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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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.

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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.
SMART CITY
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INTEGRATED URBAN SYSTEM AND ENERGY CONSUMPTION MODEL: PUBLIC AND SINGULAR BUILDINGS

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ABSTRACT

The present paper illustrates the results of the first steps of a study on one aspect investigated as the preliminary step of the definition of the analysis - comprehension model of the relation between: city, buildings, and user behavior, for the reduction of energy consumption within the research project “Smart Energy Master” for the energetic governance of the territory (PON_MIUR n. pos. 04a2_00120 CUP Ricerca: E61H12000130005), at the Department of Civil, Building and Environmental Engineering - University of Naples Federico II, principal investigator prof. Carmela Gargiulo.

Specifically the literary review aimed at determining if, and in what measure, the presence of public and singular buildings is present in the energy consumption estimate models, proposed by the scientific community, for the city or neighborhood scale. The difficulties in defining the weight of these singular buildings on the total energy consumption and the impossibility to define mean values that are significant for all subsets and different types as well as for each one, have forced model makers to either ignore them completely or chose a portion of this specific stock to include.

KEYWORDS
SEM, Smart Energy Master, Energy, Public, Singular, Buildings
1 INTRODUCTION

Nations and governments have initiated strategies and actions to reduce our dependence on non-renewable sources and our global energy consumption because of climatic change, and the necessity to translate our society to an ecologically sustainable model.

Some studies (EU Commission 2011) cite that cities and their surroundings areas consume the 80% of final energy in the European Union and more than two thirds of the population lives in urban areas.

Others (European Institute for Energy Research EIFER 2012a, 2012b) that on the European continent, cities are currently responsible for approximately 70% of the overall primary European energy consumption, and this share is expected to increase to 75% by 2030.

Analysis of the building stock of the EU (EU Report 2010) has shown that a large part, about 60%, was produced between the sixties and the eighties and anyway after the second world war. In the countries of the Mediterranean basin this percentage grows to about 70-75%. In Italy specifically the percentage is about 65%. These buildings, produced in a time before energy consumption reduction legislation, inspired by the energy crisis of the seventies came into effect, present a very low energy performance.

Since efficiency of the use of energy represents one of the main mechanisms for the reduction of CO₂ emissions, and the building sector weighs heavily on the total consumption there are ample margins of potential energy savings.

The studies on energy consumption of the building sector are usually divided in residential and non-residential, and the focus of the literary review has been on the later.

The phenomenon of high energy consumption and low energy efficiency of public buildings is common, which means there is a great energy saving potential; these include the public service sector and buildings.

The service sector, in the major industrialized countries, has a very important role in the economy but only a marginal one in the ranking of the energy consumption of the various sectors.

It is less energy intensive than the residential, transport, and industry sectors, amounting to an estimated 13-15% of the total energy consumption; but its energy demands have been in constant growth in the past years.

In Italy a recent study (Rapporto Annuale sull’Efficienza Energetica, 2013) has estimated the specific Energy consumption of buildings (kWh/year/m²) of the service sector depending on the different functions and services offered that include hotels, schools, malls, retail buildings, offices, restaurants and other services.

The energy intensity of these buildings varies from a minimum of 112-114 kWh/year/m² for offices, restaurants and other services, to a maximum of 182 kWh/year/m² for hotels.

Function plays an important part in the energy consumption profile of a building but it not the only defining characteristic. Indeed, it is well known (Fabbri et al., 2012) that energy building behavior is not only related to the construction period but also to the architectural, morphological and technological solutions that characterize each building.

1.2 MODELLING THE BUILT ENVIRONMENT

To comprehend a complex and dynamic system, such as the built environment and its relation to energy consumption, we need a model to interpret the relevant data collected and to inform decision making.

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1 Energy consumption of non residential buildings, that include service functions, commerce, and public administration are in continuous and strong growth from 9.5 Mtep in 1995 to 20 Mtep in 2010. In 2010 the energy and electricity use intensity of the service sector have registered and increase of 1.8% and 0.5% respectively compared to the year before.
Scale, resolution and relevance of the data vary and so do the measurement units; a direct comparison and correlation is difficult.

