Green Energy and Technology

Rocco Papa
Romano Fistola *Editors*

Smart Energy in the Smart City

Urban Planning for a Sustainable Future

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Preface

This collection of papers is about the energy dimension of a smart city. Its goal is to mark a boundary around the concept of "city smartness", considered with regard to the energy issue and the town planning point of view. From another perspective, the aim of this collection of writings by the main Italian research groups in the field of urban sciences, is to define how the new concept of a smart city can successfully open a new understanding of urban systems and progress towards a new style of management for our metropolis.

If we have been able to see and participate in the smart city debate, one that has been spreading all over the world during the last 2 or 3 years, it is possible to argue that the main factors of this new concept regarding human settlements are energy and technology.

The technological dimension of the smart city movement is inherent to the city itself and represents the engine that moves the urban system in its spatial and temporal development. But today's main issue is energy. Technology without energy is simply useless. It is no exaggeration to say that energy is the main challenge for the future of our cities as well as for human beings. At the same time, cities are the places where this challenge must be played out first, because cities are the main wasters of energy on the earth.

The planning of a smart city will be greatly different from the canonic urban planning of our current cities. Furthermore the energy dimension has to constitute the first issue to be considered in a new planning process. The new urban planning has to consider energy as a starting point and a goal to achieve, at the same time. Technology must be considered as a part of the planning process from the beginning. Technology, in order to know its needs, to understand and to drive urban system towards new, sustainable, and balanced conditions, has to be "adopted" and not merely "added to" the city, as we tend to do today.

Italy is a country particularly exposed to energetic problems for three main reasons:

- The geographic location of the country determines a particular vulnerability to climate change and consequently the need for large amounts of energy;
- The country has no primary energy resources available (Italy imports from abroad more than 80 % of its energy requirement);
- Due to a public referendum, no nuclear plant is available on national territory.

This study has an explicit concern about a city's energy. Again, energy has to be considered inside the urban planning process as well as inoculated within the new idea of a future city. We need new methods, new processes, and new tools to manage the urban system in order to drive it towards a smart dimension. From this concepts arises the idea of this volume which is structured along three main issues: the relationship between energy and city (in its different dimensions), a methodological aspect of energy's contribution to the urban system management, with a special focus about ontological issues, a review of case studies which describes some practices, procedures, and tools of urban planning. At the end this essay could be useful to students of urban planning, town planners, and researchers interested in understanding where the city of the future will go and what the energy contribution to this evolution will be.

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Rocco Papa
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About the Editors

Rocco Papa has been Engineer, Full Professor of Land Use Planning at the Engineering Faculty—University of Naples Federico II since 1992. He has been Editor-in-Chief of the Scientific Journal TeMA—Land Use, Mobility and Environment since 2007. He was Director of the Department of Urban and Regional Planning of University of Naples Federico II, from 1999 to 2005. He was Chairman of the Urban Transformation Company Bagnolifutura S.p.A from 2006 to 2010. He was Vice-Mayor of the Municipality of Naples, from 2001 to 2006. He was City Councilor for Livability (appointed to Town Planning and Historical Centre) for the Naples Municipality, from 1997 to 2001. With the research activity carried out continuously since 1974, he has developed according to the following four main lines: the study of the interactions between urban and mobility systems; the management and governance of metropolitan areas; the safeguard of environmental quality in highly urbanized areas; the experimentation of new protocols for urban planning tools connected with the updating of techniques, methods and models of analyses, interpretation, planning and governance of territory. He has been scientific coordinator of many research projects: Research Unit of the RESIS Project 2004–2005 ~ Project of Research and Development for Seismology and Seismic Engineering; European Project 2004–2007 "Applied multi Risk Mapping of Natural Hazards for Impacts Assessments. Contract for "Specific Targeted Research or Innovation Project (STREP)—VI Framework Program"; Research Unit of the CIPE MURST Three-year (2000–2003); Project "The Protection of Seismic Risk: Vulnerability. Analysis and Requalification of Physical and Built Environment by Means of Innovating Techniques"; Research Unit of the National Priority Scientific Research Program 2002–2004 (Projects co-financed by MIUR) "The Safeguard Historical Cultural and Landscape Values in Italian Seismic Areas". He is the author of more than 100 publications.

