - Grain legumes TOTAL - Total hectares	Hectares										4799			2287	3266		
AGRI - LGT Legumi da granella TOTALI - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - GLT - Grain legumes TOTAL - Yield (quintals / ha)	Quintals / ha										29,34			28,18	28,61		
AGRI - CVT Colture vegetali TOTALI - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - CVT vegetable crops TOTAL - Quintals collected	Quintals										24922879			21228468	25165405		
AGRI - CVT Colture vegetali TOTALI - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - CVT vegetable crops TOTAL - Total Hectares	Hectares										59339			49019	54919		
AGRI - CVT Colture vegetali TOTALI - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - CVT vegetable crops TOTAL - Yield (quintals per hectare)	Quintals / ha										420,66			434,71	459,41		
AGRI - CI Barbabietola da zucchero - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - IC Sugar beet - Quintals collected	Quintals										15525714			11202293	20505978		
AGRI - CI Barbabietola da zucchero - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - IC Sugar beet - Total Hectares	Hectares										25998			21979	2698		
AGRI - CI Barbabietola da zucchero - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - IC Sugar beet - Yield (quintals per hectare)	Quintals / ha										626,63			533,26	761,57		
AGRI - CI Colza - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - IC Colza - Quintals collected	Quintals										76056			56407	55133		
AGRI - CI Colza - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - IC Colza - Total Hectares	Hectares										2611			1949	1775		
AGRI - CI Colza - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - IC Colza - Yield (quintals per hectare)	Quintals / ha										29,13			28,94	31,68		
AGRI - CI Girasole - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - IC Sunflower - Quintals collected	Quintals										169465			153482	169361		
AGRI - CI Girasole - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - IC Sunflower - Total Hectares	Hectares										5274			536	499		
AGRI - CI Girasole - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - IC Sunflower - Yield (quintals per hectare)	Quintals / ha										32,13			28,73	33,94		
AGRI - CI Soia - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - IC Soy - Quintals collected	Quintals										858395			682082	1112423		
AGRI - CI Soia - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - IC Soy - Total Hectares	Hectares										22961			20993	25251		
AGRI - CI Soia - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - IC Soy - Yield (quintals per hectare)	Quintals / ha										37,39			32,49	44,06		
AGRI - CIT Coltivazioni industriali TOTALI - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - ICT Industrial crops TOTAL - Quintals collected	Quintals										16629630			12094264	21842895		
AGRI - CIT Coltivazioni industriali TOTALI - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - ICT Industrial crops TOTAL - Total Hectares	Hectares										56844			50281	58996		
AGRI - CIT Coltivazioni industriali TOTALI - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - ICT Industrial crops TOTAL - Yield (quintals per hectare)	Quintals / ha										306,02			250,85	370,96		
AGRI - C Mais - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - C Maize - Quintals collected	Quintals										10116350			8428944	9055602		
AGRI - C Mais - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - C Maize - Total Hectares	Hectares										9837			101591	85271		
AGRI - C Mais - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - C Maize - Yield (quintals per hectare)	Quintals / ha										102,84			82,97	106,2		
AGRI - C Sorgo da granella - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - C Grain sorghum - Quintals collected	Quintals										2116890			2087002	2636666		
AGRI - C Sorgo da granella - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - C Grain sorghum - Total Hectares	Hectares										2673			27971	31653		
AGRI - C Sorgo da granella - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - C Grain sorghum - Yield (quintals per hectare)	Quintals / ha										79,2			74,61	83,3		
AGRI - CT Cereali TOTALE - Quintali raccolti	http://statistica.regi	AGRICOLTURE	AGRI - CT Cereals TOTAL - Quintals collected	Quintals										25932821			23835901	24300931		
AGRI - CT Cereali TOTALE - Ettari totali	http://statistica.regi	AGRICOLTURE	AGRI - CT Cereals TOTAL - Total Hectares	Hectares										374821			371868	344016		
AGRI - CT Cereali TOTALE - Resa (q.li per ettaro)	http://statistica.regi	AGRICOLTURE	AGRI - CT Cereals TOTAL - Yield (quintals per hectare)	Quintals / ha										69,21			64,1	70,67		

AGRI-N.SAU--SAU--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SAU - Number of Companies	Number			1962537		1725589		1677765									
AGRI-N.SAU--SAU totale seminativi--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU arable-sowing - Number of Companies	Number			1041819		970349		966574									
AGRI-N.SAU--SAU totale coltivazioni agrarie--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU agricultural crops - Number of Companies	Number			1383718		1203187		1178228									
AGRI-N.SAU--SAU totale orti familiari--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU family gardens - Number of Companies	Number			471924		452728		409396									
AGRI-N.SAU--SAU totale prati permanenti e pascoli utilizzati--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU permanent grassland and pastures used - Number of Companies	Number			399316		346144		351677									
AGRI-N.SAU--SW totale arboricoltura da legno--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SW wood arboriculture - Number of Companies	Number			33440		29365		34781									
AGRI-N.SAU--SW totale boschi--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SW woodlands - Number of Companies	Number			389925		360638		371427									
AGRI-N.SAU--SW superficie agraria non utilizzata--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SW agricultural areas not used - Number of Companies	Number			379466		307761		337107									
AGRI-N.SAU--SW altra superficie--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SW other areas - Number of Companies	Number			1229846		1146310		1105850									
AGRI-N.SAU--SW superficie TOTALE--Num.Aziende	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SW TOTAL Area - Number of Companies	Number			1963254		1726130		1678756									
AGRI-N.SAU--SAU--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SAU - Area	Hectares			13115810,72		12707845,92		12744196,23									
AGRI-N.SAU--SAU totale seminativi--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU arable-sowing - Area	Hectares			7277912,01		7040398,27		6938830,68									
AGRI-N.SAU--SAU totale coltivazioni agrarie--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU agricultural crops - Area	Hectares			2462202,05		2285670,6		2323183,97									
AGRI-N.SAU--SAU totale orti familiari--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU family gardens - Area	Hectares			39291,56		34825,97		30425,9									
AGRI-N.SAU--SAU totale prati permanenti e pascoli utilizzati--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SAU permanent grassland and pastures used - Area	Hectares			3336405,11		3346951,09		3442342,36									
AGRI-N.SAU--SW totale arboricoltura da legno--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SW wood arboriculture - Area	Hectares			131614,16		121873,61		121420									
AGRI-N.SAU--SW totale boschi--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - Total SW woodlands - Area	Hectares			3534602,72		3648349,31		3692222,76									
AGRI-N.SAU--SW superficie agraria non utilizzata--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SW agricultural areas not used - Area	Hectares			682799,68		561402,29		592153,23									
AGRI-N.SAU--SW altra superficie--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SW other areas - Area	Hectares			767745,48		763543,15		691552,23									
AGRI-N.SAU--SW superficie TOTALE--Area	http://dati.istat.it//I	AGRICOLTURE	AGRI-N.SAU - SW TOTAL Area - Area	Hectares			18232572,77		17803014,28		17841544,45									
AGRI2 - Trinciato di mais - Resa minima (q.li/ha)	[NETAFIM, 2013, a.]	AGRICOLTURE	AGRI2 - Chopped maize - minimum yield	Quintals / ha	450															
AGRI2 - Trinciato di mais - Resa media (q.li/ha)	[NETAFIM, 2013, a.]	AGRICOLTURE	AGRI2 - Chopped maize - medium yield	Quintals / ha	575															
AGRI2 - Trinciato di mais - Resa massima (q.li/ha)	[NETAFIM, 2013, a.]	AGRICOLTURE	AGRI2 - Chopped maize - maximum yield	Quintals / ha	700															

ZOO-Aziende-14: totale bovini	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-14: Total bovines	Number			9180		9175		8522									
ZOO-Aziende-15: bovini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-15: Foreign origin bovines	Number			299		306		291									
ZOO-Aziende-19: totale bufalini	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-19: Total buffaloes	Number			4		53		13									
ZOO-Aziende-23: totale ovini	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-23: Total sheep	Number			1595		920		1315									
ZOO-Aziende-24: ovini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-24: Foreign origin sheep	Number			11		..		90									
ZOO-Aziende-28: totale caprini	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-28: Fotal caprine animals	Number			553		399		908									
ZOO-Aziende-32: totale equini	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-32: Total equines	Number			1976		2814		3161									
ZOO-Aziende-33: equini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-33: Foreign origin equines	Number			73		45		137									
ZOO-Aziende-44: totale suini	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-44: Total pigs	Number			2751		2191		1541									
ZOO-Aziende-41: scrofe montate per la prima volta	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-41: Sows covered for the first time	Number			466		178		201									
ZOO-Aziende-43: altre scrofe giovani non ancora montate	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-43: Other young sows not yet covered	Number			500		126		83									
ZOO-Aziende-45: suini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-45: Foreign origin pigs	Number			14		30		67									
ZOO-Aziende-53: totale allevamenti avicoli	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-53: Total poultry farms	Number			1154		739		702									
ZOO-Aziende-54: struzzi	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-54: Ostriches	Number			239		104		36									
ZOO-Aziende-57: conigli	http://dati.istat.it//I	LIVESTOCK	ZOO-Companies-57: Rabbits	Number			135		240		308									
ZOO-Animali-14: totale bovini	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-14: Total bovines	Number			552171		608469		593587									
ZOO-Animali-15: bovini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-15: Foreign origin bovines	Number			37391		15062		35096									
ZOO-Animali-19: totale bufalini	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-19: Total buffaloes	Number			650		317		1189									
ZOO-Animali-23: totale ovini	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-23: Total sheep	Number			105848		54093		68983									
ZOO-Animali-24: ovini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-24: Foreign origin sheep	Number			101		..		994									
ZOO-Animali-28: totale caprini	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-28: Total caprine animals	Number			4675		3081		9161									
ZOO-Animali-32: totale equini	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-32: Total equines	Number			8842		17076		15940									
ZOO-Animali-33: equini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-33: Foreign origin equines	Number			289		306		143									
ZOO-Animali-44: totale suini	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-44: Total pigs	Number			1328323		1342878		1412065									
ZOO-Animali-41: scrofe montate per la prima volta	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-41: Sows covered for the first time	Number			12561		12124		11509									
ZOO-Animali-43: altre scrofe giovani non ancora montate	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-43: Other young sows not yet covered	Number			12219		9051		10828									
ZOO-Animali-45: suini di provenienza estera	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-45: Foreign origin pigs	Number			2794		25493		4790									
ZOO-Animali-53: totale allevamenti avicoli	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-53: Total poultry farms	Number			32022069		31860039		30412647									
ZOO-Animali-54: struzzi	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-54: Ostriches	Number			25237		2744		97									
ZOO-Animali-57: conigli	http://dati.istat.it//I	LIVESTOCK	ZOO-Animals-57: Rabbits	Number			329120		439025		373255									
ZOO2-Animali--Bovini+Bufalini TOTALE	http://agri.istat.it/sa	LIVESTOCK	ZOO2-Animals - Cattle + Buffalos TOTAL	Number										578412			706422	658883	657633	
ZOO2-Animali--Suini TOTALE	http://agri.istat.it/sa	LIVESTOCK	ZOO2-Animals - Pigs TOTAL	Number										1641674			1570717	1477167	1482056	
ZOO2-Animali--Ovini TOTALE	http://agri.istat.it/sa	LIVESTOCK	ZOO2-Animals - Sheeps TOTAL	Number										88892			88835	81178	78489	
ZOO2-Animali--Caprini TOTALE	http://agri.istat.it/sa	LIVESTOCK	ZOO2-Animals - Goats TOTAL	Number										9006			13742	10469	13682	
ZOO2-Animali--Equini TOTAL	http://agri.istat.it/sa	LIVESTOCK	ZOO2-Animals - Horses TOTAL	Number										34771			35194	36298	36394	

LEGNO-F01B - Utilizzazioni legnose forestali per assortimento -Legname da LAVORO	http://agri.istat.it/sa	FOREST	WOOD-F01B - Utilization for forestry woody assortment -Wood for WORK	m3					33064					11278					14073	
LEGNO-F01B - Utilizzazioni legnose forestali per assortimento -Legname per USI COMBUSTIBILI	http://agri.istat.it/sa	FOREST	WOOD-F01B - Utilization for forestry woody assortment -Wood for FUEL	m3					264593					324393					203654	
LEGNO-F01B - Utilizzazioni legnose forestali per assortimento -Legname TOTALE	http://agri.istat.it/sa	FOREST	WOOD-F01B - Utilization for forestry woody assortment -Wood TOTAL	m3					297657					335671					217727	
LEGNO-F02 - Utilizzazioni legnose forestali per assortimento -Legname da LAVORO (in foresta e fuori foresta)	http://agri.istat.it/sa	FOREST	WOOD-F02 - Utilization for forestry woody assortment - Wood for WORK (in forest and out forest)	m3					204623					44246					30808	
LEGNO-F02 - Utilizzazioni legnose forestali per assortimento -Legname per USI COMBUSTIBILI (in foresta e fuori foresta)	http://agri.istat.it/sa	FOREST	WOOD-F02 - Utilization for forestry woody assortment - Wood for FUEL (in forest and out forest)	m3					293078					335932					219079	
LEGNO-F02 - Utilizzazioni legnose forestali per assortimento -Legname TOTALE (in foresta e fuori foresta)	http://agri.istat.it/sa	FOREST	WOOD-F02 - Utilization for forestry woody assortment - Wood TOTAL (in forest and out forest)	m3					497701					380178					249887	
LEGNO-F05 - Superficie per categoria di proprietà - Stato e Regioni	http://agri.istat.it/sa	FOREST	WOOD-F05 - Surface for property category - State and Regions	Hectares					80					177					106	
LEGNO-F05 - Superficie per categoria di proprietà - Comuni	http://agri.istat.it/sa	FOREST	WOOD-F05 - Surface for property category - Municipalities	Hectares					20					42					15	
LEGNO-F05 - Superficie per categoria di proprietà - Altri Enti	http://agri.istat.it/sa	FOREST	WOOD-F05 - Surface for property category - Other Institutions	Hectares					72					38					30	
LEGNO-F05 - Superficie per categoria di proprietà - Privati	http://agri.istat.it/sa	FOREST	WOOD-F05 - Surface for property category - Private	Hectares					2522					2976					915	
LEGNO-F05 - Superficie per categoria di proprietà - TOTALE	http://agri.istat.it/sa	FOREST	WOOD-F05 - Surface for property category - TOTAL	Hectares					2694					3233					1066	
LEGNO-F08 - Superficie forestale per zona altimetrica - MONTAGNA	http://agri.istat.it/sa	FOREST	WOOD-F08 - Forest area by altitude zone - MOUNTAIN	Hectares				271369												
LEGNO-F08 - Superficie forestale per zona altimetrica - COLLINA	http://agri.istat.it/sa	FOREST	WOOD-F08 - Forest area by altitude zone - HILL	Hectares				112351												
LEGNO-F08 - Superficie forestale per zona altimetrica - PIANURA	http://agri.istat.it/sa	FOREST	WOOD-F08 - Forest area by altitude zone - PIANURA	Hectares				21199												
LEGNO-F11 - CONIFERE - Prezzi medi della legna per uso energetico commercializzata all'imposto	http://agri.istat.it/sa	FOREST	WOOD-F11 - CONIFEROUS TREES - average prices of wood for energy use marketed at the landing	Euro/m3					20					12,34						
LEGNO-F11 - LATIFOGLIE - Prezzi medi della legna per uso energetico commercializzata all'imposto	http://agri.istat.it/sa	FOREST	WOOD-F11 - HARDWOOD SAWMILLS - average prices of wood for energy use marketed at the landing	Euro/m3					52,13					50,36						
LEGNO-EMR16- Aziende agricole e forestali	http://www.regione	FOREST	WOOD-EMR16- Farms and forestry	Number																700
LEGNO-EMR16- Imprese forestali e gestione verde e dissesto idrogeologico	http://www.regione	FOREST	WOOD-EMR16- Forestry and green management and hydrogeological Companies	Number																120
LEGNO-EMR16- ADDETTI Imprese forestali e gestione verde e dissesto idrogeologico	http://www.regione	FOREST	WOOD-EMR16- EMPLOYEES in Forestry and green management and hydrogeological Companies	Number																1800

LEGNO-COMBUSTIONE-CO2contenuto	[Frühwald, 2015, a]	FOREST	WOOD-COMBUSTION-CO2content	kg CO2 / m3 wood	917,5															
LEGNO-FISSAZIONE-CARBONIO	[INFC, 2005, a]	FOREST	WOOD-CARBON-FIXATION	Tonnes C / hectare*year	54															
LEGNO- Massa arborea secca da boschi e foreste	[INFC, 2005, a]	FOREST	WOOD- Dry tree mass from forest	Tonnes					60272000											
LEGNO- Massa di Carbonio da boschi e foreste	[INFC, 2005, a]	FOREST	WOOD- Carbon mass from forest	Tonnes					30136000											
LEGNO- Volume legno arboreo	[INFC, 2005, a]	FOREST	WOOD- Volume of wood from forest	m3					72338122									72338122		
LEGNO- Incremento forestale medio	http://www.regione	FOREST	WOOD- Average annual forest increase	m3 wood / hectare*year	4,4															
LEGNO- Incremento forestale totale	http://www.regione	FOREST	WOOD- Total annual forest increase	m3 wood / year				2379879												
LEGNO- Area forestale totale	http://www.regione	FOREST	WOOD- Total forest area	Hectares						612600										
LEGNO- Area forestale adatta alla raccolta	RER.SAPFSM	FOREST	WOOD- Forest area suitable for harvasting	Hectares						549800								546928		
LEGNO- Volume legno da arboricoltura	http://www.regione	FOREST	WOOD- Wood volume from arboriculture	m3					104563											
LEGNO- Volume legno da arboricoltura - incremento medio		FOREST	WOOD- Arboriculture annual increase	m3	10,7															
LEGNO- Volume legno forestale dei soli boschi alti	http://www.regione	FOREST	WOOD- Wood volume of the only high forest	m3					2379879											
LEGNO- Incremento forestale medio dei soli boschi alti		FOREST	WOOD- Wood volume increase of the only high forest	m3	4,3															
LEGNO- Volume legno forestale+arboricoltura	http://www.regione	FOREST	WOOD- Wood volume high forest+arboriculture	m3					2484442											
LEGNO- Area a boschi alti	RER.SAPFSM	FOREST	WOOD- High forest area	Hectares						546928								546928		
LEGNO- Volume legno stock esistente dei boschi alti	http://www.regione	FOREST	WOOD- Volume of existing stock of high forest wood	m3 wood / year				2379879										2379879		
LEGNO- Densita volumica areale unitaria esistente	http://www.regione	FOREST	WOOD- Volumic areal unitary density	m3 / hectare														132,3		
LEGNO- Peso specifico medio legna stagionata	http://www.regione	FOREST	WOOD- Average specific weight of seasoned wood	Tonnes / m3	0,6															
LEGNO- Stock esistente di legno stagionato	http://www.regione	FOREST	WOOD- Existing stock of seasoned wood	Tonnes														43402873		
LEGNO- Disponibilità massiva medio corrente	http://www.regione	FOREST	WOOD- Availability current average mass	Tonnes / hectare*year	79,36															
LEGNO- Incremento forestale medio UTILIZZATO	RER.SAPFSM	FOREST	WOOD- Average annual forest increase USED	m3 wood / hectare*year	4,35															
LEGNO- Incremento totale di legno stagionato	http://www.regione	FOREST	WOOD- Total increase of seasoned wood	Tonnes														1427927		
LEGNO- Incremento massivo di legno stagionato	http://www.regione	FOREST	WOOD- Massiv increase of seasoned wood	Tonnes / hectare*year	2,61															
LEGNO- Prelievo annuale massimo sostenibile	http://www.regione	FOREST	WOOD- Maximum sustainable annual withdrawal	Tonnes														1427927		
LEGNO- Percentuale con destinazione a legna da ardere	RER.SAPFSM	FOREST	WOOD- Percentage with destination to domestic firewood	%	70%															
LEGNO- Percentuale con destinazione per impianti energetici	RER.SAPFSM	FOREST	WOOD- Percentage with destination to power plants	%	30%															
LEGNO- Area teorica necessaria al Prelievo annuale massimo per legna da ardere	RER.SAPFSM	FOREST	WOOD- Theoric area needed for Maximum withdrawal for domestic firewood	Hectares														431624		
LEGNO- Area teorica necessaria al Prelievo annuale massimo per impianti energetici	RER.SAPFSM	FOREST	WOOD- Theoric area needed for Maximum withdrawal for power plants	Hectares														115304		
LEGNO150- Area forestale totale raggiungibile (150 m. da strade o campi)	RER.SAPFSM	FOREST	WOOD150- forestal area attainable (150 m. from roads or fields)	Hectares														430379		
LEGNO150- Area forestale totale raggiungibile (150 m. da strade o campi)	RER.SAPFSM	FOREST	WOOD150- forestal area attainable (150 m. from roads or fields)	%														78,69%		
LEGNO150- Incremento totale di legno stagionato nell area die 150m.	RER.SAPFSM	FOREST	WOOD150- Total increase of seasoned wood inside the area of 150m.	m3														1765203		
LEGNO150- Incremento totale di legno stagionato nell area die 150m.	RER.SAPFSM	FOREST	WOOD150- Total increase of seasoned wood inside the area of 150m.	Tonnes														1136490		
RIFIUTI - Produzione di rifiuti urbani - frazione umida	ARPAE Waste Report	WASTE	Waste: Urban Organic - Wet fraction	Tonnes														418659		
RIFIUTI - Produzione di rifiuti verdi (potature e girdinaggio)	ARPAE Waste Report	WASTE	Waste: Urban Organic - Green fraction	Tonnes														263751		
RIFIUTI - Produzione di rifiuti del´industria agro-alimentare	ARPAE Waste Report	WASTE	Waste: Industrial Agro-Food	Tonnes													379965			

3.4.2. STATES: Utilization rules for the GIS layers

Tabella 12- Utilization rules for the GIS layers.

STATES	PRESSURE INDICATOR	BENEFIT/BURDEN	NOTES
LAND USE:			
Natural parks and Protected areas	MW of electric power BGA plant situated inside the protected areas or within a buffer of 500 m. of them. MW.el	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	This show us the impact that the natural protected areas suffer from BGA plants.
Natural parks and Protected areas	% of Electric power BGA plant situated inside the protected areas or within a buffer of 500 m. of them, respect the total of El.power BGA of the province %	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	This show us the entity of the BGA plants that impact on natural protected areas respect to the total of BGA of the province.
Agriculture-Livestock: Manure&slurry production	% of Cows+Pig manure&slurry needed from total BGA plants, respect the total manure&slurry provincial production %	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	This parameter shows the percent of Cows+Pigs manure&slurry that is used (or can be used) respect his total production from livestock *for the calculation of this parameter it needs of the hypothetical standard BGA plant reference
Agriculture-Livestock: Manure&slurry production	Tons. of manure&slurry that exceed the BGA potential quantity of use (digestion). Tons.	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	= difference from total Tons of M&S production and those are used by BGA plants) This parameter shows the quantities of Cows+Pigs manure&slurry that is used (or can be used) respect their total production from livestock. So it is possible to estimate the number&power.el of more BGA plants that can be build. *for the calculation of this parameter it needs of the hypothetical standard BGA plant reference
Agriculture: hectares cultivated to maize+sorghum	% of maize+sorghum hectares needed to supply the BGA electric power system of the province, respect the total	//	This parameter show us the importance (magnitude) of energy crops respect the total maize+sorghum cultivations. In this context, it is not a benefit/burden parameter in itself, but it permits to describe and assess the agricultural sector of maize+sorghum production.

	maize+sorghum hectares cultivated %		*for the calculation of this parameter it needs of the hypothetical standard BGA plant reference *I´m waiting for email response about provincial yields (t./ha)
WATER:			
Water: Main rivers / freshwaters Ecological quality state	MW of electric power BGA plant situated inside a buffer of 500 m. from a river. MW.el	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	The concentration of N compounds is an important parameter to classify the Ecological quality of freshwaters. [Class 1 = Good ; Class 4 = sufficient ; ~~Class 5 = elevated~~] Class 2 = Bad quality Class 3 = Low quality The electric power of BGA plant that situated inside the buffer of 500 m of a main river show us the risk that this could influence negatively on the ecological quality of the river. They don´t exist national or regional laws that indicate a minimum distance from which is possible to build a BGA plant. Looking to the minimum distance that some (few) Municipalities have determined to build BGA plants from protected areas, we assume that the some distance of 500 m. from a river can be an acceptable distance to preserve it from most significant impact of a BGA plant.
Water: Main rivers/freshwaters net Ecological quality state	MW of electric power BGA plant situated inside a buffer of 500 m. from a river, respect the total of provincial BGA plants %	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	“ “ This show us the entity of the BGA plants situated inside the buffer of 500 m from the river, respect to the total of BGA of the province.
Water: Main rivers/freshwaters net Ecological quality state	MW of electric power BGA plant situated inside a buffer of 500 m. from a portion with bad or low ecological state river portion. MW.el	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	The concentration of N compounds is an important parameter to classify the Ecological quality of freshwaters. Class 2 = Bad quality Class 3 = Low quality The electric power of BGA plant that situated inside the buffer of 500 m of a main river show us the risk that this could influence negatively on the ecological quality of the river. They don´t exist national or regional laws that indicate a minimum distance from which is possible to build a BGA plant. Looking to the minimum distance that some (few) Municipalities have determined to build BGA plants from protected areas, we assume that the some distance of 500 m. from a river can be an acceptable distance to preserve it from most significant impact of a BGA plant. The electric power of BGA plant that situated inside the buffer of 500 m of a **BAD+LOW** ecological quality index of a river portion show us the risk that this could influence **VERY** negatively on the ecological quality of this river portion.
Water: Main rivers/freshwaters net Ecological quality	MW of electric power BGA plant situated inside a buffer of 500 m. from a	BURDEN If during the time the	“ “

state	portion with bad or low ecological state river portion. %	parameter value decreases this is a benefit; if it increases this is a burden.	This show us the entity of the BGA plants situated inside the buffer of 500 m from the river portion with **BAD/LOW** ecological state, respect to the total of BGA of the province.
SOIL:			
Soil: 0-30 cm organic Carbon content of soil (tons C /hectare)	MW of electric power BGA plant situated inside areas that have poor content of organic C (classes 1+2+3). MW.el	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	Soil classes show the organic Carbon content (t.C/ha) of soil between 0-30 cm. Class 1 = 0-40 Class 2 = 40-50 Class 3 = 50-60 Class 4 = 60-80 Class 5 = 80-100 Class 6 = 100-200 Class 7 = 300-315 We can assume that the poorest soils of C are those with a C content between 0-60 t.C/ha = classe 1+2+3 So, for the fact that digestate spreading enriches soil of organic C, and considering that digestate spreading occurs as close as possible to the BGA plant, We can say that digestate spreading produce the greater benefits where the soil is poor of organic C.
Soil: 0-30 cm organic Carbon content of soil (tons C /hectare)	MW of electric power BGA plant situated inside areas that have poor content of organic C (classes 1+2+3), respect the total BGA MW.el %	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	“ “ This show us the entity of the BGA plants situated inside the poorest C soils, respect to the total of BGA of the province, … and digestate spreading produce the greater benefits where the soil is poor of organic C.
AIR:			
Air: Regional municipality air classification for biomass and biogas plants	MW of electric power BGA plant situated inside RED municipalities MW.el	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	The regional municipality air classification shows the municipality with or without problem of air quality: • RED: exceeded the annual average of 40 micrograms / m3 both of NO2 than PM10. • ORANGE: for more 35 days/year exceeded the concentration daily limit of 50 ug / m3 of PM10 , but no exceeded for NO2 the annual average limit of 40 ug/m3 . • YELLOW: for more 35 days/year exceeded the daily limit of 50 ug / m3 of only PM10 , but occurred only in some portions of the municipality area, so scientists can define it: “municipality with hot-spot exceedances”. • GREEN: zero exceedances for both parameters limit values during all the year The BGA situated inside the RED municipalities are those that can impact more negatively on the state of air quality

<table>
<tr><td>Air:
Regional municipality air classification for biomass and biogas plants</td><td>MW of electric power BGA plant situated inside RED municipalities , respect the total BGA MW.el

%</td><td>BURDEN

If during the time the parameter value decreases this is a benefit; if it increases this is a burden.</td><td>“ “</td></tr>
<tr><td>SENSITIVITY MAP</td><td></td><td></td><td></td></tr>
<tr><td>Sensitivity:
Regional sensitivity classification for biogas plants</td><td>MW of electric power BGA plant situated inside VIOLET areas

MW.el</td><td>BURDEN

If during the time the parameter value decreases this is a benefit; if it increases this is a burden.</td><td>Sensitivity map is the product of an overlay of sensitive themes (territorial, urban, natural, legislative themes, etc..) that shows a territorial classification that permits to know the sensibility class of the territory respect to a determinate kind of energy plant. In our case about the BGA plants.

It has no legal value, but it shows to the designer and all institution of authorization which are the areas most suitable for the BGA construction and which ones where instead It should not be absolutely build them.

The sensitivity classes are the following:

<table>
<tr><td rowspan="3">VIOLET AREA</td><td>VIOLET - Exclusion zone</td></tr>
<tr><td>High Criticality: maximum spatial sensibility level.</td></tr>
<tr><td>Within the area are present the themes (at least one) that represent constraints or special protections defined by law that much unlikely to be departed</td></tr>
<tr><td rowspan="3">RED AREA</td><td>RED - It requires a deepening and a careful and detailed assessment of all the critical factors involved.</td></tr>
<tr><td>High Criticality: very high spatial sensibility level.</td></tr>
<tr><td>In the area are present themes which reveal a strong incompatibility with the inclusion of the work, expressed not by rules, but only from a technical opinion</td></tr>
<tr><td rowspan="3">YELLOW AREA</td><td>YELLOW - It is necessary an evaluation of all the critical factors involved, which in some cases might be exceeded through suitable equipment or management decisions considered case by case.</td></tr>
<tr><td>Media criticality: sensitive area, for the presence of safeguards or actual localization difficulties due to objective obstacles arising from territorial characteristics.</td></tr>
<tr><td>Within the area are present some themes (at least one) that have a certain incompatibility with the work placement.</td></tr>
<tr><td rowspan="3">WHITE AREA</td><td>WHITE - Low criticality: low spatial sensibility level</td></tr>
<tr><td>No automatic decision: we will proceed to the specific assessment of the case.</td></tr>
<tr><td>The themes present within the area reveal no special exceptions or constraints to the insertion of the work.</td></tr>
<tr><td rowspan="2">GREEN AREA</td><td>GREEN - Preferential Zone, where a plant location might be appropriate.</td></tr>
<tr><td>Within the area there are some themes resulting preferential for the work placement.</td></tr>
</table>
</td></tr>
</table>

			The BGA situated inside the VIOLET areas are those that impact more negatively on the environmental state of territory
Sensitivity: Regional sensitivity classification for biogas plants	MW of electric power BGA plant situated inside VIOLET areas %	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	" "
ENERGY:			
Energy: Electricity (MWh.el) consumed in the agriculture sector	% of electricity produced by BGA, respect total electricity consumed by agricultural sector %	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	Agricultural sector takes electricity from national electrical net. BGA plants put in their electricity in the national electrical net. This parameter can be used to quantify the degree of renewable electrical self-sufficiency of agricultural sector with BGA plants. *for the calculation of this parameter it needs of the hypothetical standard BGA plant reference
			**the data of electric production per province for biogas is not available. ***after calculation with hypothetical BGA it will be possible make a comparison with total regional electric production and so evaluate the coherence between the estimated data and the regional data.
Energy: Fuel (MWh) consumed in the agriculture sector	% of CH4 (MWh) produced by BGA, respect total fuel energy consumed by agricultural sector %	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	Agricultural sector consumes gasoline and diesel for his works. If regularly and simply available, in the future agricultural sector could convert his machinery (tractors, lorries, and heatings) from gasoline and diesel to CH4, so the air emission would be very better and the energy consumption could be renewable. This parameter can be used to quantify the degree of renewable energetic self-sufficiency of agricultural sector with BGA plants. *for the calculation of this parameter it needs of the hypothetical standard BGA plant reference
Energy: Thermal energy demand of whole province (MWh)	% of CH4 (MWh) produced by BGA, respect total thermal energy province demand %	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	In the Emilia-Romagna region most of the heat consumption is produced burning fossil CH4 (ER region has big hydrocarbon reservoirs). Through this parameter it is possible evaluate the degree of provincial renewable energy self-sufficiency coming from BGA plants. *for the calculation of this parameter it needs of the hypothetical standard BGA plant reference
Energy: CH4 demand of whole province transport sector(MWh)	% of CH4 (MWh) produced by BGA, respect total CH4 demand of transport sector %	BENEFIT If during the time the parameter value decreases this is a burden; if it increases this is a benefit.	a significant portion of all private car transport and public transport is powered by methane (ER region has big hydrocarbon reservoirs). Through this parameter it is possible evaluate the degree of provincial renewable CH4 self-sufficiency of transport sector coming from BGA plants. *for the calculation of this parameter it needs of the hypothetical standard BGA plant reference
INDIRECT TERRITORIAL STATE *			
BGA values integration	MW of electric power	BURDEN	A plant can be situated not only in a single kind of critical area, but can be situated at the same time

of pressure parameters: -Land use -Water -Air -Sensitivity	BGA plants that fall within two or more different kinds of critical areas at the same time, respect total BGA electric power (MW.el) %	If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	in two or more different kinds of critical area. In last case his impact (or the risk of impact) is bigger. This parameter shows the significance of most impactful/critical BGA plants respect the totality of BGA plants.
BGA values integration of pressure parameters: -Land use -Water -Air -Sensitivity	NUMBER of electric power BGA plants that fall within two or more different kinds of critical areas at the same time, respect total NUMBER of BGA %	BURDEN If during the time the parameter value decreases this is a benefit; if it increases this is a burden.	A plant can be situated not only in a single kind of critical area, but can be situated at the same time in two or more different kinds of critical area. In last case his impact (or the risk of impact) is bigger. This parameter shows the significance of most impactful/critical BGA plants respect the total **number** of BGA plants.
BGA values integration of pressure parameters: -Land use -Water -Air -Sensitivity	NUMBER of electric power BGA plants that fall within 2-3-4 different kinds of critical areas at the same time, respect total NUMBER of BGA LIST	LIST	A plant can be situated not only in a single kind of critical area, but can be situated at the same time in two or more different kinds of critical area. In last case his impact (or the risk of impact) is bigger. This LIST shows most impactful/critical BGA plants, indicating to the environmental control agency the list of the plants that, in first approximation, should be monitored and controlled.

3.4.3. STATES: The numerical values

Tabella 13- States: the numerical values.

