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ENERGY AND ARCHITECTURAL RETROFITTING IN THE URBAN CONTEXT OF ATHENS

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INTRODUCTION

The world is facing unprecedented speeds in climate-change leading to a notable increase in global average temperatures, commonly referred to as global warming. Cities have a crucial role, not only as potential victims of climate vulnerability but also as the main contributor (Bulkeley, H. & Castán Broto, V., 2013). It is an acknowledgeable fact that urban areas absorb and retain significantly more heat than rural areas (Oke, T.R., 1976). This difference of temperatures between cities and their surrounding is known as ‘Heat Island Effect. One of the most important factors affecting the intensity of the HIE is the configuration of buildings although, the situation differs according to the local climate. It is crucial that cities adapt to future urban climates.

Analyzing the urban character and in adittion being able to predict and control specific urban microclimates and their characteristics, may lead to the improvement on pedestrian activity in urban spaces and moreover on the performance of buildings, especially in respect to energy conservation. (Tapias & Schmitt, 2015) The necessity for energy oriented design for the cities, over the last years, has led to the emerge of energy oriented innovations in building technology in the building construction sector (Brown &Vergragt, 2008), with the latest experiences, aiming at setting to zero the energy demand and the carbon emission, not only to building scale but even to a city as a whole.

With highly advanced energy-saving technologies, energy-efficient building designs have been demonstrated and published .In other words, designers have reached a level where with the use of advanced technical knowledge could design and form zero-energy constructions and urban environments.

According to Santamouris, it is acknowledged that the global population is increasing rapidly. Yearly are added more than 80 million of people and while the total world population in 1987 was up to 5 billion, in the year 2000, nowadays it is over six billion and continues to grow (United Nations Population Fund, 1998). As it is demonstrated that urban population has faster growth that the rural one (United Nations, 1998 /World Urbanization Prospects,. The 1996 Revision, Population Davision, New York), this means, that there is a significant addition of 60 million citizens to the urban areas per year, like adding a city of the scale of Paris every month. (UNEPTIE : Tommorrow's Market : Global Trends and their Implications for Business. 2002.),

In a European level, it is proved that more than two thirds of the European population lives in urban areas (EU Report, Cities of tomorrow 2011). This increased concentration of urban population has led to a disproportional consuming of the resources and as a consequence, contributing in a negative way to the climate change (May et al., 2013). Cities, are the victim of this climate change that the world is facing. Phenomena like the urban heat island (UHI) effect and its health consequences on citizens, the extended flooding and witnessed natural disasters are putting to risk mainly the Mediterranean region. (Ferrante, 2016)

Urbanization and industrialization are dynamically related to the urban environment and the urban local microclimate behavior. Particularly, urban and industrial growth and their implied environmental changes have caused the deterioration of the urban climate. This modification shows a high variation and depends from numerous factors, such as the urban morphology, the regional local climate, regional wind characteristics, human activity etc.(Santamouris,2013).Urban areas is generally accepted that they offer a very low climatic quality. The growing urbanization of the world population set cities as the central target in the search for new approaches to environmental management[1]. Focusing to the Mediterranean region,

[1] The need for rapid and concerted action on the global scale has been officially recognized by the international community in events like the United Nations Conference on Environment and Development, held in Rio De Janeiro in 1992. Agenda XXI, one of the agreements emanating from this conference, addressed the specific issue of climate change. This is a complex and controversial phenomenon related to the increase concentrations of naturally occurring greenhouse gases in the atmosphere due to human activities. These gases, which include carbon dioxide (CO_2) and methane, trap solar heat in the atmosphere, so warming up the surface of the planet. The main source of greenhouse gases is burning of fossil fuels, such as coal, oil and gas for energy, very often in a rather inefficient way.

alongside with the energy and environmental needs, many cities have defend themselves against new and persistent social problems (unemployment, poverty, social exclusion and immigration)

The urban environmental issue, derived from climate change, is by far the biggest global concern. Thus cities, which are the main responsible for the biggest use of the environmental resources, have come to a point where should consider new forms of urban planning in accordance with the concept of sustainability. Urban planning, monitoring and mitigation techniques are essential parameters of the environmental and energy policy.

Energy efficiency in urban settings is more than a technical problem. Social aspects at a community level should be in priority and citizens should be well informed on how to be transformed into energy users. In fact, developing more sustainable consumption and production systems depend upon consumers' willingness to engage in "greener" and more collective behaviors (Peattie, 2010).

According to W. Rees there are two basic criteria that should be followed for ecological sustainability of cities:

- The consume of the renewable resources should stay up to a certain limit so as to ensure that they will not exceed their production in nature;
- The production of degraded energy by the cities must not exceed the absorbing capacity of local ecosystems;

The present research aims to discuss subjects related mainly to the energy and environmental problems of cities and their surroundings. As a wider research has a goal to verify and test, by means of dynamic simulations, the effects on the urban microclimate of the transformations induced in the outer space and see how these effects may affect the reduction of temperature in its confined environments The external areas and the surface/volume of the built area is considered as a unique interacting environment.

The configuration of buildings is one of the main parameters that influence the different microclimates in the city and vice versa at the same time, the microclimate influence the building's performance.

Outdoor environments are consisted by multi-layer elements and factors creating a complex context. Climate parameters, vegetation, surfaces and structures constantly interact with each other. Due to the resulting interconnections, these elements cannot be analyzed or controlled isolated and independently. In order to achieve an adequate and complete simulation in an urban environment all interacting factors should be considered as one system.

To achieve the goal of this research work, which is to set urban areas towards the reduction of energy consumption, it was elaborated a strategy developed in five main phases:

1. Selection, analysis and simulation with ENVI-met, (a holistic Microclimate Modelling System) on typical selected urban contexts;
2. Proposal of different sustainable urban scenes/scenarios and performance of new simulations;
3. Comparison of the results. Selection of the best proved scenario for the improvement of the microclimate in relation with Heat Island Effect according to the outcome of the previous simulations;
4. Creation of new climatic data files and performance of new simulations with the use of Design Builder on Building scale.
5. Confirmation and analysis of the influence of the improvement of the microclimate on existing buildings' energy performance;

Every hypothesis of adaptation/transformation of existing urban settings is strongly linked to the detailed reading of their typological and constructive systems as well as to the search of a sustainable integration between the buildings' characteristics and their surrounding boundary conditions. In particular, the analysis of the existing values of different building typologies and their urban surroundings as well as the consequent possible transformation aimed at the architectural and energy retrofitting in the urban context may result, at the operational level, in a critical process of re-design the built urban environment. Over the last decades, energy oriented innovations in building technology have emerged in many areas of the building construction sector.

As also reported (Todorovic 2010) cities and their surroundings arrived at point where there is a strong need for feasible more economical solutions with an integrated design where energy saving can be reached combining constructive passive tools with existing renewable energy systems, such as solar and wind energy and extension of green spaces, avoiding the more sophisticated high-tech or innovative components. Thus, instead of focusing on new developments and newly conceived buildings we need to address to the existing building stock within the active urban areas. Inevitably, the challenge is set on the existing urban areas, where indeed in very dense or historical centers the development of new concepts is highly impossible. (Ferrante & Semprini, 2011)

The volumetric configuration of the urban fabric and the materials that constitute the external surfaces are the main factors that influence the microclimate of the city. Understand and above all to be able to transform urban spaces can help to improve the thermal comfort of the exterior and interior of the built environment. This research work mainly analyzes the potential energy savings presented in the use of green and passive systems in the urban sustainable redesign. By regarding the modification of the external temperature as the main indicator of comfort, an "innovative collaboration" between environmental simulation systems is selected as the strategy/tool for energy calculation of confined living spaces.

It is beyond question that, the environmental sustainability of an existing building or a new building concept cannot be fully assessed with only an indoor environmental simulation without taking into account the urban microclimatic conditions of the surrounding urban areas where the building stands.

It is commonly accepted that good environmental performance leads to lower energy consumption in maintaining thermal comfort, which is the first step towards sustainability. Despite the recent progress in environmental simulation software tools, still exist barriers to overpass such as the lack of collaboration between software developed for large scale urban outdoor environments simulation and software specialized for indoor environments. If so, these two types of software simulations for different scale, could produce unified outputs allowing architects, urban planners and designers a more holistic apprehension of outdoor-indoor simulation that reflects more accurately the urban patterns. This thesis, focuses on developing a methodology so as to bridge this current gap and as a result, the assessment of sustainability at an urban neighborhood level can be studied more holistically, hence achieving more valid environmental simulations from an urban dwelling point of view.

Finally, specific proposals on the use and management of energy in cities that aim to contribute towards a better environmental quality and to improve the energy performance of the existing buildings are presented.

Urban sustainable oriented design should be defined as the process that takes into account the most basic elements of microclimate for design purposes (i.e., sun, wind, temperature). The application of this concept is not only to benefit from the existing urban microclimate but also to mitigate the regional existing stressed conditions and decrease the negative effects through design and planning options. However, this concept requires a more scientific approach to evaluate its true meaning (Berger 2014.), which implies a method of inquiry that must be based on empirical and measurable evidence subject to specific principles of reasoning. (E. Tapias & G. Schmitt,)

The analysis of existing built environment indicates that the critical values of the surrounding areas, together with the very poor energy performance of the existing building stock and the levels of possible transformations they imply, may introduce radical proposals for urban and building retrofitting. (Ferrante,Semprini 2011) The understanding of urban spaces and their environmental evaluation, in relation to the fundamental features of the buildings and with the outdoor spaces, are of highly importance. In terms of architectural structure, this importance is focused on the external cover of the building, which can be re-proposed by energy efficient technological solutions (green roofs, photovoltaic shells, green walls etc.) aimed at re-shaping the technical and formal aspect of the building. These solutions, could also positively affect the urban area and the surrounding environment, fostering a renovating relation and collaboration between the built space and the environmental boundary conditions.

In order to support city-planning processes, there is the need to develop these kind of strategies that allow evaluation of the best in order to provide solutions that urge the construction of future cities (Grimmond et al, 2010.). Therefore, it is important the existence of an ‘automated’ method by means of dynamic simulations, that allows the systematic exploration and evaluation of different geometric, material and applicable alternatives according the different urban setting, to explore design spaces as variants of urban forms. As a result, it will be possible to support the design process by automated strategies by exploring urban forms according to measurements and empirical findings on the relationship between the thermal comfort, microclimate data and the building geometries.

This research work, illustrates a set of demonstration projects and considering the technical, economic and environmental feasibility of nZEBs in the Athens Metropolitan Area (AMA). In particular, the energy performance of selected typical residential buildings in the AMA has been investigated, from the urban to the single building scale, in order to properly identify the energy requirements and finally propose targeted retrofitting hypothesis towards nZEBs both in building and urban scale.

Yet, all buildings’ transformations have to be tackled in a holistic and integrated manner. As it was already mentioned the volumetric configuration of the urban fabric is the main factor influencing both the indoor and outdoor thermal behavior and the microclimate. There are onvestigated the potential synergies that may arise in terms of energy savings between outdoor and indoor spaces, by using an unprecedented collaboration between different scale environmental simulation systems. Understanding and especially being able to predict and manipulate these urban microclimates may help improve different aspects of the urban environment also in social level. (E. Tapias & G. Schmitt 2014). General ideas related to the application of global and European sustainability principles, in the urban built environment, are also presented and discussed in a critical way. In order to satisfy such a multilayer set of goals, a very adequate and efficient institutional, political, social, economic and cultural regulatory framework is needed.

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CHAPTER I

ENERGY ISSUES OF THE URBAN AREAS

ABSTRACT

The context of this chapter is the analysis of the characteristics of the urban built environments and the energy issues related to the urban areas. City and climate are an old critical topic. The urban planning and building structure could be hypothesized that shows differences according to the various climatic zones. In example, cities that belong to warmer climates tend to have a more extroversion structure, more open and less dense in order to benefit from the wind and achieve as much cooling as possible. On the other hand, in cooler areas, cities tend to have a more dense character in order to maintain the heat. But cities in their majority no matter the different climate conditions show similarities to their structure, material and behavior. (Curdes, 2010)

This chapter is divided into four main parts. The first part focuses at the analytical presentation of the heat island effect on the urban areas and especially on the Mediterranean area and its particular climate. It will be also taken into consideration actual research in nearly zero energy practice, with the case of the Mediterranean area and its particular climate as the main context. It will also be analyzed the importance of green open spaces and their impact and their potential for the improvement of the urban climate. Further, will be analyzed the main energy related issues in the urban environment, its cooling demand related to the Heat Island phenomenon with the review of past and recent case studies in the Mediterranean region. Having as a starting point these studies in literature and from actual achievements in building pilot projects, a brief discussion for the current knowledge in nearly zero energy demand in building common practice is presented.

1.1 Urban climate: The heat island effect phenomenon

Climate is the average of the atmospheric conditions over an extended time over a large region. Small-scale patterns of climate, resulting from the influence of topography, soil structure, ground and urban forms, are known as microclimates. The principal parameters characterizing climate are air temperature, humidity, precipitation and wind.

The climate of cities differs from the climate of the surrounding rural areas, mainly due to the structure of cities and the heat released by vehicles. In general, the climate in cities is characterized by ambient temperatures, reduced relative humidity, reduced wind speed and reduced received direct solar radiation.

While in rural areas the use of the land is more common, in the urban environment the texture varies and the density is another factor that make more difficult to assess and predict the microclimatic conditions. It is very important to emphasize on how a building and a building's design affects its surroundings and therefore the microclimate. In order to sum up, the main differences between the urban environment and the rural areas are:

- The air temperature in the cities is much higher compared to the one of the rural surroundings;
- Apart from the air temperature difference, a significant difference it is documented to the wind speed and is highlighted that in urban zones is usually less strong;
- The lack of sunlight intensity due to urban pollution;The morphology and the orientation of a building can affect the intensity of the daylight and the direct sunlight, as the majority of tall buildings cast shadows over the others.

The assessment of the urban microclimate is difficult to be categorized as its own character prevents it. Each city's difference density, morphology or the ever ending changes that take place in an urban planning with the redesign or reconstruction of new forms and geometries or the volumes and masses and the constant change of materials, make it even more difficult to estimate the microclimate and its characteristics.

Heat island is the more documented phenomenon of climatic change (Santamouris, 2001) and it is proved by meteorologists over the last century. During this phenomenon it is observed much higher air temperature in the central urban areas compared to the suburban zones and the surrounding rural areas (Figure 1.1).

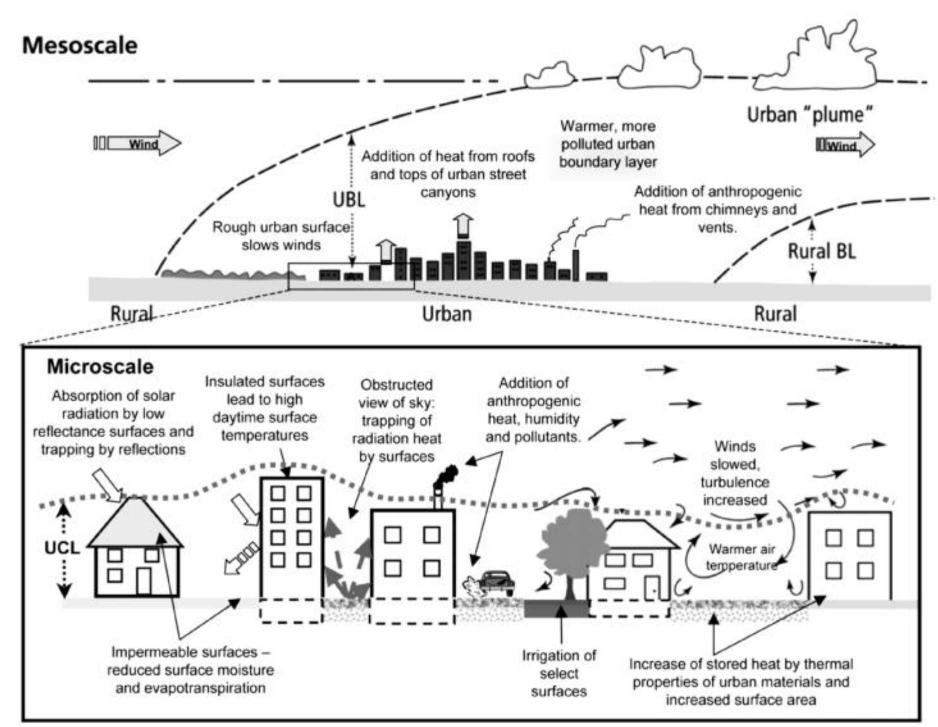

***Figure 1.1**: Representative Scheme of the Heat island Effect (source: Voogt James, How Researchers Measure Urban Heat Islands)*

Urban Heat Islands develop in areas with a high percentage of non-reflective and water-resistant surfaces and in addition the lack of green spaces. The intensity of this phenomenon could reach up to 15 K difference of air temperature while studies in the city of Athens, have revealed that the temperatures records from weather stations situated in the central urban fabric are 5–15 K higher than the ones from suburban stations (Santamouris et al, 2001). Some of the elements that are mainly related and influence the HIE phenomenon are, the building density, the urban surface and its complex geometry, the use of absorbing materials in the urban fabric, the urban canyon geometric characteristics, the lack of green spaces and the increased anthropogenic heat (Oke, Johnson, Steyn, &Watson, 1991).

Heat island, as it is stated in literature, has a very important impact on the energy consumption of buildings during the summer period. It mainly increases demand on cooling, it increases the concentration of pollutants and as a consequence causes human discomfort and numerous health problems (Cartalis et al., 2001; Hassid et al., 2000; Santamouris et al., 2001; Santamouris, Paraponiaris, & Mihalakakou, 2007; Santamouris, Pavlou, Synnefa, Niachou, & Kolokotsa, 2007; Stathopoulou, Mihalakakou, Santamouris, & Bagiorgas, 2008).

Preventing temperature increase and avoiding the heat island effect in the urban environment involves the use of many mitigation techniques. Some of the most common solutions are the application of reflective materials, incensement of the green spaces, increased convective cooling, use of water sources, etc. (Akbari et al., 1992; Gaitani, Mihalakakou, & Santamouris, 2007).

In particular, the use of cool materials presenting high reflectivity to solar radiation and high emissivity coefficient contribute highly to decrease the surface temperature of the cities (Akbari et al., 2009; Synnefa, Santamouris, & Livada, 2006; Santamouris, Synnefa, Kolokotsa, Dimitriou, & Apostolakis, 2008; Synnefa, Santamouris, & Apostolakis, 2007). Extensive green spaces and planted roofs have also a very important impact on the temperature regime of the cities (Santamouris, & Dimoudi, 2009; Santamouris et al., 2007; Shashua-Bar et al., 2010; Sfakianaki, et al. 2009; Niachou, et al. 2001; Yu & Hien, 2009).

In order to have a complete idea, about the principal microscale strategies for mitigation of the urban heat island effect are mentioned below:

- Improved air flow and natural ventilation: could be achieved by the use of ventilated roofs as they have to ability to eliminate overheating. Building orientations and organization of adequate gaps is useful for improving the air flow.
- Cool roof has the ability to reduce building's heat gains and create saving air conditioning expenditures. This in turn reduces the demand at the power plant and as a result less carbon dioxide is released and as a consequence it is reduced the air pollution.
- Replace asphalt with white pavements is a drastic solution as asphalt surface absorbs more heat compared to white pavement, and its temperature can reach even 20 Celsius degrees more than the white pavement. It is proved that lower surface temperatures contribute to decreasing the temperature of ambient air.
- Using High-Albedo material on Building surfaces[2] as the use of these materials has the same effect in the reduction of the ambient air equal to the white pavement in comparison with the asphalt.
- Increase green elements (horizontal &vertical) as it is commonly accepted that green areas in general absorb significant amount of heat. The use of extra green zones and elements in different layers (vertically or horizontally) in the urban settings, like green roofs and green walls, may provide natural ventilation and decrease the demand on cooling of the building.

[2] Albedo (reflection coefficient) derived from Latin *albedo* "whiteness" , is the diffuse reflectivity or reflecting power of a surface. It is expressed as a percentage and is measured on a scale from zero for no reflection (a perfectly black surface) to 1 for perfect reflection (a white surface).

1.1.1 Heat Island in the Mediterranean cities

It is largely demonstrated that the progressive increase of global warming will raise urban temperatures and heat island effect. This will have a tremendous impact considering that, the hot summer of 2003 with ~ 70,000 deaths, mostly in the cities, was the second heaviest natural disaster of the last 100 years in Europe[3].

As reported by many authors (Santamouris, 2001), countries in Mediterranean areas have recorded a huge increase in summer cooling demand and overheating in especially evident in urban areas.

The effects of global warming are of relevant concern for both the environment and human activities in the Mediterranean area[4]. Here, the average yearly air temperatures are expected to increase between 2.2 and 5.1°C (in summer between 2.7 and 6.4 °C). This is forecast to occur by 2100, although more recent researches show the time span may be even shorter (Hanson et al, 2007).

The 'Heat Island' (HI) phenomenon is a result of many interconnected factors (Santamouris, 2001; Yamashita, 1996) that contribute to the increase of the phenomenon such as the canyon geometry, the thermal properties of materials

[3] As reported by Santamouris et al. (2006), during the summer period, high ambient temperatures and heat waves cause dramatic problems to vulnerable population living in overheated households. In France the estimated death toll of the 2003 heat wave was about 15.000 deaths. According to the EuroSurveillance (EuroSurveillance, 2005), an estimated 22.080 excess deaths occurred in England and Wales, France, Italy and Portugal during and immediately after the heat waves of the summer of 2003. Additionally 6.595-8.648 excess deaths have been registered in Spain, of which approximately 54% occurred in August, and 1.400-2.200 even in the Netherlands, of which an estimated 500 occurred during the heat wave of 31 July-13 August. In parallel, it is reported that approximately 1.250 heat-related deaths occurred in Belgium during the summer of 2003, almost 975 excess deaths during June-August in Switzerland and 1.410 during the period August 1-24 in Baden-Württemberg, Germany. Studies in Europe and US (Michelozzi et al., 1999, Michelozzi et al., 2005, Klinenberg, 2002), show that the greatest excess in mortality was registered for people in low socioeconomic status, leaving in buildings with improper heat protection and ventilation.

[4] The Mediterranean climate is the less extensive of meso-thermal climates, according to the 20th century geographical classification developed by German climatologist Wladimir Köppen (1846-1940), which continues to be the authoritative map of the world climates in use today. Currently, the upgraded version of Köppen classification uses six letters to divide the world into six major climate regions, based on average annual precipitation, average monthly precipitation, and average monthly temperature. As also reported by Lavee (1998), Köppen defined the Mediterranean climate (or Etesian climate) as the area where: i) the mean temperature of the coldest month is between - 3°C and 18° C; ii) the summer season is generally dry and the rainfall amount of the wettest month is at least three times greater than that of the driest month; iii) the mean temperature of the warmest month is above 22°C; iv) the mean annual rainfall amount (in mm) is higher than 20 times the mean annual temperature (in degrees Celsius). The first three conditions also refer to semiarid and arid regions adjacent to Mediterranean climate zones. Thus, the crucial difference between the Mediterranean and adjacent arid climate zones is the mean annual rainfall. The Mediterranean sea contributes to the temperate warm climate, retaining heat in summer and releasing it in winter. The majority of the regions with Mediterranean climates have relatively mild winters and hot summers. However winter and summer temperatures may vary greatly between different regions. In the case of winters for instance, Lisbon experiences very mild temperatures in the winter, with frost and snow practically unknown, whereas Thessaloniki has colder winters with annual frosts and snowfall. As a further example, inland France is very different from the southern borders of Egypt or Libya. Nonetheless, many similarities can be found for a wide portion of countries bordering the basin: in almost all the coastline cities, the minimum yearly average temperature is within 5–10 °C and the maximum is within 27–34 °C, with the highest values being recorded in the Turkish coastline and Cyprus.

increasing storage of sensible heat in the fabric of the city, the anthropogenic heat and the urban greenhouse.

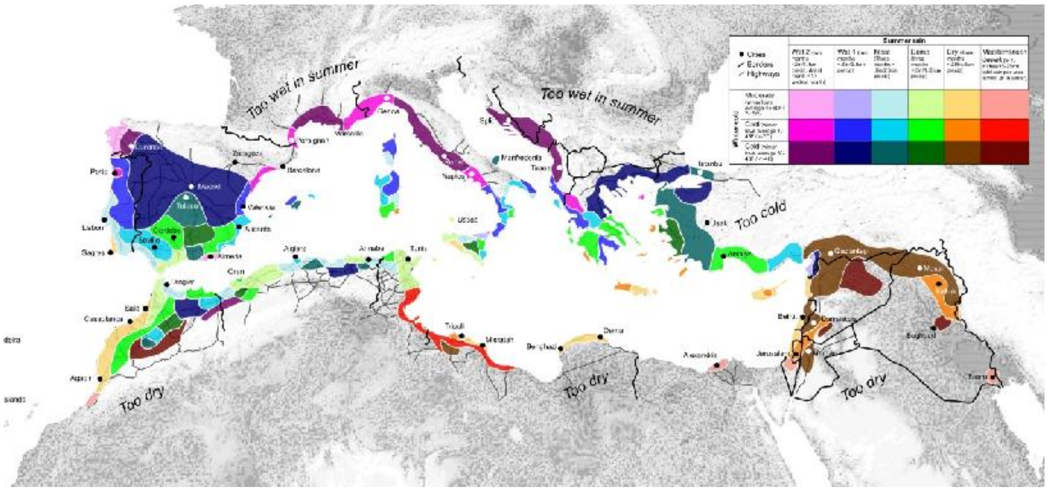

Figure 1.2 The Mediterranean climatic zones (source: Michael Mace for the Pacific Bulb Society)

Zinzi (2010) reports interesting data about the Mediterranean region defining it as a ‘geographical complex entity’ which consists of 23 seaside states with about 600 cities, 46,000 km of coastline, more than 450 million inhabitants (2005), 7.2 per cent of the world population, 9 per cent of total energy supply, 10 per cent of electricity consumption and 8 per cent of CO_2 emission (Davì and Giampaglia, 2007). According to Zinzi (2010), in this complex area, a first simple partition can be assessed on a socio-economic basis: the north rim European states and the south and east rim states, with their transition economies.

The Mediterranean is widely recognized as the area of the world in which the call for sustainable development encompasses all main issues (Plan Bleau, 2008) because of: i) it represents a fragile eco-region, where development is already set back by environmental damage; ii) it is an example of a common contrast between the developed northern part and the developing southern part.

The demographic trend is the Mediterranean Region is quite alarming: the north rim population increased by 14 per cent from 1975 to 2005, when it reached 190 million inhabitants. The south rim population has almost doubled in the same period, accounting now for more than 258 million men and women (Zinzi, 2010). The south rim trend appears to be critical in terms of environmental impact because all the issues are strictly related to the massive urban sprawl.

The urban population increased from 42 per cent of the total to 62 per cent in 2005. Another consequence of urban sprawl in several countries is that more than 20 per cent of the population moved into major cities; the percentage increased to 26 per cent in Turkey and above 35 per cent in countries such as Greece and Portugal.

Percentages above 60 per cent were recorded in smaller states, where the population is concentrated in a few urban areas, such as Israel or Jordan. According to the actual trend, it is expected that another 70 million people will live in metropolitan areas by 2025, with about 90 million expected to dwell in the coastal urban settlements. Thus, the future of Mediterranean countries relies on the implementation of new development models based on a conscious integration of environmental, social and economic issues.

As also reported by Zinzi (2010), a strong impact of the Urban Heat Island is on energy use in buildings[5].

[5] The outdoor air temperature increase has several implications at the level of energy consumption of buildings: i) energy consumption increase for cooling the building; ii) increase of peak cooling demand and, as a consequence, chillers' size increase; iii) energy price increase; iv) less 'granted' energy supply especially in crucial periods, as in summer heat waves; v) reduction in the efficacy of bio-climatic and passive cooling strategies, often based on night natural ventilation techniques, when the outdoor air temperature decreases and shows several degrees lower with respect to the indoor air.

1.3. The value of open spaces, the role of vegetation, water and selected passive techniques “mitigation techniques”

Microclimate

The microclimate of an urban area can be modified by appropriate landscaping techniques, with the use of vegetation and water surfaces, and can be applied to public places, such as parks, play-grounds and streets (Givoni, 1991)

The first stage in managing higher future internal temperatures in buildings is to attempt to make the external air as cool as possible. Within the built environment this involves enhancing the green and blue infrastructure of parks, trees, open spaces, open water and water features. There is a growing interest in the use of rooftop gardens, green walls and green roofs for their cooling effect (Liu, Baskaran , 2003). Parks and other open green spaces can be beneficial through their cooling effects in summer, through shading and transpiration (Shashua-Bar L, Swaid H, Hoffman ME.,2004) and improved access for natural wind-driven ventilation. In addition, the presence of water, plants and trees contributes to microclimate cooling, and is an important source of moisture within the mostly arid urban environment (Robitu M, Musy M, Inard C, Groleau D. 2006). Urban surfaces should be cool or reflective to limit solar gain. Pavements, car parks and roads can be constructed with lighter finishes and have more porous structures.

Improve the Urban Microclimate

Improvement of the ambient microclimate in the urban environment involving the use of more appropriate materials, increased use of green areas, use of cool sinks for heat dissipation, appropriate layout of urban canopies, etc., to counterbalance the effects of temperature increase, is among the more efficient measures. Increase of the energy consumption in the urban areas, because of the heat island effect, put a high stress to utilities that have to supply the necessary additional load. Construction of new generating plants may solve the problem but it is an unsustainable solution while it is expensive and takes a long time to construct. Adoption of measures to decrease the energy demand in the urban areas, like the use of more appropriate materials, increased plantation, use of sinks, etc, seems to be a much more reasonable option. Such a strategy, adopted by the Sacramento Municipal Utility District, (SMUD), has proved to be very effective and economically profitable,(Flavin and Lenssen, 1995),It has been calculated that a megawatt of capacity is actually eight times more expensive to produce than to save it. This because energy saving measures has low capital and no running cost, while construction of new power plants involves high capital and running costs. The optical characteristics of materials used in urban environments and especially the albedo to solar radiation and emissivity to long wave radiation have a very important impact to the urban energy balance. Yap, (Yap, D., 1975), has reported that systematic urban –rural differences of surface emissivity hold the potential to cause a portion of the heat island. Use of high albedo materials reduces the amount of solar radiation absorbed through building envelopes and urban structures and keeps their surfaces cooler. Materials with high emissivity are good emitters of long wave energy and readily release the energy that has been absorbed as short wave radiation.

Lower surface temperatures contribute to decrease the temperature of the ambient air as heat convection intensity from a cooler surface is lower. Such temperature reductions can have significant impacts on cooling energy consumption in urban areas, a fact of particular importance in hot climate cities. Trees and green spaces contribute significantly to cool our cities and save energy. Trees can provide solar protection to individual houses during the summer period while evapotranspiration from trees can reduce urban temperatures. Trees also help mitigate the greenhouse effect, filter pollutants, mask noise, prevent erosion and calm their human observers. As pointed out,'the effectiveness of vegetation depends on its intensity, shape, dimensions and placement.

Vegetation

Vegetation modifies the microclimate and the energy use of buildings by lowering the air and surface temperatures and increasing the relative humidity of the air. Furthermore, plants can control air pollution, filter the dust and reduce the level of nuisance from noise sources. Indoor simulations still tend to be isolated from an important element affecting urban microclimate, such as urban trees. The main advantage of urban trees, as a bioclimatic responsive design element is to produce shade, whereas its main disadvantage is blocking the wind (Yoshida S, Ooka R, Moshida A, Murakami S, Tominaga Y.2006). In addition the effects of specific urban tree types - for example, the different leaf area densities and evapotranspiration rates of urban trees influence solar access and heat exchanges if planted around buildings (Radhi H.2009)

Eumorfopoulou and Kontoleon (2009)and Kontoleon and Eumorfopoulou (2010) analyzed thoroughly the influence of the orientation and proportion (covering percentage) of plant-covered wall sections on the thermal behavior of typical buildings in Greece during the summer.

Limor Shashua-Bar et al. (2010) have analyzed the thermal effect on an urban street due to three levels of building densities. The study indicated the importance of urban trees in alleviating the heat island effect in a hot and humid summer. In all the studied cases, the thermal effect of the tree was found to depend mainly on its canopy coverage level and planting density in the urban street, and a little on other species characteristics.

Water surfaces

Water surfaces modify the microclimate of the surrounding area, reducing the ambient air temperature, either by evaporation, or by the contact of the hot air with the cooler water surface. Fountains, ponds, streams, waterfalls or mist sprays may be used as cooling sources, for lowering the temperature of the outdoor air and of the air entering the building.

The asphalt and concrete used in urban environments is typically too dense to allow water permeability, and therefore, drastically limits the latent heat exchange. The water and air passage allows latent heat exchange, and therefore decreases the temperature of the pavement. This, in turn, assists trees and other landscape root systems to better access air and nutrients, providing cooler root zones which result in larger and denser shading landscape materials (Goldn J, Kaloush K., 2007)

Use of Sustainable Energy Supply Systems

Sustainable energy supply systems and mainly the use of district heating and cooling systems based on the use of renewable energies like solar and biomass or the use of waste heat, is the major tool to introduce clean energy in cities. Produced energy may supply the residential sector, industry, urban agriculture, and any other sector requiring hot or cold water. District heating and cooling brings heat or cool into the buildings (by way of chilled water), and avoids a number of distributed air conditioners with poor performance and high cost. It pays itself on economies of scale but brings large energy and environmental advantages. It provides opportunities to significantly reduce electrical consumption, and thus pollutant emissions. District heating and cooling installations using renewable energies are constantly increasing in Europe. In many European countries the potential for district heating systems is very high, while the number of settlements supplied by district heating networks is continuously increasing. District cooling systems has mainly developed in the United Sates and present a number of very important advantages. The more important advantage has to do with the dramatic decrease of peak electricity load. District energy systems are very efficient as operate at high efficiencies, can increase effective building space, decrease operational , maintenance and capital cost of the user, and can improve indoor air quality as do not generate any chemical or biological pollution in the building. In parallel, district heating and cooling techniques when operated by Municipalities and Community authorities may be the source of important of revenues for the local society.

Use of Passive and Active Solar Systems in Urban Buildings

The adaptation of urban buildings to the specific environmental conditions of cities in order to efficiently incorporate solar and energy saving measures and counterbalance the radical changes and transformations of the radiative, thermal, moisture and aerodynamic characteristics of the urban environment is a major priority. This incorporates appropriate sizing and placing of the building openings, to promote solar energy utilization, enhance air flow and natural ventilation and improve daylight availability, integration of photovoltaics as well as use of passive cooling techniques to decrease cooling energy consumption and improve thermal comfort. Passive solar heating, cooling and lighting techniques have reached a high degree of technical maturity. Large scale applications, especially in new settlements, have shown that very high energy gains can be achieved while the thermal and visual comfort as well as indoor air quality are very satisfactory, (Hestnes, R.Hastings and B. Saxhof ,1997). Further penetration and use of solar technologies is associated with their adaptation to the new conditions almost imposed by the specific social, economic and technical trends dominating the overall sector of the built environment.

Passive design responds to local climate and site conditions in order to maximise the comfort and health of building users while minimising energy use. The key to designing a passive building is to take best advantage of the local climate. Passive cooling refers to any technologies or design features adopted to reduce the temperature of buildings without the need for power consumption.

To sum up, according with Curdes, in order to create a tolerable town climate, the following aspects are important:

- compact building structures for the storage of heat or coolness
- narrow streets for shading areas for the movement in hot climates
- towers, skyscrapers and wind towers to generate vertical wind during hot and windless weather
- big streets in the main wind direction for ventilation and cooling in temperate climates
- cooling and shading surfaces (trees, water, green spaces, parks, green roofs, shaded streets)
- in the north wind – lanes on slopes –, and in the south protection against the hot wind.

1.3. Analysis of the best practices in the framework of contemporary urban planning

To understand the possible strategies to be adopted for low or zero energy buildings it is also important to recall the basic bioclimatic principles of ancient and traditional architecture, which can be either used to make a proposal for the recovery of traditional constructions with peculiar bioclimatic strategies and/or translated in the present modern buildings (Cañas et al., 2004).

The importance of traditional construction as a frame of reference model of bioclimatic architecture is reported by many authors in the literature (Cañas et al., 2004; Coch, 1998). All over the world, houses, small towns and villages of the past collectively contain some of the best-preserved climatic conscious and aesthetically enjoyable traditional architectural types and techniques. Furthermore, current passive techniques used in reducing the cooling demand of buildings are based on or derive from systems and components used in the traditional and vernacular architecture[6].

Different research studies in literature on interesting examples of vernacular and traditional architecture have been selected. They are briefly illustrated in the following part of this paragraph.

Analyzing and reporting more than 200 cases of old buildings in Spain, Cañas (2004) highlighted significant points: a) The bioclimatic strategies used in popular constructions correctly respond to the conditions imposed by the climate; b) Selected strategies and technological tools for the protection against the solar radiation may be found in buildings located in the southern middle part of Spain, where the solar radiation received is very high, while, as an opposite, strategies for the use of solar radiation appear in the northern middle part of Spain where the solar radiation is lower; c) Strategies for the protection against cold temperatures agree with the regions of Spain where the temperatures are minimum; d) Generally, technological tools for the

[6] With respect to the representative or even monumental architecture, the popular architecture has been structured by people as a direct and basic response to their own needs and values (Coch, 1998). These buildings show a greater respect for the existing environment. They use local materials and techniques as far as possible, repeating and slowly modifying the course of history models and take fully into account the constraints imposed by the climate. In spite of the plurality of solutions within the different geographical contexts, it is also interesting to observe how practically identical architectural models are developed in similar climates with highly different cultures and very distant locations.

protection against rain are located mainly in areas where the averages of precipitations are high. In particular, passive regional strategies are: a) Andalusian "patios" whose function is to accumulate fresh air; b) Light color of the façade as a mechanism for the protection against solar radiation, since light colours reject the solar rays reducing solar heating; c) Use of vegetation for the shading of the housing; d) Orientation of the building for the collection of higher amount of solar radiation in winter than in summer.

Architectural structure and environmental performance have been reported also for the case study of the traditional buildings in Florina, North-West of Greece (Oikonomou et al, 2011). This study was based on the documentation and the analysis of the architectural and bioclimatic aspects of a sample of forty remaining houses of the 19th and the beginning of the 20th century. The analysis has been performed considering the building types and form, the materials and the construction techniques, whereas the analysis of bioclimatic aspects involves the thermal behavior of the building shell, the thermal and the visual comfort conditions. Traditional architecture of Florina is characterized by proper southern or eastern orientation of the buildings and by the exploitation of the prevailing winds. At a large extent, the buildings are oriented to achieve the best possible exploitation of solar radiation for passive solar heating. Natural materials are used with great efficiency and according to their physical properties and thermal characteristics (density, heat capacity, time-lag), as well as their durability, improving the inter-seasonal thermal behavior of the various spaces and enforcing the bioclimatic function of the buildings. In this way, the winter living spaces, which are situated on the ground floor, are characterized by increased thermal mass and reduced thermal losses due to the increased wall thickness and the reduced number of openings, whereas the summer living spaces on the upper floors are characterized by reduced thermal mass and enhanced ventilation due to the light-weight walls and the increased number of windows. As a whole, the traditional buildings evaluated in this study resulted in highly energy performing buildings both in the summer period and in the cold winter season[7].

[7] Computer-aided thermal analysis have shown that for the coldest day (January 26th), the main winter living spaces had slight diurnal variation and range (around 0 °C with outside temperatures below -12 °C. For the hottest day (August 25th), while the exterior temperature ranged from 22 °C (early in the morning) to 34 °C (around noon), the summer living spaces resulted warmer than the outdoor air temperatures in the morning and in the night (25 °C), but significantly fresher around noon (29 °C). When

The energy and microclimatic performance of traditional buildings have been performed also for the well-known case of ‘Sassi’, historical hypogenous buildings in South Italy (Cardinale et al., 2010). The ‘Sassi’ district of Matera, a UNESCO World Heritage since 1993, is described as an exceptional example of traditional bioclimatic Mediterranean architecture. The authors analyzed the energy performance of the hypogenous building structures during one calendar year, founding, that the huge thermal mass of the walls ensured constant and regular microclimate indoor conditions throughout the seasons, without relevant differences in the daily thermal oscillation. In spite of some air change need (thermal-hygrometric comfort values in deep hypogenous units are not fully reached), these structures present a null thermal balance during mid-season, while in the summer the floor loses heat, thereby cooling the environment. The opposite occurs in winter[8].

As a general rule, it can be stated that incorporation of traditional or traditional-based building techniques into newly designed building may help the design process to use low-cost and achievable, locally based construction practices towards the achievement of Zero Energy Balance and Zero on-site CO_2 emission within the Mediterranean climate (Ferrante et al., 2011). In the reference case study (a newly designed housing development for a site located in the south of Italy) the concurrence of different building components aims to achieve multi-purpose objectives within a same building frame.

These components mainly derive from the re-elaboration of traditional forms and techniques (building type – a courtyard house presenting a good balance among natural ventilation and building compactness-, high mass envelope features and construction from the local practices, selected passive tools for energy saving). The same components are called to be integrated with systems for energy micro-generation

natural ventilation is inserted as an additional parameter (passive cooling strategy) in the computer analysis, the inside temperature ranges from 23.5 to 27.5 °C.

[8] The monitoring campaign has confirmed all results obtained through the dynamic analysis. By quantifying the total energy balance of the hypogenous structures, the authors found the following: i) during the winter season, the heat flow loss from the walls was balanced by the positive energy gain through the floor, which stabilized the temperature that remains constant at about 12–13 °C; ii) during mid-season, exchanged heat fluxes are essentially null, resulting in a constant evolution of temperature with values of 15–16 °C; iii) in summer, the heat flow dispersed from the floor counterbalances the incoming heat flow for transmission and ventilation, reducing high summer temperatures. During the summer season the indoor temperature is in the range of 18–21 °C (specially in deep hypogea). It can be concluded that these buildings were built as ‘Zero Energy’ houses and they can be used today, after conservative and light-method based restoration processes, with limited or null use of technology energy systems.

from renewable energy sources –RES- combining existing technologies from RES into traditional building types and consolidated construction practices.

DISCUSSION

The urban heat island effect, as one of the main ecological global consequences of increased urbanization and can affect the quality of the environment and of life. The major source of UHI is the large amount of heat produced from urban structures, as they consume and re-radiate solar radiation and also from the anthropogenic heat sources. Increasing urban green areas is considered as one of the efficient strategies to mitigate UHI. It has been proved that increasing urban green areas such as parks, street trees and also by adding vertical and horizontal green elements on the building envelopes could reduce air temperature and consequently, reduce the heat island effect phenomenon. Based on several studies, temperature reduction in a green urban environment can reach up to 4 ○C as also it depends on the size of the park, the amount of trees and grass cover and the choice of material used for all external surfaces.

Therefore, it is concluded that urban greening is an efficient method in order to mitigate urban heat island effect and human health consequences of increased temperatures resulting from climate change and as a result, improve the quality of life in urban areas.

To understand the possible strategies to be adopted for low or zero energy buildings and urban environments it is also important to recall the basic bioclimatic principles of traditional architecture. Finally, it is presented in literature that current passive techniques used in reducing the cooling demand of buildings are based on systems and components used in the traditional and vernacular architecture. Appropriate future planning in cities should consider that the built environment is not just a collection of buildings, but it is in fact the physical result of various economic, social and environmental processes strongly related to the society standards and needs.

-II-

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CHAPTER II

ATHENS METROPOLITAN AREA AS A CASE STUDY

ABSTRACT

This chapter deals with the selection, the study, the urban analysis and energy demand, developed in two different urban settings of the Athens metropolitan area.

Initially is introducing the urban evolution of Athens, and how it managed to expand by covering the suburban areas and the periphery. A critical discussion concerning the proper selection of representative case studies as potential repeated indicative typical units in the framework of a whole city scale is followed. At the larger urban scale, the chapter investigates the effects of green on heat island mitigation and on the energy demand for cooling, demonstrating the paramount additional saving brought about by retrofitting the open areas and redesigning the surfaces of the built environment by using green, new materials instead of asphalt, and shading systems.

The chapter concludes with the reference of the dense heat island phenomenon witnessed in both selected case studies, underlining the series of constraints and barriers that must be overcome in order to adopt measures and actions to reach the target of nearly zero energy urban settings.

2.1. URBAN HISTORY OF ATHENS

The city of Athens represents a highly significant pilot study, both in the context of energy issues and for the increasingly emerging problems of degraded urban environments.

The urban history of Athens in the last 150 years (1830- 2000) is characterized from a notable contradiction of a city whose population expanded from 9,000 inhabitants (1824[9]) up to 3.80 million (2014) in less than 200 years, considering though the Athens Metropolitan Area as a whole, the biggest region in Attica peninsula parted from 58 municipalities[10]

The city in present years is expanding without following a specific overall plan and the organization is considered problematic and way far from the desired European patterns. However, the new city plans are followed from, not only the politicians and the experts, but also the press and all public opinion. Alongside the present and future projects, is revised a new urban legislation that often goes hand in hand with the most modernizing laws of the capitalist developed countries in Europe.

The interpretation of this "absurdity" is to be found in the relation between the state authorities and the society. The state as an institution that is leagued with a certain ideology and a specific operating mechanism and the society mechanism on the other hand, as a union of people, built in individual groupings, operating, informal or organized, motivated by the harmonization or contradictions between the interests and ideology.

Athens city area is a metropolitan area, that from further on will be also referred as AMA and is located at the south end of the Attica peninsula, surrounded by the Aegean Sea. Since 1951, suburban and exurban Athens has estimated for 95% of the growth in the metropolitan region, adding more than 2 million new inhabitants,

[9] During the years of the Greek Revolution, Athens was a small city (in 1824 has 9,000 inhabitants and occupies extension 116 hectares) destroyed and depopulated by war events. Nevertheless played an important ideological role in the symbolism of the birthplace of democracy and the source of Greek Culture and civilization –values that have been adopted by the European Enlightenment and the Greek Revolution. Therefore, Athens as the capital would have the ideological authority to incarnate the center of the scattered Greek ethnicity.

[10] The 2013 edition of Demographia World Urban Areas indicates that the Athens urban area has a population of 3.5 million, living in a land area of 225 square miles (580 square kilometres), for a density of 15,600 per square mile (6,000 per square kilometre).

compared to approximately 100,000 for the Athens center area. Since 1971, as it is shown on Figure 1, all of the population growth has been in the suburbs and exurbs.

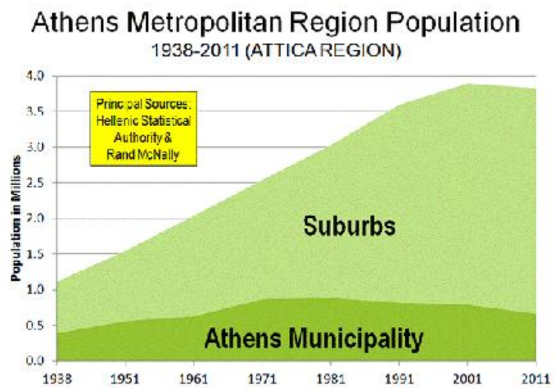


Figure 2.1: Athens growth population, Source: Wendell Cox, The Evolving Urban Form: Athens, Principal Source: Hellenic Statistical Authority& Rand McNally

Even with its current slow Athens urban area remains among the densest in the developed world (Figures 2.1 and 2.2). This places Athens slightly ahead of London (5,900 per square kilometer), about double the density of Toronto or Los Angeles and more than four times that of Portland. (Cox, 2013)

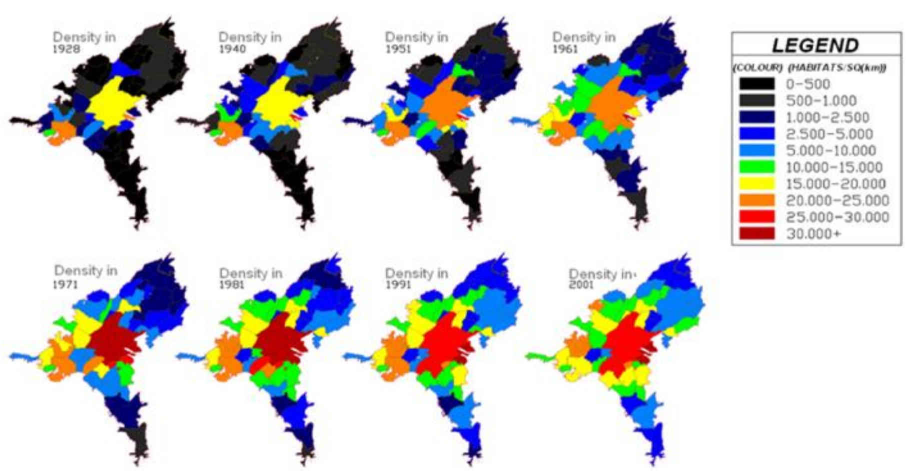


Figure 2.1: The evolution of urban density (in terms of inhabitants per square meters) in Athens by districts from 1971 to 2001.
Source:http://en.wikipedia.org/wiki/File:Population_Density_in_Athens.PNG

Greek cities, especially Athens and Thessaloniki that are the two main urban centers of Greece, experienced a major urbanization movement during the 1950s after

World War II. The regulative framework between 40's and 90's led to the city centers' shape as they are formed nowadays .The main negative characteristics of this new urban environment are the high density urban blocks, the lack of vegetation, the insufficient social spaces, the degraded public spaces and the existence of great traffic, lack of parking, insufficient public transportation and as a consequence of all those increased noise and air pollution. (Tsagkalidou, 2015)

The monumental urban structure of Athens dates back to the Otto period (1833-1864)[11], as the logical consequence of selecting Athens as the new capital. The plan is a clear response to the ideological role that has to be played by the new capital. The monumental and hierarchical structure has as a main reference the Acropolis, symbol of the ideological prestige of Athens, and the Palace. The position of the Ministries surrounding the Palace, expresses the nature of the new administrative and political power.