The multidimensional nature of the objectives, projects and energy policies adds another peculiar facet to the problem. Ordinary methods used in economic – behavior analysis are not adequate to describe the energetic - environment relation.

The availability of data and the costs involved in collecting them are key to defining the data that can be collected for energy consumption models designed for existing buildings.

For individual buildings energy consumption models generally require an amount and resolution of data that are not practical or economical to collect for large numbers of buildings.

Multi-building models need to be based on data inputs capable of providing a robust and computationally practicable methodology, giving results with an acceptable degree of accuracy.

And, in the absence of individual building surveys, these data inputs will be governed ultimately by access to suitable sources of mass data.

Because data may be difficult to access, it may be necessary to infer input values for a model, basing the inferences on relationships to other data that are both appropriate, accessible, robust and should have a verifiable provenance. For example, thermal performance of building envelopes may be inferred from the age of a building, due to the influence of building regulations.

The models used to evaluate the energy demand of the existing built patrimony can be divided in three groups (Heiple S. et al 2008, Kavgic M et al 2010):

- top-down: that use energy consumption data on an urban scale, that compared to the climatic information and the results of the statistical and population surveys are used to determine the mean value of consumption of buildings. These models are able to compare different economic variables, but they do not allow us to distinguish the spatial energy consumption variations;

- bottom-up: they use the data produced by the simulation of each building depending on their specific characteristics; the results are then collated to determine the energy consumption of the neighborhood or city or to evaluate the energy savings brought by requalification interventions. To get good results on an urban scale they need great quantities of data;

- hybrid: study the energy demand of some prototype buildings and they extrapolate them to evaluate the consumption of the city. Through a detailed spatial representation of the built environment, introducing the socio-economic data it is possible to associate to each building its consumption so that it may be compared to benchmark values. Reference buildings can also be generated through simulation, using default values for certain key inputs. Such a simulated standard can create a scale of comparison based on particular code or market standards.

The basic building information such as building age, building area, operating hours, the number of office workers and the climatic conditions all affect the building energy consumption, but the impact of climatic conditions on the energy consumption is very complex to integrate in the analysis.

2 PUBLIC AND SINGULAR BUILDINGS

As decision makers are under pressure to take large-scale actions to reduce energy consumed of regions, districts, or building sub-sectors as a whole; studies aimed at extending building level models to quantify energy consumption of a neighborhood, district, or city region have come into closer scrutiny.

The building stock has not been designed as a single unit of either construction, or operation, so energy consumption modeling of the stock covers many more combinations of variables than a single building.
Energy consumption in buildings is heavily dependent on the functions housed and the number of users; therefore buildings that house public or specialized private services or that cater to multiple and numerous users will be very different from the more frequent residential buildings.

Public buildings should be considered in a wider sense: they are necessarily both publicly owned and those used by the public.

Amongst them buildings for:

- offices,
- sports,
- education,
- healthcare,
- mixed public use,
- penitentiaries,
- barracks,
- museums
- churches

To which we should add buildings for:

- public events and conference centers,
- cultural events and shows
- hospitality and tourism

we should exclude solely social housing since it can be assimilated to generic residential functions.

Within the non-residential sector the diversity in terms of typology is vast (Buildings Performance Institute Europe 2011), and compared to the residential one it is more usual to have multiple functions coexisting in the same building.

Building age, ownership, and use pose unique challenges which affect assessment design. On a mechanical level, energy consumption patterns in non-residential buildings are vastly different from those in residential ones.

Thus, primary classification of nondomestic buildings generally follows its function. Producing a numerous range; even a simple classification, such as the N-DEEM model, is based on ten primary categories of nondomestic buildings. Each primary class or bulk type is attributed to an expected value of energy intensity, which is sometimes derived by aggregating energy intensity of sub-categories. For example, in the N-DEEM model, the primary category of health comprises of surgeries, health centers, nursing homes, and hospitals.

In a different approach, (Coffey et al. 2009) sub-categorize buildings based on age and maintenance quality of a building.

