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Journal of
Land Use, Mobility and Environment

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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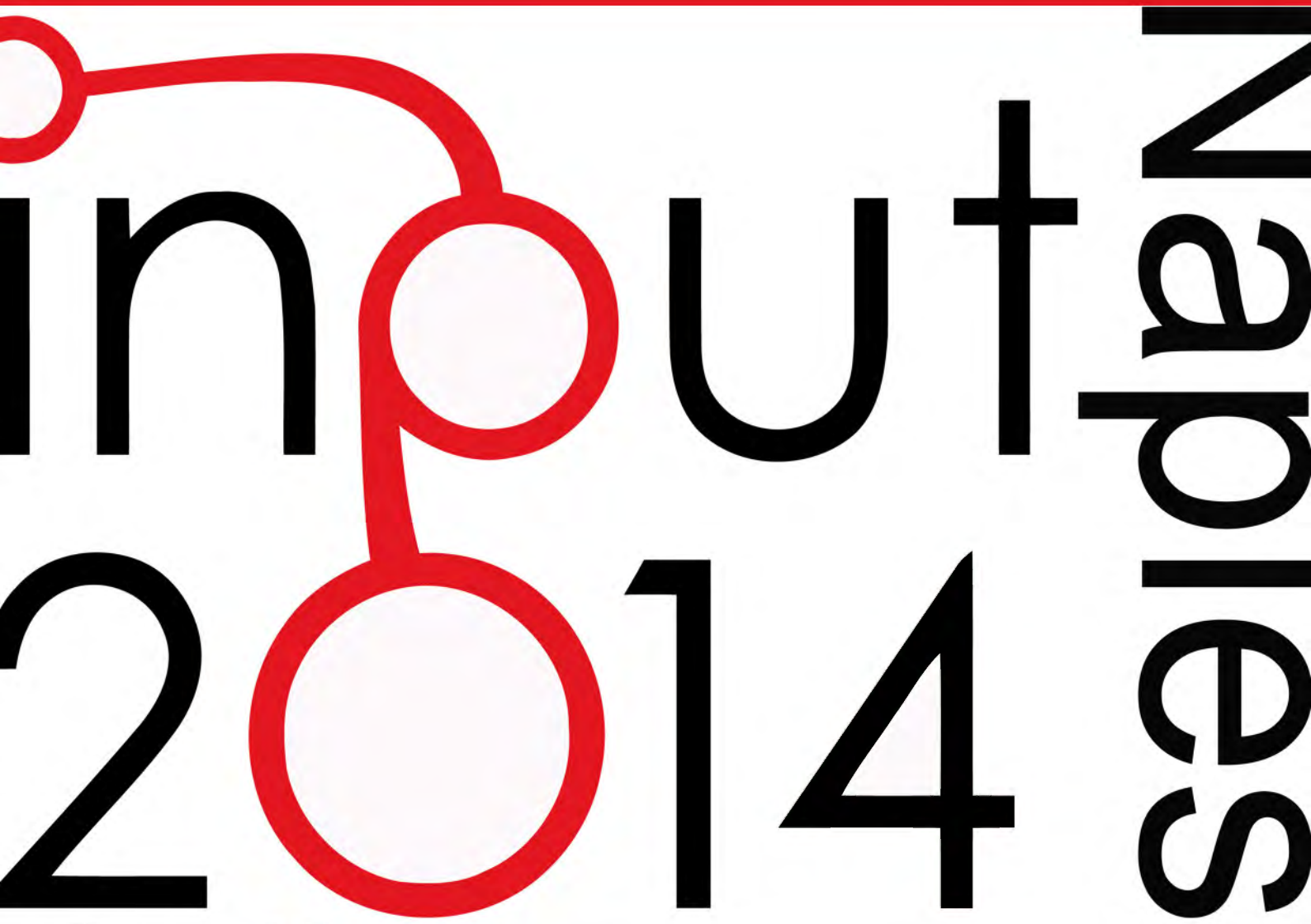

Smart City

planning for energy, transportation and sustainability of the urban system

Special issue, June 2014

print ISSN 1970-9889 e-ISSN 1970-9870
University of Naples Federico II

TeMA Journal of Land Use, Mobility and Environment

SMART CITY

PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

Special Issue, June 2014

Published by
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"

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Editor-in-chief: Rocco Papa
print ISSN 1970-9889 | on line ISSN 1970-9870
Lycence: Cancelleria del Tribunale di Napoli, n° 6 of 29/01/2008

Editorial correspondence
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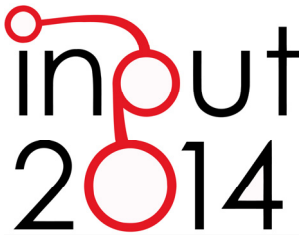
TeMA Journal of Land Use, Mobility and Environment

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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TeMA INPUT 2014
Print ISSN 1970-9889, e- ISSN 1970-9870

DOI available on the online version

SPECIAL ISSUE

Eighth International Conference INPUT
Smart City - Planning for Energy, Transportation and Sustainability of the Urban System

Naples, 4-6 June 2014

VIRTUAL POWER PLANT

ENVIRONMENTAL TECHNOLOGY MANAGEMENT TOOLS OF THE SETTLEMENT PROCESSES

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ABSTRACT

The Distributed Energy Resource (DER) systems represent a possible option for the implementation of the Low Carbon Cities development scenario, consistently with EU orientations. Many surveys, especially of engineering and information technology origin, are contributing to DER systems spread through testing the Virtual Power Plan (VVP): a technological system aimed at synchronously managing the information and energy fluxes, and able to have an effect on the urban metabolism balance and on the energy chain organizational model.