Romano Fistola has been Architect, Associate Professor at the Department of Engineering of the University of Sannio since 2004. He was permanent researcher at the Institute of Planning and Land Management of the National Research Council of Italy (Naples) from 1996 to 2003 and member of the Scientific Committee. He was also a visiting researcher at the Center for Urban and Regional Development Studies (CURDS) of the University of Newcastle upon Tyne (UK), under the direction of Prof. J.B. Goddard. Since 2004 he has been teaching the courses "Town and Country Planning" and the course of "Management of the Urban Transformations" at the Department of Engineering of the University of Sannio. He was a coordinator and member of research teams in several research projects (national and international) in the field of urban and regional planning. The main scientific topics of his researches are as follows: New technologies and the city, smart cities, complex urban systems, GIS, urban risk, and sustainable cities. He was elected a member of the Board of the Italian Regional Science Association (AISRe) and is currently a member of the Italian National Institute of Urban Planning. Since 2007 he has been the editor of the Scientific Journal TeMA—Land Use, Mobility and Environment. He is author of more than 100 papers published in national and international books and journals.

Contents

City SmartNESS: the Energy Dimension of the Urban System

Rosaria Battarra, Romano Fistola and Rosa Anna La Rocca

Abstract This paper proposes a re-thought of the concept of urban smartness, particularly referring to the energy component. Recognizing that the new technologies, which are the most popular aspect of smartness, can play a fundamental role in the new approach, it has been suggested that we consider them in an adoptive way rather than in an adjunctive way, as it is commonly intended in the general sense of a smart city. According to this vision, in the first part of the paper, a new concept of smartness is proposed (SmartNESS: Smart New Energy Saving System). This concept is also related to the possibility of identifying some leading urban functions that can play a strategic role in improving urban smartness. In this sense, in the second part, tourism is considered as a drive function able to make cities more efficient and attractive if it will be integrated inside the urban governance process. The third part of the paper highlights how the rationalization and reduction of energy consumption is one of the essential fields to rely on in order to improve the smartness of a city. This part provides an overview of the most significant initiatives that are being developed on energy efficiency, and investigates some cases particularly innovative addressing the issue with an integrated and non-sectorial approach. Through the analyzed experiences, some possible intervention strategies to integrate the issues of energy efficiency in urban planning are suggested in the conclusive part of the paper.

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1 The City: a Complex, Dynamic, Energy-Intensive System

The debate about the smart city needs a theoretical structure that seems to be difficult to frame (Papa et al. 2013). This approach has to be built in connection with the up-dated theories of urban science and has to be able to describe the new urban phenomena.

Energy and technology are actually the engines of the smart dimension of a city where it is necessary to save energy using new technologies. But first it is necessary to find a way to figure out the parts and interactions among parts inside a city in order to understand how to operate with an effective energy saving.

The first study about a city as a system was made around the Sixties, but actually this paradigm seems to be still today the best way to model urban phenomena.

In 1964, Berry published his famous book: "Cities as a system within systems of cities" (Berry 1964) in which the city is considered as a territorial system. Four years later, Ludwig von Bertalanffy published his seminal volume: "General System Theory" (von Bertalanffy 1968) to whom Berry referred a large amount of its work on this topic.

Considering these first studies, the systemic approach to city interpretation has been deeply developed by a number of urban scientists that have identified sub-systems inside the urban system. Therefore, we can assume that urban subsystems are the best targets for driving the energy saving action of the city. In other words we want to prove the hypothesis regarding the possibility of saving urban energy by acting on the urban sub-systems directly. This is possible in two ways: by reducing the urban entropy (first) and by influencing the social system trying to develop new behaviors. Considering the systemic approach for city analysis and the complex theory as well, it is possible to find an interesting new way to understand the behavior of the urban system and its trend of evolution.

Understanding urban complexity seems to be the most interesting field of research that has emerged in urban disciplines that seem to be slow in developing new paradigms of interpretation (Wallot and Gurr 2014, Mobus and Kalton 2015). In order to discompose the urban system, we can consider many urban subsystems. It is quite difficult to find a rule to understand how to define an urban subsystem. In general, we have to consider that a system has a geometry, composed of elements and relationships among them. However, the rule of geometry may not always be verified. It is surely verified if we consider the generative subsystem of the city: the geo-morphological and the socio-anthropic one. The geo-morphologic subsystem, as a whole, could represent the environmental support to the human settlement and territorial clusters and physical connections among them that compose it; the socio-anthropic subsystem contains the set made by men and human relationships. In order to identify other subsystems, we can consider the systems generated by the main one and define a sort of "dendrogram rule".

From the two main subsystems, it is possible to derive some other urban sub-systems. Starting from a geo-morphologic subsystem, we can identify a physical subsystem, made by the material part of the city; as well as starting from the socio-anthropic subsystem we can identify the functional subsystem, made by human activities. Following this rule, we can identify different subsystems inside the principal ones. For instance, inside the functional subsystem, it is possible to find as many subsystems as the urban activities are: the residential subsystem, the economic subsystem, the education subsystem, the health subsystem and so on.

