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Journal of
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This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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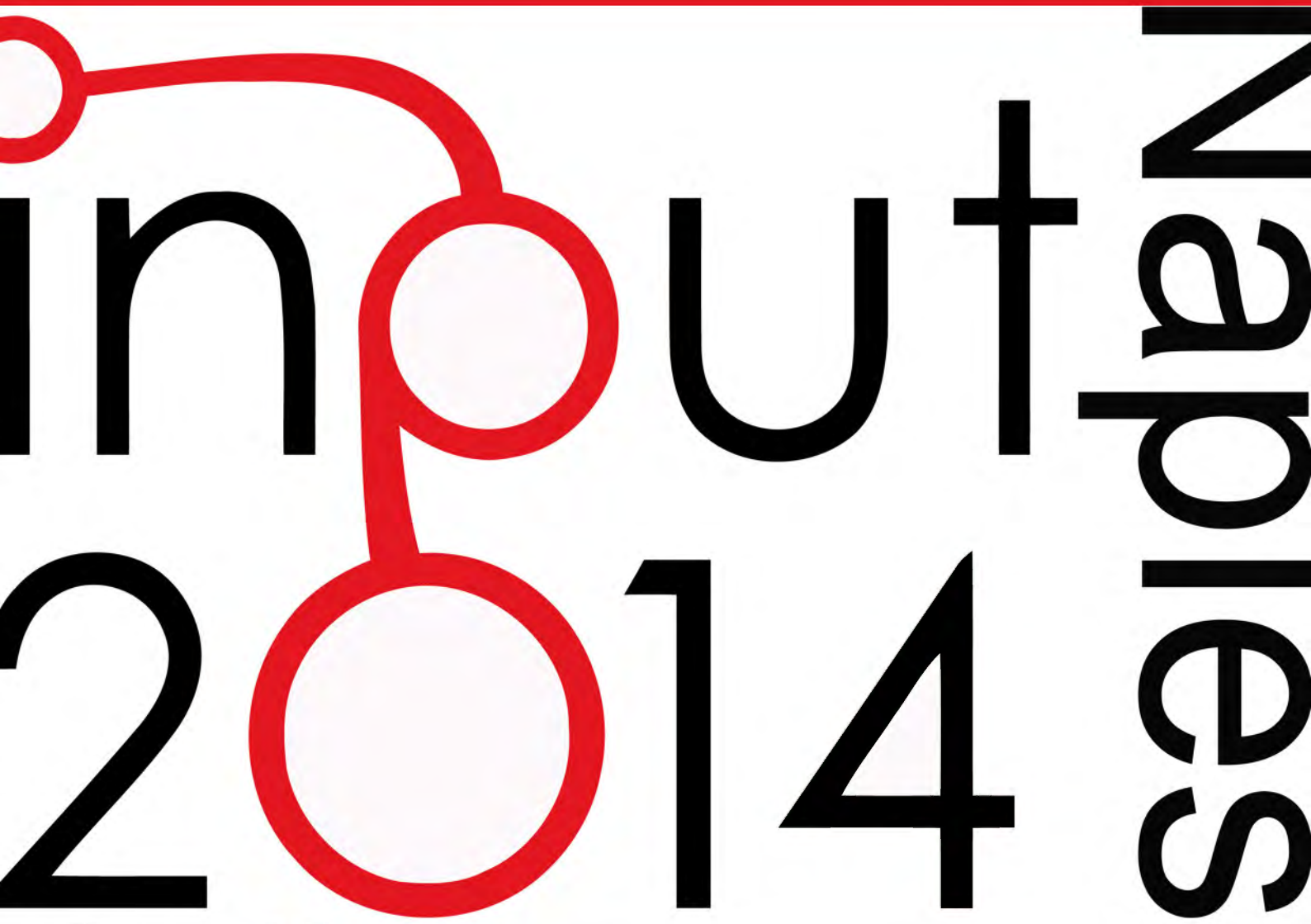

Smart City

planning for energy, transportation and sustainability of the urban system

Special issue, June 2014

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SMART CITY

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TeMA Journal of Land Use, Mobility and Environment

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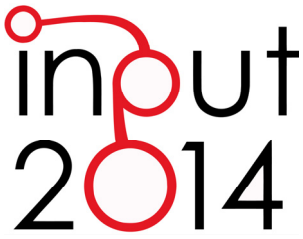
TeMA Journal of Land Use, Mobility and Environment

This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.