In the event of a wider VVP spread, consequences for the urban structure social and technical conversion process might be envisioned. Such systems gain importance in terms of starting urban renewal processes, introducing new rules for the local energy and environmental infrastructures.

In this way, it is envisioned the need for a deeper comprehension of the VVP innovative functionalities, this comprehension being significant for all the branches of knowledge which are interested in developing methods and tools for the Environmental Technology Management and Planning of the settlement processes.

The author, who is interested in producing and organizing an energy, distributed, renewable and interactive model, shows, through a critical analysis of the Electricity Networks Europe program study cases, the operating potential of the new system, emphasizing the consequences on the settlement process development, thus providing a first definition of the strategic features for the VVP technical and social implementation.

KEYWORDS

Distributed Energy Resource, Energy Planning, Urban Renewable Processes, Urban Metabolism

1 INTRODUCTION

In the latest sixties (1960s), Tomas Maldonado explained the complexity control problem (Maldonado 1970). Maldonado's consideration was a contribution to the debate about the fate of consumption society which disclosed the increasing flow of people, goods, energy and information. In respect to the emerging dynamics, a decrease of complexity came to be envisioned; the reduction was conceived not in terms of simplification of reality or of a return back to pre-industrial models, but in terms of ability of guiding the technological innovation in a less invasive way, respecting the environment precarious balance.

As it has been acknowledged, the relations between environment and technology have been progressively altered throughout the course of sixty years. First of all, this alteration has occurred through the fossil energy supply technologies, which a wide scientific literature considers the main cause of the continuous impoverishment of the eco systemic services (Rifkin 2002).

Furthermore, it has been emphasized that in European areas as well as in Western industrial societies in general, environmental vulnerability is more strictly related to the prevailing obsolete energy devices rather than to the demographic pressures dynamics, which pertain more strictly to the Asian development models (Commoner 2003).

Nowadays, the technological change concerning the energy supply system is an essential part of European Community sustainable development policy which, among different possible options, suggests the implementation on a large scale of the DER systems (Distributed Energy Resource) (European Commission 2009).

This development scenario has made possible two meaningful achievements in the last ten years: validating the energy model from a technical engineering perspective (Lasseter 2002); introducing the Virtual Power Plant, new machinery being able to coordinate in an innovative way energy and information flows (Asmus 2010).

These new resources need a more in-depth analysis focusing in particular way on the transfer process from engineering tool to a device supporting the eco efficient cities conversions and management process. Furthermore, as far as the transfer process mentioned above is concerned, it might be worthwhile emphasising the issue of the man-machine interaction.

From this perspective, it is worth quoting Winer and his pioneering cybernetics studies on complexity control, starting from human and social premises: on one hand he expounded the possibility of new technological devices supporting anthropic activities; on the other hand, he emphasised human beings peculiar tendency to social organization, thus avoiding the distortion of technological innovation concept and value (Winer 1950).

In the latest years, researches on the information development, on the messages between man and machines and between machines and machines have acquired a greater importance. Actually, the infrastructural dematerialization processes generated from informatics devices diffusion is the main focus of the current scientific debate as well as of Horizon 2020.

In relation to new themes of survey, it seems crucial a scrutinized analysis of the innovation profile and of the implementation spheres as well as of the potential consequences for the material and immaterial processes of urban planning related to the generation of the Virtual Power Plant, which is a new generation machine working as a contribution to the scientific community, in order to characterise the concept of Smart Cities.

2 VIRTUAL POWER PLANT: INNOVATION PROFILES

In the international sphere, the concept of Smart Cities is associated to a diversify sequence of experimentations (Chourabi *et al.* 2012), whose central idea concerns computer applications for the fluxes complexity management (Farhangi 2010). Although it has been acknowledged the technical feasibility of Maldonado's prophetic idea about the need for enhancing fluxes control faculties, thus keeping bringing the scientific and industrial sphere attention the implementation of a new efficient and ecological urban model seems to be still difficult. From these facts it is possible to infer that man's tendency to social organization Winer emphasised still plays a pivotal role by suggesting a fair balance between technological innovation and urban intelligence.

In this sphere, the Virtual Power Plant analysis is fulfilled through an association between technological innovation profiles and several rising features defining an evolving process:

First of all, VVP are tools capable of assembling different sustainable energy systems in only one profile; as a consequence, they are aimed at the greatest technological diversity in order to prevent the infrastructural uniformity which is typical of the fossil system. From these facts it can be deduced the capacity of a system based on energy inclinations, which become the new likely rules for the territorial infrastructural process.

Then the new devices are oriented towards a direct connection between the settlement layout spatial features and immaterial fluxes. In this way it is possible overtaking the limits of urban metabolism previous abstract model and envisioning a salvage of settlement morphological and typological conditions, which are employed in order to measure the potential level of energy infrastructure implementation.