Urban mobility represents a special subsystem because it is not located in a single site of the urban system but is articulated across the urban space. This subsystem is vital for the city. Some other cross-subsystems act as a sort of connection between two or more subsystems. The psycho-perceptive subsystem, made by the perception that city users have of urban space ("the image of the city" according to the Kevin Linch theory, Lynch 1960) is a bridge between the socio-anthropic and the physical subsystem; also the economic subsystem acts as a connection among many subsystems: socio-anthropic, functional, mobility, etc. All the urban subsystems are elements of the urban system themselves, in a holistic view of the city. At the end, we can imagine the urban system, made by all the subsystems that interact with each other in order to move the system ahead, following its trend of evolution. This moving is supported by energy (coming from natural resources) that the urban system utilizes in order to evolve and to go on. The system evolves throughout space and time by means of energy. The hypothesis is to try to reduce the consumption of energy and its waste byproducts during the development of the system, in other words try to reduce the entropy. So Smartness is related to the reduction of urban entropy.

2 Defining Urban SmartNESS (New Energy Saving System)

Considering the previous formulated hypothesis, it is possible to distinguish two different entropies inside the urban system: an entropy of evolution and an entropy of development. The first one is due to the operation of the system itself and to the interactions among the subsystems. The second is related to the use of energy because of the needs of the system to go ahead along its trend during time. The two entropies are strongly correlated because when the evolving entropy's value is low, this means that the system utilizes the resources in a right way, saving a large part of energy. In this case, the system goes on thanks to this energy that can be used for the development process (Fig. 1). In some way, the two energies are connected to the external and internal complexity described by Jorge Jost (Jost 2004).

In other words, an urban system where the evolving entropy's value is high has no possibility to go ahead along its path of development. So it is possible to say that urban smartness is related to a low level of entropy of evolution and consequently to the possibility of the system going ahead saving energy. Another consideration can be developed about the entropy of evolution: when a system uses energy in a

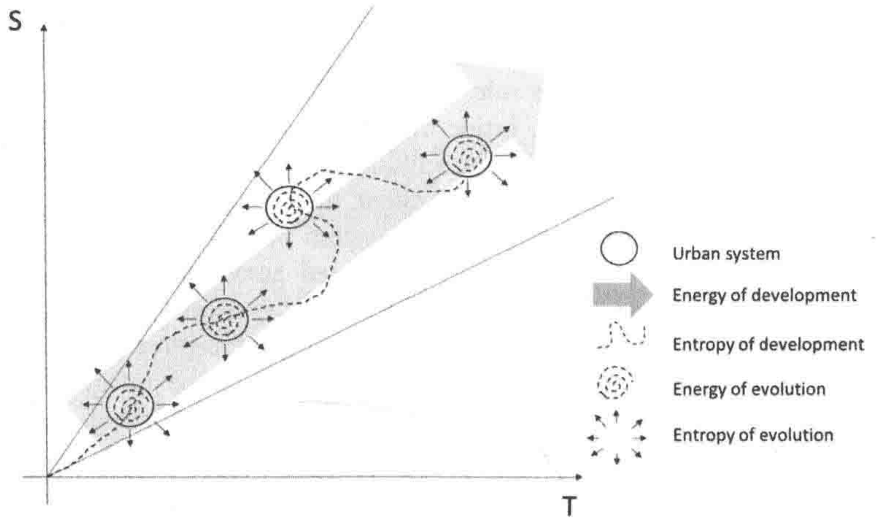

Fig. 1 The trend of the urban system with the energy of evolution conceptualized as a spiral force and the energy of development as a random path moving inside time and space

correct way, avoiding energy waste, this means that the cycle of inside energy of the system is closed. On the contrary, when within the different subsystems, discrepancies occur, these act like points of energy wasting: the cycle breaks down itself and a part of energy is dissipated (Fistola 2012). At the end, it is possible to argue that in an urban system the entropy is inversely related to smartness and moreover that a city with a number of malfunctions, inside the different subsystems (physical, functional, social and so on), cannot be “smart”. To bind together these concepts into one, it is possible to say that the real smart city is that one where the urban energy is inside an harmonic-closed circle, correctly used and saved, like in all balanced natural processes (Commoner 1971). Moving from these hypotheses we can find a new syncretic word which is a newly composed acronym: SmartNESS (Smart New Energy Saving System).

Urban SmartNESS is a concept that attempts to link the systemic approach to a need to guide the development of the city towards sustainable configurations characterized by an appropriate and innovative use of energy. The possibility of reducing the entropy of evolution is related to the capability of identifying the causes of malfunction inside different subsystems. In order to improve urban SmartNESS, actions and policies first of all have to identify all the discrepancies existing inside the urban subsystems and try to solve them. In this way, a lot of energy will be saved and the interaction among urban subsystems will transmit a new level of the urban system. The dyscrasias inside the subsystems are the wasting points of energy (resources) and the sources of entropy. This entropy has to be reduced. An example is the socio-anthropic subsystem in which the reduction of entropy is connected to the growing of social capital, an implementation of citizenship (Carta 2014) that produces, as externality, a correct use and a saving of energy within the city.