The war period (Balkan, World War I, the Asia Minor Campaign), intensify the severity of Athens compared with other cities of the country, not only in terms of the population[12] but also from economic and political point of view.

Recall that the Catastrophe involve forced and final contraction of Hellenism in the limits of the territory, and therefore makes Athens unique capital de facto. Even the large international financial crisis, combined with the installation of 1,220,000 refugees in Greece, which at that period has a population of 5,000,000 inhabitants in total, imply

[11] Otto and the Bavarian power installed in Nafplion in January 1833. That period it is developed a very keen competition and scepticism among various cities for the establishment of the capital of the State. Since 1831, the architects Kleanthis and Schaubert, old students of Schinkel, begin to prepare a plan for a new city- capital in the region of Athens. The ideological acceptance of the state as it is necessary the existence of the project and new standards. The design of architects Kleanthis and Schaubert, one the most advanced for its time, proposed a combination of rectangular grid and radial connections of central spots and large open spaces and marked with its basic choices the center of Athens. In terms of technical design it is one of the best examples of the era. The area of the project occupies a total of 300 hectares. The plan was submitted to King Otto in late 1832 and adopted in July 1833, while at the same time is taken the decision to transfer the seat of government from Nafplio to Athens. The decision on the establishment of the capital in Athens ended a long-term uncertainty. However, it marked the beginning of a literally chaotic situation on the city plan, because, from the start and out of any doubt, it appeared that the financial and technical resources to implement the plan were minimal. The successive modifications of the plan, however, changes the projected position of public buildings and especially the Palace, the large decrease (to full elimination in practice) of the area reserved for excavations can be attributed in interests on speculation in land, of Athenians and foreign owners of land. These interests were the ones that intertwined with the aims of political parties, the disputes between the State and the municipality and the lack of resources and finally leaded to inactivate the implementation of the project and the majority of the original structure, except for the layout of the main axes of the historic triangle -Panepistimiou Avenue and Pireos streets, Ermou and Athena streets- (May, E., 1929; Biris C., Μπίρης, K., 1966) that remains in the urban form of the city today.

[12] The population of the wider area of Athens-Pireus from 453.000 that it was the year 1920, in 1928 exceeds the 800.000 and in 1940 arrives to 1.124.000

an opportunistic, not solid but very rapid growth of the manufacturing sector, which is concentrated mainly in the area Athens. (Vergopoulos, 1978)

The crisis of housing in Athens is acute, while the economic crisis and high inflation block the possibility of housing construction. Rent controls that were imposed in the 1916 has resulted in the total suspension of all the construction activity. Thus, the addiction of 246.00 refugees in Athens comes to an already very acute lack of housing shortage.

It is worth to mention that during all this period even during the war period, Greeks and foreign architects and engineers are studying urban plans for Athens. These people individually, other by the state or the city council, draft some of those plans. That indicates the great concern that a big part of the citizens had for the proper expansion of Athens. (i.e Plan of Hoffmann 1910, Mawson 1914-18 and Kaliga 1925). The main objective of the projects developed is the reform of the central part of the city. However, there are expressed views and opinions on the need to design the extensions and new suburbs (i.e Plan Lelouda, Plan Kaliga Figure 2.3 &2.4).

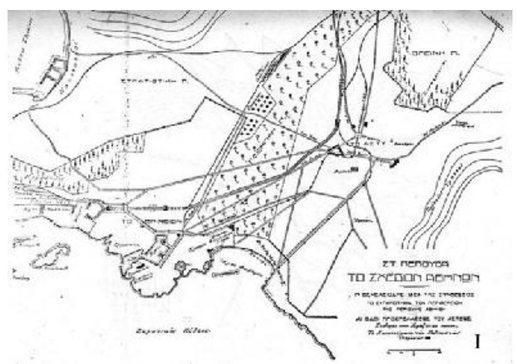
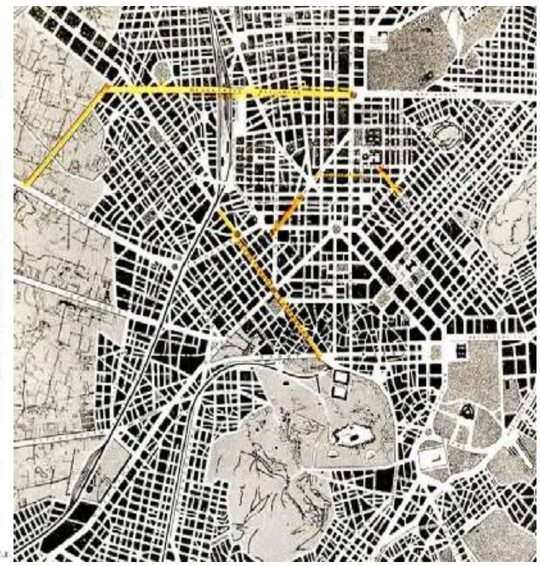


Figure 2.4: On the left the plan of Kaligas 1925. Source: YDE album
On the right the plan Lelouda 1919, source: ST. Leloudas

It is also featured a plan drawn up in 1935 by the technical department of the municipality, headed by K. Biris, (Figure 2.5 & Figure 2.6) where large green area is provided ("green issue" or green belt) which would prevent extensions in the immediate vicinity of the central zone which implement the future organization of the city (Biris, 1966) Key topics of the projects of this period are the opening of roads and the location of the public buildings. Usually the installation of buildings of similar use is proposed in the same area, called as the "center" (e.g. administrative, commercial, university center, etc.).



Figures 2.5 & 2.6: Plan of K. Biris, 1935, sources: Biris C, Technical Chronicles, Technical chamber of Greece

The illegal construction is intensifying with the tolerance and often with the support of the State if that would help to defuse the housing crisis. During this period of the illegal widespread construction, added legislation is developed for economic cooperatives, which essentially operate as a plot for widely layers of civil servants and soldiers. This situation contributes significantly to the fragmentation and real estate development of large areas of suburban land without plan or forecast how they will be integrated in the city's fabric.

It is worth mentioning that there are some cases that a local plan is applied, without any connection with the overall urban plans mentioned before, but in proportion to some of the ideas in Western Europe are considered innovative.

For the first time in Greece, it is developed a social housing program for the accommodation of refugees (Mantouvalou, 1988). The houses that were built were very few in relation to the needs. A very large percentage of the refugees were living in huts which they constructed by themselves or by other people involved by interest in the case that there was an available plot from the state. There is the construction of some group houses though in different parts of Athens and other cities. Therefore, we see that the type of the one room housing that can be joined in pairs, when the situation allows, creating a larger house (Kaisariani area), perfectly follows the provision which applies exactly the same time in the municipality of Frankfurt programs for "the poorest from poor ", headed by Ernst May (May, 1929) The same applies for the two- storey or four-storey blocks of settlements for Refugees (Kaisariani, Dourgouti, Kokkinia, Aghios Dimitrios, Agia Varvara etc.) which are designed and positioned in the plot, always according to the experimental principles implemented in Germany, in particular by Walter Gropius.

Alongside the suburbs mentioned before, there are developed as private businesses some suburbs for the middle-class (Psychiko, Ekali Filothei, Ilioupoli) and are designed according to the model of a garden city which is followed for the respective suburbs in Europe as it is shown in (central round large open spaces, radial arrangement, gardens).

It is encoded and supplemented the existing planning legislation, so setting up a modernized whole, a legislation that is valid up to nowadays. It is therefore obvious that for this period the contradiction, which applies in principle, characterizes the public policy. A political modernization that is showing technical knowledge while also seeking, through the provision of cheap land housing to defuse the critical social situations.

The same policy, the same contradictions, continue after the war until the recent years. However, is important to be noted a "dramatic" element that seems to define the evolution of the design space: a contradictory relationship to historical time, characterized by the fact that while there is an ideological obsession of an unbroken continuity of Hellenism, the actual path is marked by successive shocks and discontinuities. In what appears to have counterpart in urban planning, the element of occasional, ephemeral, the relief with the easiest management tools, even if that future is stored.

The present face of the capital is characterized by typical modern houses, which is the building of medium height. Apartment buildings that were built in the regions of the center and the periphery took the place of the neoclassical houses of great architectural value that were part of our history. So from one side is the construction of these buildings of the 50s and 60s, built by entrepreneurs manufacturers, with the method of payment, sometimes without even the architect’s study, and on the other side, the illegal construction that is increasingly rising, that turned Athens into an unidentifiable European capital.

Densification trend sped up in the 80s, and continued at the periphery. Throughout all this period many urban plans were drafted for the overall organization of the city. Alongside these projects, a new urban legislation is revised, often going hand in hand with the urban development of the western countries of Europe.

Typical modern houses characterize the current aspect of the capital. Apartment buildings built both in the center and the periphery took the place of the architectural valuable neoclassical houses (Travlos I., Τραυλός, I., 1977).Nonetheless, Athens appears to contain and preserving a still residual potentiality in terms of future capability towards a thinkable urban rebounding.

Surveying the urban planning history of Athens, we encounter the traces of multiple ideas and guidelines, which have sometimes, amplified and sometimes cancelled out one another. The attempts at organized construction the institutional and political shifts, the social reception of issues relating to the city’s cultural heritage and environment, the natural disasters, and the influxes of immigrant and refugee populations have all fed into the ever-changing urban landscape.

The present face of the capital is characterized by typical modern houses of medium height. Apartment buildings that were built in the regions of the center and the periphery took the place of the neoclassical houses of great architectural value that were part of Athens history. So from one side is the construction of these buildings of the 50s and 60s, built by entrepreneurs manufacturers, sometimes without even the architect’s study, and on the other side, the illegal construction that is increasingly rising, that turned Athens into a faceless European capital. (Toursounoglou, 2010)The 20th century brought separation and dispersal of buildings to an extent unparalleled in city history. Aerial photos and ground observation confirm this unambiguously the sharp contrast of built form between the old "city" and its newer additions is inescapable.

However, the 20th century also ushered a new form of a settlement, the vertical block, which can equal in density and habitable space to several horizontal blocks built in earlier years and thus dramatically increase the potential for people concentration.

2.1.1 The Urban Block as a typical Greek urban form

The legislative framework and constant revisions of the General Building Code of 1929 led step by step to an increased plot coverage in the urban settings of 70% having as a result high density urban blocks with a continuous outline along the street network (Pantazi, 2010). This as it is called “continuous building system” was first appeared in the period of 50’s till the 90’s and resulted in the creation of attached buildings side by side forming united street façades. Consequently, the 30% of the uncovered space was always left at the rear part of each plot without having an important use. The addition of these “leftovers”, named after the urbanist as urban voids, created a type of inner-block courtyards in providing daylight to the rear façades of the apartments and without any social character and use (Kapsali, 2012). Another important feature of the Greek urban blocks is the accumulation of the flat roofs of each building. Although, they are mostly used as space for maintenance and they lack any design touch, the roof level provides an extensive layer in the city with great environmental and social potential (Vlachou, 2011).

In Figure 2.7. can be show the two main urban block typologies[13] that can found in the city of Athens where this study is focused on and it is visible the high layout uniformity and continuity.

Figure 2.7. On the left the rectangular typical urban block typology and on the right the square typology. Source: Tsagkalidou Olga, Microclimatic Studies in the Greek Urban Environment: A Case Stuty in Thessaloniki 2015, main source: Google Earth

2.2 Geographical, geometrical and dense analysis of the AMA

To classify, organize and analyze the different density encountered in the Athens Metropolitan Area, a preliminary survey on the different urban districts has been conducted by visiting, measuring and analyzing the different areas, suburbs and periphery in the Attica Region. The subsequent categorization of results deriving from this ethnographic observation has shown that even if all these contexts belong to the same "system", different densities, different urban textures and morphologies can be found in the urban region of Attica. Obviously, they are also characterized by different climatic data, orientation and other factors. at the urban scale, but the territorial morphological asset of the natural boundary conditions around the Athens Metropolitan Area (AMA) is the main causes of the different climatic conditions within the different parts of the city, as it will be shown in the following chapter.

In this preliminary classification, six main areas have been selected to explicate these different urban textures and morphologies. Different zones in the north, south,

[13] According to the description of the spatial characteristics from Vlachou (2011) and Vogiatzi-Tamba (2009), in Athens, the Square Block's dimensions vary from 40-50 m, the H/W ratio ranges from 0.75 to 2 and the void percentage is around 6.5 – 25 % of the total block area. The Rectangular Block's dimensions is approximately 40 – 50 m by 80 – 100 m, the H/W ratio ranges from 0.2 to 0.4 and the void percentage is 10 – 28 %. The average building height mainly seen in Athens is up to 5 to 7 stories. In the city center could reach up to 9 stories, according to the density

center, east and west of the Athens Metropolitan area have been studied. Figure 2.8 reports a scheme of the typical urban texture in the AMA. All areas are represented, in the same scale, in a graphical map, indicating in black the built area and in white the streets, while in light grey are the open spaces. It is evident the difference in density and the presence or mainly the absence of green areas and open spaces. More degraded could be characterized the areas connected to the city center and the west suburbs.

Figure 2.8. Main urban textures in the Athens Metropolitan Area, from the least to the most dense (left to right: KifisiaNorth), Glyfada(South), Ag.Paraskevi(Nort-East), Ag.Varvara(South West), Peristeri(West), Center of Athens)

Urban density, in its various and different definitions, is the basic tool of the urban zoning; it is conceived as the most diffuse and necessary tool to shape cities, imposing an order on the urban development, and regulating future growth. In a city as large and as eclectic as Athens, zoning regulations are crucial to preserve the existing built environment and, at the same time, foster potential innovative new developments. In large cities and metropolitan areas, zoning provides specifications on end-use and size of buildings, contributing to the characterization of diversity of the many neighbourhoods that constitute the city[14].

As discussed, Athens has been characterized by an uncontrolled growth of massive and quite tall buildings in the early 20th century, due to the improved building's techniques, like the extended use of reinforced concrete structures, the sudden

[14] Different classes can be based on the discrete values (strong, medium, weak) of three parameters in urban planning: building continuity (continuous, medium, discontinuous), surface density (strong, medium, weak), building height (low, medium, high). The surface density is the ratio between the surface of the buildings at the ground level and the surface of the concerned area. A strong building continuity indicates that buildings predominantly structure urban spaces. Adjacent buildings, streets and artificial pavements cover more than 80% of the area. Vegetation is scarcely used, except in linear arrangement. A building discontinuity indicates that buildings and artificial pavements covers with discontinuity large spaces. Vegetation surfaces coexist with mineral spaces. The use of discrete values implies to get threshold values. Main used parameters are: BUILDING CONTINUITY (Discontinuous: isolated buildings; Means: some group of adjacent buildings; Continuous: linear or block arrangement); SURFACE DENSITY (Weak: less than 15%; Means: from 15% to 30%; Strong: more than 30%); BUILDING HEIGHT (Low: from one to four floors; Means: from five to 10 floors; High: more than 10 floors). Threshold values may be adjusted or modified to take into account various urban contexts. To limit the study of this work and to fit the correspondence with the Athens area study case we will mainly deal about downtown urban fabrics characterised by medium and strong density, continuous, medium-high height.

enlargement of housing demand, in turn given by the continuous increase of population[15].

The urban density in a residential area can be calculated in different ways, but the most usual are essentially three. The first is the ratio between the number of residential units and the urban horizontal surface; then is the ratio between the number of inhabitants and the urban horizontal surface and last but not least is the ratio between the residential surfaces and the urban horizontal surface.

Although the first method is the most commonly used from urban planner in new developments[16], it presents the disadvantage to be strictly dependent from the actual destination and use of the specific buildings. The second ratio index is used by landscape designers, geographers and infrastructures' engineers, since it is extremely useful in the calculation of the environmental urban load in a specific built context and the consequent dimensioning of its infrastructural network systems. Figure 2.9 shows the population density of the 6 representative selected urban districts in Athens. There is a coherence between this figure and figure 2.8, comparing the density of the urban tissue and the amount of habitants per square kilometre.

[15] Half a century later, a Modern emphasis had grown over public plazas and open spaces in general. Moreover the new car-based society required new spaces for parking. Therefore the next release of the Zoning Resolution included car park requirements and bulk regulations and provided extra floor bonus incentives for the creation of public plazas. Nowadays the Zoning Resolution is a planning tool constantly updated by large cities, with some main focuses like promoting mixed uses, keEPhng the city streets vibrant, and generating zoning for special districts, to enhance the character of special neighbourhoods.
[16] It is especially used from Spanish urban planners and architects (Mozas and Fernandez, 2002).

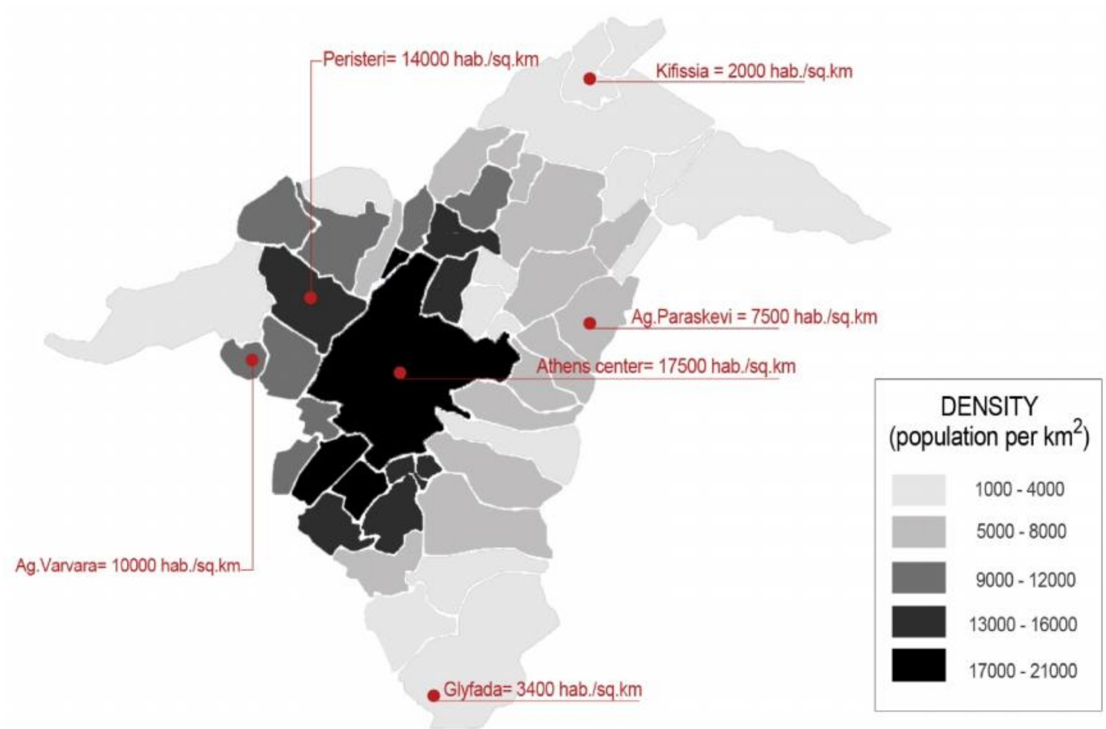


Fig. 2.9. Density of Population in six representative districts of Athens

The third ratio which is globally known as the Floor Area Ratio., F.A.R, is indicated as a measurement to identify the density of a region (Reale, 2008). This indicative number is calculated by dividing the total sum of the square meters of all the built surfaces by the square metres of the total urban open area referred to the previous measured block of buildings. F.A.R. is one of the more commonly used indexes by urban planners and designers. In fact, in the zoning resolution, the Floor Area is defined as the sum of the gross areas of the several floors of a building or buildings, measured from exterior faces of exterior walls or from the centre lines of walls separating two buildings. Even if it does not provide information of the functional use of the urban surfaces (public spaces, services, real occupied dwellings, etc.) it represents the more effective ratio to express the numerical incidence of the existing volumetric forms in the built environment. In detail, F.A.R. with an indicator below 1 represents a low density area, an indicator from 1-2 refers to a medium zone and above 2 it indicates a high/very high urban density[17].In some cases, like Athens F.A.R. could be around 3 or even more a situation that indicates a zone that is considered extremely high.

In other terms, the Floor Area Ratio (FAR) is the total floor area on a zoning lot, divided by the lot area of the same zoning lot. In other words, it is the ratio of a building's total floor area (gross floor area) to the size of the piece of land upon which it is built. This value is often used in the zoning regulative tool for the different zoning district and it can also refer to limits imposed on such a ratio. The floor area ratio can be used in zoning to limit the amount of construction in a specific area. For example, if the relevant zoning ordinance permits construction on a parcel, and if construction must adhere to a 0.10 FAR, then the total area of all floors in all buildings constructed on the parcel must be no more than one-tenth the area of the parcel itself. The correspondent formula is:

$$FAR = \frac{Total\ area\ of\ all\ the\ buildings'\ floor\ or\ total\ gross\ floor\ area}{\textbf{Total area of the urban plot}}$$

The floor area of a building usually does not include secondary structures like cellar spaces; elevator or stair voids, accessory water tanks or cooling towers, attic space providing structural headroom, floor open space or roofed terraces, bridges, breeze ways or porches, floor space used for mechanical equipment, the lowest story of a residential building, floor space in exterior not enclosed balconies and further more areas in categories like the ones mentioned above.

It is interesting taking into account the peculiarity this index has. For example, if the area of the plot is 100 square meters and an area of 100 square meters of gross floor area has been built on the plot in a four floor structure. In this case a foor floor building with 25 square meters each floor are built on a site of a total of 100 square meters. The resulting FAR according to the formula pre-mentioned will be 1.0. Thus, the same FAR could have been obtained in the different following options as for example a one story bulding covering the 100% of the plot or a four story building

[17] A FAR of 1.5 is quite high, although this density is not unusual in historical city centres like Florence, Venice or central Paris, and is considerably exceeded in most of Manhattan. It requires 4-story buildings and narrow streets with limited interior courtyards. Higher buildings would leave more room for streets and gardens, but they are hardly present in the old historical centres of the cities.

covering the 25% of the plot. As a result both situations would give a FAR 1 as according to the formula for thi first would be expressed as: (100/100= 1.0) while for the second case : [(4 x 0,25)/100= 1.0].

Consequently, a same resulting FAR does not always refer to a similar urban context as it can express as it was proved earlier, either a single-story building consuming the entire allowable area in one floor, or a multi-stories building that rises higher above the plane of the land. In this second case, the building will consequently result in a smaller footprint with respect to a single-story building of the same total floor area.

Notwithstanding the manifest degree of approximation of the FAR, which disregards important other parameters, like height, width, or length, it is important to notice that the floor area ratio well correlates with other factors relevant to zoning regulation, such as the total parking area that would be required for a public building, the total number of units that might be available for residential use, total load on municipal infrastructural services, etc. In fact, the amounts of these other important urban parameters are nearly constant for a given total floor area, regardless of how total gross floor area is distributed in parallel and/or perpendicularly with respect to the ground level.

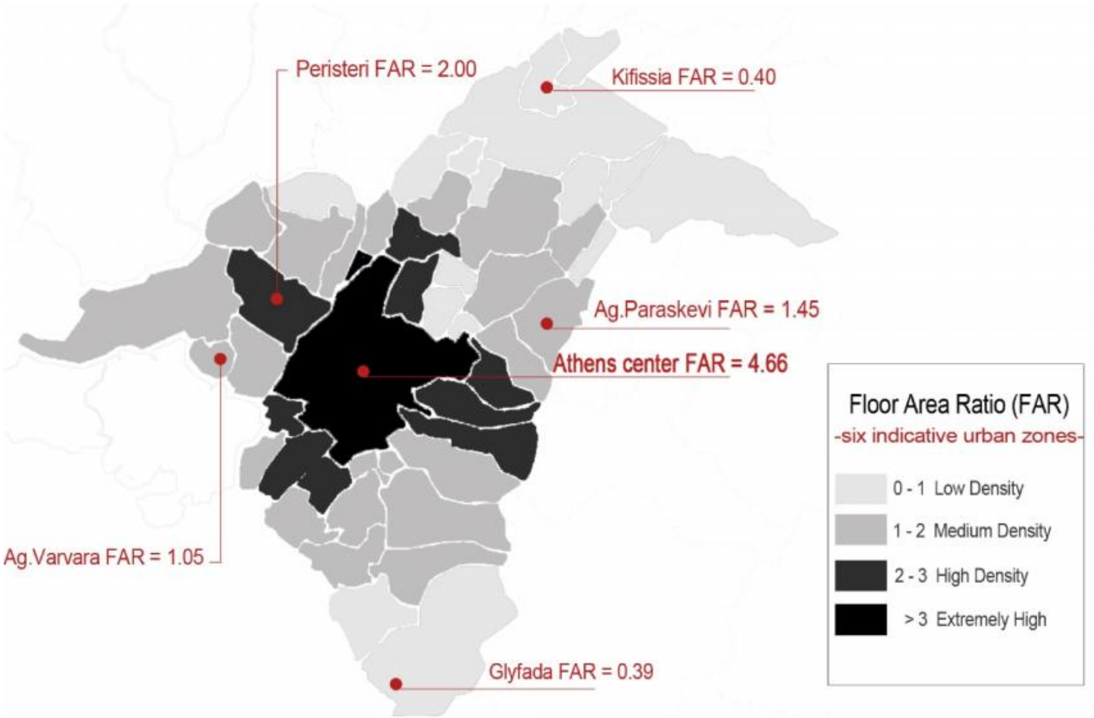


Figure 2.10: FAR (Floor Area Ratio) in six representative districts of Athens

In figure 2.10 it is indicated the FAR of the selected six representative urban zones of Athens. It is noticeable how dense is the centre of the city as the FAR measured is much more above 3, which is an indication of a zone that is considered extremely high. Peristeri which belongs to the west suburbs, also belongs to the dense areas of the urban tissue of Attica region, while Agia Paraskevi, an east located suburb, which as a size could be compared with Peristeri in fact has way lower FAR and also half of the density of the population.

Nevertheless, the form is the "genetic code" explaining the relationship between the building and the urban microclimate and disregarding the shape of urban fabrics, the way the "define their borders" with the outdoor spaces would imply a macroscopic misstep.

As a matter of fact, two basic parameters are fully related with the form of the building envelope with respect to its surrounding open areas and the way they collaborate and are attached to one another.

These factors mainly are:

i) the compactness of the buildings and building blocks, which will be further analyzed

ii) and the ability of structures to exchange air

In further detail, the factor of compactness as mentioned before, has a significant role and has to be considered for the urban character understanding. It is usually expressed as the ratio of the measured external area of the building to volume (Ae/V). The compactness is measured by the ratio of the total surfaces of external envelopes (Ae) and the total volume (V) of the buildings or consecutive building blocks. The surface mentioned includes the floor of the ground level, while wall-to-wall surfaces between adjacent buildings should be excluded. As a result, at the urban level, outer surfaces connected with a similar neighboring house will not be included (no heat exchange between thermal zones assumed at the same indoor temperature)[18].

A cross section of building blocks and different densely built urban areas in the major parts of Athens has been chosen. Overall, we compared in the main different urban contexts characterized by different population per km^2 as reported in Figure 2.9. Within these main urban areas, a further sub-division has been identified to extrapolate areas with homogeneous textures.

[18] The surface-area-to-volume ratio has physical dimension L−1 (inverse length) and is therefore expressed in units of inverse distance. As an example, a cube with sides of length 1 cm will have a surface area of 6 cm^2 and a volume of 1 cm^3. The surface to volume ratio for this cube is thus given by the following formula: SA: V= 6 cm^2 / 1 cm^3 = 6 cm^{-1}. For a given shape, SA:V is inversely proportional to size. A cube 2 cm on a side has a ratio of 3 cm−1, half that of a cube 1 cm on a side. The basic geometric forms have different ratios: the ball is 4.83 cm^{-1}, the cube, as shown is 6 cm^{-1}, a pyramid 7.21 cm^{-1}.

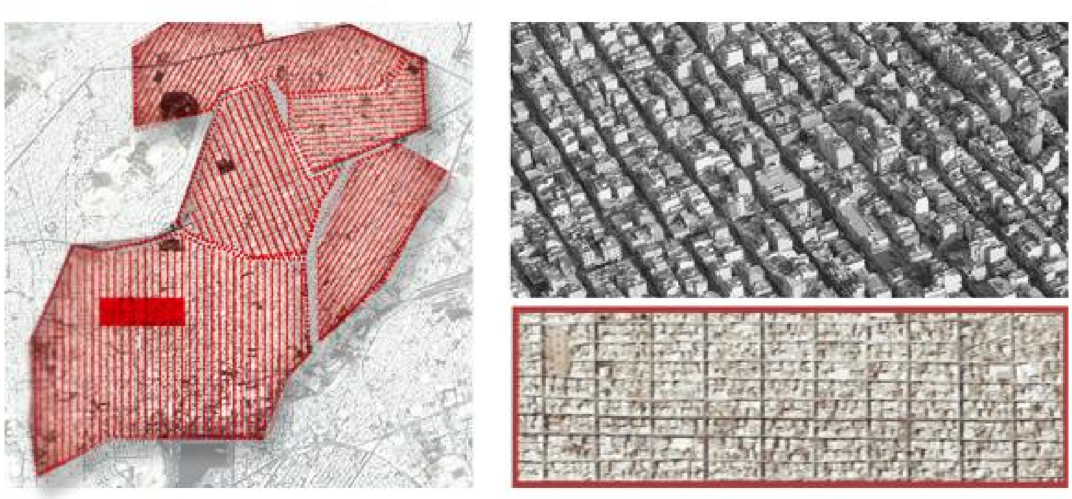


Figure 2.11. Left: an example of "homogeneous areas" at the large urban scale within the Athens Central Area; aerial view (above) and zenith view (below) within the homogeneous district. (Source: Ferrante 2016, re-elaborated by the author)

With the use 3D representation the compactness of these "homogeneous" districts was compared by using the Ae/V ratio for different urban block types. Results are shown in Table 1, a concentrated table referring to all factors mentioned above in order to have a complete image of the different urban zones.

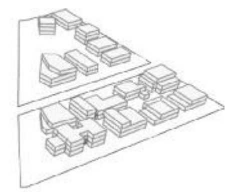
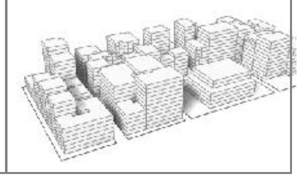
	AMA's selected districts	Inhabitants/sq.km	FAR	(Ae/V)	3D model
Low Density	Kifissia (North)	2.000	0,40	0,28 – 0,68	
	Glyfada (South)	3.200	0,39	0,33 – 0,63	
Medium Density	Aghia Paraskevi (North East)	7.500	1,45	0,38 – 0,59	
	Aghia Varvara(South-west)	10.000	1,05	0,28 – 0,43	
High Density	Peristeri (West)	14.000	1,99	0,27 – 0,45	
	Center	17.500	4,66	0,27	

Table 2.1. Different densities in the six selected representative urban districts

As observed, being the ratio between the envelope surfaces and the volume a building type depending index, a large range of Ae/V ratios' variations has been recorded in similar homogeneous districts. As an example, in the elegant district of Kifissia, north of Athens, both detached houses, villas and residential apartment buildings' blocks are present, thus resulting in the co-existence of houses and urban blocks form very porous to highly compact. On the other side, a similar variation has been encountered in the opposite case of the central Athens area. In fact, given the typical consecutive shocks and discontinuities in the urban landscape of Athens, a large set of envelope area to volume ratio (Ae/V) has been recorded in the same homogeneous district of downtown Athens. Here, if all classical blocks from the last century have a ratio lower than 0,5, the juxtaposition of higher building blocks with lower buildings - either historical or new- increases the amount of external envelopes' surfaces. The ratio of the irregular morphologies ranges from 0,24 in high dense and homogeneous urban courtyards up to 0,58, reaching values which are comparable to low-dense urban districts like Kifissia and Glyfada. (Ferrante, 2016)

Once again, the articulated geometry and the urban morphology depicted in the urban environments of the Athens metropolitan area has highlighted the need for a more detailed, case-study based, exploration of selected urban geometry in localized real urban environments. In the following paragraph additional considerations are discussed to finally identify two potential case studies.

2.3. Proposed and measured rehabilitation procedures on the street level in the center of Athens.

According to Erell et al, 2011, in order to describe the density and the physical properties of the city which affect the local microclimatic conditions, quantifiable measures should be considered. One of most common “spatial unit” that is used by urban planners and physicists in order to identify the urban character of an area and its climatological conditions is the urban canyon. There are three main factors that define its geometry and there are (i) the ratio height to width (H/W), (ii) the orientation and (iii) the Sky View Factor (SVF).

The first one is the proportion of the average building’s height in comparison to the width of the street. The second one is the direction of the urban canyon according the orientation and usually is measured in degrees and last the SVF is simple the sky dome that is visible by a point at the street level

From Figure 2.12, it is visible the connection between the H/W ratio and the sky view factor. It is documented that the higher the H/W ratio the less the SVF consequently leading to a restricted viewable sky from the ground. Cheng et al (2006) found out that a random city layout compared to a more uniform one is more favorable in terms of ‘ground openness’.

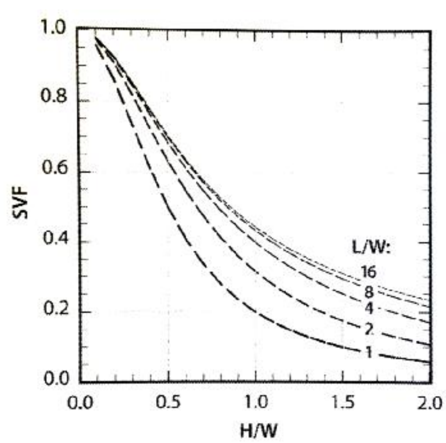


Figure 2.12. The relation between the height-to-width ratio and the sky view factor in a rectangular courtyard. (Source: Erell et al, 2011)

In addition, wind speed and direction are extremely variable in urban canyons (Santamouris et al, 2001). In general, the wind speeds of the urban could be affected by local geometries and micro-scale elements that eventually may result to higher wind speeds (Erell et al, 2011).

Experiments in the Athens central area have been performed (Ferrante et al., 1998) in ten different canyons presenting different layout, orientation, anthropogenic heat and vegetation. These measurements have been performed taking into account the surface temperature[19], air temperature[20] and wind speed[21].

To evaluate the energy saving potential of green and passive techniques in these urban environments considering the specific urban restrictions presented in the AMA, two different rehabilitation procedures have been considered:

1) Passive technological measures related to the envelope of the buildings in existing dense urban areas close to the main circulation axes;

2) Passive technological measures related to the envelope of the buildings added to (alternative) use of outdoor green spaces, courtyards and pedestrian streets like zones that tend to improve the microclimatic existing conditions in urban areas;.

A climatic conscious design of outdoor spaces as well as an appropriate use of natural components are key elements to reduce the effect of the evolution of urban areas where impermeable surfaces, uncovered landscapes and air pollutants produce higher summer temperatures and unhealthy life conditions.

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[19] Surfaces receive short wave radiation as a function of absorptivity and exposure to solar radiation, receive and emit long wave radiation as a function of their temperature, emissivity and view factor, transfer heat to or from the surrounding air and exchange heat via conduction procedures with the lower material layers. Surface temperature measurements performed from the bottom to the top of both facades of the canyon using a step of 3-3.5 m. Additional measurements have been performed in some cross sections of the canyon where different materials are used. All measurements have been performed from the street level. Temperatures of pavement, road and 5 additional points along the width of the canyon were measured.

[20] It is worthwhile remembering that temperature of the external materials in a canyon is governed by its thermal balance. The thermal balance of a surface in a canyon can be expressed as follows: $Q^* = Q_H + Q_G$; Where Q^* is the net radiation, Q_H represents the convective heat exchanges and Q_G are the conductive heat exchanges with the substrate.

[21] Wind speed measurements by means of a three-axis anemometer to measure the three components of the wind speed inside the urban canyons.

Courtyards, streets and outdoor spaces (even if reduced to the shell and envelope of the buildings within existing thickly-built urban areas) can be re-designed by using natural elements (water, green) to improve urban conditions in relation to both microclimate and reduction of pollutants.

The architectural rehabilitation design, by making use of passive cooling techniques like water, appropriate planting and vegetation, proposes alternative scenarios in the main canyons to improve thermal comfort conditions and decrease pollution loads in high temperature in the central Athens areas. The proposals are based on the following strategic objectives (iii):

i) Promotion of all forms of passive natural devices according to the potential effects on minimalizing the localized pollution problems and to enhance urban microclimate. The first step to avoiding problems of poor air quality is to reduce pollution at source by improving efficiency and extracting pollutants. The next step is to ensure that unavoidable pollutants are dispersed safely. A planning strategy to minimize pollution impact is to provide spatial separation of environmentally incompatible activities. Where open spaces and buildings are naturally ventilated, ensure that ventilation air is drawn from a source clear and green;

ii) Maximum increase of permeable surfaces in the outdoor spaces;

iii) Improvement of natural cooling, reducing solar heat gains both in the open spaces and on the building's facades (allowing protection for south east and south west facades by means of shading device systems and "natural filters"). The evaporative and transpiration cooling effects of plants are used to pre-cool ventilation air, both for the buildings and the open spaces. As shown, dense vegetation furthermore helps to filter particles from air;

iv) ensure CO_2 absorption by plants and urban pollutant dispersion by natural ventilation and night cooling.

In the rehabilitation procedure in different canyons, specific proposals involved canyons with different geometrical features, orientation, types of buildings have been hypothesised. In brief, the following strategies have been proposed:

1. Provide spatial separation between polluted areas and open public spaces by means of green pedestrian streets These main streets,

rehabilitated by trees, permeable pavements and watercourses, will provide evaporative cooling and ensure clearer air free of noise and cars;

2. Ensure openings from internal courtyards (where a higher portion of fresher and cleaner air is supposed to be available) towards open spaces and buildings' facades;

3. Increase as much as possible permeable surfaces on the pavements;

4. Provide shadow and filter for the buildings' facades (especially the south-west and south-east oriented ones) by means of selected passive techniques such as pergolas and winter gardens;

5. Creation of planted roof gardens on the bare roofs of the buildings and shaded roof gardens under-planted with shade tolerant plants.

To sum up, the obtained results and the relative mutual comparison clearly indicate that:

- the air temperature inside the canyon is much lower than the film air temperature and the surface temperature on the south-west oriented facades;

- the air temperature in the middle of the canyon is strictly influenced, governed and improved by the presence of green -green line - (which acts as the prior microclimate modifier), while the proposed shading devices do not seem to effect so importantly the air temperature inside the canyon;

- the air film temperature in the south-west facade as well as the surface temperature distribution are very lower in the theoretical shaded scenario - than in the initial one, while, as expected, the presence of green does not influence the surface temperature distribution on the façades of the building.

As a whole, this research study (POLIS, Ferrante) has demonstrated that the redesign of urban surfaces (both in relation to the building envelope and the ground level like streets, courtyards, squares, etc.) acts as the prior microclimate transformer of urban conditions and can deeply improve outdoor air climate and quality.

Nonetheless, the positive effects of each different scenario, as simulated so far, seem to address specifically and differently the various climatic parameters inside the canyon. But, as a matter of fact, the energy potential of proposed architectural measures cannot be analysed separately from an overall comprehensive investigation addressing the combination of the building with the surrounding urban boundary conditions.

2.4. Summer heat island in Athens, definition of the most critical areas as case study

In the context of the heat island research, the city of Athens represents a highly significant pilot study. Here, increasing urbanization and deficiencies in development control in the urban environment have important consequences on the thermal degradation of urban climate and the environmental efficiency of buildings in the Athens metropolitan area. As a consequence of heat balance, air temperatures in densely built urban areas of Athens are higher than the temperatures of the surrounding rural zones.

As will be shown in this paragraph, in Athens the urban heat island (UHI) is the foremost threatening issue affecting the energy demand and the comfort conditions in the built environment of the area. But Athens climate also presents a significant heating demand in the winter period, when will be considered the total energy demand of selected representative areas. In this context, it is important to observe that although Athens presents winter temperatures that are milder with respect to the severe winters of Northern Europe, it also has a significant heating demand in cold winter season[22]. January is on average the coldest month in, with usual temperature around 10°C (50°F), while the average low temperature is 7°C (45°F), and the average high is 13°C (55°F). The lowest ever recorded temperature in Athens in January is -2°C (28°F), while the highest ever recorded temperature is 21°C (70°F). As a combined result of the economic crises and energy demand in winter, a high part of the low income population has been

[22] Athens has a subtropical Mediterranean climate (according to the Köppen Classification) since it receives just enough annual precipitation to avoid Köppen's semi-arid climate classification. The dominant feature of Athens's climate is alternation between prolonged hot and dry summers and mild winters with moderate rainfall. In fact, rainfall occurs largely between the months of October and April (average of 414.1 millimetres of yearly precipitation has been registered. July and August are the driest months, where thunderstorms occur sparsely once or twice a month. Winters are mild and rainy, with a January average of 8.9 °C (48.0 °F). Snowstorms in Athens are generally infrequent (even if more frequent in the northern suburbs of the city) and can cause disruption when they occur.

found unable to cover the housing energy needs and lives in temperature conditions that are heavily outside the comfort limits[23] (Santamouris et al., 2014).

Thus Athens has to be considered as a highly representative case study for energy demand conditions, ranging from significant heating needs and high cooling demand in winter and summer seasons respectively.

Data compiled by various sources by Ferrante (1997) and surveys performed in Athens on the HI intensity -involving more than 30 urban stations- show that during hot summer seasons urban stations present temperatures that are significantly higher than the ones recorded in the comparable suburban stations (the gap varies from 5 up to 15 °C). As a consequence, the cooling load of reference buildings in city center is about twice the value of equivalent buildings in rural areas. Previous research work developed within the frame of the research project POLIS in Athens (Ferrante et al., 1998) have showed some appropriate procedures to design the use of natural components –such as green roofs and pedestrian permeable surfaces - within urban canyons. The design of outdoor spaces -even if reduced to the envelope of the buildings because of existing urban constraints within thickly-built urban areas as well as the use of natural components have been regarded as key means to improve urban conditions in relation to both microclimate and reduction of pollutants. By 'making-up' the building's surfaces and elevation facades with green components or shading devices, four different scenarios have been proposed in four different urban canyons in Athens downtown. Experimental software research models have been used to quantify the positive effects of these selected passive techniques. Obtained results clearly indicated that outer surfaces' alternative design acts as prior microclimate modifier and deeply improves outdoor air climate and quality (up to 2/3 °C reduction in ambient temperature) (Santamouris, 2001). Other significant physical factors in the thermal performance of urban environments are wind flows and air circulation (Santamouris et al, 1999), (Ricciardelli et al., 2006) as well as air stratification within urban canyons

[23] For the whole period of the study (Santamouris et al., 2014), climatic data on the outdoor environment were provided by the National Observatory of Athens. The minimum temperatures were recorded during January 2013, (0.9° C), while the corresponding minimum for December was 5.6° C. The average temperatures for December and January were 11.1°C and 10.5°C, respectively.

and open areas. It is clear that the Heat Island effect and the microclimatic conditions typical of open urban canyons appear to be strongly influenced by thermal properties of the materials and components used in the buildings and on the streets (Bitan 1992, Buttstädt et al., 2010).

The comparative research carried out by GRBES, the Research Group on Buildings Energy and Environmental Studies in the University of Athens, demonstrated that the use of cool colored materials (Synnefa et al., 2007) and thermo-chromic building coatings can contribute to energy savings in buildings, providing a thermally comfortable indoor environment and improved urban microclimatic conditions (Karlessi et al., 2009). Thus, morphological and spatial geometry of the urban textures, the thermal properties of surface coatings and green surfaces have a strong potential on the energy performance and cooling demand reduction in urban settings.

Athens is subject to a strong and predominant “heat island” effect with seasonal temperatures raising (5-7 °C) especially concentrated in the higher densely populated areas of the city center. Here, the moderate sized buildings of the suburbs have been progressively substituted by prominent structures, both considerably high and massive, generally squat and heavy, with a reciprocal proximity which alters the winds’ flow and further increases soil sealing and heat accumulation. While mitigating the winter cold season, the morphological configurations of the central Athens area leads to a drastic climate change during hot summer period, generating extreme high temperatures and consequent hazardous health conditions. Of course, this effect also undermines the energy use; in particular, it negatively affects the cooling need and the same performance of the cooling systems since in the maximum temperatures, the chillers and systems’ performance may decrease up to a quarter compared to the average seasonal efficiency.

As reported by Founda (2011), the urbanization of Athens and its effect on the temporal variation of air temperature have been stressed by many researchers, even in very early studies concerning climatic changes of the city. Most studies carried out up to the late 1980s identified the urban heat island effect on the minimum rather than on the maximum temperature (Arseni-Papadimitriou, 1973; Katsoulis and Theoharatos, 1985; Katsoulis, 1987). The urban heat effect is reported to be more pronounced in winter and is related to the heat produced by human and anthropogenic activities, especially in the evening hours, whereas mean and maximum temperatures are supposed to be less affected by the urban effect due to the influence of the sea breeze (Katsoulis, 1987). In more recent studies, however, it has been reported that the urban heat island effect is manifested mainly in the daily maximum temperature, which has increased significantly during the summer since the mid-1970s (e.g. Metaxas et al., 1991; Philandras et al., 1999; Founda et al., 2004, 2009; Mihalakakou et al., 2004).

Climatic measurements from almost 30 urban and suburban stations as well as specific measurements performed in 10 urban canyons in Athens, Greece, have been used to assess the impact of the urban climate on the energy consumption of buildings (Santamouris, 2001). It is found that for the city of Athens, where the urban heat island (UHI) intensity exceeds 10 °C, the cooling load of urban buildings may be doubled, the peak electricity load for cooling purposes may be tripled especially for higher set point temperatures, while the minimum COP value of air conditioners may be decreased up to 25% because of the higher ambient temperatures. Regarding the potential of natural ventilation techniques when applied to buildings located in urban canyons, it is found that, mainly during the day, this is seriously reduced because of the important decrease of the wind speed inside the canyon. Air flow reduction may be up to 10 times the flow that corresponds to undisturbed ambient wind conditions. Thus the UHI in Athens was found to have a stronger effect on the daily maximum summer temperature (up to 10-15 °C for urban and rural/suburban regions); (Santamouris, 2001; Santamouris, 2007, Livada et al., 2002).

Using an ensemble of regional climatic scenarios, Founda and Giannakopoulos (2009) have illustrated that, by the end of the century, maximum and minimum summer air temperatures in Athens are expected to increase by approximately 4 °C with respect to 1961–1990. It is also reported that the exceptionally hot summer of 2007 is likely to be the 'normal summer' of the period 2071–2100.

Many are the studies, the measurements and calculations in the AMA that confirmed the existence of a strong Heat Island (HI) phenomenon (Mihalakakou, Flocas, Santamouris, & Helmis, 2002; Mihalakakou, Santamouris, Papanikolaou, Cartalis, & Tsangrassoulis, 2004; Santamouris, Mihalakakou, Papanikolaou, & Assimakopoulos, 1999).

The association of the Heat Island (HI) with synoptic climatic conditions have been identified (Livada, Santamouris, Niachou, Papanikolaou, & Mihalakakou, 2002) and the influence of the surface temperature and wind conditions have been analyzed in literature (Papanikolaou, Livada, Santamouris, & Niachou, 2008; Stathopoulou et al., 2009). In parallel, the impact of various mitigation techniques involving cool and reflective materials has been identified (Doulos, S, & Livada, 2001; Karlessi, Santamouris, Apostolakis, Synnefa, & Livada, 2009; Synnefa, D, Santamouris, Tombrou, & Soulakellis, 2008; Ferrante et al., 1997, Santamouris, 2001, 2007, 2010, Giannopoulou et al., 2010). As already stated, all performed research studies on this subject -referring to the 'urban HI intensity' as the maximum temperature difference between the city and the surrounding area- demonstrate that the Athens Metropolitan Area (AMA) represents a highly significant pilot study: during hot summer seasons (corresponding to the HI upper limit during) urban stations present temperatures significantly higher than the ones recorded in the comparable suburban stations (the gap varies from 5 to 15 °C).

Furthermore, a detailed statistical analysis of the heat island characteristics and distribution in the greater Athens area has been carried out (Giannopoulou et al., 2011) using temperature data of 25 stations distributed on the city.