TeMA Journal of Land Use, Mobility and Environment

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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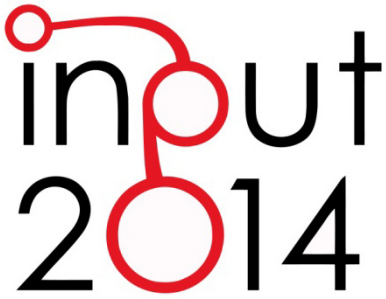

URBAN SYSTEMS AND ENERGY CONSUMPTIONS

A CRITICAL APPROACH

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ABSTRACT

City transformations are also due to the development of new energy sources, which have influenced economy and lifestyles, as well as the physical and functional organization of urban systems. Cities are the key place where it is need to act for the achievement of strategic environmental objectives, such as reducing greenhouse gas emissions and energy saving. The hard resolution of these challenges depends on several factors: their multidimensional nature, the change of the economic and settlement development model, and also the complexity of the relationships between the elements that constitute the urban systems and that affect energy consumption. According to this awareness the *Project Smart Energy Master for the energy management of territory* financed by PON 04A2_00120 R & C Axis II, from 2012 to 2015 has been developed: it is aimed at supporting local authorities in the development of strategies for the reduction of energy consumption through actions designed to change behavior (in terms of use and energy consumption) and to improve the energy efficiency of equipment and infrastructure. With the goal of describing some of the results of the methodological phase of this project, this paper proposes a review of the major studies on the issue of energy consumption at the urban scale in the first section; in the second section the outcomes of the first phase of the development of the comprehension/interpretive model related to the identification of the set of physical/environmental variables at urban scale, that most affect the energy consumption, are described; the third makes a critical review of the reference scientific literature, characterised by a too sectoral approach, compared to the complexity of the topic.

KEYWORDS

Energy consumption; Holistic approach; Urban texture and energy; Urban form.

1 INTRODUCTION

At the beginning of the last century there were only a few cities with a million inhabitants, but nowadays there are more than 400 cities where a at least million people live (Earth Policy Institute). The current high rates both of population and urbanization are expected to continue growing (80% of the population will live in cities by 2030) and these trends make energy sustainability challenge at urban scale crucial to the future of whole world. This last statement can be explained by the fact that, as most people inhabit cities, which are enlarging more and more, the latter are responsible for a great part of greenhouse emissions and a huge rate of energy consumption as well. Cities gather economic, productive, and social activities (OECD 2010) and supporting all of them requires energy, that entails producing CO_2 emissions: in this regard, several researches suggest that cities consume up of the 75% of global energy and account for 78% of carbon emissions from human activities (UN-HABITAT 2006; Stern 2006; IEA 2008). Therefore, the importance of the urban areas to address and understand environmental and energy issues is widely acknowledged. The strict and complex relations between energy, climate change and land-use, which "together are the main interconnected driving forces of human-induced global change" (Pasimeni *et al.* 2014), prove that if cities are part of the problem, they are inevitably part of the solution too. Hence, the key role of the urban systems within both European and international strategies, to achieve energy and climate change mitigation and adaptation policy targets, (IPCC 2007; COM(2010) 639; COM(2011) 112) and the scientific debate on energy issue. Actually the study of the interaction between energy and the urban built environment started to be of considerable interest since the 70s, following the period of energy crisis (Beaumont *et al.* 1981; Littler and Thomas 1985; Owens 1986) but, the relationships between the physical and functional organization of cities and energy consumption are being studied and interpreted only recently. In this context, this paper reviews the literature on energy consumption at the urban scale with the aim to describe the results of the first phase of the development of the comprehension/interpretive model related to the identification of the set of physical and environmental variables at urban scale, that most affect the energy consumptions.

