Energy aspects of urban planning. The urban heat island effect[1]

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Abstract

The research aims to analyze the tight relationship between the conformation of the city and the urban climate. The "heat island" phenomenon, typical of big urban centers, has a great impact on external temperatures, causing their increase compared to the surrounding rural areas. The study points out that the main factors responsible for such phenomenon are: the high percentage of built-up areas, the considerable presence of impermeable areas at the expense of the permeable ones, particularly green areas, the introduction of artificial heat in the atmosphere, generated by the combustion of hydrocarbon for transportations and domestic uses. Moreover a pivotal role is played by the urban canyons (which are generated by the geometrical configuration of the spaces among the buildings), the morphology of the urban tissue and the radiation properties (such as albedo and emissivity) of the surfaces. These considerations are confirmed by the results obtained in the experimentation conducted, in the city of Bari. Actually the results demonstrate that light color surfaces, with a higher level of albedo and wider green areas in some neighborhoods of Bari leads to a drop in temperatures of the external air, even of some degree days in the summertime.

The experimentation conducted outlines a guideline which considers the energy aspects of urban planning, thanks also to the possibility of realizing simulations by means of some particular software (suitable for the study of surfaces-vegetation-air interactions in the urban context) and to define different scenarios of project planning.

1. Introduction

It is recognize by several studies that the concentration of people and buildings in the city, in restricted portions of territory, causes a different characterization of the urban climate from that of the surrounding rural areas (figure 1). This generally concerns the diverse weather variables, especially the range of temperatures. It is the so-called *Urban Heat Island Effect* which depends on how the city is built, the materials employed, how the streets and buildings are arranged, as well as the level of heat generated by the combustion of hydrocarbon for the transportations and domestic uses. The geometry of streets and buildings, their shape and height (canyon effect) entrap the heat in the façade of the buildings and the streets, before releasing it in the atmosphere (figure 2).

The most evident effect of the "urban heat island" on temperatures appears during the night, since the green areas get cold rapidly, while the artificial elements remain warm longer.

The characteristics of the materials employed for the pavements, the façades and the shingles of the buildings, are decisive for the warming of urban areas. The albedo, which is the capacity of materials to reflect the sunlight (in shortwave) is particularly crucial, since it has a high impact on the energy balance and the conditions of thermal comfort. The thermo-hygrometric wellbeing depends both on objective (microclimate of the area) and subjective (physical, biological and psychological conditions of the inhabitants) features. But the most effective index to evaluate the thermal comfort is the PMV (Predicted Mean Vote) by P. O. Fanger external modified (Jendritzky, Maarouf, Staiger, 2001) which takes in consideration environmental parameters (temperature, humidity, air speed, radiation, MRT) as well as the metabolic activity and clothes.

During the last years, the consequences of the Urban Heat Island have been emphasized by the global warming, so that during the summer, in the cities, it is possible to reach very high temperatures, which can seriously affect the public health. For the first time in the world, citizens, entrepreneurs, administrators, are considering the environmental consequences of the choices that, till today, have followed only the criterion of the economical disposability.

The urban morphology, in terms of external microclimate, plays a pivotal role and it is important to specify that when we speak about urban morphology we mean the tridimensional shape of a body of buildings and the urban spaces defined by it.

The analytical evaluation of the microclimate of a urban fabric has been long since object of study of the urban microclimatology (Yoshino, 1975; Lowry, 1977; Oke, 2006) and it is a complex issue, since there are almost unlimited combinations of different climate contexts, urban geometries, climate variables and purposes of the projects.

1. This paper is the result of a work conducted by both the authors. In particular Francesco Selicato wrote the paragraph 1, 2.1 and 3, while Tiziana Cardinale paragraph 2.2.

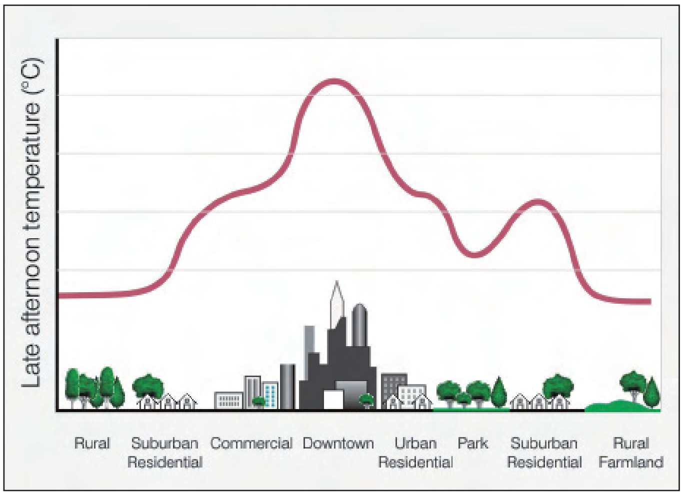


Figure 1a – The profile of the Urban Heat Island.

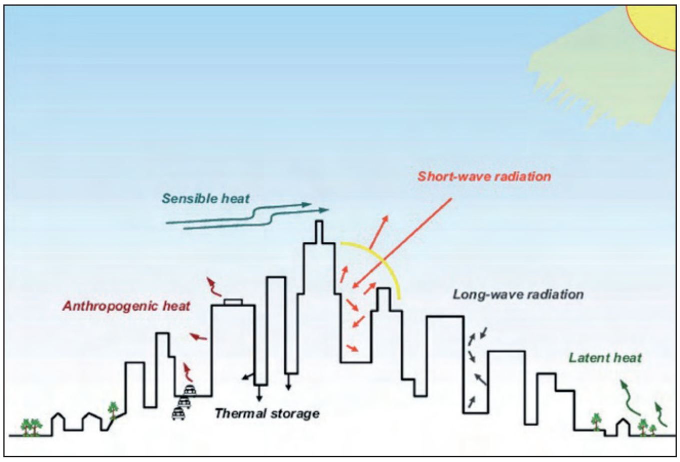


Figure 1b – Energy exchanges within the city.

The literature has identified a first classification, distinguishing the environment of the development of the heat island between rural and urban areas. Stewart (2007) and Oke (2006), two of the most expert in the field of the heat island phenomenon, explain that one-third of the studies produced during the last 30 years doesn't provide any qualitative or quantitative description of the sites, in order to distinguish them between rural or urban, while the other two-thirds focuses only on qualitative descriptions, without providing measurable criteria according to the environmental characteristics, such as the geometry of the area, exposure and shingles. The two researchers think that it is better to consider more technical and scientific models of the urban expansion and the different urban settlements with their morphology, taking account of thermal observations, as if it was possible to outline a sort of "energy signature" which does not focus only on a single building, but on blocks, districts, cities and regions.

2. An experimentation in the city of Bari

2.1 The importance of the phenomenon of the Urban Heat Island for the case study analyzed

The following work focuses, thanks also to the experimentation made by Bruse (2004) at the University of Mainz with the innovative ENVI-Met fluid dynamics software, on the identification of the heat island in the city of Bari, the climatic and morphological parameters which affect it and the requisites of thermal comfort in the surrounding environment. Therefore, the work at the beginning demonstrates the scientific basis of the phenomenon, then it considers the core issue of the identification and evaluation of the thermal comfort, and finally outlines a list of mitigation technologies and a guideline, in order to choose and evaluate proper solutions and procedures according to which develop the project planning, the recovery and restoration of the open-air areas.

Bari is characterized by a Mediterranean moderate worm climate, with a dry season in the summer. It is a typical example of the Italian East coast climate. Moreover, the sea, the lack of mountains and the East quadrant orientation are the three key elements which determine the peculiarities of the climate of Bari. In quantitative terms, the warming of the city of Bari is very high; actually, one and a half degree more can be registered during the spring and the summer, moreover the thermal amount of the daily-degrees is very high. Despite the mitigating effect of the sea, during the summer the intense warm days are increasing, reducing the number of pleasant days of the season.

The research starts with a comparison between the temperatures registered by the weather station of Bari-Airport and the weather station of Bari-city; the former is managed by the Italian Air Force and the latter by the Regional Agency for the Prevention and Protection of the Environment, ARPA-Puglia (figure 2). The data collected date back to 2010, since the weather station of ARPA provides validated data only for that year.

The first station is characterized by a rural zone, being located into an area with a very low presence of buildings, while the second station represents a urban zone, being located along the south seafront of Bari, in a highly built-up area.