The presence of the mountains Egaleo at the western part and Parnitha at the northern part and also of the mountains Penteli and Hymettus at the northern and eastern parts correspondingly, act as the major natural obstacles at the territorial scale, since it is a barrier against the north winds which dominate during the summer period at the Athens area (Etesian winds). In the analysis it is concluded that the higher air temperature values were found firstly at the western part, mainly due to the combined effect of industrialization and poor ventilation given by the territorial natural obstacles before mentioned. Secondly, high temperature values have been found at the center of Athens, due to the traffic and anthropogenic heat as well as to the presence of continuous impermeable surfaces and densely built areas. Conversely, lower values were found at the northern and the eastern part of the greater Athens area (Tables 2.2 and 2.3). According with those results it can be concluded that HI intensity presents its maximum concentration in the center and the western part of Athens area, with up to 5° C with respect to the minimum values.

Area	Station	June	July	August
Center of the city	Athens Univ.	33.9 ± 2.65	35.1 ± 2.95	31.9 ± 1.96
Northern part	N. Erythrea	30.8 ± 2.79	32.4 ± 3.16	31.4 ± 2.63
	Ano Liossia	31.6 ± 2.97	33.8 ± 2.92	32.0 ± 2.10
	Kamatero	33.6 ± 2.61	35.3 ± 3.10	32.1 ± 2.17
	N. Philadelphia	30.0 ± 2.35	32.6 ± 2.39	31.1 ± 1.52
	Maroussi	29.6 ± 2.47	32.0 ± 2.19	30.2 ± 1.48
	Mean	31.12 ± 2.980	33.23 ± 2.994	31.36 ± 2.114
Eastern part	Zografou	30.6 ± 2.54	32.4 ± 2.55	30.6 ± ± 1.78
	Kessariani	32.4 ± 2.99	33.8 ± 2.90	31.5 ± 2.33
	Ilioupooli	32.0 ± 2.47	34.0 ± 2.69	31.5 ± 1.73
	Byronas	32.7 ± 2.79	35.1 ± 2.71	33.5 ± 2.05
	Agia Paraskevi	28.1 ± 1.84	31.0 ± 2.03	30.7 ± 1.47
	Mean	31.17 ± 3.027	33.25 ± 2.930	31.57 ± 2.146
Southern part	Glyfada	29.5 ± 2.67	32.8 ± 2.11	32.6 ± 1.29
	Renti	31.7 ± 3.82	35.9 ± 2.90	36.2 ± 1.82
	Elliniko	30.2 ± 3.57	34.6 ± 2.70	35.9 ± 1.58
	Kallithea	32.0 ± 3.61	35.0 ± 2.12	33.6 ± 1.63
	Mochato	32.9 ± 3.38	35.9 ± 1.85	34.5 ± 1.31
	Mean	31.27 ± 3.608	34.84 ± 2.606	34.57 ± 2.503
Western part	Korydallos	30.4 ± 2.41	33.1 ± 2.12	31.2 ± 1.58
	Agia Varvara	32.0 ± 2.76	34.2 ± 2.31	31.8 ± 1.79
	Haidari	33.1 ± 2.98	34.1 ± 2.55	33.0 ± 2.46
	Egaleo	31.1 ± 2.98	33.8 ± 2.35	32.5 ± 1.55
	Petroupoli	33.3 ± 3.25	36.9 ± 3.22	36.2 ± 1.89
	Peristeri	32.8 ± 2.62	40.0 ± 4.36	40.6 ± 4.37
	Ilion	32.3 ± 3.02	34.5 ± 2.50	34.2 ± 2.93
	Agioi Anargyroi	32.5 ± 3.23	36.1 ± 2.03	34.7 ± 2.67
	Zefyri	31.6 ± 3.38	35.3 ± 2.82	35.0 ± 1.37
	Mean	32.13 ± 3.065	35.33 ± 3.391	34.37 ± 3.618

Table 2.2. Values of monthly maximum air temperature for all monitoring stations and mean diurnal and nocturnal temperature differences from the reference station located in the center of the city during June, July and August. (source: Giannopoulou et al., 2011).

Area	Station	June (day)	June (night)	July (day)	July (night)	August (day)	August (night)
Center of the city	Athens Univ.	159	6	271	20	164	3
Northern part	N. Erythrea	93	0	161	1	99	0
	Ano Liossia	151	1	260	9	167	0
	Kamatero	216	1	294	13	195	1
	N. Philadelphia	86	2	227	13	154	0
	Maroussi	102	1	254	7	107	0
	Mean ± s.d.	129.4	1.0	239.2	8.6	144.4	0.2
Eastern part	Zografou	167	2	218	3	117	0
	Kessariani	147	2	265	9	142	0
	Ilioupooli	136	5	260	9	155	0
	Byronas	188	11	323	50	282	13
	Agia Paraskevi	31	1	173	15	130	1
	Mean ± s.d.	133.8	4.2	247.8	17.2	165.2	2.8
Southern part	Glyfada	66	0	239	13	213	3
	Renti	126	5	299	18	298	4
	Elliniko	92	0	277	3	287	0
	Kallithea	140	42	290	23	248	4
	Moschato	115	11	339	44	297	13
	Mean ± s.d.	107.8	11.6	288.8	20.2	268.6	4.8
Western part	Korydallos	118	5	305	28	177	4
	Agia Varvara	183	6	327	38	197	6
	Haidari	167	8	295	19	198	3
	Egaleo	106	7	265	26	223	4
	Petroupoli	168	5	299	27	245	6
	Peristeri	210	6	349	24	322	0
	Ilion	174	1	311	13	259	0
	Agii Anargyri	168	1	334	17	301	0
	Zefyri	149	1	285	8	278	0
	Mean ± s.d.	160.3	4.4	307.8	21.2	244.4	2.6

Table 2.3. Number of night time and daytime hours in which the air temperature exceeds 30 °C; (Giannopoulou, et al., 2011).

According to Ferrante (2016) concerning the maximum daily air temperature values, it was found that the differences between the eastern and northern stations during June and July and also between the center of Athens and the western stations during July, were not statistically significant. As observed, the northern and the eastern parts of the Athens area present a similar temperature regime as a result of the high percentage of green areas and the absence of industrial zone. On the contrary, the center and the western part of Athens present a similar temperature regime due to the lack of green, the densely built areas and traffic.

The study of the mean maximum air temperature values for each month and for all the stations has concluded that during June higher temperatures are recorded at the center of Athens and also at the western part, while during July and August the higher temperatures are found at the southern and the western part of the greater Athens area.

In this study the distribution of the value of Humidex (H) has been estimated by means of statistical methods. Humidex values have been linked to the probability distribution of the conditions of discomfort (H> 30 H> 40), and the number of hours that the difficult conditions persist (see table 3).

From the study of those cases where H > 40, considering the air temperature, relative humidity and wind speed, it appeared that great discomfort or dangerous discomfort conditions occur, with either very high air temperatures or lower air temperature values, in combination with high relative humidity values (Giannopoulou et al., 2014).

Places	June		July		August	
	T (°C)	RH (%)	T (°C)	RH (%)	T (°C)	RH (%)
Center of the city	27.0 ± 3.7	40.6 ± 14.5	29.3 ± 3.4	43.8 ± 12.8	28.1 ± 2.9	42.3 ± 9.4
Northern part	26.4 ± 2.1	41.3 ± 12.9	28.5 ± 2.1	44.1 ± 14.1	27.3 ± 1.4	38.7 ± 11.6
Eastern part	26.8 ± 2.1	41.9 ± 11.2	29.0 ± 2.0	42.6 ± 11.6	27.7 ± 1.6	40.6 ± 8.5
Southern part	26.9 ± 2.5	48.0 ± 13.4	29.7 ± 1.7	44.4 ± 13.8	29.0 ± 1.3	39.2 ± 9.8
Western part	27.2 ± 2.3	41.6 ± 13.1	29.8 ± 2.0	40.9 ± 12.5	28.7 ± 1.5	39.2 ± 8.9

Table 2.4. Monthly air temperatures and relative humidity in 5 geographical areas of Athens. (Giannopoulou et al., 2014).

Significant deductions (iii) have been drawn from performed measurements and consequent comparative results:

- i) The geographical position of the Athens area and the morphological territorial assets of its boundary conditions characterized by the presence of the surrounding height mountains exceeding 1000 m, contributes to the development of high summer air temperatures in the whole AMA;

- ii) High air temperatures are also reinforced by the increased urbanization, industrialization, anthropogenic heat and the lack of vegetation.

- iii) In particular, during July and August, the mean and maximum air temperatures at the city center and at the western part of the city are much higher than the corresponding values for the northern and north-eastern part of the AMA.

  iv) Furthermore, from the analysis of the mean diurnal and nocturnal air temperatures in all stations and from the difference between them and the reference station located at the center of Athens, it is possible to conclude that HI during the night period is mainly observed at the western part of the city. Thus, the western Athens Metropolitan Area, together with the central Athens, presents the highest heat island (HI) (see table 2.3).

DISCUSSION

Athens experienced an intense urbanization over the last century. This has as a result to the formation of a disorganized urban tissue, with the urban block as a typical urban form and the uncovered space in the middle as one of the main elements of the urban fabric. The dense context of the city with unorganized open spaces and lack of green natural spaces resulted to the creation of the heat island phenomenon, affecting indoor conditions and increasing energy demands, degrading in total the quality of the living environment.(Stanitsa, 2015)

Thus, this growth of Athens, has led to a myriad of environmental problems. The high population density, in addition to a significant number of vehicles, has led to problems of air quality. Traffic remains congested, as the city was not designed in antiquity to handle millions of autos and taxi. Garbage disposal is a problematic area, along with potential pollution of the nearby Aegean Sea. Almost annual forest fires in the Athens region also affect the air quality.

The Greek government is keenly aware of its environmental problems and other problems caused from urban sprawl. The government program to make the Attika region a sustainable area rests on a comprehensive plan that will have to deal with the main problematic aspects: Air pollution, Waste disposal Traffic congestion, Noise pollution, Land use planning, Urban development, Environmental awareness and Appropriate legislation.

Taking under consideration that in dense cities like Athens the majority of the urban environment is already built, as a consequence, the analysis, adaptation and reuse of the existing building mass with the collaboration of the surrounding spaces by acting as a unique form, is a crucial issue in the upcoming years. Addition of complementary urban indoor and outdoor space alternatives are needed so as the city inhabitants could be attached to the social interaction, especially in dense urban contexts such as the city center of Athens.

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CHAPTER III

EXPERIMENTS ON THE OPEN AREAS OF THE URBAN SETTINGS IN ATHENS: EVRIPIDOU & PERISTERI AREAS

ABSTRACT

Urban climate conditions and the local microclimate has been always affecting factors for the urban conditions. That is due to their impact on the environment and energy consumption of the buildings and also to the affect they have on outdoor human comfort. The configuration of buildings is one of the main factors that influence the different microclimates in the city. (Tapias & Schmitt, 2014) The understanding and the manipulation of these conditions of the urban microclimates could lead to the improvement of urban thermal comfort. Thus, by simulations and experiments, and their empirical findings supporting and automated tools created, will open a new way in exploring a new design approach of urban forms according to microclimate data and the building geometries.

An interaction of the urban model and the building thermal performance, it is a leading step towards the clarification and better knowledge of the consequences of that interaction on energy requirements for winter and summer, and even on urban comfort. Finally, as a second step by focusing at the building scale, a new methodology should be developed so as to evaluate the impact of the microclimatic modifications in the building energy demands and the influence of the climatic modifications due to the urban context, upon the complete building.

This research aims to understand the influence of built environment in microclimatic variations of the open spaces in the city center of Athens and on a west suburb, Peristeri, with the intention to identify design strategies for future urban designers. This chapter is organized in two main paragraphs with the first focusing on simulations with Envi_Met of both case studies by proposing two different scenarios (1.as it is and 2.use of green and passive techniques) and the second concluding by comparing and confronting the results.

3.1. SIMULATION IN THE URBAN SCALE WITH THE USE OF ENVI-MET

Simulation is a process that by imitating a real situation can verify, find or explain a theory. The design perspective defines simulation as the creation of past, present, or future scenarios, representing interaction of crucial parameters and variables.

It is well known that modeling a built environment project may help to visualize its future impact and is an important part of responsible design decision-making (Erell, Pearlmutter, Williamson, 2011). In urban climatology there are three known types of modeling methods: physical scale models, integrated open-air models, and mathematical models. Computer programs by simulating the physical environment can produce a real word environment and we can use this knowledge in order to identify some situations. However, all types of models need validation, and because of the deficiency of well-documented high-quality data from field studies, this remains a major problem for most urban climate models (Erell, Pearlmutter, Williamson, 2011). In terms of outdoor thermal comfort, there is the need for a predicting tool by means of urban climate models and tools. Although people’s subjective perceptions and responses to the urban environment are various and not yet well understood, simulation and scenario-testing tools are always of particular importance in an assessment framework because they provide a platform for the integration of knowledge from various perspectives and comparisons of various design scenarios (Chen & Ng, 2011). These support tools can lead the research to identify how changing the design can influence the microclimate and as a consequence the outdoor thermal comfort. The general statement of this research is how urban design can influence the microclimate of an urban environment, people’s outdoor thermal comfort and also if can influence the energy performance of a building, as it is considered as a whole. Urban tissue and building envelopes are investigated in the way they interact with each other according to design changes and the microclimatic data changes. Design regulations and guidelines in this respect require comprehensive assessment before they are adopted.

Thus, city planners and authorities, when have to deal with the task of designing or redesigning urban spaces that are meant to be desirable and used rather than abandoned, will be better informed with the use of a predicting tool or a strategy that allows various design alternatives to be compared and tested in terms of effectiveness. In particular, a testing tool is needed that can provide both quantitative and qualitative understanding of the connection and interaction among microclimatic urban environment, subjective thermal behavior, and social behavior. Such a strategy should have the ability to process detailed environmental information according to time and location variations and to generate analytical results to reveal the relationship.

On how our approach in understanding the urban microclimate and apply it in practice for urban planning it is not an easy task to achieve, as trying to respond to different criteria of urban microclimate might lead to contradictory requirements. However, microclimate has an effect on a very broad range of issues encompassed in the field of urban planning and design. The different effects of urban microclimate in urban planning and design can be divided into two categories. On building scale the effect of microclimate on their energy performance and on human scale the effect on their activity, especially at street level and at the spaces named in the previous chapter as urban voids.

This research makes use of ENVI-met, an environmental and micro-climatic simulation software. It represents one of the main instruments of this research, especially for the urban scale, as it allows to model urban areas and their physics behavior and as a result to understand the possible interactions between the different elements in the studied zone.

ENVI-met is a three-dimensional computer model which analyzes micro-scale thermal interactions within urban environments. The software uses input values for buildings, vegetation, ground surfaces, climatic conditions, soils, and then simulates the modifications from the proposed building form, additional shading, alternative orientations, etc. Additionally, uses both the calculation of fluid dynamics characteristics, such as air flow and turbulence, as well as the thermodynamic processes taking place at the ground surface, at walls, at roofs and at plants. It calculates the dynamics of microclimate during a two days period. Main prognostic variables of the program are wind speed and direction, air temperature and humidity, turbulence, radiative fluxes, bioclimatology and gas and particle dispersion. The basic data structure of ENVI-met is represented in Figure 3.1.

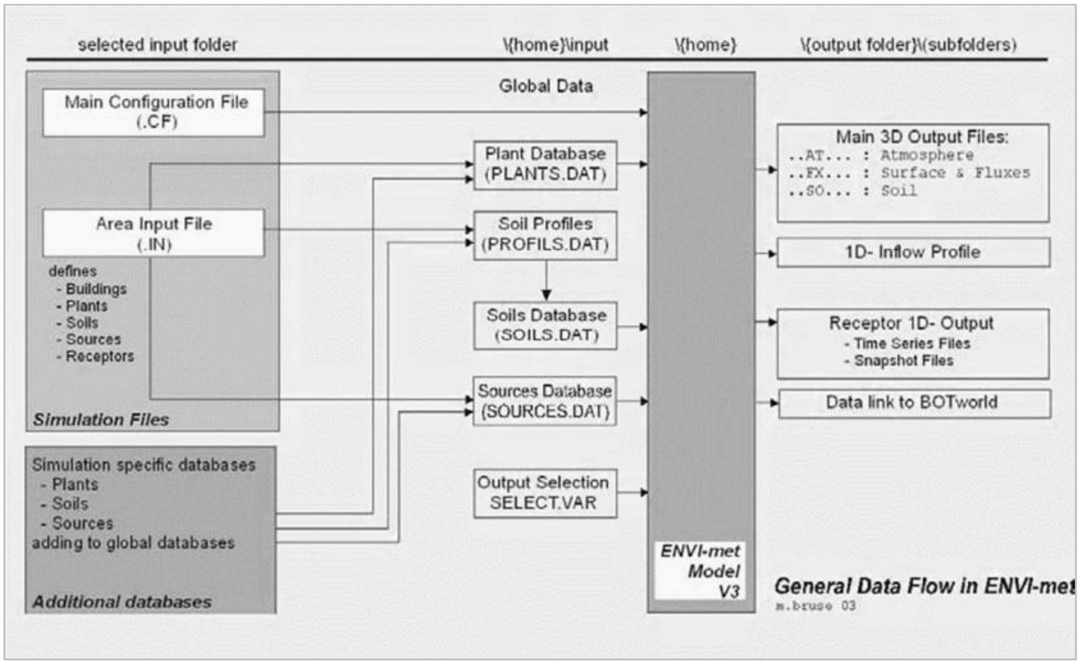

Figure 3.1: Basic data structure of ENVI-met (Source: Ozkeresteci, I., Crewe, K., Brazel, A.J. and Bruse, M. 2003)

ENVI-met takes into account all types of solar radiation (direct, reflected and diffused) and calculates the mean radiant temperature. The calculation of radiative fluxes includes the plant shading, absorption and shielding of radiation as well as the re-radiation from other plant layers. (Bruce 2007).

ENVI-met has two basic steps before the simulation is run. The first is to organize and edit the input of the urban area to be tested. For this task, the horizontal and vertical dimensions of the architectural environment are needed and additionally all the specific design urban features such as open breezeways, overhangs, horizontal surface materials, ground cover, vegetation size etc. In Figure 3.2 follows an explanatory diagram of how the input is understood by the software.

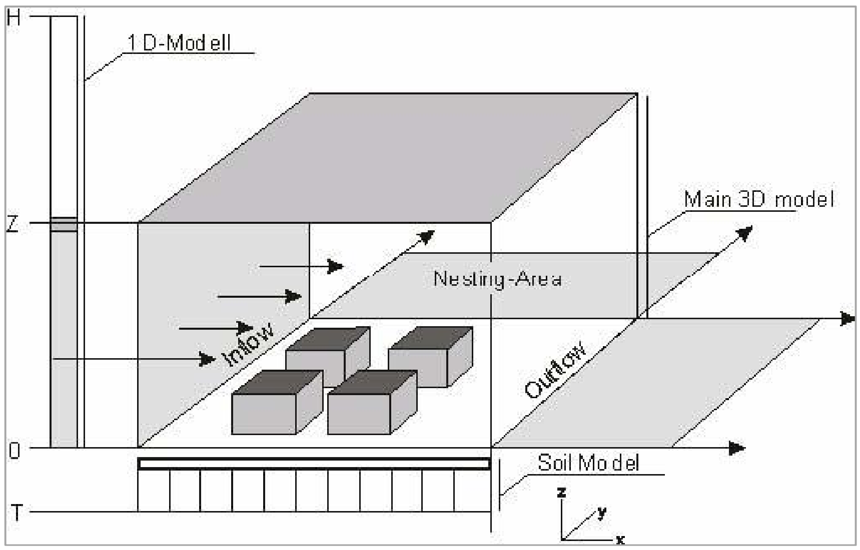

Figure.3.2 Basic layout of the fluid dynamics of the ENVImet model. (Source: Bruce 2007)

The input is designed in a three dimensional (3D) setting where the buildings, trees/vegetation, and the various surfaces are placed. These elements are represented by various size grid cells. The smaller the cell is, the finer the resolution (as small as 0.5 meter). But there is a limit for the design as the grid area can be designed at any dimension from 0.5 meters to 10 meters. For example, a 100 x 100 meter area can be represented in a 100 x 100 grid cells of 1 x1 meters each, or it can be represented by a 20 x 20 grid cells of 5 x5 meters each, depending on the size of the test area and the desired resolution. (Bruse 2007). This stage can be quite complex as the high-resolution aspects of the program enables the user to go into finer details in smaller scale. Each time it depends on the envirometal domain that is interested in doing the simulation. For example an urban planner that will focus on materials and detail design will use a higher resolution analysis of the model.

After the input of the area is set, follows the second step which needs detail information and careful editing. It is called the configuration file, where all the necessary and important climatic information about the site location, temperature, wind speed, humidity and also type of soil and vegetation are required. As a further step a holistic simulation of the selected area is processed by using both the input and the configuration file. All ouput data in order to be visualized and analyzed by the researcher should be imported and elaborated in LEONARDO 3.0.

3.1.1 Evripidou Urban Setting: measured climatic data and simulation on the scenario as built and the scenario proposed with the use of green and passive techniques

Athens by being the capital city of Greece is also dominating the Attica region with a population (5 millions) that reaches half of the total of the country’s and its characterized by a long history, part of which can be read in its urban formation. The current formation of the city center is due to the neoclassical plan of Kleanthis and Schaubert as it was mentioned in Chapter II, back in 1833. In the contemporary city fabric, the first plan which reflected the neoclassical vision of the Europeans for Athens as the renaissance of the classical ideal is not only visible but it has generated the city’s further expansion towards the suburban areas. Additionally, as it is already stated, this area along with the suburb of Peristeri present the highest heat island (HI) intensity of the whole city. For these reasons, especially the dense urban character and for the intense climatological environment the center of Athens represents one of the most interesting and challenging case studies of Europe and especially for the Mediterranean area. (Figure 3.3)

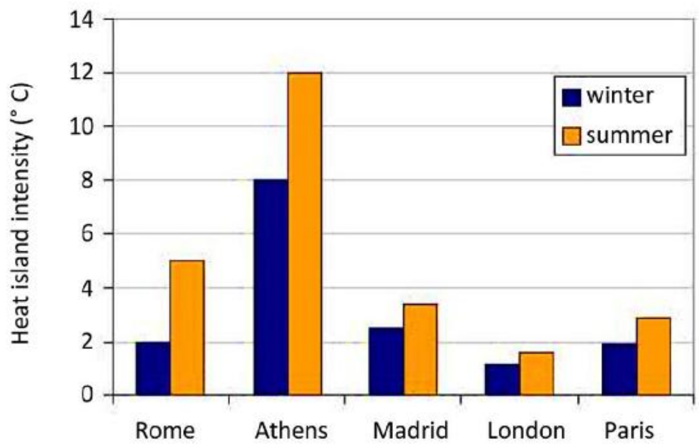

Figure 3.3: Heat island comparison among various European capitals. (Source: Alexandri, 2006)

The selected area for this research, as the first case study that will be studied, is as it is called the 'commercial triangle' which is the area around Omonoia square and its surrounding districts. The choice was based on the historical character, the importance of this neighborhood as central urban cell and the visible contradictions between the various -small in size but of major important- surroudning neighborhoods. This area is characterized of high population density and also urban density as the streets are very narrow and the buildings very high and dense. Some of the main streets, axes of this area is Pireus street, Ermou Street, Evripidou and Athinas Street. (Figure 3.4) Among the locals it is called the Geraniou zone or Psirri neighborhood for the majority of the habitants. This part of the city evidence car circulation difficulties due to the narrow street design, high traffic and lack of parking spaces. However the difficulties, Psirri is one of the most visited and active area of the center of Athens; during the day and all along the weekend shops of retail, wholesale commerce as well as cafeterias and restaurants keep the traffic on, while during the night the place gets occupied by people of almost every age and status. There is significant nightlife but also with the presence of dangerous elements that generally characterize the center of a metropolis.

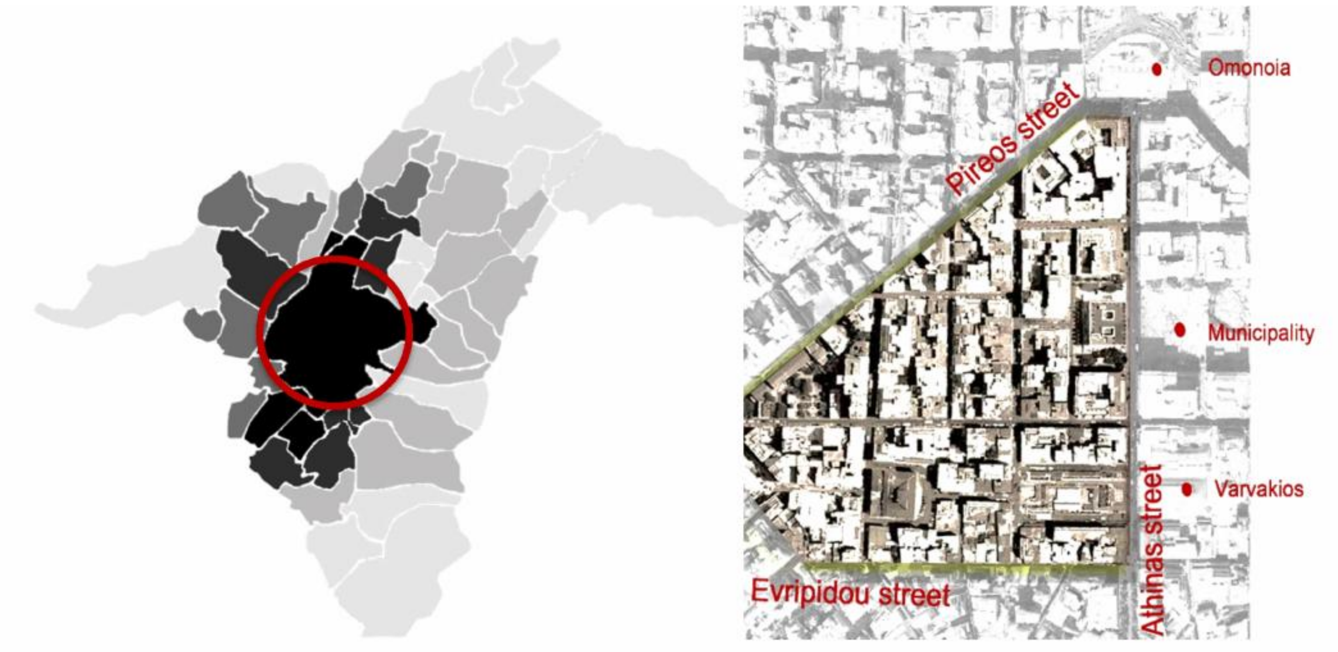

Figure 3.4. Indication of the center of Athens in the map of Attica and the selected part of Psirri area.

The urban zone selected as the reference case study of Evripidou is representative of the dense built historical area in the core centre of the City; more specifically, the selected area is also enhanced by the presence of many public services like the Municipal Hall, several Civic and Administrative offices and Central Athens Market, Varvakios market, which is the main local alimentary market with great historical importance.(Figure 3.5). The total surface of the area is 105.116 m^2, of which 99.607 m^2 is occupied by buildings and infrastructure, while the remaining 5509 m^2 are small green spots and courtyards as fragments between the buildings.The majorities of these buildings blocks present one floor for retail at the ground level. The type of construction period of the majority of the area holds back to the 65s and 70s for almost all buildings with exceptions of some older buildings, dating back to the 40s and some buildings from the neoclassical period in Athens.

To simulate the cooling potential of green in the urban setting of Evripidou, a series of simulations were executed with the use of ENVI-MET by taking into account the existing situation of the urban compound and as a second step simulations were executed with the data of a new proposed improved scenario of urban design with extended use of green, passive techniques, proposal of new surface materials etc.

The main goal here is the investigation of micro-climatic variations linked to modified parameters and their impact on buildings. The focus of the analysis is, in particular in this case study, on the possible replacement of parking spaces distributed along the narrow streets with green layers. The possible re-organization of the traffic so as to eliminate the circulation of the cars from some secondary streets and create pedestrian streets with the presence of trees and green. The change of asphalt and cement materials with light pavement tiles proved to decrease the surface temperature. Re-organization of the main axes (Athinas street) so as to create limited access of cars, eliminating the parking spots and creating more green surfaces. Re-design the square of Varvakios market, in order to plant more trees, green surfaces, water fountains and as a result create a small local park as a green zone. There is a huge absence of parks and trees in the area so the idea is where it is possible to redesign the urban texture and to create small green pockets. The same scenario is proposed for the Municipality square which is in a very small distance from the studied area. As a last step but very important is the use of the 'blind' walls in between the buildings and transform them into green walls as also the standard roofs with green ones and of the creation of roof shading systems with the use of photovoltaic system. According to a survey very few roofs are used as roof gardens till now in that area.

A packet of simulations has been modeled for this elaboration, based on reliable standard contest of the urban complex of Evripidou area. Variations in the 3d simulation models were performed concerning the addition of green spaces, the replacement of standard roofs with green ones (from 0 to 100%) and the reorganization of the car circulation in order to leave open asphalt areas that become, in a second step, permeable and planted green surfaces. In addition, one of the most important steps for the simulation of the new scenario is the creation of roof shading (from 0 to 100%).

Investigations are focused on the thermal variation resulting at the scale of the urban contest.

For the model simulations, the area of interest has been transformed in a model grid cell, with the dimension 90 x 90 x 30 grids with a resolution of 2 m x 2 m x 3m resulting in a total area of 180 x180 m in the horizontal extension and 90m in vertical extension (Figure 3.4 & Figure 3.5). The digital map data for the area was obtained by google earth but additional surveying took place to correct changes. ENVI-met uses its own graphic interface, therefore all cartographic information had to be gathered first on a digital map and then redrawn in ENVI-met‘s own graphic editor for the modeling language.

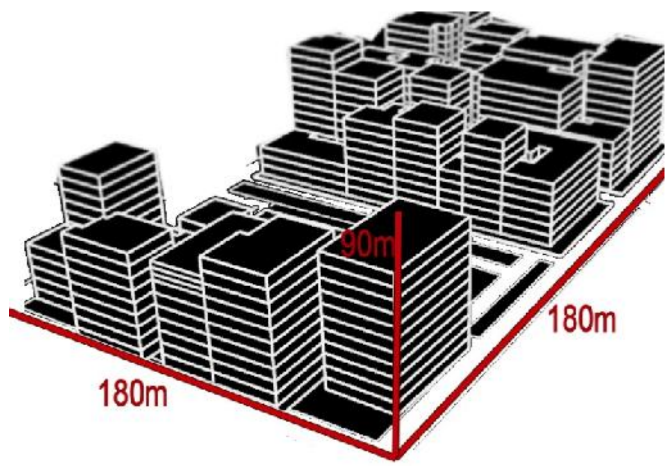

Figure 3.4. The Evripidou urban selected area in a 3D Interpretation.

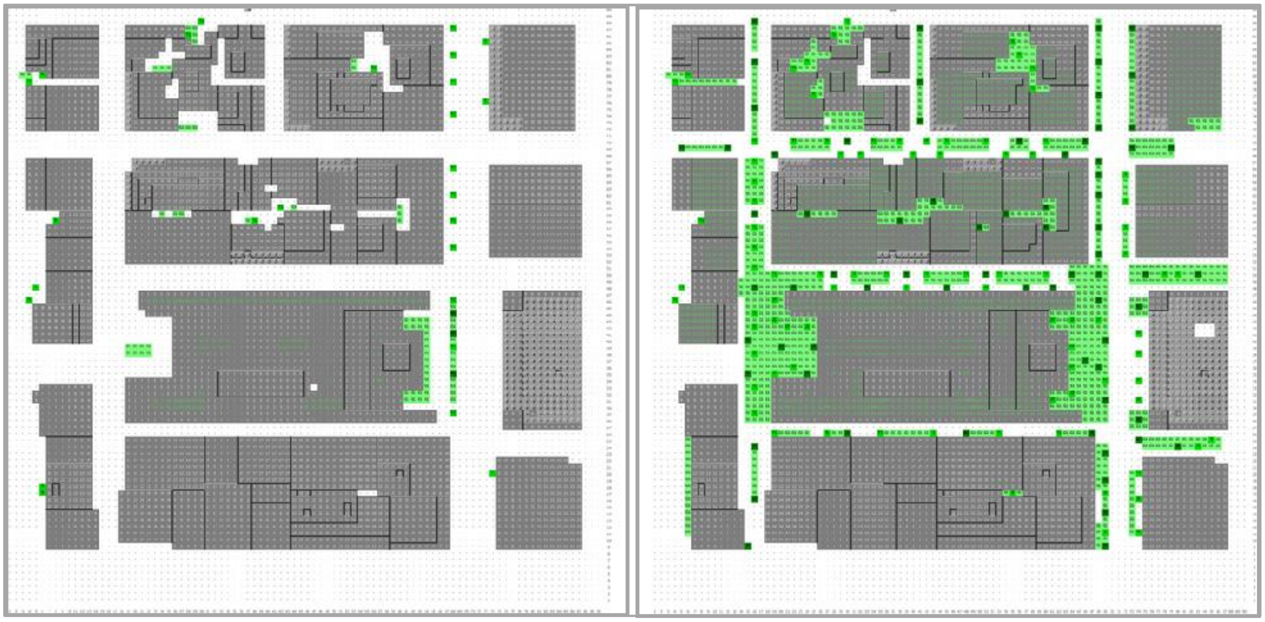

Figure 3.5. The Evripidou urban compound in the Envi-met 2D digital Interpretation in the as built (existing on the left) and as the alternative scenario (proposal on the right)

The meteorological input of a year period (2014) recorded by the urban climate station in the center of Athens plus a serious of measurements performed by the university of Athens and the department of Physics (Santamouris, 2014) was applied. For the simulation for both the existing situation and the alternative scenario, it was selected the hottest day of the summer of 2014 (9 of July) with mean Temperature in 30.1 C while the maximum is 34.7 C. The wind is in southwest direction with an average speed of 1.1 m/sec.

The lack of green spaces, lack of pedestrian streets, the high temperatures measured to the ground surface as well the high air temperature plus the indication of uncomfortable thermal sensation are some of the problematic issues that were evident in this urban setting and are the main problematic elements that the urban planners have to consider about. From the first analysis and simulation performed for a period of one day of the existing situation, the results show the need of action for drastic measurements to be taken into consideration

In a second step, it is proposed the analysis and simulation of alternative sustainable scenarios that could help into the improvement of the existing situation and come a step closer to the main goal of this research, which is the zero energy urban settings. In a brief these actions that were mentioned above are:

- Addition of trees and green surfaces on the ground level.
- Green vertical and horizontal elements (green roofs and green walls
- Shading system with photovoltaic elements on the top roofs
- Reorganization of the parking spaces and creation of pedestrian permeable streets with the change of the material used for the existing pavements
- Local park by the redesign of the square of Varvakios market

It has to be underlined that the redesign of a dense urban area like Evripidou, shows difficulties and as a result different measures and factors should be taken under consideration. Main traffic axes (like Athina Street) could not change into a pedestrian street as a whole. Different approach should be considered and proposed. In this scenario, Athina street from high traffic is transformed to a low traffic venue accessible only by public transport. Smaller perpendicular streets completing the context are transformed in pedestrian street with organized parking plots, green spots and open public spaces. (Figure 3.6)

The following figures/ maps visualize the model of the area in different conditions. The results indicated below, refer to the variety of the difference of the temperature on the surface and also the change of the temperature in different levels between the two scenarios.

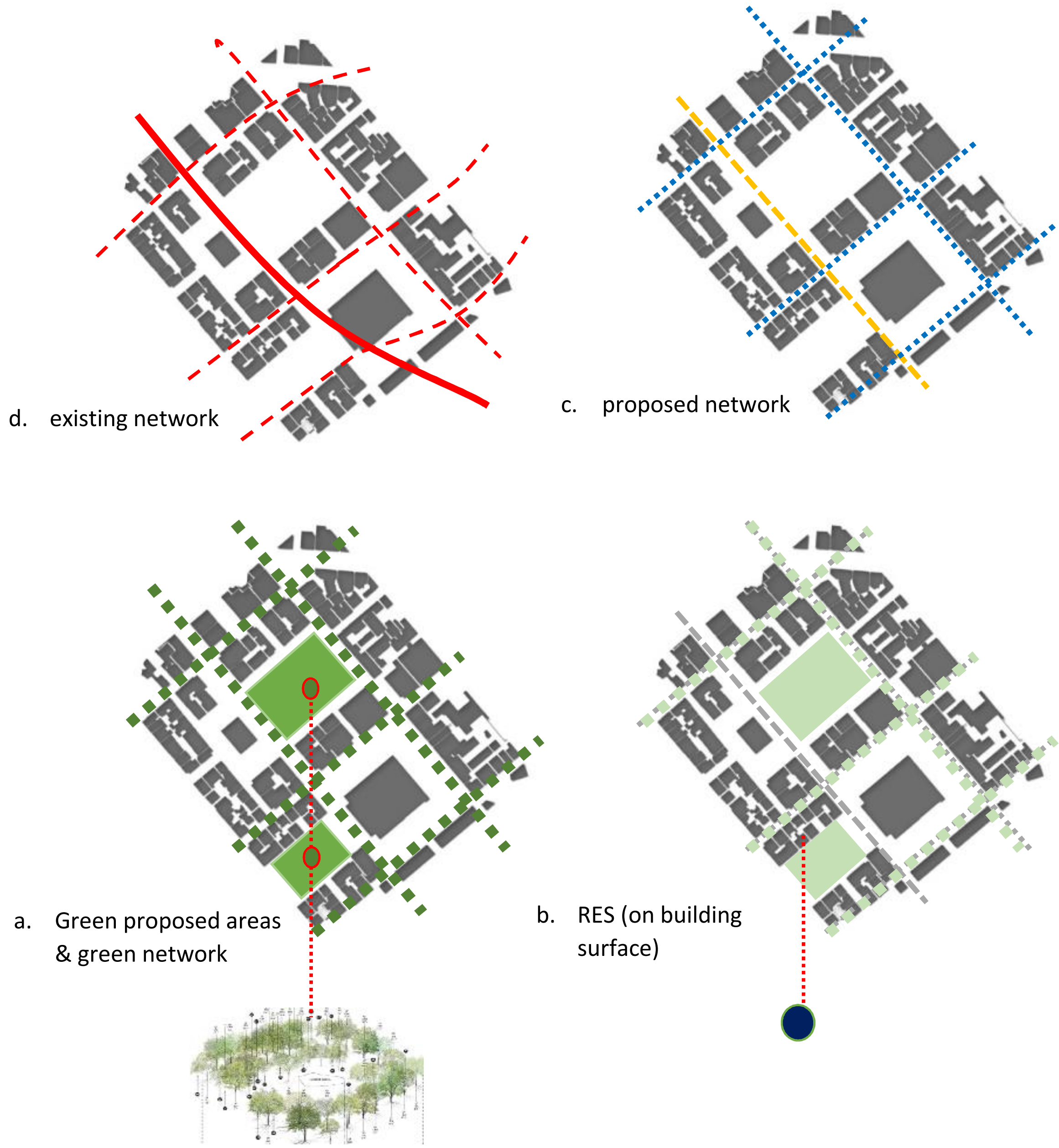

Figure 3.6. Diagram explaining in basic steps the urban strategy followed for the simulation

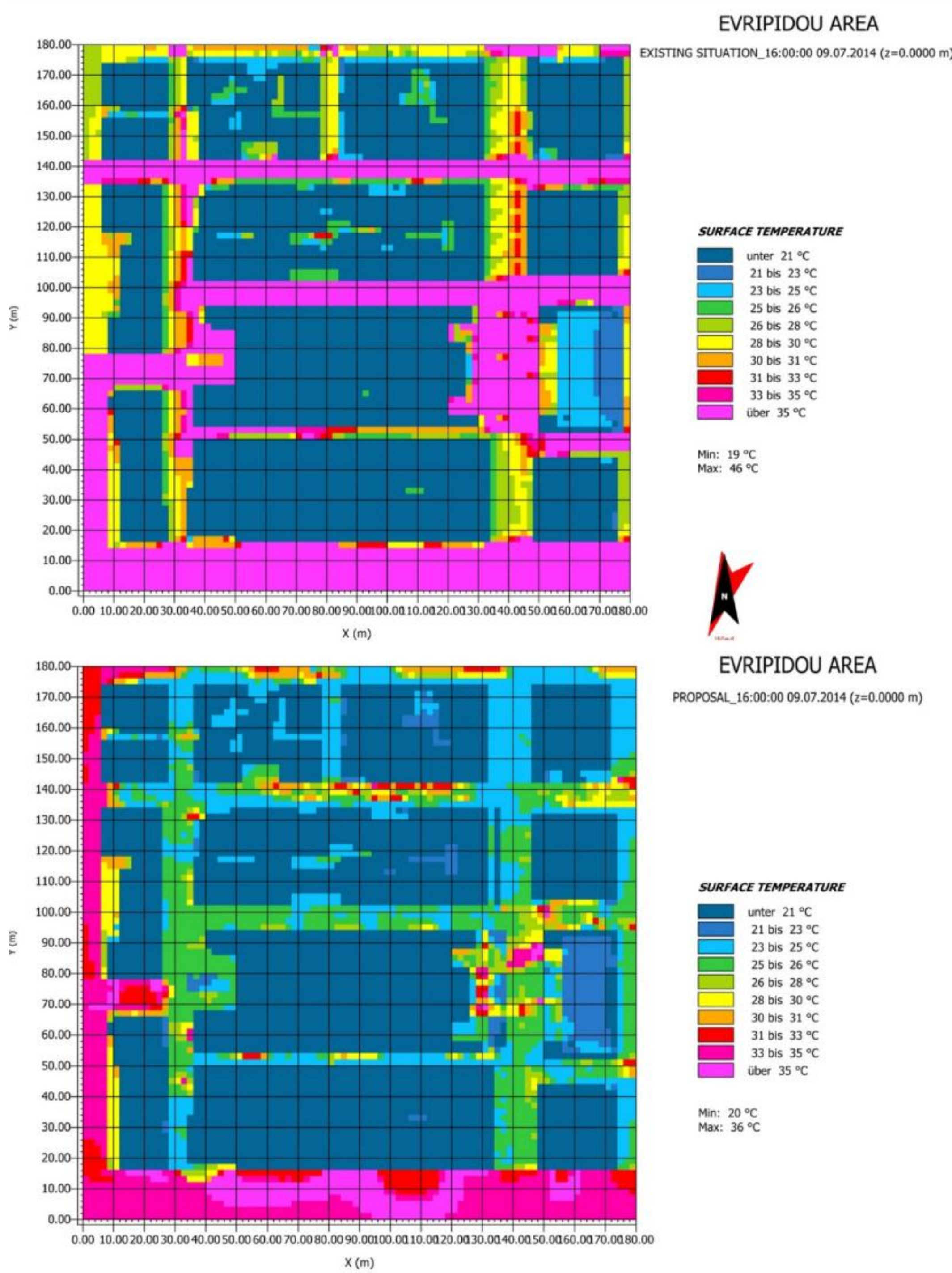

Figure 3.7. Envi-met: Results of the surface temperature at the ground level at 16.00 pm for the existing situation and comparison with the proposal.

Introducing parks instead of asphalt areas lead to a fresher air. Temperature decreases generally in a range set from 0,25 to 1,5°C, locally the difference can be 4 °C degrees, especially in the internal courts between the buildings. The addition of trees and the use of new materials also lead to a significant reduction on the surface temperature on ground level difference in surface temperatures can be more than 15 degrees. The replacement of standard roofs with green ones does not lead to a significant variations in temperatures; the maximum decrease is of 0,7°C while with the existence of shading system in the roof can reach a decrease of 1,2 °C. The use of experimentations consisted of two brief studies of the area.

For the environmental simulation with Envi-met, the same climatic data and maps where taken into account. To compare and discuss in further detail here it is provided the results of the simulation of the combination of all the proposed scenarios. It was hypothesed that the proposed scenario was executed by adding low vegetation and trees, adding green walls and green roofs were it was applicable, pedestrian streets were created and it was proposed a local park replacing the actual square of Varvakios market.

This stage is used to explore calculation and visualization potentials of the model plus also helped the researcher to hypothesize on the certain factors, of the model itself and of certain characteristic of the urban compound Variations imply a different microclimatic behavior in the models. Introducing parks and pedestrian streets with the use of new materials in place of asphalted areas lead to a fresher air. The biggest decrease was situated at the private courts between the buildings while in general as the air temperature was studied in different heights it is shown a decrease of 4%-9% from the initial temperatures.

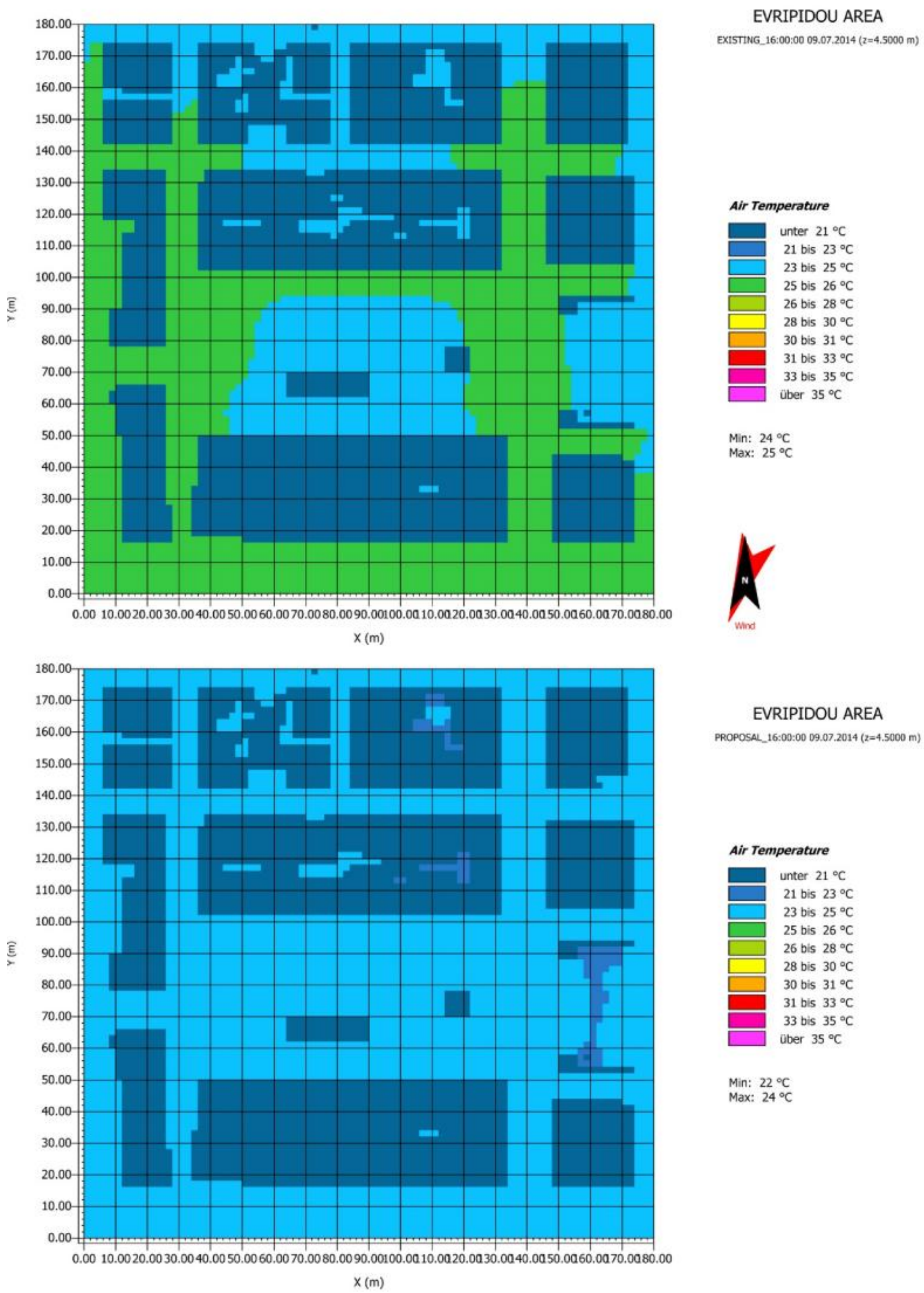

Figure 3.8. Envi-met: Relative decrease of the air temperature between the two different scenarios at a height of 4.5m at 16.00 pm.

By analyzing the previous figures (3.7 & 3.8) it is a fact that the temperature of the surface on the ground level is reduced up to 15 degrees to the majority of the area. Results show high consistencies with previous studies discussed earlier.

Selection of trees and vegetation should be made according to the dry and warm climate of Athens. Especially for summer period and the center of the city where the climatic conditions are more particular (high temperatures, dry season, mild wind, narrow streets, tall buildings). Plantation with big crown was considered to provide adequate shade but while requiring few water for irrigation. Taller trees seem more adequate as the leave the level of the pedestrians without obstacle for the circulation of air. The replacement of standard roofs with green roofs and in combination with the use of a shading system on the rooftop showed a significant decrease (about 1.5°C- 2°C).

