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INNOVATIVE TECHNIQUES FOR WASTE MANAGEMENT

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Summary

Introduction 3

1 The integrate system of urban waste collection: normative, open issues and solutions 5

1.1 European context: waste management and production in the European States 5

1.1.1 Normative 5

1.1.2 European waste production 6

1.2 Italian context: total production in the Italian Regions 9

1.2.1 Introduction 9

1.2.2 Production and sorted collection waste at national level 9

1.2.3 Production and sorted collection waste at regional level 15

1.2.4 Waste collection in Bologna 17

1.3 Waste collection in the Hera Group 19

1.3.1 Introduction 19

1.3.2 Waste disposed 20

1.3.3 Sorted waste collection 21

1.4 Innovation in the waste management system 22

2 The Hergo project: description, aims and evolution 25

2.1 Main work phases 25

2.2 Description of the project 25

2.2.1 Focus on technologies involved 27

2.3 Systems involved: WEB GIS 28

2.4 Systems involved: SAP R3 33

2.4.1 Design, planning and scheduling 33

2.4.2 Creation of containers in SAP 36

2.4.3 Route in SAP 37

2.4.3 Frequencies in SAP 41

2.4.4 Disposal orders 43

2.5 Systems involved: System of Data Acquisition (SAC) 43

2.6 Login to field devices 45

2.7 Analysis of the actual routes 47
2.7.1 Dashboard to display position and frequencies anomalies 48
2.7.2 Analysis of the actual routes 49
2.8 Added functionality: Reporting 51
2.9 From HERGO to data analysis 52
3 Development of indicators to evaluate the system 55
3.1 Use indicators 56
3.1.1 01 - Accounting Indicator: 56
3.1.2 02 - Indicator of assignment of service Orders with ESA weighing 65
3.1.3 03a - Indicator of use of Field Systems....................................... 70
3.2 Quality indicator 89
3.2.1 04 - Reporting positions indicator... 89
3.2.2 05 – Indicator of assignment of service Orders with weighing .. 103
3.2.3 06 – Positioning containers indicator.. 112
4 Improvement of collection routes of monoperator in Modena 127
4.1 Introduction 127
4.2 Data cleaning 130
4.3 Data processing.. 133
4.4 Creating a dashboard for further analysis and evidence 135
4.5 Levers Analysis 141
4.6 Conclusions 141
5 Application of Life Cycle Assessment to waste recycling 143
5.1 LCA and environmental footprint applied to the production of recycled wool…………………………... 143
5.1.1 Method description 144
5.1.2 Case study 149
5.1.3 Discussion 152
5.1.4 Conclusions... 154
6. Conclusions 155
References 157

Introduction

This work focuses on innovative approaches applied to waste management and aimed at developing strategies and actions which can be operatively integrated into the design of environmental services.

The National and European legislation encourages measures to strengthen competition in the electronic communication sector, stimulate investments, and promote freedom of choice for consumers (in order to allow them to benefit from innovative services), quality and lower rates. In this context, optimization of processes of waste collection in logistic, economic and environmental terms, is one of the crucial aspects at both small and medium scale and in larger urban areas. A critical step to analyse and improve waste management, consists in refining the collection, organization and elaboration of all the information related to the environmental services. As such, the so-called Information and Communication Technologies (ICTs) may play a relevant role.

ICTs regard integrated telecommunication systems (wired and wireless communication lines), computers, audio-video technologies and related systems and software, which enable users to create, store and share information in digital format. The significant development of ICTs, especially since the 1990s, has been variously studied and matched to the technological paradigm shifts associated with the most significant revolutions in the history of the modern economy, for sheer size and impact on growth, productivity, production and organizational structures. ICTs have, indeed, the characteristics of the 'general purpose technologies', typically linked to such revolutions: they are an input from costs decreasing over time, with vast applications, potentially pervasive, that can decrease both the commitment of other inputs and the output price, while at the same time affecting the quality of products (Treccani, Dictionary of Finance and Economy).

My research activity, described in this work, has been developed into the context of the new strategy proposed by the Hera Group in the field of waste collection and based on ICTs (Amaducci et al., 2015, 2016; Regazzi et al., 2016). This strategy is aimed at improving the management of the environmental services relying on innovative techniques that allow the optimization of both collection and transfer processes by means of informative systems for the detection of field data. The project is named HERGO, which stands for "HERA GESTIONE OPERATIVA" (Hera Operative Management).

The HERGO project reaches its greatest aspiration through the interconnection of information systems, field devices and tracking and cartographic systems where processes and systems are designed to achieve the acquisition of services carried out in the field and allow traceability at all stages.

Data collected from the systems can be verified and are therefore more reliable, making them also a valuable heritage that is taken over by the office which designs the environmental services for assessing where and how to improve processes. HERGO enters that information into a circuit that extends its life, enabling data describing the services performed today to become added value for services that will be delivered tomorrow. The circularity of the information, made possible by the complete computerization of the system, translates into the circularity of the benefits that each stage of the process transmits to the next. A more conscious design of what has already happened, indeed, simplifies the programming and scheduling of activities, making the execution of the service leaner and creating ideal conditions to improve performance and results gradually over time.

The relevance of the project has been acknowledged at national and European levels with the assignment of the awards "CIONET Italia Award 2015", for the category "Technology Driven", and "CIO European of the Year Award - 2015", for the category "Public Sector".

In parallel to technological innovations applied to improve waste collection and the management of waste flows, another issue is the promotion of recycling. Management of secondary waste plays a crucial role for the achievement of sustainability targets required to the European Countries. New models of development, based on the reduction of final disposals, are promoted regarding to those materials that may be reused and recycled. The European Countries and their governments have implemented regulations to meet targets for material recovery and reuse, in order to reduce the effects of waste production and improve environmental protection following the principle of the sustainable development. However, national policies have shown to be generally inadequate to ensure recycling targets proposed by the EU, still far from being achieved. During my research activity, I have also analysed some case studies related to recycling scenarios to demonstrate the environmental benefit deriving from this practice (Bamonti and Bonoli, 2014; Bamonti et al. 2014; Simion et al., 2014a,b; Zanni et al., 2014; Bamonti et al., 2015; Bonoli et al., 2016a,b,c; Bamonti et al., 2016). To do this, I employed the Life Cycle Assessment (LCA) approach which provides a quantification of impact reduction with respect to selected environmental categories. In the end of the thesis is presented one of the applications that I developed.

The thesis is divided into 5 chapters. The first one provides a basis to delineate the main issues related to waste management. Chapters 2-4 regards the activity I developed within the HERGO project in collaboration with the Hera Group. Chapter 5 describes the application of LCA to evaluate a scenario of recycling in the context of textile materials. A set of conclusions closes the thesis.

1 The integrate system of urban waste collection: normative, open issues and solutions

1.1 European context: waste management and production in the European States

1.1.1 Normative

Management of secondary materials plays a crucial role for the achievement of sustainability targets of European Countries. For this reason, new models of development, based on the reduction of final disposal in landfills are promoted regarding to those materials that may be reused and recycled (e.g., Bonoli and Bamonti, 2014; Bamonti et al., 2016)

European Countries and their governments have implemented regulations to meet targets for materials recovery and reuse in order to reduce the effects of waste production and to improve environmental protection following the principle of the sustainable development (World Commission on Environment and Development, 1987). However, national policies have shown to be generally inadequate to ensure the recycling targets proposed by the EU, still far to be achieved.

Waste management is a complex sector involving legislative (laws, rules, guidelines, etc.), environmental (natural resources management), economic and urban planning aspects (e.g., Bamonti et al., 2011). Generally, regulations impose targets regarding material recovery but do not indicate the optimal strategy to achieve them. The waste framework Directive 2008/98 of the European Parliament states that a recycling at least equal to 50% has to be the target for the primary flows, i.e. those related to materials such as paper, glass, plastic and metals. In this context, waste collection systems play a crucial role, affecting the volume of recyclable materials and the consequent possibility of recovery and reuse.

As said before, the European reference legislation is based on the European Directive 2008/98 CE (2008), that establishes a legal framework for the management and treatment of the waste in the EU, designed to protect the environment and human health, underlining the importance of proper management techniques, reuse and recycle waste, to the aim to reduce pressures on the resources and to improve their use.

The 2008/98 CE imposes objectives and principles to be followed for proper waste management, but how to comply and absorption of these indications are responsability of Member Countries. The following is a summary of the most significant steps of the Directive. The first point regards the indication of the correct hierarchy of waste management based on prevention, reuse, recycling, and recovery of materials or energy and, finally, is planned landfill (Fig. 1.1.1.1).

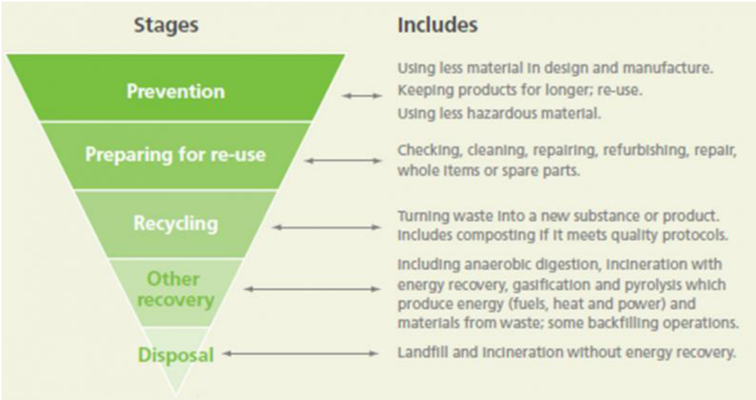


Fig.1.1.1.1 – Hierarchy of waste management

It also introduces the new recycling and recovery targets to be reached by 2020 set at 50% for domestic waste and 70% for construction and demolition waste. It does not regard some types of waste such as radioactive waste, decommissioned explosives, faecal matter, waste water and animal carcasses.

1.1.2 European waste production

According to Eurostat information, integrated with ISPRA data (2016), Italy in 2014 (considering EU 28) produced about 240.8 million tons of municipal waste, 0.5% less than 2013. In 2014 a decreasing trend of urban waste production was confirmed, started in the previous years (between 2012 and 2013, the increase was 1.5%).

Considering the EU 15 (old member states), the recorded reduction between 2013 and 2014 amounted to 0.2% (from about 208.3 million tons to about 207.9 million tons), while in reference to new Member States, a decrease of 2.3% is noted in the same period (from about 33.8 million tons to about 33 million tons) (ISPRA, 2016).

In both groups the percentage of reduction between 2013 and 2014 is lower than that recorded between 2012 and 2013. If we analyze the data of production per capita (Table 1.1.2.1 and Figure 1.1.2.1), calculated as the ratio between production and the average population of the reference year, which allows to release the information from the resident population level, we observe how the situation appears to be characterized by considerable variability going from 249 kg/inh per year in Romania to 758 kg/inh per year in Denmark.

State/Grouping	2012	2013	2014
European Union (28 SM)	487	478	474
European Union (15 SM)	528	519	516
New member state	332	322	315
Belgium	447	437	436
Bulgaria	460	432	442
Czech Republic	308	307	310
Denmark	750	752	758
Germany	619	615	618 e
Estonia	280	293	357
Ireland	587	586 s	583 m
Greece	506	509 s	513 m
Spain	468	454	435 e
France	538	517	509
Croatia	391	404	387
Italy	504	491	488
Cyprus	657	618	617 e
Latvia	301	312	325
Lithuania	445	433	433
Luxembourg	652	616	616 e
Hungary	402	378	385
Malta	588	582	600
Netherlands	549	526	527
Austria	579	578	566
Poland	317 e	297 e	272 e
Portugal	453	440	453
Romania	251	254	249
Slovenia	362	414	432
Slovakia	306	304	321
Finland	506	493	482
Sweden	450	451	438
United Kingdom	477	482	482

Tab.1.1.2.1 Per capita urban waste production in the EU area (kg/inh. per year, 2012-2014) (ISPRA, 2016).

Note: (m) data not available in Eurostat's database; the value is calculated by ISPRA considering the data relative to 2013 production; (E)Member State estimate; (S) Eurostat estimate. Source: ISPRA data processing based on Eurostat data.

Analysis of the data confirms the clear difference between the old and the new member states, with the latter characterized by the production values per capita being much lower than in the first. Indeed, per capita EU 15 is equal to 516 kg/inh. per year (-0.7% respect to 2013), while for the new member states the figure stopped at 315 kg/inh. per year (-2, 1% compared to 2013).

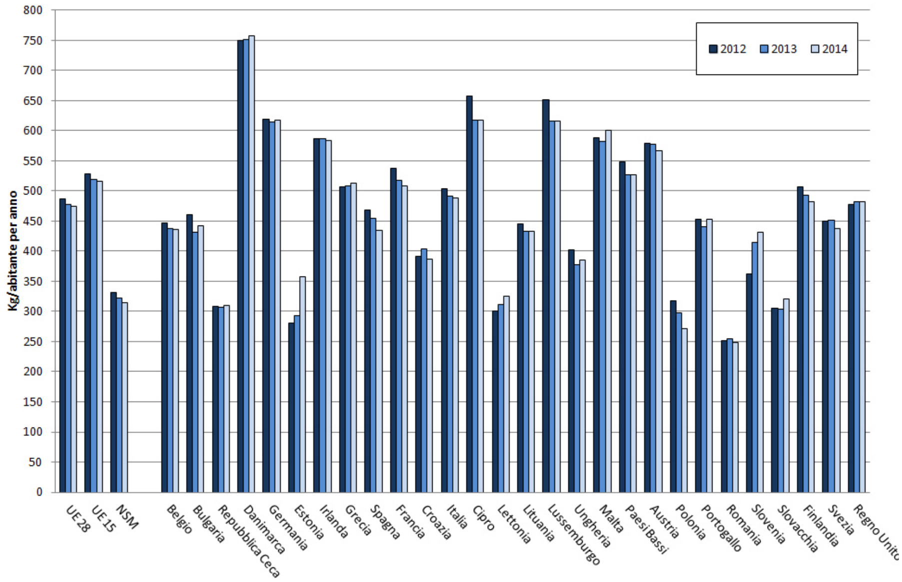


Fig. 1.1.2.1 - Production per capita of urban waste in Eu (kg / inh. per year), years 2012-2014 (ISPRA, 2016).

1.1.3 European waste management

In 2014 in the EU 28, about 28% of urban waste is managed with recycle, about 16% of it goes to composting and anaerobic digestion, while about 27% and 28% of it is, respectively, incinerated and landfilled (Fig.1.1.3.1). In the last three-year-period (2012-2014), the consolidation of the community policies and regulations to reduce the waste going to landfill, in particular biodegradable waste, clearly reflects the progress of waste quantities destined to this form of disposal.

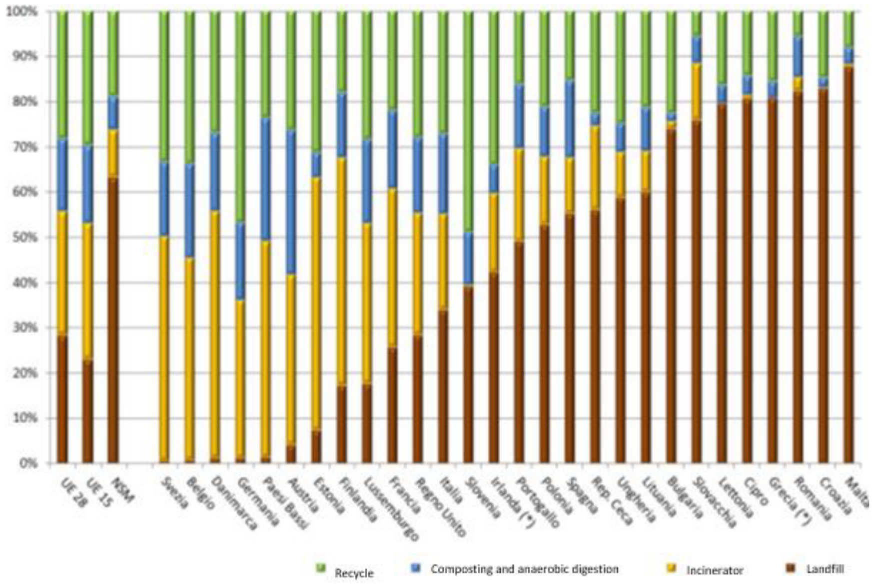


Fig. 1.1.3.1 - Percentage allocation of the Eu urban waste management, year 2014 (data sorted by increasing landfill disposal percentages) (ISPRA 2016).

At EU level 28, indeed, between 2012 and 2014 there was a decrease of 13.5%, while between 2013 and 2014, the reduction was about 7.3%. The reduction in the last two years, covers both the EU15 (-8.6%) and the new members (-4.2%). The data are significantly diversified for the EU states.

In particular, the landfill is used especially in the new member states (with a per capita average of 189 kg/inh. per year). Malta should be noted, which disposes in landfills 87.6% of waste treated. Among the old member states (characterized by an average of landfilling per capita of 117 kg/inh. per year), it is to be noted that the lower use of landfill (+ 1.4%) in Sweden, Belgium, Denmark, Germany and the Netherlands.

An opposite situation is recorded regarding to the incineration (including energy recovery), which is by far the most widespread in the EU 15 (with an average of 152 kg/inh. per year) and in the new states (on average 31 kg / inh. per year).

Even recycling and biological treatment of the biodegradable fraction (composting and anaerobic digestion) are more common in old member states (150 and 88 kg/inh.t per year, respectively, for recycling and biological treatment) than in the new members (57 and 22 kg/inh. per year for recycling and biological treatment, respectively).

1.2 Italian context: total production in the Italian Regions

1.2.1 Introduction

Waste management in Italy is governed by the IV Part of the Legislative Decree 2006, n° 152/2006, the so-called "Unique Environmental Text", issued following the EU directives on waste, hazardous waste, packaging and packaging waste. This decree has absorbed the principles and the changes introduced by Directive 2008/98 EC, conditioning all the lower levels of planning involved.

The rules obligate the major possible reduction of the waste to be sent for final disposal both in mass and volume, to enhance the prevention and re-use activities, recycling and recovery. An adequate network of facilities has to be made with the use of best available techniques and taking into account the relationship between the costs and the overall benefits. One needs to make adequate disposal of non-hazardous municipal waste in order to avoid critical situations and therefore to make full use of appropriate plants taking into account geographical context and the need for specialized plants for particular types of waste. It is also essential to use appropriate methods and technologies to ensure a high level of environmental and public health protection.

1.2.2 Production and sorted collection waste at national level

In 2015, the production of domestic waste in Italy amounts to about 29.5 million of tons, with a decrease of 0.4% in respect to 2014 (Table 1.2.2.1, Figure 1.2.2.1). Following this reduction, the production is below the level registered in 2013, with an overall decrease, compared to 2011, to almost 1.9 million tons (-5.9%).

The reduction in production per capita is lower (-0.2%, -1 kg per inh. per year, Table 1.2.2.1), because it is balanced by a simultaneous decrease of the resident population (Istat demographic balance at 31 December).

Macroarea	2011	2012	2013	2014	2015
	(1000*t)				
North	14.345,5	13.719,8	13.595,2	13.772,4	13.719,3
Center	7.018,0	6.741,2	6.629,1	6.611,0	6.555,2
South	10.022,7	9.532,5	9.348,1	9.268,3	9.249,8
Italy	**31.386,2**	**29.993,5**	**29.572,5**	**29.651,7**	**29.524,3**

Table 1.2.2.1 – Total municipal waste production by macro geographical area, years 2011 – 2015. (ISPRA, 2016).

Figure 1.2.2.2 shows the discordant trend of the three indicators. Generally, the indicator of waste production is coherent with the trend of socio-economic indicators, while, for year 2015, the decline of waste production corresponds to an increase both in the gross domestic product (+ 1.4% at current values and + 0.7% at linked values), and in the spending consumption in the resident and non-resident economic territory (+ 1.6% at current values and + 1.7% in linked values).

It should be noted that there are other factors affecting the production of municipal waste; among these are cited, for example:

• The implementation of door to door collection systems and/or punctual rate which can contribute to a reduction of improper filling;

• The reduction of the part relating to assimilated waste, as a result of direct management by the private sector, especially in the case of economically profitable types;

• The action to reduce the waste production at source as a result of specific prevention measures.

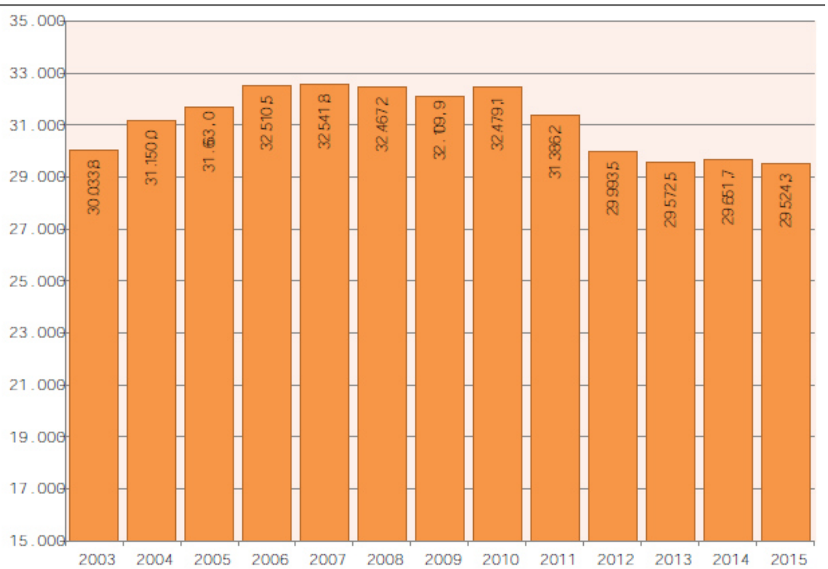


Figura 1.2.2.1 – Trend of urban waste production, years 2003 – 2015 (ISPRA, 2016).

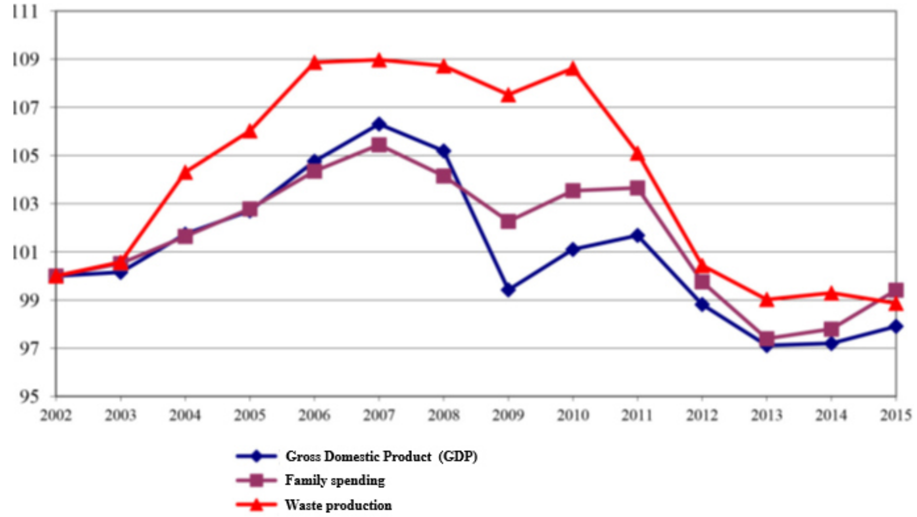


Figure 1.2.2.2 – Trend of social-economic indicator, years 2002 – 2015
Source: ISPRA, social-economic indicator data: ISTAT.

In 2015, the production of municipal waste decreased in all geographic areas, with a largest percentage decline in the center of Italy (-0.8%) and more moderate in the South (-0.2%). In the North the percentage drop is similar to the reduction observed at the national level (-0.4%). Regional data shows, however, that this lower decrease is not a result of a uniform trend in all geographical contexts. In absolute terms, the quantity of UW (urban waste) products in 2015 amounted to 13.7 million tons in the North, 6.6 million tons in the Centre and 9.2 million tons in the South (ISPRA, 2016). The last three years, the per capita production (Tab.1.2.2.2) remains mainly unchanged, amounting, in 2015, to 487 kg per inhabitant per year. As described above, the smaller contraction of per capita data than that of absolute production is due to a simultaneous decrease of the resident population (-0.2% between 2014 and 2015). In Southern Italy the decline of the population is lower than the decline of waste production, causing a slight increase in production per capita (from 443 to 444 kilograms per capita per year). In Central Italy, however, a decline in the per capita value of 0.7% related to 2014 is found, while in the North the percentage reduction is 0.2%. Central Italy, with 543 kg per capita per year, confirms itself as the geographical macro area with the highest production values per capita.

In 2015, the percentage of sorted waste collection is about 47.5% of national production, with an increase of 2.3 points in comparison to 2014 (45.2%, Figure 1.2.2.3, Table 1.2.2.3).

Macro area	**Population 2015**	**2011**	2012	2013	2014	2015
		(Kg/inh.*year)				
North	27.754.578	527,2	504,5	489,3	495,4	494,3
Center	12.067.803	605,0	581,6	549,2	546,8	543,2
South	20.843.170	486,1	462,6	446,7	443,3	443,8
Italy	**60.665.551**	**528,1**	**505,0**	**486,5**	**487,7**	**486,7**

Table 1.2.2.2 – Urban waste production per capita for geographical macroarea, years 2011 – 2015
Source: ISPRA, social-economic indicator data: ISTAT.

In absolute terms, the separate collection exceeds 14 million tonnes, an increase of 619,000 tons compared to 2014 (+ 4.6%). In the North the amount totaled at an excess of 8 million tons, in the center at almost 2.9 million tons and in the South at 3.1 million tons. These values translate into percentages, calculated relative to the total production of municipal waste for each macro-area, 58.6% for the northern regions, to 43.8% for the Centre and 33.6% for the regions of Southern Italy.

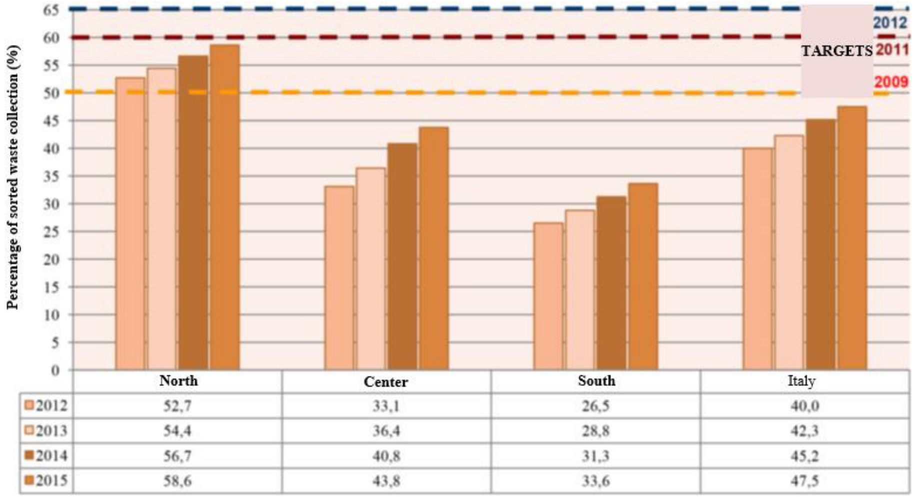


Figure 1.2.2.3 – Performance of separate collection of municipal waste, years 2012 – 2015 (ISPRA, 2016).

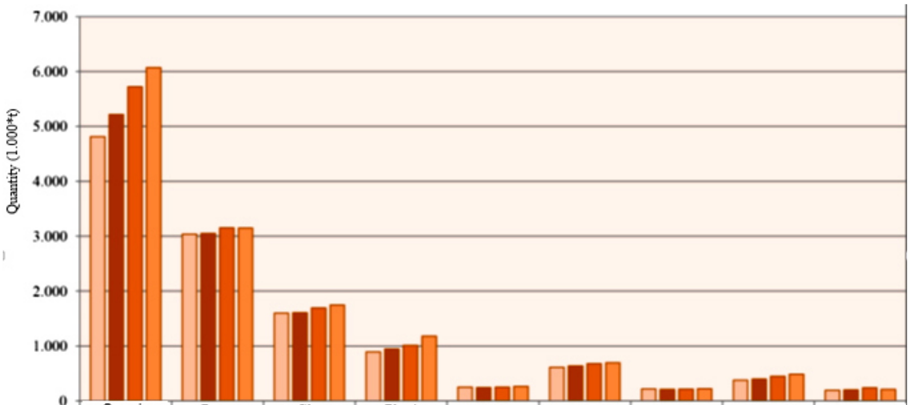
The collection per capita is 231 kg per inhabitant per year (on a national scale), with values of 290 kg per capita per year in the North (+9 kg per inhabitant per year compared to 2014), 238 kg per inhabitant per year in the Center of Italy (+15 kg per inhabitant per year) and 149 kg per capita per year in the South (+ 10 kg per inhabitant per year, Table 1.2.2.3).

	Quantitative collected (Separate collect.) (1.000*t)				Per capite (Separate collect.) (kg/ab.*anno)			
	North	**Center**	**South**	**Italy**	**North**	**Center**	**South**	**Italy**
2011	7.327,9	2.122,5	2.398,5	**11.848,0**	269	183	116	**199**
2012	7.234,4	2.229,6	2.528,3	**11.992,3**	266	192	123	**202**
2013	7.400,4	2.414,8	2.693,2	**12.508,5**	266	200	129	**206**
2014	7.803,1	2.700,2	2.898,1	**13.401,4**	281	223	139	**220**
2015	8.043,4	2.868,2	3.109,3	**14.020,9**	290	238	149	**231**

Tab.1.2.2.3 – Separate collection of municipal waste for geographical macro area, years 2011 – 2015, (ISPRA, 2016).

For the five-year period 2011-2015 there was an increase of 55 kg per inhabitant per year in the regions of Central Italy and an increase of 33 kg per inhabitant per year in the region of the South. In the North, the increase is more moderate, reaching +21 kg per inhabitant per year (Fig.1.2.2.4, Tab. 1.2.2.4).

Nationwide separate collection per capita is scoring in the five-year period, an increase of 32 kg per inhabitant per year. The analysis of the data collection of the main waste fractions shows, between 2014 and 2015, an increase of approximately 350 thousand tons (+ 6.1%) of separate collection of organic waste (wet and green), which follows the growth of about 500 thousand tons (+ 9.6%) recorded between 2013 and 2014.



	Organic	Paper	Glass	Plastic	Metal	Wood	EEE	Bulky waste	Other
2012	4.813,4	3.037,6	1.598,1	889,8	248,9	614,1	219,7	377,3	193,4
2013	5.216,9	3.051,4	1.608,1	945,2	241,0	635,2	209,2	398,5	203,0
2014	5.720,0	3.153,9	1.691,3	1.012,5	249,6	676,0	213,7	447,3	237,2
2015	6.071,5	3.149,9	1.747,8	1.178,0	261,1	695,3	222,9	484,3	210,0

Fig. 1.2.2.4 - Separate collection of main waste fractions, years 2012-2015 (ISPRA, 2016).

Note: in "Other" are also included textile waste and waste from selective collection. For those fractions, the disaggregated data 2015 is shown in Table 1.2.2.5, (ISPRA, 2016).

Waste fraction	Quantitative collected (1.000*t)			
	North	**Center**	**South**	**Italy**
Organic waste	3.385,1	1.224,0	1.462,5	**6.071,5**
Paper and cardboard	1.732,6	769,9	647,5	**3.150,0**
Glass	1.036,1	338,2	373,5	**1.747,8**
Plastic	710,2	197,6	270,3	**1.178,0**
Metal	171,0	47,6	42,5	**261,1**
Wood	514,3	112,2	68,9	**695,3**
EEE	130,6	48,2	44,1	**222,9**
Bulky waste (mix)	235,6	92,3	156,5	**484,3**
Textile	68,2	28,7	32,3	**129,0**
Selective collection	30,5	7,0	5,0	**42,4**
Others	29,3	2,8	6,4	**38,6**
Total	**8.043,4**	**2.868,2**	**3.109,3**	**14.020,9**

Tab. 1.2.2.4 – Distribution of separate collection for the main waste fractions divided for geographical macroarea (ISPRA, 2016).

Waste fractions	Quantitative per capite collected (lg*inh.*y)			
	North	**Center**	**South**	**Italy**
Organic waste	122,0	101,4	70,2	**100,1**
Paper and cardboard	62,4	63,8	31,1	**51,9**
Glass	37,3	28,0	17,9	**28,8**
Plastic	25,6	16,4	13,0	**19,4**
Metal	6,2	3,9	2,0	**4,3**
Wood	18,5	9,3	3,3	**11,5**
EEE	4,7	4,0	2,1	**3,7**
Bulky waste (mix)	8,5	7,6	7,5	**8,0**
Textile	2,5	2,4	1,5	**2,1**
Selective collection	1,1	0,6	0,2	**0,7**
Other	1,1	0,2	0,3	**0,6**
Total	**289,8**	**237,7**	**149,2**	**231,1**

Tab. 1.2.2.5 – Distribution of per capita separate collection for the main waste fractions divided by geographical macroarea, year 2015 (ISPRA, 2016).

Table 1.2.2.5 and Fig. 1.2.2.5 indicate the following quantitative of separated collection:

- The cellulose and organic parts represent, as a whole, the 66% of the total (Fig. 1.2.2.5). In addition, these two materials, with textile waste and wood, are the so-called biodegradable municipal waste, whose total quantity collected in different ways was, in 2015, 10 million tonnes (71.6% of the total collected).
- The glass collection involves 1.7 million tons, with an increase of 3.3% in respect to 2014;
- The plastic collection is almost 1.2 million tons, with an increase of 16.3% in all areas but particularly in the South of Italy.
- In the glass and plastic waste collection the packaging constitutes the predominant type of waste (85%glass, 91% plastic);
- The wood collection increases 2.9%. The total is, in 2015, 695 thousand tons, made by almost 15% of packaging.
- The metal collection is above 260 thousand tons with an increase of 4.6% in respect to 2014, with an estimate of 42% made by packaging.
- The WEEE (waste electrical and electronic equipment) collection reaches 223 thousand tons, with an increase from 2014 to 2015 of 4.3%. For this type of waste, the European and National legislation provides specific collection, recycling and overall recovery targets. From 2016 the collection target rate of 45% is applied, calculated as the ratio between the total weight of WEEE collected by the Member State in any given year and the average weight of EEE placed on the market in the same Member State, in previous three years. In 2015, the data collection per capita of WEEE amounted to 3.7 kg per capita per year, which is slightly higher than that of 2014 (3.5 kg per capita for the year). In the North and the Centre of Italy is, respectively, 4.7 and 4 kg per inhabitant per year, below the target set for 2015, while in the South, with 2.1 kg per inhabitant per year, is still far from it.

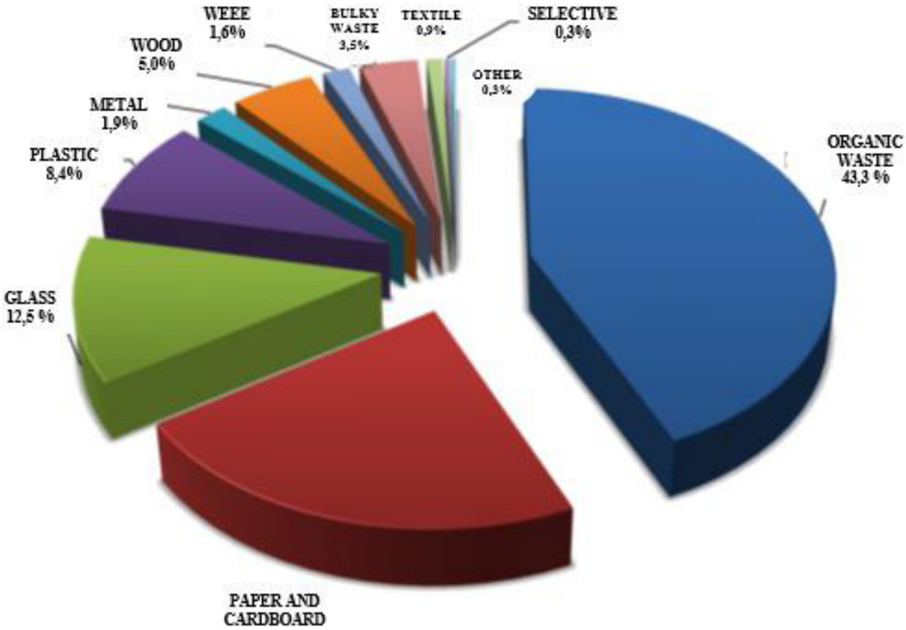


Fig. 1.2.2.5 – Distribution of separate collection, year 2015 (ISPRA, 2016).

1.2.3 Production and sorted collection waste at regional level

In eleven Italian regions between 2014 and 2015 there was a decrease in waste production (Table 1.2.3.1). In particular, Liguria, Veneto, Umbria and Lazio have the most significant value. Instead, increases are also recorded for Friuli Venezia Giulia, Emilia Romagna and Toscana regions. The other Regions have roughly stable values.

Emilia Romagna is the region with the highest production values per capita: 642 kg per inhabitant in 2015, with an increase of1.2%, over the previous year (Figure 1.2.3.1).

REGION	Total separate waste collection		Percentage of separate collection	
	2014	2015	2014	2015
	(t)		(%)	
Piemonte	1.112.885	1.130.934	54,3	55,1
Valle D’aosta	31.067	34.644	42,9	47,8
Lombardia	2.615.335	2.714.373	56,3	58,7
Trentino Alto Adige	331.925	329.449	67,0	67,4
Veneto	1.514.735	1.507.350	67,6	68,8
Friuli Venezia Giulia	334.078	353.738	60,4	62,9
Liguria	306.918	329.906	34,3	37,8
Emilia Romagna	1.556.114	1.642.974	55,1	57,5
North	**7.803.058**	**8.043.367**	**56,7**	**58,6**
Toscana	997.619	1.049.111	44,3	46,1
Umbria	233.141	226.175	48,9	48,9
Marche	458.358	458.830	57,6	57,9
Lazio	1.011.115	1.134.109	32,8	37,5
Center	**2.700.232**	**2.868.225**	**40,8**	**43,8**
Abruzzo	273.534	292.573	46,1	49,3
Molise	26.963	31.335	22,3	25,7
Campania	1.219.484	1.246.050	47,6	48,5
Puglia	496.071	571.097	25,9	30,1

Basilicata	55.447	61.444	27,6	30,9
Calabria	150.732	200.718	18,6	25,0
Sicilia	291.650	300.386	12,5	12,8
Sardegna	384.246	405.661	53,0	56,4
South	**2.898.126**	**3.109.265**	**31,3**	**33,6**
Italy	**13.401.416**	**14.020.857**	**45,2**	**47,5**

Table 1.2.3.1 – Separate collection of urban waste for all Italian Regions, years 2014 – 2015 (ISPRA, 2016).

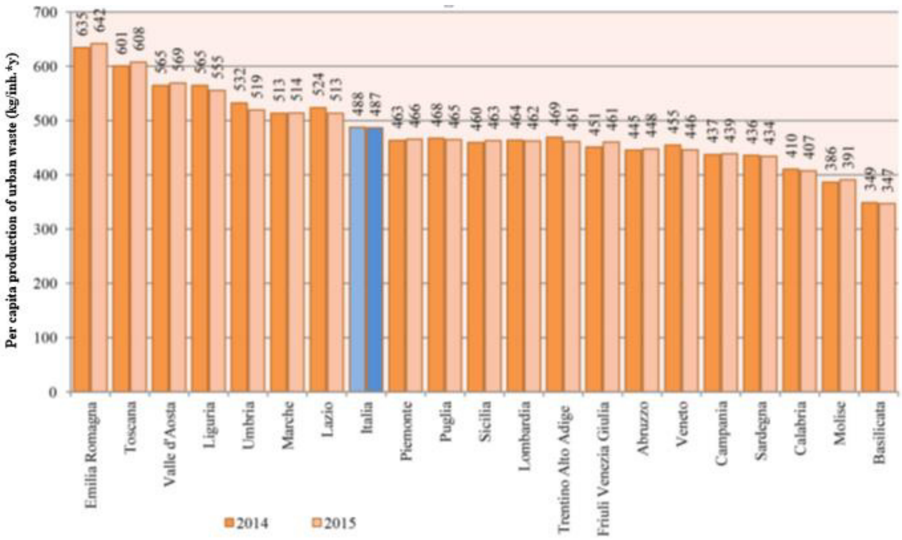


Fig. 1.2.3.1 – Per capita urban waste production for all Italian Regions, years 2014 – 2015 (ISPRA, 2016).

Among the seven provinces with a per capita production of more than 650 kg per inhabitant there are four provinces of Emilia Romagna: Reggio Emilia (with the highest production value per capita of Italy) with 750 kg per capita per year, followed by Rimini (726 kg per inhabitant per year), Ravenna and Forlì-Cesena (ISPRA, 2016). In 2015, the highest percentage of recycling is achieved by the Veneto region, with 68.8%, followed by Trentino Alto Adige with 67.4% (Table 1.2.3.1, Fig. 1.2.3.2). In 2014, both regions are already above the target of 65% set by the regulations for 2012. The Friuli Venezia Giulia percentage of waste collection stands at 62.9% and Lombardy, Marche, Emilia Romagna, Piedmont and Sardinia are above 55%.

The other Regions all stand below 50%, but some of these are placed, still higher than 45%: Abruzzo, Umbria, Campania, Valle d'Aosta and Toscana. At the provincial level, the highest levels of separate collection are detected in Treviso, which in 2015 amounted to 84.1%. At near 80% is the rate of the province of Mantova (79.9%) and equal to 78.4% that of Pordenone. Above 70% Belluno, Trento, Macerata, Parma and Vicenza are placed (Fig. 1.2.3.3). The lower levels of separate collection are observed for the Sicilian provinces of Palermo (7.8%) Syracuse (7.9%), Messina (10.1%) and Enna (10.8%).

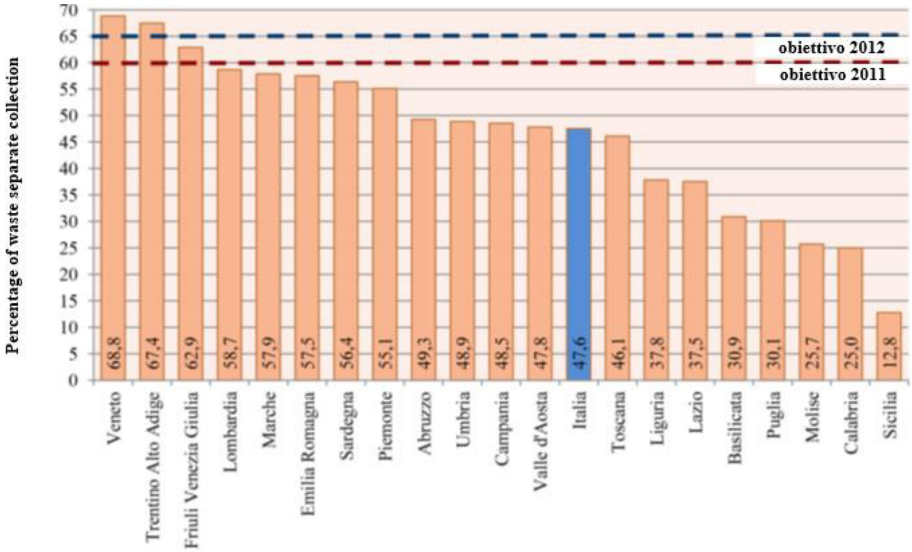


Figure 1.2.3.2 – Percentage of separate collection for all Italian Regions, years 2015

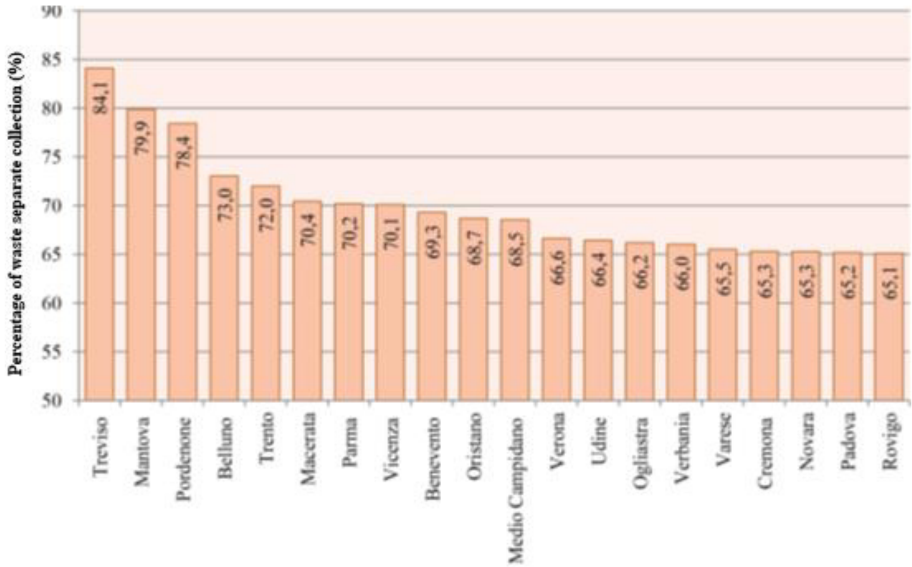


Fig. 1.2.3.3 – province with a value of separate collection higher of 65 %, year 2015

1.2.4 Waste collection in Bologna

In this chapter the analysis of waste production of municipalities with more than 200,000 inhabitants is shown, with a focus for the city of Bologna.

The municipalities with more than 200,000 inhabitants generated a total of 5.5 million tons of municipal waste, with a 0.9% decrease compared to 2014 (Table 1.2.4.1, Fig. 1.2.4.1). This reduction is more sustained than that found nationwide (-0.4%). The major urban centers have, in general, a higher production per capita than the national average and to the average of their local contexts. The per capita average of 16 municipalities analyzed amounted, in fact, to about 544 kg per capita per year, 57 kg more than the Italian average (487 kg per capita per year). The city of Bologna has a production value of waste of 555 kg/inh. per year, with an increase of 4 kg per capita compared to 2014 and higher than the average of 13%.

Municipalities	Population 2015	Urban waste production (t)				
		2011	2012	2013	2014	2015
Torino	890.529	480.625	448.864	449.699.	440.670	439.698
Milano	1.345.851	692.600	666.766	650.670	666.471	668.068
Verona	258.765	135.415	131.097	130.680	134.619	133.711
Venezia	263.352	180.045	165.035	162.448	161.669	161.142
Padova	210.401	141.056	136.236	129.261	128.577	121.195
Trieste	204.420	96.300	92.614	90.307	89.707	89.157
Genova	586.655	329.361	316.844	305.864	305.501	301.967
Bologna	**386.663**	**200.932**	**195.414**	**199.877**	**211.820**	**214.781**
Firenze	382.808	246.312	234.589	232.730	239.043	239.829
Roma	2.864.731	1.785.653	1.739.407	1.754.823	1.719.848	1.681.245
Napoli	974.074	516.673	505.362	496.555	500.086	502.181
Bari	326.344	188.034	184.226	186.687	184.896	183.164
Taranto	201.100	113.532	104.221	106.917	108.658	104.093
Palermo	674.435	371.580	346.960	339.608	345.468	345.877
Messina	238.439	212.607	116.607	114.528	111.278	112.203
Catania	314.555	224.239	207.562	204.713	205.791	208.532
Total	**10.123.122**	**5.823.964**	**5.591.804**	**5.555.367**	**5.554.102**	**5.506.843**

Table 1.2.4.1 – Waste production in the city with more of 200,000 inhabitants, years 2011 – 2015 (ISPRA, 2016)

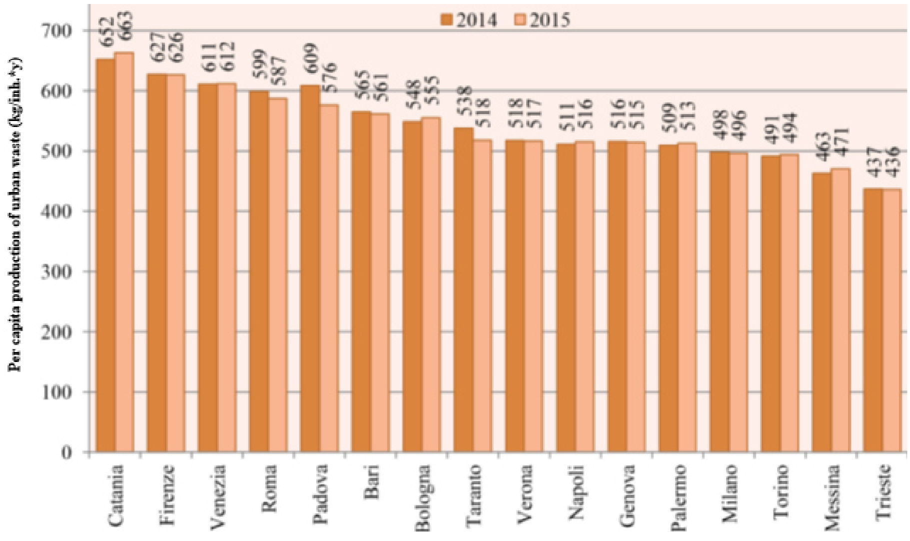


Fig. 1.2.4.1 – Waste production per capita in the city with more of 200,000 inhabitants, years 2014 – 2015 (ISPRA, 2016).

The average percentage of collection of 16 municipalities amounted to 36,3%, 11,2 points lower than the national average (ISPRA, 2016). Compared to 2014, when the average percentage of 16 municipalities stood at 33,7%, there was an increase of 2,6 points. The higher levels of separate waste collection are observed in Venezia (Fig. 1.2.4.2), with a value of 54.3%, followed by Milan (52.3%), Verona (50,8%) and Padova (50.7%). Florence has a percentage of 46.4%, Bologna to 43.6% (an increase of 5.3 points respect to 2014) and Turin to 42.4%.

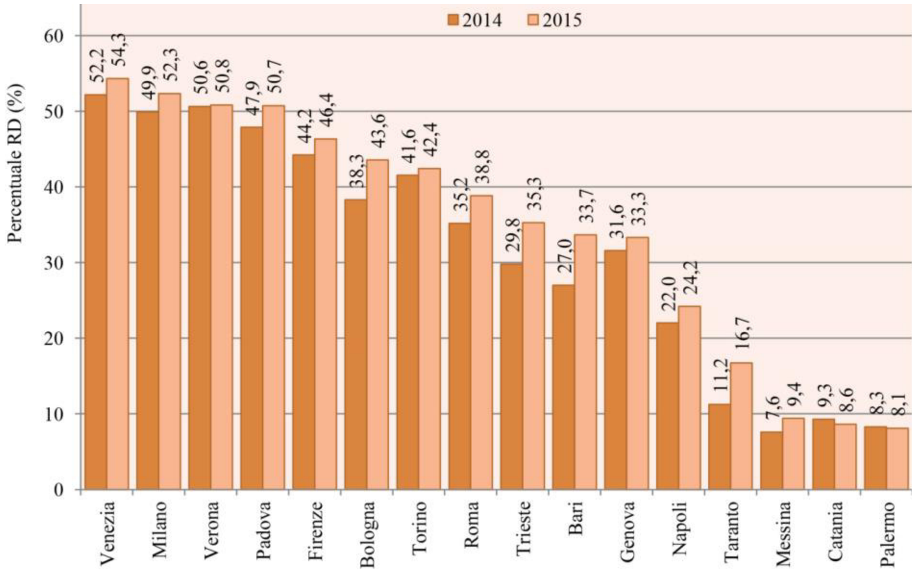


Fig. 1.2.4.2 – Distribution of the percentage of separate collection in the city with more of 200,000 inhabitants, years 2014 – 2015. (ISPRA, 2016).

The aim of Bologna is to achieve the percentage of 50% of separate collection by the application for all types of waste of the door to door collection and by the introduction of the mini-ecological island in the city Centre. In the other boroughs, the system based on the "CUP" is applied. The cup is an object assembled with the dumpster for the not-separated collection. It allows the reduction of this type of waste (20-22 liter bags) and the promotion of separate collection.

1.3 Waste collection in the Hera Group

1.3.1 Introduction

The Hera Group in 2015 served 189 municipalities and a total population of 3,3 million inhabitants. In particular, Hera supplies 133 municipalities in six provinces of the Emilia Romagna Region, and three municipalities in the province of Florence. By means of Marche Multiservizi, it serves 40 municipalities in the provinces of Pesaro and Urbino and another 6 municipalities in the province of Ancona. With AcegasApsAmga it manages environmental services in 7 municipalities belonging to the provinces of Padova and Trieste. The average weight collected per inhabitant in 2015 is 608 kg (Tab.1.3.1.1) (ISPRA, 2016).