STATES	DATA	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	
GSE Statistics: BIOMASS power plants 2015	GSE-Boll2015-BIOMASS.Num.plants (Num.)	48	25	40	33	28	32	32	34	8	280	
	GSE-Boll2015-BIOMASS.electric.power (MW.el)	72,03	33,939	76,307	45,76	16,314	34,038	182,458	28,087	18,932	507,865	
	GSE-RappStat2015-BIOMASS.electric.energy.production (MWh.el)	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	2.721	*2014
GSE Statistics: only SOLID BIOMASS power plants 2015	GSE-Boll2015-SOLIDBIOMASS.Num.plants (Num.)	3	2	2	2	2	5	4	3	1	24	
	GSE-Boll2015-SOLIDBIOMASS.electric.power (MW.el)	1,869	15,999	26,200	24,850	0,094	18,475	50,545	3,066	0,500	141,598	
	GSE-RappStat2015-SOLIDBIOMASS.electric.energy.production (MWh.el)	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	847	*2014
GSE Statistics: only BGAS plants 2015	GSE-Boll2015-BGAS.Num.plants (Num.)	33	13	33	23	25	20	21	16	4	188	
	GSE-Boll2015-BGAS.electric.power (MW.el)	30,900	9,000	33,200	14,400	15,200	9,200	22,000	8,400	3,800	146,100	
	GSE-RappStat2015-BGAS.electric.energy.production (GWh.el)	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	1.268	*2014
GSE Statistics: BIOMASS power plants 2016	GSE-Boll2016-BIOMASS.Num.plants (Num.)											
	GSE-Boll2016-BIOMASS.electric.power (MW.el)											
	GSE-RappStat2016-BIOMASS.electric.energy.production (MWh.el)											* no data
GSE Statistics: only SOLID BIOMASS power plants 2016	GSE-Boll2016-SOLIDBIOMASS.Num.plants (Num.)											
	GSE-Boll2016-SOLIDBIOMASS.electric.power (MW.el)											
	GSE-RappStat2016-SOLIDBIOMASS.electric.energy.production (MWh.el)											* no data
GSE Statistics: only BGAS plants 2016	GSE-Boll2016-BGAS.Num.plants (Num.)											
	GSE-Boll2016-BGAS.electric.power (MW.el)											
	GSE-RappStat2016-BGAS.electric.energy.production (GWh.el)											*no data

ARPAE Energy consumption 2010	ARPAE2010_THERMAL.Consumption_MWh	6.300.052	2.992.978	2.114.835	4.573.082	1.953.849	3.527.679	2.883.179	4.901.419	2.080.396	31.327.469
	ARPAE2010_Electricity.RESIDENTIAL.Consumption_MWh	1.147.186	441.500	440.824	807.100	347.200	511.780	473.900	619.500	430.969	5.219.959
	ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	97.827	218.000	85.516	96.200	66.800	64.536	161.500	94.900	26.135	911.414
	ARPAE2010_Electricity.INDUSTRY.Consumption_MWh	1.952.712	575.800	1.073.176	2.317.900	669.100	1.560.776	1.599.800	1.810.100	436.241	11.995.605
	ARPAE2010_Electricity.TERTIARY.Consumption_MWh	1.866.628	669.100	780.579	1.410.600	488.800	1.012.444	693.500	718.700	767.740	8.408.091
	ARPAE2010_Electricity.TOTAL.Consumption_MWh	5.064.353	1.904.400	2.380.095	4.631.800	1.571.900	3.149.536	2.928.700	3.243.200	1.661.084	26.535.069
	ARPAE-PAIR2014_AGRI.Diesel.C_MWh	387.925	253.435	500.138	370.970	407.362	348.778	379.724	301.326	88.457	3.038.115
	ARPAE-PAIR2014_AGRI.Gasoline.C_MWh	2.201	2.676	2.366	1.210	32	17	2.707	206	71	11.486
	ARPAE-PAIR2014_AGRI.FUEL.Tot.C_(D+G)_MWh	390.127	256.111	502.504	372.179	407.395	348.795	382.430	301.532	88.529	3.049.602
	ARPAE2010_CH4.Transport.C_MWh	414.523	139.604	149.654	277.472	125.237	198.942	148.390	208.466	90.263	1.752.551
	ARPAE2010_TRANSPORT.TOTAL.C_MWh	10.729.594	4.662.420	4.456.040	7.509.398	4.475.835	6.202.753	4.535.911	5.800.884	2.447.977	50.820.811
	ARPAE2010_CH4.ENERGY_Industrial.C_MWh	4.640.660	959.619	963.796	3.529.391	1.218.359	2.539.995	863.886	3.080.945	727.471	18.524.122
	ARPAE2010_Total.ENERGY_INDUSTRIAL.C_MWh	5.135.025	1.063.481	1.066.877	3.910.804	1.348.546	2.810.678	957.469	3.410.817	805.725	20.509.422

Emilia-Romagna Region context	Regional AREA 2015 (km2)	3.702	2.379	2.633	2.689	2.588	3.447	1.859	2.290	864	22.451
	Regional AREA 2015 (hectares)	370.238	237.860	263.269	268.891	258.768	344.718	185.920	229.048	86.385	2.245.097
	Population 2015	1.004.323	395.897	354.073	702.364	288.013	445.394	391.997	533.248	335.199	4.450.508
Low land areas (ha)	Low land areas - TotArea (ha)	370.217	237.733	262.454	268.850	258.545	344.599	185.885	229.023	86.275	2.243.582
	Low lands	195.439	59.700	262.449	140.362	118.312	123.735	155.416	115.732	25.669	1.196.813
	High lands	174.778	178.034	5	128.488	140.233	220.864	30.469	113.291	60.606	1.046.769
	% area of lowlands	52,79%	25,11%	100,00%	52,21%	45,76%	35,91%	83,61%	50,53%	29,75%	53,34%
Land use 2008 update 2011 (ha)	Land use 2008 update 2011 - TotArea (ha)	370.217	237.733	262.454	268.850	258.545	344.599	185.885	229.023	86.275	2.243.582
	Urban	39.008	17.369	31.562	31.562	16.439	24.514	19.860	26.896	12.902	220.113
	Agri	214.106	107.565	157.572	157.572	145.194	157.909	134.799	129.016	49.168	1.252.901
	Forest	107.241	110.330	73.785	73.785	88.604	152.398	20.512	68.547	22.263	717.465
	Wetland	2.335	0	961	961	50	168	5.712	343	25	10.555
	Water	7.527	2.469	4.970	4.970	8.258	9.610	5.002	4.221	1.917	48.943
TPAB.500m : Total protected areas with 500m buffer: National and regional parks + Protected areas + SIC ZPS preotected areas + Ecological readjustment areas + Protected landscapes - 2015 (km2)	SIC+ZPS areas (km2)	423,1	291,7	473,8	245,5	268,6	324,7	202,2	310,6	96,8	2.637
	Natural parks (km2)	232,6	185,3	327,7	179,2	51,1	383,9	236,2	130,8	52,0	1.779
	TPAB.500m total areas (km2)	853,5	440,2	815,7	498,1	519,2	905,5	509,0	724,0	282,5	5.548
	TPAB.500m % respect total administrative area	23,05%	18,50%	30,98%	18,52%	20,06%	26,27%	27,38%	31,62%	32,70%	24,71%
Regional air classification municipalities DAL 51 27-07-2011	Regional air classification municipalities DAL 51 27-07-2011	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map

Ecological water quality classification 2013 (km)	**Fresh water 2013 (km)**	**1.422**	**773**	**744**	**846**	**856**	**1.124**	**656**	**674**	**276**	**7.372**
	Total Km of WQ.ECO classified river	1.367	756	744	846	792	1.124	640	674	271	7.214
	WatQEco - Good	479	191	0	309	265	205	130	215	24	1.817
	WatQEco - Sufficient	206	403	432	220	220	563	361	97	78	2.578
	WatQEco - Low	511	163	266	261	189	270	114	180	85	2.039
	WatQEco - Bad	172	0	46	55	118	86	36	182	84	780
	WQ.ECOgood+sufficient	684	593	432	529	485	768	490	312	102	4.395
	WQ.ECOgood+sufficient (%)	50,05%	78,47%	58,01%	62,55%	61,20%	68,32%	76,58%	46,33%	37,66%	60,93%
	WQ.ECObad+low	683	163	312	317	307	356	150	361	169	2.819
	WQ.ECObad+low (%)	49,95%	21,53%	41,99%	37,45%	38,80%	31,68%	23,42%	53,67%	62,34%	39,07%
Organic carbon classes content soil 0-30cm 2010/2015 (ha)	**Soil content of Organic carbon - TotArea (ha)**	**364.854**	**233.121**	**246.989**	**266.100**	**251.184**	**335.517**	**178.988**	**225.802**	**51.082**	**2.243.582**
	POOR C - SoilC [Class123_0-60_Corg_t./ha] - (ha)	288.127	150.513	154.299	179.255	174.284	186.734	144.938	119.781	46.113	1.444.045
	GOOD C - SoilC [Class4567_60-315_Corg_t./ha] - (ha)	76.727	82.609	92.690	86.845	76.900	148.783	34.049	106.022	4.969	709.593
	POOR C - SoilC [cl.123] %	78,97%	64,56%	62,47%	67,36%	69,38%	55,66%	80,98%	53,05%	90,27%	64,36%
	GOOD C - SoilC [cl.4567] %	21,03%	35,44%	37,53%	32,64%	30,62%	44,34%	19,02%	46,95%	9,73%	31,63%
Energy sensitivity map ARPAE 2015	**Energy sensitivity map - TotArea (km2)**	**3.702**	**2.379**	**2.633**	**2.689**	**2.588**	**3.447**	**1.859**	**2.290**	**864**	**22.451**
	Violet area - (km2)										
	Violet area - (%)										
Agricuture cows and pigs from national Census 2010	COWS (Num.)	33.180	19.450	21.742	94.857	79.760	150.122	8.850	140.163	9.107	557.231
	PIGS (Num.)	75.340	149.918	46.917	338.238	120.074	111.889	58.439	332.168	14.477	1.247.460
Cows and Pigs CP manure & slurry production (t.)	COWS-manure = 13 t./animal/year	431.340	252.850	282.646	1.233.141	1.036.880	1.951.586	115.050	1.822.119	118.391	7.244.003
	COWS-slurry = 10 t./animal/year	331.800	194.500	217.420	948.570	797.600	1.501.220	88.500	1.401.630	91.070	5.572.310
	PIGS-slurry = 3 t./animal/year	226.020	449.754	140.751	1.014.714	360.222	335.667	175.317	996.504	43.431	3.742.380
CH4 production from CP Manure & slurry (m3)	COWS-manure = 25 m3/ t.	10.783.500	6.321.250	7.066.150	30.828.525	25.922.000	48.789.650	2.876.250	45.552.975	2.959.775	181.100.075
	COWS-slurry = 25 m3/ t.	8.295.000	4.862.500	5.435.500	23.714.250	19.940.000	37.530.500	2.212.500	35.040.750	2.276.750	139.307.750
	PIGS-slurry = 10 m3/ t.	2.260.200	4.497.540	1.407.510	10.147.140	3.602.220	3.356.670	1.753.170	9.965.040	434.310	37.423.800
Primary energy from CP CH4 (MWh) --> 9,91 kWh / m3 CH4	COWS-manure CH4 energy (MWh)	106.864.485	62.643.588	70.025.547	305.510.683	256.887.020	483.505.432	28.503.638	451.429.982	29.331.370	1.794.701.743
	COWS-slurry CH4 energy (MWh)	82.203.450	48.187.375	53.865.805	235.008.218	197.605.400	371.927.255	21.925.875	347.253.833	22.562.593	1.380.539.803
	PIGS-slurry CH4 energy (MWh)	22.398.582	44.570.621	13.948.424	100.558.157	35.698.000	33.264.600	17.373.915	98.753.546	4.304.012	370.869.858
Electric energy potential production from CH4 biogas burning (MWh) --> Electric yield = 40%	COWS-manure Electric production (MWh)	42.745.794	25.057.435	28.010.219	122.204.273	102.754.808	193.402.173	11.401.455	180.571.993	11.732.548	717.880.697
	COWS-slurry Electric production (MWh)	32.881.380	19.274.950	21.546.322	94.003.287	79.042.160	148.770.902	8.770.350	138.901.533	9.025.037	552.215.921
	PIGS-slurry Electric production (MWh)	8.959.433	17.828.249	5.579.370	40.223.263	14.279.200	13.305.840	6.949.566	39.501.419	1.721.605	148.347.943
Emilia-Romagna Statistics for agriculture 2014	Industrial crops cultivated area (ha)	12.078	0	25.621	5.335	1.670	1.866	3.088	1.950	0	58.996
	Cereals crops cultivated area (ha)	65.468	16.530	96.924	36.810	35.332	22.860	34.533	17.850	8.360	343.015
	Maize crops area (ha)	9.212	560	35.384	9.415	12.700	5.500	5.820	6.500	180	85.271
	Maize for food production (t./year)	80.255	5.040	382.147	94.150	169.602	47.862	65.034	60.210	1.260	905.560
Silage Maize production	Silage maize production (t./year)										
	Silage maize productivity (t./year/ha)										50
	CH4 from silage maize = 75 m3/t.SM										75
	CH4 primary Energy - 9.91 MWh/m3										9.91
	CH4 combustion: electric yield = 40%										40%

Agricuture cows and pigs from national Census 2010	MUN-AgriC2010_SOWING_Hectares	141.235	55.004	160.876	94.739	97.422	101.850	75.910	75.843	27.693	830.571
	MUN-AgriC2010_COWS	33.180	19.450	21.742	94.857	79.760	150.122	8.850	140.163	9.107	557.231
	MUN-AgriC2010_PIGS	75.340	149.918	46.917	338.238	120.074	111.889	58.439	332.168	14.477	1.247.460
	MUN-AgriC2010_SHEEPS	9.342	17.136	7.378	4.231	3.332	4.264	2.804	6.054	8.740	63.281
	MUN-AgriC2010_POULTRY	3.997.783	13.863.889	1.384.743	889.259	414.765	318.718	5.215.960	1.619.682	542.091	28.246.890
Emilia-Romagna Statistics for agriculture 2014	PROV.SMAIL-ER2014_AGRIworkers	15.921	15.891	13.952	1.408	9.074	9.984	15.432	10.989	4.527	97.178
	PROV.SMAIL-ER2014_INDUSTRYworkers	103.008	42.267	26.096	101.331	26.431	52.201	34.584	74.722	21.504	482.144
	PROV.SMAIL-ER2014_TERTIARYworkers	149.134	47.795	33.927	80.758	34.192	57.414	57.752	5.403	6.746	473.121
	PROV.SMAIL-ER2014_BUILDINGworkers	28.239	13.624	8.888	2.356	8.711	15.425	12.858	2.007	10.567	102.675
	PROV.SMAIL-ER2014_COMMERCEworkers	67.548	27.576	19.388	42.704	1.816	26.312	23.529	29.682	25.067	263.622
	PROV.SMAIL-ER2014_TOTALworkers	363.850	147.153	102.251	228.557	80.224	161.336	144.155	122.803	68.411	1.418.740

3.4.4. STATES: Derived values

Tabella 14- States: derived values.

DERIVED DATA FROM STATES	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
2010 Electric+thermal energy demand (MWh)	11.364.405	4.897.378	4.494.930	9.204.882	3.525.749	6.677.215	5.811.879	8.144.619	3.741.480	57.862.538
2010 Electricity demand (MWh.el)	5.064.353	1.904.400	2.380.095	4.631.800	1.571.900	3.149.536	2.928.700	3.243.200	1.661.084	26.535.069
2010 Electricity for agriculture demand (MW.el)	97.827	218.000	85.516	96.200	66.800	64.536	161.500	94.900	26.135	911.414
2010 CH4 for transport demand (MWh)	414.523	139.604	149.654	277.472	125.237	198.942	148.390	208.466	90.263	1.752.551
2011 Land use: % of agricultural area (%)	57,83%	45,25%	60,04%	58,61%	56,16%	45,82%	72,52%	56,33%	56,99%	55,84%
2015 Land use: % of total protected ecological areas comprensive of 500m buffer (%)	23,05%	18,50%	30,98%	18,52%	20,06%	26,27%	27,38%	31,62%	32,70%	24,71%
2011 Air: Regional air classification municipalities DAL 51 27-07-2011	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map
2013 Fresh water: km of good+sufficient ecological quality index (%)	50,05%	78,47%	58,01%	62,55%	61,20%	68,32%	76,58%	46,33%	37,66%	60,93%
2013 Fresh water: km of low+bad ecological quality index (%)	49,95%	21,53%	41,99%	37,45%	38,80%	31,68%	23,42%	53,67%	62,34%	39,07%
2015 Soil: Content of organic Carbon 0-30cm 0-60 t./ha = C POOR (%)	78,97%	64,56%	62,47%	67,36%	69,38%	55,66%	80,98%	53,05%	90,27%	64,36%
2015 Soil: Content of organic Carbon 0-30cm 60-315 t./ha = C RICH (%)	21,03%	35,44%	37,53%	32,64%	30,62%	44,34%	19,02%	46,95%	9,73%	31,63%
2016 Sensitivity Maps: Violet areas where it would be not possible built biomass plants	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map
2016 Sensitivity Maps: White+Green+Yellow+Red areas where it is possible built biomass plants in accordance with the requirements specifications	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map	GIS map

3.4.5. STATES: The ARPAE GIS land registers data 2015+2016

2015 - Dati ARPAE GIS land registers	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
2015 - BIOMASS.Num.plants (Num.)	**46**	**30**	**45**	**26**	**28**	**18**	**25**	**21**	**8**	**247**
2015 - BIOMASS.electric.power (MW.el)	**31,849**	**25,153**	**66,914**	**13,202**	**17,997**	**7,771**	**191,861**	**16,966**	**4,719**	**376,432**
2015 - Number of biomass plants located within TPAB.500m	9	2	9	3	2	3	9	2	2	41
2015 - Electric power of biomass plants located within TPAB.500m	8,576	0,96	10,24	0,51	1,339	1,019	27,873	1,2	0,561	52,278
2015 - % Electric power of biomass plants located within TPAB.500m respect total biomass plants	26,93%	3,82%	15,30%	3,86%	7,44%	13,11%	14,53%	7,07%	11,89%	13,89%
2015 - Number of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	12	2	9	2	3	6	2	2	1	39
2015 - Electric power of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	10,023	1,314	10,731	0,25	3,056	3,427	9,759	1,129	0	39,689
2015 - Number of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	38	26	33	21	19	10	25	9	4	185
2015 - Electric power of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	30,914	22,123	57,673	11,187	12,299	4,516	191,861	9,578	1,891	342,042
2015 - Number of biomass plants located in violet areas of sensitivity territorial maps	5	5	4	0	1	3	1	0	0	19
2015 - Electric power of biomass plants located in violet areas of sensitivity territorial maps	0,999	5,304	28,638	0	0,34	1,019	0,999	0	0	37,299
2015 - SOLID BIOMASS.Num.plants (Num.)	**13**	**6**	**3**	**4**	**3**	**1**	**5**	0	**2**	**37**
2015 - SOLID BIOMASS.electric.power (MW.el)	**1,13**	**3,264**	**27,199**	**0,5**	**1,859**	0	**72,728**	0	0	**106,68**
2015 - Number of solid biomass plants located within TPAB.500m	2	1	1	0	0	0	1	0	1	6
2015 - Electric power of solid biomass plants located within TPAB.500m	0	0,96	0	0	0	0	13,7	0	0	14,66
2015 - % Electric power of solid biomass plants located within TPAB.500m respect total solid biomass plants	0,00%	29,41%	0,00%	0,00%	0,00%	#DIV/0!	18,84%	#DIV/0!	#DIV/0!	13,74%
2015 - Number of solid biomass plants located within RED MUNICIPALITIES AIR CLASSIFICATION (DAL 51 del 26 luglio 2011)	2	0	1	1	0	0	0	0	1	5
2015 - Electric power of solid biomass plants located within RED MUNICIPALITIES AIR CLASSIFICATION (DAL 51 del 26 luglio 2011)	0,6	0	0	0,5	0	0	0	0	0	1,1
2015 - Number of solid biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	1	0	1	0	1	0	0	0	1	4
2015 - Electric power of solid biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	0	0	0	0	1,799	0	0	0	0	1,799
2015 - Number of solid biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	7	5	3	2	2	1	5	0	2	27
2015 - Electric power of solid biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	0,76	3,084	27,199	0,5	0,06	0	72,728	0	0	104,331
2015 - Number of solid biomass plants located in violet areas of sensitivity territorial maps	4	1	1	0	0	0	0	0	0	6
2015 - Electric power of solid biomass plants located in violet areas of sensitivity territorial maps	0	0,18	27,199	0	0	0	0	0	0	27,379
2015- BGAS.Num.plants (Num.)	**30**	**13**	**39**	**20**	**21**	**13**	**13**	**17**	**4**	**170**
2015- BGAS.electric.power (MW.el)	**28,674**	**9,193**	**36,816**	**12,086**	**12,863**	**5,47**	**35,019**	**14,435**	**3,266**	**157,822**
2015 - Number of BGAS plants located within TPAB.500m	7	1	8	3	2	2	5	2	0	30
2015 - Electric power of BGAS plants located within TPAB.500m	8,576	0	10,24	0,51	1,339	1,019	2,859	1,2	0	25,743
2015 - % Electric power of BGAS plants located within TPAB.500m respect total BGAS plants	29,91%	0,00%	27,81%	4,22%	10,41%	18,63%	8,16%	8,31%	0,00%	16,31%
2015 - Number of BGAS plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	10	1	7	2	1	4	0	2	0	27
2015 - Electric power of BGAS plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	10,023	0,33	9,831	0,25	0,229	3,017	0	1,129	0	24,809
2015 - Number of BGAS plants located on poor organic C soil (0-60 t./ha) 2010-2015	29	11	28	17	14	6	13	7	1	126
2015 - Electric power of BGAS plants located on poor organic C soil (0-60 t./ha) 2010-2015	28,474	8,403	28,574	10,071	9,214	3,107	35,019	7,493	0,999	131,354
2015 - Number of biogas plants located in violet areas of sensitivity territorial maps	1	2	2	0	1	1	1	0	0	8
2015 - Electric power of biogas plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	0,999	0	0	3,767
2015 - BGAS-C.E.CE num.plants (Num.)	**12**	**5**	**22**	**4**	**16**	**10**	**6**	**11**	**2**	**88**
2015 - BGAS-C.E.CE electric power (MW.el)	**10,416**	**2,009**	**19,481**	**0,995**	**9,344**	**3,472**	**5,242**	**7,006**	**1,998**	**59,963**
2015 - Number of BGAS-C.E.CE. plants located within TPAB.500m	2	0	6	0	1	1	3	1	0	14
2015 - Electric power of BGAS-C.E.CE plants located within TPAB.500m	1,998	0	5,245	0	0,34	0,02	1,998	0,1	0	9,701
2015 - % Electric power of BGAS-C.E.CE. plants located within TPAB.500m respect total BGAS-C.E.CE. plants	19,18%	0,00%	26,92%	0,00%	3,64%	0,58%	38,12%	1,43%	0,00%	16,18%
2015 - Number of BGAS-C.E.CE. plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	3	0	4	1	1	3	0	1	0	13
2015 - Electric power of BGAS-C.E.CE. plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	2,863	0	3,996	0,25	0,229	2,018	0	0,999	0	10,355
2015 - Number of BGAS-C.E.CE. plants located on poor organic C soil (0-60 t./ha) 2010-2015	11	3	15	3	11	4	6	5	1	59
2015 - Electric power of BGAS-C.E.CE. plants located on poor organic C soil (0-60 t./ha) 2010-2015	10,216	1,219	14,236	0,37	6,816	1,109	5,242	2,893	0,999	43,1
2015 - Number of BGAS-C.E.CE. plants located in violet areas of sensitivity territorial maps	1	1	2	0	1	1	1	0	0	7
2015 - Electric power of BGAS-C.E.CE. plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	0,999	0	0	3,767

2016 - Dati ARPAE GIS land registers	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
2016 - Number of biomass power plants	**62**	**34**	**51**	**35**	**33**	**29**	**36**	**28**	**8**	**316**
2016 - Electric power of biomass power plants	**39,46**	**23,765**	**52,564**	**14,678**	**18,973**	**10,821**	**169,313**	**19,93**	**4,717**	**354,221**
2016 - Number of biomass plants located within TPAB.500m	12	3	9	6	2	9	12	3	2	58
2016 - Electric power of biomass plants located within TPAB.500m	8,375	0,96	7,243	1,774	1,339	2,608	30,044	1,54	0,56	54,443
2016 - % Electric power of biomass plants located within TPAB.500m respect total biomass plants	21,22%	4,04%	13,78%	12,09%	7,06%	24,10%	17,74%	7,73%	11,87%	15,37%
2016 - Number of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	17	3	10	3	5	11	2	4	1	56
2016 - Electric power of biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	12,918	1,31	8,283	1,264	3,3	3,936	7,93	3,127	0	42,068
2016 - Number of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	51	29	39	28	23	12	36	13	4	235
2016 - Electric power of biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	36,322	21,185	43,323	11,559	12,277	5,535	169,313	11,596	1,889	312,999
2016 - Number of biomass plants located in violet areas of sensitivity territorial maps	5	6	4	0	1	3	2	0	0	21
2016 - Electric power of biomass plants located in violet areas of sensitivity territorial maps	0,999	3,8	14,539	0	0,34	1,019	1,998	0	0	22,695
2016 - SOLID BIOMASS.Num.plants (Num.)	**13**	**6**	**4**	**4**	**3**	**2**	**5**	**1**	**2**	**40**
2016 - SOLID BIOMASS.electric.power (MW.el)	**1,13**	**3,269**	**13,1**	**0,5**	**1,86**	0	**63,6**	**0,5**	0	**83,959**
2016 - Number of solid biomass plants located within TPAB.500m	2	1	1	0	0	0	1	0	1	6
2016 - Electric power of solid biomass plants located within TPAB.500m	0	0,96	0	0	0	0	13,7	0	0	14,66
2016 - % Electric power of solid biomass plants located within TPAB.500m respect total solid biomass plants	0,00%	29,37%	0,00%	0,00%	0,00%	#DIV/0!	21,54%	0,00%	#DIV/0!	17,46%
2016 - Number of solid biomass plants located within RED MUNICIPALITIES AIR CLASSIFICATION (DAL 51 del 26 luglio 2011)	2	0	2	1	0	1	0	0	1	7
2016 - Electric power of solid biomass plants located within RED MUNICIPALITIES AIR CLASSIFICATION (DAL 51 del 26 luglio 2011)	0,6	0	0	0,5	0	0	0	0	0	1,1
2016 - Number of solid biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	1	0	1	0	1	0	0	0	1	4
2016 - Electric power of solid biomass plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	0		0	0	1,8	0	0	0	0	1,8
2016 - Number of solid biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	7	5	4	2	2	2	5	1	2	30
2016 - Electric power of solid biomass plants located on poor organic C soil (0-60 t./ha) 2010-2015	0,76	3,089	13,1	0,5	0,06	0	63,6	0,5	0	81,609
2016 - Number of solid biomass plants located in violet areas of sensitivity territorial maps	4	1	1	0	0	0	0	0	0	6
2016 - Electric power of solid biomass plants located in violet areas of sensitivity territorial maps	0	0,18	13,1	0	0	0	0	0	0	13,28
2016 - Number of BGAS power plants	**46**	**17**	**44**	**29**	**25**	**23**	**24**	**23**	**4**	**235**
2016 - Electric power of BGAS power plants	**36,28**	**8,258**	**37,515**	**13,558**	**12,836**	**8,522**	**23,423**	**18,38**	**3,267**	**162,039**
2016 - Number of BGAS plants located within TPAB.500m	10	2	8	6	2	8	8	3	0	47
2016 - Electric power of BGAS plants located within TPAB.500m	8,375	0	7,243	1,774	1,339	2,608	6,854	1,54	0	29,733
2016 - % Electric power of BGAS plants located within TPAB.500m respect total BGAS plants	23,08%	0,00%	19,31%	13,08%	10,43%	30,60%	29,26%	8,38%	0,00%	18,35%
2016 - Number of BGAS plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	15	2	8	3	3	9	0	4	0	44
2016 - Electric power of BGAS plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	12,918	0,33	7,833	1,264	0,47	3,526	0	3,127	0	29,468
2016 - Number of BGAS plants located on poor organic C soil (0-60 t./ha) 2010-2015	42	14	33	24	18	7	24	10	1	173
2016 - Electric power of BGAS plants located on poor organic C soil (0-60 t./ha) 2010-2015	33,882	7,468	29,273	10,439	9,189	4,126	23,423	10,496	0,999	129,295
2016 - Number of biogas plants located in violet areas of sensitivity territorial maps	1	3	2	0	1	1	2	0	0	10
2016 - Electric power of biogas plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	1,998	0	0	4,766
2016 - BGAS-C.E.CE num.plants (Num.)	**19**	**8**	**24**	**10**	**18**	**16**	**12**	**12**	**2**	**121**
2016 - BGAS-C.E.CE electric power (MW.el)	**16,556**	**3,008**	**21,529**	**5,345**	**9,274**	**5,605**	**11,259**	**7,357**	**1,998**	**81,931**
2016 - Number of BGAS-C.CE.E plants located within TPAB.500m	3	1	6	1	1	5	4	2	0	23
2016 - Electric power of BGAS-C.E.CE plants located within TPAB.500m	2,988	0	5,245	0,999	0,34	1,089	3,996	0,44	0	15,097
2016 - % Electric power of BGAS-C.E.CE. plants located within TPAB.500m respect total BGAS-C.E.CE. plants	18,05%	0,00%	24,36%	18,69%	3,67%	19,43%	35,49%	5,98%	0,00%	18,43%
2016 - Number of BGAS-C.E.CE. plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	5	1	5	1	3	6	0	1	0	22
2016 - Electric power of BGAS-C.E.CE. plants located within buffer of 500m from bad/low ecological class of freshwater quality 2010-2013	4,866	0	4,995	0,999	0,47	2,128	0	0,999	0	14,457
2016 - Number of BGAS-C.E.CE. plants located on poor organic C soil (0-60 t./ha) 2010-2015	15	6	17	7	13	5	12	5	1	81
2016 - Electric power of BGAS-C.E.CE. plants located on poor organic C soil (0-60 t./ha) 2010-2015	14,158	2,408	16,284	3,616	6,746	2,128	11,259	2,899	0,999	60,497
2016 - Number of BGAS-C.E.CE. plants located in violet areas of sensitivity territorial maps	1	2	2	0	1	1	1	0	0	8
2016 - Electric power of BGAS-C.E.CE. plants located in violet areas of sensitivity territorial maps	0,999	0,16	1,249	0	0,34	0,02	0,999	0	0	3,767

3.1. IMPACTS

Figura 9- LCA reference for the DPSIR model.

3.1.1. IMPACTS: The quantitative LCA estimation of the main regional biomass power plants systems (*only for region)

How showed and explained in the previous Part 7 ("LCA quantitative environmental impact analysis") we built standardized profiles of 1 MW.el power for the main different plants types, then we have calculated their correlated impacts on the base of Ecoindicator'99 LCA method, and then we multiplied these impact values for their related total regional/provincial installed electric power systems.

So, to give logical continuity at this DPSIR part 8, in this chapter we propose again only the final conclusions we obtained from the just said LCA analysis of the main regional biomass plants systems.

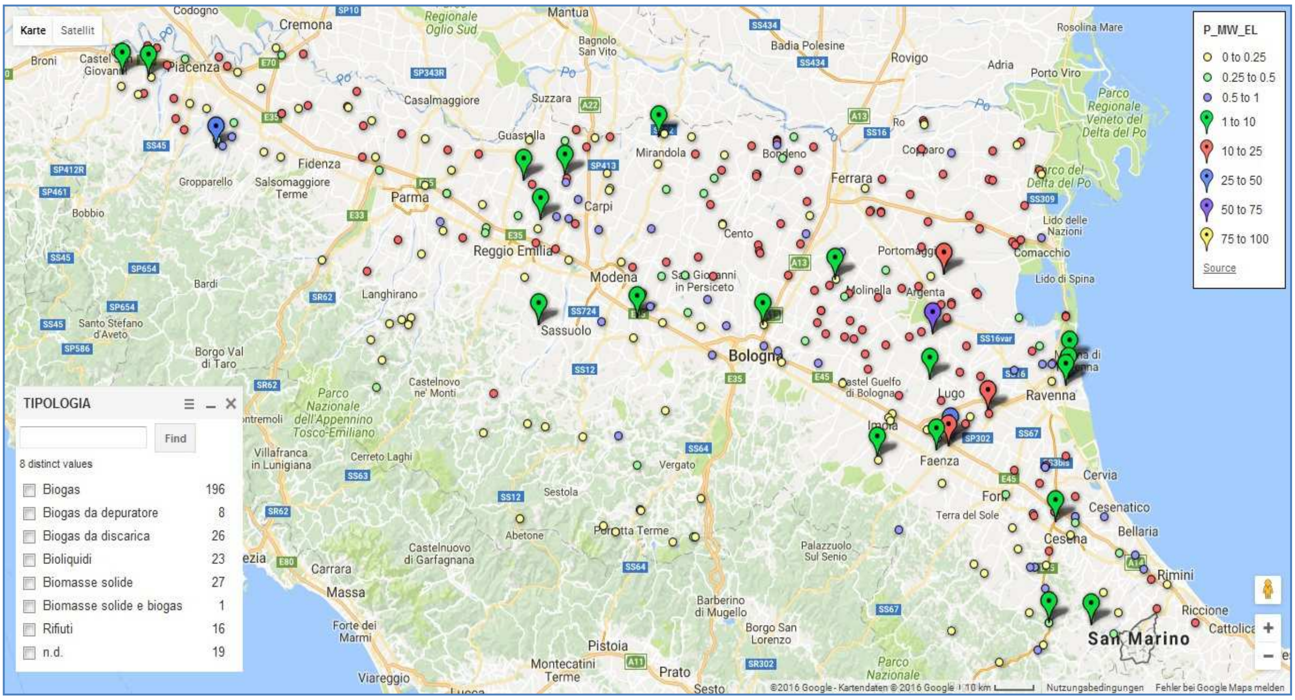


Figura 10- Biomasses power plants GIS land register - 2016 -: total.

Tabella 15- Synthesis of disaggregated types groups of biomass plants of GIS land register 2016, in terms of sum of electric power installed

MW.el power	BO	FC	FE	MO	PC	PR	RA	RE	RN	Regional
Biogas only energy crops	11,85	3,92	15,29	2,00	2,87	4,00	3,87	1,00	1,00	45,78
Biogas agri-zoo	4,71	3,01	6,24	3,35	7,41	1,61	7,99	6,36	1,00	41,67
Biogas food-industry	12,07	0,19	7,24	2,60	0,00	2,62	10,30	2,13	0,00	37,15
Solid wood biomass	1,13	3,27	14,10	0,50	1,86	0,00	63,60	0,50	0,00	84,96

3.1.2. IMPACTS: The resulted values in terms of LCA impacts and damages estimated for the whole regional electric power installed of the different biomass plants type group

Tabella 16- Synthesis of the IMPACT categories and DAMAGE macro.categories estimed for the sum of biomass electric power installed in Emilia-Romagna region, disaggregated for the their relative main group of appartenence

Estimated regional LCA Ecoindicator'99 impacts/damages ecoPoints/year amounts calculated multiply the unitary standard plant types of 1 Mw,el for 8000 working hours/year with the related regional installed electric powers		BIOGAS					WOOD COMBUSTION	
		Ecoinvent	Standard's SUM	Standard			Ecoinvent	Standard
		e08 Ecoinvent Swiss biogas ref,	SUM BG1+BG2+BG3	BG1 Standard only crops	BG2 Standard agro-zoo	BG3 Standard food industries	e07 Ecoinvent Swiss wood combustion ref,	WF3 Standard Forest wood combustion
Regional Biomass electric installed power	**MWel,**	**124,6**	**124,6**	**45,78**	**41,67**	**37,15**	**84,96**	**84,96**
IMPACTS								
Total	**Mpt**	**21,4**	**17,6**	**10,4**	**4,2**	**3,0**	**3,0**	**15,2**
Carcinogens	Mpt	0,1	9,3	6,5	2,7	0,2	0,3	0,1
Resp, organics	Mpt	0,0	0,0	0,0	0,0	0,0	0,3	0,0
Resp, inorganics	Mpt	12,1	3,3	2,3	0,9	0,0	0,1	1,5
Climate change	Mpt	5,5	1,1	0,8	0,3	0,0	0,0	1,1
Radiation	Mpt	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ozone layer	Mpt	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ecotoxicity	Mpt	0,0	0,2	0,0	0,0	0,2	0,7	0,0
Acidification/Eutrophication	Mpt	1,2	0,9	0,2	0,1	0,7	1,5	0,1
Land use	Mpt	0,1	0,0	0,0	0,0	0,0	0,0	12,1
Minerals	Mpt	2,4	2,8	0,6	0,2	2,0	0,1	0,3
DAMAGES								
Total	**Mpt**	**21,4**	**12,7**	**10,4**	**4,2**	**3,1**	**3,0**	**15,2**
Human Health	Mpt	17,7	13,5	9,6	3,9	0,0	0,3	2,7
Ecosystem Quality	Mpt	1,3	0,3	0,2	0,1	0,1	0,4	12,2
Resources	Mpt	2,4	3,7	0,6	0,2	2,9	2,3	0,3

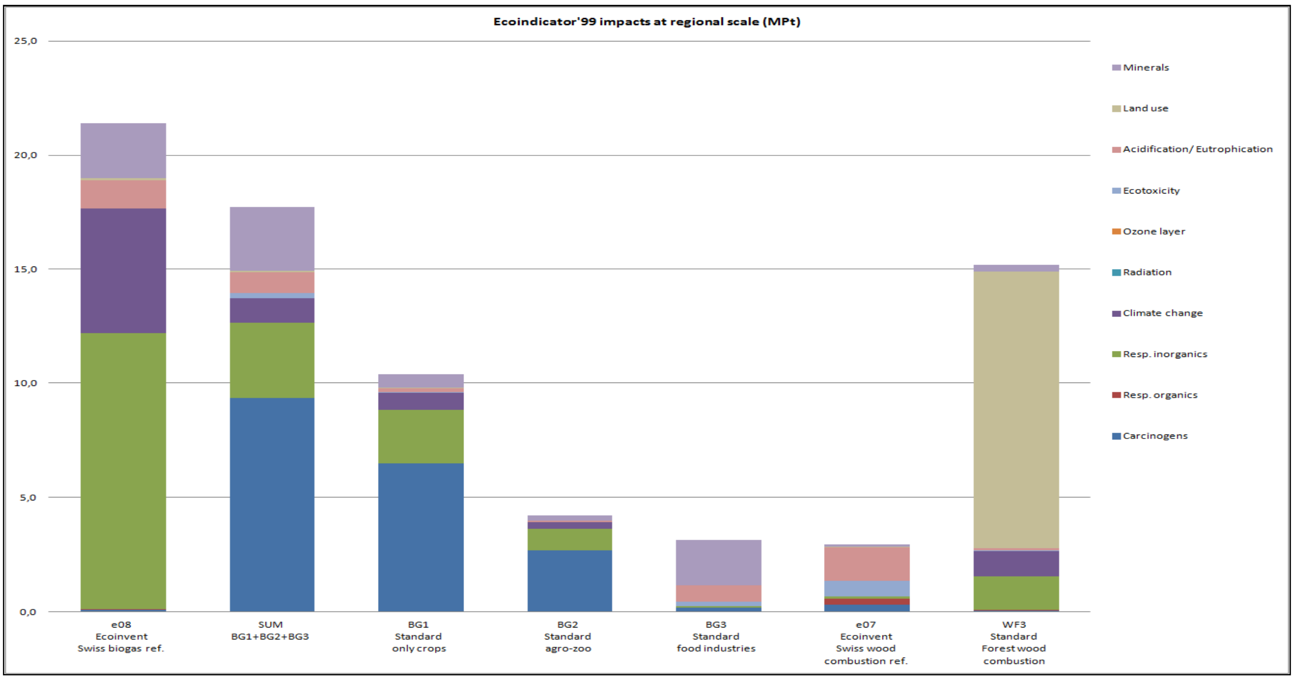


Figura 11- Synthesis of the IMPACT categories estimed for the sum of biomass electric power installed in Emilia-Romagna region, disaggregated for the their relative main group of appartenence

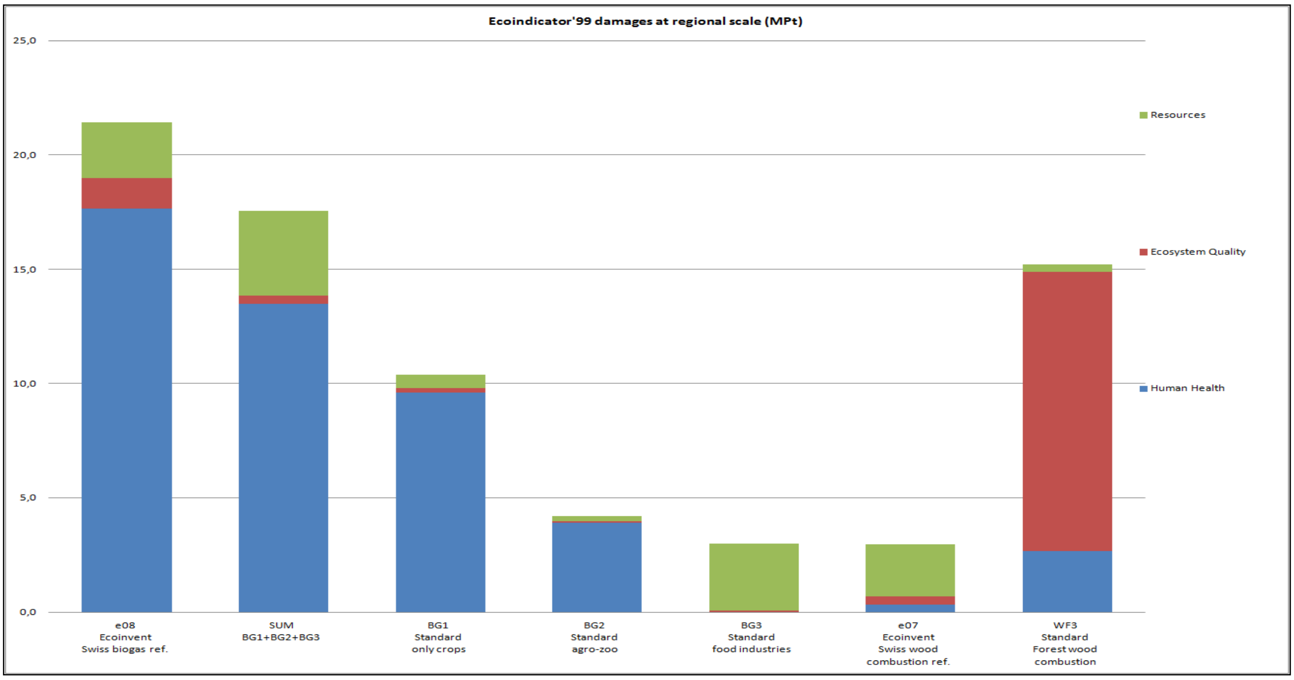


Figura 12- Synthesis of the DAMAGE macro.categories estimed for the sum of biomass electric power installed in Emilia-Romagna region, disaggregated for the their relative main group of appartenence

3.1.3. IMPACTS: The LCA approach conclusions

- We repute the values of impact/damage associated to unitary standard plants can represent a good way and assessment instrument to quantify the environmental impact/damage of a regional biogas and wood combustion energy systems, both for Emilia-Romagna and for similar territories.
- How you prefer you can easily choose and take in account both the Ecoinvent Swiss than the standard unitary references we presented to multiply them for the biomass electric power installed on your territory to calculate related Ecoindicator'99 impacts/damages.
- You can also modify the starting data of standardized plants, with their productive chains, and so after implement them as you like in a LCA software to recalculate new unitary standardized plants with Ecoindicator'99 or other LCA methodologies.
- This is a good starting point to improve correlated research, planning, sustainability balances, etc.. Unitary values here tested and presented can be an excellent screening instrument for regional assessments, especially why you only need to know the electric power installed values to obtain their LCA Ecoindicator'99 impacts/damages at regional scale.

