Smart tools for energy resilient city

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ABSTRACT. *The contemporary city, for its complexity, often fails to give answers to the various problems concerned with environmental hazard and with energy supply.*
The assumed paper, in line with what is stipulated in the field of Smart and Sustainable Cities, is aimed at achieving efficient management of urban resources through a number of actions concerning the urban "layout" (urban morphologies and relationship between settlement areas, attractors and traffic generators); energy efficiency (which you get with the reuse of waters), buildings (concerning the reuse of waters for heating), mobility (through the development of a system of green infrastructures and means of electric and hybrid mobility), water quality (through constructed wetlands trails and sewage for agricultural purposes), air quality (through solutions aiming to favor the development of alternative mobility). It is also planned the implementation of Community policies such as the "EU Water Framework Directive", the "EU Biodiversity Strategy to 2020", the "EU Climate Change Adaptation Strategy", "The Blueprint to safeguard Europe's water". some best practices Are presented as Rotterdam, Heerlen and Turnhout that show how energy is integrated in the urban support scheme.

RÉSUMÉ. *Pour sa complexité, la ville contemporaine manque souvent de réponses aux divers problèmes liés aux risques environnementaux et à l'approvisionnement en énergie.*

Cet article supposée, conforme à ce qui est stipulé dans le domaine des villes intelligentes et durables, vise à réaliser une gestion efficace des ressources urbaines à travers un certain nombre d'actions concernant le «disposition» urbain (morphologies urbaines et relations entre les zones de peuplement, les attracteurs et les générateurs de trafic) ; efficacité énergétique (que vous obtenez avec la réutilisation des eaux), bâtiments (concernant la réutilisation des eaux pour le chauffage), mobilité (à travers le développement d'un système d'infrastructures vertes et de moyens de mobilité électrique et hybride) ; qualité de l'eau (par des sentiers de zones humides aménagés et des eaux usées à des fins agricoles), qualité de l'air (par des solutions visant à favoriser le développement de la mobilité alternative). Il est également prévu de mettre en œuvre des politiques communautaires telles que la "Directive cadre sur l'eau", la "Stratégie de l'UE en faveur de la biodiversité à l'horizon 2020", la "Stratégie de l'UE en matière d'adaptation au changement climatique" et le "Plan directeur pour la préservation de l'eau de l'Europe". Certaines meilleures pratiques sont présentées

comme Rotterdam, Heerlen et Turnhout qui montrent comment l'énergie est intégrée dans le programme de soutien urbain.

KEYWORDS: urban performance, smart resilient city, smart tools.

MOTS-CLÉS: Performance urbaine; Ville intelligente et résiliente; Des outils intelligents.

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1. Introduction

In the sixties, the researches of urban themes are faced with the growing wave of social conflicts and environmental emergencies that impose new challenges and theories. Different thoughts have been produced about the city's crisis, but the city is still unprepared to give clear answers. Expectations towards a renewed offer of cities have increased in the meantime.

It is clear the increasingly difficult role of architecture and urbanism in the "construction" of the ideal cities: from the undifferentiated demand for basic services, more and more individual requests are increasingly diversified. The recent focus is on the new design requirements and criteria of performance that the city, as an urban "organism", must possess in order to meet the challenges of modernity, the demand for urban security, social inclusion, accessibility and energy saving, performance services, rationalization and optimization of environmental resources and energy efficiency as a whole. But what are the tasks and the conditions that favor the performances of the cities? First of all there is the task connected with the need to improve the cities' energy performance. The energy problem becomes, every day, more pressing for our planet. The demand for fossil fuels starts to exceed the supply, with the consequent increase in costs. To attempt a resolution it is necessary to intervene on those places where there is the greatest expenditure of energy, i.e. inside the cities (Albrechts, 2006; Albrechts, 2006; Avarello, 2000).