The waste management system has been defined by three main services:

- ✓ Territorial collections: for domestic consumers and small non-domestic users;
- ✓ Residential collection (target users): for non-domestic users that produce specific waste similar to urban waste;
- ✓ Waste collection centers: infrastructure for the separate collection of all municipal waste, including hazardous.

The system is also integrated by doorstep collection of bulky waste, of garbage from vegetation and of some types of hazardous waste (such as batteries and medicine).

The territories are divided into homogenous areas of collection (historical centers, residential, tourist and suburban areas, industrial zones) to guarantee greater efficiency. In the homogeneous areas, the most functional services are applied, to maximize recycling, its quality and to guarantee technical and economic sustainability. The different collection systems that Hera is implementing are oriented to apply the punctual rate in the future, by means of:

- Street containers with the control system and user identification;
- Door to door collection made by means of containers with tag transponder;
- Waste collection center with weighing and user registration systems.

Thousands of tonnes	2013	2014	2015
Hera	1.582,1	1.605,1	1.627,5
AcegasApsAmga	254,5	257,1	247,3
Marche Multiservizi	174,1	165,6	157,1
Totale	**2.010,6**	**2.027,8**	**2.031,9**
Kg per ab (Hera Group)	608	605	601

Tab.1.3.1.1 – Total weight of waste collected by the Hera Group (Hera Group, 2016).

In 2015 the use of landfill decreasead by 4,7% in comparison to 2014 and the total part of waste disposed of was 8,6%, in respect to the average Italian value of about 34% (fonte Eurostat 2014). So, the territories managed by Hera have already reached and exceeded the objectives for 2030, fixed by the European Union, regarding to the use of no more than 10% of disposal landfill (Tab.1.3.1.2).

	Landfill	Incinerator	Composting/Recycling
2002	49% (16,2% without pre-treatment)	25,0%	26,0%
2014	13,3% (7,0% without pre-treatment)	33,8%	52,8%
2015	8,6 (1,9% without pre-treatment)	38,5%	52,9%

Tab. 1.3.1.2 – Treatment of the waste collected by the Hera Group during the years (Hera Group, 2016).

1.3.2 Waste disposed

The plant system of Hera group includes all types of plants to recover and recycle matter and energy and to dispose of the waste. As said before, the total amount of waste treated in the landfill has been reducted in respect to 2014. Even the amount of waste treated in composting and physical chemical treatment plants decreases due to lower quantities worked in Lugo and the plant stoppage of Sant'Agata Bolognese (Tab. 1.3.2.1).

Thousands of tons	2013	2014	2015
Selection plants	378,1	445,6	432,7
Incineration and biomass power plant	1.410,6	1.402,4	1.390,3
Composting and stabilization plant	527,8	478,3	455,3
Landfill	1.252,2	1.137,3	918,5
Inerting and chemical/physical treatment	1.094,3	1.182,3	1.141,6
Other plants	1.623,7	1.779,9	1.887,2
Total	**6.286,7**	**6.425,8**	**6.225,7**

Tab. 1.3.2.1 – thousands of tons treated in 2015 by the Hera Group (Hera Group, 2016)

1.3.3 Sorted waste collection

The percentage of the sorted waste collection in the territories managed by the Hera group is about 55.4% in 2015 (ISPRA, 2015), a higher value in respect to 54% of 2014. The average Italian value is 45.2% (ISPRA, 2014). Moreover, in these areas, the percentage of sorted waste collection is doubled in comparison to 2004.

In 2015 the sorted waste collection is increased by 1.2 million tons (+2% in respect to 2014) and the total percentage result (55,4%) confirms the increase in the Triveneto Area (54,7% Padova), instead, in the Marche Multiservizi Areas (52,9%), the reduction of a percentage point is due to minor collection of inert materials in the waste collection center.

Table 1.3.3.1 shows the detail of the percentage of the single collected material per area managed by the Hera Group, North of Italy, Italy and the best Italian Region.

Kg/inh.	PAPER	GLASSES	PLASTIC	WOOD	METALS
Hera Group	76	28	23	26	9
North of Italy	63	37	37	18	6
Italy	52	28	28	11	4
Best Italian Region	81*	49**	30*	45**	11***

Table 1.3.3.1 – Percentage of single collected material per macro-area (Hera Group, 2016)

*Emilia Romagna, **Valle D'Aosta, ***Trentino Alto Adige.

In figure 1.3.3.1 the "per capita" indicators are displayed. These indicators give an accurate evaluation of the environmental benefits of the sorted waste collection. The Hera managed areas are located higher than the average Italian value and a bit lower than the total value of Northern Italy.

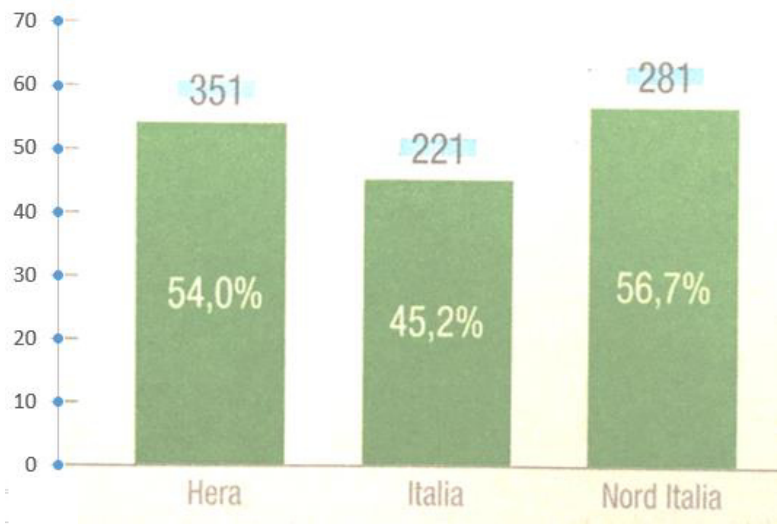


Fig. 1.3.3.1 – Pro capite indicators of separated waste collection (in blue pro capite data)

1.4 Innovation in the waste management system

The EU identified seven priority challenges in which investment in research and innovation can reach a real impact for the benefit of citizens:

- ✓ Health, demographic change and well-being;
- ✓ Food security, sustainable agriculture and forestry, marine and maritime research and the bio-economy and internal waters;
- ✓ Safe, clean and efficient energy;
- ✓ Smart, green and integrated transportation;
- ✓ **<u>Climate action, environment, resource efficiency and raw materials;</u>**
- ✓ Europe in a changing world - inclusive, innovative and reflective society;
- ✓ Secure societies: Protecting freedom and security of Europe and its citizens.

Staying at the forefront of new technologies and propose innovation allows the support of a green economy, in harmony with the natural environment. Research and innovation are critical to economic prosperity indeed experience shows that when the economic crisis limited national budgets, disparities in innovation across Europe become more evident. The waste currently accounts for 2% of EU greenhouse gas emissions and it is estimated that introducing innovation in management systems, would bring an improvement in the economy of member states and new jobs. Innovation applied to the waste management should make the system more economical and convenient for citizens and businesses, and it should be able to take into account the specific conditions of the different territories collection systems.

In this context, new technology has to ensure traceability of waste and the reliability of the data related to environmental services. It must be implemented in order to:

1. Apply the punctual rate systems to associate the best recycling for the individual citizen;

2. Know the position of the containers on the territory, the collection route, the number of actual emptying and the kilometers traveled for emptying;

3. Propose new strategies based on the data collected for the different territories;

4. Adopt strategies to improve the composition of the materials collected from the collection in the minor virtuous contexts.

5. Track and monitor the supply chain of the recycling of waste and provide guarantees ready to start again collected separately;

6. Answer any questions about the actual recovery of materials; and make transparent the process that follows the daily work of every citizen who chooses to make the collection, to demonstrate the usefulness of separate waste properly.

Traceability of waste is also important to ensure that the disposal is done according to the rules provided by law. In the second chapter, the innovative project proposed by HERA Group, to allow the informative management of environmental services, will be presented.

2 The Hergo project: description, aims and evolution

2.1 Main work phases

As anticipated, waste traceability still represents an ongoing problem with repercussions both on a logistical and environmental level. To solve this problem the Hera group has put into place a project called Hergo Ambiente, acronym for “Hera Gestione Operativa” (Hera operational management). It introduces an innovation as it permits the certified traceability, through informative support, of all the involved phases in environmental services. This is applied to all the services and territories provided for by the group (Hera Group, 2016).

Born in 2012, due to the demands of the Environmental Services, the Hergo Ambiente project was developed with the contribution of many company departments. The main phases were:

- May 2014: a new informative system replaced the old one and the central system was built with the integration of design, planning, operative programming, managing warning signs and reporting features;
- June 2014: the results of the pilot project conducted in the Romagna territory were approved, undertaken to identify the technology to install on the vehicles and to supply the workers with; at the same time the census and tagging of containers were achieved, fundamental to produce the record of the assets present in the territory and to geo-locate them;
- October 2014: the system of data acquisition started, which represents interconnection between the central system and the field devices used from the operators in the service and finally the verification of the use of the technologies to aid gradual change of execution and final accounting began;
- January 2017: Marche Multiservizi (MMS) and ACEGAS APS (AAA) started to use the HERGO Ambiente;
- Today: continuous monitoring and system development because of new needs, such as the adoption of a punctual rate.

During the first two years of my research activity I worked, in particular at the second and third phases mentioned above, while in the last year I concentrated my activity on the last point. Below, a detailed description of the main system features, that I contributed to develop and test, is provided.

2.2 Description of the project

Hergo is founded on the interconnection between information systems, field devices and tracking and cartographic systems where processes and systems have been designed to obtain data about environmental services. These systems are formed by the management system (SAP), the "System of Data Acquisition" (SAC) and field devices (SDC). Likewise, all of georeferencing and territorial management is performed thanks to WEB GIS.

The phases of the management of environmental services are drawn in the System and the planned tasks are sent to field devices and are seen from the operators. During the execution of the service the read data are tracked with the support of both on board computer (OBC) and RFID readers.

The data collected from these devices are then recorded by the "System of Data Acquisition" (SAC), that, along with "WEB GIS", sends all information collected during the execution of the service and their georeferencing to the "central informative system" (SAP).

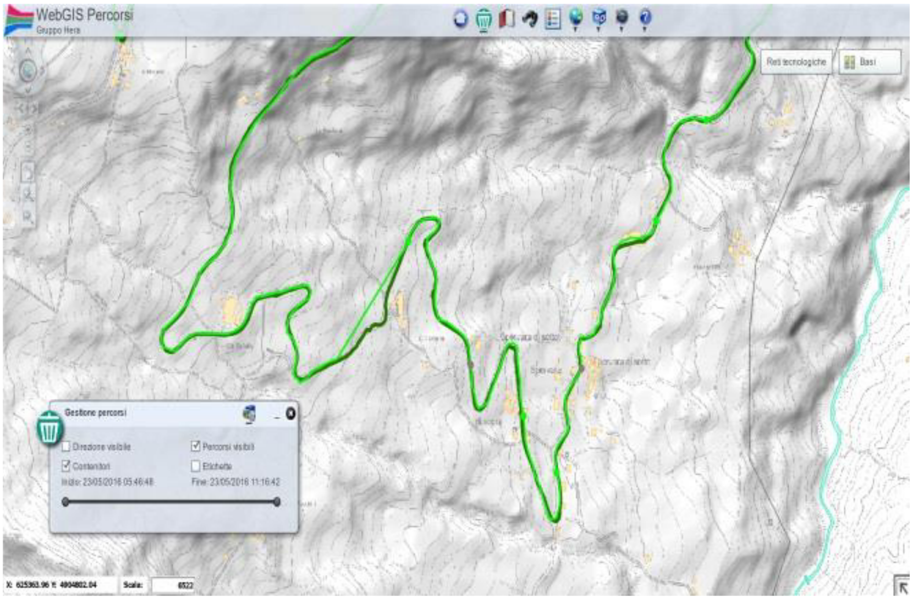


Fig. 2.2.1 – Tracking via GIS of a waste collection route

Georeferencing is made using WEB GIS that allows the checking of the presence of empty or scheduled containers and the real emptying route performed by means of transportation to provide the service (Fig.2.2.1).

The service phases are coordinated for the implementation and efficiency of the services offered, specifically through the reduction of data restitution time and manual entry errors.

The peculiarity of HERGO is therefore the ability to track, record, geo-reference and link the information taken in the field in the several stages involving environmental services, making it a structurally and functionally comprehensive system that thinks and works as a network of connections between people and interconnected devices.

Besides the extensiveness of the activities covered, Hergo represents an evolution in the management of environmental services that is unparalleled in the Italian arena and stands among the best practices also at a European level, constituting an element of excellence. Finally, it involves a total of 2.5 million people in the name of innovation and transparency (Hera Group, 2016).

As said before, HERGO is structured on three main systems: the Central Information System, The Cartographic System and Data Acquisition System, as shown in Fig. 2.2.2.

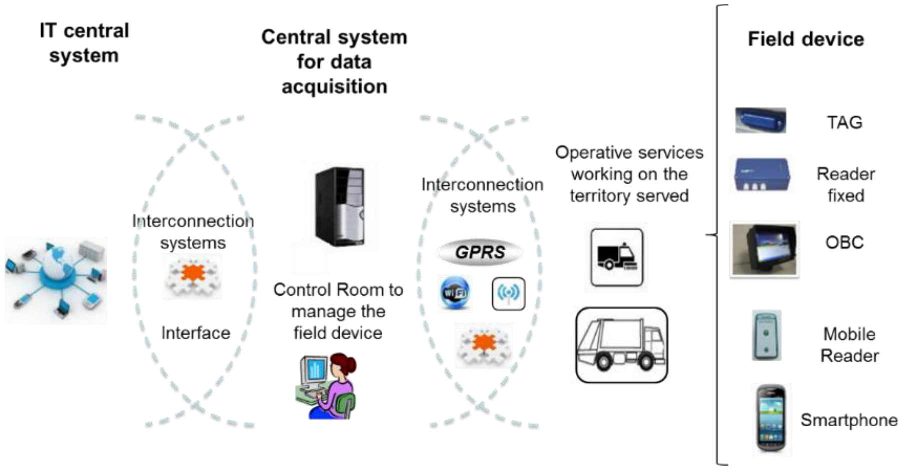


Fig. 2.2.2 - Connection between the IT systems involved in HERGO

2.2.1 Focus on technologies involved

HERGO entrusts its technological capabilities in the field devices created specifically for environmental services (Fig.2.2.1.1). Here are the devices in detail:

1) On board computer (OBC): a video terminal installed on the vehicle and interfaced with the data acquisition system and with the mobile or fixed reader. It works to store and geo-localize the information about collection and sweeping activities. It permits the operators to receive the list of the activities to be performed, to enter notes on the service provided or to send alerts for anomalies in the field;
2) Smartphone (SP): a mobile device that is supplied to operators and interfaced with the data acquisition system and with the mobile reader. It performs the same functions as the OBC, but can be transported externally to the vehicle;
3) TAG: an electronic device with memory, which is installed on the containers. Following the solicitation of antennas that transmit at known frequencies, a TAG sends the information stored therein;
4) Fixed Antenna (RRF): an electronic device installed on the vehicle used for collection. It receives and transmits electromagnetic signals. It helps a TAG to memorize the information and send it to the OBC or SP;
5) Portable antenna (RRP): a mobile electronic device supplied to operators. It performs the same functions as the fixed antennas.

There are several configurations that depend on the type of service to be performed (Fig. 2.2.1.2). For example, in the case of monoperator-services, where there is only one driver, a solution has been adopted to be utilized with an OBC connected to a fixed antenna (RRF), to allow the automatic reading of tags without the need of the operator getting out of the vehicle. Instead, in the case of sweeping, the RRF is not necessary because there is not a tag to read, but the road arcs are detected by a GPS. In other cases, where it was not possible to install the OBC and the RRF a solution has been adopted respectively to a SP and the RRP.

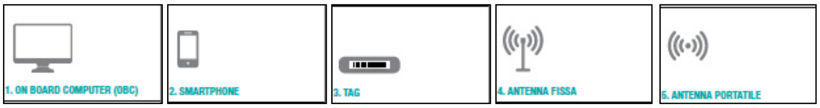


Fig. 2.2.1.1 – Field devices involved in HERGO Ambiente

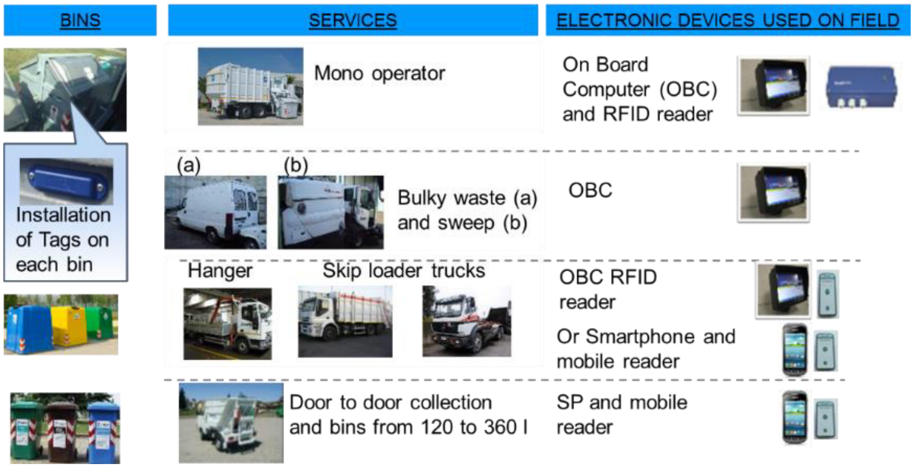


Fig. 2.2.1.2 - Possible configuration of field devices associated with services type

2.3 Systems involved: WEB GIS

The cartographic tool that supports the HERGO project is WEB GIS, designed and built with the aim to display and geo-reference the territory by means of:

- The collection point, that is a representation of GIS of all the containers physically present in the territory, split by positioning; its color depends on the service type (street collection, door to door, etc.).
- The types of containers present on the collection points;
- The difference between the types of waste collected and the types of services that are involved;
- In the case of sweeping services, road arcs to be swept.

In addition, WEB GIS is also the MASTER instrument from which you can manage the containers and ensure alignment with SAP on 'shared' objects.

In WEB GIS, the collection points are displayed within a rectangle that contains objects in number and shapes dependent on the type of containers present.

The Figure 2.3.1 shows a standard collection point with all types of containers used for separate collection, such as:

• 1 dustbin for the organic waste collection (brown square);
• 2 garbage bins for collection of undifferentiated waste (gray pentagons);
• 1 bell for glass collection (green circle);
• 2 garbage bins for plastic and paper collection (yellow and blue pentagons).

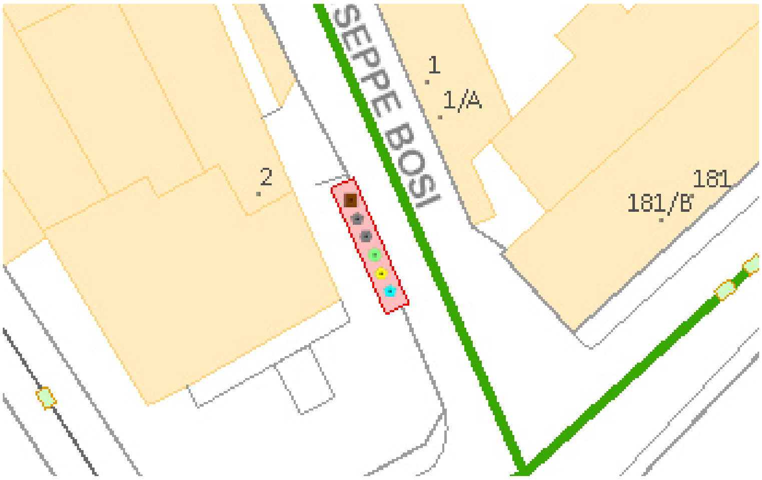


Fig.2.3.1 – Collection point in WEB GIS

The street sweeping is represented by the green line, as shown in Fig. 2.3.2.

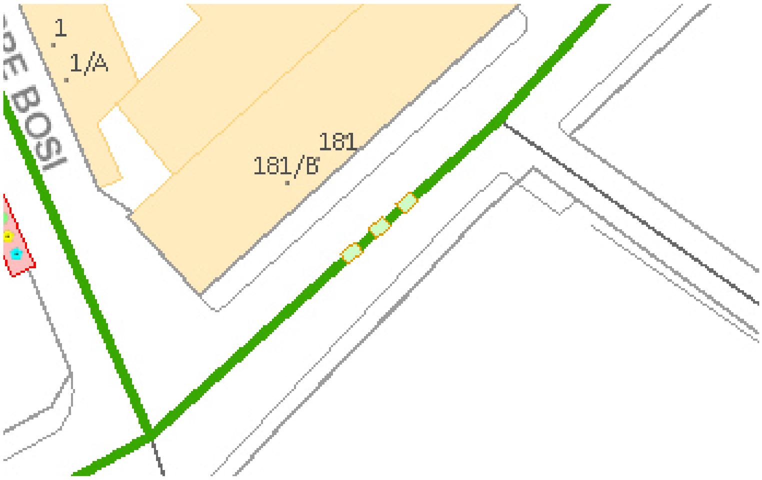
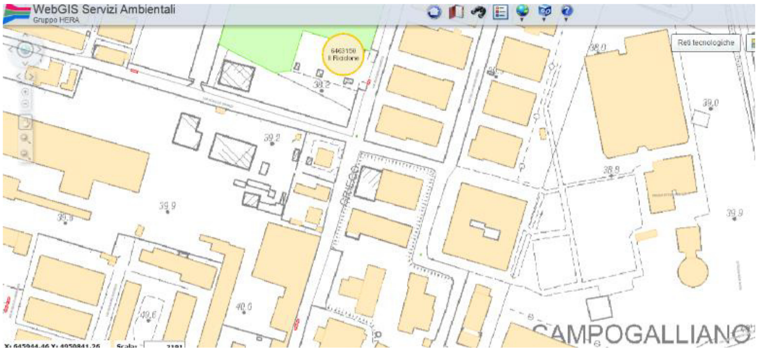


Fig.2.3.2 – WEB GIS visualization of manual or mechanized sweeping.

Each element displayed in cartography is also present in SAP, with its corresponding set of alphanumeric data. Every collection point is identified in GIS by a seven-digit code that allows the recall and viewing in SAP. Similarly, the containers are identified by unique number defined in the same way in GIS and SAP. This code number consents the identification and management in both systems. Fig.2.3.3 shows the visualization of a waste collection center in GIS (a) and its representation in SAP (b): it's possible to see the lists of installed containers in the collection point, defined by a unique equipment code.



Equipments

Pos.	Equipment	EqInf	Definizione	Cat. equip..
	600159793	☐	Contenitore generico acc piombo	9250
	600159794	☐	AREA A TERRA FERRO	9180
	600159795	☐	SCARRABILE DA LT.19000 A LT.32000	9150
	600159797	☐	AREA A TERRA INGOMBRANTI	9180
	600159798	☐	CONTENITORE GENERICO P/RAEE	9250

Fig.2.3.3 – Visualization of a waste collection center in GIS (up) and SAP (down)

Furthermore, WEB GIS permits to display the characteristics associated with collection points, containers, or road arcs (Fig. 2.3.4):

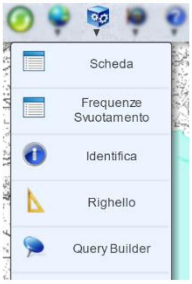


Fig. 2.3.4 – Characteristics associated to objects in WEB GIS

1. The data sheet in Fig. 2.3.5 contains the technical data of an object. All the data recorded in the system are shown by positioning the mouse on a specific object.

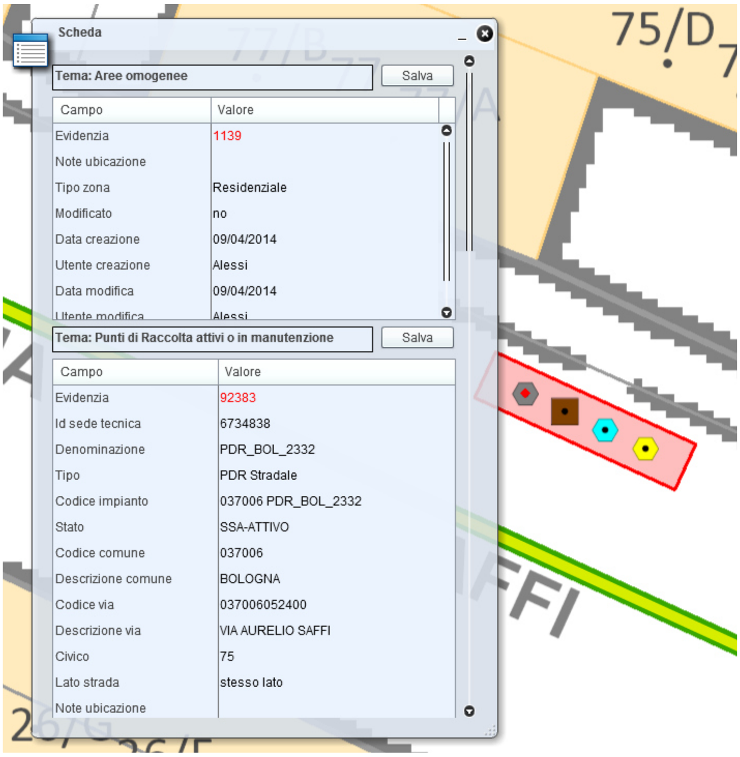


Fig. 2.3.5 – Data sheet of a collection point in WEB GIS

2. The Fig. 2.3.6 shows the emptying frequencies of an object. By clicking on the equipment number of the container, it is possible to see the data about the frequency of the emptying of containers, including the emptying route, sequence (position of container inside the route), day and expiry date of container.

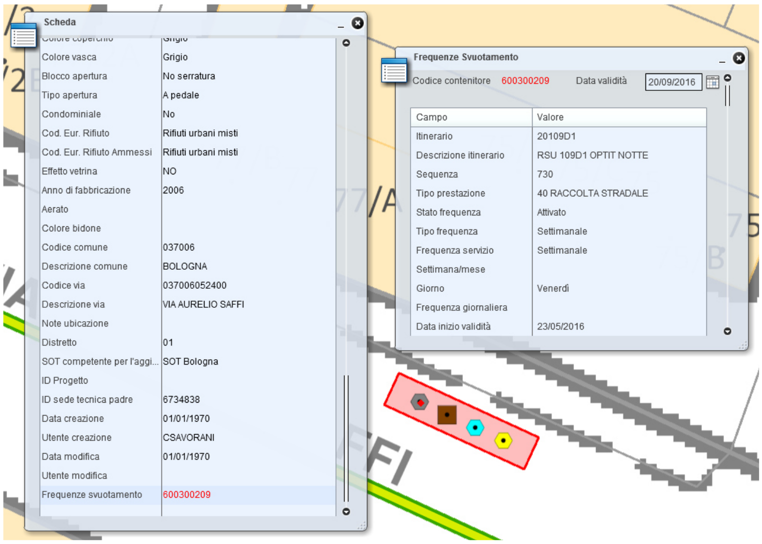


Fig. 2.3.6 – Frequency of the emptying of containers

3. Fig. 2.3.7 reports main objet data. The function “Identify” helps to analyze a collection point and to see its corresponding data (classification, street and code number, etc.).

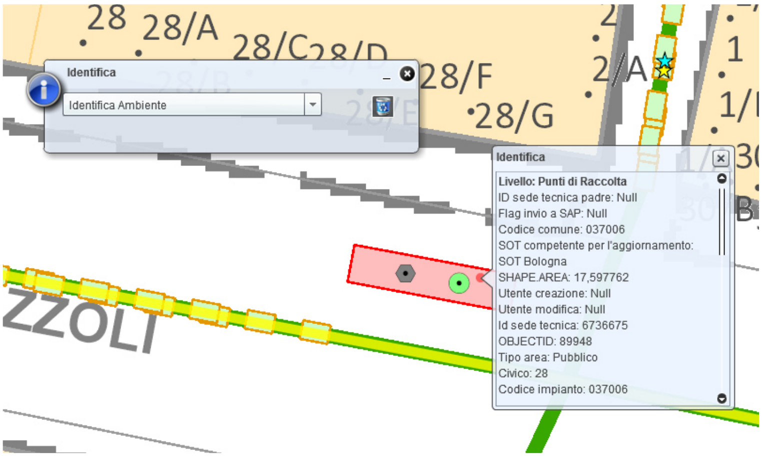
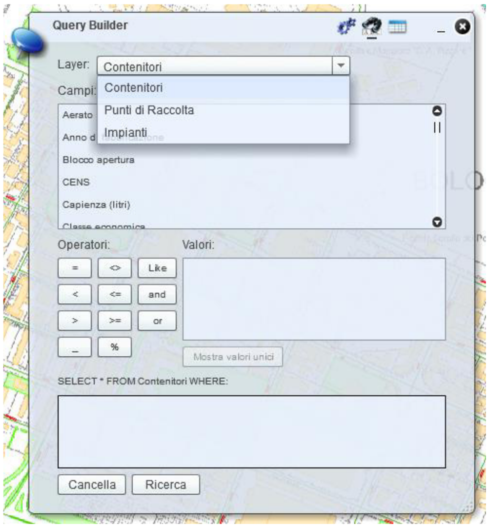


Fig. 2.3.7 – Function Identify for a collection point in GIS

4. It is possible to use the ruler: it allows the measuring of the distance between two points on the map. This function is very useful because it permits the managing of container placement and the improvement of the data system following the readings of the field devices.
5. The Fig. 2.3.8 displays the function of query builder. This function allows the visualization and eventual extraction of specific data. The search can be carried out according to three objects (containers, collection point and plants) and could have different degrees of detail, depending on the field (feature) used as a key. This function is very useful to extract all data about the collection point of a district.



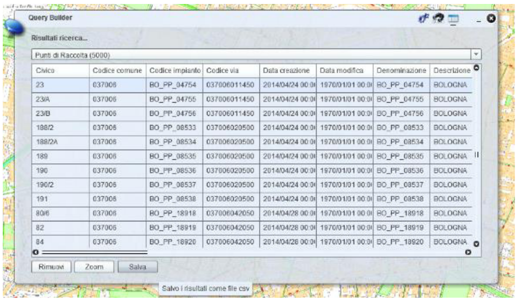


Fig. 2.3.8 – List of all containers of a specific district in GIS

WEB GIS, thanks to its add graphic layer, also displays homogeneous areas that are the areas with the same characteristics such as composition (industrial or residential area), belonging to the neighborhood or type of collection (Fig. 2.3.9)

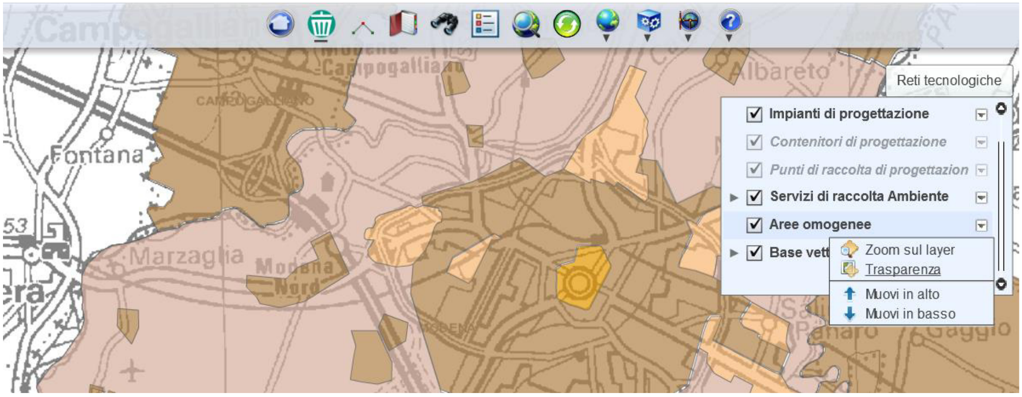


Fig. 2.3.9 – Visualization in WEB GIS of homogeneous areas of a district

2.4 Systems involved: SAP R3

2.4.1 Design, planning and scheduling

Hergo Ambiente is a system that interrelates people and technology, ensuring the connection between the several steps through which the environmental services are provided. Each step corresponds to a specific "system capability" that guides subsequent activities.

The first step in managing services is the planning of the activities. This phase is the functionality that places the system in the territory and gives shape to the service. The services are organized with the help of digital maps where the sequence of collection and sweeping events gives life to the routes of services.

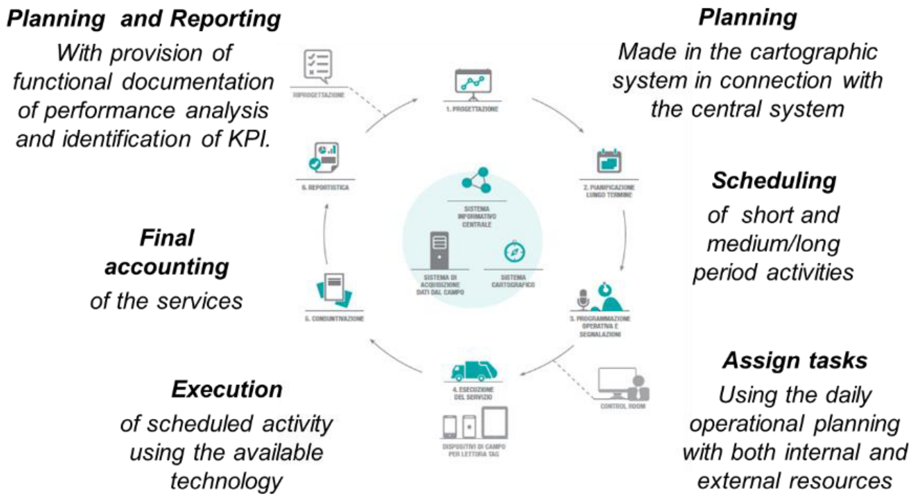


Fig. 2.4.1 - Design and planning of services in HERGO (Hera Group, 2016).

Hergo has been developed within this circular scheme to connect all the steps with the central system of data management (Fig. 2.4.1).

The circular scheme proceeds from the design to the planning, meaning the arrangement of environmental service scheduling.

In this phase, the collection and sweeping routes are associated with a frequency of execution, with defined dates and times. With this information, the system generates daily work orders, called disposal orders. With the generation of disposal orders, Hergo allows the administrators to organize daily activities, supporting them through the automatic allocation of resources and personnel with the necessary skills to perform the various planned activities. In case of unavailability of means or personnel, the system highlights the resources among the available ones, to correct the order appropriately.

There may be deviations in the planned service following alerts received from the operator. The possibility to receive alerts during service (made by citizens through call centers and other channels such as "Rifiutologo") allows the response to the demands to pick up the bulky and abandoned waste, of maintenance and relocation of containers and other reports, generating the so-called "on-call" service.

The execution of the service is related to the provision of the disposal order, thus bringing to fruition the planned service. The disposal orders are made by the central system and then they pass to the "System of Data Acquisition" and arrive to the operators through field devices.

The operator receives the list of containers to be emptied or the road lines to be swept. The execution takes place, simultaneously, both in the physical and in the digital space; the effective information about services are recorded on devices to be given back to the central system, where they are managed and processed.

Now, there is the intervention by the Control Room operator (CR). The CR is a dedicated structure that monitors the state of the technology, in which proper operation guarantees the transmission of information, limiting the time of billing of the work performed and potential imputation errors. Once the service is finished, the central system incorporates services data provided in the field. The central system is able to now get the full picture of the activities: hours worked, distance, emptied bins, and eventually notes about the status of the containers, vehicles, and collection points.

All the activities described are finally prepared for reporting and redesign phases. The set of reports produces a useful account for the analysis and improvement of the service. The data acquired in the final accounting is used to produce standardized reporting of the operational management of daily work (work shift, means used, staff employed, composition of the teams, hours of service performed, etc.).

There are also other "institutional" reports dedicated to authorities and stakeholders, concerning the users served in the waste stream, the frequency of emptying containers and road cleaning, including the activity recorded from the waste collection center.

Finally, there are also "directional" reports, useful to control the key aspects of the relationship between efficiency and effectiveness of the service and the technical-economic performance of the assets. From the report analysis, HERGO Ambiente is regenerated and the cycle begins again: the properly read and interpreted data allows finding the margins for intervention to optimize performance. The goal is to ensure the quality and lowest price of environmental services through the analysis and the ongoing review of the collection routes, the placement of containers, etc.

The effectiveness of the project has previously been evaluated in each phase thanks to the implementation of a pilot project.

The system has been developed to manage every step of the environmental services even by means of the implementation of custom procedures to support the dialogue between the SAP IS-U and R3 systems.

Hergo has been based on a waste management system characterized by three main services:

- ✓ Territorial collections: for domestic consumers and small non-domestic users;
- ✓ Residential collection (target users): for non-domestic users that produce specific waste similar to urban waste;
- ✓ Waste collection centers: are infrastructures for the separate collection of all municipal waste, including hazardous.

The system is also integrated by doorstep collection of bulky waste, of garbage from vegetation and of some types of hazardous waste (such as batteries and medicines).

Therefore, it was necessary to provide a management of all the different cases, to make the system able to track collection services performed and the amount of collected waste.

The central management system used for the HERGO is SAP R3 that needs a complex database architecture that leads to the generation of a disposal order.

The disposal order is a unique code associated with a specific date and route. It represents a unique service that allows the association of multiple information. The scheme below shows the flow that leads to the generation of a disposal order, and then the execution of the service (Fig. 2.4.2).

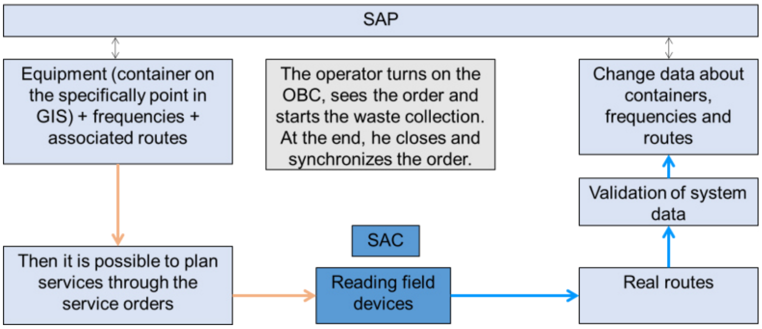


Fig. 2.4.2 – HERGO: from planning to final accounting

The first step for the generation of a disposal order is the creation of an object in SAP that corresponds to a container.

2.4.2 Creation of containers in SAP

Between 2013 and 2014 a census was carried out of all containers belonging to the Hera group, which led to the creation of more than 300,000 containers in the system SAP. All cases are associated with a given type (e.g. bell, garbage bin or dustbin), a volume and type of waste to contain. The fundamental data of these containers is the tag code that they have, which is the key to recognize them in the system. This code is in fact a unique code and is necessary data. The number of containers in the system is constantly changing.

The registry of the containers is the basis of the system, because following the generation of equipment it is possible to associate the frequencies and route and generate the disposal order. The equipment must be installed on a collection point created in WEB GIS and identified by a unique code.

The data of containers in SAP is schematically formed by:

- Material Code: a code that represents the possible combinations of waste and volume (e.g. CHE010419 = dustbin 120 liter paper).
- Data for all types of equipment: e.g. producer, TAG code, etc.;
- Specific data: e.g. the presence of a locking mechanism, etc.;

Fig. 2.4.2.1 shows an example of the containers installed on the street (a) and their representation in GIS (b) and SAP (c).

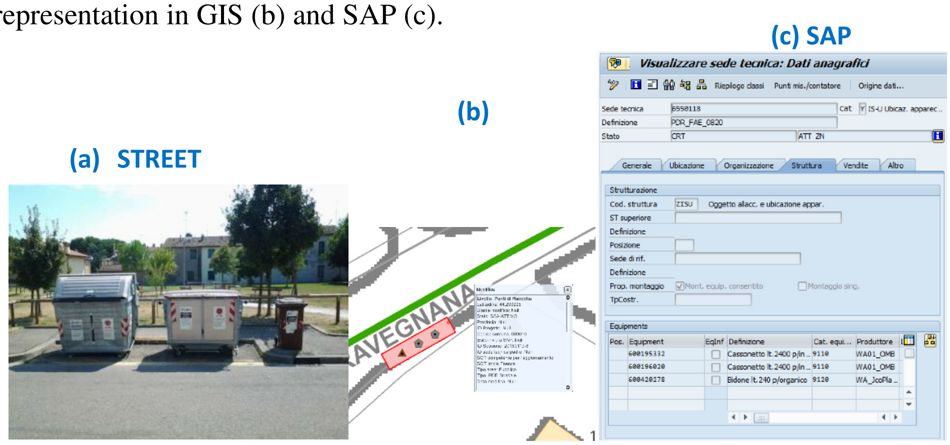


Fig. 2.4.2.1 – (a) Containers in the street and their representation in GIS (b) and SAP (c)

The collection point in SAP contains information such as the coordinates, the street and street number. It is always created by GIS and via interface it is then created in SAP.

It is possible to see for a single container the collection point on which it is installed. Fig.2.4.1.2 shows a container of 2400 liters for the collection of municipal solid waste.

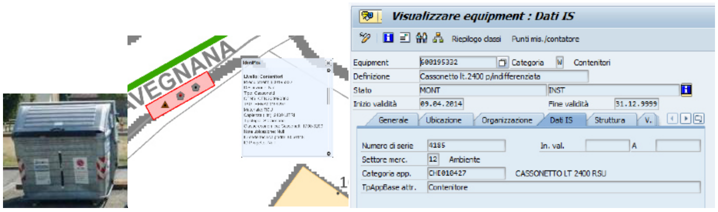


Fig. 2.4.2.1 –A container in the street (a) and its representation in GIS (b) and SAP (c)

2.4.3 Route in SAP

A route is an object created by the central system and required for the execution of a service order. This object represents the set of activities that are part of the same service, and includes a number of default information required to provide the service, such as (Fig. 2.4.3.1):

- The type of service (e.g., spider collection, street collection, door to door collection)
- Who will carry out the service;
- The kind of waste that will be collected.

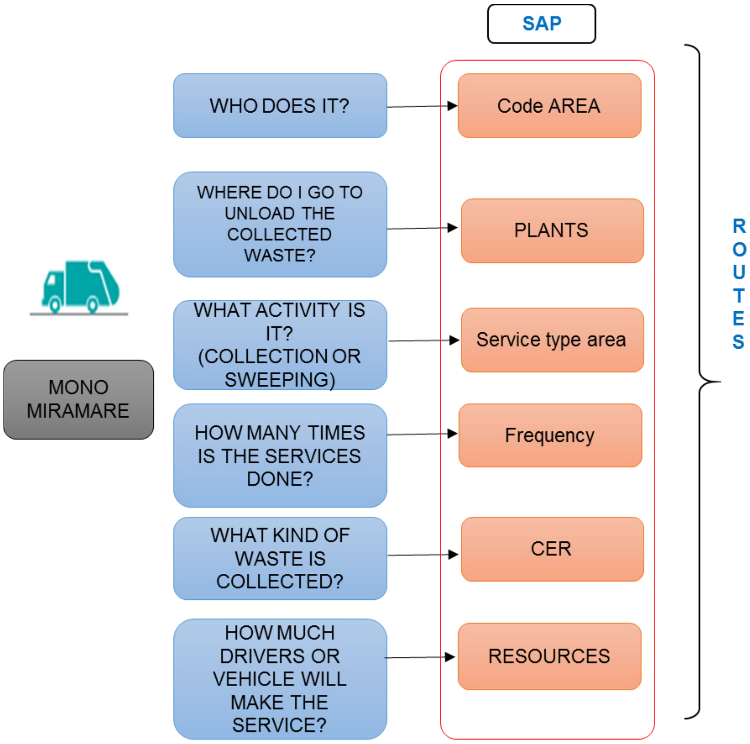


Fig. 2.4.3.1 –Information about a route

In SAP a route is created by inserting a set of mandatory information.

Fig. 2.4.3.2 shows the SAP representation of a route.

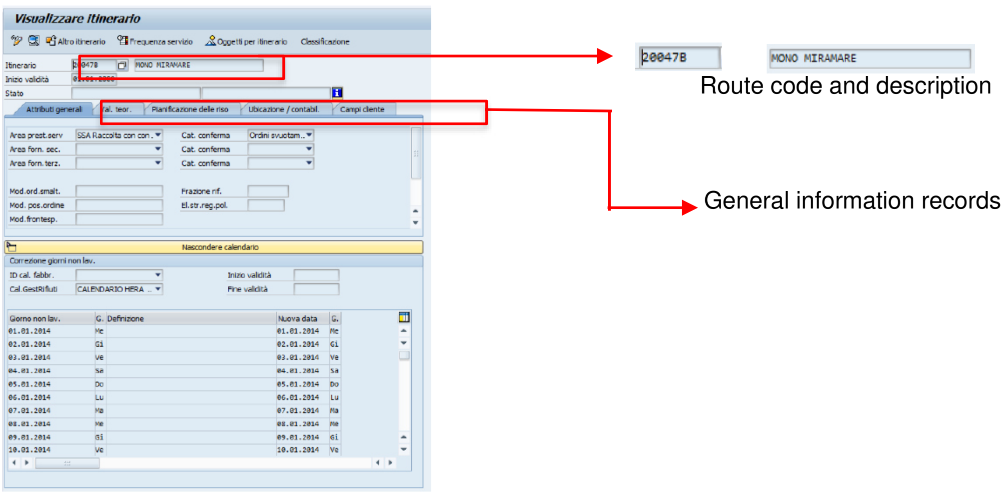


Fig. 2.4.3.2 – A route in SAP

The record "Attributi Generali" (general features, Fig. 2.4.3.3) represents the first level of characterization of the route. It defines the type of service area, that is, a code that defines the type of service performed by a route (collection, sweeping, management of waste collection center).

CODICE SAP in TABELLA	AREA PRESTAZIONE DI SERVIZIO
03	SSA Altri Servizi
05	Manut. contenitori (interne)
90	SSA Raccolta con contenitori
91	SSA Raccolta senza contenitori
93	SSA Spazzamento

CODICE SAP in TABELLA	AREA PRESTAZIONE DI SERVIZIO
94	SSA Rifiuti ingombranti
95	SSA Movimentazione contenitori
96	SSA Carro/Scarro c/o CDR
97	SSA Raccolta C/O CDR

Fig. 2.4.3.3 –"Attributi generali" (general features): information of service to be performed (a) and lists of service type areas (b)

The record "Valori teorici" (theoretical values, Fig. 2.4.3.4) presents the information of a collection/sweeping route.

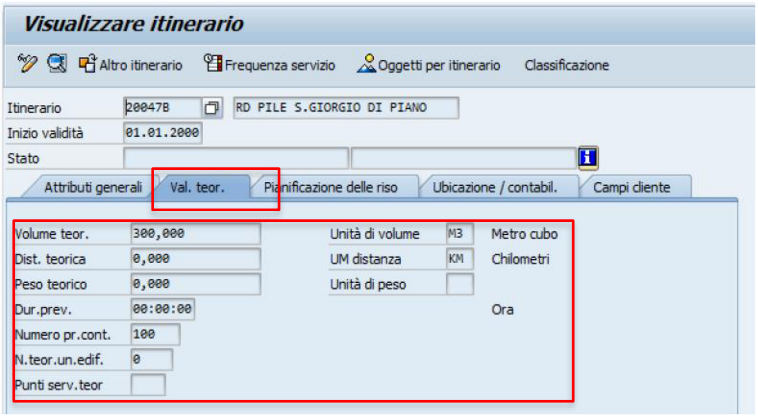


Fig. 2.4.2.4 – "Valori teorici" (Theoretical values): information about collection/sweeping route

In particular:

- Theoretical volume → estimate of average volume of the route
- Theoretical distance→ how many kilometers in a route
- Theoretical weight → the weight
- Predicted time → how much time is necessary to complete the service
- Number of containers → number of containers to be swept.

In the record "Pianificazione delle risorse" (resource planning) the macros of territorial areas of the route are defined, such as the district subdivision.

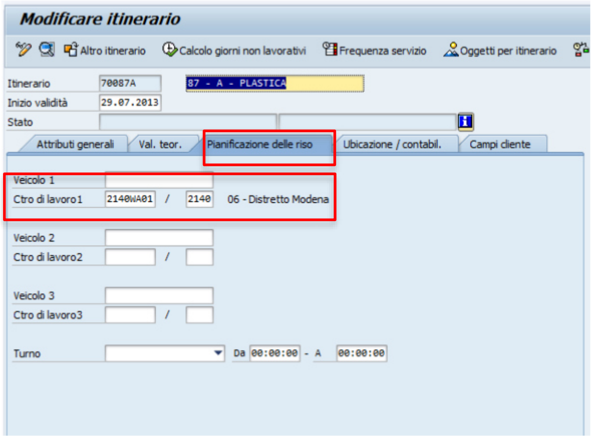


Fig. 2.4.2.5 – “Pianificazione delle risorse” (resource planning) in the registry of route: executor of the service

In the record “Ubicazione/contabil.” (Location/accounting) the information of the waste destination plant is defined. The plant indicates where the unloading takes place which is necessary information for the generation of the Transport Document.

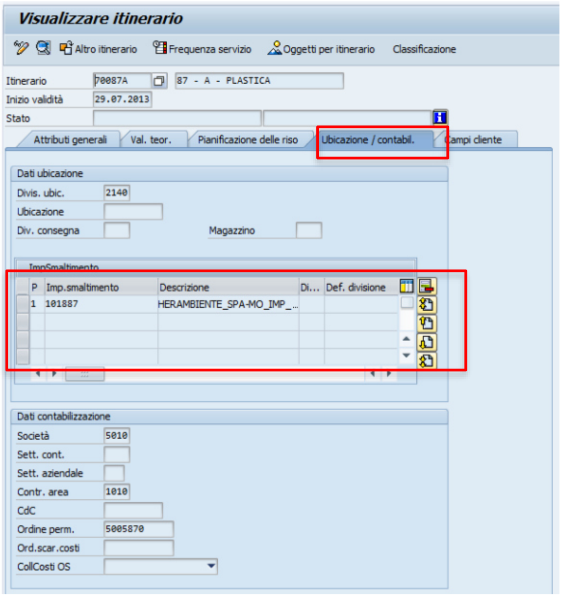


Fig. 2.4.2.6 – “Ubicazione/contabil.”(ubication-accounting): information about waste destination plant

The record “Campi cliente” (customer field) defines the information about its municipality and other information about the costs.

For weight distribution, it is necessary to define the municipality on which the service was performed, and then where the containers emptied during the route are.

The route could be:

- MONOCOMUNE → 1 municipality with 100% weight

- MULTICOMUNE → 1-n municipality with 1-n% weight

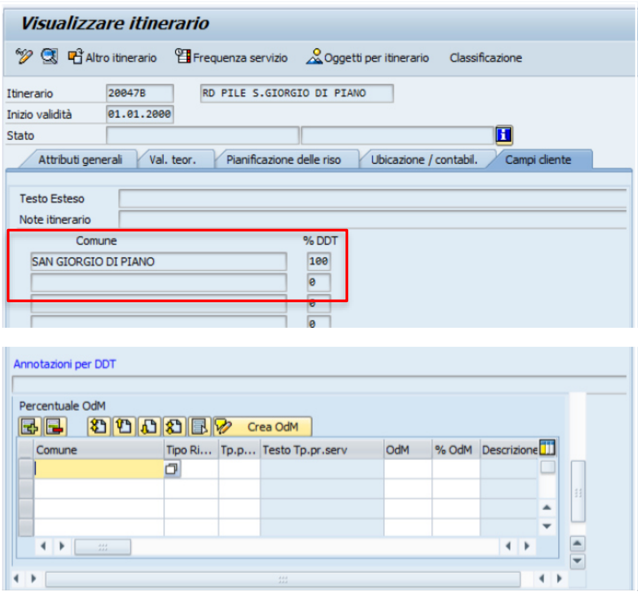


Fig. 2.4.2.7 – “Campi cliente”: information about municipality involved in the service

2.4.3 Frequencies in SAP

Inside the route there is also a section dedicated to the frequencies. It should be noted that the frequency is associated with two levels: on the route and on the container. There should never be a misalignment between these two levels, so the route frequency must be equal to the frequency of the container.

The frequency corresponding to the route is defined by the following information:

- Type of service;
- Start of the service;
- End of the service;
- Frequency: DAILY (from Monday to Sunday), WEEKLY, MONTHLY.