2 THE STATE OF CURRENT PRACTICE

According to energy consumption data of cities, over 60% is determined by mobility and buildings (IEA 2011); whereas on the one hand this state of affairs explains the great attention paid by scientific research to these fields of study, on the other it shows that energy consumption is highly dependent on both the configuration and the relationships between the components of the urban system. The buildings gather the activities that are the reason of the energy consumption (every human activity requires energy) and therefore they should be considered in relation to both their energy consumption and behavior of the users that are within them; the location of the activity involves the need to move, resulting in strong effects on the organization of the territory that cannot be overlooked in terms of resource consumption. Although this statement may seem simple and obvious, the urban dimension of research on energy consumption, defined here as the system and not the individual urban components, attracts much less interest than that of the building, that is very present within the literature.

Even though there is a great diversity of models, in terms of their purpose, features, capabilities and data requirements, related to the energy systems, which cuts across inevitably several sectors and disciplines the theoretical and application reference models for this review, refer to the main regional studies and those related to urban energy planning, in addition to the few works that have attempted to integrate the components of the urban system in the perspective of reducing energy consumption.

In current scientific literature in this field the main research branches can be synthesized as follows:

- studies related to urban morphology, with particular attention to the relationships between the urban density-urban form-transports (Banister *et al.* 1997; Williams *et al.* 2000; Salat and Morterol 2006; Cecere *et al.* 2009; Echenique *et al.* 2014);
- studies related to the solar gains and the heat loss of the urban texture, with reference to environmental and microclimatic variables (Kaiser 1996; Steemers 2003; Ratti and Morello 2005; Carneiro *et al.* 2009; Amado and Poggi 2014).

For both study areas the main results are described.

CATEGORY	RESEARCHES
Urban form-urban transport-energy consumption	Owens 1986; Newman and Kenworthy 1989; Breheny 1996; Banister *et al.* 1997; Alberti 1999; Williams *et al.* 2000; Ewing and Cervero 2001; Cecere *et al.* 2009; Holden and Norland. 2005; Salat and Morterol 2006; Andrews 2008; Ewing and Rong 2008; Pitt D. 2012; Ko 2013; Echenique *et al.* 2014.
Sunlight-solar gains-energy consumption	Givoni 1989; Baker et al 1996; Kaiser 1996; Baker and Steemers 2000; Hui 2001; Steemers 2003; Ratti and Morello 2005; Carneiro *et al.* 2009; Amado and Poggi 2014.

Tab.1 Literature review

2.1 URBAN FORM, TRANSPORT AND ENERGY

More and more policies focus on reducing greenhouse gas emissions in cities and as a consequence, a growing body of literature investigates the dependence of energy needs on the form, density and design of urban settlements.

The two main settlement models taken into consideration are those of the compact city and urban sprawl, and most scholars agree that the compact forms can affect strongly the reduction of energy consumption and greenhouse gas emissions too. Newman & Kenworthy (1989) have shown that there is an inverse correlation between urban density and energy consumption per capita, through the analysis of some thirty-two cities across the world. This study shows that the energy consumption due to transport is an inverse function of the density of population; therefore, the more the city is dispersed, the more it consumes energy, and the less sustainable it is. In addition, the cities that are characterized by a high density development, for instance Hong Kong, are the most efficient energy consumers, while low-density cities, such as those of North America and to a lesser extent those in Australia, are less efficient. Another example is New York, a compact city with a small carbon footprint in its core urban area, which annually produces

about 7 tons of greenhouse gases, a small amount compared both to other major U.S. cities, and the national average of approximately 24.5 tons (Owen, 2010).