It can be immediately noticed that the values of the variations of the temperature in the city are always positive compared with that of the airport, except for only three cases in which the values are null (Table1). The most remarkable variation can be noticed for the lowest temperatures with a ΔT of 2-3 °C, while for the medium and maximum temperatures the ΔT reaches 1-2 °C. The highest value of 3°C was registered during the summer period, in August (Figure 4). Also the maximum variations are greater for the lowest temperatures, ΔT of 4-6 °C, while for the medium temperatures the variations fall to a ΔT of 2-3°C and to ΔT of 2-4 °C for the maximum temperatures. The results clearly show that the air warming is higher in the urban environment than in the rural environment, especially during the night, exactly when the lowest temperatures are registered. Therefore it can be confirmed that the phenomenon of the heat island becomes more relevant after the sunset.

Figure 2 – The location of the two weather stations of the city of Bari.

Table 1 – Monthly mean values of the lowest, medium and maximum temperatures at the Airport weather station, of the medium and maximum variations of these temperatures compared to that registered by the City weather station during 2010.

Month	Tmin (Aer) (°C)	Avarage ΔTmin (°C)	Max ΔTmin (°C)	Tmed (Aer) (°C)	Avarage ΔTmed (°C)	Max ΔTmed (°C)	Tmax (Aer.) (°C)	Avarage ΔT max (°C)	Max ΔT max (°C)
1	6	1	4	8	1	3	11	1	4
2	5	2	4	9	1	2	13	1	3
3	6	2	5	11	1	3	15	1	4
4	10	2	4	14	1	2	18	1	4
5	13	2	6	18	1	2	23	0	2
6	18	2	5	22	0	2	26	0	2
7	21	2	4	26	1	2	29	1	4
8	20	3	5	25	1	3	29	1	3
9	16	2	4	21	1	3	25	2	4
10	13	2	5	16	2	3	20	2	4
11	10	2	4	14	2	3	18	2	4
12	6	2	4	9	1	2	13	1	2

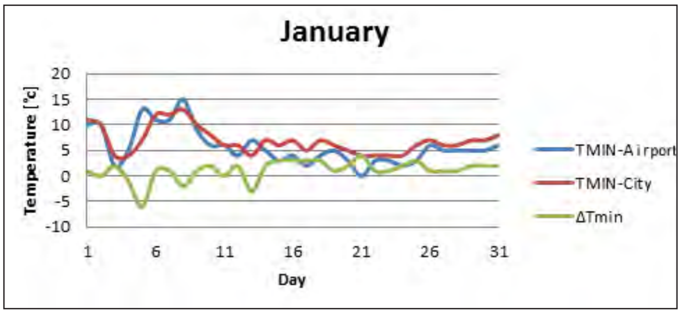


Figure 3 – Lowest temperatures in January registered by the weather stations of Bari City and Bari Airport and the differences between them.

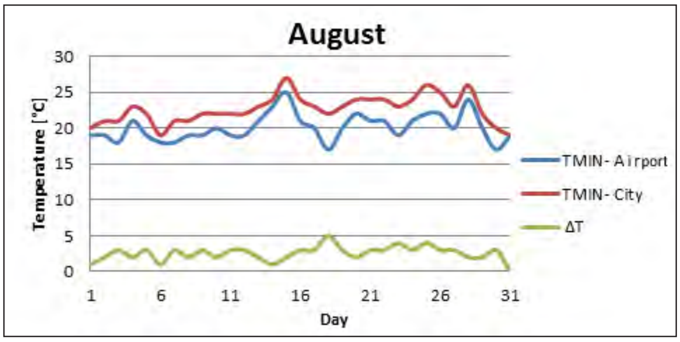


Figure 4 – Lowest temperatures in August, registered at the Weather station of Bari city and Bari airport, and the differences between them.

2.2 The influence of the urban shape in the identification of the heat island

The purpose of investigating the relationship between the heat island and the urban shape refers to the definition of the urban and morphological aspects which characterize the diverse parts of the city, aspects which correspond to different typologies of macro urban fabrics (Selicato).

After defining the classification, it was conducted a detailed simulation with the ENVI-Met software on some significant fabric-shape. The ENVI-Met software is based upon the Navier-Stokes equations and it is considered one of the most accurate in the simulation of the interactions surface-vegetation-air inside the urban environment.

The model allows to evaluate:

- The shortwave and long wave flows of radiation, considering the shading and the emissions of radiation from buildings and vegetation;
- The perspiration, the evaporation and the heat flow between the vegetation and the air, the temperatures of surfaces and walls for every point of the grid;
- The mixing of water and heat inside the soil system;
- The calculation of the bio meteorological parameters, like the mean radiant temperature and the PMV.

The software turned out to be particularly useful for other programs of energy simulation of dynamic type (Ecotect, Design Builder) in the field of the study of the urban micro climate. This is also demonstrated by the state-of-the-art in relation to its application in the field of the determination of the heat island in different climatic situations. Lahme and Bruse (2003) conducted a comparative study between the simulation with the model and a campaign of experimental measures for a small park situated in the German city of Essen. Huttner et al. (2008) analyzed two scenarios for a residential district typical of many cities of Central Europe. Yu and Hien (2006) applied the model of heat island to an area characterized by a tropical climate (Singapore). Fahmya et al. (2010) as well focused on the micro climate in an area of mid-latitude (Cairo). Ali Toudert and Mayer (2007) analyzed the urban canyon in an area characterized by hot-dry subtropical climate (Ghardaia, Algeria) with different height-width relations (H/W) of the buildings and solar orientations.

The aim of the work is to evaluate the influence of certain parameters on the development of the heat island and on the wellbeing of the inhabitants of a urban area. Such as the percentage of the built-up areas, the vegetation and the impermeable grounds, the aspect ratio of the urban canyons, the type of urban fabric and the radiation properties (albedo, emissivity) of the surfaces.

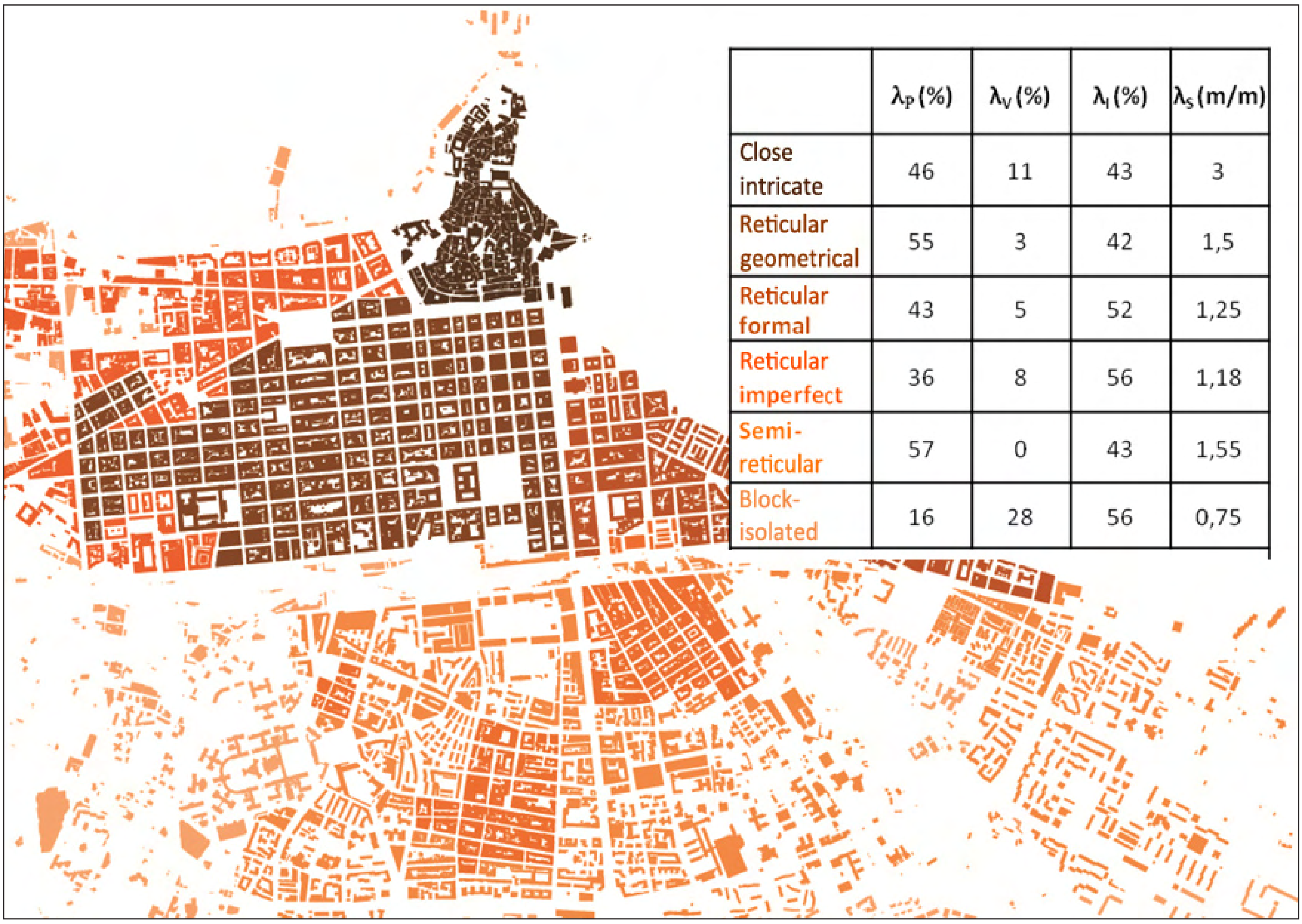
The calculation of the above parameters was realized for each different shape-fabric, in order to choose some areas to study (figure 8), and to find a correlation between urban shape and heat island (figure 5). All over the city there is a high presence of impermeable surfaces at the expense of the green ones. The plane area index, that is the ratio between the built-up plane area and the total plane area is around the 50%, except for the fabric divided in blocks, which is 16%. The aspect ratio (which is the ratio of the average height of the buildings to the width of the streets) is about 3 for the close intricate fabric, while it is about 0,75 for the fabric divided in blocks and 1,5 for the other kinds of shape-fabric.