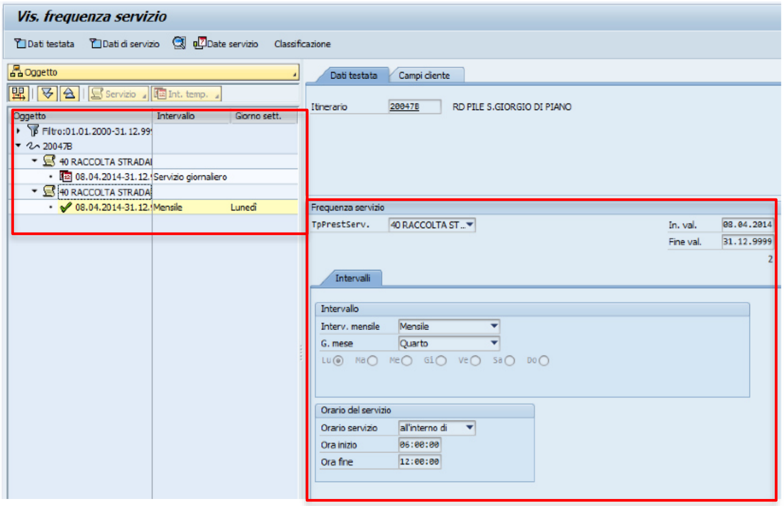


Fig. 2.4.3.1 – Information about frequencies associated with route

The frequencies thanks to an existing route can be associated with the containers which must be installed at a collection point, and vice versa, so that a disposal order can be generated for a container installed at a collection point if it has engaged at least one frequency.

At the time of creation of a route one needs to decide the type of frequency:

- WEEKLY
- MONTHLY
- DAILY
- UPON REQUEST

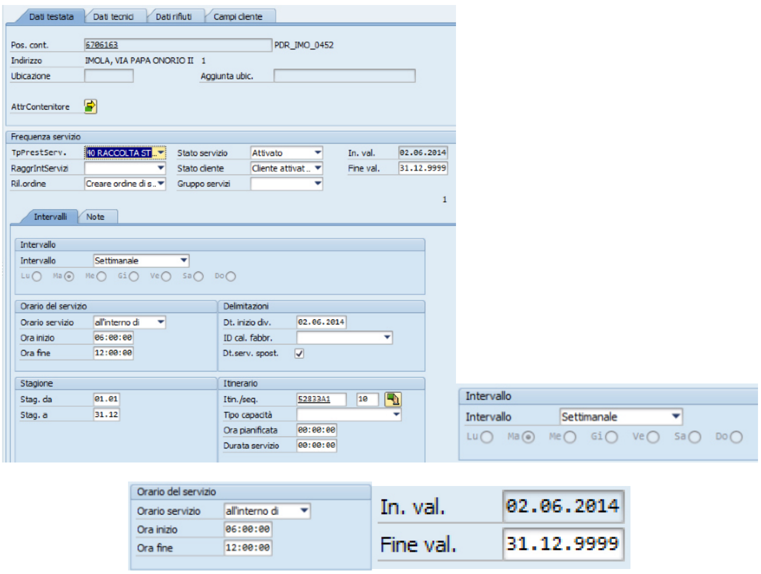


Fig. 2.4.3.2 – Information about frequencies associated with route

The information is organized into records, where it is possible to enter the basic information of each single frequency (Fig. 2.4.3.1 and 2.4.3.2) such as type of service, output frequency and time and date of start and expiry date.

For example, to create a weekly frequency (a frequency which represents a service made 1 of 7, 2 of 7, etc.) it is necessary to define how many weeks (every 2 weeks, every 3 weeks) the service is carried out and the weekday it has to be done (Su Mo Tu We Th Fr Sa).

The frequencies are unique, meaning, a service with a frequency of three times a week corresponds to three different frequencies.

There is the possibility to manage the "not scheduled" services that are those not attributable to standard frequencies, using SAP function called "blank calendar." One needs to set the calendar route as “blank” and to define a daily service. Also, a container must have at least one daily frequency.

2.4.4 Disposal orders

When the system has the objects to create a disposal order, it is possible to proceed creating it by two processes:

- on the basis of frequency data related to the route that define the frequency planning of the order and the ordered sequence of the containers;
- “on-call” services, where there is not a defined emptying frequency.

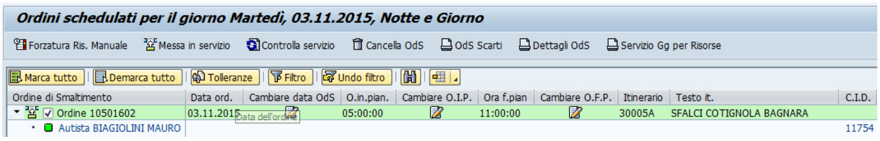


Fig. 2.4.4.1 – Service order created in SAP

After the creation, the orders are available for sending to the System of Data Acquisition (SAC). Thanks to SAC, they will then be displayed on the field devices and enable the execution and the final accounting of the services.

2.5 Systems involved: System of Data Acquisition (SAC)

“SAC” is the acronym of System of Data Acquisition and it is the intermediate system between SAP and the field devices.

In SAC it is possible to monitor the status of the disposal order, entering with the same criteria access used for its creation in SAP, such as:

- Code of disposal order
- User
- Order status
- Predicted Data
- Service type

- Predicted OBC/SP
- Predicted service data
- Real service data
- Some notes
- Route
- Other.

Fig. 2.5.2 shows a list of disposal orders created for a defined date.

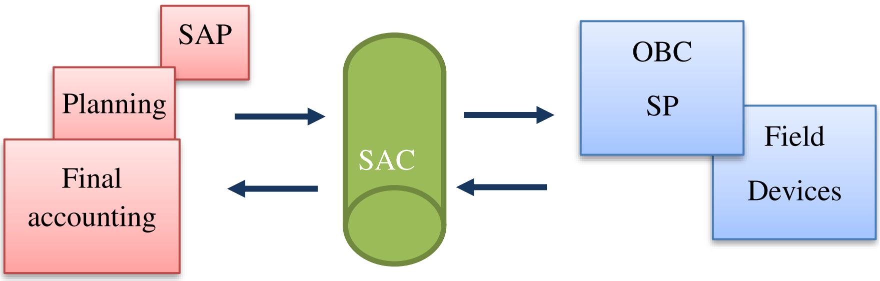


Fig. 2.5.1 – Schematic representation of the SAC system

Esporta dati: CSV senza intestazione Visualizza

	Codice OdS	Data Prevista	Turno	Stato OdS	Tipo OdS	Pos prev/cons	OBC/SP Effettivo	Reader Effetti
○	12807704_9006640	03/10/2016 00:00:00		In Coda	Raccolta	1/0		
○	12848207_9003876	03/10/2016 00:00:00		Consuntivato	Raccolta	40/100	352735060173270	NONDEFINIT
○	12848207_9005000	03/10/2016 00:00:00		Consuntivato	Raccolta	40/63	352735060092272	NONDEFINIT
○	12723958_9014539	03/10/2016 00:00:00		In Coda	Raccolta	1/0		
○	12723959_9014539	03/10/2016 00:00:00		In Coda	Raccolta	1/0		
○	12816264_9008213	03/10/2016 00:00:00		In Coda	Spazzamento	1/0		
○	12723955_9014539	03/10/2016 00:00:00		In Coda	Raccolta	2/0		
○	12804919_9014972	03/10/2016 00:00:00		In Coda	Raccolta	168/0		
○	12804919_9015188	03/10/2016 00:00:00		In Coda	Raccolta	168/0		
○	12804919 9015339	03/10/2016		In Coda	Raccolta	168/0		

Fig. 2.5.2 – Display in SAC of a list of disposal orders created for a specific date.

The disposal order status can be defined by one of these (main status):

- INSERTED (INS): the order is received by SAP but not yet available to be seen by the operator;
- TO BE IN QUEUE (INQ): the order si available to be seen by the operator.
- TAKEN OVER (PIC): the operator is working on the order;
- CLOSED (CLS): the order is closed and synchronized from field devices, but not yet visible in SAP;
- FINAL PURCHASE (CNS): the order is visible in SAP.

The order passes from INS to INQ status from eight hours before time of scheduling to eight hours after; this step allows avoiding all not performed services up to that moment from appearing.

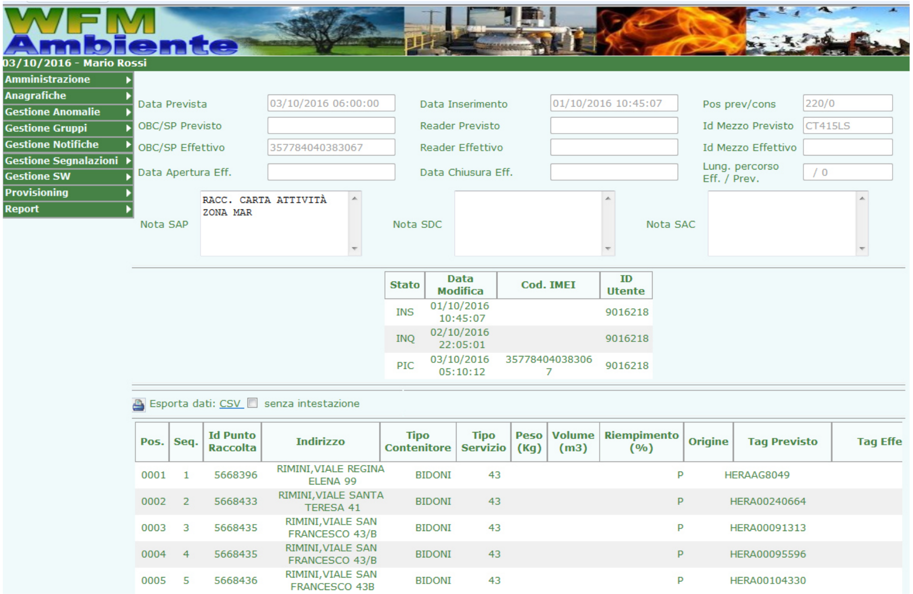


Fig. 2.5.3 –Detail of the containers to be emptied for a disposal order in SAC

2.6 Login to field devices

The information about service order passes from SAC to field devices thanks to an App called Herafid. In the App, the sequences of the containers to be emptied can be seen by the operators.

After creating service orders on SAP, they are displayed on the device. The operator to which the service is assigned, sees a line with a macro description of the service and will see in detail all containers to be emptied along that collection route. The order of the containers is assigned by SAP during the service planning.

The operator will do these activities in sequence: (Fig. 2.6.1):

- Insert the personal code in the designed area
- Insert the password in the field "«Password»"
- Click the login button
- For the Obc it is not mandatory to insert the register as it is for the SP.

Following the login, the operator sees the order and starts the service.

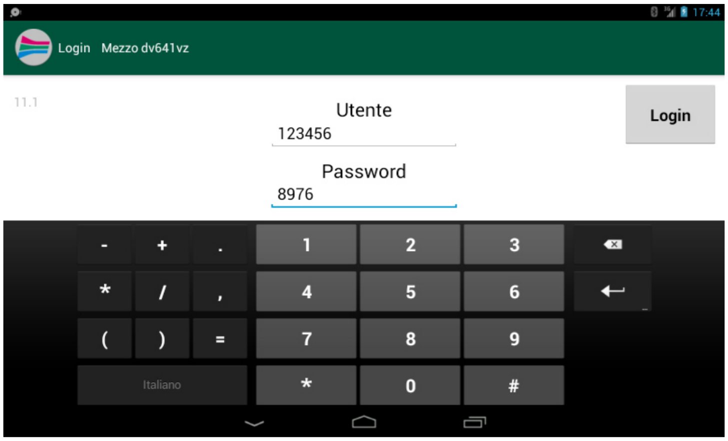


Fig. 2.6.1 – Log in the APP HERAFID

Fig. 2.6.2 – Visualization of the service orders

The pictures 2.6.2 shows how the list of containers to be emptied is seen by operators. There are four counters that give different information depending on the assigned color. In particular:

- Green counter: displays the number of planned containers that have been detected along the route;
- Red counter: displays the number of total containers associated with the service order;
- Yellow counter: displays the number of planned containers that have been detected in absence of GPS signal;
- Blue counter: displays the number of detected containers not included in the service planning.

Once the service is performed, the user synchronizes and sends it to SAC.

Also, it is possible to adopt these functions:

- User support: for assigning one or more operators to the team;
- User substitution: exclusive request to substitute an operator;

- Suspended order: request to suspend the order; it can be carried out by the same or different resources.

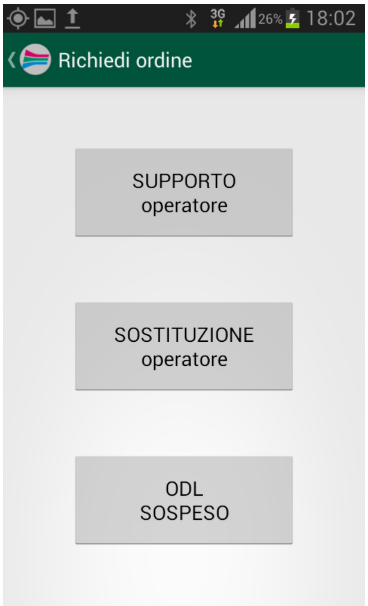


Fig. 2.6.3 – Features for special management of disposal order

2.7 Analysis of the actual routes

The use of field devices allows a detailed service management in terms of empty container, hours worked and length of service. This corresponds to a greater costs control.

It is possible to extract data in according to pre-assigned criteria, such as date and work area and view the real services carried out in the field. The extraction is done through the use of Business Object software (BO) dedicated to business intelligence (BI) which allows the extraction of the data in SAP.

Ordine di Smal	Itinerario Ordine	Itinerario Ordine di Smaltimento	Stato Utente OdS - Testo este	Tipo di Attività - Testo di media	Data Effettiva	tag pianificati	tag effettivi	letto	non fatto	letto nuovo	letto forzato	recupero
12623532	20603A	SAN LAZZARO RSU ZONA 2 POM	ODS CONSUNTIVATO DA SAC	40 RACCOLTA STRADALE	20/09/201	136	131	121	15	10		
12623533	20608M	RSU MATT MAR-GIO-SAB OZZANO	ODS CONSUNTIVATO DA SAC	40 RACCOLTA STRADALE	20/09/201	126	121	119	7	2		
12623534	20610P	PIANORO RSU POM ZONA 2	ODS CONSUNTIVATO DA SAC	40 RACCOLTA STRADALE	20/09/201	102	98	96	6	2		
12623535	20780F	TITAN BOLOGNA FRULLO	Senza attribuz.	40 RACCOLTA STRADALE		1						
12623536	20780C	TITAN BOLOGNA CERTOSA	Senza attribuz.	53 RACC. TRASBORDO/SATELLIT		1						

Fig. 2.7.1 - Estrazione di un ODS da BO

In the columns are present the data referred to the service order.

In particular:

- Service order;
- Route;
- Position: related to the effectiveness emptied container. This allow the comparison between planning and the real route.

Then it is possible to extract the detail of each container (Fig. 2.7.1).

Every line describes data belongin to the container of the service order. In the coloumn the data are related to (Fig. 2.7.1.2):

- Route;
- Collection point;
- Containers;
- Positions: data of service order related to a single reading on the field: (hour, coordinate and note).

Itinerario	Itinerario Ordine di S	Comune Pianificato - C	Punto di Ra	Via Pianificata - Chiave	Civico	Comune Effettiv	Punto di Raccolta	Via Effettiva - Chiave	Civico Effett	Sequenza
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466799	VIA GUGLIELMO MARCONI	#	#	#	#	#	480
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466821	VIA CA' FORNACETTA	3	#	#	#	#	1260
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466823	VIA CA' FORNACETTA	9	#	#	#	#	1250
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466854	VIALE DUE GIUGNO	2	#	#	#	#	710
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466855	VIALE DUE GIUGNO	3	#	#	#	#	1100
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466928	VIA MATTEI	2	#	#	#	#	740
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6467004	VIA TOLARA DI SOTTO	29	#	#	#	#	520
20608M	RSU MATT MAR-GIO-S	OZZANO DELL'EMILIA	6466986	VIA STRADELLI GUELFI	14	OZZANO DELL'EM	6466986	VIA STRADELLI GUELFI	14	1130

Contenitore	Contenitor	N.ident.Tecn. (T/	N.ident.Tecn. (TA	Orario Let	Latitudine - Chiave	Longitudine - Chiave	Nota di Conferma - Testo di me
600117412	#	HERA00435765	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600117613	#	HERA00195825	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600117612	#	HERA00195831	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600117159	#	HERA00195815	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600117165	#	HERA00195759	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600213845	#	HERA00270013	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600549137	#	HERA00016543	#	#	0.000000000000	0.000000000000	NF-> LETTURA NON FATTA (SAC)
600117499	600117499	HERA00195900	HERA00195900	13:05:35	44.471553802490	11.488173484802	L->LETTO (SAC)

Fig. 2.7.1.2 – Detail of a service order in BO

The analysis of the position take to the evaluation of the data system, in order to align the amount recognized in the field during the service to what it is present in the system. The tools in the service of a support system planners have different functions and allow the active remediation of the data in the system (dashboard for managing anomalies - Sec. 2.7.1) or offer the chance to see the real effective path, make it comparison with planned and view all the read and unread containers associated with the specific service order (SAP GIS interface - Ch. 2.7.2).

2.7.1 Dashboard to display position and frequencies anomalies

The dashboard presented in this paragraph allows the immediate display of the anomalies associated with the readings taken in the field (Fig. 2.7.1.1).

Possible recorded anomalies are of three kinds:

- **Frequency + positioning**: unplanned containers in the collection routes and situated in other collection points;
- **New TAG and TAG not found**: unplanned detected containers (frequency anomaly) with tags not present in the system;
- **Positioning:** planned containers that are read and then emptied at a distance of more than 20 meters from the collection point to which are associated in SAP/GIS.

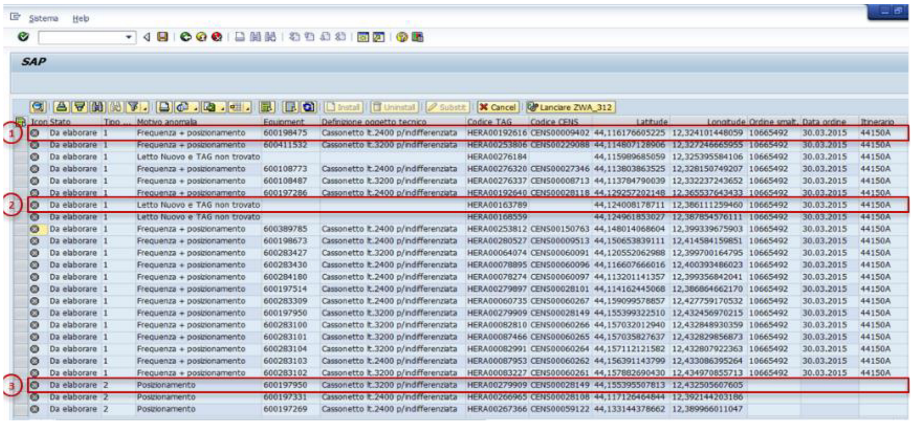


Fig. 2.7.1.1 – Dashboard used to analyse and solve the anomalies in the service orders managed with field devices

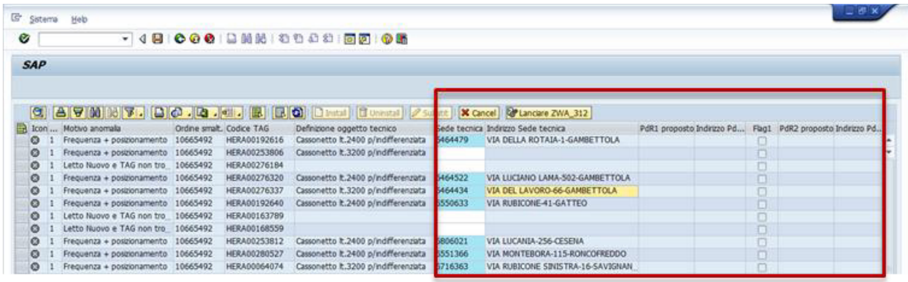


Fig. 2.7.1.2 – Focus positioning anomalies

The dashboard shows for each container the collection point in which it is installed (Fig. 2.7.1.2, blue cell) and the collection point in a range of 100 meters.

2.7.2 Analysis of the actual routes

It is possible to display the actual route and the status of planned and detected containers associated with the service provided.

The route management can be assisted through the graphical tool that connects information in GIS and SAP. Indeed, it is possible to display on GIS the effective route (Fig. 2.7.2.1).

The displayed information includes all the relevant elements of the actual route:

- Collected containers;
- Uncollected containers
- New containers:
- Direction of travel;
- Routes (green line);
- Service TIME.

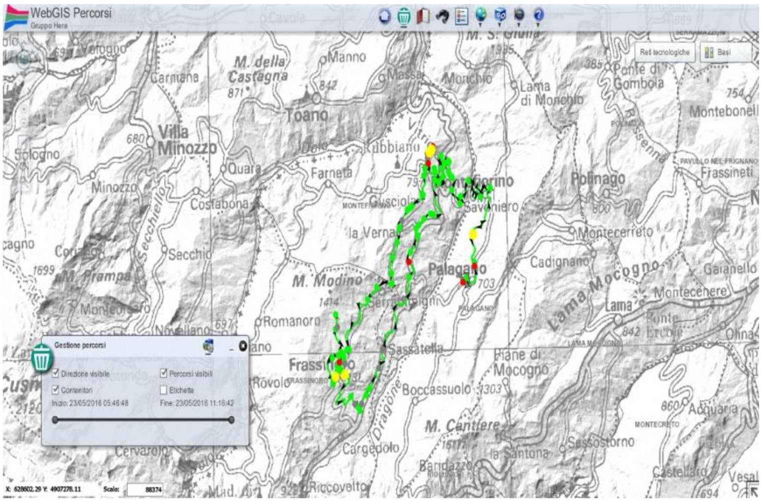


Fig. 2.7.2.1 – Effective route associated to a service order

The green line indicates the effectually route and the points inside indicate each container associated to the order. In particular, it's possible to notice the correspondence between the counters in the field seen by the operator and what reported to the effective route. In addition, the yellow points have not a corrispendonce. In fact, they specify the planned containers that are read and then emptied at a distance of more than 20 meters from the collection point to which are associated in SAP / GIS. At different colors are corresponding to different information (Fig.2.7.2.2):

1) **GREEN POINT (green counter)**: planned containers that have been detected along the route;
2) **YELLOW POINT (no correspondence)**: planned containers that are read and then emptied at a distance of more than 20 meters from the collection point to which are associated in SAP / GIS **(Positioning anomaly)**;
3) **RED POINT (red counter):** number of total **unread** containers associated with the service order
4) **GREY POINT (blue counter):** number of detected containers not included in the service planning **(Frequency anomaly).**

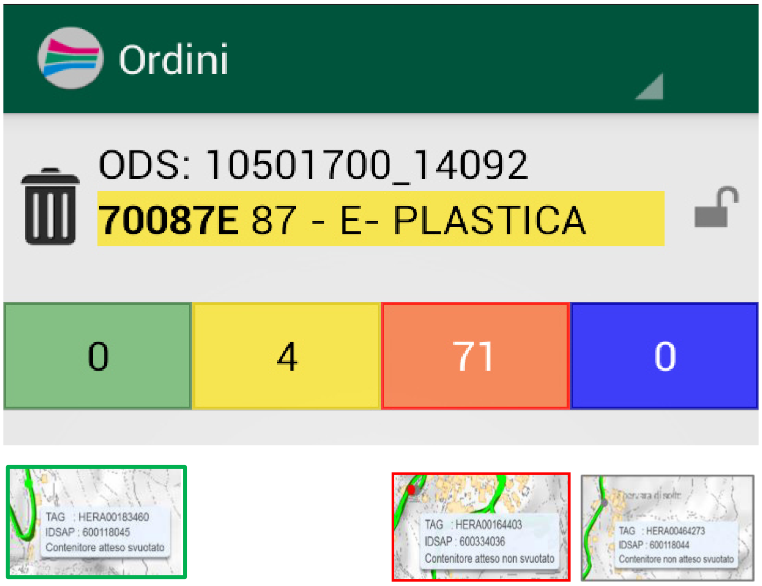


Fig. 2.7.2.2 – Correspondence between the counters in the field seen by the operator and what reported to the effective route.

For the yellow point seen in the field devices there is not correspondence with the yellow point in the effective route, but it is possible to see inside the green line the planned and emptied containers that are read at a distance of more than 20 meters from the collection point to which are associated in SAP / GIS **(Positioning anomaly)** (Fig. 2.7.2.3).

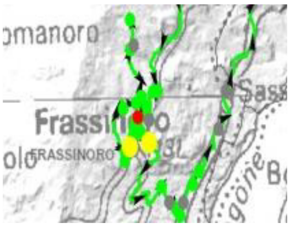


Fig. 2.7.2.3 – Planned and emptied containers that are read at a distance of more than 20 meters from the collection point to which are associated in SAP / GIS.

2.8 Added functionality: Reporting

Another important aspect of the HERGO project is the ability to manage and organize the data between multiple systems. This allows reducing the time required for troubleshooting.

It is possible to generate an object called "Reporting" to manage different type of trouble or information. The reporting is distinguished depending on their origin or type of service requested. It is therefore possible that some types of services have more input channels of the request.

The types of existing reporting are:

- Internal maintenance messages. Concerning the maintenance of vehicles and containers;
- Request for abandoned waste and requests for emptying containers;
- Requests for activities involving containers: moving, positioning, removals, replacements;
- Bulky collection;
- Reporting by Rifiutologo: signal made by users through the use of the APP Rifiutologo. It relates to the abandonment of waste, emptying containers or reports of failure of the container.

As mentioned, Hergo was built to also dialogue with other systems that have been adopted in order to have an information support for all operational activities. The need to have other systems is related to the necessity, for example, to use more simple "one-dimensional" systems (i.e. used for a part of activity) or the lack of technologies or authorizations for the use of SAP licenses, as is for Portal WEB (PWT) and the ESA system. The PWT is a web tool with limited functions used by suppliers that allows viewing, management and validation of the services provided. This tool is linked to the central system SAP, in which the final data are managed for all services performed.

ESA is a portal used in waste disposal plans for reporting waste discharges that occurred in the system. ESA should be able to associate the weights of discharges to disposal orders generated in SAP. This information is derived from the transport document that is the document required of the transporters for disposal at the plants. The ESA system will be taken up in Chapter 3, with reference to the indicator 2.

2.9 From HERGO to data analysis

The final stages of a research process are to develop and analyze data (fig. 2.9.1). Hergo was born to allow the management of the environmental services data and to analyze and evaluate the performance associated with them.

Analysis of data has a goal of discovering useful information, to suggest conclusions, and to support decision-making. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains.

Analysis refers to breaking a whole into its separate components for individual examination. Data analysis is a process for obtaining raw data and converting it into information useful for decision-making by users. Data is collected and analyzed to answer questions, test hypotheses or disprove theories.

In the following chapter the results regarding the analysis of the system (chapter 3) and an application in a project to improve the service are shown (chapter 4).

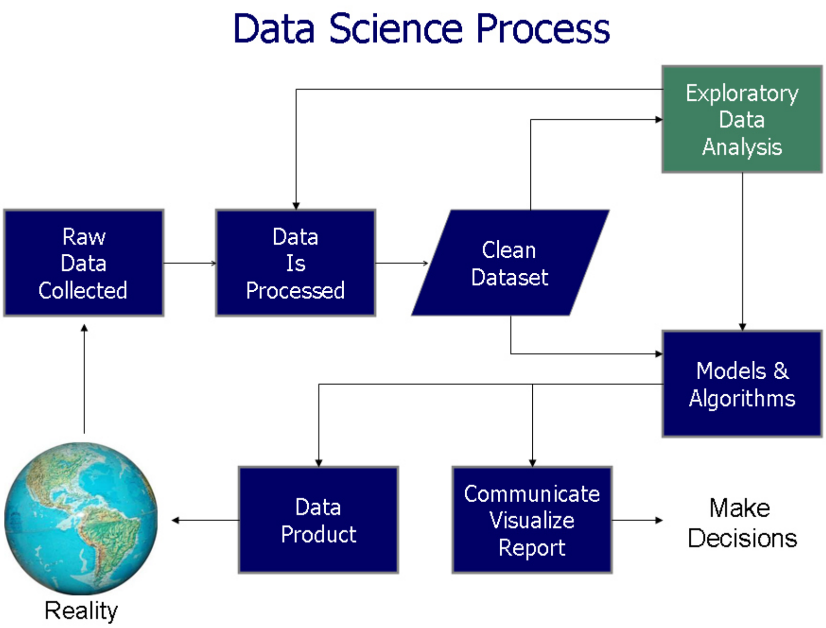


Fig. 2.9.1 – Data analysis process

3 Development of indicators to evaluate the system

The evaluation and overall monitoring of the system operation and the degree of coverage of processes, have been made using specific indicators.

The indicators identified are divided into the following two classes:

- **Use indicators**: they measure the use of the system with a focus on two main processes managed by the system;
- **Quality Indicators**: they measure the quality of managed data, with a focus on three of the main processes managed by the system.

After a first quarterly monitoring, at present the indicators are calculated monthly and aggregated to the organizational structure.

For each indicator, a data sheet was built which specifies:

- Objective and description of the indicator;
- Organisational structure in charge of the data used for the calculation;
- Expected result, variable as a function of the calculation period;
- Source of the data, as the system from which it is extracted and specific report / reference transaction;
- Specific parameters and notes which explain any assumptions upstream of the calculation.

The use indicators are:

- ✓ 01 - Accounting Indicator: it is calculated by comparing planned orders with those accounted (closed), in order to obtain a percentage metric which characterizes the state of use of the system;
- ✓ 02 - Indicator of assignment of service Orders with ESA weighing: it is calculated analyzing the weighing coming from the ESA system only for Institutional contracts; we obtain the percentage of ESA weighing, reporting an ODS SSA;
- ✓ 03 - Indicator of use of Field devices: it is calculated by comparing planned orders, related to services to be performed with field devices (SDC), to those accounted by using SDC; it is calculated as a percentage and represents the degree of use of the field systems (SDC).

Quality indicators are:

- 04 - Reporting positions indicator: it measures the degree of effectiveness of the TAG read in the field (road collection and door to door collection)
- 05 - Indicator of assignment of service Orders with weighing: it is calculated by comparing the extraction of weighing only for institutional contracts in which there is the Order SSA; the percentage of "weighing documents" created correctly is obtained.

- 06 - Positioning containers indicator: it is calculated using the dashboard of the anomalies; we obtain the percentage of containers incorrectly positioned respect to the total number of containers installed on the collection point.

In the following paragraphs the use and quality indicators are shown, calculated thanks to the data extracted from the system.

3.1 Use indicators

3.1.1 01 - Accounting Indicator:

As said above, this indicator measures the degree of use of the system as an accounting tool.

It is a percentage indicator which characterizes the state of use of the system and it is calculated by comparing planned orders with those accounted (closed). The aim of this indicator is the achievement of the value equal to one hundred percent. In this way, what is planned corresponds to what is actually done in the field. Intermediate temporal targets are (Tab. 3.1.1.1):

2016	**1° Trim.**	**2° Trim.**	**3° Trim.**	**4° Trim.**
Internal services	80%	100%	100%	100%
External services	n.a.	60%	100%	100%

Tab. 3.1.1.1 – Aims of indicator 01

Below, data for indicator 01 are presented for the year 2016 (Fig.3.1.1.1 ÷ 3.1.1.8), calculated for the first two quarters in a compact way and for the other months in a more detailed manner. The size of the graphics is proportional to the number of service orders planned per area; the percentage shown is refered to the closed service orders respect to the total number of planned orders.

The comparison between the first and second quarter 2016 (Fig. 3.1.1.1 and 3.1.1.2) shows that in the second quarter there was an improvement of the percentages for the Bologna-Imola area, a constant trend for the Modena-Ferrara area and a decline for the Romagna area and collection centers. Also, it shows that in the second quarter of 2016, 68% of ODS has been not accounted, of which 62.5% related to the outsourced activities.

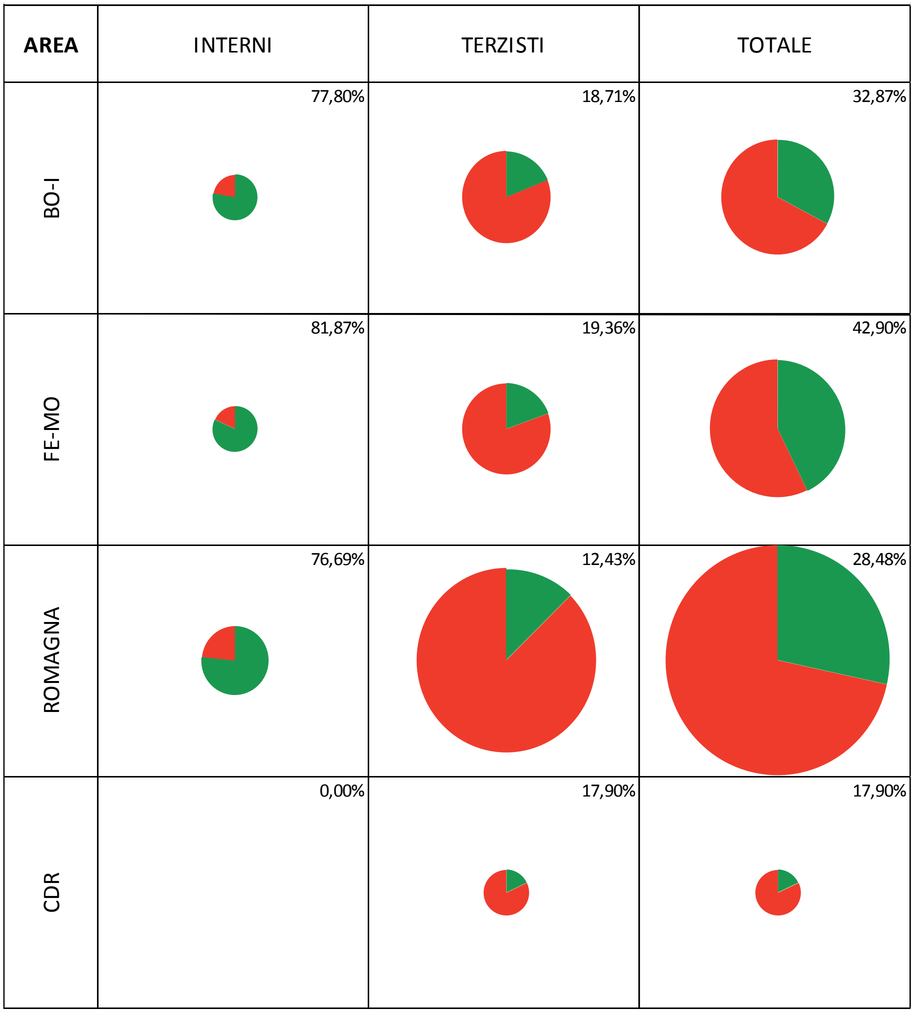
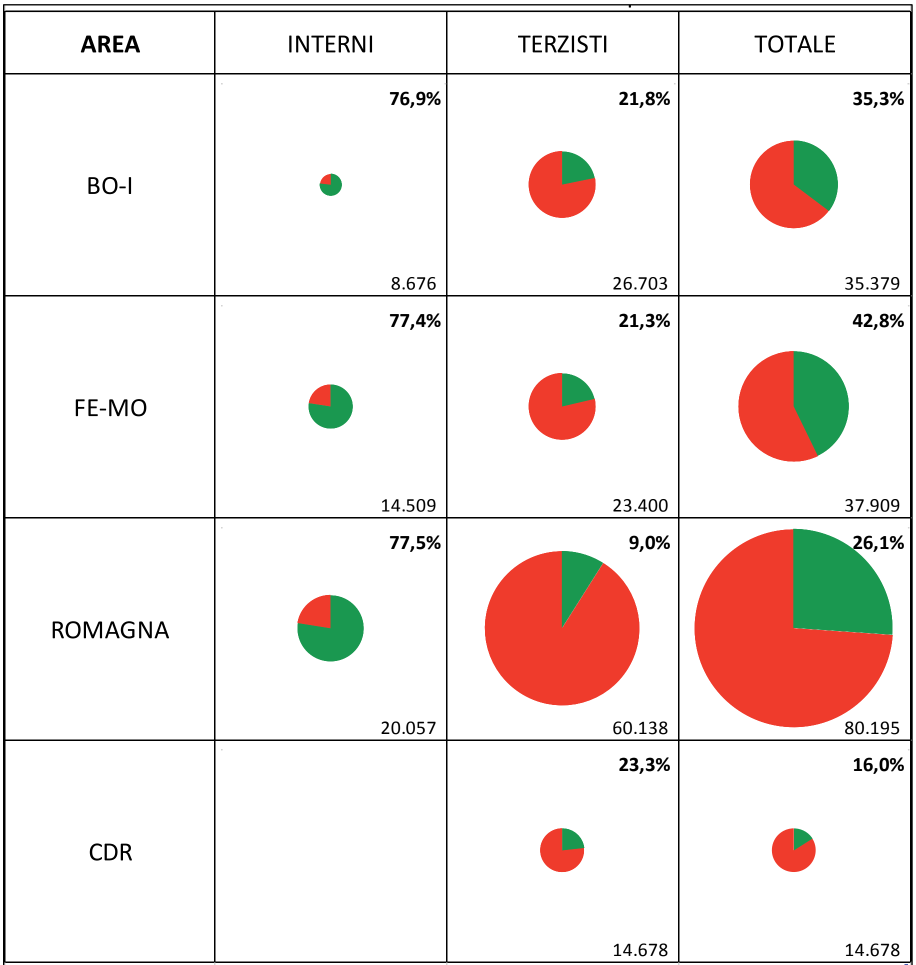


Fig. 3.1.1.1 – Indicator 01: Detail per area of accounting service orders in the first quarter 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

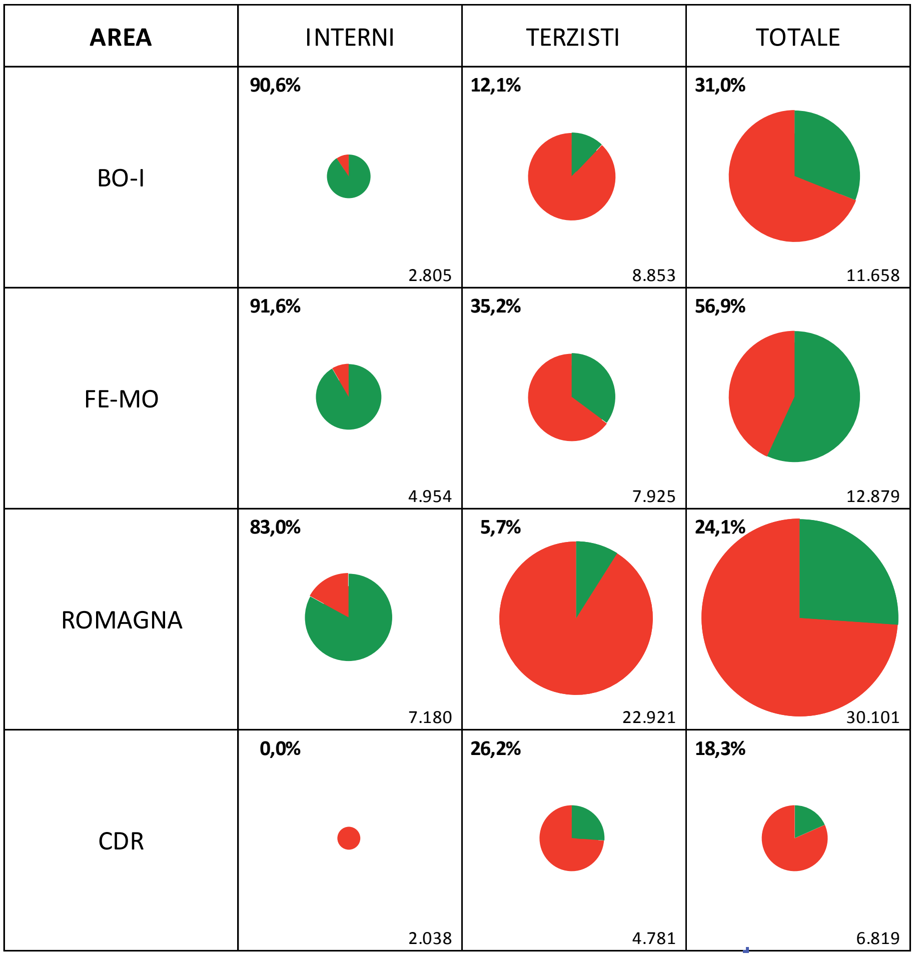


	INTERNI	TERZISTI	TOTALE
TOT ODS pianificati	*43.242*	*124.919*	*168.161*
TOT ODS chiusi	33.447	19.609	**53.056**
TOT ODS non chiusi	9.795	105.310	115.105

Fig. 3.1.1.2 – Indicator 01: Detail per area of accounting service orders in the second quarter 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

From July 2016, the analysis of the indicators was made not quarterly but monthly. Below we analyze the results month by month, comparing with the previous period. As Fig. 3.1.1.3 shows, in July the value related to the internal services improved for all areas (from 77% to 87%, excluding CDR), respect to the value of the second quarter.

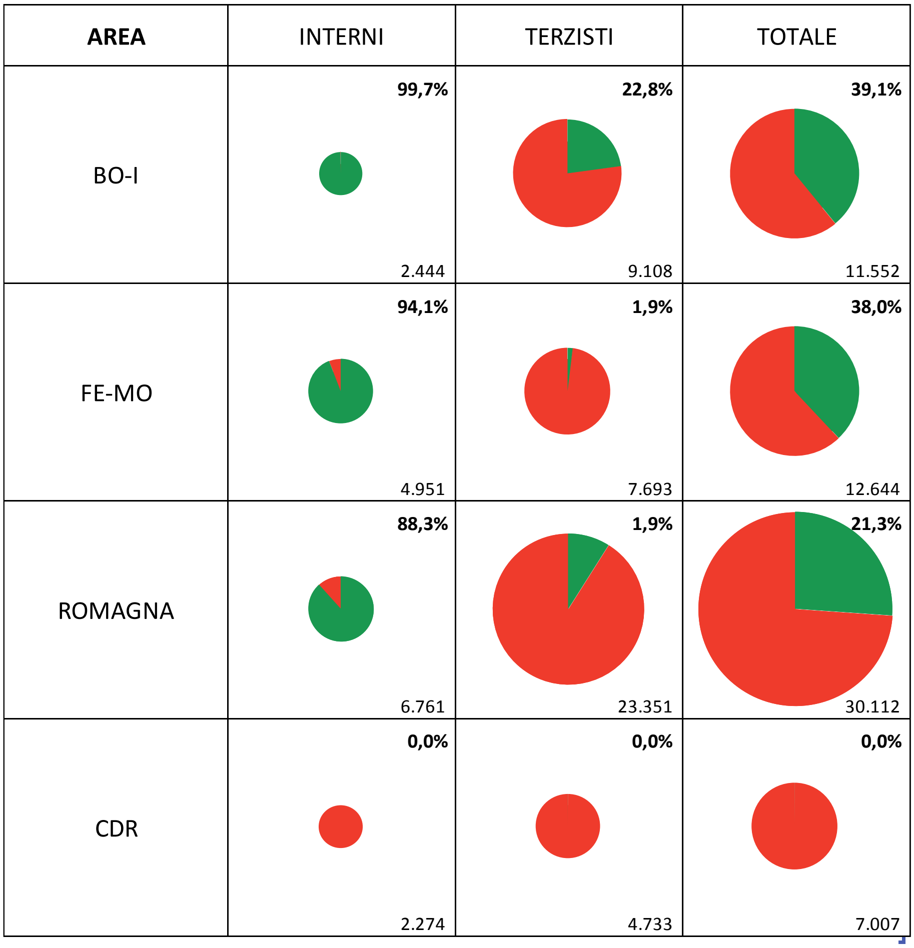
The value for sub-contractors remains in line with the second quarter (14%), producing a value of 68% of not accounted service orders (in line with the data for the second quarter), of which 90% is related to the outsourced activities.



TOT ODS pianificati	*16.977*	*44.480*	*61.457*
TOT ODS chiusi	13.036	6.417	**19.453**
TOT ODS non chiusi	3.941	38.063	42.004

Fig.3.1.1.3 - Indicator 01: Detail per area of accounting service orders in July 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

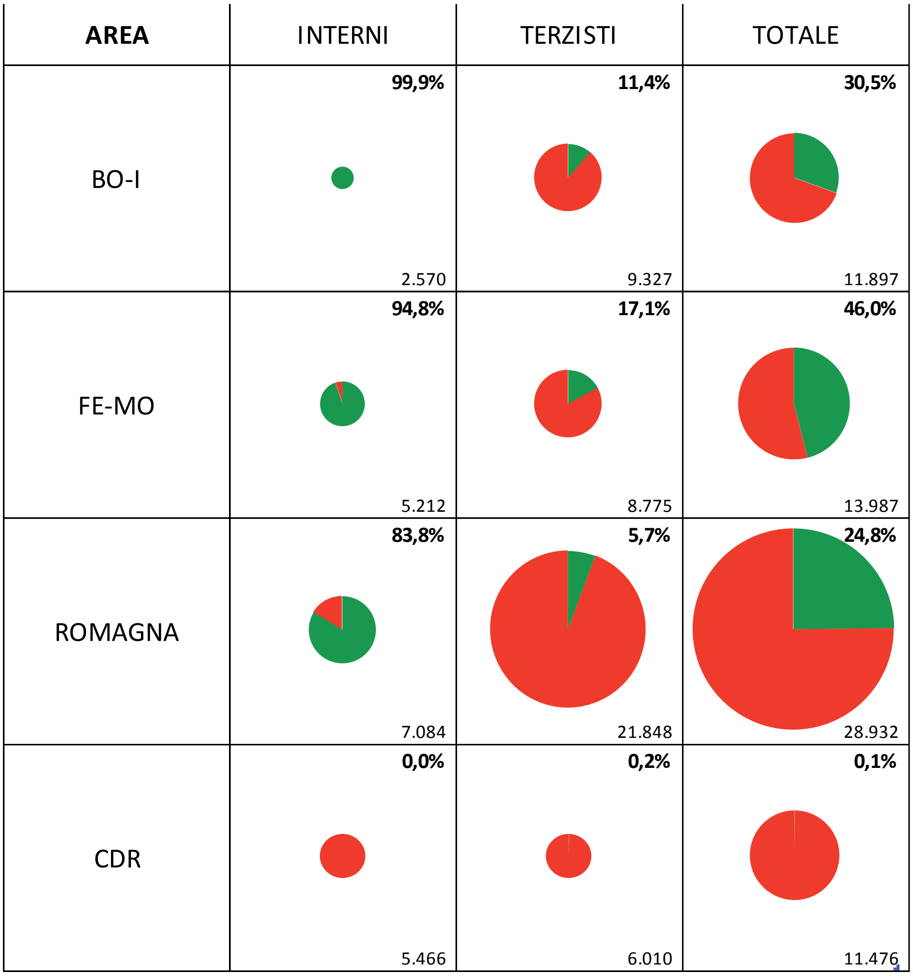
As Fig. 3.1.1.4 shows, in August the value related to the internal services is improved for all areas (from 87% to 92%, excluding CDR), respect to the value of July. The figure for the contractors shows a decrease (from 14% to 7%) due to numerous subcontractor system failures (PWT) connected to the SAP system, producing a value of 74% of not accounted service orders (more than July-69%), of which 92% are related to the outsourced activities.



TOT ODS pianificati	*16.430*	*44.885*	*61.315*
TOT ODS chiusi	13.071	2.664	**15.735**
TOT ODS non chiusi	3.359	42.221	45.580

Fig.3.1.1.4 - Indicator 01: Detail per area of accounting service orders in August 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

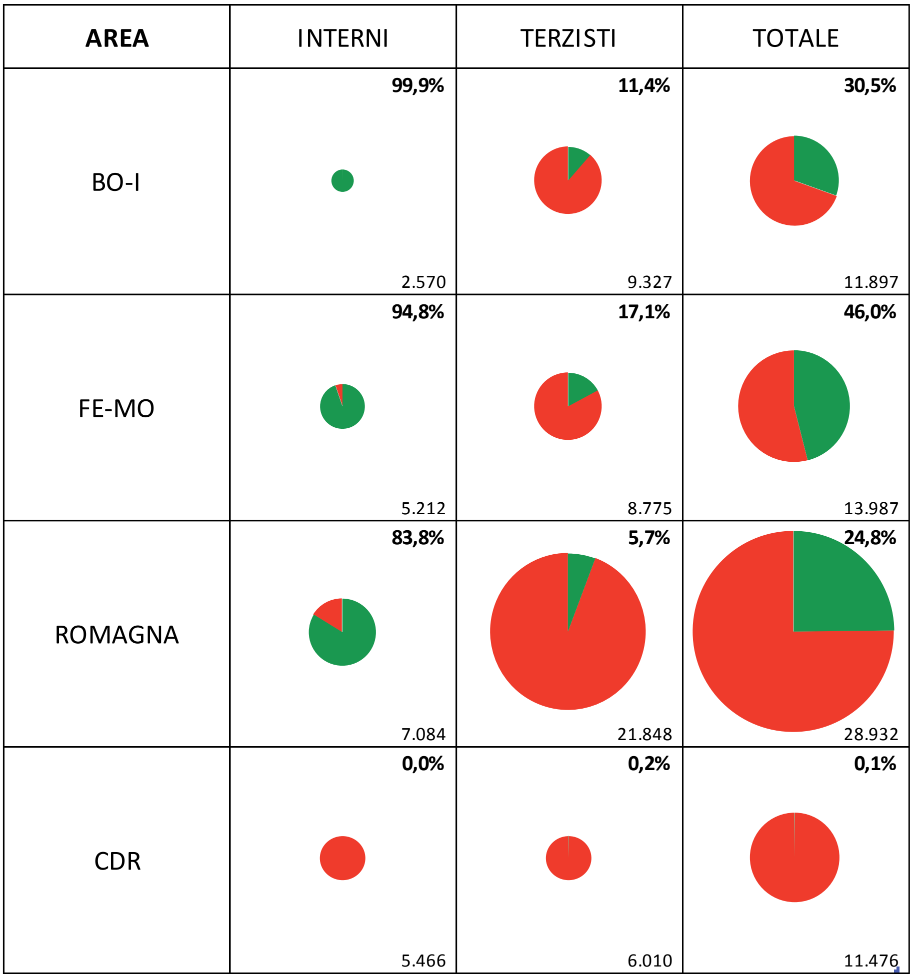
Fig. 3.1.1.5 shows that in Semptember the value related to the internal services improved for all areas (from 92% to 93%, excluding CDR), respect to the value of August. The figure for the subcontractors shows an increase (from 7% to 20%), producing a value of 65% of not accounted service orders (less than August-74%), of which 91.6% are related to the outsourced activities.



TOT ODS pianificati	*20.332*	*45.960*	*66.292*
TOT ODS chiusi	13.444	3.817	**17.261**
TOT ODS non chiusi	6.888	42.143	49.031

Fig.3.1.1.5 - Indicator 01: Detail per area of accounting service orders in September 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

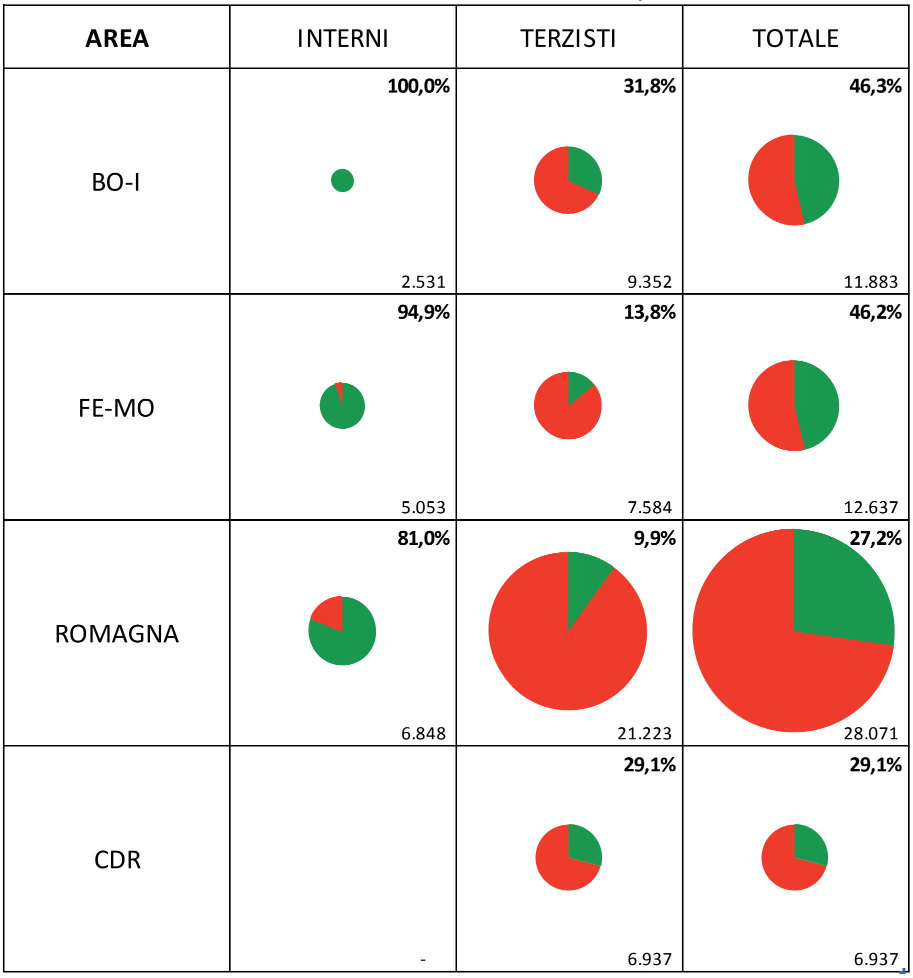
In October (Fig. 3.1.1.6) the value related to the internal services improved for all areas (from 90.5% to 93%, excluding CDR), respect to the value of September. The figure for the subcontractors shows a decrease (from 20% to 9.5%), producing a value of 75% of not accounted service orders (more than September -65%), of which 86% are related to the outsourced activities. The negative trend recorded in October may be linked to some system failures.