Finally, the new devices can work as a support to the management of connection between energy needs and consumptions. Interaction, which is meant as the innovative capacity of effectively solving the environmental imbalances, involves the invisible technology concerning the energy chain organization and the redefinition of roles and competences.

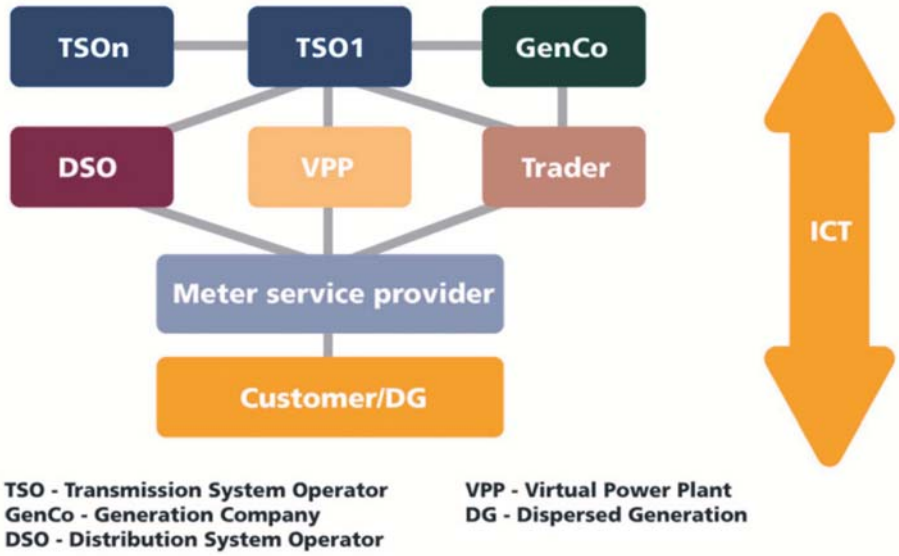

Fig. 1 The VPP represents an instrumental device involving the innovations ICT introduces in the energy supply chain different phases.

2.1 REFERENCE THEORETICAL MODEL AND PURPOSES

This survey refers to a clear theoretical framework, according to which DER systems are related to a Large Technological System (LTS) (Hughes 1985). Such a concept differs from the infrastructural economist matrix

traditional definition, in order to involve the idea of an open system interacting with the context conditions (Maldonado 1997). As far as the energy infrastructures are concerned, thanks to equipment and functionality indexes, the classification and assessment traditional system is replaced with a High Technology components model: Hardware, physical transformations; Software, intangible flows management systems; Brain-ware, man-system interaction; this model is considered more appropriate for the innovation profiles mentioned above. The general features of the theoretical structure and the components characterisation modalities have been already discussed (Sibilla 2012).

The aim of this survey is first suggesting to the scientific community a new understanding of the VVP as a supporting tool for the DER system diffusion, following the LST model, and then contributing to assess its likely consequences and application to urban planning and design processes. The survey premise lies in the awareness that VVP features envision new possible operations aimed at balancing the fate of the ongoing eco systemic impoverishment. These new generation machines are endowed with components able to receive messages from the outside as well as to change their behaviour like the autopoietic systems (Sibilla *op.cit.*). Furthermore, these machines can involve environmental cyclical variables in an arranged planning process, thus providing a meaningful contribution to the settlement structures renew, through a territorial distinction process.

The following dissertation will be focused on a selection of the most innovative applied research programs, particularly belonging to the completed and well documented Framework Programme (FP6), whose themes enumerate Virtual Power Plant technical and non technical implementation. Furthermore, the survey will analyse in depth Virtual Power Plant implementation in different geographical and urban contexts, thus implying a falsification of the innovation profiles stated before. Finally, thanks to some information collected through a survey on study cases, strategic suggestions for a LST model based application of VVP are provided.

2.2 VIRTUAL POWER PLANT: STUDY CASES

Several research programs have contributed to DER system analysis, envisioning them as a solution for future energy infrastructure. Such an evolution foresees the gradual replacement of the great traditional power plant with a renewable, interactive, safe and sustainable system for energy supply. In this context, the Electricity Networks Europe program belonging to Framework Programme (FP6) is significant. The case studies test energy system new forms of structure on territorial areas differing in geographical condition and urban structure. Some of the plans are listed as follows: *Fenix: Flexible Electricity Networks to Integrate the Expected Energy Evolution*; *Uniflex-pm: Advanced Power Converts for Universal and Flexible Power Management in Future Electricity Networks*; *Smart Grids TPS: Secretariat of the Technology Plattaform for the Electricity Networks of the future*.

The three research programs mentioned above share the same orientation, which results from observing that energy resources handed out inside the traditional distribution networks will cause operating problems in many EU countries; these problems will be due to the traditional networks incapability of supporting an energy increase from renewable sources which, as it has been acknowledged, are based on a typical intermittent operation. This technical and plant design problem shows clear operating consequences for the spread of renewable and off-center systems; consequently, such a technology might actually help to build low-carbon cities, with clear benefits for nuclear technologies. In order to exceed this operating limit, research has suggested new frontiers of experimental investigation; one of the innovative ideas lies in an aggregation of small renewable resources fueled building structures in a virtual production unit: the micro

grids. As it is possible to infer from the selected programs, this new infrastructural system questions the whole traditional energy supply apparatus.