Since the development of the phenomenon is very complicated we used, as previously said, the ENVI-Met software, but in a new and different way if compared to its employ in the previous studies. We created two files in which we collected all the data required for the simulation: a "Configuration" file and an "Input" file (Table 2).

The file "Input" includes all the geometrical descriptions and the location of the model. The values of the albedo for the asphalt road and pavements is 0.2 and 0.4, which correspond to almost black and dark gray, while for the façade of the buildings the value is 0.6, which represents a light-colored surfaces.

In the file "Configuration" are collected the meteorological data which, for the first simulation realized, correspond to the experimental data collected the 17th June 2010: the Initial Temperature Atmosphere of 23 °C registered at 6.00 AM, and the Wind Speed and Direction of 3.3 m/s and 45° relative to N clockwise (N-E).

in the areas protected from the direct sun radiation, while in the exposed areas the values reach +4, which corresponds to an intolerable heat (figure 7). These first quantitative analysis



	λ_P (%)	λ_V (%)	λ_I (%)	λ_S (m/m)
Close intricate	46	11	43	3
Reticular geometrical	55	3	42	1,5
Reticular formal	43	5	52	1,25
Reticular imperfect	36	8	56	1,18
Semi-reticular	57	0	43	1,55
Block-isolated	16	28	56	0,75

Figure 5 – Urban shape-fabric and morphological-climatic parameters for Bari city: [close intricate/reticular geometrical/reticular formal/reticular imperfect/semi-reticular/ block-divided]

λp= built-up plane area/total plane area

λv= vegetation plane area/ total plane area

λi= impermeable plane area/total plane area

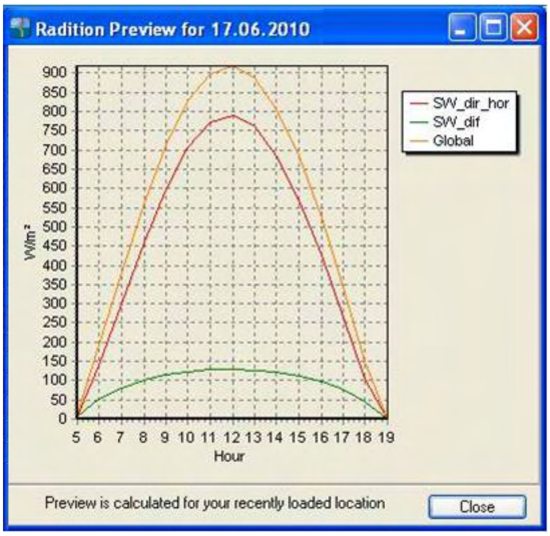
λs= aspect ratio of the urban canyons

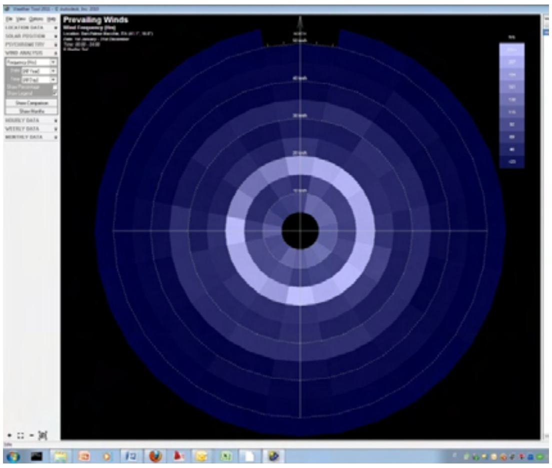
At the beginning, in order to understand the importance of the vegetation, the program ENVI-Met was employed for the microclimate forecast in a summer sunny day in the area of Piazza Garibaldi (figure 6), an urban area characterized by a high housing density with a public garden situated at the center of the urban square. The East sunny zones reach a temperature of 30°C, so that the high speed of the wind leads to a great quantity of warm air, with the following increase of the temperatures. The lowest temperatures, 27 °C, are registered inside the garden, because of the vegetation and also in the West zones, which are touched by a cooler air, thanks to the trees. The lower PMV values (between +1.5 and +2, which correspond to a tolerable heat) are registered only

shows that in order to increase the comfort, or better to say, in order to limit the discomfort during the warmest hours of the summer days it is essential to increase the areas protected from the direct sun radiation and covered by a dense vegetation. Therefore, the presence of different typologies of trees which produce a thick shading leads to the two above mentioned positive effects, contributing to a significant increase of the PMV.

Table 2 – File Input and File Configuration Solar Radiation and Wind Rose.

Altri Dati principali dell'INPUT file (Piazza Garibaldi.in)			
Surface of soils			
Code	Name	Albedo	
Emissivity			
s	Asphalt Road	0.20	0.90
p	Pavement (Concrete)	0.40	0.90
Type of vegetation			
Code	Name		
Parameter			
sk	Tree 15 m very dense, distinct crown		
layer	height, width, LAD, RAD		
Dati Principali del Configuration File (Piazza Garibaldi.cfg)			
MAIN-DATA -------------------------------			
Wind Speed in 10 m ab. Ground [m/s]			=3.3
Wind Direction (0:N..90:E..180:S..270:W..)			=45
Initial Temperature Atmosphere [K]			=296
Specific Humidity in 2500 m [g Water/kg air]			=7
Relative Humidity in 2m [%]			=60
[TIMESTEPS] [BUILDING]__Building properties			
Inside Temperature [K]			=299
Heat Transmission Walls [W/m²K]			=1.5
Heat Transmission Roofs [W/m²K]			=3
Albedo Walls			=0.6
Albedo Roofs			=0.6
[PMV]__Settings for PMV-Calculation			
Walking Speed (m/s)			=0.3
Heattransfer resistance cloths			=0.5





[in the table: Configuration file's Main data (Piazza Garibaldi); Other main INPUT file data (Piazza Garibaldi)].