TOT ODS pianificati	*20.332*	*45.960*	*66.292*
TOT ODS chiusi	13.444	3.817	**17.261**
TOT ODS non chiusi	6.888	42.143	49.031

Fig.3.1.1.6 - Indicator 01: Detail per area of accounting service orders in October 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

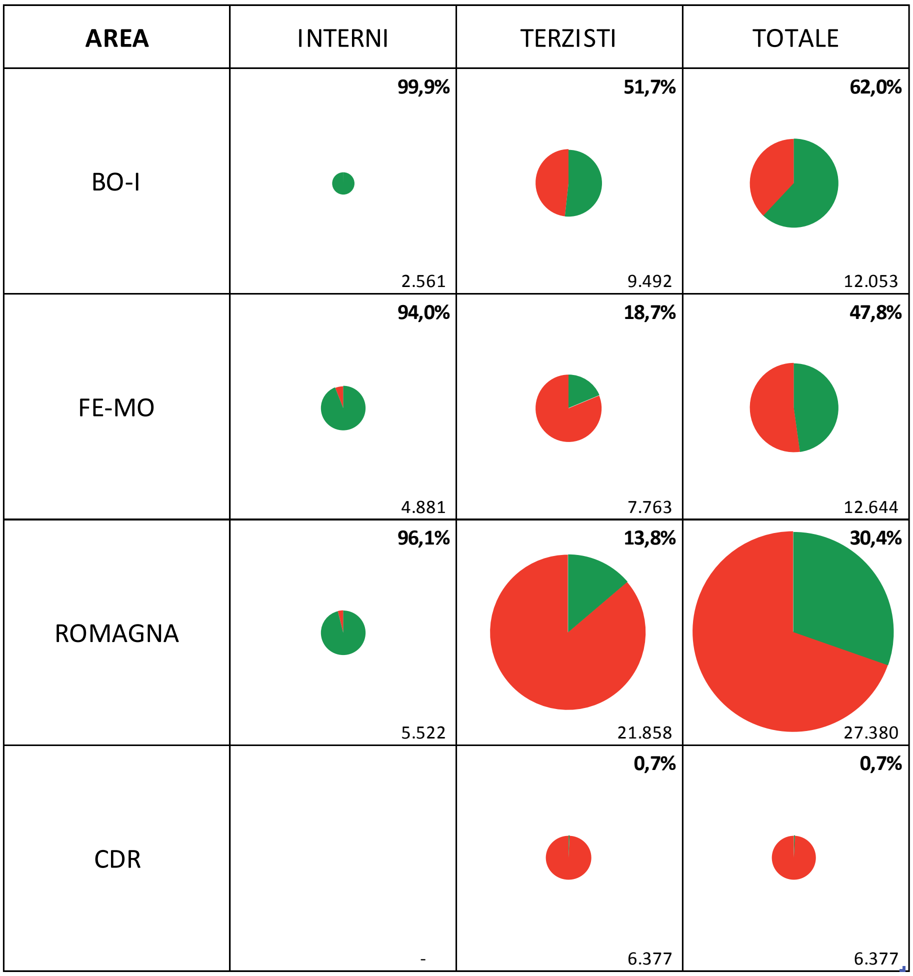
As Fig. 3.1.1.7 shows, in November the value related to the internal services decreased for all areas (from 90.5% to 89.2%, excluding CDR), respect to the value of October (the drop is in the Romagna area). The figure for the subcontractors shows an increase (from 9.5% to 16%), producing a value of 65% of not accounted service orders (less than October-74%), of which 96% are related to the outsourced activities. After the negative trend recorded in the month of October, values of November seem to be in line with those of previous months (excluding August). Regarding subcontractors, system failures still happened.



TOT ODS pianificati	*14.432*	*45.096*	*59.528*
TOT ODS chiusi	12.868	8.137	**21.005**
TOT ODS non chiusi	1.564	36.959	38.523

Fig.3.1.1.7 - Indicator 01: Detail per area of accounting service orders in November 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

As Fig. 3.1.1.8 shows, in December the value related to the internal services increased for all areas (from 89.2% to 96.1, excluding CDR), respect to the value of November. The figure for the subcontractors shows an increase (from 16% to 24%), producing a value of 63% of not accounted service orders (less than November-65%), of which 98.6% are related to the outsourced activities. It is necessary in the coming period to strengthen control over the accounting process. Regarding subcontractors, system failures still happened.



TOT ODS pianificati	*12.964*	*45.490*	*58.454*
TOT ODS chiusi	12.453	9.417	**21.870**
TOT ODS non chiusi	511	36.073	36.584

Fig.3.1.1.8 - Indicator 01: Detail per area of accounting service orders in December 2016, green represents the part of planned and accounted orders (first column: the detail of Area, second column: detail for internal service; third column: detail for external services; fourth column: total).

3.1.2 02 - Indicator of assignment of service Orders with ESA weighing

This indicator is used to measure the degree of use of the system to assign a weighing to the source system. The indicator is expressed as a percentage and it is calculated identifying the extraction of weighing ESA for institutional contracts with Order SSA (ODS SAP inserted). The aim of the indicator is to reach 100% of weighing connected to ODS.

This reunification is made at the plant, before beginning the disposal activities of the waste collected, where the driver delivers the transport document (DDT) with the ODS code associated with the collection route. The operator in the plant inserts the weighing information, including the ODS code and from this point on, through dialogue between the ESA and SAP systems, the weight can be associated with the service code.

The DDT (document of transport) is always present, as it is a document required by Italian law regarding the transport of goods, introduced as a partial replacement of the packing slip, of which the binding nature has been partially repealed by Presidential Decree August 14, 1996 n. 472. It is output to justify the transfer of a material from the transferor to the transferee through their own transport; either the goods are carried out on the sender or recipient's account, or they may be entrusted to a conveyor. It must be issued prior to the delivery or shipment of goods with an indication of the main elements of the transport. Therefore, the service is always linked to the presence of DDT and the aim of the indicator is 100%.

The targets of the indicator are:

2016	**1° Trim.**	**2° Trim.**	**3° Trim.**	**4° Trim.**
Internl services	95%	100%	100%	100%
External services	n.a.	85%	100%	100%

Tab. 3.1.1.2 – Aims of the indicator 02

Below indicator data are presented for the year 2016 (Fig.3.1.1.1 ÷ 3.1.1.8), calculated for the first two quarters in a compact way and for the other months individually.

The graph represents the percentage of orders with a weighing in ESA, with detailes on values and executor of the service area (internal or external service).

The target of the first quarter is satisfied by the total of the internal ODS for which the indicator has the value of 99.9%. Instead, the target is missed for fictitious ODS and the subcontractors (Fig.3.1.2.1).

Fig.3.1.2.1 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the first quarter of 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).

Figure 3.1.2.2 shows the indicator for the second quarter of 2016. The chart represents the percentage of orders with weighing ESA, with details of values by area and service performed (internal and external). The presence of weighing without an association to service orders (in red), highlights the lack of reunification between weighing and service order code presents in the DDT and delivered at the plant of destination. This causes the inability to value the service with the collected weight.

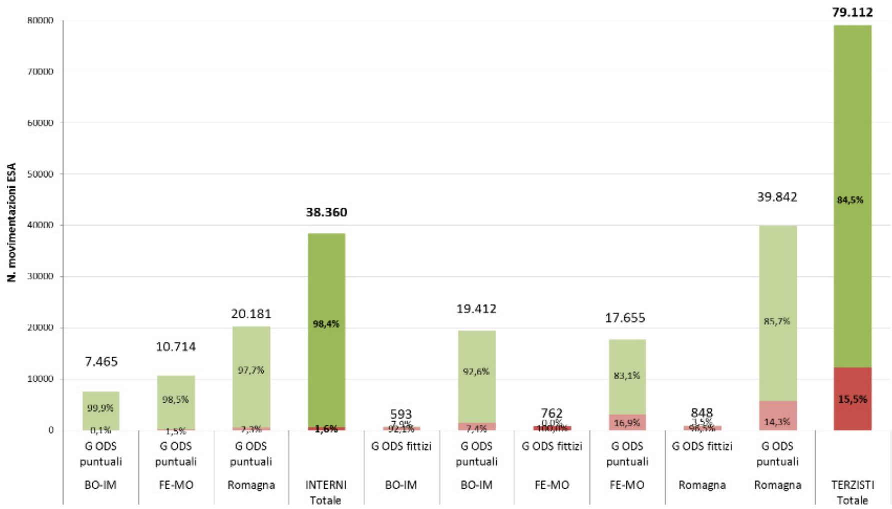


Fig.3.1.2.2 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the second quarter of 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).

Figure 3.1.2.3 shows the indicator for the month of July 2016. The total percentage of both internal and subcontractor services is substantially in line with the target set. There is an improvement on both the internal and subcontractor services (no ODS from 15.5% to 11.2%).

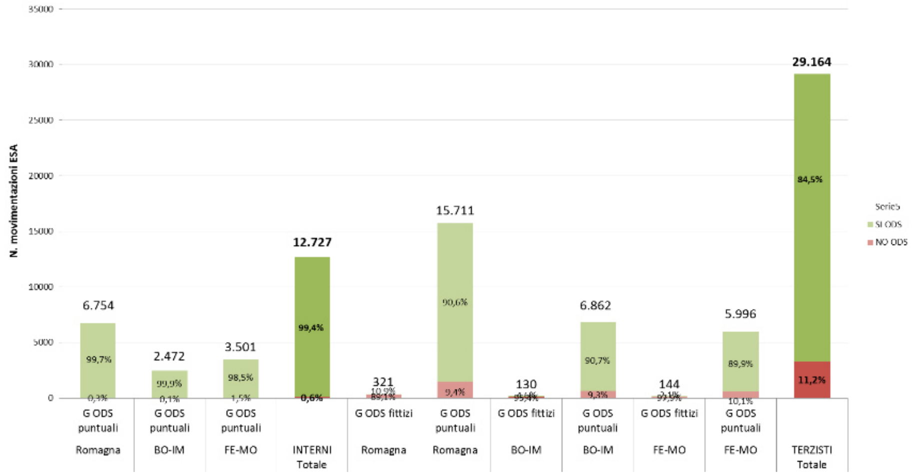
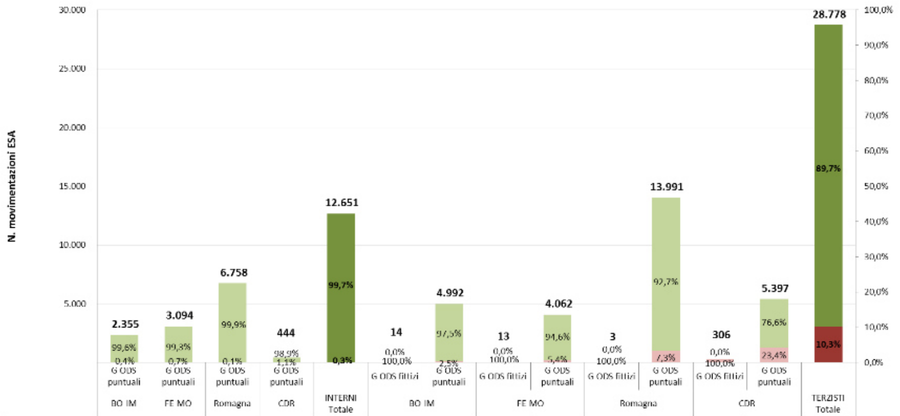


Fig.3.1.2.3 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the month of July 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).

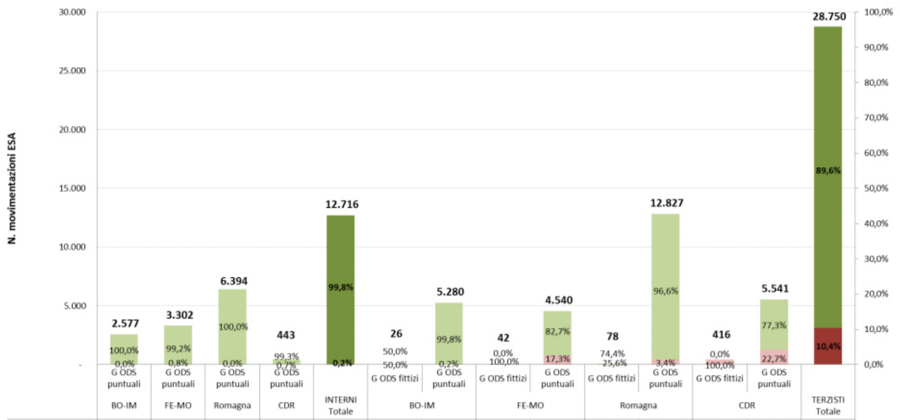
Figure 3.1.2.4 shows the indicator for the month of August 2016. The total percentage of both internal and external contractors is substantially in line with the target set. Compared to July there is an improvement on both the internal and for subcontractors (no ODS: from 11.2% to 10.3%).



	G ODS puntuali BO IM	G ODS puntuali FE MO	G ODS puntuali Romagna	G ODS puntuali CDR	INTERNI Totale	G ODS fittizi BO IM	G ODS puntuali BO IM	G ODS fittizi FE MO	G ODS puntuali FE MO	G ODS fittizi Romagna	G ODS puntuali Romagna	G ODS fittizi CDR	G ODS puntuali CDR	TERZISTI Totale
Totale complessivo	2.355	3.094	6.758	444	12.651	14	4.992	13	4.062	3	13.991	306	5.397	28.778
SI ODS	2.346	3.073	6.749	439	12.607	-	4.867	-	3.844	-	12.975	-	4.136	25.822
NO ODS	9	21	9	5	44	14	125	13	218	3	1.016	306	1.261	2.956

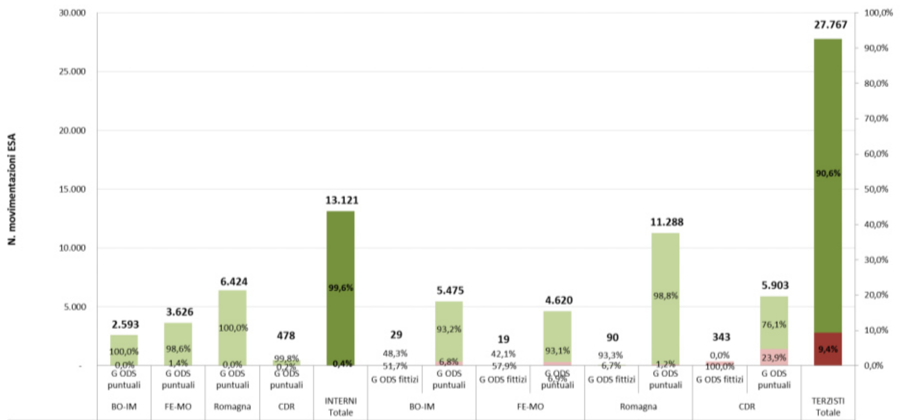
Fig.3.1.2.4 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the month of August 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).

Figure 3.1.2.5 shows the indicator for the month of September 2016. The total percentage of both internal and subcontractor services is substantially in line with the target set. Compared to August the percentage of allocation remains virtually unchanged for both the internals and the subcontractors. The same considerations hold for the months from October to December 2016 (Figures 3.1.2.6-3.1.28).



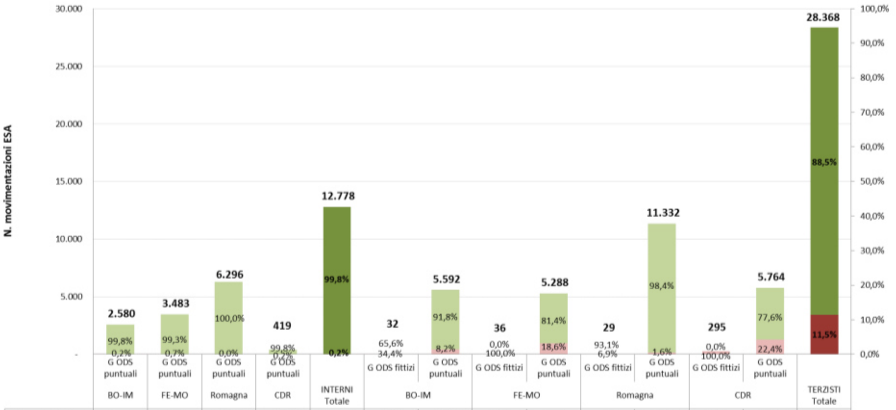
	G ODS puntuali	G ODS puntuali	G ODS puntuali	G ODS puntuali		G ODS fittizi	G ODS puntuali	G ODS fittizi	G ODS puntuali	G ODS fittizi	G ODS puntuali	G ODS fittizi	G ODS puntuali	
	BO-IM	FE-MO	Romagna	CDR	INTERNI Totale	BO-IM		FE-MO		Romagna		CDR		TERZISTI Totale
Totale complessivo	2.577	3.302	6.394	443	12.716	26	5.280	42	4.540	78	12.827	416	5.541	28.750
SI ODS	2.577	3.275	6.393	440	12.685	13	5.267	-	3.754	58	12.396	-	4.284	25.772
NO ODS	-	27	1	3	31	13	13	42	786	20	431	416	1.257	2.978

Fig.3.1.2.5 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the month of September 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).



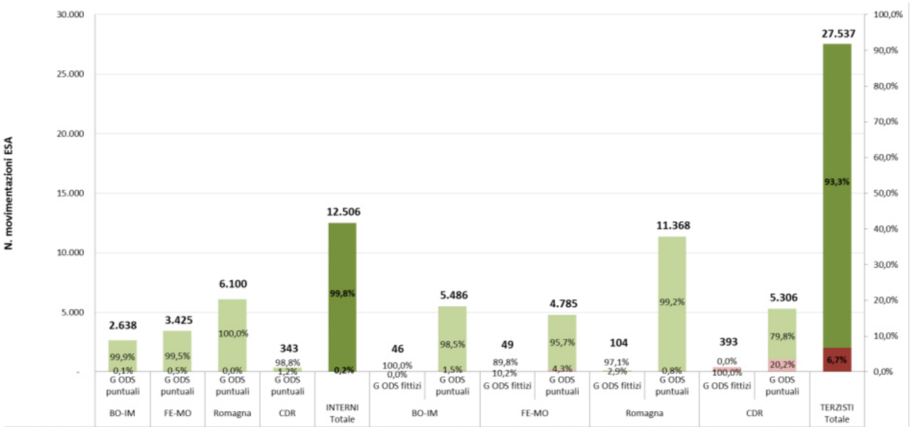
	G ODS puntuali	G ODS puntuali	G ODS puntuali	G ODS puntuali		G ODS fittizi	G ODS puntuali	G ODS fittizi	G ODS puntuali	G ODS fittizi	G ODS puntuali	G ODS fittizi	G ODS puntuali	
	BO-IM	FE-MO	Romagna	CDR	INTERNI Totale	BO-IM		FE-MO		Romagna		CDR		TERZISTI Totale
Totale complessivo	2.593	3.626	6.424	478	13.121	29	5.475	19	4.620	90	11.288	343	5.903	27.767
SI ODS	2.593	3.576	6.424	477	13.070	14	5.103	8	4.303	84	11.155	-	4.493	25.160
NO ODS	-	50	-	1	51	15	372	11	317	6	133	343	1.410	2.607

Fig.3.1.2.6 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the month of October 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).



	BO-IM G ODS puntuali	FE-MO G ODS puntuali	Romagna G ODS puntuali	CDR G ODS puntuali	INTERNI Totale	BO-IM G ODS fittizi	BO-IM G ODS puntuali	FE-MO G ODS fittizi	FE-MO G ODS puntuali	Romagna G ODS fittizi	Romagna G ODS puntuali	CDR G ODS fittizi	CDR G ODS puntuali	TERZISTI Totale
Totale complessivo	2.580	3.483	6.296	419	12.778	32	5.592	36	5.288	29	11.332	295	5.764	28.368
SI ODS	2.576	3.457	6.296	418	12.747	21	5.135	-	4.305	27	11.156	-	4.470	25.114
NO ODS	4	26	-	1	31	11	457	36	983	2	176	295	1.294	3.254

Fig.3.1.2.7 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the month of November 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).



	BO-IM G ODS puntuali	FE-MO G ODS puntuali	Romagna G ODS puntuali	CDR G ODS puntuali	INTERNI Totale	BO-IM G ODS fittizi	BO-IM G ODS puntuali	FE-MO G ODS fittizi	FE-MO G ODS puntuali	Romagna G ODS fittizi	Romagna G ODS puntuali	CDR G ODS fittizi	CDR G ODS puntuali	TERZISTI Totale
Totale complessivo	2.638	3.425	6.100	343	12.506	46	5.486	49	4.785	104	11.368	393	5.306	27.537
SI ODS	2.635	3.408	6.099	339	12.481	46	5.405	44	4.579	101	11.279	-	4.232	25.686
NO ODS	3	17	1	4	25	-	81	5	206	3	89	393	1.074	1.851

Fig.3.1.2.8 - Indicator 02: Detail per area and per type of service of percentage of service orders completeness for the month of December 2016, green represents the part of weighing with a reunification with a service order (asse x: detail per area and total for internal and external services).

3.1.3 03a - Indicator of use of Field Systems

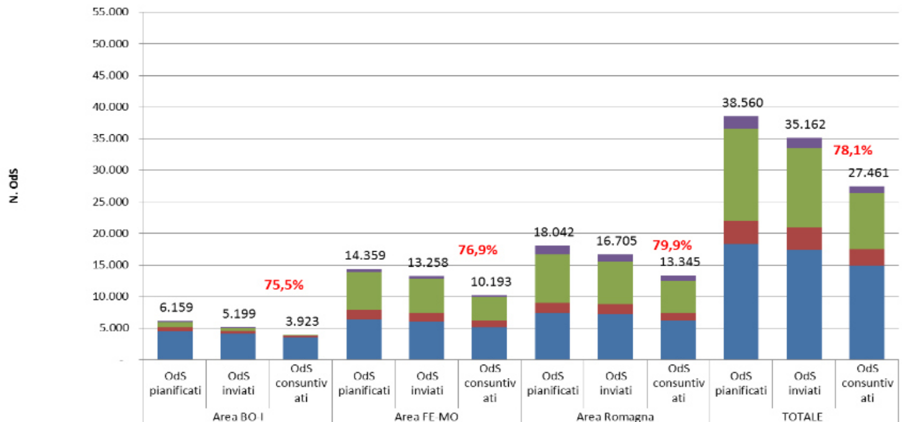
This indicator is adopted to measure the degree of use of the system to quantify the degree of reporting by field devices. The objective of this indicator is the attainment of one hundred percent. Intermediate temporal objectives are:

2016	1° Trim.	2° Trim.	3° Trim.	4° Trim.
Internal services	80%	90%	100%*	100%*
External services	n.a.	60%	70%	100%*

Tab. 3.1.3.1 – Aim of Indicator 03a

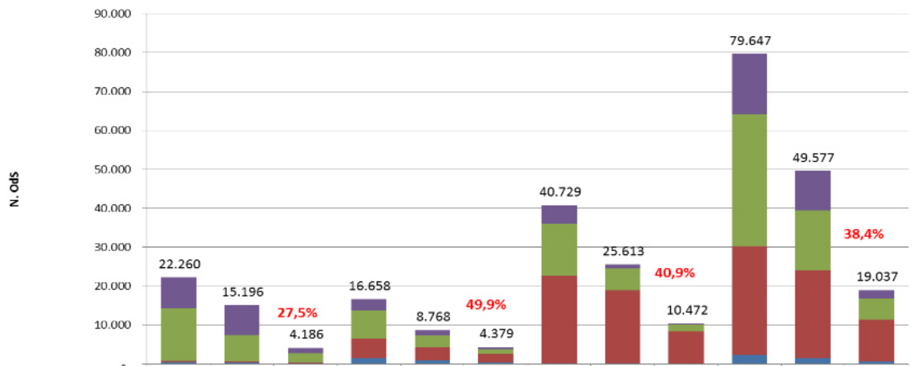
* The goal of 100% is considered to be theoretical with an estimated acceptable range of 5%, due to:
a. Stopping programmed system
b. System faults and field devices

Fig. 3.1.3.1 and 3.1.3.2 display the graphs for the indicator 03 for the first quarter in 2016. In Fig. 3.1.3.1 the chart shows in detail the percentage of accounted service orders among those scheduled and sent to SAC for internal services. In fig. 3.1.3.2 the chart shows in detail the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services. In both cases, the details of the percentage margin between the orders “planned and sent to SAC” and those “sent and accounted”, with details for the macro area and area of service provision, is explained.



	OdS pianificati	OdS inviati	OdS consuntivati	OdS pianificati	OdS inviati	OdS consuntivati	OdS pianificati	OdS inviati	OdS consuntivati	OdS pianificati	OdS inviati	OdS consuntivati
	Area BO-I			Area FE-MO			Area Romagna			TOTALE		
% consuntivati/inviati			75,5%			76,9%			79,9%			78,1%
Totale	6.159	5.199	3.923	14.359	13.258	10.193	18.042	16.705	13.345	38.560	35.162	27.461
Spazzamento	174	136	-	459	434	292	1.344	1.143	822	1.977	1.713	1.114
Altre Raccolte	839	467	113	6.005	5.392	3.661	7.675	6.722	5.062	14.519	12.581	8.836
Carico posteriore	629	519	269	1.514	1.413	1.097	1.596	1.566	1.189	3.739	3.498	2.555
Carico laterale	4.517	4.077	3.541	6.381	6.019	5.143	7.427	7.274	6.272	18.325	17.370	14.956

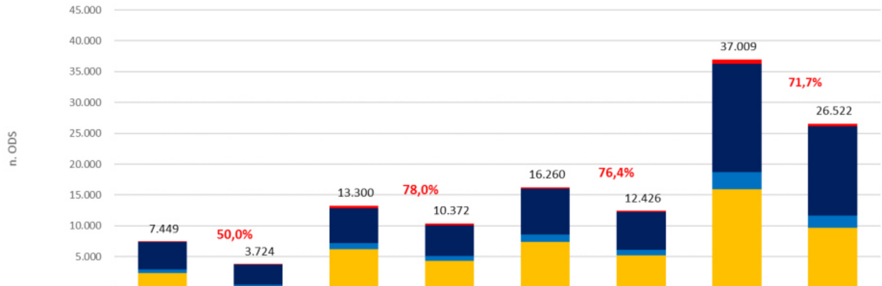
Fig. 3.1.3.1 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (First quarter 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (purple-sweeping, green-other services, red-load rear, and blue-lateral load).



	OdS pianificati	OdS inviati	OdS consuntiv ati	OdS pianificati	OdS inviati	OdS consuntiv ati	OdS pianificati	OdS inviati	OdS consuntiv ati	OdS pianificati	OdS inviati	OdS consuntiv ati
	Area BO-I			Area FE-MO			Area Romagna			TOTALE		
% consuntivati/inviati			27,5%			49,9%			40,9%			38,4%
Totale	22.260	15.196	4.186	16.658	8.768	4.379	40.729	25.613	10.472	79.647	49.577	19.037
Spazzamento	8.039	7.669	1.388	2.845	1.390	493	4.661	1.003	246	15.545	10.062	2.127
Altre Raccolte	13.310	6.765	2.418	7.165	3.080	1.287	13.340	5.590	1.788	33.815	15.435	5.493
Carico posteriore	435	322	175	5.094	3.347	2.192	22.420	18.817	8.299	27.949	22.486	10.666
Carico laterale	476	440	205	1.554	951	407	308	203	139	2.338	1.594	751

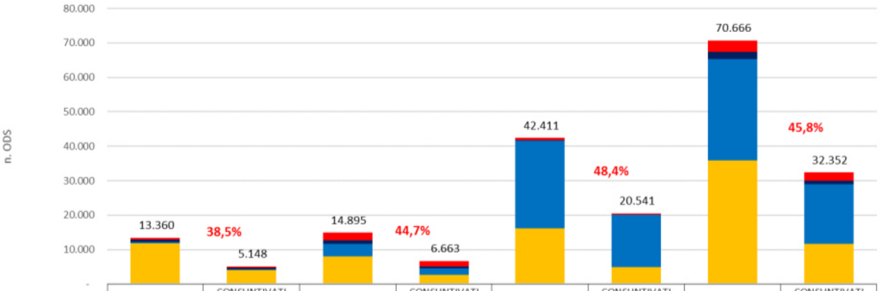
Fig. 3.1.3.2 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (First quarter 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (purple-sweeping, green-other services, red-load rear, and blue-lateral load).

For the second quarter, it was examined in detail the percentage of accounted service orders with field devices respect to those planned, for services performed by both the internals (Fig.3.1.3.3) and the subcontractors (Fig. 3.1.3.4).



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Spazzatrice	70	1,4%	398	73,1%	228	54,4%	696	59,8%
Monoperatore	4.462	73,5%	5.724	87,5%	7.400	83,5%	17.586	82,3%
Carico posteriore	588	49,1%	970	76,4%	1.278	72,5%	2.836	69,0%
Altro	2.329	6,7%	6.208	69,7%	7.354	70,6%	15.891	60,9%
TOTALE	7.449	50,0%	13.300	78,0%	16.260	76,4%	37.009	71,7%

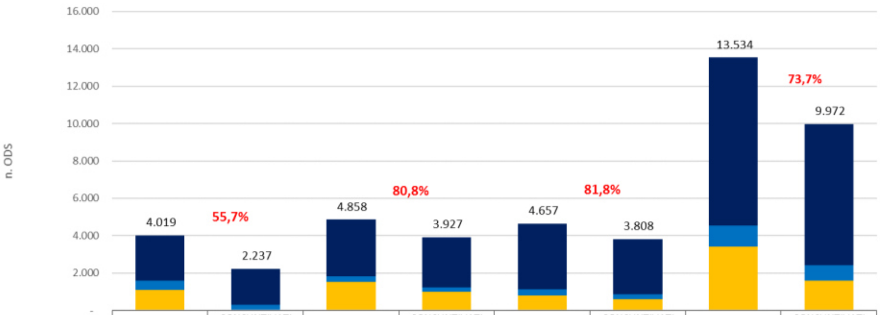
Fig. 3.1.3.3 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (Second quarter 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	471	79,2%	2.158	71,9%	569	71,0%	3.198	72,8%
Monoperatore	720	68,2%	1.102	43,7%	247	23,9%	2.069	49,9%
Carico posteriore	400	60,5%	3.673	53,1%	25.517	59,5%	29.590	58,7%
Altro	11.769	34,3%	7.962	33,7%	16.078	30,5%	35.809	32,5%
TOTALE	13.360	38,5%	14.895	44,7%	42.411	48,4%	70.666	45,8%

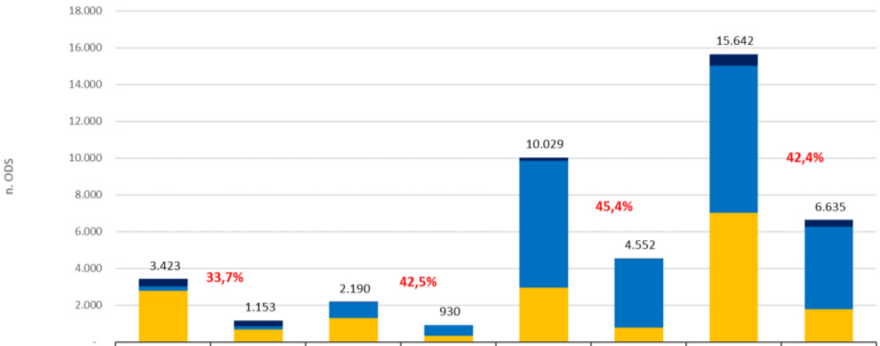
Fig. 3.1.3.4 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (First quarter 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

For the second quarter, it was possible to focus on services. It is interesting to analyze the not separated collection services provided by Hera (Fig. 3.1.3.5) and external staff (Fig. 3.1.3.6). The collection accounts for about one third of the total orders handled with field devices; although it is the priority service for implementation purposes of the timely rate, the result confirms the need for action to incentivize the use of field devices.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	2.414	79,6%	3.033	88,5%	3.539	82,9%	8.986	83,9%
Carico posteriore	494	58,5%	312	81,7%	332	83,7%	1.138	72,2%
Altro	1.111	2,4%	1.513	65,2%	786	75,8%	3.410	47,2%
TOTALE	4.019	55,7%	4.858	80,8%	4.657	81,8%	13.534	73,7%

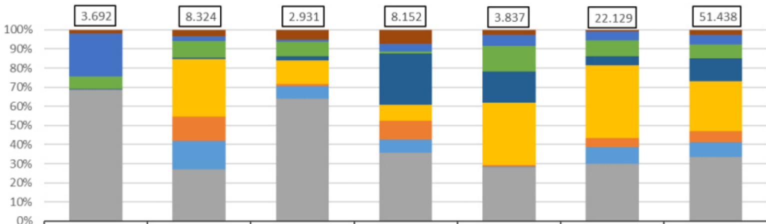
Fig. 3.1.3.5- Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services: focus of municipal solid waste (First quarter 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	416	73,6%	25	0,0%	187	31,6%	628	58,1%
Carico posteriore	231	70,1%	873	68,5%	6.895	53,8%	7.999	55,9%
Altro	2.776	24,7%	1.286	25,4%	2.947	26,6%	7.009	25,6%
TOTALE	3.423	33,7%	2.190	42,5%	10.029	45,4%	15.642	42,4%

Fig. 3.1.3.6- Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services: focus of municipal solid waste (First quarter 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

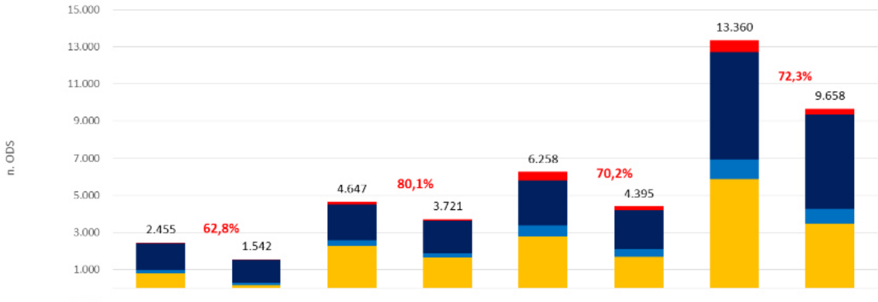
In Fig. 3.1.3.7 below the percentage of not accounted service orders for the type of activities carried out by internal and external staff is evaluated in detail.



	AREA BO-IM Interno	AREA BO-IM terzista	AREA FE-MO Interno	AREA FE-MO terzista	AREA ROMAGNA Interno	AREA ROMAGNA terzista	Totale
%spazzamento	1,9%	3,5%	5,2%	7,4%	2,7%	0,7%	2,7%
%rifiuti abbandonati	22,3%	2,5%	0,9%	3,7%	5,7%	4,8%	5,1%
%rifiuti ingombranti	6,6%	8,6%	7,8%	1,4%	13,5%	8,4%	7,1%
%scarrabili	0,4%	0,8%	2,2%	26,7%	16,4%	4,7%	12,0%
%raccolta target	0,2%	29,8%	12,2%	8,2%	32,3%	37,9%	25,8%
%pap senza contenitori	0,0%	12,9%	1,1%	9,9%	1,0%	4,7%	5,8%
%pap con contenitori	0,0%	14,7%	6,6%	7,0%	0,1%	8,9%	7,7%
%raccolta stradale	68,7%	27,3%	64,1%	35,7%	28,4%	29,9%	33,7%
TOTALE	3.692	8.324	2.931	8.152	3.837	22.129	51.438

Fig. 3.1.3.7- Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services. There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

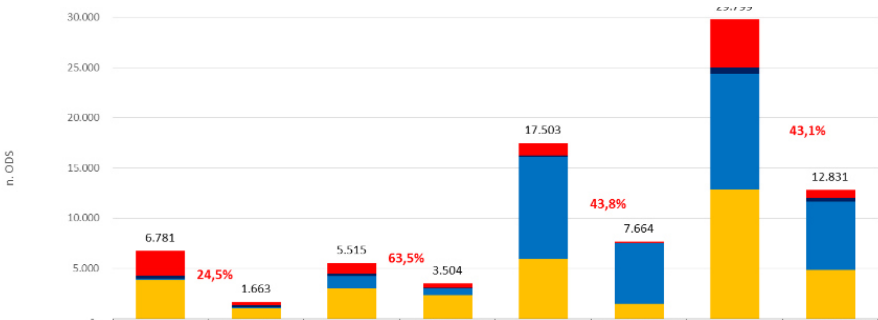
For the month of July, Fig. 3.1.3.8 displays the detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services. The result is lower than the intended objective (72.1% vs 90%), in line with the data for the second quarter. There is an improvement in the BO - IM Area (from 50% to 62.8%), partly due to the exclusion from the analysis of routes not managed with SDC, and in part to effective improvement in processes. In this period the field devices have been revised to achieve the optimal technological solution.



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Spazzatrice	57	36,8%	135	53,3%	445	43,6%	637	45,1%
Monoperatore	1.414	86,9%	1.928	91,1%	2.435	86,2%	5.777	88,0%
Carico posteriore	197	68,5%	308	76,3%	585	74,7%	1.090	74,0%
Altro	787	19,9%	2.276	72,8%	2.793	59,6%	5.856	59,4%
TOTALE	2.455	62,8%	4.647	80,1%	6.258	70,2%	13.360	72,3%

Fig. 3.1.3.8 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (July 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

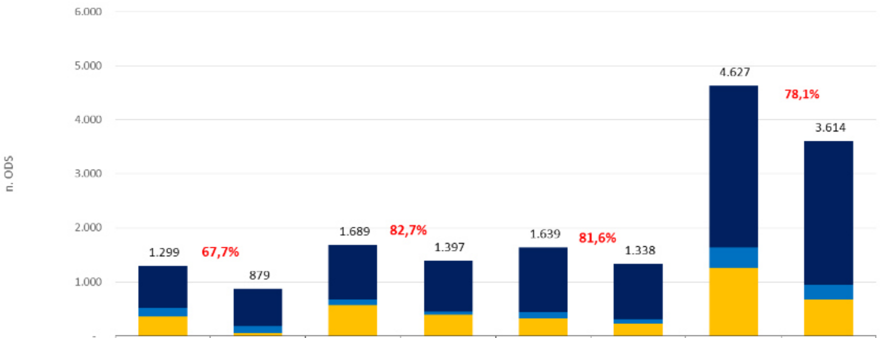
Fig. 3.1.3.9 illustrates the detail of the percentage of accounted service orders among those scheduled and sent to SAC for the services provided by external staff. The result is lower than the intended objective (43.1% vs 60%), in line with the data for the second quarter. There is an improvement in the FE - MO area (from 44.7% to 63.5%), due to effective process improvement, while there is an abnormal decline in the Bo - Im Area (from 38.5% to 24, 5%).



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Spazzatrice	2.495	12,7%	1.001	39,7%	1.279	8,9%	4.775	17,4%
Monoperatore	256	86,7%	297	31,6%	85	27,1%	638	53,1%
Carico posteriore	145	50,3%	1.206	54,6%	10.156	59,6%	11.507	58,9%
Altro	3.885	27,0%	3.011	78,2%	5.983	24,7%	12.879	37,9%
TOTALE	6.781	24,5%	5.515	63,5%	17.503	43,8%	29.799	43,1%

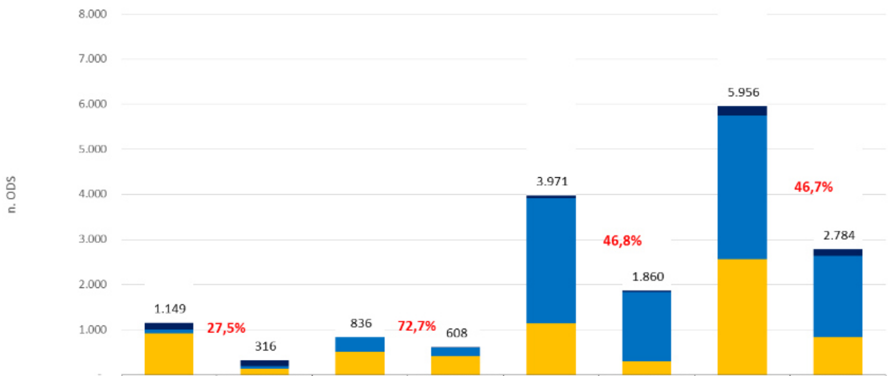
Fig. 3.1.3.9 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontracor services (July 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

Fig. 3.1.3.10 and 3.1.3.11 display the graph for only not separated collection services performed respectively by internal and external staff. The considerations made for the second quarter are valid.



	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
Monoperatore	777	88,9%	1.018	93,2%	1.198	86,1%	2.993	89,3%
Carico posteriore	166	81,3%	99	59,6%	112	68,8%	377	71,9%
Altro	356	14,9%	572	68,0%	329	69,6%	1.257	53,4%
TOTALE	1.299	67,7%	1.689	82,7%	1.639	81,6%	4.627	78,1%

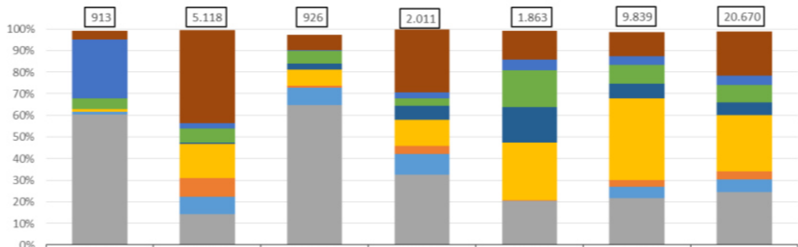
Fig. 3.1.3.10 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (July 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
Monoperatore	139	87,8%	8	50,0%	60	38,3%	207	72,0%
Carico posteriore	89	70,8%	318	62,3%	2.776	55,7%	3.183	56,7%
Altro	921	14,2%	510	79,6%	1.135	25,7%	2.566	32,3%
TOTALE	1.149	27,5%	836	72,7%	3.971	46,8%	5.956	46,7%

Fig. 3.1.3.11 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractors services (July 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).

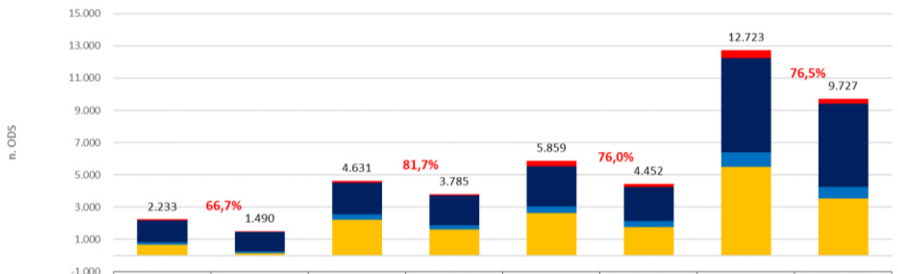
In Fig. 3.1.3.12 the percentage of not accounted service orders for the type of activities carried out by internal and external staff is evaluated in detail.



	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		Totale complessivo
	Interno	Terzista	Interno	Terzista	Interno	Terzista	
%spazzamento	3,9%	43,2%	6,9%	29,2%	13,4%	11,3%	20,6%
%rifiuti abbandonati	27,3%	2,3%	0,4%	2,8%	5,1%	4,1%	4,5%
%rifiuti ingombranti	4,9%	6,8%	5,9%	3,5%	16,8%	8,5%	8,1%
%scarrabili	0,1%	0,4%	2,7%	6,5%	16,5%	6,9%	5,7%
%raccolta target	1,3%	16,0%	7,5%	12,1%	26,7%	38,0%	26,0%
%pap senza contenitori	0,0%	8,6%	1,0%	3,6%	0,2%	2,9%	3,9%
%pap con contenitori	1,1%	8,1%	7,9%	9,4%	0,1%	5,2%	5,8%
%raccolta stradale	60,5%	14,1%	64,8%	32,6%	20,4%	21,8%	24,5%
%altro	0,9%	0,5%	2,9%	0,2%	0,9%	1,5%	1,1%
Totale complessivo	913	5.118	926	2.011	1.863	9.839	20.670

Fig. 3.1.3.12 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services (July 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

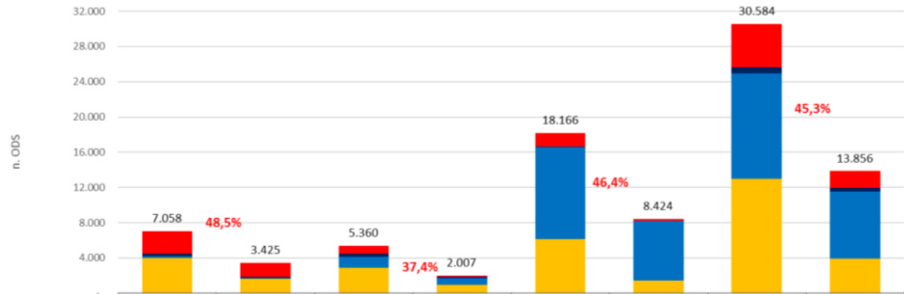
Below, for the month of August, the same considerations made for the month of July are presented. Fig. 3.1.3.13 displays a detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services. The result is lower than the intended objective (76.5% vs 90%) and increased compared to the data in July (72%). There is an improvement in the BO - IM Area (from 62.8% to 66.7%), partly due to the exclusion from the analysis of routes that should not be managed by SDC, and in part to effective process improvements.



	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
Spazzatrice	47	46,8%	120	65,8%	319	62,4%	486	61,7%
Monoperatore	1.367	90,2%	1.975	92,3%	2.489	85,0%	5.831	88,7%
Carico posteriore	143	70,6%	341	81,8%	430	84,4%	914	81,3%
Altro	676	19,8%	2.195	73,1%	2.621	67,7%	5.492	64,0%
TOTALE	2.233	66,7%	4.631	81,7%	5.859	76,0%	12.723	76,5%

Fig. 3.1.3.13 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (August 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

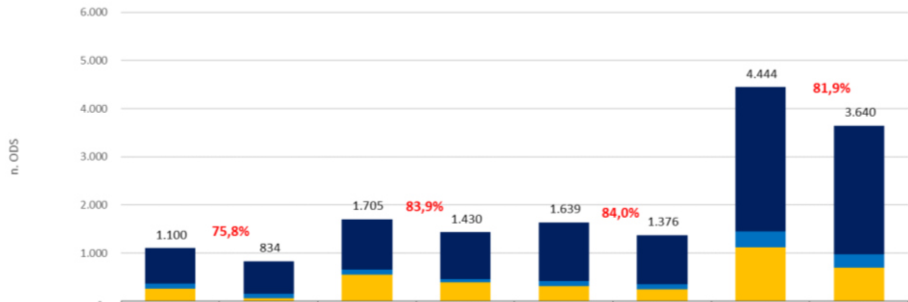
Fig. 3.1.3.14 displays a detail of the percentage of accounted service orders among those scheduled and sent to SAC for the services provided by external staff. The result is lower than the intended objective (45.3% vs 60%), and was slightly higher than in July (43%). Compared to July there is also an improvement in the BO-IM Area (from 24.5% to 48.5%), a decrease in the FE-MO Area (from 63.5% to 37.4%), and an almost constant trend in the Romagna area (from 43.8% to 46.4%).



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Spazzatrice	2.587	59,9%	882	17,6%	1.493	12,3%	4.962	38,0%
Monoperatore	253	76,3%	328	50,3%	115	51,3%	696	59,9%
Carico posteriore	206	35,9%	1.293	57,3%	10.427	65,0%	11.926	63,7%
Altro	4.012	40,1%	2.857	33,1%	6.131	22,8%	13.000	30,4%
TOTALE	7.058	48,5%	5.360	37,4%	18.166	46,4%	30.584	45,3%

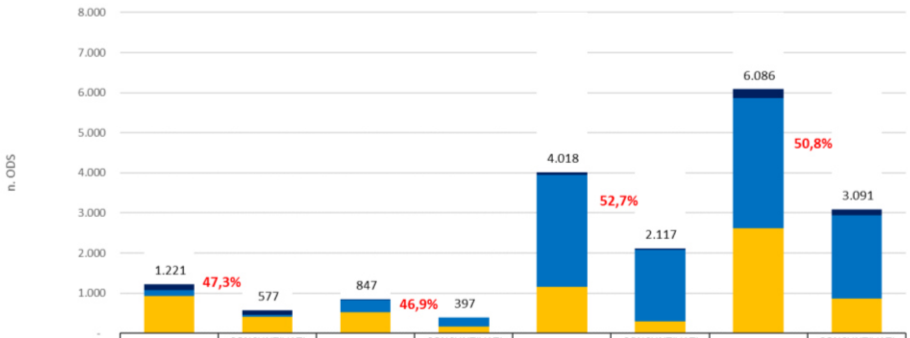
Fig. 3.1.3.14 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (August 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

In Fig. 3.1.3.15 and 3.1.3.16 there are the charts for not separated collection services performed respectively by internal and external staff. The considerations made for previous months are valid.



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Monoperatore	733	92,2%	1.050	92,0%	1.214	84,1%	2.997	88,9%
Carico posteriore	111	91,0%	102	71,6%	116	90,5%	329	84,8%
Altro	256	22,3%	553	70,7%	309	80,9%	1.118	62,4%
TOTALE	1.100	75,8%	1.705	83,9%	1.639	84,0%	4.444	81,9%

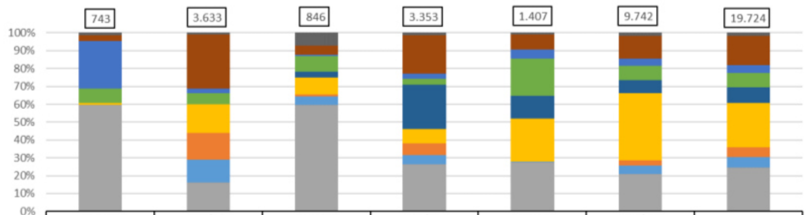
Fig. 3.1.3.15 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (August 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Monoperatore	144	78,5%	9	88,9%	63	57,1%	216	72,7%
Carico posteriore	145	39,3%	321	69,8%	2.794	64,0%	3.260	63,5%
Altro	932	43,7%	517	31,9%	1.161	25,2%	2.610	33,1%
TOTALE	1.221	47,3%	847	46,9%	4.018	52,7%	6.086	50,8%

Fig. 3.1.3.16 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (August 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).

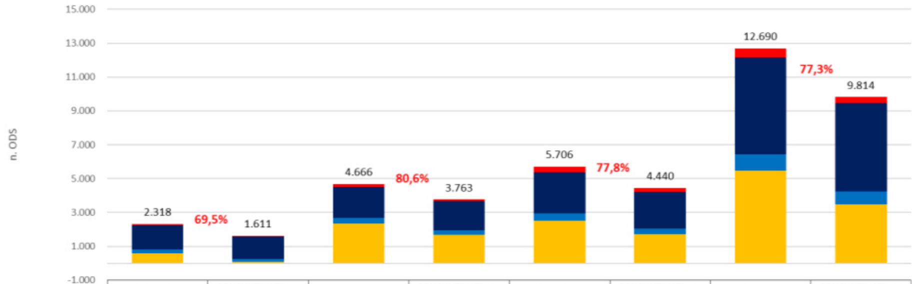
Fig. 3.1.3.17 shows in detail the percentage of not accounted service orders for the type of activities carried out by internal and external staff.