Another example is the German portion of the TABULA project (Amtmann et al 2012), that has identified four main parameters to define non-residential buildings: utilization, construction use, compactness/size of the building and the mechanical systems. Eleven categories have been identified together with four different construction year classes, chosen by considering special architectural characteristics and building materials typical of the construction periods.

The case of this form of standardization based on building use rather than its construction and physical characteristics is strong in the context of non-domestic buildings where variability in energy consumption between two buildings is dominated by the demand for activity related services (Prez-Lombard L 2008).

In the “Europe’s buildings under the microscope” survey (B.P.I.E 2011), a broad classification of the sector focused on seven categories: educational buildings, offices, hospitals, hotels and restaurants, sports
facilities, wholesale and retail trade services buildings and other types of energy consuming buildings. And in each, a wide division between various subcategories is evident. The retail and wholesale buildings comprise the largest portion of the non-residential stock in the European panorama. Since heating and cooling conditions may differ substantially from other categories due to large areas of wholesale buildings often being used only for storage purposes, these buildings are dissimilar from others. Within the subcategory retail and wholesale also pronounced differences were pointed out: within this sector there is no homogeneity in terms of size, usage pattern (use hours) and construction style. This requires special attention when looking at the retail and wholesale sub-sectors.

The survey states that office buildings are the second biggest category with a floor space corresponding to 25% of the total non-residential floor space. These buildings have similar heating and cooling conditions to residential buildings although their use is more limited in terms of time. Time defines educational buildings as well, which count for less than 20% of the entire non-residential floor space, since they are reported to have a similar usage pattern.

Hospitals, which weigh little on the total floor space balance, 7% of total non-residential floor space, weigh instead heavily on the energy balance since they have continuous usage patterns, where energy demand can vary substantially depending on the services provided, from consultation rooms to surgery rooms.

Another variability factor for existing buildings is the wide variety of technologies that are tied usually to the construction era; we could broadly divide them in:

- historical buildings (masonry)
- built between the twenties and the forties (mixed masonry and brick)
- built between the forties and the eighties (concrete non insulated structures)
- built after the eighties (concrete insulated structures)

Public buildings for their number, exemplary value, direct intervention possibility and ample energy saving margins are of crucial interest for their potential to initiate a improvement of the urban fabric. Therefore this part of the built environment has a central role in the norms that originate from the Energy Performance of Buildings Directive (EPBD) and the definitions relative to Nearly Zero-Energy Buildings in fact the article 9, paragraph 1, of the EPBD directive, sanctions that member States must: “provide so that:

a) within the 31st of December 2020 all new buildings are Nearly Zero-Energy;

b) from the 31st of December 2018 all new buildings used and owned by public entities are Nearly Zero-Energy”.

For existing buildings in general the directive stipulates that following the example of the public sector strategies should be implemented to transform them in Nearly Zero-Energy buildings.

At the moment we are falling behind the timetable since the implementation plan isn’t defined yet, in Italy an official definition of Nearly Zero-Energy has not been postulated (Progressi realizzati dagli stati membri in materia di edifici a energia quasi zero, 2013) and in general "The measures to reduce emissions and to increase renewable energy are effective "only in theory", rather than in reality" (Gargiulo et al 2012).

The attention on this sector is evident but, primarily because it is the dominant overall consumer of energy within the building stock and it plays a critical role in meeting overall carbon-reduction targets set by governments, a vast majority of published literature on the topic of consumption modeling and energy conservation strategies deals with the domestic building stock.

Another possible reason for the lack of studies on the presence of public and singular buildings within the building stock may be that large-scale assessment of the non-domestic sector is often infeasible or difficult due to the aforementioned sheer diversity of use, activities, and ownership structures within it.
But since variability in energy consumption between two buildings is dominated by the demand for activity related services (Prez-Lombard et al. 2008) the use of standardization based on building use rather than its construction and physical characteristics is strong in the context of non-domestic buildings.

Some studies conducted in Italy (Caputo et al. 2013) have tried to broaden the analysis scope of the building stock including non residential commercial buildings and the sources of energy consumption include heating, cooling, cooking, domestic hot water, lights and appliances.