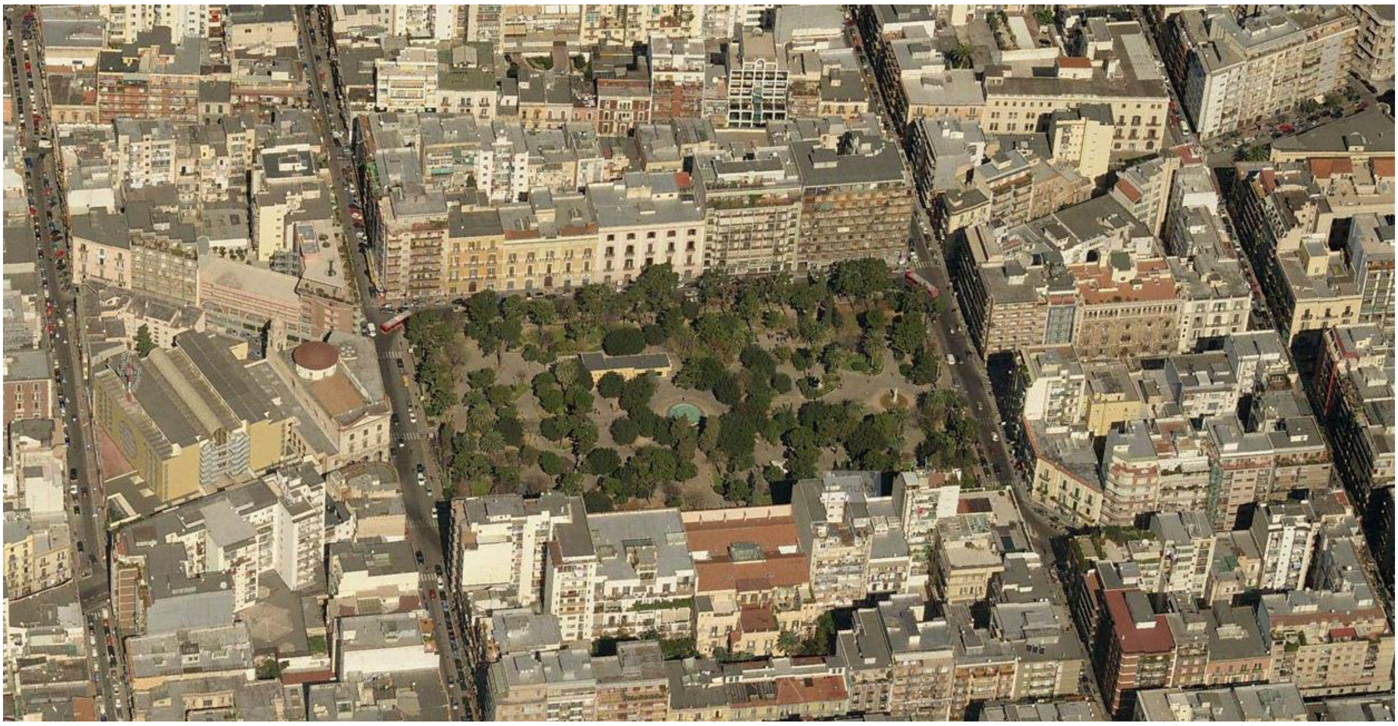


Figure 6 – The example simulation area in the city center of Bari: the garden of Piazza Garibaldi.

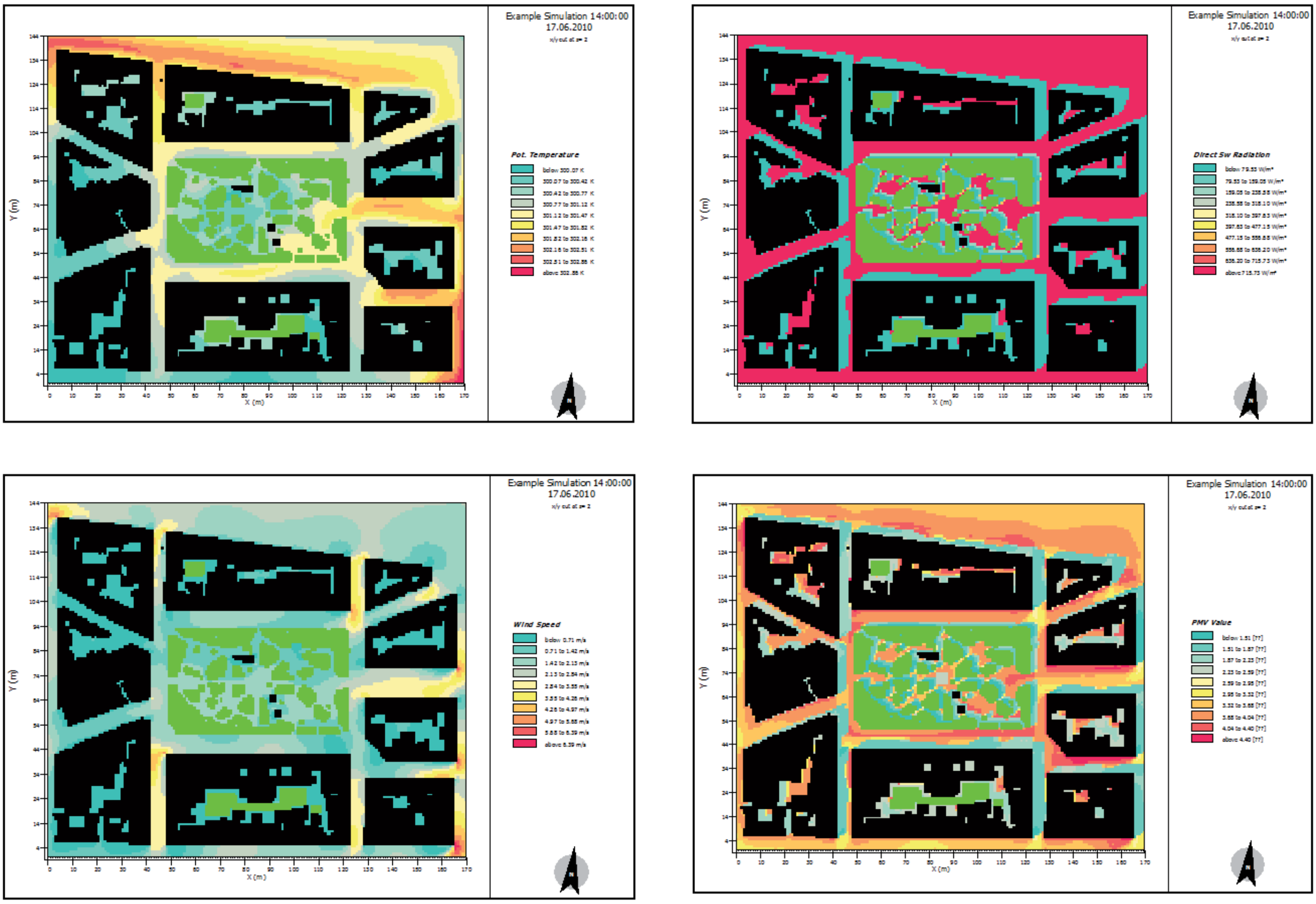


Figure 7 – Temperature, Direct Sun Radiation, Wind Speed, PMV Value at 2.00 PM in Piazza Garibaldi, Bari.

The values of the Aspect Ratio of the three selected areas (figure 8) are: 3, for the intricate and dense fabric of the Old Town; 1,5 for the reticular and geometrical fabric of the Murat area and finally 0,75 for the Japigia area, characterized by a fabric divided in blocks (figure 8).

The simulations are conducted in the same meteorological conditions of Piazza Garibaldi, but considering a lowest wind speed (0.5 m/s) and a random direction (North), since it appears from the wind rose that there isn't a predominant direction of the wind in the city of Bari. Actually, the absence of a predominant direction of the wind is a positive factor, because it facilitate the evaluation of the influence on the formation of the heat island and on the comfort for the individuals living in the urban space (1.2 m of height from the ground). It also provides a better evaluation of parameters such as the percentage of the built-up areas, of the vegetation and impermeable surfaces, the Aspect Ratio of the urban canyons, the type of urban fabrics and the radiation properties (albedo and emissivity) of the surfaces.

A first sequence of simulations is realized considering the current conditions of the quarters (Table 3). For the light-colored buildings the albedo of the façade and the roofs (for sure less influent on the wellbeing conditions of the inhabitants) is equal to 0.6. The albedo of the streets of the Old Town, paved with light-colored stones, is equal to 0.6 as well. While the albedo in Murat and Japigia quarters, with their streets (asphalt) and pavements (tiles), is around 0.4 and 0.6 (Figures 9, 10, 11, 12).

A second sequence of calculations analyzes the influence of the employ of surfaces with a lighter color (albedo 0.6) for streets and pavements of Japigia and Murat quarters (Figures 13, 14).

The first thing to notice is the higher illumination of the sun in the area of Japigia, because of the large space which separates each building, and because of the high percentage of impermeable surfaces and the unordered arrangement of the urban fabric. Therefore the temperatures in Japigia are higher, even of +3.3°C more, during the sunny hours. On the contrary, the reason for which the temperatures in the Old Town are higher than that of the Murat area, despite a less sunlight, is the higher value of the Aspect Ratio, which tends to compress the hot air in the urban canyons (the so called "thermal trap" effect). However, the warming effect in the Old Town is limited by the white color of the materials used for the buildings, which generates a high index of reflection. The Murat quarter in characterized by an east-west orientation of its grid of buildings and by the presence of real urban canyons with an average street section of 14-15 meters, which causes the creation of strong flows of air. Actually, the cool North wind enter the urban grid without finding blocks or obstacles, and provokes a pleasant decrease of the temperatures. Even the trend of the PMV comfort index, which takes in consideration both the temperature and the sun radiation, follows the trend of the temperatures, reaching the highest values of discomfort during the midday hours.