	Interno	Terzista	Interno	Terzista	Interno	Terzista	Totale complessivo
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		
%altro	1,2%	1,1%	7,3%	1,2%	1,0%	1,8%	1,7%
%spazzamento	3,4%	30,2%	4,8%	21,6%	8,5%	12,7%	16,4%
%rifiuti abbandonati	26,8%	2,6%	0,7%	3,0%	4,9%	3,8%	4,2%
%rifiuti ingombranti	8,1%	6,3%	9,0%	3,3%	20,8%	8,3%	8,0%
%scarrabili	0,0%	0,0%	3,1%	25,0%	12,8%	7,0%	8,8%
%raccolta target	0,8%	15,8%	9,7%	7,7%	24,2%	37,8%	25,0%
%pap senza contenitori	0,0%	15,1%	1,1%	6,7%	0,1%	2,8%	5,3%
%pap con contenitori	0,0%	12,7%	4,8%	5,2%	0,1%	4,7%	5,8%
%raccolta stradale	59,8%	16,3%	59,5%	26,4%	27,6%	21,1%	24,7%
Totale complessivo	743	3.633	846	3.353	1.407	9.742	19.724

Fig. 3.1.3.18 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services (August 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

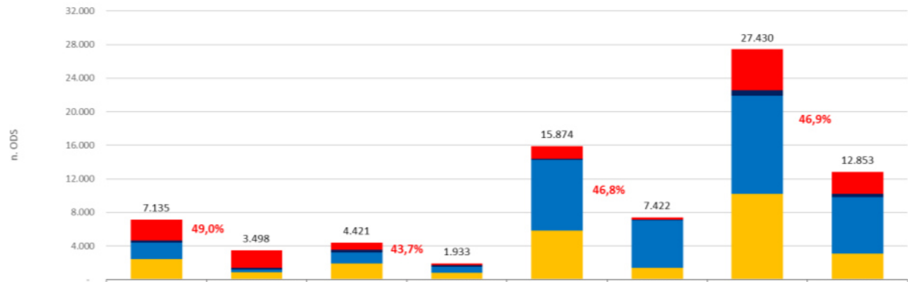
For the month of September, Fig. 3.1.3.18 displays the percentage of accounted service orders among those scheduled and sent to SAC for internal services. The result is lower than the intended objective (77.3% vs 90%) and increased compared to the data recorded in August (76.5%). There is an improvement in the BO Area - IM (from 66.7 to 69.5%), partly due to the exclusion from the analysis of routes should not be managed by SDC, and in part to effective process improvement.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	57	63,2%	148	64,9%	333	70,6%	538	68,2%
Monoperatore	1.449	91,7%	1.841	92,7%	2.438	88,3%	5.728	90,6%
Carico posteriore	213	76,5%	325	84,6%	416	81,5%	954	81,4%
Altro	599	13,9%	2.352	71,7%	2.519	68,0%	5.470	63,7%
TOTALE	2.318	69,5%	4.666	80,6%	5.706	77,8%	12.690	77,3%

Fig. 3.1.3.18 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (September 2016). Fig. 3.1.3.14 –There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

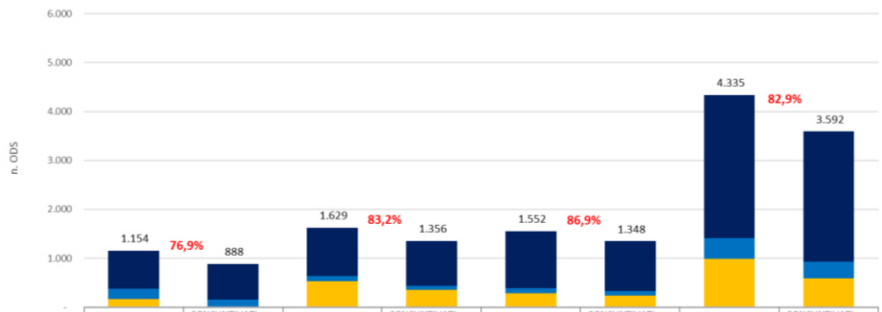
Fig. 3.1.3.19 shows a detail of the percentage of accounted service orders among those scheduled and sent to SAC for the services provided by external staff. The result is lower than the intended objective (46.9% vs 60%), and was slightly higher than in August (45.3%). There is, compared to August, a slight improvement in the BO-IM Area (48.5 to 49%), an increase in the FE-MO Area (from 37.4 to 43.7%), and a nearly constant trend in the Romagna area (from 46.4% to 46.8%).



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	2.502	84,0%	887	27,4%	1.488	19,9%	4.877	54,2%
Monoperatore	205	87,3%	334	45,5%	113	57,5%	652	60,7%
Carico posteriore	1.985	17,7%	1.255	59,7%	8.457	66,8%	11.697	57,7%
Altro	2.443	35,4%	1.945	40,6%	5.816	24,3%	10.204	30,1%
TOTALE	7.135	49,0%	4.421	43,7%	15.874	46,8%	27.430	46,9%

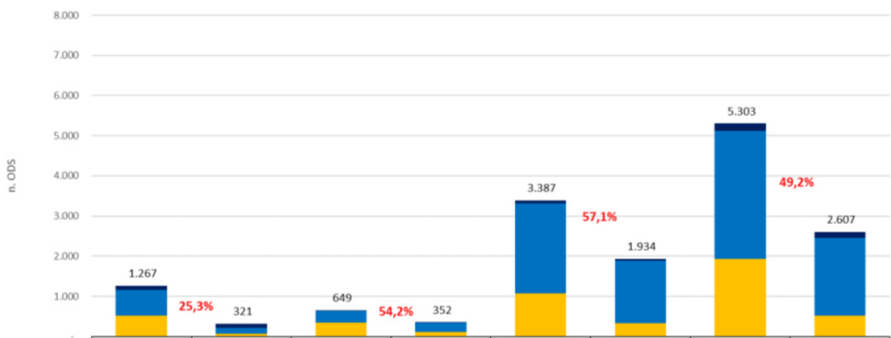
Fig. 3.1.3.19 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (September 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

In Fig. 3.1.3.20 and 3.1.3.21 there are the charts for not separated collection services performed respectively by internal and external staff. The considerations made for previous months are valid.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	771	94,3%	988	93,3%	1.163	87,5%	2.922	91,3%
Carico posteriore	211	76,3%	106	77,4%	109	83,5%	426	78,4%
Altro	172	0,0%	535	65,8%	280	85,4%	987	59,9%
TOTALE	1.154	76,9%	1.629	83,2%	1.552	86,9%	4.335	82,9%

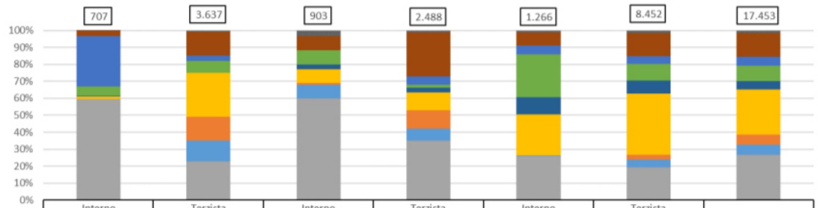
Fig. 3.1.3.20 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (September 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	107	95,3%	8	50,0%	67	68,7%	182	83,5%
Carico posteriore	643	22,2%	298	79,9%	2.248	69,2%	3.189	60,7%
Altro	517	14,7%	343	32,1%	1.072	31,1%	1.932	26,9%
TOTALE	1.267	25,3%	649	54,2%	3.387	57,1%	5.303	49,2%

Fig. 3.1.3.21 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (September 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).

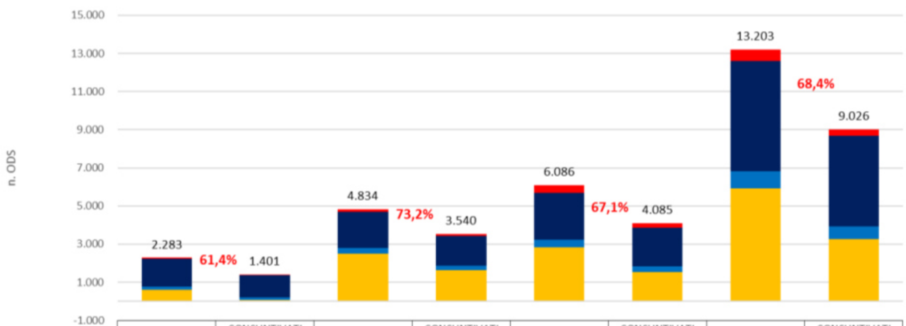
Fig. 3.1.3.22 shows in detail the percentage of not accounted service orders for the type of activities carried out by internal and external staff.



	AREA BO-IM Interno	AREA BO-IM Terzista	AREA FE-MO Interno	AREA FE-MO Terzista	AREA ROMAGNA Interno	AREA ROMAGNA Terzista	Totale complessivo
%altro	0,1%	0,8%	3,4%	1,1%	1,1%	1,7%	1,4%
%spazzamento	3,0%	14,2%	8,1%	25,8%	7,7%	13,6%	14,3%
%rifiuti abbandonati	30,0%	3,2%	0,2%	5,2%	5,5%	4,4%	5,2%
%rifiuti ingombranti	5,7%	6,9%	8,3%	1,6%	25,3%	9,9%	8,9%
%scarrabili	0,1%	0,0%	2,9%	2,7%	10,1%	7,8%	5,1%
%raccolta target	1,4%	25,7%	8,1%	10,5%	24,2%	35,9%	26,4%
%pap senza contenitori	0,0%	14,0%	0,9%	10,9%	0,0%	3,1%	6,0%
%pap con contenitori	0,0%	12,5%	8,2%	7,0%	0,1%	4,4%	6,1%
%raccolta stradale	59,7%	22,7%	59,9%	35,1%	26,1%	19,4%	26,5%
Totale complessivo	707	3.637	903	2.488	1.266	8.452	17.453

Fig. 3.1.3.22 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services (September 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

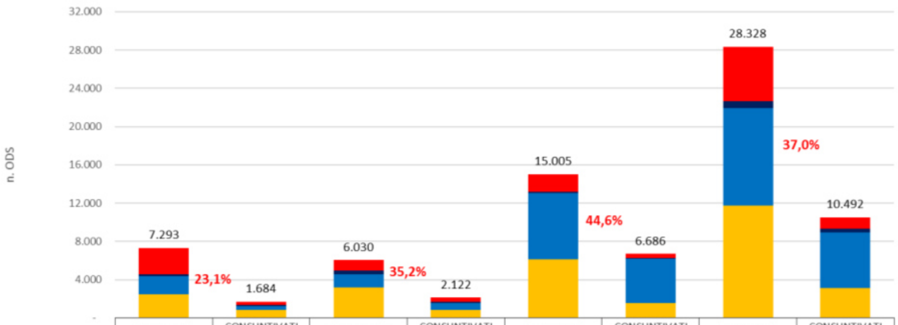
Below, for the month of October, the same considerations made for the month of September hold. Fig. 3.1.3.23 displays the percentage of accounted service orders among those scheduled and sent to SAC for internal services. The result is lower than the intended objective (68.4% vs 100%) and decreased compared to the data recorded in September (77.3%). There was a decrease in all areas: BO Area - IM from 69.5% to 61.4, Fe-MO area from 80.6 to 73.2, Romagna area from 77.8 to 67.1.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	52	76,9%	157	66,2%	399	53,9%	608	59,0%
Monoperatore	1.464	78,9%	1.876	83,4%	2.453	82,5%	5.793	81,9%
Carico posteriore	177	70,6%	306	73,5%	394	77,7%	877	74,8%
Altro	590	13,7%	2.495	66,0%	2.840	54,2%	5.925	55,1%
TOTALE	2.283	61,4%	4.834	73,2%	6.086	67,1%	13.203	68,4%

Fig. 3.1.3.23 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (October 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

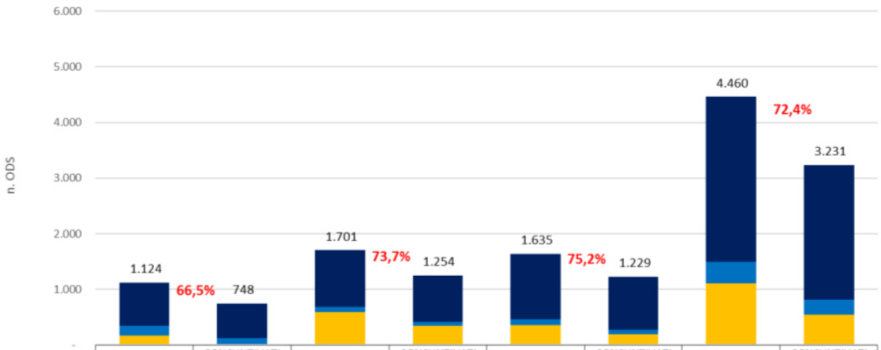
Fig. 3.1.3.24 shows a detail of the percentage of accounted service orders among those scheduled and sent to SAC for the services provided by external staff. The result is lower than the intended objective (37% vs 100%), and was slightly higher than in September (46.9%). There is, compared to September, a decrease in the BO-IM Area (from 49% to 23.1), the FE-MO Area (from 43.7% to 35.2) and the Romagna area (from 46.8% to 44.6%). The negative trend recorded in this month could be connected with the system malfunction.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	2.742	11,2%	1.099	38,9%	1.861	21,8%	5.702	20,0%
Monoperatore	179	90,5%	384	42,7%	129	58,1%	692	57,9%
Carico posteriore	1.903	21,3%	1.351	53,5%	6.923	67,7%	10.177	57,1%
Altro	2.469	32,8%	3.196	25,3%	6.092	25,0%	11.757	26,7%
TOTALE	7.293	23,1%	6.030	35,2%	15.005	44,6%	28.328	37,0%

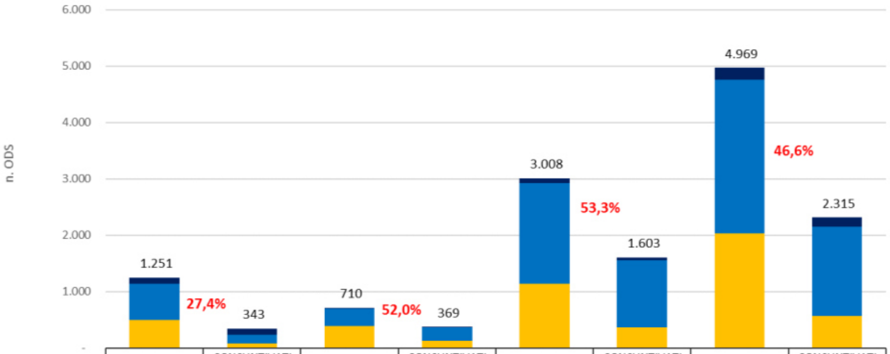
Fig. 3.1.3.24 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (October 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

In Fig. 3.1.3.25 and 3.1.3.26 are the charts for not separated collection services performed respectively by internal and external staff. The considerations made for previous months are valid.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	782	79,5%	1.014	82,8%	1.171	81,1%	2.967	81,3%
Carico posteriore	177	70,6%	96	69,8%	111	77,5%	384	72,4%
Altro	165	0,6%	591	58,7%	353	54,7%	1.109	48,8%
TOTALE	1.124	66,5%	1.701	73,7%	1.635	75,2%	4.460	72,4%

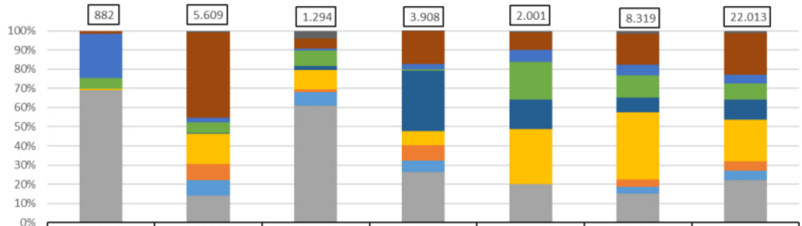
Fig. 3.1.3.25 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (October 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
Monoperatore	110	98,2%	9	100,0%	86	55,8%	205	80,5%
Carico posteriore	639	25,0%	313	73,8%	1.778	66,8%	2.730	57,8%
Altro	502	14,9%	388	33,2%	1.144	32,2%	2.034	28,1%
TOTALE	1.251	27,4%	710	52,0%	3.008	53,3%	4.969	46,6%

Fig. 3.1.3.26 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (October 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).

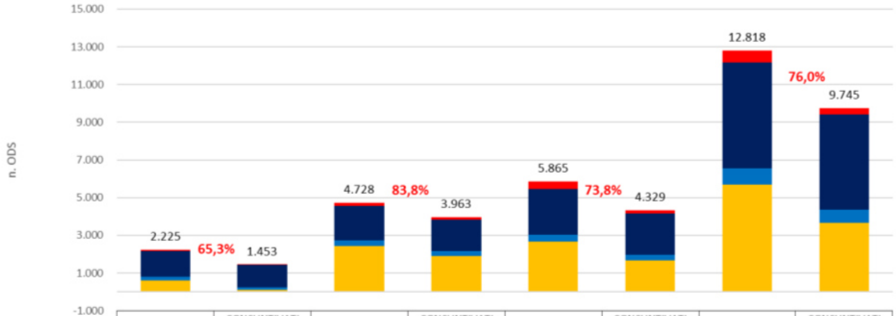
Fig. 3.1.3.27 shows in detail the percentage of not accounted service orders for the type of activities carried out by internal and external staff.



	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		Totale complessivo
	Interno	Terzista	Interno	Terzista	Interno	Terzista	
%altro	0,0%	0,7%	4,0%	0,2%	0,7%	1,4%	1,0%
%spazzamento	1,4%	44,7%	5,3%	17,0%	9,1%	16,1%	21,7%
%rifiuti abbandonati	23,4%	2,3%	0,9%	3,0%	6,2%	5,7%	4,8%
%rifiuti ingombranti	5,7%	5,6%	8,3%	0,4%	19,6%	11,7%	8,4%
%scarrabili	0,0%	0,5%	2,0%	31,8%	15,5%	7,8%	10,2%
%raccolta target	0,6%	15,9%	10,1%	7,2%	28,7%	35,0%	21,8%
%pap senza contenitori	0,0%	8,3%	1,5%	7,9%	0,1%	3,7%	5,0%
%pap con contenitori	0,0%	7,9%	7,0%	6,2%	0,0%	3,6%	4,9%
%raccolta stradale	69,0%	14,2%	60,9%	26,3%	19,9%	15,1%	22,1%
Totale complessivo	882	5.609	1.294	3.908	2.001	8.319	22.013

Fig. 3.1.3.27 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services (October 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

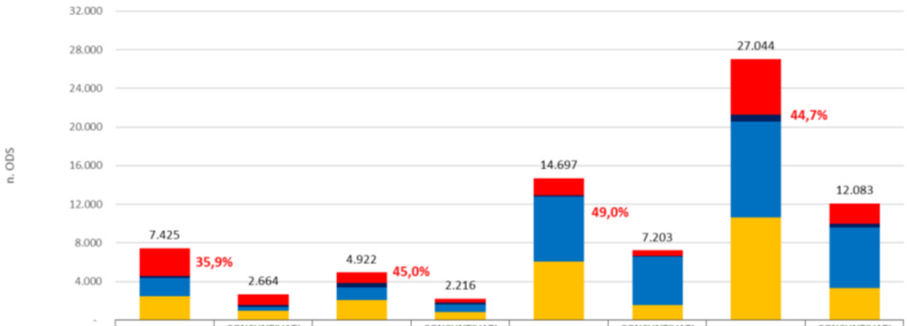
For the month of November, Fig. 3.1.3.28 displays the percentage of accounted service orders among those scheduled and sent to SAC for internal services. The result is lower than the intended objective (76.0% vs 100%) and increased compared to the data recorded in October (68.4%). There was an increase in all areas: BO Area - IM from 61.4 to 65.3, Fe-MO area from 73.2 to 83.8%, Romagna area from 67.1 to 73.8.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	52	61,5%	182	71,4%	405	45,4%	639	54,1%
Monoperatore	1.384	84,8%	1.811	93,0%	2.446	89,8%	5.641	89,6%
Carico posteriore	174	76,4%	318	83,6%	359	83,3%	851	82,0%
Altro	615	18,5%	2.417	77,9%	2.655	62,1%	5.687	64,1%
TOTALE	2.225	65,3%	4.728	83,8%	5.865	73,8%	12.818	76,0%

Fig. 3.1.3.28 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (November 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services: red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

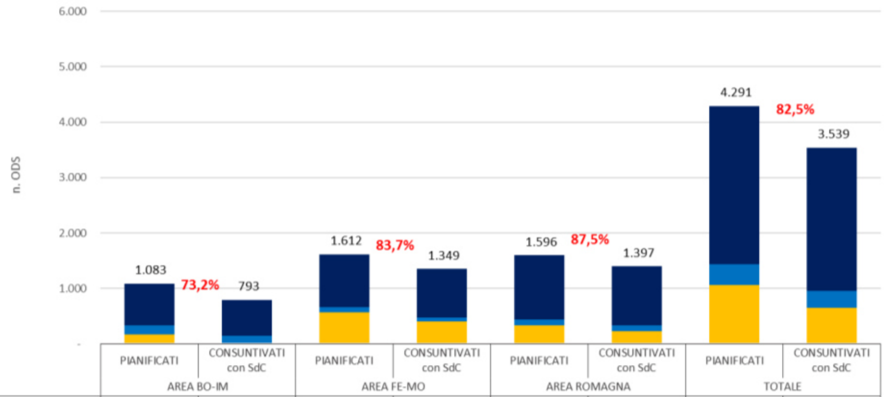
Fig. 3.1.3.29 shows a detail of the percentage of accounted service orders among those scheduled and sent to SAC for the services provided by external staff. The result is lower than the intended objective (44.7% vs 100%), and is higher than in October (37.9%). There is, compared to October, an improvement in the BO-IM Area (from 23.1 to 35.9), the FE-MO Area (from 35.2 to 45.0), and the Romagna area (from 44.6% 49.0). There is a percentage increase for all areas, back in line with the values recorded in October.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Spazzatrice	2.862	39,0%	1.115	38,1%	1.780	32,0%	5.757	36,7%
Monoperatore	191	85,9%	396	41,7%	127	55,1%	714	55,9%
Carico posteriore	1.910	20,3%	1.324	60,8%	6.728	74,9%	9.962	62,6%
Altro	2.462	40,5%	2.087	39,3%	6.062	25,1%	10.611	31,5%
TOTALE	7.425	35,9%	4.922	45,0%	14.697	49,0%	27.044	44,7%

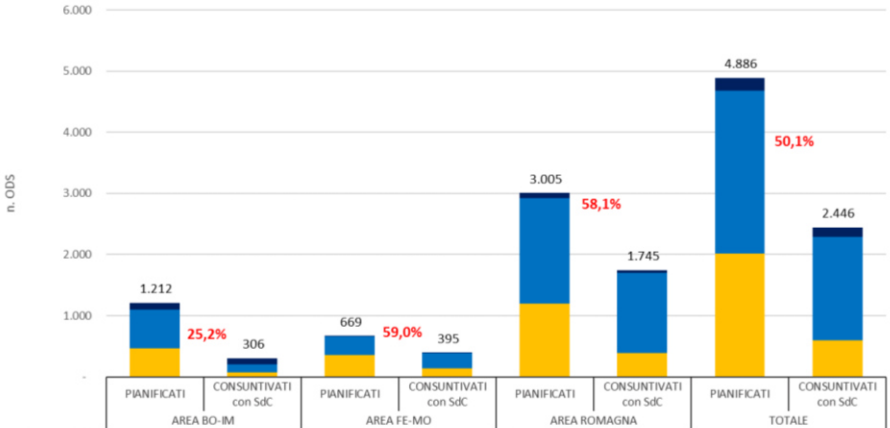
Fig. 3.1.3.29 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (November 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

In Fig. 3.1.3.30 and 3.1.3.31 are the charts for not separated collection services performed respectively by internal and external staff. The considerations made for previous months are valid.



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	747	86,9%	949	91,8%	1.154	92,5%	2.850	90,8%
Carico posteriore	173	76,9%	99	75,8%	109	89,0%	381	80,1%
Altro	163	6,7%	564	71,5%	333	69,7%	1.060	60,9%
TOTALE	1.083	73,2%	1.612	83,7%	1.596	87,5%	4.291	82,5%

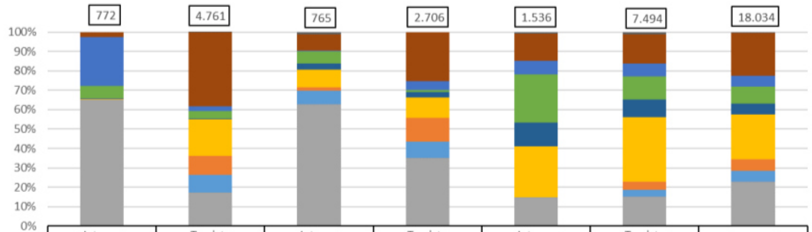
Fig. 3.1.3.30 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (November 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	111	92,8%	9	100,0%	86	53,5%	206	76,7%
Carico posteriore	636	21,1%	302	81,1%	1.721	76,3%	2.659	63,6%
Altro	465	14,8%	358	39,4%	1.198	32,2%	2.021	29,5%
TOTALE	1.212	25,2%	669	59,0%	3.005	58,1%	4.886	50,1%

Fig. 3.1.3.31 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (November 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).

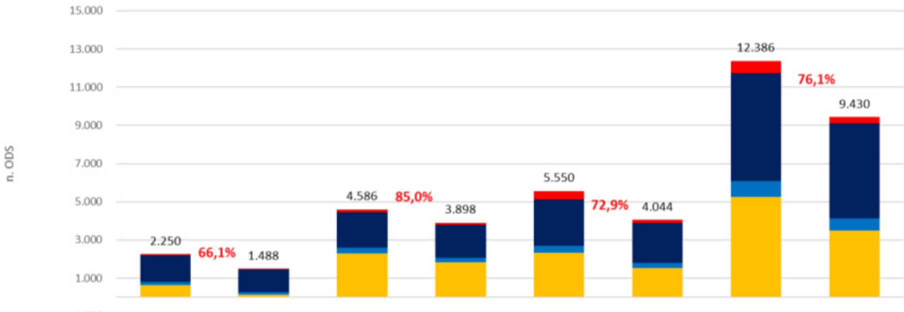
Fig. 3.1.3.32 shows in detail the percentage of not accounted service orders for the type of activities carried out by internal and external staff.



	Interno	Terzista	Interno	Terzista	Interno	Terzista	Totale complessivo
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		
%altro	0,0%	0,2%	1,2%	0,0%	0,7%	1,1%	0,6%
%spazzamento	2,6%	38,1%	8,4%	25,5%	14,1%	15,0%	21,8%
%rifiuti abbandonati	25,1%	2,6%	0,5%	4,4%	7,0%	6,7%	5,8%
%rifiuti ingombranti	6,5%	3,7%	6,1%	0,9%	24,8%	11,8%	8,7%
%scarrabili	0,1%	0,3%	3,3%	2,9%	12,4%	9,0%	5,5%
%raccolta target	0,4%	19,0%	9,0%	10,4%	26,0%	33,5%	23,1%
%pap senza contenitori	0,0%	9,8%	1,7%	12,3%	0,1%	4,1%	6,2%
%pap con contenitori	0,0%	9,2%	6,9%	8,4%	0,0%	3,5%	5,4%
%raccolta stradale	65,3%	17,1%	62,9%	35,2%	14,8%	15,2%	22,8%
Totale complessivo	772	4.761	765	2.706	1.536	7.494	18.034

Fig. 3.1.3.32 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services (November 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services: red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

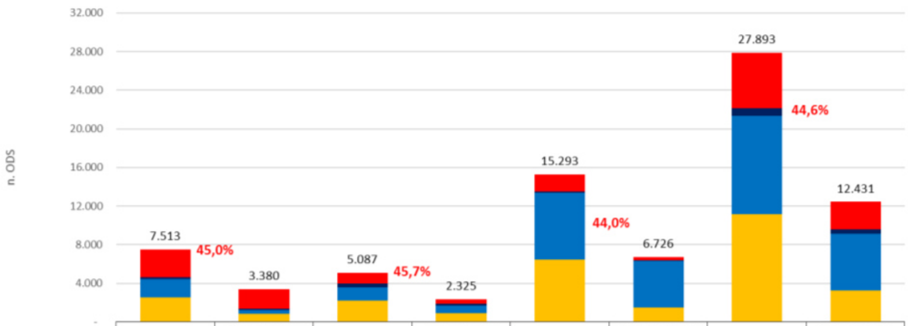
For the month of December, Fig. 3.1.3.33 displays the percentage of accounted service orders among those scheduled and sent to SAC for internal services. The result is lower than the intended objective (76.1% vs 100%) and increased compared to the data recorded in November (76.0%). There is a slightly increase in all areas: BO Area - IM from 65.3% to 66.1%, Fe-MO area from 83.8% to 85%, Romagna area from 67.1% to 73.8.



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Spazzatrice	49	73,5%	144	80,6%	443	37,0%	636	49,7%
Monoperatore	1.394	85,1%	1.852	92,6%	2.409	86,7%	5.655	88,2%
Carico posteriore	181	67,4%	305	78,7%	364	73,9%	850	74,2%
Altro	626	23,0%	2.285	80,0%	2.334	65,2%	5.245	66,6%
TOTALE	2.250	66,1%	4.586	85,0%	5.550	72,9%	12.386	76,1%

Fig. 3.1.3.33 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (December 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

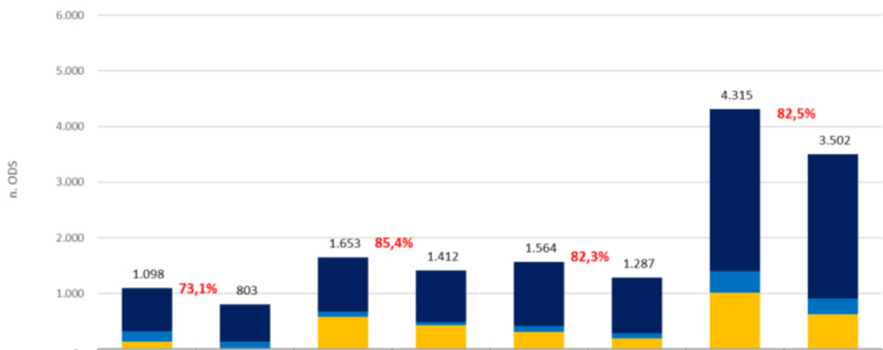
Fig. 3.1.3.34 shows a detail of the percentage of accounted service orders among those scheduled and sent to SAC for the services provided by external staff. The result is lower than the intended objective (44.6% vs 100%), and is in line with data recorded in November (44.7%). There is, compared to November, an improvement in the BO-IM Area (from 35.9% to 45.0%), the FE-MO Area (from 45.0% to 45.7%), and a decrease in the Romagna area (from 49.0 to 44%).



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Spazzatrice	2.874	70,0%	1.143	41,1%	1.774	20,7%	5.791	49,2%
Monoperatore	210	80,0%	394	50,3%	138	51,4%	742	58,9%
Carico posteriore	1.920	17,8%	1.361	57,6%	6.914	69,0%	10.195	57,9%
Altro	2.509	34,2%	2.189	39,9%	6.467	23,4%	11.165	29,1%
TOTALE	7.513	45,0%	5.087	45,7%	15.293	44,0%	27.893	44,6%

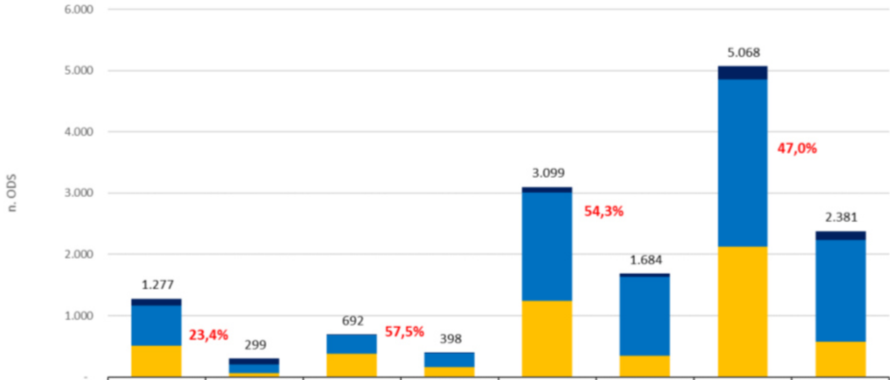
Fig. 3.1.3.34 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (December 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (red-sweeping, blu-monoperator, light blue-load rear, yellow-other services).

In Fig. 3.1.3.35 and 3.1.3.36 are the charts for not separated collection services performed respectively by internal and external staff. The considerations made for previous months are valid.



	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC	PIANIFICATI	CONSUNTIVATI con SdC
	AREA BO-IM		AREA FE-MO		AREA ROMAGNA		TOTALE	
Monoperatore	779	86,4%	984	93,9%	1.146	87,1%	2.909	89,2%
Carico posteriore	181	67,4%	93	72,0%	113	84,1%	387	73,4%
Altro	138	5,8%	576	73,1%	305	63,6%	1.019	61,1%
TOTALE	1.098	73,1%	1.653	85,4%	1.564	82,3%	4.315	81,2%

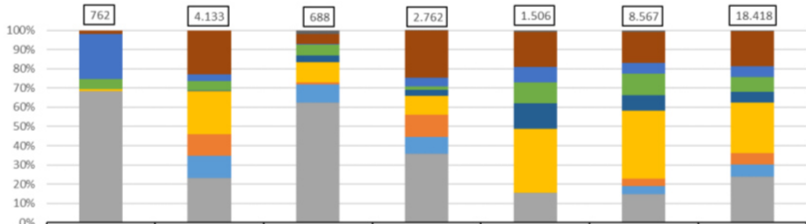
Fig. 3.1.3.35 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal services (December 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).



	AREA BO-IM PIANIFICATI	AREA BO-IM CONSUNTIVATI con SdC	AREA FE-MO PIANIFICATI	AREA FE-MO CONSUNTIVATI con SdC	AREA ROMAGNA PIANIFICATI	AREA ROMAGNA CONSUNTIVATI con SdC	TOTALE PIANIFICATI	TOTALE CONSUNTIVATI con SdC
Monoperatore	115	84,3%	7	100,0%	90	50,0%	212	70,3%
Carico posteriore	657	21,5%	308	74,7%	1.764	73,1%	2.729	60,8%
Altro	505	12,1%	377	42,7%	1.245	28,1%	2.127	26,9%
TOTALE	1.277	23,4%	692	57,5%	3.099	54,3%	5.068	47,0%

Fig. 3.1.3.36 – Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for subcontractor services (December 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services (blu-monoperator, light blue-load rear, yellow-other services).

Fig. 3.1.3.37 shows in detail the percentage of not accounted service orders for the type of activities carried out by internal and external staff.



	AREA BO-IM Interno	AREA BO-IM Terzista	AREA FE-MO Interno	AREA FE-MO Terzista	AREA ROMAGNA Interno	AREA ROMAGNA Terzista	Totale complessivo
%altro	0,0%	0,0%	1,7%	0,3%	0,7%	1,0%	0,6%
%spazzamento	1,7%	22,9%	5,4%	24,5%	18,5%	15,8%	17,9%
%rifiuti abbandonati	23,8%	3,3%	0,4%	4,5%	7,8%	5,9%	5,8%
%rifiuti ingombranti	5,2%	5,0%	5,5%	1,8%	11,0%	10,9%	7,8%
%scarrabili	0,0%	0,4%	3,6%	3,0%	13,3%	8,1%	5,5%
%raccolta target	0,8%	22,5%	10,5%	10,0%	33,1%	35,5%	26,2%
%pap senza contenitori	0,0%	11,2%	0,9%	11,5%	0,1%	3,9%	6,1%
%pap con contenitori	0,0%	11,4%	9,6%	8,7%	0,0%	4,1%	6,1%
%raccolta stradale	68,5%	23,3%	62,4%	35,7%	15,5%	14,8%	23,9%
Totale complessivo	762	4.133	688	2.762	1.506	8.567	18.418

Fig. 3.1.3.37 - Indicator 03a: Detail of the percentage of accounted service orders among those scheduled and sent to SAC for internal and subcontractor services (December 2016). There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for services: red-sweeping, light blue-abandoned waste, green-bulky waste, blue-big bins, yellow-target collection, orange - door to door collection (no bins), sky blue- door to door collection with bins, grey-street collection).

3.2 Quality indicator

3.2.1 04 - Reporting positions indicator

This indicator is used to measure the degree of effectiveness in the reading of the TAG applied to the containers.

It is a percentage indicator which characterizes the degree of effectiveness of the readings with field devices (SDC) and it is calculated by comparing the extraction of the positions of scheduled orders and sent to the data acquisition system (SAC) with those confirmed. The analysis excludes orders that do not include the reading of TAG (not to be confused with Indicator 3).

The objective of this indicator is the attainment of one hundred percent. Intermediate temporal objectives are:

2016	**1° Trim.**	**2° Trim.**	**3° Trim.**	**4° Trim.**
Internal services	n.a.	90%	100%*	100%*
External services	n.a.	50%	70%	100%*

Tab. 3.2.1.1 – Aims of indicator 04

* * The goal of 100% is considered to be theoretical with an estimated acceptable range of 5%, due to:
a. Stopping programmed system
b. System faults and field devices

The indicator is only available from the second quarter of 2016 due to the impossibility of data extraction.

Below are the charts from the analysis of positions without a reading relating to service collection and not accounting, both for internal (Fig. 3.2.1.1) and external services (Fig. 3.2.1.2).

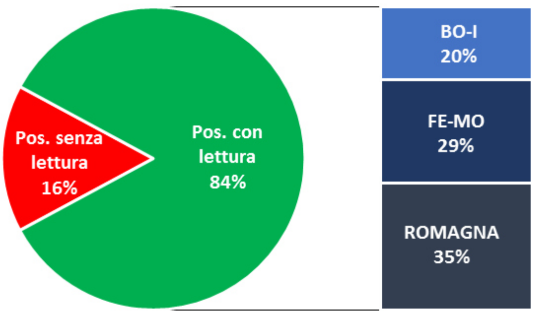


Fig. 3.2.1.1 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for internal services (second quarter 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers.

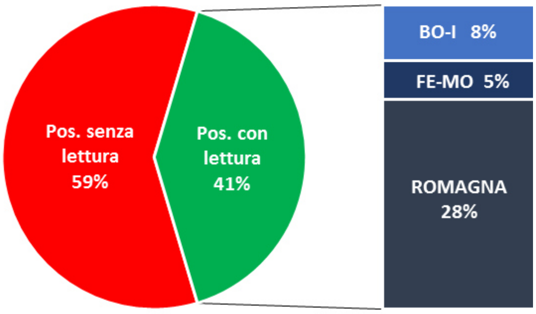


Fig. 3.2.1.2 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (second quarter 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers.

Fig. 3.2.1.3 shows the details for the order positions for internal (left column) and for external services (right column). The presence of no Facts (NF) and new readings (LN) highlights the lack of routine maintenance of planned routes. The lower the incidence of these positions are the more updated ordinary management of the routes is. In addition, for subcontractors the positive delta of actual readings (due to the presence of numerous LN) compared to those planned, is linked to the management of PAP services (door to door), where planning is done on a fictitious bin while the actual reading is done on real containers.

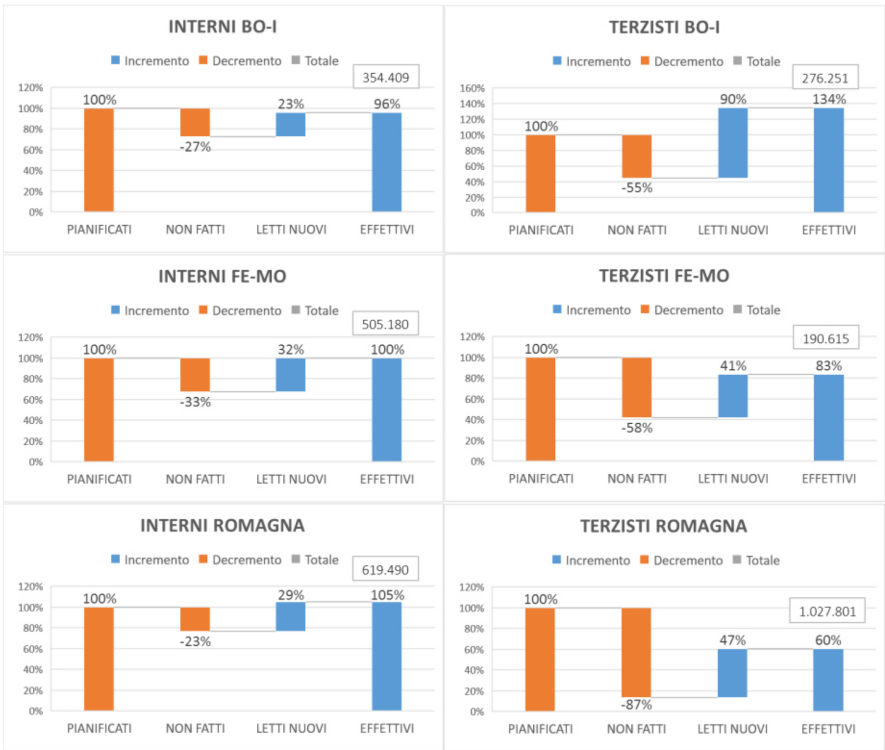
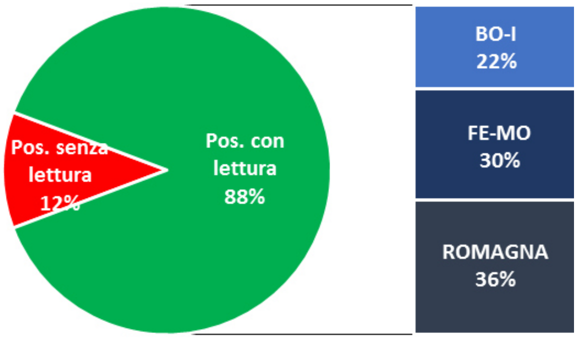


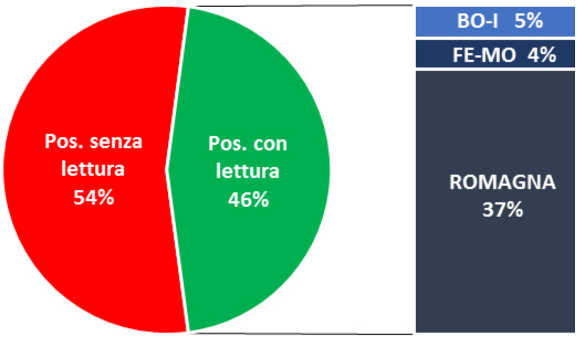
Fig. 3.2.1.3 - Indicator 04: Detail per order positions for internal (left) and subcontractor (right) service for Second quarter of 2016 (first column: total planned positions (100%), second column: not detected positions, third column: new detected positions, fourth column: actual reading positions).

Below, are the same considerations made for the second quarter for the month of July. In the figures the graphs show the results from analyses of the relative positions without a reading for internal (Fig. 3.2.1.4) and subcontractors services (Fig. 3.2. 1.5).



INTERNI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	2.294	153.199	134.795
AREA FE-MO	4.043	204.320	179.036
AREA ROMAGNA	5.242	243.155	218.028
TOTALE AREE	**11.579**	**600.674**	**531.859**

Fig. 3.2.1.4 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for internal services (July 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.



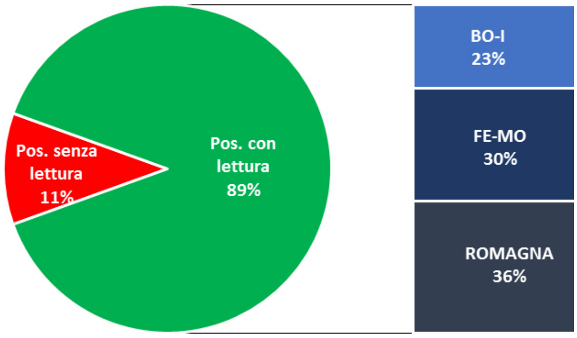
TERZISTI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	3.977	153.806	55.230
AREA FE-MO	4.187	149.231	48.968
AREA ROMAGNA	15.433	870.098	432.813
TOTALE AREE	**23.597**	**1.173.135**	**537.011**

Fig. 3.2.1.5 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (July 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.

Fig. 3.2.1.6 shows the details for the order positions for internal (left column) and external services (right column).

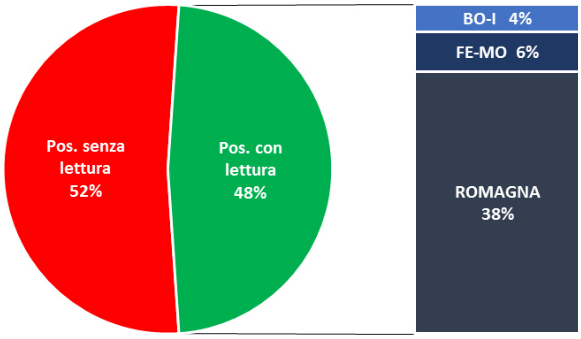
Fig. 3.2.1.6 - Indicator 04: Detail per order positions for internal (left) and subcontractor (right) service for July 2016 (first column: total planned positions (100%), second column: not detected positions, third column: new detected positions, fourth column: actual reading positions).

Below, are the same considerations made for the month of July as for the month of August. In the figures the graphs show the results from analyses of the relative positions without a reading for internal (Fig. 3.2.1.7) and subcontractors services (Fig. 3.2.1.8).



INTERNI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	2.087	154.306	138.782
AREA FE-MO	4.046	207.527	185.247
AREA ROMAGNA	4.997	247.714	218.548
TOTALE AREE	**11.130**	609.547	542.577

Fig. 3.2.1.7 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for internal services (August 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.



TERZISTI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	4.162	163.402	51.866
AREA FE-MO	4.151	166.879	72.575
AREA ROMAGNA	15.859	948.035	487.186
TOTALE AREE	**24.172**	1.278.316	611.627

Fig. 3.2.1.8 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (August 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.

Fig. 3.2.1.9 shows the details for the order positions for internal (left column) and external services (right column). The same considerations made for previous months are valid.

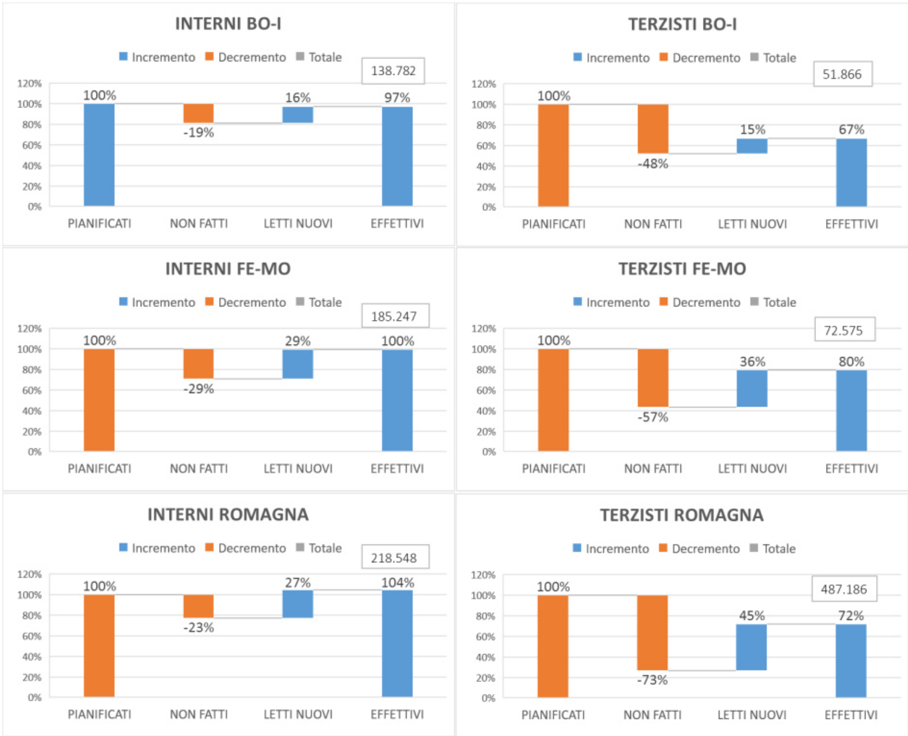
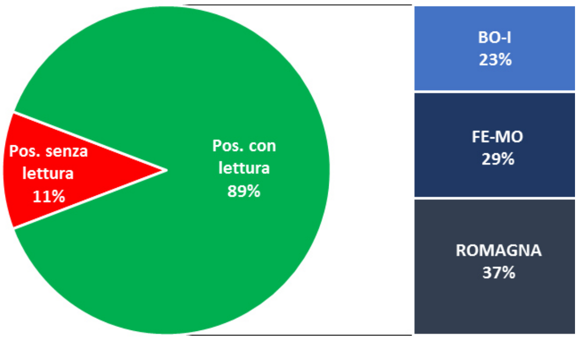


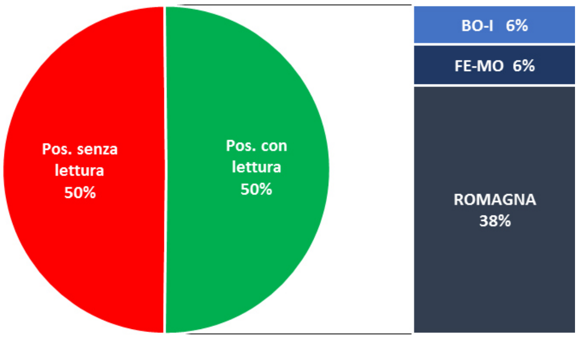
Fig. 3.2.1.9 - Indicator 04: Detail per order positions for internal (left) and subcontractor (right) service for August 2016 (first column: total planned positions (100%), second column: not detected positions, third column: new detected positions, fourth column: actual reading positions).

Below, are the same considerations made for the month of August as for the month of September. In the figures the graphs show the results from analyses of the relative positions without a reading for internal (Fig. 3.2.1.10) and subcontractors services (Fig. 3.2. 1.11). The percentage of detected positions remains unchanged for the internal (89% even in August), while there is a slight improvement for the subcontractors (from 48% to 50%).



INTERNI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	2.159	154.196	137.759
AREA FE-MO	4.071	200.526	170.458
AREA ROMAGNA	4.807	240.205	217.867
TOTALE AREE	**11.037**	594.927	526.084

Fig. 3.2.1.10 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for internal services (September 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.



TERZISTI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	4.233	164.811	66.988
AREA FE-MO	3.233	164.337	71.432
AREA ROMAGNA	13.616	793.645	426.754
TOTALE AREE	**21.082**	1.122.793	565.174

Fig. 3.2.1.11 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (September 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.

Fig. 3.2.1.12 shows the details for the order positions for internal (left column) and external services (right column). The same considerations made for previous months are valid.

