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EUROPEAN PATHWAYS FOR THE SMART CITIES TO COME

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c/o SIT*d*A onlus,
Via Toledo 402, 80134 Napoli
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INTRODUCTION

Mario Losasso,
Department of Architecture, University Federico II of Naples, Italy
mariorosario.losasso@unina.it

The opportunity offered by the dialogue with prestigious research structures such as the European Energy Research Alliance (EERA) is an opportunity to set up common scientific activities for SITdA, the Italian Society of Architectural Technology. Important public organizations, research centres and universities are affiliated to EERA and set their own scientific focus on policies and practices related to the development of innovative technologies for energy efficiency. In the presentation of the Special Issue on the theme of smart cities, the presence of the contributions related to the EERA research activity, includes scenarios of great interest for scientific cooperation within the European Strategic Energy Technology Plan and aimed at reducing emissions of greenhouse gases and the promotion of new energy technologies.

Both EERA and SITdA are related to scientific communities oriented to complementary research fields as well as to sustainable urban and territorial strategies, in which the energy factor is linked to the urbanistic field and to the climate responsive and energetically efficient settlement principles, identified as qualifying elements for resilient cities and characterized by a reduced degree of environmental vulnerability.

One of SITdA most important mission is to promote scientific dialogue in the field of technologies. From this point of view, in the urban context the theme of smart cities is relevant among those in which we note the combination of technological innovation and governance of resources and territorial development strategies. The start-up phase of the Joint Programs - JP on Smart Cities presented in Special Issue of Techne Journal represents a significant moment for the dissemination of highly qualified research contents on energy efficient cities that interact with European culture of smartness and reduction of impacts and fossil energy consumption.

It should be noted that the theme of smart cities has evolved extensively in recent years through interesting declinations and evolutions for scenarios in which urban centres will be conceived as complex entities that can self-adapt and self-regulate through the continuous flow of information, according to feed back loop processes.

The smart cities in the contemporary age are the mirror of the instauration of the innovative relationship between people, urban spaces and new digital technologies. From ICT - Information and Communication Technology - with the purpose of collecting, processing and transmitting information, we have moved on to the pervasive digitalization of the world around us. This approach represents a threshold of technology that breaks away from conventional visions, addressing a turning point towards the future of the digital revolution.

Urban development in the digital age leads to a decisive rapprochement between safe, efficient and renewable energies with information technology and the built environment. Digital tech-nologies lead directly to the definition of a new intangible urban infrastructure composed of data and information, intangible ele-ments that heavily affect the urban physical system. It is a subject that is always less a frontier and that will become an integral part of the contemporary habitat. The physical places will be inte-grated with data and information, with lifestyles and innovative concepts in the use of material and energy resources. The smart city is an intelligent city especially for the communities that live there. Intelligence is pervasive, thanks to the use of devices and strategies aimed at overcoming environmental, social and eco-nomic criticalities, in which the quality of housing is guaranteed by the diffusion of new technologies.

New systems of relationships are triggered within smart cities, such as those between urban density and energy efficiency, but also those of distributed renewable and interactive energy sys-tems, conceived within broader strategies of urban energy ret-rofitting of existing buildings. This objective is integrated with one of the most important European strategies on Neraly Zero Energy Buildings, provided for in Directive n. 31 of 2010 and being implemented within the technical policies of the member states. In the field of energy efficiency are included the new concepts of Hybrid Buildings, that are innovative in environmental be-haviour and in their changes regarding the management and processing of information flows. The complex urban system is then measured by new methods for the assessment and manage-ment of consumption and energy efficiency at the urban scale where the themes of smart energy are expressed as a new Euro-pean frontier in the field of applied research, expanding to the regional contexts with interoperability and appropriate smart city networks.

Urban intelligence is therefore placed at the service of housing quality, with conditions of well-being, security and urban gover-nance. The transformation of our cities into smart cities is there-fore implemented with the progressive integration of new digital services and technological infrastructures within the territory. This is the result of the intersection between human capital and social capital from which emerges an intelligence that, to be capable of future must inevitably be collective.

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FOREWORD

Paola Clerici Maestosi,
Coordinator for Scientific and Editorial Board of European Energy Research Alliance Joint Programme
on Smart Cities, ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development paola.clerici@enea.it

A time of challenges, great societal challenges

This was the common thread across all EU Research, Innovation and Development programmes, all Member States' activities, all RD&I programmes developed by leading countries.

To address these challenges, it is crucial to invest not only in Research and Innovation, but also in Development - with a focus on human capacity building and on international research networks. Therefore, the Joint Programme on Smart Cities and all the researchers and research institutes involved are themselves a challenge, though on a smaller scale and with well-defined timelines and contents, yet an opportunity of strategic importance, as we will try to show in this special issue.

The Joint Programme on Smart Cities is a network of researchers, experts and stakeholders, with their own approach, their own perspective, their own heart; each of them has been trying to address the major societal challenges that research is currently facing as outlined in H2020 Framework Programme.

What did it mean for us to be involved in a research network?

To use a sports metaphor, it was like being part of indoor group cycling as opposed to outdoor cycling[1].

Taking part in a indoor group cycling session means having a common objective with the group and trying to achieve it, each rider with their own strength, their own resources, their own heart, sharing a common experience at the same time and in the same place.

Likewise, our research network - set up to support Human Capacity Building - can be described as a combination of training and discussion on a common goal, i.e. Smart Cities, where each of us contributed in different manners, according to their scientific background, experience, cultural heritage, endurance, and guided by their heart.

This is the meaning and significance of this special issue.

Other special issues will follow, one every year for the next two years.

The scientific-editorial plan is the following:

- this first issue is focused on the *European pathways for the Smart Cities to come*; it has been conceived and organized along a common pathway that each of us, perhaps unconsciously, has followed over the years;
- the second issue, which will be probably published in 2019, is dedicated to technologies, systems and tools, i.e. those technologies and enablers that were delivered by RD&I over a time horizon that matches, both symbolically and concretely, the H2020 programme's time frame;
- the third issue, which will be hopefully published 2020 - early months, is focused on Smart Cities as fundamental building blocks of tomorrow's low-carbon energy system.

It's a matter of fact that Smart Cities have already entered a critical stage: after many theoretical discussions, it is now necessary to develop a sustainable path of applications.

What is likely to change is the way we look at pilot projects: they will not only need to prove that they are technologically effective in reaching the desired results, they must also be able to help develop competitive and repeatable business models to be shared by the society, the citizens, the market as well as the industrial, political and financial sectors.

This is the next challenge for Smart Cities, and this is the challenge we would like to deal with in our third and last special issue: a much more difficult and complex, but no less concrete and realistic challenge. At this stage, the purpose is no longer to design solutions, but to make a strict selection of the ideas and proposals that - after the conceptual expansion phase of the previous years - will lead to the future of Smart Cities.

NOTES

[1] Cycling is as much of a group sport as it is an individual sport. When tackling long distances, you can ride farther and longer with more people by drafting (or breaking the wind resistance) off one another to preserve energy. Indoor group cycling is a great activity for a crew, since you can have all different ability levels pedaling together, and no one gets dropped. Even if you didn't know the person on the bike next to you, you feel bonded together by the effort of the tribe.

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ARCHITECTURAL INTELLIGENCE

Emilio Faroldi, Editor in Chief
Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano, Italy
emilio.faroldi@polimi.it

The charm of architecture lies also in its intrinsic quality of providing a concrete figurative and fruitive change of the spaces we live. It is difficult to discern when architecture reveals existing tendencies or when it represents a revolutionary element for the city - understood as a strategic improvement. The contemporary city appears to be fragmented into systems, fabrics and nodes, within which it is possible to individuate "partial cities", which can interact or, in other cases, conflict with each other. The invariants of the transformation process can be found within the history of the city, considered as an entity in continuity or in opposition to the thought expressed by the previous epoch.

For the first time, the Journal undertakes such important partnership, as the one established with the *European Energy Research Alliance Joint Programme on Smart Cities*. A significant step in thinking the future and its evolutionary lines, represented by the launch of a dialogic and research debate with a high scientific and sociological value for the cities of today and tomorrow.

Nowadays, the "Smart City" represents a concrete concept of development, able to provide answers to the needs expressed by the city users; a stage of growing interrelation, at all levels, between people, services, infrastructures and built environment. The city identifies a complex system, composed by an articulated network of connections: the constant demographic growth and urbanization dynamics feed a series of social, technical and organizational problems that deeply threaten the economic and environmental sustainability of territories.

In this logic, the concept of Smart City is increasingly becoming subject of study within the architectural debate; a new model of urban development, capable of realizing a credible and intelligent response to foster a sustainable socio-economic growth.

A reality can be defined "smart" when the investment of tangible and intangible resources in communication and information infrastructures, envisages a strategic economic development; an investment, oriented to the social capital and towards a high quality of life, through an active participation of users, productive realities, governance and institutional bodies.

There is no single meaning of the term "Smart City", nor codified parameters that can represent a univocal model and reference. Also, with reference to its etymology, the term "smart" is widely used in current language referring to indicators of environmental protection, public safety, public services and infrastructures.

The coexistence of ICT with the "city of stone" is producing urban assets, which are very different from those given to us from history. Cities become smart in terms of systematization of everyday practices, in order to support individuals, buildings, systems of flows; at the same time they aim to enable the monitoring, understanding and planning of the city, improving efficiency, equity and quality of life in real time. A shift of paradigm, which is influencing the design and planning forms on several spatial and temporal levels. A perspective, which foresees a more intelligent built environment in the medium and long term, compared to continuous but unproductive short-term reflection.

Realities require slow and long sedimentation times: the positive transformation of forms and habits follow these rhythms, influencing each other. What aggregates all the categories are the strategies aimed at defining a city, which considers that within a decade more than sixty percent of the population will live in a metropolitan environment. The concept of Smart City evolved over time also through recent technological developments, which combine networks and systems of immaterial connection. Modern ICT technologies allow the creation and development of integrated, shared and interoperable knowledge bases; a centralized optimization of information and a platform to support knowledge sharing and capitalization.

This monographic issue of the journal intends to address these levels of complexity, trying to tackle, in a scientific way, themes that concern a global sphere. A window on the topic, both in terms of geography and distribution, at different scales: from policies and strategies, to built environment transformations within the broader concept of Smart Cities.

Most of the topics are attributable to the concepts of flexibility, adaptability, versatility and sustainability, as well as innovative housing models: new forms of networking and different supply chains, tools and methodologies to support new designs and processes.

The Special Issue, for its nature, aims at representing an international scientific community and foster new platforms of knowledge sharing and dissemination. This intention has been received, as demonstrated by the considerable number of contribution coming mainly from Europe, but also from United States and China.

An international objective, on common aims and investigation fields, which confirmed the success of this first fruitful cooperation between SIT*d*A and EERA, proposing a virtual roundtable about the Smart Cities to come and their founding principles.

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01 | Coverage of contributions from the
European Scientific Community

THE ROLE OF THE EERA JOINT PROGRAMME SMART CITIES IN EUROPEAN ENERGY RESEARCH

Brigitte Bach,
European Energy Research Alliance Executive Committee vice-chair

In 2018 the European Energy Research Alliance (EERA) celebrates its 10th anniversary. Founded with the aim to accelerate the development of innovative energy technologies and to pave the way towards a low-carbon Europe, this strong alliance of European public research centres and universities has developed from originally ten organisations to over 200 members across 30 countries. It forms the research pillar of the European Strategic Energy Technology Plan (SET-Plan), which is designed to develop the technologies required to meet Europe's targets on greenhouse gas emissions, renewable energy and energy efficiency over the coming decades. Building on national research initiatives, EERA has since launched 17 Joint Programmes enabling research organisations from different European countries to work together on shared priorities and research projects in fields ranging from wind and solar energy to smart grids and smart cities.

Smart Cities and communities play a prominent part in the SET Plan as fundamental building blocks of tomorrow's low-carbon energy system. The two most pressing challenges in this respect are urbanisation and climate change. Today, more people worldwide live in cities than in rural areas and around 75% of all energy is consumed in and around cities. This concentration together with the characteristics of urban morphology give cities enormous leverage in increasing energy efficiency and reducing greenhouse gas emissions. However, transforming cities into sustainable cities using innovative technology and integrated approaches requires concerted research efforts and innovation. EERA therefore launched the Joint Programme (JP) on Smart Cities in 2011 headed by AIT (Austrian Institute of Technology) to foster scientific collaboration in this field with the aim to create sustainable and energy-efficient cities, enhance research expertise, promote collaboration for a low-carbon Europe and secure European leadership in Smart Cities research.

The EERA JP on Smart Cities has made valuable contributions to the development of this important topic at the European level. It has forged strong networks and is actively involved in the SET Plan Temporary Working Group 3.2 "Smart Cities and Communites" and in the European Innovation Partnership on Smart Cities and Communities. It will also present its results at the SET Plan Conference 2018, which is due to be held in November in Vienna and contributes relevant ideas and feedback to the upcoming Framework Programme 9 for the period 2021 to 2027.

These networking activities are complemented by joint research in integrated energy planning, thermal and electrical networks, sustainable interactive buildings and renewable supply technologies. This peer-reviewed special issue on "European Pathways to Smart Cities" takes stock of the comprehensive research carried out over the past years. The EERA Executive Committee welcomes this initiative, which provides an impressive overview of the state of the art in European Smart City research aimed at supporting European cities in their urban transformation.

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POINTS OF VIEW ON EERA JOINT PROGRAMME SMART CITIES

Hans-Martin Neumann, Member for Scientific and Editorial Board of EERA JPSC,
Senior Research Engineer, Sustainable Buildings and Cities, Austrian Institute of Technology, Austria
Annemie Wyckmans, Member for Scientific and Editorial Board of EERA JPSC,
NTNU Norwegian University of Science and Technology, Faculty of Architecture and Design, Norway
Hans-Martin.Neumann@ait.ac.at
annemie.wyckmans@ntnu.no

Hans-Martin Neumann: my point of view

The EERA Joint Program Smart Cities started its activities in 2011. At that time, Smart Cities was a brand-new, and thus not yet well-defined topic. Since then, the EERA Joint Program Smart Cities made its contribution to the European Research arena in shaping the topic, and helped making it one of the most successful pillars in the energy work program in Horizon 2020.
What is new in Smart City research?
Research on urban development is not a new topic.
Urban design established itself as branch in architectural studies in the late nineteenth century and early twentieth century, and urban planning became an independent academic discipline during the 1960ies and 1970ies. The years after the United Nations Conference on Environment and Development of 1992, the so-called Rio de Janeiro Earth Summit saw a huge interest of researchers in sustainable urban development.
So, what are the new aspects addressed by Smart City research?
Firstly, Smart City puts more emphasis on the technology than previous discourses on urban development. This is a consequence of two major trends: decarbonisation and digitization. Due to global warming, the member states of the European Union have committed themselves to build a low carbon economy. Low carbon cities are a key component of this strategy, because cities are responsible for the lion's share of the greenhouse gas emissions in Europe. Low carbon cities require major technological innovation, especially in the energy sector. This applies to energy generation, where renewable energy technology is replacing technology running on fossil and nuclear fuels, to energy efficiency as well as to energy distribution and storage. Also, digitization is rapidly changing the life of the Europeans. This can be observed in the private realm, where smart phones and other smart devices are spreading rapidly, but also in the public realm: urban infrastructures, like street networks, public transport systems, electrical and thermal grids are increasingly managed by ICT technology. This does not only increase the efficiency of operations, but it also creates huge data volumes, often stored in urban data platforms. Data from these platforms and other data available in the public administration become open data and create new business opportunities for start-up ecosystems.
Secondly, Smart City research is co-creative and stakeholder-oriented. Our world is not only becoming low carbon and digitized, but also more diverse. Therefore, involvement of the users in the planning in their neighborhood, but increasingly also in the design of technological solutions, is of utmost solution for the acceptance and thus for the implementation of the solutions and their success in the market.
Thirdly, Smart Cities is focused on impact. Traditional research has often been criticized for having a rather limited impact in the outside world. Smart City research has the explicit ambition to achieve a measurable impact and to improve the life in cities. Therefore, Smart Cities research has a strong focus on piloting innovative technologies and processes in living labs, monitoring and evaluating the results of the pilots to improve the tested solutions, and finally to prepare and support the upscaling and replication of the solutions. This includes aspects of urban governance as well as innovative funding and financing mechanisms and the development and testing of new business models
Finally: Smart City research does not only require deep understanding of urban technologies, but also an interdisciplinary approach with a strong linkage to social science, as cites are complex and multidimensional phenomena.

Annemie Wyckmans: my point of view

«The research questions involved in transforming cities into Smart Cities are highly complex and can only be solved by taking an interdisciplinary, transnational approach. The European Energy Research Alliance (EERA) provides an ideal framework for this joint effort by pooling high-level energy research expertise and infrastructure across Europe»
(www.eera-sc.eu, Preface).

Since its initiation, the EERA JP on Smart Cities has hosted meetings, facilitated workshops and generated discussions regarding research and innovation needs and priorities in terms of smart cities. As new Coordinator, it is my ambition to help develop the new strategic framework of the EERA Joint Programme on Smart Cities, and help the programme to become an independent, robust partner organisation with a clear mandate to promote and strengthen the role of cities and districts as urban energy ecosystems, developing better interaction between technology, design and people, and better integration between the digital and physical urban environment.
With 23 full participants (thereof 2 umbrella organisations) and 59 associated participants (including 4 industry partners) from 20 countries contributing around 220 person years per year, as well as a City Advisory Community with members from all full participant countries, the EERA JP on Smart Cities will play a defining role in the European Research and Innovation landscape on smart cities in the years to come.
EERA Joint Programmes are expected to play an advisory role towards the European Commission, implement and develop the SET-Plan, coordinate the scientific community towards excellent research and transfer these to industry, and make all of these

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actions visible to increase their impact. As an answer to these expectations, the EERA JP on Smart Cities has created the Marketplace, the Campfire and the Academy which are currently embedded in its Work Plan and will be further strengthened during the next years.

A first goal for the next years, is to develop a joint R&I Agenda for the EERA JP on Smart Cities, based on partner interests and expectations, as basis for coordination, cooperation and co-creation of activities within the JP and with other organisations. The R&I Agenda will define the aggregated knowledge and experience of the EERA JP on Smart Cities partners in terms of the research needed in order for Europe to create and scale up smart cities, and the type of cooperation instruments required between cities, industry and research in order to develop successful pilot projects on the ground. The R&I Agenda will firmly establish EERA JP on Smart Cities as a systemic solution provide, and will be used in a meaningful and efficient manner to build the interdisciplinary, transnational approach the European Commission expects. With strong anchoring in the expectations and interests of its partners, the R&I Agenda will serve as a red thread for all joint activities in the EERA JP on Smart Cities, for internal cooperation within the EERA JP on Smart Cities, for co-creation of new projects and programmes, and for communication towards external stakeholders and organisations.

A second goal is to develop a clear identity and role for the EERA JP on Smart Cities in the European research and innovation landscape on smart cities, in alignment with organisations such as EIP SCC European Innovation Partnership on Smart Cities and Communities and UERA Urban Europe Research Alliance. The EERA JP on Smart Cities is expected to fulfil different roles in the European research and innovation landscape, as advisor towards the European Commission, as ambassador of the Strategic Energy Technology Plan, as coordinator of European research and innovation, and as support for creating competitive industries. In all of these roles, the EERA JP on Smart Cities needs to communicate in a convincing, attractive manner, building bridges within its own organisation and towards others. We aim to be a pro-active, defining presence in the European research and innovation landscape.

TOWARDS A EUROPEAN VISION FOR THE SMART CITIES TO COME

Mauro Annunziato, Member for Scientific and Editorial Board of EERA JPSC, Head for Smart Energy Networks Energy Technologies Department, ENEA -Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
Paola Clerici Maestosi, Coordinator for Scientific and Editorial Board of EERA JPSC, Senior Researcher DTE-SEN, ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy
mauro.annunziato@enea.it
paola.clerici@enea.it

Introduction

The EU budget has contributed to deploy solutions on the things that matter for Europeans: urban areas have been a key issue in EC funding programs. In fact, the EC promoted RD&I on urban areas providing support through a wide range of funding programs covering funding opportunities (H2020 pillar of "societal challenges", European Fund on Strategic Investments, European Structural and Investment Funds, Urban Innovation Actions, Urbact, Life, …). According to this approach, many Member States pooled resources at European level, achieving more than by acting alone. Therefore, together with national budgets and a wide array of legislative and regulatory instruments, the EU budget has allowed to support shared objectives and tackle common challenges including CO_2 reduction in urban areas and a carbon-neutral economy thorough initiatives aimed at implementing the so-called "Smart Cities".
It is thanks to the coordinated EU/Member State approach that RD&I pushed smart cities and smart specialisation strategies as two novelties that have been quickly adopted by policymakers and translated into specific policies and initiatives that were mainstreamed into regional policies.
Success stories and best practice challenges[1] lay on a technological focus in the fields of energy, mobility, transport, ICT, and on successful replication, which means meeting the challenges of finding suitable financing and coming up with innovative business models to create a project with strong impact and meaningful results.
Testing and developing a smart specialization strategy to transform the energy and urban landscape of cities is undoubtedly a complex task, even if encouraged by the challenging experiences of the numerous projects funded by EC. Once the tricky path of finding a successful and innovative solution is completed, the road is far from over. Overall, innovations are facing a day of reckoning; it is a time when the costs of entering the market and up scaling simply cannot be overcome. Indeed, the lack of venture capital, market failures and other barriers can bring the process to a sudden stop. This is a reality for smart city solutions, where the number of barriers are often far higher than in many other areas of innovation.
We can say that a European vision of coming Smart Cities lies on the understanding of how to move from high objectives to specific innovative solutions and how replicate successful innovations in a local context - being aware that each solution applied to a city involves a combination of technologies which are adjusted to the needs of a specific city and that can be affected by many factors (technological, financial, economic, regulatory and administrative, social and stakeholder uptake, etc.).
Therefore, this is the added value that the coordinated EU/Member State approaches in funding RD&I programmes on Smart Cities have produced within the framework of the H2020 programme.

The smart city concept

Cities and urban areas have been a key issue in EU/Member State policies and programmes, in the light of the fact that over two thirds of the European population live in urban areas and that cities were and will be places where both problems emerge and solutions are found, places which are fertile ground for science and technology growth, for boosting culture and innovation, for supporting individual and collective creativity and where, more than anywhere else, climate change mitigation can be more easily perceived. Cities play a crucial role as engines of the economy, as places of connectivity, creativity and innovation, and as centers of services for their surrounding areas. Therefore, cities are essential for a successful implementation of Europe.
Even if European cities play a key role in the lives of Europeans, it seems almost paradoxical that there is no common definition for "urban" or even for "city", and that the European Union has no explicit competence in urban development, as urban planning per se is not a European policy competence even if economic, social and territorial cohesion all have a strong urban dimension. Therefore, even if the "European model of the city" is a fascinating issue, it is clear that there is no way to adopt a single definition; however, it is still possible to move towards a shared European vision of urban development, as noted by the paper "Cities of Tomorrow" (DG Regional Policy, 2011) which consider that «there is not a single vision of the European city model but there might be as many visions as there are Europeans. These visions are diverse as they build on different realities, different strengths, weaknesses, opportunities and threats as well as different values».
This means that Europe can play a role in setting the framework and providing guiding principles which help the growth of a shared vision of European cities, where the dimension of a sustainable urban development is taken into account in an integrated way. In general terms, this is what occurred with European funding in RD&I: even though the EC has no explicit competence in urban development, policies and programmes on RD&I have undoubtedly contibuted to promote and support a shared European vision for Smart Cities.
Many of these programmes have become EU trademarks, making the EU visible and recognizable in the daily lives of its citizens.
The basic idea behind this shared vision is that European cities want to be places of advanced social progress, platforms for democracy, cultural dialogue and diversity, places of green, ecological and environmental regeneration.

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Since 2007, many discussions, workshops, white papers, documents of work have been developed about the future of cities, both at national and European level, while glossaries have been prepared according to the idea that in the transition from industrial to knowledge-based societies, the cities of the world are changing their shapes. As a result, several definitions were created: shrinking cities[2], second cities[3], slow cities[4], slum cities[5], historical cities[6], and then green cities[7], healthy cities[8], community cities[9], and - last but not least - quality-of-life cities[10].
Besides these different definitions, one has started to prevail: the Smart Cities paradigm, as a huge amount of funding - national, international and EC - has been dedicated to this, thanks to the large number of stakeholders that will be catalyzed in the design, scaling up and replicability of the Smart Cities themselves.
It is a fact that the definitions of Smart Cities have changed over the years according to aims and goals of their proponents, the last definition being that proposed by EIP in Smart Cities and Communities - Strategic and Implementation Plan: «Smart cities should be regarded as systems of people interacting with and using flows of energy, materials, services and financing to catalyze sustainable economic development, resilience and high quality of life; these flows and interactions become smart through making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management that is responsive to the social and economic needs of society»[11].

2020 and beyond

The White Paper on the future of Europe and the previous recent reflection papers have shown that the EU27 will face a wide range of challenges in the period leading up to 2025 and beyond. Among them are current trends that will remain relevant for decades to come, such as the digital revolution and globalisation, demographic change e social cohesion, economic convergence and climate change.
Sustainable development has long been at the heart of the European project. European societies today face many sustainability challenges from youth unemployment to ageing population, climate change, pollution, sustainable energy and migration. The 2030 United Nation Agenda for Sustainable Development and the sustainable development goals (SDGs) are an anchor of EU policy both internally and externally. The economic, social and environmental dimension at the heart of SDGs have largely been incorporated into the EU budget and spending programmes. They have been mainstreamed into the Europe 2020 strategy to build around education and innovation (smart), low carbon emissions, climate resilience and environmental protection (sustainable) and job creation and poverty reduction (inclusive).
As written above: many of the programmes that the EU promoted are now trademarks in the daily lives of European citizens. Indeed, there is still room for improvement to further strengthen their performance and increase their impact, by avoiding overlap or combination of instruments and promoting alignment. The current generation of programmes have incorporated important reforms: they provide more funding on key Europeans priorities such as employment, social inclusion, skills research and innovation, energy resource and efficiency, but policies have become increasingly complex to manage, hampering on-ground implementation and creating delays. The layers of controls and bureaucratic complexity make it difficult for beneficiaries to access these funds and deliver projects quickly.
Indeed, city planning activities have changed thanks to technological development and RD&I programmes. The budgetary constraints and the increasing complexity of urban investments for Smart Cities and Communities solutions have led city administrations to request the involvement of private players and to adapt the governance of cities in order to attract them. Therefore, Smart Cities evolve along with new modes of value creation through the intermediation of public-private partnerships, cross-sectorial collaborations, city-led "open innovation marketplaces" and other forms of governance.
Therefore, a much more radical approach to simplify implementation and favour more agile and flexible programming is needed for the future. The White Papers on the Future of EU Finance clearly states that hard choices will need to be made; the future EU budget should continue dealing with current trends that will shape the EU in the coming years plus additional new challenges (irregular migration and refugees, integration, control of external borders, security, fight against terrorism, common defence, …).
According to this, five illustrative scenarios with different implications for the EU finance in terms of budget size, structure and degree of change/modernization have been described:
Carrying on: the EU27 continues on delivering its positive reform agenda;
Doing less together: the EU27 is doing less together in all policy areas;
Some do more: the EU27 allows groups of Members States to do more in specific areas;
Radical redesign: the EU27 is doing more in some areas, while doing less elsewhere;
Doing much more together: the EU27 decides to do more together across all policy areas.
So, which are the possible implications for RD&I on smart cities and smart specialisation strategies? It is clear that the way budget changes - and the purpose it is used for - largely depends on the type of future envisaged for European Union and on the level of ambition and trust that Member States will choose to adopt together to shape that future. In particular, as regards RD&I programmes this scenario will deeply influence EU funding togeth-

er with the SET Plan and the upcoming FP9 (Horizon Europe), where the most reliable idea seems to be a shift from the novelties of smart cities and smart specialisation strategies to a wider idea of Positive Energy District to pave the pathways towards 100 Zero-Energy and Positive Energy Districts in Europe committed by 2025, where PED could be a seeding point to showcase, in highly concentrated form, the integration and interoperability of technologies, systems and tools .

Conclusion

We assume that there is not a single way or a single approach to transform a city into a smart city; several cities in Europe have adopted different solutions, each of them reflecting specific circumstances. As illustrated in the article "EERA Joint programme on Smart Cities: storyline, facts and figures" the JP on SC is a huge and wide-ranging R&I network where members took part actively - at both national and international level - to develop, deploy and roll out European Smart Cities. Thanks to their contributions and to the commitment of several stakeholders to transform our cities into Smart Cities, is it now possible to figure out a European way to transition towards Smart Cities? Also, is it possible to say that there is a European vision about Smart Cities? And if so, can we say that there is a European vision for coming Smart Cities?

It seems to be a general opinion that there is not a single vision for the European Smart City, but there have been as many visions as there are Europeans, as social realities within Europe differ greatly, depending on where we live and work; that European cities want to be places of advanced social progress, platforms for democracy, cultural dialogue and diversity, places of green, ecological and environmental regeneration; last but not least, that Smart cities should be regarded as systems that catalyse sustainable economic development, resilience and high quality of life by making strategic use of information and communication infrastructure and services in a process of transparent urban planning and management. According to this, it appears that these three elements could be the synthesis of the European vision about Smart Cities.

As regards the European way to transition towards Smart Cities, we could say that during the last decade, cities have become smart not only because of automatic routine functions serving end-users, buildings, traffic system, energy providers and transport already in place, but also because data - which derives from ICT applications - have been used to understand, analyze and plan the city to improve efficiency, equity and quality of life for citizens. According to this, we can foresee that the transition process which will pave the way towards coming smart cities will be mainly focused on the setting up, deployment, roll out and scalability of those smart solutions that have already been tested and experimented.

Applying smart cities solutions to limited-scale contexts has certainly enabled the testing of SCC technologies, governance models and citizen involvement; however, what is needed now, in the next future, is to ensure scalability and replicability of solutions, bearing in mind that «there is no single element that represents more than others an obstacle or an enabler to the roll-out of SCC solutions»[12].

For the near future, we need to focus on similarities in smart cities RD&I projects (i.e. paradigmatic or technological enabling factors on which various solutions are based, ways to integrate single specific technology in a whole ecosystem of interoperable solutions, ...).

If we see each SCC solution as a Lego Brick, we clearly realize that while each brick has been made as a separate object, it needs to assembled and integrated in a more structured system.

Smart cities are now approaching a critical phase: after many theoretical discussions, it is necessary to create a realistic pathway of SCC applications/solutions.

Therefore, even the way of considering pilot RD&I projects will shortly change: not only a demonstration of technological effectiveness in achieving the desired performance or KPIs, but competitive business models with a high level of replicability and scalability, widely accepted by the largest group of stakeholders (government, RD&I networks, design and construction, real estate, urban services, e-commerce, analyst, ICT and Big data, process management, financial/funding, social/civil society, ...). This is really the most challenging step of this pathway: it must be more realistic, as it is necessary to select only some SCC solutions which come from ideas that have been elaborated in a conceptual expansion phase. Therefore, in the near future urban projects requirements will rapidly change and specifications will be more compelling, allowing no more single, isolated interventions as highly technological islands.

It is a fact that today we still do not have a smart city, or rather we have a smart city limited-scale context, but we have several SCC (Smart Cities and Communities) solutions where the use of ICT infrastructure promotes a better understanding of success factors for their deployment and roll-out.

Therefore, the next step to move towards a wider European idea of Smart Cities to come could be to deploy positive energy districts thanks SCC solutions - already experimented on a limited-scale context - as the most reliable opportunity.

NOTES

[1] The making of Smart Cities: best practice across Europe, EU Smart Cities Information System, Empowering Smart Solutions for better cities, DG Energy 2017.

[2] Cities that are getting smaller in size, thus contradicting global urbanization trends. The decrease in size is often a consequence of a drop in birth rates and/or the closing of larger industrial workplaces that have contributed significantly to the growth of the cities. Many shrinking cities make dedicated efforts to adjust to the demands of the knowledge society, in which the ability to generate growth does not necessarily depends on size; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[3] Cities that stand in the shadow of the most important city in a given country or region. The definition "second city" is increasingly used about cities that have defied their status as "provincial" in recent years, and have managed to assert themselves in the competition for resources and growth, in some regions and countries, the strong first cities feel overtaken and intimidated because the combination of smaller size and independence make second cities move faster than their larger counterparts; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[4] Cities that respond to the high pulse of the modern metropolis by launching concepts that slow down the pace. These will typically be cities whose layout and amenities support a lifestyle that prioritises recreational activity, the possibility of relaxing and enjoying life. A number of these cities have joined the "Slow City Movement" inaugurated in 1999 in the Italian city of Orvieto. The original incentive for this movement was "slow food", the wish to increase the knowledge about and demand for this type of cuisine; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[5] Cities that are affected by great poverty. Such cities will typically have districts where the poorest citizens live in miserable conditions with no access to adequate health services, medical and social help, education, work, etc. These harsh conditions often make these districts appear as a threat to their surroundings: the environing communities typically react by sealing themselves off from the slum district, Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[6] Cities that have made significant historic contributions to urban development. This definition is typically used for cities listed on the UN's World Heritage List. It is also used to define cities that have historic sites, buildings, landmarks, etc. that have contributed to significant events in the world history, hereby profiling the city to the outside world. The primary challenge for cities in this category is to retain their historic distinction while still meeting the needs of modern citizens; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[7] Cities that are based on a mindset of sustainability and energy-efficient solutions with a view to reducing CO_2 emission and bringing down the consumption of energy resources. This is seen in different ways, for instance by having a well-functioning public infrastructure that ensures minimal use of cars in the city, and dense building with defined standards for building materials, design, etc. that are as environmentally friendly as possible; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[8] Cities that, according to WHO, are continually creating and improving physical and social environments and expanding community resources. These efforts enable citizens to mutually support each other in performing all functions of life and developing to their maximum potential. For an increasing number of cities, the healthy city model is seen as particularly valuable because it attracts resourceful citizens; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[9] Cities where citizens experience a special community feeling and interact closely with other people in their neighborhood. These cities create and maintain local values and ensure a sense of security for the individual citizen. They are characterized by strong cohesion that is defined by the citizens' shared values and local attachment rather than by the functions the city is expected to fulfil; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[10] Cities whose primary purpose is to ensure a high quality of life for their citizens. Their efforts range from high health standards to local initiatives that ensure a dignified life for all citizens. The latter is achieved by providing sufficient opportunities for education and work. It requires a balance between public and individual needs. Through their organization and physical layout, these cities wish to guarantee safety and security while ensuring that the individual citizen feels free and content as a member of a larger community; Huset Mandag Morgen, special edition on Futures of cities, may 2007, DK.

[11] EIP on Smart Cities and Communities - Strategic and Implementation Plan, 2013.

[12] Analysing the potential for wide scale roll-out of integrated SCC solution - Final Report, 2016.

EERA JOINT PROGRAMME ON SMART CITIES: STORYLINE, FACTS AND FIGURES

Scientific Board for EERA JPSC Special Issue 01 | 2018

Introduction

Since the beginning of this century, the rapid transition to highly urbanized populations has put societies and governments around the world in the face of unprecedented challenges regarding key themes such as sustainable development, education, energy and the environment, safety and public services among others. It has become clear that cities continue to play a key role in the lives of most Europeans, and that they have a crucial function in the social and economic development of European territories. Cities are generators of growth, yet at the same time they can foster unemployment and economic crisis; many cities show a significant loss of inclusive power and cohesion and an increase in exclusion, segregation and polarization[1]. During the same period, information and communications technologies (ICTs) have reported a dramatic growth and produced a huge amount of data, along with the belief that they can be a major instrument to solve the city's economic, social and environmental challenges. Cities have started to recognize that ICTs are essential for their vibrant social, economic and cultural life, and that they can play a central role in moving the energy system towards a more sustainable path while limiting the dramatic increase in urban energy consumption associated with CO_2 emissions.

Why a Joint Programme on Smart Cities?

Within this context, a number of players acting in this field have developed some considerations on Smart Cities. Amongst these players, EERA - the European Energy Research Alliance - organized a first awareness workshop on research and innovation challenges related to Smart Cities in Brussels in September 2010; afterwards, thanks to a series of further workshops held from December 2010 to December 2011[2], a research framework programme was shaped. In the early stage, the Joint Programme on Smart Cities (JPSC) comprised 18 full participants and 29 associated participants from 16 countries, contributing with 220 person years per year. The Joint Programme was originally structured in 4 sub-programmes (SP1 Energy in Cities; SP2 Urban Energy Networks; SP3 Energy-efficient Interactive Building; SP4 Urban city related supply technologies) with a clear focus on energy efficiency and integration of renewable energy sources within urban areas.

Today, thanks to the 2017-2019 workplan which completely redesigns EERA JPSC activities, we have 7 work packages in place to boost effectiveness on working with shared priorities and joint research projects. Furthermore, the coordination of the Joint Programme, that was performed by AIT with Brigitte Bach from December 2010 to June 2017, has now been transferred to NTNU with Annemie Wyckmans, while AIT is responsible for vice-coordination with Hans-Martin Neumann. Together, they are supporting and coordinating the R&I activities which now involve 23 full participants and 59 associated partners from 20 countries on a voluntary base and in-kind contributions.

Thanks to the 2017-2019 workplan, the aims and goals of the Joint Programme have been redesigned and readdressed. While the initial focus was only on RD&I sub-programmes and related topics, today all the activities have been structured in a more efficient way, with the identification of a coordinator for each work package (WP) and the promotion of WPs that are not only focused on RD&I (WP6 and WP7) but also on network capacity building (WP2, WP3 and WP4) and on a strong interaction with stakeholder groups (WP5).

The workplan of the JP on Smart Cities is currently organized into 7 work packages:

WP1 Management - under the coordination of NTNU - covering financial project management, organization of half-annual workshops, technical project management, monitoring and reporting for EERA secretariat and JP review;

WP2 Campfire - under the coordination of AIT - with the aim of providing contributions to the SET-Plan, to the EIP Smart Cities Market Place, to European Smart Cities Research & Innovation Roadmap;

WP3 Market Place - under the coordination of CTU Prague - whose aim is to support and promote brokerage activities, identification of H2020 proposals, Cost Action, EERA labeled project proposals;

WP4 Academy - under the coordination of ENEA - with the aim to boost academic interest and participation and to strengthen cooperation among RTOs and University partners as well as external stakeholders through different actions - including organization of symposia at the Barcelona Smart Cities Expo; setting up of an editorial strategy resulting in the first issue of the EERA Joint Programme on Smart Cities (JPSC) special issue 1/2018; setting up of a summer school and a Horizon 2020 Marie Sklodowska-Curie application;

WP5 City Advisory Board - under the coordination of VTT - which aims at organizing time-slots at EERA meetings with City Advisory Board - CAB as well as hands-on workshops with CAB to support interaction between cities and research organisations;

WP6 Expert Pool - under the coordination of NTNU - now includes the original 4 sub-programmes + the simulation task force;

WP7 Communication and dissemination - under the coordination of AIT - with the following tasks: maintenance of Web Site and Social Media, production and communication material, exhibitions, presentations and speeches.

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EERA Joint Programme on Smart Cities journey: response and contribution to societal challenges

Lesson learnt: 2010-2012

As above mentioned, the Joint Programme on Smart Cities officially started its activity late in 2010, while the Description of Work was released in October 2011.

The Summary of the Joint Programme on Smart Cities (10.2011) considered that achieving the Europe 2020 targets of the European Commission forced new challenges upon society and called for clear strategies in R&D in the field of energy. Because of the potential risks of worldwide climate change in 2011, there was, and there still is, a strong need for urgent actions, arguably the most important being to reconceive the way we consume and produce the energy that we need. In this context, the integration of renewable energy sources into urban energy networks and the increase in energy efficiency in cities became core topics to be addressed. These issues were also strongly emphasized in the European Industrial Initiative "Smart Cities and Communities" which was launched by the European Commission in June 2011. Experts continuously highlighted the importance of smart energy management at city level for achieving the ambitious targets with respect to CO_2 reductions in the long-term as outlined in the 2050 Roadmap of the EC.

The 2011 EERA JPSC Description of Work clearly stated, for the first time, that the concept of Smart City involved innovative design and intelligent operation for the entire energy system at city level as two key topics. For this reason, the 2011 Description of Work identified four major research areas related to energy technology in the context of Smart Cities:

1. Integrated urban energy planning and transformation processes.
2. Intelligent planning, design and operation of urban energy networks (thermal and electric).
3. Energy-efficient buildings as interactive elements of the urban energy system.
4. Renewable supply technologies integrated into urban infrastructure.

Therefore, within the Joint Programme on Smart Cities, the highly complex structure of a future smart energy system has been investigated on an urban level by applying innovative solutions in an interdisciplinary manner based on a clear long-term research strategy. The fundamental research motivation is reflected in the strong need for a new approach for the design, operation and optimization of urban energy systems on the basis of renewable energy sources which can only be achieved through the development of radically new scientific methodologies (in this context, the interfaces between energy grids, buildings and supply technologies play a crucial role, which cannot be entirely captured by current scientific techniques).

In the 2010-2011 period, great attention to Smart Cities was paid by RD&I.

In 2011, one of the key vehicles of the EU to accelerate the large-scale deployment of low-carbon technologies was (and still is) the European Strategic Energy Technology Plan[3], followed, among other industrial initiatives, by the Smart Cities and Communities Initiative[4].

In parallel with the Industrial Initiatives, the European Energy Research Alliance (EERA) as part of the SET Plan brings together key European organizations in the field of applied research to align their individual R&D activities to the needs of the SET Plan priorities and to establish joint programming. To this purpose, several JPs were created, among which the Joint Programme on Smart Cities represents a major contribution to achieve the high ambitions all across Europe by applying an interdisciplinary and integrated approach based on a clear research strategy in the field of urban energy technologies.

Around the same period of time, the International Energy Agency (IEA) stated that radical innovations were needed and that an "energy revolution" had to be initiated together with dramatic changes in our attitude and investment priorities (World Energy Outlook, IEA, 2009).

In those years, in an effort to find a distinct definition for "Smart Cities", extensive discussions were held among experts covering many areas related to energy technology development, environmental issues, politics and socio-economic aspects. However, following the outline of the Smart Cities and Communities Initiative of the European SET-Plan, it was clear that Smart Cities are characterized by the extensive use of low-carbon technologies combined with a smart energy management based on innovative design and operation of the entire system at city level; there was also consensus that the implementation of CO_2-saving measures should be complemented by complex stakeholder processes and innovation concepts at city level involving all relevant partners in order to start the transformation of existing cities into "Smart Cities".

It was clear that a common vision needed to be developed at city level, leading to individual roadmaps and action plans for research and implementation accompanied by knowledge management and structured monitoring programmes.

Following these indications, a first step for research was the identification and understanding of "Smart Cities" as complex structures involving a continuous interaction between the major parameters and components related to the entire energy system of a city[5]. The highly complex structure and patterns of energy flows covering the entire chain from energy production, distribution and consumption in cities should be treated with an integrated system approach heavily supported by research and development.

Therefore, a strong need for smart planning, design and operation of energy systems was identified as a correct approach to achieve the highly ambitious target of (almost) zero carbon emissions for city areas in the very near future. Another key aspect appeared to be the smart management of the energy system by means of Information and Communication Technologies (ICTs) in order to support the stochastic energy supply deriving from renewable energy sources. As a consequence, the individual components of the entire energy system, such as energy distribution grids, buildings, supply technologies and even consumers, started to play a new and important role. The continuous interaction between those users and elements started to be considered in fundamentally new design and operation concepts based on city morphology, intelligent demand side management, energy storage and the potential shift between different energy sources (electric and thermal loads).

In the light of the above considerations, it was clear that the research areas related to the concept of "Smart Cities" covered a broad range: the merging of ICTs (information and communication technologies) and energy technologies was, and still is, of highly beneficial nature to solve the research questions arising in the context of future energy systems serving as a basis for new methods with respect to smart grids and Smart Cities. Therefore, it was emphasized that the main idea behind Smart Cities was the smart integration of a whole spectrum of various technologies into an urban environment by applying an integrated approach (EERA JP on Smart Cities RESEARCH AREAS in 2011 are listed below).

Lesson learnt: 2012-2014

In July 2012, the European Commission published a communication on the transformation of the European Industrial Initiative (EII) Smart Cities and Communities into a European Innovation Partnership on Smart Cities and Communities. This new policy instrument was intended to be located across the areas of energy, transport and information and communication with the objective to catalyze progress in areas where energy production, distribution and use, mobility and transport, and information and communication technologies (ICTs) are intimately linked and offer new interdisciplinary opportunities to improve services while reducing energy and resource consumption and greenhouse gas (GHG) and other polluting emissions. The focus was on industry-led innovation as a key driver to achieve economic and social change in urban areas and promoted actions across the innovation cycle and across different sectors.

In addition, lighthouse projects were designed to trigger strategic partnerships of innovation-driven companies from the three sectors acting across geographical borders, and to forge strong partnerships with local leaders and municipal authorities in order to gain the vital support and visibility that are necessary to engage and empower citizens and local stakeholders to reduce greenhouse gas emissions and energy consumption and - more widely - to improve the urban environment.

As a result of these newly-introduced programmes and actions, the previous thematic background (10.2011) slightly changed the overall research topic of EERA Joint Programme on Smart Cities, maintaining its original 4 sub-programmes with the addition (late 2014) of another relevant topic such as the "simulation task-force"[6] while underlining that others issues closely linked to environmental aspects in urban areas, such as transport, waste, water and pollution, were not the direct scope of EERA Joint Programme on Smart Cities itself and therefore were not considered as primary fields of interest within the research programme itself[7].

On this basis, a second edition of the Description of Work was

EERA JP on Smart Cities RESEARCH AREAS (2011)

Based on the framework presented at the launch conference of the Smart Cities and Communities Initiative in June 2011, the following 4 key research areas for EERA JP on SC were identified with respect to energy issues:

SP1 Energy in Cities: Design and planning of energy-efficient urban districts and smart energy systems; detailed understanding of the energy performance characteristics of urban areas; new simulation tools for the analysis of energy flows in cities; deep knowledge of the urban morphology such as building density, typology and end-use mix. Tools and methods for further use in future holistic energy master planning.

SP2 Smart Energy Networks: Smart energy grids responsible for the intelligent management and operation of energy networks in cities utilizing the potential shift between thermal and electrical loads; integration of decentralized renewable energy sources into existing energy grids (major technical issues); interaction between mathematical modeling techniques, numerical simulation environments and advanced communication infrastructure; potential storage capacity for both electrical and thermal energy within energy networks which can be achieved by intelligent demand side management.

SP3 Energy-efficient Interactive Building: Current research on large buildings focuses on the further development of building automation control systems that allow to increase energy efficiency by including new predictive control strategies; transition from single passive building technologies to fully integrated buildings acting as active hubs in the energy grid; overall energy performance of buildings with respect to new innovative building design concept; finally, the interaction between building and the smart grid is one key aspect for future research where ICT plays a major role.

SP4 Supply Technologies: smart integration of on-site renewable energy sources into buildings and networks; cascade use of resources or poly-generation; tools for the optimal use of hybrid supply systems; large-scale experimental testing and development of new procedures and standards.

Launch conference of the Smart Cities and Communities Initiative in June 2011: the 4 key research areas created in 03.2014. While the general setting of the previous edition was preserved, the new document featured an evolution of the definition of general research areas and activities related to the concept of Smart Cities and the identification of additional areas, along with a long-term strategy with clearly defined aims and objectives as key elements for a successful performance of any scientific program dealing with complex research areas such as energy technologies for Smart Cities.

The high-level research roadmap of the Joint Programme on Smart Cities is the result of a series of workshops held during the 2012/2013[8] period, indicating a well-thought-out underlying concept for R&D.

The consistent and continuous creation and formation of a European-wide research community in the field of Smart Cities should be regarded as a distinguished added value of the Joint Programme, as such a community has not been existing before in Europe. All the scientists involved in the foreseen research activities and coming from well-respected European research institutions agreed that the sophisticated transformation of European cities into Smart Cities in order to reach the Europe 2020 targets and the long-term goals of the European 2050 Roadmap could only be achieved by major contributions from R&D adopting a highly interdisciplinary approach focused on the system behaviour of future urban energy systems.

The complexity of future energy systems in cities can only be tackled within a multi-technology perspective based on an integrated approach that requires the further intensification of transnational research co-operations on a European level. Furthermore, there continue to be a clear trend that energy technologies and ICT will continuously merge in the near future, and new expertise will be required to unlock the full potential of this interaction.

Hence, the overall objectives of the entire Joint Programme on Smart Cities could be summarized as follows:

General level Strengthen and reinforce the strategic position of EERA Joint Programming as a key instrument for a successful implementation of the European SET Plan; provide major scientific contribution to reach the 20-20-20 targets as indicated within the SET Plan by focusing on research on the integration of low-carbon technologies dedicated to city-related energy issues; guarantee future leadership of European R&D in urban energy technologies through a clear long-term research strategy; promote a strong representation of the European research community in the field of Smart Cities towards other international research partners in markets such as US, China, India, etc. acting as a "one-stop-shop" by enabling a well-coordinated dialogue and cooperation framework; expand and optimise European-wide research co-operations by facilitating the use of common research infrastructure and intensifying the existing scientific exchange among all participating partners; establish strong links with relevant industries, public institutions or other stakeholders working in the field of Smart Cities; raise awareness among various stakeholders on the topic of energy and Smart Cities through specially dedicated dissemination measures.

City context Provide the scientific basis to unlock the full potential of energy efficiency in cities and urban areas as highlighted in the Smart Cities and Communities Industrial Initiative leading to significant reductions of CO_2 emissions; based on interdisciplinary research activities, enable and endorse a massive integration of renewable energy sources (centralised and decentralised) into urban energy systems and city infrastructures in the near future; support European cities in their transformation processes towards Smart Cities with new scientific methods and tools leading to innovative transnational implementation projects on a European level; create full understanding of the complexity of the entire energy system of cities at various scales of detail (from meta-level to component level) covering the entire chain from energy generation, distribution and consumption.

Research perspective Development of essentially new scientific methodologies for city-wide energy planning in the context of traditional spatial planning and/or other environmental issues for cities; development of scientific tools that enable relevant decision makers to estimate the economic and social impact of energy infrastructures, policies and regulations concentrating on renewable energy sources and energy efficiency; capture the complex interaction between cities and their energy management system, including all individual components at different urban scales (urban energy networks, buildings, supply technologies, consumers); design fundamentally new strategies that allow for an intelligent energy management system in the context of stochastic distribution of energy supply and demand applied to different elements of the entire energy system of a city; actively promote the new role of ICT in the field of Smart Cities as necessary for the continuous interaction of all incorporated system elements; incorporate the complex role and behaviour of individual energy end-users and their specific needs in the development of the next generation of energy technologies with a particular focus on urban applications; elaborate innovative solution patterns tailored to the needs of Smart Cities for addressing new arising research questions by adopting an interdisciplinary and multi-technology approach focused on system behavior; stimulate the next generation of researchers in the academic community to step into R&D in the field of energy (EERA JP on Smart Cities RESEARCH AREAS in 2012/13 are listed below).

Lesson learnt: 2015-2018 European countries are faced with the huge challenge of increasing energy efficiency and reducing greenhouse gas emissions in order to achieve their ambitious climate protection goals. The characteristics of urban morphology and the growing trend toward urbanisation give cities enormous leverage in this respect. Smart cities use innovative technology and an integrated approach to provide high energy efficiency, sustainability and quality of life. Therefore, they play a prominent role in the European Strategic Energy Technology (SET) Plan as fundamental building blocks of tomorrow's low-carbon energy system. Concerted research efforts and innovation are required to achieve this paradigm shift in urban energy management and pave the way into the Smart cities era.

The research issues involved in transforming cities into Smart cities are highly complex and can only be solved by taking an interdisciplinary, transnational approach.

The EERA Joint Programme on Smart Cities collaborative approach, thanks to the 2017 Work Programme, now represents the added value for Europe, boosting energy expertise and positioning Europe at the forefront of international Smart cities research.

The aims of each sub-programme and the main outputs of last year are summarized below:

SP1 Energy in Cities (Coordinator: AIT; sub-coordinator: VITO) **Aims** A detailed understanding of energy performance characteristics and energy flows in urban areas is of crucial importance for the design and planning of smart energy systems. This sub-programme follows a unique integrated approach to merge urban and energy planning. The scientific tools to be developed will support cities throughout the transition process towards a low-carbon energy system - from system analysis, vision development and pathway exploration through to experimenting, assessment and implementation. The sub-programme will provide best practice examples of smart city visions for others to emulate. The design of integrated database structures and output interfaces will facilitate the planning of smart cities and subsequent monitoring of their performance based on Key Performance Indicators (KPIs). Decision support and simulation tools will be developed to model economic scenarios and energy flows and thus support experts and authorities in developing urban energy roadmaps. A strong focus will also be placed on setting up a template for the implementation of the living lab concept and interaction with other smart city aspects such as mobility, waste or water.

Output A very important result of WP1 was the H2020 project CITYkeys. This project was a response to the SCC-02-2014 Call on "Developing a framework for common, transparent data collection and performance measurement to allow comparability and replication between solutions and best-practice identification". The proposal was a direct outcome of the Joint Programme Activities and brought together three JP Smart Cities partners (VTT as project coordinator, TNO and AIT), the Cities of Wien, Tampere, Rotterdam, Zaragoza and Zagreb as well as the EUROCITIES network. The project started in February 2015 and closed in January 2017. In CITYkeys, a transparent performance measurement framework for smart city strategies and smart city

In accordance with these objectives, the four sub-programmes evolved as follows:

SP 1: Energy in Cities

The main objective of the sub-programme Energy in Cities is the development of scientific yet customer-oriented tools and methods that support the transition process towards a CO_2 neutral energy system of an entire urban area. The transition process consists of several elements: global system analysis, envisioning, exploring pathways, experimenting, assessing and translating. For each of these components, relevant support tools will be developed. In particular:

1. The development of examples of visions for smart cities that can be used as a basis for tailor-made solutions and roadmaps for each individual city.
2. The design of integrated database structures that allow cities to plan a smart city and then monitor the performance of the city during and after the transition process on the basis of well- defined Key Performance Indicators (KPI´s). Proposing output interfaces to these databases (e.g. GIS layers) to assist in the choice of the measures that will form the energy concept is of crucial importance in this context.
3. The development of new simulations tools (static and/or dynamic) that, once an energy concept has been chosen, will help produce a more detailed design of those measures and their implementation (sizing of technical components, business models), particularly in the case of pilot projects.
4. The set-up of a template for the implementation of the living lab concept into practice. This is essential since urban areas clearly have the following needs: to set priorities in the energy technology choices of a city not merely based on ad-hoc, separate, bottom-up pilot initiatives, but also based on a long-term transition process (e.g. also taking into account urban spatial planning); to combine the several scales and functions in a city (micro, macro, meso level) in order to obtain on optimal use of city data; to set-up real organizational and technological structures to establish the learning process of implementation projects in cities often referred to as living labs.

SP 2: Urban Energy Networks

Each city can be considered as an organism, with its complexity and its interlinked networks, also and maybe primarily at the energy level. Each city has its own energy metabolism, characterised by energy production, storage and consumption with their corresponding "interconnected networks": they can work properly by means of suitable interconnected sensor networks to collect data aimed at optimizing the operational logics of a smart and energy-conscious management at urban level (organic management of mobility, energy production sites, energy transport network, energy consumption sites, water, waste, etc.). Additionally, each city is in direct connection with its surroundings and beyond that are embedded into superposed energy systems at larger levels projects was developed. The development was carried out in a co-creative process involving researchers and city representatives. The performance measurement framework entails a KPI system and KPI definitions, guidelines for data collection, and a prototype for a performance measurement platform. It was validated in several partner cities. Furthermore, recommendations for the implementation of the system were developed and discussed with stakeholders. The indicators and the performance measurement frameworks were developed in close collaboration between the research organizations and the city representatives and validated in partner cities. In addition, the project provided recommendations for the deployment of the performance measurement framework, including business models and recommendations related to urban governance. (www.citykeys-project.eu) The project outcomes were very well received by the European Commission and are now taken up by standardization initiatives and by European demonstration projects such as RUGGEDISED. The project, one of the ongoing Smart City Lighthouse projects, is another valuable outcome of the activities in WP1. It was developed by the Lighthouse cities of Rotterdam, Glasgow and Umea, in close collaboration with TNO and AIT, and the fellow cities of Parma, Brno and Gdansk. Working in partnership with businesses and research centres, the six cities will demonstrate how to combine ICTs, e-mobility and energy solutions to design smart, resilient cities for all. The aim is to improve the quality of life of citizens by reducing the environmental impact of activities and creating a stimulating environment for sustainable economic development. RUGGEDISED was started in November 2016 and will run until October 2021 (http://www.ruggedised.eu/project/about/)

Evaluation frameworks for Smart Cities such as CITYkeys, and the monitoring of Smart City Lighthouse projects, such as RUGGEDISED, STARDUST and SMARTER TOGETHER were also addressed in the EERA JPSC Symposium on Key Performance Indicators, which was held on 19 November 2015 at the Smart City World Expo in Barcelona. In the following year (2016), another symposium on "The contribution of Smart City Solutions to the overall concept of the sustainable city" was held at the Smart City World Expo, this time in collaboration with the Urban Europe Research Alliance (UERA). On average, around 50 representatives from city administrations, industry and research attended these events.

SP2 Urban Energy networks (Coordinator: ENEA; sub-coordinator: AIT)

Aims Each city has its own energy metabolism, characterised by energy production, storage and consumption with their corresponding "interconnected networks". Smart cities, therefore, also require smart energy grids which are able to communicate with each other to balance thermal and electrical loads depending on supply and demand. The large-scale integration of distributed renewable energy sources into existing energy grids brings up additional challenges in the development of smart urban energy networks. This sub-programme has the objective to optimise these interconnected networks by intelligent planning, design and operation, integrating all accessible sources of renewable energy and providing flexible balancing potentials. This will be achieved by developing models for optimal management of low impact "Smart Energy Districts" and solutions for smart integration of electrical and thermal energy production, storage and

(e.g. continental). These interconnections provide a spectrum of renewable energy sources from other regions, but might also act as a sink for surplus energy from the city.

Within this scenario, the general objective of this sub-programme is to develop approaches, methods, technologies and pilot cases in order to optimize the energy metabolism of cities towards low-impact urban districts integrating all accessible sources of renewable energy and providing flexible balancing potentials, by means of an energy-conscious operation & management fed by data networks that are spread at urban level.

The research activities will mainly focus on three main tasks:

1. Smart Energy Districts – with the purpose of developing suitable models for optimal management of low-impact "Smart Energy Districts" (a settlement of various utilities such as private and public residential buildings, private and public office buildings, schools, hospitals, shopping centres, organized as a single user); solutions for a smart coupling of energy (both electrical and thermal) production, storage and consumption will be investigated and developed; mobility at district level will be also analysed in terms of energy consumption patterns.
2. Urban network integration – with the purpose of studying and developing opportunities related to the implementation of data acquisition systems at urban level (multi-information sensors networks), connected to data transmission, storage, processing and analysis; this structure will be synthesized through an integrated ICT multifunctional platform for network integration; this platform will feed an integrated management system to optimize the balance between energy offer and demand, also taking into account end-user expectations and behaviour.
3. Human factors: the citizen-city interaction – with the purpose of increasing knowledge of the human factors that influence energy uses and of developing "human oriented technologies" based on citizen needs and expectations to improve the quality of life oriented to low-energy impacts.

The milestones of the sub-programme may be synthesized as follow:

development of a methodological approach for the integration of energy networks at urban level; development of innovative solutions to optimize the link between energy offer, distribution, storage and demand (both electrical and thermal energy) in smart urban networks, taking into account the convertibility (e.g. heat pumps) and coupling (e.g. cogeneration) of different energy forms; development of multifunctional ICT platforms and integrated logics for electrical and thermal energy management in smart urban networks; ambient intelligence solutions to take into account citizen needs and expectations in low-impact cities; pilot experiments related to smart urban networks; based on the results of the experiments, understand and capitalize on human factors influencing energy uses so that a user model (all interactions affecting energy demand) can be envisaged at least on a statistical approach in order to attempt behavior prediction.

consumption at urban level. The integrated energy management systems of the future will rely on comprehensive sensor networks feeding energy-related data into a multifunctional ICT platform, which will enable a range of smart services based on real time data. The human factor will be taken into account by deepening the knowledge about citizen-city interaction and its influence on energy use to be able to design "human-oriented technologies".

Output The most important results of SP2 were an intensive dialogue among participants, improved capacity building in the direction of smart cities and smarter specialization in urban energy networks.

Basically, we have focused on the following:

- the need to build a common scientific language so that the integration of urban networks can be replicated not only within different domains of the same city but in different cities on the whole European territory. The advantage of achieving this goal is to avoid lock-in, the qualification of solutions, the reduction of costs and companies. To do this, it is necessary to define reference architectures and to share inter-operability logics. These logics are natural to develop in the research networks to then compare with companies and cities.
- sharing the solutions/criticalities encountered in smart cities projects, particularly in the SCC1 lighthouse projects, offering the opportunity to refine and reorganize given solutions in a clear and robust structure.
- the opportunity to work together in a setting where discussion and dialogue drive towards a re-definition of project proposals with more concrete, reliable and replicable solutions.

SP3 Energy-efficient Interactive Building (Coordinator: NTNU; sub-coordinator: ENEA)

Aims Buildings account for around 40 per cent of European primary energy demand. In tomorrow's smart cities, energy-efficient buildings will make use of energy conservation measures and on-site renewables to reduce their energy demand and will play a key role as interactive elements of the urban energy system. This sub-programme will develop and validate innovative, competitive holistic concepts, tools and demonstration cases for a new generation of buildings in the urban context. The main aim is to further increase their energy efficiency, enable coordinated exchange of energy with thermal and electrical grids while providing a comfortable healthy indoor environment to their users. Research in this sub-programme will mainly focus on distinctive fields such as design concepts for resource-efficient buildings, novel envelope materials and technologies that provide an optimal interface between the building and its environment as well as the integration of renewable energy systems into buildings. Emphasis will also be placed on innovative building and energy management, the energy interface between building and urban infrastructure ("building-to-grid"), smart interaction with the user as well as support strategies to achieve a multiplier effect within the broader stakeholder community.

Output In the past few years, SP3 partners have frequently discussed the role of buildings and building stock in smart cities – as places of energy consumption, generation, storage, exchange, distribution and so on. The new paradigm of community engagement mixed with decentralized energy generation and highly interconnected urban infrastructures was integrated in a wide

SP 3: Energy-efficient Interactive Buildings

The purpose of sub-programme 3 is to analyse the role and added value of energy-efficient interactive buildings for Smart Cities, and to develop a knowledge platform for Key Performance Indicators, methods, solutions and cases that contribute to their large-scale penetration. This activity cannot be managed at the national level alone. This strategic research and development activity needs to be supported by efficient coordination of EU research activities and funding, to combine the following actions: development of adequate policy and market instruments to foster demand for Energy-efficient Interactive Buildings; analysis of feedback from case studies to validate (or discard) existing models and tools; exchange of knowledge and experiences among sector stakeholders.

The research activities will primarily focus on five main tasks:

1. Optimising interactivity with real-time energy demands, climate, people, cultural heritage and urban networks to procure locally-adapted, high-quality energy-efficient buildings (WP1 Building Design).
2. Developing and validating materials and technologies that can provide the optimal interface between buildings and their surrounding site and climate (WP2 Envelope Solutions).
3. Developing and validating the energy interface between buildings and urban infrastructure, to ensure optimal energy efficiency in a larger societal perspective (WP3 Energy Management and Grids Interaction)
4. Understanding energy consumption patterns in buildings (WP4 User Interaction).
5. Close co-operation with industry, public government, media and users to help identify and improve critical success factors in business models, education and policy, which can create a multiplier effect within the broader stakeholder community and contribute to a green European economy (WP5 Support Strategies).

SP 4: Urban City-related Supply Technologies

One of the principal ideas behind smart cities is the efficient integration of on-site renewable energy sources into buildings and networks. Energy supply technologies such as heat pumps, solar thermal, photovoltaics, energy storage units, etc. play a key role in this context. The development of smart integrated energy networks will require both new components and systems, as well as a better understanding of how to integrate distributed supply technologies into urban infrastructure in an efficient and cost-effective manner.

The overall aim of SP4 is to create an integrated analytic framework that identifies tailored pathways to smart, sustainable cities from the perspective of energy supply technologies and as-

range of European projects. SP3 partners contributed to develop data, tools and verification methods of integration of robust design and smart technologies, allowing buildings to become interactive nodes of larger networks and enabling a coordinated exchange of energy with the grids while providing a comfortable healthy environment to their users.
The continued importance of energy-efficient interactive buildings in smart cities was confirmed by the SET-plan and its recent development of a roadmap for "Positive Energy Blocks/Districts" as key elements for smart sustainable cities - with strong participation of the EERA JP Smart Cities in the Temporary Working Group.

SP4 Urban City-related supply technologies (Coordinator: Campus Iberus)

Aims One of the principal ideas behind smart cities is the efficient integration of on-site renewable energy sources into buildings and networks. Energy supply technologies such as heat pumps, solar thermal, photovoltaics, energy storage units, etc. play a key role in this context. The development of smart integrated energy networks will require both new components and systems, as well as a better understanding of how to integrate distributed supply technologies into urban infrastructure in an efficient and cost-effective manner. This sub-programme aims to develop a methodology capable of dealing with complex integration of thermal and electrical energy technologies, and enabling the design and evaluation of renewable technologies integrated at district or city level. This will require the development of an appropriate modelling and simulation framework including numerical component models and libraries and an integrated, flexible and adaptive multi-level decision support framework. In addition, the city-industry interaction will be investigated to optimise available synergies such as the use of waste heat from industrial processes.

Output The main output of this sub-programme is the successful participation in the call H2020-SCC-2016-2017, SCC-1-2016-2017, Smart Cities and Communities Lighthouse projects. The project STARDUST was approved and started in October 2017. The objective of the project is to pave the way towards the transformation of carbon-supplied cities into Smart, highly efficient, intelligent and citizen-oriented cities, developing urban technical green solutions and innovative business models, integrating the domains of buildings, mobility and efficient energy through ICT, testing and validating these solutions, enabling their fast roll out in the market. Some of the main objectives of this project are:
- To develop common energy supply strategies based on the overall district energy demand (including buildings, mobility and urban services) to be followed by lighthouse cities and further replication in follower cities.
- To evaluate priorities for the smart buildings approach by taking into account the whole impact on energy savings, cost-effectiveness, integration with the built environment, and the requirements of building users.
- To assure integration and interoperability between software components, data sources, services and devices, to facilitate accessibility by third parties to STARDUST solutions, and to promote open innovation through the design and deployment of an open city information platform.

Two members of the Joint Program, VTT and UPNA (that belong

sociated sub-systems. SP4 framework is devoted to work out an improved short-term performance of our urban energy supply infrastructure via (a) an enhanced control of existing supply sub-systems and (b) an optimised operation of appropriate new sub-systems in the new building or renovation real-world contexts. More specifically, it is a means to achieve medium- and long-term forecasting of possible scenario pathways to sustainable cities based on clear taxonomies, KPIs and benchmarks. This does suggest modelling from sub-system to district scale, considering that detail level and careful selection of appropriate modelling approaches (empirical, stochastic, probabilistic, deterministic, etc.) is required, along with measured data integration.

The main objectives, within the context of the 'energy performance gap', are to evaluate the fitness-for purpose of current sub-system models, and where appropriate to develop improved approaches; given the needs of key end-users, to create an integrated adaptive 'whole system' approach that incorporates holistic factors (both technical and non-technical) related to supply sub-systems, and is interoperable with approaches taken in other SPs/JPs; to develop the 'state-of-the-art' in terms of system performance measurement, testing, QA/risk; to perform management, benchmarking and control activities within the context of existing and emerging EU standards; to test and validate the new framework by applying it to large-scale case studies in conjunction with other SPs/JPs.

SP4 is structured into 6 working packages, namely:
- WP 1: Framework for development of multi-purpose component-oriented models
- WP 2: Development of component-oriented model libraries
- WP3: System Integration
- WP 4: City-industry interaction
- WP 5: Technology Assessment
- WP 6: Scientific methods for quality assessment for urban related-energy supply technologies

to Campus Iberus), are partners in this project. UPNA plays an important role in the design and application of TIC technologies to improve city management and public engagement. After the project, Pamplona will join a new Stardust Open City Information Platform (SOCIP) that will provide data collection, data analysis, decision support tools and open data infrastructure services. Some of its citizens will have detailed information about energy recommendations for their home as personalized energy saving tips, next-day energy price profiles and customized strategies for demand using gamification techniques For the remaining citizens, a new City App will be available with integrated and georeferenced information of city infrastructures: parking lots, e-charging devices for electrical vehicles and public transportation (taxi and bus) in order to reduce energy consumption and improve city life.

An additional activity is the participation in the future Summer School organized by the University of Newcastle. Two workshops have been proposed by Campus Iberus:

- Thermal energy storage systems (TES) Workshop: This technology plays a central role in the strategies to reduce energy consumption due to heating, cooling and domestic hot water demands, increasing the efficiency of the energy systems in which they are integrated and the potential utilization of new RES. Although TES themselves do not save final energy, they are able to "move" heat and cold in space and time, correcting the mismatch between supply and demand by allowing:
  1. energy conservation by exploiting new RES;
  2. peak shavings both in electric grids and DH grids;
  3. power conservation by reducing the required power of energy conversion machines;
  4. reduced GHG emissions. Thermal Energy can be stored in the form of sensible heat, latent heat and chemical reaction.

Despite the most commonly used method remains based on sensible heat, latent heat storages, based on the employment of phase change materials (PCM), are an attractive solution as they provide higher storage density and smaller temperature difference between the absorbed and the released heat as compared to sensible heat storage.

- IoT Workshop: The advent of Smart Cities and Smart Regions demands highly interactive context-aware environments, capable of gathering large volumes of data as well as potential tele-control of multiple devices, within an IoT framework. In this context, wireless communication systems play a fundamental role in providing such interactive capabilities, due to inherent ubiquity as well as large degrees of adaption to user dynamics and demands. In this presentation, an overview of the communication systems employed in order to enable IoT systems and applications will be provided. Requirements, planning guidelines, challenges and real deployment designs will be presented, providing a comprehensive description.

Looking at the future

A review of EU27[9] cities with at least 100,000.00 residents shows that 240 (51%) have implemented or proposed Smart City initiatives[10]. It is clear that the phenomenon applies to large cities better than smaller ones. It's a matter of fact that there are Smart Cities in all EU27 countries, but these are not homogenously distributed[11]. This was also analysed by different cities and stakeholders and resulted in the Action group of "small giants" within the European Innovation Partnership on Smart Cities and Communities (EIP SCC).

Over two-thirds of sampled Smart Cities projects are still at the planning or piloting testing phases, and this is why the numbers of mature successful initiatives remain relatively low.

An analysis conducted on this topic[12] highlighted that successful projects are those with clear objectives, goals, targets and a baseline measurement system in place from the outset, followed by a strong governance, a sound business case and a strong local government. Successful projects also tend to be embedded in a comprehensive city vision where public-private partnerships are highly important, especially where the private partners bring in developer expertise, finance, technology capabilities and the involvement of citizens or others end-users. Some implementations have shown a clear gap between the involvement of a minority of pioneer users and the whole population. New methods and protocols to increase end-user collaboration could be a critical element for a successful implementation of large scale Smart Cities.

It is clear that all these aspects are needed to move towards Smart Cities but it is a fact that technological progress and innovations are at the core of Smart Cities and prompt new approaches to the management/development of cities/districts: a growing urbanization and the increased demand for efficiency in the provision of services is calling for more efficient urban management solutions. Thus, innovative technologies in urban investment have the potential to reshape the way resources are exploited to provide services.

That is probably why in the next future (2025), in EU and national RD&I programmes to come, the general orientation about Smart Cities will be on the one hand towards solutions that can be scaled (increased in size) and replicated (rolled out in a different environment as compared to the one where they have been applied in the first place), and on the other hand it will be based on smart technologies and solutions which have been designed, deployed and rolled out in Smart Cities projects to pave the way towards net-zero energy/emission districts ZEED thanks to the Positive Energy Block (PEBS)[13].

The question is: if this is the future scenario for coming EU27 cities, how does the EERA Joint Programme on Smart Cities need to evolve and transform? Undoubtedly, in the near future all EERA Joint programmes will play an advisory role for European

Commision implementing and developing SET-Plan; then JP on Smart Cities is expected to strength on JPs' members capacity building to obtain, improve and retain skills and knowledge on specific goals as well as to transfer excellent research to urban stakeholders (government, construction/design, real estate, urban services, e-commerce, analyst-IT project and Big Data, financial/funding, social/civil society).
According to this, the EERA JP on Smart Cities in the future will concentrate its efforts on a joint R&I agenda and on the development of a clear identity in the European research and innovation landscape on smart cities.

NOTES

[1] Cities of tomorrow. Challenges, vision, way forward, EU Regional Policy, October 2011; The Urabanisation of Europe and the World, Annex 1, Urban 2014; State of Euroean Cities report, EC 2010; 8th Progress report on Economic, Social and territorial Cohesion, EC 2013; World Urbanization Prospects: the 2011 revision, UN-Department of Economic and Social Affairs, N.Y. 2013.

[2] March 2011-Wien; June 2011-Wien; December 2011-Wien.

[3] Within this strategy document of the European Commission, a technology roadmap was highlighted as a basis for strategic planning and decision making, stimulating a collective approach in research, development and demonstration planning and implementation with a clear focus on large scale programmes, such as the European Industrial Initiatives (EII).

[4] This was launched in June 2011 and highlighted the importance of intelligent energy management systems in cities in order to achieve massive reductions of greenhouse gas emissions by 2020 as outlined in the "20-20-20 targets". One specific object was the sufficient market take-up of energy-efficient and low-carbon technologies and the effective spread of best practice examples of sustainable energy concepts at city level across Europe.

[5] One important aspect of "Smart Cities" appeared to be the switch from single technology applications to a multi- technology perspective combined with energy management in order to make existing energy systems of urban areas more intelligent. International experts from various fields continuously emphasize that in order to solve the complex problems of future energy systems, old co-operations and state-of-the-art solution patterns even in research will no longer be adequate strategies.

[6] A detailed and systemic approach is required to understand, simulate and optimise the emergent properties of complex urban energy systems. The key aim is to support stakeholders' decisions to maximise cities' energy autonomy and thus minimise their associated greenhouse gas emissions. This support can be provided by simulations that address and integrate all key elements of the urban energy system at appropriate spatiotemporal resolutions. As simulation-based decision support cuts across all topics of the Joint Programme, the Taskforce on Simulation Platform Development spans all four sub-programmes. Its key task is to evaluate the state-of-the-art in the modelling and simulation of urban energy systems, to identify gaps in simulation capabilities based on user requirements and to provide an overview of the data available and required for future simulation tools. The overall aim is to maximise synergies and complementarities between the individual sub-programmes in this field.

[7] However, the thematic link and exchange with these aspects, particularly with the topic of mobility and transport, have been obviously taken into account when dealing with energy-related research questions.

[8] December 2012-Rome; July 2012-Wien; December 2013-Wien; July 2013-Madrid.

[9] Directorate general for Internal Policies, Policy Department - Economic and Scientific Policy: a study, 2014.

[10] i.e.: Smart Cities and Community Lighthouse project: 10 Lighthouse Projects with 28 lighthouse cities and 24 follower cities; https://www.smartcities-infosystem.eu/scc-lighthouse-projects

[11] "Countries with largest numbers are in the UK, Spain and Italy, although the highest percentage can be seen in Italy, Austria, Denmark, Norway, Sweden, Estonia and Slovenia. Smart Cities are spread across all six characteristics but most frequently focus on Smart Environment and Smart Mobility; Data from Directorate general for Internal Policies, Policy Department - Economic and Scientific Policy: a study, 2014.

[12] Analyzing the potential for wide roll out of integrated Smart Cities and Communities solutions, A final report for DG Energy, 2016; Directorate General for Internal Policies, Policy Department - Economic and Scientific Policy: a study, 2014.

[13] Districts which consist of buildings (new, retro-fitted and historic - including offices, residential, commercials, schools, universities, hospitals, etc.) of various size which can be used as innovation-pushing "seeding-point" for these districts to showcase in highly concentrated form the integration of all aspects that are needed for net-zero-energy/emission district. Their concept is intrinsically up-scalable and they are well embedded in the spatial, economic, technical, environmental, cultural and social context. They are by design an integral part of the district/city energy and mobility system.

[14] C. Clemente, P. Civiero, Report RdS/PAR2016/033, Accordo di programma MISE-ENEA, Smart Cities and Communities, D6-Sviluppo di un modello integrato di Smart Distict Urbano - Diffusione dei risultati e Network JPSC workshop: January 2018-Genk; June 2017-Bologna; November 2016-Barcelona; July 2016-Prague; November 2015-Barcelona; June 2015-Trondheim; December 2014-Espoo; July 2014-Nottingham; July 2013-Madrid; December 2013-Wien; July 2012-Wien; December 2012-Rome; December 2011-Wien; June 2011-Wien; March 2011-Wien.

TOWARD THE SMART CITY AND BEYOND

Ernesto Antonini, Department of Artchitecture, University of Bologna, Italy
Elena Mussinelli, Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano, Italy
ernesto.antonini@unibo.it
elena.mussinelli@polimi.it

According to the advances emerged from at least two decades of intense debate within the EU and abroad, even the European Parliament recognized that the notion of "Smart City" concerns many different issues, pushed by both ICT and non-technical drivers, which overall aim is to «*seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally-based partnership*» (European Parliament, 2014).
Appealing to the wide horizon of "public issues" and the multi-layered structure of the urban-related processes and actors, the definition acknowledges that is still no common understanding about the definition of Smart City, as frequently complained by many Authors, but it also suggests that this lack doesn't affect the core of the topic nor the approaches that we can adopt to cope with it. Due to the variety of urban situations and stakeholder needs that we are facing as well as the peculiar patterns characterizing each human settlement, there is no consolidate models to be applied to make a context "smart", but rather it will be only by design that the smart features can be effectively integrated within the urban dynamics. Since the crucial role of ICT is confirmed as the main enabling factor in the path toward Smart City, its effective exploitation asks for a more performance-based attitude in developing successful applications, instead of a technology-dependent one, as sometimes it happened instead. The huge extend of the available technical innovations and the fast improvement of their features need a better and clearer vision on the goals to reach and its socially shared relevance.
However, further research and testing needed to make the potential of ICT useful and effective, developing applications that both show the benefits of the city smartness and identify constraints and feasibility conditions.
Looking at the physical dimension of the built environment - that which architects and planners are properly called to deal with- this means that we must resume focus on the optimization of construction processes and building management schemes, trying to shape them to better fit the needs of quality of life and urban welfare and to comply with socio-economic and governance targets, such as environmental sustainability and social cohesion. The resources that ICT make more and more available provide both a large palette of tools suitable for this purpose, and many opportunities for the development of new applications.
This Special Issue of Techne deals with both these targets: several papers report applications on real contexts of smart devices and tools, especially focusing on the energy performances improving at urban, district and building scale; many others deepen the definition of models and methods of monitoring, assessing, modelling and planning of policies and actions; some ones point at the measures to support sustainable city development.
This means that effectively exploiting the new opportunities provided by ICT is one of the most challenging issues for architects, urban planners and policy makers, who need to improve their skills in this field, working in closer cooperation together with both the holders of technological knowledge and the users.
Among others, two topics emerge as meaningful and promising targets for the next steps of the research in this field: the special needs of the historic heritage to consider in implementing the Smart City policies, and the applications that can be performed to deal with it; the exploration of the variety of structures and scales that the notion of "city" assumes today, including the large peri-urban and rur-urban areas with their dramatically ineffective features and critical environmental issues.
About 67% of the Italian territory is occupied by a dense network of small-scale settlements, while medium-size cities extend for 25% and largest metropolitan systems for 8% only (ISTAT, 2017). Additionally, Italy has more than 18,000 listed or protected historical centers, scattered all over the country (ANCSA 2017). This irreplaceable part of cultural heritage is as precious as it is fragile: ICT applications can provide unrivalled opportunities to better protect, manage and value it, but a special attention must be paid to integrate new features avoiding any alteration of the existing structures. Not all solutions and devices which have been developed for dense and large new cities can be merely transposed but adapted to fit the specific needs of these contexts. Furthermore, low-density sprawled settlements, high share of aged population, lack of familiarity with ICTs by companies and public administrations requires to adopt fine-tuned and tailored approaches allowing the successful exploitation of the Smart City features (Franco and Magrini 2017).
The rich panel of theoretical and methodological reviews collected in this special issue, as well as the experimental applications here documented, allows us to try to recap the operational effectiveness of the concept of "Smart City", in its various forms, as a tool distinctly characterised by a design oriented nature, aiming at the improvement of the quality of the territories through actions enhancing the "efficiency" in settlement and urban development.
The transfer of the term "smart" from the building to the urban and territorial scale represents in fact an implementation of the long process of adjective stratification that, in the last decades, has been going alongside the attribution of the word "city": strategic, sustainable, healthy and secure, green, ecological, low carbon, digital, media, smart and, today, resilient, are the attribute used to connote a new demand for quality emerging in response to the degradation of built environment.
No wonder all these forms have certain common denominators with regard to the main environmental challenges of urban development and land management. The areas of action taken into account are in fact mainly the same, referring to mobility and transport, energy and climate, waste and pollution, urban

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renewal and building construction operations. And not just this: also the policies implemented to face these challenges undertake similar issues and strategies, focusing on: a knowledge based economy; enhancing the cultural assets and the social and territorial capital by means of the subsidiarity and the participation of an active citizenship; promoting the attractiveness of places and spaces, both for locals and tourists.