During the hours in which the sunlight is minimal or null and doesn't affect the results, the lowest values of the temperature and PMV are registered in the area of Japigia, because of a larger air circulation in the wider spaces of the quarter and because of the cooling effect fostered by the evapotranspiration of the vegetation.

It is evident in the simulations with light-colored streets and with an albedo equal to 0.6 a cooling down and a decrease of the PMV, both in the Murat area and Japigia quarter. It is also clear that during the warmest days of the summer, between 12 pm and 2 pm, in the spaces more exposed to the sunlight, it would be better to choose "cold" surfaces with a high albedo (whose cost doesn't exceed that of the traditional surfaces), but always considering the dazzling effect that can be determined by the light surfaces. Therefore it is important to verify the time of exposure and durability to the sunlight of the paved surfaces and the related heat that they stored.

The combination light-colored surfaces with higher albedo and vegetations provides the best result, which can be quantified, taking Japigia as example, in a decrease of 4°C of the maximum temperature and a decrease of 1 for the maximum PMV. The green vegetation used to cover the pavements can considerably contribute to the increase of the thermal comfort, since it reduces the level of temperature and fosters the evaporative exchanges, benefiting both the sensory and living aspects.

This synergy is fundamental, since it discourages the use of the air-conditioning (with a consequent money saving). Actually, air-conditionings introduce a great quantity of energy in the atmosphere, equal to the total of the heat removed in the houses plus the electricity absorbed by the compressor of the refrigeration cycle, moreover they contribute to the increasing of air temperatures with a dangerous effect of positive feedback.

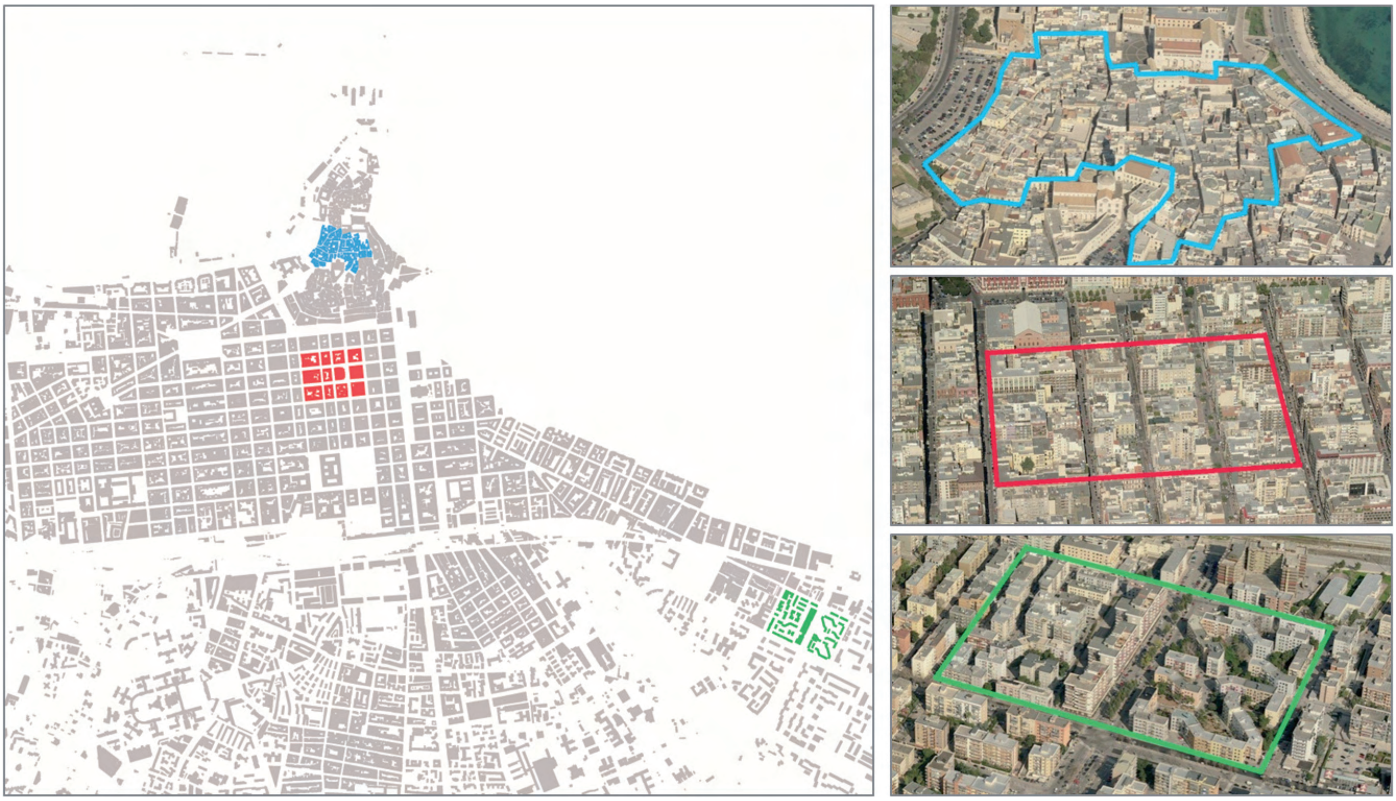


Figure 8 – Urban areas selected in the urban fabric of the city of Bari: the Old Town, Murat and Japigia areas.

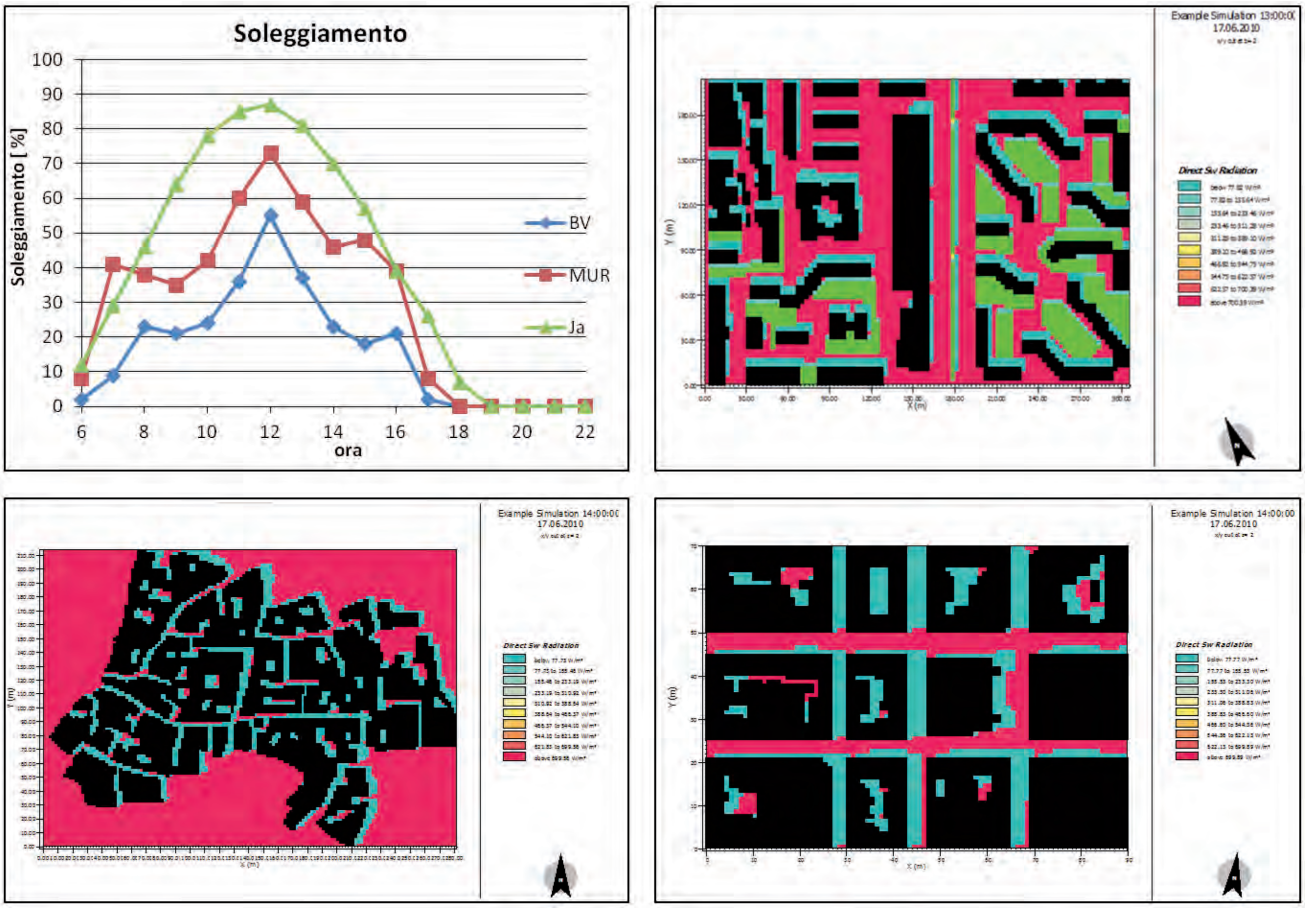


Figure 9 – Comparison of the direct solar light among the three shape-fabric at 14 o'clock.