Actually, in the current as-it-is scenario, shade is not provided due to the lack of vegetation in the area and the free spaces between the buildings. The presence of the trees is assumed to be increased and enhanced by the redesign of external surfaces, increasing the permeable surfaces and reducing the asphalt area as much as possible. There is a significant temperature reduction on the surface of the ground level due to the use of new materials and the shading provided by the vegetation. By the measurements around the central building, resulting air temperature reduction is between 0.9 to 4 degrees, with e mean reduction at 1.2 degrees, while a lower reduction is observed to the west and south part. Although it is noticeable that with the replacement of the existing square with a park (green area) on the south part of the building , helped to achieve almost equal reduction as with the north / east oriented facades.

Based on several studies, temperature reduction in a treed urban environment can reach up to 4 ○C and it depends on the size of the park, the amount of trees and grass cover in the park and the choice of species. In addition to parks, street trees could influence air temperature significantly. There is evidence that air temperature beneath both individual trees and clusters of trees are lower than temperatures in an open area, at least during the day. Green roofs are an additional means of mitigating Urban Heat

Island effect. Green roofs mitigate UHI trough removing heat by evapotranspiration, decreasing heat absorption and also reducing the need for air conditioning. Therefore, it is concluded that urban greening is an efficient method in order to mitigate urban heat island effect and human health consequences of increased temperatures resulting from climate change and hence, improve quality of life in urban areas. (Nastaran Shishegar)

3.1.2. Peristeri Urban Setting: measured climatic data & simulation on the scenario as built & the scenario proposed with the use green and passive techniques

Modern cities have a number of problems. Residents fled and continue to fleebefore them out of the city to the suburbs. Suburbs, which are almost as long as the city itself, at the time was the area that is a highly organized buffer between city life and nature and the countryside. At the same time it was space which eventually subject turned on or absorbed by the city. Contemporary suburbs, which grew to the size of comparable cities, cumulate a number of old problems of urban areas, but also produce new ones, specific to their satellite location, generated by diverse factors, including development of technology and the expansion of technology. Suburbs are no longer just for residential areas or small manufacturing and trading distant from the city center. They are also exclusive industrial areas, parks so characteristic of zoning functioning in spatial planning no major obstacles to the 80s. Low land prices have become just as attractive for people looking for a place to live and for the industry. In the wake of them also trade and other services entered a phase of migration from urban centers. In addition, the development of both the urban and surrounding satellite towns and cities make less and less urban planning for greenfield and more and more transformation parameters of existing urbanized environment. Therefore, the suburbs have become, just as city areas, a conglomerate of areas built and used in a various way.

Peristeri is located in the western part of Athens, as this area along with the center presents the highest heat island (HI) intensity of the whole city. Is after Kallithea, the biggest and the second denser suburb of the Attica region.

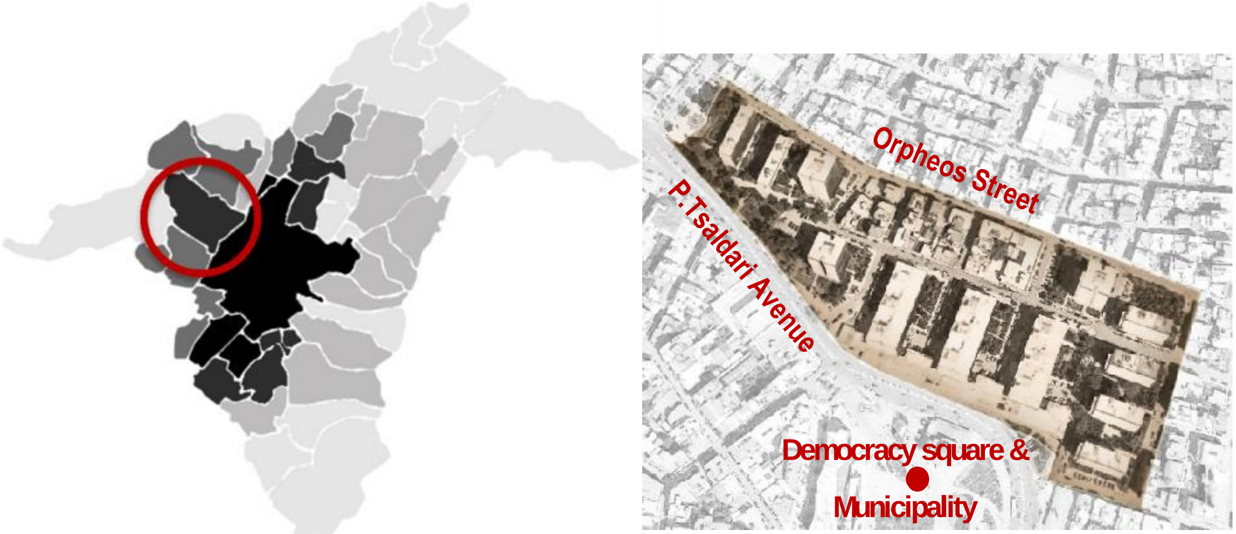

Figure.3.10.1. Indication of the Municipality of Peristeri into Attica Map

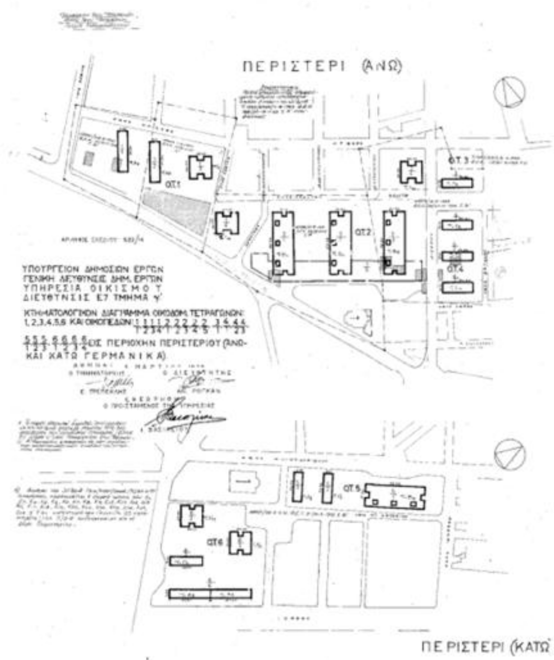

Figure.3.10.2. Original map of the area (source: Municipality of Peristeri)

The blocks of buildings that are the case study of this area, are typical social housing from the 60's constructed by pillars and beams, and as a basic structure material concrete. It is parted by: the 3 tower buildings(marked in blue), the 3 double block buildings south north oriented (marked in red) and the four east west oriented blocks (marked in yellow)(see image below). Focusing on urban areas, the proposed research considers the buildings and the related space as a whole. The urban compound extension is 37'820 m2, of which 25'713 (68%) is occupied by building construction and impermeable surfaces (parking areas and streets); the remaining (% 32) is a green open area. The built area represents the 29% (7'504 m^2) of the total impermeable surfaces.

To simulate the cooling potential of green in the urban setting of Peristeri, a series of simulations were executed with the use of ENVI-met by taking into account the existing situation of the urban compound and as a second step simulations were performed with a proposed scenario of improved sustainable urban design

The main goal here is the investigation of micro-climatic variations linked to modified parameters and their impact on buildings. The focus of the analysis is, in particular, on the possible replacement of parking areas with green parks and pedestrian streets, of standard roofs with green ones, of vertical walls to green ones and of the creation of roof shading systems with the use of photovoltaic system.

A packet of simulations has been modeled for this elaboration, based on reliable standard contest of the urban compound of Peristeri area. Variations in the models concern the replacement of standard roofs with green ones (from 0 to 100%) and the reorganization of the car circulation in order to leave open asphalt areas that become, in a second step, permeable and planted green surfaces. In addition, one of the most important steps for the simulation of the new scenario is the creation of roof shading (from 0 to 100%). Investigations are focused on the thermal variation resulting at the scale of the urban contest. Introducing parks instead of asphalt areas lead to a fresher air (temperature decreases generally in a range set from 0,25 to 1,5°C, locally the difference can be 3 °C). The replacement of standard roofs with green ones does not lead to a significant variations in temperatures; the maximum decrease is of 0,7°C while with the existence of shading system in the roof can reach a decrease of 1,2 °C.

For the model simulations, the area of interest has been transformed in a model grid with the dimension 130 x 120 x 30 grids with a resolution of 2 m x 2 m x 3m resulting in a total area of 260 x 240 m in the horizontal extension. The digital map data for the area was obtained by google earth but additional surveying took place to correct changes. ENVI-met uses its own graphic interface to plot the layout of the area, and its own configuration editor for the climatic data plus the plants, soils, and sources databases. Therefore all cartographic information had to be gathered first on a digital map and then redrawn in ENVI-met‘s own graphic editor for the modeling language.

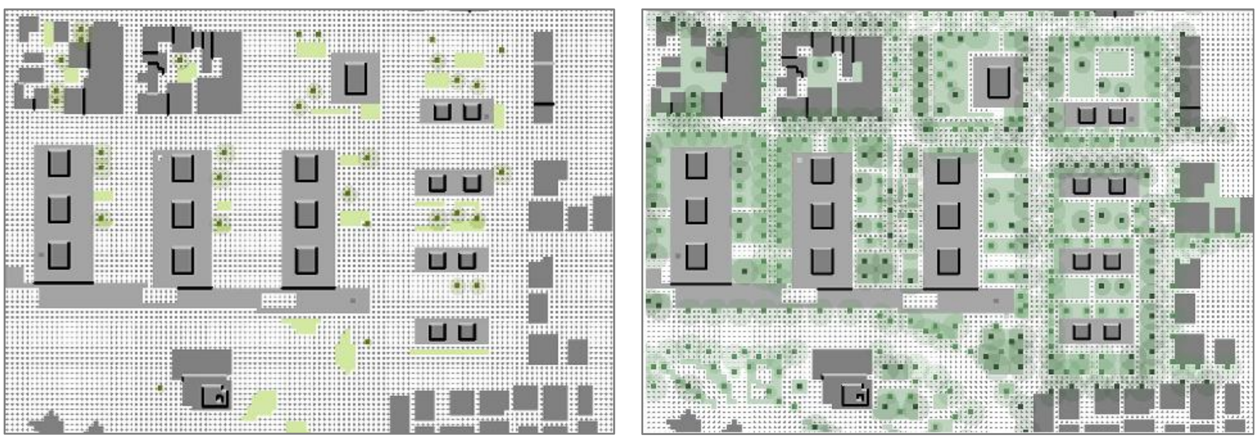

Figure 3.11. The Peristeri urban compound in the Envi-met 2D digital Interpretation in the as built (existing on the left) and as the alternative scenario (proposal on the right)

These databases (soils, plants, buildings, surface materials) are used as generic types for in the first stage, so a comparative matching to the nearest resemblances are chosen as for soil, plant and building characteristics. These data can also be localized and additional plants; soils and sources information can be added to the model. The outputs are basic 3D information on atmosphere, surface and fluxes and soils. The meteorological input of a year period (2014) recorded by the urban climate station in Peristeri plus measurements performed by the university of Athens and the department of Physics (Santamouris, 2014) was applied. For the simulation it was selected the hottest day of the summer of 2014 (9 of July) with mean Temperature in 30 C while the maximum is 35.7 C. The wind is in west direction with an average speed of 3.1 m/sec.

The lack of green spaces, lack of parking, lack of pedestrian streets, the high temperatures measured to the ground surface as well the high air temperature plus the indication of uncomfortable thermal sensation are some of the problematic issues that the urban planners have to consider about. From the previous analysis and simulation of the existing situation, the results show the need of action for drastic measurements to be taken into consideration.

In this next step, it is proposed the analysis and simulation of alternative sustainable scenarios that could help into the improvement of the existing situation and come a step closer to the goal of this research, which is the zero energy urban settings. In a brief these actions are (see also figure 12):

- Addition of trees and green surfaces on the ground level
- Green vertical and horizontal elements (green roofs and green walls
- Shading system with photovoltaic elements on the top roofs
- Reorganization of the parking spaces and creation of pedestrian permeable streets with the change of the material used for the existing pavements
- Linear park (green roof) on the existing roof of the market

The existing green are is 12.100 m2 while with the proposed scenario will be 21.780 m2, which is almost the double of the present surface.

Fig. 3.12. The urban compound in existing situation and in the proposed alternative scenario

Experimentations consisted of two brief studies of the area. The following figures (3.13 & 3.14) visualize the model of the area in different conditions[24].

[24] Data of external temperature in the model of the as it is condition have been verified with measured data by the team GRBES (Prof. Santamouris).

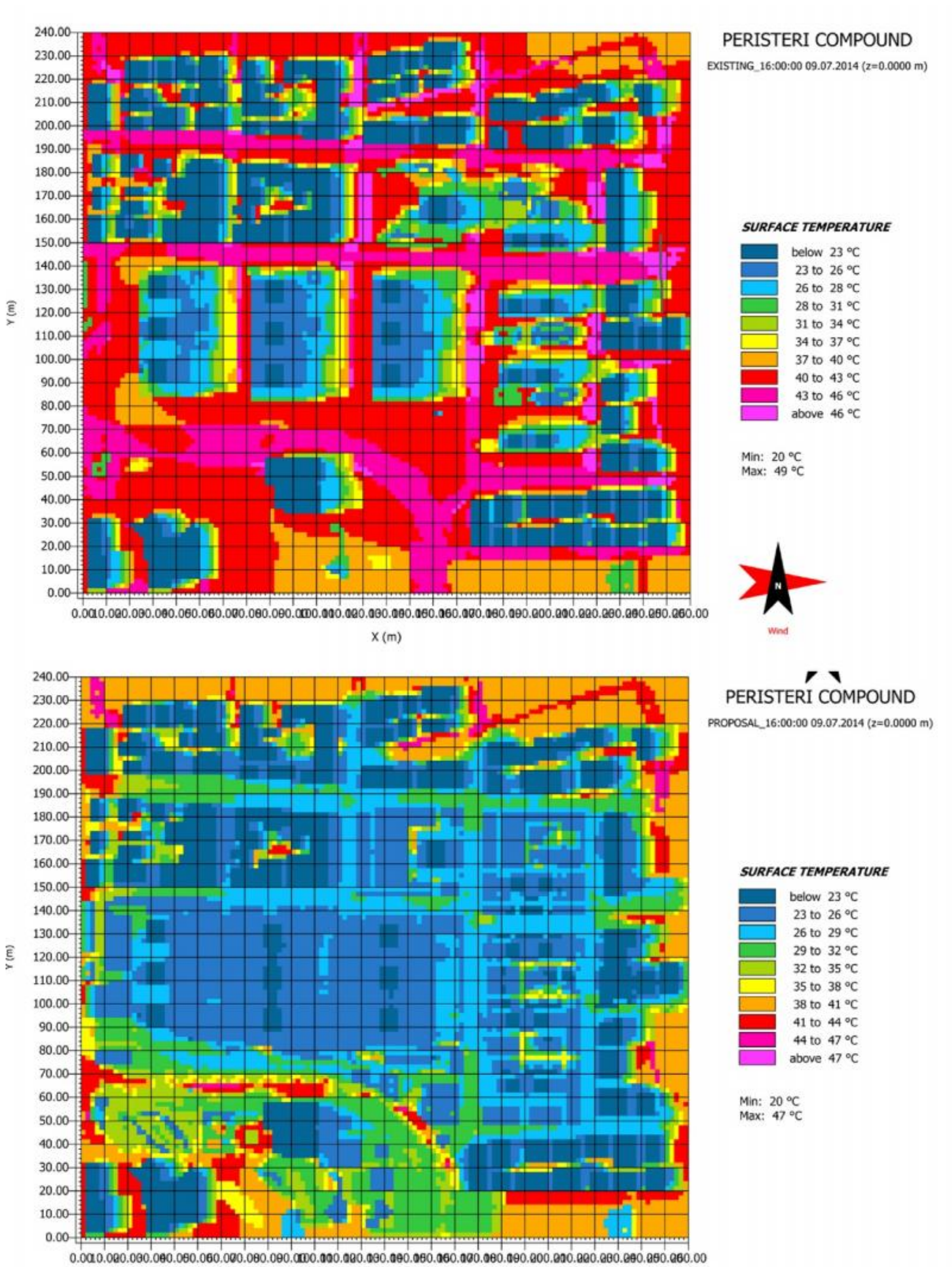

Figure 3.13. Envi-met: Results of the surface temperature at the ground level at 16.00 pm for the existing situation and comparison with the proposal.

This stage is used to explore calculation and visualization potentials of the model plus also helped the researcher to hypothesize on the certain factors, of the model itself and of certain characteristic of the urban compound[25].

For the environmental simulation with Envi-met, the same climatic data and maps where taken into account. To compare and discuss in further detail here it is provided the results of the simulation of the combination of four of the five scenarios. It was hypotisized that the proposed scenario was executed by adding low vegetation and trees, adding green walls and green roofs were it was applicable, pedestrian streets were created and it was proposed a linear park in the level of the roof of the market. Variations imply a different microclimatic behavior in the models. Introducing parks and pedestrian streets with the use of new materials in place of asphalted areas lead to a fresher air (temperature decreases generally in a range set from 0,25 to 1,5°C, locally the difference can be 3 °C).

Selection of trees and vegetation should be made according to the dry and warm climate of Athens. Plantation with big crown was considered to provide adequate shade but while requiring few water for irrigation. The replacement of standard roofs with green roofs does not seems to lead to significant variations in temperatures, being the maximum decrease equal to 0,7°C; conversely, measurements performed locally, close to one of the buildings with the use of a shading system on the rooftop show a significant decrease (about 2.5°C).

[25] Process of working with the model in the research are described by Ozkeresteci et al., 2003. These are summarized as follows. - Model shows a fine detail in the analysis of the atmospheric data form the user's point of view. - It provides area-based information about critical areas in the study domain like very hot sports, problematic areas. - It plots in 3D and 4D the path and the direction of the wind movement and particle diffusion around the landscape elements therefore critical areas of polluted spots in the study domain. - The above inferences are critical design and planning data either from an urban designer's point of view preparing a development project in the area or from the point of a planner's working in the city reviewing and communicating the development in different stages.

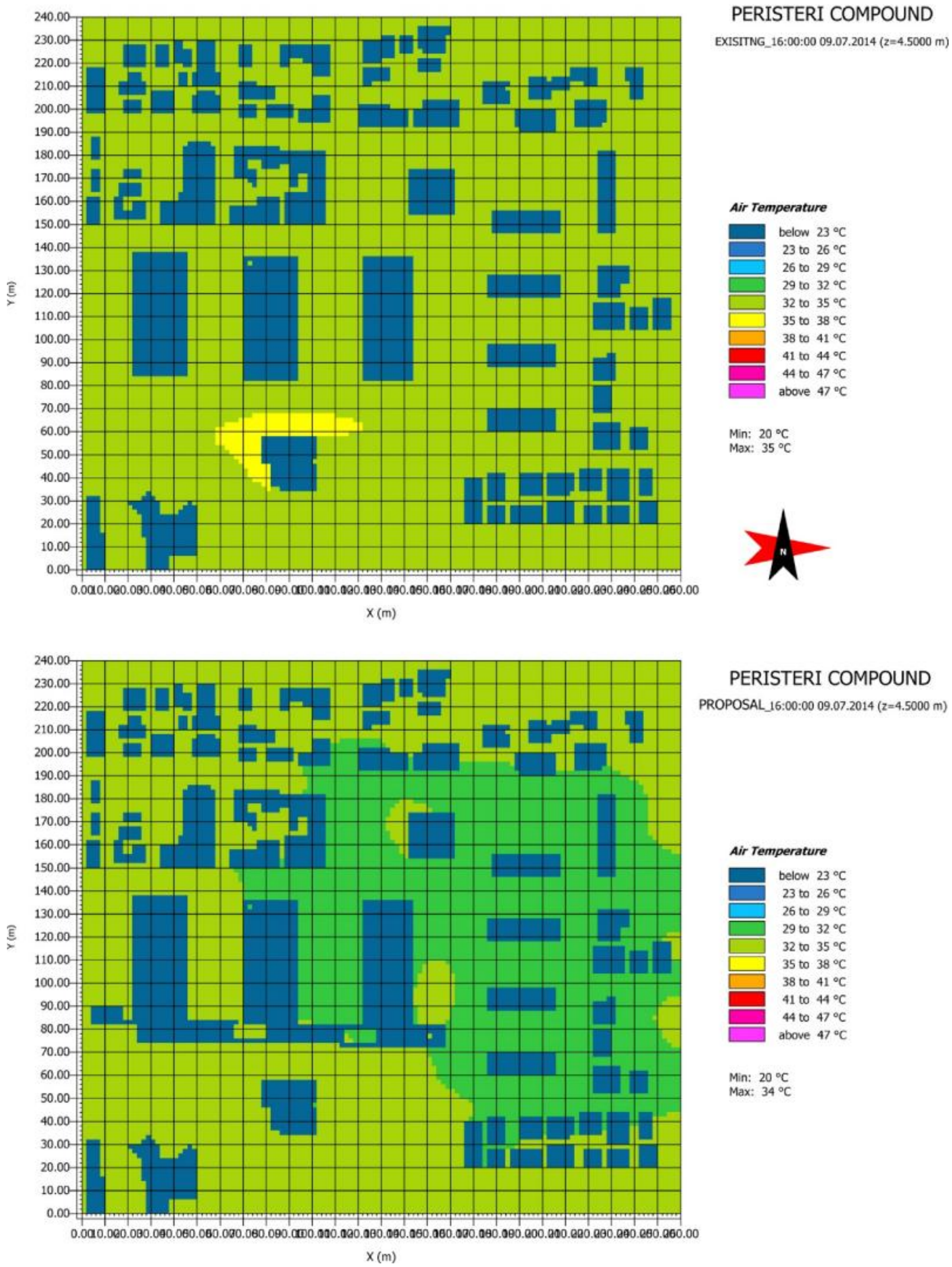

Figure 3.14. Envi-met: Results of the air temperature at the first floor level (4.5m) at 16.00 pm for the existing situation and comparison with the proposal.

Actually, in the current as-it-is scenario, shade is indeed provided by existing trees in the center of the courtyards between the buildings. The presence of the trees is assumed to be increased and enhanced by the redesign of external surfaces, increasing the permeable surfaces and reducing the asphalt area as much as possible. A great impact in local decrease in temperature is brought about the linear park and the shading of the new plantation in that area. There is a significant temperature reduction on the surface of the ground level due to the use of new materials and the shading provided by the vegetation. By the measurements around the central building, resulting air temperature reduction is between 0.5 to 2.9 degrees, while a lower reduction is observed to the west and south part.

Furthermore, by using this simulation tool it is also possible to define the area of thermal comfort[26]. A method of describing thermal comfort was developed by Ole Fanger and is referred to as Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfied (PPD). The Predicted Mean Vote (PMV) refers to a thermal scale that runs from Cold (-3) to Hot (+3), originally developed by Fanger and later adopted as an ISO standard[27].

[26] According to the ANSI/ASHRAE Standard 55-2010, thermal comfort is defined as "that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation." Also known as human comfort, thermal comfort is the occupants' satisfaction with the surrounding thermal conditions and is essential to consider when designing a structure that will be occupied by people. A cold sensation will be pleasing when the body is overheated, but unpleasant when the core is already cold. At the same time, the temperature of the skin is not uniform on all areas of the body. There are variations in different parts of the body, which reflect the variations in blood flow and subcutaneous fat. The isolation potential and quality of clothing also has a marked effect on the level and distribution of skin temperature. Thus, sensation from any particular part of the skin will depend on time, location and clothing, as well as the temperature of the surroundings.
There are six factors to take into consideration when designing for thermal comfort. Its determining factors include the following: Metabolic rate (met): The energy generated from the human body; Clothing insulation (clo): The amount of thermal insulation the person is wearing; Air temperature: Temperature of the air surrounding the occupant; Radiant temperature: The weighted average of all the temperatures from surfaces surrounding an occupant; Air velocity: Rate of air movement given distance over time; Relative humidity: Percentage of water vapour in the air. The environmental factors include temperature, radiant temperature, relative humidity, and air velocity. The personal factors are activity level (metabolic rate) and clothing. Thermal comfort is calculated as a heat transfer energy balance. Heat transfer through radiation, convection, and conduction are balanced against the occupant's metabolic rate. The heat transfer occurs between the environment and the human body, which has an area of 19 ft2. If the heat leaving the occupant is greater than the heat entering the occupant, the thermal perception is "cold." If the heat entering the occupant is greater than the heat leaving the occupant, the thermal perception is "warm" or "hot."

[27] The original data was collected by subjecting a large number of people (reputedly many thousands of Israeli soldiers) to different conditions within a climate chamber and having them select a position on the scale the best described their comfort sensation. A mathematical model of the relationship between all the environmental and physiological factors considered was then derived from the data. The result relates the size thermal comfort factors to each other through heat balance principles and produces the following sensation scale.

Value	Sensation
-3	Cold
-2	Cool
-1	Slightly Cool
0	Neutral
+1	Slightly Warm
+2	Warm
+3	Hot

Table 1. Predicted Mean Vote sensation scale

In the following map resulted by the simulation of the existing situation it is visible that the PMV in the major part of the area of interest is above 4 which indicates an extremely hot situation.

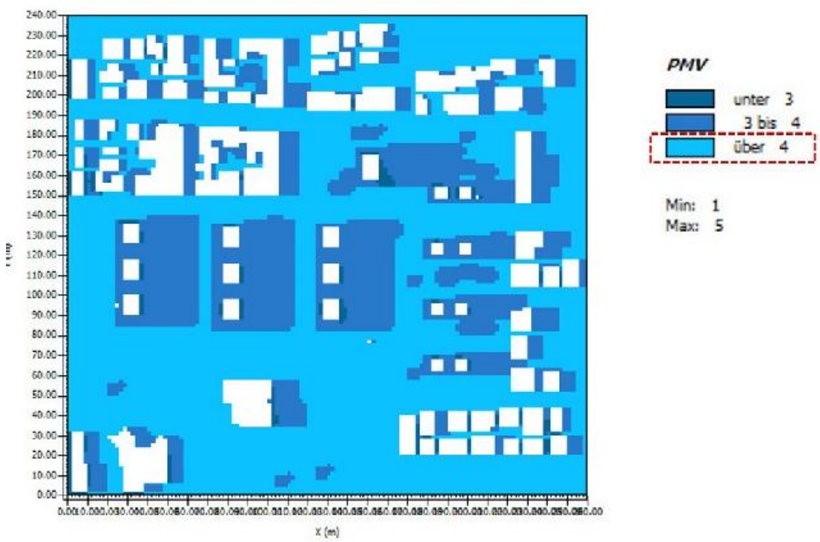

Figure 3.15. Thermal comfort interpretation in the existing area at 16.00 pm

In Figure 3.16 it is demonstrated the comparison between the temperature of the surface and the PMV between the existing situation and the modified scenario with the interventions mentioned above. The results are expressed in the terms of percentage of the surface, where they are met values of the comfort (PMV from -1 to +1). The graphs presented in figure BACFGY, compare the existing scenario (in blue) and the modified scenario (in red). In both the graphs (T and PMV), y axes indicates the percentage of the surface occupied by these values, while in x axes it is indicated the temperature expressed in Celsius degrees (graph on the left) and (on the right) the PMV values.

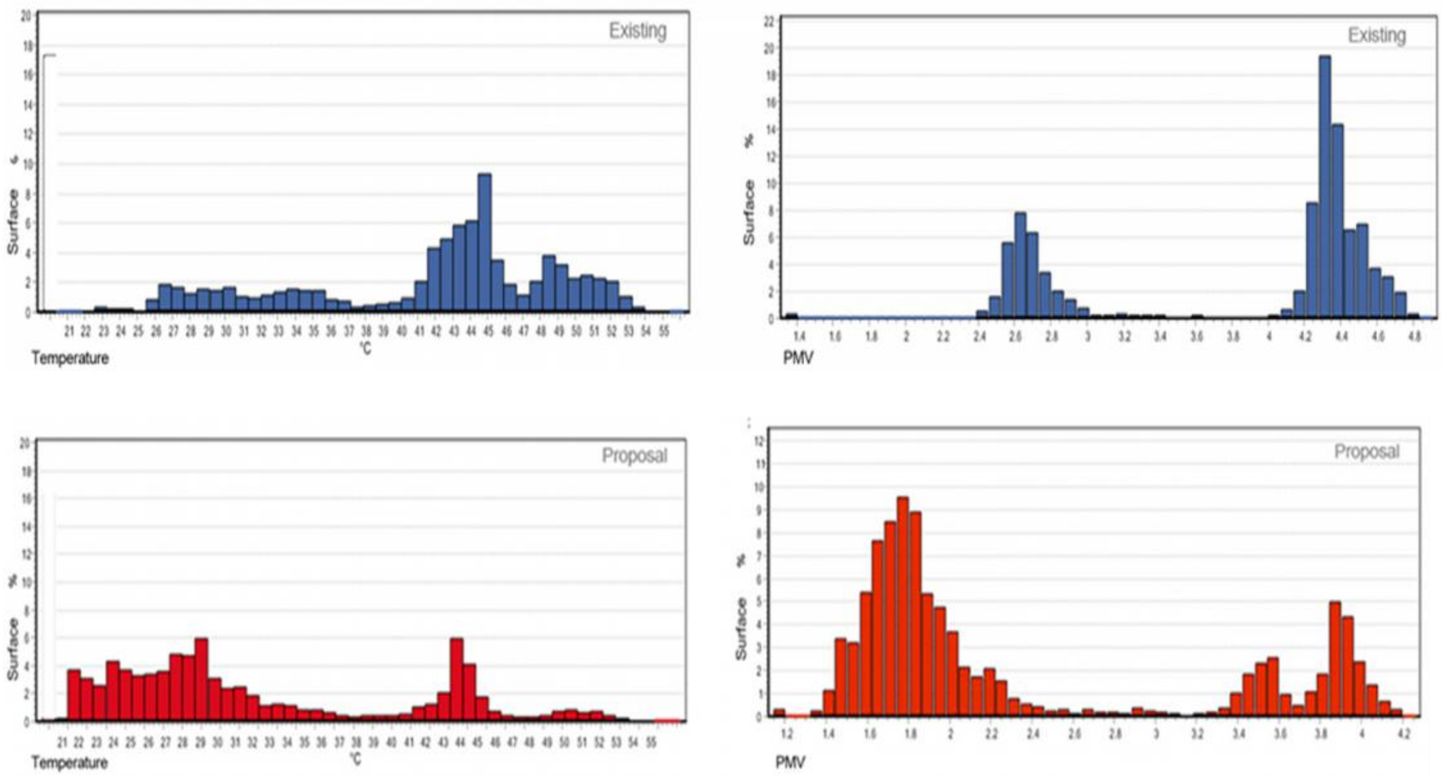

Figure 3.16. Surface temperature (on the left) and PMV (on the right).Comparison between the proposed scenario (in red) and the actual situation (in blue)

From the graphs referred to the temperature it is possible to observe that more than 60% of the external surfaces on the as built situation presents temperature more than 41 C^0, while on the modified scenario the 60% of the surface indicates a temperature less than 35 C^0. The PMV graphs indicate that in the existing situation the 70 % of the area presents values between 4-5which results to a situation of extreme discomfort; the values that correspond to the proposed scenario show that the 70% has a value from 1.4 to 2.2, values very close to the comfort level.

3.2 Analysis of the results of the simulations

In the considered two case studies, performed calculations , simulations and comparison have shown that it is possible to reach an average decrease on the mean air temperature that varies between 0,25 up to 4,5 Celsius degrees, for mainly the summer period and especially the period that corresponds to the highest temperatures. For the simulations executed both for Peristeri and Evripidou area it was considered as a reference day the hottest day of the summer of 2014 (7 of July), which according to the measurements already done by the University of Athens the department of Physics is the period which is more visible the HIE in both areas. The different compactness of the two areas leads to different energy demand and consume, according to previous studies.

By increasing the green areas, changing the surface materials replacing asphalt with pavement tiles more adaptable to a sustainable design, adding water elements, creating more parks and pedestrian streets and plus on the level of building design, adding green roofs and green walls where is applicable and also by creating shadow areas on the rooftop with photovoltaic elements, it can be observed a reduction in the air temperature, the surface temperature and as a result create and ambient with a high level of life quality and improved thermal comfort. This strategy is showing how a huge potential for energy savings lies eventually in the renovation of the existing building stock.

A complete and comprehensive simulation has been performed for both two different urban complexes considered as case studies in the Athens area.

Peristeri urban compound is characterized of an open area with stand alone buildings with the possibility to act with more possibilities in the urban redesign of the area. Possible organization of the parking spaces and creation of the double of the existing green area has shown that the air temperature around the buildings can reach up to 2.5 Celsius degrees which is an important impact. The existence of strong wind coming from the Aegean sea, the actual location of Peristeri as it is in a higher level from the centre and its medium dense urban character allows to have a sufficient decrease of the air temperature during the hot days of the summer even with the minimum basic transformations already mentioned.

On the other hand, Evripidou area that is located in the centre of Athens, it is characterized as a high dense area, with narrow streets, tall building blocks, lack of green and traffic. The existence of wind is rare as the urban complex does not allowed circulation and as a result the quality is poor.

Even if the transformation proposed in order to calculate the possible air temperature change were limited, the results show an adequate decrease. As mentioned earlier there was a reduction around the main block between 0.7 up to 1.5 Celsius degrees.

In total, it can be observed that with basic transformations in different urban compounds and mainly with the existence and the increase of the existing green

It can be observed a reduction in energy consumption that varies between 33% and 31%, showing how a huge potential for energy savings lies in the renovation of the existing building stock.

DISCUSSION

Nowadays, there is much research being done into ways to better incorporate landscape as part of urban design, to integrate new forms of green in the buildings. In recent years, very interesting examples of new public landscapes being developed, combined with increased urban density, and new recreational landscapes utilising urban sites have been realized. Theoretically, the increased density of a city should not create limits and restraints and a more sustainable approach could be introduced. (Creation of small urban gardens for recreation and food cultivation, in combination with green roofs water system that could help to collect the rain water for irrigation of the open areas). A very interesting example that has been successfully re-naturalised and turned into Public Park is the park at Port Forum in Barcelona (2006).

It is generally important to ensure and introduce the appearance of new development in tree planting and vegetation. As far the results collected on this chapter the addition of green areas in the urban environment, the use of more natural materials lead to a significant improvement of the microclimate and the outdoor comfort. Innovative ideas of vertical landscaping and the recreation of ground conditions to roof gardens, are now a realistic scenario applied in many cases. Today most cities have established policies on the principle that removal of potential green area at ground level should be offset by planting the equivalent area at roof level. France for example, is one of the few European countries that with a new innovative law have established that all the new structures are forced to have on the terraces or green roof or photovoltaic systems.

Athens, as a particular city, with a complex urban development over the years, as analysed before, is in the need of new measurements to be performed in a first level in the urban redesign and also to the adaptation of the existing buildings and structures to the energy saving demands in European and global scale. Due to its charismatic climate should be a pilot study for all the problematic cities of south Europe and the Mediterranean Area that demonstrate similar climatic data, existence of HIE phenomenon and also have similar urban geometry.

-IV-

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CHAPTER IV
FROM THE OPEN SPACE TO THE BUILDING

ABSTRACT

Over the last years a new serious situation has been created due to the intense urbanization and the decline of the external air status with severe consequences of the quality of the indoor environment. Two main sources are the main factors for this. One is the outdoor pollution and the other is related with indoor parameters. Numerous studies reported during the last years, show the serious impact of the outdoor environment to the indoor air quality (Santamouris, Asimakopoulos 2001)

In order to understand and fully comprehend the coherence of the effects related to the modified and improved external conditions (analyzed in previous chapter) with respect to the energy performance of the buildings, is important to take a further step in that research. Further simulations have been run in building scale in order to take into account the interaction between the built area and the open area. It was performed an integration of two different scale simulation programs in order to achieve a holistic approach.

This chapter deals with the selection, the study and the energy analysis developed in two urban settings of the Athens metropolitan area.

In the two selected urban settings low energy performance of the existing as built compound and building block was resulted. As a consequence alternative retrofit design scenarios were proposed. New simulations were run in order to validate and verify the energy potential saving of these selected passive techniques on building scale. As a third step the integration of both scenarios (improved microclimate and retrofitted buildings) was simulated and the resulted energy saving performance was even greater. Accordingly, the energy generation to set to zero energy the urban settings is also presented.

This part of the research demonstrates that a large set of possible solutions is technically feasible to achieve nZEBs, even in highly energy consuming buildings of existing urban compounds: the technical feasibility of nearly Zero Energy Buildings and Zero Energy Urban Settings in urban climate may be considered a realistic and credible reaching.

On chapter2 it was underlined that, during July and August, the city centre and at the western part of the city of Athens present much higher mean and maximum air temperatures than the corresponding values in the northern and north-eastern part of the AMA. Peristeri, together with the central Athens zone, affected by the highest heat island (HI) intensity of the whole AMA, they can be assumed as the ideal candidates for their poorest climatic conditions. This is caused mainly by the natural territorial morphology of the Attica region and additionally to increased documented urbanization, the lack of vegetation, impermeable areas, industrialization and anthropogenic heat.

The intense climatic conditions and as well as the different density characters that these areas present, has led to their selection as two of the most representative urban contexts in the Athenian settings regarding also the existing urban degradation. On case is formed from a very dense urban context organized by the typical Greek building blocks and small internal courtyards, while the second case is set on the peripheral urban areas with stand-alone building types.

In the western urban (Peristeri) was selected an urban settings occupied by social housing of the '60s, with typical structures built by reinforced concrete and infill walls. Conversely, in the Evripidou central Athens the selected case study consists of a very dense urban setting made up of adjacent buildings with different dimensions grouped in the distinctive courtyard of the historical parts of the city. The selection of these two urban settings as it was already mentioned, is representative because of both morphological, climatic, urban and building type aspects. In fact, these two urban areas also represent two differently dense urban compounds (Table 1).

Case Studies	inhabitants/plot (estimated)	FAR	(Ae/V)	Built / Unbuilt
Peristeri	14.000	1,99	0,28 (*)	
Evripidou	17.500	4,66	0,27	

Table 1. Different densities in the selected case studies. (*) In the case of Peristeri Ae/V values refer to the single building types (tower, block, double block)

4.1 The representative selected urban environments in the AMA

All the building types in the two Urban Settings are organized by a series of typical block buildings structured by reinforced concrete and brick walls. This a typical construction typology and is globally presented in all Attica suburbs and the city centre. It has also a common structure with similar building blocks all over Europe[28]. The western compound in the Athens' peripheral area consists of stand-alone block buildings, (Figure 4.1).

[28] Generally, modern buildings constructed after the second world war represent the larger majority (about the 60%) of the existing building stock in EU. This percentage even increases (about the 70-75%) if we confine the analysis within the boundaries of the Mediterranean European countries (Greece, Cyprus, Spain, Portugal, etc.) and slightly increases for Italy, as well (about 65%) (Ferrante, 2014).

Figure 4.1. Peristeri Workers House urban setting is featured with different building types (the double block buildings, the tower and the block buildings)(source: Google Earth, elaborated by the author)

Peristeri urban area can be characterized as an urban compound[29] as it is consisted of 12 stand-alone buildings, categorized in four different types according their orientation, their building geometry and volume. These four main building types are mentioned below (see figure 4.2,):

1. Three "tower buildings" (T11, in blue);
2. Four building blocks East-West oriented (T7, in yellow);
3. Three double building blocks North-South oriented (A7, in red);
4. Two building blocks North-South oriented (B6, in yellow).

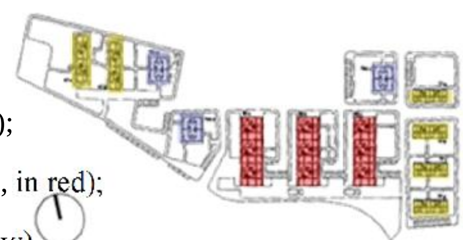


Figure 4.2. The urban compound four types of buildings

[29] The urban compound extension is 37'820 m2, of which 25'713 (68%) is occupied by building construction and impermeable surfaces (parking areas and streets); the remaining 32 % is a green open area. The build area represents the 29% (7'504 m2) of the total impermeable surfaces. (see Chapter 3)

The majority of these buildings have residential use with the only exception the building block (B6) where are located small businesses shops, offices and retail at the ground floor level the south oriented. For Peristeri urban setting, real facades' reconstruction and basic plan drawings were executed of the different building types in order to understand current modifications/appropriations of the building spaces indicating thermal and comfort needs of the inhabitants. (Figures 4.3 – 4.7). Original drawings of the compound and of each building are provided in Annex 1.

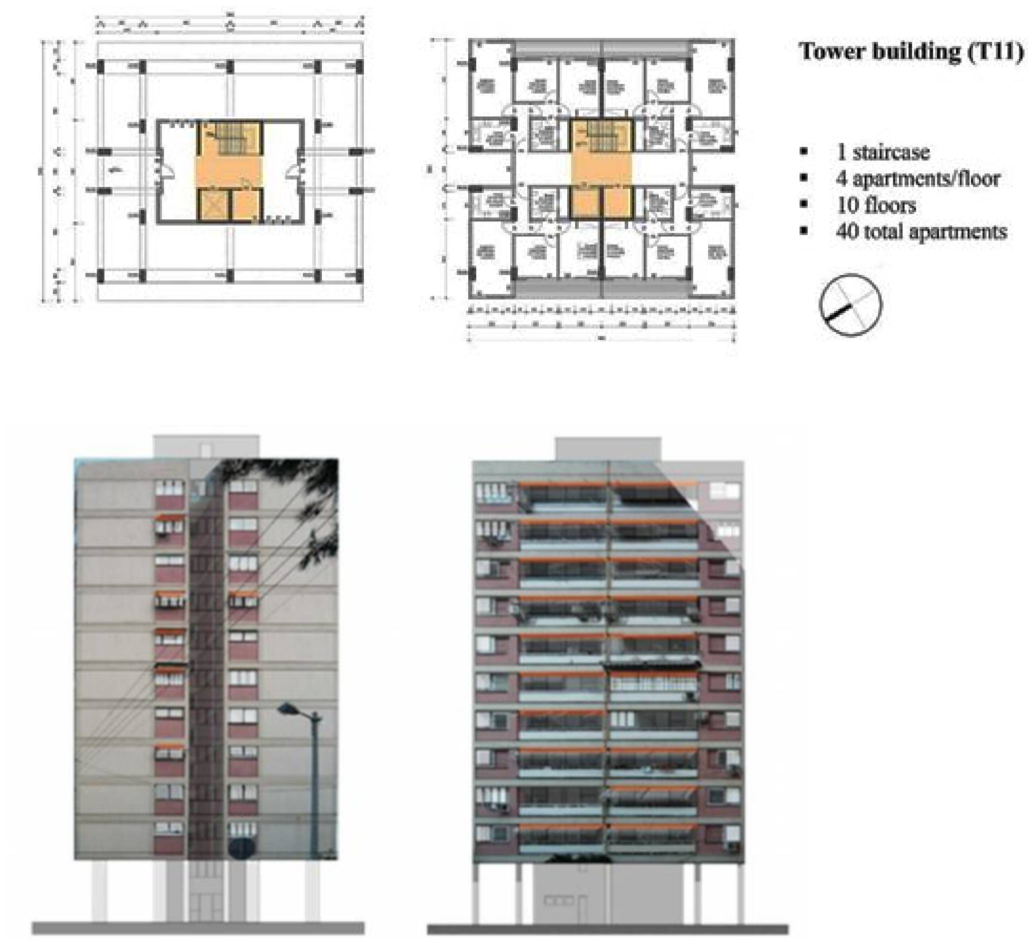


Figure 4.3& 4.4. Ground level plan and type plan, and photographic reconstruction of the façade of the tower buildings type in the urban compound of Peristeri (T11).(source: source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

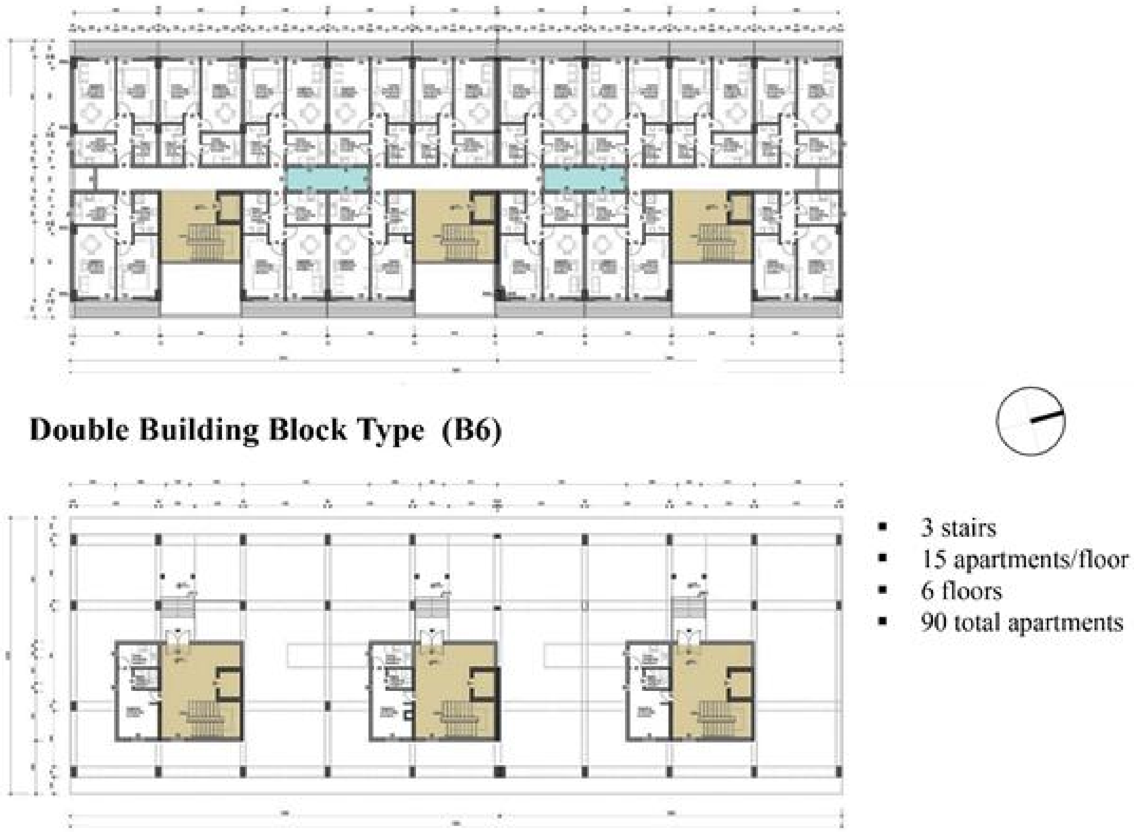


Figure 4.5. Type floor (up) and ground floor (down) of one of the 3 the double building blocks (B6). On the left, location of the double building block type in the urban setting of Peristeri

Figure 4.6. East and West facade photographic reconstruction in the double building blocks in Peristeri (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

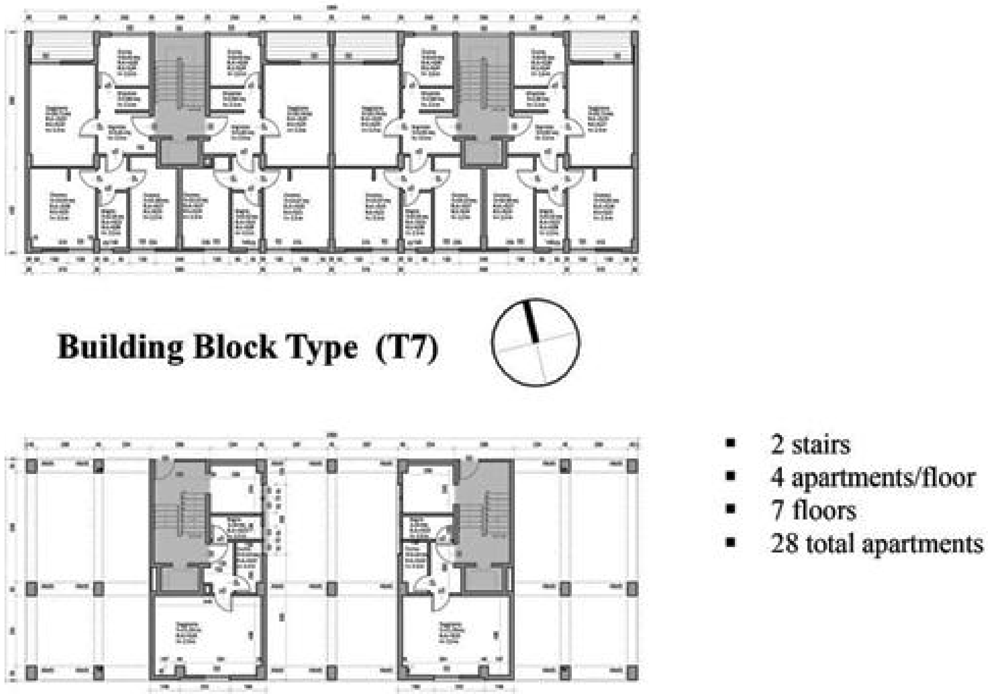


Figure 4.7. Ground and type floor of one of the 4 the building blocks (T7). On the left, location of the double building block type in the urban setting of Peristeri

On the other side, the urban block in Evripidou (Psiri area) that was selected as the reference case study it represents the dense built historical zone in the centre of Athens. Specifically, the selected area is also enhanced by the presence of many public services like the Municipal Hall, several Civic and Administrative offices and Central Athens Market as well. The considered area of Psiri is surrounded by the streets Peiraios, Athinas, Evripidou and EPikourou.