In this light, talk about smartness - whether referring to buildings, cities, territories or communities - goes well beyond the objective of promoting and implementing a systematic and extensive use of ICT in the various fields of action of the public policies, but it also requires the capacity to adopt a strategic intelligence, meaning a connected, intersectoral and multi-scalar intelligence.

Many experiments carried out and in progress at national and international level reveal the obvious limits of too sectorial interventions aiming at optimising a specific functionality, such as building's energy performance, resilience to the climate change, traffic emissions reduction, slow mobility, etc. These actions, whose value must be undoubtedly recognized for being pilot tests, often risk not only to produce partial results, in some cases completely inadequate to meet the required investments, but also to generate new imbalances and inefficiencies.

In this sense, the true intelligence of cities and territories lies in the ability to implement an integrated governance, focusing priorities and coordinating actions in a medium to long-term perspective. With a focus mainly aimed at reducing unnecessary waste and consumption, and enhancing possible synergies related to the proper use of resources, primarily by upgrading and enhancing existing assets, through systematic interventions for re-use and regeneration.

The rapid acceleration of technological innovation in areas such as big data, mobile devices, connectivity and wireless data exchange, internet of things, promises developments that are difficult to foresee today, with transfers extended to the most diverse application areas, both in terms of "soft" tools for monitoring, control and management, and in the "hard" dimension of infrastructures and services.

Beyond a purely techno-centric vision that reduces smartness to a driver for the economic development of those companies that in various ways operate in the ITC (Bolici and Mora, 2016), the outlook of a more significant and effective impact of this new form of intelligence is in a more balanced combination of socio-cultural, environmental, economic and technological factors. Able to harmonize the interventions in the various fields of strategic action - energy networks, water, atmosphere, waste, mobility and transport, health, social inclusion, education, culture and tourism, ecosystems and landscape.

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Urban densification and energy efficiency in Smart cities - the VerGe project (Switzerland)

Alessandra Barresi,
Department of Architecture and Territory, Mediterranean University of Reggio Calabria, Italy
alessandra.barresi@unirc.it

Abstract. The issues of building densification and land conservation are much debated in local development policies and are related to the rational use of local environmental and climate resources. The paper proposes a critical reading of the research project that ISAAC Institute of SUPSI University (Switzerland) carried out on these themes by analysing a case in the municipality of Lugano Paradiso. The project analyses the effect of the urban transformation in terms of energy and solar access. The proposal of the case study was aimed at highlighting the importance quantifying some of the important consequences of local planning strategies can have on energy and the environment so as to contribute to assess their impacts to meet sustainable criteria and possible improvement actions.

Keywords: Smart city, Building densification, Solar resource, Energy performance, Urban quality

Introduction

A smart city copes with the energy issue in a comprehensive manner, through a programme, concrete actions and the coordination of all stakeholders. It is a city that considers energy as a crucial resource and plans its use according to objective evaluations. It is a city that helps citizens to be part of the change, informs them on what they can do to reduce their energy consumption, and launches initiatives leading to economic advantages. Furthermore, a smart city does not separate energy and urban planning, but rather manages the interactions between the various tools, fully aware that the quality of the urban environment determines a better microclimate in which buildings consume less (Giuliano Dall'O, 2014).

In terms of urban planning, there is a general consensus among the scientific community on the need for developing compact urban settlements (Camagni, 2002). The Aalborg Charter (May 1994) already recognized the importance of implementing effective policies in land use and planning, involving a strategic environmental assessment. The emphasis was put on the opportunities offered by dense urban concentrations to provide public transport services and more efficient energy supply. Further on, the Leipzig Charter and the Toledo Declaration, 2010, pointed to the need for integrated urban development policies, which could promote, among other things, the creation and consolidation of quality public spaces, by upgrading infrastructure networks and improving energy efficiency, as well as the development of efficient and affordable public transport systems.

Moreover, new urban regulations aim to limit the extension of urban sprawl promoting compact cities, similar in the spatial distribution to the historical city that for its intrinsic nature had a compact shape on a human scale. In the last twenty years, there has been increased interest in how the form of cities can contribute to their sustainability: the concept of "urban densification" has assumed the meaning of building volumes that are more compact and closer together, developing a sustainable urban planning model and preserving public spaces. Dense cities permit lower energy consumption per capita than more dispersed suburban equivalents (Lobaccaro, Frontini, 2014).

At the same time, European energy policies stress the importance of both increasing energy supply from renewable energy sources and reducing energy demand in the final consumption sectors, with a special emphasis on the building sector. In such a framework, political statements and directives, aimed at stronger integration between energy and building sector concerns, were developed[1] (Polo Lopez, Frontini, 2015).

The paper proposes a critical analysis of the VerGe research project (2015) that ISAAC (Institute for Applied Sustainability to the Built Environment), which is part of the University of Applied Sciences of Southern Switzerland (SUPSI), carried out on the issues of building densification related to the rational use of solar energy by analysing a case study in the area of Ticino, i.e., in the municipality of Lugano Paradiso (Switzerland), whose town centre is deeply changing towards a progressive urban densification, thanks to a new urban plan and zoning regulations.

The case study is aimed at highlighting the importance of quantifying the most important consequences that local planning strategies can have on energy and the environment sector, both considering quantitative and qualitative factors, so as to be able to assess impacts useful to define synergically sustainable criteria and possible improvement actions.

The paper is divided into three paragraphs: the first stresses how topical and urgent the energy issue is and, therefore, justifies the choice to critically analyse the case study, since the VerGe project can provide an effective scientific contribution to enhancing energy efficiency in smart cities; the second focuses on the case study critically analysing it and highlighting the originality of the methodology used by the research group; finally, the last paragraph deals with the research group's final observations on the results achieved, which have led to particularly interesting guidelines for town planners and authorities, who may apply them to urban transformation processes in different urban scenarios, always respecting local specific conditions

Energy: a topical issue

Several European projects have already proposed innovative approaches to raise energy efficiency through urban development, the refurbishment of the building stock, and effective methods and tools able to evaluate solar energy aspects and support planning and design processes, which are still lacking or in a prototype stage; also a rich literature has been produced on this subject[2].

A good orientation of the building in the urban fabric does not ensure all the necessary hours of sunshine. In order to apply the rule of the "right to the sun", it is also fundamental to respect the

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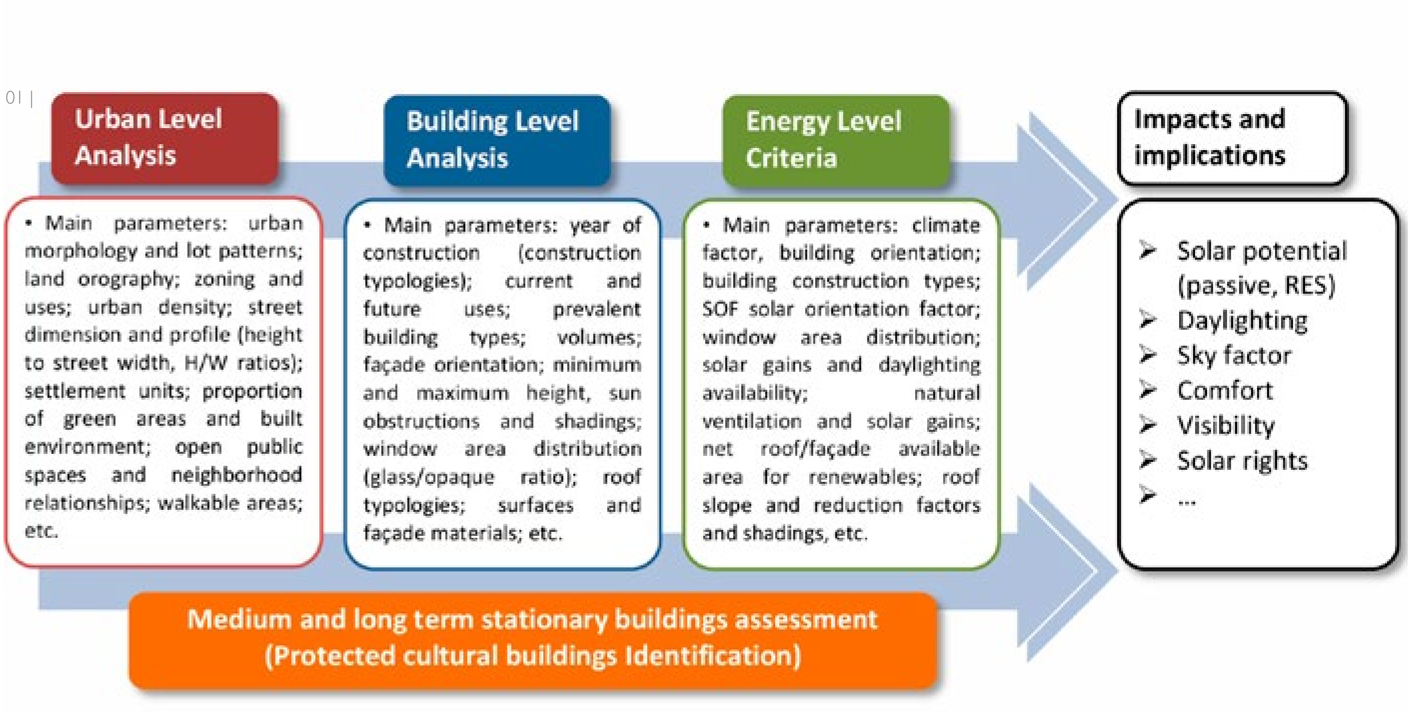


01 | Workflow diagram - methodology

right distances between buildings so that façades can receive the right amount of solar energy in winter. In the same way, factors, such as the geography and topography of a place, the type of vegetation or soil characteristics, and the built mass around the building, could affect not only the sun and daylight availability but also the local wind regime (wind speed and direction)[3].
Solar rights and solar access laws already define the proper configuration of buildings' shape, restricting the height of buildings depending on the width of the roads, in order to ensure correct sunlight and solar gain. However, past efforts were focused on single new buildings and, in particular, on a comprehensive understanding of the opportunities to exploit the sun in active and passive ways. The scientific community is, however, aware of the need to enlarge the scale of analysis and to move to urban planning and design scales. This would allow taking into account the buildings' shape, orientation and density, as well as detecting possible cumulative effects that could limit the access to sunlight or solar gains by changing the wind path and, consequently, the micro-climate, or reducing the possibility of equipping buildings with solar systems.
Moreover, the impact on solar energy availability in existing buildings (in particular historical buildings) during urban transformation is still not well understood and is a matter of research. That is why, recently, the International Energy Agency (IEA) has decided to set up a new working group on "Solar energy in urban planning" aimed at monitoring progresses in such issues. The report produced by the IEA "Illustrative Prospective of Solar Energy in urban Planning:Collection of International Case Studies" is a collection of 34 case studies - divided into new urban areas, existing urban areas, lanscapes - (IEA SHC TASK 51, 2017).
This is further evidence that the topics dealt with by the Verge research project, which is also the result of the scientific collaboration between the SUPSI University and the EIA, are extremely innovative.

Methodology

The Verge research project aimed to investigate how urban modifications, in particular, urban densification policies, could influence the energy demand, the conservation level and the solar availability of pre-existing buildings as well as the impact on the perception and visibility of the protected heritage. Based on this initial insight, the project aimed to recognize, understand and analyze different urban densification scenarios, considering the massing of the buildings and other aspects, like sky-view factors or solar radiation impact analysis, to examine if the urban pattern and the building design in the scenarios considered were suitable for the energy conservation behaviour of existing buildings.
Lugano Paradiso district is undergoing a very fast urban densification process changing its open urban sprawl into infill, with a

02 |

02 | Spatial urban planning:left picture sows the current situation and the right one represent the future Masterplan – Urban transformation in the city center of Paradiso

03 |

03 | City Center Area of paradise – current status and new status when New master Plan will be implemented

closed and compact urban fabric, as defined in the new Master Plan regulation. The new Master Plan of the area was published in May 2011 and endorsed by the State Council in June 2012[4].
To investigate the impact of urban densification on the energy behaviour of existing buildings, simulation and photographic diagnostic tools were used. The information analyzed provided basic design guidelines for urban planners or public and private institutions, responsible for the protection of cultural assets, with the purpose of seeking a new way to best utilize the methodology proposed considering solar access rights and becoming aware of the real problems caused by urban sprawl.

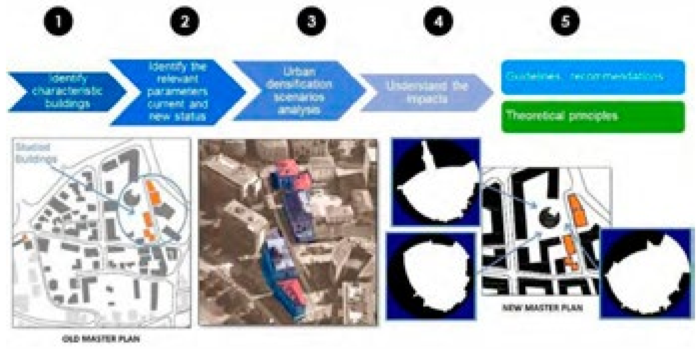
The research methodological process can be summarized as follow:

1. Identification of typical buildings (protected cultural monuments) already existing in the context of Lugano Paradiso.
2. Current and new urban transformation status analysis: Identification of the relevant parameters highly influenced by urban morphology (i.e. solar energy access, passive solar gain, daylight access, historical preservation and value, building consumption, visibility and view contact).
3. Development of different urban densification scenarios based on such parameters. Simulation tools were used in order to predict the dynamic effects of surface overshadowing at an urban scale. The two scenarios considered (the present and the future urban plan) allowed testing the urban planning solutions proposed in the master plan. Conflicts between existing buildings (in particular, protected heritage buildings) and the surrounding public urban areas were highlighted and a methodological evaluation process allowed understanding and assessing the urban densification impacts on the energy behaviour and conservation level of those buildings. In particular, such an assessment focused on the exploitation of sunlight and solar energy (both passive and active) in existing buildings and urban areas.
4. Definition of guidelines, recommendations and theoretical principles. Based on the results of the case-study, strategies able to favour effective integration and harmonization of conflicts were summarized and included at the end of the document. By doing so, the project transferred know-how and competences to municipalities.

The relevant parameters highly influenced by urban morphology, which affected energy aspects in buildings, were identified.
Different aspects and parameters linked to urban morphology and buildings typologies have a direct impact on building energy consumption, mainly on heating, cooling and ventilation performances: volumes, surfaces, streets width, façade orientation, sun obstructions and shading, etc. These key parameters allow establishing the "ideal" urban setting to reduce energy dependence on existing buildings and to improve the condition of stationary buildings in the area.
The main focus of the methodology proposed was to measure the impact and repercussions of urban changes on solar availability and their effects on the existing historical buildings and cultural monuments.
From the point of view of environmental impact, the densification process would be also a positive example of sustainability, if considering factors such as: the lower environmental impact due to greater exploitation of the soil and the minor use of free soil; the higher percentage of public spaces, and pedestrian areas; the decreases in car commuting by changing the urban mobility and urban accessibility, resulting in lower energy consumption,

04 | Process development scheme of Verge research - project

04 |



lower air pollution levels. The workflow (Fig. 1) shows that for each level of the chain, there are some important parameters that influence the energy aspects and energy balance of a building (consumption and production). At an urban level, specific urban planning significantly determines the possibility to relish solar irradiation in buildings. Solar energy exploitation on existing buildings (in particular, historical buildings) may be compromised during urban transformation. To shift the detail at a building level, always linked to the urban environment, it is necessary to examine the architectural situation already existing or under transformation. Thus, the distinctive elements of the surroundings were analysed taking into account building techniques, the year of construction, the materials used, the morphology of the buildings, and so on. Finally, all these aspects completed the assessment at an energy level. All levels have a direct impact on medium and long-term stationary buildings"[5].

It is important to underline how all the parameters taken into consideration in the urban and building level analysis affect not only the energy consumption and human comfort of a building but also the opportunity to generate energy with solar renewable resources.

The following aspects were identified as main parameters to evaluate such energy impacts (energy level): solar irradiation (solar passive strategies); sky factors modification in the urban context; human comfort; daylighting and illuminance levels; energy production and consumption (solar potential for renewable solar energy, energy efficiency of protected heritage buildings, solar rights assessment).

Simple and complex simulation analyses were performed to explain the effect of the densification process, which is taking place in Paradiso city center (CC) area, on each parameter mentioned above, and to provide the necessary background to suggest new approaches in urban planning that may guide future master plans.

Conclusions

Urban planning strategies determine the possibility to exploit solar irradiation for passive/active solar energy, daylighting, human comfort, etc., factors that may be compromised during urban transformation. In the same way, urban densification can influence the building energy demand and thermal performance, the level of conservation of existing buildings (in particular, of historical buildings) as well as the urban microclimate. Accurately quantifying these effects is a key factor for predicting reductions in solar availability, understanding their real impacts and detecting possible corrective measures.

The methodology proposed helped achieve the project goal, *i.e.* to assess properly how urban densification policies influence the energy demand, the conservation level and the solar availability of pre-existing buildings, focusing mainly on the major impacts over the protected cultural heritage, which should remain unaltered forever, while the surrounding environment is undergoing transformations.

At an urban level, streets and lots should be accurately oriented, for example, by placing buildings as close as possible to the northern boundary of the lot. At a building level, orientation, shape and height should be considered (e.g., buildings with a long axis should be oriented in order to reduce the shadow cast). Yet, the most interesting conclusion is the recognition of the key role urban planners and local authorities play in urban transformations. Urban planners write, amend, and administer standards, policies and incentives that have huge influences on the nature of changes, on the timing of future private development as well as on what, where and how local resources are used or protected.

Urban planners can set constraints, e.g., to ensure the unobstructed flow of solar energy through adjacent lots when the parceling and allotment of a particular urban area are designed. They also define ordinances specifying the standards for the exact size and location of the easement and indicating limitations on buildings or structures that could prevent the passage of light through it.

Specific ordinances on solar rights should ensure, as far as possible, daylighting and sun access on the south-facing wall of buildings during the hours of sunlight, keeping in mind latitude, topography, microclimate and the existing urbanization and vegetation, besides the uses and densities set up in the area.

The new Master Plans should consider establishing solar access standards for:

- the orientation of new roads and the lots;
- the location and height of new trees on public roads and other public properties;
- the intended use and the density of urbanization to conserve energy and/or facilitate the use of solar energy.

Communities can create incentives by streamlining the approval process, reducing authorization costs, and increasing flexibility for the integration of solar and local energy sources if all aspects are correctly considered since the first steps of urban codes.

It is important to develop also specific laws to eliminate uncertainty around where solar systems may or may not be allowed in order to ensure appropriate locations and mitigate any potential negative impacts.
Municipalities should attempt to provide basic zoning defining solar energy-related terms and determining whether solar energy systems are allowed for primary or accessory use in each zoning district.
Municipalities and urban planners should also tackle solar easement and access requirements as site planning guidelines for lot and building orientation profiles that maximize solar access, or think about easely comprehensible solar-ready development standards to be applied to buildings constructed to allow the future installation of solar energy systems.
The new ordinances should also address the PV system appearance, requiring neutral paint colors, specific forms and shapes according to the building envelope and BIPV systems, with non-active system components, customized for better and greater integration.
Finally, solar energy use, in all its forms, not only improves energy efficiency in buildings, but, since it is a renewable energy, it also fosters natural resources and reduces air pollution, greenhouse gas emissions, and dependence on fossil-fuel energy sources. In this perspective, the goal of the Verge project, fully achieved, is to demonstrate how researchers and urban planners can help municipalities to make the most of solar energy. Working together, they showed how local development regulations could support measures to better exploit solar and daylighting resources considering the peculiarities of the site and urban morphology.

ACKNOWLEDGMENTS

The Author is grateful to Architect Cristina S. Polo Lopez, researcher at the University of Applied Sciences and Arts of Southern Switzerland (SUPSI), for being helpful and for providing documents about the Verge Project.

NOTES

[1] See, for instance, the EU Directive on net energy zero buildings.

[2] Among others, the following publications are of particular interest: Amado M., Poggi F. (2012); Kanters J., Horvat M. (2012); Hanna T.P. (2016).

[3] For example, low speeds of 0.5 m/s could be problematic with cold winds, while speeds of 3 to 3.5 m/s would be desirable in hot and dry areas.

[4] Site Area: 240.000 sqm; Building Area: 330875 sqm; Area Density 1.38 inhabitant/sqm.

[5] Cfr. Polo Lopez C.S. and Frontini F. (2015), *Städtische verdichtung und energie verhalten der bestehenden gebäude - Verge project*, SUPSI, Lugano-Canobbio.

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Distributed Renewable and Interactive Energy Systems in Urban Environments

Maurizio Sibilla, Esra Kurul,
School of the Built Environment, Oxford Brookes University, United Kingdom
msibilla@brookes.ac.uk
ekurul@brookes.ac.uk

Abstract. European Policies consider a multitude of Low Carbon Technologies to transform cities to Low Carbon Cities. Some of these technologies can form distributed systems. These are new forms of Energy Networks which can contribute to reducing the vulnerability and homogenization of urban patterns as they evolve to become part of the urban infrastructure. This evolution process also involves computerizing elements of the infrastructure, and thus relates to the Smart City concept. In this sense, a Distributed and Renewable energy system becomes interactive promoting a set of novel system properties. Following a qualitative approach, this paper presents an innovative conceptual framework in order to establish, communicate and disseminate these new system properties.

Keywords: Low Carbon City, Smart City, System Innovation, Urban Patterns, Ecological Approach

Reconciling urban patterns and smart systems

Currently, the Smart City concept is recognized as a relevant theme in understanding the trajectory of urban development (European Commission, 2012). Smart city solutions are those that integrate technologies from Energy, Transport and Information and Communication Technologies (ICT). Although this concept is considered fundamental for the evolution of urban environments in the literature, its relationship with different urban patterns is not sufficiently investigated.

The term «Smart City» was introduced by the Strategic Energy Technology Plan (SETplan) in 2009 (European Commission, 2009) as a strategy for Low Carbon Cities (LLCs). It concerns the computerisation of the energy infrastructure, which has manifested new opportunities (Bribri and Krogstie, 2017). These opportunities can revolutionise the existing Energy Networks, which had been considered immutable until relatively recently (La Porte, 1994).

A large part of the literature at the intersection of Smart Cities (SC) and urban patterns, which are defined as the way in which different functions and elements of the settlement form are distributed and mixed together spatially (Lynch, 1981), focusses on the impact of the latter on energy consumption and carbon emissions (Benjamin, Tan and Razon, 2015). Other studies investigate the SC concept essentially in terms of innovative technologies and smart systems (Angelidou, 2015). The relationship between the SC concept and urban patterns, which is difficult to unravel, is largely neglected. Two key issues should be dealt with: the old, large socio-technical systems' resistance to change; and the synchronization between the individual resident's energy choices and the system's organizational principles and characteristics (Basosi, Casazza and Schnitzer, 2017). Alternative energy systems, such as the Distributed Renewable and Interactive (DRI) energy systems, are thus needed. The components of these systems can work as ecosystem service categories (i.e. supporting service[1]; provisioning service[2]; regulating service[3]; cultural service[4] (MEA, 2005).

Ackermann, Anderson, and Söder, (2001) defines a DRI as a low-medium voltage electricity system, connected directly to the place of consumption. Interactivity of the system is enabled through the diffusion of informatics devices and software, which is revolutionizing the sense of "making infrastructure". It is a system property that involves all components in multi-level interactions. At the same time, interactivity validates the concept of micro-grid as a fundamental part of the debate on energy evolution (Soshinskaya et al., 2014). It is a system property that can connect the energy system to the specificity of the local context.

The Virtual Power Plant (VPP) is the main device for managing interactivity. It is a technological system aimed at synchronously managing the information and energy fluxes. The dimensional and localization logics managed through VPP are completely different from the traditional fossil-based energy systems. Many studies have considered interactivity from the perspective of optimizing the integration of different renewable technologies by using information systems (Dimeasand and Hatziargyriou, 2007, Siano, 2014).

These studies contributed to the discourse on a new energy infrastructure system from different points of view, but an all-encompassing framework to conceptualise it has not yet been developed. Issues around their incompatibility with the old notions of infrastructure and its classification have not been explored. Given this situation, the traditional definition of infrastructure and associated indicators (Hansen, 1965) faltered.

Evolutionary integration of the alternative systems into existing urban patterns rely on an innovative approach to transforming cities to LCCs. The new approach is founded on new mechanisms for infrastructure evolution. The literature refers to these mechanisms as evolutionary mechanisms and synthetizes them in the three pertinent facets:

- The co-evolution process: synchronization of new technologies, market models, eco-system practices and final users (Foxon, 2011).
- Multi-level interactions: inter-linking the technical system and urban patterns and vice versa (Geels, 2005).
- The dynamics between the main actors of the technical innovation processes (Foxon et al., 2013).

These evolutionary mechanisms describe the general inalienable conditions in which the DRI systems are called to operate so that an innovative approach to the LCC can be constructed.

Aim and innovation profiles

A new conceptual framework is needed for the above integrated vision to be developed and embraced. It is deemed more consistent with the purposes of integrating sustainable energy services and systems with local peculiarities of settlements. This paper proposes such a novel conceptual framework, which is based on an innovative approach to the LCC and the concept of DRI Energy Systems in Urban Environments. The key concepts in this context are: urban patterns, the SC concept and DRIs (Fig. 1). The evolution trajectory of a

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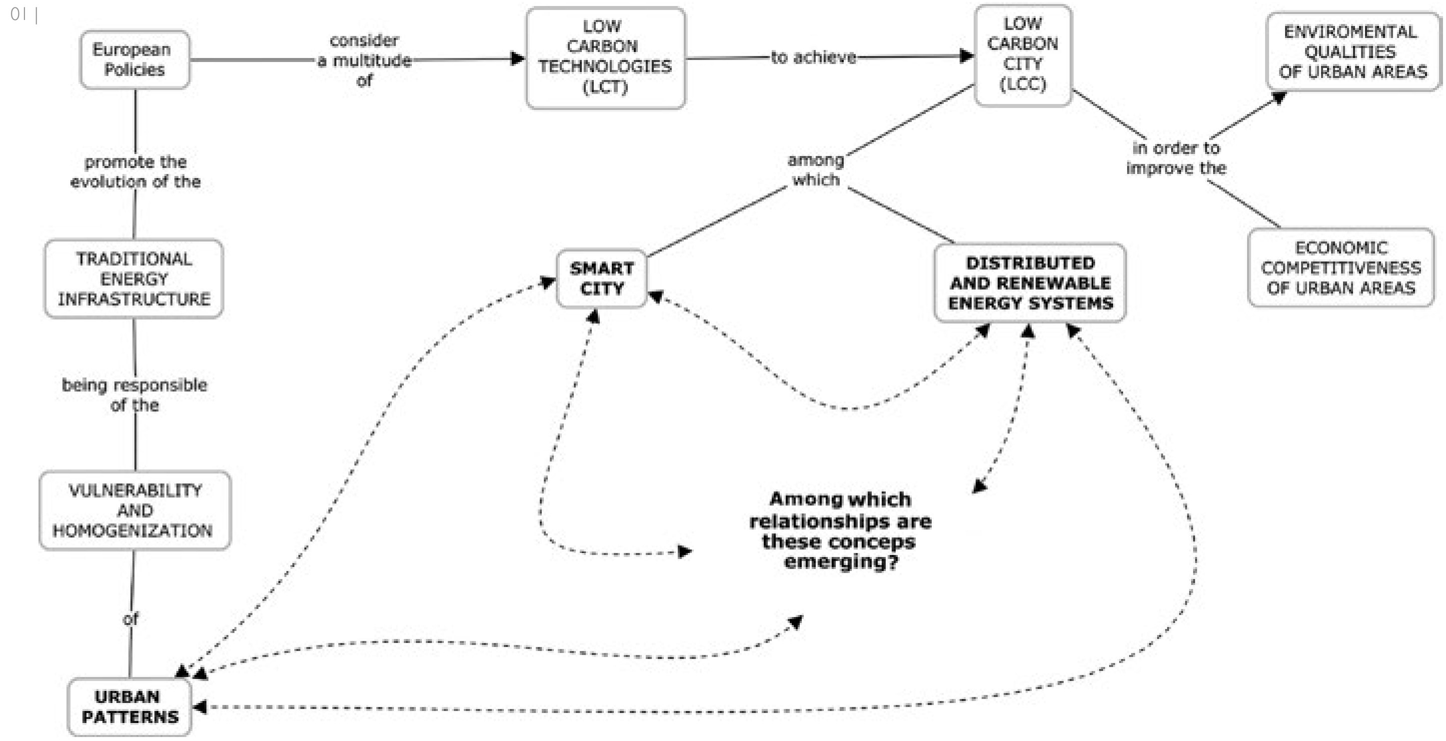

01 | Key Concepts and research question

DRI energy system will also be defined in order to synchronize the evolution of settlements with the computerization processes, embracing a broader view of the SC concept and an ecological approach toward the LCC.

This study starts by marking the mechanisms through which infrastructure evolves; circumscribes the research investigation towards the DRI system and its main features; proposes a novel conceptual framework on the DRI system; and introduces an operational framework for the DRI system, pointing out a specific socio-technical role for the Virtual Power Plant (VPP). To conclude, the authors illustrate how the new conceptual framework can enhance the SC concept.

Methodological approach

A qualitative approach has been adopted to build the conceptual framework. Qualitative content analysis of the existing literature is conducted to define the problem and identify the concepts which have the potential to offer a viable solution (Jabareen, 2009).

A process of theorization, which uses grounded theory methodology rather than description of the data and the targeted phenomenon (Jabareen, 2009), is utilised to build the conceptual framework from existent multidisciplinary literature. This framework is developed as a network of linked concepts. The proposed methodology comprises the following main phases:

Phase 1 - Identifying the DRI concepts: Concepts relevant to the energy infrastructure evolution are identified multidisciplinary literature. Hughes' (1987) Large Technological systems (LTS) concept, Zeleny's (2012, 1986) approach to the management of High Technology Components (HTCs), and Harrison and Donnelly's (2011) approach to characterising the SC are identified as the foundations of our conceptual framework.

Phase 2 - Integrating the DRI concepts: LTS, HTCs and SC are integrated. The definition of LTS is the starting point. It is deemed more consistent with the purpose of restoration of energy ecosystem services within the regulatory framework for territorial infrastructure. Hughes (1987) marks a radical change from the past and current patterns of homogenisation and vulnerability. Zeleny's approach (2012, 1986) is used to describe the evolutionary phase, in which the DRIs are called to operate. Harrison and Donnelly (2011) offer an opportunity to synchronize the algorithms and digital protocols with unique urban patterns, by improving local technological literacy, including understanding the functionalities of the VPP.

Phase 3 - Validating and rethinking the conceptual framework: The proposed conceptual framework is discussed. It denotes a multidisciplinary approach to the evolution of the energy infrastructure. It may be revised according to new insights, emerging literature, and reveals the need for a new generation of energy policies for DRI energy systems.

Phase 1. Identifying the DRI System concepts

In this section the concepts identified as the foundations of a new energy infrastructure conceptual framework are introduced. The results in Table 1 illustrate the LTS as the foundation of a DRI. Table 2 explains the HTCs. Table 3 illustrates the SC concept, pointing out the concrete possibility of synchronizing the algorithm and digital protocols within a local context and with a unique urban pattern.

Category: Large Technological System (LTS)
Concepts: Infrastructural apparatus; Vulnerability; Homogenization; Infrastructure Evolution; Local context; Reverse salient; Components.
Description: Hughes' (1987) LTS concept contrasts this obsolete infrastructure definition, and opens the debate on the relationship between technical and cultural aspects of the energy infrastructure evolution. LTS is an open system; it is ready to interact with the conditions of the local context. Its functionality is determined by the local conditions. It, therefore, has the ability to enhance the territorial re-composition process. Hughes (1987) uses the term «reverse salient» to denote the system when one or more of its components are in the outside phase, less efficient and thus retard the evolution of the system. When the outside phase affects the whole system, we have to deal with its involution.
Comments and connections: The traditional view of the fossil-based energy infrastructure is largely indifferent to the local geographical conditions. The «reverse salient» concept expresses the dynamic character of the new energy infrastructure, in which nothing is static and where the components behave as a system. It is an indicator to assess the evolutionary status of the infrastructural apparatus according to Hughes (1987). Zeleny develops a technological model to describe the evolutionary mechanisms for the components of the infrastructural apparatus. The «components» of the system is the link between Hughes' conceptualization of a LTS and Zeleny's work which identifies these components and the stages through which such systems evolve.

TAB. 1 | Large Technological System (LTS) as the foundation of a DRI

Category: High Technology Components (HTCs)
Concepts: Infrastructural apparatus; Infrastructure evolution; Components; Hardware; Software; Brainware; Technology Support Net.
Description: Zeleny (1986) states that any technology has three clearly identifiable components: Hardware describes the physical apparatus (H); Software concerns the collection of rules (Know-how, programmes and algorithms); Brainware (or Knowere) involves the scope. Technology evolves through three fundamental stages: Stage 1: the appropriate technology. The Technology Support Net is neutral because the technology apparatus is fully accepted, under the cultural, environmental, political and social conditions. Stage 2: one or more components can be improved from the functional or efficiency points of view. The Technology Support Net does not modify its cultural and technical structure, but is able to use the available technologies in a more efficient way. Stage 3: High Technology. Substantial revision both of the structure of the organization and the components. It is possible to operate in an alternative and more efficient way. More importantly, it is possible to do new things (Zeleny, 2012).
Comments and connections: Infrastructure can be conceptualized as a technological system using Zeleny's components. Hardware also describes the rationale with which the components are used. Rules regard the conduct of the components. Brainware involves applications of Hardware and Software. These components interact within a specific administrative and cultural structure. Innovation mainly changes Hardware and Software. Brainware would remain unaltered if innovation was isolated. To avoid this, innovation has to change the Technology Support Net, which consists of work rules, task rules, requisite skills, work content, standards and measures, styles, culture and organizational patterns (Zeleny, 2012). Brainware cannot be transferred, because it has to be developed in situ. Knowledge has to be produced within the specific local context and the corresponding Technology Support Net (Zeleny, 2012).

TAB. 2 | High Technology Components

Category: Smart City (with relation to the energy infrastructure theory)
Concepts: Computerizing System Processes; Infrastructural apparatus; Creative class; Synchronization.
Description: Harrison and Donnelly, (2011) provide evidence on how the pattern concept (Alexander, 1979 quoted in Harrison and Donnelly, 2011) has become the main reference for the engineering software and ICT sectors (Gamma et al., 1993 quoted in Harrison and Donnelly, 2011), even if it has not had much effect on the design and planning disciplines. SC concept can be linked with a generation of creative people and innovative tools able to observe the urban metabolism in detail. Harrison and Donnelly, (2011) explain the success of this concept with regards to the opportunity to attract the creative class. In this context, the creative class represents the digital generation that can manage the new technologies and remodel the old apparatus of the city.
Comments and connections: In the first instance, this relationship could appear to be only a cultural reference, but in reality it shows a concrete possibility to synchronize the algorithm and digital protocols within a local context and with a unique urban pattern. Creative class concept is particularly interesting in the case of the DRI system, with which the rules and the tools to construct a local urban pattern can be changed. The main DRI features, alongside the computerizing process, can help to enhance the physical and environmental local conditions in order to develop a contemporary concept of urban form.

TAB. 3 | Smart City (with relation to the energy infrastructure theory)

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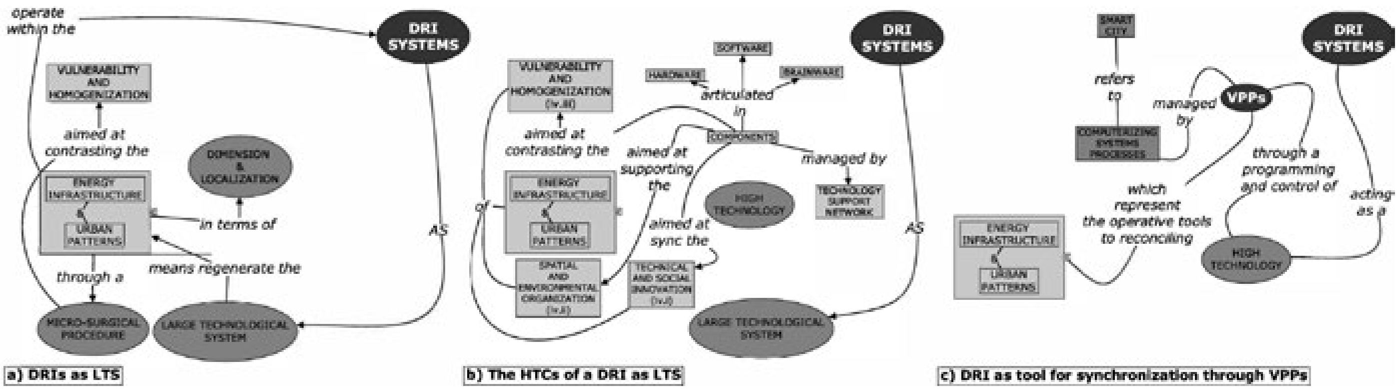


02 | Map of the Integration process of DRI features

Phase 2. Integrating the DRI System concepts

The main concern of this study is the construction of a new pattern of energy infrastructure, based on the critical evaluation of the definition of LTS, HTC and the synchronization of a computerizing algorithm and local urban settlements. This evaluation highlights the DRI evolution trajectory according to the evolutionary mechanics and the main DRI characteristics. Such DRI evolution trajectory is described as follows:

- DRI system as a LTS. Here, the way the new energy system can be adapted and implemented in relation to the local conditions is underlined in order to contrast the indifference toward the local geographical conditions, and in particular towards the vulnerability and homogenization of energy infrastructure and urban patterns.
- The HTCs of a DRI as LTS. The hypothesis within which the DRI system is called to operate in order to revolutionise energy infrastructure are described.
- DRI tool for synchronization. The VPP as a main tool to implement the new pattern of energy infrastructure is associated with the aforementioned proposition.

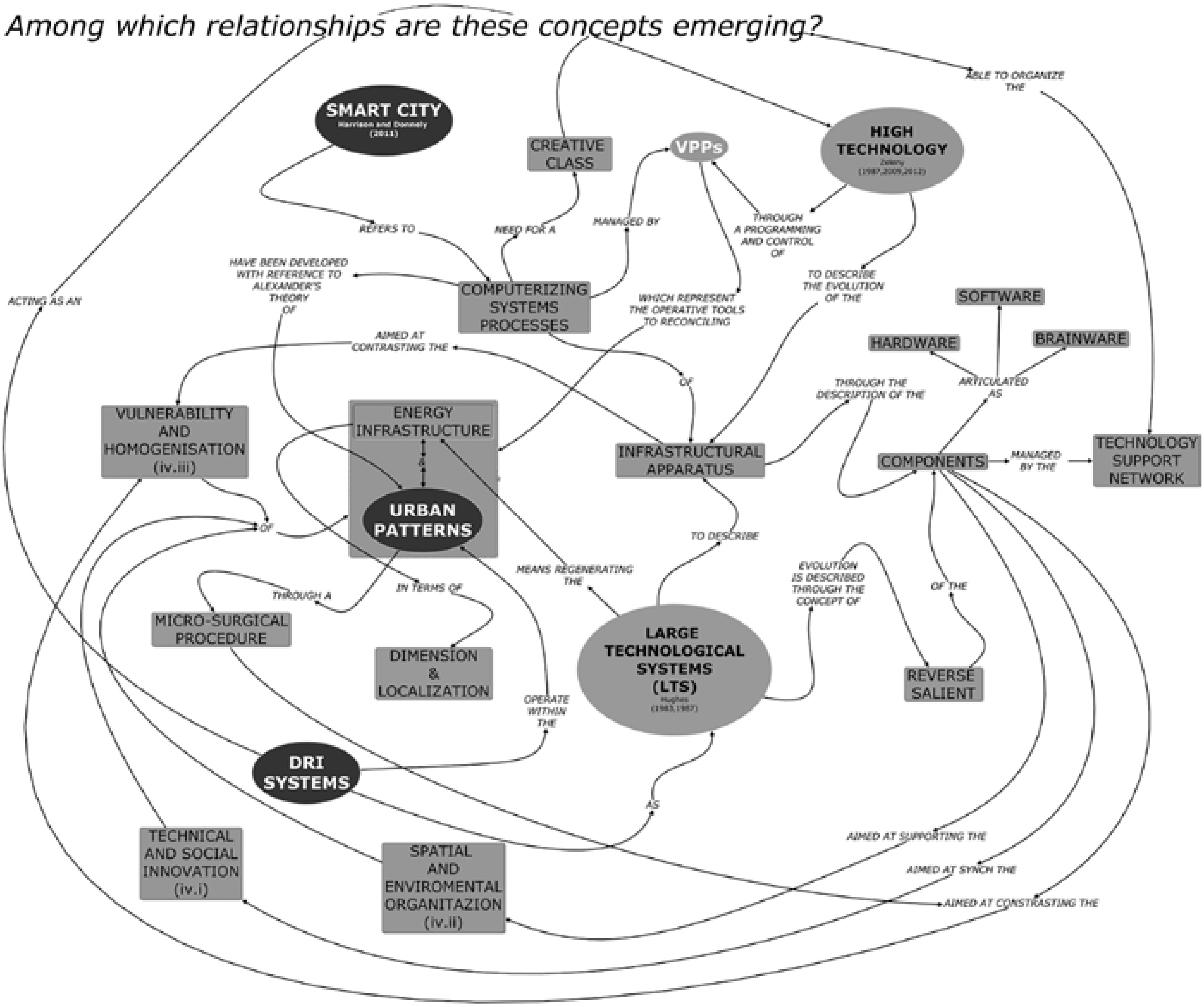
These cross-cutting issues are used to define a novel conceptual framework on energy infrastructure. A DRI system in order to support a LCC vision in ecological perspective can thus be developed and communicated.The results of the integration process are presented in detail below.

Firstly, defining the DRI system as LTS means regenerating the energy infrastructure concept in terms of dimensions and localization (Fig. 2-a). The dimension of the system is never defined a priori. It depends on two main factors: the local demand for energy and the technical capacity to organize the system. The localization of the system is highly dependent on the physical and environmental local conditions. Localization is highly dependent on the local energy availability, which concerns the efficiency of the system. In this context, the term «efficiency» refers to the application of the highest diversity technology, which has to be compatible with an environmental context. Following the LTS evolution, small-scale changes are introduced through a micro-surgical procedure (Table 4, point 1).

Secondly, the DRI system is defined through its material and immaterial components, including its main technical and non-technical features. The HTC, i.e. Hardware, Software and Brain-

1. DRI system as a LTS	Following the LTS evolution, small-scale changes are introduced through a micro-surgical procedure. Thus, there is a technical solution in the short-to-medium term. During this period, the DRI system can co-exist with the old energy infrastructure. At the same time, its components can be expanded to cover the extent of the urban area. In fact, one of the main DRI system features is its capacity to be adapted and implemented through space and time, from the micro to the macro scale. Therefore, the DRI system can fulfil its primary role, i.e. energy provision, as determined by the local geographical conditions.
2. The HTCs of a DRI as LTS	The three characteristics, which should underpin the construction and organization of the DRI system, are described below: - The DRI system acts as a High Technology System through evolution of the Support Network as a result of technical and social innovation; - The DRI system is organized through the interaction among Hardware, i.e. the spatial and environmental characteristics of the settlement, and Software, i.e. energy supply devices. Both components function according to local rules; - The DRI system is specifically aimed at supporting an ecological and efficient Brainware (i.e. cultural service). The homogenization and vulnerability of the urban settlements, which result from their reliance on fossil fuel-based energy systems, are addressed through the use of diverse and appropriate technology.
3. DRI tool for synchronization	VPPs become vehicles for the energy infrastructure evolution: - VPP programming and control, enables the synchronization between technical information and social aspects of the energy system (i.e. regulating service). The DRI system thus acts as a HTS. - The DRI system is organized through the interaction between Hardware and Software. The VPP services manage this interaction. They can optimize the eco-efficiency of spatial and environmental characteristics of the settlement; the integration of energy supply devices; and facilitate the elaboration of specific local energy infrastructure rules. - The DRI system is specifically aimed at valuing ecological and efficient Brainware, through the VPP. The VPP is an adaptable tool, which can regulate the complex local energy and information flows in a dynamic and multidimensional manner.

TAB. 4 | Integrating DRIs concepts

03 |


03 | DRIs conceptual framework. The figure shows the complex relationships on SC, DRI and Urban Pattern disclosed with the support of the qualitative methodological approach

ware, are introduced to describe the premise in which the DRI system is called to operate as a LTS (Fig. 2-b). The three characteristics are described in Table 4, point 2.

Thirdly, three factors emerge as relevant for synchronization: the VPPs are capable of assembling different sustainable energy systems in one profile; the new devices are located to exploit the energy production potential which is dependent on the interaction between the settlement layout's spatial features and immaterial fluxes; the new devices can help counter-balance energy demand and supply.

Such interpretation, which is founded on the technical possibilities widely offered by VPP, brings about a new energy infrastructure concept in terms of dimensions and localization. More specifically, VPP appears as an appropriate tool to configure and assess the DRI system as a LTS, reconciling urban patterns and smart systems (Fig. 2-c). In fact, these factors are aimed at the greatest technological diversity in order to prevent the infrastructural uniformity, which is typical of the fossil-fuel based systems. From these facts, the relationship between the energy system and the settlement's morphological and typological conditions can be deduced, becoming the new likely rules for the territorial infrastructural process. Moreover, the result of such reading of the VPP provides an expanded characterization of the hypothesis of energy infrastructure evolution (Table 4, point 3).

Finally, the inalienable DRI features on which the construction and organization of the DRI system must be based are described in Table 4.

Validating and rethinking the conceptual framework

The most significant contribution of this study is the conceptual framework which illustrates the relationships that are emerging between DRI energy systems, SC and urban patterns. These relationships support the hypothesis of the evolutionary trajectory of an energy system (Geels, 2005; Foxon, 2011). The conceptual framework takes into consideration a network of connections between material and immaterial factors, which define the main features of DRI systems, and in particular, how DRI systems should work in order to support an ecological approach to the LCC, strengthening the SC concept (Fig. 3).

The relationships revealed by the conceptual framework fill a gap in terms of how DRI systems can function as an ecosystem service with all its categories. The state of the art review on SC has shown that a large part of this literature focuses only on the computerizing process (Angelidou, 2015; Bibri and Krogstie, 2017). While it is evident that computerizing processes improve the regulating services (Dimeas and Hatziargyriou, 2007), their relation with the other categories remains sidelined. This study takes a long term vision, in which the new generation of infrastructure will be called to integrate all energy service categories.

This study is a first step for modelling the DRI systems as an ecosystem service, offering an integrated vision for DRI systems in order to reinforce their capacity to be adopted at scale to help deliver Low Carbon Cities. In this sense, the analogy that is drawn between a DRI system and a LTS, becomes a necessary condition to achieve the integration between ecosystem service categories. Consequently, the conceptual framework reinforces the vision of DRI systems as supporting services in the first place, because, DRI systems are not only an energy supply system, but also tools to re-establish the altered relations among cities, societies and landscapes.

Thus, the transition towards new energy infrastructures creates the need for a robust investigation of how such infrastructure impacts on the physical settlement. This relationship is an inalienable part of the human culture. Accordingly, this study establishes that the knowledge dissemination processes requires a cognitive apparatus, which can be used as a reference. The proposed DRI conceptual framework can provide such an apparatus, encouraging a common vision to deal with the evolutionary trajectory of the LCC taking the social and technical transformations of settlements into consideration.

Conclusions

A new conceptual framework for a distributed, renewable and interactive energy system has been proposed in order to support an ecological approach to delivering LCC. The paper has demonstrated how this conceptual framework can help: pursue an ecological path of distributed and renewable energy systems in order to counteract the LCTs that do not pay regard to the local conditions; enhance the SC concept in order to reinforce the relationship between urban patterns and computerized systems; promote the large-scale enhancement of local levels of technology literacy in order to socially construct a DRI. The conceptual framework describes the context in which the DRIs are called to operate.

In the future, a series of case studies will be conducted to test the conceptual framework in order to develop a new theory of evolutionary energy infrastructure.

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NOTES

[1] Ecosystem services that are necessary for the production of all other ecosystem services.

[2] Products obtained from ecosystems.

[3] Benefits obtained from the regulation of ecosystem processes.

[4] Non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.

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Roberta Pinna, Ezilda Costanzo, Sabrina Romano,
ENEA - Italian national agency for new technologies energy and sustainable economic development,
Energy Technology and Energy Efficiency Departments, Rome and Bologna, Italy

roberta.pinna@gmail.com
ezilda.costanzo@enea.it
sabrina.romano@enea.it

Abstract. The EPBD, 2010/31/EU directive on the energy performance of buildings, introduces the concept of Nearly Zero-Energy Building (nZEB) supporting the transition towards Zero Energy Emission Districts (ZEED) and potentially transforming cities perspectives in order to reduce human impact on the environment. The EPBD revision in course aims at decarbonising the building stock also taking into account ICT facilities and smart readiness for better knowledge, management, and efficiency both at building and at district level. Most of Italian buildings were built before the 80es' and more than 25% with specific architectural constraints. Thus the transition towards nZEBs could be extremely difficult, owing to the low new construction rate and to the feasibility of single buildings renovation.
The main objective of this paper is to investigate whether the nZEBs could be the only pathway in promoting transition towards ZEEDs, or not, and, in the former case, which would be the benefit to promote transition thanks to Energy-efficient Interactive Building.

Keywords: nZEB, Smart Buildings, ZEED

Introduction

Directive EU/31/2010 (EPBD) has introduced the nZEB concept requesting detailed definitions and national nZEB Plans in Member States. In Italy the EPBD transposition was concluded in June 2015[1], providing a new energy performance (EP) calculation methodology, stricter EP minimum requirements (including nZEB requirements), and the rules for taking into account the use of energy from renewables. In Italy a nZEB is «a building characterized by a very high energy performance in which the very low energy demand is significantly covered by renewable sources, produced within the building system boundaries»[2], meaning "on-site" and not also "nearby" as expected in the original EPBD definition.
The Italian Plan for nZEBs (called PanZEB)[3] calls for all new or deeply renovated buildings to be nZEB s from 2021 (2019 if public buildings), but some regions have set earlier targets, notably Lombardy (from 2016) and Emilia Romagna (new public buildings from 2017 and all new others from 2019).
The EPBD is currently being updated as part of the "Clean Energy for All Europeans" package[4].
The upcoming revised EPBD will boost long-term planning of energy efficiency renovations, facilitate access to financial tools, enable public authorities to invest in well-performing buildings and improve monitoring of the building stock performance. Data from EPBD energy certification (EPC) and technical system inspections will be complemented by that available from ICT integration, such as smart metering and building automation and control systems, to guide effective actions.
Smart buildings will be addressed for the first time and a *Smart Readiness Indicator (SRI)* is currently being developed within a study tendered by the European Commission.
Smartness will enable the ability of occupants and the building itself to react to comfort or operational requirements, take part in demand response and contribute to the optimal operation of the different energy systems and district infrastructures to which the building is connected.
The smartness indicator should cover flexibility features, enhanced functionalities and capabilities resulting from more interconnected and built-in intelligent devices being integrated into the conventional technical building systems. It will open to third-party systems such as the electricity grid and district, heating network, electric vehicle infrastructure and demand-response aggregators, aiming at ensuring compatibility in communications, systems control and relevant data or signals transmission[5].
Mobility will be part of the new EPBD prescriptions, encompassing pre-cabling and recharging points for electric vehicles in new parking areas.
The signs for a wider scope that encompasses other elements of the whole energy system were also evident from the European Parliament report of the proposal last October, that suggested «minimum requirements for the overall energy performance of buildings to a whole district instead of to a single building, to allow an integrated approach to the district's energy and mobility system within the scope of a holistic refurbishment scheme»[6].
In Italy, standards for second-generation smart meters for electricity, gas and water have been set in 2016[7]. The Italian main DSO is planning to install 13 million second generation meters by 2019 and another 28 million over a period of 15 years. They will also act as a smart network sensor, enabling continuous grid quality-of-service monitoring, near real-time identification of network faults and renewable micro-generation.

Italian built environment overview

In Europe, urban areas expansion rate is higher than the population growth: in the last twenty years, indeed, there has been a 20% expansion of the building areas against a population growth of only 6%[8]. In Italy a similar urbanization of agricultural lands is not proportional to the population growth that is almost limited, on the contrary. To limit further urban development and the related land-take phenomenon, the achievement of significant energy savings requires the massive renovation of existing buildings. Listed or protected historical centres, that are around 18,000 all over the country (Repellini, 2003), have relevant architectural value and their structure cannot be drastically altered; therefore, improved energy management can be envisaged as an effective alternative solution.
74% of all the residential buildings (more than 12 million totally) were built before the 80's and only 32% of these are in an "excellent" state of preservation[9]. Moreover, it is to be considered that the seismic regulations date back to 1974[10] and the first law for energy savings in buildings dates back to 1976[11].
As for the widespread edification, most of the buildings in Italy consist of single duplex houses, whereas buildings with at least 9 dwellings represent less than 5% of the total.

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Combining nZEBs should lead to ZEED districts, but the Italian urban configuration does not reach the large population density that is the main requirement for a ZEED to be economically sustainable. The largest cities are concentrated on a small area (that represents only 8% of the national territory) which is about 27,000 km^2 while medium-size cities extend for 1/4 of the Italian area: the rest of the national territory, that is about 67,4%, is occupied by small local housing systems[12.]

The Italian territory is also subject to hydrogeological risk: Italian towns with at least one area classified as high hydrogeological risky are 7,145 (i.e. 88% of the total) corresponding to about 15.8% of the Italian territory[8]; that imposes land saving and urban regeneration first, rather than random interventions on single buildings[13].

Since 1992, in the framework of urban regeneration, several Urban Recovery Programs were established[14]; these are public/private integrated programs with a total funding of 10 billion euros assigned to 76 exemplary cases in many cities. A similar initiative should be repeated to rehabilitate districts to updated energy efficiency standards.

In this context we believe Smart buildings are key to achieve ZEEDs where existing building constraints and their density should not allow the single nZEB conversion and the successive transition to ZEED districts.

nZEBs: level of knowledge and diffusion

Apart from few experienced countries with centralised data management systems in place, availability of information on energy performance of the building stock is lacking. The European Commission has launched the *EU Building Stock Observatory* in November 2016, and further efforts to know and act on energy performance progress and notably on nZEBs are ongoing[15]. Actually, even less understanding is available on implementation of ZEEDs in the EU!

Many initiatives are being born to appraise the spread of nZEB in Italy, but data are hardly accessible at the moment and some rough estimates are only available so far (Chiesa, 2017).

Within a research financed by the Ministry of Economic Development in order to monitor and improve national and regional policies, in 2017 ENEA has established a national Observatory, "Osservatorio nazionale nZEB" (Costanzo, 2017), that investigates nZEB number, typology, technologies and their driving factors such as incentives, skills, targeted research and innovation.

nZEB number is growing fast, with a percentage of nZEBs out of total issued energy performance certificates increased by 70% in Lombardy, but also, by average 10%, in other regions where mandatory legislation has not been enforced yet. In the period January 2016 - September 2017, in the four regions (Lombardy, Piedmont, Marche and Abruzzo) firstly analysed in ENEA Observatory, almost 350 nZEBs have been built complying with current standards in force, mostly new and residential buildings (more than 80% of total nZEBs).

As an estimate extended to the whole Country, nZEBs could nowadays count 0.005% of the existing national building stock. In Lombardy the rate of nZEB built in the 2016-2017 biennium is 20% of new built, a good percentage if we consider the licence and construction process scheduling.

Most of censed nZEB show a limited variety of technologies: highly insulated envelope, electric heat pumps (mostly air-water) coupled with a PV system or condensing boiler joined to solar thermal panels for domestic water heating (DWH). Half the cases have mechanical ventilation systems with heat recovery whereas use of DH in urban contexts or biomass systems in urban environments is quite absent.

Installed building automation systems and smart technologies are not trackable through energy performance certificates nowadays. Dimmers for lighting, control for heating, cooling and mechanical ventilation, monitoring and control services are present in the very small sample observed in detail. In the residential sector only some prototype and public buildings take advantage from the installation and operation of control (thermal flow, humidity, temperature) and management systems.

Yet the cost-effectiveness of these systems appears to be interesting. In the tertiary sector building technical control and management systems potential is being explored by ESCOs and aggregators while it is estimated that in the residential sector widespread implementation of demand response can save up to 10-15% of potential grid costs and 10-40% reduction of consumers' electricity bill.

The imminent publication of the nZEB Observatory on the ENEA web should allow expert users to register and feed the database with more details on existing nZEBs, related energy and comfort services (including smart technologies) and impacts.

The main Italian incentives for renovation of private (65% tax deduction scheme) and public buildings (thermal account) "encourage" the installation of intelligent metering and active control systems according to EPBD article 8[2] but initial investment to attain the nZEB standards have produced less than two dozen nZEBs so far[16]. As for multi-family building, the 2017 Financial Law extended the tax deduction scheme to end 2021, increasing the relief to 70-75% for major renovation measures that comply to stricter requirements, notably minimum energy performance of the building envelope towards "deep renovations". In seismic zones, in the case the renovation should result into a lower structural risk the relief is increased to 80-85%, with higher eligible costs limits. A mechanism to promote major renovation in multifamily building-blocks with low-income consumers was also introduced to solve the problem of the initial investment bar-

01 | ENEA Casaccia Smart Village

rier (Credit transfer). The credit can be transferred to renovation suppliers, to enterprises or organizations, to single persons. Financial institutes are not involved in this mechanism, so far.
Only three are the Italian regions that aim at nZEB standard in their invitation to tender for renovation of public buildings funded by EU Structural funds 2014-2017: anyway the introduction of building automation and control systems are among the eligible measures and their installation will be monitored in the next phase of the ENEA nZEB Observatory.
Finally, national and EU research in Italy is concentrating on cost reduction of nZEBs[17] but results in terms of paybacks and investments are extremely contradictory, going from average 14% additional cost for transforming an existing building into a nZEB (compared to standard deep renovation) to additional investment costs of about 3%, that represent a benefit for the occupants of about 67% of their operational costs, with an economic payback of about 6 years (if analysing the life cycle cost of the investment).

Towards a ZEED example in central Italy

Within the scope of the ZEEDs, the goal is not the achievement of the energy efficiency of the single building but of a network of these, so the problem cannot be addressed only by reducing the energy demand thanks to the adoption of increasingly efficient systems or components, but must be dealt with a wider vision that takes into account the management of buildings and their interaction.
For the new buildings, including nZEB, it is necessary to ensure that the energy supply is synchronized with the actual demand, in order to avoid useless waste that could reduce or nullify the efficiency of systems.
This need is even more urgent for obsolete buildings where, due to the greater energy demand, a gap between demand and supply causes more substantial energy loss.
For this reason, transforming or designing smart buildings can be a first step in achieving the goal of creating zero-energy districts. The starting point is to equip the buildings with sensors, actuation and data transmission systems: a centralized diagnostics and optimization system that allows energy and economic savings with low costs, being mainly based on automation and ICT infrastructure. This approach has become possible on a large scale thanks to new technologies available at increasingly competitive costs, e.g. wireless sensors and IoT platforms.
Considering a network of buildings allows to compare energy behaviours and therefore identify in real time any anomalous trends with the same operating conditions, to understand on which buildings a redevelopment intervention is a priority and more competitive, and finally ensures the verification and maintenance of energy performance of recently renovated buildings.
Generally, considering a network of buildings has the effect of rationalizing and simplifying the management of single buildings, because the supervision function is carried out from a single remote location, reducing operating and maintenance costs. If structured, this supervisory system is able to implement consumption optimization strategies by acting on the control systems installed in the buildings, without penalizing user comfort.
Moreover, real time monitoring and knowledge of the real behaviour of buildings allows developing predictive models of demand, allowing to reduce loads in cases where it is requested by the energy supplier both for emergency reasons and because a possible reduction of the request for energy concurrently with anticipated peaks can be rewarded by the same supplier. The ad-

vantages of this management are reflected both on the supplier that ensures greater system security and lower infrastructure costs, and on users, who are guaranteed with lower costs, thanks to the possibility of choosing to consume energy when it costs less, reduce the power used, accumulate or generate energy on their own.

ENEA, at its Research Centre in the north of Rome, has realized a network of 10 smart buildings with a total area of about 10,000 square meters (Clerici et al., 2015) (Fig 1).

These buildings have been equipped with sensors, implementation systems and data transmission for real time communication with the supervision system that is able to monitor consumption, diagnose and report malfunctions, identify incorrect behaviour of users, optimize the energy consumption of end users (air conditioning, lighting) in relation to a series of targets such as comfort, energy saving, energy expenditure and maintenance. Different levels of monitoring and control details have been adopted in these buildings, which correspond to a different number of installed instruments and costs:

- at the building level, the total electrical energy and the fraction for lighting, the driving force and the fans are monitored. Also in the HVAC plant, the electrical energy absorbed by the various components, as well as the thermal energy, is accounted.
- At zone level, electricity is monitored separately for different end uses. In this case the lights and the fans can be controlled remotely by operating the switchgear and disabling the lines in the absence of personnel.
- At the single room level, sensors, thermostats and infrared motion detectors have been installed. At this level the set point of the thermostats can be controlled according to the presence of the occupants and the external climatic conditions, while, thanks to the presence of the installed sensors, the lights are switched off in the absence of the user or sufficient ambient light level.

The control logics tested in the demonstration realized in Casaccia refer to two strategies:

- Energy on Demand: Provide the energy at the time and place where it is required, avoiding unnecessary waste (e.g. operation and ignition of plants outside of working hours).
- Optimization: Adaptive control that allows to modulate the energy demand over time in view of the variation of multiple parameters, i.e. weather, actual presence of people, any variations in the cost of the energy carrier, without sacrificing user comfort.

It has been found that the achievable saving coefficient is influenced by the following factors:

- level of control and energy performance of the original building
- behaviour of the user
- percentage of incidence of controlled uses on general consumption.

In fact, the savings coefficients are higher if the intervention is carried out on more obsolete buildings without any control system, where users have not developed their own energy awareness.

In relation to the general consumption of buildings, from the experimentation conducted, it was found that a more punctual control (at the single room level) corresponded to more substantial savings around 35%, while management at the zone level (at the level of a single electrical cabinet) or the entire building savings are reduced to less than 20%.

In general, in order to quantify the contribution to active energy efficiency from the management and control of technical building systems (such as: heating, air conditioning and lighting) we can refer to the standard UNI EN15232[18]. The standard establishes the potential savings in thermal and electrical energy that can be achieved through the introduction of specific automation functions of the plants, indicated by the standard itself, belonging to a higher class of energy efficiency (A, B, C).

The standard deals with the assessment defining "a priori" the types of intervention on the automation devices rather than on the overall intelligence of the system.

The analysis of the implemented methods can be transferred to buildings network, with particular reference to the tertiary ones (offices, schools, business centres, public agencies).

Conclusions

A high rate of energy consumption is due to unpredicted and unmetered uses. Where other solutions are not possible or too expensive, acting on such consumption component is a valuable alternative to transition towards ZEEDs.

Smart buildings are not a requirement of the present EPBD but the legislative and regulatory context is changing, opening the way to integration of the wider energy system level.

In the long term, an assessment for smartness may be integrated with the assessment for energy performance in the Energy Performance Certificates. New tools (e.g. smart metering, building automation and control systems, Smart Building Network, Smart Home Network, …) and pricing systems, financing models, new technologies for smart energy districts are now requested by, and rapidly penetrating, the markets.

There is an emerging tendency among consumers to invest in smart innovative services (assisted living, demand-response, energy consumption optimization) and private energy generation. Disruptive change is expected from the technology sector that will probably lead the way, provided it is accompanied by a prompt legislative adaptation to the new EU provisions.

Smart Buildings will propose an innovative architecture for the energy management of the building that takes into account its operating conditions and the surrounding energy system. In perspective, a new generation of smart buildings, energy-efficient interactive buildings, will play a key role in the energy balance of the network system, optimizing its energy management, interacting with the network, providing flexibility of its energy demand and optimizing the availability of renewables and taking advantage of local or distributed storage. This is in our opinion a valuable alternative to pave the pathway towards ZEEB.

NOTES

[1] Interministerial decree 26th June 2015 - "Minimum requirements of Energy Performance in Buildings".

[2] Law n. 90/2013, converting Decree 63/2013 "Transposition of Directive 2010/31/UE on Energy Performance of Buildings (Official Journal of the Italian Republic, general n.181, August 2013).

[3] "Piano d'azione nazionale per incrementare gli edifici a energia quasi zero (PAnZEB- National action plan to increase nZEBs)", approved by the interministerial Decree 19 June 2017.

[4] COM/2016/0765 final: Proposal for a directive of the European parliament and of the Council amending Directive 2010/31/EU on the energy performance of buildings. Last 19th December a political agreement has been reached between the European Parliament, the Council and the Commission and its publication is imminent.

[5] https://smartreadinessindicator.eu/.

[6] (COM(2017)0660 - C8-0394/2017 - 2017/0294(COD)) Committee on Industry, Research and Energy.

[7] Authority for electricity, gas and water, Deliberation 87/2016.

[8] Minutolo, A. and Zampetti, G. (2017), *Ecosistema Rischio, Monitoraggio sulle attività delle amministrazioni comunali per la mitigazione del rischio idrogeologico*, Legambiente.

[9] Annuario statistico italiano - dati 2017.

[10] Law No. 64/1974 National seismic regulations.

[11] Law 373/1976 "Regulations to limit energy consumption for building space heating".

[12] "Forme, livelli e dinamiche dell'urbanizzazione in Italia", 2017- ISTAT.

[13] As suggested in the DDL (project of Law) No. 2039 (2014) "Containment of land consumption and reuse of built land".

[14] Law N. 179/1992 (art. 16), and Law 493/93.

[15] Building Stock Observatory 2017 update and "Comprehensive study of building energy renovation activities and the uptake of nearly zero energy buildings in the EU" (2017/S 192-392561), in course.

[16] Tax deductions (relief) introduced by the Italian 2007 Financial Law, are key drivers of energy efficiency improvements in the housing sector. They consist of 65%-75% reductions of IRPEF (personal income tax) and IRES (corporate income tax) granted to cover expenses incurred for the overall energy performance upgrade of the building, major and minor renovations, including installation of BACS. 32 Billion EUR investments stimulated so far (from 2007) and 3,3 Billion EUR investments in 2016, amounting to nearly 0,10 Mtoe/year savings in 2016. 360,000 eligible applications for 65% tax deductions received in 2016.

[17] National studies: RdS PAR 2015 reports 120-121-122, Edifici a energia quasi zero (nZEB), Project D.2.1: Research on energy renovation of public building (public schools, hospitals, office buildings), Report RdS/PAR2013/114 (2014) and Chiesa, V. et al. (2017), *Energy Efficiency Report*, Polytechnic of Milan, EU H2020 Call EE-13-2016-2017 - Cost reduction of New nZEBs, CON-ZEBs and A-ZEB projects.

[18] European standard EN 15232-1:2017 on "Energy efficiency in buildings - Influence of Building Automation and Control and Building Management".

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Energy retrofit of tower blocks in UK: making the case for an integrated approach

Ornella Iuorio,
University of Leeds, School of civil engineering, Leeds, United Kingdom
o.iuorio@leeds.ac.uk

Abstract. Tower blocks in UK are at a critical stage. They were built at a time when no energy efficiency requirements were considered. They are now approaching the end of their design service life and they are damp, and cold place to live. Starting from the analysis about the diffusion of multi-storey buildings in EU, and the findings of other research projects such as INSPIRE and Faro, this work debates the strategies applied for energy efficiency improvement of large panel concrete buildings. This work debates the structural retrofit that in many cases are required prior to any energy retrofit intervention and draw the attention on the necessity to develop more holistic retrofit approaches, aiming to the development of best practice for energy, safety and social benefits.

Keywords: Energy efficiency, Fuel poverty, Multi-storey buildings, Retrofit

Introduction

The exponential grow of urban areas in both industrialized countries and in the Global South is responsible for depletion of natural resources and global warming. The built environment plays a key role on the triple bottom line of the sustainable development -Planet, People, Profit- and as such, the international community is promoting the development of a sustainable building market. In line with the 2020 European Strategy (United Nations, 2015) and the 2050 Roadmap, buildings energy efficiency is at the core of worldwide discussion about sustainable development and low-carbon economy. Thus, energy retrofit is a central to the discussion of architects and engineers, going from the building to the city scale.

In recent years, extensive exploration of retrofitting family buildings have been carried out. In the UK, the improvement of low-story buildings has been largely explored as testified by the New Barrack estate scheme and Kirklees Warm Zone scheme (Webber et al., 2015), or by the "Retrofit for the Future" programme, which outcomes are superbly synthesized in Marion Baeli book (Baeli, 2013). The 20 case studies exemplify pioneering approaches for a wide variety of UK construction typologies (solid masonry, cavity walls, timber frame). Fabric and heating, ventilation and air conditioning (HVAC) improvements are analysed. It clearly states "there is not a one size fits all approach" in retrofit, and it aims to build knowledge and confidence in the retrofit process. However, the retrofit of flats is not discussed. Sparse information about possible retrofit strategies and associated costs for intermediate flats is provided in (Gleeson, Yang and Lloyd, 2011), but no insights are provided for the retrofit of full tower blocks, consisting of many, interlinked flats. Multi-storey buildings have always had controversial fame, housing lower income people and offering poor comfort to the habitants. There has been a tendency of demolishing rather than converting them, with consequent strong environmental impacts. In an attempt to shift this trend the High-rise hope program (Lane, Power and Provan, 2014), led by the CASE centre, analysed energy efficiency measures and their social impacts on low-income areas, having as focus high-rise buildings. Its attention was on the £16.13 million regeneration project led by the London Borough of Hammersmith and Fulham (Fig. 1), aimed to transform the visual impact of Edward Woods at both estate and wider neighbourhood scale, while delivering energy consumption and costs reductions. The project involved extensive work on building fabric, communal areas, integration of renewables and the construction of 12 penthouses for private sale. It demonstrated that the benefits of improving energy efficiency go far beyond energy bill savings, having significant influence on human health, industrial productivity, fuel poverty alleviation and consequent national benefits. However, this scheme has been an extraordinary example, which certainly the recent tragic Grenfell tower event is shading. Since then, UK industry and policy are trying to quantify the scale of the problem. In order to discuss the challenge of improving energy efficiency and reducing fuel poverty across UK, this paper analyses the case of tower blocks in Leeds, and makes the case for a holistic retrofit approach, highlighting open questions in the final discussion section.

The case of Leeds, in West Yorkshire

The city of Leeds is the third largest city in the UK. It developed from a compact mediaeval market town and saw its first major expansion during the industrial revolution, retaining since then its industrial features. Leeds is now the centre of an urban area with a population of 2,454,000. Leeds housed a rising population after the two World Wars in high-rise buildings, known across UK as "Tower blocks". Today the city retains 116 apartment blocks (Fig. 2), higher than seven storeys, which were widely built between 1957 and 1972, and that constitute the 14% of Leeds City Council Housing stock. The towers house 8000 tenants and they are realized by twelve different construction typologies, which can be classified in twenty-two different thermal profiles. The tower blocks constitute for the council an important burden, for which the council is developing a 10 years investment plan from 2016 (Arup, 2016). The investment plan aims to achieve the ambitious objectives of reducing both carbon emissions by 40% and tenants energy bills by 10% between 2005 and 2020. These constructions are either in reinforced concrete frames, or constructed with a large concrete panel system. During previous energy efficiency campaign, some buildings have been improved through an extensive cavity wall insulation or an insulated cladding system. All these differences result in a wide variation of walls U-values that range from 0.34 to 1.56W/m^{2}K. Moreover, most of the heating infrastructure is outdated and in need of replacement.

The investment strategy developed by Arup for Leeds City Council defines five recommended interventions, providing at each intervention a scale of priority, ranging from 1 (high priority) to 4 (low priority). The priorities are as follows: priority 1, a) community heating system, b) new hot water cylinder; priority 2, c) new

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01 | Edward Woods Estate. London Borough of Hammersmith&Fulham (Photo O. Iuorio)

02 |

02 | Leeds tower blocks in their current conditions (Photo: O. Iuorio)

electric heater and controls; priority 3, d) cladding - external wall insulation; priority 4, increased roof insulation. The scenarios have been developed according to a cost effective invest-to-save strategy, based on a balance between carbon saving and reduction of energy bills.

The developed strategy looks at the towers as part of a complex city and defines community-heating clusters as a priority. What appears controversial is the poor importance given to retrofit of the building fabric. Indeed, although few have gone through previous insulation improvement, the resulting transmittance values are still far from the current UK target.

It appears clear that the strategy tends to shift the problem from fabric improvement to heating system updating. In such a way energy efficiency is surely obtained, but the requalification is approached by solving an episodic problem, rather than thinking to a long-term investment. Indeed, focusing exclusively on a single problem makes retrofit intervention limited to solving only part of the criticalities, without considering the complexity and the interrelation of all the deficiencies of the building system. Any retrofit solution conceived having in mind only one aspect is bound to failure in a long-term perspective. Certainly, interventions on mechanical and electrical systems maximize energy reduction for minimal investment. Nevertheless, an energy retrofit approach that focuses solely on equipment upgrades is 'effective but limited in the overall energy savings it can generate' (Griffin, 2016). An integrated renovation based on the envelope retrofit could instead have the potential to improve the energy performance, ensuring at the same time also other benefits related to the three dimension of sustainability (Iuorio and Romano, 2017). Energy retrofit of Leeds tower blocks should be considered as a driver of renovation at urban scale. Indeed these tower blocks are often located in deprived areas, where there is no interaction between the built environment and the urban context. In addition, they exhibit a high state of deterioration. As such, interventions on both the fabric and the structure could instead allow these buildings to improve the architectural quality and the structural safety (Romano, Iuorio, Nikitas and Negro, 2018), ensuring added property value, which can bring to a global urban regeneration.

Making the case for an integrated retrofit

Why energy retrofit of tower blocks are not considered in a more holistic perspective? Why inspection, safety and energy retrofit are not evaluated and carried out according a more coordinated effort? The tragic Grenfell tower event demonstrated the failure of an approach that looks only to one of this aspect. The verification campaign carried out to assess the quality of all the recladding interventions across UK, if from one side, for the first time, provides an overview about the extension of retrofit applications on multi-storey buildings, on the other side, demonstrates that those technical solutions have been adopted in many other buildings across UK. The verification campaign uncovers, indeed, a systemic problem.

However, a shift is possible looking at models across EU and UK that have demonstrated the feasibility of an integrated approach. In Italy, for instance, the project FARO «Innovation and sustainability of retrofit. Best practice for the retrofit and the maintenance» (Losasso, Pinto and Landolfo, 2013), identified best practices for the retrofit of existing buildings, as well as it highlights how a sustainable regeneration project requires an interdisciplinary methodological approach able to identify retrofit strategies capable to satisfy structural safety and energy requirements, as well as, been cost-effective and durable in a life time perspective. The project looked at the retrofit of buildings realized in the twentieth century. It highlights the importance of structural checks before the identification of any retrofit solutions, and demonstrates that cost-effective and sustainable solutions are the one that consider safety, energy, maintenance and costs at the same time. Case studies are used to articulate best practices. It demonstrates that often, the best solutions are the one that look at buildings starting from their use, considering the articulation of the spaces and functions within the building, and how they can be internally reorganized to make the best use of natural ventilation and solar radiations. Starting from the new distributions, the appropriate energy strategies are articulated. The project discusses the retrofit of the building fabrics in detail, and articulates the strategies in three main actions: substitution, subtraction and additions. Fig. 3, shows one of the proposed approach for the energy retrofit of a multi–storey reinforced concrete building in Mercogliano, in South of Italy, built in the ‘80s. The case demonstrates how starting from an internal redistribution of the functions, the energy retrofit can be achieved through the adoption of a double skins on the south side, that integrates the vertical and horizontal distribution systems with stairs and corridors together with the technical elements of the buffer zone made of insulation, air ventilation and shading systems. Moreover, the proposal also looks at how the economic investment could be repaid by the extension of the building with an extra floor. All the solutions envisaged for the double façade and the roof extension make use of prefabricated technology based on cold formed steel profiles, that being a light and dry technology (Iuorio, 2007), allows new functions to be integrated in the existing building without a substantial increment of loads and, allowing also to reach transmittance values for walls and roof compatible with those required today for new constructions. Moreover, industrialized prefabrication technologies can offer a better quality of workmanship and a faster construction process. The use of prefabricated systems present several sustainable advantages such as optimized constructions quality and flexible systems, cost efficiency due to prefabrication, a quick renewal process with minimized disturbances for the inhabitants, a dry construction process, an easy maintenance for planned and/or repair interventions and the potential reuse of elements at the end of the life-cycle (Iuorio, Fiorino and Landolfo, 2014).

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03 | The Mercogliano case study: before and after retrofit intervention. "Faro" research project. (Photo: M. Mucciardi)

Similarly, the more recent European project INSPIRE (Ciutina, Ungureanu, Grecea and Dubina, 2013) developed integrated strategies and policy instruments for retrofitting buildings to reduce primary energy use and GHG emissions. It looks specifically to four European countries: Denmark, Romania, Sweden and Switzerland. The project aimed at: a) assess energy efficient building retrofit strategies according to a techno-economic lens; b) assess the actors and policy instruments for energy efficient renovations; and 3) it looked at case studies of sustainable renovation.

Interestingly, one of the case studies of the INSPIRE project is a large panel concrete multi-storey building. Clearly, this case study is investigated because they represent a large share of the existing building stock in all the investigated countries. The project identifies packages of solutions that combine building fabric interventions with energy renewable technologies, district heating systems, heat pumps and more. In the assessment of the actors, policy instruments and in the economic analysis (Nagy, Fulop and Talja, 2013), the return of the investment is discussed, and one key methods that allows to achieve the return of the investment is the addition of technical elements, as balcony or building extensions, that are capable of improving the property value. Moreover, the authors have also looked at how the proposed energy retrofit solutions should go hand in hand with structural retrofit solutions, that should allow to improve the resilience of those buildings if subjected to earthquakes and/or explosion. These last are indeed key issues that national and local governments should tackle with the same effort of increasing energy efficiency and reducing fuel poverty.

Conclusion

This paper discusses the importance of looking at energy efficiency of multi-storey buildings in a more holistic way. The tragic Grenfell Tower event, that in June 2017, caused the a death tall of 71 people and many more injured, following a fire explosion in London, has brought the public attention to reflect on the approach used for the improvement of energy efficiency of multi-storey buildings. However, the building under discussion also belongs to the same typology of buildings that in 1968 were subjected to the Ronan Point collapse (Currie, Reeves and Moore, 1987), when a gas explosion blew out load bearing walls of a 21 storey tower, causing the collapse of an entire corner of the building. Time passed and many towers are still at risk of blast explosion. This paper raises the question: when will retrofit interventions start to be conceived in an integrated way? Is not the time of making the safety and the wellbeing of the occupants at the centre of the investments? Studies demonstrate the benefit that a more coordinated approach could have in terms of social benefits and industrial productivity. Building efficiency should be regarded as a mechanism capable to unlock social criticalities that are connected to technical problems. Improving energy efficiency of existing buildings should be regarded as a way to enhance local competitiveness through energy productivity, and strengthen city's economic and climate resilience.

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Hybrid Building as Social and Energy Hub for Smart Cities: Unitè 2.0, a Prototype

Luca Lanini, Department of Energy Engineering, Systems, Land and Buildings, University of Pisa, Italy l.lanini@ing.unipi.it
Eleonora Barsanti, Toscana Energia, Italy eleonora.barsanti@outlook.it

Abstract. The purpose of the master degree project «Living in the time of crisis: Unitè d'habitation 2.0» designed by Eleonora Barsanti and tutored by Luca Lanini and Sergio Russo Ermolli aims to offer a possible definition for a new housing model based on concepts like affordability and social living, but above all of flexibility, adaptability, versatility, energetic sustainability and/or production: a prototype that can be placed in any context and adapted to meet specific needs as being a node in a smart city grid. In our opinion, this process would allow us to accomplish diversity within the same building, attaining a kind of chameleon-like organism which is flexible, adaptable, versatile and an active energy hub.