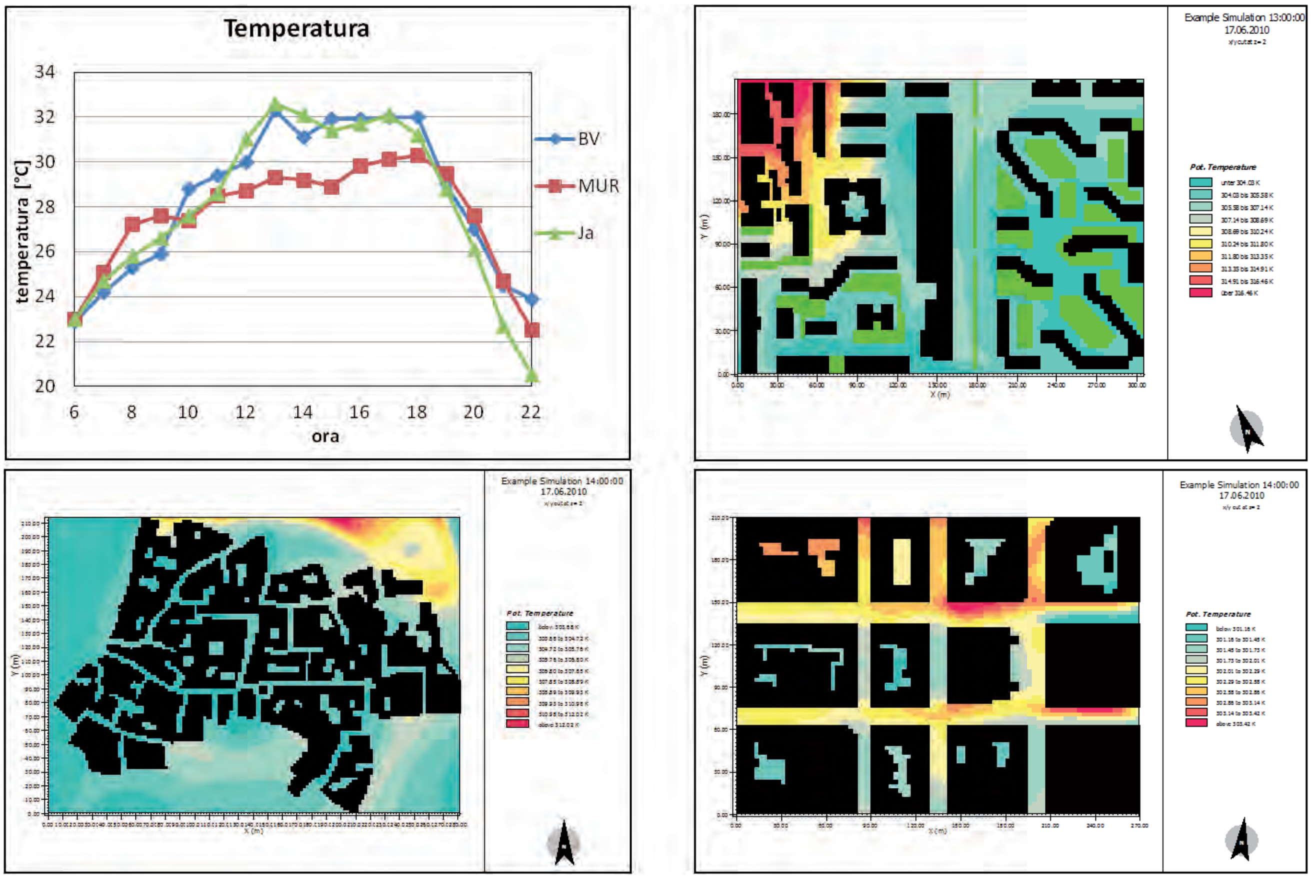


Figure 10 – Comparison of the temperatures among the three shape-fabric at 14 o'clock.

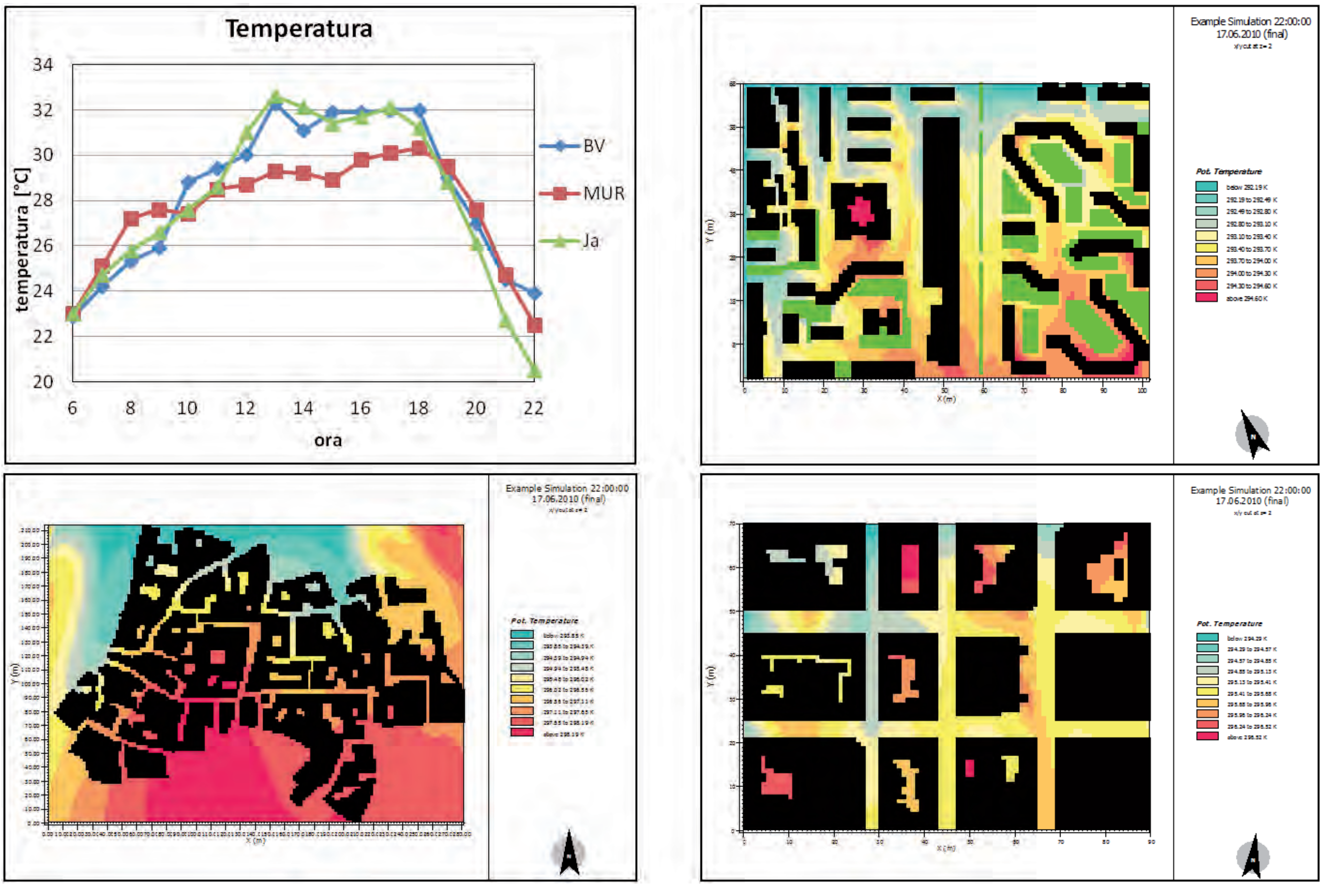


Figure 11 – Comparison of the temperatures among the three shape-fabric at 22 o' clock.