The total surface of the area is 105.116 m^2, of which 99.607 m^2 is occupied by buildings and infrastructure, while the remaining 5509 m^2 present small green spots and courtyards as fragments between the buildings. A single urban block between Sofokleous and Athinas Street formed by eleven attached buildings has been selected for further investigation. The majority of these buildings blocks present one floor for retail at the ground level. The analyzed area occupies a surface of 2.600 m^2, 2291 m^2 of buildings and 309 m^2 of interior courtyards. All buildings have a gross floor area of 11.249 m$^{2.}$The type of construction dates from the period 60’s – 70’s for almost all buildings with the only exception of the older buildings dating back to the 40s and on the Greek neoclassical period.

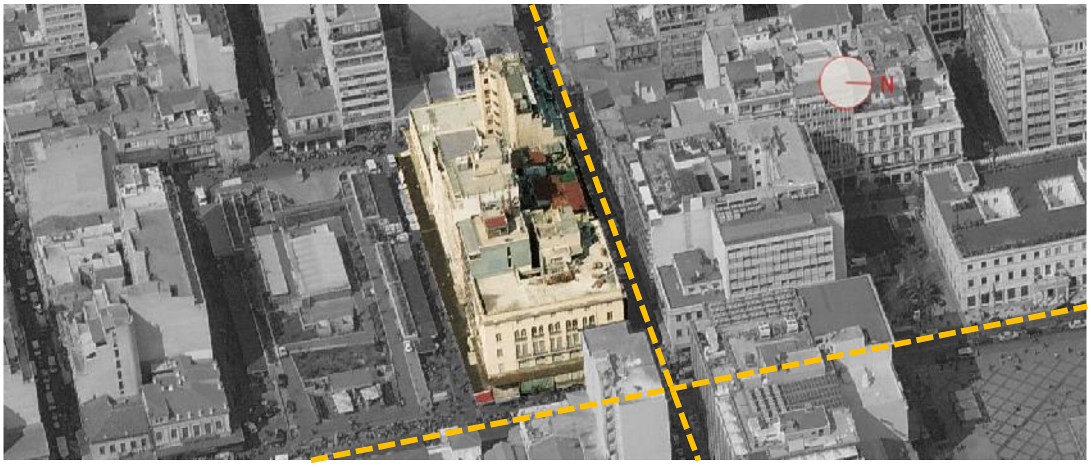
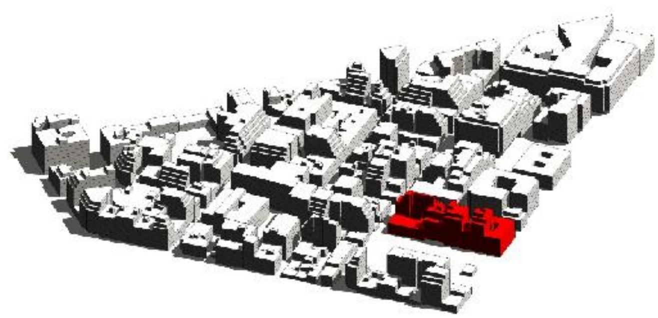


Figure 4.8 Evripidou area selected urban block representing the typical compilation of the historical centre of the city (source: Google Earth, elaborated by the author)

As observed, among the main difference between this case study and the previously examined urban compounds (Peristeri) is the population density, clearly increasing from 14,000 inhabitant/Km^2 (Peristeri) up to the centre of Athens that measures 18,000 inhabitant /Km^2. A significant factor in order to analyse and better understand the density of the area is the F.A.R., which while it was already calculated of the Psiri district at a range from 2.5 to 3,5, in fact the correspondent value of the selected area, considering it strictly within the borders of the surrounding streets, grows up to 4,33 (Figure 4.9). Similar to the previous case study, all the main structures consist of a frame of reinforced concrete beams and pillars and opaque components of semi-perforated (hollow) masonry blocks.



FAR = 4.33

Total project area = 2600 m2

Area occupied by buildings = 2291m2

Free space = 309 m2

Parking = 400 m2

Total built area of 11 units = 11250 m2

Figure 4.9. Three dimensional reconstruction of Psiri District and calculation of correspondent density expressed as FAR for the selected urban block (in red),(source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

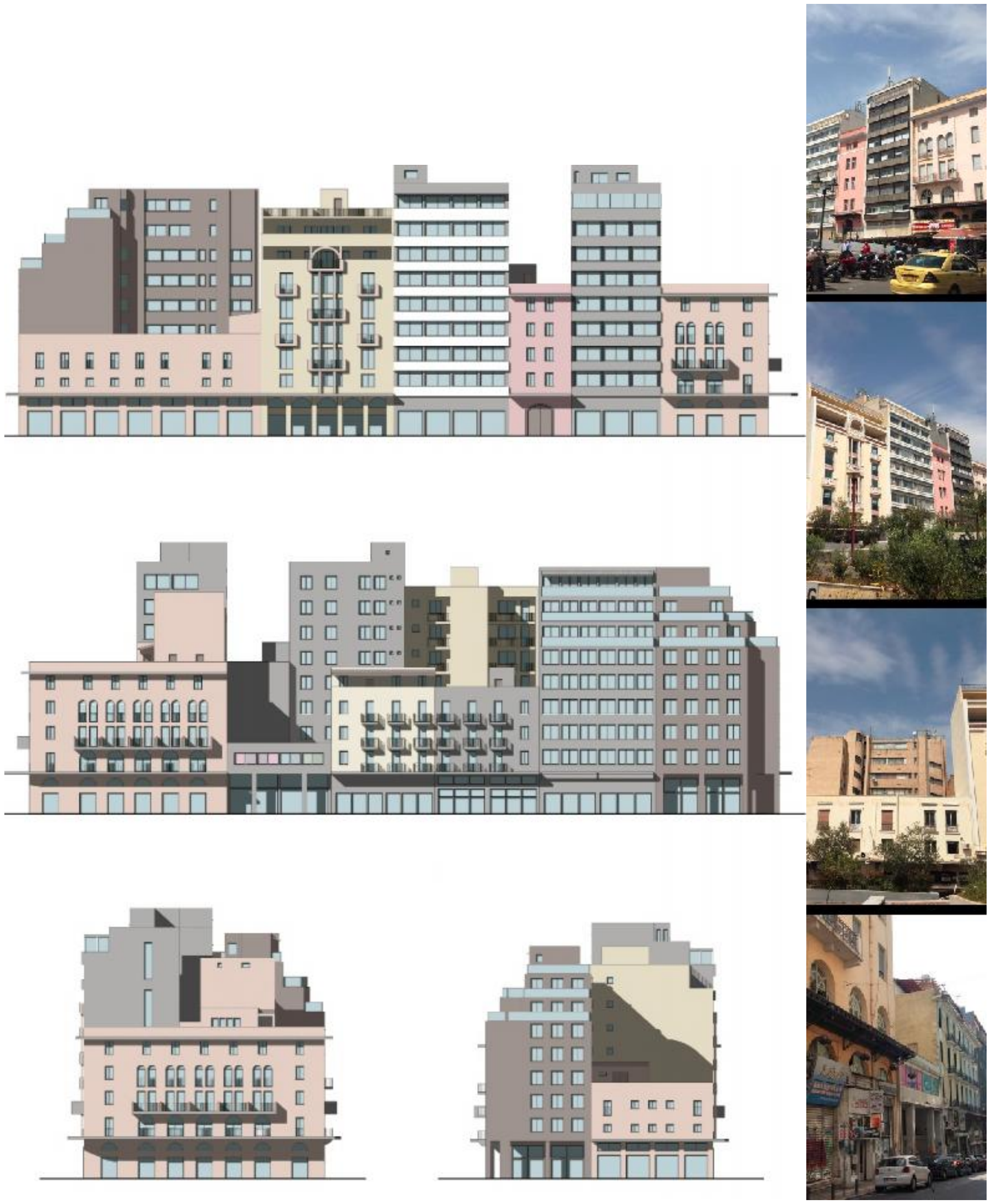


Figure 4.10. Buildings' elevations, South, North, East and West oriented (drawings source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier, photos taken by the author)

As a conclusion, Athens as a metropolitan city, presents an overall urban complexity connected with its unique urban morphology and location. It is characterized by an identifiable urban form and character. The diverse and multiple typology of the buildings, the urban gaps among the urban blocks, the intense urban canyons, and the diffuse geometry between the different urban zones set the selected case studies representative repeatable units among the urban fabric of the city despite their differences.

4.2 The Energy Demand in the selected urban environments

This next step of this research focuses on the building scale and investigates the energy performance of the selected units of the already mentioned case studies and aims to define the most appropriate solutions in order to reach the goal of a measurable reduction of building's energy requirements and examine whether and how they can be turned into nearly ZEBs.

Further analysis has been done by using simulation tools[30], resulting to assess the energy performance in the as-built scenario for both Peristeri and Evripidou. Energy simulations of this kind need a detail analysis of the structure and the space organization of each building so as to properly define the internal thermal zones of a built environment[31]. Therefore, separate volumes for each building or set of buildings have to be identified as correspondent thermal zones[32].

In order to conclude in a common and comparable results between the two case studies and avoid a fragmentation of data, all input data were commune and have been

[30] All simulations have been performed by using DesignBuilder, a fully featured interface using EnergyPlus platform to detect energy, carbon, lighting and comfort performance of buildings. EnergyPlus is the U.S. Departments of Energy's 3rd generation dynamic building energy simulation engine for modelling building, heating, cooling, lighting, ventilating and other energy flows. It has been validated under the comparative Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs BESTEST/ASHARE STD 140.

[31] A list of levels and sublevels from the building up to the division of opaque and transparent parts is generally created to run accurate dynamic simulations.

[32] 3D models for each case study have been developed to re-design the exact positioning of all opaque and transparent surfaces and climate data settings.

assumed and estimated[33].For example all the operating programs of the plant systems are according to the daily/season program presented below.

	Heating	Cooling	DHW
Summer (Apr.-Oct.)	Off 00.00 – 24.00	On 00.00–24.00 (rooms) 07.00–23.00 (living, kitchen)	On/According to occupancy
Winter (Nov-Apr)	On 00.00 – 24.00	Off 00.00 – 24.00	On/According to occupancy

Table 2. The operating programs of the plant systems

Further common but important data inputs are the local weather data[34], activity, occupation and ventilation[35] and last the characteristics of the plant systems.

It has to be remarked that the existing dissimilarities among the investigated two building types, the scale of each unit and the consistence of these urban contexts have been approached in a different level of detail concerning the simulation analysis.

Consequently, for the determination of the thermal zones on each referred different building type, unlike criteria have been adopted for in the energy analysis of the two case studies, following decremented level of details:

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[33] Among the common characters assumed for the different cases is the plant systems' equipment. Each building is assumed equipped with a central heating system using gasoil as fossil fuel. In all the visited building of Peristeri cast iron radiators are installed in the rooms of the apartments, therefore they are assumed as terminal heating plant components in all case studies. In all the different urban settings, the ethnographic observation has showed how the majority of residential units (about 95%) are equipped with air conditioning units; some others (30%-38%) use solar systems for domestic hot water. The light sources are mainly of domestic type, such as incandescent light bulbs or compact fluorescent lamps. All the buildings have a structure of reinforced concrete and exterior surfaces made up by hollow bricks and treated with plaster. Neither the flat roofs nor the vertical surfaces are insulated; in the majority of apartments the windows consist of aluminium frame systems and single glazed transparent components, prevailingly equipped with exterior shutters as windows' shading devices. The assumed operating program and the performance of the plant system do not affect the rightness of the conclusions because they have been kept constant in all simulations.

[34] A file containing all the hourly climatic data, as the dry bulb, temperature, wet bulb temperature, wind speed and direction, solar height, solar azimuth, atmospheric pressure, direct and diffuse solar radiation is contained in the default weather data, These data have been compared with simulations performed in various climatic stations of the Athens metropolitan area (GRBES, Prof. Santamouris) and, in particular with measures gathered in Peristeri urban compounds. Similarities among these data have led to the conclusion that no necessary changes should be made at this stage of the analysis.

[35] The models reported the actual organization of the plan of the building, in the different level of detail specified after this note in the plain text. In each floor the different thermal zones assumed correspond to various rooms like kitchens, bathrooms, bedrooms, living rooms and condominium areas like stairwells. The criterion chosen to make the partition into thermal zones was to differentiate rooms dEPcnding on the specific activities that are carried out in. This made it possible to associate to each zone an activity program, built according to the average behaviour of local users. The activity program defines the occupation times and ways, the use of appliances, the opening of the windows and the operation of manual or mechanical ventilation and it is used by Energy Plus to evaluate internal energy contributions. According to size and type, three up to six people usually occupies each apartment, thus a density of 0.05 people per m^2 has been assumed. The default occupancy program has been slightly changed to consider the specific composition of the dwellers: it has been estimated that about the 40% of the population is a non-working age residents, so most of them are present and carry out activities in their apartments during the whole day, while the 60% of the residents are working people and from Monday to Friday, between 9.30 and 17.30, are not at home. According to this, occupancy profiles were created for each thermal zone.

For the case of Peristeri, the analysis has been conducted considering both a *building type and apartments type* oriented focus as a single unit, considering the main thermal zones corresponding to the single apartments, each one consisting in one single thermal zone.

On the other hand, as far it concerns Evripidou central Athens area a different approach was selected. In this case an *urban oriented analysis* has been developed with the aim to focus on the different energy performances of each apartment building block. In this case a more general subdivision has been operated by defining each floor in each building of the urban courtyard as a different thermal zone.

Concerning both two urban settings (Peristeri and Evripidou) urban blocks, identical research tasks have been proposed, designed and executed:

- Evaluation of the overall energy performance and sensitivity analysis of its variability as a function of the different orientation of the buildings as well as of different internal distribution; simulations have been performed for each unit type[36].
- Evaluation of the energy performance and sensitivity analysis of its variability related to the different arrangement of the surrounding buildings within the same urban compound.
- According the simulations' results a comparison in terms of comfort, energy contributions and overall heat balance was done so as to identify the principal critical problems that are mainly affecting the building types, classify them accordingly their effects on the overall energy balance of the building and as a consequence propose targeted solutions.

•As a second step and next level of simulations a retrofitting scenario is proposed for both selected building context. The main steps to be considered and analysed are:

Propose and design multiple building basic refurbishment interventions and options in the selected reference building

[36] in Peristeri units correspond to the apartments, while for the case study of Evripidou each floor in each buildings constitutes a different thermal zone.

- Run new simulation and analyse the resulting effects that the alternative design scenarios would produce on the overall energy balance of the building, so as to have an overall image of the effectiveness of the various retrofitting options in terms of energy response.

In the next two sub paragraphs the strategy mentioned above is executed and energy demand results of each selected unit and case study is presented.

4.2.1 Peristeri urban compound

Each building type has been divided in different representative thermal zones corresponding to actual apartments of each apartment building block· The selection of the representative units (apartments), for the simulation scenarios, corresponds both due to the position of the unit in the planning and as well as their height and according also with the connection with the neighbouring units on the building and secondly, respecting their orientation (solar factor is indicative), as showed in the following figure 4.11.

As it was mentioned in previous paragraph the structural principal system is simple but common for the Athens built character and it is organized by a regular grid of beams and pillars, with most possible prefabricated slabs as the main horizontal elements. The main thermal parameters provided for the horizontal ground level, intermediate floor and roof floor and as well as for the external surface envelope have been considered the same.

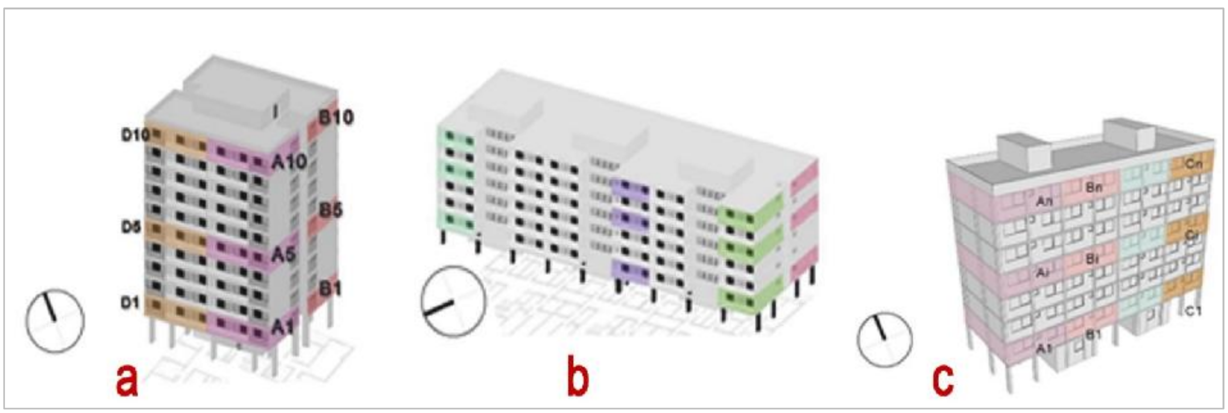


Figure 4.11. Apartments as thermal zones a) the Tower(T11), b)in the double block building (B6) and c) building block (T7) in Peristeri

A concentrated table for each building type (Tower building T11, the double building block B6 and the building block T7) of the synthetic results of the energy simulations performed for both cold winter and hot summer seasons follow. The resulting tables estimate the energy performance indexes of the single units on different location within the specific building.

Apartment/thermal zone	EPh (kWh/m^2 year)	EPc (kWh/m^2 year)
A1	89	64
A5	75	54
A10	101	72
B1	100	67
B5	94	61
B10	113	73
C1	89	49
C5	75	43
C10	101	57
D1	99	52
D5	87	45
D10	107	62

Table 3. Energy performance indexes of the different units in the tower building T11 (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

Apartment/thermal zone	EPh (kWh/m^2 year)	EPc (kWh/m^2 year)
A1	111	36
A4	89	42
A6	124	45
B1	115	40
B4	94	47
B6	129	49
C1	103	30
C4	82	34
C6	116	39
D1	107	33
D4	94	37
D6	129	43
E1	112	31
E4	90	31
E6	126	37
F1	107	29
F4	90	33
F6	125	38

Table 4. Energy performance indexes of the different units in the double building block B6 (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

Apartment/thermal zone	EPh (kWh/m^2 year)	EPc (kWh/m^2 year)
A1	113	89
A4	99	96
A7	167	106
B1	59	84
B4	71	89
B7	145	102
C1	84	95
C4	81	92
C7	170	102

Table 5. Energy performance indexes of the different units in the building block T7(source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

For further analysis in order to highlight the different energy demand of the single reference simulated units according to the different function of both the position of the unit within the building block and the solar orientation as mentioned before that considered to be the two main factors, the following graph was elaborated reported in figure 4.15.

According to Ferrante (2016), as expected, the most consuming units (both in summer and winter season) are the apartments located in the last building's floor with as covering top roof of the building. On the contrary, according to the measured results, the units/apartments with the lowest consume (in both seasons winter and summer) are demonstrated to be ones located in the intermediate building's floors. Additionally, as it was observed it is noticeable that by comparing the energy demand on residential units that are located on the same floor but with different orientation substantial differences may also be observed. As showed in the right side of the figures 4.12 & 4.13 south oriented apartments are less energy demanding than the corresponding north oriented ones, both in summer and winter condition. The following graphs are referring to the Tower T11 Block.

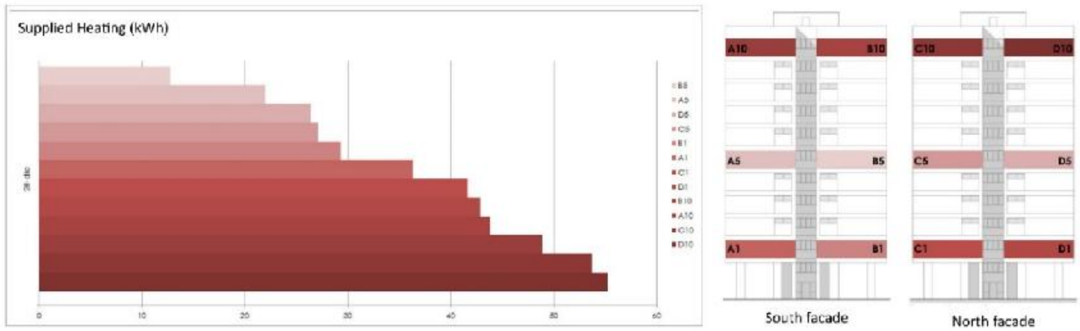


Figure 4.12. The graphs highlight the different level of energy in winter season of the reference units as a function of the position and orientation of the units within the building block (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

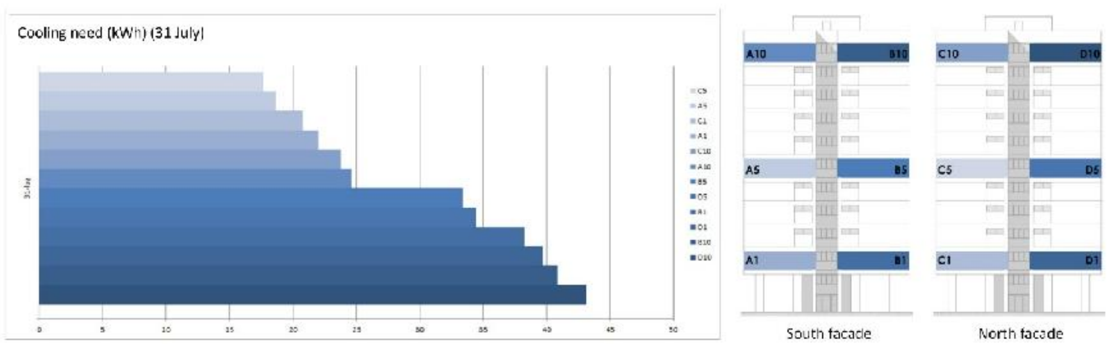


Figure 4.13 The graphs highlight the different level of energy in summer season of the reference units as a function of the position and orientation of the units within the building block (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

As a conclusion of the resulted simulation with the aim to analyse the energy demand of different selected units/apartments considered as different thermal zones, it is demonstrated that according to the orientation, location in the building and neighbour limits, apartments situated on the last floor to say that consume more and the ones in the middle are the more energy efficient both in winter and summer period. Further analysis of this different performance with new proposed scenarios will be analysed on the next paragraphs.

4.2.2 Evripidou Area

As indicated in the beginning of this chapter, the case of Evripidou urban block, was considered in different aspect in comparison from the case of Peristeri, where urban settings is formed by stand-alone buildings like.

In the second case study buildings were considered as whole units by considering their volumes in a total. In this way assumptions were hypothesized in order to simplify the implementation of the model and eventually considered as whole block at the level of the urban scale. In particular, it was decided to perform energy simulations for each floor of each building, with minimum considerations of the internal partitions of each residential units. (Figure 4.14) However, all the partitions towards unconditioned spaces like staircase and secondary volumes used for maintenance have been taken into account. Eventually, each floor in each building has been considered as a unique thermal zone with internal partitions assumed as internal mass. These more generic hypothesis was preferred due to the fact that in this way the results and the objective of the simulation wouldn't be affected as for the requested level of this investigation is not considered a major mistake. It has to be pointed out that the level of the analyses remains an energy urban energy investigation.

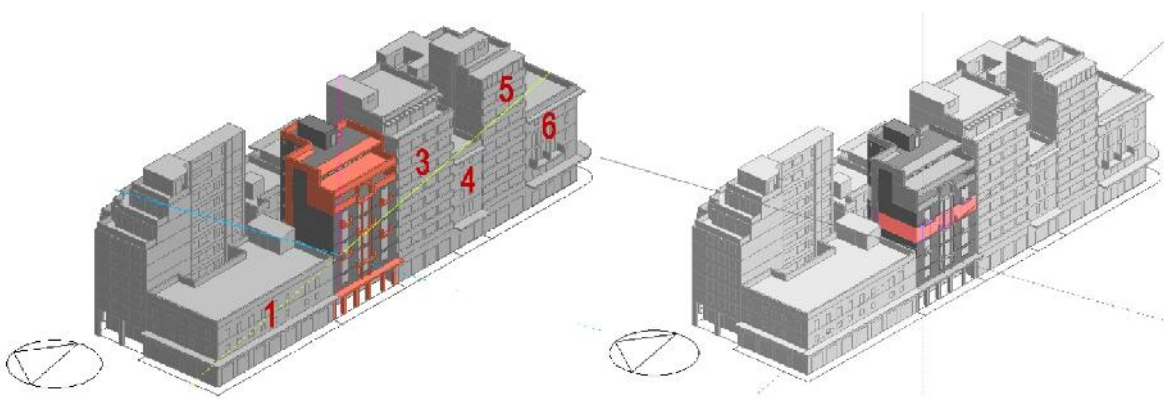


Figure 4.14. Buildings considered as different units and apartments in each level as different thermal zones in Evripidou urban block

As briefly referred, a simplified way was selected on how to organize the subdivisions of the horizontal planes. By identifying the unheated areas, such as stair volumes and elevator voids and by realizing the approximate internal partitions of the different zones for each floor the optimized subdivision was realized. Building constructions elements, thickness and height of external walls and floors have been imputed.

The main input data described in the previous paragraphs related to the Pristeri case study have been also included in this situation in the first dynamic simulation so as to figure out the thermal energy demand and succeeding in this way to control the required energy to maintain internal thermal and comfort conditions. Numerous extra physical factors like solar gains, direct gains for occupants, lighting, computer and equipment’s’ contributions, etc. have been additionally considered for the external air temperatures.

On the following holistic table the mean energy performance values for winter and summer energy demand for each building separately are demonstrated. The results’ analysis in the as built conditions is reported in the following Table 6.

Buildings	EPh (kWh/m2 year)	EPc (kWh/m2 year)
1	54	39
2	57	35
3	33	38
4	59	45
5	47	41
6	43	31
7	70	49
8	53	42
9	24	19
10	39	38
11	43	41
Mean values	**47**	**38**

Table 6. Calculation of the winter and summer needs of all analysed buildings (as built scenario) in Evripidou (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

4.2.3 Energy retrofitting scenarios for the two selected urban settings

As a next step further investigations have been performed for the possible energy retrofitting scenarios of existing buildings in Peristeri urban compound. In this case, the central double building block was selected as the most eligible unit case study energy. A comparison between the previous energy analysis of the as-built state in the specific case study and the energy saving of many proposed basic retrofitted options is demonstrated. Results of performed simulations are synthetized in the following Table 7

Building type: Double building block (B6): Gross surface 6200 square meters				
	WINTER		SUMMER	
	Q (kWh/y)	Ep (kWh/sqm*year)	Q (kWh/y)	Ep (kWh/sqm*year)
As built	354.042	117	148.274	49
1) Insulated walls	242.080	80	75650	25
2) Window's replacement	317.730	105	142.222	47
3) 1+2	205.768	68	60.520	20
4) Insulated roof	329.834	109	130.118	43
5) Insulated green roof	326.808	108	139.196	46
6) 6 (6= 3+5)	184.585	61	60.520	20

Table 2. Retrofitting options in the double building block (B6) and correspondent energy savings (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

In Peristeri urban compound, the main building block B6 was analyzed and simulated in six different scenarios in order to identify the most appropriate retrofitting actions to achieve energy consumption's reduction up to nZEBs in existing building blocks. The diagnosis in detail performance of each residential unit separately, have resulted in the assumption that in many cases there is a possibility of reaching an average Energy Performance (EP) up to 20 kWh/m2*y, by the use of insulated opaque surfaces, by insulating the roof and the walls and also by replacing the existing windows. (Ferrante, 2016)

As far it concerns Evripidou selected urban block the single retrofit options have been selected and combined in the attempt of finding the best compromise between the different - and often conflicting- winter and summer demands with existing constraints limiting the possible retrofitting actions in the existing buildings[37].

High performing windows with double glass 4mm and an air layer (12mm) and very high performing have been hypothesized.

The same retrofitting scenarios assumed to the previous case study for Building B6 of Peristeri, have been analysed separately in order to have a general idea and be ale to select the best case option and the highest performing solution. Then it was performed a simulation including all the designed retrofitting options. A detailed analysis for each scenario has been performed for all the 11 buildings in the selected area, thus obtaining, for each building, the energy requirements in both summer and winter period. The table below reports the performed calculations just for building 1.

Building 1 in Evripidou urban block: gross surface 930 square meters				
	WINTER		SUMMER	
	Q (kWh/year)	Eph (kWh/sqm*year)	Q (kWh/y)	EPc (kWh/year)
As Built	46442	47	41353	41
1) Insulated walls	105575	106	76215	76
2) Windows' replacement	17759	18	12434	12
3) 1+2	28332	28	22450	23
4) Insulated roof	28099	28	22385	22
5) Insulated green roof	44653	45	43315	43
6) 6 (6= 3+5)	49200	49	46770	47

Table 8. Different retrofit options calculated for building 1 in Evripidou urban courtyard (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

[37] In example, the polyurethane insulation on the roof while having characteristics of low thermal inertia has been considered preferable for the reduced weight with respect autoclaved aerated concrete (AAC).

As it is already mentioned in order to have a holistic view of the total energy performance the same calculations have been performed for all the 11 buildings in the selected urban block.

By the mutual comparison of all the resulted simulation among the different buildings the following conclusions can be drawn:

- The efficiency of the insulation of the vertical walls through external coatings depends on the orientation of the individual buildings. Though, it does not present the greatest advantage during the hot summer season, a fact that should be considered especially in the intense climate conditions in Athens during summer.
- The roof insulation represents always an excellent intervention for both summer and winter
- The green insulated roof produces a slight disadvantage in winter
- Among the mentioned combined interventions the combination n.3 (wall insulation +window replacement) produces the greatest benefits if compared to the insulated roof, or the isolated green roof, consumption is much lower and the resulting could increase up to three times as much.

To sum up, the first phase of the retrofitting options' design involves upgrading measures that show a positively effect on the energy performance of the existing buildings.

Ferrante (2016) demonstrated that in all the considered case studies, performed calculations have shown that it is possible to reach an average Energy Performance (EP) that varies between 50 up to 15 kWh/m2*y, for winter and summer respectively, by insulating opaque surfaces –roof and walls- and replacing existing windows .

A complete and comprehensive calculation was necessary to be performed for obtaining the global energy demands in the urban complexes studied as case studies and as pilot urban units in the Athens Metropolitan Area.

In the following Table 9 the different components of energy consumption are reported, according the different proposed scenarios: in the scenario as built, the complete renovation of all the buildings given by the retrofitting scenario n. 6 (6= 3+5), the combined scenario consisting of wall insulation, window replacement with high performing glazing components, and the insulated and green roof. It can be observed a reduction in energy consumption that varies from 33% to 31%, indicating the great potentiality for energy saving in the renovation of the existing building stock.

The performed calculations illustrated (Table 9) result in the global annual electric energy demand, that is the total amount of energy to be considered in the calculation of energy generation to be supplied to set to zero the energy balance of all the buildings in the considered urban settings.

		Urban settings	Peristeri	Evripidou	
		Number of Buildings	12	11	AS BUILT
		Total Square metres	27.368	12.233	
		Qh (winter)	3.219.845	442.425	
		Qc (summer)	1.833.656	731.565	
A		Thermal energy consumption (cold season)	3.788.053	533.043	
B		Electric energy consumption (cold season)	0	0	
C		Thermal energy consumption (hot season)	0	0	
D		Electric energy consumption (hot season)	1.097.998	438.063	
E	A + C	Total thermal energy consumption	**3.788.053**	**533.043**	
F	B + D	Total electric energy consumption	**1.097.998**	**438.063**	
G		Thermal energy reduction (cold season)	3.219.765	306.644	RETROFIT SCENARIO 6
H		Electric energy reduction (cold season)	0	0	
I		Thermal energy reduction (hot season)	0	0	
L		Electric energy reduction (hot season)	360.537	166.464	
M	E - G - I	Final thermal energy demand	568.288	226.399	
N	F - H - L	Final electric energy demand	737.461	271.599	
O		Percentage of reduction of thermal energy	**-85**	**-70**	
P		Percentage of reduction of electric energy	**-33**	**-38**	
Q		Electric energy supply for heat pump system (cold season)	340.292	183.619	
R	**N + Q**	**Annual energy demand for heating and cooling**	**1.077.754**	**455.218**	
S		Electric consumption for domestic appliances	957.880	393.715	
T	**R + S**	**Global annual electric energy demand**	**2.035.634**	**848.933**	

Table 9. Comparison of total energy consumption in the as built scenario and after the complete energy renovation (scenario 6) in the two selected urban settings (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

4.2.4. Brief notes on the energy demand in the different urban settings

It is a realistic an inevitable scenario the importance of a bioclimatic approach in urban planning and building designing so as to achieve a low energy consuming built environment and set it to zero energy. This important fact was showed and analysed in the previous chapters by the performed simulations and the results gained. In an approach like this, the most important factors should be taken under serious consideration in order to achieve the goal and determine the energy consumption such as the site location, the building orientation, the organization of the blocks and the single units that constitute them. Nevertheless, in an existing built environment and in already existing buildings, all the passive components are defined as critical features and not as variables and they can be seen and elaborated as input on the design stage or as refurbishment intervention.

However, despite the very different contexts under study and the diverse levels of energy demand registered between the single units forming the building blocks and the urban settings, a general deduction arises from the comparison of the main physical and energetic variables: in all the urban contexts the energy performance indexes are variable between 44 and 88 kWh/m^2 year for heating demand and between 36 and 100 kWh/m^2 year for cooling demand. (Ferrante 2016) Though, Evripidou area due to the urban dense geometry demonstrates the lowest values of energy demand for heating during winter and cooling during summer.

The total of the energy consuming is calculated by the sum of both cooling and heating demand, derived from the typical climate of Athens that presents very hot summer and cold winter also. The high consuming is a result of the intense climatic conditions and the very low level quality of buildings’ construction components connected with poor energy performance.

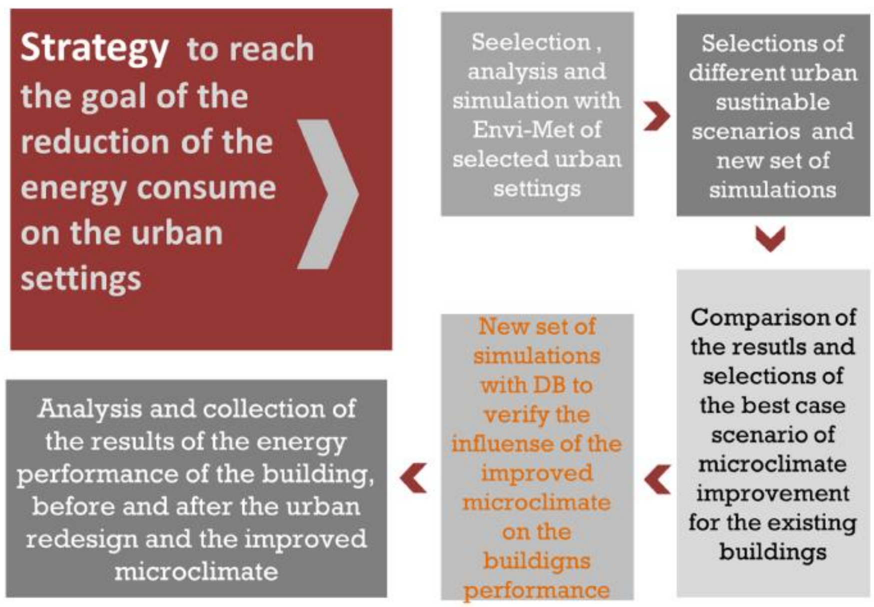
As observed,

Urban setting	**Peristeri**	**Evripidou**
Number of Buildings	12	11
Total Square metres (m^2)	27368	12233
EPh (heating) (kWh/m^2 year)	88	44
EPc (cooling) (kWh/m^2 year)	101	36
Thermal Energy consumption (winter) (kWh year)	2817456	533043
Electric Energy consumption (winter)	0	0
Electric Energy consumption (summer)	1651705	438063
Total thermal Energy consumption	**2817456**	**533043**
Total Electric Energy consumption	**1651705**	**438063**

Table 10. Total Energy demand in the different urban contexts (source: Ferrante A., 2016. Towards nearly zero energy. Urban Settings in the Mediterranean Climate. Elsevier)

4.3. Comparison of the Energy demand of the buildings in three different scenarios (as it is, using the climatic data for the HIE and the new climatic data after the simulation with Envi-met with the use of green)

Conclusions drive attention on the interactions between green area and air temperature, but also look at the impacts of these variations on project choices at urban and building level. In order to achieve the goal of zero energy urban settings a strategy of five basic steps has been followed:



- Selection, analysis and simulation with envi-met of a characteristic urban compound;
- Selection of different urban sustainable designs scenarios, perform new simulations;
- Comparison of the results and selection of the best possible scenario for the improvement of the HIE and the microclimate in the urban compound;
- Simulation with Energy Building to check the influence the improvement of the microclimate has to the existing buildings;
- Analysis and collection of the results for the building energy performance after the redesign of the urban compound and the improvement of the microclimate.

-

The sustainability of urban building design in these regions cannot be fully assessed by indoor environmental simulation not taking into account the microclimatic factors of the surrounding urban neighbourhood. It is found (Chengzhi Peng and Amr F. A. Elwan, 2012) that the current suites of outdoor and indoor simulation software do not connect with each other to give us a holistic understanding of both outdoor and indoor simulation results.

The objective of this research is that assessment of sustainability at an urban neighbourhood level can be carried out more holistically, and as a result achieving more valid environmental simulations from an urban environment point of view. The outdoor-indoor collaborated methodology is structured on a digital work among two key software platforms: (1) ENVImet for urban neighbourhood outdoor simulation, (2) Design Builder for building indoor simulation,

It is beyond question that, the environmental sustainability of an existing building or a new building concept cannot be fully assessed by indoor environmental simulation alone without taking into account the urban microclimatic conditions of the surrounding urban areas where the building stands. It is commonly accepted that good environmental performance leads to lower energy consumption in maintaining thermal comfort, which is the first step towards sustainability. Despite the recent progress in environmental simulation software tools, still exist barriers to overpass such as the lack of collaboration between software developed for large scale urban outdoor environments simulation and software specialized for indoor environments. If so, these two types of software simulations for different scale, could produce unified outputs allowing architectural and urban planners, designers a more holistic apprehension of outdoor-indoor simulation results that reflect more accurately the urban patterns. This research, focuses on developing a methodology so as to bridge this current gap and as a result, the assessment of sustainability at an urban neighborhood level can be studied more holistically, hence achieving more valid environmental simulations from an urban dwelling point of view.

Urban climatology is an interdisciplinary field which provides an important source of knowledge and data to inform urban design. However, its complexities and technicalities have prevented planning and design practices from applying rigorous climate knowledge (Oke 1984; Eliasson 2000; Ali-Toudert &. Mayer 2007; Fahmy & Sharples 2008). In searching for better supporting tools, Fahmy and coworkers highlighted that software like ENVI-met for urban microclimate modelling does not have the capability to simulate indoor climate (Fahmy et al. 2009).

In search for an alternative methodology more appropriate for sustainable urban neighbourhood design studies, this research's proposition is that weather data specific to a city site can be attained by urban micro climate modelling on the basis of the macro climate weather data collected by the weather stations. ENVI-met platform can be used to generate site-specific weather data for an urban site, which can then be loaded to programs like Design Builder so as to perform simulation of an indoor environment on site.

In the current situation, ENVI-met and Design Builder are two different software platforms and their simulation outputs are presented in different formats. A further step is required to bring the outdoor and the indoor simulation results together to reveal the total environmental performance of an urban neighbourhood. Three basic were performed in this research in order to achieve the goal of an integrated result of the two different simulations

Step 1: Simulating with the ENVI-met and collect the climatic data that derives from each scenario

Step 2: Generating urban site-specific weather data for Design Builder next step simulation

Step 3: Integrating both systems together and have an holistic analysis, by introducing the new climatic file into Design Builder's weather data and set new simulations for the building energy performance

In this next step in order to check and evaluate the improvement of the microclima of the area selected and the effect that the new climatic data have on the energy demand of the buildings, the new climatic data of the area simulated by Envi-met have been used to be intertwined with the simulation by Design Builder, using them as a new input for the re-calculation of the energy performance of the building.

The case study of Peristeri area

At this next step, as it is shown at the Figure 4.15, an area of 4x4x4m around the main central double block building has been identified. A vertical division in 5 critical points was also performed, as it is seen in Figure 4.16 (ground level, pilotis level, first floor, middle floor, last floor and 4 meters above the rooftop) so as to subtract results from all the points referred to these elevations. The scope, as mentioned, is to create a new climatic file that will refer to the climatic data gathered from the simulation with envi-ment, locally.

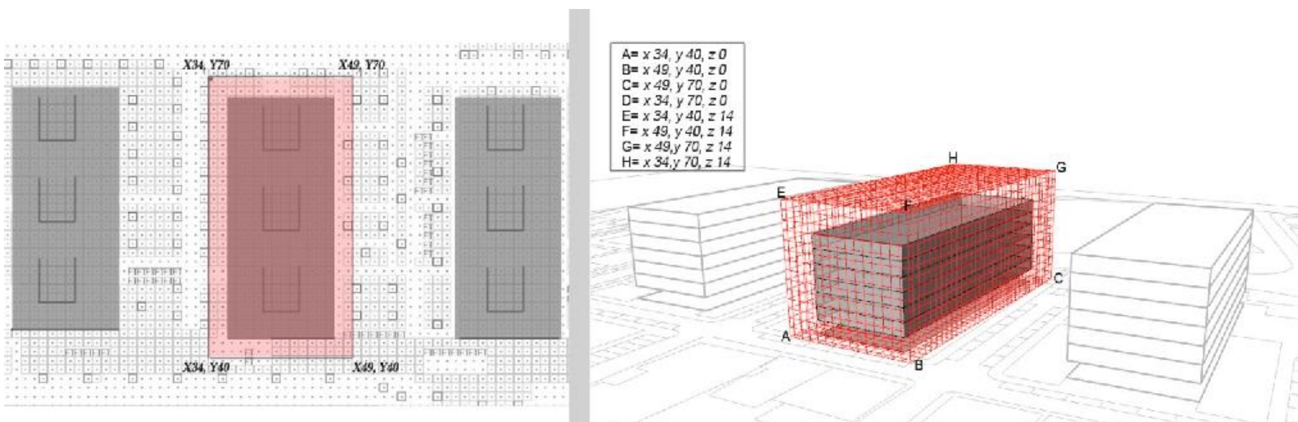


Figure 4.15 The defined area around the double block building for the new climatic data

The data extracted from the grid around the building are the temperatures referred to all those points. A, ΔT of the all temperatures was calculated for each level (one for the data from a simulation for the hottest day of the summer, and one from a simulation performed the day with a mean temperature of 26C). These data (temperature, Celsius degrees) for each critical level are then in a second step elaborated with a special program in order to create the new climatic file that can correspond to the weather data of Design Builder, for each of the selected horizontal sections. In order to perform simulation for each different building with the use of the new climatic file, every time the proper climatic file that corresponds to the selected apartment /floor of the building should be inserted to the program.

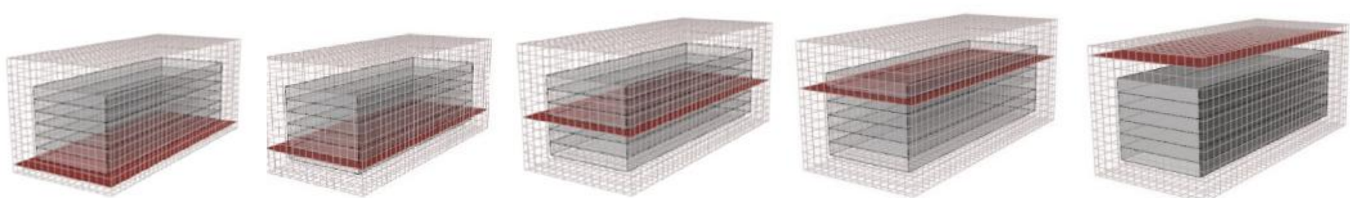


Figure 4.16. The selected horizontal sections around the double block building for the new climatic data

Last level of the simulations, will be done with all the climatic data needed for the comparison of the energy demand. More simulations with design builder are executed taking into account the existing climatic file of the program, the improved climatic file with the data extracted from envi-met, and the HIE file that was created in order to achieve a holistic analysis.

The air temperature of these points has been used for the simulation of the correspondent apartments. South-oriented residential apartments at the first, third and last floor of the double building block B6 of Peristeri have been taken as reference units. Simulations have been performed for the summer period, the hottest months and were the HIE is more evident (from 1st June until 31th August).

The standard climatic data used by design builder (IWEC climatic data file) have been modified in two different and opposite ways. On the one side, they have been decreased according to the correspondent value of external temperatures from the Envi-met calculations; on the other side, the same data have been increased as a function of measured data in the correspondent meteorological station of Peristeri (Giannopoulou et al, 2011).

Results of the energy demand for cooling (kWh) of these apartments, for the whole summer period, are reported in Figure 4.17. As shown, these results are highly variable as a function of external temperatures.

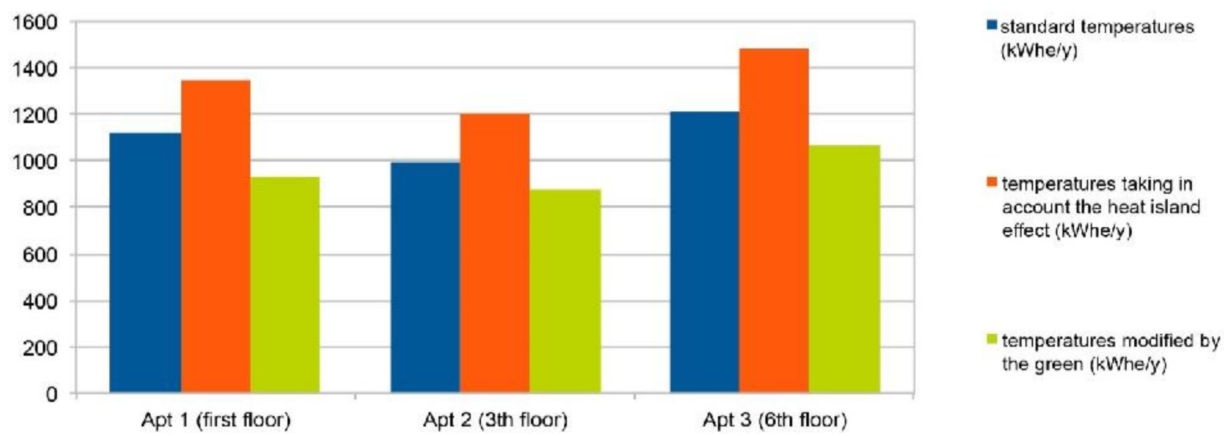


Figure 4.17. Cooling demand in three reference apartments of the building block B6 in Peristeri

As it can be observed in Table 11, values of energy demand for cooling in the selected apartment at the first floor vary between 1348,37 kWh, from the worst condition represented by the scenario considering increased air temperature due to the heat island effect to the best scenario, to 1122,55 kWh, where air temperatures have been supposed under standard condition, down to 926,54 kWh in the improved scenario due to the cooling effect of the green.

Corresponding values of energy demand for cooling in the apartment at the intermediate floor vary between 1202,45 kWh, in the worst condition represented by the scenario considering increased air temperature due to the heat island effect, to 990,98 kWh the standard scenario, where air temperatures have been supposed under standard condition down to 874,06 kWh in the improved scenario due to the cooling effect of the green.

Corresponding values of energy demand for cooling in the apartment at the last floor vary between 1483,49 kWh of the worst condition represented by the scenario considering increased air temperature due to the heat island effect, to the standard scenario, to 1211,22 kWh, where air temperatures have been supposed under standard condition down to 1067,35 kWh in the improved scenario due to the cooling effect of the green.

	Energy demand for cooling (kWh)	Energy demand for cooling (kWh)	Energy demand for cooling (kWh)
	(standard air temperatures)	(air temperatures HI effect)	(temperatures modified by green)
	(kWhe/y)	(kWhe/y)	(kWhe/y)
Apt 1 (first floor)	**1122,55**	**1348,37**	**926,54**
Apt 2 (3th floor)	**990,98**	**1202,45**	**874,06**
Apt 3 (6th floor)	**1211,22**	**1483,49**	**1067,35**

Table 11. Cooling demand values in three reference apartments of the building block B6 in Peristeri

As a concluding result, a percentage decrement of about the 20% between each scenario can be found. Globally up to about 40% reduction of energy consumption can be observed, demonstrating the huge potential of environmental modification at the urban scale on the energy performance of existing buildings. A very significant, twofold impact on heat island reduction at the urban scale and energy consumption at the building scale can be deducted as the direct by shading and green in the urban setting model.

The case study of Evripidou

The same procedure analyzed on the previous paragraph was followed for the case study of Evripidou. A south oriented building (no. 5) was selected and as horizontal sections it was taken into account the apartment of the first floor, the middle(4^{th}) one, and the top one(8^{th}). New climatic file was created for the selected horizontal sections that correspond to the city center climatic conditions and after the redesign of this studied urban area. Differences on Temperature and improvement of the local microclimate of this area was analyzed on Chapter 3. Simulations have also been performed at the same period, such as the summer period, from 1^{st} June until 31^{th} August.