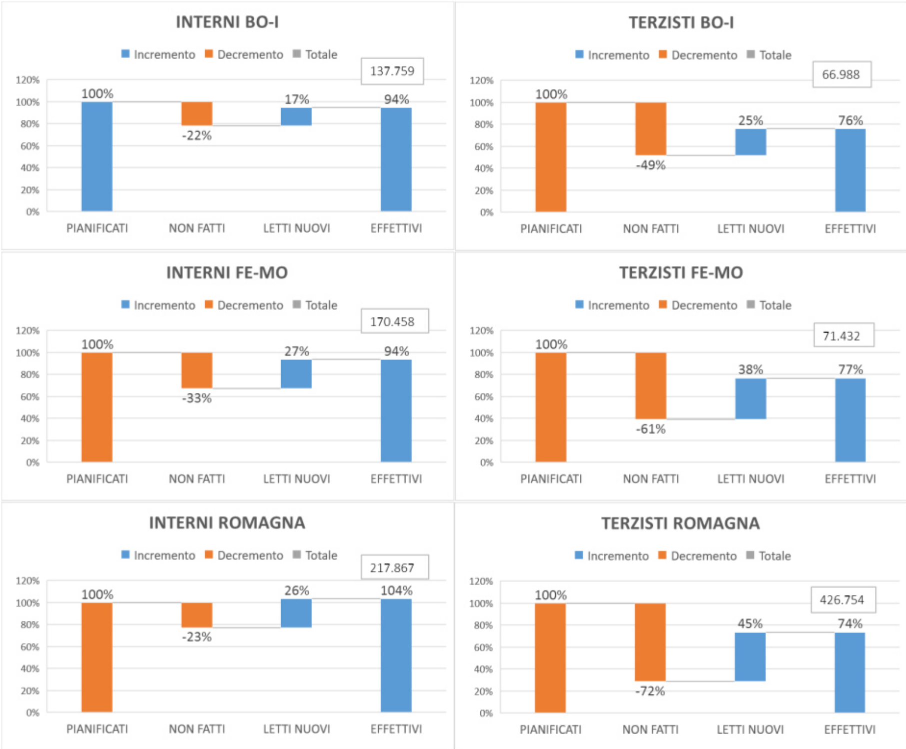
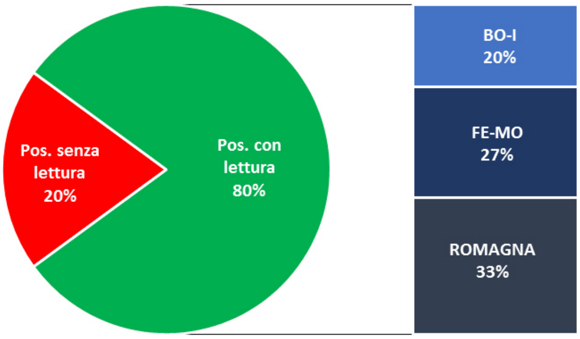


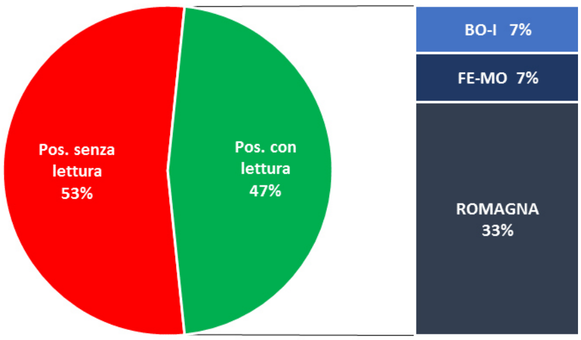
Fig. 3.2.1.12 - Indicator 04: Detail per order positions for internal (left) and subcontractor (right) service for September 2016 (first column: total planned positions (100%), second column: not detected positions, third column: new detected positions, fourth column: actual reading positions).

Below, are the same considerations made for the month of September as for the month of October. In the figures the graphs show the results from analyses of the relative positions without a reading for internal (Fig. 3.2.1.13) and subcontractors services (Fig. 3.2. 1.14). The percentage of reading positions decreases for both the internal (from 89% to 80%) and the subcontractor services (from 50% to 47%), compared to the month of September.



INTERNI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	2.128	157.870	120.074
AREA FE-MO	4.179	205.482	161.631
AREA ROMAGNA	5.050	237.700	198.715
TOTALE AREE	**11.357**	601.052	480.420

Fig. 3.2.1.13 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for internal services (October 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.



TERZISTI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	4.221	161.505	71.084
AREA FE-MO	3.458	168.750	73.069
AREA ROMAGNA	12.327	721.668	347.362
TOTALE AREE	**20.006**	1.051.923	491.515

Fig. 3.2.1.14 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (October 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.

Fig. 3.2.1.15 shows the details for the order positions for internal (left column) and external (right column) services. The same considerations made for previous months are valid.

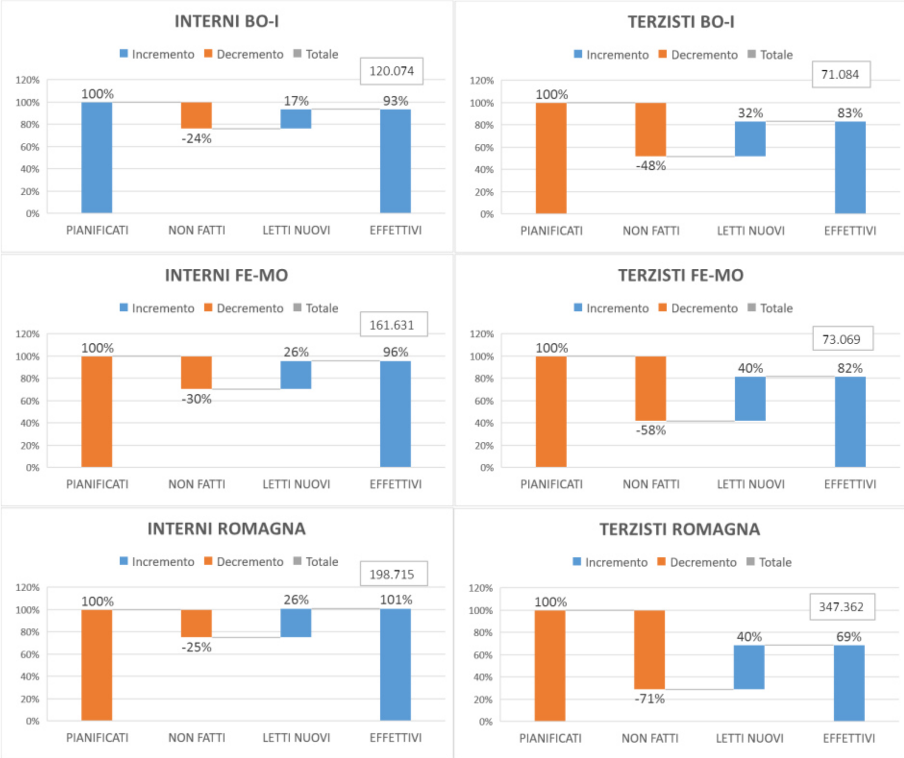
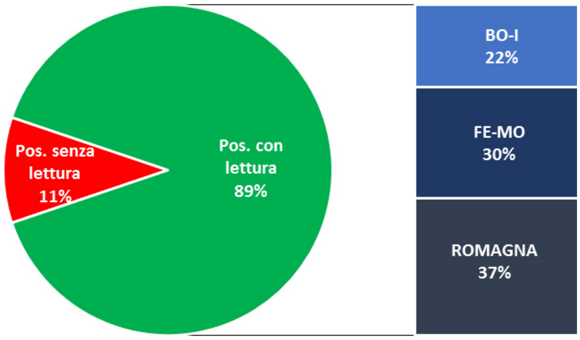


Fig. 3.2.1.15 - Indicator 04: Detail per order positions for internal (left) and subcontractor (right) service for October 2016 (first column: total planned positions (100%), second column: not detected positions, third column: new detected positions, fourth column: actual reading positions).

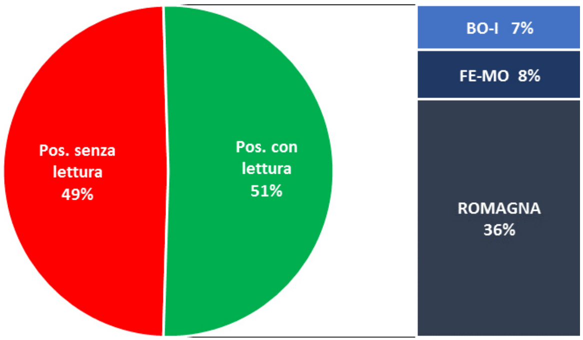
Below, are the same considerations made for the month of October as for the month of November.

In the figures the graphs show the results from analyses of the relative positions without a reading for internal (Fig. 3.2.1.16) and subcontractors services (Fig. 3.2. 1.17). The percentage of detected position increases both for the internal (from 80% to 89%) and for subcontractor services (from 48% to 50%), in respect to October.



INTERNI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	2.076	150.595	131.551
AREA FE-MO	4.031	203.300	178.380
AREA ROMAGNA	4.955	235.691	218.612
TOTALE AREE	**11.062**	589.586	528.543

Fig. 3.2.1.16 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (November 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.



TERZISTI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	4.243	160.225	71.454
AREA FE-MO	3.473	167.725	79.698
AREA ROMAGNA	12.194	716.143	380.823
TOTALE AREE	**19.910**	1.044.093	531.975

Fig. 3.2.1.17 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (November 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.

Fig. 3.2.1.18 shows the details for the order positions for internal (left column) and external (right column) services. The same considerations made for previous months are valid.

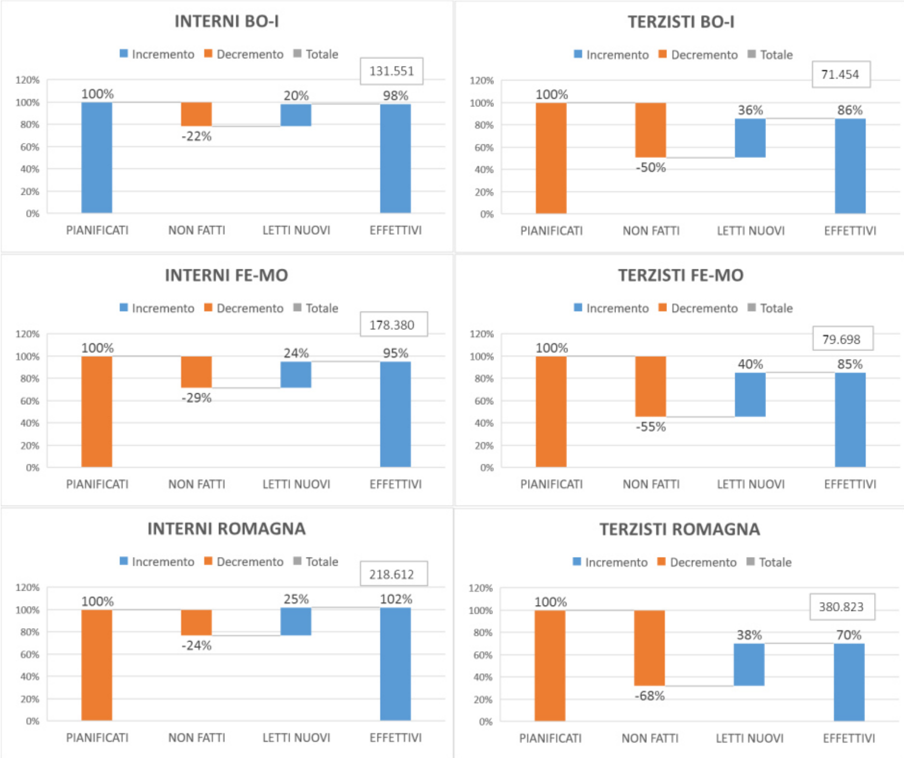
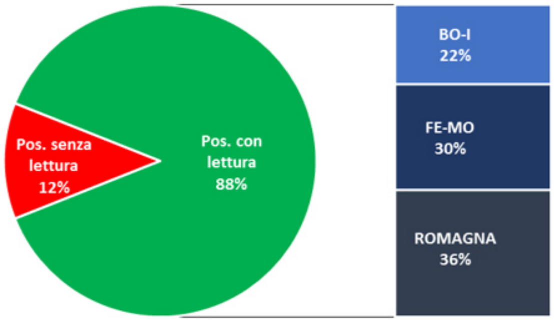


Fig. 3.2.1.18 - Indicator 04: Detail per order positions for internal (left) and subcontractor (right) service for November 2016 (first column: total planned positions (100%), second column: not detected positions, third column: new detected positions, fourth column: actual reading positions).

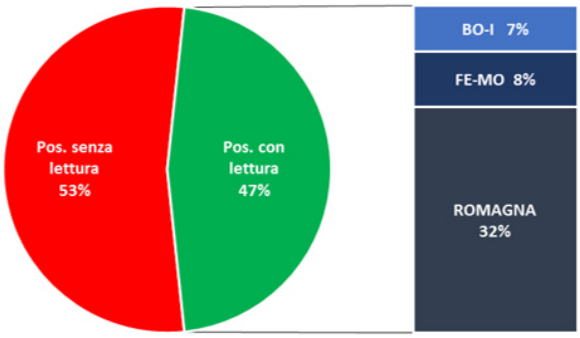
Below, are the same considerations made for the month of November as for the month of December. In the figures the graphs show the results from analyses of the relative positions without a reading for internal (Fig. 3.2.1.19) and subcontractors services (Fig. 3.2.1.20).

The percentage of detected position decreases both for the internal (from 89% to 88%) and for subcontractor services (from 51% to 47%), in respect to November.



INTERNI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	2.121	152.070	133.393
AREA FE-MO	3.998	205.748	178.909
AREA ROMAGNA	4.835	240.018	213.343
TOTALE AREE	**10.954**	597.836	525.645

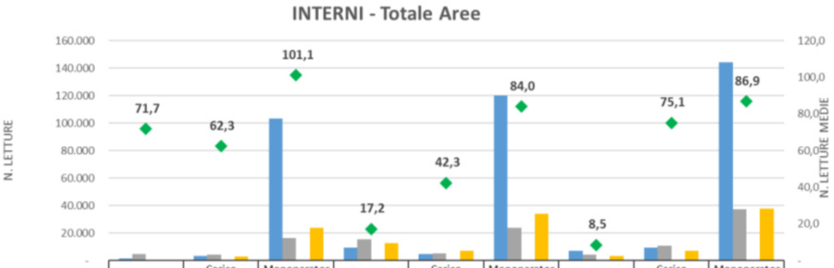
Fig. 3.2.1.19 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for internal services (December 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.



TERZISTI	ODS di raccolta pianificati	Posizioni pianificate di ODS di raccolta	Posizioni Effettive di ODS di raccolta
AREA BO-IM	4.328	165.486	70.618
AREA FE-MO	3.595	173.894	85.095
AREA ROMAGNA	12.661	740.878	348.358
TOTALE AREE	**20.584**	1.080.258	504.071

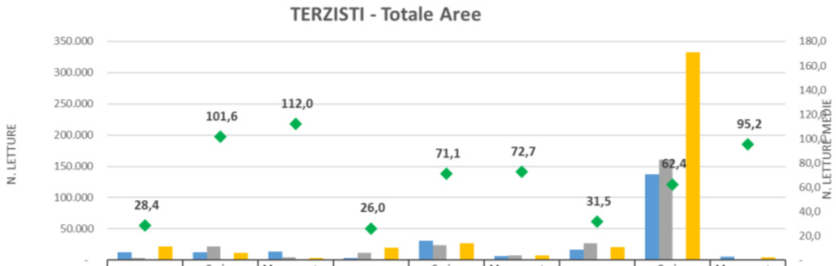
Fig. 3.2.1.20 - Indicator 04: Detail of the percentage of positions without reading associated (red) with a service order and not accounted with field devices for external services (December 2016). Green represents the planned and detected containers with a detail per area, red represents planned and not detected containers. In the table the detail for planned order service (column one), total planned containers (column two) and real detected containers (column three) is shown.

Fig. 3.2.1.21 and 3.2.1.22 show the details for the order positions for internal and external services. The same considerations made for previous months are valid.



	AREA BO-IM			AREA FE-MO			AREA ROMAGNA		
	Altro	Carico posteriore	Monoperatore	Altro	Carico posteriore	Monoperatore	Altro	Carico posteriore	Monoperatore
L->LETTO (SAC)	1.287	3.250	103.149	9.414	4.775	119.974	7.096	9.286	144.061
LN->LETTURA NUOVA (SAC)	4.594	4.352	16.315	15.211	5.377	24.007	4.285	10.909	37.246
LF->LETTURA FORZATA (SAC)	-	-	446	18	-	133	316	20	124
NF-> LETTURA NON FATTA (SAC)	514	2.708	23.919	12.780	6.847	34.201	3.395	7.155	37.646
TOT POS. EFF.	5.881	7.602	119.910	24.643	10.152	144.114	11.697	20.215	181.431
Totale ODS con letture	82	122	1.186	1.435	240	1.715	1.374	269	2.089
N. letture medie per ODS	71,7	62,3	101,1	17,2	42,3	84,0	8,5	75,1	86,9

Fig. 3.2.1.21 - Indicator 04: Detail per order positions for internal services for December 2016. There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for order positions (blue-detected position, grey-new detected positions, orange-new detected position without a tag and yellow-not detected positions).



	AREA BO-IM			AREA FE-MO			AREA ROMAGNA		
	Altro	Carico posteriore	Monoperatore	Altro	Carico posteriore	Monoperatore	Altro	Carico posteriore	Monoperatore
L->LETTO (SAC)	12.142	12.528	13.717	2.963	30.949	6.770	16.181	136.819	5.410
LN->LETTURA NUOVA (SAC)	3.219	21.468	4.678	11.945	23.750	7.504	27.380	161.030	1.347
LF->LETTURA FORZATA (SAC)	1.785	661	420	54	1.040	120	107	84	-
NF-> LETTURA NON FATTA (SAC)	21.750	11.116	3.523	19.462	27.296	7.816	21.196	332.333	4.171
TOT POS. EFF.	17.146	34.657	18.815	14.962	55.739	14.394	43.668	297.933	6.757
Totale ODS con letture	604	341	168	575	784	198	1.385	4.774	71
N. letture medie per ODS	28,4	101,6	112,0	26,0	71,1	72,7	31,5	62,4	95,2

Fig. 3.2.1.22 - Indicator 04: Detail per order positions for external services for December 2016. There is a detail per area (Area Bo.I, Area Fe-Mo, Area Romagna and total), and a detail for order positions (blue-detected position, grey-new detected positions, orange-new detected position without a tag and yellow-not detected positions).

3.2.2 05 – Indicator of assignment of service Orders with weighing

This indicator is used to measure the usage and quality degree of the system. It is calculated comparing the extraction of weighing only for institutional contracts in which there is the Order SSA with the correct association that generates the "weighing documents". The figure inserted in ESA is correct if the input generates the relative weighing document in SAP.

The aim of the indicator is to achieve one hundred percent. The temporal aim are:

2016	1° Trim.	2° Trim.	3° Trim.	4° Trim.
Interni	95%	100%	100%	100%
Esterni	95%	100%	100%	100%

Tab. 3.2.2.1 – Aim of the indicator 05

Fig. 3.2.2.1 shows the percentage of orders inserted properly evaluated on the totality of those extracted from ESA for the first quarter of 2016. They are considered correct orders which have an associated document of weighing.

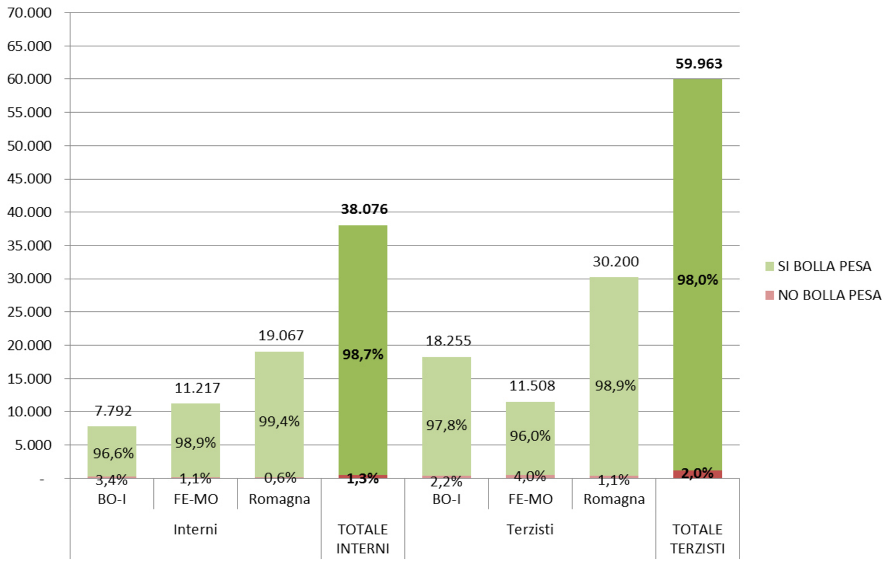


Fig. 3.2.2.1 – Indicator 05: Percentage of correct reunification (green) for service orders, first quarter of 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

Fig. 3.2.2.2 shows a focus of the delta between the date and time of disposal and the date and time of service for orders entered correctly. The presence of the transport date that exceeds the scheduled date of 24 hours (or more) highlights the management of the service with "discharges the next day", or improper use of the document of transport.

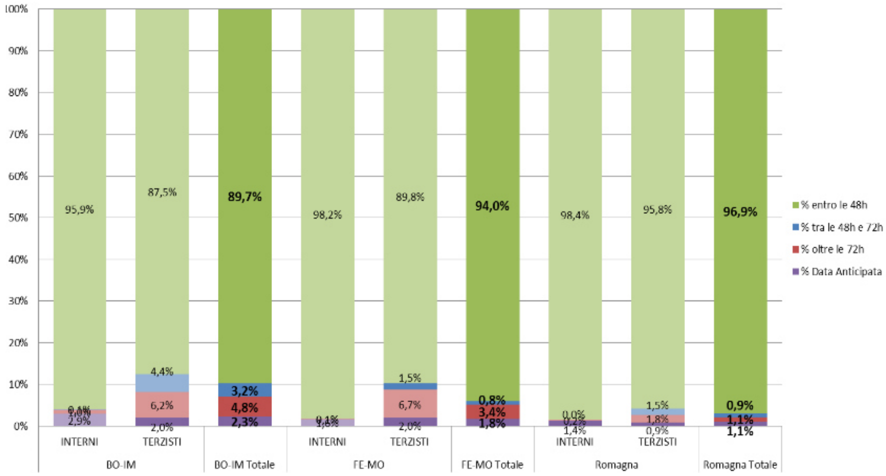


Fig. 3.2.2.2 – Focus of delta between date and hour of disposal and data and hour of service order for service orders, First quarter 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.

Fig. 3.2.2.3 shows the percentage of orders SSA inserted properly evaluated on the totality of those extracts from ESA for the second quarter of 2016. They are considered correct orders which have an associated document of weighing. The same consideration made for previous month are valid.

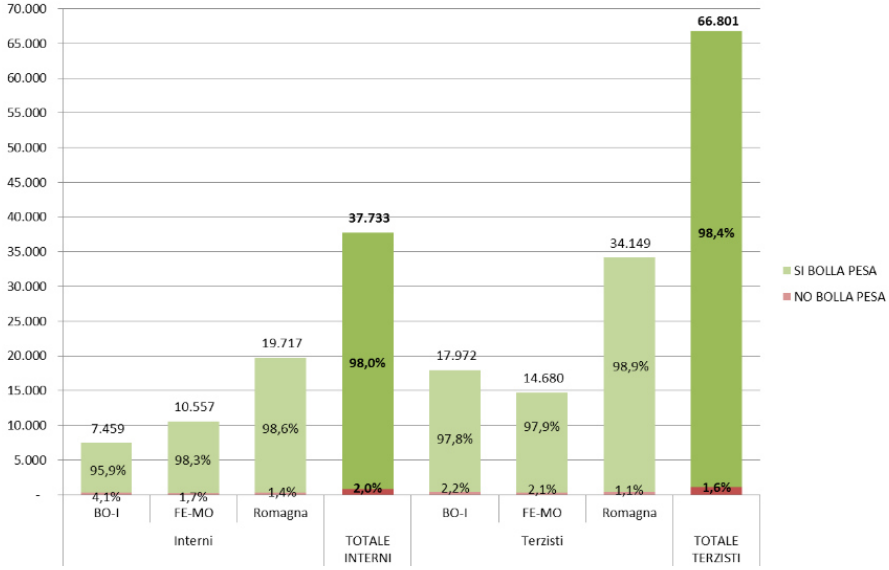


Fig. 3.2.2.3 – Indicator 05: Percentage of correct reunification (green) for service orders, second quarter of 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

Fig. 3.2.2.4 shows a focus of the delta between the date and time of disposal and the date and time service for orders entered correctly. The presence of the transport date that exceeds the scheduled date of 24 hours (or more) highlights the management of the service with "discharges the next day", or improper use of DDT.

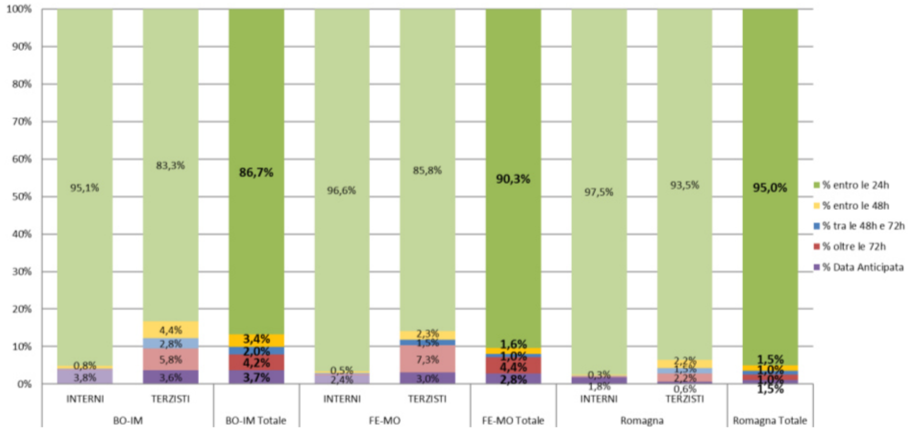


Fig. 3.2.2.4 – Focus of delta between date and hours of disposal and date and hours for service orders, Second quarter 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

Fig. 3.2.2.5 shows the percentage of orders SSA inserted properly evaluated on the totality of those extracts from ESA for the month of July. They are considered correct orders which have an associated document of weighing. The same consideration made for the second quarter are valid.

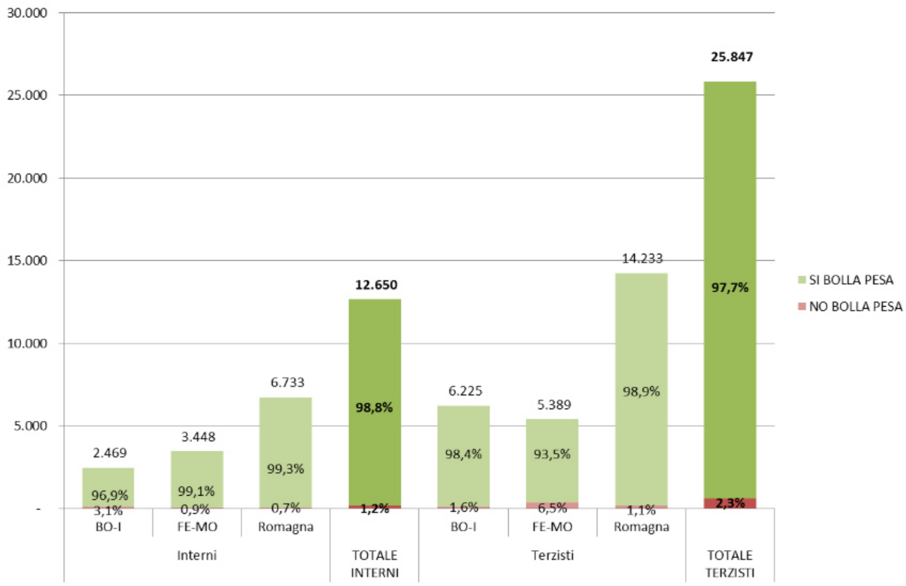


Fig. 3.2.2.5 - Indicator 05: Percentage of correct reunification (green) for service orders, July 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

Fig. 3.2.2.6 shows a focus of the delta between the date and time of disposal and the date and time service for orders entered correctly.

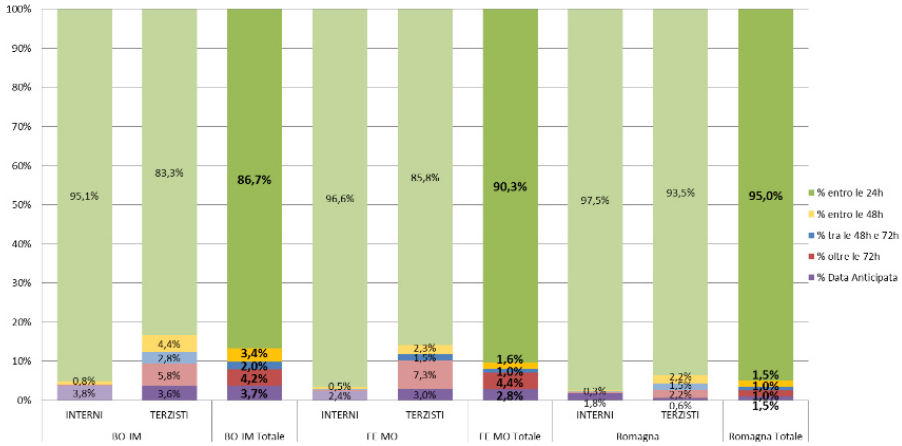
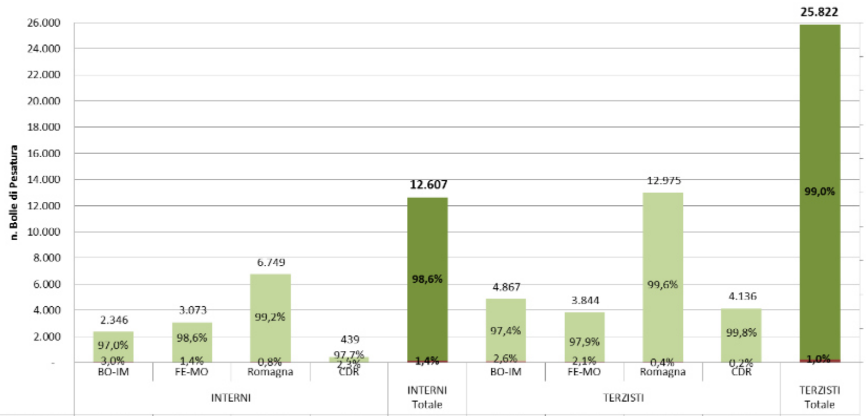


Fig. 3.2.2.6 – Focus of delta between date and hours of disposal and date and hours for service orders, July 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

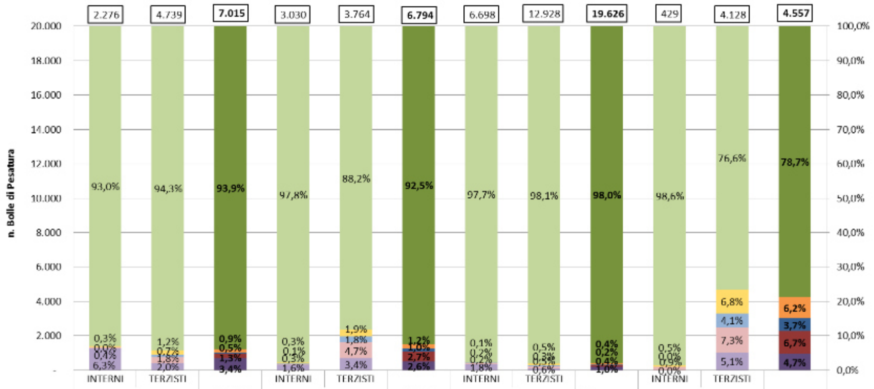
Fig. 3.2.2.7 shows the percentage of orders SSA inserted properly evaluated on the totality of those extracts from ESA for the month of August. They are considered correct orders which have an associated document of weighing. The total percentage of both internal and external services are substantially in line with the target set. The same consideration made for the second quarter are valid.



	INTERNI BO-IM	INTERNI FE-MO	INTERNI Romagna	INTERNI CDR	INTERNI Totale	TERZISTI BO-IM	TERZISTI FE-MO	TERZISTI Romagna	TERZISTI CDR	TERZISTI Totale
Totale complessivo	2.346	3.073	6.749	439	12.607	4.867	3.844	12.975	4.136	25.822
SI BOLLA PESA	2.276	3.030	6.698	429	12.433	4.739	3.764	12.928	4.128	25.559
NO BOLLA PESA	70	43	51	10	174	128	80	47	8	263

Fig. 3.2.2.7 - Indicator 05: Percentage of correct reunification (green) for service orders, August 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

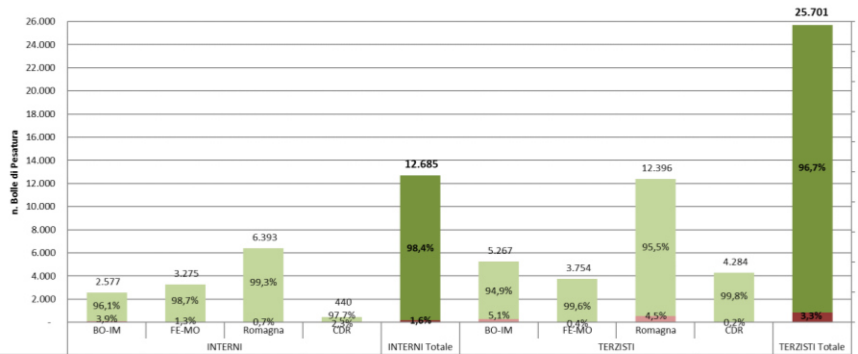
Fig. 3.2.2.8 shows a focus of the delta between the date and time of disposal and the date and time service for orders entered correctly.



	BO-IM INTERNI	BO-IM TERZISTI	BO-IM Totale	FE-MO INTERNI	FE-MO TERZISTI	FE-MO Totale	Romagna INTERNI	Romagna TERZISTI	Romagna Totale	CDR INTERNI	CDR TERZISTI	CDR Totale
entro 24h	2.116	4.468	6.584	2.963	3.319	6.282	6.542	12.682	19.224	423	3.164	3.587
tra 24h e 48h	7	58	65	10	73	83	10	68	78	2	281	283
tra 48 e 72h	1	34	35	2	67	69	13	36	49	-	169	169
oltre le 72h	9	83	92	8	176	184	13	70	83	4	302	306
Data Anticipata	143	96	239	47	129	176	120	72	192	-	212	212
Totale complessivo	2.276	4.739	7.015	3.030	3.764	6.794	6.698	12.928	19.626	429	4.128	4.557

Fig. 3.2.2.8 – Focus of delta between date and hours of disposal and date and hours for service orders, August 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

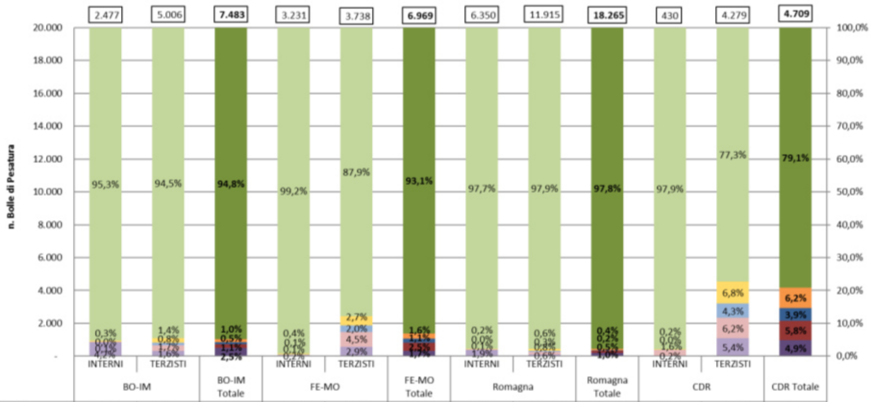
Fig. 3.2.2.9 shows the percentage of orders SSA properly inserted and evaluated on the totality of those extracted from ESA for the month of September. They are considered correct orders if they have an associated document of weighing. The total percentage of both internal and external services is substantially in line with the target set. The same considerations made for the second quarter are valid.



	INTERNI BO-IM	INTERNI FE-MO	INTERNI Romagna	INTERNI CDR	INTERNI Totale	TERZISTI BO-IM	TERZISTI FE-MO	TERZISTI Romagna	TERZISTI CDR	TERZISTI Totale
Totale complessivo	2.577	3.275	6.393	440	12.685	5.267	3.754	12.396	4.284	25.701
SI BOLLA PESA	2.477	3.231	6.349	430	12.487	5.001	3.738	11.841	4.277	24.857
NO BOLLA PESA	100	44	44	10	198	266	16	555	7	844

Fig. 3.2.2.9 - Indicator 05: Percentage of correct reunification (green) for service orders, September 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

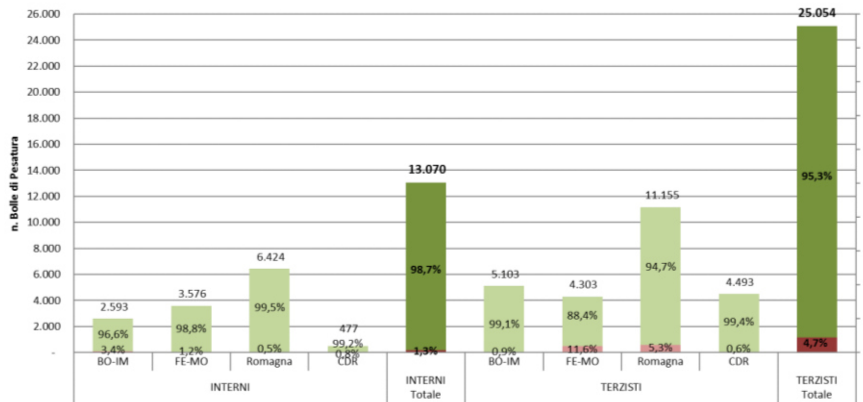
Fig. 3.2.2.10 shows a focus of the delta between the date and time of disposal and the date and time service for orders entered correctly.



	BO-IM INTERNI	BO-IM TERZISTI	BO-IM Totale	FE-MO INTERNI	FE-MO TERZISTI	FE-MO Totale	Romagna INTERNI	Romagna TERZISTI	Romagna Totale	CDR INTERNI	CDR TERZISTI	CDR Totale
entro 24h	2.361	4.731	7.092	3.205	3.284	6.489	6.206	11.659	17.865	421	3.306	3.727
tra 24h e 48h	7	71	78	12	102	114	15	66	81	1	290	291
tra 48 e 72h	1	39	40	3	75	78	2	31	33	-	186	186
oltre le 72h	3	83	86	3	169	172	8	90	98	7	266	273
Data Anticipata	105	82	187	8	108	116	119	69	188	1	231	232
Totale complessivo	2.477	5.006	7.483	3.231	3.738	6.969	6.350	11.915	18.265	430	4.279	4.709

Fig. 3.2.2.10 – Focus of delta between date and hours of disposal and date and hours for service orders, September 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

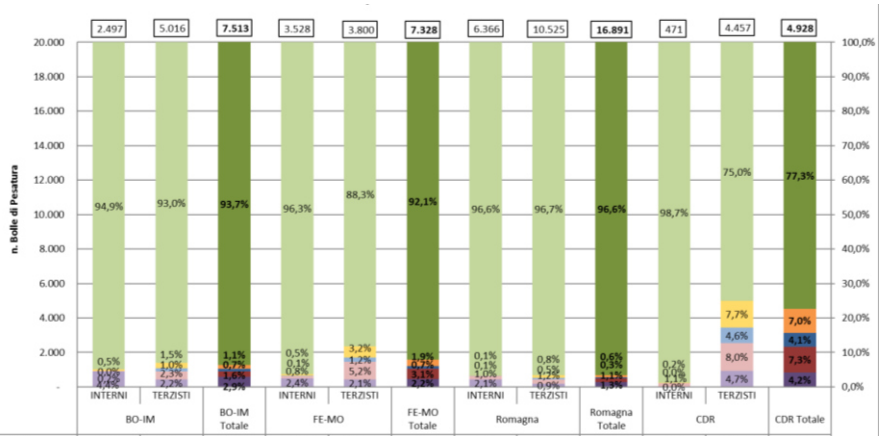
Fig. 3.2.2.11 shows the percentage of orders SSA properly inserted and evaluated on the totality of those extracted from ESA for the month of October. They are considered correct orders if they have an associated document of weighing. The total percentage of both internal and external services is substantially in line with the target set. The same considerations made for the second quarter are valid.



	INTERNI BO-IM	INTERNI FE-MO	INTERNI Romagna	INTERNI CDR	INTERNI Totale	TERZISTI BO-IM	TERZISTI FE-MO	TERZISTI Romagna	TERZISTI CDR	TERZISTI Totale
Totale complessivo	2.593	3.576	6.424	477	13.070	5.103	4.303	11.155	4.493	25.054
SI BOLLA PESA	2.504	3.534	6.391	473	12.902	5.055	3.804	10.562	4.466	23.887
NO BOLLA PESA	89	42	33	4	168	48	499	593	27	1.167

Fig. 3.2.2.11 - Indicator 05: Percentage of correct reunification (green) for service orders, October 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

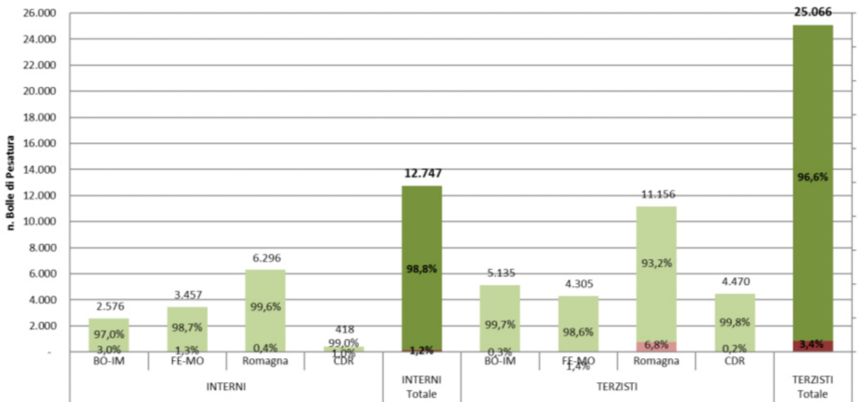
Fig. 3.2.2.12 shows a focus of the delta between the date and time of disposal and the date and time service for orders entered correctly.



	BO-IM INTERNI	BO-IM TERZISTI	BO-IM Totale	FE-MO INTERNI	FE-MO TERZISTI	FE-MO Totale	Romagna INTERNI	Romagna TERZISTI	Romagna Totale	CDR INTERNI	CDR TERZISTI	CDR Totale
entro 24h	2.370	4.667	7.037	3.396	3.354	6.750	6.150	10.174	16.324	465	3.344	3.809
tra 24h e 48h	12	74	86	19	122	141	9	84	93	1	344	345
tra 48 e 72h	1	50	51	2	46	48	9	48	57	-	204	204
oltre le 72h	4	115	119	27	199	226	65	129	194	5	357	362
Data Anticipata	110	110	220	84	79	163	133	90	223	-	208	208
Totale complessivo	2.497	5.016	7.513	3.528	3.800	7.328	6.366	10.525	16.891	471	4.457	4.928

Fig. 3.2.2.12 – Focus of delta between date and hours of disposal and date and hours for service orders, October 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

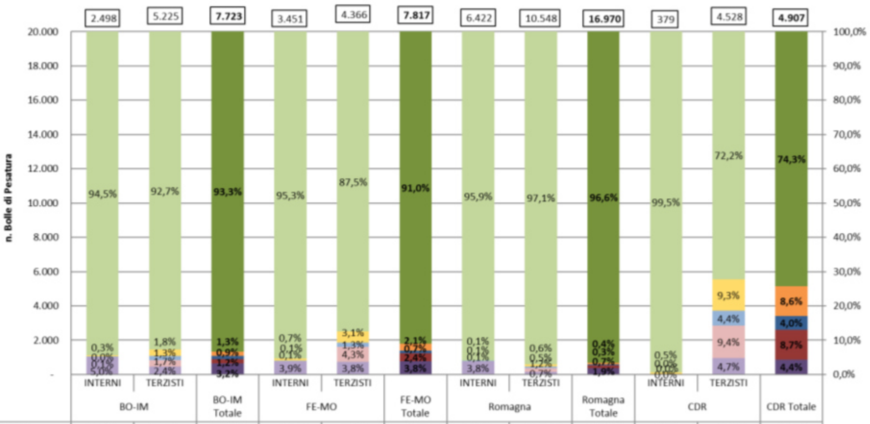
Fig. 3.2.2.13 shows the percentage of orders SSA properly inserted and evaluated on the totality of those extracted from ESA for the month of November. They are considered correct orders if they have an associated document of weighing. The total percentage of internal services is substantially in line with the target set. Indeed, there is an increase for external services (from 95.3% to 96.6%), respect to October. The same considerations made for the second quarter are valid.



	INTERNI BO-IM	INTERNI FE-MO	INTERNI Romagna	INTERNI CDR	INTERNI Totale	TERZISTI BO-IM	TERZISTI FE-MO	TERZISTI Romagna	TERZISTI CDR	TERZISTI Totale
Totale complessivo	2.576	3.457	6.296	418	12.747	5.135	4.305	11.156	4.470	25.066
SI BOLLA PESA	2.498	3.412	6.268	414	12.592	5.118	4.245	10.392	4.460	24.215
NO BOLLA PESA	78	45	28	4	155	17	60	764	10	851

Fig. 3.2.2.13 - Indicator 05: Percentage of correct reunification (green) for service orders, November 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).

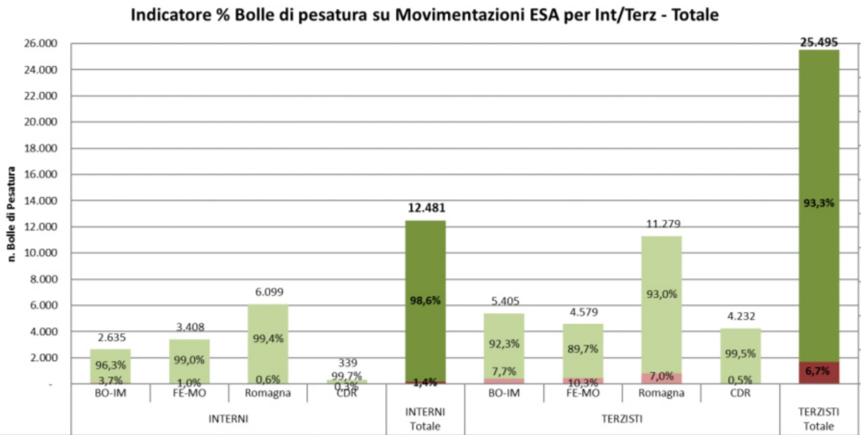
Fig. 3.2.2.14 shows a focus of the delta between the date and time of disposal and the date and time service for orders entered correctly.



	BO-IM INTERNI	BO-IM TERZISTI	BO-IM Totale	FE-MO INTERNI	FE-MO TERZISTI	FE-MO Totale	Romagna INTERNI	Romagna TERZISTI	Romagna Totale	CDR INTERNI	CDR TERZISTI	CDR Totale
entro 24h	2.361	4.845	7.206	3.289	3.821	7.110	6.161	10.238	16.399	377	3.270	3.647
tra 24h e 48h	7	95	102	25	137	162	5	66	71	2	419	421
tra 48 e 72h	1	70	71	2	56	58	4	48	52	-	197	197
oltre le 72h	3	91	94	2	188	190	5	122	127	-	427	427
Data Anticipata	126	124	250	133	164	297	247	74	321	-	215	215
Totale complessivo	2.498	5.225	7.723	3.451	4.366	7.817	6.422	10.548	16.970	379	4.528	4.907

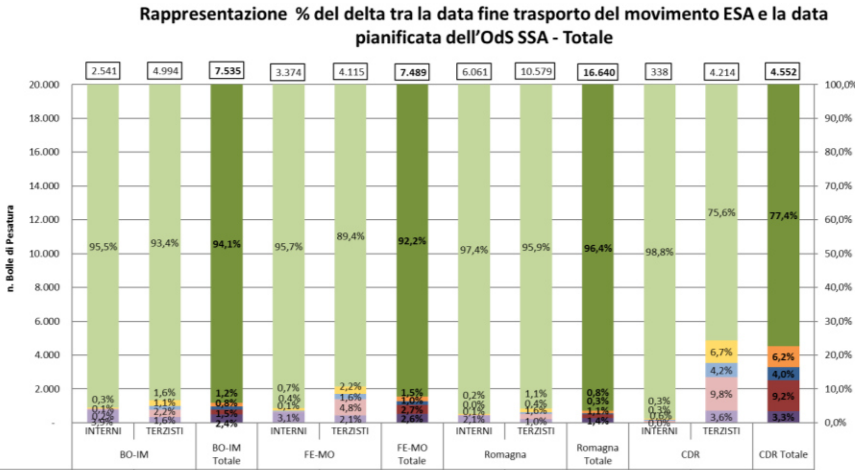
Fig. 3.2.2.14 – Focus of delta between date and hours of disposal and date and hours for service orders, November 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

Fig. 3.2.2.15 shows the percentage of orders SSA properly inserted and evaluated on the totality of those extracted from ESA for the month of December. They are considered correct orders if they have an associated document of weighing. The total percentage of internal services is substantially in line with the target set. Indeed, there is an increase for external services (from 95.3% to 96.6%), respect to October. The same considerations made for the second quarter are valid.



	INTERNI BO-IM	INTERNI FE-MO	INTERNI Romagna	INTERNI CDR	INTERNI Totale	TERZISTI BO-IM	TERZISTI FE-MO	TERZISTI Romagna	TERZISTI CDR	TERZISTI Totale
Totale complessivo	2.635	3.408	6.099	339	12.481	5.405	4.579	11.279	4.232	25.495
SI BOLLA PESA	2.538	3.373	6.060	338	12.309	4.990	4.109	10.484	4.209	23.792
NO BOLLA PESA	97	35	39	1	172	415	470	795	23	1.703

Fig. 3.2.2.15 - Indicator 05: Percentage of correct reunification (green) for service orders, December 2016. There is a detail for internal services (subdivided per area in the first, second, and third column) and external services (fifth, sixth, seventh, eighth column).



	BO-IM INTERNI	BO-IM TERZISTI	BO-IM Totale	FE-MO INTERNI	FE-MO TERZISTI	FE-MO Totale	Romagna INTERNI	Romagna TERZISTI	Romagna Totale	CDR INTERNI	CDR TERZISTI	CDR Totale
entro 24h	2.427	4.665	7.092	3.228	3.677	6.905	5.906	10.143	16.049	334	3.187	3.521
tra 24h e 48h	7	81	88	24	89	113	15	112	127	1	282	283
tra 48 e 72h	2	57	59	12	64	76	2	45	47	1	179	180
oltre le 72h	6	110	116	4	197	201	8	173	181	2	415	417
Data Anticipata	99	81	180	106	88	194	130	106	236	-	151	151
Totale complessivo	2.541	4.994	7.535	3.374	4.115	7.489	6.061	10.579	16.640	338	4.214	4.552

Fig. 3.2.2.16 – Focus of delta between date and hours of disposal and date and hours for service orders, December 2016. There is a detail for internal services (subdivided per area in the first, fourth, and seventh column) and external services (second, fifth, and eighth column). The colors represent: green - delta minor of 48 hours, skyblue - between 48 e 72 hours, red - over 72 hours, purple – anticipated date.).

3.2.3 06 – Positioning containers indicator

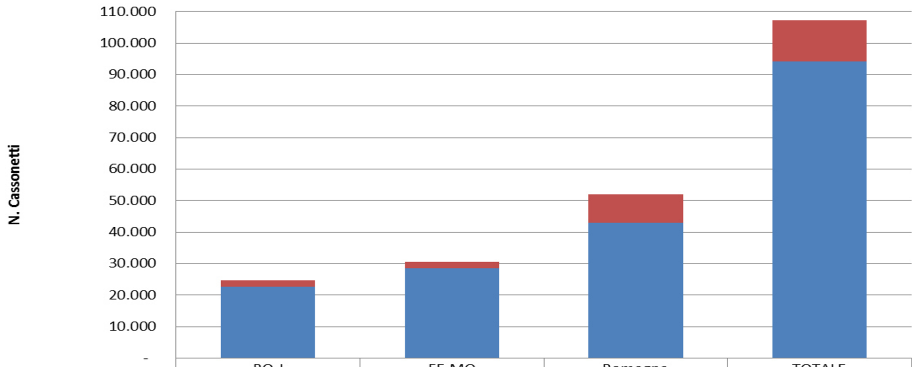
This indicator is used to evaluate the quality of the system. It quantifies the correct position of the containers. Using the dashboard of the anomalies, a percentage of abnormality positionings of the dumpster in comparison to the total number of installed bins in SAP is calculated.

2016	1° Trim.	2° Trim.	3° Trim.	4° Trim.
Anomalie	10%	5%	0%*	0%*

Tab. 3.2.3.1 – Aim of the indicator 06

* The 0% target is to be theoretically considered as the containers are moved every day in the area and the updating in the system can occur even at a length of a few days from the execution of the activity in the field.

Fig. 3.2.3.1 ÷ 3.2.3.3 highlight the positioning anomalies of the dumpster detected by field devices, refering exclusively to monoperator services. The analysis alludes to the first quarter of 2016. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.1) with the details of the anomaly detected (Fig. 3.2.3.2). A histogram is also shown with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.3).