3.2. PRESSURES/STATES INDICATORS

Figura 13- Pressureses/States reference for the DPSIR model.

3.2.1. PRESSURES/STATES: 1° level indicators: obtained values for 2015 - 2016

Tabella 17- The obtained elaborated indicators for 2015 and 2016.

2014													
GSE/ARPAE TOTAL BIOMASS power plants	**UNIT OF MISURE**	**BIOMASS 2014 GSE-TERNA**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	num.	2014 - GSE/TERNA - Number of BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	260	2014
	MW.el	2014 - GSE/TERNA -Electric power of BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	486,43	2014
	GWh.el	2014 - GSE/TERNA -Electricity production from BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	2759	2014

2015													
GSE/ARPAE TOTAL BIOMASS power plants	**UNIT OF MISURE**	**BIOMASS 2015 GSE-TERNA**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	num.	GSE-Boll2015-BIOMASS.Num.plants (Num.)	48	25	40	33	28	32	32	34	8	280	2015
	MW.el	GSE-Boll2015-BIOMASS.electric.power (MW.el)	72,03	33,939	76,307	45,76	16,314	34,038	182,458	28,087	18,932	507,87	2015
	GWh.el	2015 - GSE/TERNA -Electricity production from BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	0	*waiting data 2015
	UNIT OF MISURE	**BIOMASS 2015 ARPAE-GIS**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	num.	2015 - BIOMASS.Num.plants (Num.)	46	30	45	26	28	18	25	21	8	247	
	MWh.el	2015 - BIOMASS.electric.power (MW.el)	31,849	25,153	66,914	13,202	17,997	7,771	191,861	16,966	4,719	376,432	
GSE - SOLID BIOMASS power plants	**UNIT OF MISURE**	**SOLID BIOMASS 2015 GSE**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	Num.	GSE-Boll2015-SOLIDBIOMASS.Num.plants (Num.)	3	2	2	2	2	5	4	3	1	24	
	MW.el	GSE-Boll2015-SOLIDBIOMASS.electric.power (MW.el)	2	16	26	25	0	18	51	3	1	142	
	GWh.el	GSE-RappStat2015-SOLIDBIOMASS.electric.energy.production (MWh.el)	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~847,40~~	
	2015 GSE SolidBiomassNum / 1000ha	GSE-Boll2015-SOLIDBIOMASS.Num.plants / 1000ha of lowland	0,003	0,005	0,006	0,003	0,007	0,011	0,010	0,006	0,003	0,005	
	2015 GSE SolidBiomassMW.el / 1000inhabitants	GSE-Boll2015-SOLIDBIOMASS.Electric.power MW.el / 1000inhabitants	0,002	0,040	0,074	0,035	0,000	0,041	0,129	0,006	0,001	0,032	
	SolidBiomass2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE SOLIDBIOMASS electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	0,093%	2014
GSE - BIOGAS power plants	**UNIT OF MISURE**	**BIOGAS 2015 GSE**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	Num.	GSE-Boll2015-BGAS.Num.plants (Num.)	33	13	33	23	25	20	21	16	4	188	
	MW.el	GSE-Boll2015-BGAS.electric.power (MW.el)	30,9	9	33,2	14,4	15,2	9,2	22	8,4	3,8	146,1	
	GWh.el	GSE-RappStat2015-BGAS.electric.energy.production (GWh.el)	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	1.268	
	2015 GSE BiogasNum / 1000ha	GSE-Boll2015-BGAS.Num.plants / 1000ha of lowland	0,17	0,22	0,13	0,16	0,21	0,16	0,14	0,14	0,16	0,16	
	2015 GSE BiogasMW.el / 1000inhabitants	GSE-Boll2015-BGAS.Electric.power MW.el / 1000inhabitants	0,03	0,02	0,09	0,02	0,05	0,02	0,06	0,02	0,01	0,03	
	Biogas2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE BGAS electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	0,140%	2014

	UNIT OF MISURE	SOLID BIOMASS 2015 ARPAE-GIS	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	NOTE
ARPAE-GIS SOLID BIOMASS power plants	%	-2015- Land use: TPAB.500m - % of number of solid biomass plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomass plants	15,4%	16,7%	33,3%	0,0%	0,0%	0,0%	20,0%	#DIV/0!	50,0%	16,2%	
	%	-2015- Land use: TPAB.500m - % of electric power of solid biomass plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomass plants	0,0%	29,4%	0,0%	0,0%	0,0%	#DIV/0!	18,8%	#DIV/0!	#DIV/0!	13,7%	
	num.	-2015- Air: number of solid biomass plant within red air class municipality area respect the number of of solid biomass plants	2	0	1	1	0	0	0	0	1	5	
	%	-2015- Fresh water: % of solid biomass plant closer 500 m. from main rivers respect the number of solid biomass plants	7,7%	0,0%	33,3%	0,0%	33,3%	0,0%	0,0%	#DIV/0!	50,0%	10,8%	
	%	-2015- Soil: % solid biomass electric power installed installed within poor C soil respect the electric power of solid biomass plants	67,3%	94,5%	100,0%	100,0%	3,2%	#DIV/0!	100,0%	#DIV/0!	#DIV/0!	97,8%	
	%	-2015- Sensitivity maps: % solid biomass electric power installed installed within violet areas respect the electric power of solid biomass plants	0,0%	5,5%	100,0%	0,0%	0,0%	#DIV/0!	0,0%	#DIV/0!	#DIV/0!	25,7%	
	MWh.input	-GSE stat 2015- Energy: Stimed MWh SolidBiomasses energy combusted, starting from electricity production (= 20%.El.prod + 65%.Term.prod + 15%.lost)	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	4.237	*2014
	~~m3~~	~~Stimed m3 of CH4 produced and then burned~~	/	/	/	/	/	/	/	/	/	/	
	UNIT OF MISURE	BIOGAS 2015 ARPAE-GIS	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	NOTE
ARPAE-GIS BIOGAS power plants	%	-2015- Land use: TPAB.500m - % of number of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	23,3%	7,7%	20,5%	15,0%	9,5%	15,4%	38,5%	11,8%	0,0%	17,6%	
	%	-2015- Land use: TPAB.500m - % of electric power of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	28,6%	0,0%	26,3%	2,6%	6,4%	7,8%	22,0%	7,1%	0,0%	15,1%	
	~~num.~~	~~-2015- Air: number of biogas plant within red air class municipality area respect the number of of biogas plants~~	~~5~~	~~0~~	~~3~~	~~10~~	~~3~~	~~3~~	~~0~~	~~7~~	~~2~~	~~33~~	
	%	-2015- Fresh water: % of biogas plant closer 500 m. from main rivers respect the number of biogas plants	33,3%	7,7%	17,9%	10,0%	4,8%	30,8%	0,0%	11,8%	0,0%	15,9%	
	%	-2015- Soil: % biogas electric power installed installed within poor C soil respect the electric power of biogas plants	99,3%	91,4%	77,6%	83,3%	71,6%	56,8%	100,0%	51,9%	30,6%	83,2%	
	%	-2015- Sensitivity maps: % biogas electric power installed installed within violet areas respect the electric power of biogas plants	3,5%	1,7%	3,4%	0,0%	2,6%	0,4%	2,9%	0,0%	0,0%	2,4%	
	MWh.input	-GSE stat 2015- Energy: Stimed MWh CH4 energy production starting from electricity production (= 40% Bgas.El.prod + 40% Bgas.Term.prod + 20% Bgas.lost)	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	3.169	*2014
	m3	Stimed m3 of CH4 produced and then burned	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	298.978.774	*2014
	UNIT OF MISURE	BGAS C.E.CE. 2015 ARPAE-GIS	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	NOTE
ARPAE-GIS BIOGAS C.E.CE. Power plants	%	-2015- Land use: TPAB.500m - % of number of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	6,7%	0,0%	15,4%	0,0%	4,8%	7,7%	23,1%	5,9%	0,0%	8,2%	
	%	-2015- Land use: TPAB.500m - % of electric power of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	7,0%	0,0%	14,2%	0,0%	2,6%	0,4%	5,7%	0,7%	0,0%	6,1%	
	~~num.~~	~~-2015- Air: number of C.E.CE. biogas plant within red air class municipality area respect the number of of biogas plants~~	~~1~~	~~0~~	~~2~~	~~2~~	~~3~~	~~0~~	~~0~~	~~5~~	~~1~~	~~14~~	
	%	-2015- Fresh water: % of C.E.CE. biogas plant closer 500 m. from low/bad ecological stretch of water quality indicator of regional main rivers respect the number of biogas plants	10,0%	0,0%	10,3%	5,0%	4,8%	23,1%	0,0%	5,9%	0,0%	7,6%	
	%	-2015- Soil: % C.E.CE. biogas electric power installed installed within poor C soil respect the electric power of biogas plants	35,6%	13,3%	38,7%	3,1%	53,0%	20,3%	15,0%	20,0%	30,6%	27,3%	
	%	-2015- Sensitivity maps: % BGAS-C.E.CE. electric power installed installed within violet areas respect the electric power of biogas plants	3,5%	1,7%	3,4%	0,0%	2,6%	0,4%	2,9%	0,0%	0,0%	2,4%	

2016													
GSE/ARPAE TOTAL BIOMASS power plants	**UNIT OF MISURE**	**BIOMASS 2015 GSE-TERNA**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	num.	2016 - GSE/TERNA - Number of BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	0	*waiting data 2016
	MW.el	2016 - GSE/TERNA -Electric power of BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	0,00	*waiting data 2016
	GWh.el	2016 - GSE/TERNA -Electricity production from BIOMASS plants	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	~~n.a.~~	0	*waiting data 2016
	UNIT OF MISURE	**BIOMASS 2016 ARPAE-GIS**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	num.	2016 - Number of biomass power plants	62	34	51	35	33	29	36	28	8	316	
	MWh.el	2016 - Electric power of biomass power plants	39,46	23,765	52,564	14,678	18,973	10,821	169,313	19,93	4,717	354,221	
GSE - SOLID BIOMASS power plants	**UNIT OF MISURE**	**SOLID BIOMASS 2016 GSE**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	Num.	GSE-Boll2016-BIOMASS.Num.plants (Num.)											
	MW.el	GSE-Boll2016-BIOMASS.electric.power (MW.el)											
	GWh.el	GSE-RappStat2016-BIOMASS.electric.energy.production (MWh.el)			x NUMERO E POTENZA non ho ancora i dati GSE/TERNA 2016 ---- x PRODUZIONE non ho neanche quelli 2015								
	2016 GSE SolidBiomassNum / 1000ha	GSE-Boll2016-SOLIDBIOMASS.Num.plants / 1000ha of lowland											
	2016 GSE SolidBiomassMW.el / 1000inhabitants	GSE-Boll2016-SOLIDBIOMASS.Electric.power MW.el / 1000inhabitants											
	SolidBiomass2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE SOLIDBIOMASS electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	0,093%	2014
GSE - BIOGAS power plants	**UNIT OF MISURE**	**BIOGAS 2016 GSE**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**REGIONAL**	**NOTE**
	Num.	GSE-Boll2016-BGAS.Num.plants (Num.)											
	MW.el	GSE-Boll2016-BGAS.electric.power (MW.el)											
	GWh.el	GSE-RappStat2016-BGAS.electric.energy.production (GWh.el)			x NUMERO E POTENZA non ho ancora i dati GSE/TERNA 2016 ---- x PRODUZIONE non ho neanche quelli 2015								
	2015 GSE BiogasNum / 1000ha	GSE-Boll2015-BGAS.Num.plants / 1000ha of lowland											
	2015 GSE BiogasMW.el / 1000inhabitants	GSE-Boll2015-BGAS.Electric.power MW.el / 1000inhabitants											
	Biogas2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE BGAS electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	0,140%	2014

	UNIT OF MISURE	SOLID BIOMASSES 2016 ARPAE-GIS	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	NOTE
ARPAE-GIS SOLID BIOMASS power plants	%	-2016- Land use: TPAB.500m - % of number of solid biomass plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomass plants	15,4%	16,7%	25,0%	0,0%	0,0%	0,0%	20,0%	0,0%	50,0%	15,0%	
	%	-2016- Land use: TPAB.500m - % of electric power of solid biomass plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomass plants	0,0%	29,4%	0,0%	0,0%	0,0%	#DIV/0!	21,5%	0,0%	#DIV/0!	17,5%	
	num.	-2016- Air: number of solid biomass plant within red air class municipality area respect the number of of solid biomass plants	2	0	2	1	0	1	0	0	1	7	
	%	-2016- Fresh water: % of solid biomass plant closer 500 m. from low/bad ecological stretch of water quality indicator of regional main rivers respect the number of solid biomass plants	7,7%	0,0%	25,0%	0,0%	33,3%	0,0%	0,0%	0,0%	50,0%	10,0%	
	%	-2016- Soil: % solid biomass electric power installed installed within poor C soil respect the electric power of solid biomass plants	67,3%	94,5%	100,0%	100,0%	3,2%	#DIV/0!	100,0%	100,0%	#DIV/0!	97,2%	
	%	-2016- Sensitivity maps: % solid biomass electric power installed installed within violet areas respect the electric power of solid biomass plants	0,0%	5,5%	100,0%	0,0%	0,0%	#DIV/0!	0,0%	0,0%	#DIV/0!	15,8%	
	MWh.input	-GSE stat 2016- Energy: Stimed MWh SolidBiomasses energy combusted, starting from electricity production (= 20%.El.prod + 65%.Term.prod + 15%.lost)	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	4.237	2014
	~~m3~~	~~Stimed m3 of CH4 produced and then burned~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	
	UNIT OF MISURE	BIOGAS 2016 ARPAE-GIS	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	NOTE
ARPAE-GIS BIOGAS power plants	%	-2016- Land use: TPAB.500m - % of number of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	18,2%	0,0%	16,5%	6,1%	5,4%	11,3%	28,6%	6,7%	0,0%	12,7%	
	%	-2016- Land use: TPAB.500m - % of electric power of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	0,6%	0,0%	0,5%	1,0%	0,8%	3,6%	1,2%	0,5%	0,0%	0,1%	
	~~num.~~	~~-2016- Air: number of biogas plant within red air class municipality area respect the number of of biogas plants~~	~~8~~	~~0~~	~~5~~	~~11~~	~~3~~	~~5~~	~~0~~	~~8~~	~~4~~	~~44~~	
	%	-2016- Fresh water: % of biogas plant closer 500 m. from low/bad ecological stretch of water quality indicator of regional main rivers respect the number of biogas plants	32,6%	11,8%	18,2%	10,3%	12,0%	39,1%	0,0%	17,4%	0,0%	18,7%	
	%	-2016- Soil: % biogas electric power installed installed within poor C soil respect the electric power of biogas plants	93,4%	90,4%	78,0%	77,0%	71,6%	48,4%	100,0%	57,1%	30,6%	79,8%	
	%	-2016- Sensitivity maps: % biogas electric power installed installed within violet areas respect the electric power of biogas plants	2,8%	1,9%	3,3%	0,0%	2,6%	0,2%	8,5%	0,0%	0,0%	2,9%	
	MWh.input	-GSE stat 2016- Energy: Stimed MWh CH4 energy content, starting from electricity production (= 40% Bgas.El.prod + 40% Bgas.Term.prod + 20% Bgas.lost)	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	3.169	2014
	m3	Stimed m3 of CH4 produced and then burned	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	~~n.d.~~	298.978.774	2014
	UNIT OF MISURE	BGAS C.E.CE. 2016 ARPAE-GIS	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	NOTE
ARPAE-GIS BIOGAS C.E.CE. Power plants	%	-2016- Land use: TPAB.500m - % of number of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	6,5%	5,9%	13,6%	3,4%	4,0%	21,7%	16,7%	8,7%	0,0%	9,8%	
	%	-2016- Land use: TPAB.500m - % of electric power of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	8,2%	0,0%	14,0%	7,4%	2,6%	12,8%	17,1%	2,4%	0,0%	9,3%	
	~~num.~~	~~-2016- Air: number of C.E.CE. biogas plant within red air class municipality area respect the number of of biogas plants~~	~~1~~	~~0~~	~~2~~	~~3~~	~~3~~	~~0~~	~~0~~	~~6~~	~~1~~	~~16~~	
	%	-2016- Fresh water: % of C.E.CE. biogas plant closer 500 m. from low/bad ecological stretch of water quality indicator of regional main rivers respect the number of biogas plants	10,6%	0,0%	11,4%	3,4%	1,9%	9,3%	0,0%	4,3%	0,0%	6,2%	
	%	-2016- Soil: % C.E.CE. biogas electric power installed installed within poor C soil respect the electric power of biogas plants	30,8%	14,2%	37,0%	12,5%	27,0%	9,3%	46,9%	12,6%	25,0%	25,7%	
	%	-2016- Sensitivity maps: % BGAS-C.E.CE. electric power installed installed within violet areas respect the electric power of biogas plants	2,8%	1,9%	3,3%	0,0%	2,6%	0,2%	4,3%	0,0%	0,0%	2,3%	

3.2.2. PRESSURES/STATES: 2° level indicators: the difference values: 2016 - 2015

Tabella 18- The values obtained from the difference between the indicators values = 2016 - 2015. *[[*see the colored emojies and the relative explanation of judgment]]*

UNIT OF MISURE	GSE/TERNA BIOMASS DIFFERENCE 2015-2014	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
num.	BIOMASS.Num.plants (Num.)	/	/	/	/	/	/	/	/	/	20	:-)	2014-2015 -GSE- : The number of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE
MW.el	**BIOMASS.electric.power (MW.el)**	/	/	/	/	/	/	/	/	/	21	:-)	2014-2015 -GSE- : The electric power installed of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE
%	**BIOMASS.electric.power (%)**	/	/	/	/	/	/	/	/	/	4,41%	:-)	2014-2015 -GSE- : The electric power installed of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE
GWh.el	BIOMASS.electricity production (GWh.el)	/	/	/	/	/	/	/	/	/	-2759	/	2014-2015 -GSE- : *waiting data 2015	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE

UNIT OF MISURE	ARPAE-GIS BIOMASS DIFFERENCE 2016-2015	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
num.	BIOMASS.Num.plants (Num.)	16	4	6	9	5	11	11	7	0	69	:-)	The number of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION / PROVINCE / MUNICIPALITY	2015 - 2016	ARPAE-GIS
MWh.el	BIOMASS.electric.power (MW.el)	8	-1	-14	1	1	3	-23	3	0	-22	:-I	The big decrease of biomass electric power installed depends from the correction of RA data. In sinthesys the electric power installed in 2016 about all the sector of biomasses is pratically the same of that one of 2015	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION / PROVINCE / MUNICIPALITY	2015 - 2016	ARPAE-GIS

UNIT OF MISURE	GSE SOLID BIOMASSES DIFFERENCE 2016-2015	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
Num.	GSE-Boll2016-BIOMASS.Num.plants (Num.)	-3	-2	-2	-2	-2	-5	-4	-3	-1	-24			P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE
MW.el	GSE-Boll2016-BIOMASS.electric.power (MW.el)	-2	-16	-26	-25	0	-18	-51	-3	-1	-142			P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE
GWh.el	GSE-RappStat2016-BIOMASS.electric.energy.production (MWh.el)	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	-847		x NUMERO E POTENZA non ho ancora i dati GSE/TERNA 2016 ---- x PRODUZIONE non ho neanche quelli 2015	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE
2015 GSE SolidBiomassNum / 1000ha	GSE-Boll2016-SOLIDBIOMASS.Num.plants / 1000ha of lowland	-0,003	-0,005	-0,006	-0,003	-0,007	-0,011	-0,010	-0,006	-0,003	-0,005		* waiting data	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE
2015 GSE SolidBiomassMW.el / 1000inhabitants	GSE-Boll2016-SOLIDBIOMASS.Electric.power MW.el / 1000inhabitants	-0,002	-0,040	-0,074	-0,035	0,000	-0,041	-0,129	-0,006	-0,001	-0,032			P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE
SolidBiomass2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE SOLIDBIOMASS electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0			P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGIONAL	2014	GSE + ARPA2010

UNIT OF MISURE	GSE BIOGAS DIFFERENCE 2016-2015	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICA TOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
Num.	GSE-Boll2015-BGAS.Num.plants (Num.)	-33	-13	-33	-23	-25	-20	-21	-16	-4	-188			P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE
MW.el	GSE-Boll2015-BGAS.electric.power (MW.el)	-30,9	-9	-33,2	-14,4	-15,2	-9,2	-22	-8,4	-3,8	-146,1		x NUMERO E POTENZA non ho ancora i dati GSE/TERNA 2016 ---- x PRODUZIONE non ho neanche quelli 2015	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE
GWh.el	GSE-RappStat2015-BGAS.electric.energy.production (GWh.el)	/	/	/	/	/	/	/	/	/	-1.268	/	* waiting data	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE
2015 GSE BiogasNum / 1000ha	GSE-Boll2015-BGAS.Num.plants / 1000ha of lowland	-0,169	-0,218	-0,126	-0,164	-0,211	-0,162	-0,135	-0,138	-0,156	-0,157			P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE
2015 GSE BiogasMW.el / 1000inhabitants	GSE-Boll2015-BGAS.Electric.power MW.el / 1000inhabitants	-0,031	-0,023	-0,094	-0,021	-0,053	-0,021	-0,056	-0,016	-0,011	-0,033			P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE
Biogas2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE Biogas electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	/	/	/	/	/	/	/	/	/	0,000%			P	BIOGAS	Agriculture and food industry	REGIONAL	2014	GSE + ARPA2010

UNIT OF MISURE	ARPAE-GIS SOLID BIOMASSES DIFFERENCE 2016-2015	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICA TOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
%	Land use: TPAB.500m - % of number of solid biomasses plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomasses plants	0,0%	0,0%	-8,3%	0,0%	0,0%	0,0%	0,0%	#DIV/0!	0,0%	-1,2%	:-)	The percent of solid biomass plants located within or near protected/important ecological area is decreased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Land use: TPAB.500m - % of electric power of solid biomasses plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomasses plants	0,0%	0,0%	0,0%	0,0%	0,0%	#DIV/0!	2,7%	#DIV/0!	#DIV/0!	3,7%	:-(	The percent of electric installed power from solid biomass plants located within or near 500 m. to protected/important ecological area is increased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS
num.	Air: number of solid biomasses plant within red air class municipality area respect the number of of solid biomasses plants	0	0	1	0	0	1	0	0	0	2	:-(	The number of solid biomass plants located within red municiplaities air class from DAL 52/2011 is increased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Fresh water: % of solid biomasses plant closer 500 m. from main rivers respect the number of solid biomasses plants	0,0%	0,0%	-8,3%	0,0%	0,0%	0,0%	0,0%	#DIV/0!	0,0%	-0,8%	:-)	The percent of solid biomass plants located near 500m from the main rivers area with low/bad ecological quality is decreased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Soil: % solid biomasses electric power installed within poor C soil respect the electric power of solid biomasses plants	0,0%	0,0%	0,0%	0,0%	0,0%	#DIV/0!	0,0%	#DIV/0!	#DIV/0!	-0,6%	:-(	The percent of biogas plants located on poor organic C soil (0-60 t./ha) is decreased. (*sprawling digestate enrich soil of organic C)	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Sensitivity maps: % solid biomasses electric power installed within violet areas respect the electric power of solid biomasses plants	0,00%	-0,01%	0,00%	0,00%	0,00%	#DIV/0!	0,00%	#DIV/0!	#DIV/0!	-9,85%	:-)	The percent of electric power installed of solid biomasses plants is decreased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS
MW.input	Energy: Stimed MWh CH4 energy production starting from electricity production (= 20%.El.prod + 65%.Term.prod + 15%.lost)	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	0	:-|	* waiting data	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2014	ARPAE-elab
~~m3~~	~~Stimed m3 of CH4 produced and then burned~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	~~/~~	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2014	ARPAE-elab

UNIT OF MISURE	ARPAE-GIS BIOGAS DIFFERENCE 2016-2015	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICA TOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
%	Land use: TPAB.500m - % of number of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	-5,1%	-7,7%	-4,1%	-8,9%	-4,2%	-4,0%	-9,9%	-5,1%	0,0%	-5,0%	:-)	The percent of biogas plants located within or near protected/important ecological area is decreased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Land use: TPAB.500m - % of electric power of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	-28,0%	0,0%	-25,7%	-1,6%	-5,6%	-4,2%	-20,7%	-6,6%	0,0%	-15,0%	:-)	The percent of electric installed power from biogas plants located within or near 500 m. to protected/important ecological area is decreased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS
num.	Air: number of biogas plant within red air class municipality area respect the number of of biogas plants	3	0	2	1	0	2	0	1	2	11	:-(	The number of biogas plants located within red municiplaities air class from DAL 52/2011 is increased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Fresh water: % of biogas plant closer 500 m. from main rivers respect the number of biogas plants	-0,7%	4,1%	0,2%	0,3%	7,2%	8,4%	0,0%	5,6%	0,0%	2,8%	:-(	The percent of biogas plants located near 500m from the main rivers area with low/bad ecological quality is increased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Soil: % biogas electric power installed within poor C soil respect the electric power of biogas plants	-5,9%	-1,0%	0,4%	-6,3%	0,0%	-8,4%	0,0%	5,2%	0,0%	-3,4%	:-(	The percent of biogas plants located on poor organic C soil (0-60 t./ha) is decreased. (*sprawling digestate enrich soil of organic C)	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS
%	Sensitivity maps: % biogas electric power installed within violet areas respect the electric power of biogas plants	-0,73%	0,20%	-0,06%	0,00%	0,01%	-0,13%	5,68%	0,00%	0,00%	0,55%	:-I	The percent of electric power installed of biogas plants is very lightly increased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS
MW.input	Energy: Stimed MWh CH4 energy production starting from electricity production (= 40% Bgas.El.prod + 40% Bgas.Term.prod + 20% Bgas.lost)	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	0	:-I	* waiting data	S	BIOGAS	Agriculture and food industry	PROVINCE	2014	ARPAE-elab
m3	Stimed m3 of CH4 produced and then burned	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	#VALORE!	0	:-I	* waiting data	S	BIOGAS	Agriculture and food industry	PROVINCE	2014	ARPAE-elab

UNIT OF MISURE	ARPAE-GIS BIOGAS C.E.CE. DIFFERENCE 2016-2015	BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICA TOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE
%	Land use: TPAB.500m - % of number of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	-0,1%	5,9%	-1,7%	3,4%	-0,8%	14,0%	-6,4%	2,8%	0,0%	1,6%	:-(	The number of biogas plants C.E.CE. (supplied from energy crops and cows and pigs manure&slurry) located within or near 500m from protected/importasnt ecological area is increased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS
%	Land use: TPAB.500m - % of electric power of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	1,3%	0,0%	-0,3%	7,4%	0,0%	12,4%	11,4%	1,7%	0,0%	3,2%	:-(	The electric power installed of biogas plants C.E.CE. (supplied from energy crops and cows and pigs manure&slurry) located within or near 500m from protected/importasnt ecological area is increased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS
num.	Air: number of C.E.CE. biogas plant within red air class municipality area respect the number of of biogas plants	0	0	0	1	0	0	0	1	0	2	:-(	The number of biogas plants C.E.CE. located within red municiplaities air class from DAL 52/2011 is increased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS
%	Fresh water: % of C.E.CE. biogas plant closer 500 m. from low/bad ecological stretch of water quality indicator of regional main rivers respect the number of biogas plants	0,6%	0,0%	1,1%	-1,6%	-2,9%	-13,8%	0,0%	-1,5%	0,0%	-1,5%	:-)	The number of biogas plants C.E.CE. located near 500m from the main rivers area with low/bad ecological quality is decreased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS
%	Soil: % C.E.CE. biogas electric power installed within poor C soil respect the electric power of biogas plants	-4,8%	0,9%	-1,7%	9,4%	-26,0%	-11,0%	31,9%	-7,4%	-5,6%	-1,6%	:-(	The percent of biogas plants C.E.CE. located on poor organic C soil (0-60 t./ha) is decreased. (*sprawling digestate enrich soil of organic C)	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS
%	Sensitivity maps: % BGAS-C.E.CE. electric power installed within violet areas respect the electric power of biogas plants	-0,73%	0,20%	-0,06%	0,00%	0,01%	-0,13%	1,41%	0,00%	0,00%	-0,06%	:-I	The percent of electric power installed of solid biomasses plants is very lightly decreased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS

3.2.3. PRESSURES/STATES: Judgments (*only for Region)

Tabella 19- Synthesis of the 2° level values and judgments and the final DPSIR given judgments about the 2016 – 2015 data anlysis.
*[[*see the colored emojies - *in red on the right the final judgments]]*

UNIT OF MISURE	GSE/TERNA BIOMASS DIFFERENCE 2015-2014	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
num.	BIOMASS.Num.plants (Num.)	20	:-)	2014-2015 -GSE- : The number of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE	GSE - Total BIOMASS plants	:-)	Respect 2015, in 2016 the total regional electric power installed with biomass power plants is increased of 4,41%
MW.el	**BIOMASS.electric.power (MW.el)**	21	:-)	2014-2015 -GSE- : The electric power installed of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE			
%	**BIOMASS.electric.power (%)**	4,41%	:-)	2014-2015 -GSE- : The electric power installed of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE			
GWh.el	BIOMASS.electricity production (GWh.el)	-2759	/	2014-2015 -GSE- : *waiting data 2015	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION	2014-2015	GSE			

UNIT OF MISURE	ARPAE-GIS BIOMASS DIFFERENCE 2016-2015	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
num.	BIOMASS.Num.plants (Num.)	69	:-)	The number of biomass plants is increased	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION / PROVINCE / MUNICIPALITY	2015 - 2016	ARPAE-GIS	ARPAE-GIS - Total BIOMASS plants	:-)	Respect 2015, in 2016 the number of plants is increased of 69 new localisations. RA data need a deepening and correction. The accurancy of ARPAE-GIS for biomass plants is increasing
MWh.el	BIOMASS.electric.power (MW.el)	-22	:-I	The big decrease of biomass electric power installed depends from the correction of RA data. In sinthesys the electric power installed in 2016 about all the sector of biomasses is pratically the same of that one of 2015	P	BIOMASS (Biogas, solid biomasses, bioliquids)	Agriculture, forest, food industry	REGION / PROVINCE / MUNICIPALITY	2015 - 2016	ARPAE-GIS			

UNIT OF MISURE	GSE SOLID BIOMASSES DIFFERENCE 2016-2015	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
Num.	GSE-Boll2016-BIOMASS.Num.plants (Num.)	-24	0	0	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE	GSE - SOLID BIOMASSES plants	:-I	*Waiting data from GSE
MW.el	GSE-Boll2016-BIOMASS.electric.power (MW.el)	-142	0	0	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE			
GWh.el	GSE-RappStat2016-BIOMASS.electric.energy.production (MWh.el)	-847	0	x NUMERO E POTENZA non ho ancora i dati GSE/TERNA 2016 ---- x PRODUZIONE non ho neanche quelli 2015	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE			
2015 GSE SolidBiomassNum / 1000ha	GSE-Boll2016-SOLIDBIOMASS.Num.plants / 1000ha of lowland	-0,005	0	* waiting data	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE			
2015 GSE SolidBiomassMW.el / 1000inhabitants	GSE-Boll2016-SOLIDBIOMASS.Electric.power MW.el / 1000inhabitants	-0,032	0	0	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGION / PROVINCE	2015 - 2016	GSE			
SolidBiomass2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE SOLIDBIOMASS electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	0	0	0	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	REGIONAL	2014	GSE + ARPA2010			

UNIT OF MISURE	GSE BIOGAS DIFFERENCE 2016-2015	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
Num.	GSE-Boll2015-BGAS.Num.plants (Num.)	-188	0	0	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE	GSE - BIOGAS plants	:-I	*Waiting data from GSE
MW.el	GSE-Boll2015-BGAS.electric.power (MW.el)	-146,1	0	x NUMERO E POTENZA non ho ancora i dati GSE/TERNA 2016 ---- x PRODUZIONE non ho neanche quelli 2015	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE			
GWh.el	GSE-RappStat2015-BGAS.electric.energy.production (GWh.el)	-1.268	/	* waiting data	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE			
2015 GSE BiogasNum / 1000ha	GSE-Boll2015-BGAS.Num.plants / 1000ha of lowland	-0,157	0	0	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE			
2015 GSE BiogasMW.el / 1000inhabitants	GSE-Boll2015-BGAS.Electric.power MW.el / 1000inhabitants	-0,033	0	0	P	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	GSE			
Biogas2014MWh.el / Agriculture.electric.consumption.2010 = %	GSE Biogas electricity production 2014 MWh / ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	0,000%	0	0	P	BIOGAS	Agriculture and food industry	REGIONAL	2014	GSE + ARPA2010			