Keywords: Social housing, Hybrid building, Energy hub, Social condenser, Smart city

An unpleasant Scenario: an introduction

The great recession of 2008-2013 involved industrialized western countries and dragged the middle class down, affecting family stability and causing growing housing poverty (Forest, 2016). The increasing number of families on the brink of poverty, the reduction in the number of family members, the growing rate of unemployed young people, new immigration flows and the problem of increasingly older population have challenged housing needs (Demirkan, 2017). The quality of housing is globally undermined by city congestion caused by flows of population from the rural areas to the cities: for the first time in human history urban areas have become more populated than the rural ones (United Nations, 2006).
Furthermore, data show how «more than 35% of the world energy consumption is absorbed by contemporary housing, to cool, to heat and light homes» (Casamonti, 2011); in this sense, it is necessary to achieve a new designing process able to reduce, if not eliminate, this level of energy consumption.
Housing models like the ones built in the late Modernist Era now seem unable to satisfy the new needs of a society which is no longer static. Projects like Park Hill in Sheffield or Robin Hood Gardens in London have established innovative but flawed guidelines on collective dwellings, which nowadays need to be implemented and integrated with new paradigms and technologies (Fernández, Mozas, Ollero, 2013).
To rethink our residential stocks with low cost/high performance buildings is a crucial, gigantic task for architects, engineers and urban planners.
The heritage of a fascinating (and failed) artifact of the First Modern Age - Le Corbusier's Unitè - is analyzed in the first section of the paper (Object: a flawed genealogy); its chance of an update in the second (New Features for an Unitè d'Habitation 2.0); its role in the smart city in the third (Unitè 2.0 as Smart Node for a Smart City); an experimental typology is provided in the conclusions.

Object: a flawed genealogy

Solving problems of urban living with a unique and powerful architectural gesture is not a novelty in the history of architecture and has its ancestors in egalitarian prototypes studied and designed since the Age of Enlightenment, from the *Falansteri* to the *Alberghi de' Poveri* to the Soviet collective housing (*Dom Kommuna*)[1]. Programs rooted in utopia as well as in error.
In the past century, Le Corbusier's Unitè d'Habitation acted as the ultimate «social condenser»[2], a building conceived as a «hub» trying to define a new way of living and a new form of society as well as architectural and urban landmark in the European cityscape and mindscape. It was a hybrid building, integrating its main residential function with all the facilities (gyms, swimming pools, kindergartens etc.) the community of its inhabitants needs. It was obviously brilliantly designed and cleverly merchandised: an innovative, massive building instead of a mere cheap «container» for poor people, a sort of ocean liner suspended on *beton brut* pillars, quietly floating in the European Countryside, presented like a sort of almost logical and direct aftermath of a series of diagrams concerning density, plot areas and ground consumptions. The critical success of the Unitè quickly fell after the 50s to the point of becoming the infamous inspiration for the dreadful and omnivorous Ballard's *High-Rise*.
But, after the great recession of 2008-2013, the quest for a low cost/high performance mixed use housing building, instead of carpets of suburban detached single family houses, seems to have returned in fashion. It is paradoxical that for many of us the shape of things to come would resemble Le Corbusier's Unitè d'Habitation, reappearing from the architectural subconscious as a benevolent blueprint for a new concept of mass housing.
Would it be possible to radically update Le Corbusier's model and mend its many errors, giving a new identity and appeal to the concept of density and critical mass in residential architecture? Would it be conceivable to transform a sixty-year-old flawed masterpiece in a fascinating and true alternative to suburban living? Could such a complex, dense and massive architectural typology be withdrawn from the Le Corbusier's fabled countryside and inserted in European town fabrics, inside urban lifestyles, public infrastructure and cultural networks? How can we transform a stroke of genius, clearly designed for faceless, generic inhabitants tied in the binary loop of Rest-Work of the First Machine Age, into the realm of identity and freedom? Furthermore, would it be a feasible answer to the radical change in the demographics of our society, strongly modified by the increasing number of elderly people, emigrants and refugees? How can we rethink those breathtakingly conceived residential units (voids, double heights, *maisonettes*), clearly tailored for a family of the 50s, in a house for one of the many subgroups our society is currently divided in: mononuclear families, singles, dinkies (two people, two incomes, no children), extended families coming from different countries with different ethics and cultural backgrounds? Could a building a conceived as advanced social and architectural experiment be implemented as energy hub and/or node («energy condenser»

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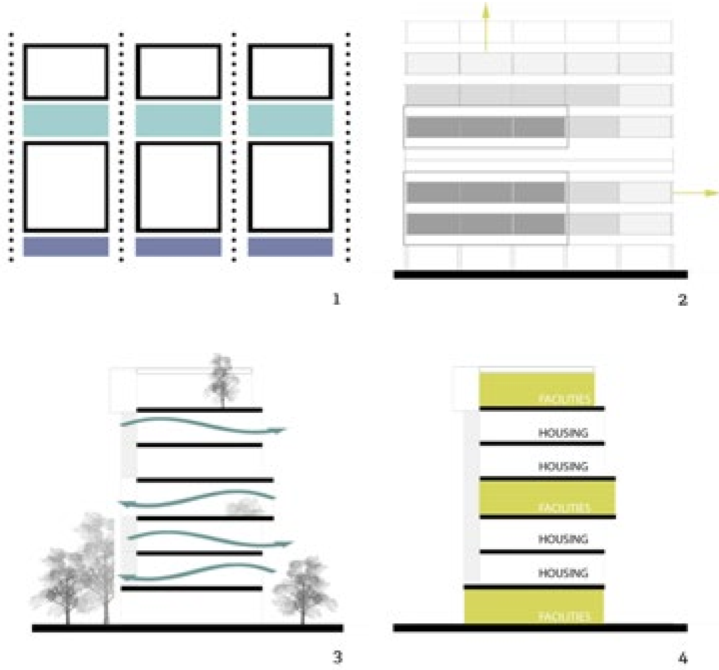


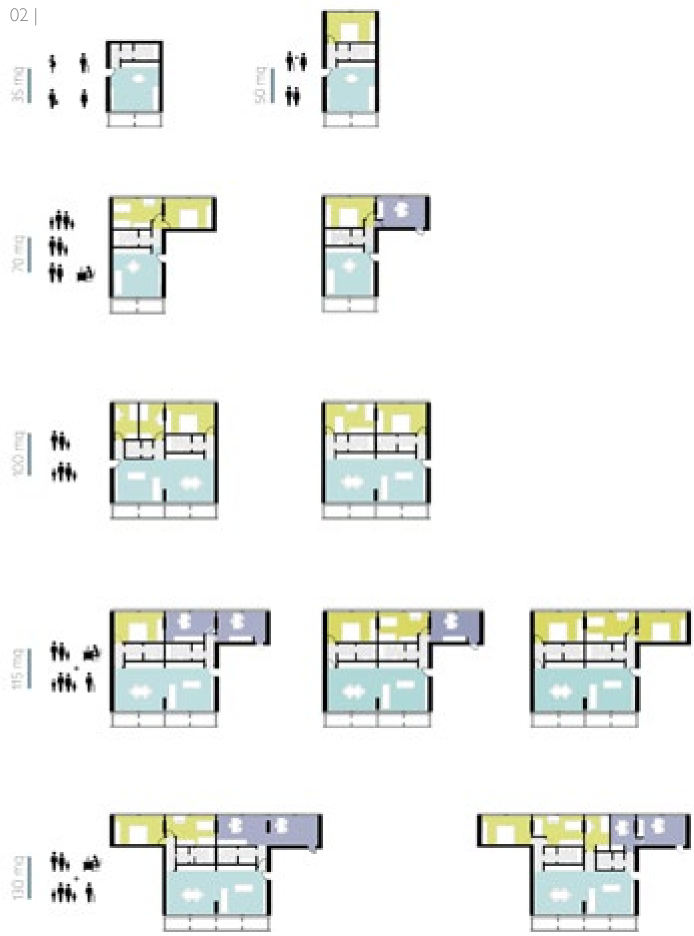
01 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype.
Design concept:
1. Design guidelines: double facing, central spine (green), living spaces, loggias (purple)
2. Unitè 2.0 could be expanded both vertically or horizontally
3. Crossed ventilation
4. Section

instead of «social condenser»?) for forthcoming «smart cities»? Could it be as relevant in shaping forms of global living environment as it was sixty years ago?
As architects, are we ready to design a Unitè d'Habitation 2.0?

New features for a Unitè d'Habitation 2.0

One of the most important features in contemporary debate on housing is defining flexible and adaptive unities and typologies, ready to satisfy the needs of inhabitants in every peculiar moment: this is the case of the Carabanchel 06 project (2002) by Aranguen y Gallegos in Madrid, in which movable walls inside dwellings allow to enlarge or reduce day and night living spaces.
The problem of increasing older population has led to projects like Torre Julia (2011) by Pau Vidal, Sergi Pons e Ricard Galiana in Barcelona which offer an integrated typology of protected residential buildings and social housing, promoting a new sense of community. The fear of losing identity and fading bonds with personal roots, which contemporary society seems to be prone to, have led municipalities and designers to integrate residential spaces with those dedicated to social, commercial and other activities, with the purpose of sharing resources among inhabitants of the whole neighborhood. This is the sense of projects like Sargfabrik (1998) by BKK in Vienna and Sugar Hill (2014) by Adjaye Associates in New York.
New social housing operations should guarantee not only social, but also economic and environmental sustainability: experiences like Moho (Modular Homes) (2004) by ShedKM in Manchester and Eda Knivsta (2015) by Andreas Martin-Löf in Stockholm are opening new possibilities for prefab and modular systems in the residential building field, guarantying high performance in terms of accessibility and affordability.
Unitè d'Habitation 2.0 should implement those guidelines and outline new ones, such as:

- a higher residential density compared to that used in their original settings. European low density suburbs are nightmarish entities of traffic, pollution, alienation, land and energy consumption and poor spatial qualities often translating in a very poor quality urban life. The compactness of the Unitè should be economically, socially and politically affordable, an outstanding architectural landmark thus saving land, infrastructure and maintenance costs. It needs to reach a critical mass to include economies of scale in a noteworthy metaphor of the size attainable by the building. A sort of advanced urban artifact stacking layers of houses and public services.
- Energy self-efficiency. The trend, strictly regulated in the EU, is towards a «Class A» and a «Carbon Neutral» building, favoring buffer systems for insulation and solar systems for wa-



02 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype.
Dwelling typologies

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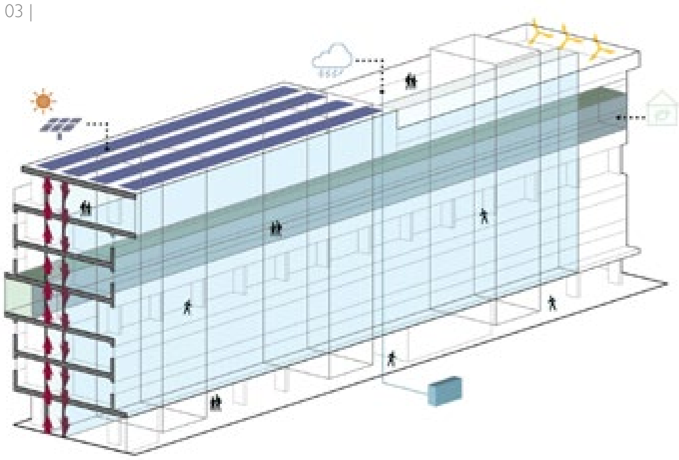

03 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype. Energy systems

ter and energy: the building is more and more conceived as an energy hub, as the radiant surface is clearly favored by its massive dimensions. High inertia architectural skin is often coupled with radiant floors and/or ceilings to make the overall systems of installations more energetically efficient. The architectural aftermath is that the façade is conceived as heavily layered, gaining a transitional width, filtered by sliding shutters, panels or blinds, loggias conceived as climate buffers. The building gets a new blurred and luminous aspect, in a process that is apparently deeply rooted in contemporary architectural sensibility and languages.

- Residential Flexibility. This happens to be the main point, attaining the general design strategy for the building: flexibility of typologies as well as of dimensions of the residential units to encounter the fluctuation of the survey and variations of the users; interior flexibility of the unit to modify it just-in-time and custom-made apartments; flexibility in the cost of the different units to assure a mixed class and cultural environment, resulting in groups of residents of different ages, origins, interests and resources. Flexibility should be attained from scratch, from the design process to promptly react to a new economic situation in the relatively long time which is necessary to develop a housing project. Flexibility rather than specialization, which means a new versatility of residential spaces. And it can be obtained with technical (great span structures, concentration of the technical modules and diffusion of the energetic and plants network) and conceptual strategies (great open isotropic spaces, ready for different interior lay-outs). A more fluid and transformable residential space can be obtained with improved division systems based on industrial and serial elements, typical of the architecture of office interiors, a lay-out which improves accessibility and adaptability for people affected by physical or psychological diseases, in a peculiar conceptual update of the *Plan Libre*. A good contemporary space is a big neutral space, with few fixed areas. The fewer, the better. As Atelier Kempe clearly stated: «Developers think that the job of an architect is to organize the floor plan according to the building rules and to design the facade. And they are right. Because of the global economy this is a very logical process. Labor is expensive in the western world and that is why it is reduced to a minimum. The next step will be that the interior as such, will completely disappear. Hence, the apartment becomes a single empty room without anything except a cable shaft and a meter. The inhabitants become self-builders who create their own living environment according to taste and budget. The Ikea concept is extended towards the complete interior. […]. The new typology of the 21st century is the loft. Sixty years after the shock of the Farnsworth House this became the most desired typology. […]. We think the loft is more of an enclosed outside space than a classical room. It is a platonic internal landscape, a piece of emptiness in the city. Its success is on one hand a sign of a more personal and individualized way of living. […]. The loft is a mix of public and private; it can be home, office or both. In former times, people went on the street now they prefer to stay at home» (Atelier Kempe-Thill, 2008). The contemporary house is not the «machine for living» imagined by Le Corbusier; it is a solid infrastructure built for different purposes and functions, a slab measured (and paid for) in square meters, available to all the fluctuations generated by markets and/or life.
- Common areas and residential facilities: pool, gyms, kindergartens, workshops, Wi-Fi areas, 24-hour laundry facilities etc. to build a new sense of community and civic conscience: «the new qualities, the specific, can come out of the extra pro-

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04 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype. Apartment interior

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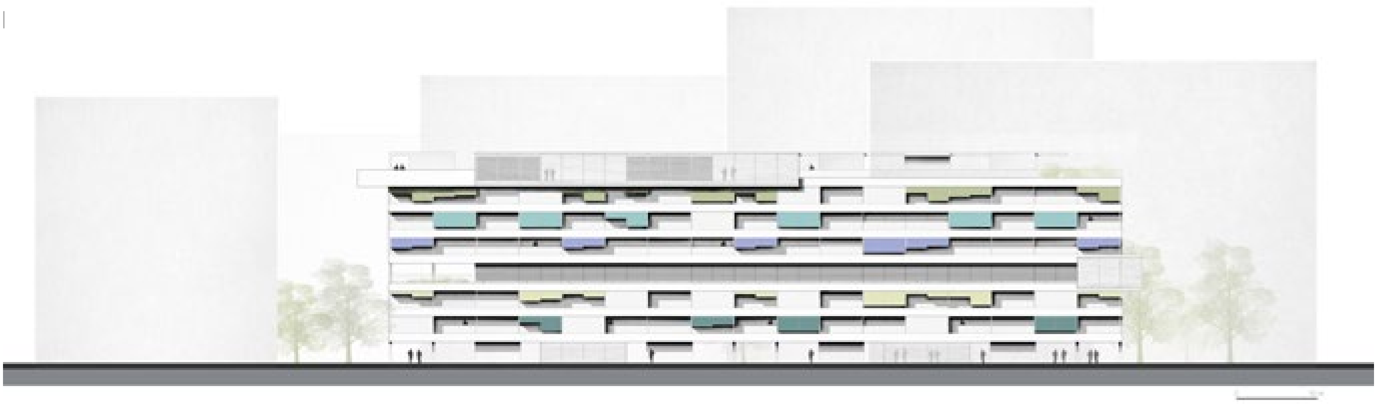
05 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype. Vertical version, elevation

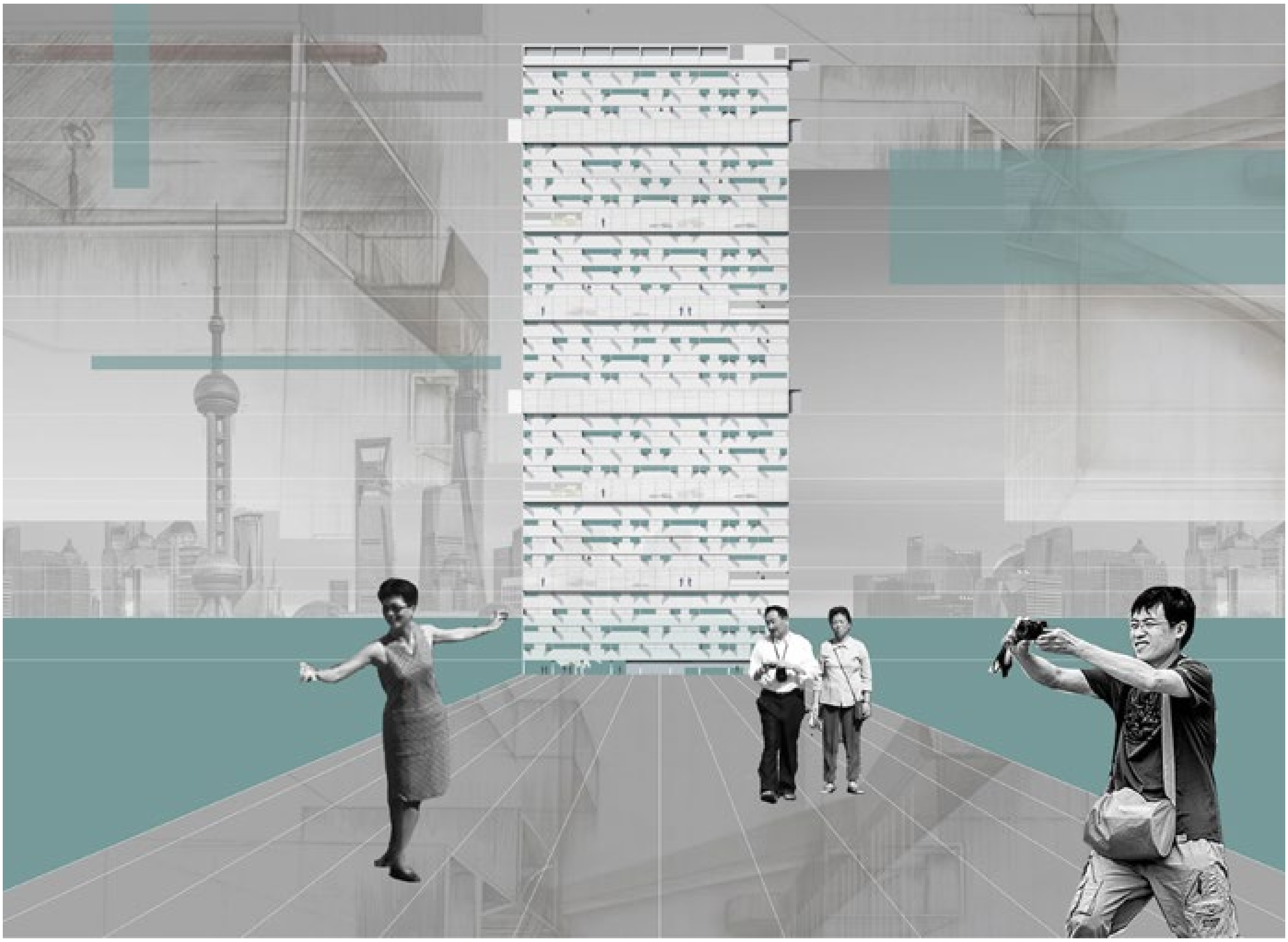
06 |



06 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype. Horizontal version, elevation

grams and spaces related to apartment buildings. Living hotels, the housing visions of the Russian constructivists come closer. […]. Service can mean on one hand persons that can eventually help like a porter; a cleaning service or a craftsman but also extra programs such as a bar, a swimming pool, a fitness club or a doctor's practice. […]. The hotel can be a perfect model for a big collective housing project» (Atelier Kempe-Thill, 2008).

- Prefab constructive systems and new, highly performant materials to cut construction and housing expenses. A contemporary constructive system optimizes the value of repetition but does not deny the identity of the individual user, eliminating debris in the construction and reducing execution time, allowing more precision, versatility and rapidity in the construction process. «Light» prefab systems based on the tactic use of modules for plants and networks instead of «hard» prefab systems based on the repetition of complete cellular modules. Traditional «heavy» enclosures based on massive wall systems have been replaced by «light» ones based on «dry» materials, such as metal sandwich or multilayered wood derived panels as well as cement-based, and/or fiber-composite ones (Landolfo, Russo Ermolli, 2012). The repercussions on construction costs have been calculated in about a 10% decrease, allowing an increase in the interior surface or higher quality finishings (Gausa, 2002). Such cost-cutting and efficiency increasing program of the complete construction process could be heavily implemented by the extensive use of Building Information Modeling Technologies (B.I.M.).



07 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype. Unitè 2.0 in a Shanghai location

Unitè 2.0 as Smart Node for a Smart City

Furthermore, the «critical mass» attained by those building would identify them at urban levels as «cornerstones, smart nodes, to promote transition towards the smart cities» (Clerici Maestosi, 2017). As Paola Clerici Maestosi points out: «One explored pathway is the one related to *energy consumption profiles of non-industrial and/or noncommercial end-users* - over the period day/week/month/year - thus considering different building types such as residential ones, buildings for maternal/child health care and schools for the first cycle (6-13 years):

- elderly or fragile end-users, for whom technological innovation relating to smart objects can promote a substantial improvement in their quality of life but also a more effective organization of the services that flow around them, resulting in the rationalization of energy consumption;
- families, single-parent or single-income families, young couples, students away from home for whom technological innovation relating to smart objects can promote sustainable energy life models using innovative urban services as facilitators in everyday life;
- infants and children as end-users of maternal/child services, First Education Cycle students for whom technological innovation can act both directly and indirectly promoting virtuous effects on families and urban lifestyles.

The hypothesis traced within working groups thus goes in the direction of creating energy districts based on urban residential blocks (social housing + houses for fragile people) and schools (buildings for maternal/child care and First Education Cycle Schools) where technological innovations are capable of promoting interaction with the city defining a smart district model» (Clerici Maestosi, 2017). Unitè 2.0 merges all those typologies into one, huge, smart building.

Conclusions: a prototype

The purpose of the master degree project «Living in the time of crisis: Unitè d'Habitation 2.0» designed by Eleonora Barsanti and tutored by Luca Lanini and Sergio Russo Ermolli aims to offer a possible definition for a new housing model based on concepts like affordability and social living, but above all of flexibility, adaptability, versatility, energetic sustainability and/or production: a prototype that can be placed in any context and adapted to meet specific needs as being a node in a smart city grid.

This project could offer an answer to the topics discussed before, bending together the following qualities:

- Compactness/High Density. It's necessary for the building to be a high density one, facing the phenomenon of urban sprawl.
- Identity. Like Le Corbusier's Unitè, this model is designed to be replicated anywhere, however, the building must be a prototype with adaptable features in function of the site and neighborhood;
- Flexibility. In a fast-changing society, it is essential to offer the possibility to transform dwellings and their composition within the whole building.
- Sociality/Sociability and the neighborhood. Loosing boundaries and social references, it is important to focus on establishing social ties among inhabitants, aiming to create a feeling of connection.
- Energetic Sustainability/Smart Node. In order to reduce the energy consumption of the residential sector, the project must provide environmentally low impact solutions. The building is more and more conceived as an energy hub, as the radiant surface is clearly favored by its massive dimensions.
- Reproducibility. In this period of financial crisis, the new Unitè d'Habitation should provide the use of mass production and prefabrication systems to reduce costs and time.

The configuration of the proposal for the *Unitè d'Habitation 2.0* begins with a modular design that offers the maximum simplicity in space organization, from the design phase/stage to construction through the whole/entire lifecycle, as well as the possibility to expand the building both vertically or horizontally.
The dwelling distribution follows a main guideline that permits double facing; two secondary guidelines represent the spine of the services (in the central area) and the balcony system, simulating a gallery or a loggia (Fig. 1).
Combining different types of designed dwellings offers a first «puzzle» solution, which, however, can be modified during the use of the building by merging two apartments or by redistributing rooms (Fig. 2).
With the purpose of integrating the inhabitants in the Unitè and them with the whole neighborhood, the building will accommodate spaces for activities and services and energy generation (Fig. 3): those spaces are designed to be as free as possible in order to be flexible to the requirements (Fig. 4).
The strength of the project is the ability to guarantee, on a fixed grid, the freedom to organize rooms and services that can be chosen from a sort of catalogue of potentials without representing a definitive configuration. To allow this process, it's fundamental to have new technology such as a metal dry system so that, as soon as the structure is defined, it is possible to add elements that define the building with different colors, insulation systems or spatial configurations (Figg. 5-6).

08 |

08 | Hybrid Building as Social and Energy Hub for Smart Cities: a Prototype. Unitè 2.0 in a New York location

Along with this generic, conceptual lay-out, the external skin is the adaptive interface with the specific context and climate (Figg. 7-8). In our opinion, this process would allow us to accomplish diversity within the same building, attaining a kind of chameleon-like organism which is *flexible, adaptable, versatile and an active energy hub*.

NOTES

[1] The «usual suspect» as forefather of Le Corbusier's Unitè is Mosej Ginzburg's Narkonfim.

[2] The term «social condenser» was invented by Russian constructivists and related to all architectural artifacts conceived as trasformative machines of the social and living behavior of their inhabitants.

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A minimum set of common principles for enabling Smart City Interoperability

Angelo Frascella, Arianna Brutti, Nicola Gessa, Piero De Sabbata, Cristiano Novelli,
Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, Bologna, Italy
Martin Burns, National Institute of Standards and Technology, Gaithersburg, United States
Vatsal Bhatt, United States Green Building Council, Washington DC, United States
Raffaele Ianniello, Department of Computer Science and Engineering, University of Bologna, Italy
Linghao He, United States Green Building Council, Washington DC, United States

angelo.frascella@enea.it
arianna.brutti@enea.it
nicola.gessa@enea.it
piero.desabbata@enea.it
cristiano.novelli@enea.it
martin.burns@nist.gov
vbhatt@usgbc.org
raffaele.ianniello@unibo.it
lhe@usgbc.org

Abstract. The current investments for smart infrastructure development in cities result in the proliferation of self-consistent and closed applications (often called “silos”), which provide services with strong vertical integration but without ease of mutual horizontal integration. This paper investigates the state of several initiatives addressing this problem. It arrives at a proposal for diminishing and, ideally, breaking down these silos. This vision can be achieved by introducing the idea of building Smart Cities on a common set of architectural principles, Pivotal Points of Interoperability (PPI), and by applying these principles to the definition of a set of open Smart City Platform Specifications.

Keywords: Smart City, Interoperability, Standard

Introduction

Recent reviews describe many investments for smart infrastructures in cities (NIST, 2018) (Catriona MANVILLE, 2014), such as smart metering or sensors for intelligent mobility/lightning. Cities are going beyond the experimentation phase of innovative applications demonstrating benefits and feasibility of the smart city concepts (European Commission, 2017).
The result is a proliferation of services for citizens and public administrations with many new data sources, applications and data managers. Unfortunately, they are designed as single applications with their own specific objectives and functions.
Such silos hamper the diffusion of open data, raise the amount of investments for any new service, prevent citizens and public administrations from obtaining full advantage from the existing infrastructures and services, and hinder the composability of solutions and services and their replicability within different cities and contexts - thus favouring vendor lock-in. All these criticalities raise the challenge for interoperability between services and across the domains of the smart city.
This paper investigates the state of prominent initiatives and approaches dealing with this challenge and presents a proposal for diminishing and, ideally, breaking down interoperability barriers among silos.
The concepts of Interoperability and related standards are outlined in the next section.
The following sections are dedicated to the landscape of the current initiatives, including standardization and novel approaches like Pivotal Points of Interoperability (PPI) introduced in the Internet of things - enabled Smart City Framework, also known as the IES-City Framework (IES-City).
The last two sections present a proposal for Smart City Platform Specifications (SCPS) as a mean to tackle the interoperability issues in the smart cities domain and summarize conclusions of this paper.

Definition of interoperability and standards

Interoperability is a key enabler for new information flows among smart city or Internet of Things (IoT) applications. However, turning this enabler into cogent technical specifications is not yet clear. Interoperable systems share a common meaning of the exchanged information, and this information must elicit agreed-upon types of response.
A reasonable definition of Interoperability for smart cities might be found in (Gary Locke, 2010): «the capability of two or more networks, systems, devices, applications, or components to exchange and readily use information, securely, effectively, and with little or no inconvenience to the user».
An important concept implied by the previous definition is that interoperability is a complex property resulting from a broad set of aspects: functional, business, human, trustworthiness, timing, data, boundaries, composition and lifecycle (CPS Public WG, 2016).
Standardization has achieved different maturity levels on these aspects: substantive progresses has been made at the technical level with faster and more secure protocols for data transmission (GSM for example); progress has been smaller on the facilitation of application integration.
Smart Cities are growing thanks to both digital migration of existing services and the composition of new services upon existing ones. The number of potential new applications and services (and data flows to deploy) is rapidly increasing (Hollands, 2008; Vatsal Bhatt, 2017). Factors hampering interoperability include the number of already existing solutions with different institutions and organisations in charge, along with the lack of convergence in the field of the standardization initiatives.

State of Art about present Smart City initiatives

The proliferation of architectural design efforts for smart cities has resulted in divergent and, sometimes, non-aligned standards.
Looking at the many Smart City initiatives trying to address this problem, it is evident how strong a motivation this subject has within the smart city community. These initiatives try to act on the following issues:
- Lack of coherence in existing Smart City standards.
- Lack of mechanisms for comparing and harmonizing standardization initiatives.
- Lack of harmonization and coherence among the existing architectural efforts.

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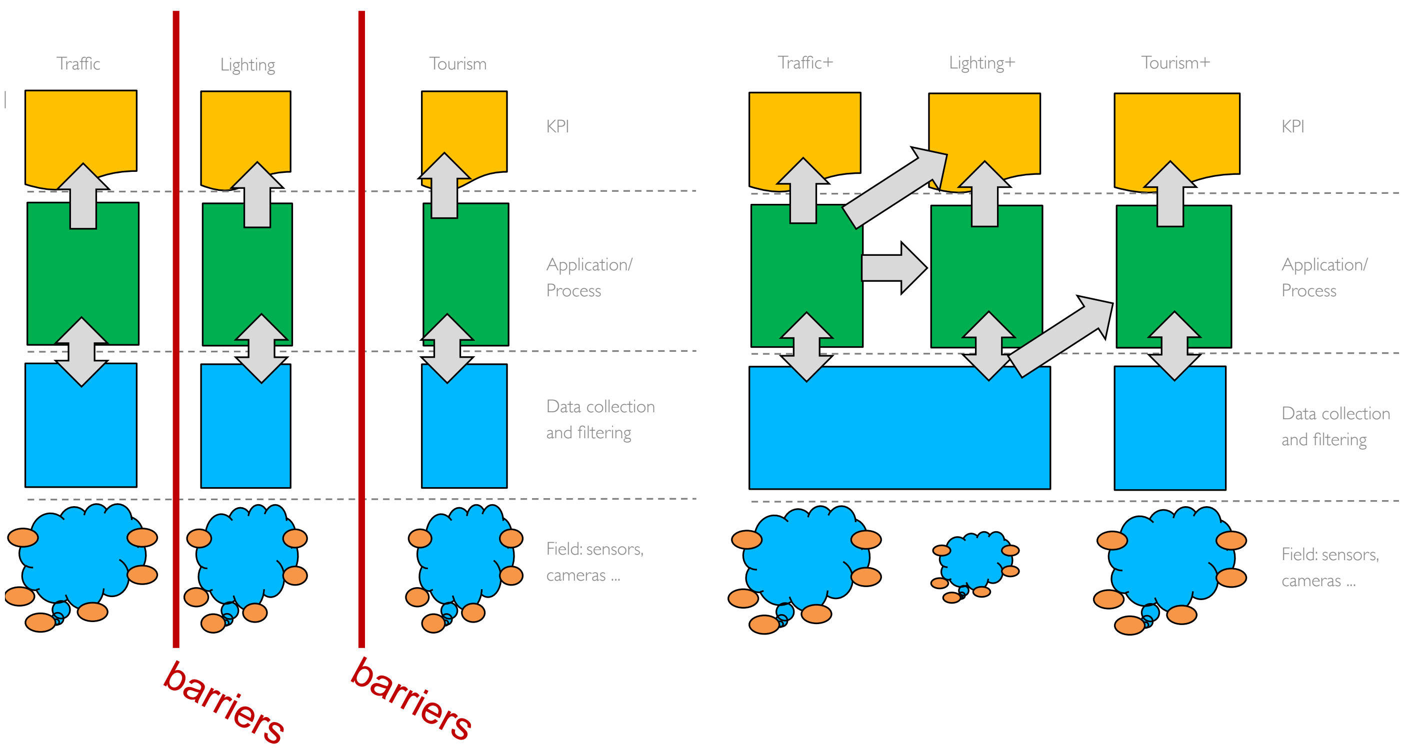
They address interoperability issues from varied perspectives as illustrated in Figure 3:

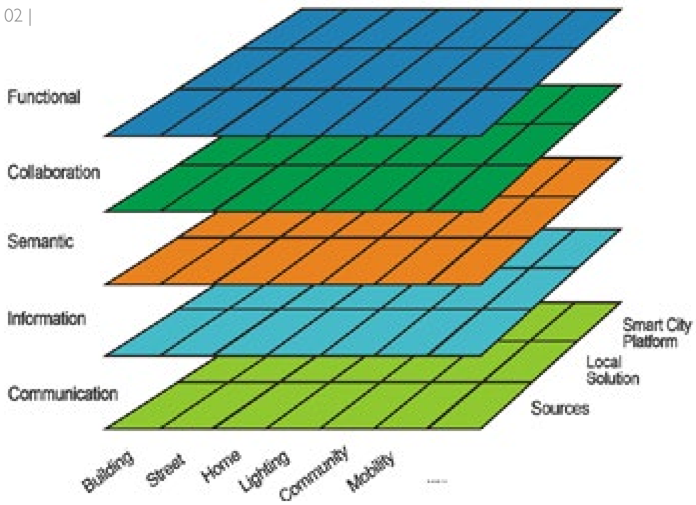
- the starting point for working on the coherence of existing standards is to understand their landscape: The British Standards Institution (BSI) analyzed existing Smart City-oriented standards. The result was a report called "Mapping Smart City Standards" (BSI, 2016), which organizes the standards into three levels (technical, process and strategic standards).
- In order to compare Smart City projects from an interoperability perspective, it is desirable to establish a reference analysis framework: In the Smart Grid context a very powerful model exists: the Smart Grid Architecture Model (SGAM) (SGCG, 2012), built by the Smart Grid Coordination Group (which joins CEN, CENELEC and ETSI). It enables identification of data exchange interfaces, standard classification and mapping of different architectures on the same reference model. Its success inspired different efforts to imitate it in the Smart City context. Some examples are the Smart City Infrastructure Model (SCIAM) (Marion Gottschalk, 2017) and the Generic Smart City Architecture Model (GSCAM) (Christian Neureiter, 2014).
- An important dimension for achieving harmonization among different standardization initiatives is the identification of an optimal implementation policy: an effort in this sense is carried out by the European project ESPRESSO, which is making recommendations in favor of the adoption of a global Smart City Strategy (ESPRESSO, 2016). These recommendations comprise the use of standards, specification of data formats and avoidance of supplier lock-in. Another European initiative is the Sector Forum on Smart and Sustainable Cities and Communities (SF-SSCC), involving the main European Standardization Development Organization (CEN, CENELEC and ETSI) (CEN-CENELEC, 2017).
- Other initiatives are working on putting many cities around one common architecture: The City Protocol Society (Aloisi, 2016) is developing a network of cities including Amsterdam, Dubai, Barcelona and Montevideo based on its Functional Platform; similarly, the Open & Agile Smart Cities (OASC) initiative comprises more than 50 cities using FIWARE based architectures (FIWARE, 2015). Another approach, driven by the Global City Team Challenge, convenes sets of cities and providers as "super clusters" to produce open "blueprints" for sets of Smart City applications (NIST, 2018).

01 |



01 | Smart City silos

02 |



02 | Reference model for the Smart City Interoperability

Based on the SGAM and related works, we are proposing our analysis grid (Fig. 2), with a third axis: Information and Communications Technology (ICT) (z-axis), along with application domains (x-axis) and, critical to our paper aims, the interoperability layers (y-axis). And these latter are: Functional (key concepts, component, functionalities), Collaboration (configuration of interoperable communications), Semantic (semantic of the common language), Information (syntax of the common language) and Communication (data exchange interfaces).
A principle gap observed in the collection of approaches reviewed above is the lack of consensus on both a common language/taxonomy and a set of Smart City architectural principles (the definition of "Smart City" itself is not singular (Hollands, 2008).
Finding this consensus would allow the distance between different sets of standards and architectures to be dramatically reduced and this in turn would allow the previous approaches to be more effective. Starting from this idea, the IES-City project was initiated.

International initiative on interoperability: the IES City Framework

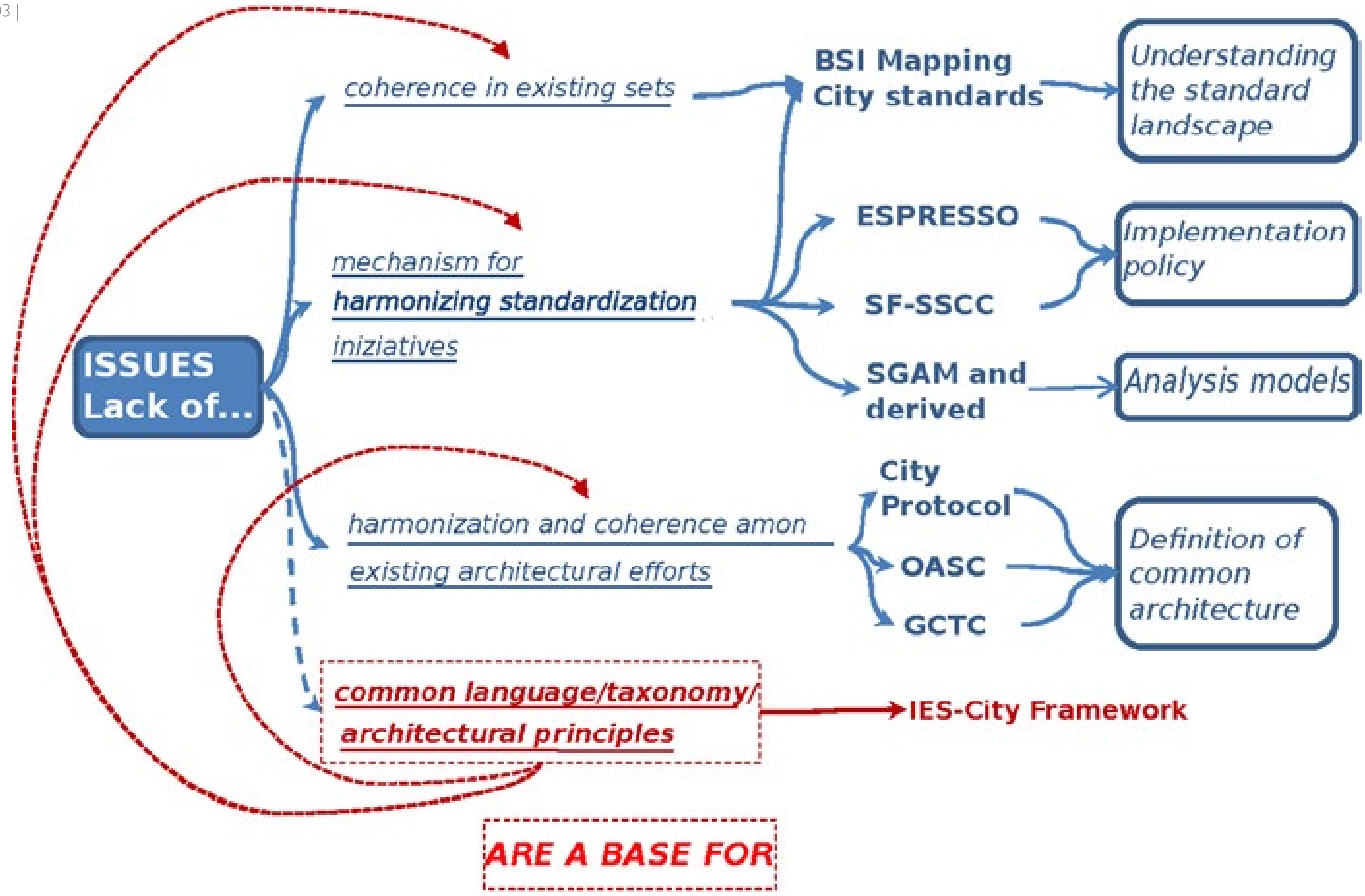
IES-City puts forward an analytical means and set of concepts to assist in the compositional convergence (aka horizontal interoperability) of smart city applications. A key concept is that, although smart city applications are developed by siloed teams, there are common choices that they have made that simplify integration: PPI (IES-City Framework, 2018). Additionally, these common choices are actuated at a small number of key integration points termed Zones of Concern (ZofC).

The analytical means are the application framework and the pivotal points of interoperability analysis.

- Application Framework: provides concepts and tools helping to identify requirements for feasibility of Smart City applications and related achievable benefits, with case-studies. Through this tool, implemented as a spreadsheet, early investigations into the functional and technical requirements, readiness of city infrastructure, and benefits to city stakeholders may be readily performed. Analysis of over 100 smart city applications are included in this data set and tool.
- PPI Analysis: Whereas each existing technology is documented in significant detail, IES-City constructs a simple analytical technique based on a spreadsheet and the NIST CPS Framework to produce a distillation of the key technology choices made in composing an application. The CPS Framework identifies a dictionary of hierarchically arranged concerns about which requirements are developed and designs made to realize them. For example, if a smart city application has concerns about cybersecurity, it would identify these concerns according to the CPS Framework aspect of Trustworthiness which has sub-concerns of security, privacy, safety, resilience, and reliability. Security has sub-concerns of physical and cyber security. In IES-City, a set of technology under study is analyzed as to whether they address these common concerns, and if so, what technology solution they used. Knowledge of these choices reduces the complexity of integrating a new application with an existing one due to these pivotal points of interoperability because the developers understand these key interface choices.
- ZofC considers that groups of concerns can be realized in sets of services bundled and exposed as a known interface. To assemble an application out of an ocean of available technical choices, there are typically three roles of developers – the application developer, the device developer, and the infrastructure (often cloud) service provider. Since these roles are common, bundles of services implementing ZofC can be focused on a *Northbound Interface* where applications find services, and a *Southbound Interface* where devices find services.

The Italian consultation initiative about interoperability

The identification of a set of common principles is essential to break down interoperability barriers among silos and exploit the potential of city's infrastructures. It is not sufficient to identify only common technical principles. To make them effective, a common strategy, shared between all the involved stakeholders in a smart city, district or national level, should be defined in order to create the conditions to favor and improve their adoption. This conclusion derives from the consideration that the transfor-



03 | Collocation of the existing initiatives with respect of issues and leverages

mation process, to make the cities "smarter", requires addressing the needs of technological as well as of conceptual and methodological, and that this can be achieved only through creating synergies between all involved stakeholders.
An example of this kind of effort is currently in progress in Italy: an activity, named National Convergence Table (NCT). Involving research and industrial communities and cities, NCT has been launched by ENEA to identify a subset of common principles, identifying key PPI, fitting with national requirements defining a roadmap for their adoption, and thus creating a national ecosystem in which technologies can be integrated, replicated and customized.
Under the umbrella of the NTC, a round table on Interoperability, organized by ENEA, MIUR and MISE took place in November 2017, promoting a fruitful discussion on Interoperability among national key stakeholders. Findings have been collected and contributed to develop key point (such as: different building automation protocols, different energy management software, different proprietary devices and different semantic are used in national project; interface different standards; concern of data privacy and protection of personal data; sensitive data should be separated from operational data in smart meters to avoid vendor lock-in and the data access issues, …) within the SET-Plan Action 3.1 Temporary Working group on Energy Consumers. The initiative is continuing and other meetings are being scheduled.

One of the first outcomes of the NCT has been the recognition of the key role played by the public administrations in the efforts needed to activate the city's change. This resulted in the identification of public calls for tenders as powerful leveraging means for applying common interoperability principles. At the same time a lack of interoperability skills in the many public administrations has been observed.
Starting from this awareness, the NCT identified as its first objective, the definition of a set of open, scalable, modular, standards-based, and general specifications based on common principles enabling the interoperable data exchange between the vertical smart city's silos. The public administration will be able to use this set of specifications as the basis for technical annexes in public tenders, and so leading their service providers to adopt common and shared approaches and solutions.
The use of such a specification aims to defend city administrations from potential "vendor lock-in" by clearly stating data requirements. The specification also provides for the ability to preserve legacy solutions and technologies.
The Smart City Platform Specification (SCPS), is in progress. It is managed by ENEA with the support of Bologna University on the Semantic level but is open to everyone. Stakeholders are encouraged to contribute by providing use cases related to specific sub-domains.

NOTHBOUND INTERFACE	CPS FRAMEWORK: ASPECTS AND CONCERNS
Aspect/Concern	**Description**
Data	Concerns about data interoperability including fusion, metadata, type, identity, etc.
data semantics	Concerns related to the agreed and shared meaning(s) of data held within, generated by, and transiting a system
data models	Structure of data/information
granularity	Granularity of data
meaning	Semantic meaning of data element

The principles at the base of the SCPS

The design and definition of the SCPS benefits from our study and practical experience on projects about Enterprise Interoperability and involvement in IES-City. Starting from these studies we identified some crucial and general principles:

- avoidance of semantic ambiguities in specification definition, to ensure the interoperability between the applications;
- clear definition of the specification life-cycle: every step related with the SCPS (for example, definition, implementation, adoption, configuration, etc.) is considered and described;
- use of a flexible data format that is enforced by semantic constraints;
- usability of the specification, which is written for different kinds of users, technical or domain expert, management personnel, and end users.

Since the objective of SCPS is strictly related to the cross-domain data exchange at the application level (the "Northbound" interface, as defined by the IES-City), we mainly considered the PPIs related to data models and data meaning concerns (Fig. 4), on which we derived the definition of two pillars for SCPS:

- Semantic modelling (*data semantic concern*): The aim is to reduce or eliminate terminological confusion with the definition of shared knowledge and terminology. Ontology definitions can help in this task, and can represent a common basis to address communication management and resolving semantic ambiguity. Modularity and reusability are two key features that make ontologies a proper tool to be used inside the platform. This, in turn, matches well to a general requirement of modularity and scalability. We used ontology to describe the semantic structure of the data model, fixing properties, characteristics and data context.
- Syntax adoption (*data model concern*): This breaks down interoperability barriers by defining formats and interfaces for data exchange. Considering the wide scope of scenarios related to Smart Cities, we adopted a horizontal approach for standardisation, defining a general data format able to represent a broad set of measured data, coming from different sources and managed by different applications. This data format is used to provide a first validation step, while a deeper validation is performed using semantic validation against the ontological definition of the data model. In this way we have a general approach for managing data exchange among different application in a Smart Cities, but we can also provide application-specific profiles for data exchange.

Short description of the SCPS

The Smart City Specification (SCPS) provides a common set of concepts and artifacts for implementing a horizontal platform enabling exchange of data among vertical smart city applications. On the basis of the reference model (Fig. 2), the SCPS was split into five levels, coherent with the interoperability layers. Moreover, according to the enunciated principles, it was considered to be modular, in the sense that ideally each level could be adopted independently from the others. This aims to favor, for example, a path of gradual adoption of the SCPS, on the basis of need.

The Communication (Web Service Interface definition), Collaboration (data exchange setup) and Functional (Smart City Platform Architecture description) levels are implemented according a traditional approach (e.g. WSDL for SOAP WS). The architectural principles, explored in the previous paragraphs, were used in the definition of Information and Communication levels:

- Information Level: defines a format to provide for the interoperable exchange of data between heterogeneous systems or applications. It is composed of an abstract model and two syntactic implementations (JSON and XML). This data is designed in a flexible way to support various kinds of data coming from any vertical system or application. The data model is made of three parts:
    - specifications: a list of properties that comprise the meta-definition (meaning, data type and unit of measure) of the data to be exchanged. For example, the exchange data about average electric consumption of public buildings would be defined as the "average electric consumption" property having data type "double" and measurement unit "kilowatt hour";
    - context: provides contextualization information (e.g. the time zone related to the time stamps);
    - values: contains the measured data on the declared properties, organized in key-value pairs, together with time-period/instant to which they refer (for example the average consumption, hour by hour, of the monitored building).
- This data model can be imagined as a table, which names of columns are defined case by case.
- Semantic Level: provides the ontology defining the concepts and the structures of specific application data model, which

usually are defined at the Information Level, for assuring not only the semantic interoperability due to shared meaning, but also as a part of the formal validation of the format.

Conclusions

Interoperability is fundamental for smart cities, but is hampered by the ad hoc way in which cities are becoming smarter. Many initiatives are trying to address this problem, but there is a lack of consensus on both common language/taxonomy and architectural principles.

IES-City Framework, an international initiative launched by NIST, proposes to ameliorate this challenge by revealing a set of common Pivotal Points of Interoperability obtained through the comparison of existing smart city architectures. In Italy, the consideration of the IES-City approach to the national context through the Italian Convergence Table involving their principal smart city stakeholders, has indicated that a lever for applying common interoperability principles can be the creation of shared tender specifications. The goal of this effort is to write reusable technical annexes for acquisitions related to data exchange among vertical smart city applications. This involves the PPI discovered through the IES-City methodology and are related to data format and data meaning concerns.

The application of this approach has been carried out with the definition of a set of Smart City Platform Specifications, modular, replicable and potentially applicable both to new and to existing systems. Currently these specifications are being validated in a laboratory context. The next step will be the validation in a real district.

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Regional Energy Transition (RET): how to improve the connection of praxis and theory?

Barend van Engelenburg, Nienke Maas,
TNO, Netherlands

barend.vanengelenburg@tno.nl
nienke.maas@tno.nl

Abstract. A regional energy transition (RET) implies a drastic transformation of the energy system and, hence, a lot of challenges. A RET calls for an integrative local approach. In this essay we describe and compare the current practice and the state of knowledge on this topic. We find that theory has not yet developed sufficiently to address the practical challenges. Part of the problem is that what has been developed has too little connection with local practice. We conclude that the development of theoretical knowledge must be better attuned to the needs of the practitioners.

Keywords: Energy system transformation, Regional planning, Climate change mitigation

Introduction (1)

Deep greenhouse gas reductions will require a drastic transformation of the energy system (see e.g. EEA, 2017 and IEA, 2017). In this essay we will focus on the regional approach for such an energy transformation. We will refer to this as Regional Energy Transition (=RET). One could substitute RET for "Smart Cities" or "Sustainable Urban Planning" and you will get a similar analysis, because all three are associated with multiple interests/values of stakeholders, institutional complexity and scientific uncertainty.

This essay first sketches the challenges involved in a RET (§2). Then it describes the current state of knowledge and tools that could support a RET (§3). In §4 we draw conclusions by comparing knowledge development with the challenges of a RET. This essay is based on preliminary research results of the ESTRAC research project *Transforming Regions*[1].

Challenges of RET (2)

A regional energy transition (=RET) is a process to achieve a certain outcome (=deep emission reductions). A region is defined as a coherent geographical area, varying from a district to an area with several municipalities or cities. A regional energy system is also internationally interconnected in most parts of Europe. Figure 1 makes tangible that a RET involves different geographical levels.

In the Netherlands, a pilot on RET was organised: regional energy strategies (RES). The pilot was carried out in five regions in the Netherlands and was finalized with two evaluations (Schuurs and Schwencke, 2017; Bosman et al, 2017). These evaluations helped us to frame the challenges of a RET in a concrete way. The challenges were divided according to three topics: stakeholder involvement, organisation of a RET, and the possible transformation of the energy system.

Involve stakeholders

A lot of parties or persons are affected by a RET: residents, local companies, local authorities (provinces, municipalities, water authorities), utility companies (energy, energy infrastructure and water), real estate owners, project developers and so on. In the implementation of a RET, stakeholders are mutually dependent on each other, not only within the region, but also outside. Decisions on the national level determine to a large part which local system changes are possible: e.g. legislation on energy infrastructure or on pricing (taxes). Local decisions influence the realisation of national transformations. Some local decisions require the cooperation with other local levels: for instance, if citizens in one neighbourhood want district heating, this may require other nearby neighbourhoods to also adopt district heating in order to be feasible. The interdependency of stakeholders also has a financial side: common or collective business cases could lead to the lowest social costs for all. And last but not least, the issue of timing: decisions of stakeholders mostly do not happen simultaneously because activities of individuals will not be synchronous. A regional approach could be used to organise the interaction with all stakeholders in a satisfactory way; a way that leads to collective support and to the least (collective) costs solutions.

Another key issue for a RET is leadership: one needs 'something/someone' to organise this collective effort. In most regions there is no single stakeholder that would be exclusively in charge of the RET activity. And mostly no stakeholder can decide about investments of other stakeholders. This means that an initiator is needed. Often, stakeholders are looking at a local authority to act as such, but there are alternatives. Examples could be energy network operators wishing to extend their assets or housing corporations needing to renovate their buildings. This 'choice' of the initiator can be highly coincidental and this contingency can and will have an impact on the dynamics of stakeholder involvement as a whole. In a general sense, every stakeholder can (justly) question the legitimacy of the initiator as the responsible actor for a RET.

In summary the main challenges are:

- Large diversity of relevant stakeholders and interdependency of decisions.
- Leadership- who can be a trusted and convincing initiator?

Organizing a RET

The organisation of a RET is connected to the plans of stakeholders in the region. Most stakeholders have their own plans at a strategic, tactical and operational level. A strategic plan articulates the long-term ambition, for example: 'Region X wants to lead the way in the energy transition in the coming 15 years'. The stakeholders have to find a way to align their own strategic plans with the common and shared strategic plan for the RET. The strategic plans of national or multinational companies will surpass the boundaries of the region. These companies will have to fit the

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strategy for the region internally with their own management and strategic department.
Next, the tactical and operational plans of all relevant stakeholders have to be adapted to that strategic plan. Examples of tactical plans are: a plan for a sustainable heat supply or a plan on stimulating electric transport. Examples of operational plans are: (i) a housing association that will isolate its building stock in one street by providing double glazing or (ii) a network operator that will change the gas infrastructure to an electric grid in a specific location. The collaboration inside a RET could lead to common tactical plans (e.g. on 'heat', on 'mobility'). No matter what will happen, these adaptations will lead to iterations within the organisation of each stakeholder and the outcomes of those iterations could very well lead to new discussions on the strategic or tactical level. It could also cause problems at the operational level. This interaction and iteration at and with the different levels can go on for some time. Figure 2 gives an idea of the connection between types of plans.
What makes things even more complicated, is the fact that each plan comes with its own decision cycle and timing. The time horizon of the plans varies per level (strategic is longer term, operational is short term) and per stakeholder: long term for a local authority can be 15-50 years, for a housing association 25-30 years and for a company even less than 10 years.
In summary the main challenges are:
- Achieve a common process for decision-making and implementation;
- Analyse and understand the interconnectedness of all stakeholders and their activities, at all relevant scales;
- Find ways to match timing and content of all types of plans of all relevant stakeholders in the region.

Transforming the energy system

A RET assumes a drastic transformation of the energy system: at the supply side, at the demand side, as well as in the intermediate part (storage, transformation and distribution). The adjustments at the supply side need to match changes in energy demand and the other way around. The following sections provide a short overview of the trends and possibilities in the demand, the supply and the intermediate part:

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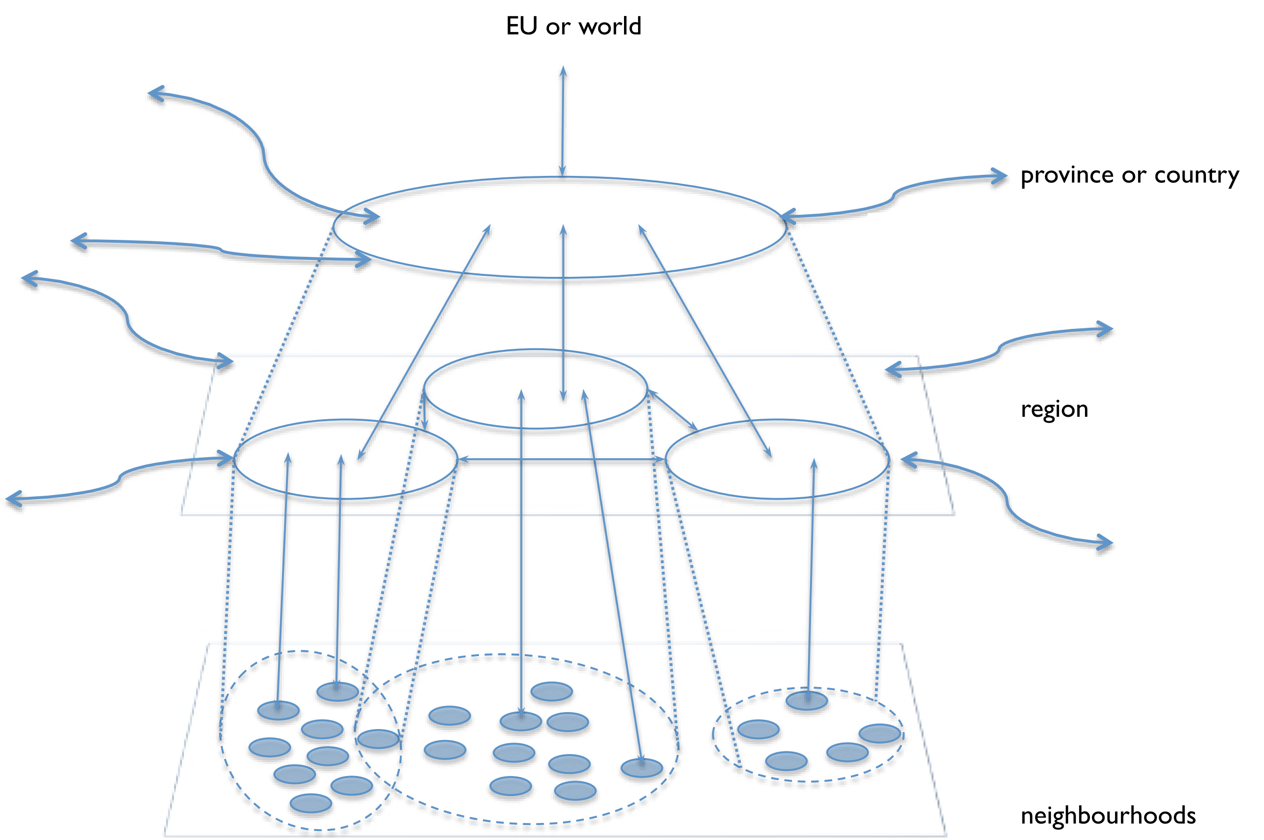
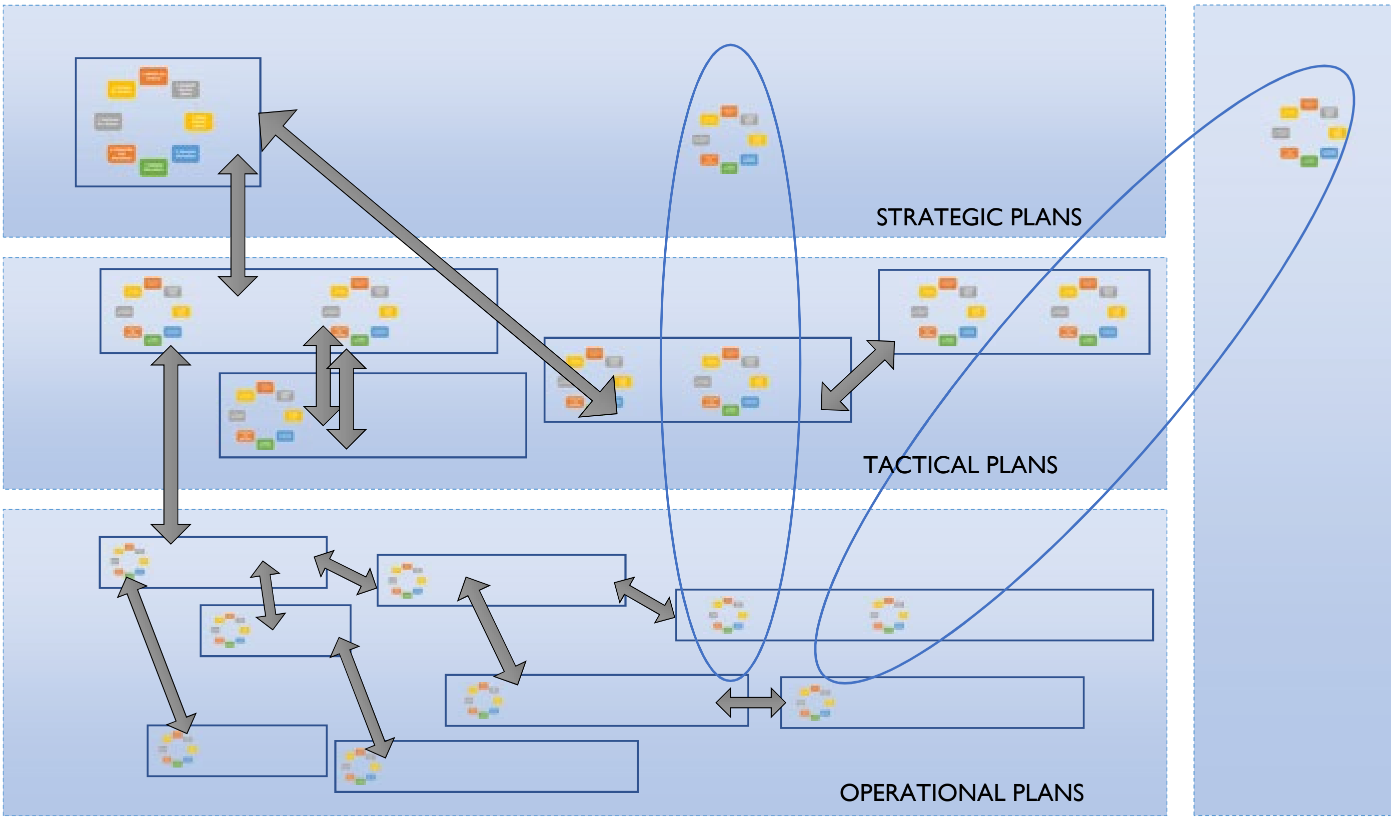


01 | Interconnectedness of activities in a region with activities at other levels

02 | INSIDEREGION

OUTSIDE REGION



02 | Inclusion of the decision framework into planning at the different levels of regional development

- **Buildings.** New buildings meet stringent energy performance standards, which significantly reduce heat demand. This low heat demand makes electrification of the heating systems possible by using electric heat pumps. For existing buildings the picture is different: electrification only seems possible in combination with large-scale renovations. In cases with higher remaining heat demand, partial electrification (= hybrid heat pumps combined with a gas-fired boiler) can be an alternative. Other alternatives are gas-fired systems or district heating.
- **Transport.** There is a trend towards electrification of transport and zero emission vehicles. The design of the e-charging infrastructure is still under development. There are a lot of open questions with regards to type and scale. Hydrogen powered fuel cell electric vehicles increasingly seem to present a viable alternative in case of energy-intensive transport applications (for instance heavy duty trucks and regional buses). And probably some applications will continue to rely on the use of liquid fuels, for instance aviation and international shipping.
- **Supply side**. All energy carriers (in the current system: electricity, natural gas, gasoline, kerosene etc.) are expected to become climate-neutral. Electricity may be generated from renewable sources like solar and wind power or from the conversion of climate-neutral fuels. The gaseous and fluid alternatives can either be bio-based or synthetic fuels based on hydrogen and a climate-neutral carbon source. District heating systems can be fed with climate neutral heat (like residual heat from industry or geothermal heat).
- **Storage and distribution.** Demand and supply of energy (electricity in particular) most often do not occur at the same location or at the same moment. Therefore, some form of national grid is required for the transportation and storage of energy carriers. Such grids are very capital intensive. This results in high costs at the beginning and benefits that are only realized (much) later. Another important aspect is to ensure that demand can always be met. The current energy system can easily fulfil this criterion: storage costs for fossil fuels are

low and large-scale thermal power plants for electricity can easily be operated to achieve a good fit between supply and demand. The new energy system will depend more on intermittent electricity sources and seasonal biomass. This means that buffers must be made to handle daily fluctuations as well as seasonal fluctuations. Large-scale storage of electricity and heat, but also of gases is necessary but such systems are still technologically and economically premature.

Looking at these trends and possibilities, the following main challenges can be observed:
- Uncertainty with regards to solutions. There are a lot of options to achieve a RET. It is not yet clear what options fit best in what situation. The interdependencies between decisions of various stakeholders also increase the uncertainty.
- Uncertainty with regards to data. There is a lot of different data on the different solutions. Sometimes exaggerated by proponents or opponents of single options. On the other hand, the development state of new options is changing. This means that the corresponding techno-economic data cannot be very accurate. The interdependency of solutions adds to this uncertainty.
- Prisoners' dilemma. The collective part of the solutions (like grids and district heating) could help to bring down the social costs of the energy system. Investments for the collective parts are big and risky and the income comes (much) later and is not certain.

Available knowledge and tools (3)

A scientific literature survey[2] has been carried out in the ESTRAC project. Scientific research gives a very clear conclusion on complex societal issues. Tackling these complex societal can only be done by adaptive management or "learning by doing": an iterative process of analysing, documenting, envisioning, experimenting, evaluating, and adjusting policies and procedures (see e.g. Woestenburg et al, 2017). An important requirement is to have a holistic or systemic view and not a linear or partial view on the problem (APSC, 2007). Based on the challenges addressed in §2, we can conclude that a RET is such a complex societal issue. So the first conclusion is that a RET needs a systems approach (including system integration) and adaptive management.
Below we will summarise the lessons from the survey for the following subjects: (i) stakeholder involvement and (ii) tools, models and methods. In the ESTRAC survey we also found that the article of Bibri & Krogstie (2017) is a very helpful summary of scientific results for most of the subjects relevant for a RET.

Stakeholder involvement

The scientific literature on the involvement of stakeholders in complex processes is very clear: real collaboration with all relevant stakeholders is essential to achieve lasting results (and current practice generally falls short in this respect). In the case of a RET 'all relevant stakeholders' means: everyone who has an interest in the area. These are all residents in the area, all companies based in the area, all employers of those companies, all real estate owners in the area, all local authorities, all owners of the infrastructure in the area and all suppliers of energy to the area.
The other main lesson is the magic word "trust" (or rather: an observed lack of trust between relevant parties). Real cooperation is the only way to build trust, and trust is what is needed for all parties to act together, and acting together is a prerequisite for the adaptive approach that is needed to deal with this complex planning situation.
Scientific literature also gives some guidance for the effectiveness of these interactive processes:
- **Clarity and transparency.** To build the necessary trust, the analytical part needs to be clear to and transparent for all stakeholders, and they must be able to understand the inputs and the outputs (and their possible relations). The chosen energy solutions should be relevant and realistic to the stakeholders throughout all phases of development: from a vision to the final construction plan.
- **Incorporate the knowledge of all.** Using, and building on, the knowledge and experience of all stakeholders involved is not only effective in gathering local data but it also helps to increase the feeling of joint ownership and the credibility of the whole project.
- **Systematic learning.** It is very effective and efficient to organise cooperation in such a way that those involved are learning together. When stakeholders are learning together, they get a shared understanding of the issues at stake and they (as a group) become more able to adapt to the unexpected events to be faced.

Tools, models and methods

A wide range of tools, models and methods are available to support a RET. In the ESTRAC program, factsheets have been made of about 40 of those tools. Below we will discuss these tools in two categories: (1) organisational models and (2) techno-economical tools.

Organisation models

The organisation of a RET resembles decision-making in spatial planning. Analytical models for such decision-making are mostly characterised by a decision cycle that is derived from the general PDCA (Plan-Do-Check-Act) cycle: the idea is that decision-making is a cyclic process and this cycle consists of separate serial activities. These cyclic models are meant to be able to carry out a meaningful conversation about the organization; they are not meant to be an exact description of the succession of processes. One can, for instance, focus on the step of *problem identification* and what is needed to organise that step in the right way and what existing (analytical) support tools are available and relevant. It might be useful for a RET initiator to use a specific cyclic model for the organisation of the RET. Up until now we did not find any scientific report on the practical use of specific cyclic models in real life cases[3]. We did find a lot of other scientific lessons. Bibri & Krogstie (2017), among others, point out that it is essential (for success) to have a common and shared problem definition, to achieve real large-scale cooperation and to monitor the organisational process. One could use so-called co-creation methods, where different parties practically work together to explore and find solutions that are broadly supported. Such methods help to engage stakeholders in transition processes. It is also essential for the initiator to monitor the status of the common support at all times. This means that next to the material progress, also the attitude of the stakeholders should be monitored continuously.

Techno-economical models Pfenninger et al (2014) and Hall & Buckley (2016) describe and review a broad set of models that could be useful for energy system transformation, from energy system models to bottom-up (cost) engineering. Together these models enable the analysis of the energy supply and demand in a region; make it possible to develop scenarios; determine a preferred mix of technologies, given certain constraints; simulate behaviour of energy producers and consumers in response to prices and other signals, etc. These tools could support a RET in getting all relevant information at the table in each step of the decision cycle.

Each tool has its own scope and goal. The scope and goal determine the level of data. For a national roadmap one can use simpler models with average data, for a regional energy plan one needs to determine the actual costs, effect and capacity of concrete actions. No matter what is done, it is essential that the tools are "transparent" in the sense that each stakeholder understands at least conceptually why, what and how it is implemented and that the outcome is broadly trusted and accepted.

The analysis and assessment of all available techno-economical models in ESTRAC is still going on. The good news is that for all phases of the decision cycle, one or more tools are available and applicable for a RET. The bad news is that hardly any of these tools are ready-for-use and most of them have to be tailored to a specific region; some of these tools are very data-intensive; and some need data that are not available yet.

Conclusions (4) We start with a couple of observations:

- **Experience is recent and growing**. Nearly all integrated local approaches started their development after 2010. Currently some cities, regional authorities, and regional stakeholders are trying to use some form of an integrated approach. The experience is still building up. Scientific research on the new approaches has only just started.
- **There are relevant lessons from sustainable urban planning**. Integrated approaches have their roots in sustainable urban planning (SUP). Several articles on SUP contain a review of an overall approach in practice. Next to Bibri and Krogstie (2017), a complete volume of the journal *Current Opinions in Environmental Sustainability*[4] can be seen as a state-of-the-art on SUP. Both sources give a lot of general and specific lessons learned: on the opportunities in cities, on governance ('urban living labs'), on innovative processes, on involving citizens and residents, on the role of stakeholders, on ICT and combining smartness with sustainability.
- **There is a need for tested decision-making approaches**. Looking at the challenges of RET (see §2), we observe a large need of verified decision-making approaches. The scientific testing of such approaches is still absent. This should be a challenge to all (social) scientists active in sustainable development (or other complex societal problems).
- **Guidance for practical application is needed**. A RET practitioner would tell you that there is too much "out there", and he does not know how to choose the tools and the approaches and how to assess the results. They ask for some kind of guidance or guidebooks (Bosman et al, 2017).

Comparing the challenges of the current RET practices with the current state of knowledge, we can only conclude that knowledge and tools do not match the needs of the practitioners. Practice and theory need to be connected in a better way. The theory has not yet developed sufficiently, and what is being developed has too little connection with practice. The current state-of-the-art of knowledge and tools can at most be called promising, but certainly not fit for practice, as Bibri and Krogstie rightly conclude: "*The findings show that existing smart city approaches […] are associated with many issues and challenges—when it comes to their development and implementation as to the incorporation of and contribution to the fundamental goals of sustainable development, respectively. […] Therefore, there are several critical questions to address or problems to investigate concerning definitional, conceptual, theoretical, analytical, evaluative, empirical, and practical aspects.*" (2017, p. 208). We strongly recommend to carry out scientific research more closely with practice and practitioners, and to intensify this research especially in two directions: (i) decision-making at local level and (ii) testing integrated tools for RET.

NOTES

[1] This research is, however, still in progress, see acknowledgements.

[2] Articles and reports on the following subjects: (sustainable) urban planning; smart cities; sustainable development; achieving climate change goals in cities and regions; and regional economic development.

[3] In the scientific literature we could not find one review of a practical integrated approach for sustainable (urban or regional) planning neither could we find detailed evaluations of such an integrated approach in real life.

[4] *Current Opinions in Environmental Sustainability*, Vol. 22, October 2016. This is a special issue on the subject of "System dynamics and sustainability" and according to the editors especially focused on urban transitions to sustainability and resilience.

ACKNOLEDGMENTS

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Towards energy optimized cities

Ali Hainoun, Ghazal Etminan,
Center for Energy, Sustainable Buildings and Cities, AIT Austrian Institute of Technology GmbH, Seibersdorf, Austria
Ali.Hainoun@ait.ac.at
Ghazal.Etminan@ait.ac.at

Abstract. This work deals with the application of a bottom-up and scenario-based approach to analyse the future urban energy development. For this purpose, consistent scenarios of long term socio-economic, technological and demographic developments of the considered urban area are prepared. The key development parameters focus on technology and infrastructure transformation related to EE improvement and electrification in all consumption sectors, including the shifts in mobility modes and lifestyle changes driven by financial incentives and environmental awareness. The concept systematically relates the specific energy needs for producing various services and commodities to the social, economic and technological factors that affect the demand for a particular fuel.

Keywords: Sustainable urban development, Bottom-up approach, Development scenarios, Energy services, Sector of consumptions

Introduction

The ongoing transition to a resource-efficient and low-carbon economy presents the adequate response to the perceived sustainable development revealed in the recently adopted UN sustainable development goals (SDGs). Current observations show that urban areas account for the main resources consumption and are responsible for about 70% of GHG emissions. With the projected increase of urbanization rate up to 80% by 2050, the pressure on our limited resources and related environmental implications will further increase calling for comprehensive, interdisciplinary and sustainable solutions.

Cities, as centre of urban activities, require innovative solutions to tackle this looming challenge and lead the urban transformation in a sustainable fashion to ensure sustainable cities and communities according to Goal-11 of SDGs taking into consideration Goal-12 tackling the global need for ensuring sustainable consumption and production patterns (UN-SDGs, 2016). To ensure their sustainable development in social, economic and environmental dimensions, cities need to combine economic growth with social equity and environmental congeniality, i.e. a minimum production of wastes (emissions, effluent and solid waste) (UN-Habitat, 2008; Mirakyan and DeGuio, 2013). This leads unavoidably to the integrated concept of minimizing the inputs of materials, water and energy and maximizing their recycling and reuse. The consequence for the city energy system is the successive reduction of the use of fossil fuels to the minimum possible on the way of its full replacement by renewable energies in combination with the substantial improvement of energy efficiency. Important part of this effort is the application of a nexus scheme, that implies among others energy reuse from wastes, wastewater and waste heat[1].

To respond to the interdisciplinary challenge of the ongoing urban transformation, consolidated actions are needed to ensure inclusive and integrated solutions. One of the key aspects in such effort is to ensure access to affordable and clean energy that - in accordance to Goal 7 of SDGs - enables providing reliable and sustainable energy services (like illumination, information processing, thermal comfort, mobility) which drives our intensive and highly concentrated socio-economic activities within cities. Considering its interdependency with other systems, energy system plays a vital role for ensuring sustainable urban development and thus covering the synergies between Goal-7, Goal-11 and Goal-12 (among other SDGs) during the formulation of sustainable urban energy strategies offering a suitable approach to attain energy optimized cities on the way to achieve inclusive and resilient cities.

In fact, the intensive and highly concentrated socio-economic activities within cities offer the opportunity to employ adequate measures of energy saving and harnessing of existing synergies to simulate the final energy demand by consumption sector and energy form and subsequently optimize the energy supply covering the whole energy chains from the energy resources to the final demand level. The sector-wise assessment of urban energy consumption is a very useful first approach to develop long-term energy demand projection and help to formulate urban GHG mitigation and decarbonization strategies. Besides, it serves as a benchmarking for more sophisticated spatio-temporal approaches that take into consideration the spatial distribution of energy consumption (and onsite production) within the city and surrounding areas and thus enable more accurate optimization of energy strategy within an integrated energy-demand-supply analysis[2] (Alhamwi et al., 2017; Arne and Espegren, 2016).

Methodological Approach

This work demonstrates the application of an end-use based bottom-up approach to model the future development of urban energy demand using the model MAED being traditionally used for national and regional energy demand projection. However, with some modifications the model is adaptable for application on an urban region with predefined system boundaries comprising the city and its surrounding peri-urban and rural areas. The applied concept disaggregates the urban energy demand by sector of consumption comprising building (household and service), industry and transportation (Hainoun et al., 2006). As presented in Figure 1 each of those sectors is disaggregated in various sub-sectors following the socio-economic and technological determinants driving the energy consumptions. The different activities in each sub-sector are correlated to specified energy services being covered by the useful energies in form of heat, motive power and specific electricity use. The available conversion technologies at the end-use level of consumers convert the provided final energy into the desired useful energy to cover the needed energy services. The fundamental principle of the model relies up on relating the specific energy needs for producing various ser-

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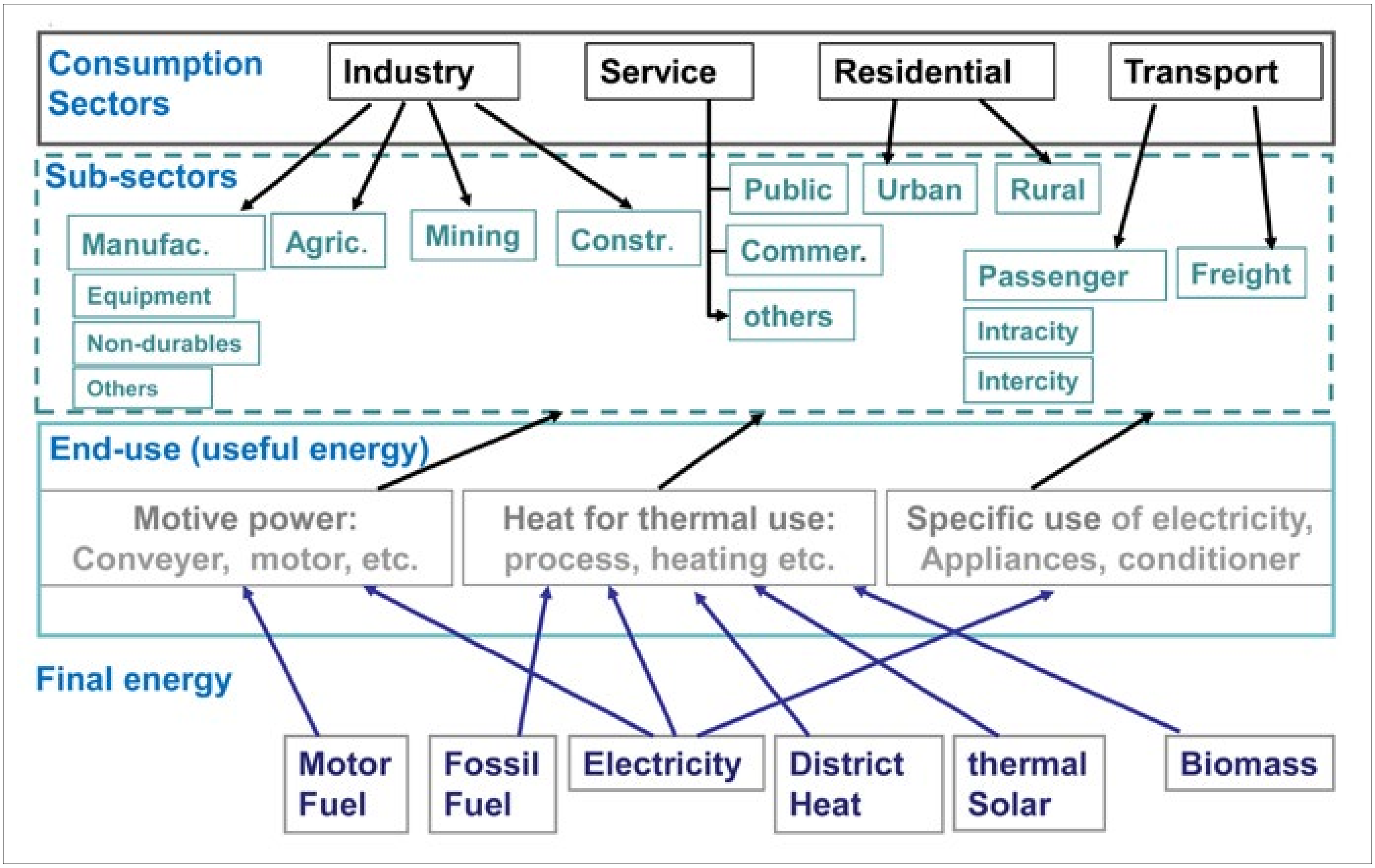

01 | Disaggregation of urban final energy by consumption by sector and energy form

vices and commodities to the social, economic and technological factors driving the demand on a particular fuel. Furthermore, it offers a flexible framework for projecting future trends and anticipating change in energy needs following alternative scenarios of socioeconomic and technological development.