The Smart Grids TPS program is one of the main spreading tools of the achievements concerning the energy infrastructural system evolution in Europe. Particularly, the survey provides documentary evidence of the diversified Information Communication Technologies (ICT) implementation to the new energy structure interactive operation, based on the distributed generation model. The program approach consists in investigating the ICT impact, through a new analysis of the whole energy chain. Indeed, this kind of systems integrates into each other over every level of the chain: energy production, management, allocation and final uses (European Commission 2007).

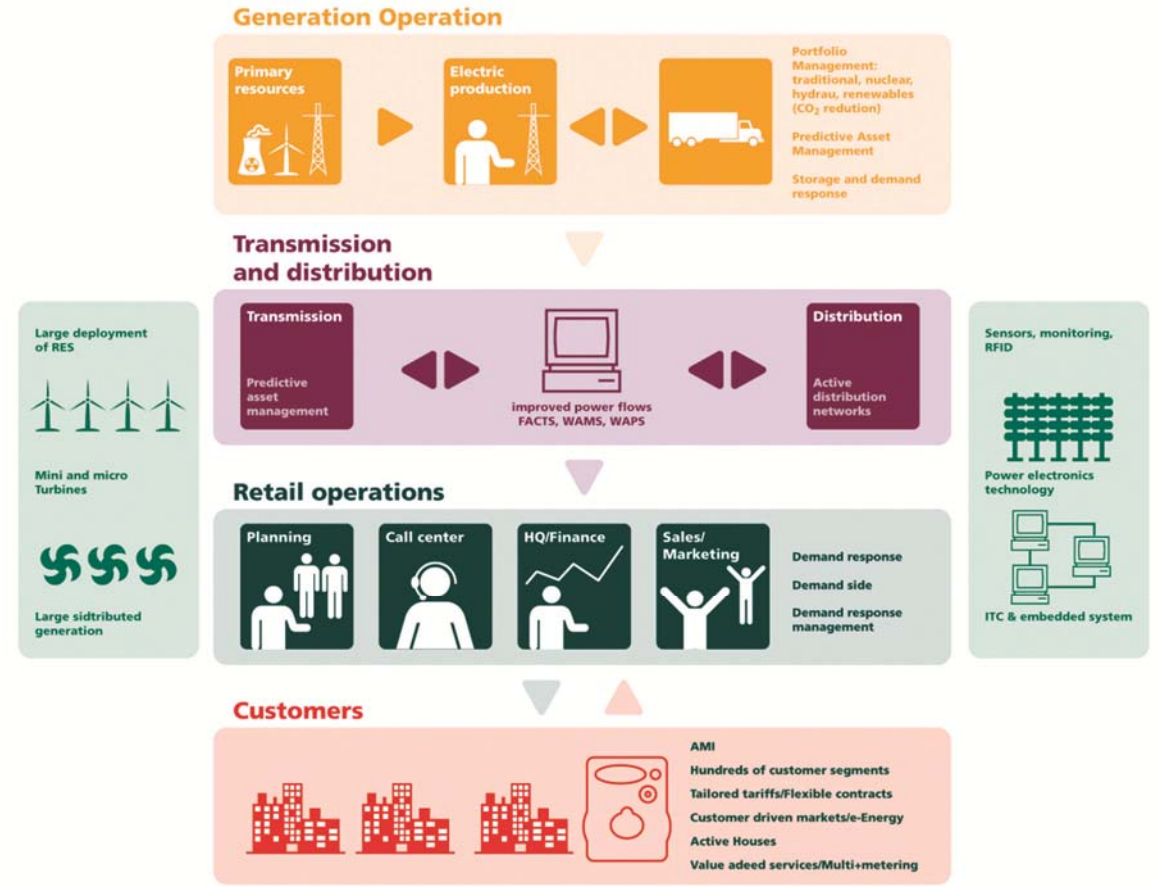

Fig. 2 The figure shows the different levels of innovation distributed generation and computerized control introduce in the energy supply chain.

The Uniflex-pm program focuses on the state of art of renewable technologies; it discusses the potential of the wind power, as well as of the solar energy and of the biomass CHP (combined heat and power) system; additionally it also discusses the conservation of energy technological potential. Even though on one hand, the survey clearly explains the product innovation in terms of efficiency and the current limits to a presuming energy independence implementation in the short term; on the other hand, it faces the integration issue from a non technical point of view, thus examining in depth the market rules innovation dynamics, according to the renewable and interactive micro grids logic. In such a context, the ICT systems work as an adjustment tool not only to the energy fluxes, but also to information aimed at self regulating of the exchange and of the operating system in agreement with local peculiarities. Such an agreement requires a deep knowledge of territory, by mapping for instance, the renewable energy sources (Iov *et al.* 2009).