In cities there is an energy consumption equal to 75% of the total energy and a production of climate-altering gases equal to 80% of the world's production. Cities are among the most responsible for climate change; the activities that take place within them represent direct and indirect sources of climate-altering gas emissions. Cities, according to a study by the United Nations Intergovernmental Panel on Climate Change (IPCC), are responsible for 75% of global energy-related CO2 emissions, and produce 40% of global greenhouse gas emissions. This situation will be further aggravated as a result of the current urbanization process which will increase the percentage of the population living in urban centers from the current 50% of the world population to 60% in 2030 and to 70% in 2050. At the same time the world population will continue to grow above all in the poorest countries.

As highlighted, the contemporary city, for the complexity that distinguishes itself and for the political and technical difficulty of territorial government, often fails to give answers to the countless urban problems in terms of containment of energy consumption, efficiency, performance of services and infrastructure, technological risk, social inclusion and urban security.

Atmospheric and water pollution, non-optimal waste management, social

segregation, energy inefficiency, consumption of soil and non-renewable resources, the environmental impact of new interventions in saturated systems, impose certain responses in terms of new methods of building and managing the city in its systemic logic.

Some cities, which have a historical delay in the adaptation of collective services and equipment, are now unprepared to give adequate answers to the diversified demand for increasingly specialized services, of accessibility and use of the city performance, of need for energy saving. The main task is to optimize the relationship between city and energy and to achieve this goal by creating a synergy between smart cities and smart communities.

The city, therefore, must renew itself, must face the complexity of the issues related to its being a "contemporary" city, a city of change. But there is a structural gap: the city does not succeed in following the "times" and the speed of the social and physical transformations. In the various sectors (building, transport, energy, environmental...), practices with a sectoral terrain are experimented, albeit with a high degree of deepening, and are difficult to connect in a systemic logic. The city is not considered an organism but a sum of parts that hardly interact with each other; the objectives achieved are sectoral and do not produce the multiplier effect deriving from the application of a systemic approach.

In the absence of a timely and adequate design response, the city suffers planning inertia, the lack of future strategies and visions, the lack of adequate interventions for resilience.

Resilience is one of the last challenges of contemporary planning, it requires forms of adaptation to be implemented at local level, studying the vulnerabilities, the fragilities, the risks, the interventions to be implemented and the possible solutions. The ways to make resilient cities must include solutions that can guarantee their functioning in a constantly changing environment, ensuring the resilience of the entire local/regional system.

It is needed to intervene with a "shock therapy", because more a city is refractory to changes and less willing to get involved, then invest in itself and attract the "opportunities" for renewal requested by the European funding for the urban polizie. Assuming that the urban morphology, the density of the building, the typology and the final mix can contribute to improving the energy performance of urban areas, the question is how new smart planning models - proposed or in use - can guarantee energy control (Fazia, 2012; Moraci and Fazia, 2013).

The achievement of energy efficiency thresholds - to achieve by implementing the smart planning - could give the possibility of conveying territorial brands, that is to say the qualifications and awards recognized to virtuous cities (a sort of energy efficiency brand). This brand will become a reward measure - through the signing of specific "Contracts for energy resilient city" - and an incentive for the participation in the implementation of the interventions. The energy resilient city contract takes the form of a multi-sectoral participatory process, aimed at the integrated management of the territory of the networks and its resources and the system of this

process has as its final outcome the punctual "local voluntary agreements" in the various territories, therefore operational acts that are agreed between the administrations, the citizens and the representatives of the categories that have interests linked to the territories (for example the world of production, trade associations, citizens associations, etc.) (Moraci and Fazia, 2013). The innovativeness of this tool is therefore in the fact of wanting to be a contribution to overcoming the logic of the territorial emergency made more and more vulnerable by the lack of maintenance, wanting to put in place an integrated policy that involves all stakeholders to active prevention and capable of producing positive consequences also on an economic level.

2. Smart approaches for a resilient city

The focus is on the efficiency of transport networks, on the control of morphotypological and performance elements, on the organization of the city (settlement areas, attractors and traffic generators), on urban dynamics (mobility, use of services, distribution of residences, activities, ...), from which derive energy demand and consumption, higher environmental and social cost of transport. To make the city resilient, it is necessary to optimize the environmental performance of the territory (maintenance, recovery and design adjustment) consolidating and engineering the security conditions in terms of improving the quality of life, strengthening of services and infrastructures capable of triggering user satisfaction, accessibility, alternative mobility and territorial welfare (Savitch and Kantor, 2002; Sasso, 2003). To do this it is necessary to define a smart planning through which to plan interventions to improve the performance of buildings (relating to the reuse of water for heating), mobility (through the development of a system of green infrastructures and means of electricity and hybrid mobility), water quality (through construction of wet paths and sewers for agricultural purposes), air quality (through alternative solutions) (Gastaldi, 2003).