Base year Energy Consumption

The starting point of the energy demand analysis is the defining of a base year reflecting the current energy consumption of the considered urban region. The base year is selected to be as close as possible to the current state and to represent the typical consumption behaviours of the considered urban region. The base year reconstruction implies establishing the mathematical relationships between final energy demand and related demographic, socio-economic and technological drivers. This process comprises the following steps:

1. Disaggregation of final energy demand of the urban region by the end-use categories for the base year 2015 by the consumption sector (household, service, industry, agriculture and transportation) and the useful energy form of heat, motor fuel and electricity for specific uses.
2. Data preparation for current final energy consumptions by sector and fuel type within the considered city-region based on available official data and additional international references. The interaction with the stakeholders via workshop organization and direct communication is essential for data collection, provision and final preparation. Moreover, the stakeholder's involvement is vital for the later stage of scenario development.
3. Identification of demographic, social, economic and technological drivers determining the demand on energy services like population, dwelling size and type, GDP value added of industry and service activities, inter- and intracity mobility of passengers and freights, penetration rate of different fuel carriers and the end-use conversion technologies.
4. Reconstruction of the base year final energy consumptions

by calibrating the established mathematical relationships between energy demand and related demographic, socio-economic and technological drivers.

Future Development Scenarios

Starting from the established base year the future final energy development is projected based on consistent scenarios reflecting the expected long term socio-economic, demographic and technological developments and the official energy policy of the considered city region. The key development parameters -for the conceived urban energy transition- focus on technology and infrastructure transformation related to EE improvement and increased electrification in all consumption sectors, including the shifts in mobility modes and lifestyle changes driven among others by financial incentives and environmental awareness (Fig. 2).

Due to the high uncertainty in developing the driving factors different development scenarios are designed reflecting different development paths of the conceived future vision. Concerning the addressed problem, the scenario is understood as an alternative image of how the future might unfold and thus represents plausible future state of a system resulting from a set of mutually consistent assumptions. Following this approach, the considered sscenarios are constructed to cover plausible range, in which urban future evolution of economy, demography, technology as well social and environmental aspects is expected to lie.

In view of the big amount of required data and the different employed disciplines in designing the future development scenarios, a co-design process is being applied that involves various local stakeholders and urban decision-makers within the development process. Within this analysis two scenarios are considered. Beside the envisaged development trend reflecting the desired sustainable urban energy development along the anticipated urban transformation, a reference development scenario reflecting the business as usual (BAU) trend is developed offering a benchmark basis to evaluate the effectiveness of the assumed optimization and transformation measures of the sustainable urban energy scenario (SUS). Furthermore, SUS should ensure integrating

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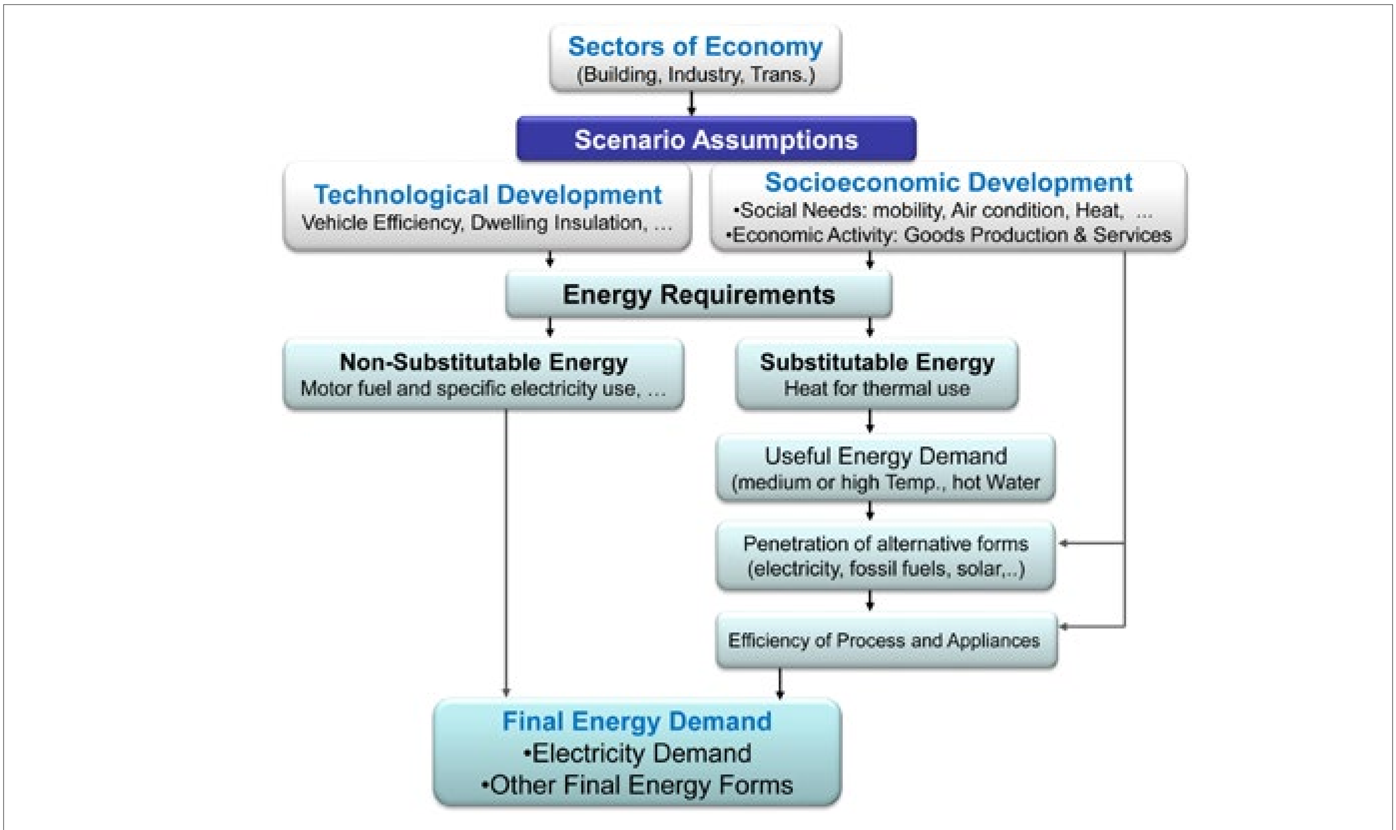

02 | Main steps of designing future development scenarios for final urban energy demand projection

the targets of Goals 7, 11, 12 of UN-SDGs. In a final stage the results of the projected final energy demand are monitored using key performance indicators (KPIs) derived from the indicators of selected SDGs beside the officially adopted energy and urban development strategies of the considered city.
Finally, the achieved results of the developed scenarios should prove to be consistent with the key assumptions and applied policies. This means that the resulting evolution of the energy demand will not lead to questioning the validity of key socio-economic and technological hypothesis of the scenario.

Final Energy Demand Projection of Vienna Region 2015-2050

The above presented approach is being applied as part of the effort to formulate a sustainable energy strategy for the region of Vienna city. Furthermore, the project will comprise the construction of a decarbonization scenario. In the following a description of the Vienna city region and final energy demand for the year 2015 is presented. The information provided, are part of an extensive set of socio-economic, demographic and technological data being under processing to design the base year and formulate the future development scenarios following the concepts described above. Very important is the Vienna energy policy adopted by Vienna City Council on Smart City Wien Framework Strategy 2050.
The results will be published in a later stage subject to further approval by AIT and different stakeholders of Vienna city.

Overview of Vienna City

The City of Vienna, is Austria's Capital with 1.87 million inhabitants, located in the northeastern Austria embedded in a larger functional urban area hosting around 3 million inhabitants[3]. Observing a net-migration of above 20.000 people per year, it is expected that Vienna will reach 2 million inhabitants latest 2025. The elevation range is between 150 and 542 m. Vienna's areal extent is 414 km^2. 50% is green space - forming with the forest areas of the hilly Wienerwald ranging from the West to the North and agricultural areas in the eastern and southern outskirts as well as nature protection areas along the Danube River the green belt around the built-up area. Inside Vienna various small to large parks and the 21-km long Danube Island (an artificial flood protection measure) support this greening strategy. Nevertheless, the green space is not evenly distributed – while the 13th district Hiezing in the southwest has a green space share of 70% while the 8th district Josefstadt near the city centre has a green space share of 1.9%. Vienna is one of the wealthiest regions in the European Union: Its GDP per capita reach EUR 47,700 per capita (2016) which is 159% of the EU average. Vienna constituted 25.7% of Austria's GDP in 2013. With a share of 85.5% the service sector is Vienna's most important economic sector. Industry and commerce have a share of 14.5%. This constitution is essential for the final energy consumption of the city. Within the service sector the tourism industry plays a considerable role hosting 15 million overnight stays and uncounted millions of day tourists. The overnight stays alone sum up to a daily average of around 50,000 people requiring accommodation with food, water and energy.

Energy Demand

Vienna's current annual final energy demand amounts to 36,800 GWh distributed by consumption sector to 30% household, 25% services, 8% by production including agriculture and 37% for transportation. Related secondary energy supply reaches about 40,600 GWh, distributed by fuel type to 36% natural gas, 13% electricity, 1% district heating (requiring solid waste through waste incineration), 11% renewables (biomass, wind), 32% oil products and 4% coal. Vienna's energy supply is like all cities very much depending on imports. 88.2% of the energy supply is imported. 12.8% comes from local sources which are renewables (8.6% - biomass, hydropower) and waste incineration 3.8% comes from reuse of waste heat.

Vienna Energy Policy

Vienna has strict energy policy guidelines:

- Conservation of the environment and resources.
- Rational and economical use of energy.
- Safe, fairly priced and need-based supply.
- Social compatibility and satisfied customers and
- Economic efficiency and competitiveness.

The Vienna City Council has adopted the Smart City Wien Framework Strategy 2050. It is a long-term umbrella strategy that is supposed to establish a conducive, long-term and structural framework in order to reduce carbon dioxide emissions from 3.1 tons per capita to 1 tons per capita by 2050, have 50% of Vienna's gross energy consumption originate from renewable sources and to reduce motorized individual traffic from the current 28% to 15% by 2030. A stated goal is that, by 2050, all vehicles within the municipal boundaries will run without conventional propulsion technologies.
The key stakeholders for the scenario development will be the Energy Planning, MA20 Vienna administration department responsible for energy strategy development, and Wien Energie - Vienna utility company responsible for energy supply.

Conclusion

This work demonstrates the application of an end-use based bottom-up approach to model the future development of urban energy demand following a predefined system boundary comprising the city and its surrounding peri-urban and rural areas. The applied concept disaggregates the urban energy demand by sector of consumption comprising building (household and service), industry and transportation. The sector-wise assessment of urban energy consumption proves to be a very useful first approach to develop long-term energy demand projection and help to formulate urban decarbonization strategies. Besides, it serves as a benchmarking for more sophisticated spatio-temporal approaches that take into consideration the spatial distribution of energy consumption (and onsite production) within the city and surrounding areas and thus enable more accurate optimization of energy strategy within an integrated energy-demand-supply analysis. The presented concept is being applied as part of the effort to formulate a sustainable energy strategy for the region of Vienna city up to the year 2050.

NOTES

[1] This approach is part of an integrated concept being established by AIT to model the urban Energy-Water-Food-Nexus with application on the Vienna urban region.

[2] Along this effort a new modelling framework is being under establishment by AIT to tackle the issue of integrated urban energy system modelling (IUESM).

[3] https://www.wien.gv.at/statistik/pdf/viennainfigures-2017.pdf

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Stephan Hartmann
Magistrat der Stadt Wien, Austria

As an urban planner working in the field of smart city development, I support activities optimizing integrated energy and urban planning. The proposed concept within the article "toward energy optimized cities" is in line with this ambition and relevant for urban energy strategies.

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Urban energy performance monitoring for Smart City decision support environments

RESEARCH AND EXPERIMENTATION

Massimiliano Condotta, University Iuav of Venice, Department of Design and Arts, Italy massimiliano.condotta@iuav.it
Giovanni Borga, University Iuav of Venice, Department of Design and Planning in Complex Environments, Italy giovanni.borga@iuav.it

Abstract. In this essay we wish to present an interdisciplinary study carried out in the framework of two Interreg Italy-Austria projects which were intended to design methodologies, simulation tools and decision support instruments to face energy challenges within the overall Smart City concept.
The proposed strategy uses a physical model ("City Model") and an energy behavior model ("City Sensing") of the urban environment. They were developed using two different approaches: the first is mainly based on analysis of surveys data and the second one on simulations and processing of large-scale datasets. "City Model" and "City Sensing" were then merged to provide an Urban Building Energy Model - that we called "City Energy Model" - integrated with a Participatory Public GIS platform.

Keywords: Energy in cities, City energy demand, Simulation tools, Energy networks, ICT

Scenario

There is still no common understanding about the definition and concept of Smart City. In a study aimed at providing background information and advice on Smart Cities in the European Union, the European Parliament acknowledges that there are many definitions, some focusing on ICT as a technology driver, while other broader definitions include socio-economic and governance aspects, such as the use of social participation to enhance sustainability, quality of life and urban welfare. The study concludes that a Smart City is a city «seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally-based partnership» (European Parliament, 2014). In accordance with this definition, but shifting the emphasis onto sustainability, we support the idea that «the smart city is intended to deal with or mitigate, through the highest efficiency and resource optimization, the problems generated by rapid urbanization and population growth, such as energy supply, waste management, and mobility» (Calvillo, 2016).
Translated into architectural terms and considering the context of European cities characterized mainly by an old, energy-inefficient building stock, it means optimization of processes, systems and conditions related to heating and cooling. Technically, this process can take place through retrofitting of private buildings undertaken by householders - either spontaneously or prompted by public regulations and incentives, or else through retrofitting of public buildings by direct intervention of local authorities.
While these are optimization processes to be carried out on single buildings, to achieve tangible results they must be applied pervasively at urban level. It follows, that an appropriate decision support environment capable of estimating energy demand and building energy behavior can better drive the operation.
On the other hand, another alternative or additional optimization process could be the improvement of energy systems at urban level, such as the creation or integration of mixed energy networks to obtain "holistic energy systems" where, once again, single buildings represent the terminal elements of the whole system. In this case, the estimation of buildings' energy demands is a key aspect, wherein estimation methods could be based either on a top-down or bottom-up approach (Swan and Ugursal, 2009). But considering that single buildings represent the terminal elements of the city system and a «scenario analysis for retrofit or new design is only possible at the building scale» (Monteiro et.al., 2018), decision support environments must be based on "bottom-up approaches" aimed at understanding the details of energy consumption and the effects of potential retrofitting actions on buildings (Reinhart and Davila, 2016).
Even the design of a "holistic energy master plan" needs to start from information at building level. In fact, in a smart city scenario, houses and buildings may play the role of "prosumers" because they both consume and produce electricity. Once again, bottom-up approaches are fundamental to investigate supply-demand dynamics properly.

State of the Art

Working on an urban scale with bottom-up approaches means considering thousands of buildings and calculating the energy demand for each of them. The solution is to rely on «urban building energy models (henceforth referred to as UBEMs) [that] are expected to become a key planning tool for utilities, municipalities, urban planners and even architects working on campus level projects» (Reinhart and Davila, 2016).
Recent research has developed several methods for UBEM construction. They are quite similar to each other; what is different is the information source and data processing, where «data conversion, mapping procedures and building stock data collection still represent technical barriers in the development of UBEMs» (Cerezo et. al., 2016).
The "New York City Building Energy Map!" project (Sustainable Engineering Lab, 2012) subdivides buildings according to functional typology and fixes a standard energy demand per floor area for each specific typology. Values are derived from the "Residential Energy Consumption Survey (RECS)" and the "Commercial Buildings Energy Consumption Survey (CBECS)".
The "SusCity" project (SusCity, 2017) used data from national census to determinate the age and construction type of buildings, but «although this information was accessed at buildings level, due to privacy requirements, the information is publicly available only at statistical subsection level, corresponding to a small aggregation of buildings, typically a quarter block» (Monteiro et.al., 2018). To fill that gap, many other local data sources were used.
From an analysis of the state of the art, it emerges that many of the studies apply elaborated procedures tailored to place-specific conditions; they can be considered prototypes. As a re-

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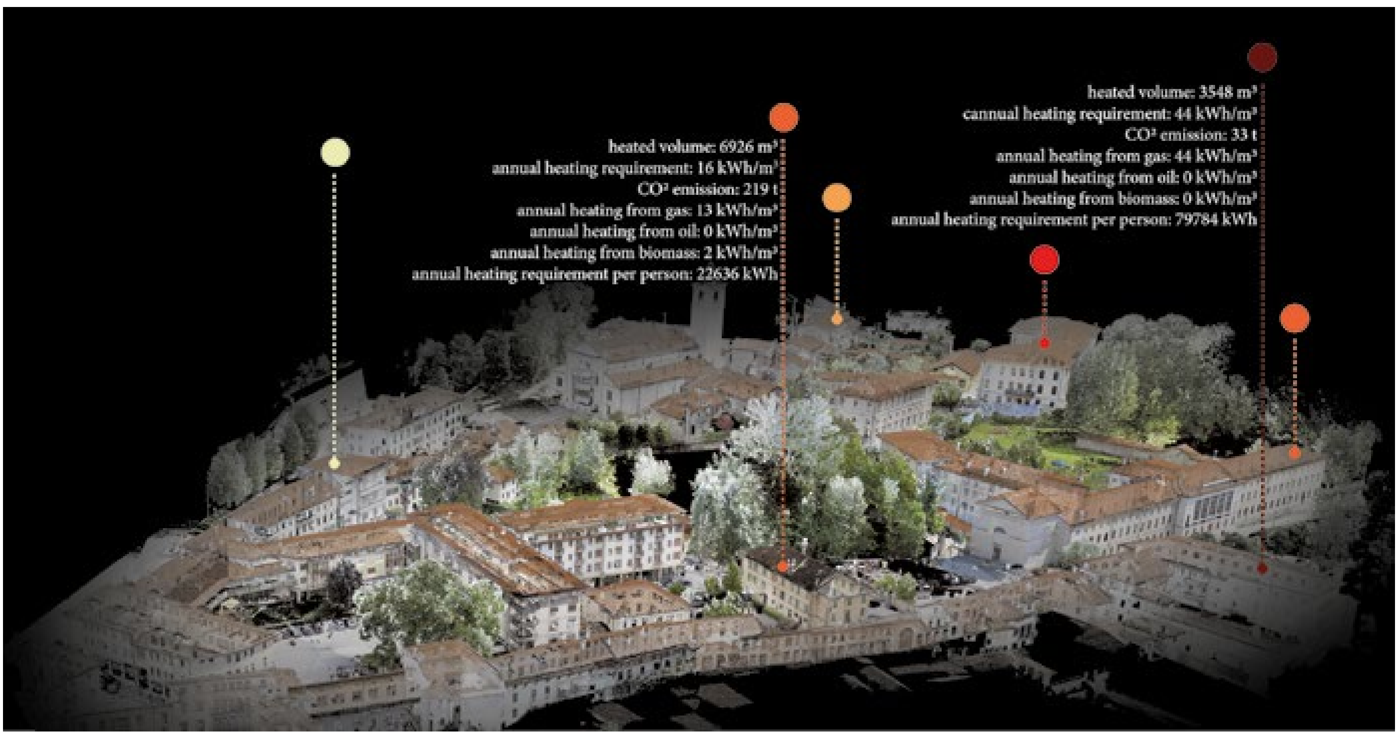
01 |

01 | An elaboration of the "City Model" used to calculate solar irradiation

sult, these procedures are feasible in the case of experimental research but are not suitable for use as standard methods to be carried out by city administrations or communities at national or European level.

Research and Experimentation Objectives

The study presented in this article aims at improving energy efficiency approach by developing scalable and "easy-to-use" methodologies and simulation tools for decision support systems to face energy challenges within the overall Smart City concept.
The work was carried out in the framework of two joint European research projects; one has recently been concluded and the second, a spinoff project from the first one, is still ongoing. The first project is UEb: "Urban Energy Web, shared knowledge for the reduction of energy consumption and development of renewable energy on an urban scale"[1]. The second one is the IDEE project: "Network of research institutions for planning efficient energy systems in urban areas"[2]. Both projects have been financed by the Interreg V-A Italy-Austria programme and are being applied and tested in the city of Feltre (Belluno, Italy).
The main objective is the development of new methodologies and simulation tools to create decision support environments based on a detailed understanding of the energy performance of urban areas. Tools and methodologies have to be user-friendly, suitable for use by experts and urban stakeholder/communities, and they need to be replicable.
A further objective is to set up strategies and tools to approach the design of hybrid supply systems. Expected scenario applications are both the planning of the best possible configuration of any energy network and assessing whether it is more cost-effective to create an energy network or invest in the retrofitting of buildings.
The overall objective of the research is to develop methodologies and tools able to trigger some of the elements that characterize Smart Cities: "Better planning", "Participatory approaches", "Pervasive use of Information and Communication Technologies".



02 |

02 | A conceptual representation of the "City Energy Model"

03 |

03 | The "Urban Energy Pattern" as displayed by the PPGIS of the UEb project; on the right the info box for customization of the index parameters

Methodology, Originality and Research Output

Conceptually, the whole research is based on the dual "City Model"/"City Sensing" strategy.

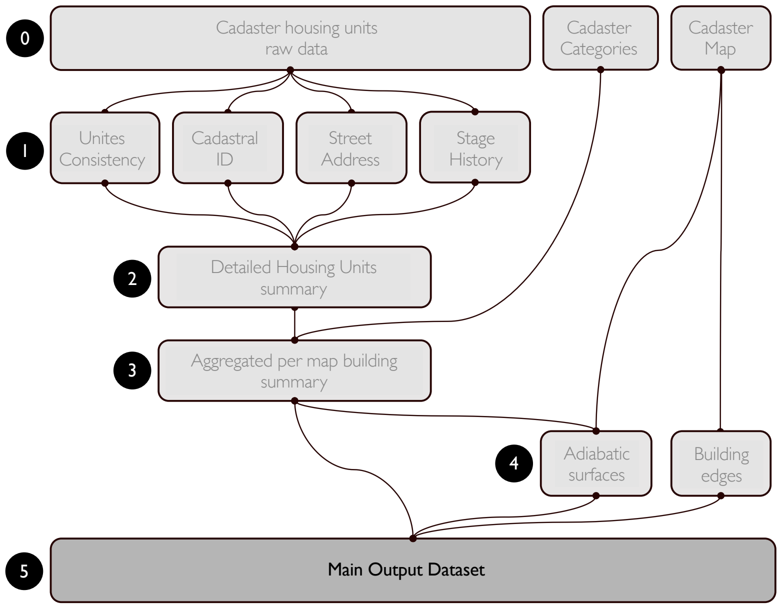
When assessing a city, City Model and City Sensing are two specific information clusters that can help design geo-data models dealing with complex urban issues like those related to energy. The City Model cluster is based on an intensive data retrieving phase aimed at acquiring high-density/low temporal resolution information about morphological and physical city characteristics. The City Sensing cluster is based on the integration of heterogeneous datasets that are continuously updated by technological systems (e.g. sensors), measurement campaigns, surveys and content-enriching processes that provide information on specific elements of a city, such as, for example, buildings. It is reasonable to assume that their integration produces a very complete information framework of a city called "City Energy Model", which is basically a thematic characterization of a UBEM.

In UEb, the approach is based on a massive survey campaign. The City Model is therefore built up by processing hi-res avionic orto-photos, avionic and drone laser scanner point cloud datasets and the result is a 3D model of the city that can be managed and elaborated using processing software. The City Sensing, on the other hand, consists of several geocoded datasets such as gas/wood/oil real consumption and a series of thermographic images of the urban building stock.

UEb City Model, City Sensing and City Energy Model feed data into a geo-web interactive platform which provides social network tools to administrators, technicians, energy companies and citizens, so they can better understand the energy behavior of their city. Through the UEb platform, users can browse several thematic interactive maps; one of these maps shows the so-called "Urban Energy Pattern", which is a parametric index that helps to understand the correlation between consumption, dispersions, emissions and inhabitant behavior (Figure 3).

In this respect, «in recent years, there is a concern to bring academic practices of GIS to the public realm, usually known as Public Participation Geographic Systems (PPGIS)» (Monteiro et. al. 2018). The UEb portal is basically the implementation of a PPGIS

04 |

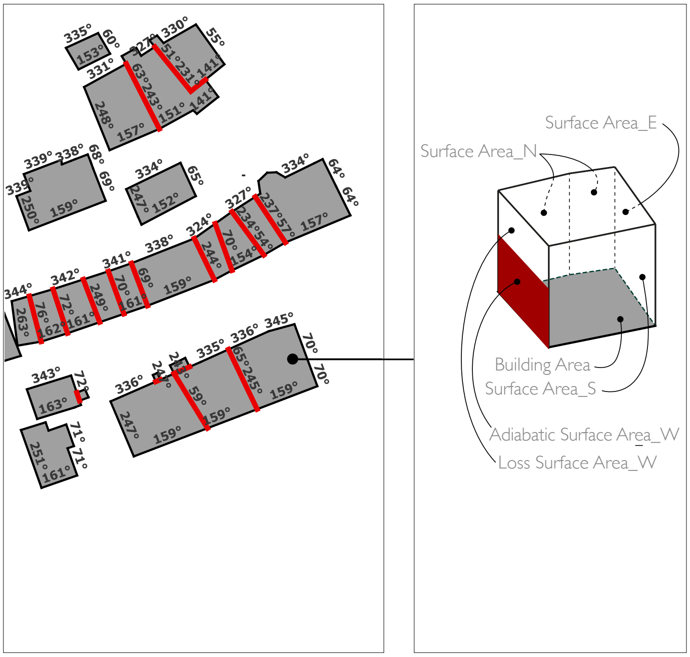


In stage #1 it is calculated units consistency of each building (indeed each building may contain one or more housing units).
The result summary of stage #2 provides details per housing unit whilst aggregation in stage #3 filters-in proper residential units using a category list, and computes summary values per single building.
In stage #4, a GIS polygon analysis and a self-intersect geo-processing operation return building edges orientation and area of adiabatic surfaces.
Main Output Dataset (stage #5) contains buildings' physical dimensions, external surfaces, adiabatic surfaces and loss surfaces area per compass-point.

04 | Geo-DBMS multi-stage processing procedure

05 |

Field name	Field content description	unit
OverGroundFloors	Number of over-ground floors	number
UnderGroundFloors	Number of under-ground floors	number
TotalFloors	Total amount of floors	number
BuildingArea	Building base surface area	m^2
TotalFloorsSurfaceArea	Sum of each level surface	m^2
SurfaceArea_N	North-oriented surfaces total area	m^2
SurfaceArea_E	East-oriented surfaces total area	m^2
SurfaceArea_W	West-oriented surfaces total area	m^2
SurfaceArea_S	South-oriented surfaces total area	m^2
AdiabaticSurfaceArea_N	Adiabatic North-oriented surface total area	m^2
AdiabaticSurfaceArea_E	Adiabatic East-oriented surface total area	m^2
AdiabaticSurfaceArea_W	Adiabatic West-oriented surface total area	m^2
AdiabaticSurfaceArea_S	Adiabatic South-oriented surface total area	m^2
WindowArea_N	North-facing windows surfaces area	m^2
WindowArea_E	East-facing windows surfaces area	m^2
WindowArea_S	Soth-facing windows surfaces area	m^2
WindowArea_W	West-facing windows surfaces area	m^2
LossSurfaceArea_N	North-oriented loss surfaces total area	m^2
LossSurfaceArea_E	East-oriented loss surfaces total area	m^2
LossSurfaceArea_S	West-oriented loss surfaces total area	m^2
LossSurfaceArea_W	South-oriented loss surfaces total area	m^2



05 | Geometric parameters output list resulting from geo-database processing. The map shows azimuthal orientation of building edges used to compute areas per compass-point and adiabatic surfaces highlighted in red

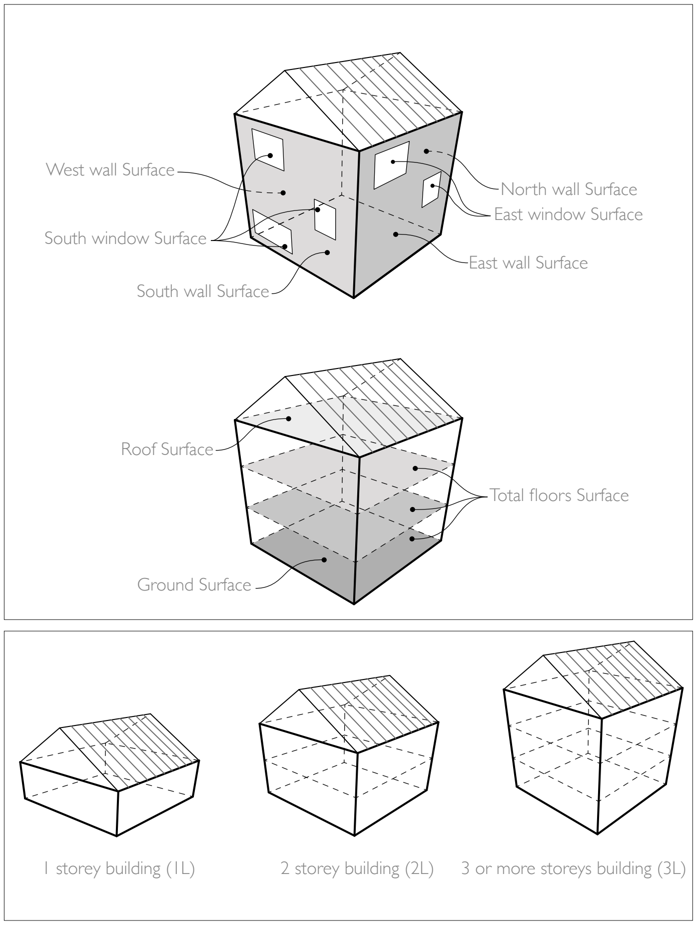
aimed at improving public engagement in policy-making processes allowing participants to dynamically interact with the input, analyzing and visualizing alternatives.
The experience of the UEb research demonstrated that while, on the one hand, the approach used gives good results in terms of correspondence with reality, on the other hand, it is still affected by difficulties in data collection. UEb is based on "reconstructed models of the urban environment" that give important results but cannot be applied on a large scale. In fact, survey campaigns for City Model construction are time- and money-consuming, while data acquisition from energy companies most of the time involves complex operations.
For this reason, in IDEE, we devised and tested an alternative approach for the construction of UBEMs, relying on data that can be easily accessed and obtained by any public administration.
This approach is no longer based on surveys and measurement of real phenomena, but on "simulated models of the urban environment". In order to define a replicable methodology, the physical-morphological features of the buildings are firstly obtained by processing the national cadastral database that has homogeneous characteristics for almost all Italian municipalities.
The City Model is generated through the multi-stage processing procedure explained in Figure 4. The output of a geo-DBMS processing procedure is a building unit's dataset (see Figure 5) in which 21 different physical/geometric parameters are calculated for each building in the urban stock.
The City Sensing section contains the technical characteristics of buildings, that determinate their energy behavior. They were derived from public National Census data of 2001 and 2011; starting from this information, thermal transmittance for building components are determined according to each of the seven construction periods into which we have subdivided the building stock; U-values result from literature review and research (TABULA, 2017).
The City Energy Model is the result of multiple dynamic energy simulations (using Design Builder software) based on a parametric model for the definition of typical dispersions of the external envelopes of buildings. This model is built up considering typology, number of levels (floors), construction period and building use, but it also takes into account building orientation and the influence of adiabatic surfaces (calculated in the GIS procedure and explained in Figures 5 and 6). In this way, multiple dynamic energy simulations give an overview of the typical energy demand for each combination of building types and characteristics.
Simulations are based on a set of typical buildings with a 100 m^2 gross basement area and a WWR (wall to window ratio) of 10% for each external wall. The set includes three main types of buildings, depending on the number of levels (L1, L2, L3). Simulations are performed for each of the three building models and for each construction period. In this way, for each construction period it is possible to calculate the typical energy loss due to transmission per square meter of each external surface, also considering wall orientation. A similar approach is used to calculate typical solar gain per square meter of each of the four orientations of the window surfaces. Internal gain and ventilation loss are calculated during simulations for each thermal zone of the reference model and are then parameterized according to square meters of total floor surfaces.
The simulation series yields a set of values (in kWh/m^2) that indicate the total annual amount of energy loss and gain per square meter of either wall surface, window surface or floor surface. These values, multiplied by the geometrical extension of walls, windows and floors of a building give the annual energy demand of that building according to the general formula:

$$Q_{H,nd} = (Q_{H,tr} + Q_{H,ve}) - \eta_{H,gn} (Q_{in} + Q_{sol})$$

where $Q_{H,nd}$ is energy loss due to transmission, $Q_{H,ve}$ is energy loss due to ventilation, Q_{in} is internal gain and Q_{sol} solar gain. The utilization factor ($\eta_{H,gn}$) has been assumed as 0.80, taking into account the typical dynamic behavior of buildings.
The table in Figure 6 summarizes all the values generated by energy simulations - each value has been calculated for each construction period, in total we have a table of 196 loss and gain values in kWh/m^2 - and describes the geometric elements used for parametrizing energy loss or gain of the building.
The formula in Figure 7 represents the final simulation running in the GIS environment, which combines the typical energy demand of each individual building with the corresponding geometric parameters.
The main output of the IDEE approach is information about the energy demand of buildings mapped at city level, for each individual building. It is worth noting that energy demand was calculated using dynamic building energy simulation procedures. This allows determining annual heating and cooling energy requirements and peak power demand for heating and cooling.
Knowing annual heating energy requirements is useful for planning retrofitting measures and policies, while peak demand, combined with annual requirements, is indispensable information for planning energy network systems. On this aspect, a further development of the IDEE project in the future will be its integration with "Rivus". It is an open-source software which implements a «linear mixed-integer optimization model for urban energy infrastructure» (Dorfner, 2016) to assess energy network construction/extension scenarios based on input about available commodities, energy conversion processes, basic demand and peaks during daytime, costs and demand areas.

06 |

	Parametrization surface	Variabile name
Transmission loss: $Q_{H,tr}$	Ground Surface (1 storey buildings)	$Q_{H,tr}(S_G)1l$
	Ground Surface (2 storeys buildings)	$Q_{H,tr}(S_G)2l$
	Ground Surface (3 or more storeys buildings)	$Q_{H,tr}(S_G)3l$
	Roof Surface (1 storey buildings)	$Q_{H,tr}(S_R)1l$
	Roof Surface (2 storeys buildings)	$Q_{H,tr}(S_R)2l$
	Roof Surface (3 or more storeys buildings)	$Q_{H,tr}(S_R)3l$
	East wall Surface (1 storey buildings)	$Q_{H,tr}(S_E)1l$
	East wall Surface (2 storeys buildings)	$Q_{H,tr}(S_E)2l$
	East wall Surface (3 or more storeys buildings)	$Q_{H,tr}(S_E)3l$
	North wall Surface (1 storey buildings)	$Q_{H,tr}(S_N)1l$
	North wall Surface (2 storeys buildings)	$Q_{H,tr}(S_N)2l$
	North wall Surface (3 or more storeys buildings)	$Q_{H,tr}(S_N)3l$
	West wall Surface (1 storey buildings)	$Q_{H,tr}(S_W)1l$
	West wall Surface (2 storeys buildings)	$Q_{H,tr}(S_W)2l$
	West wall Surface (3 or more storeys buildings)	$Q_{H,tr}(S_W)3l$
	South wall Surface (1 storey buildings)	$Q_{H,tr}(S_S)1l$
	South wall Surface (2 storeys buildings)	$Q_{H,tr}(S_S)2l$
	South wall Surface (3 or more storeys buildings)	$Q_{H,tr}(S_S)3l$
	East windows Surface	$Q_{H,tr}(S_{WE})$
	Nord windows Surface	$Q_{H,tr}(S_{WN})$
	West windows Surface	$Q_{H,tr}(S_{WW})$
	Sud windows Surface	$Q_{H,tr}(S_{WS})$
Ventilation loss: $Q_{H,ve}$	Total floors Surface	$Q_{H,ve}(S_{TF})$
Internal gain: Q_{in}	Total floors Surface	$Q_{in}(S_{TF})$
Solar gain: Q_{sol}	East windows Surface	$Q_{sol}(S_{WE})$
	Nord windows Surface	$Q_{sol}(S_{WN})$
	West windows Surfac	$Q_{sol}(S_{WW})$
	South windows Surface	$Q_{sol}(S_{WS})$



06 | Parameters produced by Energy Dynamic Simulation

07 |

$$Q_{H,nd} = (Q_{H,tr} + Q_{H,ve}) - \eta_{H,gn}\,(Q_{in} + Q_{sol})$$

$$Q_{H,tr} = (Q_{H,tr}(S_G)\varkappa l \cdot BuildingArea) + (Q_{H,tr}(S_R)\varkappa l \cdot BuildingArea) + (Q_{H,tr}(S_E)\varkappa l \cdot LossSurfaceArea\_E) + (Q_{H,tr}(S_N)\varkappa l \cdot LossSurfaceArea\_N) + (Q_{H,tr}(S_W)\varkappa l \cdot LossSurfaceArea\_W) + (Q_{H,tr}(S_S)\varkappa l \cdot LossSurfaceArea\_S) + (Q_{H,tr}(S_{WE}) \cdot WindowArea\_E) + (Q_{H,tr}(S_{WN}) \cdot WindowArea\_N) + (Q_{H,tr}(S_{WW}) \cdot WindowArea\_W) + (Q_{H,tr}(S_{WS}) \cdot WindowArea\_S)$$

$$Q_{H,VE} = Q_{H,ve}(S_{TF}) \cdot TotalFloorsSurfaceArea$$

$$Q_{in} = Q_{in}(S_{TF}) \cdot TotalFloorsSurfaceArea$$

$$Q_{sol} = (Q_{sol}(S_{WE}) \cdot WindowArea\_E) + (Q_{sol}(S_{WN}) \cdot WindowArea\_N) + (Q_{sol}(S_{WW}) \cdot WindowArea\_W) + (Q_{sol}(S_{WS}) \cdot WindowArea\_S)$$

07 | Formula utilized in the GIS environment to calculate the annual heating energy demand for each building; the formula merges energetic data of the Dynamic Energy Simulations (Figure 6) with geometric data of buildings (Figure 5)

Results, Implications and Impact

The first part of the project, concerning UEb methodology and tools and their application in the test case of Feltre, is already concluded. Project results and impacts can be assessed according to the three elements that characterize Smart Cities indicated in the Research and Experimentation paragraph.

Regarding "Participatory Approaches", mapping of city energy behavior information from PPGIS promoted a transparent and collaborative process, allowing us to integrate more traditional approaches in the final decision, such as public meetings and surveys on focus groups. With citizens participating in the process, more informed decisions can be made, and awareness of environmental issues is enhanced (Monteiro et. al. 2018). This blended participatory approach (mixing traditional meeting with online platform) is commonly used in some initiatives promoted by the municipal government (*Casa dei beni comuni* and *Feltre Rinnova*) aimed at encouraging participatory planning and common actions for renewing heating systems in houses.

As for "Better Planning", the mapping of building-specific energy demand at city level has been used by the municipal authorities to better tune the City SEAP and as background information to prepare retrofitting plans for public buildings and preliminary plans for the construction of a mini district heating system.

"Intelligent use of Information and Communication Technologies" has been a key aspect of the whole project evidenced by the project output and results. On the other hand, the application of this work methodology in the territory demonstrated that proper and extensive use of ICT can help municipal authorities to become more efficient and effective.

Limits of the Research, Future Development and Conclusion

The experience acquired in Feltre teaches us that it is fundamental to build a user-friendly, easy replicable and updatable system in order to produce effective UBEMs.

In striving to achieve these goals, common pitfalls are mostly related to complexity in data retrieving and integration, as well as in difficulties to implement replicable tools and procedures. Therefore, the IDEE strategy is based on large-scale datasets (even though less detailed and up-to-date) and standardized procedures to provide end-users with an easy-to-use "toolkit" for processing data.

In a sense, the main limitations of the IDEE strategy are related to the above-mentioned assumptions. Census data have been used because of their large-scale homogeneity; unfortunately, they are not available (due to privacy regulations) for details about single buildings, so some calculation parameters must be statistically estimated. For this reason, a further step of the project will be to update and improve the quality of the City Sensing model. Some automatic procedures are needed to process new survey information and data sources such as a questionnaire addressed to householders, construction license databases and other detailed data about building characteristics.

The UEb project represents an important step in the project development process and the IDEE approach intends to overcome some of its shortcomings in defining a scalable methodology. In this ongoing research process, the UEb dataset will be used to validate the results of IDEE simulations and set-up corrective parameters.

The last step to be implemented will be a pilot based on Rivus software to support energy network scenario assessment. One of the actual weaknesses of Rivus regards the availability of a detailed enough dataset about energy demand: to develop a scenario, only the building's area is used to estimate energy demand. The IDEE output dataset - which contains detailed information about energy demands for each single building - will feed information into the Rivus database that will finally be transformed into a web-oriented application aimed at improving decision-making processes for the benefit of experts and administrators.

To conclude, the aim of our research project is to develop approaches, tools and methodologies that can contribute to optimizing the management of resource use for buildings. The IDEE project is not a point of arrival but a concrete opportunity to extend the international network started up with UEb and continue conducting research on energy efficiency issues in urban areas. The methodologies and tools implemented with these activities will remain publicly available to researchers, experts, administrators and citizens who intend to develop services in the framework of the European Pathways to Smart Cities.

ACKNOWLEDGMENTS OF VALUE

Valter Bonan
Local authority on participatory democracy, energy and environment of the City of Feltre

The City of Feltre Administration has given its support and full contribution to the UEb and IDEE projects. These projects succeeded in combining research, innovation and experimentation with concrete potentialities and opportunities to reduce consumption by improving territorial energy efficiency. The process activated, and the quality of the research applied to the city context, had the merit of making recognizable, and implicitly consolidating, the possible virtuous relations of reciprocity and mutuality between research activities and management and participatory planning - which is one of the objectives of the City of Feltre. It is no coincidence that the portal developed for the project - already connected to our public ICT systems and portals - has produced a concrete urban analysis and is now a strategic support system to be used in drafting the SEAP plan and monitoring its results. On the other hand, the innovative survey models of UEb and IDEE methodologies, the related databases and intuitive methods of browsing and displaying information have disseminated new knowledge and increased awareness among the population, previously difficult to attain without such an instrument.

NOTES

[1] www.urbanenergyweb.eu

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Urban energy assessment by means of simulation techniques

Silvia Soutullo, Jose Antonio Ferrer, Maria del Rosario Heras,
Energy Efficiency of Buildings R&D Unit 7 Renewable Division, CIEMAT, Madrid, Spain

silvia.soutullo@ciemat.es
ja.ferrer@ciemat.es
mrosario.heras@ciemat.es

Abstract. Current trends in energy consumption and greenhouse emissions make energy problems in cities take special importance. This situation has led to evaluate different urban configurations that combine the reduction of the energy demands with the optimization of the energy generation systems including renewable sources. The use of dynamic simulation programs allows the quantification of the energy impacts produce by the building stock and the energy generation systems that make up an urban area. Simulation environments have been defined to evaluate and optimize the energy performance of urban areas. This paper presents a modular methodology based on phases to develop a global urban model. This methodology has considered many variables that characterize an urban area.

Keywords: Dynamic modelling, Urban areas, Modular methodology

Introduction

Currently, cities are responsible for many environmental, social and economic problems that affect humanity due to their high-energy consumption. With the aim of minimizing the urban energy trends, the European Union is promoting several programs, platforms and directives in urban areas (Directive 2010/31/EU) to develop clean, safe and efficient sources of energy in cities (Connolly et al., 2014). Effective implementation of the European energy proposals supposes great efforts to improve the building renovation, maximize the efficiency of grids and infrastructures, promote the use of high-efficiency cogeneration and district heating and cooling or maximize the renewable share into the energy market.

The Spanish energy import dependency (73%) is much higher than the mean of the European Union (54%), with a renewable production of 13% (Eurostat Statistics, 2017; COM (2015)/080/EU). This situation has led to design more sustainable cities with more efficient buildings and optimized energy systems that integrate renewable sources. But it is necessary to quantify the energy impact produced by the building stock and energy generation systems into the urban areas. With this objective, simulation programs are presented as excellent tools to analyze the energy performance of urban areas. These programs consider all the energy balances produced by external and internal fluctuations, solving the coupled and time-dependent equations (Crawley et al., 2008) and setting the limits of the model as well as the boundary conditions. The use of dynamic simulation programs allows modifying input variables, parameters and boundary conditions at small time steps. But these programs require an exhaustive definition of the inlet information and a greater computing capacity to solve the mathematical equations that characterize the urban system.

The use of these simulation tools with experimental data recorder in urban areas, enable the validation and calibration of the theoretical models used (Enríquez et al., 2017, Díaz et al., 2015, Sánchez et al., 2012).

In this line, the Energy Efficiency in Buildings research unit of CIEMAT has carried out a theoretical methodology to evaluate the energy performance of urban areas over specific periods of time. This methodology has been developed coupling modular simulation environments to analyze, in a realistic and rigorous manner, the dynamic performance of whole system.

Methodology

The simulation process has been understood as a closed loop between local renewable resources, building stock, urban planners, energy generation plants, distribution systems, mandatory regulations and energy patterns. The overall objective is the development of global simulation models to analyze the energy performance of urban areas over specific periods of time. With this philosophy, an iterative methodology based on phases has been carried out:

- Initial considerations.
- Building simulation models.
- Energy generation and distribution models.
- Simulation environments.
- Energetic assessments and optimization process.

Dynamic simulation process

The energy quantification of urban systems has been done linking different simulation models. These models are described by a set of coupled mathematical equations with time dependence. Dynamic simulation tools, based on numerical methods, have been used to solve these equations in short time steps, considering the boundary conditions given by the surrounding environment.

Initial considerations

Previous to the modelling process it is necessary to define the boundary conditions and the inlet information required to characterize the urban area. These considerations depend on the studied location but specific information always must be collected: climate, building stock, user's patterns, energy systems, energy storage and mandatory restrictions. This information should be provided by real data (building projects, energy audits, energy certificates or monitoring campaigns) but, in many cases, it is not possible, implying many assumptions.

One of the most critical points when assessing the energy performance of urban systems is the availability of representative climatic databases. These files should be created through the treatment of the principal meteorological variables registered by weather stations over long periods of time (Soutullo et al., 2017_1). Hourly and annual patterns of the meteorologi-

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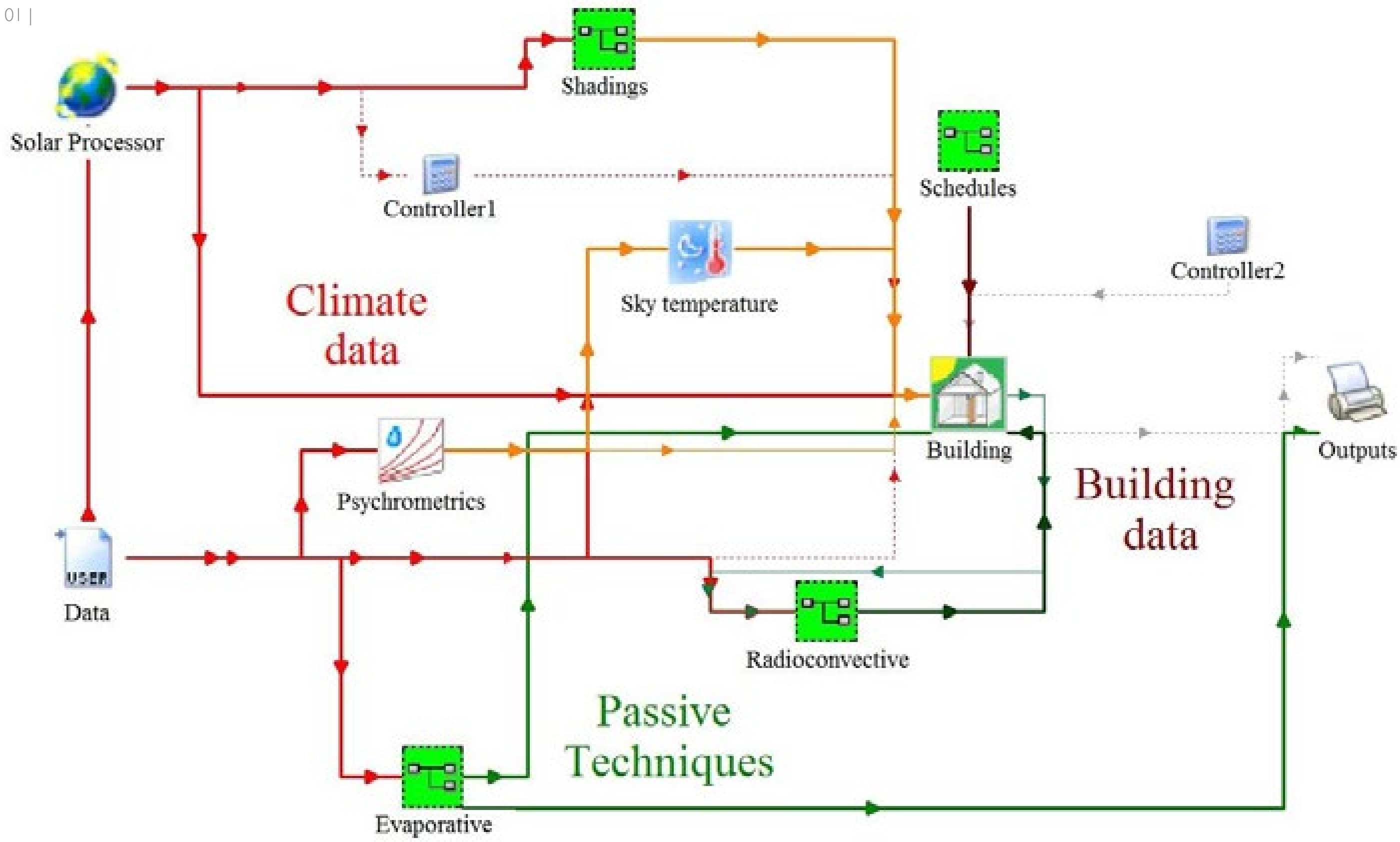

01 | Structure of the building TRNSYS project

cal variables determine the renewable potentials and the best combination of passive and active techniques to be implemented (Givoni, 1994).

The second issue to consider is the definition of the building characteristics considering the building stock, building envelopes, operational conditions, air movements and mandatory regulations. These factors have been used to create a complex selection matrix that feeds the simulation models (Soutullo et al., 2017_2).

Finally, it is necessary to define the main characteristics of the energy systems (generation plants and energy distributed systems) to create an optimal configuration that supplies the urban energy demands (Buonomano et al., 2012). Building loads, climatic conditions, efficiency curves, regulatory and space restrictions have been used to feed the energy models.

Building models

Dynamic simulation tools have been used to analyze the hygro-thermal and mechanical behavior of buildings (Fig. 1). All the aspects considered by the selection matrix have been taken into account to create a simulation matrix that represents new and existing buildings.

New models have been developed to quantify the energy performance of some specific techniques that are not considered in the basic building models (Jiménez and Madsen, 2008). Techniques such as solar chimneys (Martí and Heras, 2007), wind towers (Soutullo et al., 2012), ventilated façades (Giancola et al., 2012), glazed galleries (Suárez et al., 2011) or radiant panels (Ferrer et al., 2015) have been implemented into the global model. The coupling between new models and basic building models improves the accuracy and quality of the final results.

Air renovations from outside through windows, doors, air ducts...can lead to increase the thermal loads in buildings, so it is very important to minimize air infiltrations (Enríquez et al., 2010) and optimize natural and mechanical ventilation (Enríquez et al., 2015).

Finally, the user behavior has a great influence on the energy performance of the building. Factors such as occupancy (Díaz et al., 2017), internal gains or set point temperatures are important issues to obtain an accuracy building model. The use of real data to evaluate the building performance minimizes the error obtained in the results.

Energy system models Dynamic simulation programs have been selected to model the global performance of energy systems (Fig. 2). The main objective is to optimize different scenarios to supply the urban energy demands and maximize the renewable contribution. These models consider the generation and distribution of energy and the energy exchanges produced during the system operation.

Two configurations have been considered: building and district levels. The building level has been developed to supply the energy demand of a single building. These models are composed by power generation elements (heat, cold and electricity), storage elements and energy distribution elements to the end user (Soutullo et al., 2011_1). The district level has been developed through distributed polygeneration systems (Bujedo et al., 2017). These models are composed by different subsystems: biomass boilers, photovoltaic panels, solar collectors, wind turbines, cogeneration systems, absorption chillers, conventional systems and storage elements. All these subsystems are connected in different closed loops, which represent specific circuits of the whole system (Soutullo et al., 2016_1).

The correct system operation is regulated by pumps, valves and controllers. Real characteristics and performance curves for each subsystem, building energy profiles, space restrictions and mandatory regulations have been used as input values into the simulation models. Climatic data has been used to determine the renewable potential and boundary conditions. The use of real databases minimizes the final deviation from the real situation.

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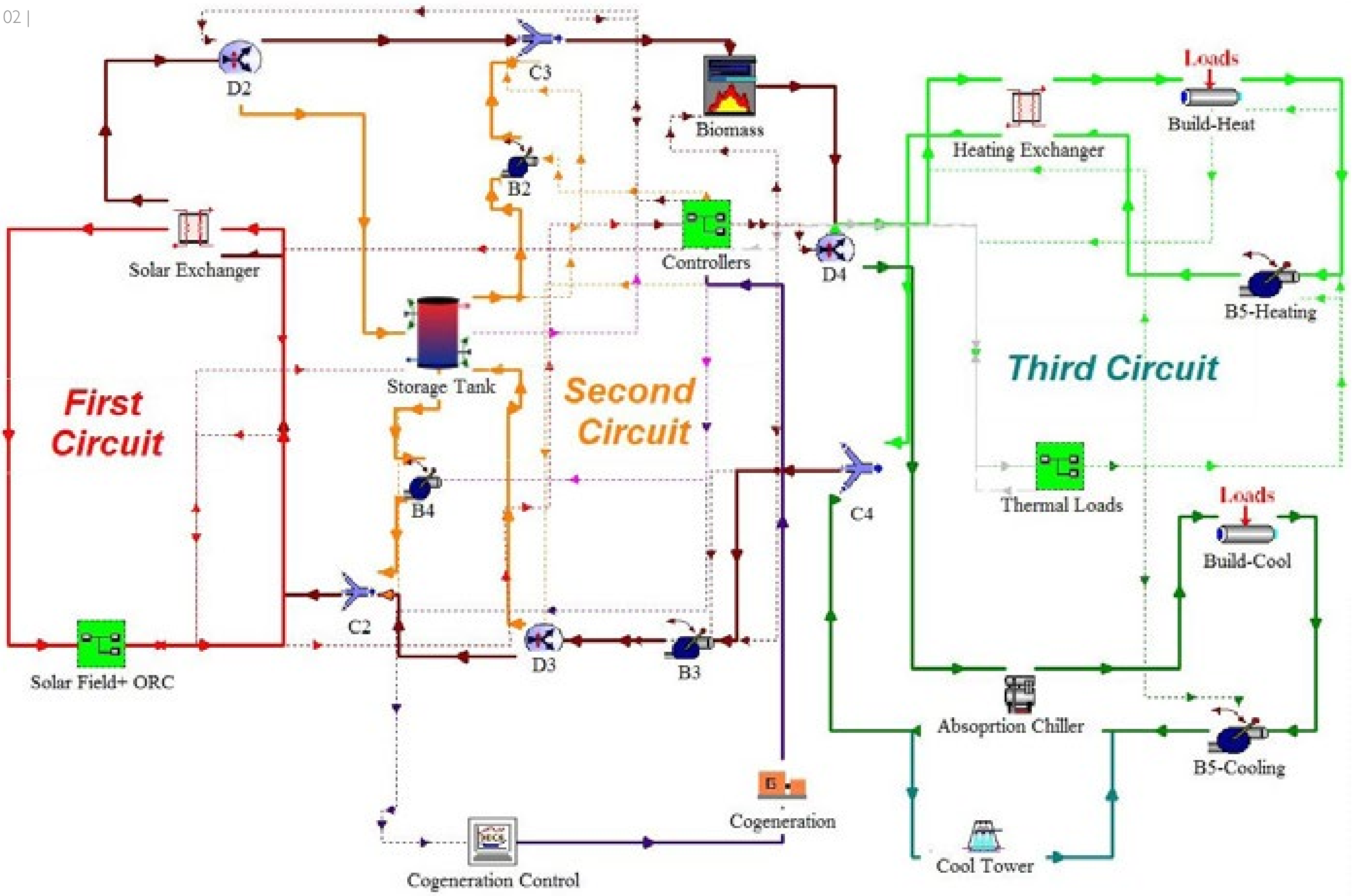

02 | Thermal poligeneration plant for a district area modelled in TRNSYS

Initially, renewable systems are used to supply the thermal and electrical loads of the building stock. There are many possibilities to incorporate these energy systems into the urban patters. The first possibility is the integration into the structure of the buildings. Solar thermal collectors or photovoltaic panels can be integrated into the walls, roofs or shading devices, reaching high levels of renewable fractions (Díaz et al., 2015, Soutullo et al., 2010). Wind small turbines can be integrated in the building structure too, but there are many structural and technical problems that should be solved. The analysis of the solar and wind potential as well as the restrictions of the available area determines whether it is necessary to use other renewable systems such as biomass boilers (García Fernandez et al., 2012). The second possibility consists of designing generation plants according to the space restrictions, distances of pipes, energy losses and mandatory regulations.
If is not possible to supply the energy consumption by renewable systems, conventional systems should be installed.
A local distribution has been included to minimize the losses produced by the distance between the generation plant and the consumption points.

Energy assessments Global models of urban areas allow analyzing its energy performance considering constructive considerations, passive and active strategies, power generation systems, storage elements and distributed energy systems.
These global models have been used to evaluate the energy performance of different urban areas. Firstly building models have been introduced into the simulation tools to evaluate its energy needs. Secondly all the refurbishment measures proposed have been evaluated through simulation batteries, obtaining the energy fluctuations produced by the perturbations of the basic model (Soutullo et al., 2018). Finally the power generation systems are coupled to the building loads to supply the energy demands. The dimensions of these systems are optimized in terms of the objectives set at the beginning of the simulation process. The final results are the energy demands and the coverage achieved by the renewable systems (Bujedo et al., 2017, Soutullo et al., 2016_1).
To quantify the energy performance to variations of the selected variables, sensitivity analyzes have been done (Lomas and Eppel, 1992). Parametric runs have been executed varying only one of these values while the rest remain constant. The final objectives set the outputs of the simulations, which are defined as cost functions of the parametric runs.
An optimization process has been done to improve the efficiency of the urban system. This process has been carried out by batteries of simulations to quantify the model response to fluctuations of the selected variables. This phase extents until the optimal solution is obtained. This solution combines all the initial requirements of the project at a reasonable cost and with the minimum greenhouse gases emissions. Depending on the computational capacity, the variables available and the level of difficulty expected, uni-objective or multi-objective assessments have been done.
The improvements of the building performance and the renewable potential have been quantified in different Spanish cities applying this modular methodology. The PRENDE project (www.tucasaesmas.com) quantified the influence of constructive parameters of the residential building stock of Madrid. This project considered the climatic conditions and the economic cost of the refurbishment measures proposed through a citizen-oriented platform (Soutullo et al., 2018). The PSE-ARFRISOL project (www.arfrisol.es) modeled and monitored 5 buildings in Spain constructed with bioclimatic criterions and renewable energies. The DEPOLIGEN project quantified theoretically the renewable potential achieved by a poligeneration plant placed in different Spanish cities. These plants were designed with the combination of renewable energies, electrical and thermal storages and cogeneration systems (Soutullo et al., 2016_1).
Experimental data are needed to validate and calibrate the simulation models of urban areas (Enríquez et al. 2017, Soutullo et al., 2011_2). This procedure allows minimizing the differences between the theoretical and real energy profiles, and enables to predict the future behavior of urban areas with more accuracy.
Finally, it is important to design efficient cities with high level of comfort sensations, which includes air quality (Sánchez et al. 2015), illumination, noise and thermal comfort (Giancola et al., 2014). Thermal comfort has been quantified through hourly profiles of the thermal sensation in the studied areas. Two different scenarios have been studied: outdoors and indoors. Dynamic models have been developed to analyze outdoor comfort levels to increase the sustainability of the zone (Soutullo et al., 2011_3) and minimize the pollutants emissions (Santiago et al., 2017). Indoor comfort assessments have been carried out through experimental campaigns to quantify the energy savings achieved by the implementation of efficient measures in buildings (Soutullo et al., 2016_2).

Conclusions A modular methodology to evaluate the energy performance of urban areas has been developed. This procedure has considered different aspects of districts such as climate, building stock, architectonical designs, envelopes, thermal and electrical generation systems, storage elements and distributed systems. Renewable energies have been used to supply the energy demands individually in the building or through a polygeneration network for a district.

Real information about buildings and energy systems are used as inputs of a complex matrix that characterize the global performance of the urban area. This matrix is modeled in a flexible simulation environment to evaluate energy balances and patterns, comfort sensations, energy quantification to external variations and energy optimization of the system. The use of real data reduces the final deviation from the real situation.

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Juan Antonio de Isabel García
CEO GEOTER - GEOTHERMAL ENERGY S.L., Madrid, España
juan.isabel@geoter.es

The development of theoretical tools to characterize the energy performance of an urban area represents an important issue to optimize its energy consumption and minimize its pollutants emissions. The modular methodology created by CIEMAT supposes another step in the energy quantification of cities. The application of this methodology facilitates the global optimization of the urban systems with different configurations, so I think that this research work it is of great interest.

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Linking future energy systems with heritage requalification in Smart Cities. On-going research and experimentation in the city of Trento (IT)

Maria Beatrice Andreucci, Department of Planning, Design, Technology of Architecture,
Sapienza University of Rome, Italy
mbeatrice.andreucci@uniroma1.it

Abstract. Future Energy Systems in midsized Italian Smart Cities are highly dependent upon the pursuit of a smarter grid based on active end-user engagement, the use of distributed energy resources and real-time demand response. In Trento, due to its climatic conditions, the issue of smart energy systems is particularly relevant and its future smart electric grid is expected to produce energy efficiency improvements to the city's historic municipal buildings, as well as to private residences and businesses. With the contribution of Trento's Smart City Municipal Office, latest evidence of current approach to urban smart energy systems is presented, highlighting strategies and innovative solutions, benefitting the whole community within the framework of the broader European goals for sustainability.

Keywords: Trento Smart City, Smart Energy Systems, Smart grid, Heritage requalification, Citizen science

Introduction

Cities are the fastest growing form of settlement worldwide, requiring sustainable energy systems to deal with their increasing density and size. Urban centres are responsible for 67% of the global energy demand and consume 40% of world's energy overall, contributing to climate change being responsible for 70% of global greenhouse gas emissions (UN, 2008).

A large part of the urban population live in small or medium-sized cities[1] which play a role in the well-being and livelihood not only of their own inhabitants, but also of the rural populations surrounding them. They are centres for public and private services, as well as for local and regional knowledge production, innovation and infrastructure.

Small and medium-sized cities often play a pivotal role within regional economies. They constitute the building blocks of urban regions and lend character and distinctiveness to their regional landscapes (Knox et al., 2009). It has been argued that their growth and development structure in Western Europe constitutes the most balanced urban system in the world (ESPON, 2006). The generic features of small and medium-sized cities - particularly their human scale, liveability, the convivial-ity of their neighbourhoods, and their local, cultural and historical characters - in many ways constitute an ideal of sustainable urbanism (Farr, 2008). Small and medium-sized cities are, therefore, essential for restricting rural out-migration, and are indispensable for strengthening territorial cohesion and achieving balanced regional development.

Trento Smart Energy City

The Smart City as a concept, ambitions, deployed technologies and programmes rapidly gained traction in Trento from the late 2000s onwards and on the basis of the Smart City Index[2] (EY, 2016) the city is currently considered at the forefront of energy efficiency. Trento has been selected in 2014 as an IEEE Core Smart City[3] in consideration to its specific research and experimentation focusing on six significant areas: Big Data/Open Data, Fostering Smart Mobility for Mid-sized Cities, Innovative Tourism Services, Smart Citizens for Healthy Cities, Energy Systems, and e-Government. Pursuing Big Data and Open Data, Trento is integrating and unifying a formerly fragmented administrative IT structure. The city is also restructuring its internal processes to empower an open data culture and move from an internal to a shared data management approach, even extending across its province. University and research institutions are delivering common initiatives to improve economic operators' and citizens' awareness about key issues (Molinari et al., 2015).

Trento's efforts at Fostering Smart Mobility for Mid-sized Cities aim at providing citizens and visitors with improved, real-time information on public transportation, traffic, multi-modal transportation services and infrastructure that supports both solutions and application development for citizen services (Bedini et al., 2015). In developing Innovative Tourism Services, Trento seeks to optimize the "guest experience" by integrating information and services for an end-to-end tourism ecosystem[4] (Lorenzi et al., 2015). The concept of Smart Citizens for Healthy Cities takes "health" beyond mere physical wellbeing to encompass social, economic and informational opportunities. Trento, as other cities in Europe, faces the challenge of an aging population and a digital divide that can leave the segments of society with unequal opportunities in these areas (Nollo et al., 2015).

Effective future Energy Systems in Trento Smart City will depend on the engagement of energy end-users and the pursuit of energy efficiency, distributed energy resources and real-time demand response (Andreottola et al., 2014). E-Government will focus on producing a knowledgeable citizen with access to municipal, citizen-generated data and a 'one-stop shop' way to access it via a simple, trusted, complete, connected and open system (Fioroni et al., 2015).

Given the Alpine climate of Trento, the issue of smart energy systems is particularly relevant, especially as far as the building energy efficiency is concerned. The Municipality of Trento joined the Covenant of Mayors for energy efficiency (EUSEW, 2008) in 2014 by activating procedures to involve the citizenry in the development and implementation of a sustainable energy action plan, which consists of two parts. The Baseline Emission Inventory (BEI) provides information on current and future CO_2 emissions, quantifies the amount of CO_2 to be reduced and identifies the critical issues and opportunities for sustainable energy development of the municipality, along with the potentials of renewable energy resources. The Sustainable Energy Action Plan[5] (SEAP) has identified the actions to be pursued in order to achieve the CO_2 reduction defined in the BEI. Key strategies, as identified by the SEAP

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01 | "Le Albere" green neighborhood (RPBW, 2002-2016), 11 hectares urban expansion in a former Michelin factory site in south-west Trento. Image credits: M. B. Andreucci

of Trento, include: the compulsory energy certification of Municipality buildings, especially kindergartens and schools; pilot actions in significant sectors, for the identification of the best operational methods in large buildings with centralized HVAC systems; the construction of new city infrastructures and the retrofit of old ones, e.g., street lighting systems to reduce light pollution and consumption and to improve safety and quality of life; and regulatory actions, such as the definition of building regulations.

Linking future energy systems with heritage requalification

The heritage of public properties of the Province of Trento is complex: 700 buildings (9,539 dwellings) are owned by the social housing company, while 166 buildings constitute the public building stock (Berlanda & Verones, 2017), including a relevant number of institutional structures dedicated to education and sports facilities. An Energy Manager currently handles the energy dissipation of those structures, with 70% of social housing buildings, and 60% of public building stock registering consumption higher than 120 kWh/m^2y and 45 kWh/m^3y, respectively (Berlanda & Verones, 2017). Substantial energy savings have been target-

ed - 60% for the social housing and 40% for the public buildings, respectively - with the planning of several building requalification projects (light and deep retrofit) and a preliminarily estimated investment budget of 150 ml euro (Berlanda & Verones, 2017).
Other important actions are progressing under the City Council for Energy Efficiency and Smart Building. A certified information database (the registry of the municipal property) has been created from the aggregation of several existing databases held by different subjects. Various initiatives to train municipal employees and to promote good practices and guidelines for sustainability are also on-going.
Regarding the development of simulation tools, Trento has been involved in two European projects - i-SCOPE and SUNSHINE - and specific models for its territory have been tested with informative results on the basis of the already mentioned relevant real estate and energy consumption data of public buildings managed by the Municipality.

From planning to delivery STARDUST- Holistic and integrated urban model for Trento Smart City

STARDUST is a project funded under the European Union's Horizon 2020 Smart Cities and Communities lighthouse programme. Trento's STARDUST project has been selected by the European Commission among 17 candidates, and funded with a budget of 21 million euros. Together with Pamplona (Spain) and Tampere (Finland), Trento became in October 2017 a lighthouse city designated to develop innovative urban solutions, deploy smart integration measures, test and validate technical solutions and innovative business models. Specifically, the project for Trento involves 3 ITC cross bound action fields: energy transition in the southern urban district with the renovation of 3 of the 14 tower buildings; installation of e-mobility infrastructure (E-VANS and V2G) in the northern logistic district and a car sharing hub (E-Vehicles) in the city center; and citizens' participation related to engaging the population in a structured and constructive dialog by creating a Local Deployment Desk able to involve relevant stakeholders and increase acceptance and consensus.

02 |

02 | The Gold LEED certified Sciences Museum "MuSe" (RPBW, 2002-2013) is located in the post-industrial brownfield of "Le Albere", thus reinforcing the cultural identity of this area of Trento. Image credits: Hufton+Crow

03 |

03 | "Palazzo Geremia" (XV) Trento Municipality's iconic heritage building, restored in 1993. Image credits: M. B. Andreucci

The STARDUST project is expected to provide Trento's stakeholders with useful insights supporting the smart integration of "appropriate" technologies with accompanying education and other holistic measures, able to generate desired socio-economic progress through innovative citizens and community engaging platforms, promoting healthy urban relationships and welfare in the highly competitive economy of the Trentino region.

NOTES

[1] Urban areas in OECD countries are classified as: large metropolitan areas if they have a population of 1.5 million or more; metropolitan areas if their population is between 500,000 and 1.5 million; medium-size urban areas if their population is between 200,000 and 500,000; and, small urban areas if their population is between 50,000 and 200,000 (OECD, 2012; 2016).

[2] EY has been systematically monitoring the ICT diffusion through the Smart City Index, ranking 116 Italian primary municipalities with respect to several thematic areas, from broadband infrastructure to digital services (mobility, education, healthcare, etc.), and 470 indicators of urban sustainable development.

[3] The Institute of Electrical and Electronics Engineers IEEE Core Smart Cities program recognizes and helps cities that are establishing and investing both human and financial capital into smart city plans. Core Smart Cities were chosen through a process assessing criteria including focus, commitment, diversity, roadmap, presence of a strong IEEE Chapter/Section and of a diverse and committed team of partners from the local municipality, to universities, and industries. The selection process also took into account geographic diversity. Acceptance into the initiative required an articulated, pragmatic plan for how the city can become smarter in how it is run, with the goal of improving its citizens' quality of life. Selected cities receive investment in funding and strategic and practical expert advice to help conduct activities and further the wellbeing of their citizens in a sustainable environment. Current IEEE Core Smart Cities include Casablanca, Morocco; Guadalajara, Mexico; Kansas City, Missouri, USA; Trento, Italy; and Wuxi, China).

[4] Complete system models that can relate drivers of change, such as climate change, to effects on ecosystem structure and functions (Fulton, 2010).

[5] The SEAP relies on a Counsellor for Mobility (political reference), an Environmental Service Manager, an Integrated Solid Waste Project Manager, an Energy Manager, an Enterprise and Citizens Desk Manager, a Planning and Urban Mobility Manager and an Officer for Research and Statistics.

ACKNOWLEDMENTS OF VALUE

Giacomo Fioroni

Head of Smart Cities Office, Municipality of Trento

Trento fares well in terms of implementing smart city solutions especially in the areas of energy, e-government and mobility. However, prominent among the most difficult challenges faced by the smart city officers is the integration of critical areas of the smart city instead of dealing with them as watertight compartments; the new strategy for Trento Smart City foresees precisely this. This is technically complex and burdensome from an economic point of view: we have to set up the so-called "Smart City operating system", thus laying the foundations for innovative services starting from: an IoT Platform - to systematically collect RT data placed on different physical infrastructures by means of different technological solutions; a Data Platform - to manage, store, analyse and distribute the data gathered from sensors, bringing them together with data owned by the PA and with those collected through crowdsourcing and crowdsensing; interoperability and Integration mechanisms - to guarantee collection of and access to data regardless of the technology used to gather them; dashboard visualization and analytics mechanisms - to visualize data in a format that is understandable and to analyse the different data collected because, in the end, every good decision must be well informed. Trento is a medium-sized city and cannot exploit national PON-Metro fund, specifically thought for metropolitan cities like Milan, Rome and Florence. Consequently, we have to be creative and take advantage of what our area offers, leveraging on: enabling platforms set up by our Province (e.g. open data platform), developing a strong partnership with Bruno Kessler Foundation and the EU projects in which we are official partner. Regarding BKF, in 2015 we signed a memorandum of understanding with the aim of implementing Smart Cities and Communities initiatives. Since then, we have realized many smart projects and we have just started a Smart City Lab focused on one specific neighbourhood ('Vela') in Trento with the aim to implement a first part of the infrastructure mentioned before and to test innovative solutions and services. On the other hand, we are also using the precious funds from EU projects to set up some of the infrastructure needed. Specifically, we are currently involved in four H2020 projects focusing on Social innovation (WeLive), digital services (Simpatico), Big Data for mobility (QROWD) and Smart Cities & Communities (Stardust). The journey is long and is certainly not an easy one, but we are moving in the right direction in accordance with the role conferred on us by IEEE in 2014, being regarded as of one of the 10 top smart cities in the world. Certainly, it is our desire to continue to deserve this award.

04 |

04 | Trento Open City Platform. It allows for the construction of a federated national platform for service and data sharing among public administrations for the benefit of citizens and businesses. Image credits: Alex Tomasi

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Smart Urban Districts: Dynamic Energy Systems for synergic interactions between Building and City

Fabrizio Tucci, Department Planning, Design, Technology of Architecture, Sapienza Università di Roma, Itay fabrizio.tucci@uniroma1.it
Daniele Santucci, Chair of Building Technology and Climate Responsive Design, Technische Universität München, Germany daniele.santucci@tum.de
Elisabeth Endres, IB Hausladen Engineering Firm, Kircheim-München, Germany elisabeth.endres@ibhausladen.de
Gerhard Hausladen, Emeritus, Technische Universität München, Germany gerhard.hausladen@ibhausladen.de

Abstract. The primary purpose of this paper is to illustrate the process of experimental research regarding the smart and synergic urban districts/smart and dynamic energy systems relationship, conducted by the authors as part of their activities at Technische Universität München and carried out until realization on both an urban and an architectural scale. The research and applicative experimentation regarded seven German urban situations on the conforming dimension of the "smart district" (between 15,000 and 20,000 inhabitants): the urban communities of Feldkirchen, Aschheim, and Kirchheim, the historical centres of the cities of Iphofen and Taufkirchen, the municipality of Ismaning, and the Wüstenahorn neighbourhood in Coburg. The various urban communities that were the object of research signed an agreement with the Technical University of Munich as part of the German national line of research called "Energienutzungsplan" - "Energy Use Plan" - supported by the Ministry of the Environment of Bavaria, for which the authors were awarded grants and served as rapporteurs.

Keywords: Smart Energy Systems, Smart Synergic Districts, Dynamic Simulation Tools, Positive Energy Architecture, Energy Integrated Storage

Introduction: overall considerations

The constantly growing threat of climate change, excessive consumption of energy with its harmful emissions, and a dearth of resources - and particularly of fossil energy resources: these are an explosive combination that make this one of the biggest issues in our time, and the most urgent problem to be coped with for our common future. It is a challenge that involves the life of every human being, that must indispensably be met through the contributions of a multitude of stakeholders: administrators, politicians, technicians, and consumers (Dohler et al., 2016).

The need to reduce energy consumption, to transfer production towards renewable sources, and to best distribute and share the fruits of this production in a manner that is smart and adaptive to the different requirements is a widespread and widely shared problem that may even be quantified in its basic approach: to be able to cover total energy needs using renewable energy sources, the reduction in overall consumption must be equal to two thirds of the current value, since the total potential that may be obtained from renewable energies equals approximately one third of the total (Hausladen, Liedl, Saldanha, 2015).

However, this is but one aspect of the problem. It is well known, and also quantified, that the activity of building generates a consumption of resources that is increasing exponentially due to demographic growth and the planet's development. To deal with this phenomenon, research has created instruments to assess the savings potential and to construct buildings and urban settlements with an energy requirement that is minimum or even negative - which is to say capable of reversing their course and transforming them from energy *demanders* into energy *producers* not only for themselves, but also to obtain a surplus to be distributed to those who need it. This practice is now being trialled on a worldwide scale, and there are currently many examples bearing witness to the possibility of constructing buildings that produce more energy than they consume (Campbell, 2012). But almost all the best and most virtuous architectures produced from this perspective have been "prototypes", experimentations of "models", "race cars" of a sort, on which to explore possibilities and test cutting-edge systems and technologies through which to acquire knowledge to be transferred in the current practice of designing and building.

What is new is that today, thanks to the numerous experiments and the many prototypes anticipating present and future potentials, we now have all the technologies to construct buildings with a minimum energy requirement, and with no excessive additional costs. And the most important thing is that these examples highlight a new degree of complexity for the system: a vision must be built that considers not only the building in the context of the city and in the relationships, it imposes, but *the city as a whole* and *the network of relationships between its parts* (including buildings) as the linchpin of the question to be dealt with and resolved (Herzog, Steckeweh, 2010).

From the strict standpoint of energy and thermodynamics, the city offers a vast range of systems with different temperature levels, and structures with alternating needs and load curves - elements that can and must be placed in relation to one another. Simultaneity of demand may be reconsidered by assessing the availability of thermal energy derived from systems that can be integrated with one another due to non-coinciding temperatures and load curves, and by deferring the need. These aspects make it possible to create - if one so wishes - exceptional synergistic effects within the network of buildings and between the parts of the city with different functional profiles and use intervals. Energy may be taken into consideration as a function of the "value" it takes on, in relation to the systems and to the necessary operating temperatures.

To summarize, it is not a matter, then, of a challenge linked to technology and to systems, but one linked to the creation of a strategic path in which the process we have thus far applied must be inverted: until today, we have calibrated production to the energy requirements imposed by the buildings' construction characteristics and their functional profiles. In the future, however, we should calibrate requirements to production capacity and to its availability over time to the entire scale of the city understood as a "smart environment" (Pedersen Zari, Jenkin, 2012).

In the setting in which we are called upon to intervene, architects and in particular technologists have an essential task and a strategic role, since through design they generate not just an idea, but a full-blown *vision* that is realized in the project intervention, and that must take a multitude of aspects into account, from design to urban planning, from costs to environmental issues, from beauty

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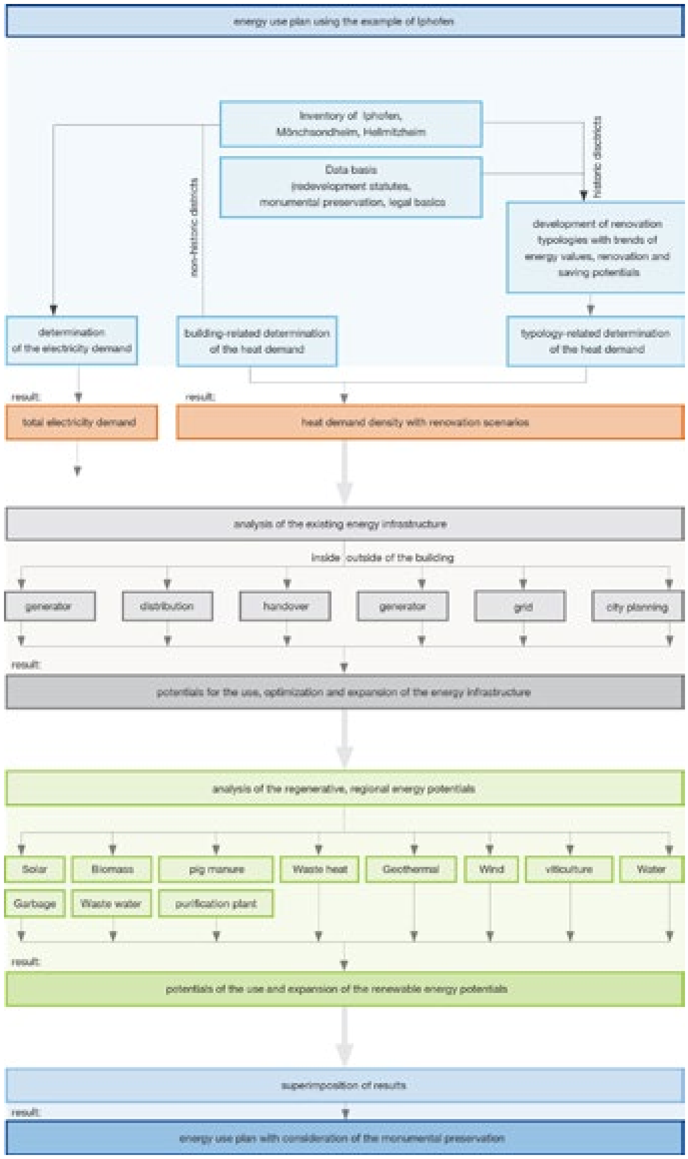

to the demands imposed by the social sciences, and from exploiting natural capital to making the most of cultural, social, and technological capital (Hausladen, Tucci, 2017).