Adopting some simple hypothesis taken from the UNI TS 11300 norms, the energy consumption, the efficiency of the characteristics of the building stock are assumed; in particular from the UNI TS 11300-2, (2008) the typical efficiencies of heating systems reported in and the typical efficiencies and UNI TS 11300-3, (2010) of cooling systems.

To determine the percentage of the building stock to be attributed to residential or commercial use, statistical data provided by the National Census, which is focused on residential utilization, was used and further elaborated.

Taking the “total dwelling area” of each census tract, the net total residential volume was calculated and the gross residential volume was estimated based on the correction factor reported in the standard UNI TS 11300-1 (2008).

The volume of commercial buildings was then estimated as the difference between the total building volume obtained by the dimensional data extracted from the maps and the residential volume available for each census tract.

Still the study did not consider the service sector or other buildings such as schools, hospitals, barracks, churches, etc.

Because of the sheer size of the assets involved and the functional diversification of the public buildings it appears obvious that they are an important quota of the entire built environment, even if smaller by far than the residential building one. Therefore an improvement in their energy efficiency can contribute to the effectiveness of energy policies.

We should consider as well the peculiar characteristics of this part of the built environment that can deliver, for equal volumes, larger energy savings than those obtained by other segments of the built environment because of:

− specific high energy use functions;
− the use of buildings adapted to functions different from the original ones;
− the higher energy demand per volume unit that derives from scarce control of public spending
− low maintenance of the buildings and mechanical systems

to initiate actions to reduce the energy consumption trough retrofits, a complete analysis of the energy consumption of this sector is fundamental to determine as well if:

− The magnitude of the supply contract with the energy provider is commensurate to the requirements for each building
− how energy demands change during the seasons and the time of day to corroborate the intervention strategies decisions
− compare the specific energy consumptions of different buildings to identify anomalies
− compare the detailed energy consumption of each building with the benchmark values for the specific building type.
Concerning methodological issues, retrofit actions are likely to be practically complex because they include other concepts, such as economic and aesthetic considerations, besides the energy and environmental aspects. The final choices depend on a variety of environmental technological and economic mechanisms.

3 PRELIMINARY RESULTS

Considering these difficulties, in the data collection moment, specific attention is needed to choose the parameters and indicators useful for our analysis. Briefly we shall describe the preliminary considerations that have guided our choices on this topic.

First a list of possible sources of relevant data was drawn, from these records we have then chosen the parameters that could bring us nearer to our optimal analysis data set.

Geomorphic data is easily collected through the consolidated instruments that are essential to the preliminary steps of any urban plan, determining surfaces, heights, volumes; still these needed to be enriched with info about use typologies. The presence of public and singular buildings was highlighted and in general the percentage of non residential functions for each edifice was quantified.

Therefore the following parameters are collected for the creation of the model:

Name of the parameter: Total floor area.
- typology: descriptive
- measurement unit: sq.m.
- description: Total floor area, is the sum of all useful floor areas of each storey above and below ground, usable attic included.
- calculation or survey method: survey from aerial photogrammetry
- ease or calculation and comparison: high

Name of the parameter: construction era.
- typology: descriptive
- measurement unit: range
- description: the construction era of the building useful to estimate the construction technologies
- calculation or survey method: survey from aerial photogrammetry building is hypnotized within the approximate era of the neighborhood
- ease or calculation and comparison: high

Name of the parameter: Net floor area.
- typology: descriptive
- measurement unit: sq.m.
- description: Net floor area, is the sum of all net floor areas of each storey above and below ground, usable attic included; estimated subtracting from the total floor area the external walls and the vertical connections.
- calculation or survey method: estimated percentile bearing on the total floor area derived from the construction era
- ease or calculation and comparison: high

Name of the parameter: building height.
- typology: descriptive
- measurement unit: m.
Name of the parameter: number of floors.
- description: building height, the vertical distance of the highest roof eave above the mean finished grade of the ground adjoining the building.
- calculation or survey method: survey from aerial photogrammetry
- ease or calculation and comparison: high

Name of the parameter: air-conditioned volume.
- description: the total building volume served by the mechanical systems.
- calculation or survey method: building footprint per building height
- ease or calculation and comparison: high