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	8,6%	6,3%	17,3%	12,2%
% Corretti	91,4%	93,7%	82,7%	87,8%
TOT CASSONETTI	24.779	30.477	51.928	107.184
TOT ANOMALIE	2.125	1.909	8.998	13.032

Fig. 3.2.3.1 – Percentage indicator of uncorrect positionings for dumpsters per area, First quarter 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

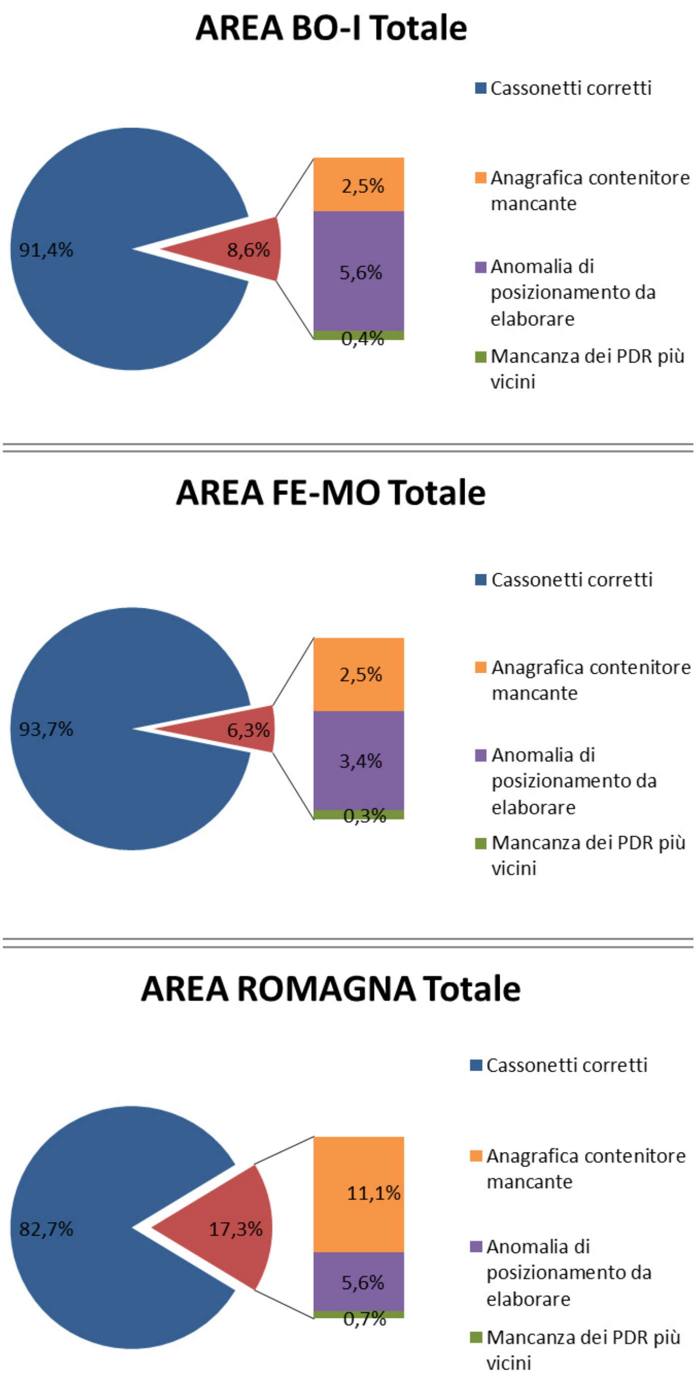
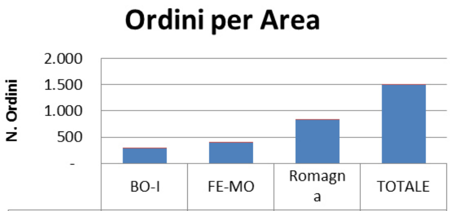


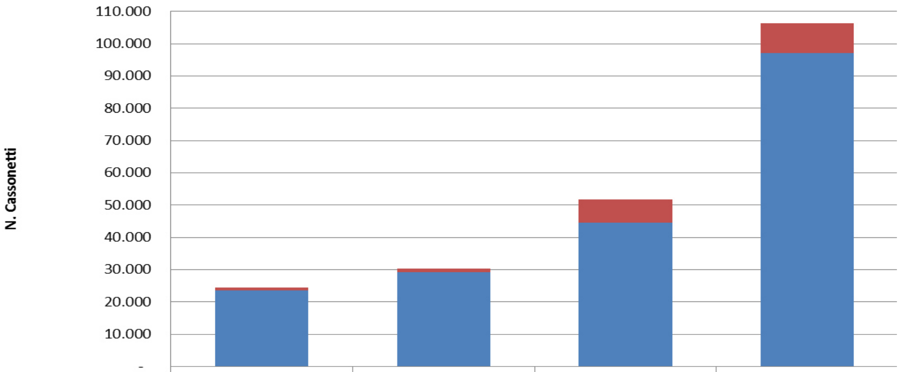
Fig. 3.2.3.2 – Detail of uncorrect positionings for dumpsters per area, First quarter 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	BO-I	FE-MO	Romagna	TOTALE
%	19%	26%	55%	100%
N. ORDINI	285	391	825	1.501

Fig. 3.2.3.3 – Detail of analized orders per area, First quarter of 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

Fig. 3.2.3.4 ÷ 3.2.3.6 highlight the positioning anomalies of the containers detected by field devices, refering exclusively to monoperator services. The analysis alludes to the second quarter of 2016. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.4) with the details of the anomaly detected (Fig. 3.2.3.5). A histogram is also shown with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.6).



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	4,1%	3,3%	14,0%	8,7%
% Corretti	95,9%	96,7%	86,0%	91,3%
TOT CASSONETTI	24.502	30.234	51.740	106.476
TOT ANOMALIE	1.013	997	7.266	9.276

Fig. 3.2.3.4 – Percentage indicator of uncorrect positionings for dumpsters per area, Second quarter 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

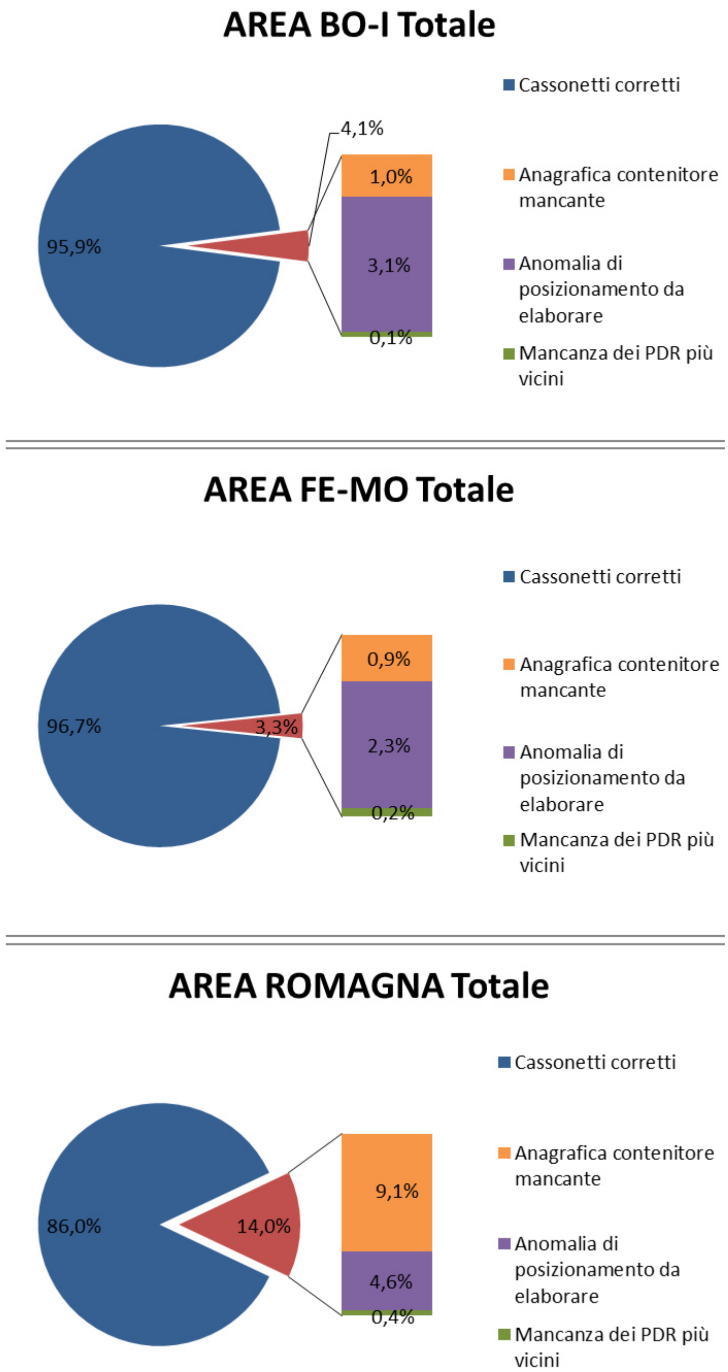
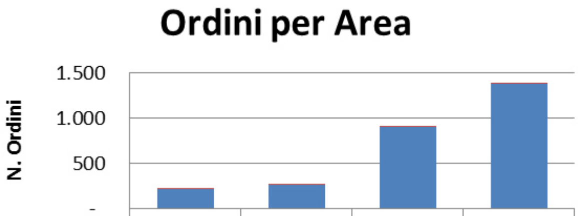


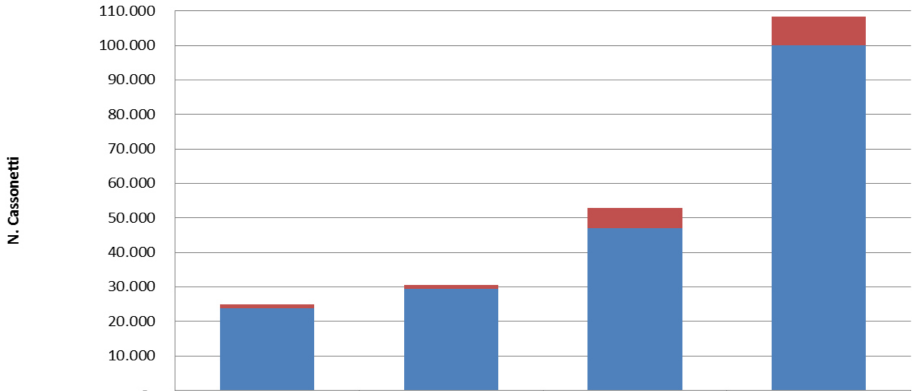
Fig. 3.2.3.5 – Detail of uncorrect positionings for dumpsters per area, Second quarter 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	BO-I	FE-MO	Romagn a	TOTALE
%	16%	19%	65%	100%
N. ORDINI	217	262	899	1.378

Fig. 3.2.3.6 – Detail of analized orders per area, Second quarter of 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

Fig. 3.2.3.7 ÷ 3.2.3.9 highlight the positioning anomalies of the containers detected by field devices, refering exclusively to monoperator services. The analysis alludes to the month of July. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.8) with the details of the anomaly detected (Fig. 3.2.3.9). A histogram is also shown a histogram with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.3). There is an improvement compared to the second quarter particularly in the Romagna Area (from 14% to 11.3%), due to the completion of route data recovery.



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	4,8%	3,7%	11,3%	7,7%
% Corretti	95,2%	96,3%	88,7%	92,3%
TOT CASSONETTI	24.894	30.544	52.919	108.357
TOT ANOMALIE	1.201	1.124	5.966	8.291

Fig. 3.2.3.7 – Percentage indicator of uncorrect positionings for dumpsters per area, July 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

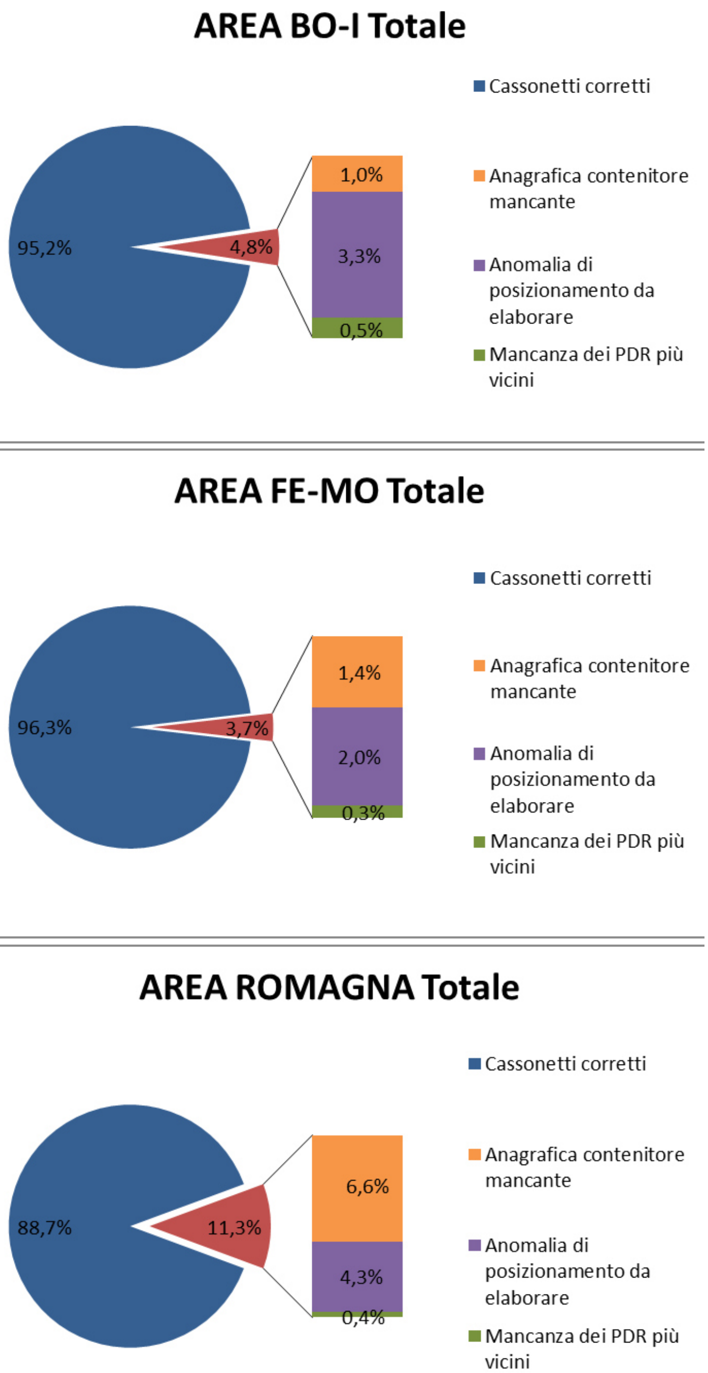
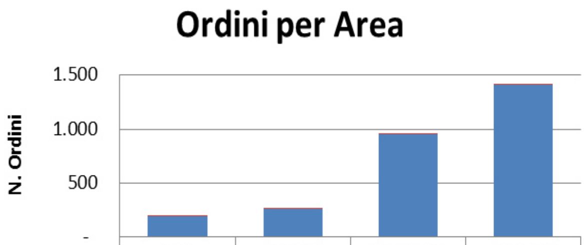


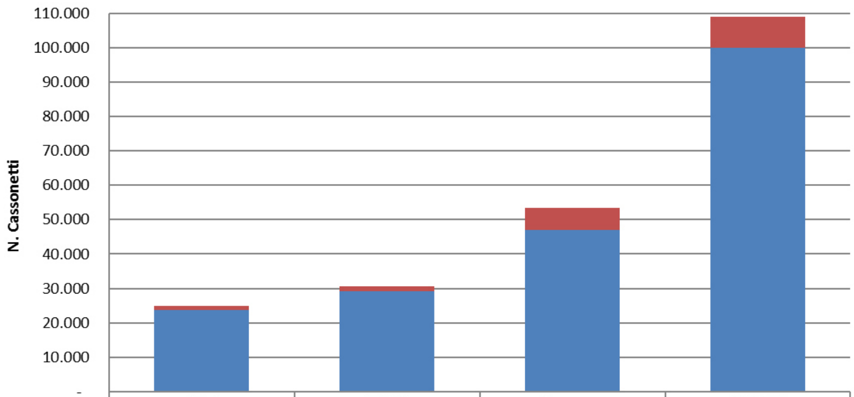
Fig. 3.2.3.8 – Detail of uncorrect positionings for dumpsters per area, July 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	BO-I	FE-MO	Romagna	TOTALE
%	14%	19%	68%	100%
N. ORDINI	195	264	954	1.413

Fig. 3.2.3.9 – Detail of analized orders per area, First quarter ofJuly 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

Fig. 3.2.3.10 ÷ 3.2.3.12 highlight the positioning anomalies of the containers detected by field devices, refering exclusively to monoperator services. The analysis alludes to the month of August. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.10) with the details of the anomaly detected (Fig. 3.2.3.11). A histogram is also shown with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.12). The data related to the total percentage of anomalies recorded for August are in line with those of July (from 7.7% to 8.3%).



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	4,6%	4,8%	12,0%	8,3%
% Corretti	95,4%	95,2%	88,0%	91,7%
TOT CASSONETTI	24.943	30.621	53.346	108.910

Fig. 3.2.3.10 – Percentage indicator of uncorrect positionings for dumpsters per area, August 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

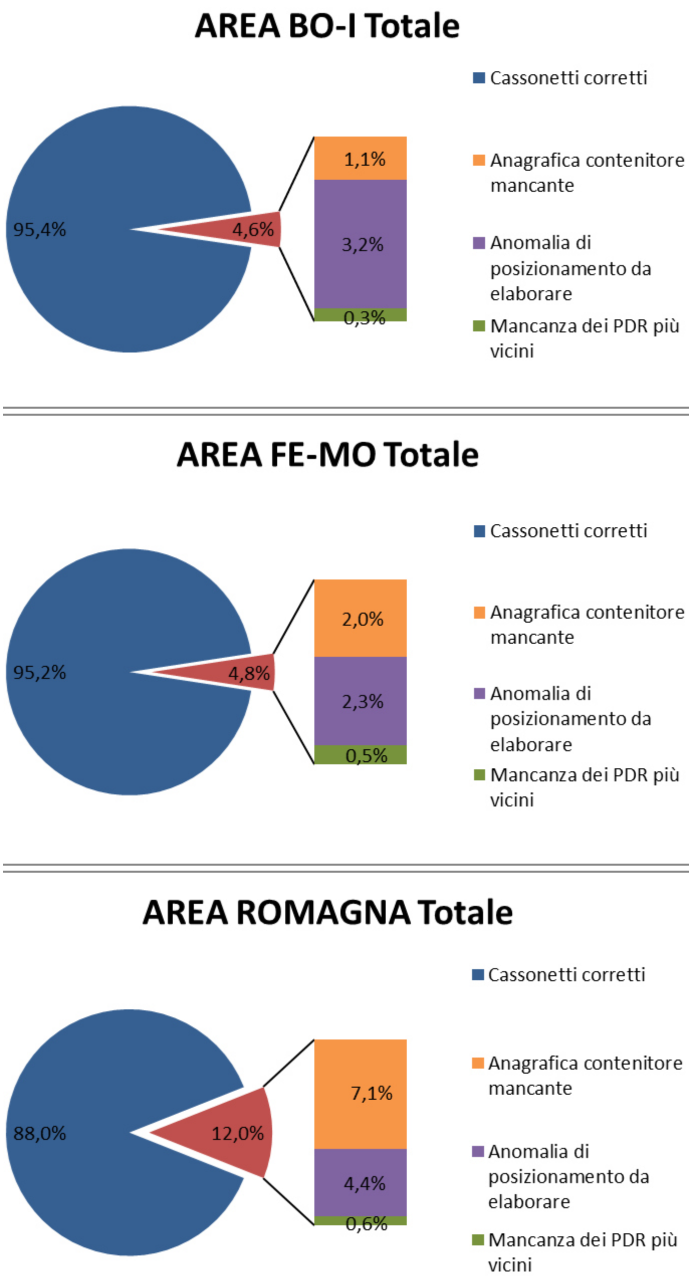
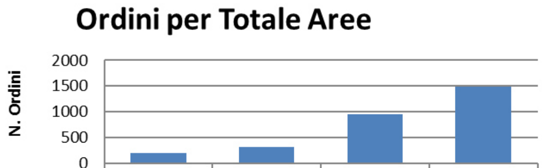


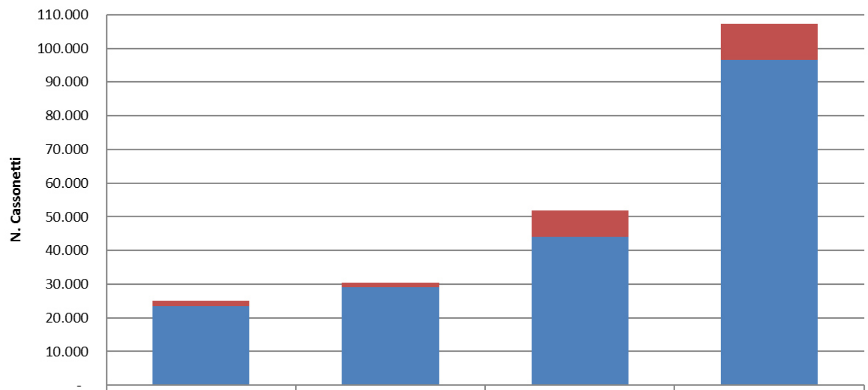
Fig. 3.2.3.11 – Detail of uncorrect positionings for dumpsters per area, August 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	AREA BO-IM	AREA FE-MO	AREA ROMAGNA	Totale
% ordini area su totali	14%	22%	65%	100%
N. ORDINI	204	323	958	1485

Fig. 3.2.3.12 – Detail of analized orders per area, August 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

Fig. 3.2.3.13 ÷ 3.2.3.15 highlight the positioning anomalies of the containers detected by field devices, refering exclusively to monoperator services. The analysis alludes to the month of September. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.13) with the details of the anomaly detected (Fig. 3.2.3.14). A histogram is also shown with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.15). There is an increase of anomalies compared to August (from 8,3% to 9,9%).



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	6,4%	4,0%	15,1%	9,9%
% Corretti	93,6%	96,0%	84,9%	90,1%
TOT CASSONETTI	25.046	30.362	51.848	107.256

Fig. 3.2.3.13 – Percentage indicator of uncorrect positionings for dumpsters per area, September 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

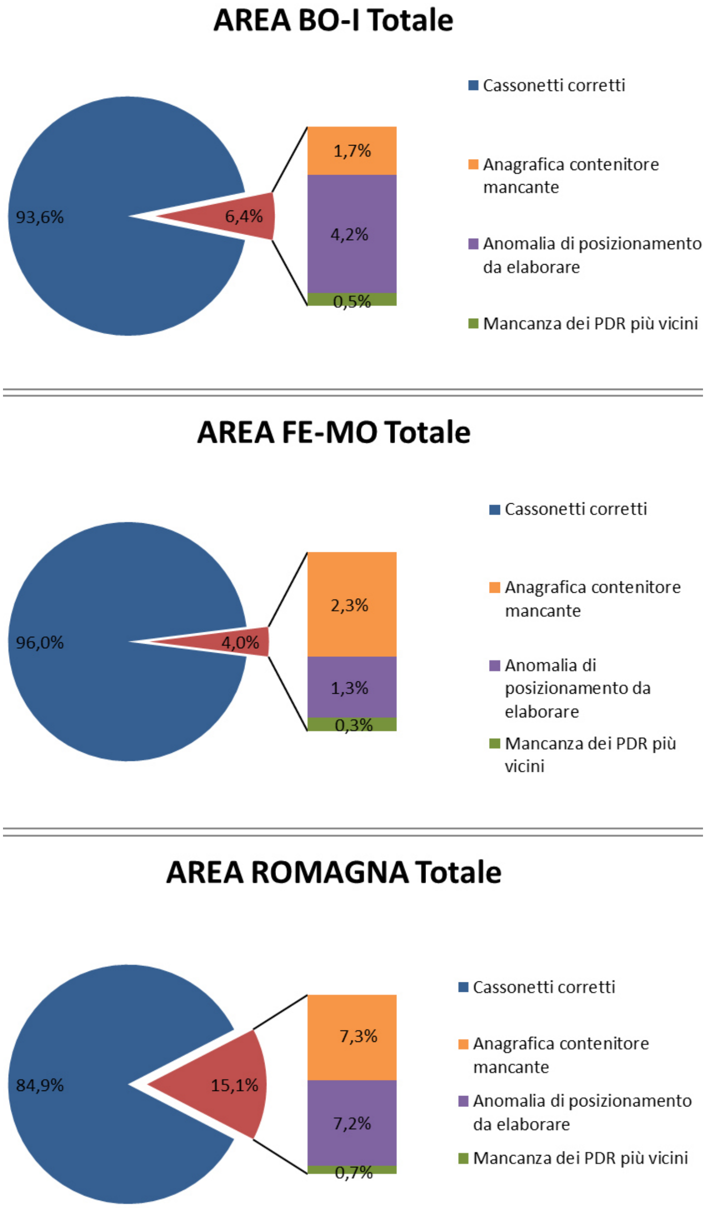
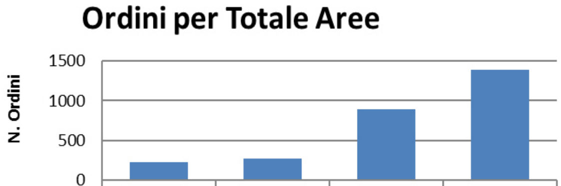


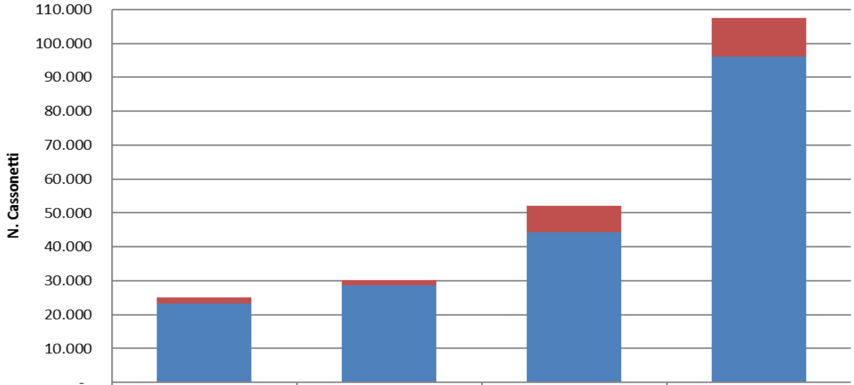
Fig. 3.2.3.14 – Detail of uncorrect positionings for dumpsters per area, September 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	AREA BO-IM	AREA FE-MO	AREA ROMAGNA	Totale
% ordini area su totali	16%	20%	64%	100%
N. ORDINI	224	271	886	1381

Fig. 3.2.3.15 – Detail of analized orders per area, September 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

Fig. 3.2.3.16 ÷ 3.2.3.18 highlight the positioning anomalies of the containers detected by field devices, referring exclusively to monoperator services. The analysis alludes to the month of October 2016. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.16) with the details of the anomaly detected (Fig. 3.2.3.17). A histogram is also shown with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.18). There is an increase compared to September (from 9,9% to 10,5%).



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	7,5%	5,1%	15,2%	10,5%
% Corretti	92,5%	94,9%	84,8%	89,5%
TOT CASSONETTI	25.037	30.265	52.123	107.425

Fig. 3.2.3.16 – Percentage indicator of uncorrect positionings for dumpsters per area, October 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

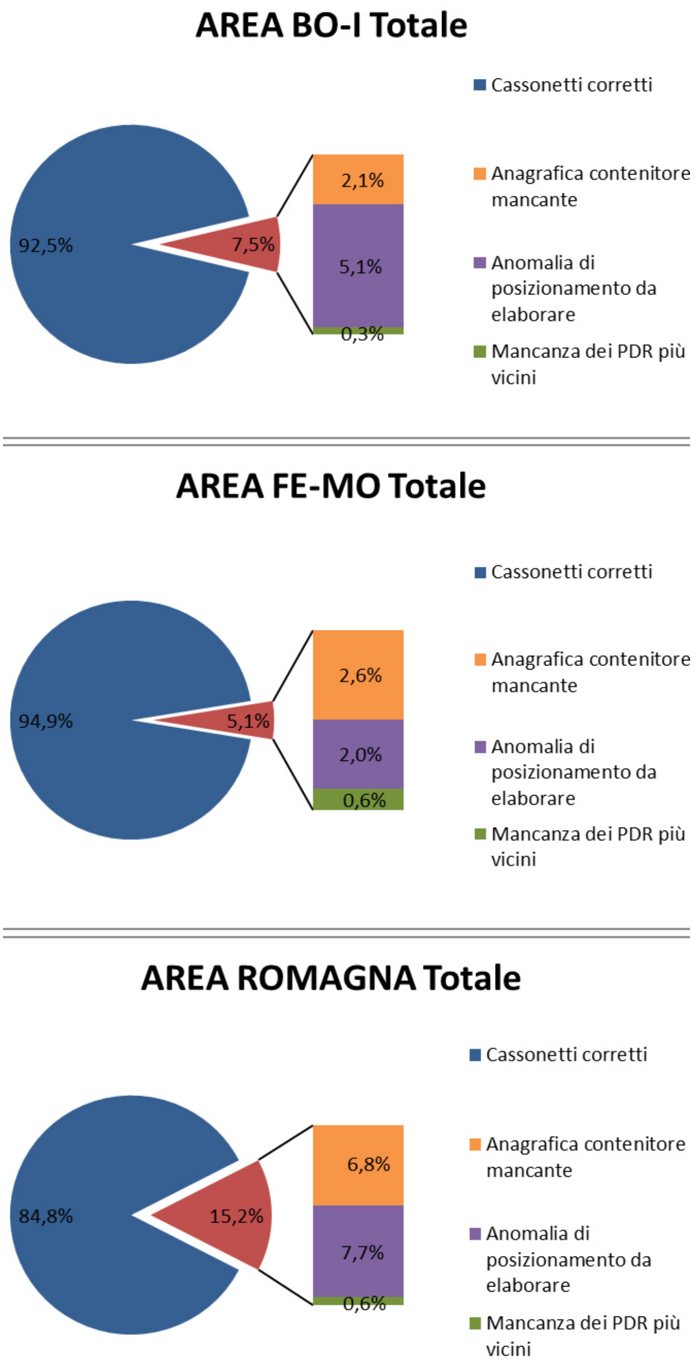
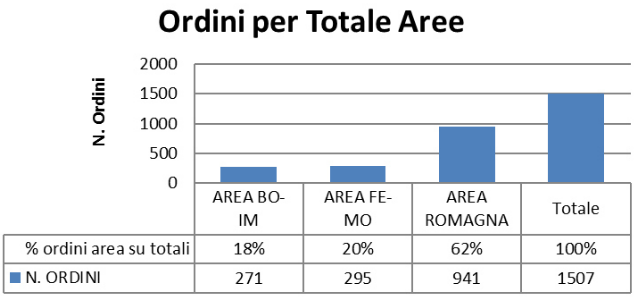


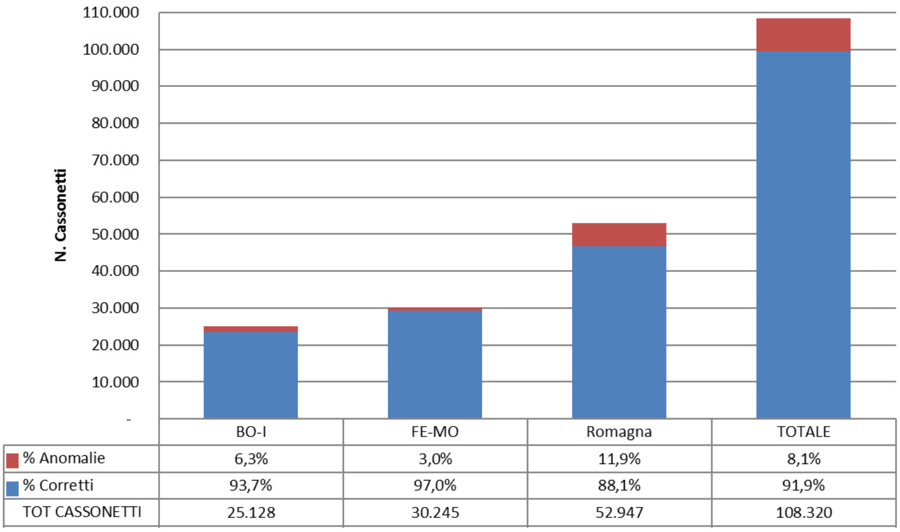
Fig. 3.2.3.17 – Detail of uncorrect positionings for dumpsters per area, October 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	AREA BO-IM	AREA FE-MO	AREA ROMAGNA	Totale
% ordini area su totali	18%	20%	62%	100%
N. ORDINI	271	295	941	1507

Fig. 3.2.3.18 – Detail of analized orders per area, October 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

Fig. 3.2.3.19 ÷ 3.2.3.21 highlight the positioning anomalies of the containers detected by field devices, refering exclusively to monoperator services. The analysis alludes to the month of November 2016. It considers the percentage of dumpster anomalies by area (Fig.3.2.3.19) with the details of the anomaly detected (Fig. 3.2.3.20). It is also shown a histogram with the details of the number of collection orders by area, which generated anomalies (Fig.3.2.3.21). There is a decrease compared to October (from 8,3% to 9,9%).



	BO-I	FE-MO	Romagna	TOTALE
% Anomalie	6,3%	3,0%	11,9%	8,1%
% Corretti	93,7%	97,0%	88,1%	91,9%
TOT CASSONETTI	25.128	30.245	52.947	108.320

Fig. 3.2.3.19 – Percentage indicator of uncorrect positionings for dumpsters per area, November 2016. Red represents the uncorrect positioning, while skyblue refers to the correct positioning. There is also a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

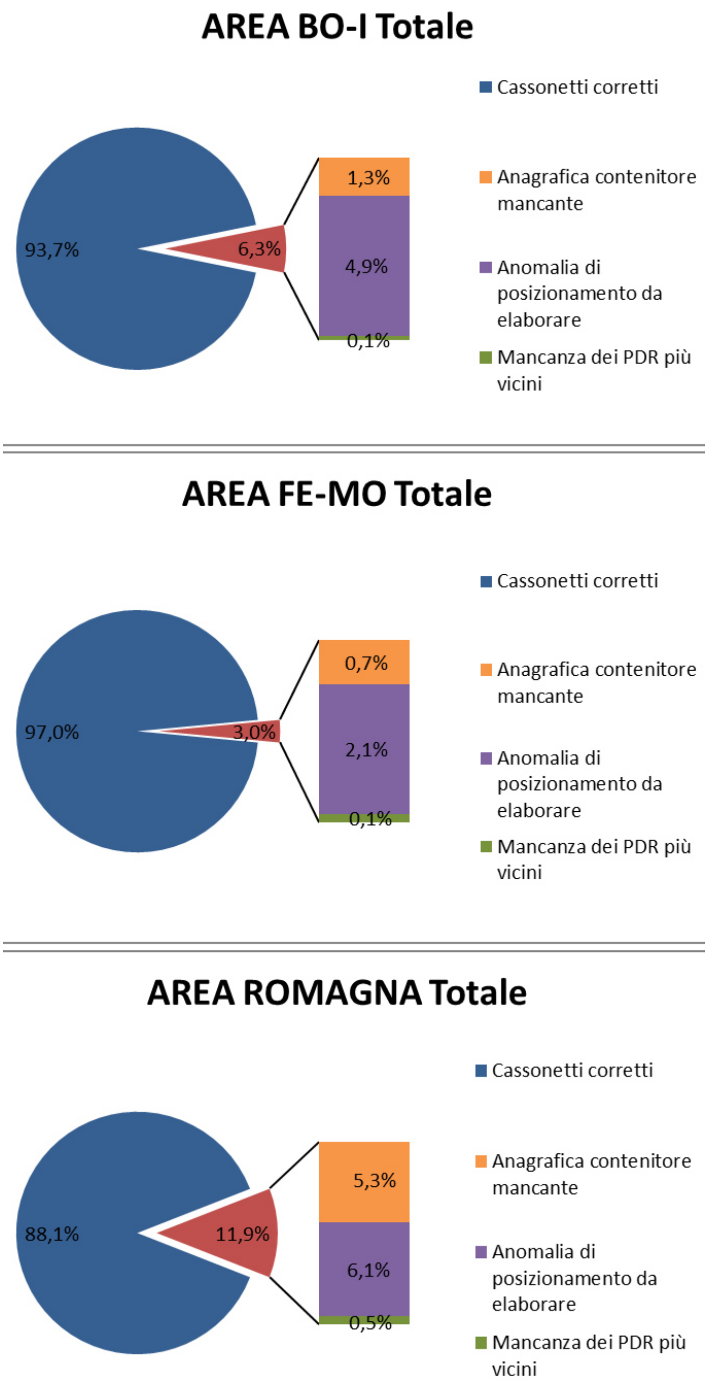
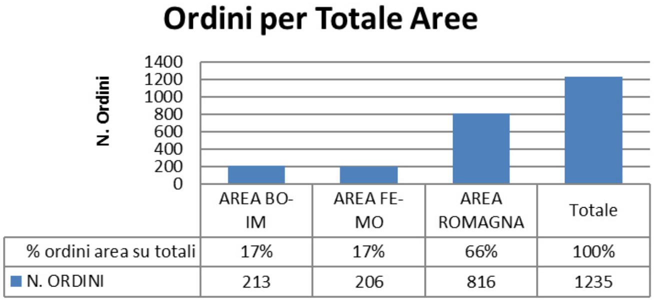


Fig. 3.2.3.20 – Detail of uncorrect positionings for dumpsters per area, November 2016. Blue represents the correct positioning, orange the lack of registry in SAP, purple the anomalies to be processed and green the lack of the nearest collection point. There is a detail per area: Bologna - Imola (first picture), Ferrara-Modena (second picture), Romagna (third picture).



	AREA BO-IM	AREA FE-MO	AREA ROMAGNA	Totale
% ordini area su totali	17%	17%	66%	100%
N. ORDINI	213	206	816	1235

Fig. 3.2.3.21 – Detail of analized orders per area, November 2016. Blue represents the orders associated with correct positioning, red with uncorrect positioning. There is a detail per area: Bologna - Imola (first column), Ferrara-Modena (second column), Romagna (third column).

4 Improvement of collection routes of monoperator in Modena

In this chapter, a first application of the Hergo system is presented. The application regards the redesign of a collection service in the municipality of Modena.

In this context, I focused on the identification of all the useful data that could be dervide from the HERGO system and I developed preliminary analysis to provide the company LABELAB srl and the office design of the Technical Coordination and Innovation (CTI) of Hera SpA, the necessary basis for the realization of the project named "monooperator- Modena”.

The phases of the project were:

(i) Definition of the application field (CTI);

(ii) Extraction of data and preliminary considerations (CTI);

(iii) Data validation provided by the system (CTI-Labelab-Area Modena);

(iv) Construction of specific indicators to assess the benchmark (CTI - Labelab)

(v) Input for the construction of new optimization scenarios of services (CTI-Labelab-Area Modena);

4.1 Introduction

The aim of the project is to improve the saturation of the collection routes in compliance with the working hour variation for drivers based on the new national labor contract. Optimization of routes may provide an increased flexibility in the service planning.

This project regards the analysis of collection routes in the city of Modena for:

(i) Not separate waste (current saturation degree is about 70%);

(ii) Separate plastic and paper fractions (current saturation degree is about 30%);

(iii) Green and pruning.

The data used for the analysis are referred to a period of six months from January to June 2016.

The service area of Modena’s municipality is often connected with the neighbouring municipalities, as the figure 4.1.1 shows.

The collection frequency of waste is defined in Table 4.1.1:

Waste	Frequency
Paper	1/7
Plastica	1/7
Not separated waste	1/7 – 1/14
Green and pruning	1/7

Tab. 4.1.1 – Emptied frequency of waste collected with monoperator in Modena area

The starting database is obtained from the combination of reports with different information, using the ODS code as the main link key, which - as mentioned - is a unique number assigned to a specific route on a specific date. Data provided by HERGO are:

- Weighing data: weighing associated with disposal orders within each service, associated to the date and time of disposal;
- Actual emptied container: information relating to the collection, volumes involved, scheduled containers, executed containers and the amounts accounting for means and employees;
- Information about distance traveled (kilometers) and the actual duration of the session (hours) for each service;
- Data of vehicles for internal and external services; this report gives the information related to the MTT, the age and the number of axles of the vehicle;
- Starting time of transportation for service order;
- Duration of stopping at the plant for each ODS.

As a first step, the weighings of six months associated with these services have been extracted, together with the boundary conditions such as the type of route, the type of vehicle used and the work area. Disposal plant is another filter assigned.

From 13.511 total discharges, only those of the city of Modena and neighboring municipalities have been considered, since they have been recognized as the most representative. The others, without correct reunification for DDT and service order, have been removed. Through the weighs assigned for the municipality of Modena, the correct ODS have been recognized and for each of them the spent time in the disposal plant has been defined. This data is not always available, since sometimes the operator turns off the OBC before entering at the plant. As such, among the 4.891 lines extracted, only 2.667 have been recognized as reliable regarding to the overall necessary data for the analysis. (Fig. 4.1.2).

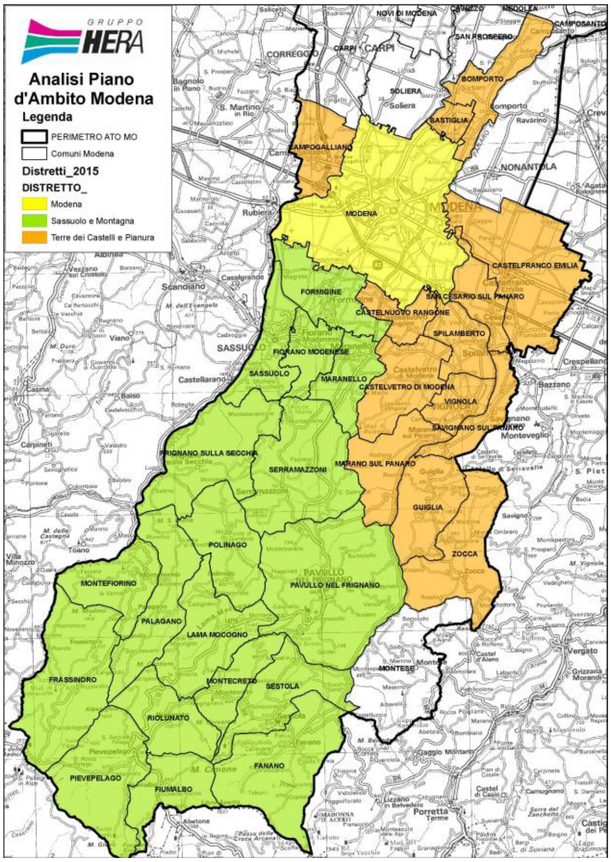


Fig. 4.1.1 – Area Modena's territories managed by Hera spa

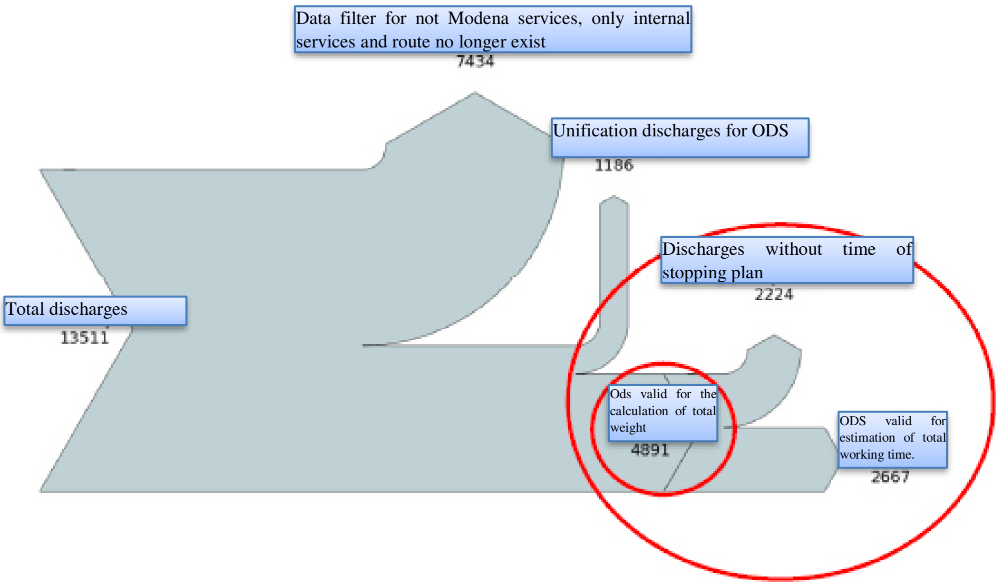


Fig. 4.1.2 –Data flow of the project: from comprehensive database to solid database

4.2 Data cleaning

Thank to the mentioned procedure, a preliminary database has been obtained, in which some data are missed but it is useful for the purposes of weighing calculation (Tab.4.2.1):

WASTE	N. ods (not separated discharges for same ODS)	N. ods (separated discharges for same ODS)	N. route	Weight (t)
Paper	1.078	1.167	49	4.685
Plastic	1.376	1.510	56	5.206
Not separated waste	2.157	3.066	68	29.614
Green and pruning	280	334	15	1.934
Total	**4.891**	**6.077**	**188**	**42.439**

Tab. 4.2.1 – Initial data base

The Weight (t) represents the sum of the weights of different type of waste collected in the period from January to June 2016; the column N.ods (not separated discharges for same ODS) represents the total number of service orders with at least one discharge, and N. ods (separated discharges for same ODS) represents the total number of discharges associated with the total of ODS in the previous column.

For the calculation of the indicators, a database where all data are known is used, as summarized in Table 4.2.2:

WASTE	N. ods (separated discharges for same ODS)	N. ods (separated discharges for same ODS)	N. route
Paper	612	613	49
Plastic	780	782	56
Not separated waste	1.184	1.517	67
Green and pruning	91	95	15
Total	**2.667**	**3.007**	**187**

Tab. 4.2.2 – Synthesis of reference database for the calculation of final indicators

The final database is shown in Table 4.2.3:

WASTE	A Valid ODS to calculate the total weight	B Valid ods to calculate working time	C Incidence percentage (C=B/A)
	n.	n.	%
Paper	1.078	612	56.8%
Plastic	1.376	780	56.7%
Not separated waste	2.157	1.184	54.9%
Green and pruning	280	91	32.5%
Total	**4.891**	**2.667**	**54.5%**

Tab. 4.2.3 – Final database

Also for the evaluation of working-time a database has been developed, as fig.4.2.4 shows:

Waste	Total (h)
Paper	3.786
Plastica	4.738
Not separated waste	7.141
Green and pruning	586
Total	**16.251**

Tab. 4.2.4 – Database used to evaluate the working-time

The column of total time (h) indicates the total hours associated with the collection service in the period from February to June 2016. The cost of the service involving driver plus vehicle is about 70 € /h; for the period the total cost is 1.137 K€.

The collection service could be theoretically divided into 4 macro phases (Fig. 4.2.1):

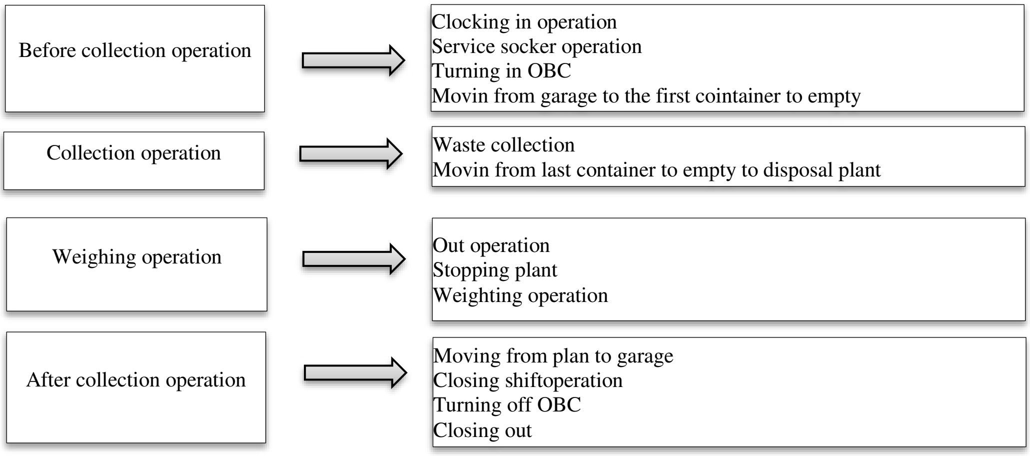


Fig. 4.2.1 – Macro phases of collection services

The same information is shown in the figure 4.2.2:

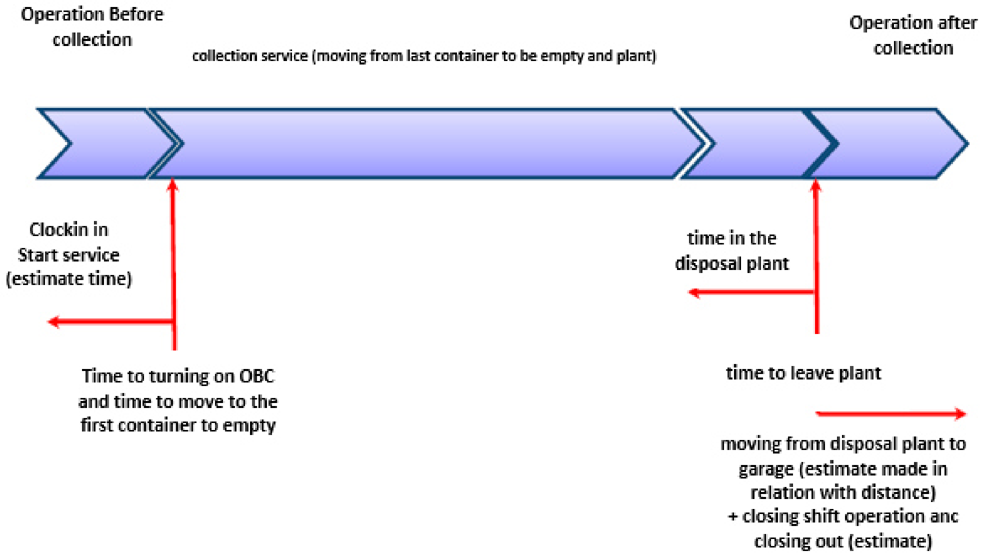


Fig. 4.2.2 – Total service time

In accordance with the Modena-area, calculation of service duration has been made taking account of:

- T Start: time of turning on OBC minus estimated startup time

- T End: time to entry in the disposal plant (real), plus the residence time in the disposal plant (real) plus the time estimated for the complete closure of the shift (hours necessary to leave the plant plus estimated time for the closing operations of the shift).I

WASTE	Disposal plant	Time for the operation before the service	Time for Collection service	Stop at the disposal plant	Return to car park	Time for operation to close the shift
Not separated waste	Waste to energy plant (WTE)	+12 minutes	Variable	Variable	+15 minutes	+30 minutes
Plastic, Paper	waste treatment facility	+12 minutes	Variable	Variable	+20 minutes	+30 minutes
Green	Composting plant	+12 minutes	Variable	Variable	+40 minutes	+30 minutes

Tab. 4.2.5 – Time of the service

The time for the closing operations of the shift is estimated at approximately 30 minutes and considers the following tasks for all drivers and all fractions:

- Dry duct: in the garage, there are lances to wash the vehicles; after his shift every driver has to wash the duct of his vehicle. The duct is located near of the pressure area where the smallest part of waste is collected during the phases of presser movement;

- Get gas: currently the distributor is located within the area;

- Cabin cleaning: cleaning of dashboard, windows, doors and platforms;

- Parking vehicle;

- Any reports to do in the case of failures of the vehicle

- Compilation of the paper document

- Delivery of collection folder

- Delivery of verbal to report the collection service (new container, not detected container, etc).

4.3 Data processing

A statistical analysis for any itinerary that includes all the information of the collection routes has been developed.

Specifically, a worksheet for each route of collection has been produced; the information included are: name of route, name of municipality, ODS number, type of waste, discharges and actual number of weighing. For each route, graphics have been obtained concerning: the net weight, the duration of the shift, the number of containers emptied and the saturation of the vehicle (*).

(*) specific worksheet for the routes with multiple discharges are created, considering the number of discharges and analyzed the performance of each segment within the path.

A set of indicators for each route has been developed, grouped into two main areas:

- ✓ Incidence Indicators
- ✓ Performance indicators.

The incidence indicators are two:

- ✓ Weight of Route in the total routes considered for fraction;
- ✓ Route incidence in terms of time associated to the weight with respect to the total routes considered per fraction.

The performance indicators are (average, min, max and variance):

- ✓ Saturation of vehicle used in the collection service;
- ✓ Kg/h of waste collected;
- ✓ Kg/km of waste collected;
- ✓ Emptying per hour;
- ✓ Emptying of cycles per km;
- ✓ Time in the disposal plant;
- ✓ Incidence of time in the disposal plant respect to the total time of the service;
- ✓ Total route time;
- ✓ Incidence of the actual time of the route respct to the theoretical time.