UNIT OF MISURE	ARPAE-GIS SOLID BIOMASSES DIFFERENCE 2016-2015	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
%	Land use: TPAB.500m - % of number of solid biomasses plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomasses plants	-1,2%	:-)	The percent of solid biomass plants located within or near protected/important ecological area is decreased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS	ARPAE-GIS - SOLID BIOMASS plants territorial situation	:-)	Respect 2015, in 2016 the percentual of the number of solid biomass plants located near 500m or within protected areas and low quality rivers is decreased
%	Land use: TPAB.500m - % of electric power of solid biomasses plant located within proctected areas or within the buffer of 500m from them, respect total provincial solid biomasses plants	3,7%	:-(	The percent of electric installed power from solid biomass plants located within or near 500 m. to protected/important ecological area is increased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
num.	Air: number of solid biomasses plant within red air class municipality area respect the number of of solid biomasses plants	2	:-(	The number of solid biomass plants located within red municiplaities air class from DAL 52/2011 is increased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Fresh water: % of solid biomasses plant closer 500 m. from main rivers respect the number of solid biomasses plants	-0,8%	:-)	The percent of solid biomass plants located near 500m from the main rivers area with low/bad ecological quality is decreased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Soil: % solid biomasses electric power installed within poor C soil respect the electric power of solid biomasses plants	-0,6%	:-(	The percent of biogas plants located on poor organic C soil (0-60 t./ha) is decreased. (*sprawling digestate enrich soil of organic C)	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Sensitivity maps: % solid biomasses electric power installed within violet areas respect the electric power of solid biomasses plants	0,0%	:-I	The percent of electric power installed of solid biomasses plants is decreased	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
MW.input	Energy: Stimed MWh CH4 energy production starting from electricity production (= 20%.El.prod + 65%.Term.prod + 15%.lost)	0	:-I	* waiting data	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2014	ARPAE-elab			
~~m3~~	~~Stimed m3 of CH4 produced and then burned~~	/	/	/	P	SOLID BIOMASSES	Forest, arboriculture, wood industry, agro-food industry	PROVINCE	2014	ARPAE-elab			

UNIT OF MISURE	ARPAE-GIS BIOGAS DIFFERENCE 2016-2015	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
%	Land use: TPAB.500m - % of number of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	-5,0%	:-)	The percent of biogas plants located within or near protected/important ecological area is decreased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS	ARPAE-GIS - BIOGAS plants territorial situation	:-)	Respect 2015, in 2016 the percentual of the number of biogas plants located near 500m or within protected areas is decreased. (but is increased the number of biogas plants located low quality river).
%	Land use: TPAB.500m - % of electric power of biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	-15,0%	:-)	The percent of electric installed power from biogas plants located within or near 500 m. to protected/important ecological area is decreased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
~~num.~~	~~Air: number of biogas plant within red air class municipality area respect the number of of biogas plants~~	~~11~~	~~:-(~~	~~The number of biogas plants located within red municiplaities air class from DAL 52/2011 is increased~~	~~S~~	~~BIOGAS~~	~~Agriculture and food industry~~	~~PROVINCE~~	~~2015 - 2016~~	~~ARPAE-GIS~~			
%	Fresh water: % of biogas plant closer 500 m. from main rivers respect the number of biogas plants	2,8%	:-(	The percent of biogas plants located near 500m from the main rivers area with low/bad ecological quality is increased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Soil: % biogas electric power installed within poor C soil respect the electric power of biogas plants	-3,4%	:-(	The percent of biogas plants located on poor organic C soil (0-60 t./ha) is decreased. (*sprawling digestate enrich soil of organic C)	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Sensitivity maps: % biogas electric power installed within violet areas respect the electric power of biogas plants	-0,7%	:-I	The percent of electric power installed of biogas plants is very lightly increased	S	BIOGAS	Agriculture and food industry	PROVINCE	2015 - 2016	ARPAE-GIS			
MW.input	Energy: Stimed MWh CH4 energy production starting from electricity production (= 40% Bgas.El.prod + 40% Bgas.Term.prod + 20% Bgas.lost)	0	:-I	* waiting data	S	BIOGAS	Agriculture and food industry	PROVINCE	2014	ARPAE-elab			
m3	Stimed m3 of CH4 produced and then burned	0	:-I	* waiting data	S	BIOGAS	Agriculture and food industry	PROVINCE	2014	ARPAE-elab			

UNIT OF MISURE	ARPAE-GIS BIOGAS C.E.CE. DIFFERENCE 2016-2015	REGIONAL	REGIONAL TREND	COMMENT (regional referred)	TYPE OF INDICATOR	SECTOR	OTHER INTERESTED SECTORS	SPATIAL SCALE	TIME COVERAGE	SOURCE	THEME	TREND	RESULT
%	Land use: TPAB.500m - % of number of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	1,6%	:-(	The number of biogas plants C.E.CE. (supplied from energy crops and cows and pigs manure&slurry) located within or near 500m from protected/importasnt ecological area is increased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS	ARPAE-GIS - BIOGAS.C.E.CE. Agricultural-zootechnic plants territorial situation	:-(	Respect 2015, in 2016 the percentual of the number of biogas .C.E.CE. Agricultural-zootechnic plants located near 500m or within protected areas or within 500m buffer from low quality river is increased.
%	Land use: TPAB.500m - % of electric power of C.E.CE. biogas plant located within proctected areas or within the buffer of 500m from them, respect total provincial Biogas plants	3,2%	:-(	The electric power installed of biogas plants C.E.CE. (supplied from energy crops and cows and pigs manure&slurry) located within or near 500m from protected/importasnt ecological area is increased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS			
num.	Air: number of C.E.CE. biogas plant within red air class municipality area respect the number of of biogas plants	2	:-(	The number of biogas plants C.E.CE. located within red municiplaities air class from DAL 52/2011 is increased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Fresh water: % of C.E.CE. biogas plant closer 500 m. from low/bad ecological stretch of water quality indicator of regional main rivers respect the number of biogas plants	-1,5%	:-)	The number of biogas plants C.E.CE. located near 500m from the main rivers area with low/bad ecological quality is decreased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Soil: % C.E.CE. biogas electric power installed within poor C soil respect the electric power of biogas plants	-1,6%	:-(	The percent of biogas plants C.E.CE. located on poor organic C soil (0-60 t./ha) is decreased. (*sprawling digestate enrich soil of organic C)	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS			
%	Sensitivity maps: % BGAS-C.E.CE. electric power installed within violet areas respect the electric power of biogas plants	-0,1%	:-I	The percent of electric power installed of solid biomasses plants is very lightly decreased	S	BIOGAS C.E.CE. from agriculture and cows&pigs livestocks	Agriculture	PROVINCE	2015 - 2016	ARPAE-GIS			

3.2.4. Appendix 1 : Pressure/States indicators values at provincial scale

Tabella 20- Pressures/States indicators values at provincial scale.

			BO	FC	FE	MO	PC	PR	RA	RE	RN	TOT-RER
		Number Biomass plants	31	19	40	21	22	14	15	19	4	185
		C	12	9	22	4	16	10	7	11	2	93
		AC	7	0	6	3	0	2	1	3	0	22
		A	1	0	0	0	0	0	3	0	0	4
		D	1	4	0	2	0	0	1	0	0	8
		F	0	2	0	0	0	0	0	0	1	3
		R	9	2	3	7	0	0	2	3	0	26
		other	1	2	9	5	6	2	1	2	1	29
		Total biomass electric power MW	29.039	19.189	37.815	12.086	13.861	5.47	35.614	14.53	3.266	171
		C_Mw	10.416	5.945	19.481	0.995	9.344	3.472	5.837	7.006	1.998	64
		AC_MW	6.85	0	8.991	2.598	0	1.998	0.845	1.129	0	22
		A_MW	0.999	0	0	0	0	0	27.072	0	0	28
		D_MW	2.38	0.97	0	0.21	0	0	0	0	0	4
		R_MW	0	5.25	0	0	0	0	0	0	0.998	6
		R_MW	8.394	4.964	2.35	4.273	0	0	0.861	6.3	0	27
		other_MW	0	2.06	6.993	4.01	4.517	0	0.999	0.095	0.27	19
COMPONENT	**STATE**	**BENEFITS BURDENS**	**BO**	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**TOT**
LAND USE	Total area (km2)		3702	2379	2633	2689	2588	3447	1859	2290	864	22451
LAND USE	**Total area (ha)**		**370217**	**237733**	**262454**	**268850**	**258545**	**344599**	**185885**	**229023**	**86275**	**2243582**
LAND USE	Low lands area (ha)		195439	59700	262449	140362	118312	123735	155416	115732	25669	1196813
LAND USE	High lands area (ha)		174778	178034	~~5~~	128488	140233	220864	30469	113291	60606	1046769
LAND USE	Protected areas and natural parks (ha)		28422	19000	32112	18245	5043	38516	24074	35741	8296	209449

LAND USE	Agricultural area (ha)		214106	107565	157572	157572	145194	157909	134799	129016	49168	1252901
LAND USE	% of lowlands on total area (%)		52.79%	25.11%	100.00%	52.21%	45.76%	35.91%	83.61%	50.53%	29.75%	53.34%
LAND USE	% Protected areas and natural parks on total area (%)		7.68%	7.99%	12.24%	6.79%	1.95%	11.18%	12.95%	15.61%	9.62%	9.34%
LAND USE	% of agricultural area on total area (%)		57.83%	45.25%	60.04%	58.61%	56.16%	45.82%	72.52%	56.33%	56.99%	55.84%
LAND USE	% of maize crops area on agricultural area (%)		4.30%	0.52%	22.46%	5.98%	8.75%	3.48%	4.32%	5.04%	0.37%	6.81%
AGRICULTURE	Industrial crops cultivated area (ha)	Inductrial crops total (ha)	12078	0	25621	5335	1670	1866	3088	1950	0	58996
AGRICULTURE	Cereals crops cultivated area (ha)	Cereals Total (ha)	65468	16530	96924	36810	35332	22860	34533	17850	8360	343015
AGRICULTURE	Maize crops area (ha)	Maize (ha)	9212	560	35384	9415	12700	5500	5820	6500	180	85271
AGRICULTURE	Sorghum crops area (ha)	Sorghum (ha)	10900	1980	5487	5850	493	600	4713	780	850	31653
WATER	Total km of water (km.s)		1367	756	744	846	792	1124	640	674	271	7214
WATER	Km.s of rivers with good quality water (W.Chem.1.good_km.s)		1367	737	736	762	792	1093	632	660	217	6996
WATER	Km.s of rivers with bad quality water (W.Chem.2.bad_ km.s)		0	19	8	84	0	31	8	14	54	218
WATER	good - WatQEco1		479	191	0	309	265	205	130	215	24	1817
WATER	bad - WatQEco2		172	0	46	55	118	86	36	182	84	780
WATER	low - WatQEco3		511	163	266	261	189	270	114	180	85	2039
WATER	sufficient - WatQEco4		206	403	432	220	220	563	361	97	78	2578

WATER	bad+low _WQ.ECO.23		683	163	312	317	307	356	150	361	169	2819
WATER	% Good-Qchem rivers (%)		100.00%	97.52%	98.87%	90.06%	100.00%	97.23%	98.71%	97.95%	80.23%	96.98%
WATER	% Bad-Qchem rivers (%)		0.00%	2.48%	1.13%	9.94%	0.00%	2.77%	1.29%	2.05%	19.77%	3.02%
WATER	% WQ.ECO_bad+low (%)		49.95%	21.53%	41.99%	37.45%	38.80%	31.68%	23.42%	53.67%	62.34%	39.07%
[4] SOIL	SoilCClass123_0-60_Corg_t./ha		288127	150513	154299	179255	174284	186734	144938	119781	46113	1444045
SOIL	SoilCClass4567_60-315_Corg_t./ha		76727	82609	92690	86845	76900	148783	34049	106022	4969	709593
SOIL	SoilC123%		78.97%	64.56%	62.47%	67.36%	69.38%	55.66%	80.98%	53.05%	90.27%	64.36%
SOIL	SoilC4567%		21.03%	35.44%	37.53%	32.64%	30.62%	44.34%	19.02%	46.95%	9.73%	31.63%
			BO	**FC**	**FE**	**MO**	**PC**	**PR**	**RA**	**RE**	**RN**	**TOT-RER**
AIR [5]	1_RED_Q_area_(?)		1 p 0.865 MW.el									
AIR	2_ORANGE_Q_area_(?)											
AIR	3_YELLOW_Q_area_(?)											
AIR	4_GREEN_Q_area_(?)											
AIR	Power of plants that inside RED quality air area (Num.)											
AIR	Power of plants that inside ORANGE quality air area (Num.)											
AIR	Power of plants that inside YELLOW quality air area (Num.)											

[4] In my first opinion spreading digestate enriches soil of organic Carbon, so it is good there would be biogas plant where soil is poor of organic Carbon - Classes 1+2+3 = 0-60 t. orgC / ha -.

[5] In overcoming areas and in areas at risk of exceeding identified with red, orange and yellow in the map of Zoning PM10 / NO2 attached to Resolution D.A.L. 51 of 26 July 2011, it is necessary to undertake an evaluation of the emission balance of the plant and any integrated planned actions.

AIR	Power of plants that inside GREEN quality air area (Num.)										
ENERGY	Total Thermal demand (MWh)	ARPAE2010_THERMAL.Consumption_MWh	6300052	2992978	2114835	4573082	1953849	3527679	2883179	4901419	2080396	31327469
ENERGY	Total Electric demand (MWh)	ARPAE2010_Electricity.TOTAL.Consumption_MWh	5064353	1904400	2380095	4631800	1571900	3149536	2928700	3243200	1661084	26535069
ENERGY	Residential Electric demand (MWh)	ARPAE2010_Electricity.RESIDENTIAL.Consumption_MWh	1147186	441500	440824	807100	347200	511780	473900	619500	430969	5219959
ENERGY	Agriculture Electric demand (MWh)	ARPAE2010_Electricity.AGRICULTURE.Consumption_MWh	97827	218000	85516	96200	66800	64536	161500	94900	26135	911414
ENERGY	Industrial Electric demand (MWh)	ARPAE2010_Electricity.INDUSTRY.Consumption_MWh	1952712	575800	1073176	2317900	669100	1560776	1599800	1810100	436241	11995605
ENERGY	Tertiary Electric demand (MWh)	ARPAE2010_Electricity.TERTIARY.Consumption_MWh	1866628	669100	780579	1410600	488800	1012444	693500	718700	767740	8408091
FUEL	Fuel for agriculture transport demand (MWh)	ARPAE-PAIR2014_AGRI.FUEL.Tot.C_(D+G)_MWh	390127	256111	502504	372179	407395	348795	382430	301532	88529	3049602
FUEL	CH4 Fuel total transport demand (MWh)	ARPAE2010_CH4.Transport.C_MWh	414523	139604	149654	277472	125237	198942	148390	208466	90263	1752551
ENERGY Fuel potential	CH4 Energy from Silage Maize (MWh) CH4.Energy - 9.91 MWh/m3	(MWh)									
ELECTRIC energy potential production (yield=40%)	Electricity production from Silage Maize (MWh.el) Electric yield = 40%	(MWh.el)									
ENERGY Fuel potential	CH4 Energy from Silage Sorghum	(MWh)									

	(MWh) CH4.Energy - 9.91 MWh/m3											
ELECTRIC energy potential production (yield=40%)	Electricity production from Silage Sorghum (MWh.el) Electric yield = 40%	(MWh.el)										
Agri ANIMALS	No.COWS - MUN-AgriC2010_COWS	No.COWS	33180	19450	21742	94857	79760	150122	8850	140163	9107	557231
Agri ANIMALS	No.PIGS - MUN-AgriC2010_PIGS	No.PIGS	75340	149918	46917	338238	120074	111889	58439	332168	14477	1247460
COWS-manure	13 - (t./animal/year)	(t.)	431340	252850	282646	1233141	1036880	1951586	115050	1822119	118391	7244003
COWS-slurry	10 - (t./animal/year)	(t.)	331800	194500	217420	948570	797600	1501220	88500	1401630	91070	5572310
PIGS-slurry	3 - (t./animal/year)	(t.)	226020	449754	140751	1014714	360222	335667	175317	996504	43431	3742380
ENERGY Fuel potential	CH4_cow-manure	(MWh)	106864485	62643588	70025547	305510683	256887020	483505432	28503638	451429982	29331370	1794701743
ENERGY Fuel potential	CH4_cow_slurry	(MWh)	82203450	48187375	53865805	235008218	197605400	371927255	21925875	347253833	22562593	1380539803
ENERGY Fuel potential	CH4_pig_slurry	(MWh)	22398582	44570621	13948424	100558157	35698000	33264600	17373915	98753546	4304012	370869858
ELECTRIC energy potential production (yield=40%)	MWh.el_cow-manure	(MWh.el)	42745794	25057435	28010219	122204273	102754808	193402173	11401455	180571993	11732548	717880697
ELECTRIC energy potential production (yield=40%)	MWh.el _cow_slurry	(MWh.el)	32881380	19274950	21546322	94003287	79042160	148770902	8770350	138901533	9025037	552215921
ELECTRIC energy potential production (yield=40%)	MWh.el _pig_slurry	(MWh.el)	8959433	17828249	5579370	40223263	14279200	13305840	6949566	39501419	1721605	148347943

4. THE FINAL DPSIR PLANNING JUDGMENTS (*only for region)

*Tabella 21- Final DPSIR 2016 – 2015 planning judgments about the regional biomass power plants system (*only for region).*

THEME	TREND	RESULT
GSE - Total BIOMASS plants	:-)	Respect 2015, in 2016 the total regional electric power installed with biomass power plants is increased of 4,41%
THEME	**TREND**	**RESULT**
ARPAE-GIS - Total BIOMASS plants	:-)	Respect 2015, in 2016 the number of plants is increased of 69 new localisations. RA data need a deepening and correction. The accurancy of ARPAE-GIS for biomass plants is increasing
THEME	**TREND**	**RESULT**
GSE - SOLID BIOMASSES plants	:-I	*Waiting data from GSE
THEME	**TREND**	**RESULT**
GSE - BIOGAS plants	:-I	*Waiting data from GSE
THEME	**TREND**	**RESULT**
ARPAE-GIS - SOLID BIOMASS plants territorial situation	:-)	Respect 2015, in 2016 the percentual of the number of solid biomass plants located near 500m or within protected areas and low quality rivers is decreased
THEME	**TREND**	**RESULT**
ARPAE-GIS - BIOGAS plants territorial situation	:-)	Respect 2015, in 2016 the percentual of the number of biogas plants located near 500m or within protected areas is decreased. (but is increased the number of biogas plants located low quality river).
THEME	**TREND**	**RESULT**
ARPAE-GIS - BIOGAS.C.E.CE. Agricultural-zootechnic plants territorial situation	:-(	Respect 2015, in 2016 the percentual of the number of biogas .C.E.CE. Agricultural-zootechnic plants located near 500m or within protected areas or within 500m buffer from low quality river is increased.

4.1. RESPONSES

Figura 14- Responses reference for the DPSIR model.

4.1.1. Plans and programs until 2015

*Tabella 22- Plans and programs until 2015 (*see chapter 3 of part 2 of this research to read better them).*

	TERRITORIAL LEVEL *planes and programs previous untill 2015	PLANS AND PRORGRAMS (p/p)	AXES of p/p	ACTIONS AND MISURES of axes of p/p	FINANCED ACTIVITIES
BIOMASS POWER PLANTS	UE	HORIZON 2020	/	/	/
	REGIONAL	PER 2011-2013 Regional Energetic Plan (PTA Technical Actuative Plan)	Axle 3 - Development and energetic qualification of agricolture sector	Action 3.1 - Supporting to the production of agro-energy	A) Investments for the energy production from renewable sources, included those finalized to biomass production B) Incentives for innovative systems of biomass combustion with the minimum environmental impact
				Action 3.2 - Supporting to projects of energy qualification for agro-farm	A) Diversifications in not agricultural activties B) Realization of intervents for the construction of plants that are turned to the production and distribution of bioenergies C) Regional Plan for the development of agro-energies
			Axle 6 - Regulamentation of the agricultural sector	Action 6.3 - Discipline for the geographic localisation of plants fueled with renewable sources	Elaboration and indication of areas and sites that are not idoneus for the installation of plants fueled by renewable sources
	REGIONAL	PRSR 2007-2013 Agricultural development plan	Axle 1 – Improvement of the competity of the agro-forestal sector	Action 2 - Misure 121 - Modernisation of farms	The misure consist in a support to the farms throught the financing of material and/or immatirial investments, that be: - destinated to improve the global return of the farm; - conform to the comunitary norms that are applicable to the investment definited; -finalized to increase the competitivity of the farm, with particular regard to the businness needs of technology innovation; - referred to the productive chains that are identified in the axle strategies.
			Axle 3 - Quality of life in rural areas and diversification of rural economy	Misure 311 - Diversification in not agricultural activities	Aims: - integration of the farmer's income; - increasing of the actrattivity of the rural environment as seat of investments and residence; - realization of in interventions for the construction of plants finalized to the production and distribution of bioenergies.
	REGIONAL	PAIR2020 Integrated Plan for the Air Quality (*pubblicato nel 2013)	Section III - Misures for productive activities	Article 19 - Prescriptions and other conditions for the authorizations	Article 19 - Prescriptions and other conditions for the authorizations
				Article 20 - Balance Zero	Article 20 - Balance Zero
			Section IV - Agriculture	Article 21 - Misures of promotion for good agricoltural practices	Article 21 - Misures of promotion for good agricoltural practices
			Section V - Sustainable energy use	Article 23 - Misures of promotion for the enviornmenta sustainablity of public buildings and of the electric power plants throught the use of not emissive renewable energy sources	Article 23 - Promotion misures for the environmental sustainability of public buildings and of electric energy plant throught the use of not emitting renewable energy sources
				Article 26 - Regulatory of the combustion apparatus destinated to domestic heating	Article 26 - Regulatory of the combustion apparatus destinated to domestic heating
				Article 31 - Monitoring	Article 31 - Monitoring
	REGIONAL	POR-Fesr 2014-2020 Companies Plan	Axle 3 - Competitivity and actractivity of the productive system	Actions - All - Economic support for the companies	Actions - All - Economic support for the companies
			Axle 4 - Promotion of low carbon economy in the territories and in the productive system	Action 4.1.2 - Installation of production systems from renewable energy sources	Action 4.1.2 - Installation of production systems from renewable energy sources
				Azione 4.2.1 -Incentives finalized to the riduction of energy consumes and of greenhouse gasses	Azione 4.2.1 - Incentives finalized to the riduction of energy consumes and of greenhouse gasses

	LIVELLO TERRITORIALE (fino al 2015)	PIANI/PROGRAMMI	ASSI dei piani/programmi	AZIONI E MISURE degli Assi dei piani/programmi	ATTIVITA' FINANZIATE
IMPIANTI ENERGETICI A BIOMASSE	UE	HORIZON 2020	/	/	/
	REGIONE Emilia-Romagna	PER 2011-2013 Piano Energetico Regionale (PTA Piano Tecnico Attuativo)	Asse 3 - Sviluppo e qualificazione energetica del settore agricolo	AZIONE 3.1 - Sostegno alla produzione di agroenergie	A) Investimenti per la produzione di energia da fonti rinnovabili, inclusi quelli finalizzati alla produzione di biomasse B) Incentivi per sistemi innovativi di combustione delle biomasse a minimo impatto ambientale
				AZIONE 3.2 - Sostegno a progetti di qualificazione energetica delle imprese agricole	A) Diversificazioni in attività non agricole B) Realizzazione di interventi per la costruzione di impianti volti alla produzione e alla distribuzione di bioenergie C) Piano Regionale per lo sviluppo delle agro-energie
			Asse 6 - Regolamentazione del settore	AZIONE 6.3 - Disciplina della localizzazione degli impianti alimentati da fonti rinnovabili	Elaborazione della indicazione di aree e siti non idonei alla installazione di impianti alimentati da fonti rinnovabili
	REGIONE Emilia-Romagna	PRSR 2007-2013 Programma di Sviluppo rurale	ASSE 1 – Miglioramento della competitività del settore agricolo e forestale	AZIONE 2 - MISURA 121 - Ammodernamento delle aziende agricole	La Misura consiste in un sostegno alle imprese agricole mediante il finanziamento di investimenti materiali e/o immateriali, che siano: - destinati a migliorare il rendimento globale dell'azienda agricola; - conformi alle norme comunitarie applicabili all'investimento interessato; - finalizzati ad aumentare la competitività dell'impresa stessa, con particolare riguardo alle esigenze aziendali di innovazione tecnologica; - riferiti alle filiere identificate nelle strategie dell'Asse
			ASSE 3 - Qualità della vita nelle zone rurali e diversificazione dell'economia rurale	MISURA 311 - Diversificazione in attività non agricole	Obiettivi: -"Integrazione del reddito dell'imprenditore agricolo"; -"Accrescimento dell'attrattività dell'ambiente rurale come sede di investimenti e residenza"; -"Realizzazione di interventi per la costruzione di impianti volti alla produzione e alla distribuzione di bioenergie".
	REGIONE Emilia-Romagna	PAIR2020 Piano Aria Integrato (*pubblicato nel 2013)	SEZIONE III - MISURE IN MATERIA DI ATTIVITA' PRODUTTIVE	Articolo 19 - Prescrizioni e altre condizioni per le autorizzazioni	Articolo 19 - Prescrizioni e altre condizioni per le autorizzazioni
				Articolo 20 - Saldo zero	Articolo 20 - Saldo zero
			SEZIONE IV - AGRICOLTURA	Articolo 21 - Misure di promozione di buone pratiche agricole	Articolo 21 - Misure di promozione di buone pratiche agricole
			SEZIONE V USO SOSTENIBILE DELL'ENERGIA	Articolo 23 - Misure di promozione per la sostenibilità ambientale degli edifici pubblici e degli impianti di produzione di energia elettrica mediante l'utilizzo di fonti di energia rinnovabile non emissiva	Articolo 23 - Misure di promozione per la sostenibilità ambientale degli edifici pubblici e degli impianti di produzione di energia elettrica mediante l'utilizzo di fonti di energia rinnovabile non emissiva
				Articolo 26 - Regolamentazione degli apparecchi di combustione destinati al riscaldamento domestico	Articolo 26 - Regolamentazione degli apparecchi di combustione destinati al riscaldamento domestico
				Articolo 31 - Monitoraggio	Articolo 31 - Monitoraggio
	REGIONE Emilia-Romagna	POR-Fesr 2014-2020 Programma operativo regionale	Asse 3 - Competitività e attrattività del sistema produttivo	AZIONI - Tutte - Sostegno economico per le imprese	AZIONI - Tutte - Sostegno economico per le imprese
			Asse 4 - Promozione della low carbon economy nei territori e nel sistema produttivo	Azione 4.1.2 - Installazione di sistemi di produzione da FER da destinare all'autoconsumo ……	Azione 4.1.2 - Installazione di sistemi di produzione da FER da destinare all'autoconsumo ……
				Azione 4.2.1 : Incentivi finalizzati alla riduzione dei consumi energetici e delle emissione di gas climalteranti ……	Azione 4.2.1 : Incentivi finalizzati alla riduzione dei consumi energetici e delle emissione di gas climalteranti ……

4.1.2. Regional Energy Plan 2016-2030: technical operating plan 2017-2020

*Tabella 23- Regional Energy Plan 2016-2030: technical operating plan 2017-2020 (*see chapter 3 of part 2 of this research to read better them).*

PER - PTA 2017-2019		PER - PTA 2017-2019	
Asse 1. Sviluppo del sistema regionale della ricerca, innovazione e formazione		**Axis 1. Development of a regional system of research, innovation and training**	
	Sostegno ai laboratori di ricerca della Rete Alta Tecnologia		Support to the network of research laboratories High Technology
	Sostegno ai progetti di ricerca innovativi promossi da Enti, imprese, associazioni		Support for innovative research projects promoted by institutions, enterprises, associations
	Riordino del sistema delle qualifiche professionali		Reorganization of the system of professional qualifications
Asse 2. Sviluppo della green economy e dei green jobs		**Axis 2. Development of green economy and green jobs**	
	Azioni formative in materia di green economy		training actions in the field of green economy
	Sostegno a progetti di filiera della green economy		Support for the green economy sector projects
	Sostegno allo sviluppo di nuove imprese della green economy		Support for the development of new businesses in the green economy
	Svil.di finanza agevolata e di garanzia per green-economy		Development of subsidized finance and guarantee for green economy
	Rafforzamento dell'Osservatorio GreenER		Strengthening Observatory Greener
	Sviluppo di protocolli, intese, convenzioni con soggetti terzi		Development of protocols, agreements, conventions with third parties
Asse 3. Qualificazione delle imprese (industria, terziario e agricoltura)		**Axis 3. Qualification of companies (industry, services and agriculture)**	
	Sost.progetti efficien. en. imprese (reti locali, Energy Management, ecc.)		Support energy efficiency projects companies (local area networks, energy management, etc.).
	Qualificazione energetica e ambientale delle aree produttive		energy and environmental efficiency of productive areas
	Sostegno alla produzione di agro-energie		Support for the production of agro-energy
	Sost. progetti di qualificazione energ. di imprese agricole		Support for energ qualifying projects. of agricultural enterprises
Asse 4. Qualificazione edilizia, urbana e territoriale		**Axis 4. Qualification construction, urban and regional**	
	Qualificazione energetica dell'edilizia e del patrimonio pubblico		Energy qualification and construction of public assets
	Riqualificazione energetica urbana e territoriale		Upgrading energy urban and regional
	Sostegno a FER (autoproduzione, assetto cogenerativo)		RES support (self-production, cogeneration)
	Sviluppo di smart grid		smart grid development
	Qualificazione energetica dell'edilizia privata		private building energy qualification
	Sviluppo delle procedure di certificazione energetica degli edifici		Development of energy certification procedures for buildings
Asse 5. Sviluppo della mobilità sostenibile		**Axis 5. Development of sustainable mobility**	
	Sostegno alla realizzazione dei PUMS		Support for carrying PUMS
	Sostegno all'infomobilità		mobile information support
	Sviluppo del trasporto pubblico locale		local public transport development
	Interventi per l'interscambio modale		Interventions for modal interchange
	Promozione dell'infrastrutturazione per la mobilità ciclopedonale		dell'infrastrutturazione promotion for bicycle and pedestrian mobility
	Pianificazione integrata e banca dati indicatori di mobilità e trasporto		integrated bank and mobility indicators data and transport planning
	Sost. a misure finalizzate a diffusione di veicoli a ridotte emissioni		Support for measures aimed at dissemination of low emission vehicles
	Sostegno a misure incentivazione trasporto su ferro di merci e persone		Support for incentive measures on iron transport of goods and people
Asse 6. Regolamentazione del settore		**Axis 6. Regulation of the sector**	
	Aggiornamento della L.R. n. 26/2004		Update L.R. n. 26/2004
	Aggiornam. regol. per localizzazione impianti a FER per prod.elettrica		For update. regol. by localization systems for ERF prod.elettrica
	Attività di semplificaz. e coordinam. per la regolamentazione del settore		simplification and coordination for the regulation of the sector
	Nuova Legge Regionale sulla pianificazione territoriale ed urbanistica		New Regional Law on Territorial and Urban Planning
Asse 7. Sostegno del ruolo degli Enti locali		**Axis 7. Support the role of local authorities**	
	Sostegno a preparazione e monitoraggio dei PAES/PAESC		Support for preparation and monitoring of SEAP / PAESC
	Sostegno all'attuazione dei PAES/PAESC		Support for the implementation of the SEAP / PAESC
	Sost. a svil. di funzione energia nei Comuni e nelle Unioni di Comuni		Support svil. energy function in the municipalities and unions of municipalities
	Sost.programmaz. en. locale, Sportelli En. e Agenzie per l'energia territ.		Local support energetic programming, Doors Energy and Agencies for territorial energy
Asse 8. Informazione, comunicazione e assistenza tecnica		**Axis 8. Information, communication and technical assistance**	
	Sviluppo dello Sportello Energia regionale		Development of ATM Regional Energy
	Rapporti con le scuole e le Università		Relationships with schools and universities
	Informazione e orientamento		Information and guidance
	Gestione del Piano energetico regionale		Management of the Regional Energy Plan
	Sistema Informativo ed Osservatorio energ. regionali		Information System and Monitoring energ. regional
	Monitoraggio e valutazione degli interventi		Monitoring and evaluation of interventions

Index - part 10 -

RESULTS AND CONCLUSIONS

1. FRAMEWORK

So, at the end, we can resume in an ordered way all the conclusions we have discovered in the present research, that it was composed by the following analyzes, at provincial and regional scale:

Part 1:

- Sustainable development;
- LCA Life Cycle Analysis;
- Knowledge of the different biomass power plants types;
- Knowledge of the main aspects and limits for biomass plants authorization;
- Preliminary considerations about the different biomass plants systems;
- Socio-economic considerations about the different biomass plants systems;

Part 2:

- Regional energy budgets for Emilia-Romagna region;
- Regional air emissions inventory 2010;
- Regional plans and programs regarding bio-energy production;
- Overview on economic incentives for renewable energies until 2016;

Part 3:

- Regional energy power plants GIS land registers;
- Regional biomass energy power plants GIS land register 2015+206;

Part 4:

- Environmental planning assessment methods;
- DPSIR model;
- Sensibility map method;
- Forest wood potentiality method;
- LCA environmental quantitative impacts/damage method;
- The whole DPSIR GIS LCA framework created to assess the regional biomass plants provincial/regional systems;

Part 5:

- The sensibility maps method application for biogas and solid biomass power plants;

Part 6:

- The forest wood availability GIS analysis;
- The comparison between electric+thermal and only thermal wood combustion plants;
- The forest wood and energy budgets, and the maximum sustainable wood plants system at provincial/regional scale;

Part 7:

- LCA environmental impact quantitative analysis at regional scale;
- The 11 case studies;
- The 1 MW.electric standardized created different biomass plants;
- LCA Ecoindicator’99 impact/assessment method application;
- Comparison between the 1 MW.electric standardized plants and the LCA Ecoinvent LCA database references;
- Quantitative estimation of the regional biomass plants systems in terms of LCA Ecoindicator’99 impacts and damages method;

Part 8:

- The DPSIR territorial analysis of the 4 main biomass power plants systems;
- Drivers data: energy demand, agriculture or industries byproducts;
- Pressures data: biomass power plants GIS land registers 2015+2016;
- States GIS data: GIS layers;
- Pressure/States indicators;
- Pressure/States indicators environmental judgments;
- Responses: plans and programs;

Part 9:

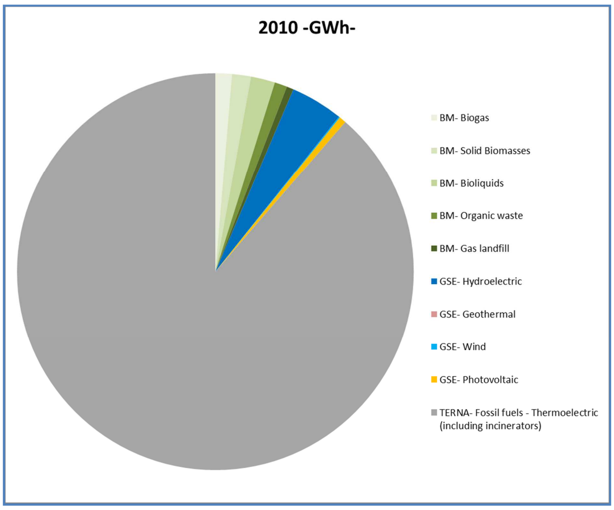
- Final planning conclusions.

2. REGIONAL ENERGY BUDGETS (2010-2014)

From the data showed in part 2, we can see that in 2014 the total regional energy production coming from renewable sources goes over the 20% requested by 2020 European Plan.
In particular the regional electric energy production from biogas is 6,55%, from solid biomass (mainly wood) is 4,36% , and from bioliquid plants is 3,29%, that in total represent the 14,2%.

Tabella 1- Electric energy production in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

Produzione elettrica	Electric Production	2010 -GWh-	2010 - %	2014 -GWh-	2014 - %
BM- Biogas	BM- Biogas	360.1	1.34%	1272.3	6.55%
BM- Biomasse solide	BM- Solid Biomasses	415.4	1.54%	847.4	4.36%
BM- Bioliquidi	BM- Bioliquids	530	1.97%	639.3	3.29%
BM- Rifiuti organici	BM- Organic waste	274.7	1.02%	0	0.00%
BM- Biogas da discarica	BM- Gas landfill	152.9	0.57%	0	0.00%
GSE- Idroelettrico	GSE- Hydroelectric	1150.2	4.27%	1277.1	6.58%
GSE- Geothermico	GSE- Geothermal	0	0.00%	0	0.00%
GSE- Eolico	GSE- Wind	24.7	0.09%	27.2	0.14%
GSE- Fotovoltaico	GSE- Photovoltaic	153.1	0.57%	2093.1	10.78%
TERNA- Termoelectric Combustibili Fossili (*incluso i termovalorizzatori)	TERNA- Fossil fuels - Thermoelectric (*including incinerators)	23855.5	88.63%	13264.1	68.30%
TOTALE	TOTAL	26917	100.00%	19421	100.00%



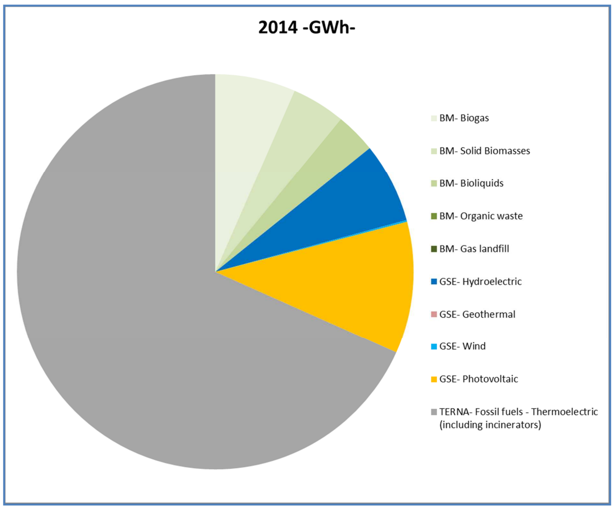


Figura 1- Electric energy production in the Emilia-Romagna region - GSE/TERNA data - years 2010 and 2014

3. REGIONAL AGRICULTURAL AIR EMISSIONS INVENTORY 2010

- Source: Arpae-Inemar-2010 -

Looking the data of ARPA-INEMAR regional air emission inventory 2010, we see that the great importance of quantities emitted from the agricultural sector (violet colour), in particular for NH3 (96%), CH4 (38%) and N2O (75%).