The micro grid management is the main focus also of the Fenix program which is aimed at increasing the off-center systems diffusion by analyzing their feasibility as well as optimizing their contribution to the electric energy traditional system. The program just mentioned is one of the first in Europe introducing a wider concept of the VVP practical potential. Also in this case, the main theme is the energy and information fluxes control, but, differently from the former cases, experimentations provide more cause for reflection over the infrastructural systems innovation and territorial vocations; this difference is due to the fact that in this case, two different geographical areas are compared in order to define the network optimization features in relation to specific local needs, thus testing the VVP as a tool able to foster the infrastructural distinction process (Kieny *et al.* 2009).

2.3 VIRTUAL POWER PLANT: PRACTICAL EXPERIMENT

Within the Fenix program, the Virtual Power Plant acquires innovative and peculiar features. It is called Large Scale Virtual Power Plant (LSVPP), thus showing its role as an instrument for assessing flexibility and integrating ability, in only one technological profile of different renewable sources supply systems, geographically scattered. The estimation of the system effectiveness refers to two application scenarios in extremely different areas: Working Borough Council (Great Britain), called North scenario, and Alava (Spain), South scenario. These areas differ from each other in terms of geographical and climate profile, social characterization and of the settlement structures typological and morphological configuration.

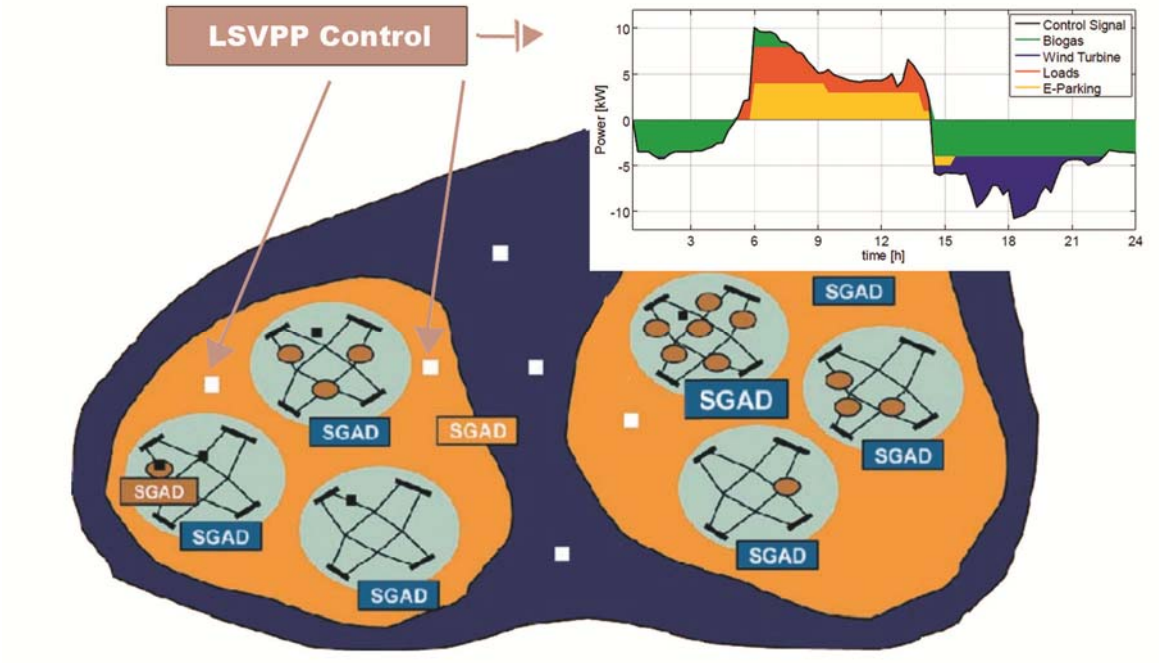

Fig. 3 The Fenix program tested the energy supply different systems integration, these systems being implemented in different environmental areas. Through the LSVPP supervision, optimization scenarios concerning energy efficiency and cost throughout the day are identified

As far as the Working Borough Council study case is concerned, the plan of action has established the installation of intelligent meter aimed at supervising the small plants already distributed on the territory analysed. The aim of such an installation was double. On one hand, the experimentation surveyed the energy system behaviour by changing the perspective from a single system logic to aggregated profiles, thus converting itself in an infrastructural system. On the other hand, it assessed the supplying systems

pertinence in relation to energy final use; in other words, every supplying system in the whole structure acquires a specific weight depending on its contribution in that practical case.

As far as Alava study case is concerned, the proof program analyzed different varieties of built urban tissue. In this case, the electricity grid covers an area of 2,963 km, with a population of 300,000 people and, consequently, a service addressed to 169,000 users living in different areas: 70% urban areas, 12% sub-urban areas, 17% rural areas. This experimentation involves all the renewable technologies: Aeolian, photovoltaic, cogeneration, micro hydroelectric and biomass systems. In such a case, the technological diversity made possible testing activity and reactivity to the assembled systems local context circumstances, thus providing differentiated assessment of the renewable systems that can be used in relation to the typological and morphological features of the settlement structures.

In both cases, energy systems pertinence was assessed through simulations of virtual production and consumption cases, by the VPP implementation.