Methodological approach: the first trials of synergic interactions between Building and City

It has by now been made absolutely clear that the aspect that most influences sustainability in the design definition phase is that of assessing the impact and the effects of the intervention on the entire built environment. It is necessary to reconsider the possibility of taking action on the existing stock, with programming to regard intervention on an urban scale rather than the construction of new buildings. If the latter can easily achieve the objective of zero emissions and zero energy balance, the existing stock, on the other hand, represents the nucleus upon which to take action in order to drastically reduce energy current consumption while at the same time improving its ecological and environmental performance (Tucci, 2011).
An important recent conquest, a decisive factor for building an effective intervention vision for the existing consolidated or even historical building stock, is the acquisition of the technological/design knowledge accompanying the awareness that interventions to reduce the energy requirement may exclude invasive measures on the envelope, if interventions on the forms of energy provision and on the usable air conditioning systems are planned. Moreover, the position of the existing buildings integrated into the urban context makes them well connected to the functions of supporting the activities and the existing networks. These elements are essential in a sustainable strategy, both to limit private transport and incentivize the use of public transport, and to maximize the efficiency and performance of existing infrastructure networks - thus making it possible at the same time to effect serious efficiency operations while safeguarding the prospect that the building stock that is not ancient or under protection might in many cases still be considered as bearing testimony to an era (Battisti et al., 2015).
The following examples demonstrate that this vision, and its methodology built over the years by the research group, can be applied to urban settings, including those quite different from one another.
First, there are two cases of intervention in the early 2000s on building aggregates of such a size as to be held significant, in terms of impacts, on the scale of the urban district; these cases, on which the authors worked in experimental fashion, were the basis for the development of the subsequent *smart and green city* experiences[1].
The seat of the urban complex of the Episcopal Curia (Ordinariat) of Munich - a large historical building complex in which it was necessary to conserve architectural characteristics while reducing to a minimum the interventions to the exterior envelopes and to the interior floors and ceilings - required design choices differing greatly from requalification operations, including those of energy/environmental upgrade, as usually adopted to that time. The doors and windows were replaced and since intervening on the horizontal surfaces was not possible, the choice was made to activate the walls with a radiant heat system inserted between the plaster and the heat insulation. The energy supply is guaranteed by the return circuit of the city's district heating, which makes it possible to use temperatures lower than those needed for the previously installed system of radiators, thereby raising the degree of effectiveness of the district heating itself.
The strategy for the energetical refurbishment of the German Academy in Rome "Villa Massimo"[2] bases on the intention to create a zero-energy balance of the whole property by applying technological solutions excluding invasive interventions on the fabric. The German Academy in Rome is the first property that is selected to demonstrate technical innovation combined with the research and development on integrated design applied to an existing extra-

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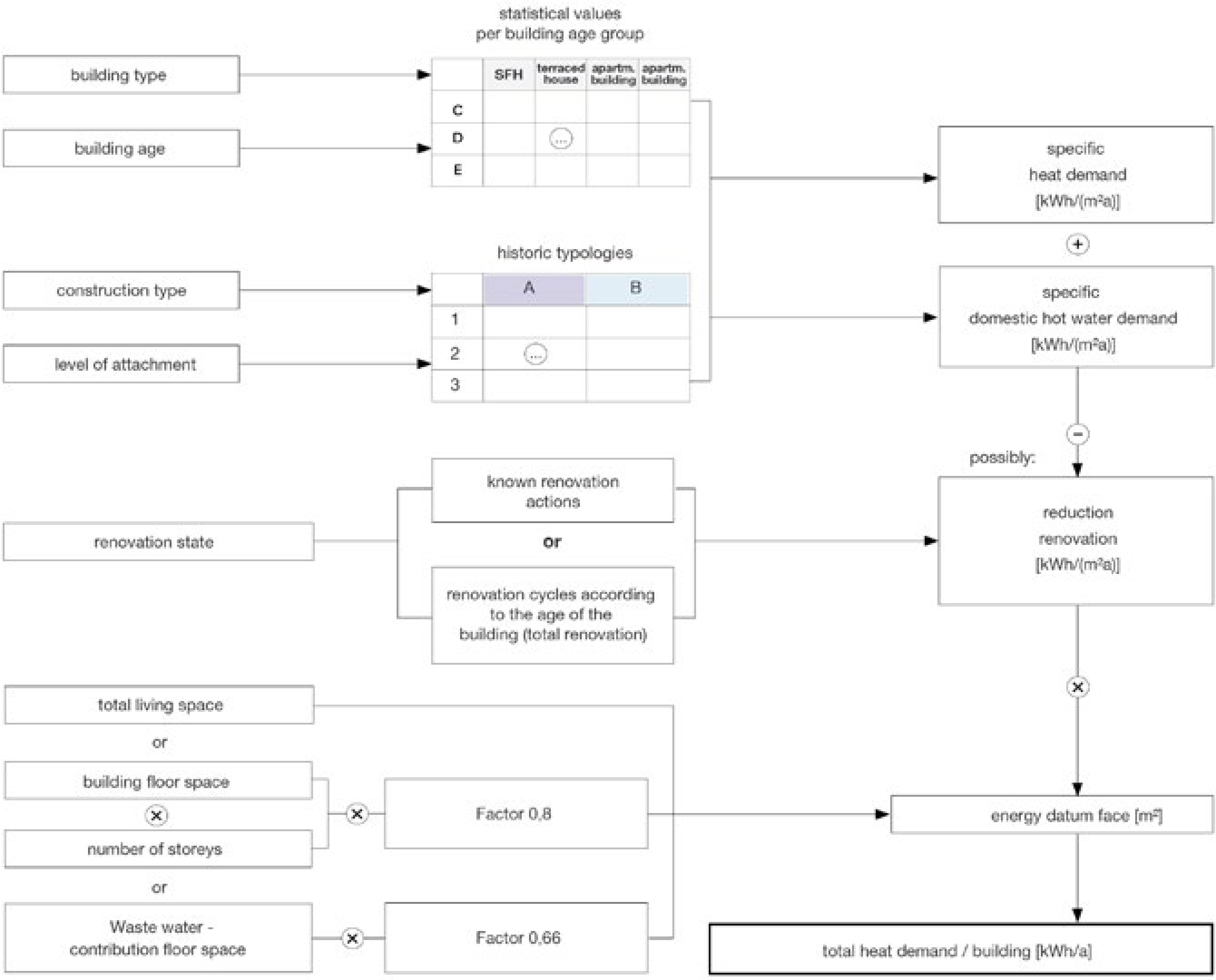
02 | Steps of the stock and potential analysis of historical districts

territorial property of the Federal Republic of Germany. Through the development of the design and through the implementation of interventions on the building stock, the complex should become a positive example of the use of innovative technologies and its integration in a complex of great historical value.
The overall target of the initiative is the formulation of a strategy to reduce the energy consumption, to implement renewables and to evaluate synergetic effects in a listed historic building complex without interfering with the architectural quality. The choice to examine the property of the German Academy in Rome, was originated on the one hand by the request to act on a building of particular historical value, on the other to interact with the warm climate also in relation to the use of solar energy. The property has the potential to explore the combination of load curves from different usage increasing comfort by reducing the current consumption and costs. The aspects of conservation and reconstruction of the architectural significance generally drive refurbishments of historic and heritage buildings, without enough attention to energetical aspects. Historical and monumental buildings present a series of architectural characteristics, which define identity of urban environments. For this reason, the proposed strategy bases on reducing the primary energy demand of the property through technologies that avoid invasive interventions on the built environment.
The use of renewable energy determines the need to constantly define the criteria and the way of interaction with the building. The design of increasingly sophisticated systems to produce clean energy must have as its primary objective the maximum integration with the architecture.

In this sense, the key aspect for the definition of the energy supply system is the determination of potentials deriving from renewable resources and their availability, considering the context and the existing infrastructure. Another aspect to be taken into consideration is the temporal availability of production and therefore the simultaneity of production and consumption. In the design phase, needs and the load profiles should be therefore identified and classified, comparing them to the available potential out of fluctuating renewable sources. In an optimized system the production and consumption must match and have to be put in effective relation.
Following this premise, the Villa Massimo project evaluated the possibility to achieve a substantial reduction in energy requirements by exploiting the network and the relationship with the city as a condition to prefigure new scenarios. The project's goal is to achieve an annual zero primary energy balance by experimenting innovative systems and technologies and redefining the role of the historic buildings in the context of existing structures and the local energy grid.
In the case of the complex of the German Academy in Rome the interactions and the synergetic effects between buildings are considered since there are several functions and load curves, and, consequently different technical systems. The villa, with the administrative functions has different comfort and energy requirements as the residential buildings that are used continuously. While the villa has a peak demand due to overheating in summer and significant internal loads during exhibitions and events, other buildings, which account for 75% of the total area, have a relatively low demand for cooling but have a high consumption of hot water. In this sense, the two structures are put in relation to integrate each other´s curves and demands. The project for the Villa Massimo is an example for an integral planning methodology dealing with passive and active components to deal with the historical building stock and with the transformation of built structures in the post fossil decade, without losing architectural building culture (Endres, Santucci, 2014).

Cases of study, towards the Smart Environment: seven experimentations of Smart Urban Districts

On the urban and territorial dimension, which revolves around the applicative experimentation of the Smart Cities theme, several applicative research efforts have yielded innovations in the way of organizing the design approach and of intervening in a manner fully aware of the value, in terms of culture and identity, of the settings, while at the same time highly effective in the results from the standpoint of performance.
The design of the communities of Feldkirchen, Aschheim, and Kirchheim is an initial case of what can be done on the territo-



Tab. 1: specific heating demand for residential buildings [kWh/(m²a)], according [Born et al. 2011]

building age	building year	SFH SDH	terraced house	apartm. building	apartm. building (big)	high rise
		[kWh/(m²a)]				
A	before 1918 half-timbered	183		190		
B	before 1918	181	154	144	127	
C	1919-1948	165	137	168	144	
D	1949-1957	181	157	156	143	
E	1958-1968	147	106	130	132	114
F	1969-1978	156	128	134	118	114
G	1979-1983	118	128	118	114	
H	1984-1994	133	99	123	82	
I	1995-2001	110	78	93	73	
J	ab 2002	89	87	80	51	

Tab. 2: Specific domestic hot water demand for residential buildings [kWh/(m²a)], according to [Hausladen et al., 2011]

building age	building year	SFH SDH	terraced house	apartm. building	apartm. building (big)	high rise
		[kWh/(m²a)]				
A	before 1918 half-timbered	21	18	24	27	n.a., alternatively the values for the big apartment building can be used
B	before1918	21	18	24	27	
C	1919-1948	20	20	29	33	
D	1949-1957	19	20	25	28	
E	1958-1968	18	20	20	24	
F	1969-1978	16	20	23	18	
G	1979-1983	14	16	20	18	
H	1984-1994	19	21	21	21	
I	1995-2001	19	19	21	21	
J	ab 2002	n.a., alternatively the values for building age I can be used				

03 | Determination of the heat demand of the studied historical districts

rial scale. The three communities on Munich's eastern periphery signed an agreement for the installation of deep geothermal probes. This choice makes it possible to obtain, through a centralized generation system, a considerable quantity of high-temperature thermal energy, at approximately 90°C. Following this, a study was drawn up to test its effects on the modes of energy distribution and on the possibilities that this intervention determines. The building stock was classified by age and type of systems, and use temperature of the heating systems. This zoning enables the breakdown into divisions that use high temperatures, and others that can exploit the temperature levels of the return circuit. A cascade system is thus obtained that exploits all the available thermal energy.

The project fits into the research line carried forward by the Technical University of Munich called "*Energienutzungsplan*" - the energy use plan - supported by the Ministry of the Environment of Bavaria (Bayerisches Staatsministerium für Umwelt und Gesundheit, 2011). This instrument was created to analyze the composition of the buildings in the urban centres from the standpoint of the thermal energy requirement. The analysis regards type, age, the systems installed, the quality of the envelope, and consequently the density of consumption. Subsequently, both the energy potential that can be obtained from renewable sources and the residual resources made available by industrial processes, by waste-to-energy, as well as all the distributed energy generation systems, are quantified. The results of the analysis and quantification are associated with the available resources and placed in relation to the network that integrates the components and exploits their synergistic effects. An essential element of this strategy is the analysis of and comparison between supply and demand. The term "supply" is understood as centralized energy production, rates, temporal availability, and value from the ecological standpoint. The term "demand," on the other hand, is understood as the load profile of the various forms of thermal and electric energy required. As they intersect, the two categories create an interface we might define of the management: analysis and definition of the load profile, management of peaks, and temporary energy storage.

A similar experience was dealt with in the plan for Taufkirchen, a city of 10,000 inhabitants located to the northeast of Munich. Currently, most of the buildings are heated using Diesel or gas boilers and electricity is withdrawn from the grid. The analysis measured the systems, classifying them by age and type, and by consumption density. Moreover, the surrounding territory was analyzed from the standpoint of potential energy generation, as there are numerous biogas systems connected to cogeneration plants. The contribution of energy that can be obtained from the biomass available on the territory was quantified, and placed in relation to the buildings' requirement.

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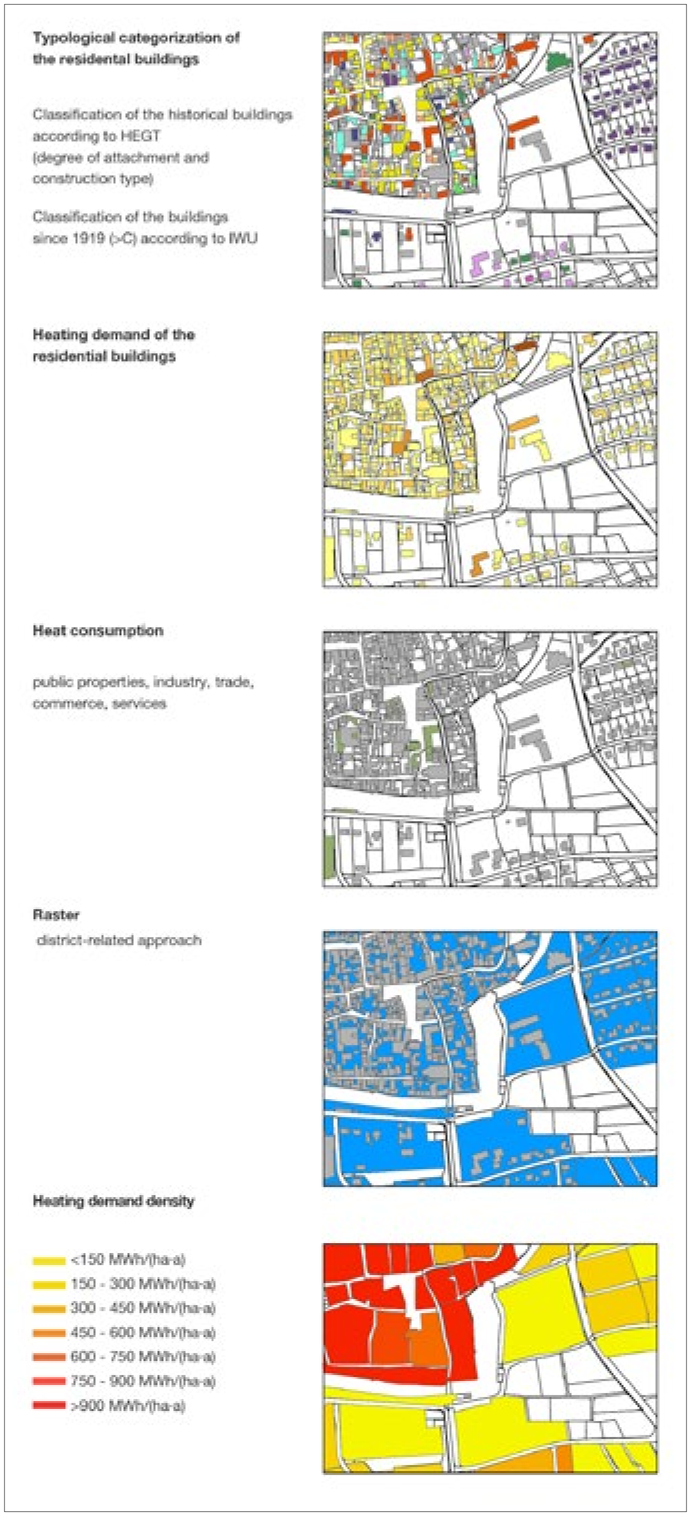
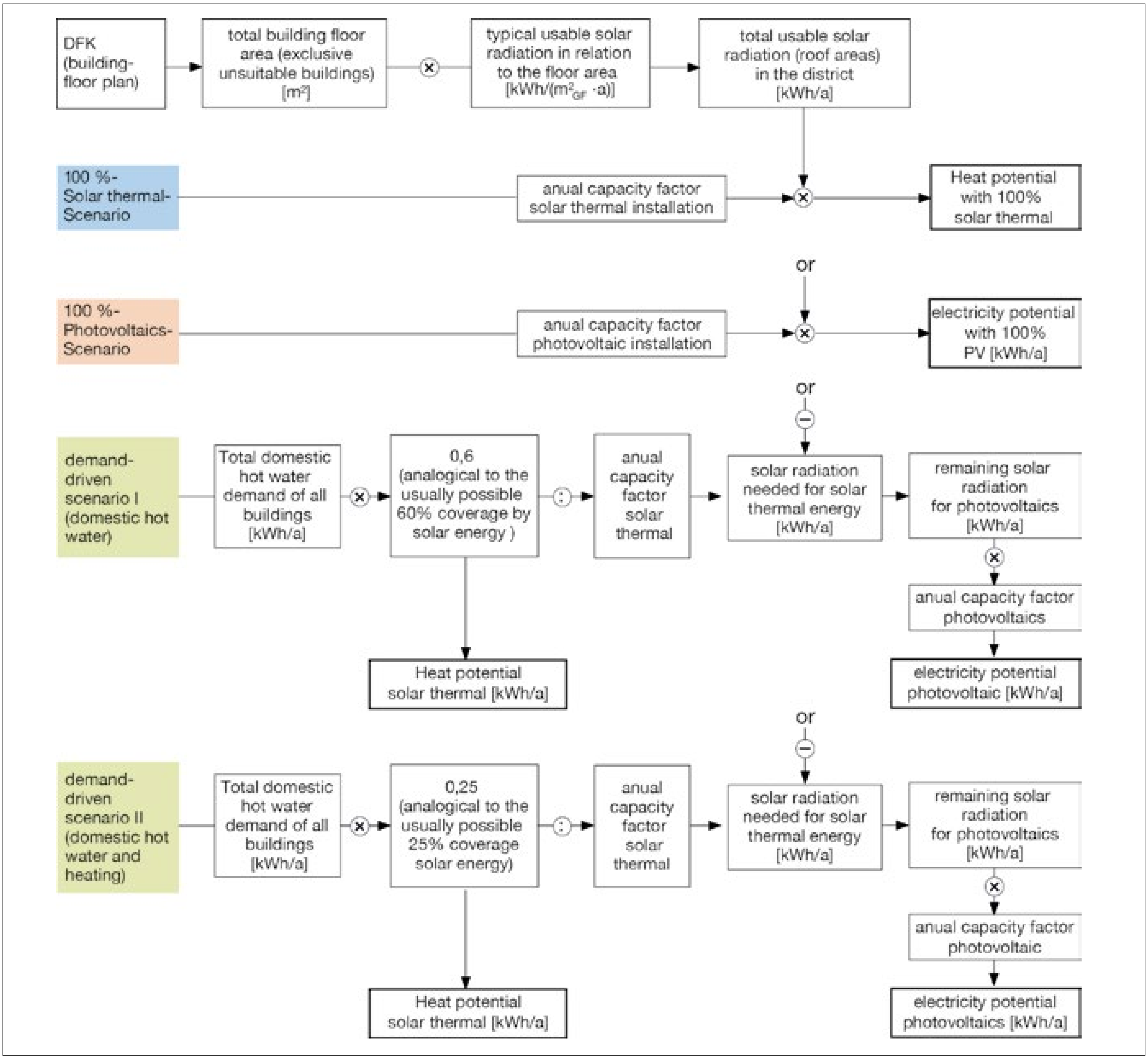


04 | Pictograms: Creation of a heating energy demand density map

05 | Renovation-matrix: construction type A, construction type B. Building Typology (Values for two- to four- story buildings)



06 | Solar potential determination

This approach made it possible to develop a project to connect the generation plants distributed in the territory, and to integrate the systems: cogeneration covers both a part of the thermal energy for heating and a significant portion of electric energy. This configuration allow new plants to be created to integrate existing production (Bayerisches Staatsministerium für Umwelt und Gesundheit, 2011).
The project to upgrade the Wüstenahorn neighbourhood in Coburg dealt with the issue of the energy upgrade of a popular building settlement from the 1950s. The neighbourhood has a very high energy consumption due to insufficient heat insulation and obsolete plant. To reduce the energy requirement, a combination of different forms of generation was provided for: geothermal probes associated with new radiant heating systems, and cogeneration systems. This choice makes it possible to produce electrical energy while at the same time obtaining two different temperature levels: high, needed to produce sanitary hot water and usable on pre-existing heating systems, and low, for radiant heating systems.
The use profiles of residential buildings are integrated into those dedicated to the commercial and tertiary sectors, creating a constant, regular energy demand. In this way, peaks in demand are eliminated, which generally do not coincide with peaks in production from renewable sources. This classification of needs makes it possible to find more effective forms of energy supply in which the availability of energy coincides over time with production. The energy requirement is covered by the photovoltaic plants located on building rooftops and on the large station roof,

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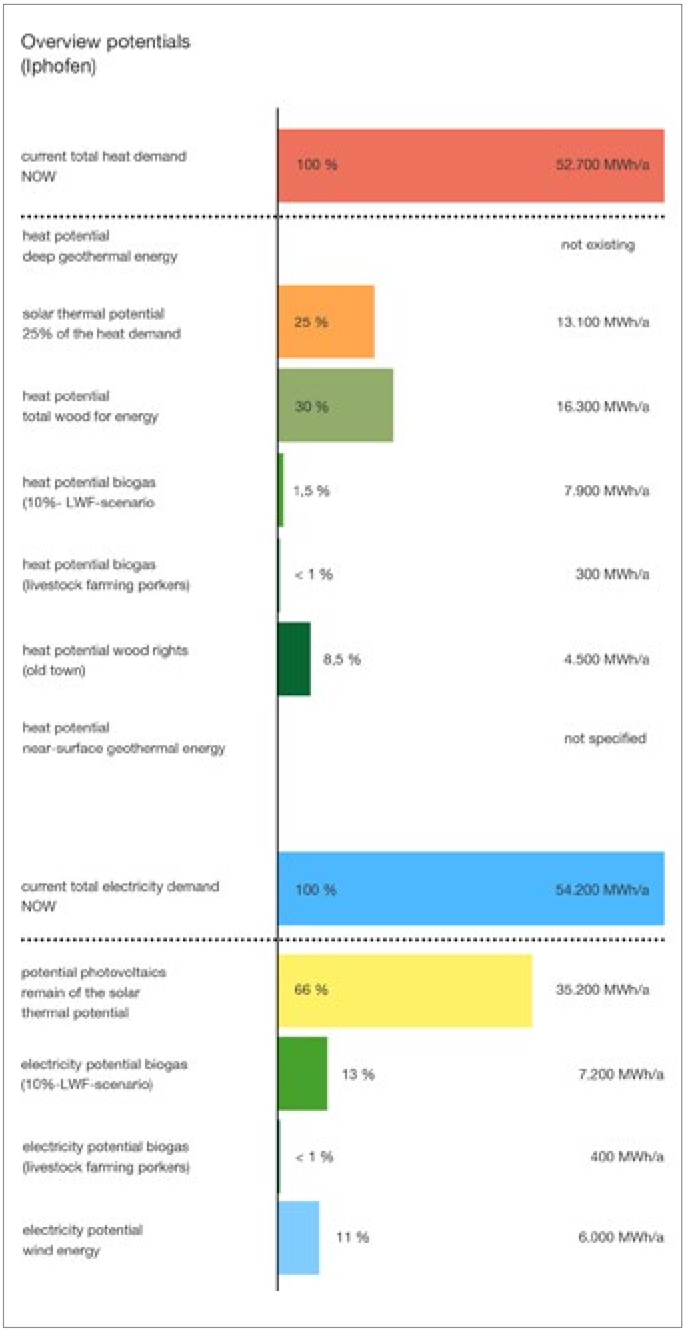


07 | Overview of the energy potentials (Iphofen)

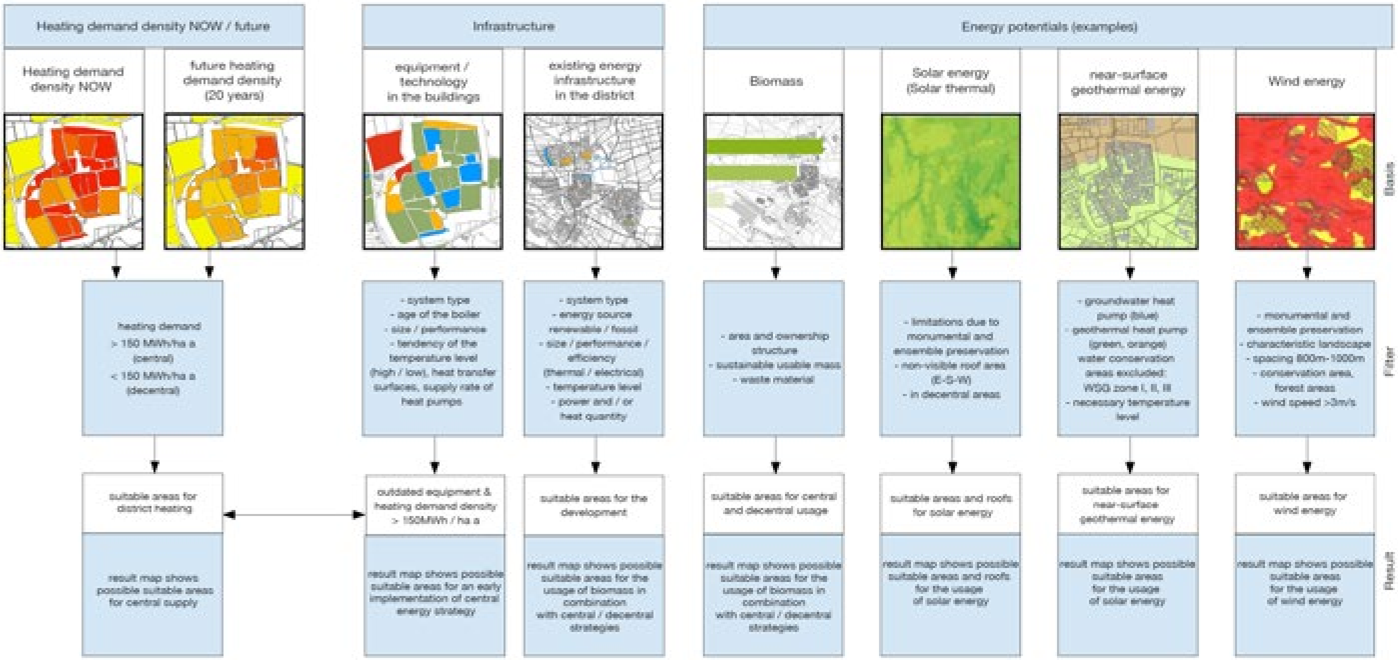
which cover the electricity requirement, assisted by cogeneration plants dedicated to producing thermal energy for heat and sanitary hot water, as well as to covering any peaks in electricity demand. The thermal energy requirement for cooling, on the other hand, is guaranteed by heat exchangers deployed in specific, known points for extremely low temperatures, even in the summer period (BSUG, 2011).

Ismaning is a municipality of 15,000 inhabitants located to the north of Munich, between the centre and the airport, for which a feasibility study was done. The study describes a highly efficient scenario for procuring and distributing energy that does not interfere with existing structures. As in prior experiences, areas with different construction types, requirements, and consumption densities were identified. In parallel, the energy potentials from renewable sources were quantified, opting in particular for photovoltaic and geothermal, and the existing infrastructure networks were surveyed. The possible interventions on existing buildings, aimed at reducing the thermal energy requirement for heating, were listed, and the industrial settlements generating residual heat were identified. The latter on the one hand yield heat that may be recovered and used to climatize other buildings, and on the other have a thermal energy requirement for cooling. This gave rise to the idea of creating a network to distribute the cold generated via the absorption systems (BSUG, 2011). The scenario planned by the study will be realized in the near future through financing by the municipality.

The same methodological approach was applied in the design for the historic centre of Iphofen (Fig. 1).

Iphofen is a city in Franconia known above all for wine production and for its beautiful and virtually intact historic centre. The buildings, the so-called *Fachwerkhäuser*, were built with characteristic wood frames, and have a very high thermal energy requirement for heating. The energy upgrade project identified the strategies to prevent invasive interventions on the ancient envelopes, also by identifying, in parallel, the alternative measures for reducing the energy requirement. Since the region has a great production of lumber, cogeneration plants were planned for the generation of thermal energy, deployed on the territory to cover - with the delivery circuit for high-temperature needs, and with the return circuit - the systems in the most recently constructed buildings. The study does not rule out the possibility of intervening on the envelopes, but guides the reduction of the city's overall need for primary energy towards forms of generation and above all of "dynamic" and "adaptive" interaction between systems at different temperatures in order to guarantee safeguarding the historic buildings (Fig. 2) (Hausladen, 2012).

Given the delicate nature, the difficulty, but also the central importance of the issue represented by this experience, the decision has been made to take it as an example of the seven experimenta-

08 | 

08 | Filtering through the heat energy demand density map, infrastructure and energy potentials

tion cases on the urban districts presented in this paper, assigning the 8 images, tables, and graphics[3] the task of illustrating the process in a more in-depth manner, and the results.
A careful study was carried out, aimed at classifying the entire stock (Fig. 3) in accordance with the energy demand values (useful energy) for specific heating demand values (Fig. 3, Tab. 1) and the domestic hot water demand values (Fig. 3, Tab. 2), which yielded a heat requirement density map (Fig. 4).
Fig. 5's technical data sheets provide important information on aspects of historical compatibility, the building's physical and energy importance, and legal requirements. Although the study was developed for the city of Iphofen, it is generally transferable to other cases for the efficiency of historic centres, as the fundamental legal and physical relationships are listed. In the data sheets, letter A indicates the construction class, whose U values of the exterior walls are within an interval of +/- 1.4 W/m²K. In this case, the walls of the "reference building " were calculated with a U value of 1.4 W/m²K. Letter B stands for construction Class, whose U values of the exterior walls are included within an interval of +/- 2.4 W/m²K. The approximate characteristic value for the adequate implementation of the central energy procurement solutions is 150 MWh/ha per year.
First of all, this means that the energy requirements connected with space in neighbourhoods are closely correlated with the potential for using renewable energies at a central or local level. The example of Iphofen shows that structural density has a decisive influence on energy absorption density. Secondly, it was found that the thermal quality of the building's fabric is crucial. The greater the energy absorption density is, the greater is the potential for centralized use of renewable energies. From this, it may be concluded that the districts with high structural density have a high potential for centralized assistance, upon which different intervention scenarios for a Smart Urban District (Fig. 6) may be constructed.
The choice of the most suitable design intervention in the specific context of Iphofen is thus reached, and may be summarized in Fig. 7, showing the current total heat and the total electricity demand (current state), in addition to overviewing energy potential in the municipality of Iphofen. For solar potential, consideration was made of a 25% maximum share of coverage of solar thermal energy. The remaining coverage areas are then assessed for use by photovoltaics. The biogas potential is based on a 10% use of total agricultural land, in line with the share currently used in Germany for energy production.
For the intervention, it was identified which areas are most suited for central or decentralized assistance (Fig. 8). Here, in addition to the current heat demand, the future heat need is also taken into account. Future demand takes account of the reduction in energy absorption density through the buildings' requalification. The approx-

imate threshold of 150 MWh/ha per year mentioned above may be used to identify areas suitable for the concepts of centralized supply, keeping in mind that, at the central institutional level, local heating networks are promoted, with regenerative function starting from an energy absorption density of 0.5 MWh/trm per year.
The results point to a reduction in energy consumption from fossil fuels of 65% for thermal energy and 91% for electrical energy.

Conclusions in progress

The experimentations that were presented, all of which completed, demonstrate that it is possible, today, to regenerate the urban settlements and the network of their buildings and open spaces, making them capable of sustaining themselves, drastically reducing the requirement of primary energy, and bringing emissions to zero, while improving their environmental comfort.
We have seen how effective, from the standpoint of the methodological approach, the arrangement can be of starting from the innovative, mixed modes of producing entirely zero-emission energy, through the use of new systems for the dynamic storage of surplus energy: this was why a *Simulation Tool* was implemented, making it possible to assess, in the design phase, the effects on the modes of distribution of the energy produced in various, integrated ways, entirely from renewable sources, and on the possibilities these interventions determine. We point out that the *Tool* has central importance, providing accurate analysis of the composition of the buildings in urban centres, from the standpoint of the thermal energy requirement - an analysis that regards type, age, systems installed, quality of the envelope, and consequently the density of consumption.
We have also seen how key a passage in methodological innovation is the subsequent quantification of the energy potential obtainable from renewable sources, as well as that of the residual resources made available by the processes of distributed energy generation. In practice, the experimentation showed that only in this way can the results of the analysis and of the quantification be effectively associated with the available resources and placed in relation to the network that integrates the components and exploits their synergistic effects. And it is to be borne in mind that current research frontiers in this setting are oriented to the theme of constant "dynamic" adaptation of the needs both to the potential of production and to the (growing and innovative) possibilities for storing the generated energy.
The prospects are outlined and proved by the excellent results of the first real experimentations: only through a highly accurate management of energy, integrated into the architectural and urban systems - which "dynamically" and "adaptively" considers and associates the load profile of production and absorption, the types of requirements, the temperature levels and the interaction between the various forms of production - will it be possible to achieve real *smart cities* with *net zero energy*, or even *positive energy* and *zero emissions*. And in this perspective, it is important to keep in mind that in the design conception phase, it was essential in these experiences of experimental research - and it will always remain so in the future - to devote very careful consideration to the form, the technological characteristics, and the relationships of the urban and building structures, as well as the existing energy infrastructures and networks, by seeking the optimal combination to place them in relation to one another, by broadening the system's limits, and by redrawing the boundaries of the energy balance in relation to the broader vision and conception of the architectural and urban systems typical of technological design in an international perspective.

NOTES

[1] Another trial case in addition to those illustrated in the text, must be pointed out, marking an occasion for experimentation encouraged by the research group on the issues deal with in this passage of the paper. This is the large *Munich Re* building complex, built in the 1980s and the object of an upgrade competition in the early 2000s, which in effect constitutes an additional example of this approach. The design competition was won by proposing not to intervene on the façades, considering them to be an undeniable testimony of a period, while showing preference to replacing the air conditioning systems and the energy supply procedures. The existing air systems were replaced with radiant heating systems and low-enthalpy cooling. The proposed solution was assessed from the standpoint of primary energy savings, comparing the solution involving the heat insulation of the façade - assuming that this could be done without modifying the existing envelope - with the one excluding it. After 80 years of use, the variant without heat insulation reaches an equivalent primary energy requirement since, in this case, the consumption linked to manufacturing that insulation need not be considered. The proposed solution, which entails no modification to the façade system, turns out to be, in terms of energy, just as sound, but avoids any intervention on the envelope.

[2] The project procedure started in 2010 with an initiative funded by the "German Federal Environmental Foundation" (Deutsche Bundesstiftung Umwelt). This first phase had its core on the definition of optimization the performance of the existing technical supply systems integrating renewables in the complex. To the first feasibility study a second phase of investigation succeeded, supported by joint funding from the Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie (BMWi)), the Ministry of Transportation and Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung (BMVBS)) as well as through a grant from the Government of the Federal Republic of Germany through the "Beauftragten der Bundesregierung für Kultur und Medien (BKM)".

[3] Figures 1, 2, 4, 5, 7 and 8 come from: Hausladen et al., 2012. Figures 3 and 6 come from: Hausladen et al., 2011.

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Edo Ronchi
National Council of the Green Economy

If we are to achieve the 80-90% reductions in greenhouse gas emissions needed to limit the average temperature increase to below 2°C as established by the Paris Climate Agreement, it is crucial to be able to meet the energy, electricity, and thermal needs of existing buildings using renewable sources alone. This is to be done by coping with the problems of the production and discontinuity of some of these sources and with issues of inconstant availability, while setting targets for the greater efficiency and considerable energy savings needed to achieve adequate performance with 100% renewable energy.
The experimentations presented by this study, addressing the possible relationship between "smart and synergic urban districts" and "smart and dynamic energy systems," show that if the right questions are asked, answers are found - and that these answers are already today technologically practicable and economically feasible. There appears to be great potential to spread these experimentations: existing buildings and the characteristics of urban districts in the considered conditions are numerous and ubiquitous; urban areas show a frequent presence of differentiated energy demands; the possibilities of integrated recourse to differentiated forms of renewable sources (geothermal, biomass cogeneration, solar and wind) are widely accessible, as are the various energy storage technologies; the combined, "dynamic" use of measures and technologies to reduce energy consumption and for the efficient employment of renewable resources, although highly innovative and advanced in the described experimentations, appears broadly feasible in urban landscapes where there is a desire to promote it.
In brief, the research and experimentation presented in the paper by Tucci, Santucci, Endres and Hausladen are convincing, showing that Smart Buildings and Smart Urban Districts are feasible today, if we have the desire (while in the awareness that they require great awareness and clear vision) and if we have the multidisciplinary skills needed to carry out all the phases in the knowledge-design-realization process, from systematic energy and environmental diagnoses of buildings and urban districts, to the complex process of the creative, innovative, and dynamic conception of the uses of potential and different renewable sources for procuring power, and the design and realization of necessary and adequate interventions in the dimension that is both architectural and urban.

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Service design for smart energy management: simulation tools and energy maps

RESEARCH AND EXPERIMENTATION

andrea.boeri@unibo.it
jacopo.gaspari@unibo.it
valentina.gianfrate@unibo.it
danila.longo@unibo.it

Andrea Boeri, Jacopo Gaspari, Valentina Gianfrate, Danilo Longo,
Department of Architecture, University of Bologna, Italy

Abstract. Within the complex and interrelated nature of the smart city concept, the importance of considering both the potential contribute of informed end-users and the impacts of a more organized – district based – approach to energy management are rising as relevant topics. This paper reports the progress of a research aimed to map energy use at district level, translating the zoning concept to balance actions to be delivered in different areas into a city level perspective. The adoption of energy maps is aimed to facilitate the understanding and the communication of the potential impacts in order to increase end-users and key-players awareness on the energy issue as well as to support decision makers to prioritize actions according to a shared systemic approach.

Keywords: Service design, Smart energy management, Zoning approach

Context and research framework

A number of studies and evidences carried out by the EU Building Stock Observatory, Eurostat, Buildings Performance Institute Europe, currently attribute 40% of total European energy consumption, which corresponds to about 1/3 of CO_2 emissions, to the built environment and the European Union (EU) is spending huge efforts to boost energy saving measures to meet the goal of achieving neutral energy districts by 2050 (European Union, 2012). However, population growth in cities, metropolis and - globally speaking - in megacities contributes not only to the direct increase energy demand but also generates new kind of problems such as waste management, traffic congestion, use of land and resources - just to mention some very evident examples - which are responsible of indirect energy demand streams and of huge environmental impacts. The different nature of such issues and the different socio-political contexts typically originate complex interrelated challenges involving a number of different stakeholders from decision makers to end-users that make quite hard to adopt reliable predictive models and find exportable and replicable solutions. The urgency to provide effective pathways to face these challenges and the related complexity is triggering many cities to find smarter solutions under the umbrella of the "smart city". Despite the concept has known a rapid diffusion, a shared and consistent definition is still lacking within practitioners and academia creating a quite heterogeneous understanding of what smart city is or may be. According to Chourabi (Chourabi et al., 2012), smart cities can be associated to different characteristics depending on the disciplinary approach the phenomenon is approached, but generally they are associated to:

- a forward looking way in managing social, economic, environmental, mobility, liveability issues based on the increase of citizens awareness and their active participation in the processes (Giffinger, 2007);
- a capability of monitoring and integrated data dealing with major infrastructures with the aim to enable service improvements to the citizens (Hall, 2000);
- a connection between physical infrastructures and IT infrastructure to leverage the collective intelligence of the city (Harrison et al., 2010);
- a commitment to be smart with reference to create more efficient, sustainable, liveable conditions;
- a capacity to integrate city management complexity within an ICT and web based real to speed up processes and services (Toppeta, 2010);
- a use of Smart Computing technologies to make infrastructures and components more intelligent, interconnected and efficient (Washburn, 2010).

A wide and extensive literature review (Anthopoulos, 2012; Neirotti, 2014), related to several disciplinary sectors, allows to focus on the complex nature of smart cities development where a number of critical factors, such as management and organization, technological availability and access, governance and policies, people and communities engagement, economic trends, infrastructures and services, interact each other making very hard to provide a coherent vision to coordinate all potential actions running at city level.

Despite this plurality of topics - to which several definitions are related - making a city "smart" is frequently associated with the energy challenge within an ICT integrated approach. This is mainly due to the interlinked understanding of smart grids that significantly contributed in the recent past to evolve the energy efficiency topic at city level becoming a main asset of several projects at different levels.

However, the smart city approach is also emerging as a strategy to mitigate the problems generated by the urban population growth and rapid urbanization in a broader perspective. If on the one hand great effort has been spent to foster technological solutions and infrastructures with the purpose of driving the progresses in the energy sector, on the other one less advances were achieved in creating tools and measures to define planning and management integrated solutions able to support decision and policy makers as well as the key players to address actions in the mid-long term. This systems integration is useful to align innovation activities, products and services with regulations, policy, industry and investors needs, business models, and to facilitate the assessment of the potential risks and innovation impacts.

The emerging smart city vision integrates large and small scales energy initiatives and solutions, including major infrastructure investments, improvements in energy efficiency, fuel poverty resolution, users' behaviours awareness increasing. A key issue is therefore to define a proper scale according to the specific local conditions. The Energy Efficient Building European Initiative (E2B EI), promoted by the European Construction Technology Platform

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(ECTP), considers the urban scale and, in particular, the concept of district the ideal experimentation field for connecting the city as a whole while maximizing the benefit obtained at the small-medium scale.
This points out another critical element dealing with the notion of district which is often traditionally associated with administrative or geographical boundaries or organizational model, based on the optimization of production processes according to partnerships, relations, logistics among different entities, rather than to established communities or unconventional relations dealing with people or activities interactions. In the last decade, district has been associated to a more dynamic concept, going beyond structured institutional models, which can assume variable boundaries according to thematic approaches.
Considering the complexity and interdisciplinary nature of the described framework, this paper reports the progress of a research aimed to support energy management at district scale using simulation tools and energy maps.

A contribution for innovation

The city of Bologna has a recognised position in national smart city ranking and developed many initiatives to improve smart solution at different levels and established a quite consolidated cooperation with the University of Bologna in delivering smart city oriented projects particularly dealing with the energy topic. Within these initiatives the research team of Technology for Architecture of the Department of Architecture (UNIBO-DA) was involved in different projects from building to city scale detecting a lack of a systematic approach in creating synergies between the ongoing or envisaged actions that is probably due to the differentiated nature of funding schemes as well as of political umbrella. Nevertheless, this lack of interconnection, which also depends on the different scale of projects and allocated resources, represents a significant barrier to achieve a coherent and updated vision of the potential impacts that the combination of any single action may produce on the city as a whole in the mid-long term.
The main contribution the research team intends to pursue for innovating (Marceau, 2008) the approach at city scale is to integrate existing technologies, solutions and strategies in a more complex system of analysis and management of the urban fabric with the scope to reveal those urban areas characterized by energy homogeneity and balance them into a system based on a logic of compensation and connection.
This concept moves the city vision from the individual action logic to a comprehensive one at city level where the notion of district is associated to homogeneous energy areas. This is connected with energy use and with the building stock consistency and typologies (especially from a constructive point of view)

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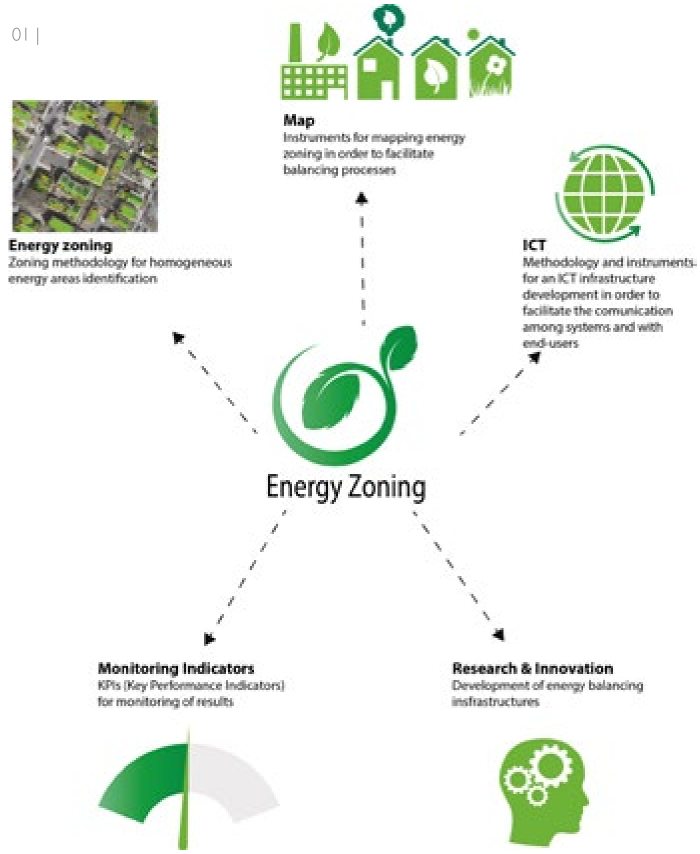

but also it strongly deals with key-players awareness and participation within the process. The research proposition is indeed connected with investigating how service design can be applied to support smart city planning, development and management with a specific focus on energy system and considering community services and innovative business opportunities.
«From a service logic perspective, innovative services are not defined in terms of their new features, but in terms of how they change customer thinking, participation and capabilities to create and realize value» (Teixeira, 2012). Thus, the transition towards a more sustainable, smart and integrated urban system requires important changes in design system, smart technologies and services for "energy consumers", operation phase, regulations, etc., involving actors and engaging consumers in the process, as SET Plan foresees. The most effective plans (Trencher, 2017) demonstrate how energy-related services are connected to city priorities such as social inclusivity, economic development and environmental protection, establishing a new framework to promote best-practices in green procurement. In other words, the team is involved in matching solutions that make energy demand more efficient considering sustainable energy resources, developing a systemic architecture capable of processing multiple and complex data and planning both the efficiency and the maintenance intervention on the built environment.
With this purpose, a key-role is played by the definition of a communication infrastructure for exchanging and processing data related to energy management to identify integrated urban district models and achieve the optimization of neutral districts. This approach is particularly relevant in the peripheral/suburban urban areas where deep renovations can take place and the

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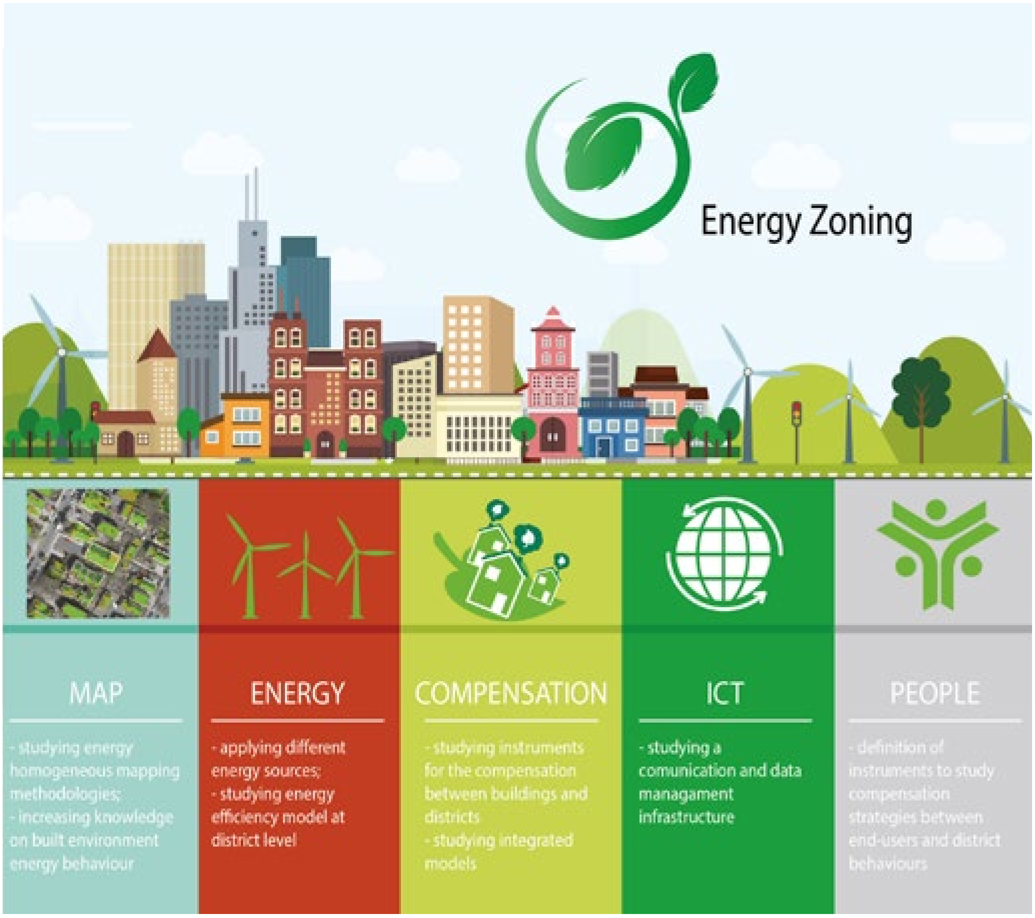

02 | An interrelated model for the built environment

energy plus of the "virtuous" areas (positive energy districts) can compensate the energy needs of non-renovated areas, creating "neutral" districts, through a Smart Connected Districts approach and a related energy zoning at city level (Fig. 1).
Integrated facility management models aimed at the environmentally sustainable management of buildings and urban areas can facilitate the transition to low-carbon and resilient urban districts.

Research methodology

This research methodology is based on the concept of zoning, assuming the dimension of the districts as a unit of reference. District energy planning requires an assessment of current energy needs and the likely evolution over time of this factor. To define the consumption trends of the district a set of indicators dealing with technical and economic parameters as well as the social and environmental dimensions is needed. Therefore, a multi-parameter matrix supports the definition of demand profiles while each of these parameters requires a specific analysis within the data management process. The definition of the characteristics of the communication infrastructure to manage the collected data, through the analysis of the overall scenario, is important to appropriately identify (both in terms of typology and density) the different urban objects (buildings) as well as the typologies of information that each of them generate. In this framework, network architecture plays a fundamental role.
Furthermore, the communication infrastructure is comprehensive of information deriving from citizens/users of buildings, and achieved through the analysis of specific social investigation tools and techniques. These tools include survey about users' satisfaction, about their living conditions, analysis of their behaviour through direct observation and sensors, effects on the energy bills, etc. These information are used to obtain a complete frame about the living environment conditions, and the involvement of users in this monitoring campaign is the first step to increase their awareness about their consumes, possible energy savings and energy expenditures. The acquired data become part of the following phase adopting a user driven approach.
This approach is intended as multi-criteria and trans-disciplinary (architecture technology, ICT, smart grids and infrastructures) work, and it is the basis of service design for smart energy management. In particular, indicators typically linked to buildings with a systemic vision on an urban scale are to be correlated through ICT based systems. The use of ICT technologies is used to manage energy demand more efficiently, linking the concept of energy efficiency to the broader topic of Smart Cities. This implies the need to put in relation the energy characteristics of the city and the habits of citizens/users, optimizing energy and information flows management.
The idea is to create a set of maps with a user-friendly interface able to combine different layers:

- technical layers, visualizing data output deriving from sensors, digital elaborations, etc.;
- social layers, including the data deriving from surveys, direct observations, collaborative meetings results.

The intersection between different sources of data facilitate the understanding of relations between the energy performance of buildings (whole districts) and the human perceptions about comfort, opinions about energy services, etc.

This first set of maps can be progressively integrated by new layers, about context conditions, statistical information, data deriving from innovative and sophisticated sensors and monitoring systems, localization of constraints for the improvement of energy performances, etc.

The final aim is to obtain a flexible urban tool, able to help the city management in the identification of potential "energy districts", integrating the energy issues in the urban design, analysing energy impacts, state of maintenance of the infrastructure, conditions to promote energy communities, etc. and, at the same time, to offer an easy communication tool to visualize the "human interaction" at district scale (Fig. 2).

Discussion and further developments

Although the research is not concluded yet, the first outcomes on the adopted methodology and the implementation of the systemic approach to enable energy maps generation encourage to positively consider the potentialities of the study in improving synergies creation and in addressing actions into a more organised transition vision.

Maps to support integrated facility management models are helpful to visualize future energy demands based on medium-long-term scenarios of socioeconomic, technological and demographic development at urban scale. Energy demand can be disaggregated into a large number of end-use categories corresponding to different goods and services. The influences of social, economic and technological driving factors are estimated starting from given scenarios. Thanks to these visualizations is possible to achieve an overall picture of future energy demand growth at district and city scale. This also open some market opportunities in providing dedicated services that may be addressed to end-users, companies or decision makers in order to effectively benefit of the available information and optimization procedures.

The originality of this research is tied with its scalable approach and methodology, which is not addressed to map single interventions but their effects at district/city level. This can be of help in defining the public authorities' priorities and also in connecting actions to their impacts on the local communities creating informed target groups able to support the transition toward a low carbon society.

As the scope of the study is to translate the zoning approach into services for the community, and not only into a supporting tool for the public authorities to assign priorities and connect actions, a feedback on the general concept, on the potential deriving impacts and on the relate market opportunities was asked to an independent subject - not directly involved in the project - in order to embed remarks, suggestions and comments into the monitoring of the project advance. The feedback from Manutencoop, a leading facility management company operating on Bologna territory and in many others Italian cities, is: «On one hand, this improved awareness may better inform the decisions that players in the energy sector need to face and on the other hand, could foster the generation of brand-new services, adding value to the energy demand profiling that is a potential valuable asset in the green market. Looking forward to the implementation of the National Energy Strategy recently issued in Italy by the Ministry of Economic Development, energy demand and energy capacity planning seem to play a dramatic role in meeting the high-level expectation of a better energy consumption and a more efficient energy production: in view of that, such research project can cast new light on potential new business case that may arise by including energy priorities with urban development and city management. Surely, this process must consider the possible issues involving data management and protection, but we are confident that these can be overcome through the adoption of a district-level-scale data source, allowing working with aggregated figures. An insight for further development of this research is the creation of focus groups, ideally including some industrial players/suppliers, in order to pinpoint the design of new services and to explore their market exploitation. This should certainly be of help in the case the research's team intends to provide solid indications on how to translate the outcomes of the study into business opportunities, not just limited to IoT applications and other technologic aspects that already are deeply rooted in the literature of Smart Cities research, but also including the service management dimension at urban level».

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Maurizio Massanelli, Francesco Della Fornace, Luca Macca, Eleonora Santoro

Manutencoop

The study addresses a very relevant issue taking into account real impacts stemming from every single action and the role they play into the process for the achievement of a comprehensive smart city dimension.

Since corrective measures to manage such differentiated initiatives, that also involves heterogeneous forms of financial backing, could hardly become a feasible solution in the short run, the idea of working on the concept of energy zoning seems noteworthy from a stakeholder perspective. This process could be initiated right away, undertaken by collecting data or processing existing ones and ultimately providing useful visual outputs (i.e. maps) easily understandable for everyone concerned, whether they be decision makers, administrators or laypersons. In the near future, such sharing of information among all the stakeholders seems to be a crucial capability for change management in citizens and policy makers perceptions and for improvement of their reciprocal relationships.

A more relevant concern to face within a replicability perspective is represented by the different "size" homogeneous energy districts may have, according to the city typology: this may be adjusted once the experimentation on Bologna pilot will been completed and assessed even though it still fosters the idea of a valuable service management layer which is able to interconnect different city areas with different needs, requirements and features to provide and effective city management proposition.

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Smart city actions to support sustainable city development

Kari Kankaala, City of Tampere
Maarit Vehiläinen, City of Tampere
Pellervo Matilainen, Skaska Oy
Pauli Välimäki, City of Tampere

kari.kankaala@tampere.fi
maarit.vehvilainen@tampere.fi
pellervo.matilainen@skanska.fi
pauli.valimaki@tampere.fi

Abstract. Cities are at the heart of global challenges and its solutions. When occupying only 3% of Earth's land, they are both the engines of economic growth with 80% of the global GDP but at the same time cities are emitting 75% of global green house gases. The aim of this paper was to focus on how different city development programs have been developing and how they are supporting the city's strategic goals. This paper has shown self-assessment results of 37 projects from four different programs in the city of Tampere. The projects were evaluated against five themes: people, planet, propagation, governance and scalability/replicability. The results showed that the environmental indicators had high scores. Also, the governance focus had a high scores in most of the projects. The people focus was highest in project themes on smart cities. Some of the ecological projects were in nature very technical, which is the reason why they did not score that high in people theme. The results showed clearly that the scalability and replicability are becoming very important elements in the existing and coming projects in cities. This could be also clearly seen in the analyses where the scalability and replicability of the different projects has been important in last 5-10 years and it seem that especially in the recent years the importance has a high impact. From our study we could initially conclude that the program based approach in city's economic development seems to provide one strand of continuation in implementation of the city's economic development policy and that the impact of its implementation improves. The hierarchical roles of different sets of projects as well as that of the sub-ecosystems that have carried out the project(s) indicates that the ecosystem approach is a useful one. The results also highllighted the role of programs as platforms for for innovation and co-creation between citizens, companies, research organizations and public sector. In these ecosystems value is created to all stakeholders. The value may be direct financial value but may well be also indirect such as R&D related, community value etc. The role of the cities is very important in this ecosystem value creation as they are considered to be a neutral body with focus on the public interest, not a vested one. As the role of cities is growing to be paramount also in innovation, this should be reflected in regional, national and EU level innovation policies, funding schemes and regulations as well as in execution of innovations.

Keywords: Smart City, Sustainability, Strategy

Introduction

Cities are at the heart of global challenges and its solutions. When occupying only 3% of Earth's land, they are both the engines of economic growth with 80% of the global GDP (UN-Habitat, 2015), also most of innovations are created in cities, at the same time 75% of global green house gases are originated from cities (UN, 2016). Therefore, cities can be seen as main couse and victims of climate change (Alberti et al., 2003). However, cities are also in best position to solve such grand challenges through efficiency (Rode & Burdett, 2011) and innovation (Airaksinen et al., 2016). Consequently, they have recently been put in the centre of several major political agreements, such as the Sustainable Development Goals (United Nations, 2018) and the New Urban Agenda (UN-Habitat, 2016). Due to rapid urbanisation (UN Habitat, 2015), additional challenges are created e.g. social. This further highlighting cities' urgency to strive to urban sustainability, i.e. to equitably meet the social, economic, environmental, and governance needs.

The technical development to tackle these problems is accelerating with such technologies as sustainable energy solutions, construction technologies, IoT, robotics or data science. This puts cities as the key stakeholder in the middle of innovation development to solve these problems. Therefore cities have an increasingly important role in the innovation ecosystems (Finnish Ministry of Economic Affairs and Employment, 2017). This has led to the current role of cities globally in solving these challenges through a variety of initiatives often termed smart cities. Another megatrend is the empowerment of citizens and the new values of work-force of the 21st century. The cities are to be transformed only with their citizens co-creating the new city.

The situation is new for cities and they need to acquire novel ways of working with companies, research organizations and citizens. While small-scale such developments have taken place gradually over the years, the scale and impact of the current transformation requires ecosystems. Ecosystems beat individual organizations. They are dynamic and co-evolving communities of diverse actors who create and capture new value through both collaboration and competition. Ecosystems accelerate learning and innovation as well as foster sharing and co-creation. They can create and serve communities and harness their creativity and intelligence. Ecosystems create new ways to address fundamental human needs and desires and drive new collaboration to address rising social and environmental challenges.

The city of Tampere was a typical European midsized industrial city until late 1980s and early 1990s. Due to changes in its economic structure it was forced to reinvent its economic development strategies. The city put all its economic development eggs in one basket: capitalizing on the knowledge generated at the educational institutions from vocational schools to universities and it in a manner we now term ecosystems: all stakeholders have been involved ever since. This shift in strategy did not prevent the vanishing of textile industry from the regions but it did its share in transforming the traditional metal manufacturing industries to an interesting European hub of intelligent mobile machinery. Further, the city became the largest global R&D site of the Nokia corporation at its peak due to the decades long development of relevant technologies and skills in the region.

The city has carried out its economic development strategy via focused development programs first e.g. on manufacturing, ICT, health technologies and now more recently e.g. on sustainable development, creative industries and open innovation and smart cities. The role of these programs is to serve as a catalyst in enhancing respective industries, start-up generation and university-industry collaboration as well as city transformation. These programs have been combined with national funding means as well as with private investments and have generated typically a return on city's investments with factor of 10-30.

In this paper we will discuss impact of projects carried out un-

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der four umbrella programs (termed for the purposes of this paper ECO2, INKA, 6Cities and SMART). We also study whether these programs have created a logical development continuum from one program to another or whether they have been isolated projects that serve only one-time purpose. This study is done utilizing the CITYKEYS (www.citykeys-project.eu) framework.

Methods

Development programs studied

In this paper, we have chosen to study four programs (ECO2, INKA, 6Cities and SMART) that have been somewhat differently initiated programs but all these are under the umbrella theme sustainable development of cities. ECO2 (ECO2, 2016 and Välimäki et al. 2013) is a city initiated multiyear multimillion program that was followed in Tampere by Open Tampere (2010-2016), a similar development program as ECO2 but focused on open innovation. INKA, on the other hand, was a national government program to enhance city development. This was intertwined in Tampere with its own ECO2 and Open Tampere programs. 6Cities is a joint undertaking of the six largest cities and jointly funded by European Union and the cities. In Tampere, this was again intertwined with the local development strategy and funding tool Open Tampere.

We also try to track how projects in these programs paved the way to the current large Smart Tampere initiative of the city which focuses on various aspects of smart city development. Smart Tampere was started in 2016.

ECO2 development program 2010-2015 started as a co-operation initiative between the city of Tampere and the Finnish innovation fund Sitra. The target was to decrease greenhouse emissions and develop eco efficient and low-carbon procedures to do so while creating opportunities for businesses to develop their emerging green business ideas or to provide solutions to that parties involved in the program. The operational model was much the same as of the earlier development programs, i.e. ecosystem approach.

During the last two years of ECO2, its activities were intertwined with the national government innovative city program INKA and its smart city theme (2014-2016) the coordination of which was allocated to the city of Tampere by the national government. By the end of 2015, in Tampere there were 18 INKA projects initiated or underway with financial value of some 14 M€. Smart mobility, smart lighting, energy efficient buildings and industrial symbioses were the major topics under INKA Smart City theme.

As the ECO2 program raised the awareness among the six largest cities on sustainability issues, the cities soon decided that they would attack some challenges jointly. A tool for this was available in the new European Union structural funds program and its city focused ITI initiative. The six largest cities in Finland

Scalability and Replicability
Score 10 High Scalability and replicability, the solution/process can be implemented in at European/Global level
Score 7 Rather high scalability and replicability, the solution/process can be implemented in at national level
Score 4 Low scalability and replicability, the solution/process can be implemented in at regional level
Score 1 Lowest scalability and replicability, the solution/process is city specific
Planet
Score 10 High eco-efficiency/planet indicators, minimises the energy and resource use, uses holistic approach and best available technologies
Score 7 Uses best practices
Score 4 minimum requirements based on legal requirements
Score1 Low eco-efficiency, no specific attention to Planet indicators
People
Score 10 High eco-efficiency/people indicators, high social inclusiveness
Score 7 Uses best practices
Score 4 minimum requirements based on legal requirements
Score1 Low social aspect, no specific attention to People indicators
Prosperity
Score 10 High long term economic performance/prosperity indicators,
Score 7 Uses best practices
Score 4 minimum performance
Score1 Low long term economic performance, no specific attention to Prosperity indicators
Governance
Score 10 High multilevel governance and all stakeholders engagement/governance indicators high
Score 7 Uses best practices
Score 4 minimum requirements based on legal requirements
Score1 Low governance efficiency, no specific attention to Governance indicators

TAB. 1 | Assessment scale

created a joint strategy (termed 6Cities strategy) to attack joint challenges The execution of this 6Cities strategy started in 2014 and continues until the end of this structural fund period 2020. The broad focus of 6Cities falls under three themes: open data and interfaces, open innovation platforms and open participation and co-creation.

The city of Tampere continues its program based regional development now through Smart Tampere initiative (2017-2022) where the goals are to achieve growth and value for all smart Tampere ecosystem participants, to increase smart Tampere ecosystem participants international competitiveness, to attract and grow talent, knowledge and skills in smart Tampere ecosystem to contribute to a sustainable Tampere community and to increase the quality of life in Tampere.

Assessment methods of the programs and projects

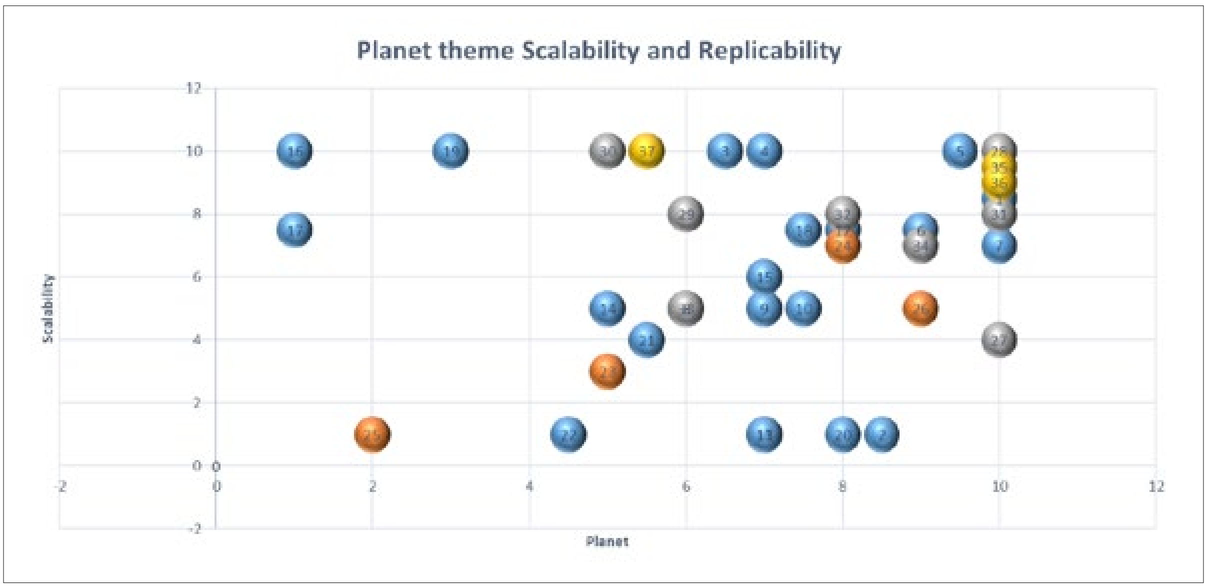
All together 37 projects from years 2010 to 2017 were assessed. From the projects 22 were included in the ECO2 program, 5 to Inka, 7 projects to 6Cities and 3 to SMART. The assessment has four main themes; People, Planet, Prosperity and Governance as well as Scalability and Replicability according to CITYkeys (www.citykeys-project.eu). The projects were assessed with the following scale shown in Table 1. The projects were evaluated by using self-evaluation method and by investigating the finishing reports of the projects.

Results

Planet

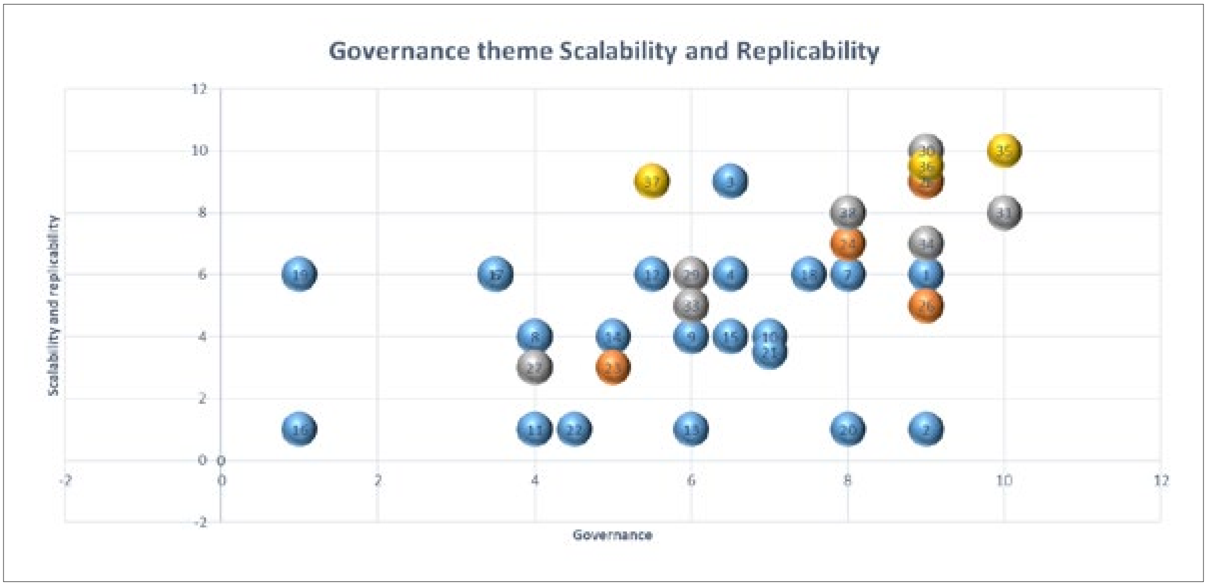
Planet diagram shows that Planet theme scalability and replicability are above average in most of the projects. Also the scalability and replicability tends to be on satisfactory level or higher. The planet theme has been one of the main goals of the ECO2 projects. Even in the first three-year-period the focus has been in developing the new eco efficient and low carbon procedures and co-operation with partners working in the field of energy efficient building and innovative solutions in renewable energy sources (RES). Planet diagram also shows that there are continuums, one project serves as a base towards next project. That is why e.g. project KEKO (#1) stands up as one of the most eco-efficient (high score in Planet theme) and scalable projects. In KEKO project calculation and estimation tool was developed for the carbon footprint and eco efficiency comparison. In Tampere pilot targets of the project were Härmälänranta 2 city plan and blueprint of the Vuores Isokuusi area. Another project that is valued as a base for new projects is #7 OKRA where main goal was to develop control mechanisms for sustainable building methods and roadmap for that. Recommendations from the ERA17-roadmap enables anticipation of the tightening regulations of the energy efficiency especially in the construction field. Härmälänranta pilot area has a continuum in the new project like Horizon 2020 lighthouse project called

01 |



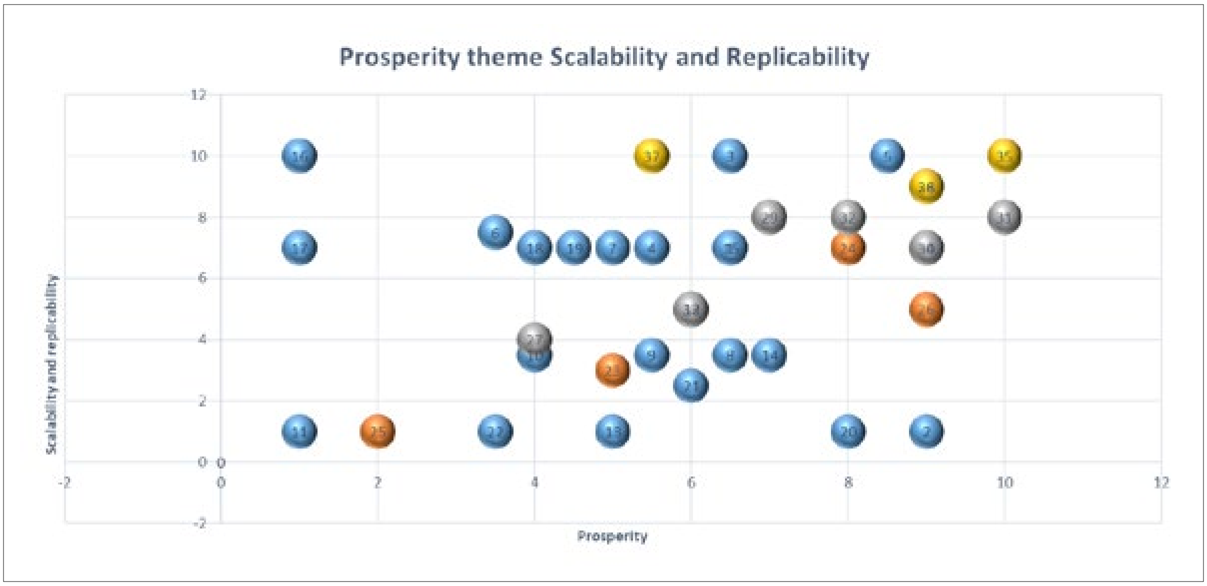
01 | The assessment of Planet theme. Blue circle corresponds to ECO2 program, orange to INKA, yellow to SMART and grey to 6Cities

02 |



02 | The assessment of Governance theme. Blue circle corresponds to ECO2 program, orange to INKA, yellow to SMART and grey to 6Cities

03 |



03 | The assessment of Prosperity theme. Blue circle corresponds to ECO2 program, orange to INKA, yellow to SMART and grey to 6Cities

Stardust where Tampere city wants to promote cooperation between actors in seeking the best energy concept which balances the best way the energy supply and energy use by using the best available technologies.

Governance

The systematic involvement and coordinated work is visible also in the diagram describing the effectiveness in governance theme and scalability in that side. ECO2 program has implemented e.g. the city strategy of the low carbon and other clean climate targets by coordinating and planning eco efficient procedures and carrying out projects involving solutions in the areas of the green energy, building and smart mobility.

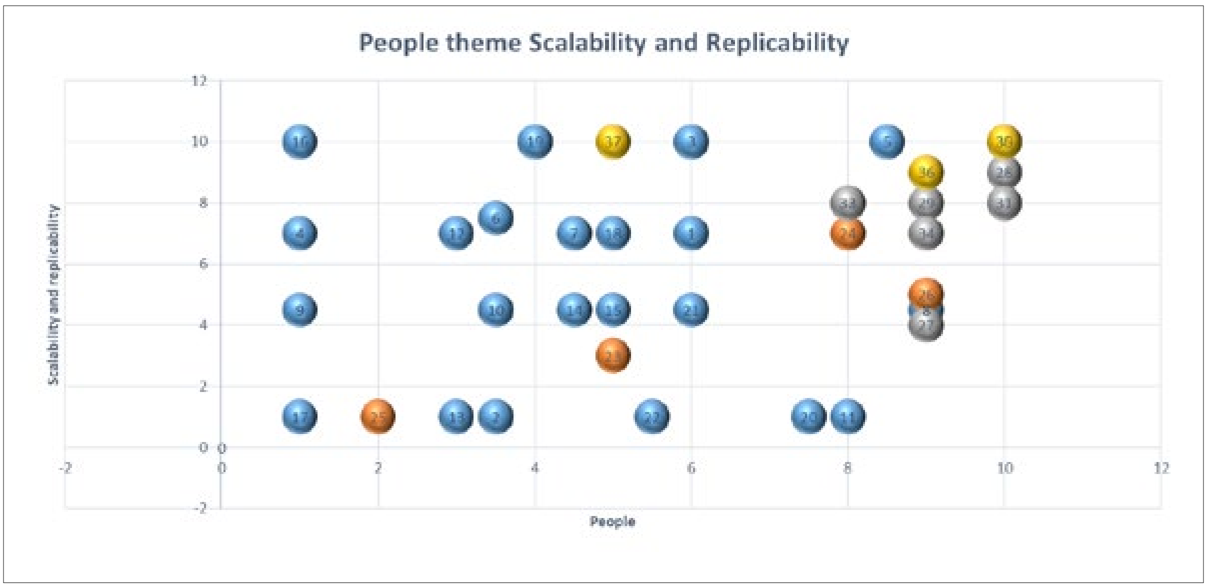
The co-operation between different units within the city organization and with external partners has been important. Communication has been an essential part of the way of acting in the projects. Participation in the EU Covenant of Mayors and targets set by the program were made possible with the determined work done in the ECO2 program. From the diagram we can pick as an example a 6Cities project SenCity which is building a smart LED lighting and digital service platform with sensors in six cities in Finland. In the pilots the aim has been to employ lighting infrastructure as a service platform forming a backbone for internet of things for the cities and partners. The extent to which administrative departments contribute to smart lighting system has been high, and instead of piloting we can talk about business as usual as lighting has clear plans to be renewed in the entire city and work has been started, and also censoring innovative systems are planned in several areas. Energy efficiency and clear savings were the accelerators that made fast decisions possible. Tampere is also preparing its own 3D model, project #30, and open data and interface project has brought data about the city closer to the citizen.

The city's substantial role as a facilitator and coordinator shows in the governance theme effectivity.

Prosperity

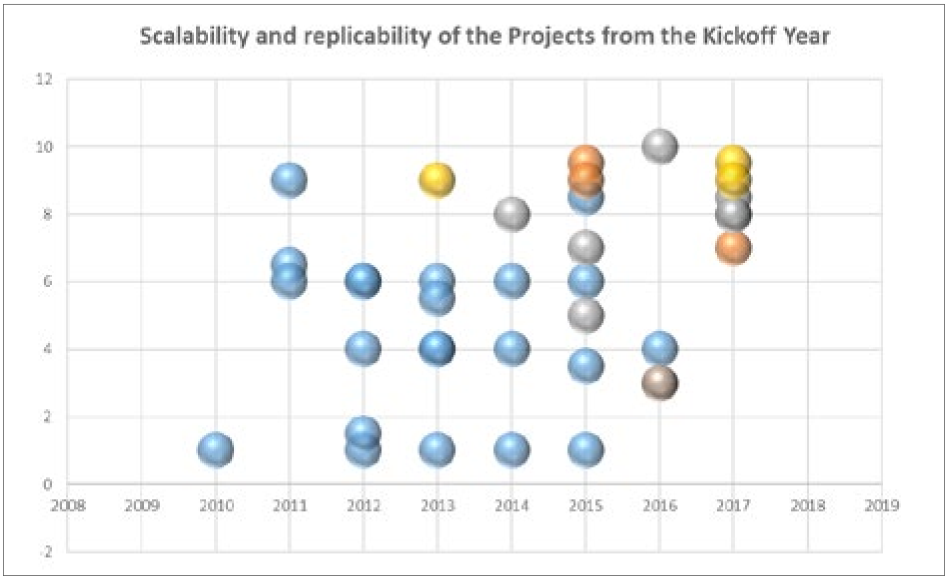
The intention behind each smart city program is to improve outcomes for citizens. In a smart city, digital systems are supporting infrastructures, e.g. using information and communications technology that monitors the safety and operations of energy and water systems, transportation networks, and other services. Prosperity comes from better connected, more efficient and environmentally friendly resulting in a more attractive city people for people to live in and work in. When examining the third diagram (prosperity vs. scalability) it can be seen that projects are spread more evenly in different quarters and effectiveness is more adequate and situated in the middle rather and in the left or right. Prosperity is value that is hard to measure. Project's direct impact towards unemployment rate is difficult to verify. New business models, on the other hand, can be seen as part of the effectiveness of the prosperity theme and correlation towards project can be identified. Projects EU-GUGLE #37 and TARMO (and TARMO+) #8 have made good co-operation and interest amongst housing cooperatives towards energy efficiency has increased in Tampere. Pilots in these projects has been in the essential in boosting up the energy efficient and innovative repairing in the city. CITIKEYS #5 the common key performance indicator projects to smart cities has increased the awareness of the prosperity indicators thus e.g. latest EU Horizon lighthouse projects Stardust #35 and Unalab #38 will have the prosperity indicators as part of the measurements with business modelling and ecosystem implementation, thus the expectations with scalability and effectiveness are high with these projects. Construction business is material intensive field that uses various kind of materials, and also produces tons of waste. Even though waste gets exploited efficiently challenge is the circulation and increasing the level of re-usage of the materials. The sixcity project #31 CircHubs also holds great expectations towards prosperity. It targets to find new business models and activities within hubs of the circular economics and using digitalization. Innovations evolved are planned to be commercialized with co-operation between Finnish cities and with means of transparency overlapping work gets avoided. Overall the effectivity in prosperity theme remains to lower level than in planet and governance themes. Challenge in INKA and other corresponding projects is that operating models and innovation platforms are developed in the schemes that tend to stay disconnected from the city's and other stakeholders' strategic work, and thus the business model creation is deficient. In part of the projects the operation fragmented se-

04 |



04 | The assessment of Planet theme. Blue circle corresponds to ECO2 program, orange to INKA, yellow to SMART and grey to 6Cities

05 |



05 | The assessment of scalability and replicability based on the kick-off of the project. Blue circle corresponds to ECO2 program, orange to INKA, yellow to SMART and grey to 6Cities

verely and projects were lacking collaboration between working partners. The vitality of the city is more often seen as more beneficial outcome than the concrete growth in the business world.