- NH3 emission derive from fertilizers spreading, but also from the manure and slurry of livestock. For this reason it is very important treat the latters with anaerobic digestion to decrease their NH3 content.
- We can also say the same thing about the agricultural N2O emission that represent the 75% of his total regional emission.
- The same reasoning it can be done for the CH4: a lot of CH4 emission derive from digestion of livestock, but also in a significante part they derive also from the fermentation of all agricultural and/or organic waste and byproducts. So it is very important that the CH4 which would be freed open natural fermentation process could be done and collected inside the biogas plants, so to can be burnt (CH4 has a GWP = 24 , while CO2 has a GWP = 1).

Tabella 2- Regional emission inventory summary 2010 of Emilia-Romagna

	CO		COV		NOx		SO_2		PM_{10}		NH_3		CH_4		CO_2		N_2O	
	tonn	%	tonn	%	tonn	%	tonn	%	tonn	%	tonn	%	tonn	%	ktonn	%	tonn	%
M 1: Combustione - Energia	6.003	3	1.534	2	9.482	9	430	2	86	1	0	0	4.135	2	9.956	25	79	1
M 2: Combustione - non industriale	83.256	47	28.309	29	8.729	8	1.194	7	5.395	40	154	0	5.479	3	10.093	26	956	11
M 3: Combustione - industria	4.501	3	1.770	2	12.207	11	9.773	56	993	7	0	0	358	0	6.468	17	391	4
M 4: Processi produttivi	8.333	5	7.645	8	3.077	3	4.540	26	617	5	1.106	2	868	1	3.920	10	30	0
M 5: Estraz. Distribuz. combustibili fossili	0	0	5.187	5	0	0	0	0	0	0	0	0	40.319	24	0	0		0
M 6: Uso solventi	0	0	39.883	40	15	0	2	0	4	0	1	0	0	0	0	0		0
M 7: Trasporti stradali	68.266	39	12.498	13	60.675	57	371	2	4.593	34	832	2	1.138	1	12.697	32	356	4
M 8: Altre sorgenti mobili	6.231	4	2.055	2	11.300	11	1.005	6	1.524	11	2	0	48	0	934	2	306	3
M 9: Trattamento e smaltimento rifiuti	255	0	62	0	622	1	183	1	6	0	128	0	53.351	31	550	1	156	2
M 10: Agricoltura	0	0	59	0	637	1	0	0	418	3	49.299	96	63.680	38	0	0	6.785	75
M 11: Altre sorgenti di emissione ed assorbimenti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-5.455	-14	0	0
Totale	176.846	100	99.002	100	106.745	100	17.499	100	13.637	100	51.522	100	169.377	100	39.163	100	9.059	100

4. REGIONAL PLANS AND PROGRAMS

In this research we have only schematized the old and new regional plans and programs that can influence the energy production from biomasses. Until now the Region doesn't actuate the monitoring of the energy and environmental effect of these plans/programs, so for the moment it is impossible analyze their effects. Our analysis is anyway helpful to have the reference framework about what Region makes and what could make.

*Tabella 2- Plans and programs until 2015 (*see chapter 3 of part 2 of this research to read better them).* [1234]

	TERRITORIAL LEVEL *planes and programs previous untill 2015	PLANS AND PRORGRAMS (p/p)	AXES of p/p	ACTIONS AND MISURES of axes of p/p	FINANCED ACTIVITIES
BIOMASS POWER PLANTS	UE	HORIZON 2020	/	/	/
	REGIONAL	PER 2011-2013 Regional Energetic Plan (PTA Technical Actuative Plan)	Axle 3 - Development and energetic qualification of agricolture sector	Action 3.1 - Supporting to the production of agro-energy	A) Investments for the energy production from renewable sources, included those finalized to biomass production B) Incentives for innovative systems of biomass combustion with the minimum environmental impact
				Action 3.2 - Supporting to projects of energy qualification for agro-farm	A) Diversifications in not agricultural activties B) Realization of intervents for the construction of plants that are turned to the production and distribution of bioenergies C) Regional Plan for the development of agro-energies
			Axle 6 - Regulamentation of the agricultural sector	Action 6.3 - Discipline for the geographic localisation of plants fueled with renewable sources	Elaboration and indication of areas and sites that are not idoneus for the installation of plants fueled by renewable sources
	REGIONAL	PRSR 2007-2013 Agricultural development plan	Axle 1 – Emprovement of the competity of the agro-forestal sector	Action 2 - Misure 121 - Modernisation of farms	The misure consist in a support to the farms throught the financing of material and/or immatirial investments, that be: - destinated to improve the global return of the farm; - conform to the comunitary norms that are applicable to the investment definited; -finalized to increase the competitivity of the farm, with particular regard to the businness needs of technology innovation; - referred to the productive chains that are identified in the axle strategies.
			Axle 3 - Quality of life in rural areas and diversification of rural economy	Misure 311 - Diversification in not agricultural activities	Aims: - integration of the farmer's income; - increasing of the actrattivity of the rural environment as seat of investments and residence; - realization of in interventions for the construction of plants finalized to the production and distribution of bioenergies.
	REGIONAL	PAIR2020 Integrated Plan for the Air Quality (*pubblicato nel 2013)	Section III - Misures for productive activities	Article 19 - Prescriptions and other conditions for the authorizations	Article 19 - Prescriptions and other conditions for the authorizations
				Article 20 - Balance Zero	Article 20 - Balance Zero
			Section IV - Agriculture	Article 21 - Misures of promotion for good agricoltural practices	Article 21 - Misures of promotion for good agricoltural practices
			Section V - Sustainable energy use	Article 23 - Misures of promotion for the enviornmenta sustainablity of public buildings and of the electric power plants throught the use of not emissive renewable energy sources	Article 23 - Promotion misures for the environmental sustainability of public buildings and of electric energy plant throught the use of not emitting renewable energy sources
				Article 26 - Regulatory of the combustion apparatus destinated to domestic heating	Article 26 - Regulatory of the combustion apparatus destinated to domestic heating
				Article 31 - Monitoring	Article 31 - Monitoring
	REGIONAL	POR-Fesr 2014-2020 Companies Plan	Axle 3 - Competitivity and actractivity of the productive system	Actions - All - Economic support for the companies	Actions - All - Economic support for the companies
			Axle 4 - Promotion of low carbon economy in the territories and in the productive system	Action 4.1.2 - Installation of production systems from renewable energy sources	Action 4.1.2 - Installation of production systems from renewable energy sources
				Azione 4.2.1 -Incentives finalized to the riduction of energy consumes and of greenhouse gasses	Azione 4.2.1 - Incentives finalized to the riduction of energy consumes and of greenhouse gasses

	LIVELLO TERRITORIALE (fino al 2015)	PIANI/PROGRAMMI	ASSI dei piani/programmi	AZIONI E MISURE degli Assi dei piani/programmi	ATTIVITA' FINANZIATE
IMPIANTI ENERGETICI A BIOMASSE	UE	HORIZON 2020	/	/	/
	REGIONE Emilia-Romagna	PER 2011-2013 Piano Energetico Regionale (PTA Piano Tecnico Attuativo)	Asse 3 - Sviluppo e qualificazione energetica del settore agricolo	AZIONE 3.1 - Sostegno alla produzione di agroenergie	A) Investimenti per la produzione di energia da fonti rinnovabili, inclusi quelli finalizzati alla produzione di biomasse B) Incentivi per sistemi innovativi di combustione delle biomasse a minimo impatto ambientale
				AZIONE 3.2 - Sostegno a progetti di qualificazione energetica delle imprese agricole	A) Diversificazioni in attività non agricole B) Realizzazione di interventi per la costruzione di impianti volti alla produzione e alla distribuzione di bioenergie C) Piano Regionale per lo sviluppo delle agro-energie
			Asse 6 - Regolamentazione del settore	AZIONE 6.3 - Disciplina della localizzazione degli impianti alimentati da fonti rinnovabili	Elaborazione della indicazione di aree e siti non idonei alla installazione di impianti alimentati da fonti rinnovabili
	REGIONE Emilia-Romagna	PRSR 2007-2013 Programma di Sviluppo rurale	ASSE 1 – Miglioramento della competitività del settore agricolo e forestale	AZIONE 2 - MISURA 121 - Ammodernamento delle aziende agricole	La Misura consiste in un sostegno alle imprese agricole mediante il finanziamento di investimenti materiali e/o immateriali, che siano: - destinati a migliorare il rendimento globale dell'azienda agricola; - conformi alle norme comunitarie applicabili all'investimento interessato; - finalizzati ad aumentare la competitività dell'impresa stessa, con particolare riguardo alle esigenze aziendali di innovazione tecnologica; - riferiti alle filiere identificate nelle strategie dell'Asse
			ASSE 3 - Qualità della vita nelle zone rurali e diversificazione dell'economia rurale	MISURA 311 - Diversificazione in attività non agricole	Obiettivi: -"Integrazione del reddito dell'imprenditore agricolo"; -"Accrescimento dell'attrattività dell'ambiente rurale come sede di investimenti e residenza"; -"Realizzazione di interventi per la costruzione di impianti volti alla produzione e alla distribuzione di bioenergie".
	REGIONE Emilia-Romagna	PAIR2020 Piano Aria Integrato (*pubblicato nel 2013)	SEZIONE III - MISURE IN MATERIA DI ATTIVITA' PRODUTTIVE	Articolo 19 - Prescrizioni e altre condizioni per le autorizzazioni	Articolo 19 - Prescrizioni e altre condizioni per le autorizzazioni
				Articolo 20 - Saldo zero	Articolo 20 - Saldo zero
			SEZIONE IV - AGRICOLTURA	Articolo 21 - Misure di promozione di buone pratiche agricole	Articolo 21 - Misure di promozione di buone pratiche agricole
			SEZIONE V USO SOSTENIBILE DELL'ENERGIA	Articolo 23 - Misure di promozione per la sostenibilità ambientale degli edifici pubblici e degli impianti di produzione di energia elettrica mediante l'utilizzo di fonti di energia rinnovabile non emissiva	Articolo 23 - Misure di promozione per la sostenibilità ambientale degli edifici pubblici e degli impianti di produzione di energia elettrica mediante l'utilizzo di fonti di energia rinnovabile non emissiva
				Articolo 26 - Regolamentazione degli apparecchi di combustione destinati al riscaldamento domestico	Articolo 26 - Regolamentazione degli apparecchi di combustione destinati al riscaldamento domestico
				Articolo 31 - Monitoraggio	Articolo 31 - Monitoraggio
	REGIONE Emilia-Romagna	POR-Fesr 2014-2020 Programma operativo regionale	Asse 3 - Competitività e attrattività del sistema produttivo	AZIONI - Tutte - Sostegno economico per le imprese	AZIONI - Tutte - Sostegno economico per le imprese
			Asse 4 - Promozione della low carbon economy nei territori e nel sistema produttivo	Azione 4.1.2 - Installazione di sistemi di produzione da FER da destinare all'autoconsumo ……	Azione 4.1.2 - Installazione di sistemi di produzione da FER da destinare all'autoconsumo ……
				Azione 4.2.1 : Incentivi finalizzati alla riduzione dei consumi energetici e delle emissione di gas climalteranti ……	Azione 4.2.1 : Incentivi finalizzati alla riduzione dei consumi energetici e delle emissione di gas climalteranti ……

*Tabella 3- Regional Energy Plan 2016-2030: technical operating plan 2017-2020 (*see chapter 3 of part 2 of this research to read better them).* [5]

PER - PTA 2017-2019		PER - PTA 2017-2019	
Asse 1. Sviluppo del sistema regionale della ricerca, innovazione e formazione		Axis 1. Development of a regional system of research, innovation and training	
	Sostegno ai laboratori di ricerca della Rete Alta Tecnologia		Support to the network of research laboratories High Technology
	Sostegno ai progetti di ricerca innovativi promossi da Enti, imprese, associazioni		Support for innovative research projects promoted by institutions, enterprises, associations
	Riordino del sistema delle qualifiche professionali		Reorganization of the system of professional qualifications
Asse 2. Sviluppo della green economy e dei green jobs		Axis 2. Development of green economy and green jobs	
	Azioni formative in materia di green economy		training actions in the field of green economy
	Sostegno a progetti di filiera della green economy		Support for the green economy sector projects
	Sostegno allo sviluppo di nuove imprese della green economy		Support for the development of new businesses in the green economy
	Svil di finanza agevolata e di garanzia per green-economy		Development of subsidized finance and guarantee for green economy
	Rafforzamento dell'Osservatorio GreenER		Strengthening Observatory Greener
	Sviluppo di protocolli, intese, convenzioni con soggetti terzi		Development of protocols, agreements, conventions with third parties
Asse 3. Qualificazione delle imprese (industria, terziario e agricoltura)		Axis 3. Qualification of companies (industry, services and agriculture)	
	Sost. progetti efficien. en. imprese (reti locali, Energy Management, ecc.)		Support energy efficiency projects companies (local area networks, energy management, etc.)
	Qualificazione energetica e ambientale delle aree produttive		energy and environmental efficiency of productive areas
	Sostegno alla produzione di agro-energie		Support for the production of agro-energy
	Sost. progetti di qualificazione energ. di imprese agricole		Support for energ qualifying projects. of agricultural enterprises
Asse 4. Qualificazione edilizia, urbana e territoriale		Axis 4. Qualification construction, urban and regional	
	Qualificazione energetica dell'edilizia e del patrimonio pubblico		Energy qualification and construction of public assets
	Riqualificazione energetica urbana e territoriale		Upgrading energy urban and regional
	Sostegno a FER (autoproduzione, assetto cogenerativo)		RES support (self-production, cogeneration)
	Sviluppo di smart grid		smart grid development
	Qualificazione energetica dell'edilizia privata		private building energy qualification
	Sviluppo delle procedure di certificazione energetica degli edifici		Development of energy certification procedures for buildings
Asse 5. Sviluppo della mobilità sostenibile		Axis 5. Development of sustainable mobility	
	Sostegno alla realizzazione dei PUMS		Support for carrying PUMS
	Sostegno all'infomobilità		mobile information support
	Sviluppo del trasporto pubblico locale		local public transport development
	Interventi per l'interscambio modale		Interventions for modal interchange
	Promozione dell'infrastrutturazione per la mobilità ciclopedonale		dell'infrastrutturazione promotion for bicycle and pedestrian mobility
	Pianificazione integrata e banca dati indicatori di mobilità e trasporto		integrated bank and mobility indicators data and transport planning
	Sost. a misure finalizzate a diffusione di veicoli a ridotte emissioni		Support for measures aimed at dissemination of low emission vehicles
	Sostegno a misure incentivazione trasporto su ferro di merci e persone		Support for incentive measures on iron transport of goods and people
Asse 6. Regolamentazione del settore		Axis 6. Regulation of the sector	
	Aggiornamento della L.R. n. 26/2004		Update L.R. n. 26/2004
	Aggiornam. regol. per localizzazione impianti a FER per prod elettrica		For update. regol. by localization systems for ERF prod elettrica
	Attività di semplificaz. e coordinam. per la regolamentazione del settore		simplification and coordination for the regulation of the sector
	Nuova Legge Regionale sulla pianificazione territoriale ed urbanistica		New Regional Law on Territorial and Urban Planning
Asse 7. Sostegno del ruolo degli Enti locali		Axis 7. Support the role of local authorities	
	Sostegno a preparazione e monitoraggio dei PAES/PAESC		Support for preparation and monitoring of SEAP / PAESC
	Sostegno all'attuazione dei PAES/PAESC		Support for the implementation of the SEAP / PAESC
	Sost. a svil. di funzione energia nei Comuni e nelle Unioni di Comuni		Support svil. energy function in the municipalities and unions of municipalities
	Sost programmaz. en. locale. Sportelli En. e Agenzie per l'energia terr.		Local support energetic programming, Doors Energy and Agencies for territorial energy
Asse 8. Informazione, comunicazione e assistenza tecnica		Axis 8. Information, communication and technical assistance	
	Sviluppo dello Sportello Energia regionale		Development of ATM Regional Energy
	Rapporti con le scuole e le Università		Relationships with schools and universities
	Informazione e orientamento		Information and guidance
	Gestione del Piano energetico regionale		Management of the Regional Energy Plan
	Sistema Informativo ed Osservatorio energ. regionali		Information System and Monitoring energ. regional
	Monitoraggio e valutazione degli interventi		Monitoring and evaluation of interventions

1 PER 2011-2013: Regional Energetic Plan (PTA Technical Actuative Plan);
2 PRSR 2007-2013: Agricultural development plan;
3 PAIR 2020: Integrated Plan for the Air Quality (*published inl 2013);
4 POR-FESR 2014-2020: Regional actuative program for productive activities;
5 PER 2016-2030: Regional Energy Plan of Emilia-Romagna: 2016-2030 + Triennial Implementation Plan 2017-2019.

5. REGIONAL BIOMASS POWER PLANTS GIS LAND REGISTERS 2015+2016

The biomass power plants system of Emilia-Romagna region can be described by the following figures and tables. (https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031).

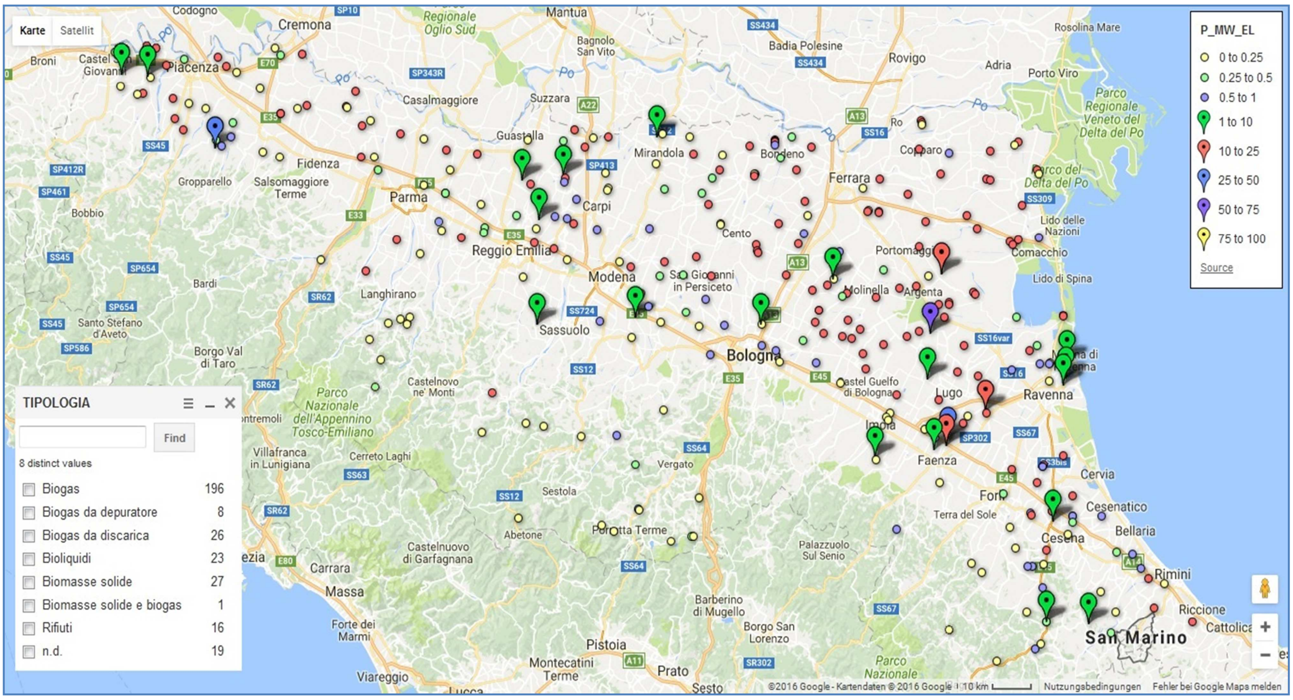


Figura 3- Biomasses power plants GIS land register - 2016 -: total.

Tabella 4- Number of biomass plants GIS land register per type and Provinces. (2015 + 2016).

		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2015 -Number of plants-	C	12	2	20	3	13	6	6	8	3	73
	AC	6	0	6	3	0	2	1	3	0	21
	A	1	0	0	0	0	0	2	0	0	3
	D	1	4	0	2	0	0	1	0	0	8
	F	0	4	2	1	3	4	1	3	0	18
	R	9	2	3	7	0	0	2	3	0	26
	Other	1	1	8	4	5	1	0	0	1	21
	Tot Biogas plants	30	13	39	20	21	13	13	17	4	170
SOLID BIOMASS 2015 -Number of plants-	L	13	6	3	4	3	1	5	0	2	37
TOTAL BIOMASS PLANTS 2015 -Number of plants-	TOTAL	43	19	42	24	24	14	18	17	6	207
		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2016 -Number of plants-	C	19	8	24	10	18	16	12	12	2	121
	AC	14	1	8	4	1	5	4	4	0	41
	A	1	0	0	0	0	0	4	0	0	5
	D	1	4	0	2	0	0	1	0	0	8
	F	0	1	1	1	0	0	1	0	1	5
	R	9	2	3	7	0	0	2	3	0	26
	Other	2	1	8	5	6	2	0	4	1	29
	Tot Biogas plants	46	17	44	29	25	23	24	23	4	235
SOLID BIOMASS 2016 -Number of plants-	L	13	6	4	4	3	2	5	1	2	40
TOTAL BIOMASS PLANTS 2016 -Number of plants-	TOTAL	59	23	48	33	28	25	29	24	6	275

Tabella 5- Electric power of biomass plants GIS land register per type and Provinces. (2015 + 2016).

		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2015 - Electric power (MW.el)-	C_MW.el	7,484	0	8,991	1,298	0	1,998	27,917	1,129	0	48,817
	AC_MW.el	10,416	0,79	18,232	2,175	8,889	3,352	5,242	6,299	1,998	57,393
	A_MW.el	2,38	0,97	0	0,21	0	0	0	0	0	3,56
	D_MW.el	0	0	0	0	0	0	0,999	0	0	0,999
	F_MW.el	0	2,469	1,249	0,12	0,455	0,12	0	0,707	0,998	6,118
	R_MW.el	0	0	5,994	4,01	3,519	0	0	0	0,27	13,793
	Other_MW.el	8,394	4,964	2,35	4,273	0	0	0,861	6,3	0	27,142
	Total_MW.el	28,674	9,193	36,816	12,086	12,863	5,47	35,019	14,435	3,266	157,822
SOLID BIOMASS 2015 - Electric power (MW.el)-	L	1,13	3,264	27,199	0,5	1,859	0	72,728	0	0	106,68
TOTAL BIOMASS PLANTS 2015 -Electric power (MW.el)-	TOTAL	29,804	12,457	64,015	12,586	14,722	5,47	107,747	14,435	3,266	264,502
		BO	FC	FE	MO	PC	PR	RA	RE	RN	REGIONAL
BIOGAS 2016 - Electric power (MW.el)-	C_MW.el	11,436	0,19	7,243	1,299	0	2,318	10,305	2,128	0	34,919
	AC_MW.el	16,506	1,789	20,28	6,276	8,574	5,705	11,259	6,307	1,998	78,694
	A_MW.el	2,38	0,97	0	0,21	0	0	0	0	0	3,56
	D_MW.el	0	0,63	0	0	0	0	0	0	0	0,63
	F_MW.el	0,31	1,219	2,248	0,369	0,7	0,2	0,999	1,05	0,999	8,094
	R_MW.el	0,999	0	5,994	1,585	3,562	0,299	0	3,296	0,27	16,005
	Other_MW.el	4,649	3,46	1,75	3,819	0	0	0,86	5,599	0	20,137
	Total_MW.el	36,28	8,258	37,515	13,558	12,836	8,522	23,423	18,38	3,267	162,039
SOLID BIOMASS 2016 - Electric power (MW.el)-	L	1,13	3,269	13,1	0,5	1,86	0	63,6	0,5	0	83,959
TOTAL BIOMASS PLANTS 2016 -Electric power (MW.el)-	TOTAL	37,41	11,527	50,615	14,058	14,696	8,522	87,023	18,88	3,267	245,998

6. TERRITORIAL SENSIBILITY MAPS

Creating the regional environmental sensibility maps for wood biomass and biogas plants, now we are able to know what are the plants that are located in territories where they should not have been built for environmental and administrative reasons. Even if our maps has no values of law but only of a summary of latter, and for this each single plant project has be singularly specifically analyzed, now, consulting the sensibility maps, both the authorization authorities than the proponents have an important additional tool for their insights about, like also the monitoring authorities that will be able to detect the plants that are located in particularly sensitive territories not adapted to these kind of power plants. (https://www.arpae.it/dettaglio_generale.asp?id=3778&idlivello=2031).

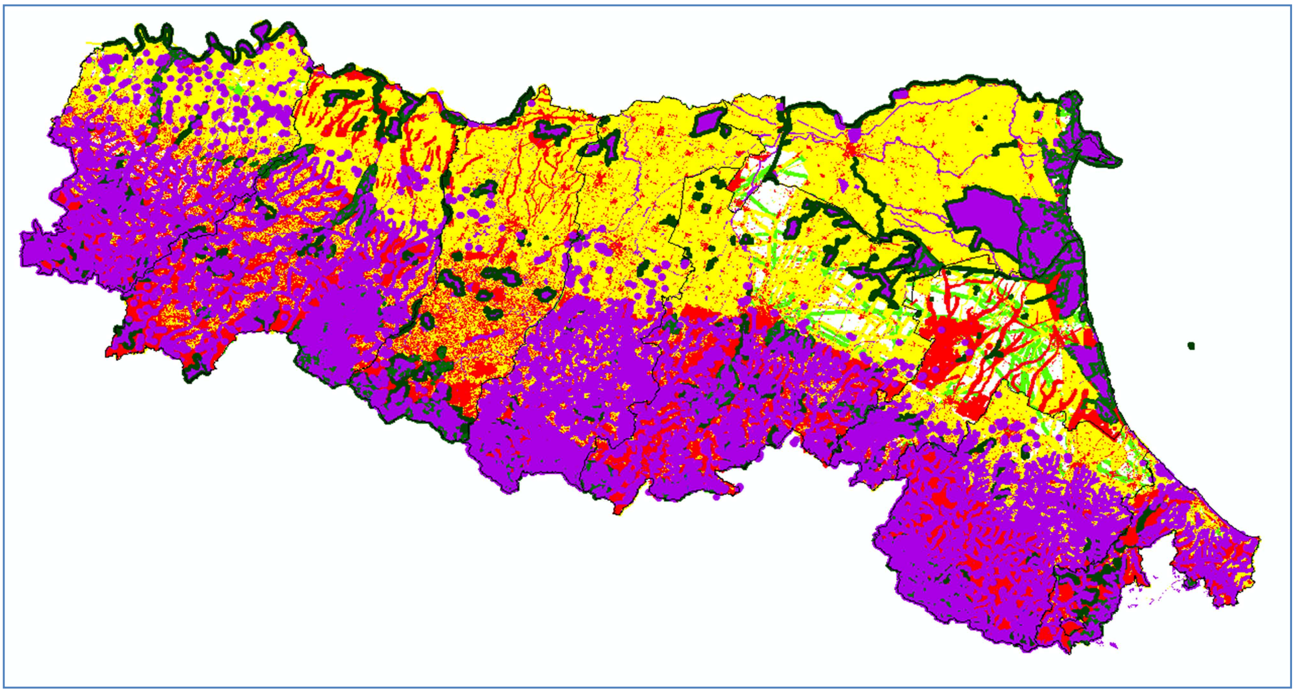


Figura 4- Regional map of the environmental sensibility for SOLID COMBUSTION biomass plants.

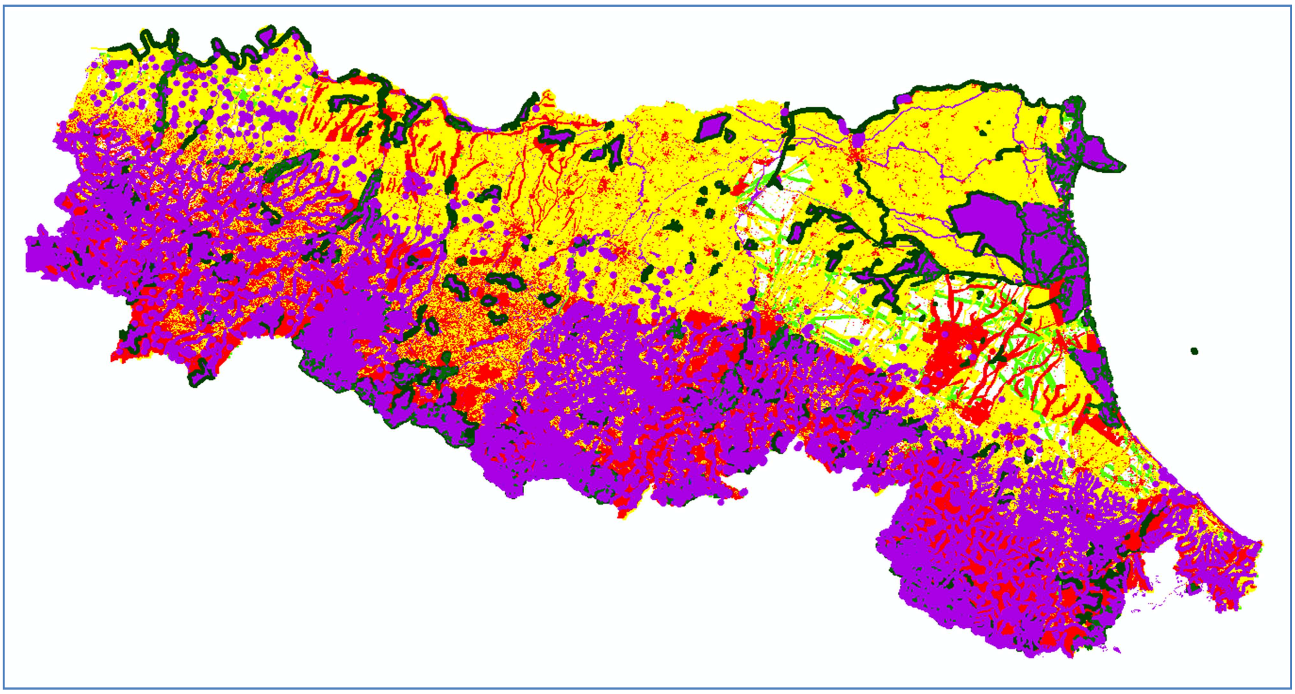


Figura 5- Regional map of the environmental sensibility for BIOGAS plants.

7. FOREST WOOD SUSTAINABLE ENERGY POTENTIALITY AND BUDGETS

1. The Emilia-Romagna Region estimates that 70% of wood harvested by forest is sold and used as a fire in traditional fireplaces and stoves, while only 30% is potentially available for sale to wood combustion plants. [Informal datum, [RER.SAPFSM, 2015, b].
2. The firewood market for fireplaces and domestic stoves (including commercial pizza ovens such as pizzerias, etc.) allows the sale of the product in knots at prices around 10 to 17 euros / quintal (average = 13,5 euro / q.le);
   The wood market for biomass combustion power plants, on the other hand, allows the sale of wood harvested at prices around 2 to 3 euros/quintal (average = 2.5 euros / q.le). [Informal datum, [RER.SAPFSM, 2015, b], while the Borgo Val di Taro hospital in the province of Parma burns wood pulp from 60 to 85 euros / ton. (Average = 7.25 euro / q.le) [RER.DG Agriculture, 2016,a].
3. The domestic heating implemented using fireplaces / domestic stoves, if one part is characterized by a low energy efficiency and a considerable emission of particulate matter and pollutants, on the other hand allows the personalized management of combustion for periods of time segmented (eg. 10 hours on 24), while the management of the combustion of a biomass energy plant, with the sole aim of producing only thermal energy, runs 24 hours a day for about 1500 hours / year).
4. Firewood requires significant minor workings compared to chips and / or pellets, and therefore implies far less fuel consumption of fossil fuels for pulping and / or pelletising from which less fossil CO2 emissions per unit of product.
5. Taking out a sustainable forestry forest should not only consider the rate of forest growth (average value = 4.4 mc / ha * year), but it must also take account of the fact that such levies can only be made in the forestry around 150 meters from the forest roads because over these distances the conferment to the truck would be too expensive in terms of logistics convenience.
6. Wood procurement, whatever its destination, must take into account that 50% of the regional forest areas are owned by private individuals, which may therefore pay for (or refuse) the forest exploitation of their properties; 30% of the woods in the Region are within farms; The remaining 20% of forest areas are publicly owned (14.8% state ownership and 5.2% regional ownership).

7.1.1. The regional map of useful woody forest potentiality (MRPELFU)

Thanks to the support of the Emilia-Romagna Region - Forest Protected Areas and Mountain Development [RER.SAPFSM, 2015, b.], has been elaborated and the " REGIONAL MAP OF HELPFUL WOODY FOREST POTENTIALITY " that shows all the forest, and their types, reachable by woodsmen (in the buffer of 150 m. from road and/or agricultural fields) from which derive the numerical values of forest wood (and related energy) collectable and usable, in a sustainable way, for the firewood market and to supply combustion plants of solid wood biomass.
With a total forest area of 612,600 hectares (update RER 2006) and the subsequent elimination of shrubby areas and shrubby pine forests according to SAPFSM [6] cartography updated to 2014, the Emilia-Romagna Region has 546,928 hectares of land high-wood available [7] to supply wood biomass.

[6] Protected Areas for Forestry and Mountain Office of the Emilia-Romagna Region.
[7] Although patchy forests should also be excluded from the counts of the available areas to supply timber as it is impossible to collect them systematically with the usual forest machinery, it was considered appropriate to count them equally as in the vast majority of the time the timber recovered from maintenance Repairs are given, together with agricultural and urban potato, to generic energy use.

According to the INFC-2005 [8], this forest extension consists of 72,338,122 cubic meters of wood, with an average woody increase of 2,379,879 cubic meters per year.

FOREST TYPES (updated 2014)	RER -2014- FOREST AREA (ha)	INFC 2005 Average increment (mc/year) for all regional forest	INFC 2005 Average increment (mc/ha/year) for single hectare
Boschi alti CEDUI	390.568		
Boschi alti A FUSTAIE	156.360		
TOTAL FOREST AREAS -2014-	546.928	2.379.879 mc/year	4,4 mc/year/ha
TOTAL FOREST AREAS -2014-	/	1.427.927 seasoned wood tons./year	2,64 seasoned wood tons./year/ha

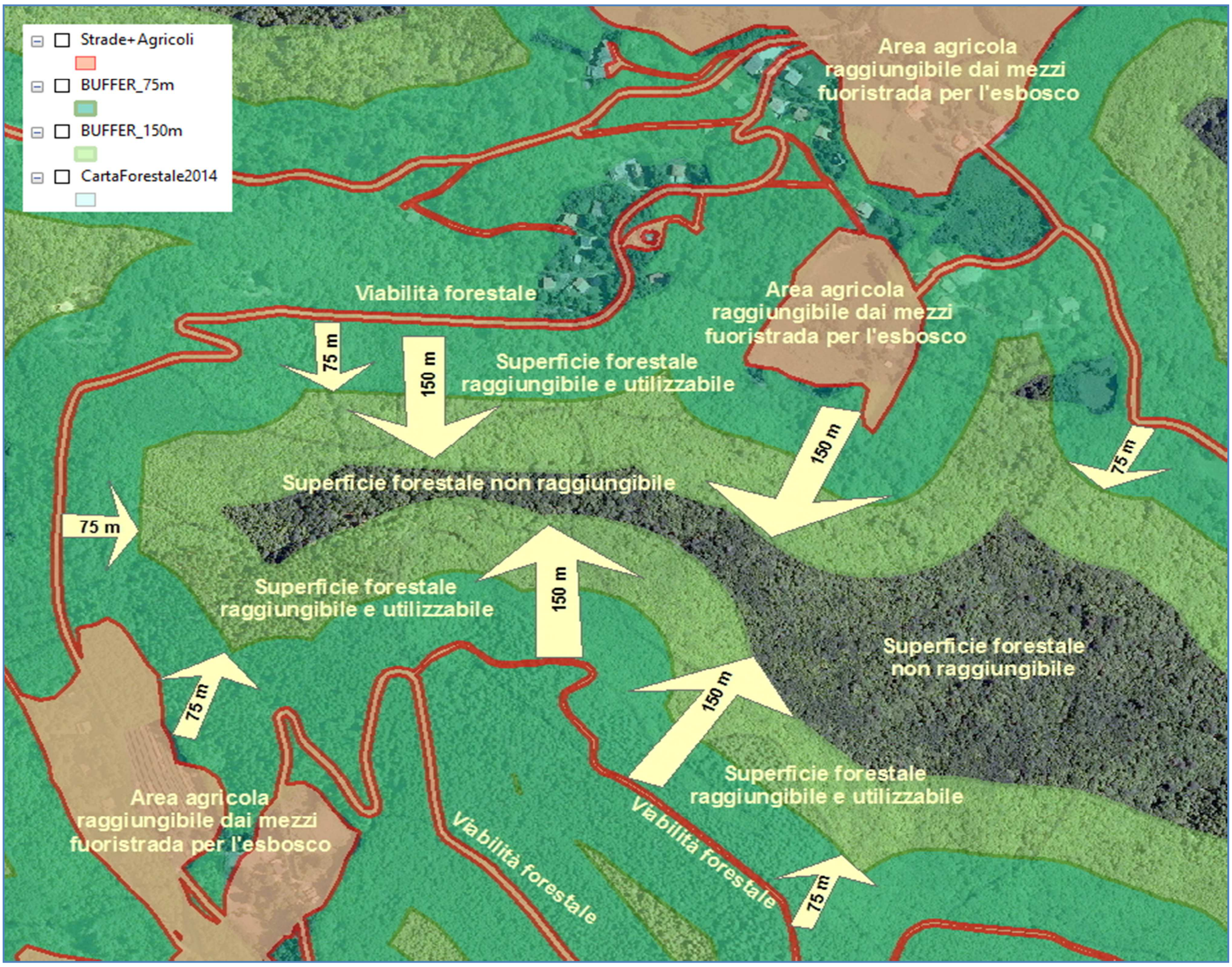


Figura 6- Particular of the regional map of useful woody forest potentiality (MRPELFU: visualization of useful areas where it is possible collect forestall wood.