The standard climatic data used by design builder (IWEC climatic data file) have been modified in two different and opposite ways. On the one side, they have been decreased according to the correspondent value of external temperatures from the Envi-met calculations; on the other side, the same data have been increased as a function of measured data in the correspondent meteorological station of the centre of Athens.

Results of the energy demand for cooling (kWh) of these apartments, for the whole summer period, are reported in figure 4.18. As shown, these results are highly variable as a function of external temperatures.

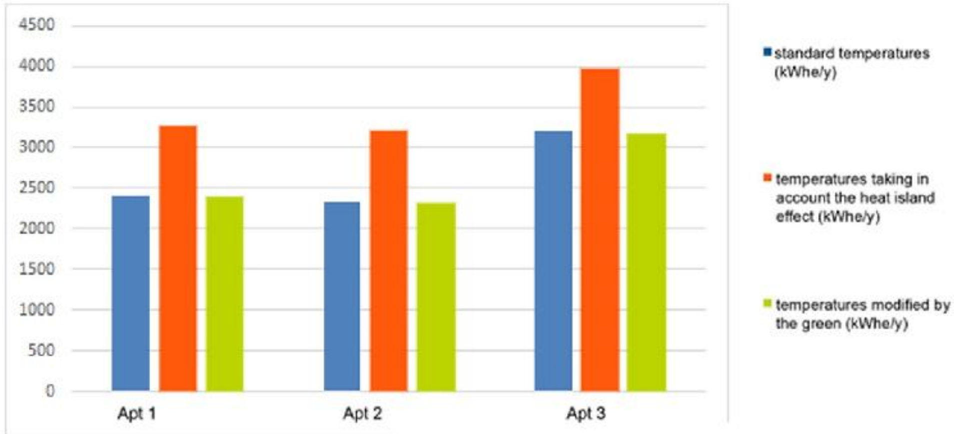


Figure 4.18. Cooling demand in the three reference apartments of the building No.10 in Evripidou urban block

A percentage decrement of about the 33% between the proposed 'green' scenario can be found. The difference between the actual situation and the improved scenario is not so important, but the HIE situation is actually the reality in the centre of Athens. This can be explained by the high compactness and density of the specific urban context and due to the limitation and the constraints for an extended urban sustainable redesign of the area, due to limited open spaces, already built plots, narrow streets and main traffic axes.

Thus, this analysis is demonstrating the huge potential of environmental modification at the urban scale on the energy performance of existing buildings. A very significant, twofold impact on heat island reduction at the urban scale and energy consumption at the building scale can be deducted as the direct by shading and green in the urban setting model.

Results of these simulations are highly consistent with data and correspondent values reported by Santamouris (Santamouris, 2014; Santamouris et al. 2015). In fact, as illustrated by Santamouris et al. and already reported energy penalty of ambient overheating is quite high and depends mainly on the characteristics of the building stock, the climate zone, the urban form (and its boundary conditions) as well as the type of the provided energy services. A significant increase of the energy consumption of buildings, caused by the ambient temperature intensification in metropolitan areas, was calculated for the period 1970–2010. In particular, for the case study of Athens a percentage increase of the base electricity load per degree of temperature increase equal to 4,1% was found. In particular, in Athens Santamouris (2014) found that the cooling load has increased from 99.5 $kWh/m^2/y$ in 1970 to 124.8% in 2010, while the corresponding heating load has decreased from 39.4 $kWh/m^2/y$ in 1970 to 31.7 $kWh/m^2/y$. (Ferrante, 2016)

Urban heat island and global warming increase the temperature of metropolitan cities like Athens and exacerbate the energy demand of buildings. In particular Santamouris (2014) found that energy increase is very significant in cooling dominated zones; there the rise of the summer energy needs is much higher than the possible decrease of the heating needs in winter, as can be observed by the figures reported. Although the available studies comparing the energy consumption of similar buildings located in urban and rural zones are quite limited, existing data reveals that the average increase of the cooling load because of the heat island is statistically significant and in average is close to 13%. So far, limited studies are available regarding the global energy penalty induced by the urban warming on the total building stock of a city[38].

[38] As shown by Santamouris (2014) and Santamouris et al. (2015), calculations performed for a set of different cities around the world have demonstrated that the global energy impact of higher urban temperatures is very important. The average global energy penalty per unit of city surface is significant (2.4 kWh/m^2), while the average Global Energy penalty per unit of surface and degree of UHI intensity is close to 0.74 $kWh/m^2/K$. In parallel, the average global energy penalty per person is close to 237 kWh/p and the global energy penalty per person and per degree of the UHI intensity is around to 70 kWh/p/K. These figures consist of preliminary information may change when more data are available. Based on a significant number of studies it is calculated that the average increase of the cooling demand of representative buildings during that period 1970-2010 was close to 23%. In parallel, the corresponding average reduction of the heating load is around to 19%, while during the same period, the average total energy load of representative buildings spent for heating and cooling purposes increased by 11%. The specific studies and analysis make clear that urban warming has a very significant impact on the global energy consumption of buildings.

A holistic approach

From the previous results both from Peristeri and Evripidou area it was identified the importance of the presence of green in both cases. Although, on Peristeri stand-alone buildings the effect was more noticeable and the decrease of the energy demand was measurable not only in comparison to the HI effect but also on the normal standard climatic conditions. As a result the same apartments already simulated in their as it is conditioned in a next step were simulated on the retrofitted scenario and the three different climatic conditions so as to compare and discuss all the possible results on the energy performance of the building in the urban context.

The same procedure analyzed on the previous paragraphs was followed. The south-oriented residential apartments at the first, third and last floor of the double building block B6 of Peristeri have been taken as reference units. Simulations have been performed for the summer period, the hottest months and were the HIE is more evident (from 1st June until 31th August). The apartments are now simulated on the best renovation scenario which corresponds to: roof and wall insulation, new windows, green roof.

New climatic file was created for the selected horizontal sections that correspond to Peristeri climatic conditions and to the new greener redesign of this studied urban area.

The standard climatic data used by design builder (IWEC climatic data file) have been modified in two different and opposite ways. On the one side, they have been decreased according to the correspondent value of external temperatures from the Envi-met calculations; on the other side, the same data have been increased as a function of measured data in the correspondent meteorological station of the center of Athens.

Results of the energy demand for cooling (kWh) of these apartments, for the whole summer period, are reported in Table 12. As shown, these results are highly variable as a function of external temperatures.

	Energy demand for cooling (kWh)		
	(standard air temperature)	(HI effect)	(Modified by green)
	(kWhe/y)	(kWhe/y)	(kWhe/y)
As it is scenario			
Apt 1 (first floor)	1122,55	1348,37	926,54
Apt 2 (3th floor)	990,98	1202,45	874,06
Apt 3 (6th floor)	1211,22	1483,49	1067,35
Rennovation scenario			
Apt 1 (first floor)	876	1029	742
Apt 2 (3th floor)	867	1000	793
Apt 3 (6th floor)	948	1092	893

Table 12. Cooling demand values in three reference apartments in the built as it is and in the basic renovation of the building block B6 in Peristeri on the three proposed urban scenarios.

In this total and comparative table a lot of interesting results and assumptions can be analyzed.

First it can be concluded that comparing the first column (standard air) that refers to the renovated apartment and the third column (modified by green) that refers to the ‘ as it is’ apartment the energy demand expressed in KWHe/y result at the same level, which more specifically means that in case studies like the urban context of Peristeri, by adding extra green on the outdoor environment, by changing the material and create shading spots, so in detail improving the microclimate may lead to the same results of a standard building retrofitting. This can also be effective in cost analysis demand in a whole neighborhood.

Second, it can be observed, as far it concerns the HIE and the intense climatic conditions documented especially on Peristeri area, by the basic retrofitting on a building scale the energy demand for cooling of the apartment does not arrive to the equal level if we compare it with the demand on the scenario with the improved microclimate and without any renovation on the building. It is resulted that the improvement of the microclimate on the urban context and of the outdoor conditions in this case is more effective.

Third can be highlighted that depending the case study and the conditions of each building and the external area, the best case scenario is the combination of the improvement of the microclimate which is a result of a sustainable redesign in an urban scale and a standard retrofitting of the building. As it derives from the Table 12 the percentage of decreasement on energy demand for apartment on the 6^{th} and the last floor of the building,between the as built scenario and standard climatic conditions and the renovated building with the improved by green climatic conditions, can reach a 30-40 %.

It can be concluded urban settings and buildings in order to reduce the specific impact of urban heat island and global overheating on electricity consumption should be more adaptable to specific climatic conditions considering the built environment in its different scales and conceiving the retrofitting options in the existing built environment and in its urban boundary conditions as a unique system. In fact, energy demand and energy retrofitting options should be observed, with the same gravity also to the open spaces and environments of the city and not only in reference on the building block, thus considering the buildings and the related open spaces as the main sector of energy investigation and the consequent global effects that result from the collaborative strategy and its effects of all the buildings and open areas of the urban environment.

As a consequence of this chapter, it can be told with certainty that the nearly zero energy buildings may reduce in a significant way the energy needs and thus the resulting stress to the utilities and the consumers. In parallel it was documented that the urban adaptation and the development by the use of advanced and mitigation techniques and technologies with the achievable goal to decrease the outdoor climatic conditions in the built environments, may also reduce considerably urban temperatures.

4.4 The energy saving potential of green and passive techniques in the urban environments

The increased industrialization and the replacement of natural landscapes and constructed dense built zones has radical affected the urban environment and as an extension its atmosphere, causing the thermal degradation of urban climate and the environmental efficiency of buildings. The resulting evolution of urban areas created a situation where the temperature of the cities is much hotter than the one of its surroundings. The last decades, the average annual temperatures in many cities have increased by as much as 3°C.

Morphological and spatial geometry of buildings, together with the thermal properties of surface coatings and, most of all, green surfaces have a strong potential on the energy performance and cooling demand reduction in urban areas. Thus, planning strategies to reduce the cooling demand at the city level of the Mediterranean Region should consider green and natural components as the main tools for improving climatic conditions urban areas.

At the territorial and urban scale it has been largely demonstrated that plants have a strong effect on climate: trees and green spaces can help cool our cities (Santamouris, 2001) (Buttstädt et al, 2010) and save energy (Yamashita, 1996). As it was mentioned on previous chapters, green also help the mitigation of the greenhouse effect, act as filter pollutants, and filter city's noise (Ferrante and Mihalakakou, 2001).

Therefore, considering vegetation in urban areas can alleviate the greenhouse. In the Mediterranean hot climate, vegetation planted around buildings can alter the energy balance as well as cooling energy requirements of buildings by sheltering windows, walls, and rooftop from strong solar radiation as well as radiation reflected from the surroundings.

According to Ferrante (2016) "*Realization and awareness of the climate conditions, seasonal variations and climate change bring additional demands on the planning and design of urban developments. In this context, an urban 'climate-sensitive' design may be defined as a process that considers the fundamental elements of microclimates (e.g., sun, wind, temperature) for design purposes. This concept is* *applied to benefit from the positivity of natural sources in urban microclimate conditions and to mitigate, decrease and counterbalance the negative effects of urban dis-functionality through appropriate design and planning options."*

Improvement of the ambient microclimate in the urban environment involving the use of more appropriate materials, increased use of green areas, use of cool sinks for heat dissipation, appropriate layout of urban canopies, etc., to counterbalance the effects of energy consumption's increase in the urban areas. Construction of new generating plants may help solving the energy generation to achieve nearly zero energy buildings but cannot consist in the sole options as far as it concerns the outdoor climatic issues. Adoption of measures to decrease the energy demand in the urban areas, like the use of more appropriate materials, increased plantation, use of sinks, etc., seems to be a much more reasonable option[39].

With the redesign of the the building's surfaces and facades by adding green components or shading devices in the two different case studies in Athens, different scenarios have been proposed and the obtained results of the experimental software research models that was used to quantify the positive effects of these selected passive techniques it was clearly highlighted that outer surfaces' alternative design acts as a principal microclimate modifier and deeply improves outdoor air climate and quality (up to 2/3 °C reduction in ambient temperature) (Santamouris, 2001)[40]. Although the limits of the existing urban constraints in dense built urban zones the design of outdoor spaces -even if reduced to the envelope of the buildings has been regarded as a key factor to improve urban conditions in relation to both microclimate and reduction of pollutants.

[39] Such a strategy, adopted by the Sacramento Municipal Utility District, (SMUD), has proved to be very effective and economically profitable, (Flavin and Lenssen, 1995). It has been calculated that a megawatt of capacity is actually eight times more expensive to produce than to save it. This because energy saving measures has low capital and no running cost, while construction of new power plants involves high capital and running costs.

[40] Other significant physical factors in the thermal performance of urban environments are wind flows and air circulation (Santamouris et al, 1999), (Ricciardelli et al, 2006) as well as air stratification within urban canyons. In particular the heat island effect and the microclimatic conditions typical of urban canyons (Bitan, 1992) appear to be strongly influenced by thermal properties of the materials and components used in the buildings and on the streets (Buttstädt et al, 2010). Comparative research studies demonstrated that the use of cool coloured materials (Synnefa et al, 2007) and thermo-chromic building coatings can contribute to energy savings in buildings, providing a thermally comfortable indoor environment, and, at the same time, highly improve the urban microclimatic conditions (Karlessi et al, 2009).

DISCUSSION

The nearly zero energy buildings of the selected urban settings is an achievable goa. Although, a large set of possible solutions from best available products and components should be technically applicable to achieve nZEBs, even in highly energy consuming buildings. In both considered cases, to reach the Zero Energy, passive retrofitting interventions and improvement of the microclimate are both necessary.

A combination of alternatives solutions in order to reach the objective of the effective reduction of energy consumption towards zero energy buildings and districts is and remains an objective is necessary. Especially in the Mediterranean urban areas, where the intense combination of HI phenomena and global overheating is higly documented, the use of open spaces, where water, green and selected passive techniques may foster and accelerate the significant reduction in terms of energy consumption is a main strategy that should be followed.

To sum up, the chapter has discussed and demonstrated the technical feasibility of nearly Zero Energy in highly energy consuming building stock and urban settings of Athens, a representative city of the Mediterranean Area. A further step is needed in the effort of understanding the potential mutual effects of modified external conditions with respect to the energy performance of existing buildings. To provide an idea of the potential of outdoor modifications on the energy performance of existing buildings in this urban compound taking into account the mutual interactions between buildings and open areas, further simulations have been run. In this chapter, is reported the investigation into a new methodological framework for bridging the current gaps between urban microclimate simulation at a neighborhood scale and indoor environmental analysis at a single building level.

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CHAPTER V
POLICY RECOMMENDATION

PURPOSE STATEMENT

There is an increased awareness on how to design in accordance with the environment and the climate. "*Different climatic aspects such as climate conditions, seasonal variations and climate change bring additional demands on the planning and design of urban developments. Urban 'climate-sensitive' design is defined as a process that considers the fundamental elements of microclimates (e.g., sun, wind, temperature) for design purposes. This concept is applied not only to benefit from the existing urban microclimate but also to mitigate it's already stressed condition and decrease the negative effects through design and planning options. However, this concept requires a more scientific approach to evaluate its true meaning, which implies a method of inquiry that must be based on empirical and measurable evidence subject to specific principles of reasoning*." (Tapias &Schmitt,2014)

Cities demand a high-level of city planning with knowledge on how to adapt, transform and reinvent built environments. In this sense, it is useful to consider architectural design as a particular type of problem-solving process. In order to support urban planning processes, there is a need of an automated method that could provide solutions that help the construction of future cities.

The urban sustainability is a not a simple concept. The scenario of a sustainable city refers to the future of the city and its citizens, to an effective local and interacted policy making with the existence of economic and social aspects, environmental long term objectives. It is illustrated in many researches that an energy policy is the main aspect and a key factor for urban sustainability.

As a consequence by taking into account the social economical aspect and the energy consumption a holistic solution is promoted with the use of a multilayer urban policy with main principles of energy saving and urban sustainability.

. In this framework the awakening of awareness of the citizens is important and could be achieved with information projects, workshops and communication campaigns. It is stated that the successful exchange of knowledge and information is underdeveloped. It is also important to have comparative studies of sustainable city efforts in general.

Data for the case study of Greece have been collected by the report represented for the EEI project “Monitoring of Energy Efficiency in EU 27, Norway and Croatia (ODYSSEE-MURE)”. Energy efficiency trends and policies of the period 2000 – 2013 are analyzed and collected here as a summary.

In an overall view, till 2008 there was a yearly average energy consumption of 3% with a total incensement by 18% during the period 2000-2007. However, both the implementation of energy use improvement and the economic decline had as a result to a significant reduction of final energy consumption. The total final energy consumption during this period follows an average decreasing trend of 6% per year, that lead to a significant reduction of final energy consumption by 30% during this period. (CRES, 2015)

Due to economic downturn, Greece is a particular case for the European Union energy consumption analysis. From ELSTAT and Eurostat is possible to highlight the result of the economic recession on the Greek economy during the period 2007-2013. All sectors of economic activity show a decrease in Gross Value Added, particularly for the period 2009-2013, where the impact of the economic recession was being felt in the real economy.

The development of the net disposable Income per inhabitant appears to follow gross national product which shows a continuous annual increase during the period 2006-2009 and a significant annual decrease in the period 2009-2013. The total reduction in the Net Disposable Income per inhabitant amounts to 21% in the period 2009-2013 and 10% during the period 2006-2013 (Figure 5.1). (CRES, 2015)

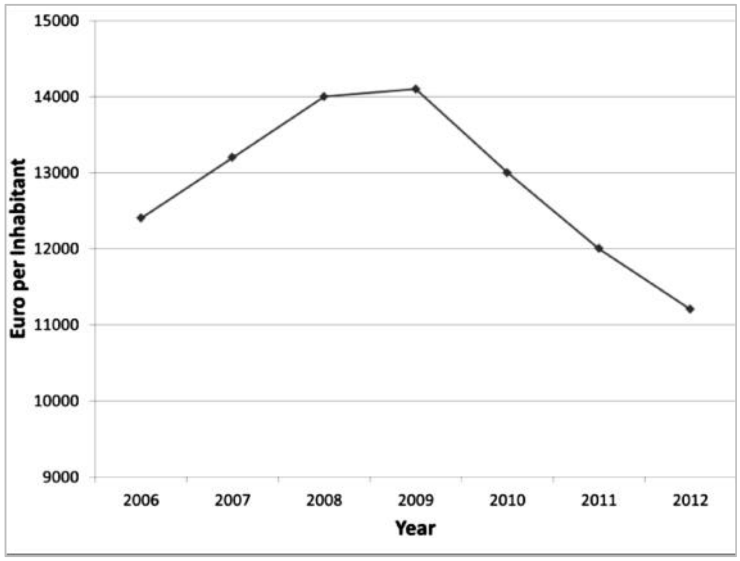


Figure 5.1: Reduction in the net disposable income per inhabitant (Source EUROSTAT)

In this framework on EU H2020 targets (20% energy reduction ect.) there are two very challenging sectors in Greece: (i) Building sector and (ii) Transportation

Building sector in Greece consumes the 37% of the final energy. Until 2006 the residential final consumption was increasing steadily, though the effects of the already mentioned economic downturn with the combination of the energy efficiency measures that have been implemented on 2007, led to a significant decrease on the residential sector. The residential energy efficiency index (ODEX) for Greece has decreased regularly by 14%, between the years 2000 and 2013.

On the second sector, the transportation, it is noticeable that the period from 2000 to 2009, the final energy consumption had a steadily increase of final energy till a 26%. This situation showed to change and lead to a decrease due to the reduction of petroleum products consumption. The last years a decrease of 31% according to 2000 was documented and this is highly due to the measures that contributed to the significant energy savings. (High taxation of vehicles with CO2 emissions, public awareness and education measures to increase use of public transport and promotion of economical driving).

5.1. Energy efficiency policy background. European directives, National & local legislative framework

In order to have a holistic approach the main Greek laws and regulations, and also local standards were analysed.

In 2009, the Greek government followed a political strategy with the initiative of 'green sustainable development'. This political reform led to numerous and policy measures that include the establishment of the Ministry for the Environment, Energy and Climate Change (YPEKA) with the aim to bring under ones control, the administrative structure respecting the bodies and the authorities involved taking into account energy, environment and fiscal considerations including the long term requirements to address climate change.

Specifically, a comprehensive institutional framework for the energy efficiency and certification of buildings, the technical specifications of new buildings, the obligations of the public sector and energy providers, and the mechanism to monitor and assess progress in the achievement of the national target was developed.

Emphasis was put on developing the appropriate structures (records, databases, technical guides), necessary for implementing the regulatory framework developed, as well as on public consultation with market players, with a view to ensure that this regulatory frame-work is widely accepted. It was established the Special Secretariat for the Environment and energy Inspectorate (SSEEI) under the responsibility of the Ministry of Energy in order to control and monitor the implementation of Law 3661/2008[41] and the measures concerning the reduction of energy consumption of buildings, and issuing energy efficiency certificates.

The main pillar of all the efforts towards achieving the EU target of improving energy efficiency is Directive 2006/32/EC, transposed into Greek legislation by means of Law 3855/2010[42].

[41] Law 3661/2008 (Government Gazette, Series I, and No 89) was released by the Greek government in May 2008 and refers to the obligatory measurements for the reduction of the energy consume of the buildings. It was also introduced the regulation of the energy performance of buildings.

[42] Law 3855/2010 (Government Gazette, Series I, and No 95) was released by the Greek government on June 2010 and refers to the obligatory measurements for the reduction of the energy final consume, energy services and extra regulations. The national goals and target are introduced and formalized about the energy saving, the legislative framework is set and are foreseen the economical means for the achievement of these goals

The main actions and measures that were launched from 2007 onwards as part of achieving energy savings target at a rate of 9% in end-use until 2016, were implemented at national level and mainly involved the development of the institutional and regulatory frame-work for adopting policies, obligations and strategies in all end-use sectors, as part of improving energy efficiency.

"In October 2012, the European Commission adopted the new Directive 2012/27/EU on energy efficiency with clear focus on achieving the overall energy efficiency target of reducing primary energy consumption by 20% by 2020. The requirement to amend Directive 2006/32/EC on energy services and to adopt the new Directive 2012/27/EU on energy efficiency was the result of the signs of divergence in achieving the target of Directive 2006/32/EC which were apparent from the National Energy Efficiency Action Plans (NEEAP I & II) already submitted by the Member States, and the need to update the legal framework for energy efficiency in the EU.

Directive 2012/27/EC came into force on 4 December 2012, repealing Directive 2006/32/EC and Directive 2004/8/EC on cogeneration, with a deadline for compliance of 5 June 2014. Progress towards the indicative energy savings target of 9% by 2016 under Directive 2006/32/EC is a benchmark in the context of Directive 2012/27/EU and is part of this National Energy Efficiency Action Plan (NEEAP)".(CRES, 2015)

5.2 PRINCIPAL NATIONAL ENERGY EFFICIENCY TARGETS [43]

Energy efficiency new Law 4342/2015 introduces some important milestones demonstrating the trend of compliance with the recommendations of the 2012/27/EU Directive. A national energy strategy and an energy efficiency target was set for 2020.

This section presents main energy efficiency measures, which will be adopted for the implementation of Articles 20 and 21 of the Law 4342/2015 and are more connected with this research,

Financial support for energy saving technologies and research

For the information and research level, the Greek government aims to achieve public aid mainly for private investment for renewable energy sources, promote cooperation between undertakings, research bodies and educational institutes so as to develop research projects and as a result to achieve the production of innovative products.

This could be possible with the financial support of various investing programmes for energy saving technologies and research [Law 3908/2011 'Enhancing Private Investment for Economic Development, Entrepreneurship and Regional Cohesion' (Government Gazette, Series I, No 8, 01-02-2011), as recently amended by Law 4146/2013 'Creation of a Development Friendly Environment for Strategic and Private Investments and other provisions' (Government Gazette, Series I, No 90, 18-04-2013), aims at strengthening financial support to investments for the promotion of the green economy.]

[43] The information mentioned and analyzed at this chapter consist part of the "Energy Efficiency trends and policies in Greece"(Minas Iatridis, Centre for Renewable Energy Sources and Saving (CRES), Greece ,Fotini Karamani, Centre for Renewable Energy Sources and Saving (CRES), Greece, 2015)

Increase on building factor and Tax exemptions on energy savings interventions

Numerous laws have introduced taxes incentives with the aim to promote energy efficient technologies / interventions.

As an example increase of the plot ratio to 10% in eligible if the building constructed on that plot demonstrates high energy efficiency ratio or environmental performance (The Article 25 of Law 4067/2012 (Government Gazette, Series I, No 79, 09-04-2012) 'New Building Code'). There is a series of measures that could be followed so as to have a plot ratio increase up to 25%.

In case that the plot is at least 4000 sq.m. (art.10 of the Law) and it is provided up to 100% to common public, use is eligible an increase of the plot ratio by 35% and additional height up to 30% the above the permitted limit of the area, under the conditions that the percentage reduction of the authorized area of plot has a reduction of 35% and the number of buildings created are less than B / 2. (B=existing building)

Is allowed the unification of internal courtyards of the blocks with the scope of the common use of the occupants but by respecting the rights of the ownership. In this way an increase up to 20% of the permitted building is allowed while maintaining the compulsory open spaces. (For property of the State or the municipality, the increase of the building factor is 50%),

"*The Law 4178/2013 'Tackling illegal building - Environmental Balance and other provisions' (Government Gazette, Series I, No 174, 08-08-2013) provides that a joint decision of the Ministers for Finance and for Environment, Energy and Climate Change may allow the amounts paid for services rendered, work and materials on the energy upgrade and the structural adequacy of buildings erected before 2003 to be offset against the special fine, up to 50% of the fine. Moreover, Article 51 provides that for legally existing uses of buildings or facilities which are retained, and also for uses covered by building permits issued under Article 26 of Law 2831/2000, it is permitted, within a period of three years, to carry out energy upgrading works and works on the layout of building with the purpose of improving the environment, on the basis of the building regulations which were applicable at the time the derogation was granted.*

The Laws 4110/2013 (Government Gazette, Series I, No 17, 23-01-2013) and 4172/2013 (Government Gazette, Series I, No 167, 23-07-2013) repealed the exemptions for expenses for energy efficiency improvement interventions, as implemented under Law 3522/2006 (Government Gazette, Series I, No 276, 22-12-2006) and Law 3842/2010 (Government Gazette, Series I, No 58, 23-04-2010)" (CRES, 2015).

However, the new legislation is expected to introduce a reduction in income taxation at a specific percentage of the costs for energy upgrading interventions (install a natural gas system, thermal insulation, solar systems etc), of buildings. In general the New Building law 4067 *(Government Gazette, Series I, No 79, 09-04-2012)* is focused on the energy efficiency at the urban scale and building scale.

To sum up, the two main areas that has introduced are:

1.Increase of the building factor

- Creates incentives to increase the building rate to offset environmental or social benefits. I.e. creating energy building, green roofs, land combinations, limited coverage, and use of external insulation and thick walls of natural materials, double energy shells.

2.Promotes the bioclimatic design and energy savings

- Is not counted in construction and covering factor, the structures and the elements used for improving the bioclimatic behaviour of the building and reducing the energy consumption
-

Puclic spaces: a bioclimatic upgrade

At the urban level, bioclimatic interventions in areas where intense climatic problems are documented with the purpose to improve the level and quality of life, improve local economic conditions, improve the microclimate and all the social factors associated with the phenomenon of climate change in the cities. The programme 'Bioclimatic upgrades of public open spaces' has specific climate targets and are accompanied by fully developed studies and research. Indicative interventions are the increase of open spaces while reducing the hard surfaces by replacing the materials with adequate ones with criteria of reducing pollutants, photovoltaic surfaces, etc.

Introducing shading systems in street level, green areas, organized spaces adaptable for summer and winter period.

Energy Saving Programme

"Energy Saving" (ΕΞΟΙΚΟΝΟΜΩ in Greek) programme has as a purpose the implementation of multiple actions and best practices for achieving the reduction of energy consumption so as to urban scale but with a main target the building sector. The law aims at upgrading the public spaces and of implementing technical interventions/ actions to raise knowledge and motivate citizens, local authorities, public and private sector in supporting the energy saving measures

5.3 ANALYSIS AND RECOMMENDATION

It is a reality that Europe is leading towards a shared and common vision of urban development. Despite the clear potential of urban areas for assisting the EU's economic, social and cultural development, the EU policy response has been slow and with a holistic approach. Cities and urban environments should have a more important part in the design and execution of EU policies and that decision making should reflect in a better way the urban reality. With around two thirds of all EU sectoral policies having an impact on Europe's towns and cities, the EU is dependent on them for their successful implementation and for achieving the Europe 2020 objectives of smart, sustainable and economic growth. Thus, it is impossible to meet the Europe 2020 objectives if sectors like environment or transport are put in isolation. In order to deliver the best result, should be ensured more effective coordination and collaboration between the decisions and policies referred to urban areas. Additionally, all the efforts including local, national and EU levels of governance should meet with the goal to deliver the best results. This can be achieved by developing a common framework of action an EU urban agenda. (C. van Lierop, EU 2015)

However, despite discussions for decades at intergovernmental level on coordination of urban related topics, progress remains limited. Cities have increasing difficulties in dealing with the effects of climate change (heat, heavy rainfall, etc.), congestion and air quality in cities is often deteriorating, urban poverty remains an issue, etc. To address these challenges, the city level needs to be better taken into account when designing and implementing EU policies.

This chapter aims at proposing and offering a practical guideline with reference to urbanistic design approach, based on a comparison with other energy policies around Europe. The list of sectors analysed and proposed are based on the results and the hypothetical scenarios of this research that can be implemented in various urban complexes in the Mediterranean area which have similar climatic and geometrical characteristics as the two case studies presented in the urban complex of Athens, Greece.

In the urban environment it is extremely important to design outdoor spaces in a unified approach that interferes with the building surface. In cases where exist urban constraints due to dense built urban areas, the intervention is reduced to the level of the envelope of the buildings, (with green façade components or shading devices).Also the a the use of natural components have been regarded as key means to improve urban conditions in relation to both microclimate and reduction of pollutants.

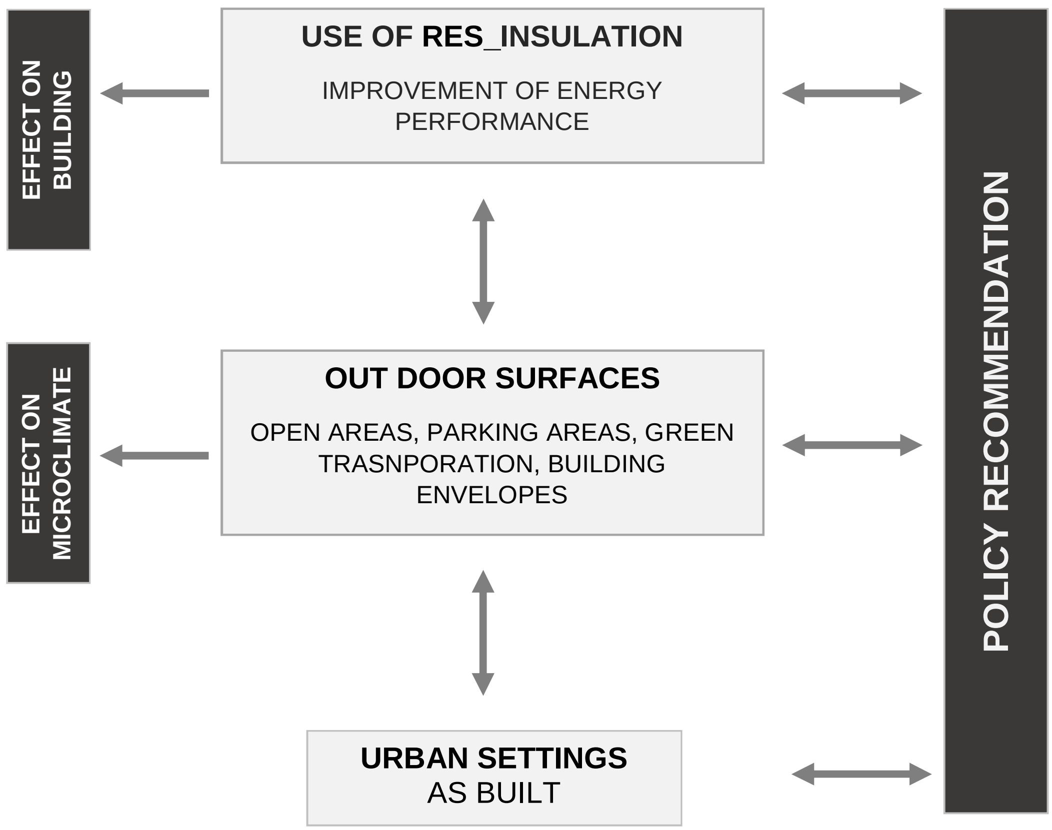
Improvement of the ambient microclimate can be achieved and is proved on this research in the urban environment by the use of more appropriate materials, increased use of green areas, use of cool sinks for heat dissipation, appropriate layout of urban canopies, etc., to counterbalance the effects of energy consumption's increase in the urban areas. Construction of new generating plants may help solving the energy generation to achieve nearly zero energy buildings but cannot consist in the sole options as far as it concerns the outdoor climatic issues. Adoption of measures to decrease the energy demand in the urban areas, like the use of more appropriate materials, increased plantation, use of sinks, etc., seems to be a much more reasonable option[44].

[44] Such a strategy, adopted by the Sacramento Municipal Utility District, (SMUD), has proved to be very effective and economically profitable, (Flavin and Lenssen, 1995). It has been calculated that a megawatt of capacity is actually eight times more expensive to produce than to save it. This because energy saving measures has low capital and no running cost, while construction of new power plants involves high capital and running costs.

As it was mentioned in previous chapter measurements developed by the Group Building Environmental Studies, have shown a dramatic higher temperature in the Central Athens area than in the Suburban areas by 10-15 °C. In the same research frame, research works developed within the frame of the Research Project POLIS in Athens (Ferrante et al., 1998) have showed some appropriate procedures to design the use of natural components such as green roofs and pedestrian permeable surfaces in the streets- within urban canyons. It is evident that microclimatic enhancements in urban scale involving water systems, planting of trees and lightening of colours in urban surfaces may be able to decrease pollution loads and save huge amounts of energy, improving consequently both indoor and outdoor comfort conditions. In such dense urban environment, where open free spaces among buildings or large courtyards are not always available the possible use of passive natural elements are necessary/. An urban energy concept has to address these problems investigating, at a smaller scale, the building envelope and the potential of selected passive techniques such as building materials and components, shading devices (including green ones such as pergola), low albedo surfaces, in order to minimize thermal discomfort both in the open spaces and into the buildings. Although it was showed in previous chapter, by analysing the results of the improvement of the microclimate that with the use of passive natural elements on the courtyards of Evripidou area, that locally there was demonstrated a reduction of temperature up to 5 C degrees.

This outcome should be under consideration for decision makers and planners that using new energy legislations, i.e. Law 4067/2012 art.10, analysed on previous paragraph on how unifying the courtyards and exploit it by the public could also increase the plot ratio and it could actually create a new urban reality if they are exploited and used thoroughly and properly.

In the dynamic scheme below it is shown a conceptual connection and the steps between the levels of interaction for a holistic approach on urban and building sustainability. The results of this research verify that by improving the microclimate of an urban area there is a significant decrease on the building energy demand on cooling during summer period.



There is a big list of proposals on how to decrease the energy consumption of buildings in a city level. However, and according to this research perspective, the main concerns and technological ideas that may be well highlighted in priority are:

- Improve the Urban Microclimate with the aim to defeat heat island and reduce the energy needs for cooling for the summer period;
- Adopt the concept of the compact city. Reducing the needs for transport as well as the energy consumption of buildings is gaining an increasing acceptance. Increase on dependence on public transports, cycling and walking may be applied to create a more sustainable urban environment.
- Use of sustainable energy supply systems based on the use of renewable sources like solar and biomass district heating and cooling both in urban and building scale.
- Integration of passive techniques in the envelope of new and existing buildings.

In parallel, a series of institutional, economic and regulatory actions are evaluated as important.

- The development of a new more efficient legislative frame on the energy performance of buildings. The development of the new European Directive on the Energy Performance of Buildings is a very good base to further improve the efficiency of urban buildings.
- Integration of the environmental cost in the price of goods and services
- Adoption of 'green awareness' by the inhabitans
- Involvement of local authorities on the production, maintenance and management of the energy systems on the city level.

In the following tables some of the above most indicative and critical ideas are further developed.

I.

OBJECTIVE/GOALS	**To achieve livable urban environments and sustainable neighbourhoods**
TARGET GROUP	Local governments, state authorities, private sector
TOOLS/ INSTRUMENTS/ MEASURES	Public-private partnerships are defined as an official agreement between a public authority and a private sector in order to deliver a service or public benefit. These partnerships play a crucial role in building complete neighbourhoods and livable urban environments with access to public transit.
CRITICAL ISSUES	Agencies and cities cannot create transit-oriented communities on their own. However, typical challenges to developing transit-oriented urban development include: Land public ownership: government agencies may lease land, instead of selling outright, to developers, as in this way it is affected the financing rates available to developers. Delays in construction and safety reviews. Challenges in marketing developments once complete. Local authorities can overcome these challenges through: Funding for specific projects referred to infrastructure development, land acquisition, assistance with pre-costs. Faster review times by the local agencies. Take into consideration as guidance other European successful large scale public- private collaboration

II.

OBJECTIVE/ GOALS	**Recommendations for Promoting Renewable Energy: State and Local Governments as key factors in providing investment motives**
TARGET GROUP	State - Local governments
TOOLS/ INSTRUMENTS/ MEASURES	Long-term investment by governments is critical to supporting the types of technology development and implementation needed in order to encourage a renewable future and a sustainable design. State and local government play a key role.
CRITICAL ISSUES	There is a significant opportunity for states to expand tax incentives designed to improve industrial energy efficiency. Local governments should take effective action to reduce their own carbon footprint. Local governments can reduce taxation to commercial and residential enterprises who reduce their environmental impact through the installation of green technologies. These investments must be significant so as to make the green technologies affordable to large percentage of the population.

III.

OBJECTIVE/GOALS	**Unique European standards for energy efficient buildings and environments**
TARGET GROUP	European Commission, Member countries, Local governments and authorities
TOOLS/ INSTSRUMENTS/ MEASURES	In the common aim to promote and achieve energy efficiency in buildings and urban environments and to guarantee reliability, it is necessary to create a unique standard and commit to it.
CRITICAL ISSUES	Collaboration and cooperation between the member countries' governments should be achieved in order to consign to a main standard. The economy would have clear benefits and the construction and engineering sector be more competitive. Each country and the responsible municipalities, which often control and write the building code regulation, should implement their own regulations and choose differing standards for the promotion of energy efficient buildings. A coordinated process could result in better synergies.

IV.

OBJECTIVE/ GOALS	**Use of intelligent and public transport systems as a medium to improve high mobility in towns and cities. Mobility including busses, trams, E-cars, E-scooters and bicycles as a part of transforming the transport sector**
TARGET GROUP	Public authorities, planners and engineers, businesses, companies
TOOLS/ INSTRUMENTS/ MEASURES	The current transport system in all the cities especially in Greece, and specifically the automobile-dependent part of transportation systems, is based on fossil fuels. Fossil fuel engines are not efficient and are one of the main contributors to emissions and the air pollution in large cities and also climate change. All car producers are responsible to change their technologies and invest in hybrid and electric technologies. Reducing CO2 emissions is a target that has to be fulfilled by 2020 within the EU , in order to avoid financial punishments. E-mobility is an opportunity to reduce emissions, noise and fine dust in towns and cities.
CRITICAL ISSUES	E-mobility is predicted to be the future technology and is starting to gain broader interest. Reliable vehicles are on the market (by producers such as Nissan, BMW, Renault, VW) and different countries around Europe start to force E-mobility and to punish fossil fuel cars. In Norway for example, conventional cars are taxed highly In Estonia a dense infrastructure of fast-charging stations was established and the purchase of E-vehicles is highly subsidized. The EU has targets to increase the fleet of electric and hybrid cars until 2020 by a significant amount. E-vehicles (also buses, scooters and E-bikes) are more energy efficient than the traditional fossil fuel vehicles. They also create new industries as well as new jobs. Furthermore planners should consider this new approach as it will affect the way urban planning is considered.

V.

OBJECTIVE/ GOALS	**Creation of cycling highways and urban infrastructure, promote urban cycling share by implementing public bike sharing system**
TARGET GROUP	Public and local authorities, Mayors, planners and engineers
TOOLS/ INSTRUMENT/ MEASURES	Athens in particular but also big towns and cities of Greece are characterized by being dense; dense in terms of population, infrastructure, building sector, cultures, etc. There is a significant increase in the will of people worldwide to live in cities. This is a challenge and opportunity at the same time. The challenge is how people can move around the complex city urban tissue with the minimum of time. The Opportunity is, in everything being close together. Traditional traffic (cars etc) can be step by step be excluded and should start concentrating on environmental friendly and energy efficient transport modes if possible. Cars could be avoided in well-organized urban environments and every distance could be done by public transportation, cycling and walking.
CRITICAL ISSUES	Traditionally cycling European cities such as Copenhagen and Amsterdam have proved, that a real increase in cycling share can only be achieved by infrastructural and awareness raising measures. It is highly important to have fast and sufficiently proportioned cycling highways (e.g. in London). Furthermore bike sharing schemes in larger cities may help to promote cycling Special bikes, such as peddles, folding bikes and especially cargo bike broadens the use of cycling. These actions if applied to urban planning assure the increase of the green surfaces and pedestrian streets as less high traffic streets will be needed. Planners should take under consideration that with the suitable design and analysis of the situation described the gain of open spaces in local level will be significally augment. As a result apart from the energy efficiency of the bicycles by their own, this new approach will promote a more sustainable holistic design for the whole city. By organizing locally the neighbourhoods and then step by step interconnecting them, Athens for example or every large city, can reach to a point that will have a sustainable network of circulation, green and open space. This measures should be taken under the consideration and the approval of the local authorities and interact with the local regulations.

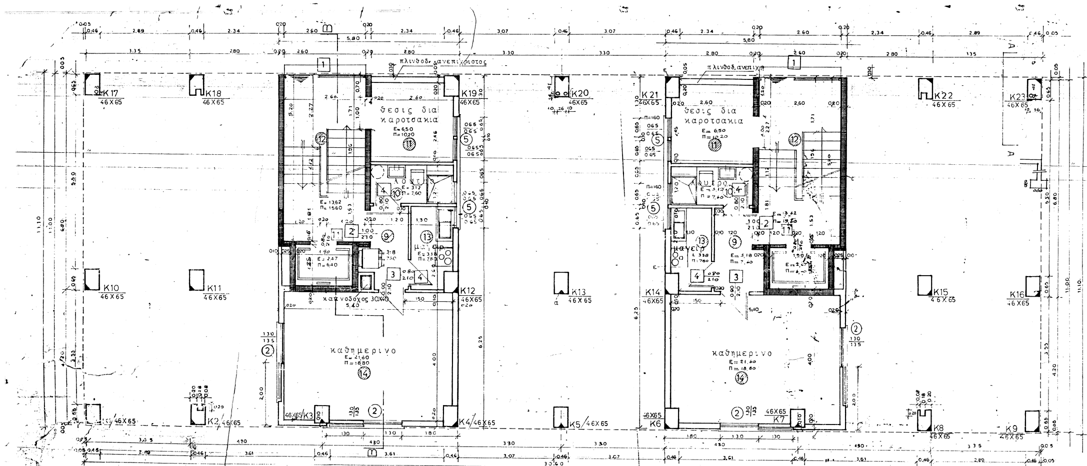
VI.

OBJECTIVE/ GOALS	**Reduce the restrictions on the use of self-produced electricity. Promote the use of photovoltaic panels and systems and minimize the taxation of self-produced solar energy or other renewable energy.**
TARGET GROUP	State - Local governments
TOOLS/ INSTRUMENT/ MEASURES	In some countries, the use of photovoltaic systems is not in favour of the citizens. In Germany and Austria, for example, a solar tax will be and has been implemented, respectively, which will tax the use of self-produced electricity of solar power. In Greece also, until now the building restrictions, the high cost and the long bureaucratic procedure was setting boundaries for the people to think in an energy efficient way and to invest to that.
CRITICAL ISSUES	National authorities should release the market of producers. As a result in this kind of market will be expected that technological development will go faster that under strict regulations. This is also applicable to all complementary technologies such as PV systems etc. Especially to countries of South Europe like Greece, where the climatic conditions are in favor of these technologies the investment on this projects will be suitable due to these specific climatic circumstances.

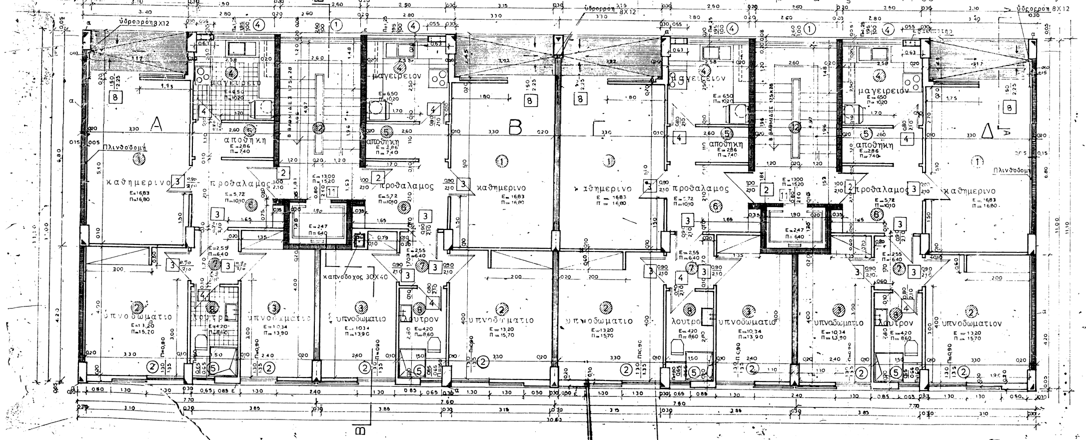
This research work has demonstrated that the existence of green areas as a consequence of a more sustainable urban design (new materials, shadow systems, reduction of traffic etc.), has e significant effect on the energy performance on a building scale. These, outcomes could already be included in the existing legislative framework of Greece. Therefore, it is highlighted that there should be more incentives in the legislative level of Greece, regarding the addiction of green.