The smart approach defines the homogeneous criteria to be used for the control of the effects that the urban layout - its implications and overall functioning - produces on the ability of cities to be smart. The transformation of a city into a "Smart City" involves investments and interventions in all sectors, from energy to mobility, from the economy to urban planning, in an interdisciplinary context aimed at optimizing resources and results

Fundamental for the success of a Smart City is the adoption of an overall strategy of interventions framed in a unitary and coherent design and aimed at the realization of one or more clear and defined, scheduled objectives, in order not to disperde public and private investment.

Therefore, according to the Smart City approach, this ambitious goal can be pursued exclusively by setting up, on a synergistic and reticular basis, and in an eco-sustainable way, multiple areas such as the avant-garde urban-architectural paradigms, strategies of futuristic transport, innovative tools for the production and use of energy resources, advanced policies for safeguarding the eco-system and

waste collection and transformation, intelligent governance and supervision systems and pervasive ICT technologies.

The principle of efficiency is at the basis of the planning and performance on which the agenda of all renewable cities is based, while the principle of energy conservation is at the base of the civic behavior of the citizen. For this reason, the smart city must weld "city instances", transform the detractors of urban quality (and the contingent problems that are inherent in every urban reality) into new quality and performance requirements; it must face the rapid extension of the residential, commercial, industrial and tourism fabric, energy inefficiency and climate change with suitable tools to support smart growth responding to the challenge of increasing its competitiveness, identifying forms of service and models of innovative management that, with regard to the types of envisaged activities, are able to effectively use the available resources (Janin-Rivolin, 1999; Eger, 2009).

Improving the city-energy relationship means, above all, controlling the urban energy needs/consumption and the production of alternative energy, but also implementing energy-saving measures in all sectors. Understanding how the effective involvement of all sectors of "urban life" can contribute to the creation of the smart city.

A smart city must favor the use of sustainable energy sources and the consequent reduction in the use of polluting substances; the building sector contributes to the design of green buildings with low environmental impact, using renewable resources for the production of electricity and heat; Infrastructure connectivity is essential for the implementation of the smart city and for its economic development. Mobility is conceived in a green key: the intelligent public car parks located outside the city and well connected to the urban hub allow a significant decrease in urban pollution and the use of car sharing (and bike sharing, car pooling, smart electric recharges, precision navigation, info-mobility) is an economically efficient, low environmental impact practice, perfect for optimizing city mobility, avoiding waste and pollution (Mezzi and Pelizzaro, 2016; Galderisi and Ferrara, 2012; Union, 2011).

These are the milestones of the biggest smart city projects: the Dubai Smart City project involves the sectors of economy, transport, but also energy resources, passing through the building sector and urban planning. With the Smart City project, Barcelona’s government promotes digitization aimed at speeding up services. The Singapore project has a more complex connotation: the Malaysian capital has created the Singapore Smart Nation program, to bring innovation and efficiency throughout the nation. Singapore uses detection devices to monitor traffic, indicate break-ins or report hazards (data related not only to the movement of citizens, but also to consumption and their habits in such a way as to allow the Government to act in case of emergency). Transforming the smart city into a "smart platform ".

"Safer Milan" is the initiative able to make the city of Milan safer through the use of new technologies, especially on the cybersecurity front, but also to encourage innovation and training activities. Within the project there is the Security Operation Center which integrates the physical security systems, of traffic and environmental monitoring already in operation, with adequately protected networks and platforms,

using the most advanced cybersecurity solutions". The only common denominator among the various smart city plans announced around the world is connectivity. They call it "urban cloud" and it is in fact the new digital geography of our cities, which is realized starting from the continuous flow of data and information generated by the interconnection of active devices, both personal and automatic.