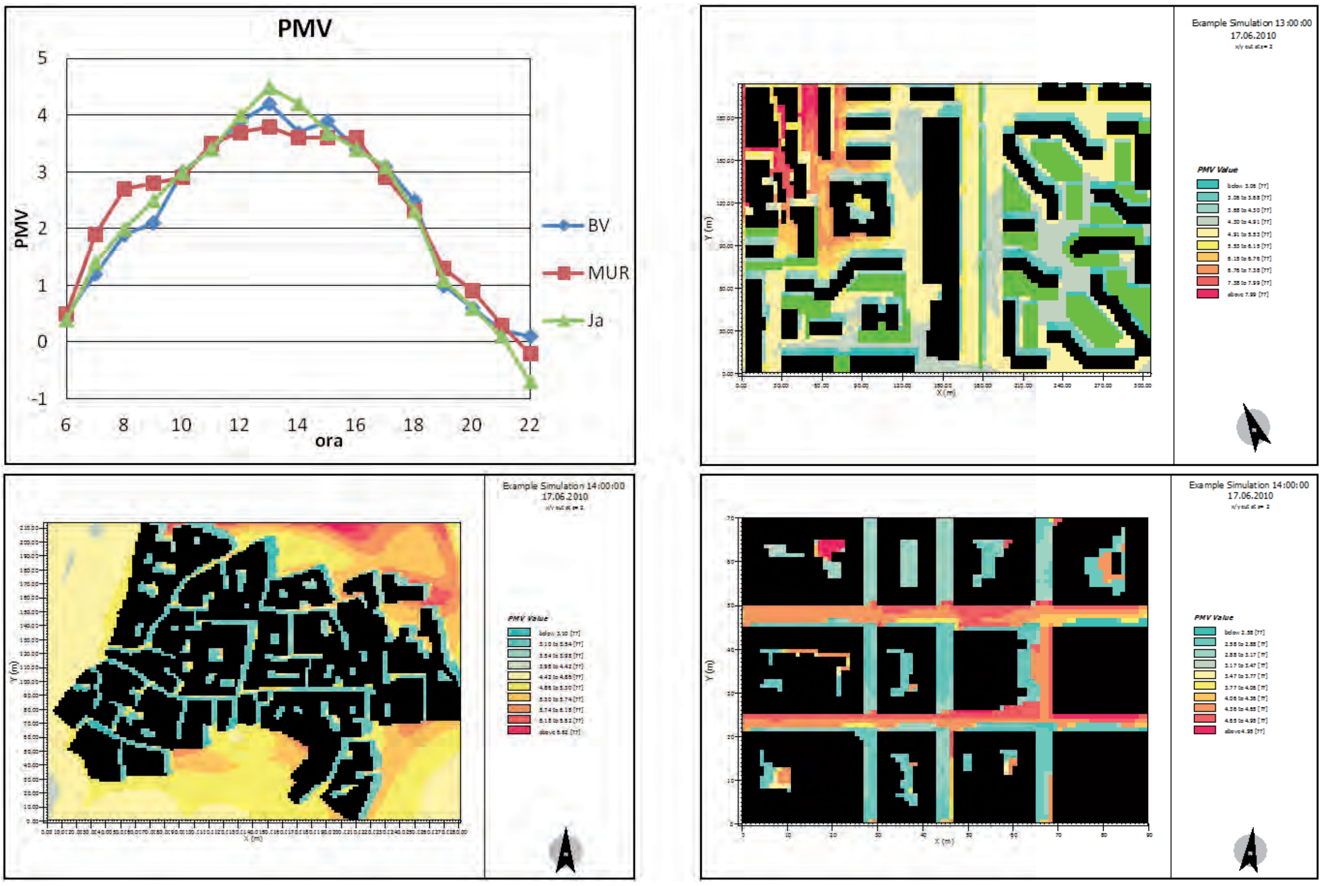


Figure 12 – Comparison of the PMV values in the three shape-fabric at 14 o'clock.

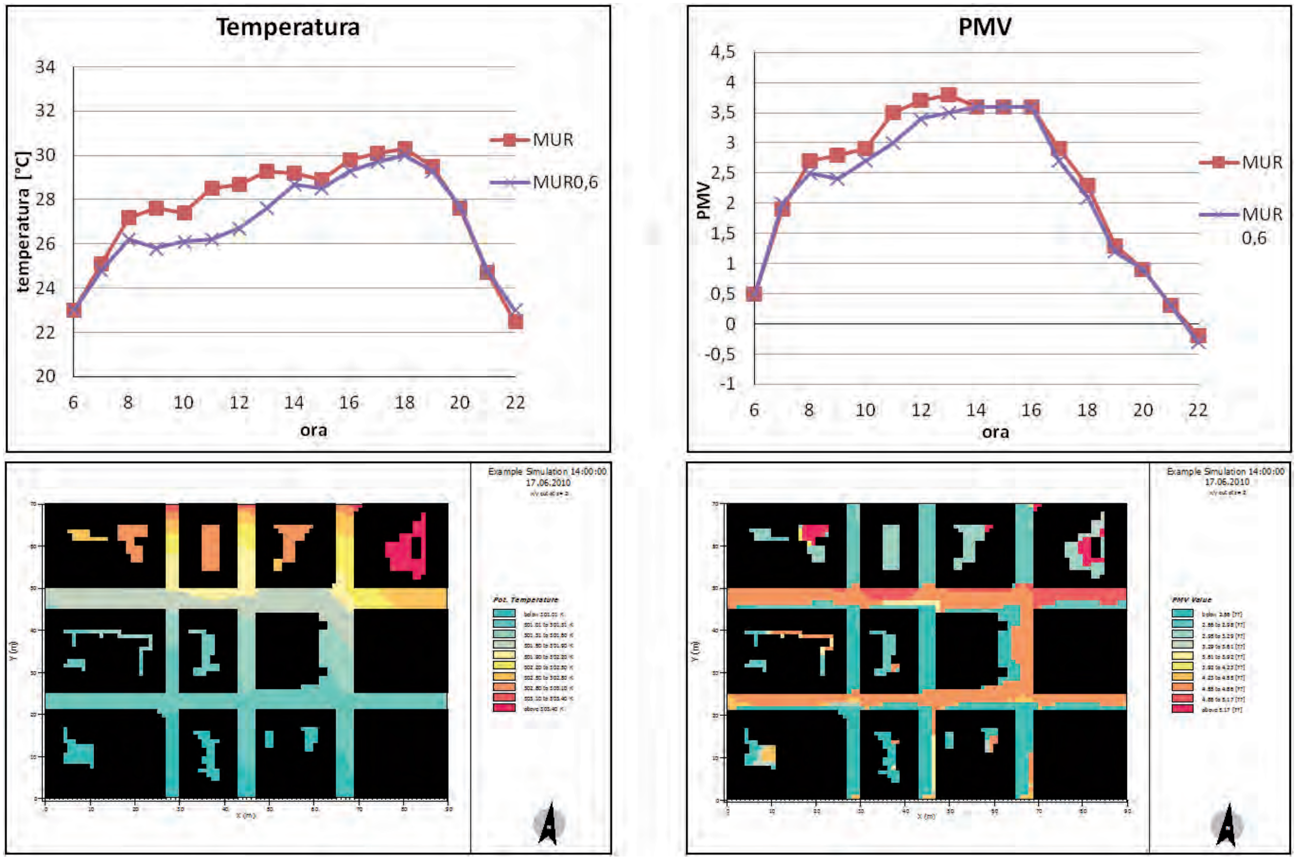


Figure 13 – Comparison of the temperatures and PMV values in current conditions (albedo: asphalt= 0,2 and pavements=0,4) and modified conditions (albedo: asphalt and pavements=0,6) for the Murat quarter.