A total of 186 worksheets, for each route involved, have been produced.

Below there is an example of a worksheet. All indicators for a specific route have been developed (Tab. 4.3.1 ÷ 4.3.3 and Fig. 4.3.1 ÷ 4.3.4).

Route worskheet	
Route code	**70080LC**
Time slot	**Morning**
Municipality	**Modena**
N. ODS	**9**
Type of waste	**Paper**
N. discharges	**9**

Tab. 4.3.1: Type of worksheet of route 70080LC

Incidence Indicator	
Total weigh of route respect to the total routes involved	0,82%
Time of incidence of route	1,49%

Tab. 4.3.2: Incidence indicator of route 70080LC

Performance indicator	Average	Variance -	Variance +	min	max
Saturation Index	32,40%	28%	37%	27%	41%
kg/h	829	736	921	679	1.005
kg/km	96	77	115	78	145
N. Emptying/h	17	25	18	12	19
Time in the disposal plant	00:27:52	00:18:54	00:36:50	00:11:53	00:39:32
Time of the route	06:15:10	05:58:00	06:32:19	05:50:04	06:50:42
kg/container	00:00:00	00:00:00	63	40	81
Saturation Index respect to the theoretical time (6 hours)	104%	99%	109%	97%	114%
Incidence of time at the plant respect to the total time	7,36%	5,20%	9,51%	3,34%	10,17%

Tab. 4.3.3: Perfomance indicator of route 70080LC

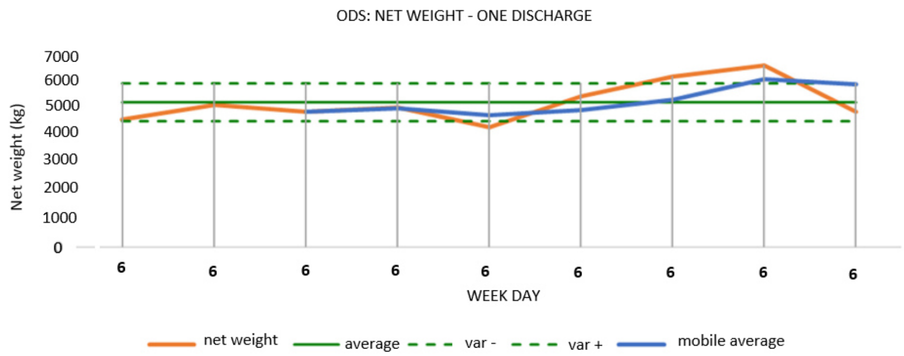


Fig. 4.3.1: Net Weight indicator for services with a single discharge

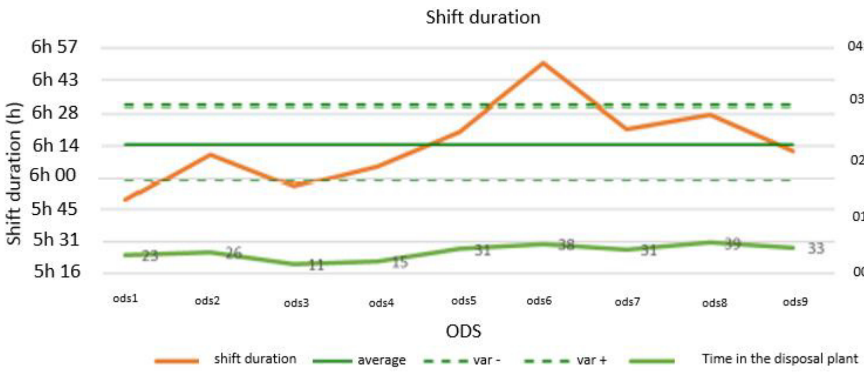


Fig. 4.3.2: Indicator of shift duration

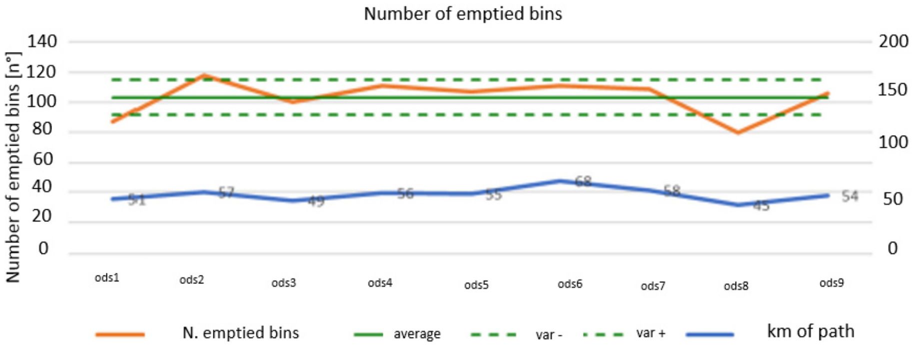


Fig. 4.3.3: Indicator of number of emptied bins

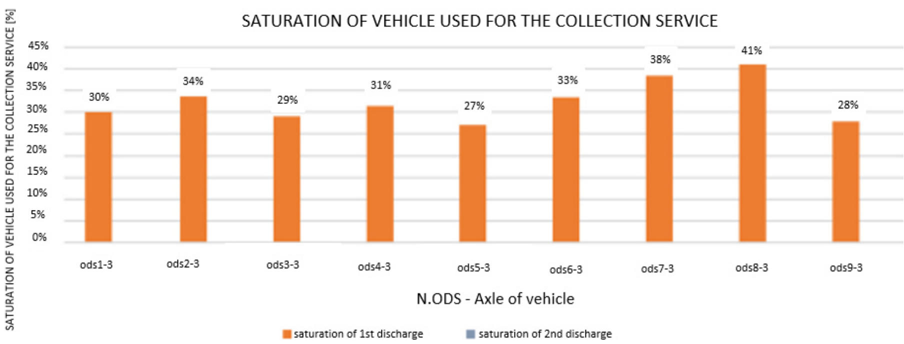


Fig. 4.3.4: Indicator of saturation of vehicle used for collection service

4.4 Creating a dashboard for further analysis and evidence

Based on the indicators, for each route the average values have been derived as reported in tab. 4.4.1:

N. Indicator	INDICATOR	DESCRIPTION
1	Average of saturation index (weight of emptied container/max payload)	For single discharge, it is the ratio between the weight of the waste collected and the car payload, while for double discharges, it is the average of the ratios between the first and second weighing
2	Average of indicator kg/h	Ratio between the collected weight and the total time of service
3	Average of indicator kg/km	Ratio between the collected weight and the path (km)
4	Average of kg/bin	Ratio between collected weight and number of emptied bins
5	Average of indicator (h/number of emptied bins)	Ratio between collected weight and actual duration of shift
6	Average of indicator (km/number of emptied bins)	Ratio between collected weight and actual path (km)
7	Average of average of time in the disposal plant	Time spent in the disposal plant
8	Average of incidence of time in the disposal plant respect to the shift time	Ratio between time in the disposal plant and the duration of the shift
9	Average of saturation Index respect to the theoretical time (6 hours)	Ratio between the actual and theoretical duration (6 hours) of the shift
10	Average of indicence weight respect to the total route involved	Ratio between the sum of collected weight for the code route and specific waste, and the total of that collected waste
11	Average of incidence of the route (time)	Ratio between the sum of time for the code route and specific waste, and the total of that collected waste

Tab. 4.4.1 – Development of a statistical analysis for each route

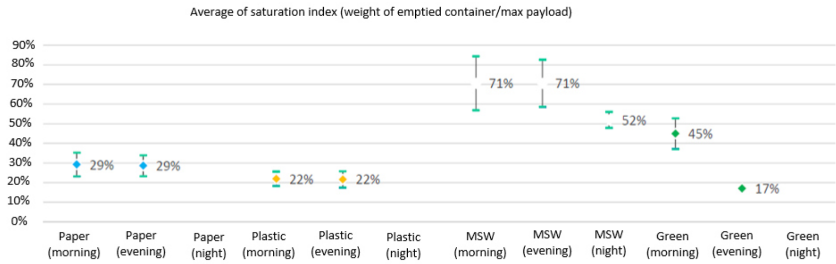
The overall statistical analysis is reported in a dashboard, in which the synthetic values for each route are included (Tab.4.4.2).

ROUTE code (PAPER)	N.ODS	1 [%]	2 [kg/h]	3 [kg/km]	4 [kg/n.bins]	5 [emptiyng/h]	6 [emptiyng/km]	7 [h]	8 [%]	9 [%]	10 [%]	11 [%]
70080L	9	39,06%	1022,12	128,68	56,29	18,10	2,29	00:27:11	7,00%	106,89%	1,02%	0,18%
70080LA	13	32,49%	866,34	94,43	49,97	17,31	1,97	00:22:07	6,05%	98,71%	1,16%	0,17%
70080LB	7	30,10%	771,03	86,31	47,58	16,21	1,81	00:32:05	8,54%	103,48%	0,58%	0,18%
70080LC	9	32,44%	828,74	96,19	51,25	16,53	1,89	00:27:52	7,36%	104,21%	0,82%	0,18%
70080M	8	33,08%	964,51	139,70	53,99	18,19	2,64	00:26:25	7,57%	97,04%	0,79%	0,17%
70080MA	6	40,28%	1.109,96	168,72	61,08	18,19	2,77	00:22:40	6,32%	99,03%	0,69%	0.17%
70080NA	2	26,55%	637,65	89,39	49,26	12,91	1,81	00:15:35	4,06%	107,68%	0.14%	0,18%
70080NB	1	32,30%	873,38	123,92	72,22	12,09	1,72	00:24:26	6,84%	99,23%	0,09%	0,17%
70080ND	1	18,79%	580,84	76,22	49,65	11,70	1,54	00:25:19	8,66%	81,20%	0,05%	0,14%

Attention level	
(green)	Low
(yellow)	Medium
(red)	High

Tab. 4.4.2 – Dashboard of overall statistical analysis for route

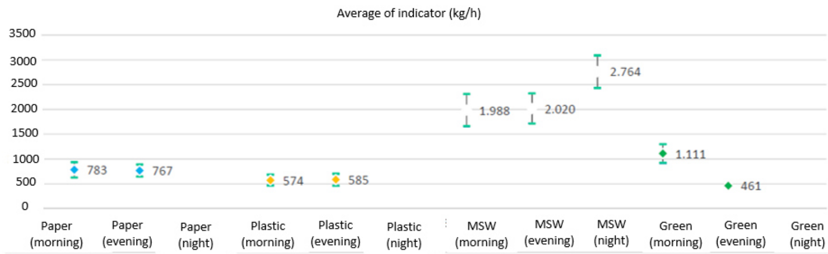
Some critical aspects, which have to be improved for each route, have been highlighted with this analysis. Below, the overall evidence based on the previous analysis are proposed. Figure 4.4.1 shows generalized margins of increase of the saturation index.



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	29,27%	28,64%	-	21,97%	21,63%	-	70,65%	70,62%	51,98%	45,00%	17,06%	-
min	9,47%	13,76%	-	10,86%	11,40%	-	42,81%	41,51%	46,53%	33,25%	-	-
max	40,28%	35,13%	-	28,55%	31,91%	-	100,63%	101,85%	58,03%	58,98%	-	-

Fig. 4.4.1 – Average of saturation index (weight of emptied container/max payload)

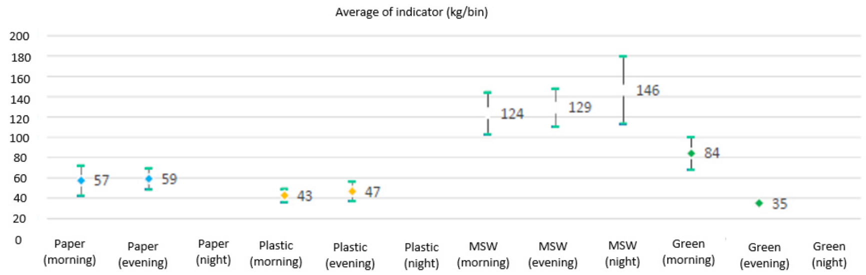
The average of kilograms of waste collected per hour shows small differences between the morning and afternoon shifts, and a substantial increase for the evening shift associated with the not separated collection service (Fig.4.4.2).



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	783	767	-	574	585	-	1.988	2.020	2.764	1.111	461	-
min	342	430	-	243	359	-	1.153	1.138	2.322	814	-	-
max	1.109	954	-	753	840	-	2.846	2.637	3.335	1.416	-	-

Fig. 4.4.2 – Average of indicator kg/h (kg/h)

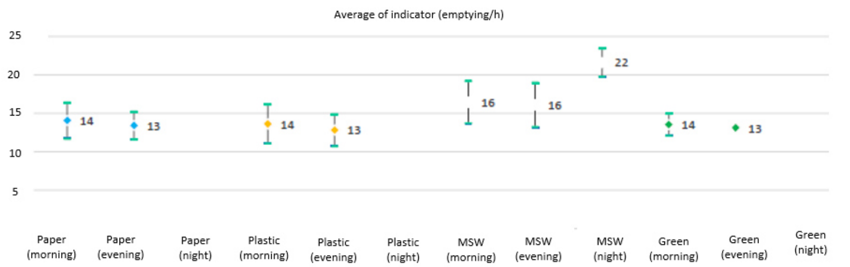
The result shown in Fig. 4.4.3 is also particularly significant. The indicator "average kilograms collected per container", highlights a very low value in the paper collection service.



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	57,38	59,07	-	42,69	46,73	-	123,74	129,33	146,47	84,15	35,15	-
min	28,40	40,71	-	29,61	27,08	-	78,49	97,41	119,54	58,39	-	-
max	115,92	87,80	-	55,91	68,57	-	174,32	174,83	235,62	114,60	-	-

Fig. 4.4.3 – Average of indicator kg/bin (kg/number of emptied bins)

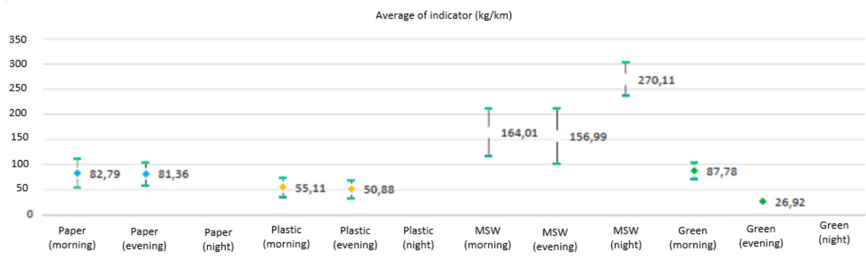
The average of the number of emptying bins made per hour (number of bins emptied in a shift) shows minimal differences between the morning and afternoon shifts, and a substantial increase for the evening shift related to the not separated collection service (Fig.4.4. 4).



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	14,07	13,43	-	13,63	12,82	-	16,45	16,11	21,61	13,53	13,13	-
min	9,61	9,70	-	6,49	8,83	-	10,97	8,43	18,67	11,13	-	-
max	18,19	16,37	-	18,79	18,72	-	25,43	22,99	24,85	16,32	-	-

Fig. 4.4.4 – Average of indicator of emptying/hour

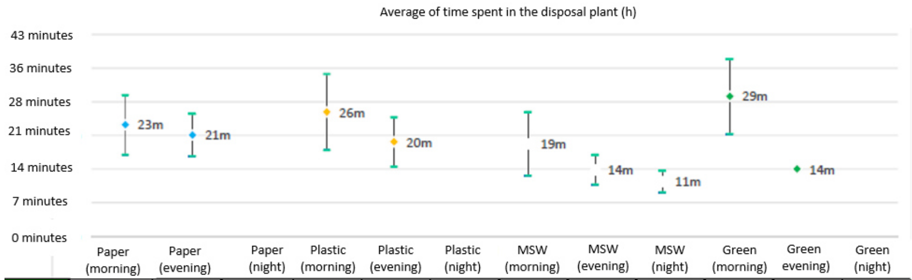
The same considerations are valid for the average "emptied kilograms per kilometer". The indicator highlights small differences between the morning and afternoon shifts and a substantial increase for the evening shift of not separated collection service (Fig. 4.4.5)



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	82,79	81,36	-	55,11	50,88	-	164,01	156,99	270,11	87,78	26,92	-
min	31,94	42,39	-	21,07	23,28	-	70,06	61,54	200,93	61,39	-	-
max	168,72	117,79	-	98,65	99,42	-	304,29	323,17	312,36	114,19	-	-

Fig. 4.4.5 – Average of indicator kg/km

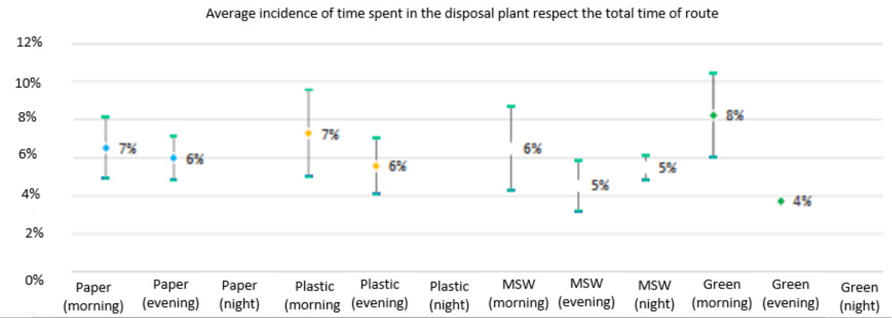
For the average time in the disposal plant there are obvious differences between the morning shifts (longer durations) and the afternoon shifts with high variability in the morning shift (Fig. 4.4.6):



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green evening)	Green (night)
media	0.23.53	0.21.41	-	0.26.36	0.20.14	-	0.19.51	0.14.18	0.11.45	0.29.57	0.14.26	-
min	0.14.45	0.16.38	-	0.08.09	0.08.53	-	0.05.24	0.05.25	0.09.01	0.15.42	-	-
max	0.51.16	0.34.30	-	0.46.58	0.37.53	-	0.40.36	0.22.10	0.15.20	0.42.16	-	-

Fig. 4.4.6 – Average of average time spent in the disposal plant

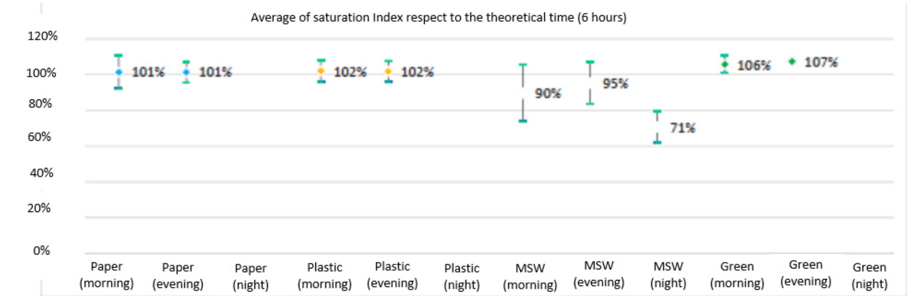
The same consideration can be made for the calculation of the average incidence of the time spent in the disposal plant with respect to the total time of a route. Figure 4.4.7 shows the obvious differences between the morning and afternoon shifts, with high variability in the morning.



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	6,52%	5,99%	-	7,29%	5,57%	-	6,49%	4,54%	5,49%	8,24%	3,71%	-
min	4,06%	4,33%	-	2,13%	2,34%	-	1,51%	1,41%	4,41%	4,53%	-	-
max	12,70%	8,62%	-	15,43%	10,75%	-	12,28%	8,04%	6,76%	12,23%	-	-

Fig. 4.4.7 – Average incidence of time spent in the disposal plant respect the total time of route

The average index of time saturation for a route indicates the 100% of saturation for plastic, green and paper routes, both in the morning and evening, while margins for improvement for the collection of non separated municipal waste are still present (Fig. 4.4.8).



	Paper (morning)	Paper (evening)	Paper (night)	Plastic (morning)	Plastic (evening)	Plastic (night)	MSW (morning)	MSW (evening)	MSW (night)	Green (morning)	Green (evening)	Green (night)
media	101,40%	101,36%	-	102,12%	101,80%	-	89,66%	95,27%	70,73%	105,79%	107,43%	-
min	57,80%	90,14%	-	84,79%	85,61%	-	48,32%	64,14%	59,89%	97,24%	-	-
max	116,12%	111,60%	-	114,76%	113,02%	-	107,18%	112,92%	85,98%	116,15%	-	-

Fig. 4.4.8 - Average of saturation Index respect to the theoretical time (6 hours)

In addition to the average of the indicators, averages of actual time have been calculated. Table 4.4.3 shows the synthesis of the number of disposal orders considered per waste, the total time (hours) of collection service in the period from February to June and the average actual time (hours) for each service.

Synthesis of total of service order and collection service time per waste			
WASTE	ODS	Sum of actual time of service	Average of actual time of service
	N°	Hours	Hours
Paper	612	3.785,82	6,19
Plastic	780	4.738,34	6,07
MSW	1.184	7,141,11	6,03
Green	91	585,97	6,44
Total	2.667	16.251,14	6,09

Tab. 4.4.3 – Synthesis of total of service order and collection service time per waste

Tab. 4.4.4 shows the synthesis per waste (paper, plastic, MSW and green) of variation time from predicted to actual shift (morning, afternoon and evening), in absolute terms of total hours.

Moreover, there are also the estimated values of hours of "no shift saturation", defined as the sum of hours for each ODS that did not cover the duration of the session as required by the contract (6 hours per day); these are the hours paid but not worked, and the estimated values extraordinary hours: aggregate number of hours of each ODS that exceed the length of the shift as provided by the contract (6 hours / day), hours paid as overtime.

Synthesis of estimated total hours of "no shift saturation" per waste								
WASTE	Morning (shift 04:00-10:00)		Evening (shift 10:00-16:00)		Night (shift 18:00-21:00)		Total	
	estimated total hours overtime	estimated total of no saturation shift	estimated total hours overtime	estimated total of no saturation shift	estimated total hours overtime	estimated total of no saturation shift	estimated total hours overtime	estimated total of no saturation shift
Paper	132	42	66	44	-	-	200	87
Plastic	92	44	83	73	-	-	175	116
MSW	146	85	100	109	44	59	290	253
Green	38	4	6	-	-	-	44	4
Total	410	175	254	226	44	59	709	460

Tab.4.4.4 – Synthesis of estimated total hours of no shift saturation per waste

4.5 Levers Analysis

The analyses have highlighted the possible levers on which to act to make an optimization of the collection route. The first intervention could regard a greater flexibility of work shifts, in relation to the new contract that provides two hours more per week. For example, a flexible closure of the session and a "bank of hours" could be allowed, with the conservation of overtime, with the possibility to reuse them then in other shifts with less saturation.

The second intervention could concern the distribution of resources, the use of vehicles with four axles and the distribution of services depending on the weekly calendar, with the search of homogeneus discharges with a higher level of saturation. Another aspect to improve on is the optimization of the waste collection regarding the actual time spent in the disposal plants.

The discharge operation could be reduced with the adoption of plant design or management solutions such as: telepass to speed up entry and registration into the system, possibility of night discharge when the plant is closed, programming of discharges, double weighing and redistribution of the most critical services. It is possible then to hypothesize a service with the new design criteria, considering the achievement of minimum objectives of the service, such as the number of minimum emptied bins or saturation of the means of transportation. Finally, all these points may be summarized in a totally new redesign of the service that takes into account all these possible interventions.

4.6 Conclusions

The project to revisit the collection route of Modena is the first environmental project involving the use of actual data. This possibility is given by HERGO system, which allowed not to proceed to estimates but rather for definite data, returning at the same time greater reliability of results and the shortest analysis time.

5 Application of Life Cycle Assessment to waste recycling

In parallel to technological innovations applied to improve waste collection and the management of waste flows, another issue is the promotion of recycling. Management of secondary waste plays a crucial role for the achievement of sustainability targets in the European Countries. New models of development, based on the reduction of final disposals, are promoted regarding to those materials that may be reused and recycled. European countries and their governments have implemented regulations to meet targets for materials recovery and reuse in order to reduce the effects of waste production and to improve environmental protection following the principle of the sustainable development. However, national policies have shown to be generally inadequate to ensure the recycling targets proposed by the EU, still far to be achieved. In the following, a scenario referred to textile material is analyzed by means of Life Cycle Assessment to quantify the environmental benefit of recycling (Bamonti et al., 2016).

5.1 LCA and environmental footprint applied to the production of recycled wool

The Product Environmental Footprint (PEF) is a measure of natural resources exploitation and environmental impacts for which a given product is responsible within its life-cycle (e.g., Ewing et al., 2011; Kjaer et al., 2015). This is different respect to carbon and water footprint, focused specifically on greenhouse gas emissions and freshwater consumption, respectively (e.g., Hoekstra, 2003; Hertwich, 2009), while the ecological footprint captures the impacts on the biosphere's regenerative capacity (Wackernagel et al., 1999). All these methods can be applied at different scales (e.g., products, cities, regions, nations). Though partial overlaps exist among these approaches, the carbon, water and ecological footprints provide, in general, complementary information that can be jointly analyzed to quantify pressures induced by human activities on the atmosphere, hydrosphere and biosphere compartments (Galli et al., 2012).

The PEF approach was introduced by the European Commission (EU, 2013a) in the context of the Communication "Building the Single Market for Green Products" (EC, 2013) with the aim of enhancing comparability between products as a basis for environmental products declaration and promotion of Life Cycle Assessment (LCA) approach amongst industries (e.g., Finkbeiner, 2014; Lehmann et al., 2016, and references therein). It consists in a multi-criteria method aimed at identifying the environmental performance of a good or service throughout its life cycle. All the relevant supply chain activities, from extraction of raw materials to final waste management, are considered (EC, 2012; EU, 2013b). The PEF method relies on well-known guides among with the European Standards ISO 14040 (2006) and ISO 14044

(2006), the International Reference Life Cycle Data System Handbook (ILCD, 2011), and the Greenhouse Gas Protocol (WRI and WBCSD, 2011). Environmental impacts of material/energy flows as well as emissions and wastes are computed via LCA.

Application of the PEF approach provides: (i) information about the environmental performance of a product or service, (ii) a support for eco-design strategies and for the optimization of the processes included in the product life cycle, and (iii) the identification of significant environmental impacts useful to the application of eco-labels criteria. The PEF approach may be relevant for an increasing number of industries interested in developing strategies for the reduction of environmental impacts associated with products life cycles (Kjaer et al., 2015).

To increase the environmental performance of a product, it may be relevant to use recycled materials as promoted by European regulations (EC, 2008) and reports (e.g., ISPRA, 2011). Here, we explore this opportunity in the context of the textile sector for which a critical issue consists in the reduction of the environmental impact associated with the phases of a textile product's life cycle. Increasing attention is paid to improve sustainability in materials and processes, in government regulations and in the development of environmentally-friendly technologies. Recycling of end-of-life textile products may also play an important role (e.g. Blackburn, 2009). Some studies have been conducted to demonstrate the convenience of textile recycling relying on, e.g., the computation of the carbon footprint (Muthu et al., 2012) or the energy footprint (Woolridge et al., 2006) to assess benefit of recycling operations.

Here, a case study is presented in the following, related to the production of recycled wool and we apply the PEF approach in order to (i) identify the most significant impacts and environmental demanding processes of the product life cycle, (ii) demonstrate how the use of recycled fibers significantly improves the environmental performance of wool production, reducing the amount of material involved with the processes associated with the most relevant impacts. To do this, we employ data belonging to a textile industry in the district of Prato (Italy). Our analysis may also represent a benchmark in the adoption of the PEF approach to assess the environmental impacts of a textile product.

5.1.1 Method description

In the framework of the PEF methodology, based on LCA (ISO 14040), the following steps are relevant: (i) goal and scope definition for the study, (ii) inventory analysis referred to input/output data associated with each process included in the product life cycle, (iii) impact assessment by means of a set of metrics/indicators, (iv) interpretation of the results in accordance with the aims of the study, as defined at the beginning. In this subsection, we focus on the analysis of the inventory that is divided into several steps in turn, as depicted in Figure 5.1.1.

Data referred to the processes involved in the product life cycle are typically distinguished into two categories on the basis of the collection strategy. The first category includes specific data, i.e. input/output data that are directly measured in each process. As an example, energy, water and materials may fall into the category of specific input data, while emission measurements typically represent specific output data. The second category is that of generic data, resulting from literature, statistics, projects or databases and that should be properly employed to fill the gaps in the availability of specific data.

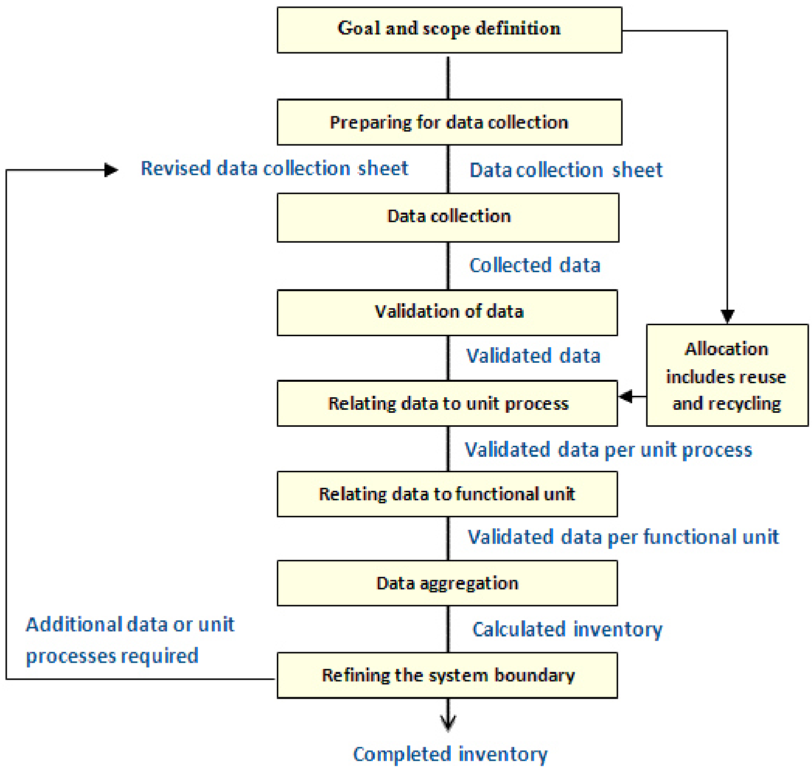


Fig. 5.1.1 – Flow chart of the inventory analysis according to ISO 14041

Once collected relevant data, a set of metrics are used for data quality assessment. The PEF protocol requires a semi-quantitative assessment procedure based on expert judgment, according to a set of criteria listed in the following (see ISO 14044, 2006; EC, 2012, for more details):

- technological representativeness (TeR), representing the "*degree to which the dataset reflects the true population of interest regarding technology*";
- geographical representativeness (G), representing the "*degree to which the dataset reflects the true population of interest regarding geography*";

- time-related representativeness (Ti), representing the "*degree to which the dataset reflects the specific conditions of the system being considered regarding the time/age of the data*";
- completeness (C), determined "*with respect to the coverage for each impact category and in comparison to a hypothetical ideal data quality*";
- parameter uncertainty (P), determined for the resource use and emission data by means of the "*qualitative expert judgment or relative standard deviation as a % if a Monte Carlo simulation is used*";
- methodological appropriateness and consistency (M), assessing if "*the applied Life Cycle Inventory methods and methodological choices are in line with the goal and scope of the dataset, especially its intended applications as support to decisions. The methods have also been consistently applied across all data".*

The first five criteria are directly referred to data, while the last one evaluates if the approach is PEF compliant. The value assigned to each of these parameters may range between 1 and 5, where 1 corresponds to a very good quality level, while 5 is associated to a very poor level of data quality according to given criteria (EC, 2012). By calculating the average of these values, it is possible to identify a unique parameter representing the overall data quality rating (*DQR*):

$$DQR = \frac{TeR + GR + TiR + C + P + M}{6}$$

According to the value assumed by the *DQR*, it is possible to classify data quality as reported in Table 5.1.1. A very good level of data quality is defined as the case in which the inventory "*meets the criterion to a very high degree, without need for improvements*" and this is typically achieved when the technological/geographical/time-related representativeness are evaluated as context–specific, a virtually negligible uncertainty is associated with parameters, a full compliance with the requirements of the PEF approach is observed and a very good completeness (>90%) is detected. On the contrary, the overall data quality is very poor when completeness decreases below 50%, parameter uncertainty is high and none of the methods required by the PEF methodology (specifically: end of life modeling, system boundary following the approach from cradle to grave and multi-functionality according to ISO 14040/44) are employed (EC, 2012).

The value of the *DQR* index is first computed for (i) each process involved in the life cycle analysis, and (ii) both specific and generic data. As a consequence, a total value is then calculated (for all the processes taken into account) as the average of all the ratings computed for specific and generic data. Completeness, related to the coverage of each EF impact category, respect to a hypothetical ideal data quality, is expressed by C as the share of elementary flows included in the inventory and is particularly important for the robustness of the method. For PEF compliance, a “good quality” evaluation ($DQR \leq 3.0$) should be associated at least to the 70% of the contributions to each EF impact category (EC, 2012).

Overall DQR	***Data quality level***
$DQR \leq 1.6$	excellent quality
$1.6 \leq DQR \leq 2.0$	very good quality
$2.0 \leq DQR \leq 3.0$	good quality
$3.0 \leq DQR \leq 4.0$	fair quality
$DQR \geq 4.0$	poor quality

Tab. 5.1.1 – Classification of the overall data quality based on the *DQR values*

The PEF methodology defines specific impact categories to study the environmental footprint of a given product. Nevertheless, it is allowed to select additional impact categories related to environmental aspects of interest for the study. Table 5.1.2 collects the impact categories that we employed to analyze our case study. Note that, in the simulation code we used, SIMAPRO (Goedkoop et al., 2013), it was not implemented the method ILCD 2001; however, we derive useful information from other impact categories employing the same indicators. We also considered the impact category *Cumulative Energy Demand* (CED) developed by Frischknecht and Jungbluth (2007) and already included in the software.

Regarding to the other methods, we adopted the CML 2001 that proposes a set of impact categories and characterization methods for the impact assessment step. Specifically, the Eco-indicator 99 and the EPS method are selected as damage approaches; the CML 2001 impact assessment method implemented in Ecoinvent consists in the set of impact categories defined for the midpoint approach (Guinée et al., 2002, for more details). Based on the CML 2001 method we analyzed the following impact categories: (i) climate change, for which the characterization model is developed by the IPCC, related to emissions of greenhouse gases to air, and expressed as Global Warming Potential for time horizon 100 years (GWP100), (ii) stratospheric Ozone depletion, for which the characterization model is developed by the World Meteorological Organization (WMO), related to ozone depletion potential of different gasses, (iii) depletion of abiotic resources, related to extraction of minerals and fossil fuels due to inputs in the system, (iv) fresh-water aquatic eco-toxicity, related to the impact on fresh water ecosystems, as a result of emissions of toxic substances to air, water and soil and expressed as eco-toxicity potential (FAETP) based on USES-LCA, describing fate, exposure and effects of toxic substances.

	Impact category	*Method*	*Indicator*
1	Climate change (GWP 100)	CML 2001	kg carbon dioxide/kg emission
2	Stratospheric Ozone depletion	CML 2001	kg CFC-11 equivalent/ kg emission
3	Depletion of abiotic resources	CML 2001	kg antimony equivalents/kg extraction
4	Natural land transformation	RECIPE	m^2
5	Human toxicity – cancer effects	USETOX	CTUh comparative toxic units
6	Human toxicity – non cancer effects	USETOX	CTUh comparative toxic units
7	Fresh-water aquatic eco-toxicity	CML 2001	1,4-dichlorobenzene equivalents/kg emission
8	Inorganic particles released into the air	IMPACT 2001	kg PM2.5 equivalent
9	Ionising radiation	RECIPE	kg (U^{235} to air)
10	Photochemical oxidant formation	RECIPE	kg (NMVOC to air)
11	Eutrophication	TRACI	kg N eq/kg substance
12	Freshwater eutrophication	RECIPE	kg (P to freshwater)
13	Marine eutrophication	RECIPE	kg (N to freshwater)
14	Water depletion	RECIPE	m^3 water eq
15	Acidification	TRACI 2	molc H+ eq
16	Cumulative Energy Demand	CED	MJ

Tab. 5.1.2 – EF impact categories, methods and indicators employed to quantify the impacts

We also employed the RECIPE method that implements both midpoint (problem oriented) and endpoint (damage oriented) impact categories. The midpoint characterization factors are multiplied by damage factors, to obtain the endpoint characterization values. This method is based on the integration of the problem-oriented approach of the CML method and the damage-oriented approach of Eco-indicator 99. Based on the RECIPE method we analyzed the following impact categories: (i) natural land transformation, defined by the amount of natural land transformed and occupied for a certain time, (ii) ionising radiation, accounting for the level of exposure, (iii) photochemical oxidant formation, defined as the marginal change in the 24h-average European concentration of ozone due to a marginal change in emission of a given substance, (iv) freshwater eutrophication, accounting for the environmental persistence of the emission of P containing nutrients (v) marine eutrophication, accounting for the environmental persistence of the emission of N containing nutrients (vi) water depletion, define by the amount of fresh water consumption. These impact categories are characterized at midpoint level. The midpoint impact categories are aggregated into three endpoint categories, i.e. human health, ecosystems and resource surplus costs, that finally give rise to a single score (for more details refer to Goedkoop et al., 2009).

Among the other methods we employed, the USETOX model is used to account for human and eco-toxicological impacts and it is designed to describe the fate, exposure and effects of chemicals (Rosenbaum et al., 2011). TRACI is a tool for the reduction and assessment of chemical and other environmental impacts and consists in a stand-alone computer program developed by the U.S. Environmental Protection Agency. It is a midpoint oriented life cycle impact assessment methodology that we adopted to account for eutrophication and acidification.

5.1.2 Case study

In this work, we analyze a case study referred to the production of recycled wool. Specifically, our aim is to assess the environmental performance of this product by employing the PEF methodology, with particular attention on the inventory analysis and selection of impact categories. Note that a comparison between the environmental performance of recycled and virgin wool goes beyond the aims of this work and it is not critical in the context of the PEF approach.

The system boundaries are defined by considering all the procurement activities associated with raw materials, resource consumption and emissions. The steps related to the product use and the end of life scenario are not analyzed in this study. This approach is not in contrast with what is reported in the reference guidelines, which require the system boundaries to include upstream activities (such as raw materials and energy production) and production activities (e.g. wool production).

Four main processes have been identified in the production of recycled wool for the selected case study. The first regards the supply of clippings, by means of materials coming from Italy and foreign countries (mainly Middle East countries). Environmental impacts associated with this process are mainly due to transport activities. As a second step, the incoming materials are selected and sorted by color and type before being sent to the subsequent process of ragging. The latter represents the third relevant process and the fibers, obtained at this stage, whose colors need to be modified, are finally sent to the dyeing process. The selection process is particularly relevant, reducing the material subject to dyeing. For this case study, it resulted that only the 42% of the incoming material is dyed. This contributes significantly to increase the environmental efficiency of the whole production of recycled wool. Figure 5.1.2 depicts the workflow required to obtain recycled wool, based on the steps described above, together with the flows of energy and materials involved.

Data referred to the year 2014 are used to build the inventory for the application of the PEF methodology. The analysis of data quality, in line with the PEF Protocol, has led to the computation of the *DQR* index in (1) for both specific and generic data. Considering all the processes involved, the quality associated with the specific data is excellent (*DQR = 1.23*); note, that this evaluation is confirmed when analyzing the quality of specific data for each single process. Generic data are included in the inventory to integrate the information required by the analysis. Specifically, missed data are obtained resorting to the Ecoinvent database and their overall quality is evaluated as good (*DQR = 2.3*).

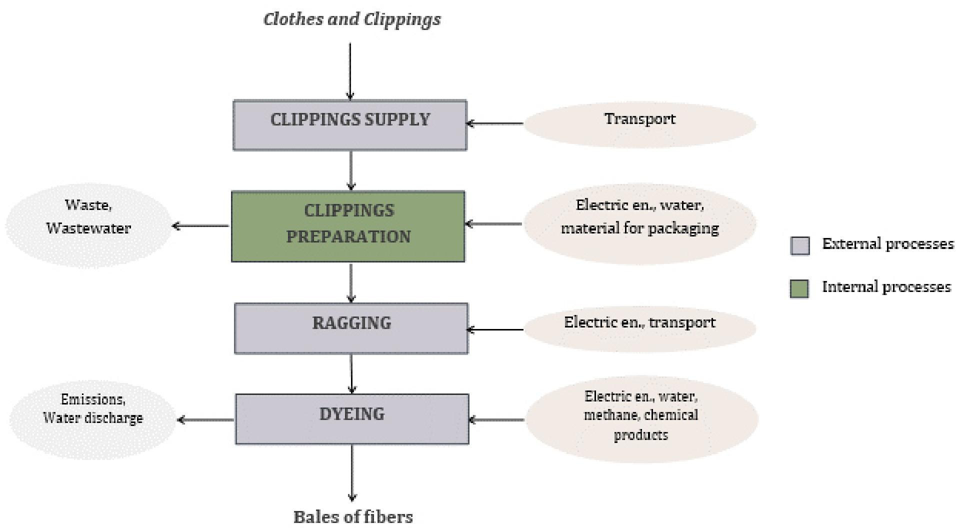


Fig. 5.1.2 – Flow chart of recycled wool production

The functional unit chosen to evaluate the processes is 1 kg of recycled wool. The emissions considered as relevant are collected in Table 5.1.3; data are reported for each process.

Emissions	*Unit*	*Total amount*	*Portion of each process (%)*			
			Clippings supply	*Clippings preparation*	*Ragging*	*Dyeing*
Sea transport	t km	1.54	100.0	0.0	0.0	0.0
Land transport	kg km	135.31	91.5	0.6	5.5	2.3
Electric energy	kWh	0.82	0.0	5.5	18.4	76.1
Methane	m^3	0.12	0.0	0.0	0.0	100.0
Water	kg	0.12	0.0	100.0	0.0	0.0
Water - well	m^3	0.002	0.0	0.0	0.0	100.0
Water treatment	m^3	2.14	0.0	0.0	0.0	100.0
Recycling	g	8.07	0.0	100.0	0.0	0.0
Iron	g	14.13	4.4	95.6	0.0	0.0
Polyethylene	g	9.00	6.8	93.2	0.0	0.0
Dye	g	16.80	0.0	0.0	0.0	100.0
Wetting agent	g	0.84	0.0	0.0	0.0	100.0
Acetic acet	g	2.10	0.0	0.0	0.0	100.0
Soda	g	2.78	0.0	0.0	0.0	100.0
Air Emissions	*Unit*	*Total amount*	*Clippings supply*	*Clippings preparation*	*Ragging*	*Dyeing*
Total Organic Carbon	mg	7.90	0.0	0.0	0.0	100.0
Dust	mg	159.92	0.0	0.0	0.0	100.0
Nitrogen oxides	mg	1061.82	0.0	0.0	0.0	100.0
Ammonia	mg	6.33	0.0	0.0	0.0	100.0
Sulfuric acid	mg	930.10	0.0	0.0	0.0	100.0
Formic acid	mg	744.09	0.0	0.0	0.0	100.0
Acetic acid	mg	10.98	0.0	0.0	0.0	100.0

Tab. 5.1.3 – Emission inventory for the production of recycled wool for the selected case study.

5.1.3 Discussion

LCA has been realized by means of the code SIMAPRO (Goedkoop et al., 2013). The analysis reveals the contribution of the diverse processes to each impact category. Figure 5.1.3 shows, for each selected impact category (see Table 5.1.2), the contribution (in percent) of the main processes involved in the production of recycled wool. The step that mainly produces significant impacts is dyeing, even if only the 42% of fibers is subject to this process. Indeed, dyeing operation is particularly onerous due to energy consumption and chemical substances employed in the process. Other high-impact processes are clippings supply, due to sea/land transport activities associated with not negligible emissions, and clippings preparation. On the contrary, the process of ragging produces the overall lower impact for the selected categories.

The Eco-indicator approach (Goedkoop and Spriensma, 2001) has been also employed in order to quantify the overall impact of the recycled wool production, exemplified by means of the selected case study. Figure 5.1.4 shows analogue results obtained with this method and ordered for impact categories. It is possible to observe that previous analysis are confirmed by this approach; dyeing, in particular, is the process that primarily compromises the environmental performance of the entire production cycle.

Finally, the contribution (in percent) of each impact category to the *single point eco-indicator score* has been computed. The most relevant categories for this case study are: the depletion of abiotic resources (45.8%), the inorganic particles released into the air (30.8%), the climate change (18.5%), and the human toxicity – cancer effects (2.5%). This is due to the high electric/thermal energy consumption and to small quantities of carcinogens released mainly during dyeing. This leads to a value of the indicator equal to 0.127 with a maximum contribution of dyeing (77.3%); clippings preparation, clippings supply and ragging are responsible for the 13.3%, 5.6% and 3.8% respectively.

In the following, more details are provided for the most relevant impact categories identified by the previous analysis. Looking at the indicator accounting for climate changes, it is possible to observe that about the 75% of the impact is due to the process of dyeing; ragging is responsible for the 9%, while the processes of clippings supply and preparation are both responsible for the 8%. The high-impact of dyeing is mainly associated with the production/consumption of electric energy (42%) and the production/consumption of natural gas (27%). The indicator accounting for inorganic emissions into the atmosphere reveals that the impact of dyeing is about 74%, followed by clippings supply (13%), clippings preparation (7%) and ragging (6%). For this impact category, in the dyeing process, the consumption of electric energy and natural gas has the greatest influence together with the use of chemical substances. Similarly, the indicator accounting for the depletion of abiotic resources shows that the impact of dyeing is about the 73% mainly due to the energy production required by the process. Another important impact category is that related to human toxicity and, in particular, to carcinogens. The process of dyeing is responsible for the 84% of the total impact and also in this case, the consumption of electric energy (34.4%) and thermal energy (23.9%) play the main role. Nevertheless, the contribution of the use of chemical substances (4.2%) has to be taken into account for this impact category.

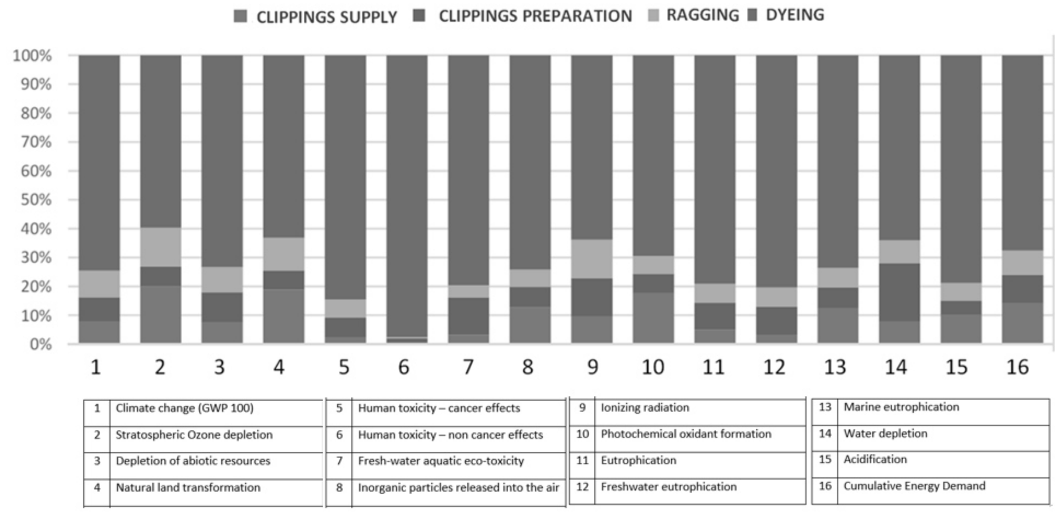


Fig. 5.1.3 – Impacts of the main processes involved in the production of recycled wool for each impact category

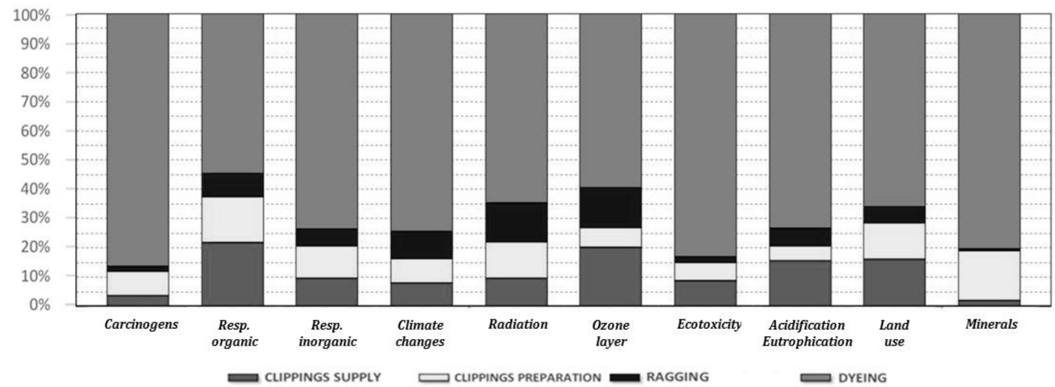


Fig. 5.1.4 – Impacts of the main processes involved in the production of recycled wool by means of the Eco-indicator approach.

Our results confirm findings provided by other studies, showing the critical role played by the dyeing process (e.g., Kant, 2012; Parisi et al., 2015). Note that, while most of studies, regarding textile production, investigated the effectiveness of (i) alternative environmentally-friendly technologies or (ii) recycling of textile process waste, here we provide a quantitative analysis about the advantages associated with the recycling of end-of-life textile materials. In doing this, we obtained results consistent with other analysis (e.g., Woolridge et al., 2006; Blackburn, 2009; Muthu et al., 2012) based on other footprint approaches rather than the PEF.

5.1.4 Conclusions

In this study, we focused on recycling of end-of-life products in the textile sectors. Specifically, we analyzed a case study related to recycled wool production. Similar issues have been typically investigated by means of LCA in the context of traditional, e.g., carbon/water footprint. Here, we quantify the impacts associated with each relevant process in the life cycle of recycled wool relying on the PEF methodology, thus providing a benchmark in the use of this approach. Our results showed that dyeing is the most environmental demanding process inside the product life cycle, thus supporting previous analyses in literature. In addition, we highlighted how the use of recycled materials strongly increases the environmental performance of wool production, by reducing at the 42% the material involved in the dyeing process. This is relevant to support recycling as promoted by the EU directives and regulations on waste management. Our analysis also revealed that the principal impact categories (such as climate changes, inorganic emissions into the atmosphere, abiotic resources depletion and human toxicity) are mainly influenced by energy production and consumption. The use of chemical substances plays also a relevant role regarding to toxicity and soil/water pollution. Hence, strategies based on recycling of end-of-life textile materials may be properly combined with the use of environmentally-friendly technologies and with recycling of textile process waste, in order to further improve the environmental efficiency of production systems. In conclusion, the following actions are identified as relevant in order to increase the environmental performance of wool production (as exemplified by the selected case study): (i) improving the efficiency of the clippings supply process in order enhance the use of recycled materials, (ii) employing chemical substances with lower environmental impact, and (iii) reducing the energy demand associated with the product life cycle, introducing the use of renewable energy.

6. Conclusions

Innovative approaches based on ICTs, for the improvement of waste collection and management, have been developed in collaboration with the Hera Group and presented in this work together with a first suite of indicators to assess their performance. These approaches belong to a project named HERGO which realizes the complete traceability of collection processes by means of the digital management of service data.

Indicators show that the HERGO system is progressively reaching the complete coverage of collection processes, although some difficulties still exist mainly due to the correct employment of field devices. Indicators are also useful to understand how and where it is necessary to act in order to rapidly improve the system and solve detection problems.

The traceability of processes is intended to be the basis for future developments aimed at improving the environmental services. In this work, a first application of data collected into the HERGO system is shown, for the optimization of the monoperator collection routes in Modena. HERGO favors a more rational and efficient definition of collection routes, contributing to the decrease of consumption and environmental impact.

The complete computerization of processes makes possible the precise measurement of services provided and thus represents an important step towards the maturation of a scenario that, in the future, may be able to introduce the punctual rate, and promote correct behavior related to recycling and waste reduction.

LCA has been applied in parallel with the main research activity described above, to show how recycling materials may strongly decrease the environmental impacts of production processes. For the sake of brevity, in this thesis only the analysis of a case study has been shown, related to the recycling of textile materials. Results showed a significant decrease of the environmental impact due to the reduction of chemical substances employed in the production process.

Under future scenarios related to climate change, the identification of innovative solutions to reduce resources consumption and depletion, may significantly produce benefit at global level for the society as a whole. As such, analysis and methods employed in this work are in line with the priorities and requirements of the European programmes for climate and row materials.

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