3. New smart tools for the energy resilient city

What is needed is also a tool for the control and manage of public spaces and services, for the optimization and safety of the urban facilities. That is to say, smart planning. It is in a nutshell the new model of integrated planning of the energy resilient city, which is not limited to standards and codes but it also provides the "participated" construction of cities (Fazia, 2011; Pitto, 2004; Scagliotti, 2008; Evola, Marletta and Cimino), the management of its implementation also through monitoring of environmental data. Within this new model, in which the smart sectors compete (mobility, waste, safety and security, sustainable construction, waste treatment, sustainable water cycle and land consumption ...), it is necessary to understand how urban organization can influence energy savings, how the management of transformations (urban planning) can determine the most suitable urban organization, how the relationship between energy consumption and physical and functional organization of settlements can influence energy savings.

Local authorities are key players in developing and fighting climate change. The European project launched by Oettinger for Smart Cities is ambitious, it is a cross-sector industrial initiative aimed at developing "energy-saving solutions in cities". The project is expected to evolve into a European innovation partnership, i.e. one of the flagship initiatives of the "Europe 2020" strategy. The political will, that accompanies the European Smart Cities iniziative, goes precisely in this direction: smart growth.

That is to encourage the competitiveness of urban environments by developing innovative solutions aimed at fighting climate change, but also social inclusion and mobility. It is also an opportunity for Italy to relaunch the dynamism of its territories and together promote the local and national industrial fabric that could be involved.

The expected impacts listed in the work program in relation to the smart city are to be linked to the re-launch and the projection of their skills in the local and international field and to the strengthening of ties with the territory, namely:

connect the plurality of subjects located in the Smart City technology supply chain in order to promote their cooperation and interaction, in order to achieve a new synergy between scientific and cultural skills and excellences and productive and entrepreneurial skills;

- establish a stable link between the world of research, the world of production of goods and services, the world of credit and the territory, in order to encourage the widespread development of innovation processes;

- facilitating the use of scientific and technological skills in the area and favoring users' access to knowledge and research products also through the progressive systematization of information, aimed at building shared databases;
- enhancing and facilitating access to research facilities and tools, including through the implementation of specific initiatives concerning the strengthening of infrastructures and intangible networks that make existing resources available;
- develop support interventions to favor the presence of the regional research and innovation system in major EU and international projects;
- provide network services to small and medium-sized enterprises and activate interventions aimed at fostering collaboration between companies for dimensional growth and internationalization;
- to stimulate industrial research, increase patent capacity and support pre-competitive development;
- promote the development of technological entrepreneurship in the relevant sectors with the creation and strengthening of new high-tech companies;
- promote higher education, encourage the inclusion of highly qualified human resources in the companies in the supply chain, spread the culture of innovation

Starting from building sector, all buildings can be managed remotely and will have automatic and intelligent systems to reduce consumption and prevent accidents. The new buildings, it is hoped, will be not only anti-seismic, but also able to guarantee security in case of floods and extreme weather events. Then the cities will be more populous and above all more densely populated, with population concentrated in a relatively small area: this will allow less consumption of land and increase efficiency in terms of urban travel and domestic consumption. With the goal of achieving total energy self-sufficiency. New models for food production will emerge in cities: urban agriculture will include innovative and experimental systems, greenhouses on roofs of buildings, vertical gardens, automated farms, vegetable gardens within schools and companies, collaborative cultivation and domestic systems of agricultural production (Moraci *et al.*, 2018).

4. Smart cities and resilient environments: Rotterdam, Heerlen and Turnhout

The Netherlands is a fragile and vulnerable land; spatial planning is very important, just as important is the resilience of the system and its adaptation to climate change. Rotterdam is a delta city and, in a period of heavy climate change, it will experiment more extreme weather conditions, such as heavier rainstorms, longer periods of drought and more heat waves, as well as higher water levels in the river Meuse; so is important to know that it is a deep vulnerable city and need right

strategies to overcome the problem and to be adapted to conseguences of climate change.