[8] - 2nd National Inventory of Forests and Carbon Tanks 2005.

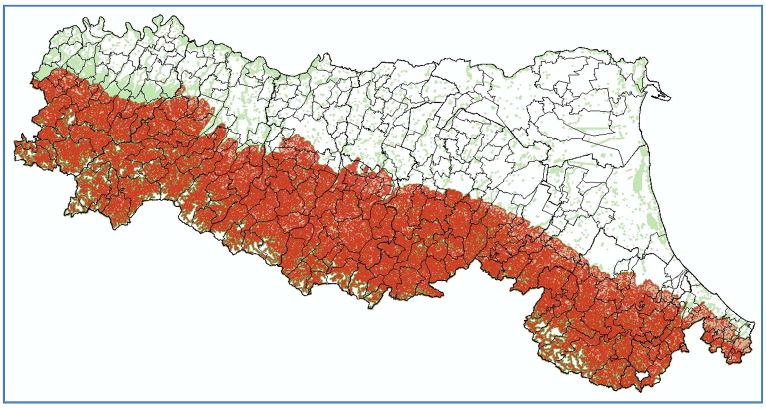


Figura 7- Visualisation at regional scale of MRPELFU map for useful areas where it is possible collect forestall wood.

7.1.2. Maximum sustainable number of energy wood plants

From the MRPELFU map we have calculated the wood availability budget that quantifies how many biomass wood power plants can be genuinely sustainably supplied by the Emilia-Romagna forests. In general in the region only the 30% of massive weight of forest wood is available for energy plants, which equates to the 23% of forest areas.
The conclusion is that the regional forest of Emilia-Romagna are able to supply 24 wood combustion plants of 1 MW.electric that needs 11000 t./year of seasoned wood, while if all wood plants would produce only thermal energy for remote heating, only for 4000 hours/year, the forest could support 75 plants per year of 2,4 MW.thermal each one.

Tabella 6- Regional forest energy wood budget that consider only the amount of wood available for energy plants

	Superficie delle formazioni a Boschi alti (ha)	Incremento volumico medio corrente (mc/anno)	Incremento volumico areale unitario medio corrente (mc/anno*ha)	Peso specifico medio della legna stagionata (ton/mc)	Tonnellate di legname stagionato (ton.)	Incremento massico medio corrente (ton/anno*ha)	Num. Impianti 1.MW ELETTRICO (11.000 ton/anno) 8.000 ore/anno	Num. Impianti 1.MW ELETTRICO (13.000 ton/anno) 8.000 ore/anno	Num. Impianti 2,4.MW TERMICO (3.500 ton/anno) [9] 4.000 ore anno
LEGNA PER IMPIANTI ENERGETICI pioppi,salici, conifere, castagno	**98.996**	**514.287**	**5,2**	**0,51**	**261.800**	**2,64**	**24**	**20**	**75**
%	**23,00%**	**29,13%**			**23,04%**				

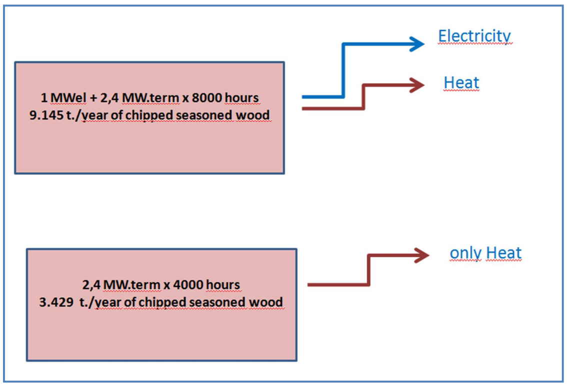


Figura 8- Conceptual scheme of the comparison

[9] For reasons of simplification, the value of 3,429 tons / year was approximated by over 3,500 tons / year..

7.1.3. Regional scale synthesis

Tabella 7- Reference synthesis at regional scale

	Superfice forestale idonea (ha)	Superfice di esbosco potenziale (150 m da viabilità)	%	Stima prelievo sostenibile (mc)	Peso specifico MEDIO della legna stagionata TOTALE (ton./mc)	Tonnellate prelievo sostenibile (ton.)	MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)
Legna totale disponibile	**546.928**	**430.379**	**100,00%**	**1.765.203**	**0,64**	**1.136.490**	**3.523.119**
Legna da ardere	**431.624**	**331.383**	**76,96%**	**1.250.916**	**0,7**	**874.690**	**2.711.539**
Legna per impianti energetici	**115.304**	**98.996**	**23,04%**	**514.287**	**0,51**	**261.800**	**811.580**
Num. Impianti 1.MW ELETTRICO (11.000 ton/anno) 8000 ore/anno	**24**						
Num. Impianti 1.MW ELETTRICO (13.000 ton/anno) 8000 ore/anno	**20**						
Num. Impianti 2,4.MW TERMICO (3.500 ton/anno) 4000 ore/anno	**75**						

7.1.4. Provincial scale synthesis

Tabella 8- Synthesis for Province of energy availability from forestall wood

	LEGNA DA ARDERE		LEGNA PER IMPIANTI ENERGETICI		NUMERO di impianti energetici equivalenti	NUMERO di impianti energetici equivalenti	NUMERO di impianti energetici equivalenti
Provincia	**Tonnellate prelievo sostenibile (ton.)**	**MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)**	**Tonnellate prelievo sostenibile (ton.)**	**MWh disponibili da Potere Calorifico MEDIO =(CA.FF.OO+Bibliografia)/2 pari a [(2,67+3,5)/2] = 3,1 kWh/kg (MWh)**	**da 1 MW ELETTRICO approvvigionabili (11.000 ton./anno) per 8.000 ore/anno**	**da 1 MW ELETTRICO approvvigionabili (13.00 ton./anno) per 8.000 ore/anno**	**da 2,4 MW TERMICI approvvigionabili (3.500 ton./anno) per 4.000 ore/anno**
Piacenza	144.868	449.090	34.372	106.552	3,1	2,6	9,8
Parma	249.353	772.993	39.758	123.248	3,6	3,1	11,4
Reggio Emilia	98.961	306.779	27.199	84.317	2,5	2,1	7,8
Modena	108.076	335.035	40.736	126.280	3,7	3,1	11,6
Bologna	118.632	367.759	47.724	147.944	4,3	3,7	13,6
Ferrara	2.864	8.880	1.338	4.146	0,1	0,1	0,4
Ravenna	16.520	51.212	17.019	52.757	1,5	1,3	4,9
Forli'-Cesena	108.942	337.721	42.808	132.705	3,9	3,3	12,2
Rimini	27.425	85.018	6.193	19.198	0,6	0,5	1,8
Totale	**874.690**	**2.711.539**	**261.800**	**811.580**	**23,8**	**20,1**	**74,8**

7.1.5. The final forest wood regional budget

If we assume that all the solid biomass energy plants would be of the wood combustion plants type, and that they would have energy yields similar at those standardized we created, where to produce 8000 MWh/year of electricity it needs 12766 tons./year of fresh wood, that is 7660 tons./year of seasoned wood, we estimate that actually:

- If all the forest wood sustainable production (HQ High Quality firewood + LQ Low Quality wood for energy plants) would be used to supply the whole actual solid biomass power plants system of 141,6 MW electric power at all (as it would be all composed by forest wood combustion plants), the whole regional forest could supply 1,048 times the actual system.
- If it would be used only LQ wood, the regional forest could supply only 0,314 forest wood combustion systems.
- In this moment we are not able to say how many plants are supplied with what kind of wood biomass. We don't know how many plants are supplied with sawdust and remains of carpentry and similar, how many are supplied with wood from arboriculture and how many from forest wood. So in reality the regional wood/energy budget we proposed is only theoretical.

7.1.1. The case of the big PWCP wood biomass plant : 30 MW.electric

- In the special case study analyzed of PWCP (the solid wood combustion plant of 30 MW.electric power authorized and actually under construction in the province of Ravenna, that should be supplied with wood coming from 8000 hectares of Populus L. arboriculture) the calculation show that if it would be supplied only with only LQ forest wood, the regional forest would be able to supply at all 1,48 plants like this one; while if it would be used both HQ+LQ forest wood, the regional forest could supply 4,95 plants like this one.
- In addition to this, we have to say that even if PWCP [10] declared that the plant will use mainly wood coming from Populus L. using 8000 hectares of fields that produce every year 62 tons./year/ha of fresh wood, in reality from the bibliography for the north Italy we found values of yield of 30 tons./year/ha until a minimum value of 6,27 tons./year/ha, which implies a cultivation areas extremely bigger, 43.202 hectares, as showed in the figure.

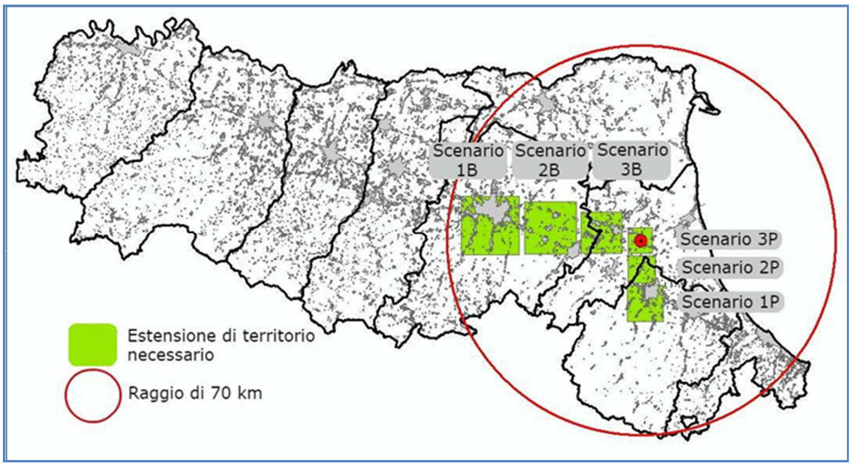


Figura 9- Visual comparison of the different areas needed to cultivate to Populus L. , from the minimum area declared by PWCP (3P = 8000 hectares) until the maximum area on the base of bibliography data (1B = 43.202 hectares).

[10] PWCP needs 270.880 tons./year of seasoned wood (492.509 tons./year of fresh wood) for a power of 30 MW.electric + 92,9.thermal, to produce 240 GWh.electricity/year.

8. THE QUANTITATIVE LCA ENVIRONMENTAL ASSESSMENT

To calculate the environmental impacts an damages categories of the different regional biomass plants systems, we did:

1. We have collected the all the main data of 12 case studies with also 3 additional scenarios for Populus L. arboriculture, about plants and their productive chains (data are available in the previous chapters).
2. We built 8 different theoretical standardized realistic biomass plants (4 biogas and 4 wood combustion) including their productive chains (data are available in the previous chapters).
3. We got the biogas and wood combustion plants reference from Switzerland (and for other main energy sources different from biomass) from Ecoinvent LCA database.
4. We implemented all in the Simapro 7.3 software and we runned all for 8000 MWh.electricity production like functional unit, using Ecoindicator’99 LCA method.
5. So, at first we have obtained the corresponded environmental impacts and damages categories and macro-categories values in terms of ecoPoints of Ecoindicator’99 LCA method.
6. After we compared their values between themselves, concluding that our 8 standardized biomass plants are acceptable and comparable with the values obtained from corresponded Ecoinvent Swiss LCA db references and with the initial 11 case studies.
7. At the end we have multiplied their related unitary impacts/damages with their regional electric power sums of the different main groups, so to obtain an LCA estimed quantitative measurement of the global regional environmental impacts and damages due to the different groups of biomass plants in terms of Ecoindicator’99 LCA method.
8. The base data of the standardized unitary plants and their obtained values can be very helpful in case of comparison with other energy systems, both at unitary level than at regional level, and also for future emission inventories.

Following the final values obtained:

Tabella 9- Classification of biomass plants analyzed with LCA Ecoindicathor’99 method .

			PRODUCTIVE CHAIN
TOTAL BIOMASS PLANTS	BIOGAS PLANTS	**C**	Energy crops and/or livestocks effluents
		AC	Agri-Food industry with part of Energy crops and/or lifestocks efflents
		A	Agri-Food industry
		D	Sewage depuration
		F	Organic urban waste
		R	Landfill
		n.d.	Unknown
	SOLID BIOMASS PLANTS	**L**	Wood combustion (assumed all like forestal wood)
		~~**O**~~	~~Organic waste combustion~~
	~~BIOLIQUIDS~~	~~**BEP**~~	~~Bioethanol production~~
		~~**BDP**~~	~~Biodiesel production~~
		~~**BPP**~~	~~Bioproducts production~~
		~~**n.d.**~~	~~Unknown~~

8.1.1. LCA unitary impacts and damages estimated for 1 MW.el power biomass type group plant

Tabella 10 - Synthesis of the IMPACT categories and DAMAGE macro.categories for 8000 MWhel production.

Ecoindicator'99 results 1 MWel. power 8000 MWhel./year		**BIOGAS**					**WOOD COMBUSTION**	
		e08 Ecoinvent Swiss biogas ref.	BG1 Standard only crops	BG2 Standard agro-zoo	BG3 Standard food industries	BG4 Standard organic waste	e07 Ecoinvent Swiss wood combustion ref.	WF3 Standard Forest wood combustion
• **IMPACTS**								
Total	**Pt**	**171841**	**102191**	**226507**	**101018**	**84612**	**34728**	**178936**
Carcinogens	Pt	663	57858	141533	64299	4565	3762	690
Resp. organics	Pt	157	97	149	63	263	2980	88
Resp. inorganics	Pt	97053	26483	50850	22378	1325	896	17555
Climate change	Pt	43843	9557	16829	6869	70	337	13001
Radiation	Pt	17	4	7	3	5	1	2
Ozone layer	Pt	5	14	14	6	2	2	5
Ecotoxicity	Pt	57	106	204	83	5851	7935	35
Acidification/ Eutrophication	Pt	9864	1610	3577	1581	18887	17319	1367
Land use	Pt	839	572	720	303	54	55	142536
Minerals	Pt	19341	5890	12622	5433	53590	1440	3659
• **DAMAGES**								
Total	**Pt**	**171841**	**102191**	**226507**	**101018**	84612	**34728**	**178936**
Human Health	Pt	141739	94013	209384	93619	456	3762	31339
Ecosystem Quality	Pt	10761	2288	4501	1966	1658	4214	143938
Resources	Pt	19341	5890	12622	5433	78389	26751	3659

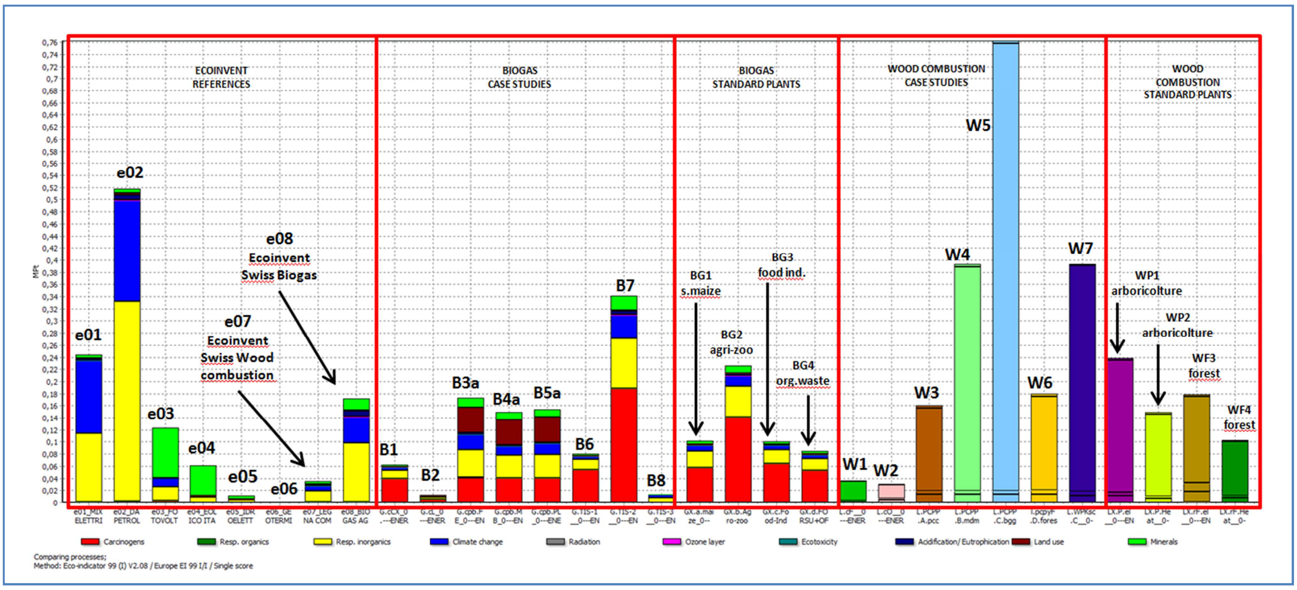


Figura 10- Functional unit: Overall results of the comparison for 8000 MWh. Electricity produced with the different energy source systems, in terms of IMPACTS categories measured with Ecoindicator'99 LCA method, internal to the general DPSIR assessment scheme adopted [11].

[11] With a so big number of subjects, the software has some limits with graph colors. In previous parts you will find graphs with right colors.

8.1.2. LCA quantitative impacts and damages values for the main electric biomass plants systems at regional scale for Emilia-Romagna region

Tabella 11- Synthesis of disaggregated types groups of biomass plants of GIS land register 2016, in terms of sum of electric power installed, at provincial and regional scal..

MW.el power	BO	FC	FE	MO	PC	PR	RA	RE	RN	Regional
Biogas only energy crops	11,85	3,92	15,29	2,00	2,87	4,00	3,87	1,00	1,00	45,78
Biogas Agri-zoo farm	4,71	3,01	6,24	3,35	7,41	1,61	7,99	6,36	1,00	41,67
Biogas Agri-food.industry	12,07	0,19	7,24	2,60	0,00	2,62	10,30	2,13	0,00	37,15
Solid wood biomass	1,13	3,27	14,10	0,50	1,86	0,00	63,60	0,50	0,00	84,96

Tabella 12 - Synthesis of IMPACT categories and DAMAGE macro.categories Ecoindicator'99 result values, in MegaPoints, of the single and summed different regional biomass power plants systems.

Ecoindicator'99 impacts/damages MPoints/year amounts		BIOGAS					WOOD COMBUSTION	
		Ecoinvent	Standardized's SUM	Standardized			Ecoinvent	Standard
		e08 Ecoinvent Swiss biogas ref.	SUM BG1+BG2+BG3	BG1 Standard only crops	BG2 Standard agro-zoo	BG3 Standard food industries	e07 Ecoinvent Swiss wood combustion ref.	WF3 Standard Forest wood combustion
Regional Biomass electric installed power	**MW el.**	**124.6**	**124.6**	**45.78**	**41.67**	**37.15**	**84.96**	**84.96**
IMPACTS								
Total	**Mpt**	**21.4**	**17.6**	**10.4**	**4.2**	**3.0**	**3.0**	**15.2**
Carcinogens	Mpt	0.1	9.3	6.5	2.7	0.2	0.3	0.1
Resp. organics	Mpt	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Resp. inorganics	Mpt	12.1	3.3	2.3	0.9	0.0	0.1	1.5
Climate change	Mpt	5.5	1.1	0.8	0.3	0.0	0.0	1.1
Radiation	Mpt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ozone layer	Mpt	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ecotoxicity	Mpt	0.0	0.2	0.0	0.0	0.2	0.7	0.0
Acidification/Eutrophication	Mpt	1.2	0.9	0.2	0.1	0.7	1.5	0.1
Land use	Mpt	0.1	0.0	0.0	0.0	0.0	0.0	12.1
Minerals	Mpt	2.4	2.8	0.6	0.2	2.0	0.1	0.3
DAMAGES								
Total	**Mpt**	**21.4**	**12.7**	**10.4**	**4.2**	**3.1**	**3.0**	**15.2**
Human Health	Mpt	17.7	13.5	9.6	3.9	0.0	0.3	2.7
Ecosystem Quality	Mpt	1.3	0.3	0.2	0.1	0.1	0.4	12.2
Resources	Mpt	2.4	3.7	0.6	0.2	2.9	2.3	0.3

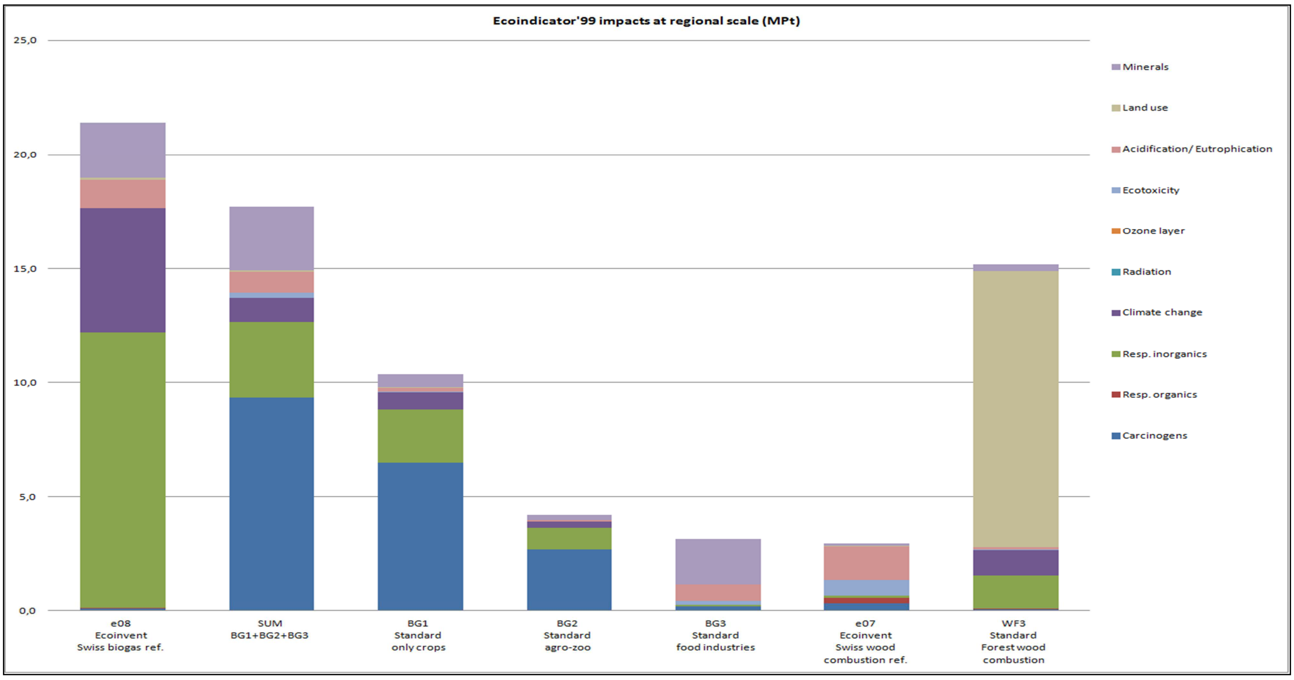


Figura 11 - Synthesis of impact categories Ecoindicator’99 result values, in MegaPoints, of the single and summed different regional biomass power plants systems.

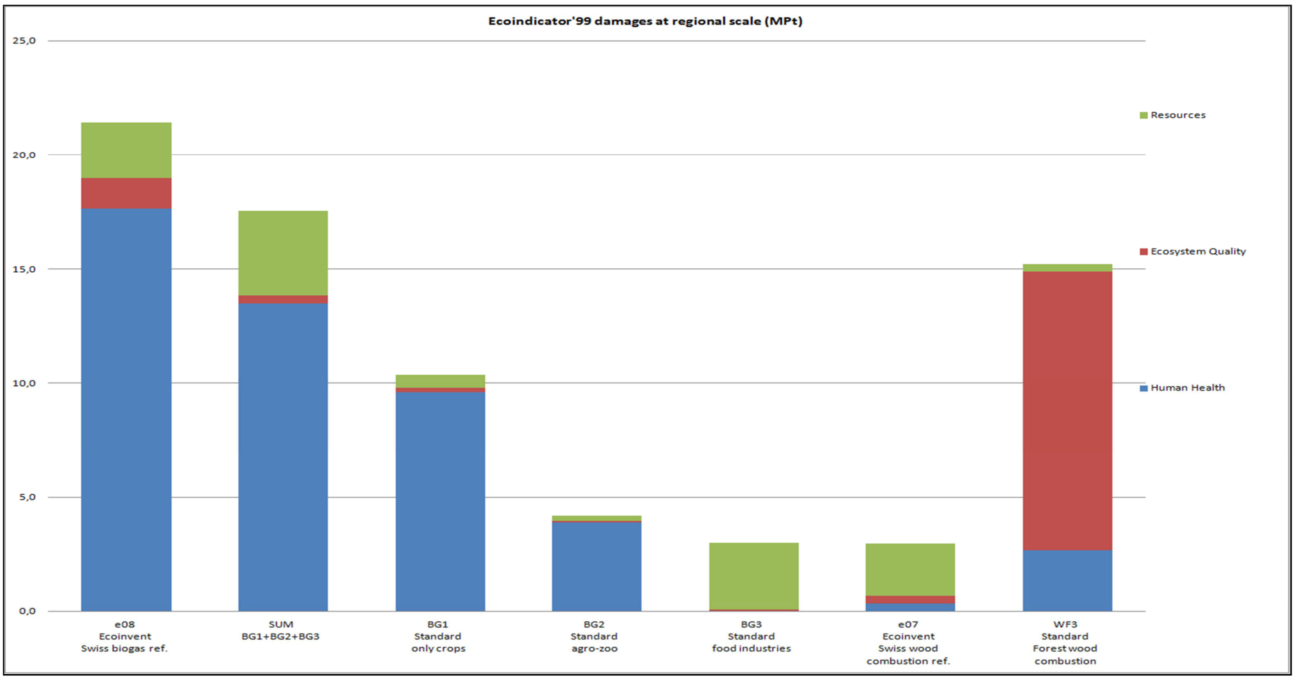


Figura 12 - Synthesis of damage macro.categories Ecoindicator’99 result values, in MegaPoints, of the single and summed different regional biomass power plants systems.

9. THE BIOMASS DPSIR MODEL

9.1.1. The biomass DPSIR model

To be able to assess, and monitor over time, overall environmental situation and impacts, benefits and burdens related to the development of the biomass plants system/s in a given area, through a DPSIR model, we can start from the situation showed on the following figure and then imagine to have to compile the remaining part of the lists that complete the DPSIR voices. While a significant amount of data have been calculated in the previous chapters, other significant data are here presented for first time.

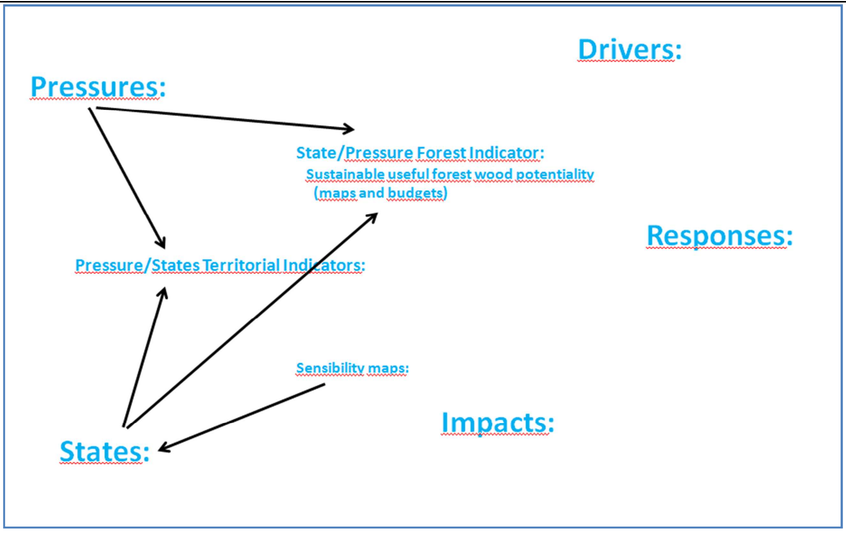


Figura 13- DPSIR conceptual scheme.

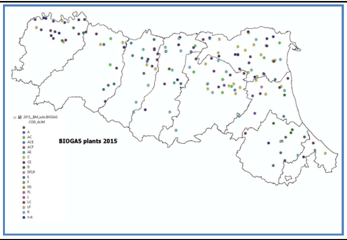


Figura 14- Biomass plants 2015

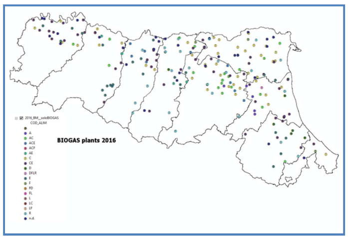


Figura 15- Biomass plants 2016

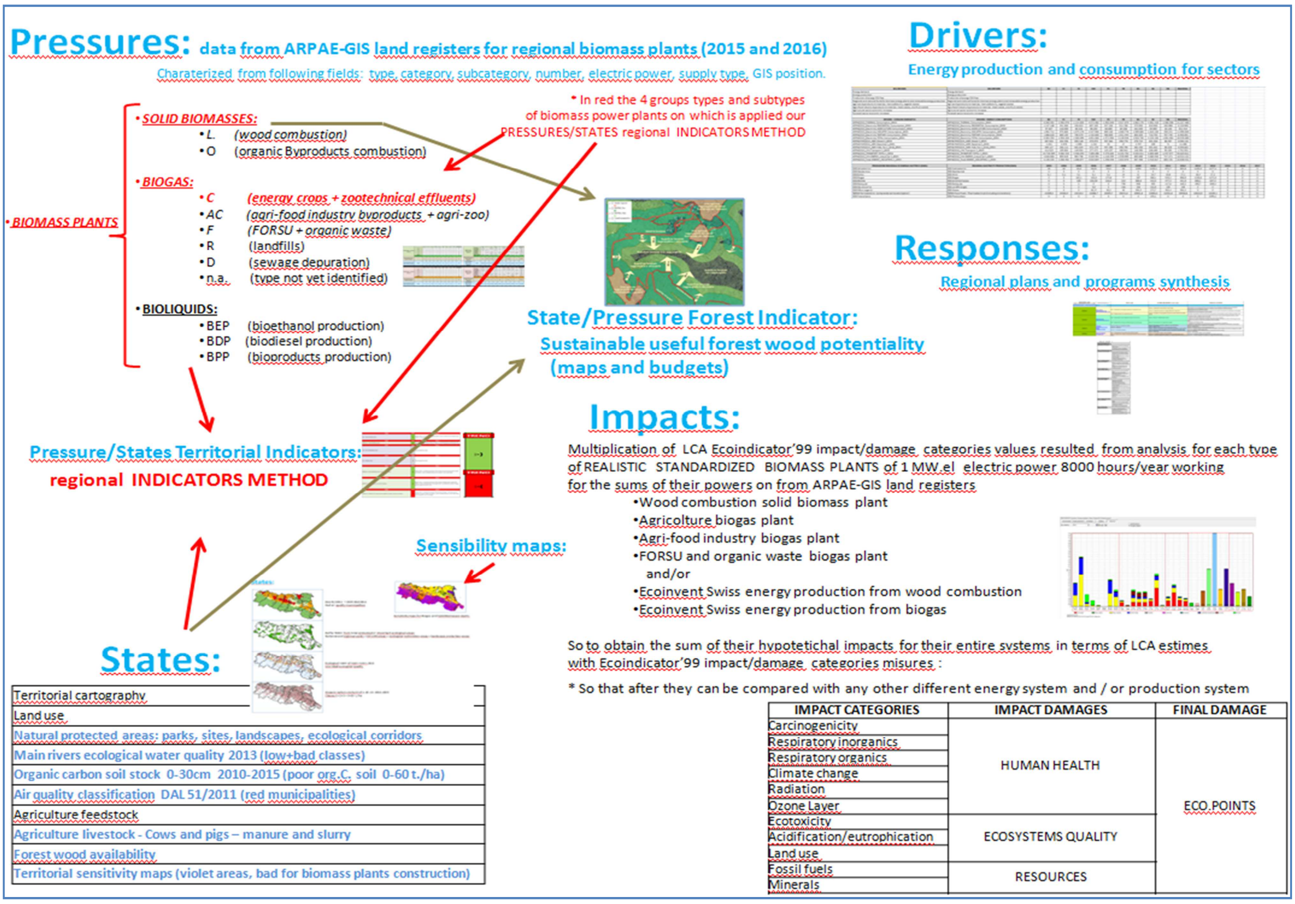


Figura 16- Synthethic frame of DPSIR model used in this research.

9.1.2. States: GIS layers used for informative/numerical states values

Geographically we have chosen 5 territorial GIS layers on which to overlap our 2 biomass plants GIS land registers (2015+2016) and so elaborate the helpful indicators that we will show a little bit further on. [12]

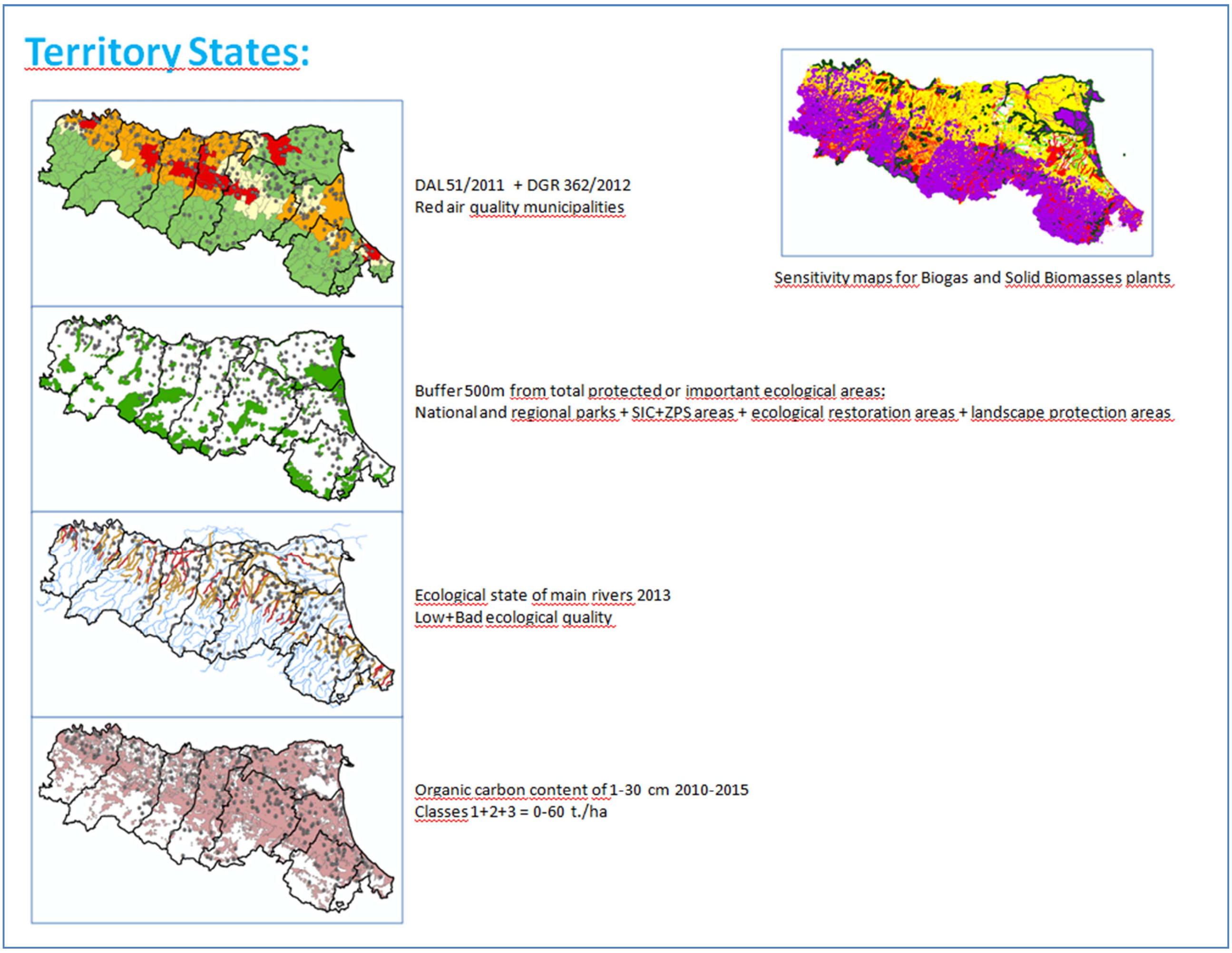


Figura 17- States: The 5 GIS layers used like informative states to elaborate the indicators of the DPSIR model.

[12] In a first time we thought to misure how many plants there would be near 500 m. far from centers inhabited, but immediately it resulted that practically all plants are located within a their buffer, so we didn't use this indicator.