ANNEX 1

Γ7



κατοψις ισογειου κλιμαξ 1:50



κατοψις τυπικου οροφου κλιμαξ 1:50

διαμερισματα Α,Β,Γ,Δ

- καθημερινο 1
- υπνοδωματιο 2
- υπνοδωματιο 3
- μαγειρειο 4
- αποθηκη 5
- προθαλαμος 6
- διαδρομος 7
- λουτρο 8

θυρωρειο

- διαδρομος 9
- λουτρο 10
- χωρος δια καροτσακια 11
- κλιμακοστασιο 12
- μαγειρειο 13
- καθημερινο 14

Αριθμός δωματίου 1

Αριθμός παραθύρου 1

πιναξ διαστασεων υποστυλωματων

οροφος	K1 K9	K2 K8	K3 K7	K4 K6	K5	K10 K16	K11 K15	K12 K14	K13	K17 K23	K18 K22	K19 K21	K20
1ος	30x55	30x50	30x50	30x50	30x50	30x55	45x65	45x65	45x65	30x55	30x60	30x50	30x60
2ος	30x50	30x45	30x50	30x45	30x45	30x50	40x65	40x65	40x65	40x65	30x45	30x45	30x55
3ος	30x45	30x40	30x40	30x40	30x40	30x45	40x55	40x55	40x55	30x45	30x40	30x40	30x45
4ος	30x40	30x35	30x35	30x35	30x35	30x40	35x50	35x50	35x50	30x40	30x35	30x35	30x40
5ος	30x30	30x30	25x30	30x30	30x30	30x30	30x40	30x40	30x40	30x30	30x30	30x30	30x30
6ος	30x30	30x30	25x25	30x30	30x30	30x30	25x35	25x35	25x35	30x30	30x30	30x30	30x30

ΑΝΑΘΕΩΡΗΣΙΣ ΑΠΡΙΛΙΟΣ 1970

Τροποποιησιν αφορωσα εις

1. Τοποθετησιν πτεριγιου θεμελιωσεως ισογειου στοας
2. Ενσωματωσιν γαλβανισμενων υδρορροων εξωτα υποστυλωματα ισογειου

Ο ΑΡΧΙΤΕΚΤΩΝ	Ο ΕΛΕΓΞΑΣ	ΕΘΕΩΡΗΘΗ
Τ. ΣΑΠΟΥΝΑΚΗΣ	Ε. ΤΡΕΠΕΚΛΗΣ	ΑΧ. ΣΠΑΝΟΣ

ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ
ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ ΔΙΕΥΘΥΝΣΙΣ Ε7

ΜΕΛΕΤΗ	ΠΟΛΥΚΑΤΟΚΙΑ ΤΥΠΟΥ - Γ7		
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ΘΕΜΑ ΠΙΝΑΚΟΣ	ΚΑΤΟΨΙΣ ΙΣΟΓ. & ΤΥΠ. ΟΡΟΦ.		ΚΛΙΜΑΞ 1:50
Ημερομηνια	Ο ΑΡΧΙΤΕΚΤΩΝ Ο. ΣΥΓΚΟΥΡΙΑΔΟΥ	Ο ΣΧΕΔΙΑΣΑΣ Ε. ΛΑΜΠΙΡΗ	Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΟΥ ΤΜΗΜΑΤΟΣ Ε7 Ε. ΤΡΕΠΕΚΛΗΣ
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ΕΦΑΡΜΟΓΗ 1) 2) 3) 4)	ΕΓΚΡΙΣΙΣ — Ο ΓΕΝΙΚΟΣ Δ/ΝΤΗΣ ΔΗΜ. ΕΡΓΩΝ Α. ΚΟΡΚΟΛΟΠΟΥΛΟΣ		

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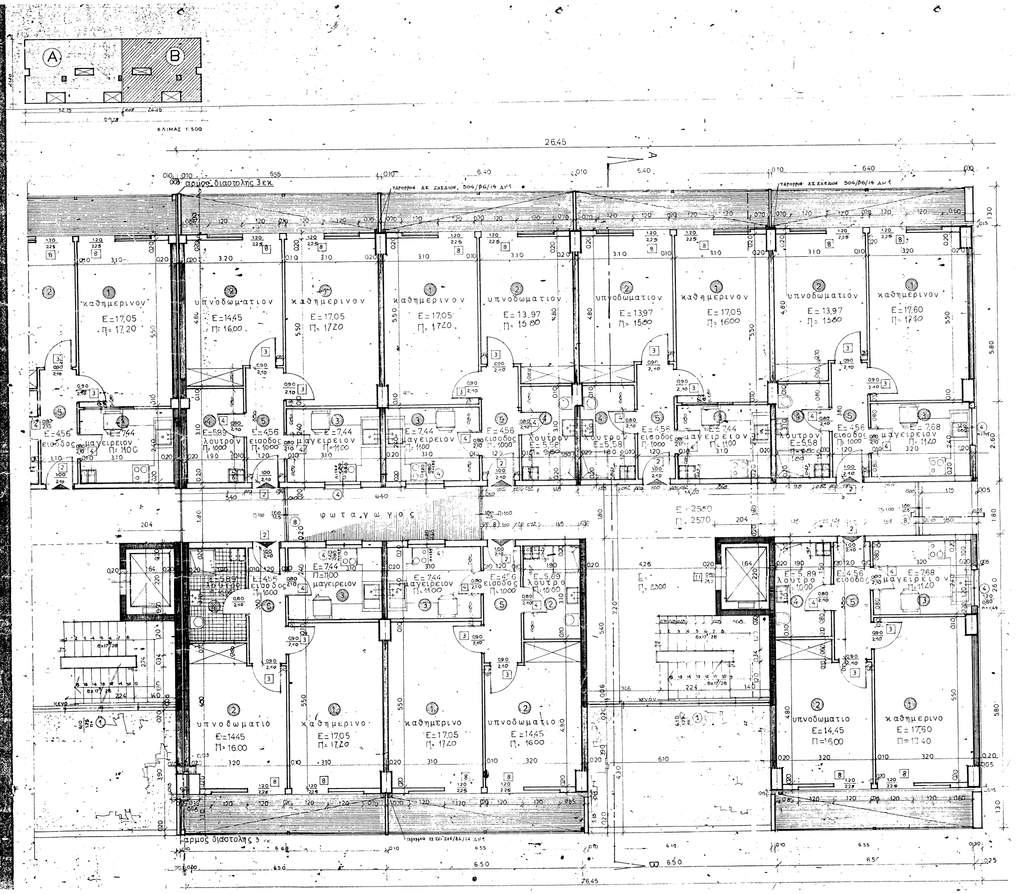
ΤΥΠΟΣ Β6



1 καθημερινον
2 υπνοδωματιον
3 μαγειρειον
4 λουτρον
5 εισοδος

Β6

ΑΝΑΘΕΩΡΗΣΙΣ ΑΠΡΙΛΙΟΣ 1970

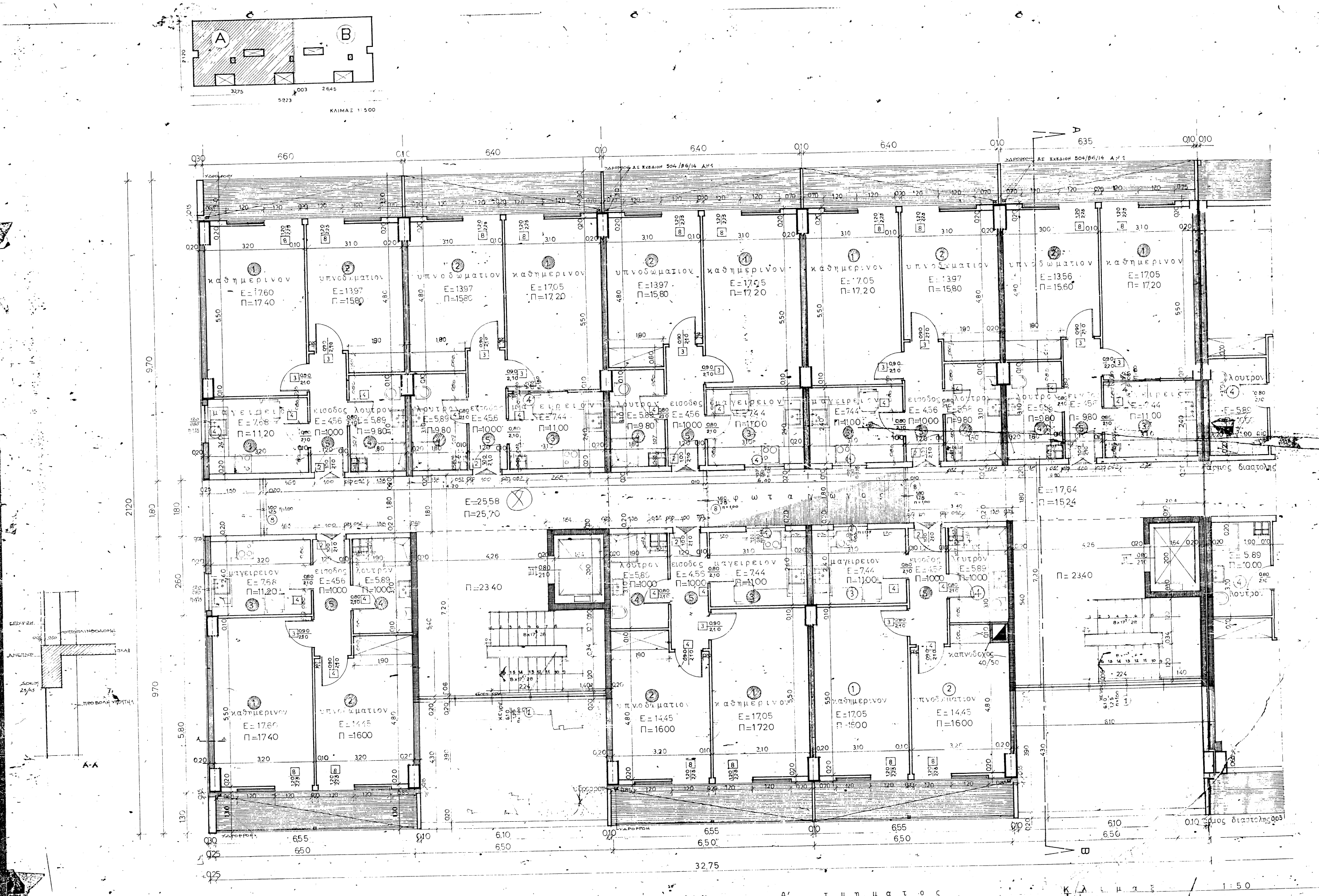
Τροποποίησις ἀφορῶσα εἰς
1) Τὴν θέσιν τῶν ὑδρορροῶν ἐπὶ τῶν ἐξωστῶν
2) Τὴν τοποθέτησιν κιγκλιδώματος εἰς τὸ πλατύσκαλον τῆς κλίμακος

Ο ΑΡΧΙΤΕΚΤΩΝ	Ο ΕΛΕΓΞΑΣ	ΕΘΕΩΡΗΘΗ
Τ. ΣΑΠΟΥΝΑΚΗΣ	Ε. ΤΡΕΠΕΚΛΗΣ	ΑΧ. ΣΠΑΝΟΣ

ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ
ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ ΔΙΕΥΘΥΝΣΙΣ Ε7

ΜΕΛΕΤΗ	ΠΟΛΥΚΑΤΟΙΚΙΑ ΤΥΠΟΥ Β6		
ΤΕΥΧΟΣ	ΣΧΕΔΙΑ ΚΑΤΑΣΚΕΥΗΣ		ΑΡ. ΣΧ 504/Β6
ΘΕΜΑ ΠΙΝΑΚΟΣ	ΚΑΤΟΨΙΣ ΤΥΠΙΚΟΥ ΟΡΟΦΟΥ Β'ΤΜΗΜΑ		ΚΛΙΜΑΞ 1:50
Ἡμερομηνία	Ο ΑΡΧΙΤΕΚΤΩΝ Ε. ΓΟΥΛΙΟΥ	Ο ΣΧΕΔΙΑΣΑΣ Κ. ΜΑΥΡΟΜΜΑΤΗ	Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΜΗΜΑΤΟΣ Ε7 Ε. ΤΡΕΠΕΚΛΗΣ
ΑΠΟΦΑΣΙΣ ΥΠΟΥΡΓΟΥ Ε 20040 / 1781 6/6/1969	ΘΕΩΡΗΣΙΣ Ο ΔΙΕΥΘΥΝΤΗΣ ΑΧ. ΣΠΑΝΟΣ		Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΗΣ ΥΠΗΡΕΣΙΑΣ Ι. ΒΑΣΙΛΕΙΟ
ΕΦΑΡΜΟΓΗ 1) 2) 3) 4)	ΕΓΚΡΙΣΙΣ Ο ΓΕΝΙΚΟΣ Δ/ΝΤΗΣ ΔΗΜ. ΕΡΓΩΝ Α. ΚΟΡΚΟΛΟΠΟΥΛΟΣ		

24-5-69
εἰδοποιήθη



κατοψις τυπικου οροφου Α' τμηματος — ΚΛΙΜΑΞ 1:50

① καθημερινον
② υπνοδωματιον
③ μαγειρειον
④ λουτρον
⑤ εισοδος

ΑΝΑΘΕΩΡΗΣΙΣ ΑΠΡΙΛΙΟΣ 1970

Τροποποίησις ἀφορῶσα εἰς
1 Τὴν θέσιν τῶν ὑδρορροῶν ἐπὶ τῶν ἐξωστῶν
2 Τὴν τοποθέτησιν κιγκλιδώματος εἰς τὸ πλατύσκαλον τῆς κλίμακος

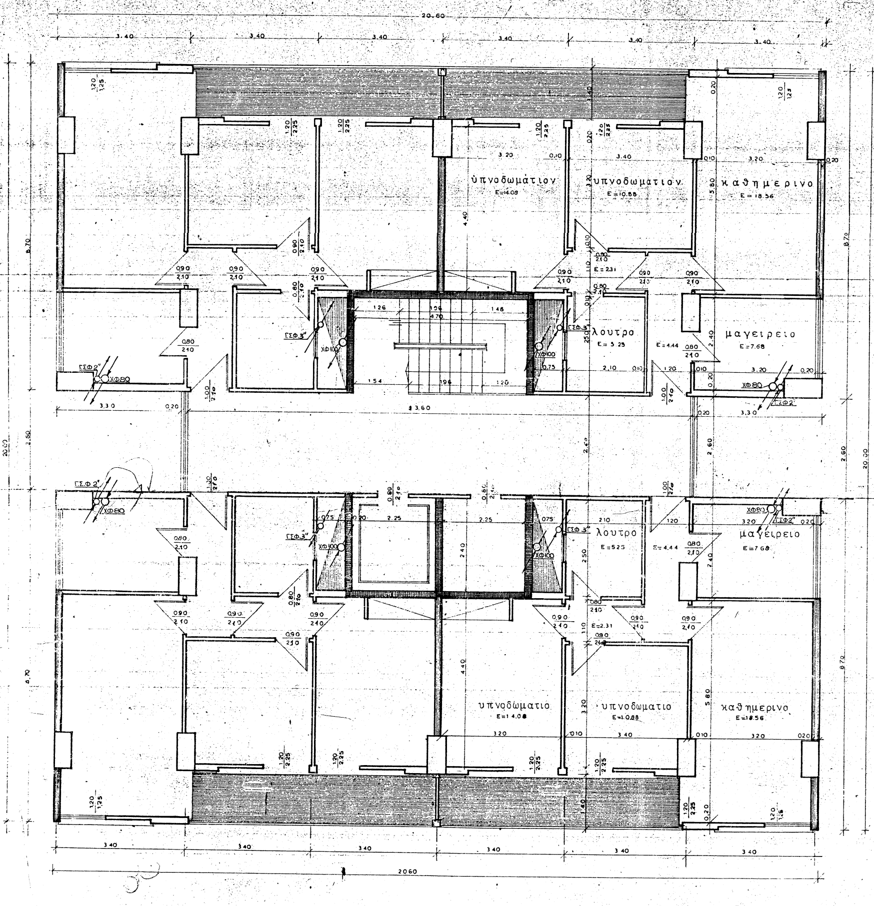
Ο ΑΡΧΙΤΕΚΤΩΝ — Ο ΕΛΕΓΞΑΣ — ΕΘΕΩΡΗΘΗ
Τ. ΣΑΠΟΥΝΑΚΗΣ — Ε. ΤΡΕΠΕΚΛΗΣ — ΑΧ. ΣΠΑΝΟΣ

ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ ΔΙΕΥΘΥΝΣΙΣ Ε7			
ΜΕΛΕΤΗ	ΠΟΛΥΚΑΤΟΙΚΙΑ ΤΥΠΟΥ Β6		
ΤΕΥΧΟΣ	ΣΧΕΔΙΑ ΚΑΤΑΣΚΕΥΗΣ		ΑΡ. ΣΧ.504/Β6
ΘΕΜΑ ΠΙΝΑΚΟΣ	ΚΑΤΟΨΙΣ ΤΥΠΙΚΟΥ ΟΡΟΦΟΥ Α' ΤΜΗΜΑ		ΚΛΙΜΑΞ 1:50
Ἡμερομηνία	Ο ΑΡΧΙΤΕΚΤΩΝ Ε. ΓΟΥΛΙΟΥ	Ο ΣΧΕΔΙΑΣΑΣ Κ. ΜΑΥΡΟΜΜΑΤΗ	Ο ΠΡΟΪΣΤΑΜΕΝΟΣ ΤΜΗΜΑΤΟΣ Ε7 Ε. ΤΡΕΠΕΚΛΗΣ
ΑΠΟΦΑΣΙΣ ΥΠΟΥΡΓΟΥ Ε 20040 | 1781 6/6/1969	ΘΕΩΡΗΣΙΣ Ο ΔΙΕΥΘΥΝΤΗΣ ΑΧ. ΣΠΑΝΟΣ		Ο ΠΡΟΪΣΤΑΜΕΝΟΣ ΤΗΣ ΥΠΗΡΕΣΙΑΣ Ι. ΒΑΣΙΛΕΙΟΥ
ΕΦΑΡΜΟΓΗ 1) 2) 3) 4)	ΕΓΚΡΙΣΙΣ Ο ΓΕΝΙΚΟΣ Δ/ΝΤΗΣ ΔΗΜ. ΕΡΓΩΝ Α. ΚΟΡΚΟΛΟΠΟΥΛΟΣ		

29.5.69

B6

896



κατοψις τυπικου οροφου κλιμαξ 1:50

Γ11

ΕΝΕΚΡΙΘΗ

ΣΠΑΝΟΣ

ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ ΔΙΕΥΘΥΝΣΕΙΣ Ε7 και Ε4			
ΜΕΛΕΤΗ	ΕΣΩΤΕΡΙΚΩΝ ΕΓΚΑΤΑΣΤΑΣΕΩΝ ΠΟΛΥΚΑΤΟΙΚΙΩΝ ΤΥΠΟΥ Γ11		
ΘΕΜΑ ΣΧΕΔΙΟΥ	ΣΤΗΛΑΙ ΑΠΟΧΕΤΕΥΣΕΩΝ ΕΙΣ ΤΥΠΙΚΟΝ ΟΡΟΦΟΝ		ΑΡΙΘΜΟΣ ΣΧΕΔΙΟΥ Α5
ΜΕΛΕΤΗΣΑΣ	ΕΛΕΓΞΑΣ	Δ/ΝΤΗΣ Ε7	Δ/ΝΤΗΣ Ε4
Ι. ΜΑΤΖΟΥΡΑΝΗΣ	Δ. ΚΑΡΑΜΠΙΝΗΣ	ΑΧ. ΣΠΑΝΟΣ	Γ. ΧΡΙΣΤΟΠΟΥΛΟΣ
ΣΧΕΔ. 90			ΚΛ. 1:50

ΕΘΕΩΡΗΘΗ

Ο Δ/ντής Ε7

ΑΧ. ΣΠΑΝΟΣ

Εισήχθη 12-6-69

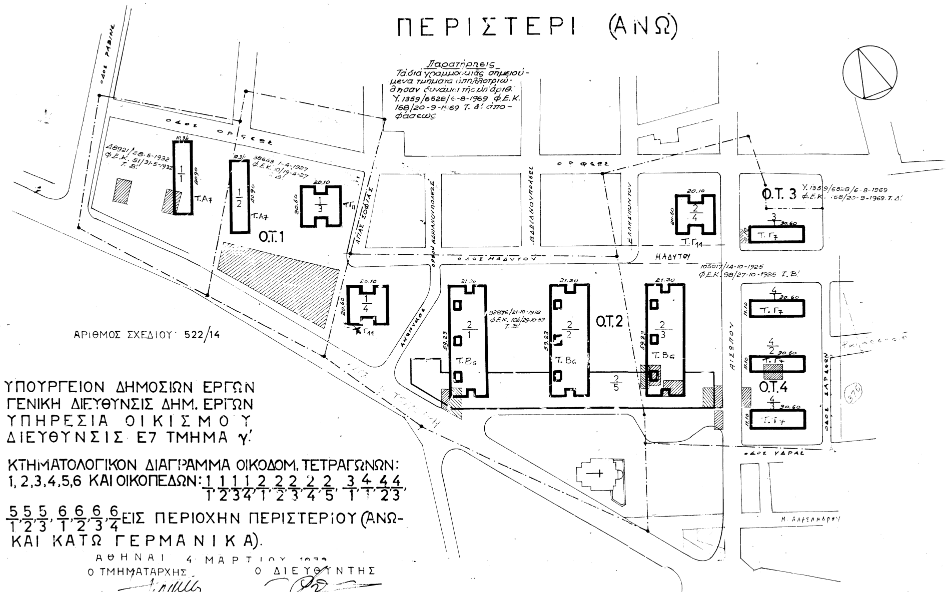
Συνεζητήθη αυθημερόν

Ενεκρίθη

Πράξις 1062

6811 ΠΕΡΙΣΤΕΡΙ (ΑΝΩ)

Υπουργείον Κοιν. Υπηρεσιών
Δ/νσις Τεχν. Υπηρεσιών
Τμήμα Τοπογραφήσεων



ΑΡΙΘΜΟΣ ΣΧΕΔΙΟΥ 522/14

ΥΠΟΥΡΓΕΙΟΝ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ
ΓΕΝΙΚΗ ΔΙΕΥΘΥΝΣΙΣ ΔΗΜ. ΕΡΓΩΝ
ΥΠΗΡΕΣΙΑ ΟΙΚΙΣΜΟΥ
ΔΙΕΥΘΥΝΣΙΣ Ε7 ΤΜΗΜΑ γ'

ΚΤΗΜΑΤΟΛΟΓΙΚΟΝ ΔΙΑΓΡΑΜΜΑ ΟΙΚΟΔΟΜ. ΤΕΤΡΑΓΩΝΩΝ: 1, 2, 3, 4, 5, 6 ΚΑΙ ΟΙΚΟΠΕΔΩΝ: $\frac{1}{1}, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \frac{2}{1}, \frac{2}{2}, \frac{2}{3}, \frac{2}{4}, \frac{2}{5}, \frac{3}{1}, \frac{4}{1}, \frac{4}{2}, \frac{4}{3}, \frac{5}{1}, \frac{5}{2}, \frac{5}{3}, \frac{6}{1}, \frac{6}{2}, \frac{6}{3}, \frac{6}{4}$ ΕΙΣ ΠΕΡΙΟΧΗΝ ΠΕΡΙΣΤΕΡΙΟΥ (ΑΝΩ ΚΑΙ ΚΑΤΩ ΓΕΡΜΑΝΙΚΑ).

ΑΘΗΝΑΙ 4 ΜΑΡΤΙΟΥ 1972

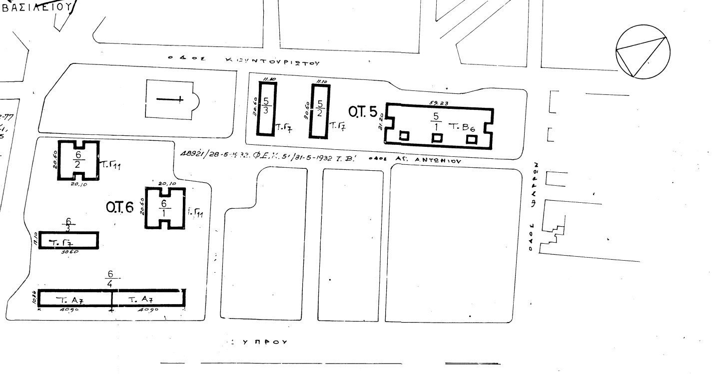
Ο ΤΜΗΜΑΤΑΡΧΗΣ
Ε. ΤΡΕΠΕΚΛΗΣ

Ο ΔΙΕΥΘΥΝΤΗΣ
ΑΝ. ΡΟΓΚΑΝ

ΕΘΕΩΡΗΘΗ
Ο ΠΡΟΙΣΤΑΜΕΝΟΣ ΤΗΣ ΥΠΗΡΕΣΙΑΣ
Ι. ΒΑΣΙΛΕΙΟΥ

1) Τό παρόν αποτελεί ακριβές αντίγραφον εκ του υπ' αριθ. 522/14/4 Μαρτίου 1972 Διαγράμματος της Υπηρεσίας Οικισμού (Δ/νσις Ε7 Τμήμα γ') του Υπουργείου Δημ. Έργων.-
2) Αι διαστάσεις ελήφθησαν εκ των αντιστοίχων κατασκευαστικών σχεδίων της Υπηρεσίας Οικισμού.

3) Δυνάμει της υπ' αριθ. Γ5γ/11901/2046/76/25-2-77 αποφάσεως, παραχωρείται η δωρεά χρήσις των Κ1, Κ2, Κ3, Κ4, Κ5, Κ6, Κ7, Κ8, Κ9, Κ12, Κ13, Κ14, Κ15, Κ16, Κ17, Κ18, Κ19, Κ22, Κ23, Κ24, Κ25, Κ26, Κ27, Κ28 κ' Κ30 καταστημάτων (σύνολο 25 καταστήματα) της 2/5-Π πολυκατοικίας εις τό Δήμο Περιστερίου.-



ΠΕΡΙΣΤΕΡΙ (ΚΑΤΩ)

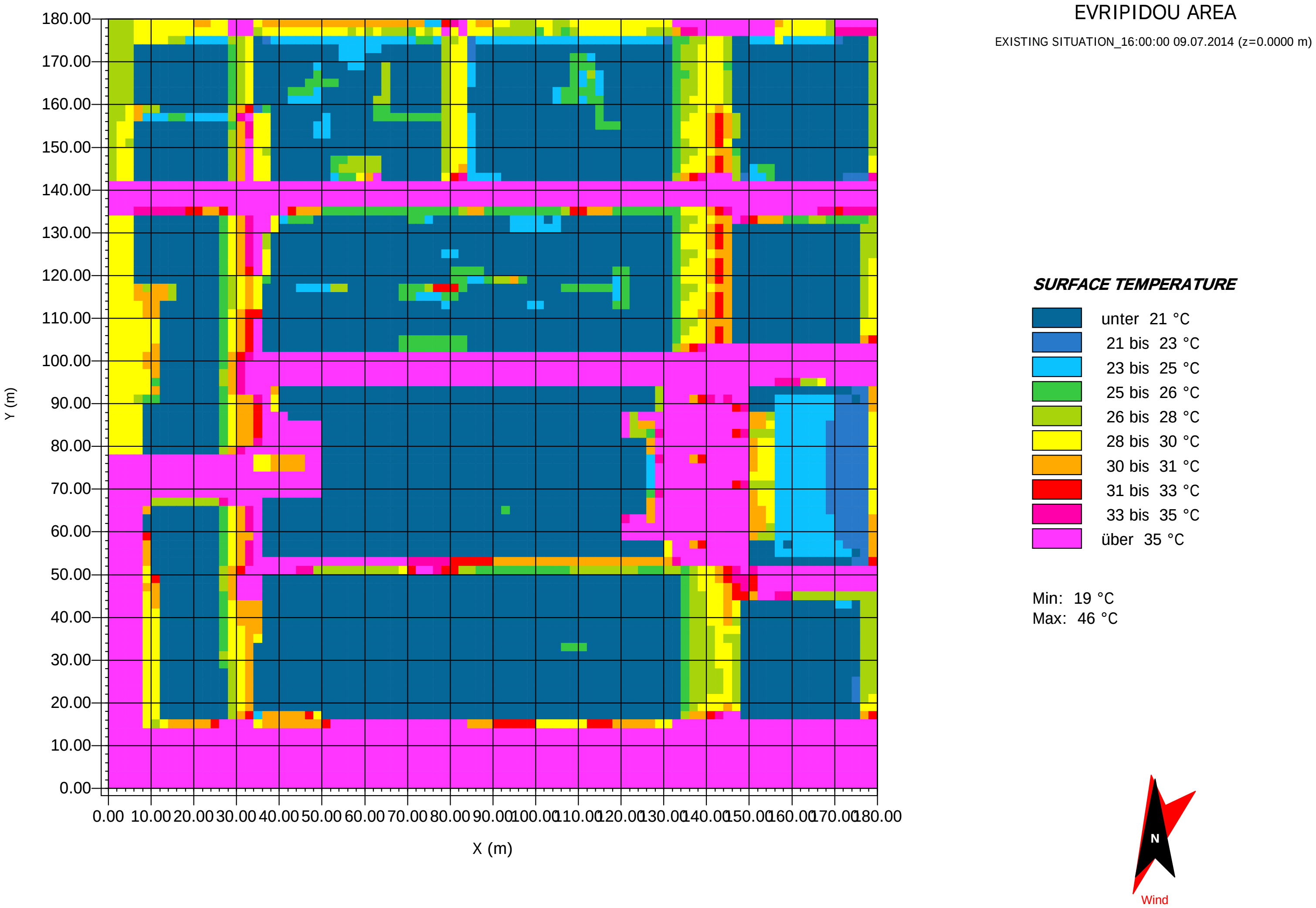
Εν Αθήναις τη 9-12-1972
Διά την ακρίβειαν της αντιγραφής
ο Προϊστάμ. Τμήμ. Τοπογραφήσεων.
Ιωάννης Γεωργιάδης

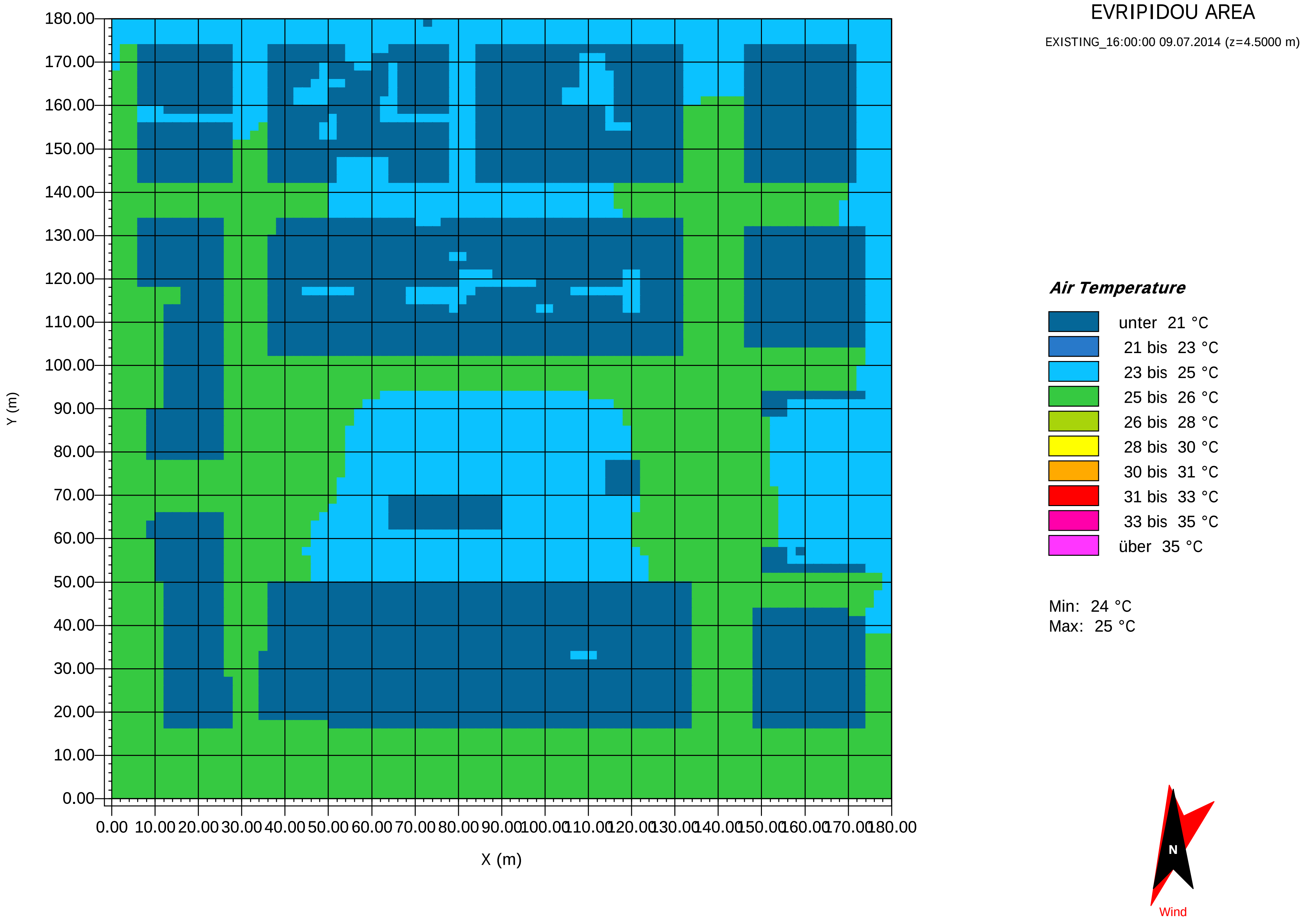
6811

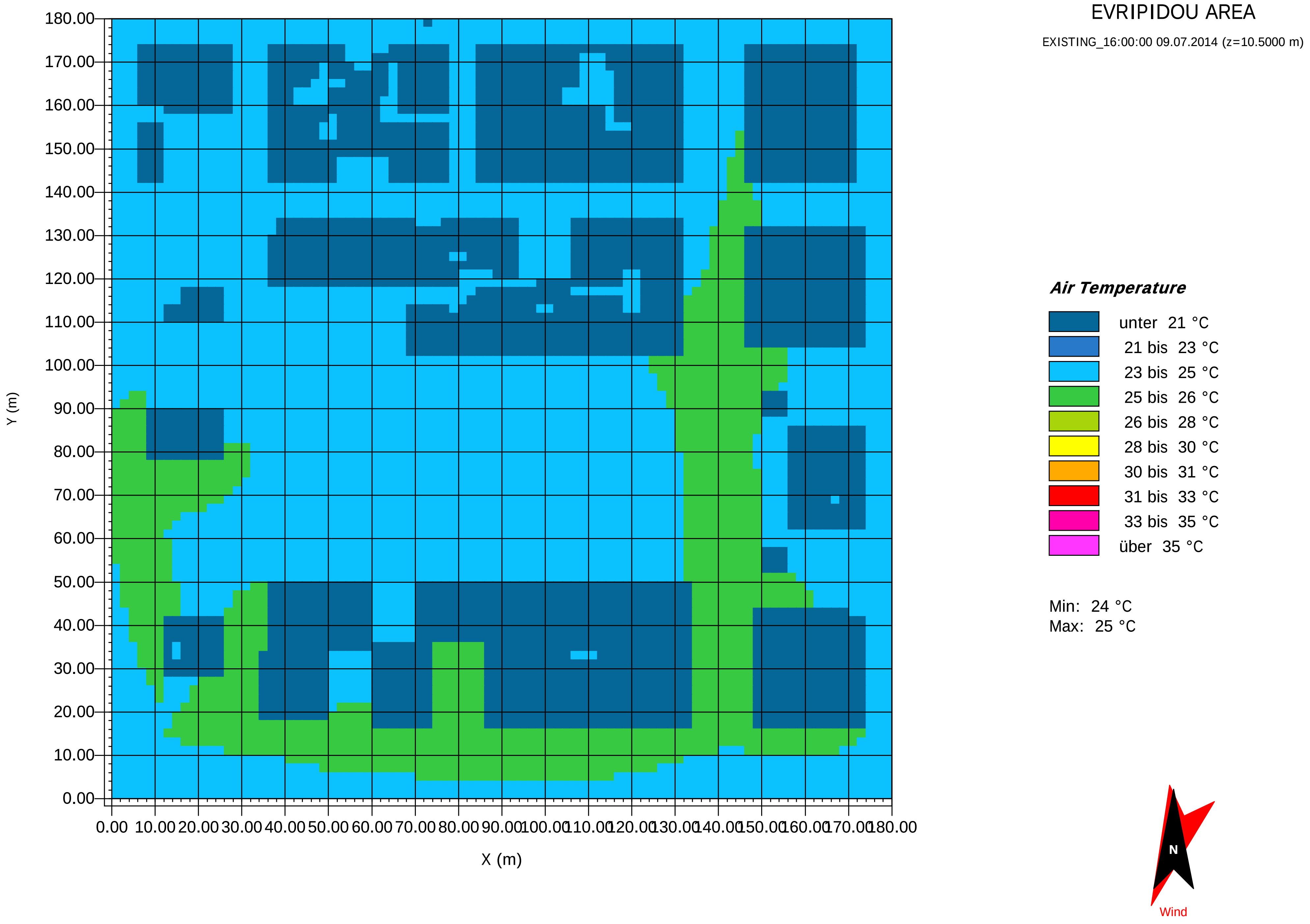
ANNEX 2

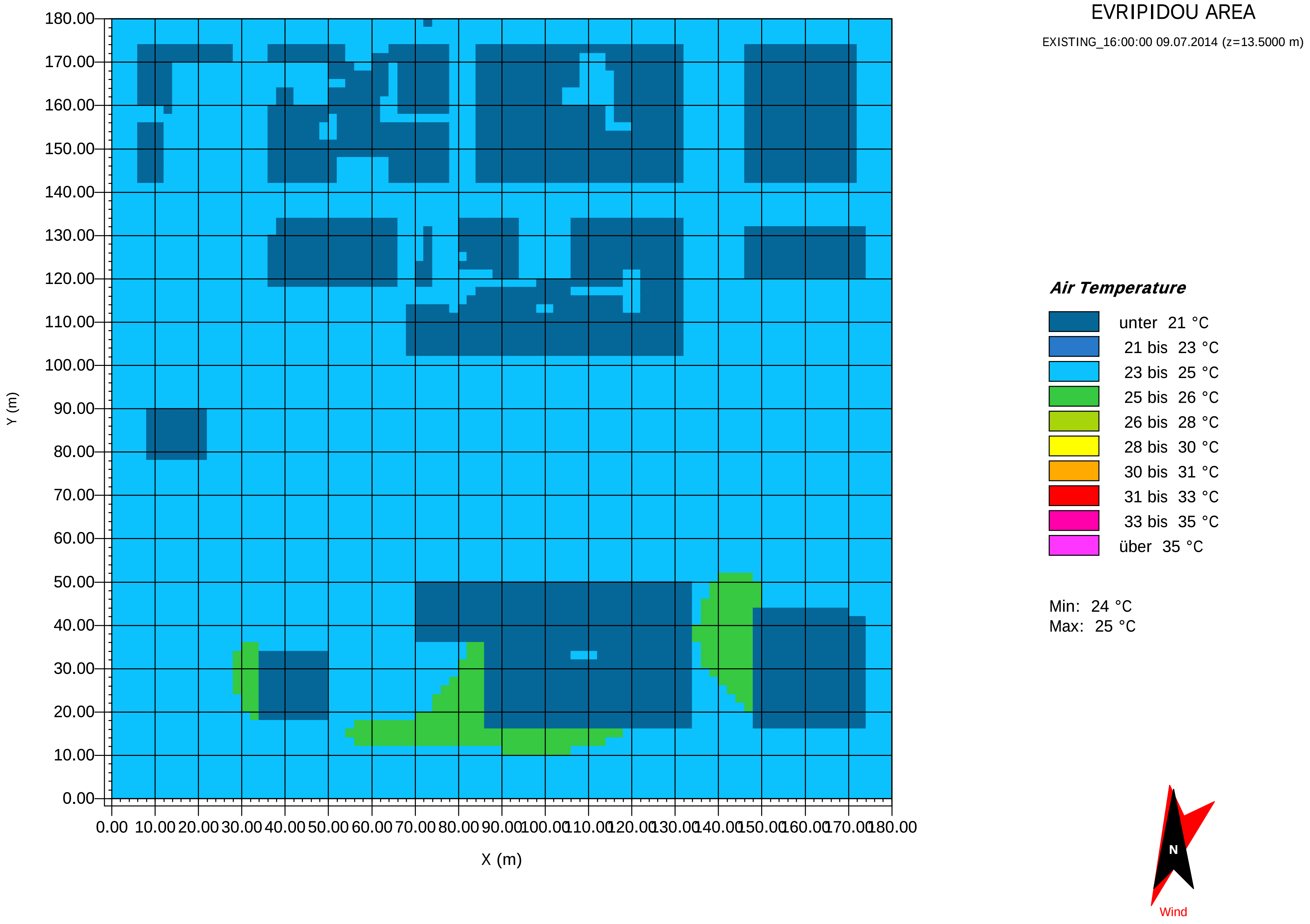
EVRIPIDOU AREA

EXISTING SITUATION

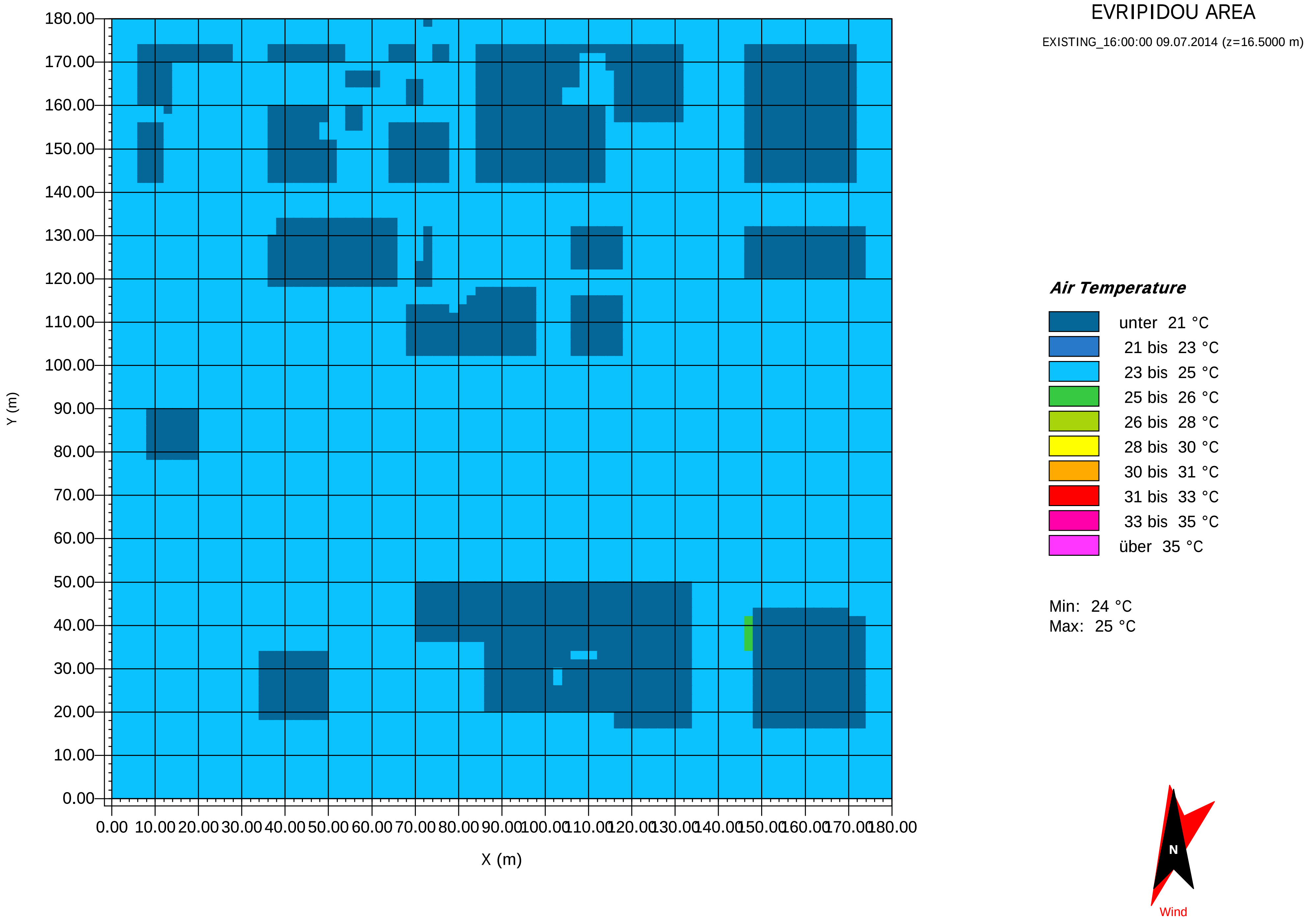

EVRIPIDOU AREA
EXISTING SITUATION_16:00:00 09.07.2014 (z=0.0000 m)
SURFACE TEMPERATURE
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 19 °C
Max: 46 °C
Y (m)
X (m)
N
Wind


EVRIPIDOU AREA
EXISTING_16:00:00 09.07.2014 (z=4.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 24 °C
Max: 25 °C
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
N
Wind


EVRIPIDOU AREA
EXISTING_16:00:00 09.07.2014 (z=10.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 24 °C
Max: 25 °C
Y (m)
X (m)
N
Wind



EVRIPIDOU AREA
EXISTING_16:00:00 09.07.2014 (z=13.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 24 °C
Max: 25 °C
N
Wind
X (m)
Y (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00

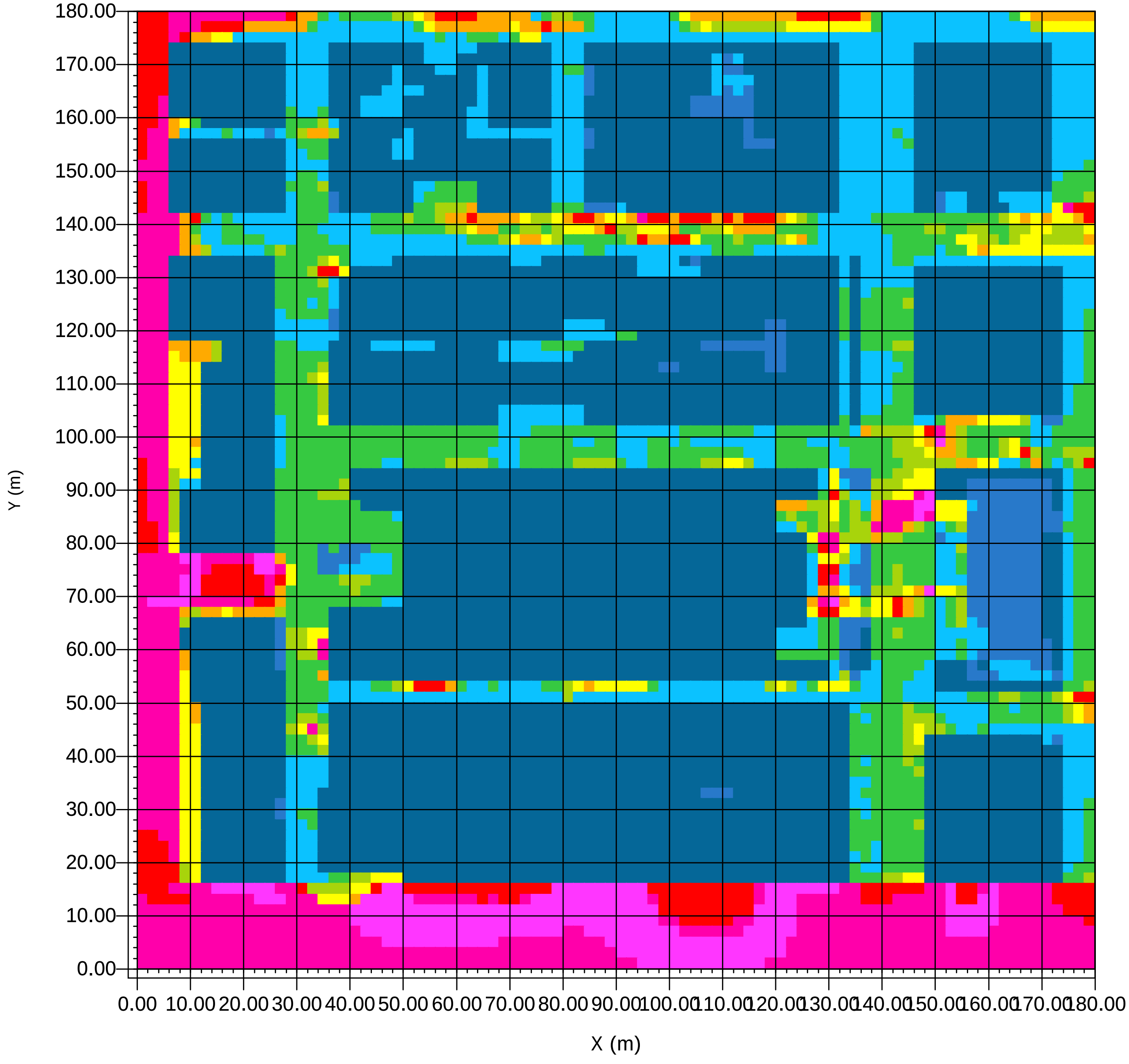


EVRIPIDOU AREA
EXISTING_16:00:00 09.07.2014 (z=16.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 24 °C
Max: 25 °C
N
Wind
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00

EVRIPIDOU AREA
PROPOSAL

EVRIPIDOU AREA

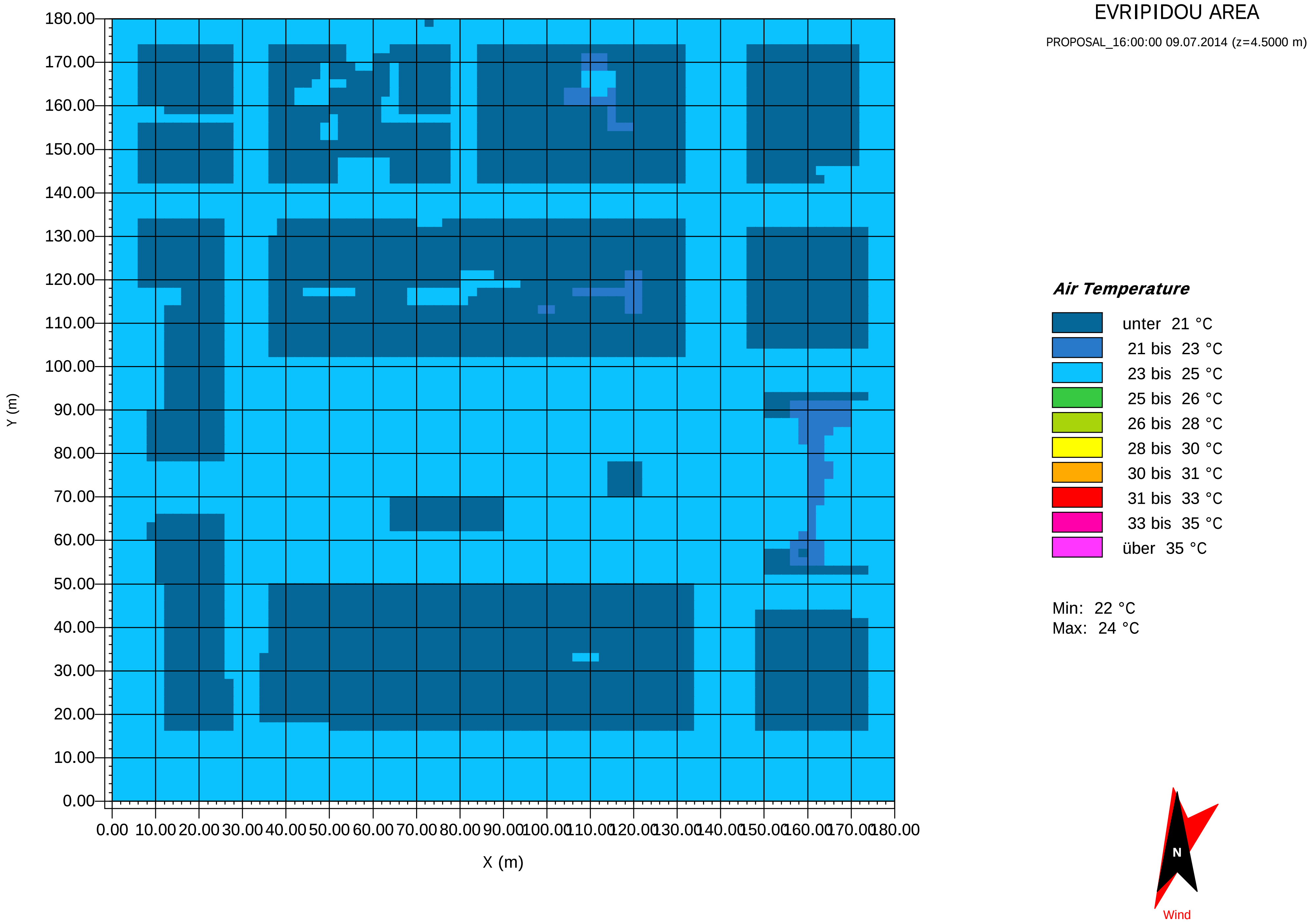
PROPOSAL_16:00:00 09.07.2014 (z=0.0000 m)