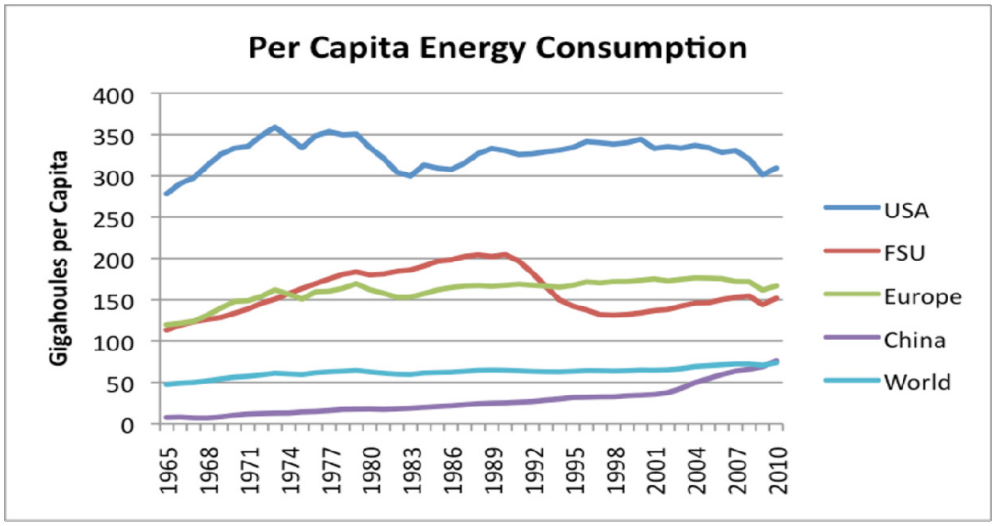

Fig. 1 Comparison between worldwide per capita energy consumptions

The fundamental reason of the remarkable consensus for more compact cities is related to mobility: low-density cities are, in fact, characterized by highly dispersed activity and a consequent heavy dependence on private transport. Even Owen (1986), analyzing the link between urban form, land use planning and energy consumption, argues that by minimizing the need to travel you can have a positive impact on the reduction of these consumptions, even though "at particular high-density, the energy consumption benefits may begin to be outweighed by the side benefits arising from congestion".

Holden and Norland (2005), Andrews (2008), Ewing and Rong (2008) and Pitt (2012) have carried out a comparison of the energy consumption of compact urban areas and energy consumption in areas affected by sprawl. The comparison demonstrates that urban sprawl is characterized by higher energy consumption, because the variable that is most influential is the size of the housing units: larger residences (terraced houses) localized especially in the suburban areas or in the expanding ones, compared to the apartments in central urban areas, require greater amounts of energy for different end uses (heating, cooling, etc.). In addition, the energy consumption per capita and for families in compact urban areas characterized by high density housing is lower than in areas with low population and territorial density (37,7 compared to 27,2 million Btu/year, Ko 2013)

2.2 SOLAR GAINS AND ENERGY CONSUMPTION

In contrast to the supporters of the compact city, who believe that the most important advantages are related to the least energy intensive activity pattern, that help to cope with climate change challenge, a lot of evidences on the influence of urban form and density on sunlight availability should be considered (McPherson 1994; Hui 2001). In fact, if the urban energy consumptions are related to the geometry and morphology, they also depend on the availability of daylight, and then from the urban microclimate (Steemers 2003; Ratti *et al.* 2005): "the outdoor temperature, wind speed and solar radiation to which an individual building is exposed is the local microclimate as modified by the 'structure' of the city, mainly of the neighbourhood where the building is located" (Givoni 1989).

Since the 1990's Banister, Baker and Steemers have been studying how the physical characteristics of an urban area, with particular attention to the buildings, influence the solar gains and the availability of sunlight. The barrier effect to solar radiation determined by the proximity of buildings affects, for example, the passive solar conditioning, the possibility of using photovoltaic technologies and so renewable energy sources, and on phenomena such as the urban heat island: the temperatures are higher in urban areas than in neighboring ones. A compact form with high levels of urban density can minimizes heat loss, exacerbating, at the same time, the urban heat island (Krishan *et al.* 2001). In this regard, many scholars have conducted research to understand whether and how much the presence of green areas and water bodies affects the urban microclimate and energy consumption. Bolund and Hunhammar (1999), Akbari *et al.* (2001), Yamamoto (2004) and Hong Ye *et al.* (2013) have found that the greater the presence of green areas in cities is, the lower the energy consumption and CO_2 emissions are. Trees promote natural ventilation, cool the air through the process of evapotranspiration, thus helping to keep buildings cooler in summer and warmer in the winter, as they can produce a barrier against the cold winds.
Before offering causes for reflections on this brief review, a set of physical and environmental variables to refer to the study of energy consumption at the urban scale, are proposed below.