People

Smart city ideology has concentrated on city infrastructure like connectivity and sensors, but the focus has started to move closer to heart of the cities - citizens, people who live and work in the cities. It is important to take into account people aspect also in the measures of effectiveness in the project. People diagram shows the diffused bubbles from left to right. Scalability can be great, but the effectivity of the same project is thought to be low. E.g. in the program #16 TZIIP application for carpool was created. Basically readiness for using carpool is there and the need exists, but for some reason Tziip-application has no users. Reaching people is difficult which in turn affects to the accessibility to city services. In order to get the data closer to citizen, meaning people and companies, communication and dissemination is essential within the projects. EU Horizon projects have clear dissemination plans both global and local ones in order to get visibility and increase the awareness of the smart city projects.

Overall scalability and replicability of the evaluated projects

Comprehension to possibilities as well as problems in efficient city planning in Finland and also in Europe has increased within almost ten years during which eco efficiency projects as well as other innovative and smart schemes have been managed and coordinated. Peer support and learning are important in order to put activities done in the own city into perspective and compare to plans outside own "backyard". Therefore, scalability and replicability are becoming very important elements in the existing and coming projects. This can be also clearly seen in Figure 5, the scalability and replicability of the different projects has been important in last 5-10 years and it seem that especially in the recent years the importance has a high impact. One observation is that there seem to be evolution in time in all scalability vs. planet/governance/prosperity/people diagrams. Namely, when looking at the temporal relation of projects it may be concluded that the later the project has started, the more they are located in the upper right hand corner, having higher scalability and also higher effectiveness on the x-axis (planet, governance, prosperity or people). This would indicate a learning pattern towards projects with larger impact. The same could be observed in Figure 5 (scalability vs. project starting year).

What we may initially conclude from the above, is that the program based approach in city's economic development seems to provide one strand of continuation in implementation of the city's economic development policy and that the impact of its implementation improves. The hierarchical roles of different sets of projects as well as that of the sub-ecosystems that have carried out the project(s) indicates that the ecosystem approach is a useful one.

The projects that are being and have been carried out under the umbrellas of the economic development programs show the increasing role of cities in national or local innovation systems. The role of cities and city regions in innovation has clearly shifted from a solely enabling one to that of an actor. Another crucial change is that cities are now considered as platforms for innovation and co-creation between citizens, companies, research organizations and public sector. The more active cities are in this, the better they will succeed in capitalizing on the novel role of cities in an environment where the speed of chance is unprecedented.

In these (sub)ecosystems value is created to all stakeholders, large and small, private or public. The value may be direct financial value but may well be also indirect such as R&D related, community value etc. The role of the cities is very important in this ecosystem value creation as they are considered to be a neutral body with focus on the public interest, not a vested one.

Discussion and conclusion

The aim of this paper was to focus on how different city development programs have been developing and how they are supporting the city's strategic goals. This paper has shown self-assessment results of 37 projects from four different programs in the city of Tampere. The projects were evaluated against five themes: people, planet, propagation, governance and scalability/replicability. The themes were based on CITYkeys assessment framework.

As well known, many cities have very ambitious goals for environmental sustainability. This was also clearly shown in the analyses of the projects in Tampere. The planet indicators had high scores. Also, the governance focus has had a high importance in Finnish cities which can be seen also in high scores in governance themes in most of the projects.

The people focus is highest in project themes on smart cities. Some of the ECO2 projects were in nature very technical, e.g. focusing on developing renewable energy generation technologies, which is the reason why they did not score that high in people theme.

One of cities main goals is to scale and replicate good solutions. In addition, the other important goal is to increase the impact of the development project on desired topic. The results clearly showed that the scalability and replicability are becoming very important elements in the existing and coming projects in cities. This could be also clearly seen in the analyses where the scalability and replicability of the different projects has been important in last 5-10 years and it seem that especially in the recent years the importance has a high impact.

In addition to scalability and replicability the importance of enabling and creating new ecosystems and new models for value creation has increased. There is a clear evidence that the urban areas are becoming crucial for supporting new innovations. From our study we could initially conclude that the program based approach in city's economic development seems to provide one strand of continuation in implementation of the city's economic development policy and that the impact of its implementation improves. The hierarchical roles of different sets of projects as well as that of the sub-ecosystems that have carried out the project(s) indicates that the ecosystem approach is a useful one.

Also it can be seen that the development programs in city show the increasing role of cities in national or local innovation systems. The cities are not anymore solely enablers but also active actors. In addition, the city platforms are seen as as platforms for innovation and co-creation between citizens, companies, research organizations and public sector. The more active cities are in this, the better they will succeed in capitalizing on the novel role of cities in an environment where the speed of chance is unprecedented.

In these ecosystems value is created to all stakeholders. The value may be direct financial value but may well be also indirect such as R&D related, community value etc. The role of the cities is very important in this ecosystem value creation as they are considered to be a neutral body with focus on the public interest, not a vested one.

As the role of cities is growing to be paramount also in innovation, this should be reflected in regional, national and EU level innovation policies, funding schemes and regulations as well as in execution of innovations.

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Miimu Airaksinen
Managing Director and CEO, Finnish Association of Civil Engineers, Helsinki, Finland

In order to stear the city towards its strategic goals, evidence based research is needed to support and guide cities actions towards sustainability. Therefore this research has much importance for the whole city development frame work.

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A new collaborative model for a holistic and sustainable metropolitan planning

Edi Valpreda, ENEA - Italian national agency for new technologies energy and sustainable economic development, Italy
Lorenzo Moretti, Maria Anna Segreto, Francesca Cappellaro,
ENEA - Italian national agency for new technologies energy and sustainable economic development, Italy
William Brunelli, Confindustria Emilia - Area Centro, Italy

edi.valpreda@enea.it
lorenzo.moretti@enea.it
W.Brunelli@confindustriaemilia.it
mariaanna.segreto@enea.it
francesca.cappellaro@enea.it

Abstract. The purpose of our contribution is to provide insight into an innovative, shared and transferable model to assist the evolution and sustainable planning of an urban-industrial metropolitan area through a bottom-up involvement of the industrial community and local stakeholders. The presence of industrial urban districts has become a typical feature in Italy as a result of urban spreading. The presence of SMEs in urban ecosystems is a new fundamental opportunity for the design and planning of spaces as well as for the planning of smart energy systems and life quality in the cities.
We tested this approach in Roveri, a historical industrial district in transition located within the urban boundary of Bologna. This paper describes the first results obtained with a number of tools and actions aimed at making the community and stakeholders conscious of the district's potential and to enable them to lead its development.

Keywords: SMEs, Metropolitan area, Energy efficiency, Circular economy, Holistic approach

Introduction

Until now, urban stakeholders have thought of industrial and urban areas as separate entities in terms of energy systems, transports and service planning and overall quality-of-life standards. As they become aware of the presence of urban manufacturing, with its socio-economic and environmental implications and emerging opportunities, an evolution of the spatial relationship between cities and industrial environments becomes necessary. This trend can be observed in Italy as well as in many other industrialized countries worldwide.

The relationship between current urban planning practices and the places where urban industries are growing today is largely based on the conflict between the city center and the industrial periphery.

Industries have become urban industries with the growth of urbanized areas over the last twenty years. This happened without planning an integration between the needs of the city center and those of this new industrial periphery that has no inhabitants but every day employs energy resources and handles a huge amount of people from the city center (and outside).

After a post-industrial trend in which European cities moved industries outside of the urban boundary, today industries - mainly SMEs - are located within the city, even more so because they occupy whole districts that were once "close to" the city and now are in physical continuity with the city.

Even if they are often referred to as a value, they are not perceived as a key component of the city. In Italy, the lack of experience in the district management of this kind of industrial settlements (in which hundreds of companies are located) makes it harder to bring together typical "urban needs" (based on citizen housing) and "industrial needs".

The management and planning of tomorrow's sustainable and smart cities imply the ability to adopt a strategic approach on energy use and production, to apply technologies for innovation, to use financial tools to achieve progress, but primarily to know the needs, consumptions, opportunities to apply innovation and achieve more sustainable goals.

Worldwide, it is recognized that buildings account for about 40 percent of total energy consumption and contribute a corresponding percentage to overall carbon emissions. As 41% of the European population lives in the cities (Eurostat, 2017), this influenced the attention to new urban policies, in favor of a culture of the efficiency for private and public buildings and in favor of policies for a more sustainable emission-free urban mobility.

The presence of hundreds of productive enterprises in the citizen ecosystem is not yet adequately perceived both as a problem and an opportunity and needs to be fully included in policies aimed at a new smart sustainable urban ecosystem development.

A correct and updated knowledge of the new urban ecosystem is crucial to support a new holistic "urban-industrial" community as a basis to develop a new smart urban planning system.

At the same time, it is essential that the industrial district community (that generally does not coincide with the boundaries of an urban neighborhood), even without a manager, becomes visible to itself and to the nearby urban environments. We applied the experience to a real Bologna historical district, Roveri, a mixed industrial area that covers an area of about 2 square kilometers, where we developed tools and methods that could be transferred to many other metropolitan environments.

The industrial-urban ecosystems

A new smart and sustainable urban planning must be based on an effective urban industry management focused on the environmental problems related to company activities and on the interactions arising from the constraints of adjusting industrial needs to an urban context and vice-versa. Today, urban planning in our cities mainly involves urban renewal, with an adaptation of urban planning methods to existing cities. Industrial regeneration inside cities represents an additional problem that cities, normally, are not ready to address and solve (Hatuka and Ben-Joseph, 2017). As technologies that permeate citizens' life continuously produce and utilize data, a sustainable planning needs information more than data, which can come from a smart data processing. Ours is the big data time, so we think we know everything and that there is already too much data available on everything. However, the knowledge required to plan smart cities and territories has special features that need specific data for quality, accuracy and mainly updating, since urban and industrial settlements have a high intrinsic dynamism and the information becomes quickly obsolescent. Moreover, the knowledge for sustainable planning also needs to

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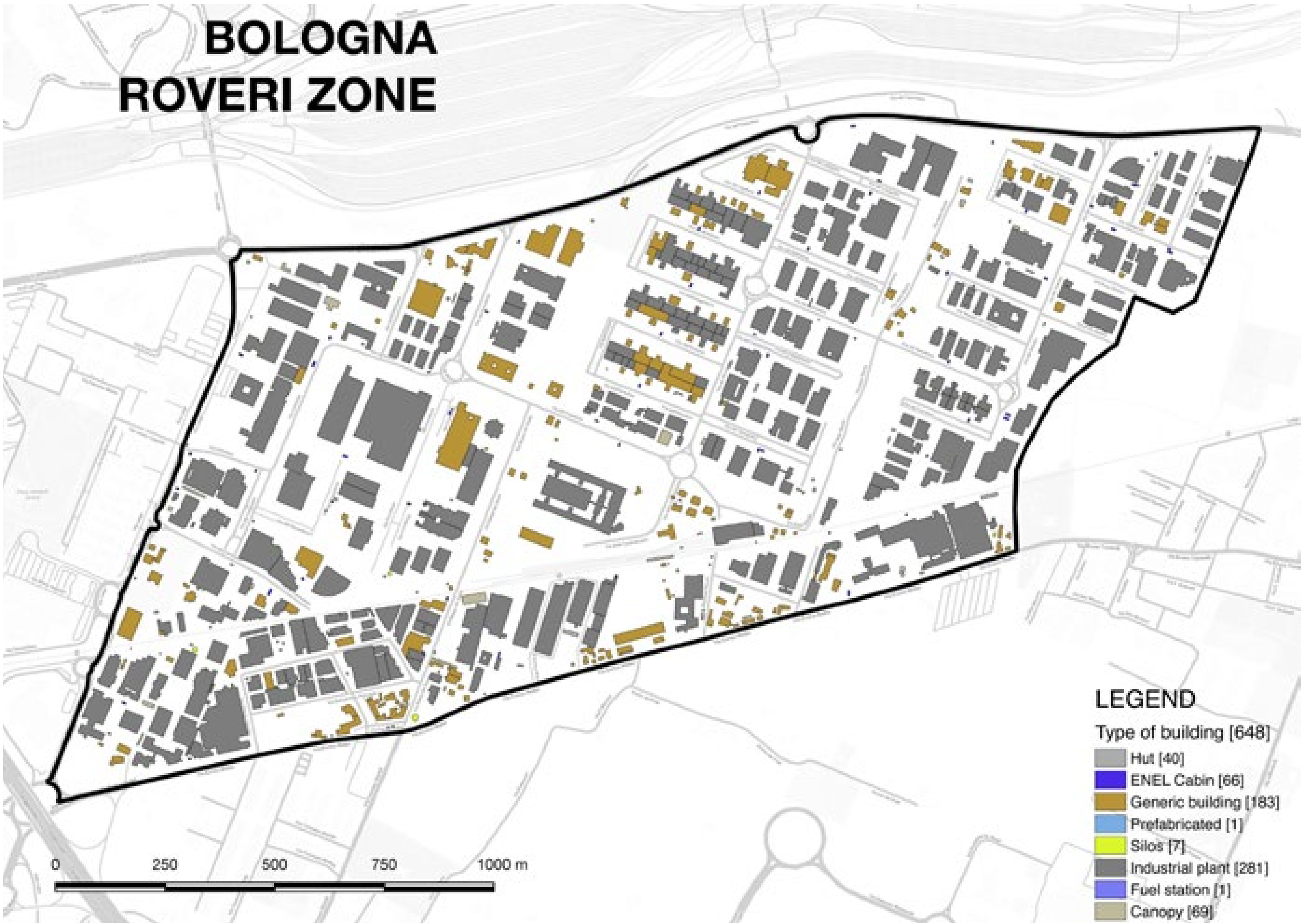

01 | Roveri district: buildings occurrence and type
(from Bologna Municipal Cartography)

be based on confidential information that refers to the inhabitants' behavior, lifestyles, as well as on industrial subjects' activity and resources. Therefore, it is difficult to find useful data for good planning, and this data needs to be refashioned frequently - and in many cases it is not currently available. The principle "know well to manage well" and the need to open up the city to its industrial soul has led us to imagine a dynamic and holistic knowledge system that can derive data dynamically from many different sources and, by relating and combining them, produce useful information. This tool (that can be regarded more as a system than a tool) will create the basis of an ongoing process in which technology helps the community to know itself, to make it recognizable to the outside and to its stakeholders, and to allow the community to become aware of its possibility to improve both the quality of the life and production by acting as a whole in sustainable strategies for energy, services, events, to be used and shared . Moreover, the system was planned to be alive: it can grow with new data through technology (interoperability approach), agreements with public and private entities that produce, update and use processed data, and finally through input from the community that the system depicts. This paper discusses the first results of our work that was carried out on real data in real environments. This dynamic approach is also possible because the activity is part of a greater project, "Roveri Smart Village", shared between public and private partners; the purpose is to set up a system based on methods and tools, to support the dynamic transition towards the sustainable smart district of an old industrial area of Bologna by keeping and emphasizing its industrial nature. Against this institutional background, public and private agreements on data access, use and updating have been scheduled. As the activity was started to provide answers to real

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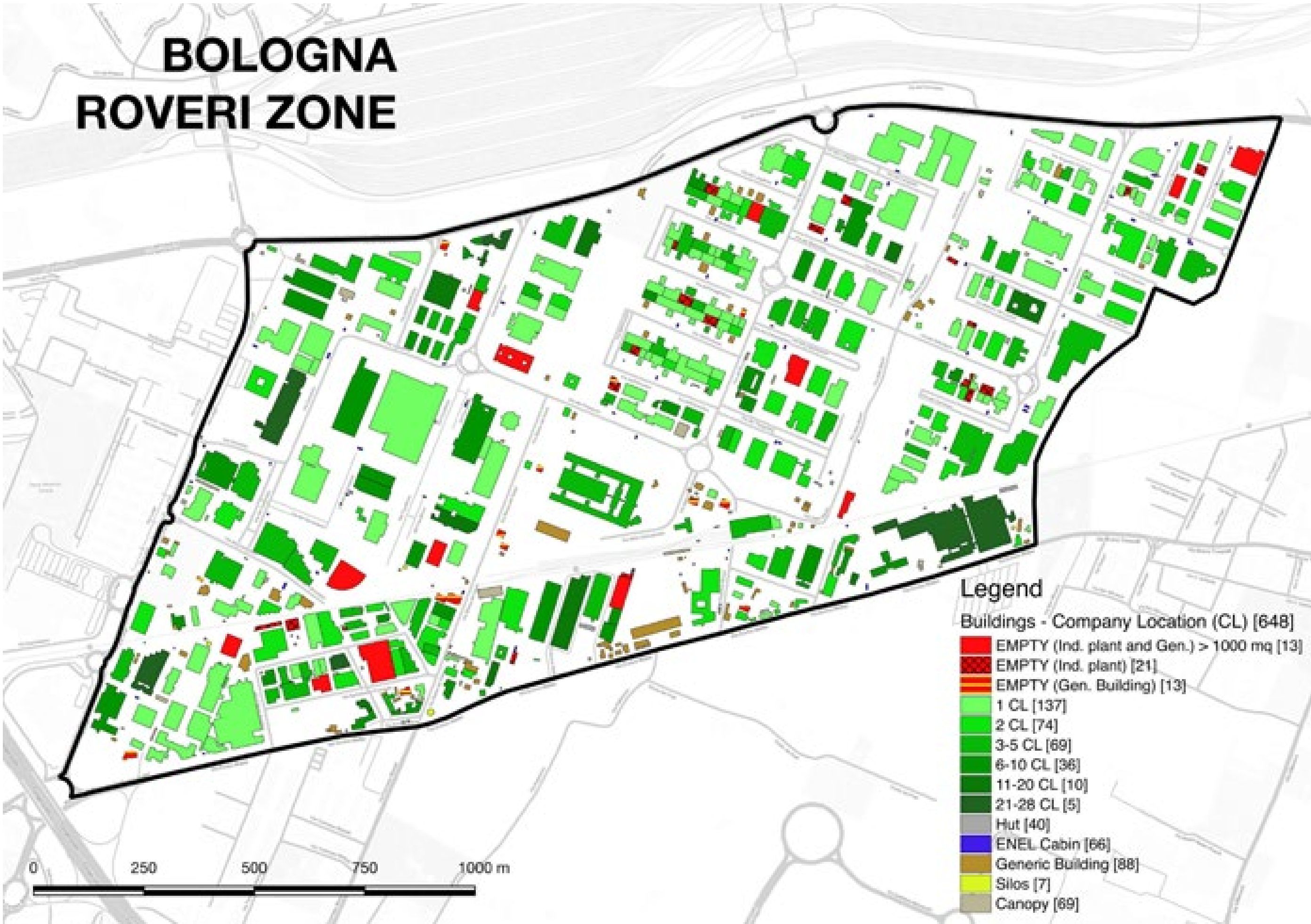

02 | Activities and companies occurrence in the buildings

questions coming both from a community (mainly entrepreneurs) and planners, the first results depict the informative infrastructure for future improvements on energy efficiency, circular economy, sustainable viability topics. But first, some crucial data is needed: what are the companies in Roveri today, and how many are they? What has been the effect of economic crisis on companies? How have they changed over time?

A geographical model to plan strategies for an industrial urban area

To date, we have completed the first tool of the Roveri holistic knowledge system (Roveri Smart Map) that aims to assess and describe the current presence of industries in the district.
We chose geo-data (and methods to relate these) that could allow us and future users to gain results, to update such results repetitively and to grow by using new information mainly referred to productive units (and buildings). Also, the possibility to export our results to other locations guided the data model approach. The majority of data used were made available to the Authors under the institutional agreements of the Roveri Smart Village Project.
The Roveri industrial district is still characterized by its industrial buildings dating back to the 1970s, within the latest industrial planning act approved by the municipality of Bologna; while the activities have changed many times over the years, the built pattern of the area is unchanged.
So, we refer all data and information to the polygons-buildings that design the fabric of this industrial area. With this assumption, we based the data model on these buildings on the geometries

coming from the cartographic database of the Municipality of Bologna (UTM32-ETRS89).

Polygons-buildings are in the original dataset, described by attributes such as univocal code, addresses (street name field, civic number) and main use (text fields). Other attributes are presented in separate shape-files, linkable to the buildings' code, such as streets (line features, with their name attributes), and civic numbers (point features). In a separate file, point features are linkable to data from the municipal technical land register, shown as polygon features that intersect building polygon features (Fig 1).

On the other hand, in order to know which kind of industrial activities was carried out inside these buildings, data on companies were derived from the Chamber of Commerce's dataset updated to May 2017, made available for the project and limited to the Roveri district area by the Metropolitan City of Bologna. These data contain information on all kinds of business companies in Roveri, each classified by name, address (street name and civic number), company's settlement numbers, activity startup and closing date (if applicable) (since 1960), VAT number, ATECO code, identifying the activity standardized category. Such data are not georeferred but contain geometric information that we highlighted through topological procedures. As the relationship between building geometries and companies/activities was not unique, the data were not logically coherent, and many times some pieces of information were lacking (i.e. no company results in a building recognized as an industrial one), sometimes it was duplicated, sometimes it was "combined" (i.e. more than one civic address refer to one company with many different settlements), etc.

Moreover, since logical inconsistencies on street names, civic number formats or company names are frequently the result of data integration, further activity of alignment of data content is essential. A Geographic Information System (GIS) was indispensable to achieve these results; to this end, different software programs were used. Filemaker Pro software was chosen to create a specific application to perform this task. An open-source GIS software, QGIS, was used to create the smart-map with which all thematic geographic relationships were made.

Many data were recovered or selected by means of geocoding procedures that allowed to include and integrate all compound data, referring to the open digital cartography OpenStreetMap® (OSM) licensed under the Open Data Commons Open Database License (ODbL) by the OpenStreetMap Foundation (OSMF).

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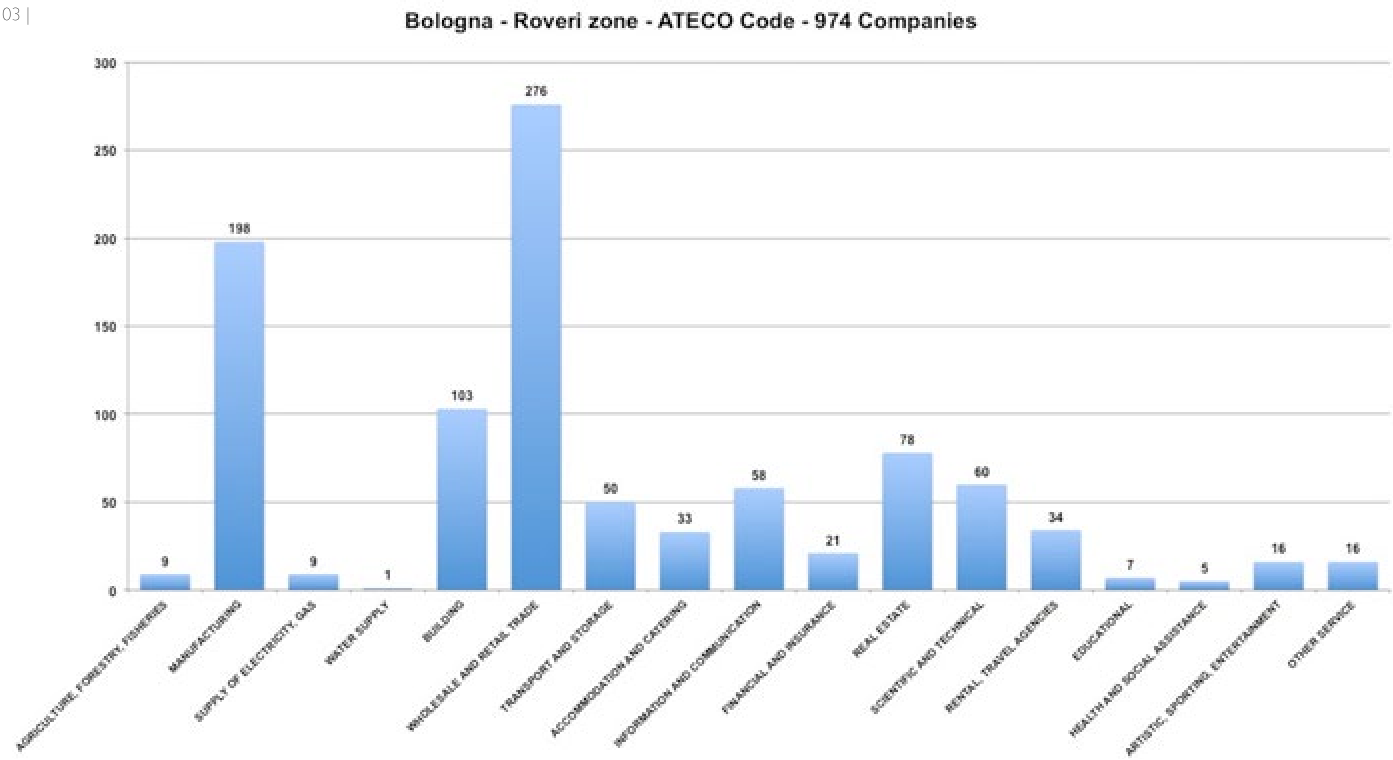

03 | Current activities/companies in Roveri area, classified on ATECO codes

OSM data, although with different archiving formats, libraries (SQLite), coordinates and projection systems (GC-WGS84), are very consistent and have a geometrical congruence to the Municipal features. In addition, Google Maps was used for the web smart-map edition. The geocoding of addresses was implemented through a GIS application, created within the database itself, which reads addresses and converts them, through Google Maps libraries, into two numeric fields, latitude and longitude in decimal degrees, so that eventually they are displayed on a map to see any errors and positions outside of the study area.

Homogenous data were obtained to correlate them and search for errors and duplications through repeatable procedures, created specifically for the management of these different types of data.

Additional tests were also done, not only for errors or failures but also to make company addresses homogeneous with the addresses of the cartographic buildings. Some tests were carried out with field surveys and control via Google Street View, flanking it with the cartography of buildings directly on a special Webgis application. At this stage of data processing, 648 building-polygons were identified, corresponding to 2521 records from the Chamber of Commerce, each describing a real activity in the Roveri district. But still, it is not possible to make a distinction between active businesses and ceased businesses.

To discriminate in a repeatable way the present industrial activity from the past one, and to identify vacant buildings, other complex spatial and logical queries were arranged.

The final results showed 1121 addresses of current activities occupying 331 buildings and related to 974 active companies. Among these, 13 buildings (1 of which is residential) covering an area of over 1000 square meters are empty; 34 buildings of less than 1000 square meters are also vacant, 13 of which are not industrial. The accuracy and complexity of this work allows to appraise the number of activities performed inside the same building and to classify buildings also on this basis (Fig. 2).

In the final smart map for Roveri, every building is linked to its address, type, name, and number of activities or company; each activity (or company) is described through its name, VAT number, ATECO code, startup (or ending) date.

Conclusions

The analysis of activities based on the ATECO code and on the startup and ending of these activities has a great value in order to plan strategies for this industrial area. These data show that despite a great dynamism in the companies represented during the latest years, the manufacturing sector is still the most present (Fig. 3). Moreover, the resulting outline shows how activities are changing in response to the last economic crisis, and how the closeness of the city, together with the decrease in real estate values, has influenced the introduction of new brands and new company models. Data highlight the industrial district dynamism and polymorphism that occur, still now, without any private or public management.

This information is crucial, within the knowledge society, for the planning of smart cities where industrial environments are present, and to plan and manage environmental and energy performances of these areas. We tried to create not only a knowledge tool, but rather a system that can be used to enter, extract and update information on the life of urban industrial settlements. The final aim is to learn how to plan, including multidisciplinary knowledge and citizen involvement, and to allow not only spatial reasoning but also the evaluation of various scenarios and alternatives for territorial intelligence governance (Laurini, 2017).

The Roveri Smart Village Project, which includes the above-described activities, involves researchers, entrepreneurs, and public administration, which represent the necessary condition to concretely implement it. The activity is ongoing to fix tools as living and replicable knowledge systems. The results described in this paper offer local stakeholders the opportunity to know substantial traits of the urban industrial setting that otherwise would not be available. Also, the smart map aims to give visibility and relevance to hundreds of individual companies that are often not sufficiently represented by trade associations. The Roveri community's awareness request was expressed by the active listening approach adopted by the Authors with the purpose of creating a community feeling without any strong management of the community. The Roveri community is very interested in the Project and in the tools presented in this work, which are perceived as a real way to know itself and to make itself visible outside of its boundaries and to the whole city.

Therefore, we will accompany them to use and improve these tools with the addition of additional data that only can be provided by those who live (or work) in the district: security, calamities, traffic, events, job offers, real estate news, etc. At the same time, the results discussed in this paper will lay down the basis to support their broader application in the fields of SME energy consumptions, energy efficiency, circular economy and industrial symbiosis. This chance is coming from European funded projects that the Authors will apply to this district as project demonstration area.

The approach, the procedures and the tool system are suitable to be transferred to other industrial-urban environments, and to be applied on a wider scale to value and monitor the trends of industrial presence, real estate value, etc.

Many of the activities described in this paper were carried out by the Roveri Smart Village management board (following a decision of the Municipality of Bologna) of which Authors are the instituting subjects.

ACKNOWLEDGMENTS OF VALUE

Ing. Giovanni Fini

Technical Coordination of Environmental Quality, Environment and Energy Sector, Department of Urban Regeneration, Municipality of Bologna

The activities described in this paper offer local stakeholders the opportunity to know the substantial traits of an urban industrial setting that otherwise would not be available. The presence of industrial settlements in the urban texture remains insufficiently studied, even though it occurs very commonly in Italy and particularly in the Emilia-Romagna Region.

Knowledge is a key factor to plan and manage environmental performances in these areas. The Roveri Smart Village Project, which includes the results described in this paper, involves researchers, entrepreneurs and public administration at various levels which represent the necessary condition to achieve concrete goals. The tools presented by the Authors have been developed for integrating the existing GI-instruments to be easily and free usable into the planning tools of local stakeholders.

Tiziana Ferrari

General Manager CONFINDUSTRIA EMILIA

This paper describes an initiative that will develop methods and tools that can be usefully used to support some institutional competences within our Organization. The smart map described in the paper, among other things, was designed with the perspective of becoming a reference instrument for energy efficiency and circular economy scenarios, and more in general to support a new planning for the sustainable development of an existing industrial area in transition.

In collaboration with ENEA, we promoted the Roveri Smart Village project, which includes this activity, since its early stages, precisely because we believe that a transversal action of knowledge and applications shared with research institutions, entrepreneurs and administrators can give a new and fundamental contribution to business innovation practices, with the goal of improving the quality and attractiveness of the production that we are interested in providing to our companies.

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The network construction of the "public city". @22Barcelona: a smart neighbourhood in a Smart City

Laura Ricci, Carmela Mariano,
Department of Planning, Design and Technology of Architecture, Sapienza University, Rome, Italy
laura.ricci@uniroma1.it
carmela.mariano@uniroma1.it

Abstract. The metropolitanisation process that affects the contemporany city, climate change, the depletion of ecological and energy sources all demand a unified, integrated and interscalar public government strategy that makes urban regeneration and the restoration of territorial balance its priorities.
Such a strategy has been the benchmark for drafting the 12 priority themes of the Urban Agenda for the EU and policies that aim to promote the smart sustainability and efficiency of cities. In this framework, the @22Barcelona project in Barcelona, presented in this paper, represents an emblematic example selected from the case studies of the "Mediterranean Europe: Strategies of urban and metropolitan rebalancing and the construction of the public city" research project (2016).

Keywords: Public city, Networks, Urban regeneration, Innovation, Environmental sustainability

The "public city" and urban regeneration: in favour of an integrated strategy (LR)

This reflection refers to a part of the national and international research work[1] that its authors have been conducting for many years now regarding the issue of contemporary city government.

The contemporary city seems to be the result of a process of "metropolitanisation" that has changed the structure of Italy's territory and the meaning of problems affecting cities, the environment and the landscape (Oliva, 2010): «A city characterised by an extensively and uniformly "urban" dimension […]; by the unsustainability of its transport infrastructure; by high levels of land consumption; by the structural lack of public spaces» (Ricci, 2017); and by a high proportion of dilapidated, neglected and under-utilised areas.

The spontaneous nature of metropolitanisation - during phases such as the current global recession, the increase in the world population, climate change, territorial imbalances and the depletion of ecological and energy resources - demands a "unified, integrated and interscalar public government strategy" that makes "urban regeneration and the restoration of a territorial balance" its main priorities in order to restore the prospect of fairness, quality and efficiency to contemporary city government.

Such a strategy should envisage a new de-centralised arrangement featuring a "polycentric, sustainable and accessible urban structure" that has been verified in the light of its economic feasibility and social demands (Ricci, 2014) in order to guarantee the right to the city that all communities who live there should enjoy.

Such a strategy should provide an integrated answer to demands for environmental regeneration, social revitalisation and the cultural and economic enhancement of cities, in line with the principles of sustainable environmental and socio-economic development (Sbetti et al., 2016), prioritising the safeguarding and enhancement of identity-forming public assets upon which the "public city" can be newly founded, and a strategy that is broadly in line with EU policies, including the most recent examples addressing smart cities (the Europe 2020 Strategy)[2].

The integrated nature of regeneration strategy, as defined by the European Union (2007)[3] as a: [...] renewal process, i.e. some form of repair or improvement [...] targeted at revitalising problem areas - namely by addressing shortcomings in natural and built environments, heritage conservation, social integration and employment and economic activities - in cities and their surroundings, but also in rural settings represents a benchmark for identifying the Urban Agenda's 12 priority themes[4], designed to provide common solutions that will lead to the regeneration of urban areas and the implementation of best practices.

This is reflected in policies promoting smart-inspired sustainability and efficiency in cities, such as *Smart governance, Smart economy, Smart mobility, Smart environment, Smart living* and *Smart people* (Giffinger et al., 2007), in order to improve living standards and cultural, economic and social growth, such as those funded by the European Commission's Smart Cities and Communities European Innovation Partnership (SCC EIP) and the Smart Cities Stakeholder Platform, along with funding programmes such as Horizon 2020, the Connecting Europe Facility, and the 2014-2020 Cohesion Funds for renewable energy, energy efficiency, smart grids and mobility.

The fine-tuning of this strategy has adopted «[...] the construction of the "public city" as its reference matrix, reviving urban "voids" […] public spaces and services that have fallen into neglect and obsolescence; derelict areas […] railway infrastructure […] and natural features through a compensatory process of regeneration, thanks to the creation of infrastructure, services, parks, social housing and temporary uses» (Ricci, 2017).

The decision to consider the "public city" as a benchmark reaffirms a primary aspect of regeneration not only as town planning strategy addressing the physical, functional side of cities but as a way of promoting social inclusion as well.

The construction of the "public city" comes about whilst keeping three main perspectives in mind: the "structural", "morphological" and "environmental perspectives".

Firstly, it considers the "public city" as a primary structure, a way of guaranteeing more suitable living standards that meet demands for the right to education, health and shelter as well as public mobility, the tangible and intangible access to goods and services and the environment (Ricci, 2017). This perspective focuses on the measures and implementational mechanisms that, as part of a service-providing policy, guarantee both the identification of a system of public areas and their actual acquisition, creation, management and use (Oliva, 2010).

The "public city" is also understood as a way of highlighting the specific features of places as a manifestation of the historical,

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01 | @22 Pla, (Ayuntament de Barcelona)

cultural and social identity of local communities, and as a way of reconstructing links between physical continuity and social integration and between the specific form and cultural identity of a place, as an answer to the fragmentation and standardisation of contemporary cities (Macchi Cassia, 1991; Borja and Muxi, 2001). Last but not least, the "public city" is seen as a driver of sustainable development and environmental regeneration that can implement urban regeneration strategies based on the principles of ecological/environmental potential that connect every town planning and construction project to actions designed to improve the fundamental resources of air, water and land (Ricci, 2014).

The research, its aims and method: in favour of an experimental dimension (LR)

This is the cultural context surrounding Barcelona's @22 project, which is one of the case studies featured in the "Mediterranean Europe: Strategies of urban and metropolitan rebalancing and the construction of public city" research project (2016).
The question of what methodological references and measures should be used to create the "public city" as part of a territorial rebalancing and regeneration strategy is therefore the main aim of this research.
To this end, the research has promoted a discussion amongst international experts, whilst adopting an inductive, reiterated, interscalar and integrated method, calling on different fields to study the issue, aware that the fragmentation of knowledge has proved unable to pursue complex aims, such as those that affect contemporary city.
Interscalarity and integration are guaranteed with the use of three different "levels" of investigation and planning - "vast", "communal" and "local" - and three different complementary and interactive "perspectives": "structural", "morphological" and "environmental". Taking its cue from the current debate and the most important trials now underway, this discussion has ended up identifying a reference framework for constructing the "public city" in Italy and in the rest of Europe, achieved by meeting three requirements.
The first two requirements, "contextualisation" and "operational effectiveness", focus on methodological and practical references that can be traced back to the organisational models adopted for the network construction of the "public city"- which should be applied on the basis of the perspectives and levels identified - starting with the close scrutiny of the ongoing debate and research as well as the best practices to be found in Italian, French and Spanish cities.
Such experiences were chosen from reports by local authorities, operators, associations and trade journals, validating the choice

02 | The transformation of the District of Poblenou,
(Photo Marc Arias)

of best practices through at least three sources that could highlight its innovative nature, any international recognition garnered or its ranking in the field.
The third requirement, "experimentation", aimed to set up a new reference framework for constructing the "public city", starting with the dialectic reconstruction of the interpretational and planning categories identified, which are reflected in strategies, tools and implementational mechanisms that hark back to national legislation in order to contribute to its reform and innovation.
This requirement also confirms the central importance of experimentation in this research, the ethical and civic nature of its efforts, the social aims of the project's disciplines, the relevance of its mission to the management of public assets and the construction of new systems that guarantee high standards of living for the communities dwelling there.

@22Barcelona: the innovation district (CM)

The project for the urban regeneration of the @22 district launched in Barcelona in 2000 is a trial that pre-empts many important guidelines for smart cities and emblematically harks back to the methodological references of this research.
In terms of the requirements of "interscalarity" and "integration", it reflects a town planning process divided up into levels - vast plan, local plan and urban projects - through which the three perspectives adopted - "structural", "morphological" and "environmental" - can be applied[5].
Launched by the Municipality of Barcelona in conjunction with the *Area Metropolitana de Barcelona,* the project aims to create a new centrality that can act as a driver for the entire metropolitan system in the former industrial estate of Poblenou, a 200-hectare site that was abandoned in the early 1980s and nicknamed "Catalonia's Manchester"[6].
Thanks to a change in the *Pla General Metropolità de Barcelona* (PGM) zoning regulations of 1976, the *@22Pla* was drafted with the aim of turning the area into an innovative district that could attract knowledge-based businesses, replacing industrial activities with those linked to the new economy (media, design, ICT, energy). The project involved companies, universities, technological research institutes and business incubators, guaranteeing space, services and incentives in order to create a diverse technological centre that would be integrated in the urban fabric with a high-tech infrastructural network (Pareja-Eastaway, 2017; Jutgla and Pallares-Barbera, 2015; Marti-Costa and Pradel, 2011) (Fig. 1).
The *@22Pla* therefore fosters a regeneration strategy that will be flexible over time, that is suited to the characteristics of the district and that meets the requirements of quality, practicality, in-

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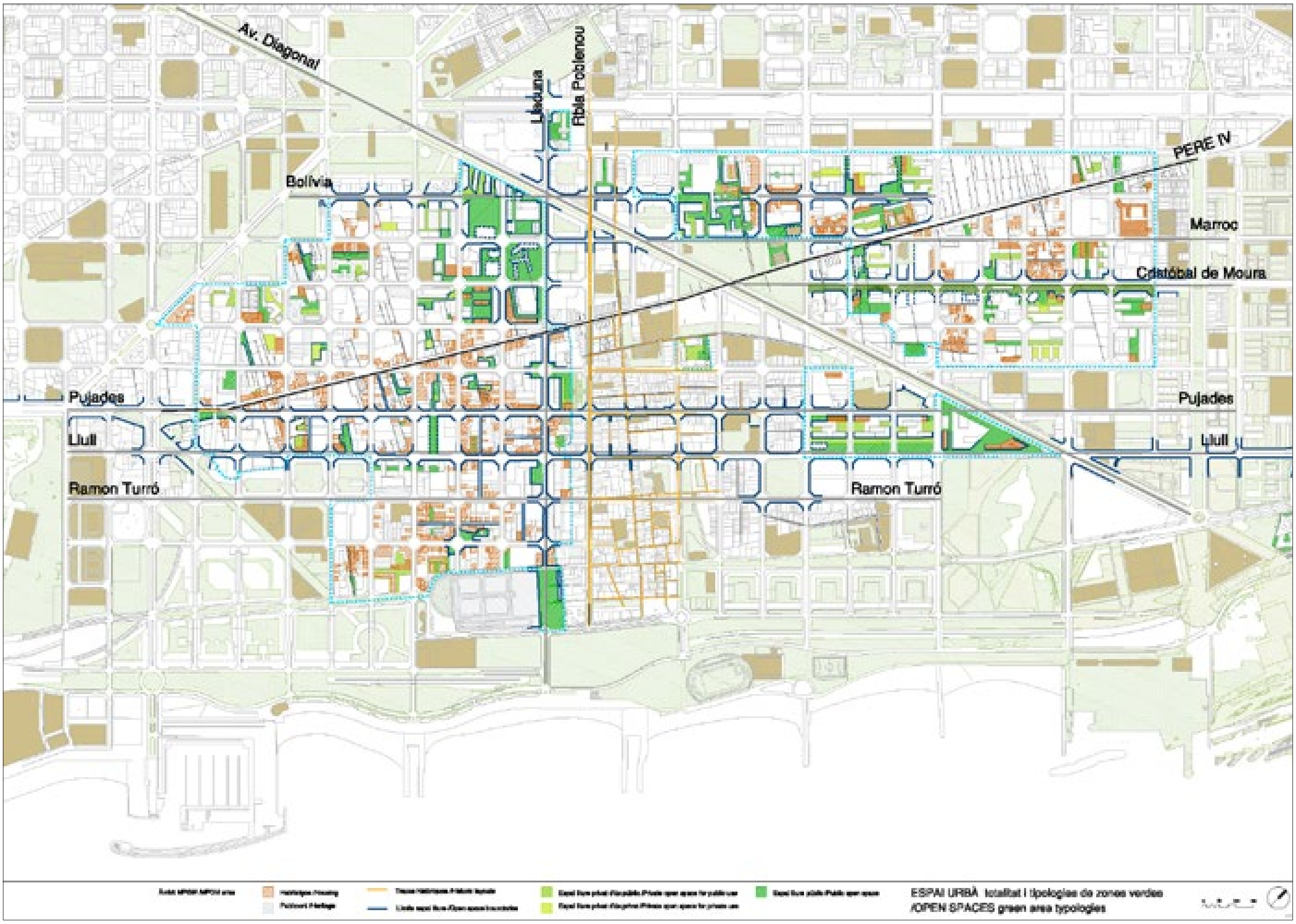

03 | The project for public spaces, (Ayuntament de Barcelona)

novation and integration, whilst preserving traces of the district's industrial past (Morrison, 2017).
Implementation is ensured by a system of working plans envisaged in the PGM (*planeamiento derivado*), known as PERIs (*Plan Especial de Reforma Interior*), which apply to six strategic areas and describe in detail the improvement work to be done at different levels: from the larger-scale aspects concerning adjacent city blocks to a single block or part of it, right down to individual buildings.
As regards the "structural perspective" when it comes to constructing the "public city", as a primary structure for urban and metropolitan rebalancing, the *@22Pla* contributes to the design of the polycentric settlement system of the Metropolitan Area of Barcelona, based on urban and local centres distributed throughout the territory, all of which are highly accessible.
In keeping with this perspective, the presence of public government to ensure the management and supervision of the entire process, the involvement of a number of players (institutions, politicians, operators, experts, universities, associations, residents), the new procedures adopted and the new implementation mechanisms that all combine to focus on a general aim of quality guarantee that the requirements of *Smart governance, Smart people* and *Smart economy* will be met.
The process is a kind of public initiative supported by a substantial European grant and by public-private partnerships, where the local authority is dealing with a brownfield site that is almost entirely private, built up and exceedingly fragmentary.
The project aims to create an ecologically efficient, high-density fabric, characterised by *functional mix* and by the presence of many public services thanks to the way it resorts to implementation mechanisms, such as compensatory acquisition, which have permitted the local authority to receive (in exchange for the increased construction possibilities) 30% of the estate from the developers, free of charge, for public facilities; a proportion of social housing; funds for urbanisation and the improvement of underground utilities (Oliva, 2004) (Fig. 2).
In keeping with the "morphological perspective" when it comes to constructing the "public city", as a matrix for the urban regeneration strategy, for reconstructing the links between physical continuity and social integration and between form and cultural identity, the project aims to regenerate a derelict brownfield site featuring dilapidated buildings and physical, functional and social marginalisation with the improvement and activation of public and private services, parks and social housing, infrastructure and a model of inclusive and sustainable mobility, the fostering of a combination of different residential and non-residential

uses, all with a view to the preservation and enhancement of cultural heritage, of the layout of Plan Cerdà's city blocks and the factories found there (Masboungi, 2010).
The central position of public spaces, the pursuit of urban quality, the recognisability of the layout and the enhancement of the site's identity-forming characteristics all guarantee that the requirements of *Smart people, Smart living* and *Smart mobility* are met.
The layout of collective spaces contributes to social safety and the socio-economic and cultural recovery of the district and is therefore one of the essential axes of the project's spatial design. Parks and gardens are laid out in a sequence of large open areas - the Parc de Litoral, the future Plaça de les Glòries, the Parc Central - which will be linked to smaller city squares and streets in keeping with the buildings, spaces that allow different users to interact (Mariano, 2015) (Fig. 3).
In order to maintain the historical and cultural identity of the area, the urban fabric's morphological features are strengthened by demolishing, replacing and changing the use of buildings and by enhancing monuments of historical and architectural importance, which are the object of specific goals in the 2006 *Pla especial de Protecciò del Patrimoni Industrial del Poblenou*.
As regards the "environmental perspective" with a view to the creation of the "public city"as drivers for sustainable development, the project manifests a direct interest in the hierarchical creation of "ecological networks" through the modification of public transport infrastructure so as to guarantee high levels of social inclusion, the expansion of various different forms of sustainable mobility, the ecological linking of gardens and parkland and the renovation of nearby residual, inaccessible spaces (Gasparrini, 2015; Pareja-Eastaway, and Piqué, J., 2014).
The overturning of the hierarchy that organises the different parts of the infrastructure system in favour of bicycle and pedestrian mobility, the decision to use technological solutions for smart lighting and for managing waste, the monitoring of air quality and traffic flow management all guarantee that *Smart mobility, Smart environment* and *Smart living* requirements are met.
The *Ajuntament de Barcelona* has prepared a special plan for infrastructure (the PEI *Pla Especial d'Infraestructures*) which addresses telecommunications, the water supply, refuse collection, energy and mobility systems in public spaces with the aim of creating both an infrastructural network featuring a highly competitive standard as a distinctive feature of the district that can attract large companies working in the field of know-how, production and new technologies and of testing, in an innovative way, the planning of a system of public spaces that is linked to the infrastructure system.
This gives rise to a new urbanisation model reflected in an avant-garde network of underground infrastructure that connects city blocks and ensures that services are distributed throughout the district, involving the creation of a modern network for energy, telecommunications, teleheating and automated vacuum waste collection, prioritising energy efficiency and the responsible use of natural resources (Oliva, 2004).

The new urban question in Italy: in favour of a structural reform (LR, CM)

This research highlights how the new urban question and the need for a new type of *welfare* require the introduction of an up-to-date concept that, in reaffirming the essential importance of an experimental approach, recognises the new multi-scalar, multi-dimensional vision of cities.
New issues such as the urban repercussions of ecological matters, the role of infrastructural networks in redesigning cities and their economic reorganisation, the strategies of social inclusion and the construction of the "public city" are amongst the essential aims of the Urban Agenda in Europe, of the programmes put in place in cities and the fields of training and research in the foremost educational institutions.
Urban regeneration must therefore take on a central role when fine-tuning the national urban agenda as well, given that it is an essential part of the day-to-day policy governing cities, taking its cue from the details of the Italian legislative framework, aware of how damaging it is to move forward by dumbing down and mechanically accepting European policies.
Therefore the research, convinced that regeneration cannot be achieved without a structural reform of national town planning regulations, has embraced the urgency of launching a process that will review the measures traditionally used to construct the "public city" - which would report to a central government office tasked with managing these issues - in order to implement policies, measures and mechanisms that can make the concept of urban regeneration and "territorial government" a reality[7].
In doing so, it would also acknowledge the repercussions that such a strategy would have on the social and ethical aspects of "project disciplines", highlighting the opportunity to put training courses in place, which are currently lacking in this country, designed to create skills that can be applied to urban regeneration processes.

NOTES

[1] See, among others, the 2012 university research project entitled "La Città sulla Città: Processi di rigenerazione urbana e politiche abitative: costruire il rapporto pubblico/private" (Scientific director: C. Mariano); the 2016 research project entitled "Europa Mediterranea: Strategie di riequilibrio urbano e metropolitano e costruzione della città pubblica" (Scientific director: L. Ricci); and the Sapienza University-ENSA Toulouse 2013 research project entitled "Costruire la Città Pubblica: Strategie e strumenti per il recupero del patrimonio edilizio esistente", UIF, (Scientific director: L. Ricci).

[2] See the European Commission's "Europe 2020: a strategy for smart, sustainable and inclusive growth", Brussels, 2010.

[3] See the European Commission's "State aid control and regeneration of deprived urban areas", Brussels, 2007.

[4] See the Urban Agenda for the EU, "Pact of Amsterdam", 30/5/2016. The 12 priority themes are: inclusion of migrants and refugees; air quality; urban poverty; housing; circular economy; jobs and skills in the local economy; climate adaptation; energy transition; the sustainable use of land and nature-based solutions; urban mobility; digital transition; and innovative and responsible public procurement.

[5] The study involved interviewing fundamental players, including the Direcciò d'Urbanisme, Ayuntament de Barcelona, a group of lecturers from the Universidad Politécnica de Catalunya.

[6] This involves 3.2 million sq. m of land set aside for manufacturing, 800,000 sqm for housing and 120,000 sqm of parkland; over 7,000 companies, 4,400 workers and 90,000 residents.

[7] See the parliamentary inquest into the conditions of security and the state of decay of cities and their suburbs, "Concluding Report", December 2017.

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The @22Barcelona project described in the article is undoubtedly an excellent example of the multi-faceted nature of the most ground-breaking urban regeneration projects, which combine various different fields and scales of work. The attention paid to designing public spaces that are integrated with the city's infrastructural system (mobility, ecological networks, water supplies, ICT, etc.) particularly highlight the usefulness of an integrated approach to town planning that can tackle environmental challenges and climate change with far-reaching repercussions on social aspects, the economy and employment.
The Green City Network promoted by the Sustainable Development Foundation involves Italian cities and intends to support them in implementing these kinds of projects, developing guidelines for green cities that can provide an operational framework for local authorities and other players interested in launching projects featuring multi-scalar and multi-disciplinary approaches like those found in the @22Barcelona plan.
The green, smart city model that the Network aims to support hopes to achieve high ecological quality whilst maximising the social and economic benefits, and allows us to identify priority working axes (environment, resources, climate), enhancing the links between various different fields and encouraging a greater level of cooperation at all levels of territorial government which - as shown in the paper - are essential if we want to launch ground-breaking urban regeneration projects in Italy as well. Furthermore, the act of involving stakeholders and allowing them to participate, as mentioned in the article, and the exchange of best practices as a way of qualifying the "public city" has proved decisive.

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MedZEB: a new holistic approach for the deep energy retrofitting of residential buildings

RESEARCH AND EXPERIMENTATION

padula@itc.cnr.it
picenni@itc.cnr.it
r.malvezzi@certimac.it
l.laghi@certimac.it
jms@us.es
francisco.flor@uca.es
cmateo@five.es
lsoto@five.es
masim@phys.uoa.gr
karlessith@phys.uoa.gr

Marco Padula, Francesca Picenni, National Research Council of Italy, Institute for Construction Technologies
Roberto Malvezzi, Luca Laghi, CertiMaC
José Manuel Salmeròn Lissén, Francisco José Sanchez de la Flor, Universidad de Sevilla, Spain
Carolina Mateo-Cecilia, Laura Soto-Francés, Intituto Valenciano de la Edificaciòn
Maragarita-Niki Assimakopoulos, Theoni Karlessi, National and Kapodistrian University of Athens

Abstract. The MedZEB (Mediterranean Zero Energy Building) approach aims at stimulating the market uptake of energy deep and beyond retrofitting of existing buildings of the Mediterranean. Its holistic nature implies the evaluation and integration of a range of relevant factors and the effective support to the retrofitting supply chain, also with the help of an ICT platform. Main concern of the approach are residential buildings within a framework dealing with High TRL levels and with already on the market technologies to be combined to create Med-specific cost-optimal Packages of technical Solutions, linked to a Voluntary Certification Scheme. The triggered creation of trust and information exchange will pave the way to new investments and strengthen the Med deep and beyond retrofitting network.

Keywords: MedZEB, Energy retrofitting, Holistic approach, Cost-optimal solutions, ICT platform

Introduction

The research & experimentation project described here tackles the reduction of EU building stock energy consumption by introducing a new holistic approach: The MedZEB (Mediterranean Zero Energy Building)[1]. It aims at stimulating the market uptake of energy deep-and-beyond retrofitting of existing buildings of the Mediterranean areas which, with respect to other EU countries, are characterized by many peculiarities: coupling of heating and cooling challenges (BPIE, 2011), prevalence of private ownership, unbalanced income ratio between elder and younger social groups (within the €-area, this holds for Greece, Italy, Spain and France)[2], prevalence of old and modern (up to 1990) buildings (86%). While EU is still facing a low renovation rate (just around 1%) Med countries, on their turn, show a significant gap in the policy evolution of energy savings target at 2020 (almost 5.7%), rising up to 9.6% with reference to the residential stock (E. Tritopoulou, C. Nychtis, ELIH-MED. Med countries face also a delay in the nZEB performance definition (BPIE, 2015), in the introduction of smart solutions for the urban development, as confirmed by the smart cities EU ranking[3], and in the private investments in smart grids (JRC, 2017). Figg. 1-3 show a synthetic review of EU strategies concerning Energy Efficiency of Buildings (EEB); the weaknesses detected correspond to some of the main key issues identified by this project for unlocking the deep-and-beyond retrofitting market.

MedZEB approach definition

The project individuates the Med space as a "catchment area" where common transnational measures can be activated to enable the achievement of general objectives s. a.:

- **reconnecting** the fragmented value chain in the retrofitting market;
- **rebuilding** a framework of trust around the deep and beyond retrofitting market;
- **increasing** the overall convenience and appeal of the retrofitting interventions.

Core of the project is the development of a holistic, transparent and adaptive approach (MedZEB) focused on the residential built stock (private and public) and aimed at providing a generally valid cost-optimal renovation strategy for individual buildings. Main features of the "MedZEB approach" are:

1. **Holistic**. It will encompass and integrate all the most relevant elements of the retrofitting supply chain:
- **Technological aspects**: optimization of available technologies (from TRL 9 to already-in-the-market solutions), to compose cost-optimal packages of solutions according to a "one-stop shop" logic; the set will include passive or natural solutions for energy efficiency, ICT solutions for consumers' awareness energy saving, and smart solutions both at the building (smart monitoring) and at the district (smart grids) scale.
- **Financial aspects**: testing of available innovative financial solutions essential for unlocking the deep retrofitting market uptake. Several solutions (i.e. guarantee and solidarity funds, credit transfer mechanisms, etc.) and models (i.e. ERDF funds, ESCO, mixed models, etc.) will converge into a single tool for identifying proper financing paths. Initiatives s. a. the EU Project "Energy Efficient Mortgages Action Plan" (EeMAP) will be taken into account. Improvements of the current regulatory frameworks will also be proposed.
- **Engagement and training actions**: knowledge transfer and behavioural upgrade for final users (owners and inhabitants), direct training activities for building professionals, entrepreneurs, workers and policy makers.

2. **Transparent**. It will be characterized by three main elements:
- **MedZEB protocol**: guarantee scheme for the good execution of the retrofitting process along the whole value chain; all subjects involved are enabled to cooperate according to shared quality principles and procedures.
- **MedZEB Voluntary Certification Scheme (VCS):** integration of existing EPC schemes referred to relative savings classes, and based on staged renovation pathways. The VCS's scope is to testify the compliance of the interventions with the MedZEB

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protocol and to introduce further quality indicators to create added value for the investments.

- **ICT open platform**. Assisted digital marketplace for matching demand and offer within the Med energy retrofitting market and along the whole value chain, for re-creating and enhancing trust among owners and investors, and for increasing the overall attractiveness of such market.

3. **Adaptive**. Buildings are elements of a wider context with which they interact at many levels, which will be addressed by focusing on:

- **persons: care for well-being**. Increased well-being of closed spaces is an added value for convincing people to undertake renovation interventions, as discomfort is often associated to multiple pathologies (e.g. Sick Building Syndrome, breathing disease, allergies). A modification of the current metabolic standards will be proposed as well, by taking into account the actual values of metabolic rate for females (B. R. M. Kingma, 2015). A MedZEB multi-layer ICT smart control system will be defined (e.g. based on inner and outer temperature, natural lighting and shading, humidity, presence of people, etc.), for the (self)monitoring of consumptions and behavioural enhancement.
- **Resources: step-by-step renovation approach**. Such an approach, already tested in other EU projects[5] and proposed by technical references (BPIE, 2016b), divides the deep renovation process into self-standing interventions on basis of minimum savings and Return on Investment (Fig. 4). In this way, the overall investment can be split along a wider time span with multiple advantages: i) reduced financial intensity; ii) higher grip on savings monitoring; iii) reduction of the perceived risk; iv) mitigation of shortcomings. This approach is mostly suitable in the absence of incentives for deep renovation, but it could effectively target all situations where no one-step intervention is possible. To this extent, every building can be associated to a Renovation Individual Roadmap (RIR, based on the BPIE "building passport"), which will include the cost/benefit analysis of all the renovation steps. Financial and regulatory proposals proposals will be studied in order to support investors to proceed after the first step, by mitigating the "decreasing return law" for reaching the highest standards.
- **Situations: alternative investment options**. Not all buildings, especially in the Med area, have the potential to reach high energy standard; in these cases, MedZEB proposes an alternative investment based on the use of RES. This RESALT concept could be pursued e.g. for fulfilling the last step (= towards nZEB) of a renovation pathway, whenever this is not economically feasible. Alternative investments can be aggregated in joint initiatives at the urban district, thus stimulating the rise

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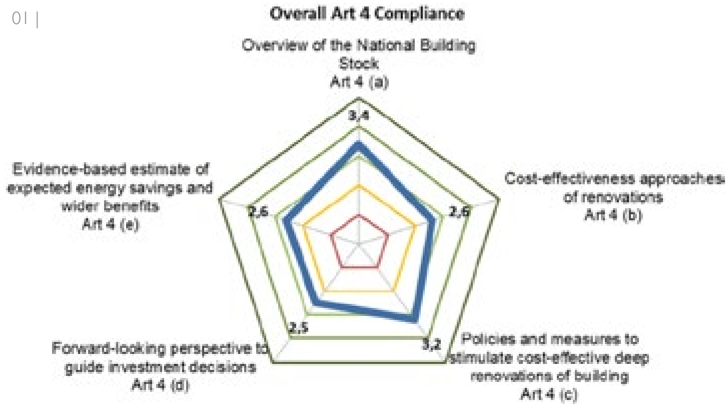

01 | Overall compliance of all EU Member States with the EPBD recast (Energy Performance of Building Directive) Art. 4 (BPIE, 2016)

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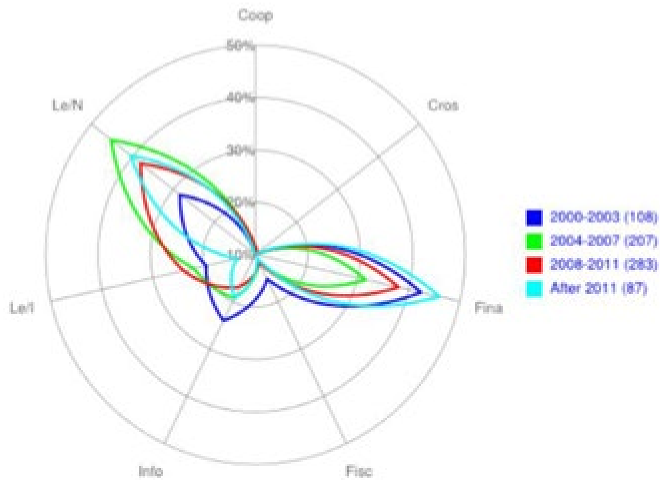

02 | Changes in policy mix in terms of number of measures introduced by type and by period of time[4] (Odyssee-Mure, 2015)

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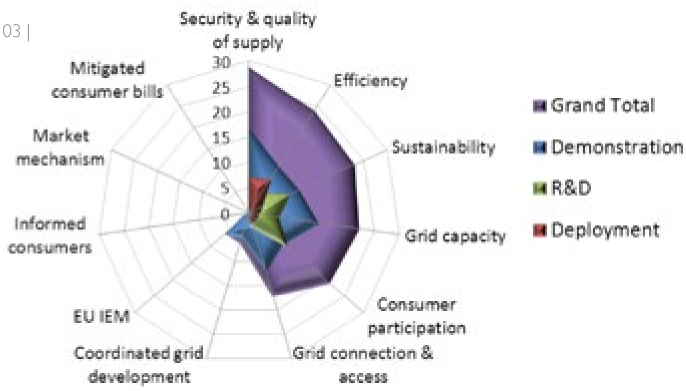

03 | Cumulative benefits effects of smart grids projects across EU (JRC, 2011)

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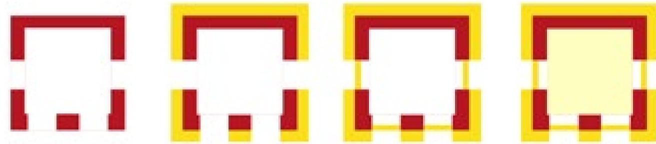

04 | Step-by-step retrofitting concept (EUROPHIT, 2015)

of energy aware communities, such as Local Energy Cooperatives (LECs). RESALT concept complies with the most recent trends on RES integration in the nZEB standard (JRC, 2016).

- **Contexts: smart integration**. The integration of systems across sectors is achieved by assuming a smart grids approach aimed at producing significant energy savings when combined with building management systems. At the building level, a smart monitoring system can cut the annual household consumptions up to 10% in Europe (OECD, 2017). The achievement of ZEB standards requires the integration in the grid of bioclimatic design, EE technologies and RES, as well as the consideration of the following aspects:
  - installation of smart metering;
  - demand response and users' engagement;
  - technical distribution infrastructure;
  - interoperability criteria (D. Kolokotsa, 2016).

  To this extent, MedZEB will draw from the SMART GEMS project, where a large number of case studies (at the building and district level) have been assessed in order to analyse the following aspects of smart grids: improvement of reliability, mitigation of security risks, increase of EE and integration of smart monitoring and control. The iterative approach was based on a three-phase cycle expansion:
  - the users/consumers aspects, mainly focused on smart and zero energy buildings analysis;
  - the smart grids penetration at district and city level;
  - optimization of smart grids operation, enhancement of skills and collaboration (Karlessi et al., 2017).
- **Environments: district scale design**. According to the MedZEB approach, the energy saving starts from the very outside of the building. Indeed, Med cities are well known hot spots: urban heat island effect raises the temperature of big cities by 1 to 3°C. There is an increasing convention that the absence of vegetation and natural shadings, presence of asphalt, concrete, buildings, and other surfaces disrupting the natural cooling effect are the most relevant heat island effect factors in Med climates (Gomez, Salvador & Dominguez, 1998). Basing on this, the MedZEB approach will take into account the following design aspects (also by drawing from the RepublicMed project):
  - **Micro-climatic analysis**: mapping of existing Land Use on GIS platform, and a climatic sub-regioning to identify building energy requirements;
  - **Shading by greening**: reducing the summer exposition through a careful design of the green. Vegetation has a cooling effect of between 1-4,7 C° in 100-1000m (Schmidt, 2006; Norton et al., 2013) and trees shadow on façades and roofs reduces the demand for refrigeration. This means up to 25% of the building energy saving (Nichols Consulting Engineers, 2012) and the improvement of human health and perception of health (EPAOAP, 2008).
  - **Reducing heat islands** by choosing the right pavement. Although there is no consensus definition, cold pavements are those that have less surface temperature and accumulate less heat than traditional pavements through different properties, mainly related to a high albedo and high emissivity (EPAOAP, 2008). Among these, vegetated or non-vegetated pavements allow for a higher permeability of soils.
  - **Natural ventilation at district level**. Urban geometry affects directly urban heat island effect. The most well-known effect is the urban street canyon effect, occurring if a relation H/W>1 exists; it is classified according to the usual relations of H/W and Sky View Factor (SVF) (Ali-Toudert & Mayuer, 2006). The ideal situation for main streets would be east-west orientation, and small connections with north-south orientation, blocking solar radiation with appropriate vegetation (Brophy, et al., 2000). In hot areas such as Med, an H/W ratio>0.5 is recommended to reduce the solar incidence during the day (Shishegar, 2013). A proper design of the outer space can also increase natural air movements, due to the formation of delta pressures between different parts of a neighbourhood.

Tailored	Transparent	Holistic	Adaptive
MedZEB approach	HAPPEN Platform	Engagement &Training	to persons: focus on well-being
		Financing & Regulation	to resources: step-by-step approach
	MedZEB protocol		to situations: alternative investments
		Optimal solutions	to contexts: smartness
			to environments: district scale design

Tab. 1 | MedZEB Approach main features

Tab. 1

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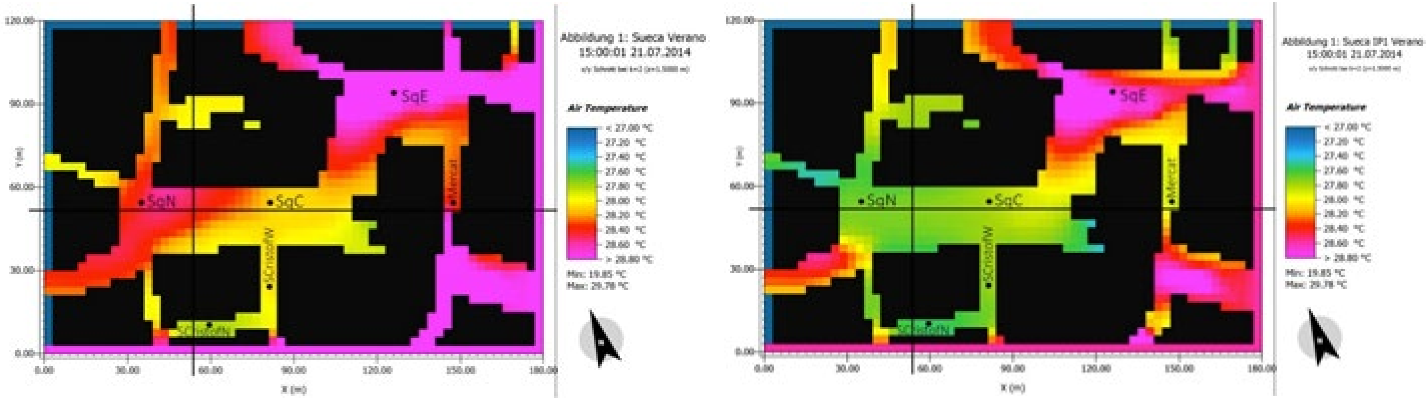

05 | Current Summer State of a real Urban Space (Sueca, Spain) and design scenario, where trees are to be used in the principal square to provide shading and evapotranspiration (Source: Republic Med project)

Research structure

The project goes through a "one-time-last-time" process for producing the most suitable solutions for unlocking the retrofitting market in the Med space. This process encompasses two main parts (Fig. 5):

- **Background Work** (research part): it is aimed at producing a flexible set of integrated solutions tailored for the Med residential built stock; in particular, the work will consist of: 1) an accurate review of the most relevant and up-to-date solutions and 2) an extensive optimization action aimed at producing a flexible set of integrated technical solutions for the Med residential built stock and at defining financial and regulatory aspects tailored for the Med market;
- **Pilots Testbed** (experimental part): the solutions will be tested on real Med pilot case studies, which will also support the incubation of wider partnerships and the increase of exploitation opportunities. Figure 6 reports the expected impacts of MedZEB pilots in the short (2020) and long (2030) term. Living Labs (LL) will be activated in the pilot to support the innovation process, thus de-fragmenting the supply and value chain at local level and supporting the knowledge raising of inhabitants and workers. LL will engage four main target stakeholders (companies, users, public organisations and researchers) in real-world context activities which, according to the 5 Living Lab components (Ståhlbröst and Holst, 2012) will be facilitated by ICT embedded in the HAPPEN platform. ICT will offer new ways of cooperating and co-creating in each Living Lab, as well as across all the activated ones, thus giving access to a multi-contextual environment. A holistic monitoring of the pilots at the home (self-monitoring of the inhabitants), building (aggregated monitoring) and district (smart grids) level will be carried out.

Optimum analysis methodology

Taking into consideration both the cost optimal Life Cycle Cost (LCC) and the holistic impact, the MedZEB holistic approach will identify, for each reference building and in each representative climate in MED countries, an integrated set of renovation measures considering the country specific peculiarities, combined actions on the building envelope, technological systems (including passive solutions), RES integration and measures applied at district level. In order to define such Packages of Solutions (PoS) an optimization methodology, i.e. SEDICAE (Aparicio Ruiz et al., 2014), allows the exact solution to be reached in a very low CPU time. The optimization procedure aims at obtaining the minimum global cost in the life cycle of the building but also the best, i.e. the cheapest, combinations (Pareto Front) for their final energy consumption.

To obtain the optimum solution, the proposed methodology is based on different steps. Conditioning demands, energy consumption and global cost of the initial case are assessed by a detailed software tool and then by a simplified one. A first adjustment of the simplified method is defined. The adjusted simplified method is both fast and accurate and is used for building the Pareto Front (Fig. 7) to determine the best combination of life cycle cost versus energy consumption. In order to identify the Pareto Front, 6 different cases are evaluated, i.e. initial case {1}, minimum global cost case {4} and minimum energy consumption with the initial global cost {6}. The proposed method allows the optimum solution to be found with only 7 detailed simulations: the 6 Pareto Front characteristic cases and the new optimum. Its accuracy is guaranteed by the adjustment and re-adjustment steps of the procedure. By applying this procedure to Spanish reference buildings located in different climate zones (A3-Cadiz to E1 Burgos), it was possible to demonstrate that a 60% energy saving (i.e. deep renovation) may be achieved on primary energy consumption.

06 |

HAPPEN POTENTIAL IMPACT EVALUATION																				
		LEVEL 1. Direct pilot impacts (within the duration of the project - 2020)											LEVEL 2. Expected pilot impacts (2030)							
		FRONTRUNNER PILOTS (FP)			THEMATIC/PERSPECTIVE PILOTS (T/PP)						TOTAL level 1		REPLICATION POTENTIAL (RP)						TOTAL level 2	
	A	B	C	D	E	F	G	H	I	L			M	N	O	P	Q	R		
	Country	ES	FR	IT	SI	HR	HR	GR	GR	CY			ES	FR	IT	SI	HR	HR		
	Partner	EIG	EPA	H&D	ZRM	IRE	IRE	UoA	AEG	CEA			EIG	EPA	H&D	ZRM	IRE	IRE		
raw	Frontrunner pilots + Support pilots	Castellon de la Plana	Mars.	Milan	Brezno	Buzet	Rasa	Athens	Lesvos Paros	Strovo-los			Castellon de la Plana	Mars.	Milan	Slovenia (*)	IRENA (**)	Labin stan LoS (***)		
1	*PPI-A:* Building area involved [m²]	3 698	2 100	4 000	350	1900	829	830	1175	5007	19 889	m²	239 446	32 040	115 500	1 000 000	221 111	29 876	1 637 973	m²
2	*PPI-B:* N° of buildings involved	1	6	2	1	1	1	1	6	2	21	buildings	73	89	75	1 500	96	70	1 903	buildings
3	N° of dwellings	36	34	40	6	-	-	-	-	3	119	dwellings	2 338	535	1 650	17 500	-	529	22 552	dwellings
4	Average area per dwelling [m²]	103	60	100	58.3	-	-	-	-	-			102	60	70	57	-	56		
5	Energy Performance (EPC scheme) [kWh/m²year]	179	198	220	182	84	237	108	150	384			179	204	230	330	156	85		
6	Estimated energy consumption [MWh/year]	662	417	880	63.7	159.41	196.14	89.64	176.25	1921.9			42 861	6 536	26 565	330 000	34 463	2 539		
7	Energy consumption reduction - MedZEB [%]	60	70	60	60	60	60	60	60	60			60	60	60	60	60	60		
8	***PPI-E: Energy Savings triggered [MWh]***	***397***	***292***	***528***	***38.22***	***95.646***	***117.68***	***53.784***	***105.75***	***1153.1***	*2.78*	GWh	***25 716***	***3 922***	***15 939***	***198 000***	***20 678***	***1 523***	*265.78*	GWh
9	***PPI-F: RES triggered [MWh]***	***132***	***62***	***176***	***12.74***	***31.882***	***39.228***	***17.928***	***35.25***	***384.37***	*0.89*	GWh	***8 572***	***1 307***	***5 313***	***66 000***	***6 893***	***508***	*88.59*	GWh
10	*PPI-H:* Greenhouses Gas Reduction [tonCO_2]	134	98	178	12.9	32.3	39.7	18.2	35.7	389.4	939	tonCO_2	8684	1324	5382	66858	6982	514	89 744.49	tonCO_2
11	*PPI-D:* Cumulative Investments by EU stakeholders [M€]	2.22	0.34	2.00	0.10	1.24	0.05	0.10	0.10	0.23	6.38	M€	11.10	5.00	38.50	300.00	44.22	5.13	403.95	M€

06 | MedZEB pilots' impacts

ICT Platform

The development of the HAPPEN platform, a critical factor of this research, will go through four phases, with the aim of delivering a highly usable and target-oriented digital marketplace:

- **scouting/analysis/exploitation**: capitalisation of existing open solutions, with particular attention to those developed by EU funded projects, which will undergo a multi-viewpoint selection process made by energy efficiency, finance, economics, ICT and market experts to identify matches with target users expected needs. As a result, an entry-level platform providing basic functionalities will be delivered as a basis for the co-design activities.
- **Customisation through the Living Labs**: participants give feedback on the general user experience, new functionality desired and other requirements of the entry-level prototype.
- **Co-design sessions**: transnational representatives of the entities taking part in the research and those leading the Living Labs will meet each six months to discuss the implementation of the gathered feedbacks, review and fine-tune the platform's contents and features.
- **Beta-testing with final users**: competent subjects will carry out a beta-testing phase interacting directly with the platform management team through a specific area of the platform itself.

This structured process will bring to the definition of three different usage environments mirroring the research holistic features:

- **How does it HAPPEN?** educational tools and training materials on the deep retrofitting and the MedZEB approach to let non energy-expert users build a preliminary knowledge.
- **What HAPPENs?** cost optimal packages of solutions identified through the research in object will be uploaded to be interactively accessed.
- **Make it HAPPEN!** innovative financial solutions, incentive systems and business model descriptions tested in the Mediterranean space mapped on a Geographical Information System (GIS).

A user configuration tool will guide users through these environments, helping them in the choice of the most suitable technical and financial energy efficient solutions and paving the way for direct contacts with local operators. This platform will incorporate, process and render in a more interactive, usable and inclusive way the results and outputs of the research. Therefore, it will be brought to the market to support matchmaking and decision making processes of both inexperienced and specialists in the deep and beyond retrofitting market of the Med area, thus becoming the EU reference portal for Med Energy deep retrofitting.

Conclusions

In this paper, the essential concepts and methodologies for the construction of a holistic MedZEB approach in EEB have been illustrated. Such endeavour will be carried out in the next three years; its final aim is to activate a Med-scale retrofitting market, based on the awareness that common issues can be addressed

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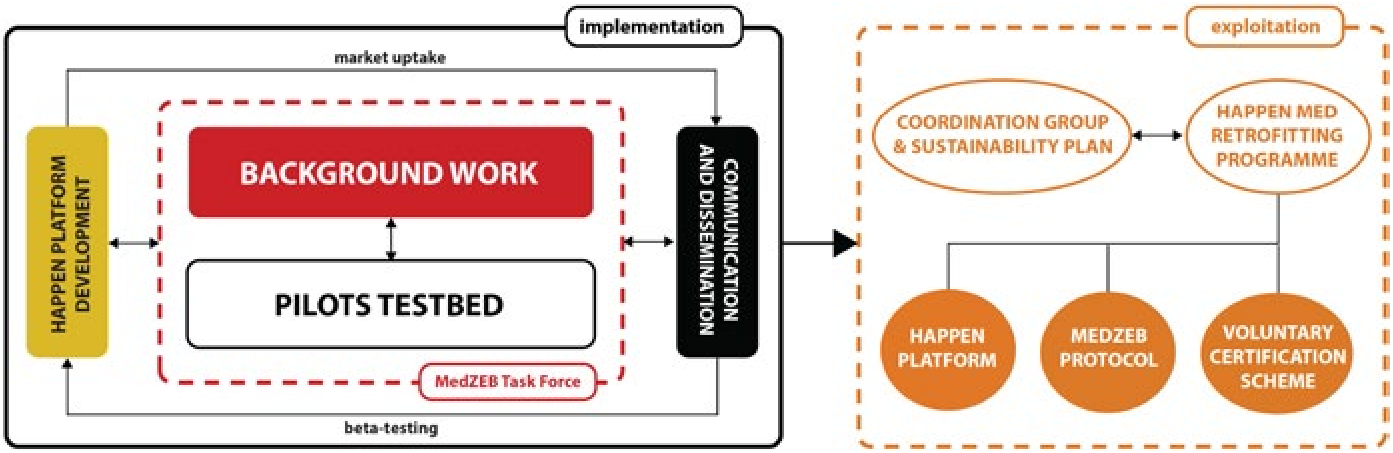


07 | Project Rationale

properly only by assuming shared approaches and solutions. Collaboration and trust become the leading key-words of the MedZEB path by putting men and their living sphere at the core of the renovation market. In this sense, communities, more than consuming individuals, value-chains, more than isolated operators, and neighbourhoods, more than single buildings, are regarded as the proper realms for unlocking the uptake of best practices and high impacts. A pilot testbed will be developed across the Med countries, supported by the HAPPEN platform; acting as a backbone of the project, providing a proper experimentation field for the research outputs and for the construction of MedZEB-inspired networks. On this basis, it will be possible to scale-up the MedZEB approach into a real Med-scale retrofitting programme, where all the results and achievements obtained will nurture the roll out of further opportunities, according to the project motto: "this is the way to make it HAPPEN!"

The authors express their thanks to Dr. Giulia de Aloysio and Dr. Chiara Ugolini from CertiMaC for the significant contribution that has been given.