3 VIRTUAL POWER PLANT: A TOOL FOR TERRITORIAL VOCATIONS

The Fenix program emphasised the several aspects the VPP involves. One of the first aspects is the operation supervision of the several systems whose complexity varies with the networks extension as well as with users and with the riches of connected supplying systems. In this sense, the VPP turns to a Technical VPP (TVPP) whose task is coordinating the several information for the network operations; for instance, the several intermittences coordination and, consequently, the different intensity and frequency profiles, associated by assuming a hybrid photovoltaic and wind system. Another meaningful aspect lies in the possibility of constructing virtual scenarios or controlling and adjusting the real ones to current needs. This is a regulatory tool thanks to which the VPP turns to a Commerce VPP (CVPP) programmed in order to balance the different components features in relation to the optimisation of consumption, monetary costs, environmental carrying capacity and market regulations.

The aspects experimentations emphasised are significant and the technical feasibility resolution represents a starting point in relation to the innovative themes discussed. Since the Fenix Program closing (2009), other experimentations on VPP have been fulfilled, increasing these new machineries possible implementation. Consistently with this continuous increase, this survey will is suggesting a capacities transfer of the new instrumental systems as urban and territorial renewal tools. In this sense, the Fenix program stresses some peculiarities of the VPP as a tool for:

- programming the potential levels of the territorial renewable energy infrastructures;
- assessing the territorial energy vocations, in agreement with the local context material and immaterial conditions;
- planning connections between physical structures and energy and information flows in a single optimisation profile;
- testing the technical, adjustable and resilient operation for an active energy system.

Emphasised in this way, the innovation profiles produced by the VPP show direct connections with the urban planning and design processes, where the new equipment implementation makes possible and beneficial the development of rising capacities such as:

- the technological capacity of choice making, defining priorities and differentiating energy on the base of territorial needs and vocations, which can be estimated through active and analytical processes;
- technical capacity of introducing environmental variables in the different levels and phases of the energy system construction, involving the innovative rules concerning the settlement physical structure;

– the capacity of managing an energy dynamic and interactive chain; from this perspective the Prosumer (producer-consumer) is a central figure which gathers all the social, legal and economic innovations, associated to the new energy model.

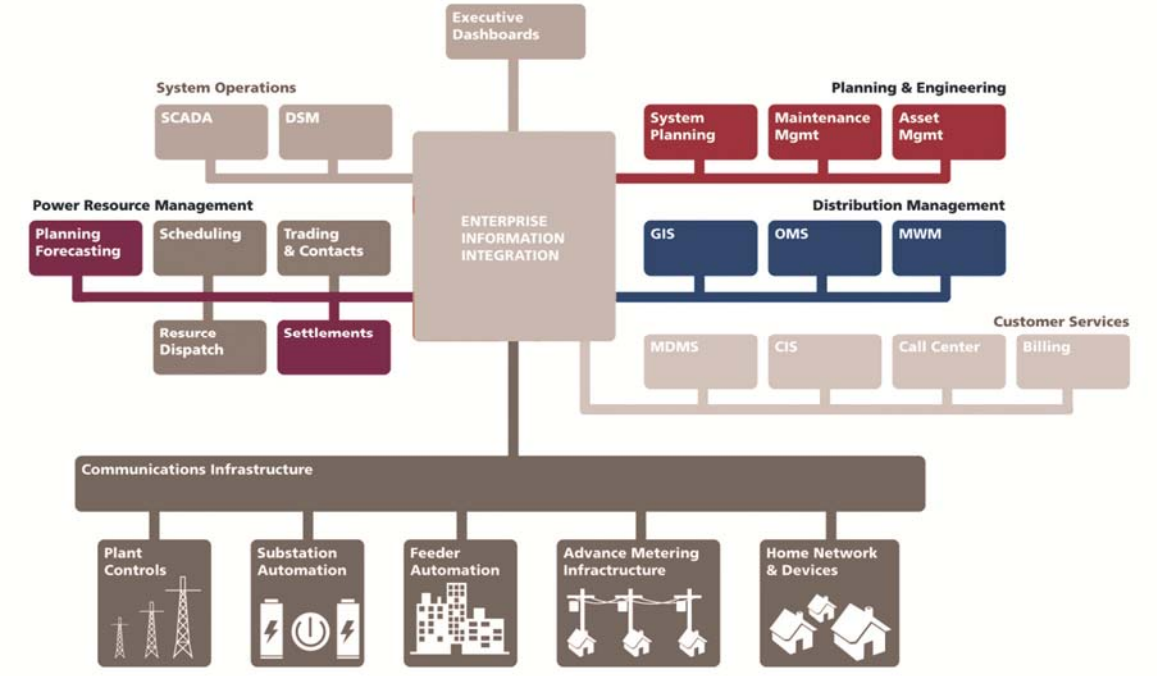

Fig. 4 The ability of testing information complex fluxes can envision new developments of the energy – settlement shapes interaction planning and management. Therefore, new key concepts and energy planning priority elements are conceived.

3.1 IMPLEMENTATION FEATURES

Introducing innovation profiles within weak and little accustomed to change infrastructural systems such as the fossil system, involves a series of normative, technological, social and market obstacles. Electricity Networks Europe program, and in particular way, the surveys submitted suggest innovative feasibility exactly through the DER system integration in Micro Grids, which are organized by VPP capacities. The micro dimension, indeed, represents in the short term the best intervention scale to work out a kind of complexity that might be too high, taking the risk of causing the failure of an actual opportunity for the settlement structure renewal. The network logic, by virtue of VPP adjustment capacities, makes possible in the medium term aggregations in increasingly large units with an increasingly big importance both for the energy free market logics and for defining a specific territorial energy planning.