3 A SET OF PHYSICAL AND ENVIRONMENTAL VARIABLES

The state of the art described above suggests that the study of energy consumption at the urban scale cannot be separated from the knowledge neither of the physical- characteristics of the study area, or of the climatic and environmental conditions and nor even of their relationships. Therefore, the present work wants to contribute to the development of a knowledge framework of the energy saving issue at the urban scale, proposing a set of variables to be used in the building up a new comprehension/interpretive model of city.
In order to identify these variables, it is also useful to illustrate a research conducted in Europe by the CSTB (Centre Scientifique et Technique du Bâtiment), which investigated the relationship between urban density, morphology of the city and the different forms that the various combinations may assume (especially with regard to the transport network, comparing the urban texture of some cities in Europe and Asia) in 2006. Salat & Nowacki, two of the CSTB researchers who conducted the research, studied a sample of one hundred neighborhoods in six cities in the world to measure the shape parameters that affect energy consumption; these parameters, integrated and correlated to each other, would produce an energy improvement of the city, far superior to that one caused by the interventions related to the isolation of the buildings and the optimization of distribution networks.
The identification of variables, based on the research described above, has taken into account both the numerous studies that have applied the bottom-up models (models that use disaggregated data to determine the energy consumption of different end uses related to individual or groups of buildings) and the few quantitative experiments carried out in groups of buildings or on the neighborhood scale (Howard *et al.* 2012; Soltani *et al.* 2012; Ugursal and Swan 2009; Ko and Radke 2013). This choice has been inevitable, as the vast majority of the scientific attention has been paid to the minute scale such as the building one. Two major categories of variables have been identified, the physical and environmental ones, (Table 2) which describe, respectively, the morphology and geometry of the urban texture and the climatic and context characteristics.

ID	CATEGORY	PARAMETERS	INCIDENCE ON ENERGY CONSUMPTION
1	physical variable	urban horizon angle	high
2	physical variable	aspect ratio	high
3	physical variable	territorial density	high
4	physical variable	population density	high
5	physical variable	surface/volume ratio	high
6	physical variable	building floor area	high
7	physical variable	slope	low
8	environmental variable	building function	high
9	environmental variable	building orientation	high
10	environmental variable	green area density	high
11	environmental variable	public transport network density	high
12	environmental variable	ventilation	low
13	environmental variable	sky view factor	low
14	environmental variable	albedo	low
15	environmental variable	climatic zone	low
16	environmental variable	degree days	low

Tab.2 Variable set

These parameters represent the most significant features and the most widely used in the studies carried out up to the present; their incidence on energy consumption can be assessed only qualitatively, according to the fact that both the interactions and the effects of urban form and geometry on energy consumptions still continue to be understudied and controversial (Alberti 1999). In practice, it is a set of variables based on the proposed literature review and not on empirical findings or field work.

It is worth noting that in this set of parameters there are many related to the urban form that should be taken into account not only in their specificity but, above all, deepening their relations, in order to achieve in a concrete way the objective of energy consumptions and greenhouse gas emissions reduction. The study of the interrelations that are established between the physical and environmental elements must not be carried out separately from those relating to other components of an urban system but, on the contrary, it is necessary to study them comprehensively, using a holistic approach to identify the elements and connections that have the greatest impact on energy consumption.

Therefore, the proposed variables represent only a first step in the development of a wider set of parameters with which to analyze and interpret the relationships between different components of an urban system from the energy saving perspective. This regard derives from the awareness that the experiments and the models developed so far have not studied sufficiently the urban significance of the energy issue, on which we want to offer cause for reflection in the following section.