The water, in its countless garments, is the center of the city and of the urban project and it is often precisely the element that qualifies it, making it sustainable and resilient; water has to be used but it is also the main component of a series of hydrogeological risks from which we need to protect ourselves. Climate change is taking place in a changing world; in the water cities, urban projects that are aware of the fragility and vulnerability of the territory must be promoted (Galderisi, Ferrara, 2012). It is necessary to implement urban resilience actions able to mitigate natural risks by converting territorial problems into territorial resources and opportunities. There is a need to implement a conscious and smart urban governance and to undertake urban awareness actions aimed at the awareness of the community; a community which becomes an active part in promoting urban resilience policies and in creating a sustainable city.

Rotterdam has been protecting itself from the threat of the water from the rivers and especially from the sea for centuries. The dams and dikes, belonging to primary and secondary defenses, have managed the risk of flooding and have helped the drainage of urban land. For this reason Rotterdam is considered one of the safest delta cities in the world although Rotterdam iso ne of the most vulnerable city in the world. The Rotterdam Programme on Sustainability and Climate Change focus on some priority, on some urban topic such as enhancing sustainability, producing a greener and more Energy saving environment, reducing CO2 emissions and working with polpe and communities to promote awareness for the best management of natural hazards and resources. (Wapperom, 2010; Rotterdam, 2016; Commission, 2008).

Rotterdam is an example of resilience and adaptation to climate change; the theme of urban resilience has been under the attention of the municipality for about fifteen years and Legambiente has included the Dutch city as one of the examples to follow in the 2017 "Cities to the challenge of climate" dossier; moreover, in the central districts of Rotterdam, urban retrofitting actions are experimented through new technologies and new functions applied to existing structures, and in line with the climatic changes taking place.

Rotterdam is also experimenting with some innovative building technologies; for example, is adopting architectural technology solutions that adapt to the fluctuation of water levels with the introduction of the obligation, by 2025, to create sustainable constructions with floating quarters, in areas outside the banks; the urban water system is also being resilient with the creation of tanks for the storage of excess rainwater (Commission, 2008).

Rotterdam is the inspiring example to other delta cities around the world going through a sustainability approach; as a green city is an attractive and resilient city where people love to live, work and relax; sustainability is an integral part of all area development projects in Rotterdam; sustainable areas are future-proof areas with good living conditions. The Rotterdam City Council is committed to making Rotterdam a leader in sustainable urban living.

The front runner position of the Heerlen and Turnhout site is based to show how this kind of energy (low-exergy) is utilized and integrated in the urban support scheme. This approach will be able to generate idea's, concepts, strategies, business cases and real data on that issue. Turnhout and Heerlen focus now on optimizing the energy flows in the DHC-grid (district heating and cooling grid) (Borelli, Repetto and Schenone, 2017; Balocco, Rocchetti and Niccolai, 2018).

Heerlen is developing a use of thermal water as energy for heating. The city Council implemented a strong use/recovery of energy from water. In Heerlen, the Mijnwater project originated from a Interreg IIIb pilot and is developed to supply heat and cold to 150.000 m2 building area. Mijnwater has a mission to substantially contribute to the ambition of the region to become energy neutral. To reach this aim Mijnwater is adding intelligence and sustainable sources to the grid, as such growing towards a full 4-th generation DHC-grid. Mijnwater has the experience of developing a DHC grid in a green field environment and is still expanding its working area towards 200.000 m2 (500 dwellings, offices, sports centre, supermarket, hotel, data centre, etc.) and further on. Implementing new groups of customers and new techniques will extend this experience, which can be applied to other regions. Mijnwater also is able to deliver energetic, financial and technical KPI's and can act as a living lab for testing new ideas. They are very advanced in getting heat and cooling energy out of water; the water is in mine pits all over the city. The storage capacity is calculated to be equivalent to the thermal capacity of 1,4 million Tesla car batteries. Mijnwater BV is the operating company of the Municipality of Heerlen to develop, exploit and innovate the low-exergy DHC-grid based on shallow geothermal energy. The project developed in Heerlen won the European Geothermal Innovation Award 2015.