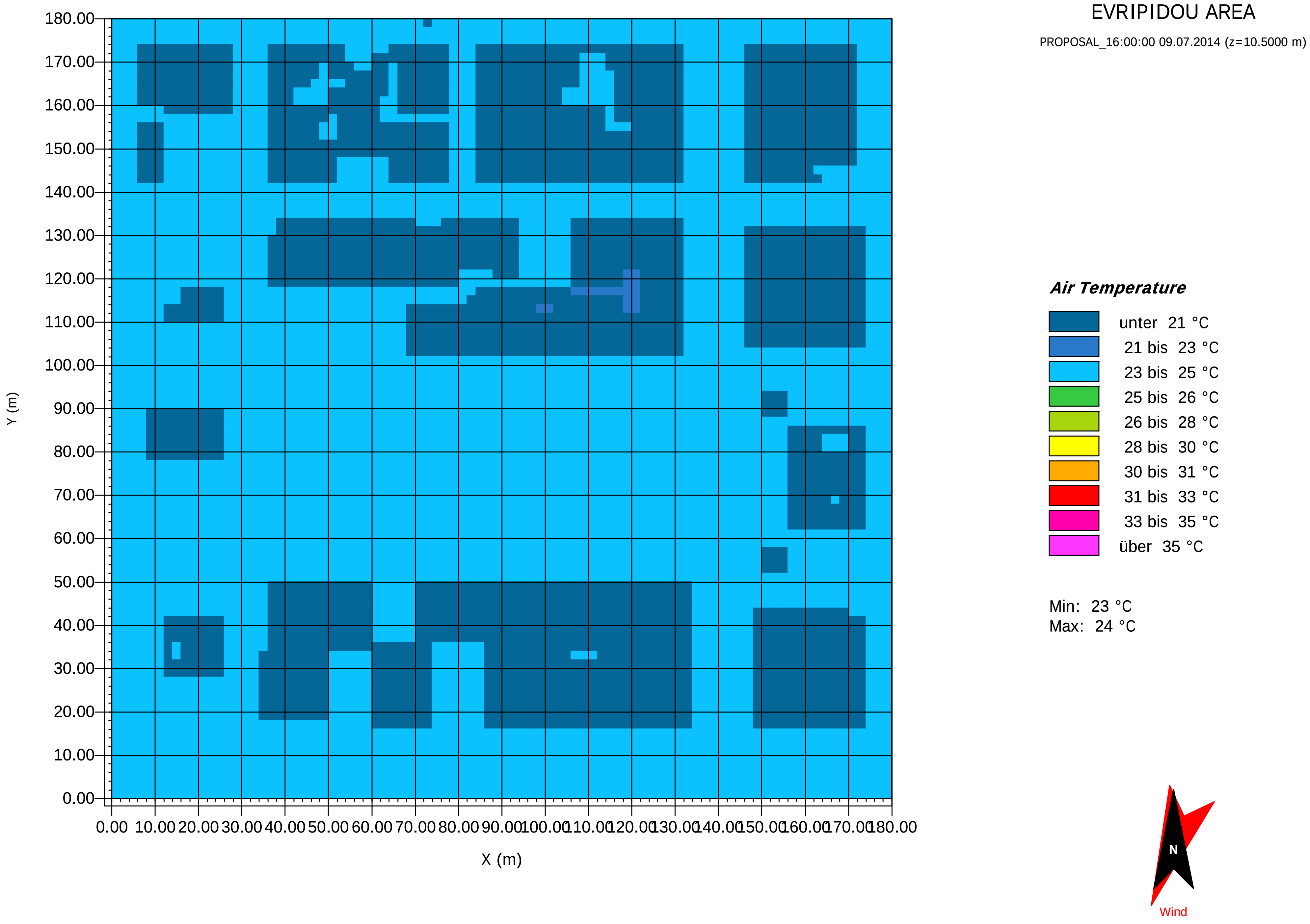


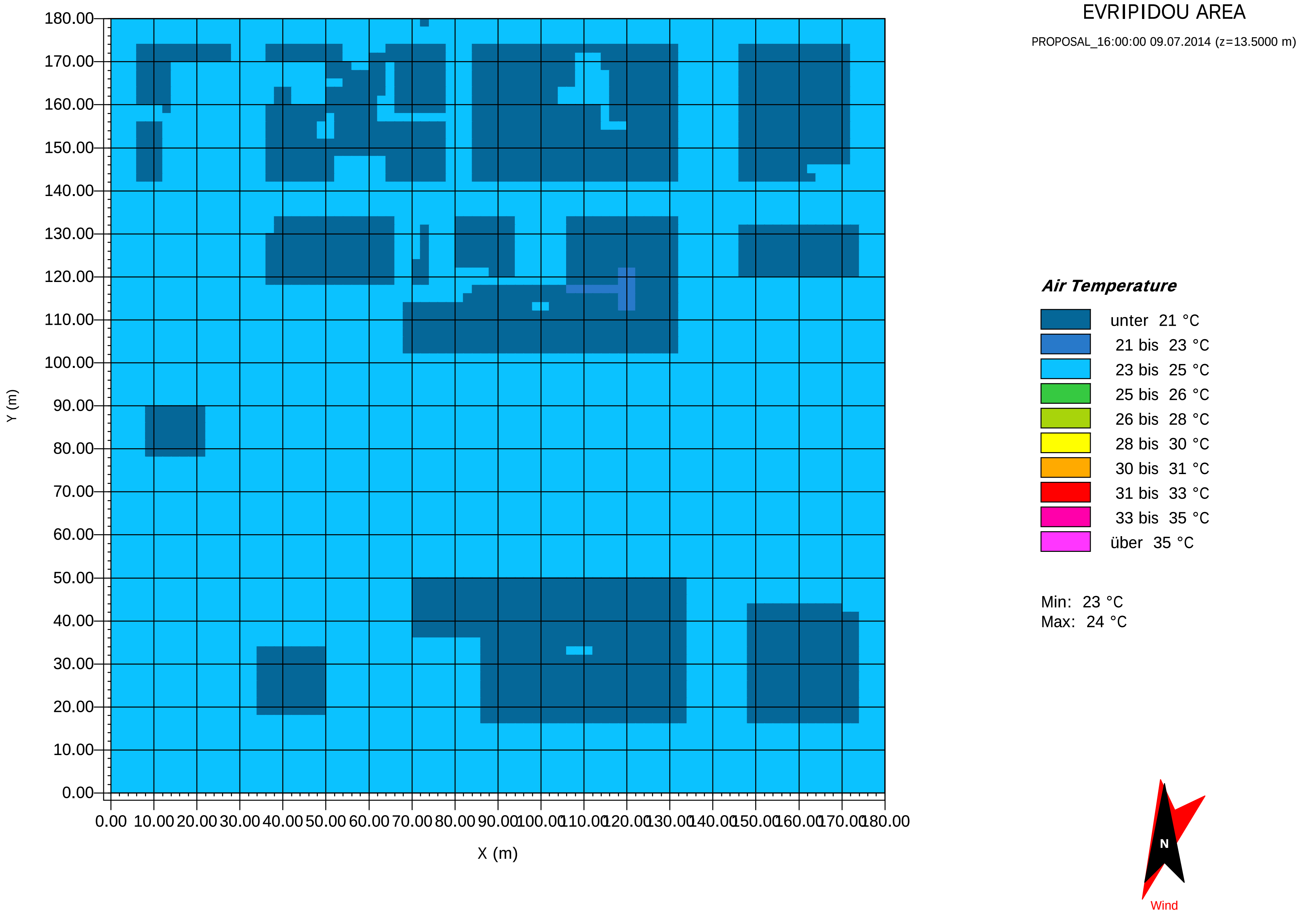
SURFACE TEMPERATURE

unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C

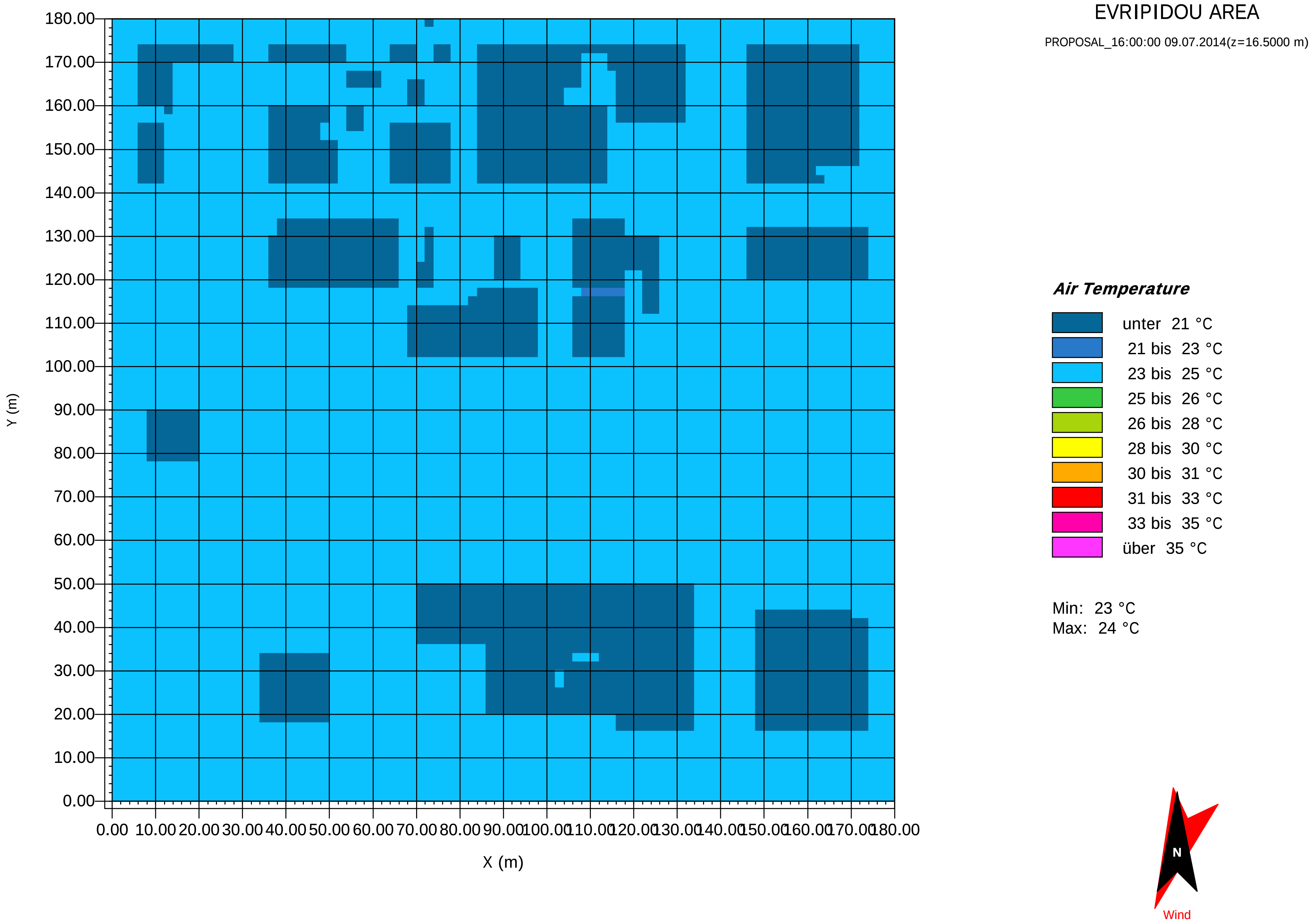
Min: 20 °C
Max: 36 °C


EVRIPIDOU AREA
PROPOSAL_16:00:00 09.07.2014 (z=4.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 22 °C
Max: 24 °C
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
N
Wind


EVRIPIDOU AREA
PROPOSAL_16:00:00 09.07.2014 (z=10.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 23 °C
Max: 24 °C
N
Wind
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00



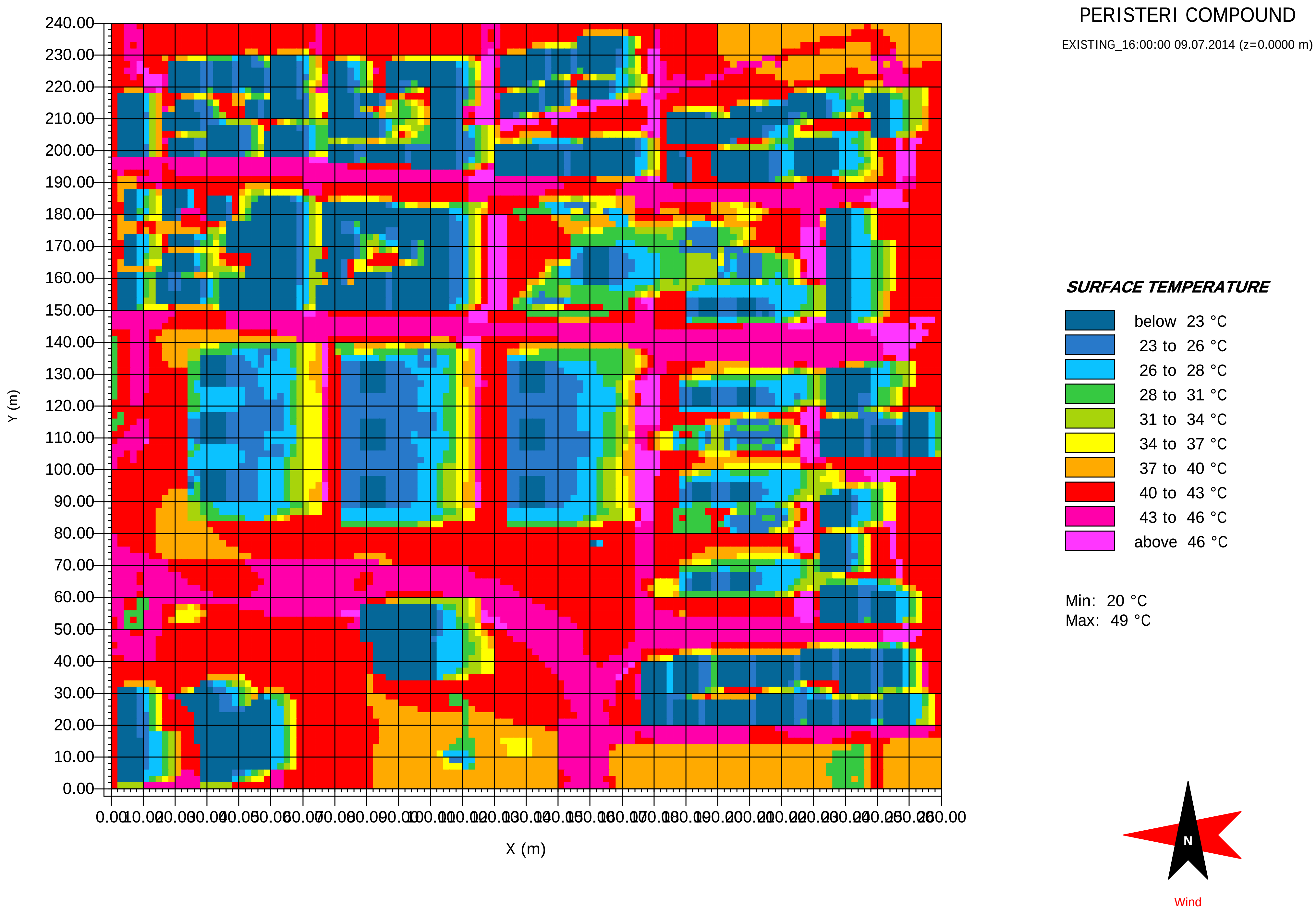
EVRIPIDOU AREA
PROPOSAL_16:00:00 09.07.2014 (z=13.5000 m)
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 23 °C
Max: 24 °C
N
Wind



EVRIPIDOU AREA
PROPOSAL_16:00:00 09.07.2014(z=16.5000 m)
Air Temperature
unter 21 °C
21 bis 23 °C
23 bis 25 °C
25 bis 26 °C
26 bis 28 °C
28 bis 30 °C
30 bis 31 °C
31 bis 33 °C
33 bis 35 °C
über 35 °C
Min: 23 °C
Max: 24 °C
N
Wind
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00

PERISTERI AREA

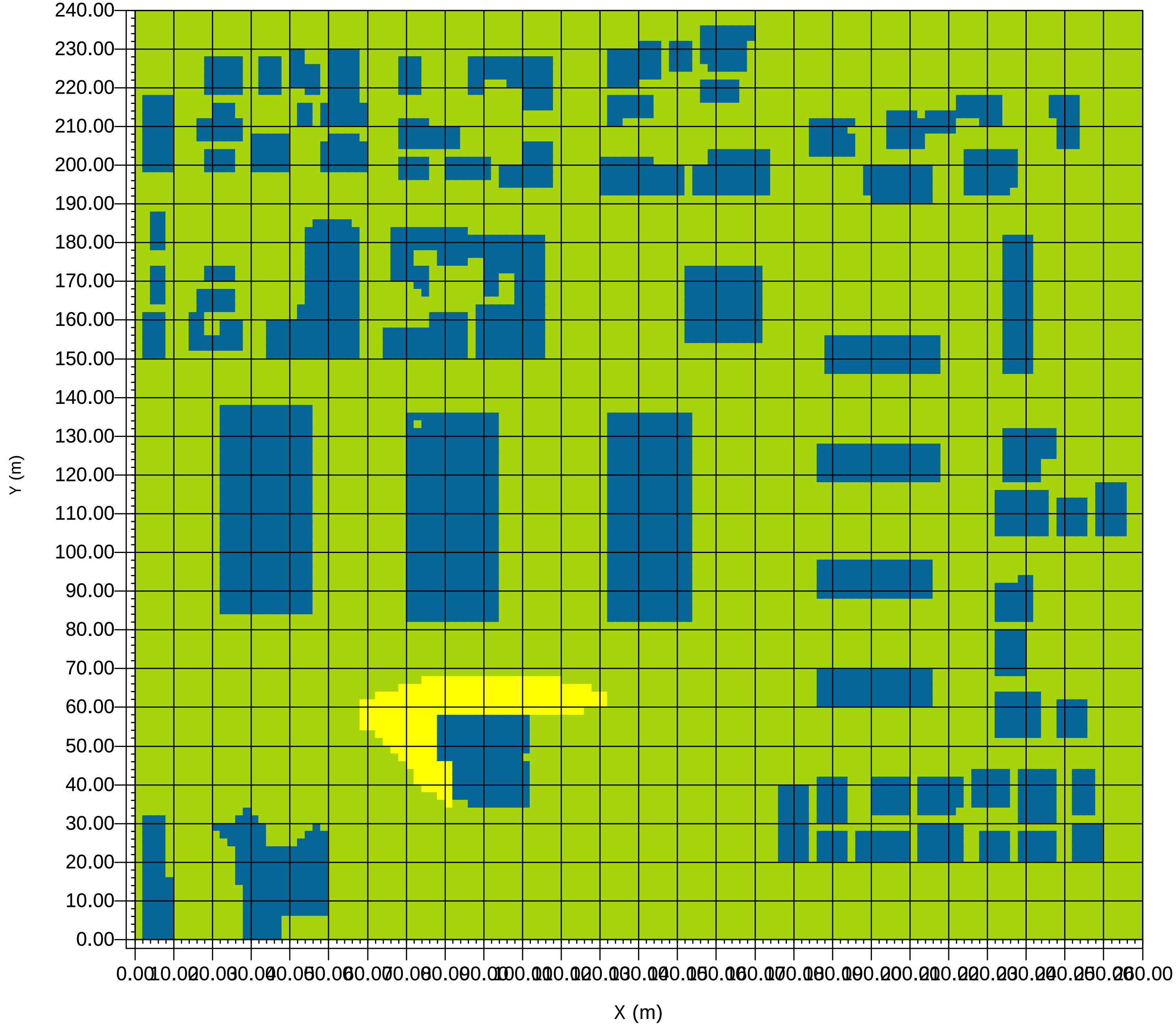
EXISTING SITUATION



PERISTERI COMPOUND
EXISTING_16:00:00 09.07.2014 (z=0.0000 m)
SURFACE TEMPERATURE
below 23 °C
23 to 26 °C
26 to 28 °C
28 to 31 °C
31 to 34 °C
34 to 37 °C
37 to 40 °C
40 to 43 °C
43 to 46 °C
above 46 °C
Min: 20 °C
Max: 49 °C
Y (m)
X (m)
N
Wind

PERISTERI COMPOUND

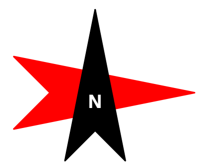
EXISITNG_16:00:00 09.07.2014 (z=4.5000 m)

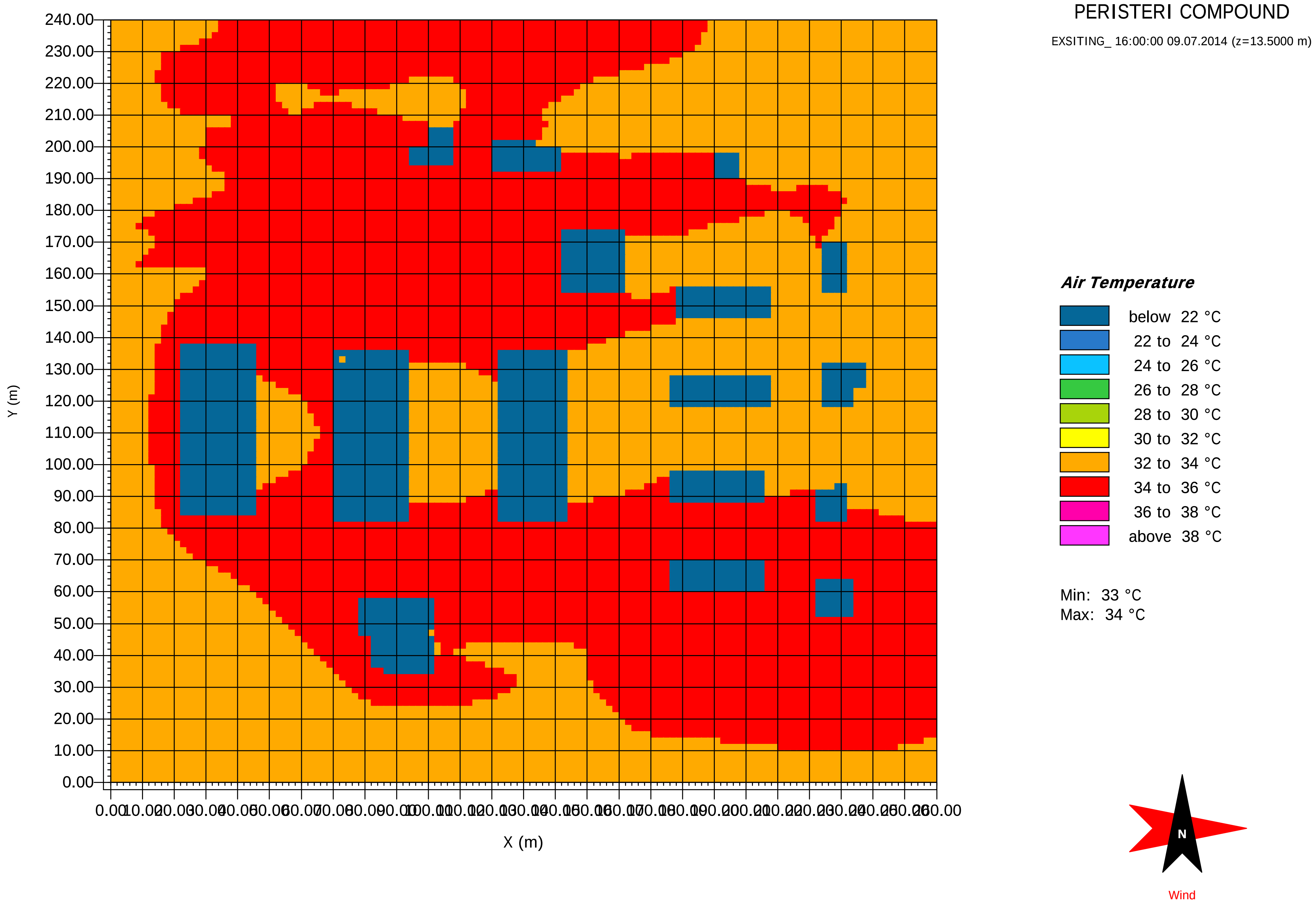


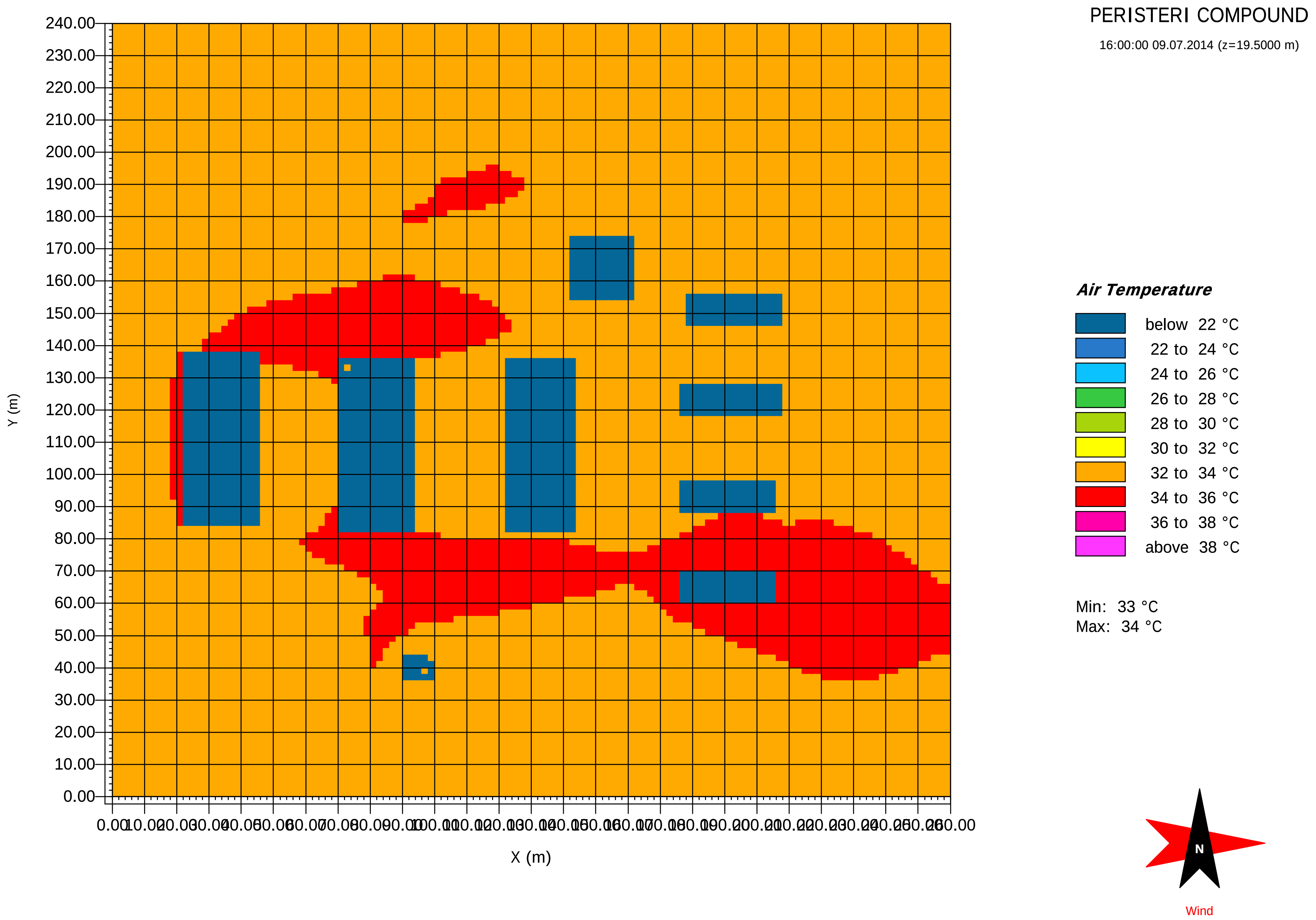
Air Temperature

below 23 °C
23 to 26 °C
26 to 29 °C
29 to 32 °C
32 to 35 °C
35 to 38 °C
38 to 41 °C
41 to 44 °C
44 to 47 °C
above 47 °C

Min: 20 °C
Max: 35 °C




PERISTERI COMPOUND
EXSITING_ 16:00:00 09.07.2014 (z=13.5000 m)
Air Temperature
below 22 °C
22 to 24 °C
24 to 26 °C
26 to 28 °C
28 to 30 °C
30 to 32 °C
32 to 34 °C
34 to 36 °C
36 to 38 °C
above 38 °C
Min: 33 °C
Max: 34 °C
Y (m)
X (m)
N
Wind


PERISTERI COMPOUND
16:00:00 09.07.2014 (z=19.5000 m)
Air Temperature
below 22 °C
22 to 24 °C
24 to 26 °C
26 to 28 °C
28 to 30 °C
30 to 32 °C
32 to 34 °C
34 to 36 °C
36 to 38 °C
above 38 °C
Min: 33 °C
Max: 34 °C
N
Wind
Y (m)
X (m)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
110.00
120.00
130.00
140.00
150.00
160.00
170.00
180.00
190.00
200.00
210.00
220.00
230.00
240.00
250.00
260.00

PERISTERI AREA PROPOSAL

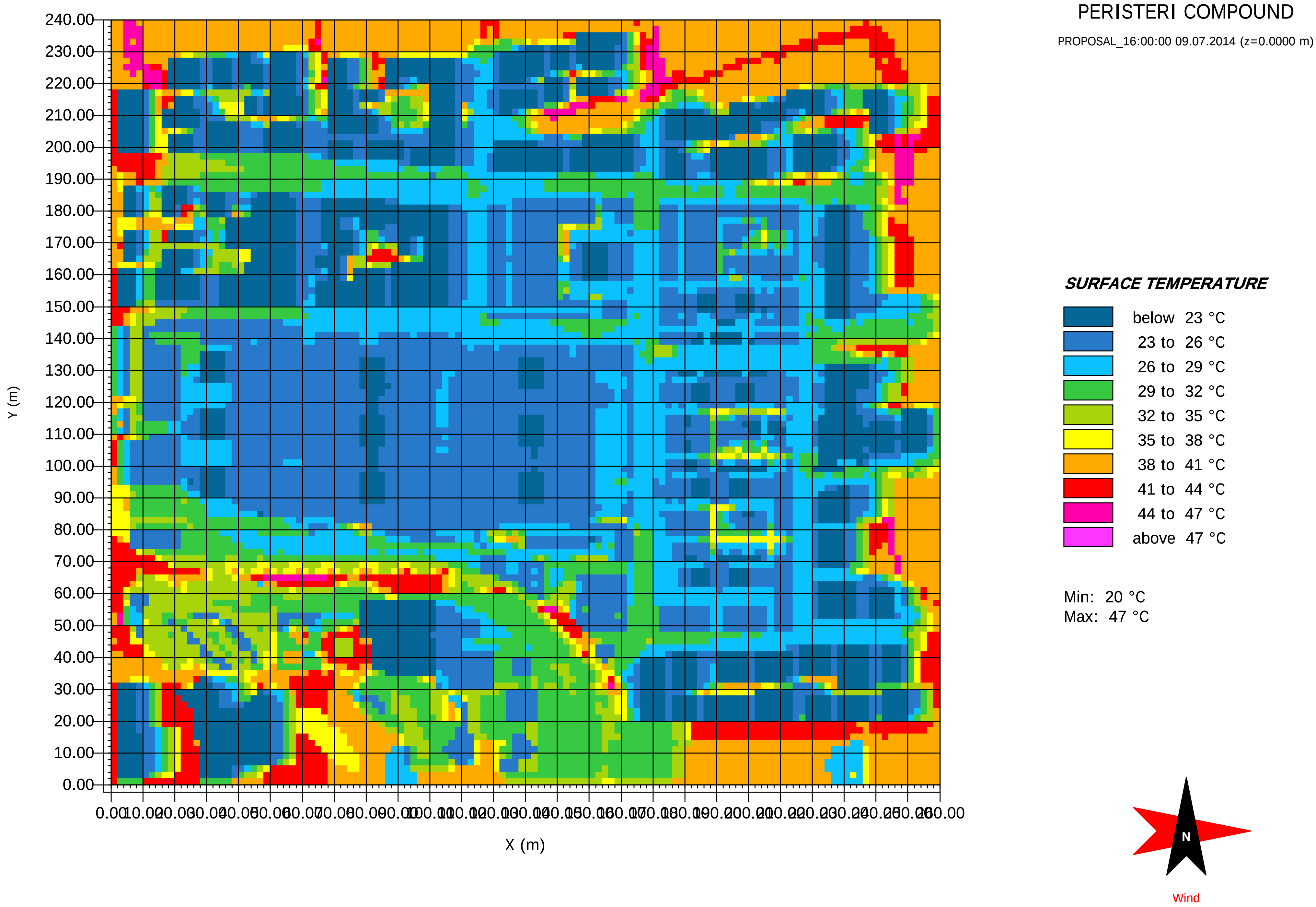
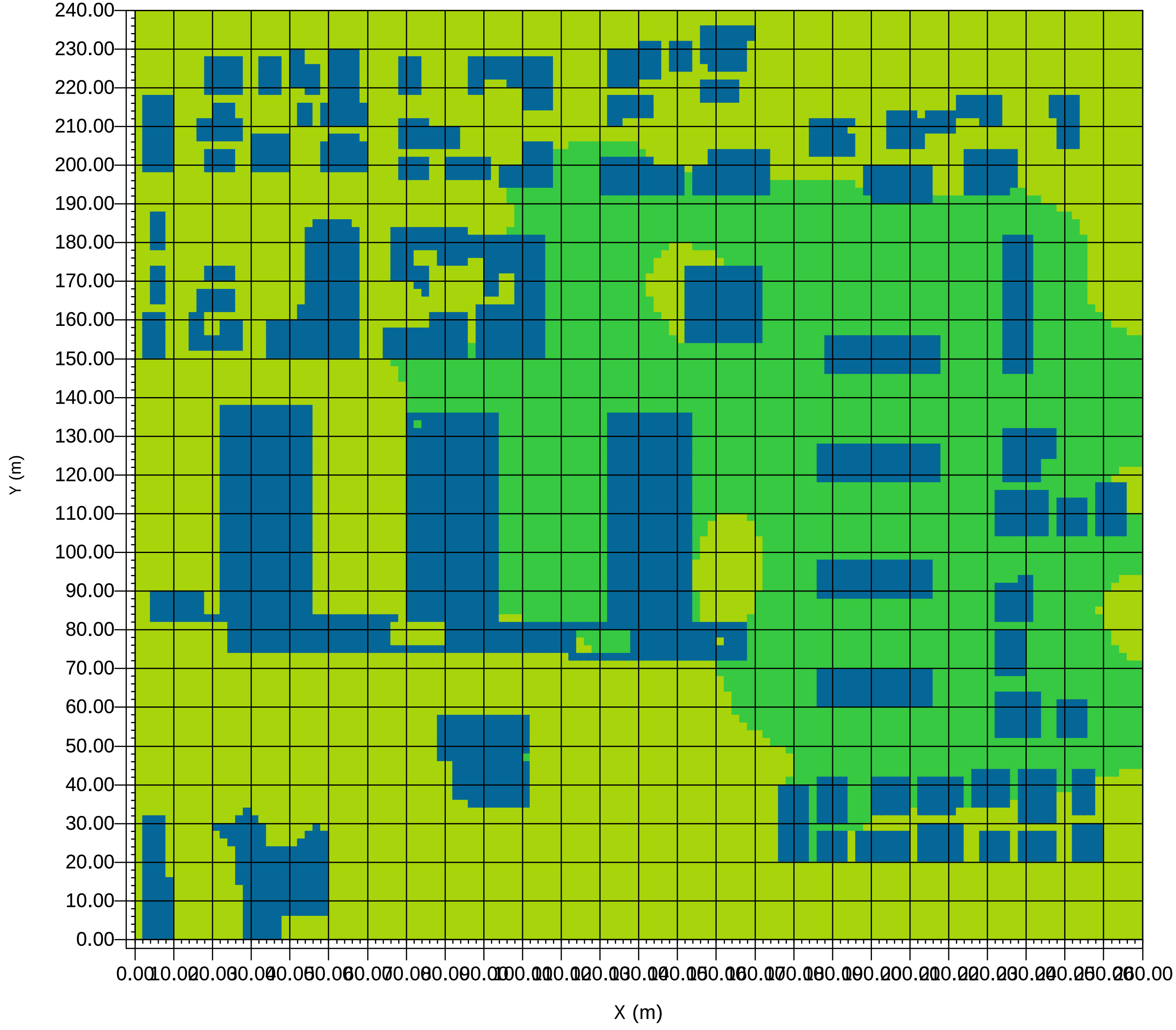
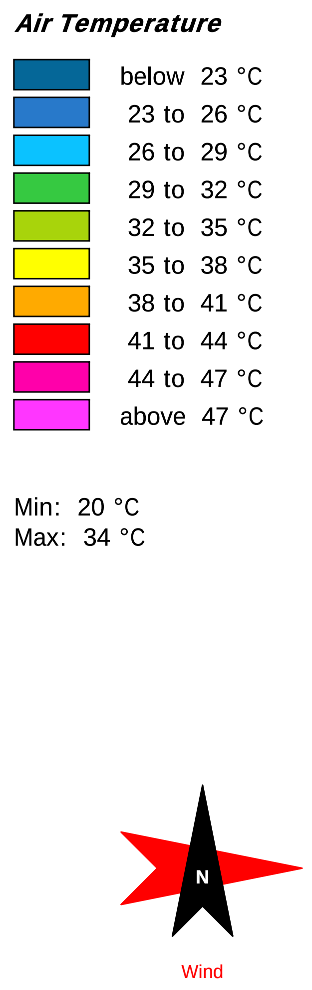
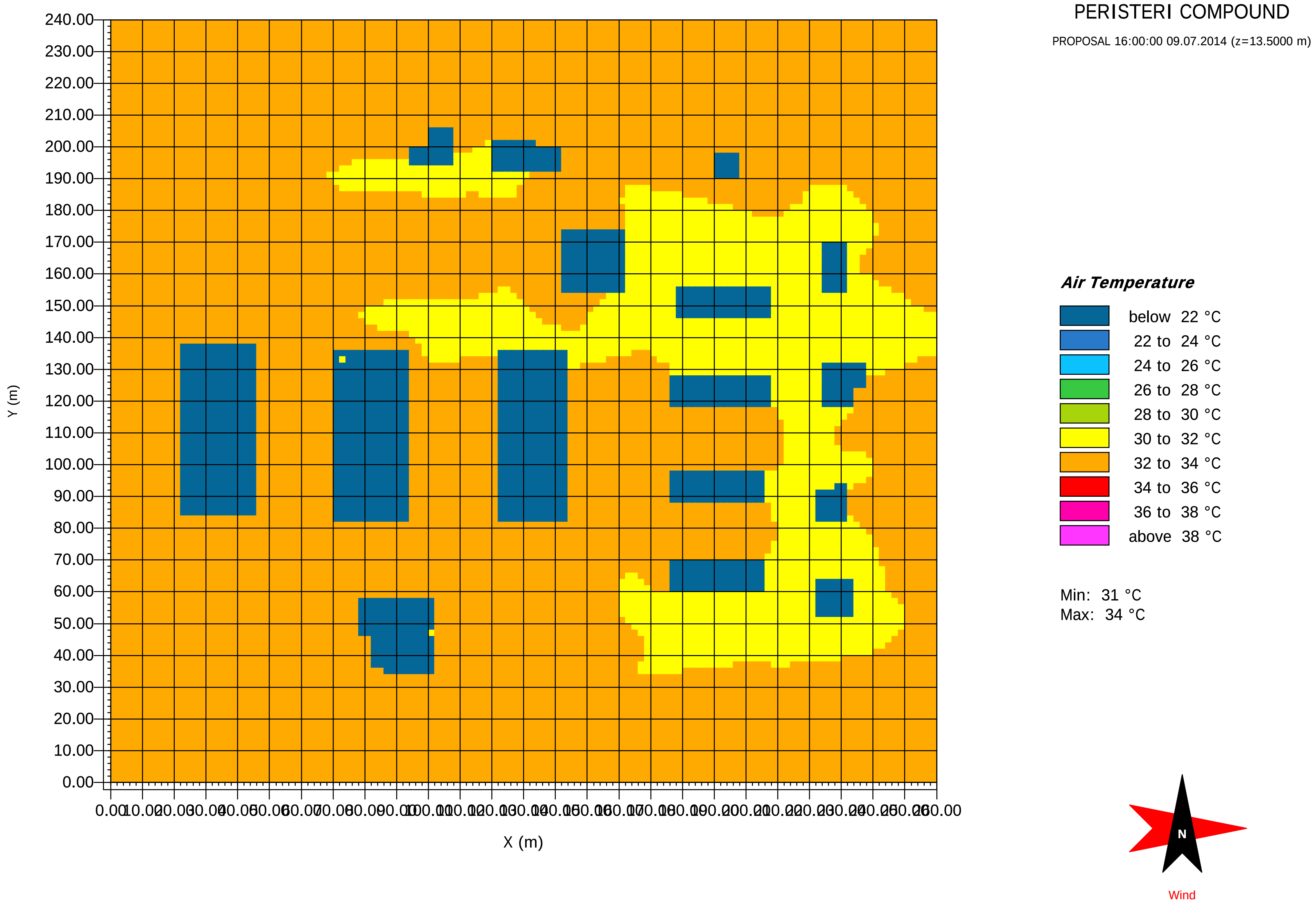

PERISTERI COMPOUND
PROPOSAL_16:00:00 09.07.2014 (z=0.0000 m)
SURFACE TEMPERATURE
below 23 °C
23 to 26 °C
26 to 29 °C
29 to 32 °C
32 to 35 °C
35 to 38 °C
38 to 41 °C
41 to 44 °C
44 to 47 °C
above 47 °C
Min: 20 °C
Max: 47 °C
Y (m)
240.00
230.00
220.00
210.00
200.00
190.00
180.00
170.00
160.00
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
X (m)
N
Wind

Figure 1: Simulation
Peristeri 16:00:00 09.07.2014

x/y Cut at k=5 (z=4.5000 m)

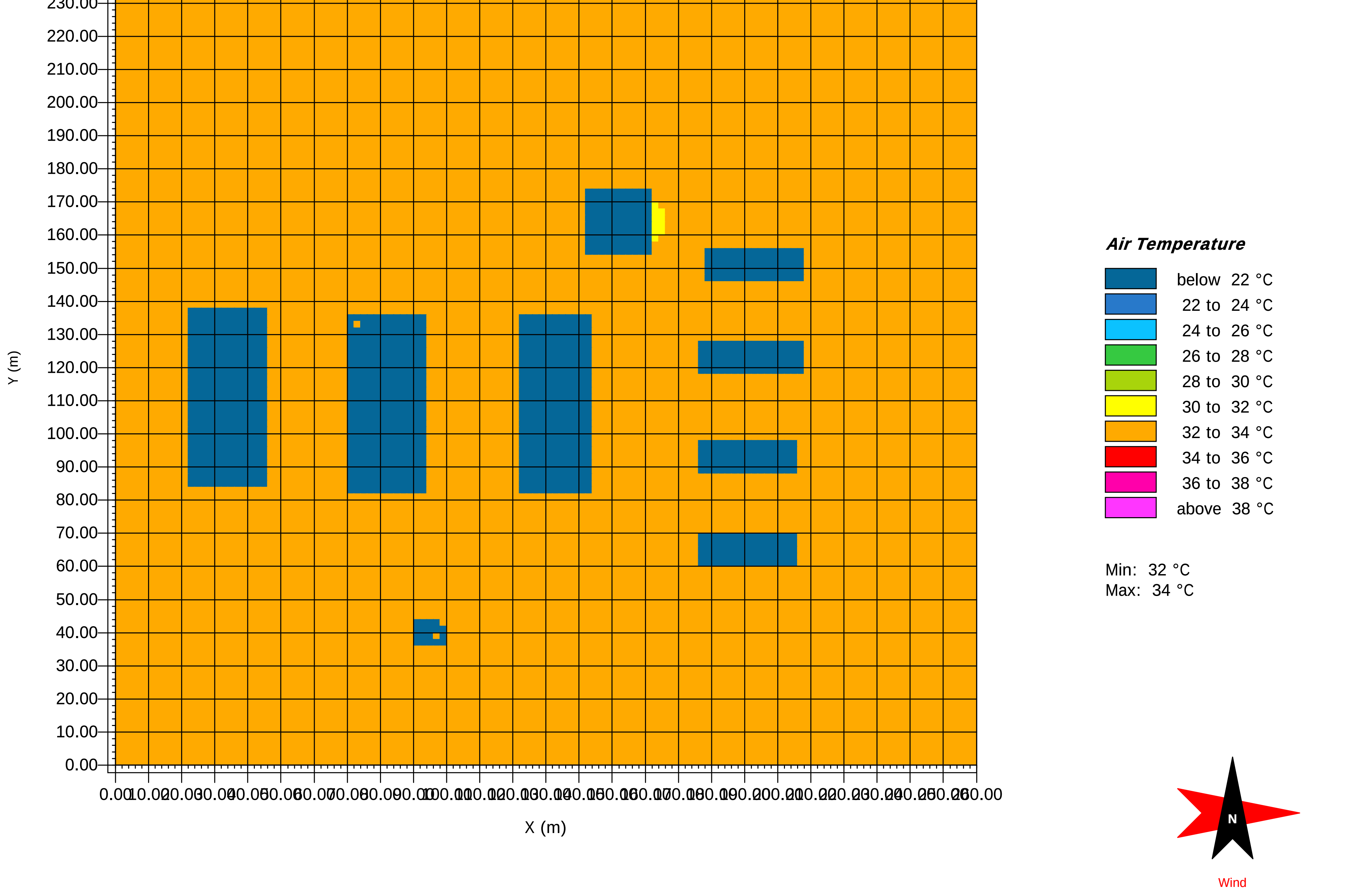





PERISTERI COMPOUND
PROPOSAL 16:00:00 09.07.2014 (z=13.5000 m)
Air Temperature
below 22 °C
22 to 24 °C
24 to 26 °C
26 to 28 °C
28 to 30 °C
30 to 32 °C
32 to 34 °C
34 to 36 °C
36 to 38 °C
above 38 °C
Min: 31 °C
Max: 34 °C
Y (m)
X (m)
N
Wind

PERISTERI COMPOUND

PROPOSAL 16:00:00 09.07.2014 (z=19.5000 m)



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Law 3855/2010 - Measures to improve energy efficiency in end-use, energy services and other provisions

Law 3899/2010 - Urgent measures for the implementation of the support program of the Greek Economy

Law 3908/2011 - Aid for Private Investment to promote Economic Growth, Entrepreneurship and Regional Cohesion

Law 4001/2011 - Operation of Electricity and Gas Energy Markets, for Exploration, Production and Transmission Networks of Hydrocarbons and other provisions

Law 4046 / 2012 - Approval of Plans of Financial Facilitation between the European Financial Stability Facility (E.F.S.F.), the Greek Republic and the Bank of Greece, the Plan of Memorandum of Understanding between the Greek Republic, the European Commission and the Bank of Greece

Law 4110/2013 - Provisions on the Taxation of Income, Regulations on Issues pertaining to the competence of the Ministry of Finance and other regulations

Law 4146/2013 - Creation of a Development Friendly Environment for Strategic and Private Investments

Law 4178/2013 - Tackle illegal building , environmental balance and other provisions

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