In relation to the state of art as well as to European energy policy orientations and Horizon 2020 research themes, it seems worthwhile declaring the presence of a urban intelligence as a rising capacity of a complete balance between technological innovation and environmental quality, this being a balance where energy infrastructural innovation might work as an instrument for the mandatory need for counteracting the settlement structure uniformity and vulnerability. It is on the base of this need that the VPP analysis should turn from an engineering perspective to a larger scientific disciplinary perspective, since the energy and information flows synchronized control represents an impulse to contrast the environmental unconcern forms.

The new interactive renewable off-center infrastructural energy model calls for the capacity of modelling the complex dynamics and interdependence among fluxes, through a synchronized involvement of the economic, environmental and technological aspects. The fulfilled surveys show that the implemented experimentations

are all subordinated to the construction of work tables which are rich of stakeholders. Actually, it seems it does not exist a mechanically established model able to consistently foster the configuration of a micro grid. Despite the innovations and the capacity just emphasised, new generation machines still have the same problem as the previous generations: this is a technology which a sense and a value should be assigned to. In relation to this aspect, the study cases analysis was aimed at estimating the purposes and the strategies implemented in order to diffuse the DER systems; particularly, the survey documented a series of cases where the VPP role proved to work as a structure for programming, assessing, planning and testing the micro grid typology. The implementation features suggested refers to material and immaterial actions able to explain the several aspects it is worth taking into account; furthermore these features are addressed to all the subjects and spheres likely involved. In general, they are aimed at facilitating the introduction of innovation profiles within local peculiarities, thus recommending themselves as a benchmark for the building of work tables able to bring out implementation priorities and peculiarities related to the surveyed context.

3.2 STRATEGIC PROFILE

As it has already mentioned, the DER implementation systems through the VPP are based on a series of purposes and strategies which can be changed and upgraded; they are summarized below.
Purposes:

- Introduce DER systems in urban design and planning.
- Disseminate actions to build supply chains of local micro-grids.
- Determine opportunities for social-economic development related to the local micro-grids.
- Optimize quality and performance of energy supply and storage equipment.
- Develop advanced management strategies for the local micro-grids.

Strategies:

- Implement training and disseminate useful information to the energy operators who will be involved in the project DER.
- Organisation of workshops to involve local operators and actors in order to overcome barriers and start building appropriate energy supply chains .
- Establish differentiated incentives according to specific DER systems .
- Test the Large Scale Virtual Power Plant (LSVPP), evaluating the flexibility and controllability of energy supply and the provision of specific ancillary services for the local context.
- Implement the potential of the most effective forms of Renewable Energy Production and the most appropriate technology of energy storage, in single or diversified form, and manage them through integrated platforms (LSVPP).
- Define technical, economic, social and regulatory aspects for the integration procedures of each specific DER system.
- Quantify, through simulation tools, the impact of DER penetration, in order to design more effective cost allocation systems of local energy trade mechanisms as well as the most appropriate ancillary services.
- Preparation of specific databases containing information on public and private buildings as well as on the geographical and climate conditions needed to configure the type of DER system.
- Evaluate the potential of local energy market and demand for energy in order to simulate development scenarios for the integration of DER systems.

– Prepare recommendations and action plans at a local level for the implementation of policies to develop "green" local grids.