Turnhout in Belgium, experimented since 2005 the implementation of a very proactive plan to provide sustainable heating in the city region, involving various sources inclusing geothermal energy is being worked out. The masterplan includes a sustainable heat net in the city, with a planned integration of using geothermal heat. In 2016, the first small district heating grid in the city (one of the first in the country) was taken into service with a bio mass boiler as the transitional technology. This system is being expanded, to supply 600 homes an office building. The goal is to scale the system up, to be able to support a business case for additional wells to be drilled for geothermal sources. At this moment a second area in the city could be integrated in a heat grid, including 2.800 new houses and an existing, but to be expanded, large regional hospital. Historical heritage (e.g. the Castle of Turnhout, built in the 12th century, today in use as a court house) that could be connected to a heat grid with renewable geothermal energy, can be converted to a sustainable building, without impacting its cultural and historical value.

5. Conclusion

From the analysis of the experiences carried out in this manuscript emerges that the project and the management of the city through smart planning must contribute to the achievement of some main macro objectives in terms of:

- an improvement in the relationship between urban form and energy consumption; favoring through appropriate design guidelines for eventual redesign of the spaces and for new interventions, the appropriate actions to achieve the best and most effective compromise between form and energy consumption;
- an improvement in the relationship between smart buildings and smart cities; the design of the smart city will involve, in particular, residential and specialist buildings (structures, systems and external elements) and their relationship with the functionality of the system will be verified through an IT device at the service of the urban management;
- the setting up of the technologal systems and of the infrastructures network in the ground and in the subsoil;
- the improvement of energy use for different human activities through appropriate IT tools;
- organize and optimize pervasive ICT technologies, Smart Grids, decision support systems, advanced services for citizens, Smart Buildings, sustainable mobility of housing quality and security in a single laboratory for the city of the future.
- Intervene in existing sensitive nodes to transform them physically wherever possible, and submit them to "computer" and / or structural controls for all sources of risk (pollution, technological risk, social segregation ...), for a smart city-smart living.
- Ensuring monitoring, designing monitoring systems and defining factors for quality control.

The Rotterdam's experience shows that there is the need to implement a conscious and smart urban governance and to undertake urban awareness actions that aim at the awareness of the communities, which becomes an active part in promoting urban resilience policies and in creating the sustainable city. The involvement of private is also crucial, taking place in two ways: firstly, individuals are involved in the thematic awareness process and become aware of the environmental risks associated with climate change; secondly, precisely because of this mature awareness, they become an active part of the adaptation policy by implementing some strategic actions in the areas they own or by encouraging participation in the case of interventions in public areas through forms of associationism and smart communities.

If the meaning of "Smart City" in its complexity includes Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, Smart living, we are called on to develop - working in close collaboration with public and private entities that operate on territories - a platform design, a set of actions that aim to make them "smart", as it can produce high technology, reduce energy consumption in buildings, promote clean transport and improve the overall quality of life of all its inhabitants. The prospect of smart cities is to think of urban organisms that produce

a better management from their own internal capacity, mobilizing technology and behavioral resources, capable of making more sustainable, and therefore more attractive, the urban environment. The environmental virtuosity has to be a common element of all the smart and resilient city.

La Progettazione della città smart attraverso lo smart planning deve stabilire i criteri progettuali legati all'efficienza energetica, mettere a sistema le diverse componenti della filiera smart, e anche i risultati e le esternalità del progetto per consentire la mappatura ed il controllo del comportamento ambientale ed energetico degli edifici.

Resilient city is a conquest of contemporary planning, deriving by smart tools applied to cities and urban settlements to govern and manage urban transformations in relation to climate change and mitigation of environmental hazards. Resilience is a concept comprimed in the meaning of smart city and, contempled in the paradygm of smart planning. Smart city is caused by smart planning that has the resilience as one of its main aims. (Bagnasco, 1999; Cancilia and Bosso, 2012). Resilience thinking has to be incorporated in the policymaking and initiatives across all domains of city government, including across social, physical and economic programmes. This could promote the implementation of a really smart, cohesive, inclusive and resilient city (Pietro, 2004).

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