Tabella 13- The 5 GIS layers used like informative/numerical states to elaborate the indicators of the DPSIR model

ORIGINAL STARTING GIS LAYER STATES	INDICATORS	BENEFIT/BURDENS
Pressure/State: Biomass power plants GIS land registers 2015+2016	Pressure/State: - Increment/decrement of number, electric power, location of the 4 different groups of biomass plants systems.	PRESSURE/STATE
Land use: Natural parks and protected areas: - Areas of natural parks and protected areas.	Land use: - Biomass plants situated within protected areas or within the buffer of 500 m. from them.	BURDEN
Water: Ecological quality 2010-2013: - Km of main rivers classified with good and sufficient ecological quality. - Km of main rivers with bad and low ecological quality.	Water: - Biomass plants situated close 500 m. from river segments with low/bad ecological quality index.	BURDEN
Soil: superficial organic carbon content (0-30 cm) of soil: - poor organic carbon soil (0-60 org.C t./ha). - sufficient+rich organic carbon soil (60-270 org.C t./ha).	Soil: - Biomass plants situated on poor organic carbon soil (0-60 org.C t./ha).	BENEFIT [13]
Land use: Sensibility maps: - Areas (VIOLET) where it should not built biomass energy plants. - Areas (red, yellow, green, white) where it should not built biomass energy plants.	Sensibility maps: - Biomass plants situated within violet areas where it should not built biomass energy plants.	BURDEN
Air: DAL 51/2011: - Bad (red) quality air municipalities. - Not bad (orange, yellow, green) quality air municipalities.	Air: - Biomass plants situated MW.electric power inside bad (red) municipalities.	BURDEN

[13] The spreading of digestate or biochar on soil enrich his content of organic Carbon, so where the soil is poor of org. Carbon the presence of biomass plants (and overall biogas) that produce and spreading digestate is seen like a benefit for environment

9.1.1. The final DPSIR planning JUDGMENTS (*only for region)

At the end of all the process of data and indicator elaboration, whose data is presented in the previous chapters, we arrived at the following judgments about the situation 2016 of the regional biomass power plants systems:

*Tabella 14- Final DPSIR 2016 – 2015 planning judgments about the regional biomass power plants system (*only for region).*

THEME	TREND	RESULT
GSE - Total BIOMASS plants	:-)	Respect 2015, in 2016 the total regional electric power installed with biomass power plants is increased of 4,41%
THEME	TREND	RESULT
ARPAE-GIS - Total BIOMASS plants	:-)	Respect 2015, in 2016 the number of plants is increased of 69 new localisations. RA data need a deepening and correction. The accurancy of ARPAE-GIS for biomass plants is increasing
THEME	TREND	RESULT
GSE - SOLID BIOMASSES plants	:-I	*Waiting data from GSE
THEME	TREND	RESULT
GSE - BIOGAS plants	:-I	*Waiting data from GSE
THEME	TREND	RESULT
ARPAE-GIS - SOLID BIOMASS plants territorial situation	:-)	Respect 2015, in 2016 the percentual of the number of solid biomass plants located near 500m or within protected areas and low quality rivers is decreased
THEME	TREND	RESULT
ARPAE-GIS - BIOGAS plants territorial situation	:-)	Respect 2015, in 2016 the percentual of the number of biogas plants located near 500m or within protected areas is decreased. (but is increased the number of biogas plants located low quality river).
THEME	TREND	RESULT
ARPAE-GIS - BIOGAS.C.E.CE. Agricultural-zootechnic plants territorial situation	:-(	Respect 2015, in 2016 the percentual of the number of biogas .C.E.CE. Agricultural-zootechnic plants located near 500m or within protected areas or within 500m buffer from low quality river is increased.

10. CONCLUSION

First of all is important understand the biogas (and bioliquid) plants represent a plant type completely different from the solid wood combustion plant. While the first uses agricultural energy crops and organic waste and byproducts, increasingly tending them to energy crops for an obvious issue of cost, the second burns wood biomass that mainly comes from forest and only in second instance from arboriculture or wood industry. So, even if both are squared in the big categories of renewable energy source from biomass, the planning about them must treat them like two absolutely different types. Biogas and bioliquid plants use organic waste and bioproducts coming from agri-livestocks farm and food industries to produce methane or fuel liquids, while the wood combustion plants burn wood coming from a total different productive chain.

After this, we can affirm that biogas and bioliquid energy plants are necessary to purse the goal of a circular economy, from an hand to maximize the economical profits and efficiencies and from other because if the organic waste would not ferment in a controlled environment with the CH4 recovery and his next combustion, with a free fermentation of organic matters would they would be produced a lot more CH4 (GWP = 24) that will be let free in atmosphere going to increase in a significant way the greenhouse effect and climate change. Clearly this speech cannot be done for wood combustion.

10.1.1. Preliminary considerations

From the social point of view very often the population of the territory near a biomass plant is contrary to its building considering it a big source of air pollution and traffic .
In addition to this often it happens that residential buildings located in the vicinity of the site where it is built the biomass plant suffer very consistent real estate depreciation precisely because of the construction of the latter.

In addition to this, in the design and approval of a biomass plant it would be appropriate to assess:

- from a socio-economic point of view, the possible variation of prices and market availability of the biomass needed by that specific plant;
- from the environmental point of view, both the initial phase of construction of the plant, upstream of the operating phase, and that of its final disposal, or possible conversion.

Currently most of the energy biomass plants remain in profitable in business thanks to the economic incentives given by the State system for energy produced from renewable sources, such as that of the biomass plants in fact. It is therefore important to consider that:

- If all the investment for the construction and operation of a plant is calculated on the time period (usually 20 years) of validity of economic incentives for energy from renewable sources, there is the real danger that, once finished the period of economic incentives, the plant is no longer economically viable and therefore the owner considers appropriate shut down the business, without addressing the issue of dismissing and the environmental restoration of the production site, which would thus become a sort of abandoned industrial site.
- The construction of a biomass plant, necessarily, is a strong local market factor of influence for sales / purchase of the biomass, both during the exercise that at the end of the activity.

For example, in relation to the first case, if the system uses specially cultivated biomasses (eg. shredded corn) or collected nearby (eg. firewood from forest maintenance), the local market price of these biomasses could undergo significant increases and / or decreased precisely due the great needs of the plant. All the more reason further significant price and availability fluctuations of the biomass will take place when the plant will finish its activities and therefore will no longer be required in the volumes required before.

From the social point of view very often the population of the territory near a biomass plant is contrary to its big building considering it a great source of air pollution, smell and traffic.
Based on this, it often happens that residential buildings located nearby of the site where it is built the biomass plant suffer very substantial real estate depreciation precisely because of the plant construction.
In addition to this, in the design and authorization of a biomass plant it would be appropriate to assess:

- from the socio-economic point of view, the possible future variation of prices and of market availability of the biomass related to the specific plant.
- from the environmental point of view, both the initial phase of construction of the plant, upstream of the operating phase, and that of its final disposal or possible conversion.

10.1.2. About the regional wood combustion plants system

Assuming that the regional solid biomass plants system would be constituted only by wood combustion plants, comparing this with the regional forest wood available potentiality map we constructed with the regional GIS land register 2016, we can say the if all the forest wood sustainable production (HQ High Quality firewood + LQ Low Quality wood for energy plants) would be used to supply the whole actual solid biomass power plants system of 141,6 MW electric power at all (as it would be all composed by forest wood combustion plants), the whole regional forest could supply 1,048 times the actual system, while if it would be used only LQ wood, the regional forest could supply only 0,314 forest wood combustion systems.
So, at the light of our information, we can say that actually the regional wood combustion plants system is in equilibrium with the productivity of the Emilia-Romagna regional forest. This can be considered a good thing, but we have not to forgot that a forest is a complex ecological environmental that supplies function and services to a big community of biodiversity. A forest cannot be considered like a maize field, because when a forest receives a bad management and/or a overexploitation, this one will not more be able to restart like an intensive agricultural field.
From a strictly economic point of view, is extremely important consider the fact that the HQ forest firewood is sold around the price of 13,5 euro/quintal, while the LQ wood adapted for wood combustion plants around 2,5 euro/quintal. So think to built big wood combustion plant is a big error because consuming a constantly big amount of forest wood at low price, in every case it will take away HQ wood to the firewood local markets, causing significant losses of job places at local level.
We have also to consider that, the best thing should be that one to construct wood combustion plants only dedicated to remote heating, without electric energy production, that work only in the 6 cold months per year (actually we estime the regional forest could be able to supply 75 plants of 2,4 MW.thermal power) avoiding to built wood combustion electric plants that work 12 months per year, 8000 work hours/year (actually we estime the regional forest could supply 24 plants of 1 MW.electric power each one); this due the different efficiencies and utilization managements.

At the end, we think the wood biomass combustion plants should be constructed only if little, around 250 Kw.electric power, so to be helpful at local scale and in harmony of the local socio-economic situation. The best thing remains to build little wood combustion plant dedicated to thermal energy production and distribution, like to heat up hospital and public offices located in mountain areas.
Noteworthy is the particular case of PWCP wood combustion plant of 30 MW.electric power, that is authorized and under construction in Ravenna province that is projected to be supplied with wood from 8000 hectares of Populus L. arboriculture, for wich it appears very underestimated, and that on the base of bibliographic information could be arrive to require over 40000 hectares of this arboriculture, that is an extremely big area. On the other side we calculated that if this plant will use only forest wood, if it would be supplied only with only LQ forest wood, the regional forest would be able to supply at all 1,48 plants like this one; while if it would be used both HQ+LQ forest wood, the regional forest could supply 4,95 plants like this.

- **Regarding the exploitation of forest wood biomass for energy purposes:**

It is very important the assessment and protection of forest wood market because, currently in Emilia-Romagna about 70% of the forest wood is harvested and sold as firewood for fireplaces and commercial activities at prices ranging between 10 and 17 EUR / quintal, while only 30% is of low quality and therefore available to the power equipment with prices that vary from 35 euro / ton for wood as such, up to euro 75 / ton for wood chips.

1.1. If the wooden market prefers move towards the sale of firewood, the planned expenditure for woody biomass for a given power plant may gradually increase and then cause, as in the previous case, the supply of chipped wood biomass from sites gradually furthest (with consequent greater fuel consumption and traffic, etc ..).
1.2. Vice versa, in case they become to constitute some forestry consortiums of economic size larger than usual, and if these make contracts dedicated to supply power plant , it could mean that:
    - It could occur an unsustainable over-exploitation of the forest, in order to counterbalance the lower unit price with more (unsustainable) amount of collected firewood.
    - The prices of the firewood could significantly increase, which could result in:
        - greater procurement costs for commercial exercises (eg. pizzerias);
        - greater procurement costs for domestic users, with subsequent migration of domestic heating systems towards the use of fossil fuels, with increase in fossil CO_2 emissions, in fact.
1.3. Being very difficult to check whether the exploitation of forests is carried out in a sustainable manner, the great demands of woody biomass from power plants could lead to:
    - over-exploitation of forests, with:
        - decrease in forest stock base;
        - consequent animal biodiversity loss due to the latter;
        - increase in problems of hydrogeological instability of the slopes.

- **The supposed scenario where entire solid biomass plants systems is equated to all wood combustion plants and all the wood comes from Populus L. arboriculture:**

On the base of this, weighting the arboriculture area needed by PWCP wood combustion plant case study, for which we found a seasoned wood productivity range that goes from the

maximum Populus L. productivity of 62 tons/year per hectare of fresh wood (33,9 tons/year/ha of seasoned wood) declared from PWCP, until the minimum productivity found in bibliography of 11,4 tons/year per hectare of fresh wood (6,27 tons/year/ha of seasoned wood), we can estimate that to supply a standardized unitary 1 MW.el wood combustion plant that needs 12766 tons/year of fresh wood (7660 tons/year of seasoned wood) it needs an arboriculture area (land use) between 205,9 hectares until 1119,8 hectares respectively.
So, starting from the case study of PWCP (30 MW.electric power) that when it will be activated will need a fixed Populus L. arboriculture area between 8000 ha until 43202 ha, if we do the same calculation for the actual solid biomass system, here entirely equated to wood combustion plants, equal to 141,6 MW electric power [14] , we can estimate that for the latter there should be a need of a fixed arboriculture area between 29155 hectares and 158564 hectares respectively.

- **<u>In the context of the energy biomass plants that combust forest wood, we must consider the big difference between the plants dedicated exclusively to the production of heat versus those dedicated primarily to the production of electricity and only in the second instance to the heat production.</u>**

A combustion biomass power plant finalized to only production of heat for remote heating operating 4000 hours / year (6 winter months, 24h / 24h) has wood consumption very lower than those of an equivalent plant finalized primarily to the production of electric energy operating all year round (8000 hours / year, 24h / 24h).
In thermic field, these systems should then be compared with their residential setting directly heated with firewood through stoves and / or domestic fireplaces. In this case, although the fireplaces and stoves are significantly less efficient in terms of thermal useful energy yield useful (besides the fact that it believes are more polluting from the point of view of emissions into the atmosphere of fine particles) is necessary to take into account that the fireplaces and stoves typically stay on about 12 hours a day , for 6 winter months (4000 hours / year, 12h / 24h). Logically their performance and energy efficiency depends both by the characteristics of the model, that by the type of home / building in which they are installed.

In light of the above mentioned cases we can therefore assume that a power plant using wood biomass with an electric power equal to 1 MWel, running for 8,000 hours / year, requires a consumption of matured wood chip (humidity = W = 30%) between 9000 and 17000 tons /year.

- **<u>A sample scenarios of local economy influence associated with construction and putting in activity of a wood combustion power plant:</u>**

It is very important the assessment and protection of forest wood market since, at present about 70% of the forest wood is harvested and sold as firewood for fireplaces and commercial activities at prices ranging between 10 and 17 € / quintal, while only 30% is low quality wood and therefore available to the power plants with prices that vary from 3.5 EUR / quintal for wood as such, up to 7.5 EUR / quintal for wood chips. [15]

1) In the case the wooden market prefers to move towards the sale of firewood to burn (due, for example, of significant increases in the price of diesel and natural gas for home heating), the prices of wood biomass destined to a specific power plant could gradually increase with the

[14] Excluding the 30 MW.el of the under construction PWCP plant.
[15] Source: RER.SAPFSM, 2015, a. - Emilia-Romagna Region - Service Protected Areas, Forests and Mountain Development.

passage of time and thus compel, as in the previous case, the supply of chipped woody biomass from more distant harvesting points (with consequent greater fuel consumption and traffic).

2) Vice versa, in case they become to constitute some forestry consortiums of economic size larger than usual, and if these would stipulate contracts dedicated to the supply of wood to the power plant, it could mean that:
   - It could occur an unsustainable over-exploitation of the forest, in order to counterbalance the lower unit price of wood with more (unsustainable) amounts of collected wood.
   - Prices of firewood could significantly increase, that could cause:
     - greater procurement costs for commercial exercises (eg. pizzerias).
     - greater procurement costs for domestic users, with subsequent migration of domestic heating systems towards the use of fossil fuels, with increase in fossil CO_2 emissions.

3) Being very difficult to control the effective sustainable exploitation operated in the forests, great demands of woody biomass by power plants could lead to:
   - an excessive exploitation of forests, with:
     - decrease of the base forest stock;
     - consequential animal biodiversity loss due to the latter;
     - increase in problems of hydrogeological instability of the scope;

- **The forest is not just wood production but is a producer of very important and fundamental functions and services that are not directly measurable ecosystems.**

Concerning the exploitation of forestry wood, we would like to remind you that a forest can not be conceived as a simple wood-producing territory, but contains a full set of environmental, natural, ecological and eco-systemic functions and services as well as humans. Which is right to do some example: CO_2 absorption, air purification, life generator and biodiversity, water purifier, hydrogeological soil and slope, landscape, etc .. etc .. It is not the objective of this research To deepen these very important aspects.

10.1.3. About the regional biogas plants system

Actually the regional biogas plants systems appears to be in a sufficiently good situation. Most of biogas plants reflect the needs of agricultural, livestock and food- industires sectors to treat their byproducts, both for integrative economic gain than, how said, for the environmental need to treat them and avoid pollution and CH_4 emission deriving from their free fermentation.

- **The induced variation of residential building selling prices caused from the construction of a biogas plant:**

From the social point of view very often the population of the territory near a biomass plant is contrary to its building considering it a big source of air pollution and traffic .
In addition to this often it happens that residential buildings located in the vicinity of the site where it is built the biomass plant suffer very consistent real estate depreciation precisely because of the construction of the latter.
In addition to this, in the design and approval of a biomass plant it would be appropriate to assess:

- from a socio-economic point of view, the possible variation of prices and market availability of the biomass needed by that specific plant;
- from the environmental point of view, both the initial phase of construction of the plant, upstream of the operating phase, and that of its final disposal, or possible conversion.

- **The induced variation of crops selling prices caused from the construction of a biogas plant:**

On the one hand there is the possibility that the cultivation of maize for energy purposes can significantly influence the food maize market prices (for feeding stuff and / or human consumption) causing an increase in the sale / purchase price. There may therefore happen that with the passage of the years the farmers raise their own product prices on the basis of the high demand / availability. The price increase would cover both maize for food / animal consumption that corn destined to the biomass plant. This eventuality would force the plant operator to purchase maize at a lower prices from crops located at a greater distance from the plant, which would lead to more traffic on the roads, higher consumption of fossil fuels, and therefore at increased pollution, more fossil CO2 emissions and greater social disturbance .
Vice versa, it can also happen that the availability of a power plant for energy purposes to purchase very large quantities of biomass, could cause a lowering of the sale / purchase price of maize, to the total detriment of farmers were forced to sell their maize at very minor prices , causing their depletion.

- **About genetic modificated crops utilization**

GM crops should be absolutely avoided because, in addition to disturb very significantly the prices of sales / purchase market, they could give rise to agro-ecological contamination at infesting level and also to the modification of plant ecological and animal populations (eg. bees , small mammals and birds, etc ..) and, further, may then force the farmers to increase the use of pesticides, poisons, etc ..

- **A sample scenarios of local economy influence associated with construction and putting in activity of a biogas power plant:**

4) On one side there is the possibility that the cultivation of maize for energy purposes can significantly influence the the food maize market prices (for animal and/or human consumption) causing an increase in the sale / purchase price.
   That is, it may be that with the passing of the years the the farmers raise the price of maize on the basis of high demand / availability. And the price higher will affect both maize for food and/or animal consumption that maize destined to biomass plant.
   This eventuality, as well as distorting the local market of maize, would force the system operator to purchase a lower corn prices from crops located at a greater distance from the plant, which would lead to higher consumption of diesel fuel for transportation (and therefore more fossil CO2 emissions) and to more traffic on the roads.

5) Vice versa, it can also happen that the availability of a power plant to buy energy for very high amounts, can cause a lowering of the sale / purchase price of maize, to the total detriment of farmers, who are forced to sell their maize at prices very lower , leading to their depletion.

10.1.4. Socio-economic considerations

From the social point of view very often the population of the territory near a biomass plant is contrary to its big building considering it a great source of air pollution, smell and traffic.
Based on this, it often happens that residential buildings located nearby of the site where it is built the biomass plant suffer very substantial real estate depreciation precisely because of the plant construction.
In addition to this, in the design and authorization of a biomass plant it would be appropriate to assess:

- from the socio-economic point of view, the possible future variation of prices and of market availability of the biomass related to the specific plant.
- from the environmental point of view, both the initial phase of construction of the plant, upstream of the operating phase, and that of its final disposal or possible conversion.

At present, in fact, most of the biomass power plant remains profitable business thanks to the economic incentives provided by the State system for energy produced from renewable sources, such as that of the biomass plants indeed. From here it is therefore important to consider that:

- If all the investment for the construction and operation of a plant is calculated on the temporal validity period of economic incentives for energy from renewable sources (activable until 06/07/2012 for 15-20 years in Italy[16]), there is the real danger that, once exhausted the period of economic incentives, the plant is no longer economically viable and therefore the owner deems appropriate to close the business, without addressing the issue of disposal and the environmental restoration of the production site, which would become then a sort of abandoned industrial site.

- The construction of a biomass plant, clear, represents a strong influencer of the local market biomass sales/purchase.
  For example, if the plant uses specially grown biomasses (eg. chopped maize) or harvested nearby (eg. Firewood from forest maintenance), the local market price of these biomasses could suffer significant increases and / or decreases in precisely due of the great needs of the plant. All the more reason, further significant price fluctuations and availability of biomass will take place when the plant will finish its activities and therefore will no longer be required the quantities needed before.

We propose for this purpose some sample scenarios of local economy associated with construction and putting in activity of a biomass power plant:

10.1.4.1. (A) - About agricultural energy crops

About agricultural energy crops we can assume the following situations:

6) On one side there is the possibility that the cultivation of maize for energy purposes can significantly influence the the food maize market prices (for animal and/or human consumption) causing an increase in the sale / purchase price.

[16] In Italy have been different economic incentives programs for renewable energy sources more or less every three year in the past, significantly different between them. Until last regulation it was possible receive a good price to sale every single electric kWh produced to the National Electric Manager Authority (GSE in Italian) for the next 15-20 years after the official registration like renewable energy productor. Now, starting from the Minister Decree of 23 july 2016, it is possible obtain only the economic incentive until 50% of the total cost for the construction of the biomass plant.

That is, it may be thatwith the passing of the years the the farmers raise the price of maize on the basis of high demand / availability. And the price higher will affect both maize for food and/or animal consumption that maize destined to biomass plant.
This eventuality, as well as distorting the local market of maize, would force the system operator to purchase a lower corn prices from crops located at a greater distance from the plant, which would lead to higher consumption of diesel fuel for transportation (and therefore more fossil CO2 emissions) and to more traffic on the roads.

7) Vice versa, it can also happen that the availability of a power plant to buy energy for very high amounts, can cause a lowering of the sale / purchase price of maize, to the total detriment of farmers, who are forced to sell their maize at prices very lower , leading to their depletion.

8) Absolutely to be avoided should be GMO crops because in addition to very significantly disturb the prices of sales / purchase market, could give rise to agro-ecological contaminations at infesting level and also to the modification of vegetal and animal ecological populations (eg . bees, small mammals and birds, etc ..) which, further, may then force the agricultural land to an increased use of pesticides, poisons, etc ..

10.1.4.2. (B) - About the exploitation of forest wood biomass

It is very important the assessment and protection of forest wood market since, at present about 70% of the forest wood is harvested and sold as firewood for fireplaces and commercial activities at prices ranging between 10 and 17 € / quintal, while only 30% is low quality wood and therefore available to the power plants with prices that vary from 3.5 EUR / quintal for wood as such, up to 7.5 EUR / quintal for wood chips. [17]

9) In the case the wooden market prefers to move towards the sale of firewood to burn (due, for example, of significant increases in the price of diesel and natural gas for home heating), the prices of wood biomass destined to a specific power plant could gradually increase with the passage of time and thus compel, as in the previous case, the supply of chipped woody biomass from more distant harvesting points (with consequent greater fuel consumption and traffic).

10) Vice versa, in case they become to constitute some forestry consortiums of economic size larger than usual, and if these would stipulate contracts dedicated to the supply of wood to the power plant, it could mean that:
    - It could occur an unsustainable over-exploitation of the forest, in order to counterbalance the lower unit price of wood with more (unsustainable) amounts of collected wood.
    - Prices of firewood could significantly increase, that could cause:
        - greater procurement costs for commercial exercises (eg. pizzerias).
        - greater procurement costs for domestic users, with subsequent migration of domestic heating systems towards the use of fossil fuels, with increase in fossil CO2 emissions.

11) Being very difficult to control the effective sustainable exploitation operated in the forests, great demands of woody biomass by power plants could lead to:
    - an excessive exploitation of forests, with:
        - decrease of the base forest stock;
        - consequential animal biodiversity loss due to the latter;
        - increase in problems of hydrogeological instability of the scope.

[17] Source: RER.SAPFSM, 2015, a. - Emilia-Romagna Region - Service Protected Areas, Forests and Mountain Development.

10.1.4.3. (C) - Wood combustion: Electric VS Thermal

In the context of energy plants field with forest wood biomass, , you have to consider the big difference among the plants dedicated exclusively to the production of heat than those dedicated first and foremost to the production of electricity and only in the second instance the production of heat.

An energy plant fueled with wood biomass finalized to only production of heat for district heating active 3600 hours / year (5 months winter, 24h / 24h) has wood consumptions much lower than those of an equivalent plant finalized primarily for electricity production that is active all year round (8000 hours / year, 24h / 24h). [18]

In thermal field, these systems should then be compared with the corresponding residential context directly heated with firewood through stoves and / or domestic fireplaces.
In this case, although the fireplaces and stoves are much less efficient in terms of useful thermal energy efficiency, besides the fact that they are considered the most polluting in terms of emissions of fine particles, it is necessary to keep in mind that the fireplaces and stoves typically remain lit 12 hours a day for 5 winter months (3600 hours / year, 12h / 24h).
Logically their performance and energy efficiency depends both on the characteristics of the model, than by the type of home / building in which they are installed:

In light of the above cases we can therefore assume that a power plant using wood biomass with an electric power equal to 1 MWel, running for 8,000 hours / year, requires a mature wood chip consumption (humidity = W = 30%) between 9000 and 17000 tons / year. [19]

Numerically this concept can be represented by the following comparison table:

Tabella 15- General comparison between an electric+thermal wood and an only thermal wood combustion plant.

	Plant of 1.0 MW.el working for 8,000 hours/year	Plant of 2.4 MW.ter working for 3,600 hours/year
Chipped mature wood consumption	9,000-17,000 = 13,000 tons/year	2,571.5 tons/year
Working hours	8,000	3,600
Calorific power of chipped wood	3.5 kWh/kg	3.5 kWh/kg
Energy inbound	45,550 MWh	9,000 MWh
Electric efficiency (%)	17,6%	/
Electric power	1 MWel	/
Enlectric Energy produced	8,000 MWh.el	/
Thermal efficiency (%)	42.2%	80%
Themal power	2.4 MWt	2.4 MWt
Useful thermal energy	19,200 MWh.t	7,200 MWh.t
Energetic loss (%)	40.2%	20%

In extreme synthesis, we can approximate the concept that from the point of view of the woody biomass consumption (and therefore the use and management of energy, together with the related pollutant emissions (PM10, PM2.5, NOx, etc ..) and re-entries of biogenic CO2 in the atmosphere), num.1 wood power plant of 1 electrical MW + 2.4 thermal MW working for 8,000 hours / year, which consumes 13,000 tons. of wood per year , implies the same impact of num. 5 exclusively

[18] A year consists of 8760 hours, but generally you use the value equal to 8000 hours to take into account the process stops, maintenance, repairs, etc ..
[19] Source 1 : RER.SAPFSM, 2015, a. – Sorce 2: average data collected for the present study that will be shown later in the next chapters.

thermal wood power plants working for 3,600 hours/year with the same thermal power (2.4 thermal MW) each one. So, being understood all the differences of the cases, a merely informative nature, at equal consumption of woody biomass and thus of use of forested areas and related biogenic CO2 budgets, it deemed correct to assume the following two limit example cases:

- Construction by a private entity of an electrical and thermal power plant, which requires an average consumption of 13,000 tons. of matured woody biomass taken from the territory / forests publicly owned, ie owned by the whole community of the territory, which will be paid to the consortium of foresters 7.5 euro / quintal, and whose revenues will be obtained from:
    - the sale of electric energy to the National Electric Manager at the price that comprehends the economic national incentives,
    - and from the sale of thermal energy in district heating sold to public and private structures located nearby, at a specific price;
- Construction of num. 5 exclusively thermal power plants by territorial public entities that, respect to the same purchase price of wood chips from forestry consortiums, will cover the heating requirements, only in winter, of the Community of the neighboring territories through the sale of heath at preferential prices, compensative of the forest exploitation.

Tabella 16- General comparison between an electric+thermal wood and an only thermal wood combustion plant.

	Plant of 1.0 MW.el + 2.4 MW.ter working for 8,000 hours/year	Plant of 2.4 MW.ter working for 3,600 hours/year
Chipped seasoned wood consumption	13,000 tons/year	13,000 tons/year
Number of plants	1	5

10.1.4.4. (D) - The forest: an ecosystem and not only wood producer

Concerning the exploitation of forestry wood, we would like to remind you that a forest can not be conceived as a simple wood-producing territory, but contains a full set of environmental, natural, ecological and eco-systemic functions and services as well as humans. Which is right to do some example: CO2 absorption, air purification, life generator and biodiversity, water purifier, hydrogeological soil and slope, landscape, etc .. etc .. It is not the objective of this research To deepen these very important aspects.

10.1.5. Results and conclusion

In this research we have proposed and actuated an integrate system of assessment that permit us to evaluate at regional/provincial scale the biomass energy system (and his sub-systems) from different points of view:

1. We collected data and constructed the Emilia-Romagna regional GIS land registers 2015 and 2016 for all the different biomass plant types correlated with their supply productive chains.
2. From a geographic territorial planning point of view, with the sensibility maps, we are able to know what are the most suitable area where to built biomass plants and what the worst. Through these maps we are also able to identify the plants that are already built in bad areas, so it is possible consider them like those to monitor and control with major priority.
3. From a general territorial point of view, with the DPSIR indicators model we constructed, we created a method to evaluate, both at provincial than regional level, the geographical situation of the state and evolution of the main biomass power plants systems.
   Even if the actual result can appear not so important because we used only the data of two subsequent years (2015 and 2016), in reality from a first point of view it permits us to evaluate in a complete way an energy system that in strong increase that was not ever assessed before; in addiction the adopted method in the future will permit us to evaluate the trends, forms and evolutions of our territorial biomass plants systems using a better time distance, like for example of five years, as 2016-2020.
   From our 2015-2016 DPSIR analysis the general situation of Emilia-Romagna biomass plants systems appears to be quite good: the renewable energy production from biomass begins to be significant, and there is a sufficiently good geographic territorial distribution; there are some plants that are located in violet area of sensibility map and that they need to be monitored and controlled with major attention respect the others.
4. It is important remember that the construction of biomass plants (especially biogas) can disturb the near inhabitants, both for air quality and smells, than for decrease of economic values of residential buildings located nearby. It can be said the same for wood combustion biomass, even if usually they have not the dimensions and the power magnitude of the biogas ones.
5. There are big social problems about the big PWCP wood combustion plant of 30 MW.el power that is authorized and under construction, and is very probable that a so big plant will create significant variation about the prices of wood it needs, both it will come from arboriculture than from forest. It is realistic think that this plant could not survive due the fact both that when it was projected it was thought that the national economic incentives that at that time were would continue along the time, but now is not more so (now in 2016 the incentives for renewable energy are provided only for the construction and not more for the KWh of produced energy like in the past it was projected), than due the fact that his big wood need will modify the market and the sell prices of wood around it. In addiction is important underline that his supply impact about the needed wood is equal to around 1/5 of the whole actual regional solid (assumed wood combustion) biomass system, that is 141,6 MW.el . In the case of his activation it will be absolutely necessary monitor it to avoid that for economic reasons the plant could use other types of biomass fuel like urban or industrial inorganic waste, or oil from palm imported from abroad, or other type of organic oil that will produce big land exploitation and/or smells. Absolutely, viewed his very big dimension, this plant will must be accurately monitored and controlled.
6. About the quantitative assessment and measurement of environmental impacts and damages of the regional biomass plants system and sub-systems, through the LCA approach actuated with the construction standardized realistic theoretical unitary different types of biomass plants and their productive chains, representative of 1 MW electric power plant that produce 8000 MWh.electricity per year, we were able to estimate the impacts and damages Ecoindicator’99 values of our biomass systems at regional level, multiplying their unitary impacts/damages with the regional biomass electric power installed.

In addition to this, the unitary standardized plants we created can be used for calculations in other regions, and/or corrected and modified on the base of the aims, besides the fact that they can be implemented and calculated both with LCA Ecoindicator'99 method, than with other LCA methods like Impact.2002, Edip.2003, IPCC GWP 100y 2007, etc.. . The available standardized data we presented are fundamental for this.

7. While the biogas standardized plants use different mix of organic biomass types (silage maize, silage sorghum, manure and slurry, agro-food byproducts, etc..), and so different quantities in function of their types, the wood combustion plants burns wood that more or less independently from the quality/type, have always the same calorific power and so they need always the same quantities of wood. For a production of 8000 MWh/year electricity we estimated it needs of 7660 tons./year of seasoned wood, corresponding to 12766 tons of fresh wood.
8. On the base of forest, roads and inhabited centers cartographies, we created the useful forest wood potentiality map that permitted us to calculate sustainable forest wood availability at regional/provincial scale and, comparing it with the GIS biomass land register 2016, to calculate the wood energy budget including both the useful wood energy offer than the theoretical demand, including also the segmentation of the forest wood market prices where the HQ firewood represent the 70% of the forest production and it is sold around 13,5 euro/quintal, while the LQ wood that represent the 30% of the production is adapted to wood combustion plants and is sold around 2,5 euro/quintal.
9. From this, it results that if all the forest wood sustainable production (HQ High Quality firewood + LQ Low Quality wood for energy plants) would be used to supply the whole actual solid biomass power plants system of 141,6 MW electric power at all (as it would be all composed by forest wood combustion plants), the whole regional forest could supply 1,048 times the actual system, while if it would be used only LQ wood, the regional forest could supply only 0,314 forest wood combustion systems.
10. In addiction we created their related equivalent standardized wood combustion plants of 2,4 MW.thermal that produce only thermal energy for remote heating and work only for the 6 cold months (4000 hours).

    Clearly, with the same quantity of burned wood, the only thermal wood combustion plants have a major energetic yield and, assuming that all the heat produced would be distributed in a good way, if equated to the corresponding electrical energy produced by electric+thermal wood plants, where extremely often the produced heat is not used and so wasted, the conclusion is that use wood to produce electric energy is an extremely wrong choice. This because the average efficiency for electricity production is around 22,2 % with the thermal efficiency of 66,7 % that usually is wasted, while the average efficiency for a plant that produce only heat (and that is used through remote heating) is around 85,7 % . This both in the scenario where the only heat plant works 4000 hours/year using 3830 tons/year of seasoned wood, (only for the 6 cold months), than 8000 hours/year using 7660 tons/year of seasoned wood (12 months).
11. We created also the scenario of wood combustion plant supplied only with wood coming from Populus L. arboriculture.

    On the base of this, weighting the arboriculture area needed by PWCP wood combustion plant case study, for which we found a seasoned wood productivity range that goes from the maximum Populus L. productivity of 62 tons/year/ha of fresh wood (33,9 tons/year/ha of seasoned wood) declared from PWCP, until the minimum productivity found in bibliography of 11,4 tons/year per hectare of fresh wood (6,27 tons/year/ha of seasoned wood), we can estimate that to supply a standardized unitary 1 MW.el wood combustion plant that needs 12766 tons/year of fresh wood (7660 tons/year of seasoned wood) it needs an arboriculture area (land use) between 205,9 hectares until 1119,8 hectares respectively.
12. So, starting from the case study of PWCP (30 MW.electric power) that when it will be activated will need a fixed Populus L. arboriculture area between 8000 ha until 43202 ha, if we do the same calculation for the actual solid biomass system, here entirely equated to wood combustion

plants, equal to 141,6 MW electric power 20 , we can estimate that for the latter there should be a need of a fixed arboriculture area between 29155 hectares and 158564 hectares respectively. Considering that the lowland represents the 47,8% (1056964 km2 = 105696400 hectares) of the total regional extension (2211222 km2), in the worst case of arboriculture[21] the PWCP plant would need the occupation of the 4,1 % total regional lowland, that for a single wood combustion plant of 30 MW.el, is really hight and unsustainable.

13. About the LCA analysis, we repute the values of impact/damage associated to unitary standard plants can represent a good way and assessment instrument to quantify the environmental impact/damage of a regional biogas and wood combustion energy systems, both for Emilia-Romagna and for similar territories. How you prefer you can easily choose and take in account both the Ecoinvent Swiss than the standard unitary references we presented to multiply them for the biomass electric power installed on your territory to calculate related Ecoindicator'99 impacts/damages. You can also modify the starting data of standardized plants, with their productive chains, and so after implement them as you like in a LCA software to recalculate new unitary standardized plants with Ecoindicator'99 or other LCA methodologies. This is a good starting point to improve correlated research, planning, sustainability balances, etc.. Unitary values here tested and presented can be an excellent screening instrument for regional assessments, especially why you only need to know the electric power installed values to obtain their LCA Ecoindicator'99 impacts/damages at regional scale.
14. About DPSIR responses, we have identified with the regional plans and programs adopted by the region until 2015 and in the new operative Energy Plan 2017-2020 / 2016-2030 we were able to say nothing, because it was never done a monitoring of the disbursed economic incentives in relation to the environmental expected (and/or obtained) effects. Clearly if this kind of monitoring is not done, it will be always impossible correlate their effectiveness, and their improvement. Actually all the regional economic incentives for biomass energy and/or their productive chain, can be helpful to the environmental-social-economic correlated productive sectors, but this only at an empirical level, without any numerical technical evidence.