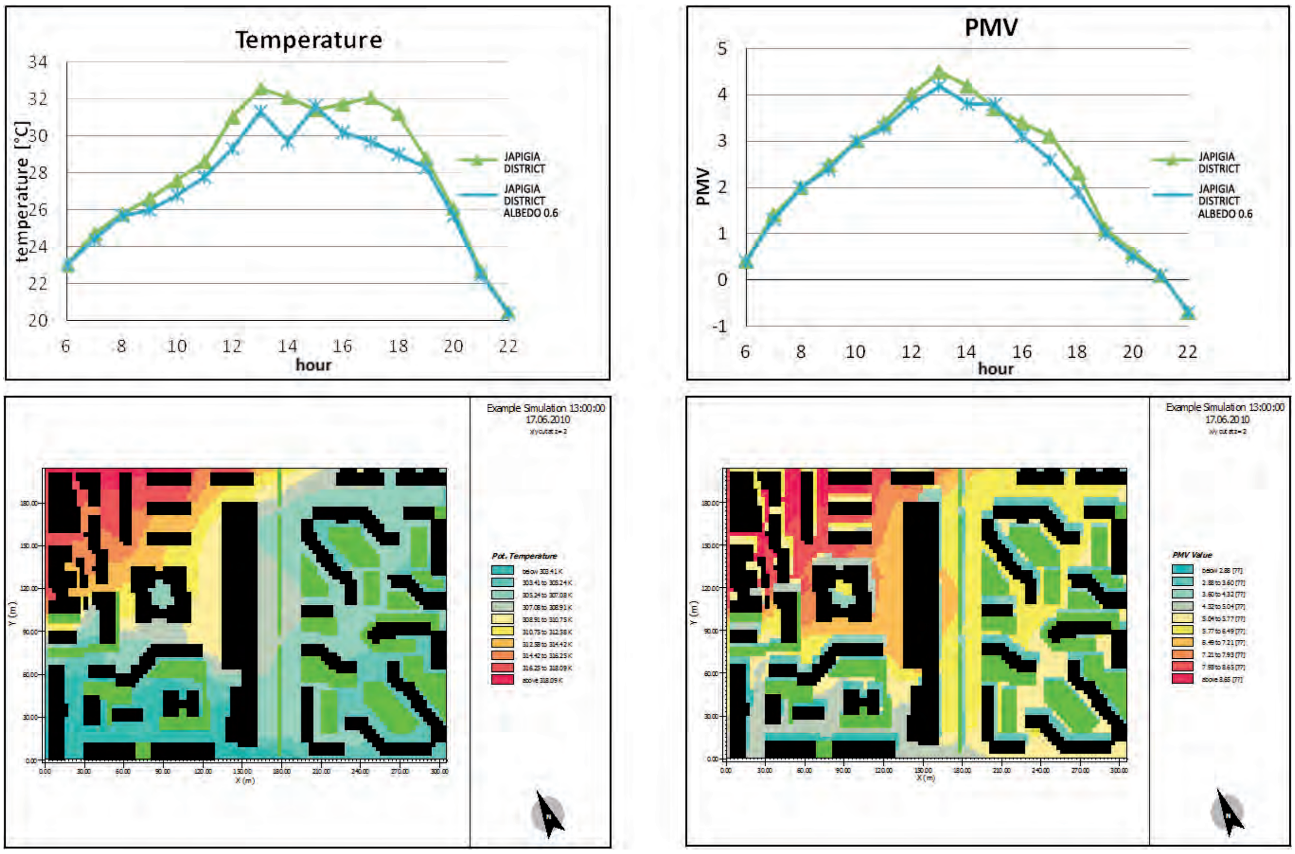


Figure 14 – Comparison of the temperatures and PMV values in current conditions (albedo: asphalt= 0,2 and pavements=0,4) and modified conditions (albedo: asphalt and pavements=0,6) for Japigia quarter.

Table 3 – Values of the temperatures and PMV in the three shape-fabric in current conditions.

	HISTORICAL CENTRE Built areas=74 % Green areas=0% Impermeable surfaces=26% Vertical ratio=3			MURATTIANO DISTRICT Built areas=62 % Green areas=0% Impermeable surfaces=38% Vertical ratio=1,5			JAPIGIA DISTRICT Built areas=34% Green areas=10% Impermeable surfaces=56% Vertical ratio=0,75		
Ora	T [°C]	Area sol. [%]	PMV	T [°C]	Area sol. [%]	PMV	T [°C]	Area sol.[%]	PMV
6	22.9	2	0.5	23.0	8	0.5	23.0	12	0.4
7	24.2	9	1.2	25.1	41	1.9	24.7	29	1.4
8	25.3	23	1.9	27.2	38	2.7	25.8	46	2.0
9	25.9	21	2.1	27.6	35	2.8	26.6	64	2.5
10	28.8	24	3.0	27.4	42	2.9	27.6	78	3.0
11	29.4	36	3.4	28.5	60	3.5	28.6	85	3.4
12	30.0	55	3.9	28.7	73	3.7	31.0	87	4.0
13	32.3	37	4.2	29.3	59	3.8	32.6	81	4.5
14	31.1	23	3.7	29.2	46	3.6	32.1	70	4.2
15	31.9	18	3.9	28.9	48	3.6	31.4	57	3.7
16	31.9	21	3.4	29.8	39	3.6	31.7	39	3.4
17	32.0	2	3.1	30.1	8	2.9	32.1	26	3.1
18	32.0	0	2.5	30.3	0	2.3	31.2	7	2.3
19	29.0	0	1.0	29.5	0	1.3	28.8	0	1.1
20	27.0	0	0.6	27.6	0	0.9	26.1	0	0.6
21	24.5	0	0.2	24.7	0	0.3	22.7	0	0.1
22	23.9	0	0.1	22.5	0	-0.2	20.5	0	-0.7

3. Prospects and conclusions

Thanks to the above experimentation it is possible to outline a guideline which considers the energy aspects and offers the ENVI-Met model as a tool to outline new different scenarios in the field of urban planning.

If it is true that the presence of comfortable open spaces plays a significant role in the urban planning, it is also true that the combined effects of sun radiation, temperature, humidity and wind contribute significantly to turn the urban space into a comfortable area. The climatic factors as well contribute to define how the urban space can be used (walking, standing, sitting, walking slowly, walking faster, or physical activities).

For the above reasons it is necessary to recognize the importance of the characteristics of the micro climates in an open urban space and their implications in terms of comfort for the inhabitants. For the urban spaces already built-up and arranged it is possible to study their current environmental characteristics, and maybe to draw up a mitigation plan or some improvements, in order to choose the most comfortable areas in which arrange the activities for the inhabitants.

The outcomes of the study are utilizable both in the central phase of the elaboration of the project, in order to integrate corrective and improving measures by means of an increase and a better arrangement of the green areas, an adequate choice of the materials, and in the final phase, as a tool to test the efficiency of the project.

The most significant parameters are: the choice of the materials; the sky view factor SVF; the orientation of streets and buildings; the height and distance ratio among the buildings; the study of the shadows and the sun axonometry; the collocation of the vegetation.

The use of appropriate materials, the so called "cold" materials, can optimize the conditions of thermal comfort during the summer. The high albedo of these materials reduces the heat storage caused by the direct sun radiation and the infrared radiation released by the surrounding urban area and by a high emissivity factor, both for the shortwave and long wave radiations. Moreover these materials warm up scarcely and release rapidly the energy absorbed. Their employ in the urban planning contributes to cool down the surface temperatures which affect the thermal exchange with the air.

The Sky View Factor establishes the radiant heat exchange between the city and the sky. A decrease of the Sky View Factor, caused by high buildings and other obstructions, reduces the night radiative cooling, therefore it is a factor that must be controlled. A correct planning of the street sections contributes to reduce the so called "urban canyon" effect. It must be prevented that the sun radiation absorbed and then released by the pavements and building surfaces after the daily exposure, would be captured by other buildings, limiting the thermal exchange toward the sky during the hours of the night. It can be generally said that a low Sky View Factor has a negative influence on the heat island.

About the orientation of streets and buildings, it must be attempted an optimization of the sunny areas during the winter, and a reduction of the sunlight exposure during the summer periods. The arrangement of the buildings must considers the main summer wind flows, in order to adopt strategies of natural cooling. Actually the study of the direction and intensity of the winds, of the trails created by the volumes of the buildings and the obstacles, implies a better control of the internal and external micro climate.

The ratio between the height and the distance of the buildings depends on the sunlight, therefore on the climate. Generally, it is possible to say that there is an optimal condition when a curtain has a complete sunshine, free from the across buildings influence. However, the ratio between the height and the distance cannot be unique, it actually varies depending on the orientation and the volumes that the area can produce.

The creation of green areas in the urban space represents a fundamental factor, also in relation to the urban micro climate. Compared to the other "urban" elements, the green plays a significant role and it is quite distinctive since it is a living entity, therefore it involves all our senses. The urbanization alters the climate persistently, with considerable effects on the solar radiation, temperature, relative humidity, precipitation and wind. It becomes crucial to consider these factors in order to appropriately plant and arrange the vegetation of the city.

We have to move our focus on the environmental quality of the urban spaces, but to do so it is fundamental that the public authorities develop a cultural sensitivity toward this issue, in order to avoid project interventions which alter negatively the urban micro climate. The researches and the analysis, like those reported in the paper, help us to define standard criterions in order to achieve a better quality of the environment and the climate of the urban space in its entirety. Those criterions, which are part of the guidelines, can provide a valid support, even to the public authorities, for the promotion and implementation of strategies of planning and requalification of the urban open spaces.

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