4 THE NEED OF A DIFFERENT APPROACH TO ENERGY ISSUE AT URBAN SCALE

The multi-dimensional nature of the energy issue should make us reflect on the range of interventions to implement for the energy consumptions reduction, as well as on the study of the relationships between the components of the urban system and the energy so far made in the scientific literature. The scientific debate does not seem to have understood neither the energy value of urban areas, nor the importance of looking at urban planning disciplines as a new way of thinking about energy, compared to the current approach which is still inadequate, in contrast to the complexity of the topic. The majority of the research efforts are almost

exclusively about the performance and energy efficiency of buildings, renewable energy plants and transport systems, rather than the urban system in its entirety and complexity. Quantitative and holistic studies that deal with energy issue at urban scale by considering the interactions among several urban components have not been attempted yet.

The reduction of energy consumption at the urban scale is tackled with a sectoral approach, by assessing the link between energy and just one urban component, and this risks to lead to an oversimplification of both the input information and, especially, of the results obtained. For example, within the LT model (Ratti *et al.* 2005), developed for the study of the relationships between urban form and energy consumption, the authors consider the parameters of the urban form selected independently from each other, without taking into account the connections between them. In contrast, in a study carried out in New York City (Howard *et al.* 2012) the energy consumptions of Manhattan are related to the use and floor area of buildings, without reference to geometry, morphology or microclimate of the area of study, except through some purely qualitative assessment: "as one would expect a consumption normalized by block area would show particularly high values for parts of the city where the buildings are tightly packed and tall".

What emerges from the researches that claim to study the energy consumptions at the urban scale is that the latter are either related to the physical structure of the study area (form, density, etc.), or are related to the building scale, considering buildings as "self-defined entities" (Ratti *et al.* 2005). Based on this state of affairs is possible to make two observations:

- the results are mostly qualitative, as these studies strongly depend on the context of the methods used, geographic region, climate and other specific conditions and so caution should be used when attempting to generalize or compare the results from one study to another. For example, in the cities of Northern Europe, because of the latitude and the consequent low solar inclination, urban density affects the solar accessibility more than in other urban areas (Strømann *et al.* 2012); however, if we think of the Mediterranean climates, where energy consumption is increasingly affected by the growing demand for air conditioning in summer, the dense urban settings, allowing to reduce direct heat gains by the effect of the mutual obstructions, appear to be more efficient.
- the conclusions may be uncertain and opposite, as in the case of the urban development forms: for example, the apparent paradox between the general tendency to densify in order to reduce transportation costs and to increase the energy efficiency of the city and the impact that this process has on the urban microclimate and even the quality of life in the city, still remains unsolved.

  Although the density has a deep relationship with the urban morphology, it is not sufficient alone to ensure high levels of quality and energy efficiency of cities.

Furthermore, referring to the building scale, the results of these studies may no longer be valid when the scale of intervention is expanded, because of the complex interactions that exist within an urban system (Bourdic and Salat 2012).

It is clear that the absence of a comprehensive theoretical framework does not allow to generalize individual results and make convincing conclusions. In this perspective, the role of researchers and urban planners in developing methods, techniques and strategies for the reduction of energy consumption in the city, already made difficult by the complexity both of the topic and urban systems, is even more daunting.

According to what has just been described, the interpretive paradigm used until now for the study of energy consumption at the urban scale turns out to be far from the holistic-systemic approach characterizing the management of territorial transformations. A systemic and cross approach of this type should be adopted in order to understand how to act on the relations between the elements that make up the urban system as a determinant of energy consumption. Broadening our vision and considering the city as a whole, would

promote the adoption of a global vision that deals in an integrated manner with the overall city, the efficiency of its form and its infrastructure, the behavior of its users and the effectiveness of new technologies.

In this perspective the research project Smart Energy Master (SEM) has been developed, in line with existing EU policies that call for "a holistic approach to energy and environmental issues, as the many social, economic, cultural and natural components of urban systems are interwoven in a unique manner "(EU 2011). The SEM project, in fact, is aimed at the development of a model of energy efficiency of the territory, with reference to urban areas, and is characterized by a systemic approach based on the indissoluble relationship between transformations of the territory, urban planning, distribution of activities, the government of the mobility and energy habits of users.

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IMAGES SOURCES

Fig. 1: http://www.eea.europa.eu/.

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