10.1.6. Final conclusions

Energy from biomass absolutely cannot be the solution. Necessarily the real renewable energy must come from sources that don't need resources consumption, like photovoltaic, solar, tidal, wind, geothermal, and so on.
Agricultural crops, arboriculture and forest exploitation imply an excessive consumption of not renewable resources (land use, fossil fuels consumption, fertilizers and pesticides use, forest ecosystem and biodiversity damages, etc..). Spending energy, fossil fuels and resources to cultivate land or exploit forest is not so renewable and, in addition to this, these systems are so linked to the consumption of fossil fuels that future foreseeable increases in the cost of oil and fossil fuels, which will sooner or later come true due to their progressive consumption, will be able to become quickly not sustainable from the only simple economic point of view. A biomass energy system based on fossil fuels consumption (for cultivation, exploitation, transport, etc..) that can fail due the variation of petroleum costs is a very bad system, not autosustainable.
On the contrary, the utilization of biomasses to produce energy should be encouraged and promoted in the ambit of circular economy systems, where the energy production is not the primary purpose but a necessary integrative second one. In close harmony with the circular economy processes, all the organic byproducts coming from agro-food and wood industries (and similar), should be encouraged and promoted to be used in final to produce energy, to valorize them and so obtain the maximum results with the minimum costs in term of resources, land uses, ecosystems, economy,

[20] Excluding the 30 MW.el of the under construction PWCP plant
[21] 43202 ha.

society, etc.. trying to arrive to a complete productive circular renewable systems. From this point of view is right affirm that necessary the byproducts reutilization for energy scopes (or other) is absolutely necessary and should be obligatory.
We cannot permit ourselves to consume fossil fuels energy to produce renewable energy (it is a non-sense), and we must absolutely create circular productive systems where all the waste are used as byproducts, so to obtain energy from organic renewable biodegradable “waste” coming from productive and consumption economic chains.
We have not also forget that to monitor and manage a good planning of the biomass energy production sector is absolutely indispensable the monitoring of the regional plans and programs about the correlated productive/environmental sectors like those of Air, Agriculture, Energy, Productive Activities, and others. Unfortunately this was never did until now, even if it would be absolutely necessary for a correct planning and management.

In conclusion, at regional scale:

- The biogas power plants systems situation appears to be reasonably good:

    - Independently from the installed electric power, from our DPSIR analysis don’t result particular negative cases; the biogas plants located in violet areas of our sensibility map should be those to monitor and control better and more frequently. We have to never forget that to have a circular sustainable economy we need biogas plants to recover all the agri-zoo and food industry byproducts, so to avoid their free fermentation that should produce and release free methane in atmosphere and so to avoid to squander the energy and the matter contained inside them;
    - From our 2015-2016 DPSIR analysis the general situation of Emilia-Romagna biomass plants systems appears to be quite good: the renewable energy production from biomass begins to be significant, and there is a sufficiently good geographic territorial distribution; there are some plants that are located in violet area of sensibility map and that they need to be monitored and controlled with major attention respect the others.

- On the contrary, the solid biomass (wood combustion) plants system appears to be in fragile equilibrium with the forest wood sustainable production potentiality:

    - It results that if all the forest wood sustainable production (HQ High Quality firewood + LQ Low Quality wood for energy plants) would be used to supply the whole actual solid biomass power plants system of 141,6 MW electric power at all (as it would be all composed by forest wood combustion plants), the whole regional forest could supply 1,048 times the actual system, while if it would be used only LQ wood, the regional forest could supply only 0,314 forest wood combustion systems;
    - Consider that the 70% of the forest wood is HQ high quality wood and can be collected from people and sold like firewood at prices around 17 euro/quintal, while the price of LW low quality wood (30%) usually is burned in energy plants and payed around 3,5 euro/quintal.

    - There are big social problems about the single specific big PWCP wood combustion plant of 30 MW.el power located in Ravenna province that is authorized and under construction, and is very probable that a so big plant will create significant variation about the prices of wood it needs, both it will come from arboriculture than from forest. It is realistic think that this plant could not survive due the fact both that when it was projected it was thought that the national economic incentives that at that time were would continue along the time, but now is not more so (now in 2016 the incentives for renewable energy are provided only for the construction and not more for the KWh of produced energy like in the past it was projected), than due the fact that his big wood need will modify the market and the sell prices of wood around it.

- In addiction is important underline that his supply impact about the needed wood is equal to around 1/5 of the whole actual regional solid (assumed wood combustion) biomass system, that is 141,6 MW.el and, in the case it will be used wood from Populus L arboriculture in the better case it will be necessary 8000 hectares of land dedicated to the cultivation, while in the worst case could be needed more than 42000 hectares dedicated to the arboriculture.

  In case of his activation it will be absolutely necessary monitor it to avoid that:
  - the regional and locals wood prices market would be very distorted;
  - the regional and local exploitation of forest wood would be excessive;
  - for economic reasons the plant could use other types of biomass fuel like urban or industrial inorganic waste, or oil from palm imported from abroad, or other type of organic oil that will produce big land exploitation and/or smells.

  Absolutely, viewed his very big dimension, this plant will must be accurately monitored and controlled, both the plant for his atmospheric emissions than for his productive chain of supply (both in terms of forest/land exploitation, than in terms of wood market prices distortion, than in terms of fossil fuels consumed for transports from far).

- In conclusion it should be strongly avoided:
  - to build other wood combustion plants bigger 0,5 MWel electric power;
  - to build them far from the wood production places;
  - to build them for electricity production, because it need much more wood and usually their thermal energy production is wasted;

- while should be encouraged:
  - the construction of only little thermal wood combustion plants that use all the thermal energy produced for remote heating, collecting wood from nearby forest so to need little distances of transport and to be able to control it in the case the exploitation of the forest (or arboricultured lands) could be excessive.

At last, about the assessment methodologies used in this research we think that they can be very useful instrument for a correct sustainable planning at regional and/or provincial scale.

THANK YOU VERY MUCH

FOR YOUR ATTENCTION

Index - part 11 -

Appendix:
ITALIAN ECONOMIC INCENTIVES SYSTEM FOR RENEWABLE ENERGIES

1. GENERAL OVERVIEW ON ECONOMIC INCENTIVES FOR RENEWABLE ENERGIES updated to 1 august 2016

Find your way around the many paths of economic incentives for renewable energy_ implemented untill today, It's quite complex.
This chapter tries to provide a general overview of incentive schemes relating to the production of electricity from RES market renewable sources in Italy, currently active and / or already implemented and concluded.

Readers who wish to study with accuracy and technical arguments summarized here necessarily have to refer to the web pages of the GSE.

1.1. CURRENT OPERATING ENVIRONMENT OF THE ITALIAN MARKET OF ECONOMIC INCENTIVES TO SUPPORT THE PRODUCTION OF ELECTRICITY FROM RENEWABLE SOURCES - TO AUGUST 1, 2016 -

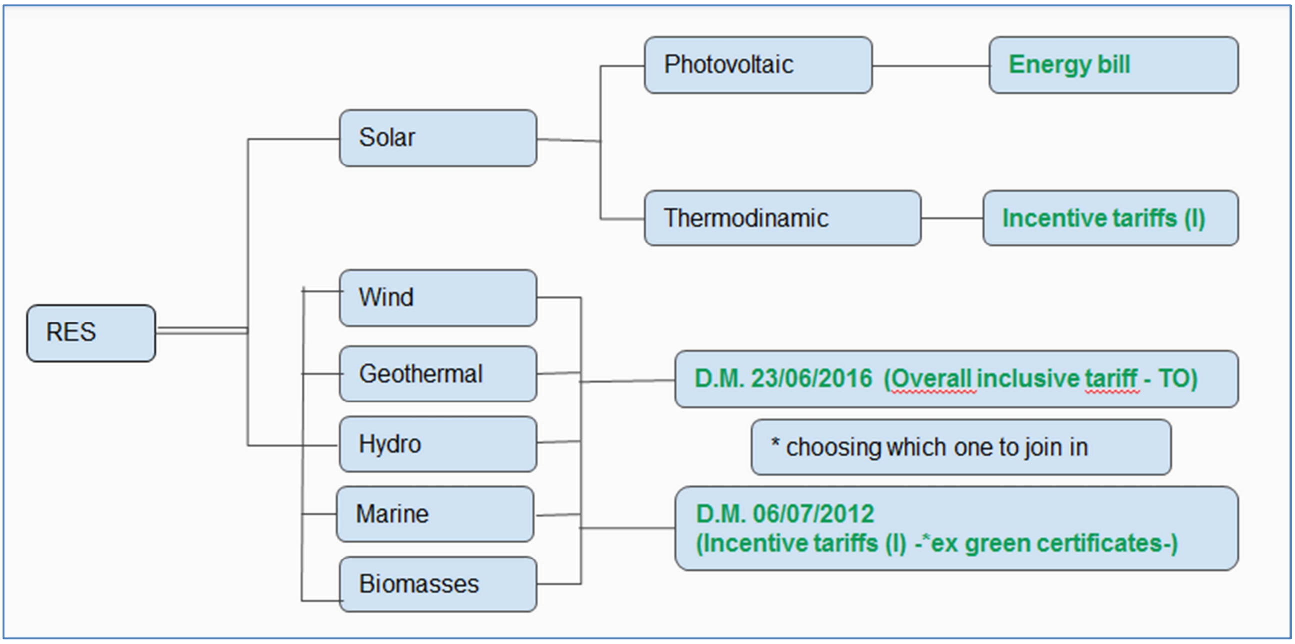


Figura 1- Schematic frame of electric energy incentives for renewable energy production (untill 1 august 2016).

The **DM 23 June 2016** encourages the production of electricity from plants using renewable sources, other than photovoltaics, which came into operation from 1 January 2013.
It also replaces the incentives established by the previous **DM 6 July 2012** and regulates the mandatory migration from the incentive system of Green Certificates (GC) to that of the Incentive tariff (I).

The methods of encouraging the production of electricity from plants using renewable sources (excluding photovoltaic systems) including the biomass plants, are established by the **DM 6 July 2012**, which among other things regulates migration from the past incentive system of Green Certificates (GC) to that of the Incentive tariffs (I).

The **DM 23 June 2016** provides for two different incentive mechanisms, based on baseline power, the renewable source and the type of system. In practice it requires the producer of electricity from RES to choose whether to use the incentive system (TO) or the one (I).

- **Overall incentive Tariff (TO)** regulated by **DM 23 June 2016** is available for power plants up to 1 MW, determined by the sum of the Basic incentive Tariff (Tb) + the amount of any awards.
  Producers may require the payment of a Overall incentive Tariff (TO) for a period of 15 years for the power plants with annual average nominal power:
  - not exceeding 0.500 MW for 2016
  - or, not exceeding 1 MW for 2012

- The **Incentive Tariff , said also Incentive (I)** is regulated by **DM 6 July 2012** and is available for power plants over 1 MW, and for those of until 1 MW, which do not opt for the Overall inclusive Tariff (TO) calculated as the difference between the Basic incentive Tariff (Tb) and the price zonal hours of energy.

La Overall inclusive Tariff (TO) or the Incentive (I) are measured from the value of the Basic incentive Tariff (Tb), and are paid by the GSE National Electric Services Manager.

1.1.1. The past mechanism of green certificates (GC) within the meaning of Legislative Decree 28/2011

From 1 January 2016, as required by **DM 6 July 2012**, the mechanism of Green Certificates (GC) is replaced by a new form of incentive (I).
Those who have already acquired the right to GC retain the benefit for the remaining facilitated period, but in a different form. The new incentive is obtained by accessing GRIN, the computer system of the GSE that manages the recognition of tariffs.

- **What are GC**

The Green Certificates are negotiable securities issued by the GSE in proportion to the energy produced by a IAFR qualified plant (IAFR = plant powered by renewable sources), which entered into service before December 31, 2012 under the provisions of Legislative Decree no. 28/2011, in variable number depending on the type of renewable source and on the realized plant intervention (new construction, reactivation, upgrading and rebuilding).

The incentive mechanism with Green Certificates is based on the obligation, placed from regulation on load of producers and importers of electricity produced from non-renewable sources to feed every year in the power system a minimum quota of electricity produced by plants renewables.
The ownership of Green Certificates demonstrates the fulfillment of this obligation: each Green Certificate conventionally certifies the production of 1 MWh of renewable energy. The Green Certificates are valid for three years: those issued for the production of electricity in a given year (reference year of GC) can be used to fulfill the obligation even in the next two years.
The obligation can be fulfilled in two ways: by entering the net electricity produced from renewable sources, or by purchasing green certificates from producers of "green energy."

- **How obtain GC**

The producer may request the issue of Green Certificates downstream of the positive outcome of the "plant qualification process powered by renewable sources" (qualification _).
Only for the annual average nominal power not exceeding 1 MW (0.2 MW for wind power plants), with the exclusion of solar energy, can be exercised the right of option between the Green Certificates and Overall incentive Tariff.
Concurrently with the first issue of Green Certificates, the GSE actives , in favor of the producer, a "property bill" for the "deposit" of certificates.
GSE keeps track of the Green Certificates emissions and related transactions through a computer system dedicated to which holders of the ownership account can access, following the assignment of an identification code by the GSE.
The ownership account is also enabled for producers and / or importers subjects to the obligation referred in article 11 of D.lgs.79 / 99, upon its receipt by the GSE, self-certification attesting production and / or import non-renewable, and in favor of those who wish to engage in trading activities of Green Certificates.
The ownership account is also enabled for producers and / or importers subjected to the obligation referred in article 11 of D.lgs.79 / 99, upon its receipt by the GSE, self-certification attesting production and / or import non-renewable, as well as in favor of those who wishing to operate trading activities for Green Certificates.
It is possible consult via internet, through restricted access, the status of your account property, either to accommodate acquisitions and / or sales of green certificates, and to verify, in a direct and immediate, transactions that occurred.

1.1.2. BIOMASS POWER PLANTS

Currently the method of encouraging the production of electricity from biomass, are established by DM 23 June 2016. For tables of tariffs of biomass, please refer to the decree link: http://www.gse.it/it/salastampa/GSE_Documenti/Decreto_MiSE_23giugno2016_Incentivi_rinnovabili_diverse_da_fotovoltaico.pdf

The DM 23 June 2016 identifies, for each source, type of plant and power class, the value of the incentive basic tariffs (Tb) reference for plants that entered into service with effect from the various dates as defined in Annex.1, Table 1.1. of DM 23 June 2016 [1] .

- **Current system in force established by DM 23 June 2016**

DM 23 june 2016 defines the basic incentive tariffs (Tb) for bioenergy plants that are listed in the table below:

Tabella 1- basic incentive tariffs (Tb) for bioenergy from DM 23 june 2016.

Renewable source	Tipology	Power (kW)	Tb = Basic incentive tariff (€/MWh)
Biogas	a) products of biologic origin	1<P≤300	170
		300<P≤600	140
		600<P≤1000	120
		1000<P≤5000	97
		P>5000	85
	b) byproducts of biologic origin	1<P≤300	233
		300<P≤600	180
		600<P≤1000	160
		1000<P≤5000	112
		P>5000	/
Biomass	a) products of biologic origin	1<P≤300	210
		300<P≤1000	150
		1000<P≤5000	115
		P>5000	/
	b) byproducts of biologic origin	1<P≤300	286
		300<P≤1000	185
		1000<P≤5000	140
		P>5000	/
	c) waste for which the biodegradable fraction is determined in the manner described in Annex 2 of DM 6/7/2012	1<P≤5000	/
		P>5000	119
Soustainable bioliquids		1<P≤5000	60
		P>5000	/

[1] Previously it was referred to the DM July 6, 2012 for plants that began operating before 1 January 2013.

Incentive tariff (I) ex Green Certificates (MIGRATION)

By 2016, as required by **DM 6 July 2012**, the Green Certificates mechanism is replaced by a new form of incentive (I). The incentive, also called incentive tariff (I), is calculated as follows:

$$\mathbf{I = K * (180 - Re) * 0.78}$$

The incentive (I) is therefore proportional to the product of the coefficient **(k)** and the difference between the reference value of a GC (1 GC = 180 € / MWh) and the selling price **(Re)**; all it multiplied by 0.78 .
"Re" is equivalent to the electricity selling price set annually by the Authority.

For plants that entered into service after 31 December 2007, GSE releases Green Certificates for 15 years, multiplying the net energy EI recognized to the intervention performed for constants, differentiated by source, of Table 1 of the 2008 Finance Act (updated by Law 99 of 23/07/2009):

Tabella 2- Updated table of K coefficients of DM 6 july 2012:

N.	SOURCE	COEFFICIENT: K
1	Wind for plants above 200 kW	1.00
1bis	Offshore wind	1.50
3	Geothermal	0.90
4	Wave and tidal	1.80
5	Hydraulics different from that of the previous point	1.00
6	Biodegradable waste, biomass other than those described in paragraph	1.30
7	Biomass and biogas produced from agricultural activities, livestock and forestry from short chain	1.80
8	Landfill gas and sewage treatment plant gas and biogases other than those of the previous point	0.80

Come si calcola

L'incentivo, anche detto tariffa incentivante, viene così calcolato:
I = k x (180 - Re) x 0,78
L'incentivo (I) è dunque commisurato al prodotto tra il coefficiente (k) e la differenza tra il valore di riferimento di un CV (180 euro per MWh) ed il prezzo di cessione dell'energia (Re); il tutto moltiplicato per 0,78.

Per correttezza di calcolo occorre considerare che:

A) Il coefficiente "k" è generalmente pari a 1 per gli impianti entrati in esercizio entro il 31 dicembre 2007. Per quelli entrati in esercizio dopo tale data, k assume differenti valori a seconda del tipo di fonte rinnovabile utilizzata:

FONTE	K
Eolica	1,00
Geotermica	0,90
Idraulica	1,00
Rifiuti biodegradabili, biomasse diverse da quelle di cui al punto successivo	1,30
Biomasse e biogas prodotti da attività agricola, allevamento e forestale da filiera corta	1,80
Gas di discarica e gas residuati dai processi di depurazione e biogas diversi da quelli del punto precedente	0,80

B) Per tutti gli impianti, tranne quelli elencati di seguito al punto 1, "**Re**" equivale al prezzo di cessione dell'energia elettrica definito dall'Autorità annualmente sulla base delle condizioni economiche registrate sul mercato nell'anno precedente.

1. Per gli impianti a biomasse entrati in esercizio entro il 31 dicembre 2012 - esclusi gli impianti a biogas - e per gli impianti "ex-zuccherifici" inclusi nei progetti di riconversione del settore bieticolo saccarifero il "**Re**" per il calcolo dell'incentivo è fisso e pari a quello registrato nel 2012.
Per gli impianti a bioliquidi cogenerativi, entrati in esercizio entro l'11 luglio 2012 e per gli impianti a bioliquidi integrati in reti interne di utenza o in sistemi efficienti di utenza entrati in esercizio entro l'11 luglio 2012, il "**Re**" per il calcolo dell'incentivo è fisso e pari a quello registrato nel 2009.

Per gli impianti cogenerativi abbinati al teleriscaldamento, anche connessi ad ambienti agricoli, entrati in esercizio **entro il 31 dicembre 2012**, l'incentivo è pari a:
I = (D - Re)

"**D**" rappresenta la somma tra:
- il prezzo medio di mercato dei certificati verdi per impianti di cogenerazione abbinati a teleriscaldamento registrato nel 2010 e
- il prezzo di cessione dell'energia del 2010;

"**Re**" equivale al prezzo di cessione dell'energia elettrica definito dall'Autorità annualmente sulla base delle condizioni economiche registrate sul mercato nell'anno precedente.

The Green Certificates are released in function of the net energy produced by the plant Ea.
The energy Ea net, however, not always constitutes directly the reference period for calculating the number of belonging green certificates.
There are different types of site actions (-new building, -riattivaction, -strengthening, - total or partial rebuiding) giving the right to obtain the incentives of all or part of net electricity produced as specified by the DM 18/12/2008 , along with several RES and other renewable but not completely equivalent to these, as some types of hybrid plants (Fossil fuels + RES), some thermal power plants combined with district heating networks, etc ...
We propose here to follow some references regarding the green certificates related to the biomass sector:
GC Release from short chain; GC Release period; Food chain from biomass; Cumulation of incentives; Bioliquids sustainability; Pellets and wood chips; Etc .. .. We refer the reader to the web pages of the GSE for specific more detailed analysis: > GSE GC <

- **Previous system instituted by DM 6 july 2012**

The basic incentive tariffs for bioenergy plants for 2012 are applicable for installations with annual average nominal power not exceeding 1 MW and are listed in the DM 6 July 2012 Annex 1, Table 1.1. given below:

Tabella 3- basic incentive tariffs (Tb) for bioenergy from DM 6 july 2012.

Renewable source	Tipology	Power (kW)	Tb = Basic incentive tariff (€/MWh)
Landfill gas		1<P≤1000	99
		1000<P≤5000	94
		P>5000	90
Gas from sewage depuration processes		1<P≤1000	111
		1000<P≤5000	88
		P>5000	55
Biogas	**a) products of biologic origin**	1<P≤300	180
		300<P≤600	160
		600<P≤1000	140
		1000<P≤5000	104
		P>5000	91
	b) byproducts of biologic origin	1<P≤300	236
		300<P≤600	206
		600<P≤1000	178
		1000<P≤5000	125
		P>5000	101
	c) waste for which the biodegradable fraction is determined in the manner described in Annex 2 of DM 6/7/2012	1<P≤1000	216
		1000<P≤5000	109
		P>5000	85
Biomass	**a) products of biologic origin**	1<P≤300	229
		300<P≤1000	180
		1000<P≤5000	133
		P>5000	122
	b) byproducts of biologic origin	1<P≤300	257
		300<P≤1000	209
		1000<P≤5000	161
		P>5000	145
	c) waste for which the biodegradable fraction is determined in the manner described in Annex 2 of DM 6/7/2012	1<P≤5000	174
		P>5000	125
Soustainable bioliquids		1<P≤5000	121
		P>5000	110

- **More previously system instituted by DM 18 december 2008**

Before 2012 the modalities of incentives were described in the **DM 18/12/2008** and its inclusive tariffs for different types of renewable sources are listed in Table 3 of the Finance Act of 2008, stated below:

Tabella 4- Incentive tariffs for bioenergy from DM 18 december 2008.

N°	SOURCE	TARIFF (€/kWh)
1	Wind for plants lower 200 kW	0.30
3	Geothermal	0.20
4	Wave and tidal	0.34
5	Hydraulic (other)	0.22
6	Biogas and biomass	0.28
8	Landfill gas, residual gases from purification processes and liquid biofuels	0.18

1.1.3. PHOTOVOLTAIC

The Energy Bill was introduced in Italy with the EU directive for renewable sources (Directive 2001/77 / EC), implemented with the approval of the Legislative Decree 387 of 2003.

This mechanism, which rewards with incentive tariffs the energy produced by photovoltaic systems for a period of 20 years, became operational with the entry into force of the implementing decrees of 28 July 2005 and 6 February 2006.

The Energy Bill is the program that encourages for operating the electricity produced by photovoltaic plants connected to the grid. This incentive system was introduced in Italy in 2005, with the Ministerial Decree of 28 July 2005 (First Energy Bill) successively regulated by other decrees, the latest Ministerial Decree of 5 July 2012 (Fifth Conto Energia). The latter ceased to apply 6 July 2013.

NOTE: The sixth energy bill yet doesn't exist, at 01/08/2016.

■ Fifth (V) energy bill (DM 5 july 2012)

The tariffs set by the fifth energy bill, contained in D.M. 5 July 2012, have ceased to apply on July 6, 2013. The Fifth Energy Bill pays with a overall inclusive tariff the quota of net energy delivered to the grid combined with a tariff premium on the quota of net energy self-consumed in site.

The following table contains the tariffs for photovoltaic systems (excluding plants built on buildings) for the year 2012 and following, divided by semester of application.

Tabella 5- Incentive tariffs for solar energy from DM 5 july 2012.

	Power range	Overall tariff [€/MWh]	Premium tarif [€/MWh]
1° semester	1≤P≤3	201	119
	3<P≤20	189	107
	20<P≤200	168	86
	200<P<1000	135	53
	1000<P≤ 5000	120	38
	P>5000	113	31
2° semester	1≤P≤3	176	94
	3<P≤20	165	83
	20<P≤200	151	69
	200<P<1000	124	42
	1000<P≤ 5000	113	31
	P>5000	106	24
3° semester	1≤P≤3	152	70
	3<P≤20	144	62
	20<P≤200	136	54
	200<P<1000	113	31
	1000<P≤ 5000	106	24
	P>5000	99	17
4° semester	1≤P≤3	140	58
	3<P≤20	133	51
	20<P≤200	126	44
	200<P<1000	107	25
	1000<P≤ 5000	101	19
	P>5000	95	13
5° semester	1≤P≤3	130	48
	3<P≤20	124	42
	20<P≤200	118	36
	200<P<1000	102	20
	1000<P≤ 5000	97	15
	P>5000	92	10
* for each next semester it applies a deduction of 15% from the starting price.			

■ Fourth (IV) energy bill (DM 5 may 2011)

For plants that entered into service after 31 May 2011, before the fifth energy bill, are valid the rules laid down by the fourth energy bill, described by D.M. 05/05/2011.

Tabella 6- Incentive tariffs for solar energy from DM 5 may 2011.

Tariff 2011	Power range	Plants on buildings (euro/kWh)	Other photovoltaic plants (euro/kWh)
Giugno	1≤P≤3	0.387	0.344
	3<P≤20	0.356	0.319
	20<P≤200	0.338	0.306
	200<P<1000	0.325	0.291
	1000<P≤ 5000	0.314	0.277
	P>5000	0.299	0.264
Luglio	1≤P≤3	0.379	0.337
	3<P≤20	0.349	0.312
	20<P≤200	0.331	0.3
	200<P<1000	0.315	0.276
	1000<P≤ 5000	0.298	0.264
	P>5000	0.284	0.251
Agosto	1≤P≤3	0.368	0.327
	3<P≤20	0.339	0.303
	20<P≤200	0.321	0.291
	200<P<1000	0.303	0.263
	1000<P≤ 5000	0.28	0.25
	P>5000	0.269	0.238
Settembre	1≤P≤3	0.361	0.316
	3<P≤20	0.325	0.289
	20<P≤200	0.307	0.271
	200<P<1000	0.298	0.245
	1000<P≤ 5000	0.278	0.243
	P>5000	0.264	0.231
Ottobre	1≤P≤3	0.345	0.302
	3<P≤20	0.31	0.276
	20<P≤200	0.293	0.258
	200<P<1000	0.285	0.233
	1000<P≤ 5000	0.256	0.223
	P>5000	0.243	0.212
Novembre	1≤P≤3	0.32	0.281
	3<P≤20	0.288	0.256
	20<P≤200	0.272	0.24
	200<P<1000	0.265	0.21
	1000<P≤ 5000	0.233	0.201
	P>5000	0.221	0.191
Dicembre	1≤P≤3	0.298	0.261
	3<P≤20	0.268	0.238
	20<P≤200	0.253	0.224
	200<P<1000	0.246	0.189
	1000<P≤ 5000	0.212	0.181
	P>5000	0.199	0.172

1.1.4. THERMODYNAMIC SOLAR

The incentive mechanism in the energy bill for solar thermal plants, regulated in principle by D.M. 11 April 2008 and subsequent amendments made by D.M. 6 July 2012 (now replaced by the Ministerial Decree of 23 June 2016) pays, with special tariffs, the electricity produced by a solar thermal power plant for a period of 25 years.

Link to tariffs: http://www.gse.it/it/Conto%20Energia/Solare%20termodinamico/Pages/default.aspx

1.1.5. WIND ENERGY

Currently the method of encouraging the production of electricity from wind farms connected to the grid, are established by DM 23 June 2016.

Tabella 7- Incentive tariffs for wind energy from DM 23 june 2016.

Fonte rinnovabile	Tipologia	Potenza	VITA UTILE degli IMPIANTI	TARIFFA
		kW	anni	€/MWh
Eolica	On-shore	1<P≤20	20	250
		20<P≤60	20	190
		60<P≤200	20	160
		200<P≤1000	20	140
		1000<P≤5000	20	130
		P>5000	20	110
	Off-shore (1)	1<P≤5000	-	-
		P>5000	25	165

1.1.6. HYDROELECTRIC

Currently the method of encouraging the production of electricity from hydroelectric palnts connected to the grid, are established by DM 23 June 2016.

Tabella 8- Incentive tariffs for hydroelectric energy from DM 23 june 2016.

Fonte rinnovabile	Tipologia	Potenza	VITA UTILE degli IMPIANTI	TARIFFA
		kW	anni	€/MWh
Idraulica	ad acqua fluente	1<P≤250	20	210
		250<P≤500	20	195
		500<P≤1000	20	150
		1000<P≤5000	25	125
		P>5000	30	90
	a bacino o a serbatoio	1<P≤5000	25	101
		P>5000	30	90

1.1.7. GEOTHERMAL ENERGY

Currently the method of encouraging the production of electricity from geoelectric plants connected to the grid, are established by DM 23 June 2016.

Tabella 9- Incentive tariffs for geothermal energy from DM 23 june 2016.

Fonte rinnovabile	Tipologia	Potenza	VITA UTILE degli IMPIANTI	TARIFFA
		kW	anni	€/MWh
Geotermica		1<P≤1000	20	134
		1000<P≤5000	25	98
		P>5000	25	84

1.1.8. MARINE ENERGY

Currently the method of encouraging the production of electricity from marine plants connected to the grid, are established by DM 23 June 2016.

Tabella 10- Incentive tariffs for marine energy from DM 23 june 2016.

Fonte rinnovabile	Tipologia	Potenza	VITA UTILE degli IMPIANTI	TARIFFA
		kW	anni	€/MWh
Oceanica (comprese maree e moto ondoso)		1<P≤5000	15	300
		P>5000	-	-

1.2. DEDICATED RETREAT AND EXCHANGE ON SITE

These are benefits that can not be accessed if it benefits from the incentives of the DM 6 july 2012.

1.2.1. Dedicated retreat

The dedicated retreadl is a simplified mode available to producers for the sale of electricity fed into the grid, as an alternative to bilateral agreements or direct sales on the stock exchange.
It consists of the electricity selling fed into the grid to the Energy Services Operator - GSE S.p.A. (GSE), which shall reward it, corresponding to the producers a price for every kWh withdrawn.

Link table of minimum prices for 2016:
http://www.gse.it/it/Ritiro%20e%20scambio/GSE_Documenti/Ritiro%20dedicato/Prezzi%20minimi%20garantiti/Prezzi%20minimi%20garantiti%202016.pdf

They may request access to the dedicated retreat plants fueled by RES and NOT RES complying with the following conditions::

- **Renewable sources:**

Rated apparent power lower than 10 MW powered by renewable sources, including the attributable production of hybrid plants;
For any power plants that produce electricity from these renewable sources: wind, solar, geothermal, wave, tidal, hydro (limited to river plants);

- **Not renewable sources:**

Rated apparent power lower than 10 MW powered by renewable sources, including the not attributable production of hybrid plants;
Apparent rated power equal to or greater than 10 MW, powered by various renewable sources from wind power, solar, geothermal, wave, tidal and hydropower, limited for the latter source to flowing water installations, as long as the ownership of a self-producer.

1.2.2. Exchange on site

The Exchange on site is a specific type of electric energy enhancement that allows the manufacturer, to produce a specific form of consumption by entering the net electricity produced but not directly self-consumed, and then pick it up at a different time than that in where production takes place.
The Exchange on site is provided:

- To the end customer inside a "More Simple Production System and Consumption" (so-called ASSPC) that is simultaneously also a producer of electricity from the production plants that make up the ASSPC;
- To the end client holder of a set of sampling points and the placing, not necessarily coincident between them, which, at the same time, is both producer of electricity in relation to production installations connected to through the aforementioned points (so-called on-site exchange elsewhere).

1.3. QUALIFICATIONS AND CERTIFICATES

- **GENERAL SCHEM FOR QUALIFICATIONS AND CERTIFICATES**

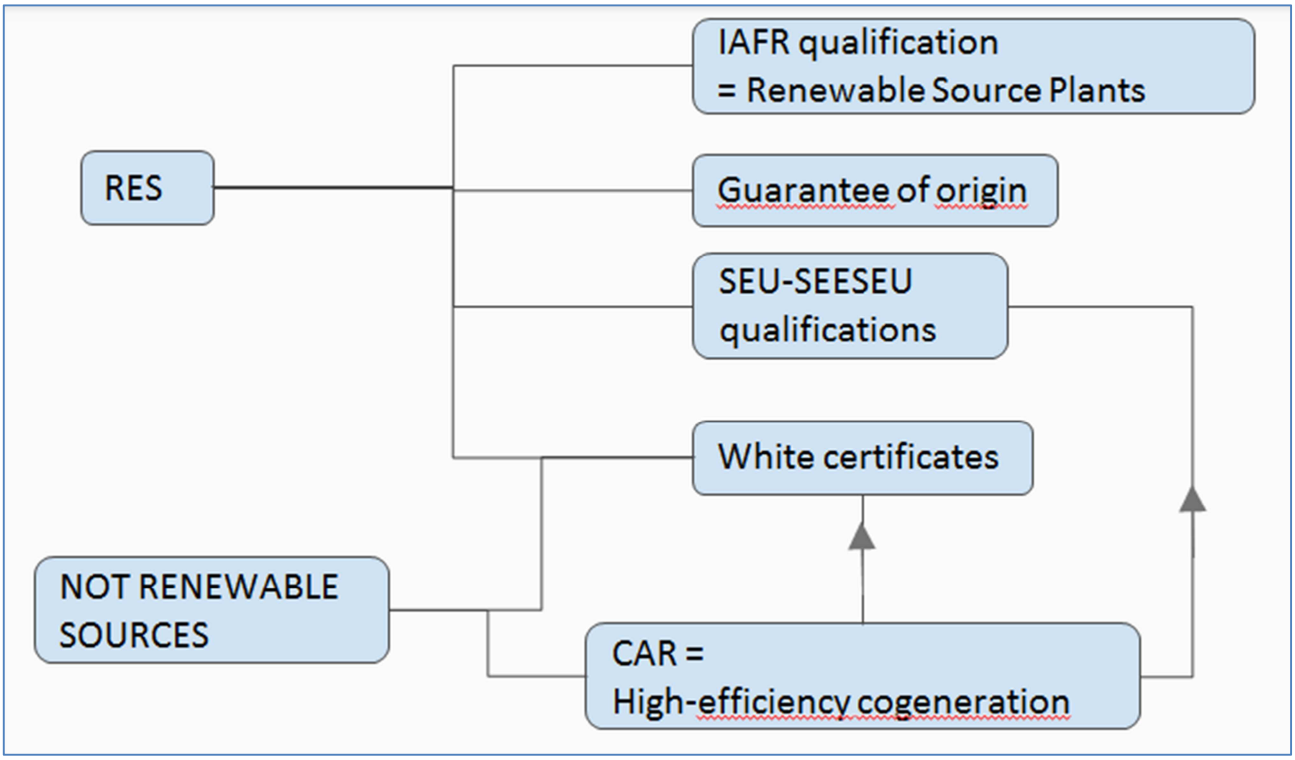


Figura 2- General schem for qualifications and certificates

- **IAFR qualification**

Qualification of plants powered by renewable sources, regulated by the DM 18/12/2008, is a necessary prerequisite for obtaining Green Certificates (GC), or to access the Overall incentive Tariff (TO). They may qualify as systems using "energy from renewable sources" or renewable non-fossil sources, such as:

- Wind;
- Solar;
- Aereothermal;
- Geothermal;
- Hydrothermal and oceanic;
- Hydro;
- From biomass;
- From gas from landfill;
- From sewage depuration processes;
- From biogas.

- **GO - guarantee of origin**

Guarantee of Origin (OW) is an electronic certification confirming renewable origin of the sources used by qualified plants IGO.
Each title GO is issued by the GSE for each MWh of electricity fed into the grid, in accordance with the Directive 2009/28 / EC.

The GO certificate, of the value equal to 1 MWh, defined according to commercial rounding criteria, is released on a monthly basis by the GSE in reference to the electricity fed into the grid, net of auxiliary services, in accordance with the Directive 2009 / 28 / EC.
This titles are issued, transferred and canceled electronically, through the "Portal GO" and expires after one year from the production of electricity which it refers, at the latest, 31 March of the following year.

- **SEU-SEESEU qualifications**

The Efficient Systems Utility Systems (SEU and SEESEU) are Simple Production and consumption systems made up at least by one production plant and by a consumption unit directly connected to each other via a private without obligation of connection link to a third party, but directly or indirectly connected at least to one point of public network.

Obtaining the status of HUS or SEESEU, released by GSE, it implies the recognition of favorable tariff conditions on electricity consumed and not withdrawn from the network.

The requirements for the obtaining of the qualification are the following:

- one or more of the power plants (with a capacity not exceeding 20 MW and total installed on the same site), powered by renewable sources or high-efficiency cogeneration, managed by the same producer, eventually different to the end customer;

- a unit of consumption of a single end user;

- **CAR - high-efficiency cogeneration**

Cogeneration is the simultaneous production, in a single process, electricity - or mechanical - and heat. For the approval of the High Efficiency condition (CAR) of cogeneration units, we must make reference to criteria established by D.M. August 4, 2011.
For cogeneration units recognized CAR is provided access to the Energy Efficiency System (TEE) or white certificates, according to the conditions and procedures established by the Ministerial Decree of 5 September 2011. Also with them it can also access to SEU- qualifications SEESEU.

- **TEE - white certificates (energy efficiency titles)**

White certificates, also known as "Energy Efficiency Titles" (TEE), are marketable securities that certify the achievement of energy savings among end users of energy through interventions and to increase energy efficiency projects.

The white certificate system was introduced in the Italian legislation by the Ministerial Decrees of 20 July 2004 and subsequent amendments and provides that the distributors of electricity and natural gas annually to reach certain savings quantitative targets for primary energy, expressed in equivalent tons of saved Petroleum (TEP).

A certificate equivalent to the saving of a ton of oil equivalent (TOE).

The Cogeneration High Efficiency units (CAR) can access the white certificate system according to the conditions and procedures established by the Ministerial Decree of 5 September 2011.

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All the data tables and GIS layers are available to free download at the following web-link:

https://drive.google.com/drive/folders/0B_Zr5PU8qrFxV2hUSGJvdlpiSXc?usp=sharing

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