3 New Technology for Urban SmartNESS: Adoption Versus Adjunction

Urban SmartNESS could be achieved through a new way to use new technology. What it is necessary to clarify is that the innovation, communication technology (ICT) could be a strategic factor in order to activate the process of entropy mitigation inside the urban subsystems. In other words, the ICT have to be considered as an internal element useful to mitigate energy wasting and able to allow a real-time monitoring of the development of an urban system. Moreover, the new technologies, which are the most popular aspect of the smartness, can play a fundamental role in the new approach by considering them in an "adoptive" way and not in an "adjunctive" way, as it is commonly intended in the concept of a smart city.

Nowadays the ICT seems to be an external element (maybe just a showcase element) to classify "smart" a specific human settlement. If the city is equipped with a technological system for traffic control or for air pollution monitoring, it is quickly considered, or worst classified, as a "smart city", even if the buildings are crumbling, the social conflict is high and the queue at the post office is endless.

On the contrary, we want to state that "smartness" is related first to a low level of entropy that can be achieved through a technological adoption rather than a technological adjunction.

Urban smartness (referred to technology) is represented by the capability of the urban system of collecting, transmitting, elaborating and adopting information and data about its states, the active phenomena, the energy flows and physical flows, the intensity of activities and so on. In another words, "smartness" is not just related to the capability of the city to collect and store data but, actually, to the possibility of elaborating and using these data (big data) in order to activate a new organization of the system itself and minimize entropy. This condition (the minimization of entropy) makes a city smarter (Fistola and La Rocca 2013).

In a way, the Tower of Winds in Tokyo by the famous architect Toyo Ito (Fig. 2) could represent an effective example of this capability from an architectural point of view. This building was an element of an old aeration system located inside the district of Yokohama. Ito transformed the old building (located in the historical city) into a new piece of the city, able to catch information from its environment and transform it in light on its skin, with a continuous metamorphosis of its aspect (and role) inside the urban system. Data coming from the urban environment (noises, winds, etc.) are elaborated in order to activate different configurations of the building inside the urban system.

In this sense, it could be possible to say that smartness of a city is strictly connected to its capability of energy saving, in terms of entropy mitigation. In a smart city, the mitigation of entropy has to be a primary target and it can be achieved performing the following actions:

- minimizing entropy through the resolution of dyscrasias existing inside the urban system;

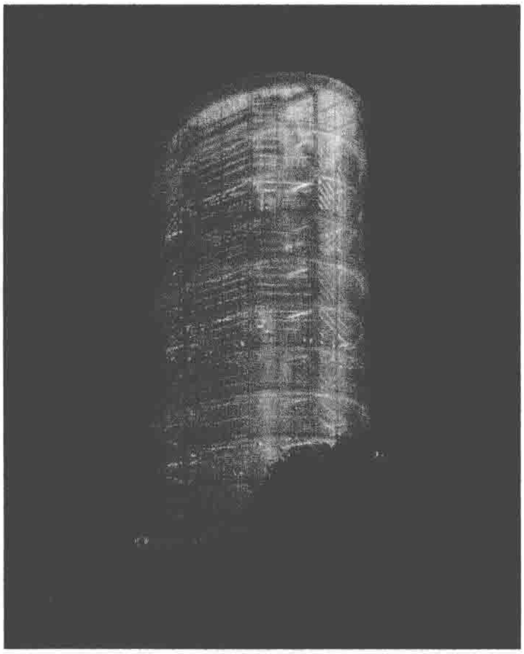

Fig. 2 The tower of winds in Yokohama by Toyo Ito

- minimizing entropy adopting new technologies to monitor and redefining the organization of the urban system;
- minimizing entropy by a saving use of urban energy in a general way (considering natural resources as energy for urban development) as well as in the specific behavior of daily life of inhabitants.
- minimizing entropy by considering a number of driving urban functions that can lead the urban system toward a new state characterized by a high level of energy saving and efficiency.

Furthermore, the new technologies, and in particular cloud computing, enable the creation of repositories of "dynamic knowledge" within which the by-products from the smart city are stored, processed, and reused, even for complex and composite urban systems within the government itself. Some urban functions can be identified to act as the driving function in new urban amenities; for such activities will be necessary to propose a redefinition and a systemic reorganization, including the use of new technologies.

Some recent urban operations seem to be going in this direction and represent interesting examples to analyze.

4 Tourism as a Driving Function

This part explores a specific aspect of analyzing urban tourism as a phenomenon that can affect the competitiveness and the overall well-being of the urban system. The condition to achieve this livability's objective can be identified in the need to