NOTES

[1] Approach to be developed by the project N. 785072 HAPPEN - Holistic APproach and Platform for the deep renovation of the med residential built ENvironment, Horizon 2020, Call EE-11-2017, April 2018-March 2021; Lead Partner: ITC-CNR.

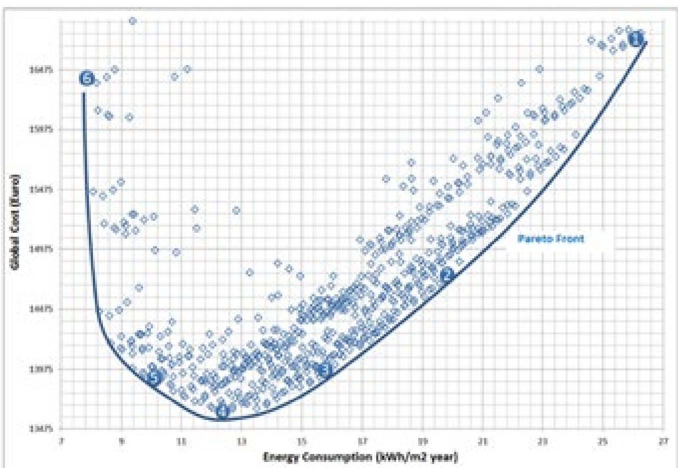
[2] Eurostat: ilc_lvho02, 2014; ilc_li11, 2015.

[3] http://www.smart-cities.eu/ranking.html

[4] Legend: Coop=Cooperative measures; Cros=Cross-sectoral measures; Fina=Financial measures; Fisc=Fiscal measures; Inf=Information/education/training; Le/N=Legislative /Normative; Mark=New market-based instruments.

[5] See e.g. the results from EUROPHIT project (IEE).

08 |



08 | Characteristics cases defining the Pareto Front (Global cost vs. Energy consumption)

ACKNOWLEDGMENTS OF VALUE

César Mifsut Garcia
Entitat Valenciana d'Habitage i Sòl (EVha)

EVha deals both public dwellings and lot development into Valencian Land territory, and currently covers the refurbishment of hundreds of social flats per year. EVha looks with special attention to the development of the MedZEB approach, as it pursues the awareness raising on energy efficiency criteria in a holistic development of refurbishment and building features, thus covering EVha's institutional interests: the definition of nZEB criteria addressing specifically the Med area, to be called for compliance treating to companies and professional formation on them, and the behavior re-education on those matters in collaboration with tenants and cultural and neighbourhood associations. EVha is also interested in assuming the research results, apply them within a first intervention and extend them to further locations. EVha believe that the greatest challenge in sharing these new MedZEB criteria is the exchange of knowledge among partners from the same geographic conditions in our Mediterranean area. To this extent, we think that the creation of the HAPPEN platform will be an indisputable added value of this experimentation.

Alexandre Sorrentino
Direction de la stratégie et de la prospective
Établissement Public d'Aménagement Euroméditerranée (EPAEM), Marseille

The target to be reached, also in the case of the energy renovation challenge of the Med built environment, must be that of establishing a contextual model that specifically takes into account climate, sociological, geo-graphic and social background of the population, as well as the characteristics of their houses. The way to achieve such recognition of a model or practices is to test together, to find answers to the price-quality-sustainability-comfort equation. This is exactly what MedZeb aims to do. As an urban planner, our practice is as much about new construction as renovation of old housing in Marseille, a 26-century-old city. Taking part in an experimental approach such as MedZEB should allow us to deal more effectively with the renovation of old buildings while preserving their architectural values. Working in this way will allow to engage the population not as a sum of consumers, but as a community, thus enabling the coupling of smart solutions with the enhancement of smart citizens, and activating district-scale effects. The diversity of partners of the MedZEB project is an asset for the success of this project with ambitions and common causes: find replicable solutions to the problems of energy renovation of old buildings in Mediterranean cities. It is a challenge and an imperative, at the same time, to ensure a transition towards a more sustainable urban living quality.

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The role of IPES social housing in the EU Sinfonia Project for a "Bolzano Smart City"

Michela Toni, Maddalena Coccagna,
Department of Architecture, University of Ferrara, Italy

michela.toni@unife.it
maddalena.coccagna@unife.it

Abstract. Bolzano is experimenting an integrated approach to improve the quality of life and to implement the features of sustainability; within 2018 it will become, together with Innsbruck, the first "smart city" in Europe in the framework of the European Sinfonia Project. In this in-depth analysis, the role of IPES (*Istituto Edilizia Sociale Provincia Autonoma di Bolzano*) has been studied within the design Project of two specific sites. The general aim is to understand how the construction process has been implemented by the Institute, highlighting both any possible boundary to the development of energy-efficient solutions on an urban scale learned in parallel with the economic and social impact of the design itself.

Keywords: Bolzano Smart City, IPES multivariable approach, Social Housing, Sustainability, Innovation as process

The study of the experimentation taking place in Bolzano should be important if wondering about the challenges arising from of a "smart approach" in a city development. The city candidate several social building and urban infrastructures to the European Sinfonia Project "*Smart Initiative of Cities Fully Committed to Invest in Advanced Large-scale Energy Solutions*"[1], to be the first medium-sized European city (together with Innsbruck, in Austria) to test urban-scale strategies for a sustainable "smart" residential model. Sinfonia, co-funded under the 7th Framework Programme through the competition "*Energy - Smart Cities & Communities 2013*", brought to Bolzano 8.7 million Euros of the European Union out of a total actual cost of the activities of 30 million, with a substantial contribution from other regional and national promotional measures and from the own funds of the Bodies involved.
The "Smart" choice of the area is based on activities having an immediate impact on citizens, thanks also to the innovative boost promoted by research centres and public bodies on the production system and the designers, the so-called "*cooperation at triple helix level (government, academy, industry)*" (Vettorato, 2017). Throughout the European Region Tyrol-South Tyrol-Trentino[2], this kind of strategy receives substantial backing thanks to the co-existence of many other activities co-financed by the Autonomous Provinces of Trento and Bolzano, by partly state-owned companies and by the European Community, which are highly complementary to one another. The work of making the innovation systematic is therefore taking place here in areas larger than the mere city and that can be recognised by their cultural, social and geographical identities.
It actually criticized the effective contribution of the so called "smart urban declination" to meet the living needs within the urbanised environments. The American writer Bruce Sterling, who teaches "Media and Design" at the European Graduate School, recently made a severe analysis about the socio-economic consequences of a 'global connection' in terms of divide in technology, people control and risk of marginalization (Sterling, 2018). Moreover, looking at Europe, we are well aware of the role of "smart" approaches and digital technologies on the fragility of cities, affected by: change in population, people aging, new flows of immigrants, obsolescence of buildings and infrastructures (functional and technical) and demands for a better connection between new economies and suitable conditions to develop them (regulations, networks, etc.).
Focusing on a "smart vision" of the city just on energy-related aspects, as defined by the European Sinfonia Project, entails the risk of taking care of technical benefits, from the functioning of urban systems and infrastructures to that of housing and components to test a scaling, from the city to the building, but outside a real global effect on the modification of living styles. In this framework IPES exploits the chance of a European comparison between energy efficiency model to emphasise its own specific aims of social cohesion, building quality as a whole and economic management of their real estates.

Bolzano Smart City

In Bolzano, several organizations are taking part in the Sinfonia Project: EURAC Research[3] (*Accademia Europea di Bolzano*, district leader); the Bolzano City Council[4]; IPES[5] (*Istituto per l'Edilizia Sociale*); Alperia Spa[6] (former SEL Spa); Agenzia per l'Energia Alto Adige-CasaClima[7] and the TIS Innovation Park[8]. Started in June 2014, the "pilot" stage will end in May 2019.
The project concerns both the refurbishment of existing social building complexes and measures for improving the efficiency of service networks on an urban scale.
IPES, the largest builder in South Tyrol and expert in social building, alongside the Bolzano city council, within all planned networking activities, aims to lower the energy consumption of its real estate of 40% and to bring the availability of renewal sources up to 20% by cutting energy consumption, providing links to district, photovoltaic systems, SWH systems and LEDs for both street lighting systems and the common areas of requalified buildings. The final results will be checked by the Alto Adige CasaClima Energy Agency, to refine the new Certification Standard for Refurbished Buildings ("CasaClima R"[9]), so as to calibrate the potential improvement of performance achievable by existing buildings.
The activities on an urban scale include intelligent devices installed by the Council, 150 totems providing LED street lighting, in addition to allowing recharging of electric bicycles and (one out of three) also of electric cars. They will be installed on the outskirts due to reasons of safety of the inhabitants, along cycle paths and within the Sinfonia building refurbishments. This approach to "smart points" suggests for a new path for urban design aimed at safety and not just on energy purposes.
The specific attention on environment has been translated, in Sinfonia, on analysing new methods to increase renewable

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01 |

01 | Demonstration for designers, condominium managers and tenants, showing the innovations applied to the IPES building complex in Bolzano (Via Brescia) within the Sinfonia Project

sources and to reduce air pollutants. This section of the project is based on the Council's plan already taking place to provide connections to the district heating system (not included in Sinfonia as it has already been financed), alongside the monitoring by EURAC of the environmental performance of the activities, by lowering nitrogen oxide levels thanks to the new LED street lighting, to promotion of electric transport systems and to district heating of homes.
EURAC coordinates the monitoring of all the project's activities and feeds back the results, through the multi-factor "Activity Schedule" envisaged by Sinfonia, to be a base for similar experiences in the five European cities due to follow Bolzano and Innsbruck (the so-called "Early Adopter Cities": Boras, La Rochelle, Paphos, Rosenheim and Seville) and then many other "Replication Cities", already applying to join the project.
As in all European projects, great attention is paid to the demonstration of the "work in progress", developed here by EURAC supporting IPES, by scheduling Study Tours during which technicians and trainers are available to illustrate (above all to private designers and condominium managers) all the improvement activities carried out and the technologies adopted, using a demo home and illustration panels. The work done with the inhabitants, guided by designers, is addressed to a participated planning of the districts as a whole that should be better analysed as soon as all meetings took place. The stages explained during the field tours include, as an example, the opening times of the windows to be correlated with the forced ventilation, the care of the insulating cladding and the layers of vertical and horizontal closings, with a set of models made by the winning building contractors (Fig. 1).
The driving role of IPES proceeds according to the EU's indications focussing on global local conditions: «The main policy goals are to spur novel solutions and partnerships to urban challenges and to create an open community of practice»[10] (European Commission, 2013).

IPES's multivariable approach

The peculiarities of IPES's working method contribute to a decisive extent to achieving the aims of Sinfonia.
The Institute defined the minimum design standards and managed the works, thus closely monitoring the progress and the outcomes of the choices made, leaving to outside professionals (selected through design competitions) the developing of new functional and architectural models.
The design work is guided by IPES *Technical Regulations*, including *Design Criteria and Standard Technical and Construction Solutions,* a document continuously up-dated in parallel with the Institute yearly experience in construction and maintenance activities. This method can be defined a "multi-variable approach", relating the requested levels of quality (referred to energy saving, safety, exploitability, etc.) to the available economic resources, using unit prices defined in the feasibility plan. This strong shift towards the contractor of the responsibility for checking the preliminary project is currently in line with the latest ANAC provisions for national public contracts.
While in the *Preliminary Project* stage IPES works towards obtaining the best quality/price ratio, it is in the following stages of the *Final Project* and the *Executive Project* that preparation of the design strategy, on the basis of which the contractors are able to formulate their offers, is achieved.
Also when it comes to contracting out the works, planning how the worksite is organised and working out the *detailed calculations of measurements* and the *estimated measurements*, the contractors can propose solutions in terms of quality (70 % of the score) and of prices (30% of the score). IPES provides, as a basis for the calculations, a set of *Selected items of the specification*, including standard materials and building systems to be used, together with the relevant *Unit Prices*.
One tender after the other, the feasible solutions at the disposal of IPES increase, thus improving the reliability of its decision-making process (requisites, performance, cost), having more available choices at the time of the executive project, when specific importance can be attributed (and it has to be properly managed) to different factors such as low energy consumption, the guarantee of durability and maintainability (simple and inexpensive).

02 |

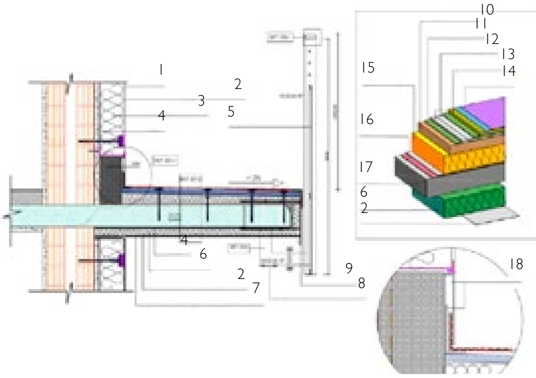
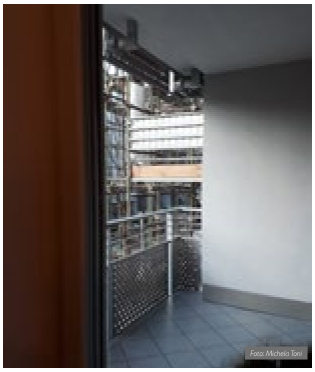
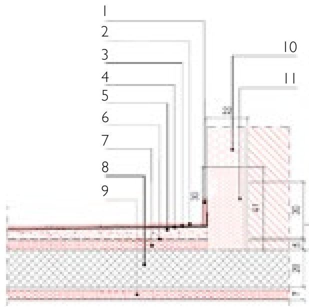
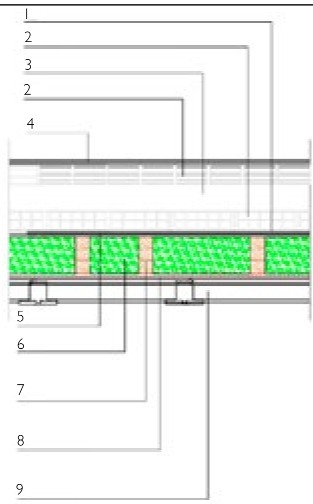
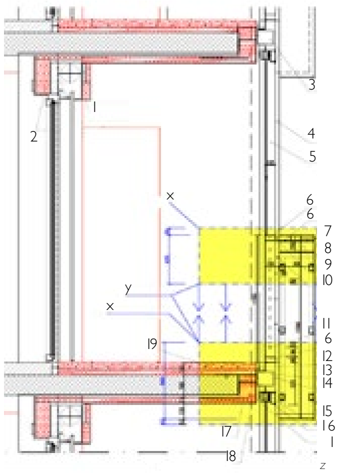
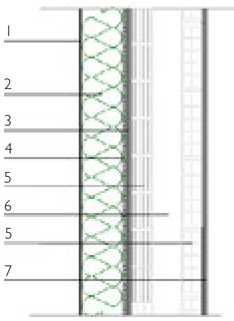
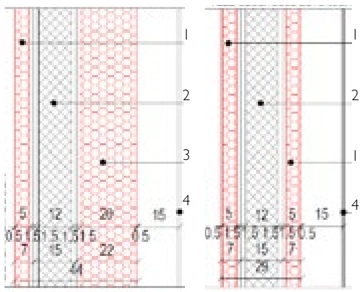
	Europa-Novacella Quarter, via Brescia 1-3-5; via Cagliari 10-10/A	Don Bosco Quarter, via Similaun 10-12-14
Map Plot map		
Gross volume	31,700.00 m^3	16,798.00 m^3
Gross surface	9,402.54 m^2	4,863.53 m^2
N. of dwellings	106	59

02 | IPES's complexes in Bolzano involved in the Sinfonia Project

Faced with solutions that have already been verified, the contractors can suggest variants, showing their ability to provide a better quality/price ratio. Offering solutions better than standard quality can enable contractors to be awarded a contract.

The technological culture of social building

To illustrate this multivariable approach, the complexes in Via Brescia and in Via Similaun in Bolzano, requalification of which as envisaged in the Sinfonia project were chosen as examples of activities. Their requalification has almost been completed, without making the inhabitants move out[11] and safeguarding the comfort of the inhabitants during the building works (Fig. 2). The activities were planned by Studio Tecnico Vettori and Area Architetti Associati, both of Bolzano.
The study was developed by visiting and investigating in depth two of the worksites chosen as study cases, so as to evaluate in the field different design strategies. One of the means for acquiring knowledge consisted of interviewing parties such as designers, site engineers, persons in charge of the single activities and the Project Manager following all the experimenting for IPES. This analysis followed the in-depth investigations into the field of construction in South Tyrol and of IPES's work, which have already been published (see references).
The works with people living in the flats, in order to lower the social impact but also to save the costs for moving people away, led IPES to promote site management techniques keeping the inconvenience for the inhabitants, the length of the stages of work affecting the single inhabitants and the interference inside the common areas, to a minimum. Indeed, when evaluating the bids, at the time of awarding the works to the contractors, in both cases analysed, it was precisely the organisation of the site that rewarded the winning contractor.
The accessibility of all the homes and the usability of the services is guaranteed by the contractor, in one case with a site elevator and personnel available 24 hours a day to help the inhabitants and, in the other one, with the installation of temporary kitchens outside the buildings.
The experimenting with the buildings included in Sinfonia, now half-way along its path, enabled definite synergies to be developed between requalification of buildings (comfort and maintainability) and of the district concerned (social safety and improvement of formal quality) and then of the whole city (intelligent public lighting, studies for up-grading the existing district heating network and for lowering nitrogen-based pollutants).
At building level, both projects called for better control of the common areas, thanks above all to closing of the condominium areas, stronger lighting and use of LEDs in the common parts as well as requalification of the green areas.
The configurations of the two projects can be grasped with the formal features distinguishing them, without any prejudice for the similarity of the energy performance and comfort (Fig. 3).
The demolition of the concrete parapets on the balconies has been planned so as to ensure a continuity of the external insulation of the walls and floor flabs, replacing them with lighter materials. In particular, in Via Similaun, a new façade system realized with a steel structure anchored to the building supporting a wooden sun-screens, provides a solar control and the integration of solar heating systems.
Lowering of the energy consumption is envisaged in both buildings, from 180 kWh/sqm per year to about 20 kWh/sqm per year (Fig. 4), as well as the installation of roof-photovoltaic and SWH panels. In addition, in Via Brescia a new multi-purpose façade with SWH has been installed on the South side (Fig. 5).
The great insulation of buildings and the high percentage of en-

	Europa-Novacella Quarter, via Brescia Images: © Studio Tecnico Vettori	Don Bosco Quarter, via Similaun Images: © Area Architetti Associati
Balcony refurbishment (thermal bridge)	  1 Paintwork 2 6 to 7-mm thick silicate plaster 3 16-cm thick rockwool 4 Adhesive 5 3-mm thick rockwool panel 6 5-cm thick rockwool panels 7 Enamel paint 8 Corner for hooking the parapet 9 Aluminium cover 10 Fibre-cement panel 11 Primer 12 Waterproofing 13 Self-levelling layer 14 Finishing of creative design 15 Insulation with slope 16 Separating layer 17 Floor slab 18 Aluminium flashing	 1 Porcelain stoneware skirting 2 Porcelain stoneware tilles 3 Cement-based adhesive 4 Elastic two-component waterproofing liquid 5 Concrete screed, slope 1 % 6 Separating layer 7 5-cm thick XPS panels 8 Floor slab 9 5-cm thick rockwool panels 10 20-cm thick rockwool panels 11 30 cm high XPS skirting 
Multifuntional Façade and wall section	1 Plaster 2 Wall made of hollow bricks, 10 cm 3 Air space, 6 cm 4 Inside plaster 5 Adhesive 6 15 cm thick rockwool panel 7 6x16 cm wooden uprights 8 Windproof membrane 9 Solar collectors 	 1 Cables for wiring system 2 Controlled mechanical ventilation built into the box 3 Anchor plate 4 Main front upright 5 Intermediate front upright 6 Metal section, 50x100 mm 7 Metal section, 50x200 mm 8 Metal piece, 100x300 mm, with drip edge 9 Bracket 10 Bracket box 11 Metal rod, Ø30 mm 12 Water drainage channel 13 Bracket 14 Metal curtain 15 Metal box with substructure for stiffening and drip edge 16 Motorised roller blind 17 Flat hot galvanised steel section for supporting floor 18 Stainless steel drip tray section on ends of balconies X Sample to be made Y Parts to be joined together
Wall section	1 5-mm thick silicate finishing layer 2 Feldspar rockwool panels, 16 mm thick 3 Plaster 4 Adhesive 5 Partition made of hoolow bricks, 10 cm 6 6-cm air space 7 Inside plaster 	 1 Rockwool panels, 5 cm 2 Existing plastered reinforced concrete wall 3 Rockwool panels, 20 cm 4 Aluminium sheeting as coating

03 | Technical details of the designed building works

04 |

	Europa-Novacella Quarter	Don Bosco Quarter
Energy consumption Before	220,78 kWh/m^{2}yr	211,93 kWh/m^{2}yr
Energy consumption After	61,00 kWh/m^{2}yr	61,34 kWh/m^{2}yr
Total Building Energy Use After included RES *	48,53 kWh/m^{2}yr	43,61 kWh/m^{2}yr
RES contribution	54%	58%
Global efficiency	15,91 kg CO_2/m^{2}yr	13,55 kg CO_2/m^{2}yr
* RES (Renewable Energy Sources)		

04 | Energy performances of the complexes before and after the activities

ergy coming from renewable sources leads to a drastic drop in the need for heat (Fig. 6). On the other hand, this led to critical issues when evaluating the effectiveness of the parallel urban-scale solutions aiming at increasing energy production (such as district heating, co-generation and other solutions), not needed by the designed building improvement.

In any case, the ex-post checking of the results, from May 2018 to May 2019 (so as to take all the seasonal factors into account) will place other data at disposal for further processing. To do this, sensors have been applied inside some of the sample flats (chosen at random but trying to distribute them in different parts of the building). These devices for monitoring the tempera-

05 |

05 | Building works on the multipurpose façade in Via Brescia

ture, the moisture of the air, the ventilation performance and the opening of the windows, managing the data on a practically constant basis (data acquired every 5') by the system kept by IPES. Alperia, on the other hand, will take care of energy monitoring referred to the continuous consumption of both the buildings and the sample flats at a city level (therefore including the houses requalified by the Bolzano City Council) and also taking into account the data from the district heating network.

Conclusions

Everything described here, from the network among partners to the use of a multivariable method for defining and controlling the projects, from care for on-site organisation and safety to keeping inconvenience for inhabitants to a minimum, to the reduction of energy costs for users, of air pollution and of IPES's management costs (also with ex post checks), makes the IPES's experience a work method to tend towards, and the reliability of which can only inspire confidence on the part of other builders, whether public or private, that the effort made is worth the time it takes and the skills needed.

NOTES

[1] Sinfonia. Low Carbon Cities for Better Living (www.sinfonia-smartcities.eu).

[2] In 2011 the EUREGIO-GECT was founded, based on the Regulation No. 1082 of the European Parliament. The purpose of the EGTC is to foster and facilitate trans-border, trans-national and interregional cooperation between the Tyrol, South Tyrol-Alto Adige and Trentino (http://www.europaregion.info/en/egtc.asp).

[3] www.eurac.edu

[4] www.comune.bolzano.it

06 |

06 | Building improvements: Via Brescia and Via Similaun

[5] www.ipes.bz.it

[6] www.alperia.eu

[7] www.agenziacasaclima.it

[8] www.tis.bz.it

[9] http://www.agenziacasaclima.it/it/certificazione-edifici/risanare-con-casa clima-1257.html

[10] *An integrated Research and Innovation Framework for Smart and Sustainable Cities intends to: · Better coordinate, streamline and focus the existing and future research and innovation activities and initiatives on urban issues across Horizon 2020 and future Framework Programmes. · Enable a sustainable and systemic approach to innovation, by fostering co-creation, codevelopment and co-implementation with different actors and citizens in cities across the Union and worldwide. · Develop new business and governance models, mobilise new partnerships and investments, and facilitate market uptake of visionary solutions and approaches needed to enhance urban resilience. · Provide the knowledge and evidence base to inform decision on investments in key infrastructure for cities and urban regions as well as to inform policy-making, planning and land use management. (European Commission, 2017).*

[11] Only about 5% of the flats were empty at the time of the works, a physiological percentage due to the rotation of tenants.

ACKNOWLEDGMENTS OF VALUE

Institut für den sozialen Wohnbau des Landes Südtirol

Social Housing Institute - Südtirol

We feel that it is useful to let the working method of IPES become known outside South Tyrol, because promoting cultural exchanges is fundamental in order to let the Institute's commitment in the field of social housing in which it is active grow constantly. In this respect, contact with the architect Michela Toni, professor at the Department of Architecture of Ferrara University, is of interest for us. Since 2006 she has been carrying out research in the field of constructions in South Tyrol, and during this period has written texts and organised study trips for the students attending her courses, creating a bridge with the university that, ever since it was first established, has repeatedly been found the leading Italian school of architecture (see "Valutazioni Censis, Centro Studi Investimenti Sociali").

We are currently particularly pleased that Michela Toni is carrying out research into the role of IPES in the framework of the experiments of the European Sinfonia Project, involving profitably in this activity also a colleague from her own Department, the architect Maddalena Coccagna. We therefore have a positive feeling that the opportunity of this international issue of TECHNE was grasped by the two university professors to summarise some of the results of their research activity on the Project under way, for the benefit of a public of experts.

We find the contribution of Professors Toni e Coccagna effective since:

- it makes it possible to understand how the evolution of Bolzano towards becoming a European "smart city" benefits specifically from the experience acquired over the years by IPES in the construction of buildings of high quality from the points of view of energy and maintenance, setting the goal of developing social relations among the inhabitants;
- it goes into the details of the holistic approach to technical and procedural solutions, of which IPES's leadership is confirmed;
- it puts forward some important initial critical thoughts about the deep-reaching meaning of a smart approach to the transformation of cities.

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Tools and techniques supporting new nZEB design methodologies in Mediterranean climate

RESEARCH AND EXPERIMENTATION

Alessandro Claudi de Saint Mihiel,
Department of Architecture, University "Federico II" of Naples, Italy
alessandro.claudi@unina.it

Abstract. The paper refers to the final phase of the Smart Case research project "Innovative solutions for the optimization of multi-functional primary energy consumption and indoor living conditions in the Building System". The aim of the research was to develop tools and methodologies to support and orient the design of new buildings in the Mediterranean area, with regard to the selection of envelope technologies for the best overall energetic and environmental performance of the building system. Further research developments on the topic may concern actions aimed at moving from the Nearly Zero Energy to the Plus Energy model. The interaction between the building and the smart grid will be one of the main aspects to be investigated with a systemic perspective towards smart cities.

Keywords: nZEB, Energy efficiency, Building envelope, Smart building/grid

Scenario

The current debate on the need to express the energy-environment-development trinomial with the aim of safeguarding the planet, saving resources, guaranteeing comfort and safety conditions, highlights the need to identify appropriate design strategies and methods of intervention able to seize the opportunity to set up new built spaces.

The components to be considered in a process of transformation towards a smart city are complex and numerous; they concern the development and implementation of new technologies, new practices and governance procedures, such as the definition of new energy policies, land management, transport and services, but also aspects related to emerging areas such as green and low-carbon economy, mitigation and adaptation strategies to climate change, social inclusion and local development, environmental protection and resilience of the built environment (Claudi, 2014).

In this scenario, the paper refers to the final phase of the Smart Case research project[1] "Innovative solutions for the optimization of multi-functional primary energy consumption and indoor living conditions in the Building System" (PON R&C 2007-2013) developed within the STRESS Scarl Consortium, a high technology District for sustainable buildings, which has represented a research path in which the technology transfer process, in the sense of transmission of knowledge and skills, has conveyed a technological innovation based on advanced aggregation methods and on "networking" capability between the business world and research structures.

The research areas have focused on topics in which some technical inadequacies related to the current design and construction practices are critically considered, aiming at the use of new and more efficient technologies for the performance improvement, not only oriented towards the optimization of the energy aspects, but also to the overall quality of the building system. This is possible through integrated design interventions aimed at overcoming a linear concept of the design process and through the ability to prefigure and verify the effectiveness of the transformations in projects simultaneously carried out on multiple levels and by multiple actors (Claudi; Musarella, 2016).

The Smart Case research: goals, methodology and results

The contribution of the researchers of the Department of Architecture of the University Federico II of Naples, lied in the identification of design strategies for the optimization of primary energy consumption and indoor livability in relation to new buildings, aiming to reduce building energy demand.

The research started from the assumption that the current state of knowledge is based on the awareness that the energy efficiency of buildings is determined to a large extent by the envelope performance[2], the efficiency of plants and the passive control systems for summer and winter comfort. The objective was therefore to develop support and orientation tools and methodologies for new construction interventions in the Mediterranean area, with regard to the selection of envelope technologies for the best overall energetic and environmental performance of the building system.

The work intended to create a system of data, design parameters and significant aspects typical of the Mediterranean climate, useful for the implementation of the architectural concept; in particular, the aim was to investigate to what extent the topics for the project of nZEB in Mediterranean climate - such as the orientation, the shape of the building, the mass and the insulation of the envelope, the use of high performance materials, the solutions for the mitigation of solar irradiation and its related thermal load, the natural ventilation, shading and passive cooling systems - represent key elements to maximize the overall performance of the residential unit, leading to the achievement of the set goals.

In this context, the design of a demonstrator building near completion in Benevento has represented an opportunity for implementing design, construction and plant innovative methodologies for the integrated design and construction of a Net Zero Energy Building (nZEB) (Fig. 1).

The demonstrator building, intended to accommodate students of the University of Sannio, aims to meet short/medium term housing needs. The identified dwelling type - single family house - is directly related to the identified users and requires innovative responses to the changed contemporary conditions of living in architectural, technological, plant and environmental terms[3].

An approach based on parametric environmental design was introduced at an advanced stage to support the design of the demonstrator building, using lighting simulations related to the incident solar radiation on glazed elements as tools for the evaluation, correction and optimization of the design solution[4].

This methodology was aimed at optimizing the quantity and

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01 | Demonstrator building, Benevento.
Study render

quality of the internal natural lighting and therefore the factors related to energy saving combined with the indoor comfort of future users.
The first phase of the research has focused on the recovery of all the climatic data of the study site, the city of Benevento, in order to analyse different solutions in the most accurate way possible.
Subsequently, two different calculation models were produced through the simulated based design: one for the *Reference Building* (namely the project building deprived of any projection or shielding), the other for the *Design Building* (namely the building in progress), setting a series of comparisons based on the ranges of values (250-5000 lux) and on the calculation methods (simulations at 9:00 am and at 3:00 pm on September 21st and March 21st) proposed by the GBC LEED protocol with regard to Indoor Environmental Quality. From this set of simulations it was found that the Design Building did not reach the pre-set natural light benchmarks. At the same time, the summer irradiation values on windows were analysed, with the aim of reducing them by at least 40%, comparing the reference building to the design building, in order to find the right balance between the amount of light and the solar radiation and avoid indoor overheating.
After evaluating the simulations and comparisons results, a third calculation model was developed for an *Upgraded Design Building* to get as close as possible to the goal of illuminating 75% of indoor surface by natural light, as required by LEED credit (USA), and reducing by at least 40% the summer irradiation values compared to the reference building.
The changes have concerned the definition of a new form for the roof projections in order to intercept a greater amount of natural light without increasing the amount of solar radiation on the envelope. The Upgraded Design Building is simply a new version of the Design Building, as far as possible, "optimized" on the pre-set benchmarks, and it condenses the set of factors that can be taken into account to rethink the whole or part of the initial building (Figures 2, 3, 4).
The data-sheets related to the different calculation models have represented effective tools to detect any problem or advantage of a solution compared to another; the obtained data set was translated into new design guidelines that led to an improved building, in part different from the initial one, that, in its final form, has optimized the natural light factor while controlling the excessive summer irradiation of the transparent envelope. After checking all the variables and selecting the technological and formal solutions for achieving the nZEB performance, everything has been translated into the project, producing two-dimensional and three-dimensional graphics for its implementation and communication.
The study shows that in Mediterranean climates the tools and methodologies supporting nZEB design have to relate to design strategies characterized by a strong respect for the context, with particular attention to recurring architectural forms and typologies, to prevailing technological solutions, to materials, textures and colours connoting the buildings developed over the centuries which today identify homogeneous geographical and cultural areas. A design oriented to contain energy consumption and to housing comfort, able to take advantage of local natural

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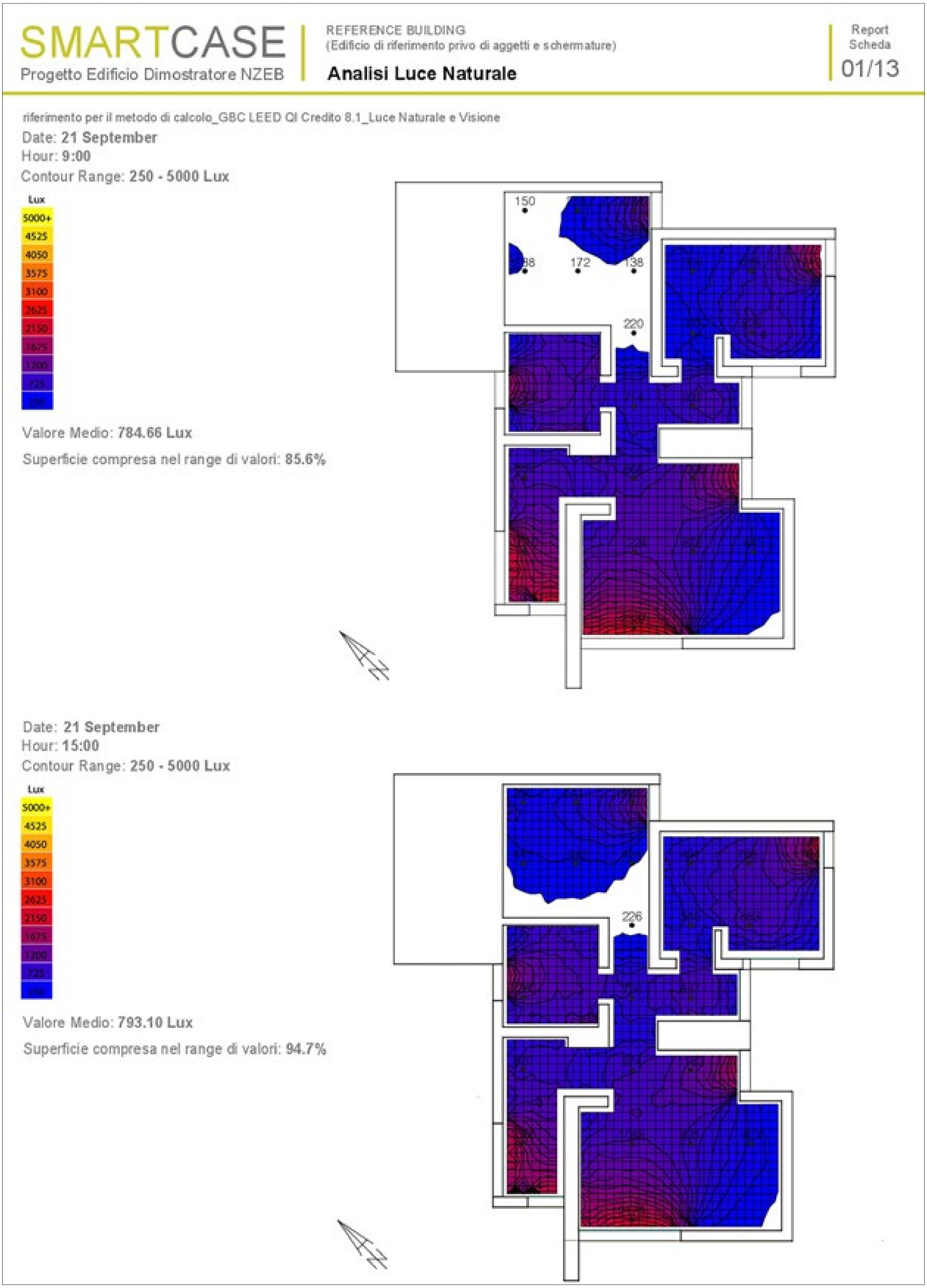
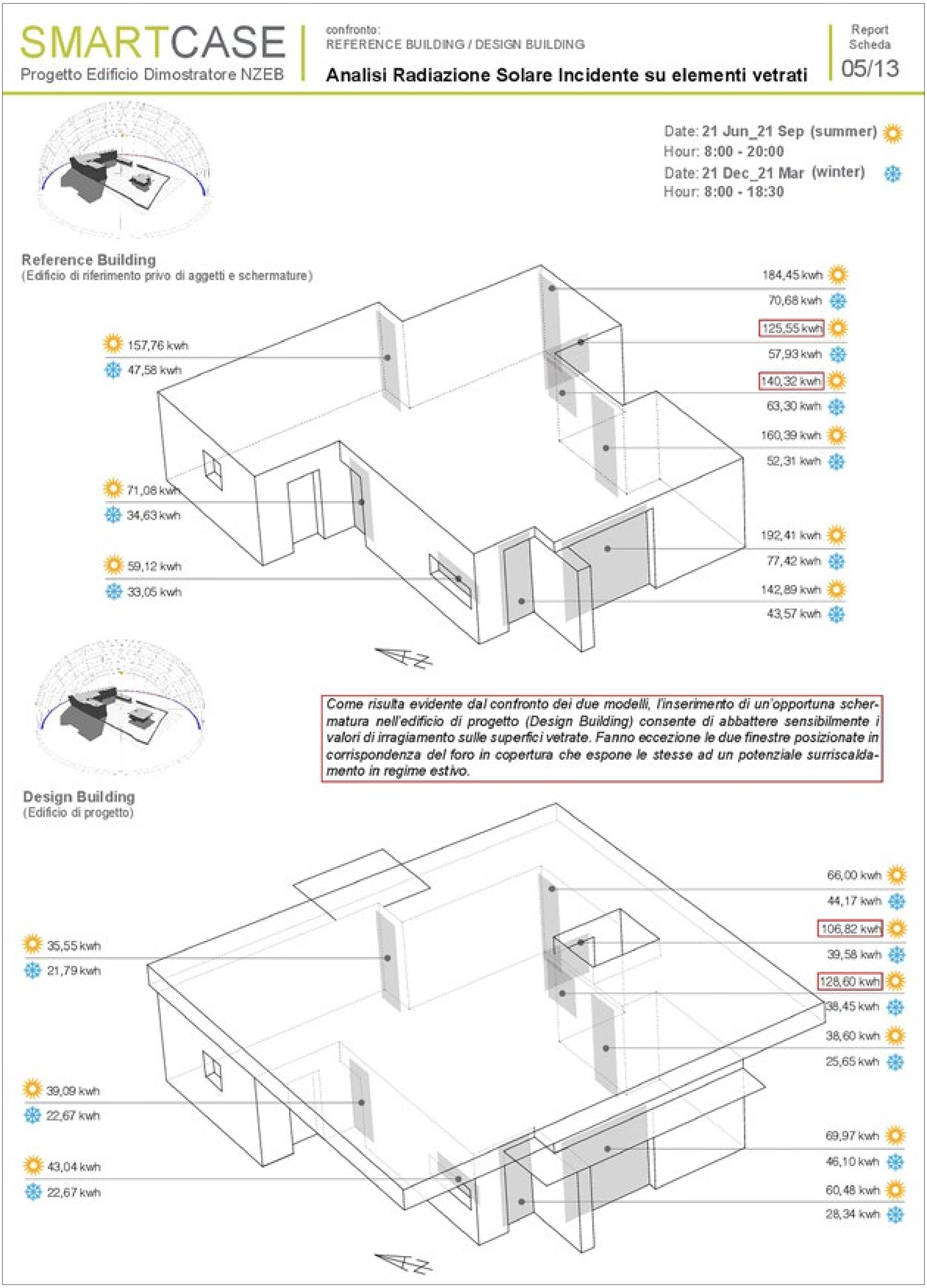
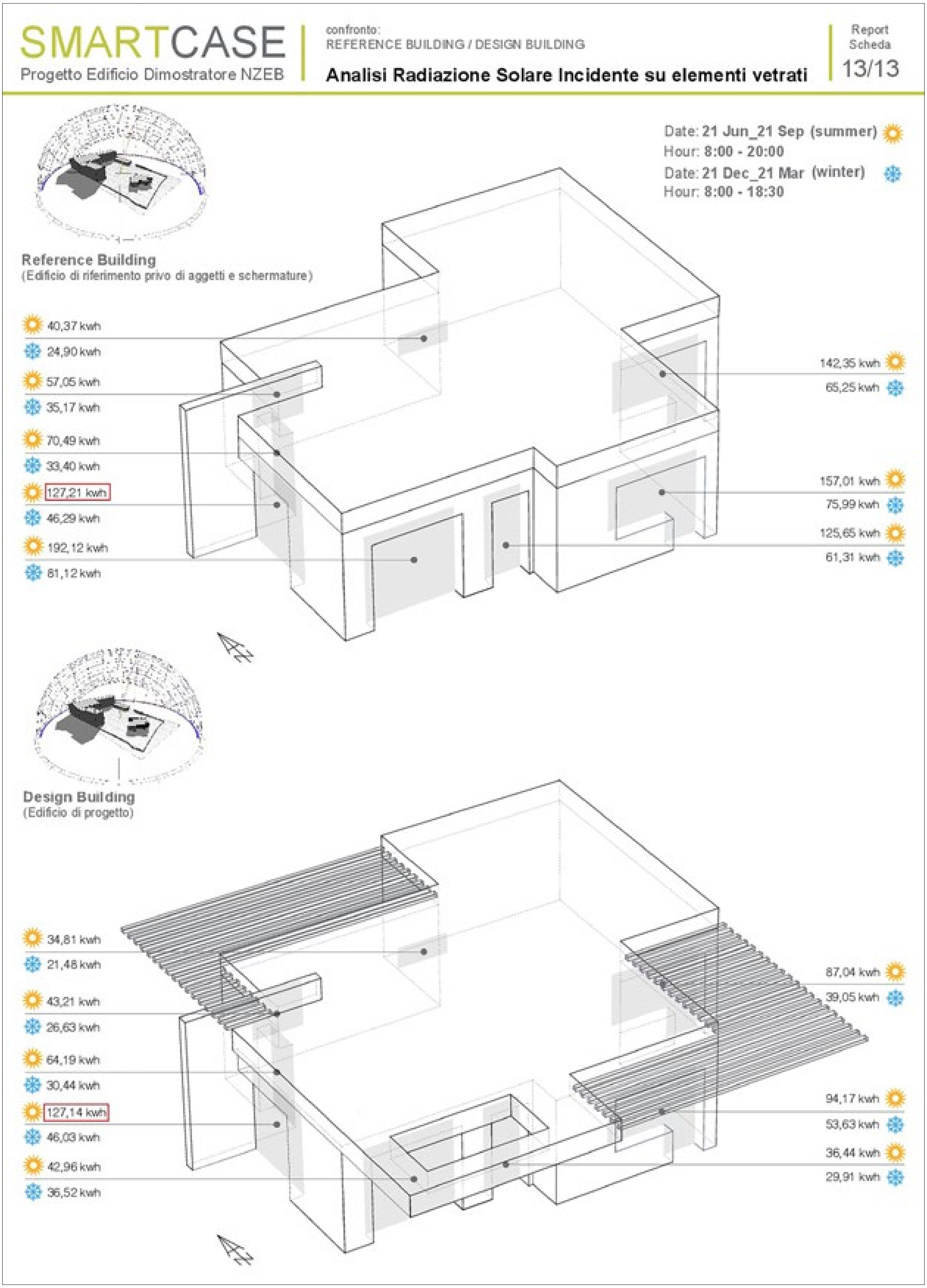


02 | Simulations for the optimization of the relationship between the shape of the building and the levels of natural lighting and reduction of the thermal load on the transparent envelope



03 | Simulations for the optimization of the relationship between the shape of the building and the levels of natural lighting and reduction of the thermal load on the transparent envelope



04 | Simulations for the optimization of the relationship between the shape of the building and the levels of natural lighting and reduction of the thermal load on the transparent envelope

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05-06 | Demonstrator building, Benevento. Construction phases: assembly of X-Lam panels (Cross Laminated Timber) and stratification of the external walls. The choice of the Fibertherm Flex 180 panel contributes to ensure a good thermal inertia thanks to its mass, making it suitable for the reference climate context

resources and climate, is generally based on a bioclimatic approach, aiming at controlling three levels at the same time: climate-environmental, typological and technical-executive (Lavagna, 2010).

An original aspect of the research lies in the use of a systemic approach, based on tools that incorporate modelling and simulation in relation to requirements related to the reference context, to the intended use and to the typological aspects (as well as to the containment of energy consumption), studying how and to what extent the envelope design will have to be adjusted or misaligned by the "passive house" energy standards designed for the Central European climate.

In this regard, it is reaffirmed that the Passivhaus model, born in the climatic, cultural and constructive context of Central Europe, makes little sense if applied in the Mediterranean area, where the main parameter to take into account is perhaps the flexibility of the solutions, that have to be adjusted to different climatic summer and winter conditions, with mild intermediate seasons in which ventilation and lighting topics prevail over the strictly thermal ones, not to mention the cultural and social values (Sala, 2012) (Figures 5, 6).

Some experiences carried out in different geographical areas have shown that there are no standardized solutions valid for any latitude, that architectural optimization is no less efficient than plant optimization, that the choice of materials cannot exclusively depend on their level of ecologicality, that the simple implementation of eco-efficient system devices does not automatically make the building they are part of sustainable, that the assessment of the building energy performance cannot be separated from a thorough post-occupancy verification (Russo Ermolli, 2013).

The main output of the research activity, beyond the methodological and the skills integration aspects that have characterized the whole process, is related to the experimental verification applied to the demonstrator building. Thanks to the sensors for monitoring the confined space environmental conditions (sensors for detecting temperature and humidity, air quality, occupancy and illumination) and the thermal performance of the opaque and transparent envelope (surface temperature values, solar radiation, infrared radiation) it will be possible, through the effective use of the building and the systemic organization of the collected data, to intervene for subsequent corrective solutions while continuing to optimize indoor well-being of the users performance (Figures 7, 8).

The need to develop exemplifying cases also originates from the consideration that the European directives on sustainable design and energy efficiency, as transposed at national level, are scarcely observed in the current design practices.

Future developments, integration between building and smart grid

Further research on this topic may concern actions aimed at the transition from the Nearly Zero Energy, to the Net Zero Energy, up to the Plus Energy model, for which the integration of renewable energy sources in architecture is strategic. The interaction between the nZEB building and the smart grid will be one of the main aspects to be investigated with a systemic perspective towards the smart cities. In this sense, cities must push the extensive use of systems for generating and accumulating energy sources and the development of smart grids, for a flexible and adaptable distribution over time.

The cornerstones to be pursued are those that will cut down and progressively eliminate harmful climate-altering emissions over time, moving from nZEB - *Nearly Zero Energy Building* model to nZEA - *Net Zero Energy Architecture* model, which surpasses the building scale to achieve a strong interaction and exchange between architecture and urban dimension, to nPEA - *Net Positive Energy Architecture* model; the latter marks the definitive transition not only to the self-production of the energy needed by the architectural or urban organism, but also to the surplus of produced energy that focuses on the new frontier theme of the dynamic management of the total amount of energy, generated and distributed according to users needs, contexts and moments of the day or season of the year (Tucci, 2017). In this direction, to support the development of the "intangible" performance of an energy-efficient, responsible and sustainable settlement, the planning and experimentation contributions offered by the use of smart grids are increasingly important and significant, as systems capable of intelligently integrate the actions of the connected users - producers and consumers - in order to distribute energy in an efficient, sustainable, economic, and safe way (Boeri et al., 2017).

In the context of energy, environmental and social emergency of cities, such a laboratory of innovation can become a benchmark and a reference model for urban regeneration interventions that put smart buildings on the grid, connecting users, tracing consumption profiles, planning the energy production and redistributing the surplus.

The interaction between the building and the smart grid is therefore a key aspect for the future research in which ICTs will play a decisive role. The integration of sensors and control units will allow the acquisition of aggregated data from multiple buildings, allowing a better configuration of the grids as a function of an energy demand no longer assessed only at individual level but also at building and/or district scale, according to a smart building/smart city logic (Dassori Morbiducci, 2013).

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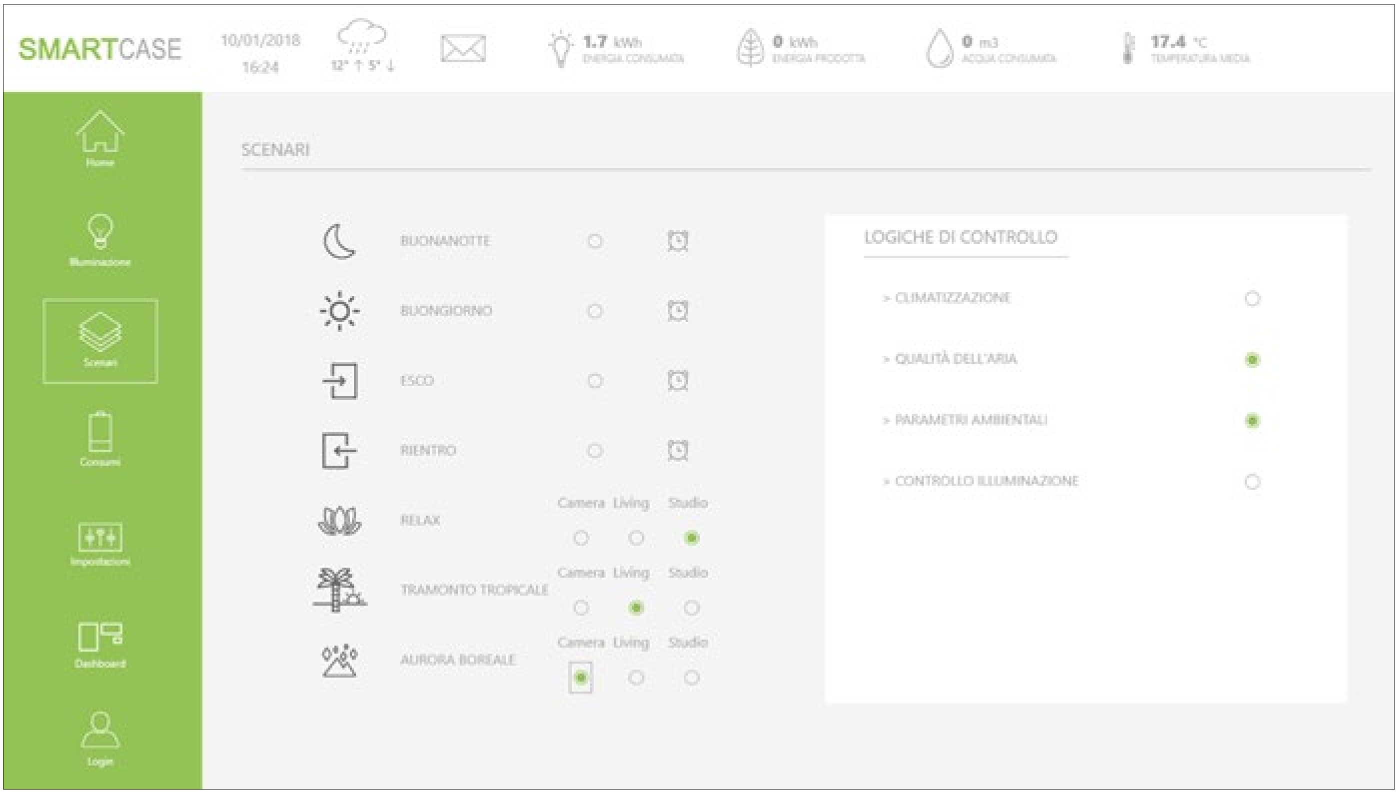
07 | Demonstrator building, Benevento. nZEB near completion



08 | The monitoring and control system is mainly based on three "infrastructures": the first one, the Building Management System (BMS), regards measurement and control functions; the second one, the Living Lab, is a monitoring system for research and validation purposes; the third one concerns the software for the management and control of the hardware part, the functioning logics and the user interface.

The BMS provides the user with the ability to activate/plan a series of smart processes specifically designed to optimize the use of lighting and air conditioning systems. BMS information can also be accessed remotely through an App developed for Android devices that connects to the measurement database installed in the building's technical room. The functionality of the mobile app is mainly addressed to the user's control of some BMS features

NOTES

[1] The Smart Case research project, articulated in the period 2013-2017, has had the contribution of the University Federico II of Naples and the University of Sannio, Research Centers and industrial partners and the collaboration of local authorities and institutions that have provided important support to the research activity. The general scientific coordination is entrusted to prof. G.P. Vanoli of the Engineering Department of the University of Sannio, while the coordination for the STRESS Scarl Actuator is entrusted to Eng. F. De Falco. The Research Group within the Department of Architecture of the University Federico II of Naples consists of prof. A. Claudi de Saint Mihiel (coordinator and scientific manager), prof. M. Bellomo, U. Caturano, A. D'Agostino, P. De Toro, D. French, M. Losasso, A. Piemontese, with the contribution of: arch. E. Buiano, E.A. De Nicola, C. Filagrossi Ambrosino, C. Girardi, E. Porcaro, T. Venditto, C. Tomeo.

[2] It is important to underline that the scientific literature related to 2050 trends highlights the strategic role of the building envelope in terms of adaptability, integrability and efficiency to meet the needs of resilient buildings and cities.

[3] The cultural renewal induced by the affirmation of energy efficiency and sustainability of the interventions has begun to invest in recent times the residential sector, as well as the production for residential use. The research on the residence has undergone a major acceleration thanks to the promotion action carried out by the European regulatory provisions on energy saving and users comfort (Girardi, 2013). At the same time users have developed new needs to satisfy, in addition to the primary need of living (Arbizzani 2012).

[4] Simulation activities and the related 2D and 3D graphic restitution have been edited by the arch. E.A. De Nicola, winner of the scholarship "Applications of innovative methodologies for the integrated design of nZEB in reference to a scale demonstrator building and/or a refurbishment of a part of the existing building" - SMART CASE Research, coordinator: Prof. A. Claudi de Saint Mihiel.

ACKNOWLEDGMENTS OF VALUE

Among the different and qualified stakeholders who have given their contribution in specific ways and in different phases we mention: the vice-president of the Campania Region Fulvio Bonavitacola, who underlined how, thanks to the forthcoming phase of data monitoring and testing on the demonstrator building, the Campania Region will be able to use the obtained results to "instruct" the new Regional Piano Casa, aimed at the energy refurbishment of the existing building stock. Moreover, with regard to the large amount of both public and private buildings - of no historical and architectural value - built in the post-war period, the Region will operate through demolition and reconstruction interventions «observing the demonstrator so that the decision maker can decide well» in relation with design and plant solutions studied and adopted for its design and construction. The president of STRESS - high technology District for sustainable buildings - Ennio Rubino, remarked how The Smart Case project «has shown that it is possible to provide the territory with "concrete objects" as results of industrial research projects financed with European structural funds». The demonstrator building is an intervention of great experimental value for the definition of standards and guidelines for the construction of near zero energy buildings in Mediterranean climates. Vito Grassi, sole director of Graded and vice-president of the Unione Industriali di Napoli, has expressed his satisfaction for having contributed to the realization of what will become a permanent laboratory for testing the most advanced technologies in terms of building sustainability. The nZEB demonstrator represents the practical proof of the fact that the growth of our productive fabric necessarily passes through an ever closer collaboration between companies, the university system and the research world in tune with the national strategies for the promotion and activation of the "Digital Innovation Hub" foreseen by the Industry Plan (Piano Industria) 4.0.

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Work on the informal city. Restoring the environmental balance of cities from their outskirts

Eliana Cangelli,
Department Planning Design Architecture Technology, Sapienza University of Rome, Italy
eliana.cangelli@uniroma1.it

Abstract. By describing an experimentation carried out on a 'informal' settlement in the far north east outskirts of the Municipality of Rome, the paper aims to demonstrate in which way outskirts can become an extraordinary opportunity to activate processes of smart urban regeneration. The paper describes a project developed on the area of Tragliatella in Rome, with the aim of developing a codified design methodology for the recovery of unauthorised residential settlements in the outskirts of the city, lacking primary urbanization works and essential services, and requiring redevelopment processes in order to ensure their liveability. The project proposes a smart model linked not only to the energy performance of the buildings, rather to all the other environmental parameters of the urban settlement (i.e. soil permeability, heat island effect, micro-climatic comfort in outdoor spaces, etc.). The experimental design approach, outlined in this paper, could be effectively transposed to other fragmentary suburban settlements, characterized by the low quality level of the houses, whose origin is not necessarily spontaneous.

Keywords: Energy districts, Energy positive blocks, Renewable energy sources, Informal city, Smart grids

Research framework

In this paper the term "informal city" refers to those areas, part of the outskirt of large cities, developed in unauthorised fashion. Illicit constructions, born as a spontaneous remedy to the shortage of housing, over time become a full-fledged part of the urban construction system, to the point of being acknowledged by government bodies and authorities as well. In the case of Rome, more than a third of all residential housing was built in unauthorised fashion, and more than a third of the city's population lives in areas originally developed without legal approval (Cellamare, 2013).

The present research focuses on the recovery of these settlements, through a set of sustainability strategies not limited just to the energy issues, but aimed at rebalancing the flow of resources within the system and with the rest of the city. By operating in systematic fashion to increase the density and complete the fabric of the "informal city", a process of renewal that aims to restore the environmental balance of the city can be set in motion. Most importantly, promoting the transformation of these areas of spontaneous growth can favour a reconversion of the city's energy system. By means of neighborhood and building-scale regeneration operations, such settlements can generate most of their energy from renewables but, moreover, be able "to generate sufficient flows of energy, water, and waste to enable potential borrowing, balancing, and stealing among systems" (Fraker, 2013). This approach is part of the international literature framework of design studies and experimentations on sustainable neighborhoods, conducted over the past 20-30 years. A context characterized on one hand by experimentations on the creation of new self-sufficient settlements, such as: Bo01, between Copenhagen, Denmark, and Malmö, in Sweden (1996-2001); Hammarby Sjöstad in Stockholm (1993-2015); the Solar City Linz (1995-2002); BedZED in Wallington, London (2002); the Vauban in Freiburg (1998-2000). On the other hand, the most recent experiments concern the regeneration of urban sectors with the achievement of eco-district standards, as in the particularly relevant case of the *Clichy-Batignolles* district in Paris (2002-2020); or even systematic urban-scale interventions to reduce CO_2 emissions, such as the *Glasgow City Energy and Carbon Masterplan*.

In line with these experiences, the experimental project proposed in the paper introduces innovative construction and technological systems but above all specifically declines the sustainability strategies on the spontaneous settlements of the Roman metropolitan context. In this way, environmental strategies are adapted to the crucial objective of the recovery of the informal city, in which the consumption of soil has generated imbalances to be recomposed with a systemic approach that looks to the suburbs as a resource for the environmental rebalancing of the whole city.

Tragliatella: a case study for the regeneration of unauthorised settlements

This experimental research has been solicited by the Municipality of Rome with the aim of developing a codified design methodology for the recovery of unauthorised residential settlements in the outskirts of the city, lacking primary urbanization works and essential services, and requiring redevelopment processes in order to ensure their liveability. The unauthorised suburban areas, built as spontaneous settlements in response to the lack of social housing in the outskirts of Rome, have been under attention by the administration for over 30 years. In the last decade the administration of the Municipality of Rome has proceeded to the delimitation of their perimeter. Named *Toponimi*, these built areas of illegal origin occupy about 4.000 hectares of the Roman metropolitan area, subdivided into 71 zones[1]. The Municipality has defined a specific regulatory procedure for the recovery of these areas, named *Executive Plan*[2], which regulates the completion of the urban fabric by increasing its density[3] with the construction of new houses. At the same time, the Plans identify the areas for the missing primary and secondary urbanization works. Through the tool of the *Executive Plan*, the Administration tries to fill the structural deficiencies of public and private services that characterize the *Toponimi*. The aim is to "mend" the fragmentary urban fabric, enhancing their vocation as "autonomous" settlements, in an overall vision of Rome as a polycentric metropolitan city.

Citizens are an active part of the recovery process: they participate and monitor the hypotheses of the public administration through specific associations called *Consorzi di Autorecupero*[4].

The area of this experimental research, the Toponimo of Traglia-

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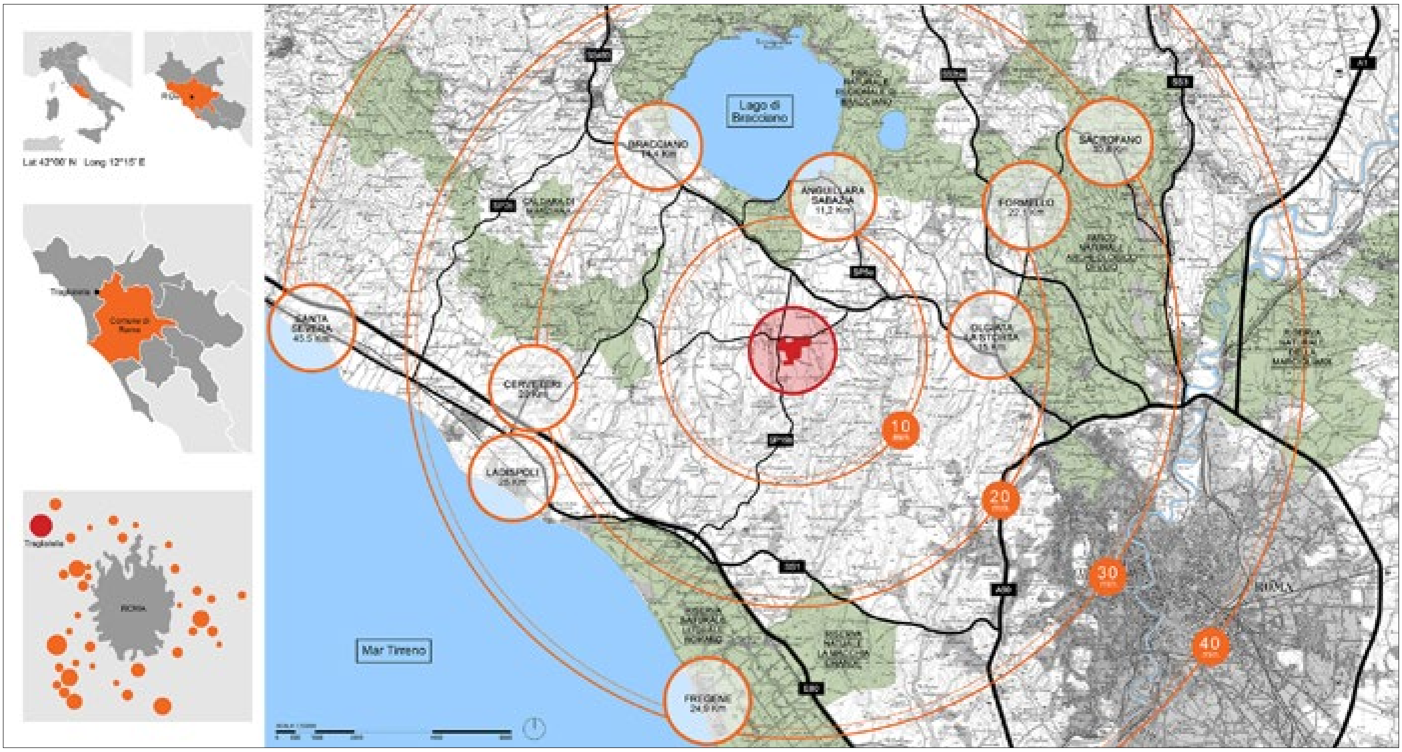


01 | Tragliatella's Geographical Context

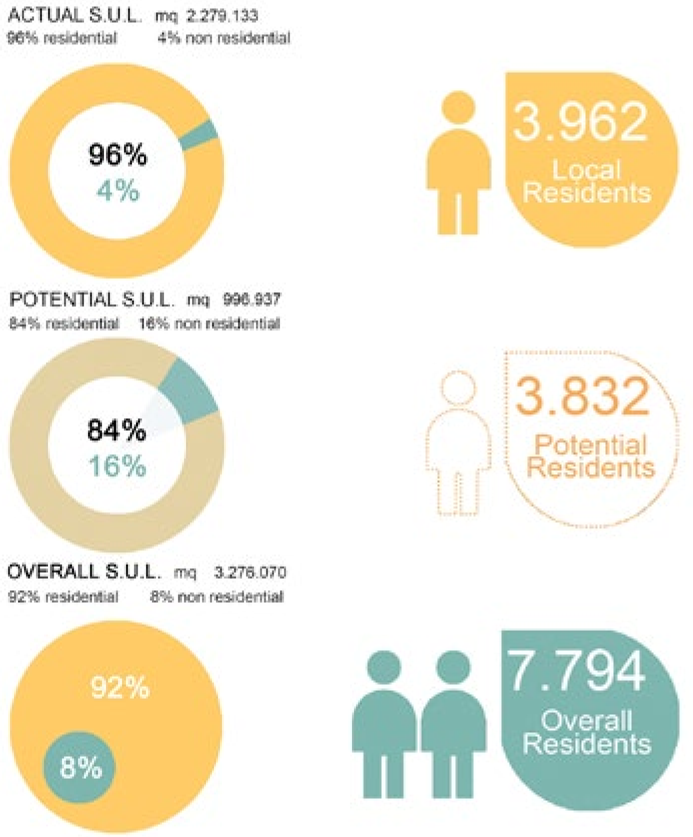
tella, was identified through a process that involved the University, the Municipality of Rome and the local Consorzi di Autorecupero, who participated in the development of the project and evaluated its outcomes.

Tragliatella is a formerly illegal settlement, located in the north-western sector of Rome, on the border with the Municipality of Anguillara Sabazia. Tragliatella has an overall extension of about 147,04 ha, of which 22 ha are destined by the *Executive Plan*[5] to accommodate public spaces and services, including schools, as well as to the completion of the road network. Currently, Tragliatella has about 3.900 inhabitants while, according to the *Executive Plan*, at the end of the recovery process it will host 7.794 people.

The first illegal buildings in Tragliatella were built in the 70s. The relative proximity to the city of Rome (about 50 minutes by car), the presence of small urban centres bordering the area, reachable in a few minutes by car, the agricultural and rural context and the possibility of glimpsing the sea were the main elements of attraction for the new inhabitants. In a historical period of deregulation, they counted on the possibility of a fast *Condono* (regularisation procedure) and on the subsequent realization of the primary infrastructures by the Administration. The settlement grew spontaneously with continuity until 2003 without the necessary infrastructures (roads, sewers, public lighting, water purifiers, schools). Today the area is affected by a significant state of decay, with the existing buildings having a poor quality and low energy performances. Public spaces and services are lacking, most of the roads are unpaved, without public lighting, and only part of the settlement has been equipped with a sewage system.

Objectives of the project and stakeholders' involvement

Through an experimental project carried out on the case study of Tragliatella, the Research Group[6] has developed a set of strategies to turn the neighbourhood into a model sustainable suburban settlement, self-sufficient in terms of energy, resources and economy, by enhancing the rural characteristics of the context. This objective derives from a systematic dialogue between the Research Group and the stakeholders involved in the process: Municipality of Rome - Urban Planning and Implementation Department, Alessandro Coppola; Roma Resiliente, Coordinator Iolanda Fiori; Consorzio Periferie Romane, Luciano Bucheri; Comitato di Quartiere Tragliatella, Nino Bufalini. The whole Working Group shared the will to integrate the *Executive Plan* with sustainability strategies, in order to boost the environmental, social and economic potentialities of the neighbourhood. Through periodical meetings, the Working Group progressively checked



02 | The Executive Plan n. 19.08 of the Toponimo of Tragliatella indicates the current and potential population that will settle in the area. Source: http://www.urbanistica.comune.roma.it/partec-tragliatella.html

and adapted the proposed development model for Tragliatella. The research was presented in several public meetings attended by the Municipality of Rome and the *Consorzi*. Among these, the most important are the one held in an intermediate stage of research development, aimed at communicating the proposed intervention methodology for the regeneration of Tragliatella[7]; the second one dedicated to the presentation and discussion of the results of the application of the methodology itself[8]. Both meetings were an opportunity to establish a dialogue between the stakeholders involved, not without moments of strain due to the need to combine different positions.
Finally the model was considered appropriate both by the Administration and by the citizens' associations: the first in fact had sensed the possibility of recovering a compromised territory, consumed by a disorderly construction, while simultaneously reducing the burden of travel to the city; the second believed that a more ambitious process than the realization of the basic infrastructures would allow the economic and social development of the community of Tragliatella, the increase of the architectural quality and the consequent valorisation of the area.
Based on this premise, the project aims at turning Tragliatella into a model of *circular district*, replicable in the recovery of urban suburbs, achieving a high level of:
- functionality and liveability of the urban habitat;
- architectural, environmental, energetic and technological quality of buildings and open spaces through affordable solutions;
- energy efficiency and ecological effectiveness of the proposed urban structure through the application of networks for the distribution of information and energy.

Research methodology and design strategies

The present experimental research was carried out according to an iterative model, which required the application of methods and tools, useful for representing the information in a reticular form and for evaluating alternative regeneration scenarios applied to the study area.
The first phase of the research has seen a confrontation for the selection of the Tragliatella pilot case with the Operative Unit dedicated to the Recovery Plans of the *Toponimi* within the Municipality of Rome, and the *Consorzi di Autorecupero*. In the subsequent research phase of methodological formalization, the Research group organized a series of surveys on the area, interviews and questionnaires with the citizens and meetings with the stakeholders.
Afterwards, two different levels of analysis and design experimentation were tackled, at the urban scale and at the building scale, in order to produce a masterplan proposal.

Urban level

At the basis of the development of the masterplan there is the application of qualitative and quantitative analysis of the characteristics of the territory, with reference to both the metropolitan area of Rome and to the specific area of the Tragliatella district. In fact, only through a targeted cognitive analytical investigation, it is possible to define an innovative settlement model, both on the environmental and on the economic and social side by identifying the local sources of renewable energy available, the characteristics of the territory that can activate small-scale economies, the potential of urban spaces to foster social inclusion and quality of life.
The analysis of the *Natural System at the urban scale* made it possible to verify the presence and size of extensive crops (cereals

03 |


03 | Typical Tragliatella's Buildings

and hay) and of intensive crops (olive groves and vineyards). This led to identify the possibility of exploiting the Roman countryside both from the perception point of view (as landscape) and as an engine for the development of new production cycles, linked to food and energy.
The analysis of the *Anthropic System at the urban scale* highlighted both critical issues to be solved and potentialities. The services present on the territory and their accessibility in terms of travel times were mapped, verifying the presence and quality of the existing public transport networks. From this analysis, an uneven distribution of services was found, exacerbated by the discomfort of having to travel long distances without the support of adequate public mobility. On the contrary, if the district was equipped with the services that are lacking today, it could benefit from its position at a crossroad of flows that from Rome move northwards, and be integrated with the neighbouring centres of Bracciano and Anguillara. A great potentiality was revealed by the analysis of the landscape: Tragliatella is close to the Archaeological Park of Veio and to the Regional Natural Park of Bracciano, which represent a relevant landscape resource and, together with the Roman countryside, constitute a system needing to be preserved and enhanced. The proximity to the lake villages, Bracciano and Anguillara, are a further resource for the *Toponimo*.
The results of the analysis on the specific area of Tragliatella highlighted different issues related to low population density, poor architectural quality, security problems that occur in the construction of fences and gates, the absence of public spaces for aggregation, the isolation of the *Toponimo*, due to the lack of an internal road network and interchange nodes with external mobility. At the same time, some potentialities were found concerning: the orthogonality of the road fabric favouring the recognisability of the road network and the new constructions' orientation; the presence of many green plots, currently uncultivated and abandoned, which can be included in a program for the development of public parks and domestic vegetable gardens. Following these analysis, a general masterplan for Tragliatella was produced, defining the layout of a settlement, drawing resources for its development from the rural context, through theoretical and technical insights on:

- diffused and renewable energy production technologies to enhance the environmental characteristics of the context, for example in terms of biomass produced in the immediate proximity of the settlement;
- innovative methods of economic development linked to the specific features of the context, such as self-production and farm-to-table sale of locally produced food;
- solutions for sustainable mobility, both in terms of proximity and connection with the rest of the city;

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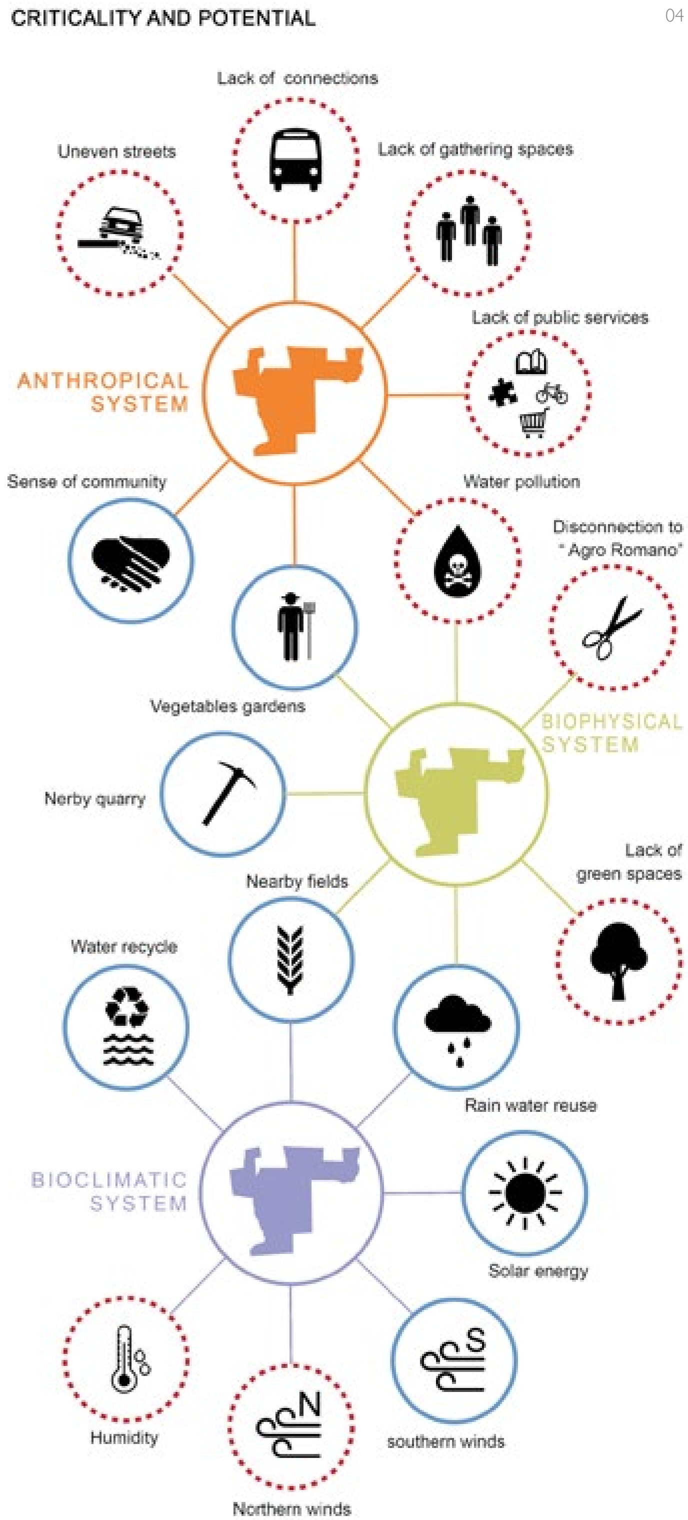

04 | Strengths and Weaknesses of the Area

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05 | Visions of Different Areas of the Tragliatella's Project

- technologies for the sustainable management of resource flows, including water, materials and waste.

Thus the idea of an *Agricultural Community* emerged, enhancing the potentialities of the *Toponimo* in order to develop:
- *local economic networks,* based on a short food supply chain, redefining the relationship between producer and consumer;
- *local energy networks*, able to exploit not only the energy sources normally available such as sun and wind, but also the most typical sources of the specific context, such as a not intensive production of biomass from agricultural and forestry residues (crops mowing and pruning) and waste from the farms and agri-food industries present in the area;
- *social networks* aimed at increasing the sense of community among the inhabitants of Tragliatella through shared vegetable gardens and local agricultural activities;
- *cultural networks* through the creation of outdoor public spaces and paths links to the nearby relevant parks and natural areas, with the aim of enhancing the suburban ecological potential and promoting environmental awareness.

The masterplan transforms this vision into punctual strategies of intervention:
- the equal distribution of new public services inside the district, with the creation of educational services, in addition to the kindergarten and primary school outlined in the *Executive Plan*, such as a research centre on agriculture and food;
- the insertion of aggregation spaces throughout the urban fabric, such as squares, small gardens and playgrounds for children;
- the reorganization of the internal road structure, a new hierarchy of roads according to three different types of streets, based on the vehicle flow, and the implementation of advanced solutions for sustainable mobility;
- technologies for the sustainable management of the water cycle, such as small watercourses along the roadways' sides, with the double function of the recovery and disposal of rainwater and of the control of microclimatic comfort of outdoor areas during summer;
- infrastructures for closing the different loops of resource pertaining to the urban metabolism, first and foremost the waste cycle.

The masterplan finally defines new construction sectors differentiated through two main types of residences:
- *Agro-Houses:* houses related to agricultural activities, placed in proximity to common spaces used for urban gardens and animal farms;
- *Urban-Houses:* more compact and intensive houses, compared to Agro-Houses, hosting small commercial spaces.

Building level

In response to the main objective of creating a self-sufficient urban settlement, and to the request of the local associations of citizens of having specific recommendations for the development of the new houses, the project addresses the building scale as well. Thus, the main experimental result consists in the definition of 'Positive Energy Housing Models', replicable in a designed pattern. The models are low-cost houses, appropriate to Tragliatella's context, with specific architectural and technological characteristics, and defined environmental and energy performances. In particular, they satisfy bioclimatic criteria and integrate renewable energy systems and coordinated exchange of energy with smart energy grids. The model houses use innovative prefabricated construction systems[9] taking into account the entire life cycle of the building. Being active in terms of energy production, fully integrated into the overall energy network, and achieving optimal management of water and waste, the model houses also balance the related operating costs.

Results: "Positive Energy Housing Models" within a circular district

The project proposes a smart model linked not only to the energy performance of the buildings, rather to all the other environmental parameters of the urban settlement (i.e. soil permeability, heat island effect, micro-climatic comfort in outdoor spaces, etc.). The critical analysis of the *ex ante* status of the districts, allowed to identified the most appropriate innovative solutions for closing the loops of materials and other resources inside the system. Thus new virtuous economic cycles can be created, simultaneously limiting environmental pollution. The project actions must involve, as happened with Tragliatella, local administration, citizens, designers and cultural organizations to find practical and durable solutions.