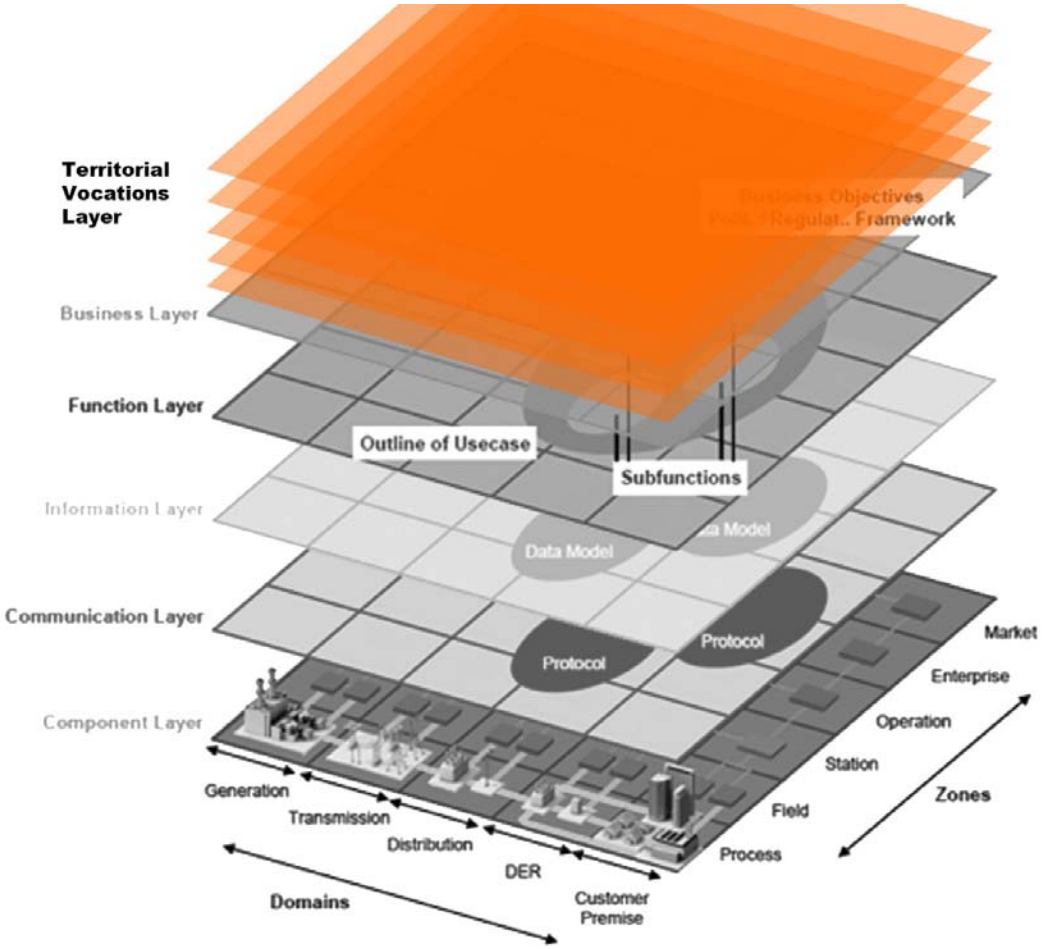

Fig. 5 One of the still open challenges consists in using the VPP in order to integrate territorial vocations in the local planning reasoning, these vocations being, for example, the energy potentialities of specific territorial areas.

4 CONCLUSIONS

Thanks to the survey here submitted it has been possible to bring out the fact that the interactive, renewable, and distributed energy model nowadays represents a considerable infrastructural system for the purpose of helping to build Low Carbon Cities. Furthermore, the survey was aimed at emphasising other aspects besides the technical capacity, thus involving the sense and value both of the technological innovation and of the environmental qualities, which can be related to the VPP implementation possibilities; as a consequence, the VPP is suggested as an appropriate tool for the environmental technological management of the new energy model. It has been emphasised the VPP capacity, on one hand, of integrating the complexities derived from local geographical condition within its own operating procedure, and on the other hand, of managing and coordinating the energy and information flows inside a high technological diversity system. Moreover, the new tool the survey suggests is able to: show the regions energy vocations during an urban development planning phase; explain through virtual simulations the efficiency of the physical integration process between settlement structure and sustainable energy system; supervise during the operating phase the different operating levels, thus adjusting itself to the external circumstances changes.

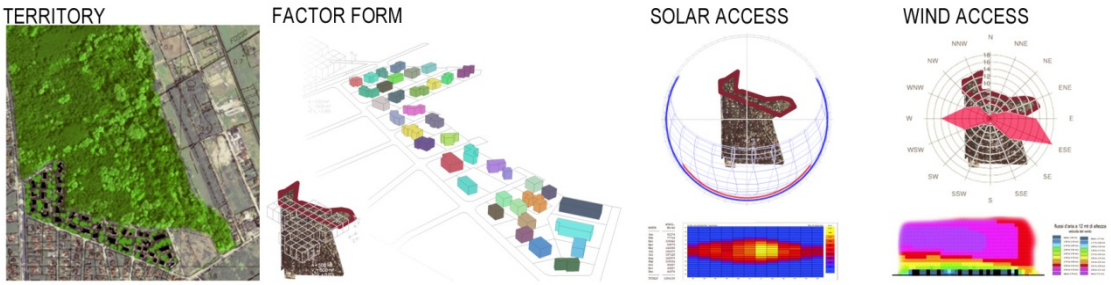

Fig. 6 Case study in progress: Regional Park San Rossore, Tuscany, Italy. The pictures show the energy territorial vocation which come into view at different examination and information levels. This information could be managed by the VPP, optimizing integration in the planning tools.

Furthermore, the survey collected and sorted a sequence of purposes and strategies aimed at fostering the integrated implementation of the VPP meant as urban renewal instrument. Concluding, the analysis here discussed represents a contribution for the success of a new infrastructural model which proves to be more suitable to the interactions between material and immaterial processes; this model is observed in the similarities between Large Scale Virtual Power Plant and Large Technological system. Quoting Zeleny, these new technologies can be defined as "High Technologies" able to work efficiently on their own if it is possible to discover their components and interactions, and their overall symbiotic action within human systems (Zeleny *op.cit.*). Therefore, new generation machines can foster an appropriate social conversion alongside the technological one.

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IMAGES SOURCES

Fig. 1-2: Advisory Council of the European Technology Platform (ETP) (2010), The Smart Grids Strategic Deployment Document, Brussels, 44.

Fig. 3: FENIX program, modified by author.

Fig. 4: Advisory Council of the European Technology Platform (ETP) (2010), The Smart Grids Strategic Deployment Document, Brussels, 26, modified by author.

Fig. 5: SG-CG/M490/A Framework for Smart Grid Standardization, modified by author.

Fig. 6: Images processed by the author.

AUTHORS' PROFILE

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