Name of the parameter: number of units.
- description: the number of functional units of each building.
- calculation or survey method: data from land registry
- ease or calculation and comparison: low

Name of the parameter: form factor.
- description: surface to volume ratio.
- calculation or survey method: survey from aerial photogrammetry
- ease or calculation and comparison: high

Name of the parameter: façade orientation.
- description: degrees of the main building façade relative to the north.
- calculation or survey method: survey from aerial photogrammetry
- ease or calculation and comparison: high

Name of the parameter: degree days.
- description: the sum of the average temperature on any given day, subtracted from the base temperature.
- calculation or survey method: from charts present in the norms
- ease or calculation and comparison: high
Name of the parameter: energy intensity.
- typology: performance
- measurement unit: kWh/sq.m./year
- description: the total energy used by the building per square meter each year.
- calculation or survey method: dividing the estimated energy consumption per unit of floor surface.
- ease or calculation and comparison: medium

Name of the parameter: function.
- typology: descriptive
- measurement unit: list
- description: the prevalent use of the building.
- calculation or survey method: survey from aerial 45° photogrammetry.
- ease or calculation and comparison: medium

Name of the parameter: education level.
- typology: descriptive
- measurement unit: list
- description: the type of educational function housed in the building.
- calculation or survey method: data from relevant public agency.
- ease or calculation and comparison: high

Name of the parameter: education level.
- typology: descriptive
- measurement unit: list
- description: the type of educational function housed in the building.
- calculation or survey method: data from relevant public agency.
- ease or calculation and comparison: high

Name of the parameter: healthcare service type.
- typology: descriptive
- measurement unit: list
- description: the type of healthcare service housed in the building.
- calculation or survey method: data from relevant public agency.
- ease or calculation and comparison: high

But, due to the extreme difficulty of retrieving data related to the age of each building, the age of the building, as mentioned, is hypnotized within the approximate era of the neighborhood; the kind of building technologies and the mechanical systems, each profoundly tied to energy consumption, have been momentarily excluded from the model.

To determine the energy intensity of each typology, consumption data needs to be collected from multiple energy suppliers and then geo referenced.

This data is collected by public offices but it is not introduced in a geographic information system and is therefore not useful to extrapolate the information we need; an accurate correlation on the building scale is needed that expurgates individual consumptions for privacy reasons.
4 CONCLUSIONS

Even if there aren’t comprehensive models that include singular buildings, there are many studies that have considered the energy consumption of each subset and specific building type. Analyzing the work done in this direction it is apparent that high energy use buildings, present as a small percentage of the building stock, still represent a large portion of the end use of thermal and electrical energy use on an urban scale.

Dividing the non residential building stock in commercial and service sectors, on the one side, and singular and public buildings on the other, it is evident that two different approaches are needed to include them in an urban energy model. The first are characterized by ample surfaces with almost homogeneous hourly usage and comparable energy intensities; therefore they can be estimated and evaluated using prototypical example models as benchmarks for the whole sector, taking into account the specific and common considerations on building age, technologies, localization etc. that are used for the residential sector.

On the other hand singular and public buildings for their intrinsic extraordinary characteristics are more difficult to include. Energy intensity, hourly usage, end use of energy, user presence differ widely; therefore it’s necessary to develop for each subset and building type a specific modeling unit that can consider its particular characteristics and be plugged in the global model as needed.

For each building type the specific energy intensity must be evaluated and tied to the characteristic that drives energy consumption; this characteristic may not be the overall surface of the building unit.

Still these analysis methods implement a partial view of the problem since they, for example, consider energy consumption tied to built volume, use, technological characteristics of the building envelope and ignore the type, age and control strategy of the mechanical systems.

Another critical point is the difficulty to correlate energy use in the building stock with the presence of onsite renewable source energy generation.

Because of their exemplary value, for public buildings, a repository of energy certification documentation is being created; even if the rating is a useful indicator to compare a building relative to another of the same type, or its expected benchmark, it does not correspond to its actual energy use and therefore it is not useful as a data source for energy consumption.

Still it could be useful for the definition of the technological characteristics of the building envelope and the mechanical systems if the simplified rating system, which infers characteristics from age, was not used.

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