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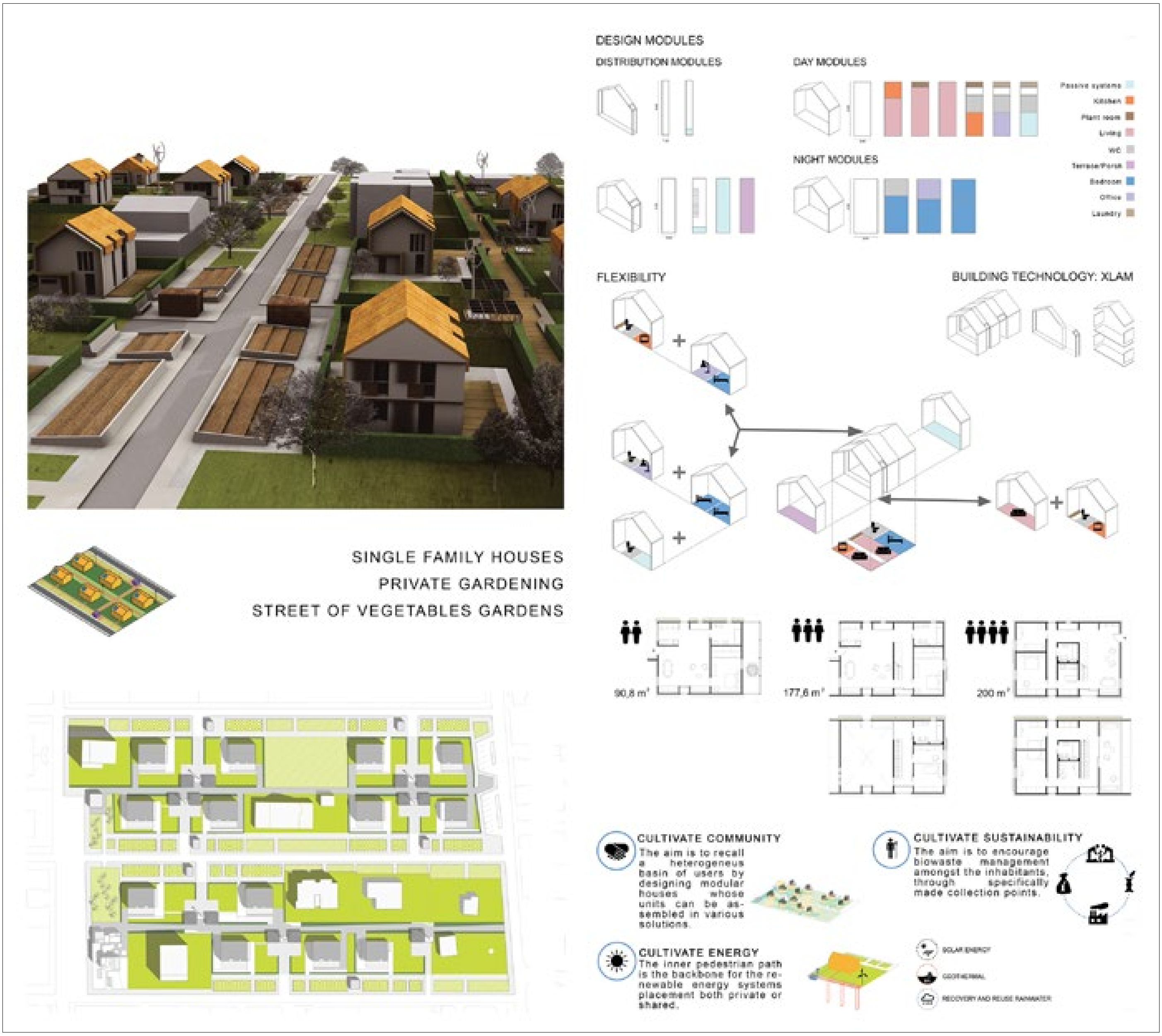

06 | Single Family House Positive Energy Model

As regards the energy issue, which was one of the major topics of the research, the overall energy model has been developed starting from the detection of the energy consumption of the existing housing in Tragliatella. Currently the buildings have very low levels of efficiency (200 Kwh/sqm/yr). The objective of the project is to cover the energy needs of both present and future buildings with renewable energy production systems, possibly producing a surplus of energy, to cover part of the consumption of the neighbouring areas. The energy supply is ensured by the extensive use of integrated photovoltaic systems on the buildings, combined with two potential other renewable energy sources: low-enthalpy geothermal energy, or a biomass power station, using waste from the local farms and agricultural activities. The solutions adopted in the "Positive Energy Housing Models" and the retrofit strategies for existing buildings, verified through simulation, certify a possible 75% reduction of energy needs for the new houses, compared to the existing building stock in Tragliatella, and a 20-50% reduction for existing buildings after retrofit[10]. The buildings could also be connected to a smart grid which enables a dynamic energy distribution in real time. In this scenario the users can easily monitor their energy consumption while improving their environmental behaviour. Thus the houses potentially provide a surplus of energy which can be used for the neighbouring areas. Thanks to the new national regulations concerning the Vehicle to Grid system[11], the direct involvement of the owners as small energy producers also allows to encourage citizens to purchase and use electric cars, which can also be used to enter energy in the network. This can contribute to the energy supply balance as a sort of distributed storage.

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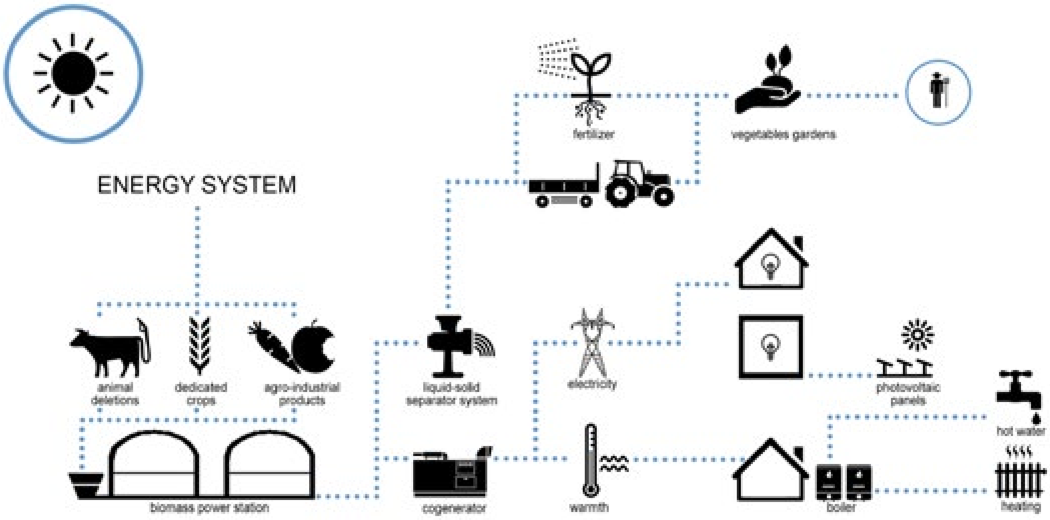

07 | Layout of the Energy System

Conclusions

The outcomes of the analysis and design method, developed in the experimentation, represent a virtuous and repeatable example. Based on the premise of the Tragliatella project, the experimental approach outlined above could be effectively transposed to other fragmentary suburban settlements, characterized by the low quality level of the houses, whose origin is not necessarily spontaneous.

Regarding the process of implementation of the Tragliatella project, the experimentation, begun in 2014 and continued throughout 2016, has paid the sudden change in the political Administration of the Municipality of Rome, with a temporary stop in the project approval process. The administrative continuity is in fact necessary to guarantee the completion of the process, while the Municipality of Rome has suffered a continuous political turnover in the last years. However recently the administration has shown a renewed interest in the regeneration of *Toponimi* areas, reactivating participatory processes with the consortia and citizens' committees. Despite the lack of decision-making continuity and resources, today all the stakeholders are willing to reactivate the recovery process of the *Toponimi*.

NOTES

[1] These areas have been identified in the general plan of the Municipality of Rome approved with the Resolution no. 18 adopted by Municipal Council on the 12th February 2008.

[2] The process of approval of the Executive Plans by the Municipality of Rome took place through three important participatory steps: the first in December 2009 (Resolution No. 122); the second in July 2010 (Executive Resolution No. 513) and the most recent in September 2010 (Executive Resolution No. 276).

[3] At the end of the implementation of all the Executive Plans it is expected that the general gross floor area will increase from the current 2,279,133 sqm (96% residential and 4% non-residential) to 3,276,080 sqm (92% residential and 8% non-residential), with a significant increase of public services and spaces. The population will pass from 58.462 to 80.765 inhabitants. Source: http://www.urbanistica.comune.roma.it/toponimi-stato.html.

[4] The Consorzi di Autorecupero are associations of citizens who illegally built their homes and afterwards got together, in compliance with the National Law n. 724/1994 (Secondo Condono Edilizio) and a subsequent series of Municipal resolutions, with the aim of collecting the concession fees due to the Municipality of Rome to use them for the urbanization works to be realized in their settlement. Source: https://www.comune.roma.it/pcr/it/dip_pol_riq_per_zone_op.page.

[5] Source: Municipality of Rome, "Piano Esecutivo per il recupero urbanistico del nucleo di edilizia ex abusiva: n. 19.08 denominato 'Tragliatella'" adopted by the Municipality of Rome with Resolution No. 35/2013, available at: http://www.urbanistica.comune.roma.it/partec-tragliatella.html.

[6] The research has been developed at the Department of Planning, Design, Technology of Architecture of Sapienza University of Rome. Principal Investigator Eliana Cangelli, Research Group architects Paola Altamura, Francesco Antinori, Massimiliano Coccia, Michele Conteduca, Caterina Reccia.

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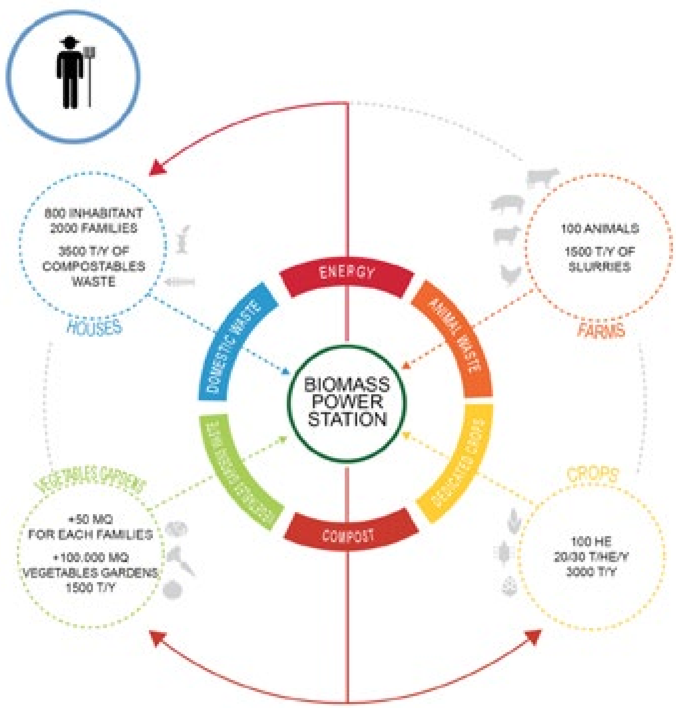

08 | Supply of the Biomass Power Station

[7] Conference "Next City. La nuova periferia di Roma, tra sostenibilità e sviluppo", Casa dell'Architettura, Rome, 03/12/2013.

[8] Conference "AbitareVerde. Bioarchitettura e urbanistica sostenibile", Casa dell'Architettura, Rome, 04/04/2014. The results of the educational experimentation conducted in parallel with the research were also rewarded with the Urbanpromo Prize in 2015 (http://urbanpromo.it/2015-en/urbanpromogiovani/tragliatella-flip-a-coin-for-a-toponimo-in-rome/).

[9] The model houses are based on wood construction technologies (Xlam), hemp-based insulation and high recycled content materials for the finishing. These solutions, combined with photovoltaic and geothermal energy systems, allow to reduce the overall energy consumption to a maximum of 35-40 kwh/sqm per year. Bioclimatic solutions such as large screened windows to the south orientation ensure heat gains in winter while avoiding overheating in summer. Buffer spaces and solar greenhouses, whenever used in the housing model, are designed in order to ensure their complete opening in the summer.

[10] The estimate of the reduction of the overall energy consumption of the Toponimo was led through a comparative method based on the estimate of the average consumption for the different energy functions (electricity, heating, cooling) of existing buildings provided by the ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development).

[11] This system has been introduced for the first time in Italy through the National Budget Law 2018.

ACNKOWLEDGMENTS OF VALUE

Luciano Bucheri
Director of Consorzio Periferie Romane (Roman Outskirts Consortium)

Tragliatella is one of the 29 Toponimi for which the Municipality of Rome has defined and pre-approved an Executive Plan. It is the second largest of the 69 Toponimi identified by the Rome Town Plan. Tragliatella has an area of 145 hectares and has 3,880 inhabitants, which means about 1,175 families. At the end of the implementation of the Executive Plan, the total expected residents will be 8,500, which means 2,775 families.
Almost 78% of these families (2,164) formally subscribed to the Executive Plan, acting as owners of lots of land or of existing houses associated in the "Consortium of Tragliatella". This implied a complex level of discussion and a certain quality of the involvement of many citizens, certainly not on generic subjects, looking for a consensus to be torn out in some way, but on complex technical-urbanistic aspects, on problems directly concerning their future life conditions! Dozens and dozens of assemblies, held over many years, were needed to reach a level of consensus of such relevance.
In these years, both the awareness of being part of a collective body and of the undoubted technical complexity of the issued involved in this process has matured. This in fact made it possible to strengthen the dialogue between institutions and citizens, not just expressed by slogans or in sterile contraposition between rulers and governed citizens, but in a real collaborative experience involving sustainability issues.
Thanks to the Tragliatella's project, as well as to akin processes in the other Toponimi, the civil conscience has grown positively. Nevertheless, as is known, every goal achieved increases the level of responsibility. On the part of the Institutions, not to follow up to these innovative processes with the due conviction and intelligence, could lead citizens' disappointment to turn into conscious anger.

PICTURE CREDITS

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Smart Cities and Historical Heritage

Giovanna Franco,
Department of Architecture and Design, University of Genoa, Italy
francog@arch.unige.it

Abstract. The theme of smart grids will connote in the immediate future the production and distribution of electricity, integrating effectively and in a sustainable way energy deriving from large power stations with that distributed and supplied by renewable sources. In programmes of urban redevelopment, however, the historical city has not yet been subject to significant experimentation, also due to the specific safeguard on this kind of Heritage. This reflection opens up interesting new perspectives of research and operations, which could significantly contribute to the pursuit of the aims of the Smart City. This is the main goal of the research here presented and focused on the binomial renovation of an historical complex/enhancement and upgrading of its energy efficiency.

Keywords: Renewable Energy, Heritage, Micro-generation, Sustainability, Management

Introduction and State of the Art

Cultural Heritage and the debate regarding is protection are increasingly compared to the concepts of growth and sustainable development, starting from the observation that Heritage, as an expression of civilisation, is the first and clearest cultural reference point for a specific place. The approach to sustainability in the historical Heritage, bearer of cultural values, can be declined with different attitudes (Barthler-Bouchier, 2013; Dvornik-Perhavec, 2014); not by chance, the complexity of the problem is taken into account by environmental certification protocols specifically assessed for the historical Heritage, such as LEED Italy and GBC Historic Building, as its direct consequence. These are important experiences, witness to the essential need for a complex, careful and olistic approach to the ecological footprint of all the interventions, even on historical Heritage (Magrini and Franco, 2016). Within this huge framework, energy efficiency of built Heritage constitutes only one, perhaps the most problematic, of the aspects of the problem, on which today it seems indispensable to compare (Pracchi et al., 2010; Pankhurst et al., 2013; Hartman, 2013, Lucchi and Pracchi, 2013).

A significant portion of historical Heritage, in fact, is still air-conditioned and heated with inefficient plants and recurring to fossil fuels, with high energy costs and significant emissions of pollutants into the atmosphere. Even the European research funding program Horizon 2020 individuated, as priority actions, strategies for energy improvement and thermal enhancement of historical buildings and cultural districts, indicating as specific objectives of research: product and process innovation; the development and validation of suitable environmental performance assessment methods; financial strategies, to make large-scale interventions implementable, especially on public property assets.

Energy Efficiency of historical Heritage in its widest meanings is therefore a topic of international scientific debate as demonstrated in some recent conferences (Kilian et al., 2010; Broström et al., 2011; AiCARR, 2014; Lopez et al., 2014; De Bouw et al., 2016), and of methodological and applied research, to fulfil community goals and the EeB PPP roadmap, Energy efficiency of Buildings - Public Private Partnership (Troy, 2014).

It is unfortunately true that the risk in conceiving new relationship between Sustainability and Heritage in many current realities is all too often reduced just to the mere application of products and technologies to save primary energy, which does not always trigger an effective, conscious and virtuous cultural advance towards the real sustainability of our future life (Staudenmaier, 1988).

On the contrary, the aspiration to a quality that is not only technical opens up new research themes. On the one hand, it can lead to the production of new systems and components, more compatible with existing values, developing a creative approach to architectural design. On the other hand, it opens to the identification and definition of new criteria and guidelines for active protection of architectural and landscape heritage (Changeworks, 2008, Cornwall Council Historic Environment Service, Edinburgh World Heritage, English Heritage, 2008, 2010, Historic Scotland, 2013, MiBACT, 2015).

However, some issues and problems still remain open; they regard the possible inclusion of historical Heritage within urban Smart City programs, to which the research here presented has tried to give a contribution.

Main Object and Aims of the Research

New strategies for public lighting, district heating systems, systems of distributed co-generation, systems of smart energy management, systems of production with the integration of renewable sources are all themes which, for a while now, have represented specific applications of "Smart Cities" programs but, until now, have not had any concrete experimentation on the historical and Cultural Heritage.

From here, we find the first question on which this research is based: is it possible to find space within smart grids for ancient buildings, until now excluded by any planning attempt that goes beyond experimentation on individual products? Consider, then, historical buildings not only as consumers but also as real producers of energy, implementing technology that is already available on the market and transferring them to the sector of renovation and restoration.

This articles proposes a brief overview of the two-yearly research on an historical monumental complex, the *Albergo dei Poveri* in Genoa which, given its dimensions and particular collocation in the urban context, may be assimilated into a real urban district (Figs. 1, 2, 3). Built between the mid-seventeenth to the mid-nineteenth century, it is owned by a private institution and al-

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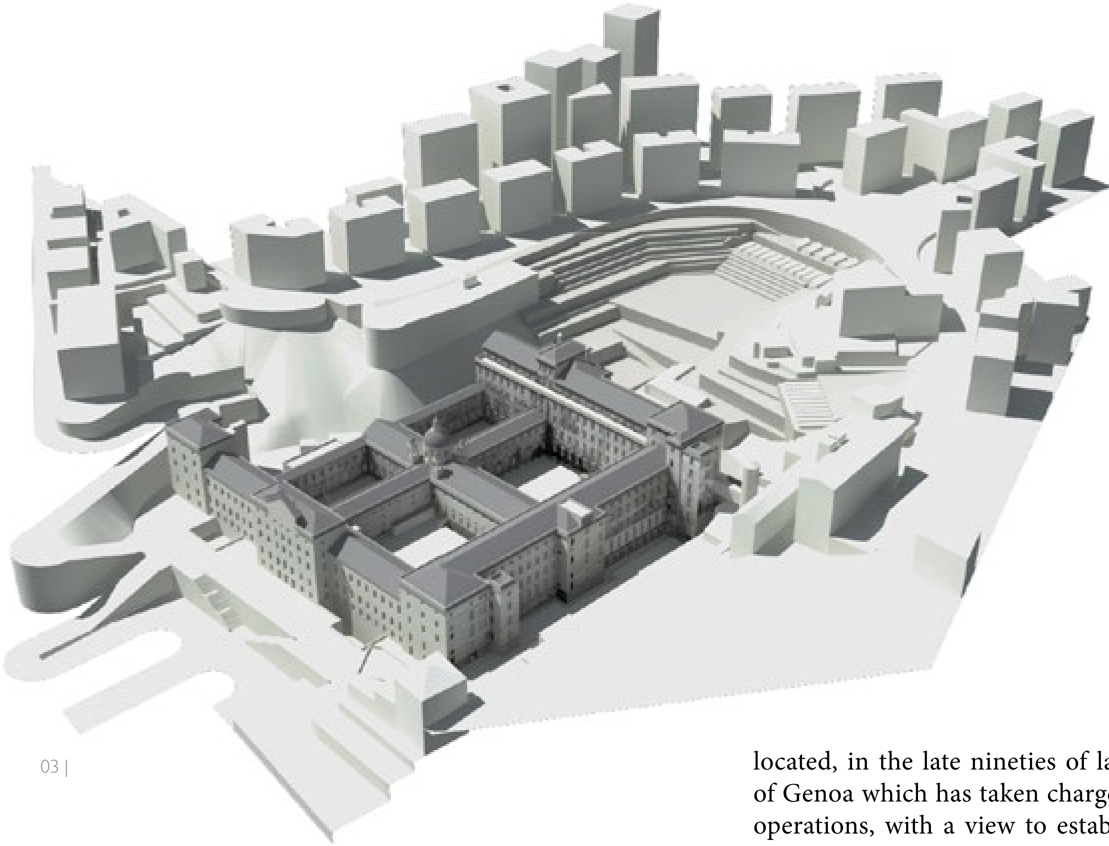

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01 | Aerial view of the centre of Genoa. Highlighted the monumental historical complex of the *Albergo dei Poveri*, the Valley *Carbonara* and other university buildings seen as a District

02 | View of the *Albergo dei Poveri* from the north side

03 | Model of the complex of the *Albergo dei Poveri* and of the *Valletta Carbonara* (Macchioni, E. 2013)

located, in the late nineties of last century, to the University of Genoa which has taken charge of the renovation and reuse operations, with a view to establishing the teaching and departmental headquarters of the faculties of humanities. Currently, only a small part of the available spaces has been recovered (Table 1, Fig. 4); the remaining part, especially in the northern wing, is exposed to the degradation actions, waiting for its restoration and reuse. For this reason, in 2011 the University entrusted the Post-Graduate School in Architectural Heritage and Landscape (under the scientific responsibility of the author and prof. S.F. Musso) with a campaign of studies and research preliminary to the complete restoration and reuse of the complex. From here, the idea of including it in the programs of Genoa Smart City, proposing the project to the Liguria Region (which financed it), to the Rector of the

	Surface (gross) m²
Renovated area	18,750
Area to be renovated and reused	48,000
Total area of the complex	66,750
Area of Valley *Carbonara*	25,000

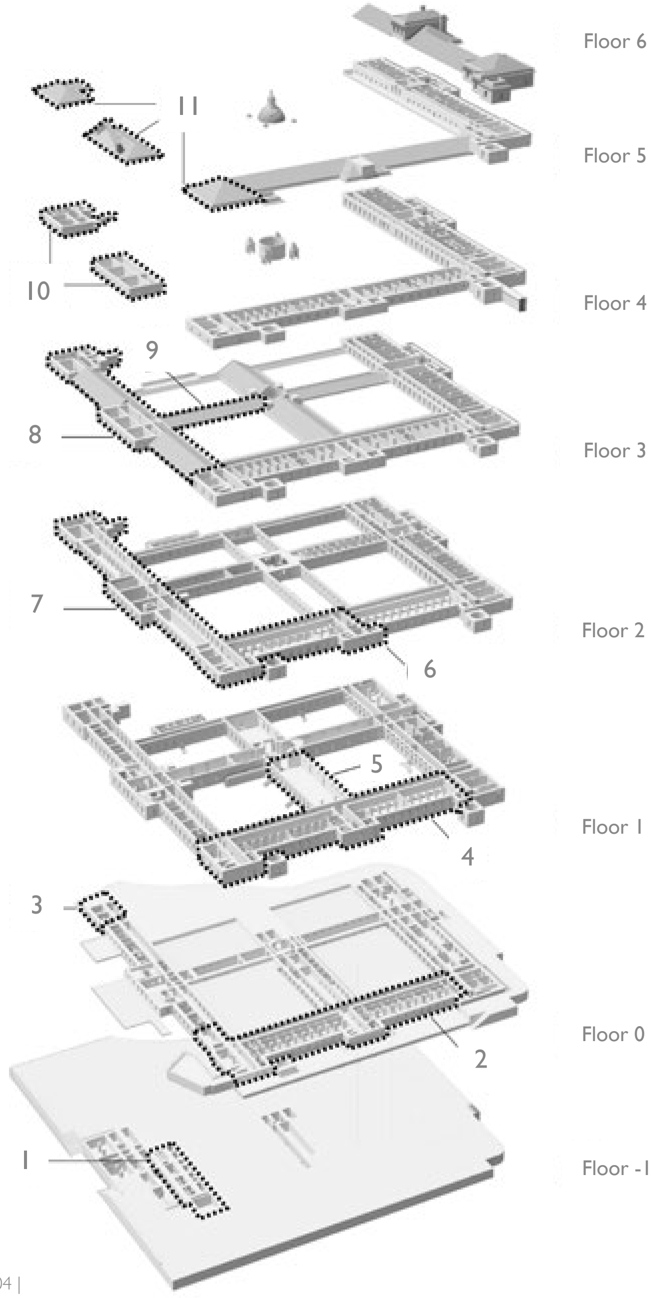
Tab. 1 | Total surfaces of the complex of the *Albergo dei Poveri* and the Valley *Carbonara*

Electricity E_{EL}	Thermal energy E_{THERM}	Primary energy E_{PRIM}
kWh_{el}	kWh_{therm}	Tep
956,000	2,496,000	428

Tab. 2 | Quantification of the overall demand of the portion of the complex to be renovated

University, to the Mayor of the city, to the Superintendent of the Ministry of Cultural Goods (MiBACT). The proposal contemplated the ambitious challenge of overcoming prejudices, conflicts and cultural taboos between the field of Architectural preservation and the one, more technical, of Energy Efficiency in buildings. Main aim of this challenge was the attempt to attribute to the monumental complex the role of a new "pole", as an energy producer at the service of the nearby "University District" (*Palazzo Belimbau* and *Palazzo Serra* in *Piazza della Nunziata* and other university buildings in *via Balbi*, among which are the headquarters).

In order to arrive at a pilot program capable of representing a best practice experience transferable to other contexts, it was necessary to synergistically study a number of aspects involving also different stakeholders who shared common objectives of preservation, enhancement and improvement of Cultural Heritage. The feasibility study focused on the possible improvement of thermal performance and micro-generation; it would not have been possible without the work carried out by the group headed by the Post-Graduate School (working on historical and archive inquiry, survey laser scanning campaign, diagnosis of materials, construction techniques and structural behaviour, technological deficits, monitoring of environmental conditions and of old technical plants and nets). At the same time, with another ministerial financing (PRIN Programme), the same monumental complex was used as experimentation field to apply the BIM model, identifying and solving problematic issues related to the application, to the built heritage, of an instrument created to optimize the new construction procedures (Fig. 5). Only in this way, merging all the research synergies, it was possible to answer the numerous and complex questions raised by the whole project.



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04 | Identification of the spaces already in use as University. 1. Technical plants. 2, 4, 7. Classrooms. 3, 8, 10. Department of Political Sciences. 5. Aula Magna. 6. Library E. Vidal. 9. University Language Laboratory. 11. Services (Macchioni, E. 2016. Graduate in Architectural Heritage and Landscape, University of Genoa)

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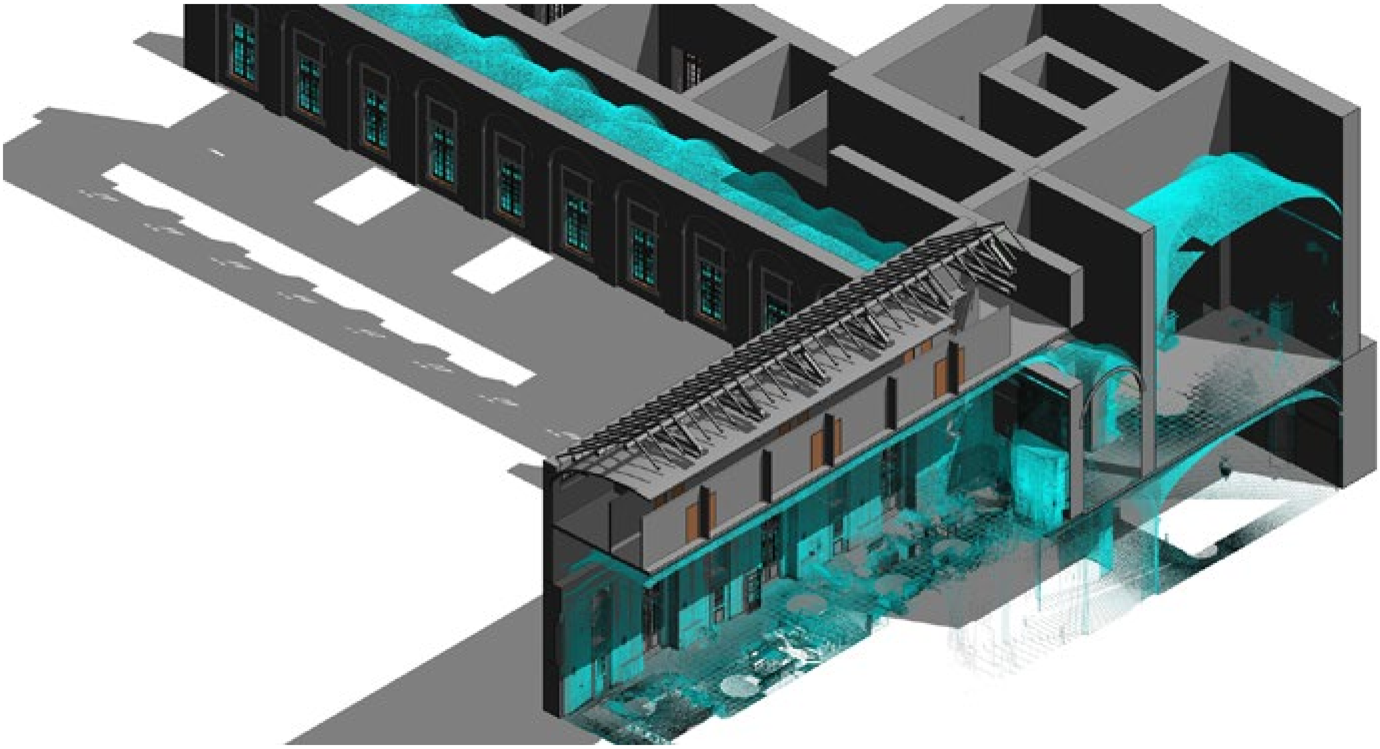

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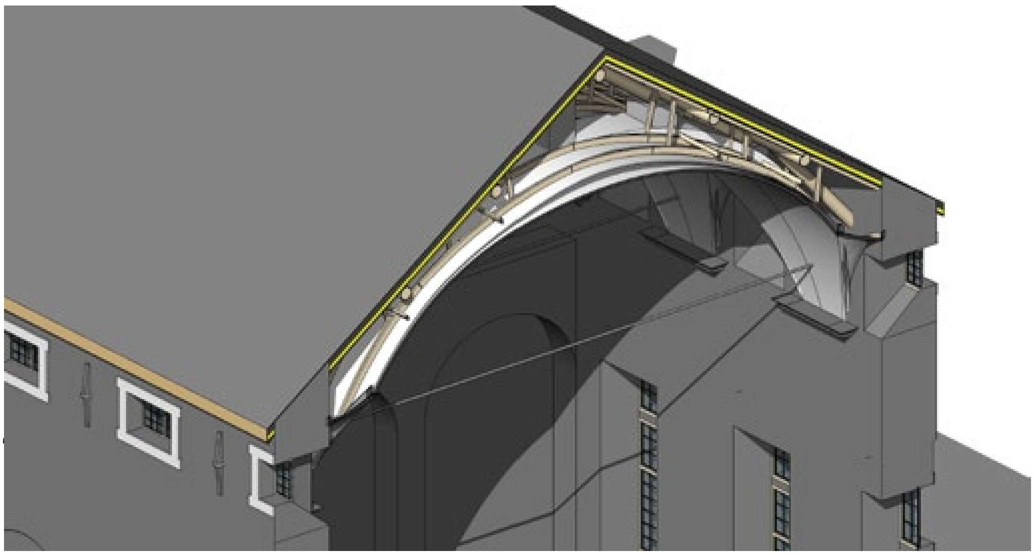


05 | Laser scanner survey and 3D modelling (BIM Autodesk Revit) of the south wing. (Babbetto, R., 2014. PhD course in Architectural Preservation, Politecnico di Milano)

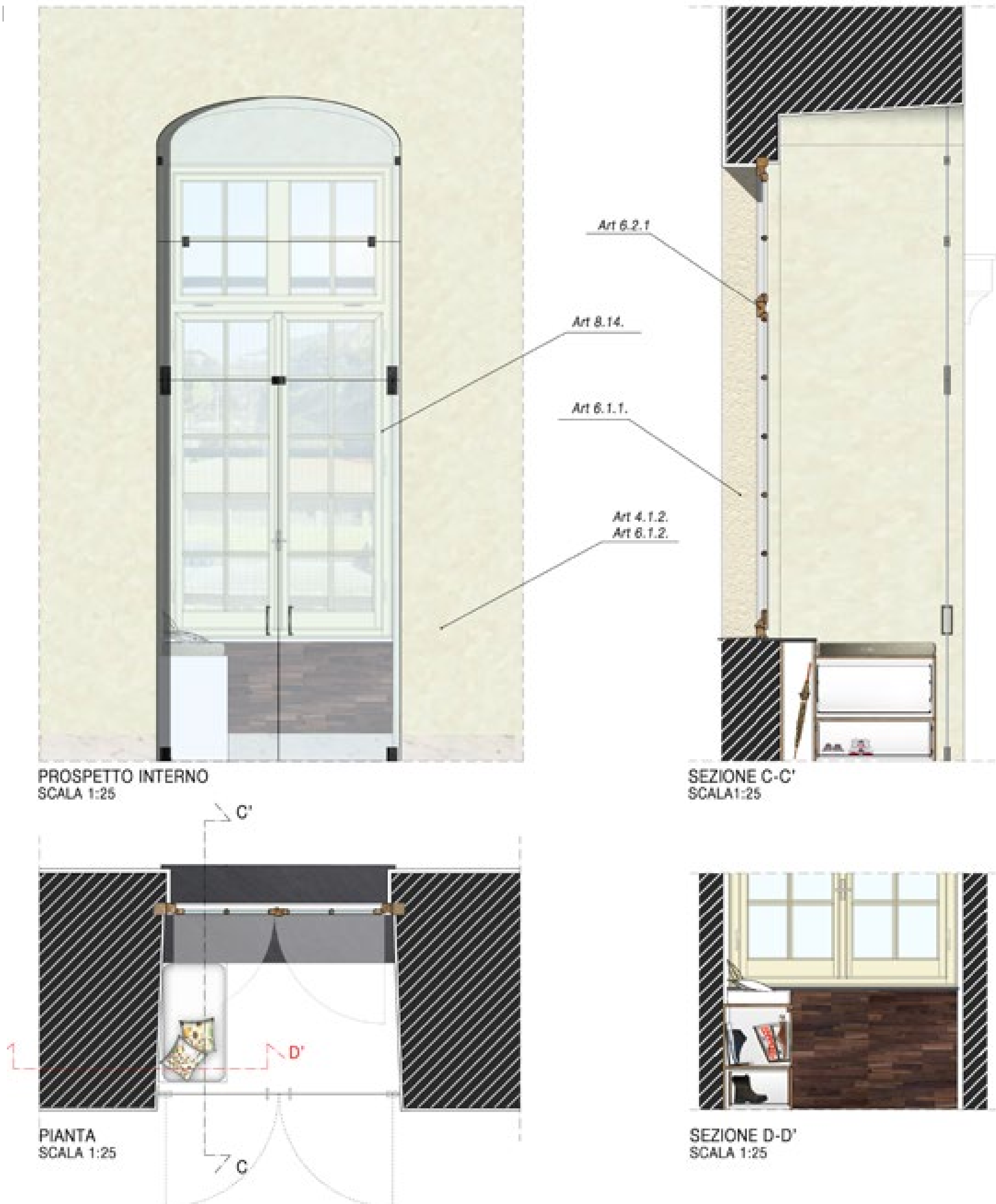
06 | Thermal improvement of the roof (BIM model, Babbetto, R. 2015)

Methodology: principles, phases and tools

In order to tackle such a complex issue, a multidisciplinary research group was set up, with expertise on architectural design and restoration, building physics, thermodynamics and plant engineering, which was joined by an industrial partner. One of the objectives of the work was also to implement a technology on the market (specifically, the gas micro-turbines for the co-generation produced by *Ansaldo Energia*). Already at the very preliminary stage some strategic choices have been made, that is to adopt technologies compatible with the preservation of existing architectural features also demonstrating the possibility of resorting to sources powered by renewable energy.

The methodological approach has been "systemic", which tends to reach the optimization of the systems rather than the maximization of one with respect to the others. This has meant giving up the satisfaction of the requisites imposed by national legislation, above all in terms of thermal performance, in favour of a simply enhancement, compensated from micro-generation.

After an energy audit (thermal behaviour of external walls, windows and roofs and quantification of energy needs), the most appropriate passive technologies were identified. The envisaged actions would have referred, in particular, to the smart use of energy for the liveability and management of that heritage, to energy saving for its heating, cooling, and for the necessary energy supply of the other plant equipment and to a possible autono-



07 | Proposal for a new window system in the northern wing, doubling the existing one (Bresolin, G., Stagnaro, I., Tomasetti, G. 2012)

mous energy production inside them or around (widespread micro-generation), always in compliance with the existing protection obligations.

The successive phases previewed an assessment of the effectiveness after the application of these technologies in terms of energy savings and, as a last stage, a global energy balance.

A specific research activity then concerned the definition of compatibility criteria between new technologies (with a specific study on photovoltaics) and the conservation of the material and testimonial values of the historical complex (Changeworks, 2009; Dessì, 2013; English Heritage, 2009; Franco, 2015; Giallocosta and Piccardo, 2014; Historic Scotland, 2014; Moschella, 2013; Munari Probst, 2012, Polo Lopez, 2014; Scudo, 2013).

In more detail, the feasibility study has been organized in the following phases:

1. Calculation of the energy requirement for the building envelope on the portion of the complex still to be recovered (around 135.000 m^3) and in current situation, using a steady state method software in compliance with national and regional laws and regulations.
2. Validation of the calculation assumptions through a comparison with the current consumption of the already recovered part of the complex, which exhibits the same morphological and constructive characteristics as the parts still to be recovered.
3. Calculation of new energy requirements, based on the new uses set out, account being taken of low consumption technologies, such as led lighting (Table 2).
4. Identification of the most suitable energy improvement interventions on the so called “building envelope” (mostly insulations) compatible with the morphological and architectural

Floor	S	V	PTHERM	A	B	C	D
	m²	m³	W	%	%	%	%
Ground	2,848.29	15,653.46	132,608	0	0	-4.49	-29.32
First	5,386.,75	45,953.53	459,081	-1.58	-5.74	-2.43	-23.60
Second	4,061.86	23,305.34	289,454	-3.37	-15.39	-2.95	-22.02
Third	4,312.80	22,140.82	191,532	0	0	-3.59	-29.30
Fourth	3,683.66	19,123.43	240,915	-5.10	-18.92	-2.75	-20.10
Fifth	1,558.95	6,778.12	131,734	-9.04	-37.68	-2.18	-14.19
Sixth	407.76	2,108.32	49,922	-8.56	-33.09	-2.04	-13.84

Tab. 3 | Percentage variations of thermal power in the different insulation scenarios. S Net surface, V Net volume, PTHERM Thermal Power, A (Insulation of the roof), B (Insulation of the attic floor), C (Insulation of the outer perimeter wall in the sub-window portion), D (Insertion of a new internal window/door)

features of the complex; assessment of the resultant benefits in terms of energy saving.

5. Feasibility investigation on inserting cogeneration plants (micro gas turbines for the production of thermal and electrical energy), considering the needs and requirement of new previewed uses (point 3); insertion of PV glass to glass cells on the old greenhouses in the Valley *Carbonara*.
6. Calculation of the whole energy balance deriving from the application of the considered technologies.

Main results

The feasibility study demonstrated the correctness of the adopted strategy and has come to rather precise technical indications, in terms of necessary insulations and sizing of the micro-turbines and PV cells.

As concerning the enhancement of thermal behaviour of the old complex, the greatest benefits in terms of energy saving may be achieved by improving the performances of the roof (intervention A) (Fig. 6) and the under-roof environments (the attic floor, intervention B). With regard to perimeter walls, account has only been taken of the insulation of the portion under the window, less thick than the rest of the wall and more exposed to infiltration-originated humidity (intervention C), in order to save old lime plaster, both internal and external, to be restored. A significant gain can also be achieved by improving the performance of external doors and windows; for conservative reasons, it was preferable to think about their restoration plus the insertion, in the thickness of the wall, of a new certified window (intervention D) (Fig. 7). All these techniques have been evaluated in terms of energy gains (Table 3).

Concerning the cogeneration system, the optimal use presupposes a continuous full-load operating regime within the 24-hour cycle (maximum performance) and an "onsite" consumption of the entire electricity and heat produced.

During the winter period, part of the thermal energy consumption might be covered by a first unit operating for 4,344 hours (24 hours/day for 6 months) and by a second unit operating for 2,172 h only (12 hours/day for 6 months from 8h00 to 20h00) (Table 4). Added to this is the energy produced by PV, to be used both by the *Albergo* its self and the neighboring university buildings (Fig. 8).

Conclusions

Based on the methodology adopted in this work, recently published (Franco and Magrini, 2017), new researches have been set up on the Energy Efficiency of the monumental historical Heritage in the region and in other Italian contexts, sensitizing owners and managers of prestigious property estates. Various are the players this awareness-making process is addressed to:

- Owners, be they public (or religious) or private organizations, often oblivious to the most recent scientific issues but interested in "sustainable" management (also financially) of the heritage they are responsible for, as well as the possibility to access financing in the form of incentives and fiscal relief.
- Technicians and professionals. These two categories may, for example, be compelled to undertake permanent professional training programmes offered by dedicated recognized organizations.
- Superintendence officials representing the authorities appointed to evaluate and approve proposed projects on the basis of tried and tested preservation practices.

ETERM-CHP N°1+2	EEL-CHP N°1+2	Nh-CHP N°1+2
kWhth/year	kWhel/year	kWhel/year
1,456,908	872,400	8,724

Tab. 4 | Overall data on energy production through the use of two cogenerators

08 | Restoration of the greenhouses system with glass PV cells (photo-simulation) (Macchioni, E. 2016)

Considering Cultural Heritage not only as a petrified memory of the past, but also as an active resource for the future, reusing and valorising it, means changing how we think of preservation; no more merely the purely aesthetic perception of production and landscapes as they are, but considering it now as a process of revitalisation for the benefit of all, with all the challenges this entails.

ACKNOWLEDGMENTS OF VALUE

The research, financed by Liguria Region, was offered to the University of Genoa (in the person of its Rector and Building Manager), who is in charge of the management of the historical complex of the Albergo dei Poveri as well as owner of other monumental buildings, some of them actually under renovation and restoration (Palazzo Belimbau in Piazza della Nunziata). Those responsible for the maintenance, management and future development of the Athenaeum building stock, on the basis of the feasibility study presented here, have started a fruitful dialogue with the Protection Authorities to include also historical heritage in Energy Efficiency and energy saving programs. This feasibility study has also been presented to the university commission in charge of electric energy saving, in order to merge all these research and studies proposals into a coherent and common framework.

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The SELFIE façade system. From Smart Buildings to Smart grid

Rosa Romano, Paola Gallo,
Department of Architecture, University of Florence, Italy

rosa.romano@unifi.it
paola.gallo@unifi.it

Abstract. The aim of the SELFIE (Smart and Efficient Layers for Innovative Envelope) project was to develop novel adaptive envelope systems for nZEBs, within the framework of a smart city, in order to facilitate the exploitation of RES at building scale and simultaneously decrease the energy consumptions and improve indoor environmental quality in non-residential buildings.
The process of designing innovative technological systems, capable of integrating smart materials and novel technologies, into the new construction and/or renovation of buildings, will be described in this paper. The objective is demonstrated how it is possible transferring know-how from different production sectors aimed to reduction of environmental impact of the built environment of our cities.

Keywords: Adaptive façade, nZEB, Renewable energy, Smart building, Smart materials

Introduction

A shared definition for Smart Cities might still lead to extensive discussions among experts, covering many areas related to energy technology development, environmental issues, politics and socio-economic aspects. Furthermore, following the outlines of the Smart Cities and Communities Initiative of the European SETPlan, Smart Cities are clearly focused on the promotion and dissemination of a new generation of innovative, intelligent and energy-efficient buildings: smart buildings and energy-efficient interactive buildings. In particular, the latter represent the next generation of buildings, where energy efficiency is not exclusively achieved by a single building but rather involves the entire energy infrastructure network of the city, and where buildings represent essential and strategic nodes for exchanging of production of energy (Arbizzani, Civiero, Ortega Madrigal and Serrano Lanzarote, 2015).
A smart built environment requires energy-system-responsive buildings ready to meet the needs of electricity, district heating and cooling grids and the broader energy system. Buildings are smart when they optimize the interplay between individualised consumer settings and physical energy flows e.g. in heating, cooling and ventilation systems. (De Groote, Volt, Bean, 2017)
In this context, what role will innovation in systems and components play in the future? Will we be able to change existent technological systems and develop innovative products in order to influence the building market or create new ideas capable of changing the lifestyle of people within the framework of smart city and/or smart building concepts? The answer to these questions is to achieve a sustainable good quality construction as an ongoing process starting with the new characteristics and opportunities for enterprises and to develop new components, such as adaptive envelopes, with high efficiency in order to satisfy the construction market and meet user demand for high-performance (Gallo, 2014).
For decades, architects and building scientists have envisioned the possibility of the envelopes of future buildings replicating human skin's adaptive response to changing environmental conditions (Davis, 1981; Wigginton and Harris, 2002). Advances in material technology and building automation systems are drawing these parallels between adaptive envelopes and the intelligent response of human behaviour and skin to environmental stimuli, seen as an increasingly feasible way of regulating energy flows through a building's thermal barrier in a controlled manner that promotes energy reduction and occupant comfort.
Michael Wigginton and Jude Harris (2002) in their text on Intelligent Skin define this concept as an active and dynamic control system capable of regulating the interchange of energy passing between the inside and outside of an environment, ensuring an excellent level of comfort through the possibility of automatically varying the building's structure. A large number of sensors can regulate the system with precision, transforming the building into a smart building. The variability of the façade system makes it possible to regulate heat and light energy flows through its conformational layers, and has defined an evolution in research linked to phase change materials, advanced glass surfaces, such as electrochromic and/or photochromic glass, or mobile (horizontal and vertical) external screening systems.
The concept of the smart building is, therefore, closely linked to that of the smart façade, as the façade itself is the main element capable of changing its structure to ensure the required performances, emphasizing its resemblance to human skin. With these complex and multi-layer envelope systems, there is always the possibility of manual or automatic control so that the energy flows passing through them can be managed efficiently. The envelope thereby becomes a real organic system connected to the building's central control system and to the air conditioning system, which can be compared with the human artery system (Romano, 2011).
Moreover, the targets set by the Energy Performance of Buildings Directive 2010/31/EU and Energy Efficiency Directive 2012/27/EU on the energy performance of buildings, the rising cost of fossil fuels in recent years, as well as high emissions and tiny air pollution particles have led to the development of a new generation of smart buildings for a new generation of smart cities.
In this legislative and cultural contest, in Italy to overcome these barriers and driven by the scenarios presented by the European Community, the Italian Ministry of Education, Universities and Research and the Regional Administration of Tuscany funded a research project named SELFIE. It aimed to develop synergies between industrial companies, builders and research centres to increase competitiveness in the building sector and meet European and Italian standard requirements. The project aimed to increase energy savings in the Mediterranean climate, focusing

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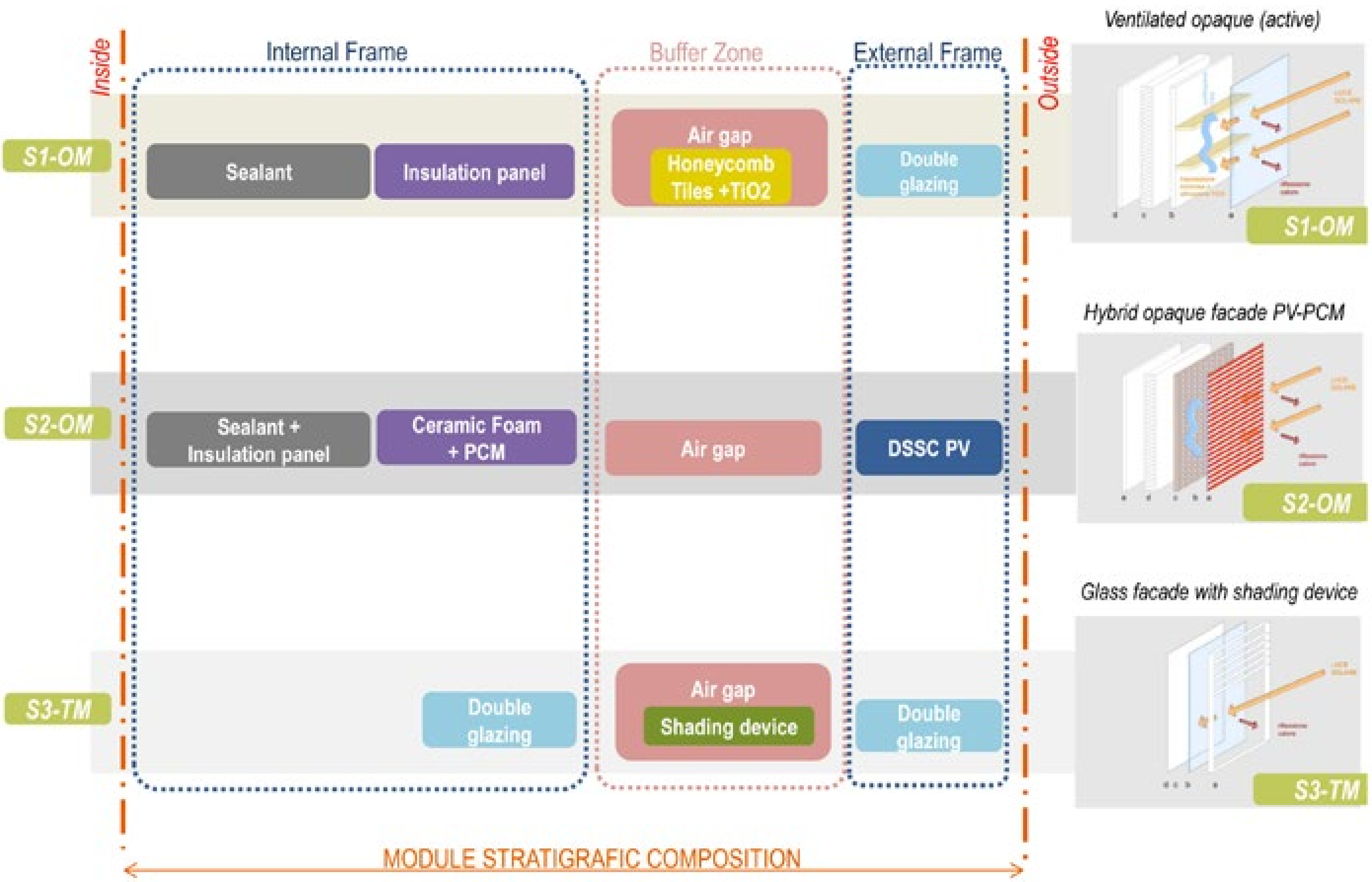

01 | Diagram showing the stratigraphic composition of SELFIE Modules

on summer comfort, developing and testing innovative envelope solutions. The research, in fact, is mainly focused on the design, testing and prototyping of innovative components for adaptive building envelopes, able to decrease energy consumption in line with the nZEB target for existing and/or new buildings located in South Europe.
For these reasons, the aims of this paper is to describe the process of designing innovative technological systems, , capable of integrating energy savings, smart materials and novel technologies, that can be combined into the new construction and/or renovation of buildings in smart cities located in the Mediterranean area.

The SELFIE research project

The SELFIE components were elements for a vertical envelope with advanced environmental characteristics that could easily be adapted to different types of buildings and different construction systems, capable of meeting environmental compatibility requirements in terms of Life Cycle Analysis, enabling reduced energy consumption and the lowering of greenhouse gases on a global scale.
SELFIE building components actually meet the new requirements dictated by the environmental crisis, which increasingly calls for the scaled down use of conventional energy resources and consequently fewer climate-altering emissions in the air. As a result, advanced technical components are required for use in both new builds and restructuring and redevelopment projects.
The possibility of integrating energy production technologies in the façade system (such as photovoltaic modules) and innovative materials capable of integrating dynamically with the climatic conditions makes the three envelope components assembled in the SELFIE façade prototype particularly suitable for future integrations in smart urban contexts. These are highly innovative technological solutions able of transforming new and/or existing buildings into autonomous built environments from an energy and dynamic point of view thanks to the presence of interactive materials and systems.

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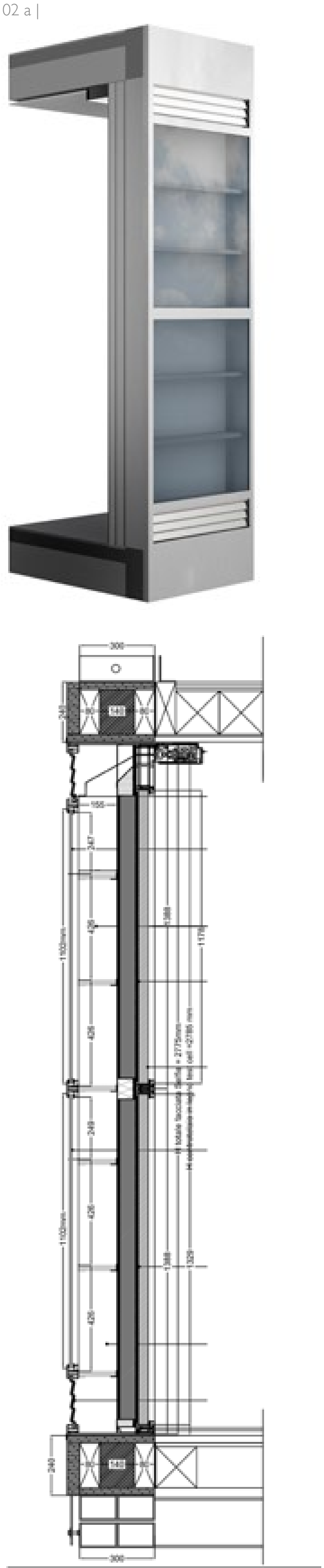

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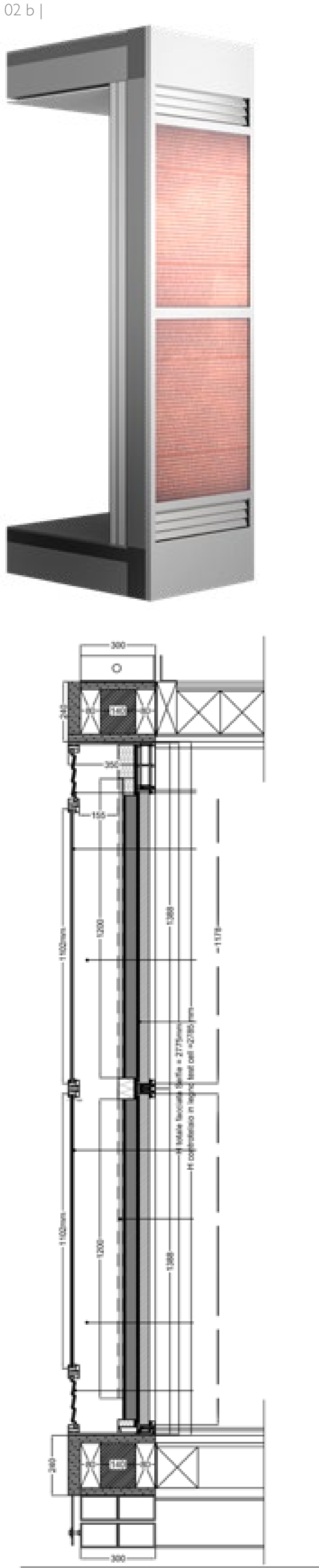

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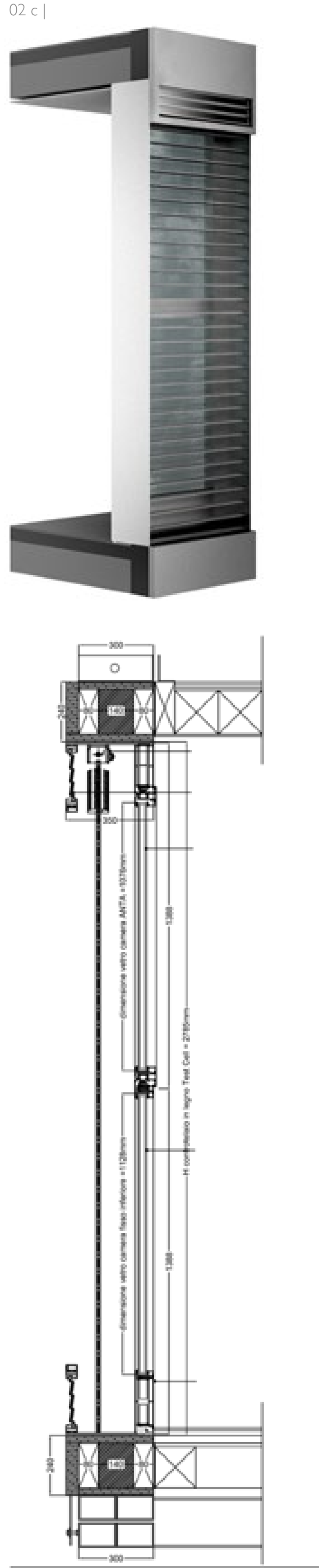

02 | a) SELFIE 1: render and technological detail
b) SELFIE 2: render and technological detail
c) SELFIE 3: render and technological detail

The three components of the SELFIE façade system

The three prototypes of the SELFIE façade system, modular, dry assembled and combinable, designed to measure 92.5x140 cm, and can be configured into different geometric dispositions (Fig. 1).

As part of the research, we project six modules (two for each type identified by the project) aggregated within a double skin façade prototype, measuring 280x280 cm.

Each component appears as a double-frame structure allowing different layers assembled and multiple and specific functions of each layer to be combined. In particular, the internal frame accommodates elements designed to perform thermo-acoustic insulation and closure functions; while the external frame accommodates the surface closure layers exposed to atmospheric agents.

The general aim of the research was to develop envelope components that make it possible to assemble façade that integrate innovative materials and system solutions that can be incorporated into renewable energy generation systems.

SELFIE 1. Ventilated opaque façade

The aim of the façade component SELFIE 1 (Fig. 2a) is to reduce heat dispersion to the outside in order to contain energy consumption in both summer and winter. It contains an integrated system made up of ceramic honeycomb panels treated with photocatalytic paint, which contributes to air purification in the buffer zone.

The mainly "passive" function of the component provides for the integration of "active" elements (ventilation grills and heat exchangers) in order to exploit the winter greenhouse effect and ventilate the confined environment with sanitized air drawn in from the air gap between the internal opaque closure and the external transparent closure (Barbosa, Ip 2014).

The SELFIE 1 functional layers from the outside to the inside:

1. Laminated glass with PVB (Poly Vinyl Butyral) and IR (Infrared Reflective) coatings.
   This is a laminated glass sheet 12.76 mm thick, with a self-cleaning external treatment, coupled with PVB for greater mechanical resistance. The PVB is made of nanocomposite IR reflecting materials to reduce overheating phenomena inside the air chamber.
2. Mobile ventilation grills
   These are two aluminium outlets (h 18 cm, l 8.64 cm), positioned in the lower and upper part of the external layer, with horizontal slats that rotate on their axes thereby opening and closing the air gap according to the external climatic conditions and the need to reduce or increase the thermal transmittance of the component.
3. Air gap
   This is a buffer zone, 15.5 cm thick, for the passage of air from the outside to the inside in winter and from the outside to the outside in the summer months.
4. Ceramic honeycomb panel loaded with TiO2 (Titanium Dioxide)
   These are ceramic honeycomb panels measuring 15x15x2 cm surface treated with TiO2, aligned horizontally inside the air gap in six parallel rows. This geometric configuration ensures the air is purified as it passes through.
5. Thermo-acoustic insulation panel
   Internal closure and support layer, made up of an "ALU-Silent" composite thermo-acoustic insulating sandwich panel formed of an outer sheet of powder-coated aluminium, an inner sheet of tray-shaped aluminium and insulating layers made of self-extinguishing EPS (expanded polystyrene), drywall sheets and polyethylene a wool mattress produced from recycled bottles PET (Polyethylene terephthalate), total thickness 11.50 cm.
6. Three-way heat exchanger
   A small-scale three-way heat recovery aeration system, installed in the top part of the inner layer. This system, which has been altered with respect to market solutions, has been designed to optimize air conditioning in the indoor environment in the winter months thanks to the possibility of using purified air heated by the greenhouse effect in the air gap. In the summer, to avoid overheating in the air gap, the exchanger works as a fan directly expelling exhausted air from the confined space to the outside.

SELFIE 2. Hybrid opaque façade

The façade component SELFIE 2 (Fig. 2b) designed with the aim of:

- reducing heat dispersion to the outside in the winter months thanks to the presence of a thermo-acoustic insulating panel, identical in thickness and characteristics to that used in SELFIE 1;
- increasing thermal inertia in the summer months thanks to the presence of a panel made from an aluminium frame, vertically infilled by two glass sheets filled on the inside with ceramic foam loaded with PCM (Phase Change Materials). (thickness 2 cm);
- producing renewable energy thanks to the presence on the outer layer of an innovative DSSC (Dye-Sensitized Solar Cell) photovoltaic panel which produces electricity irrespective of its orientation (kWp: 0.028).

The component's performance is optimized by the presence of a buffer zone between the photovoltaic panel and the panel containing PCM, in which the speed of the passing air flow can be regulated thanks to the presence of mobile grills placed at the top and bottom of the façade system.

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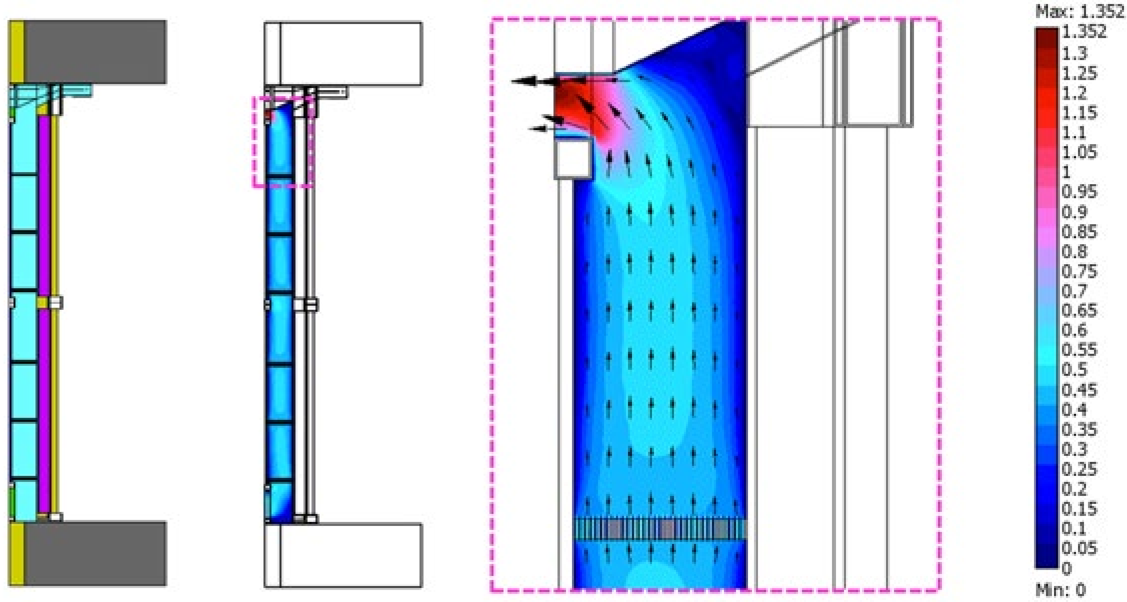

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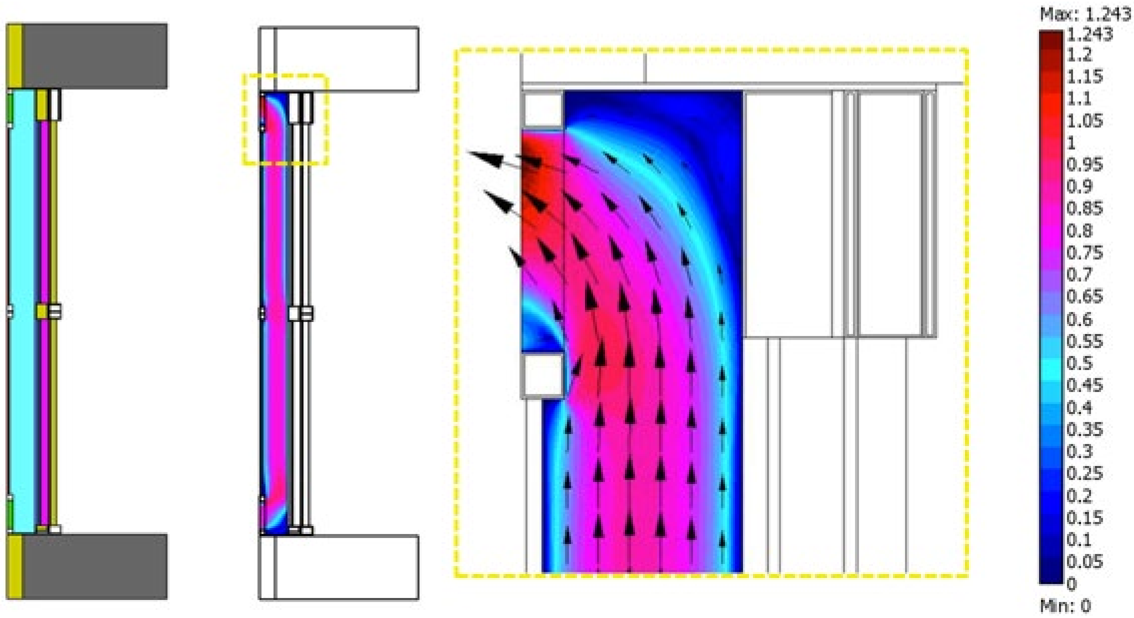

03 | Selfie 1. Stationary analysis of the motion fields (m/s) of air flows inside the air gap in the daylight hours of the summer months. Authors: prof. Carla Balocco, ing. Giuseppe Petrone (DIIEF)

04 | Selfie 2. Stationary analysis of the motion fields (m/s) of air flows inside the air gap in the daylight hours of the summer months. Authors: prof. Carla Balocco, ing. Giuseppe Petrone (DIIEF)

SELFIE 3. Glass façade with screening

The SELFIE 3 (Fig. 2c) façade component designed to control incident solar radiation, limiting the passage of the thermal component (thereby avoiding summer overheating) and controlling the light component (to ensure good natural lighting in the confined spaces throughout the year).
The external sheet of the system is made of laminated glass with an integrated layer of PVB treated with IR coatings, mounted on an aluminium frame with thermal break. A solar screen created with motorized aluminium blades is positioned outside to further reduce indoor overheating in the summer months.

Simulation and analysis in design phase

In the concept stage, for the three SELFIE components and the façade prototype constructed with them, CFD (Computational Fluid Dynamics) and FEM (Finite Element Method) simulations were made using a multiphysics approach in steady and dynamic conditions (Favoino, Goia, Perino, Serra 2016). In particular, researchers from the UNIFI DIEF (Florence Industrial Engineering Department) operating unit developed solid two-dimensional models of the SELFIE components, against which to analyse the resolution of the motion and temperature fields inside the air gap, concurrently with reference meteoclimatic electrical transients. (Balocco, Petrone 2017)
The models made it possible to assess the thermophysical and energy performances of the system as the geometric-functional configurations varied during the design phase, providing input on fundamental design details, such as the width of the buffer zone and/or the size and positioning of the ventilation outlets.
The simulations conducted in the preliminary phase, allowed us to verify the façade performances in terms of heat dissipa-

tion during the summer season (ventilation flow rate, thermal power extracted for ventilation, thermal flow transmitted to indoor environments, periodic thermal transmittance), and in terms of energy containment and how the system operates as a passive solar element during the winter season (thermal buffering, periodic thermal transmittance, thermal flow dispersed from the indoor environment, free solar contribution to indoor environments). (Darkwa, Li, Chow, 2014).

The results obtained have highlighted, as in the SELFIE 1 and 2 (Fig. 3, Fig. 4) the ventilation rate of the cavity, is the wall working fundamental parameter useful to control the optimal transfer of the heat received by the external façade in the summer season. In particular, experimental data analysis has proved that mechanical ventilation is necessary in the SELFIE 2 in the presence of a radiant barrier effect of the wall during summer nigh-time. In this component, in particular, the energy benefit due to the phase change materials (PCM) has been studied in order to discharge the storage effect of the external and internal heat, through night ventilation.

Referring to the thermal flux transferred to the indoor environment, the results show that thermo-physical behaviour of the three SELFIE systems during winter conditions is very similar. Analysing results obtained for winter, it must be considered that when the external air temperature is lower than the internal one, there may be appreciable values of the incident solar radiation; this fact guarantees the natural convection inside the air cavity and then the chimney effect (with natural draft due to the air density differences, i.e., the effect of buoyancy forces). The chimney effect is also present without important values of the incident solar radiation because, in any case, the air warms up assuring the natural draft in the cavity. From the thermal exchange point of view, the total heat losses through the building components of each SELFIE system are not favourable, but the advantage consists of vapour condensation removal.

In the next few months, the SELFIE façade prototype will be tested to assess the performances of the component in a real application (Abitare Mediterraneo outdoor test cell) (Fig. 5) to compare them with the results obtained in the preliminary phase through the CFD and FEM simulations.

Material	Density	Thermal Conductivity	Specific Heat at Constant Pressure
	kgm^{-3}	$Wm^{-1}K^{-1}$	$Jkg^{-1}K^{-1}$
EPS	32	0.03	1700
Concrete	2200	1.8	880
Ceramic/TiO_2	2100	1.63	1016
PET	1380	0.28	1050
Plasterboard	1900	0.20	840
Aluminium	2800	200	900
Air	pR-1*I-1	0.026	1010
Ceramic foam/ Decanoic acid	1179	$0.789^{(S)}\div 0.627^{(L)}$	1500
IR Glass/DSSC Glass	2410	0.937	840

TAB. 1 | Thermophysical properties of the materials integrated in the SELFIE components

Conclusion

Cities already consume 75% of global energy resources and account for 80% of emissions. By 2050, 66% of the world's population will live in cities. Cities are faced with these challenges, as well as the high expectations of citizens, severe budget constraints, and the need to attract jobs and investment. It follows that in order to become more efficient, sustainable, liveable, and attractive, cities need to become smarter.

Sector agencies define a smart city as cooperation and information sharing across sectors and systems to achieve sustainable outcomes. Information comes from connected devices, and today 45 per cent come from smart homes and smart commercial buildings. According to recent estimates, the total number of connected devices will grow from 1.1 billion in 2015 to 9,7 billion in 2020.

Many European cities are already beginning to create digital infrastructures that collect, manage, and analyse data from connected assets. Government agencies and wider groups of stakeholders are using "digital hubs" to gain new operational insights enable a more predictive approach and, in turn, improve the efficiency and quality of services.

Within this framework, the SELFIE project research shows how innovation within a project, company and occupational industry provides the opportunity to achieve significant benefits, and in a smart city it is a requirement for continued existence. In addition, in an effort to catalyse innovation in environmental building performances, the impetus for SELFIE will not be to simply create new building products for the built environment, but to develop enabling technologies that can engage in seeking a balance between aesthetics and efficacy.

The right number and the extensive professional expertise of the partners involved in the SELFIE research project, will guarantee its success and the actual possibility of developing new conceptual and operational tools to support the innovation process in the smart city and adaptive envelope field in order to promote nZEB buildings as envisaged in EU directives and the European SETPlan.

05 |

05 | SELFIE façade prototype being monitored at the *Abitare Mediterraneo* test cell in Florence

Research developed thanks to MIUR (Ministry of Education, Universities and Research) and Tuscany Region (FAR-FAS 2014). Official in charge for Tuscany Region, dott. Lorenzo Bacci.
SELFIE project has been declared effectiveness for the industrial development of the building sector, since the results obtained, in terms of technological solutions developed, are an industrial attractiveness into local scenario.

ACKNOWLEDGMENTS OF VALUE

Research developed thanks to MIUR (Ministry of Education, Universities and Research) and Tuscany Region (FAR-FAS 2014).
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Furthermore, the authors would like to acknowledge all partners involved in the consortium that worked in synergy to study, design, test and build the innovative SELFIE façade solutions:
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INTRODUCTION: WHY A VIRTUAL ROUND TABLE ON SMART CITIES?

Paola Clerici Maestosi,
Coordinator for Scientific and Editorial Board of European Energy Research Alliance Joint Programme on Smart Cities, ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
paola.clerici@enea.it

Regardless the source, energy is a major factor for development. It is needed for transport, industrial and commercial activities, buildings and infrastructures, water distribution and food production - to quote a few. As a matter of fact,most of these activities take place in or around cities, which are responsible - on average - for more than 75% of a country's Gross Domestic Product (GDP) and can therefore be considered as the main engines of global economic growth. To run their activities, cities require an uninterrupted supply of energy. A sustainable urban energy system needs low carbon technologies on the supply side and an efficient distribution infrastructure as well as lower consumption on the end-user side.
The aim of this Virtual Round Table[1] is to present the perspectives of representatives of selected stakeholder groups we consider as key actors for urban development.
According to the above scheme, the Virtual Round Table Editorial Board[2] have identified four main stakeholder groups: Governmental Stakeholders; Research Stakeholder; Design/Construction and Real Estate Stakeholders; Social/Civil Society Stakeholders. For each group the Editorial Board elaborated a set of questions; each stakeholder group is introduced by a member of the Editorial Board, who - at the end of the contribution - identify the main findings.
Highlights on the topic are provided in the Foreword by Magdalena Andreea Strachinescu Olteanu - Head of Unit, New Energy Technologies, Innovation and Clean Coal, Directorate General for Energy, European Commission - and by Eddy Hartog - Head of Unit Smart Mobility and Living, Directorate General Communications Networks, Content and Technology, European Commission. I would like to thank them and express my sincere appreciation for their contribution.

01 |

Government Stakeholders
Research and Innovation Stakeholders
Design/Construction Stakeholders
Real Estate Stakeholders
Urban Services Stakeholder
eCommerce Stakeholders
Analyst, IT project and Big Data Stakeholders
BPM Stakeholders
Financial/funding Stakeholders
Social/Civil Society Stakeholders

07 | Urban Stakeholder, from RdS, SCC solutions for Smart Urban District, PAR2016/033

NOTES

[1] The Virtual Round Table on Smart Cities is more than a collection of points of view. A Round Table asks for selected speakers to present in depth - and discuss - at their best, a set of given questions.
Our Virtual Round Table is a Round Table in the sense that a set of questions have been given, then the answer - among the same Stakeholder Group - have been circulated for fine tuning. Then it is Virtual as the most of our key note speakers didn't have the opportunity to meet.

[2] Paola Clerici Maestosi, Paolo Civiero, Elena Guarneri.

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FOREWORD

Magdalena Andreea Strachinescu Olteanu, Head of Unit, New Energy Technologies, Innovation and Clean Coal, Directorate General for Energy, European Commission
Eddy Hartog, Head of Unit Smart Mobility and Living, Directorate General Communications Networks, Content and Technology, European Commission

The current accelerated urbanisation and the progressing climate change go along with many big challenges. While current progress in energy efficiency, cutting CO_2 emissions and the use of renewables is encouraging, far more needs to be done. A smart city should be first of all the city that people want to live in because it provides a healthy, safe and creative ecosystem to live and work in.

The EU actively fosters an urban development that is economically and environmentally sustainable, taking full advantage of the opportunities that digital solutions provide through the Internet of Things, broadband communication networks, big data, and artificial intelligence. Already in 2012 the Commission launched the European Innovation Partnership for Smart Cities and Communities to mobilise the main actors across the areas of energy, transport and ICT to this effect. The EIP SCC has already delivered on:

- creating a smart city market place where suppliers and cities meet in order to find the most cost-efficient Smart Cities solutions;
- taking concrete steps to avoid vendor lock-in and/or the implementation of non-interoperable solutions. As a first example, a standardised reference architecture and design principles for urban platforms were created. As a second example, the EIP SCC facilitated the delivery of a smart lamppost standard and the aggregation of demand for procurement purposes.

The European Commission has also triggered the development of a common ontology for smart appliances called SAREF, allowing different devices to exchange information with any energy management system and the smart grid for a more efficient and flexible energy use. Work is ongoing to extend SAREF to smart cities.

This work was closely linked to the EU research and innovation funding programmes FP7 and H2020, where we have dedicated specific calls for Smart Cities and Communities since 2013. More than 200 projects have been granted to stimulate the take up and large-scale deployment of smart-city technologies and many significant outputs of them have been obtained in the fields of energy, mobility and digital solutions. A good example of these are the 12 Horizon2020 Smart Cities Lighthouse projects representing approx. € 270 million of EU funding are operational in 78 cities working with partners from industry, SMEs and research to improve quality of life of European citizens and competitiveness of our cities. Relevant stakeholders have also met in the Smart Grids Task Force in order to share insights and good practices to overcome existing technical and regulatory barriers in the take up of smart energy solutions; helping to shape EU smart grid policies.

In the 2016 Energy package the European Commission included important digital elements such as the equipment of building automation and control systems in residential and non-residential buildings which are above a certain size and/or energy consumption level or installed power. Another significant release has been the setup of the Smart Readiness Indicator. This indicator will assess the readiness of a building to interact with their occupants and the energy grid. Because of this, smart buildings linked to autonomous electric vehicles, being able to optimise their energy consumption and CO_2 emissions, will be a key component within the forthcoming smart city scenario.

The European Commission appreciates the work of the EERA Joint Programme on Smart Cities and their drive to create a deeper understanding of all the underlying elements and their interdependencies. This knowledge will help to create citizen-centred, progressive and attractive smart cities that with these attributes will also gain a competitive edge.

Magdalena Andreea Strachinescu Olteanu
Head of Unit, New energy technologies, innovation and clean coal, Directorate General for Energy, European Commission

Eddy Hartog
Head of Unit Smart Mobility and Living, Directorate General Communications Networks, Content and Technology, European Commission

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GOVERNAMENTAL STAKEHOLDER GROUP

A Dialogue between **Paolo Civiero** and **Gunter Amesberger, Pasquale Capezzuto, Xavier Normand** and **Rasmus Reeh**

paolo.civiero@uniroma1.it

Cities are facing considerable population growth, increasing pressures and economic burdens. To remain competitive and achieve sustainable growth, cities must find ways to boost their efficiency and reduce costs while ensuring good quality of life for all citizens.
Smart Cities seem the only way that energy systems can be brought onto a sustainable track. This transformation of a city into a Smart City however, calls for both a cultural and a dimensional change, a new scenario that goes beyond cities, regions and nations. It requires that cities broaden their perspective, think globally and search for innovative solutions at a European level and beyond.
According a Smart Cities concept, digital technologies and the use of different types of web platforms will help to transform cities into better place for public services, sustainable use of resources and less impact on the environment, even if innovative technologies are not the only solutions to increase the quality of cities and to ensure the direct relationship between citizens and Institutions.
A Smart City is a complex place where the traditional networks and the use of digital and telecommunication technologies are made more efficient for the benefit of its inhabitants and businesses. So a Smart City concept goes beyond the only use of ICT for better services, resource use and less emissions, and means smarter urban planning, transport networks, upgraded water supply and waste disposal facilities, and more efficient ways to light and heat buildings.
In this scenario, cities are gradually shifting towards innovation, following or supporting sometimes the steps of the private sector toward sustainable enterprises, and also encompassing a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population.
The participants in the VRT are key note representatives of four European Municipalities, involved in different innovative project programs on Smart Cities.

Paolo Civiero *The development of sustainable and energy-efficient "Smart Cities" is the only way to move the energy system towards a more sustainable path and to limit the drastic increase in urban energy consumption associated with CO_2 emissions?*
Gunter Amesberger It should be remarked at the outset that the term Smart City has gone through some significant changes: at the end of the 20th century, a Smart City accommodated the information and communications technology sector (ICT), which was pushing ahead with the modern infrastructure of the city. A Smart City applied ICT innovatively for controlling urban developments. This perspective primarily had the use of new technologies (innovations) in sight.
The term Smart City broadened out later: a city was now seen as smart when the relevant political, business and civil society stakeholders demonstrated that they were capable of cooperation flexible in the face of change and innovative in the face of challenges. In summary, a Smart City can be defined as the achievement of maximum quality of life with a minimum use of resources with the aid of the intelligent digital networking of digital technologies. Resources deployment naturally applies above all else to the energy sector and the CO_2-emissions that are linked with this. The consequence of this is that Smart Cities are in fact the only way that energy systems can be brought onto a sustainable track. Energy consumption in particular depends on various factors of influence and it was against this background that the City of Linz already participated in the Smart City Profiles project on the initiative of the Association of Austrian Cities back in 2012. The objective of this project consisted in identifying indicators within a range of thematic topics in the context of developing a Smart City. The topics concerned in which the focus was on climate and energy relevant factors, comprised the areas of Building and settlement structures; Transport and mobility, Technical infrastructure; Economy and population; Politics, administration and governance. These thematic topics together with the appropriate indicators will make it possible to create a city profile, which can be a support in the steering of municipal development through to a Smart City.
Pasquale Capezzuto Smart City paradigm, through a global approach, allows cities: (a) governing its energy consumption (thanks to technological innovation and energy management)

Gunter Amesberger
Municipality of LINZ, Austria.
Director Urban planning, Technics and Environment

Pasquale Capezzuto
Municipality of Bari, Italy.
Head of Energy and Plants Office in Urban Planning and Private Building Department, Former Coordinator of Bari Smart City Project

Xavier Normand
City of Grenoble, France.
Former program manager "Sustainable Urban Development", Founder and CEO of "XN conseil", consulting and expertise in the field of sustainable urban development projects

Rasmus Reeh
Municipality of Copenhagen, Denmark.
Senior Advisor of Copenhagen Solutions Lab and Project Lead of the project Innovatorium Nordhavn

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moving towards decarbonisation of urban energy systems by energy efficiency improvement and renewable local supplies at district scale; (b) promoting virtuous citizens behaviour and awareness of their own energy consumption (smart metering, automation, active home, renewable local supplies for distributed energy production); (c) improving lifestyle in mobility (intermodal public transport use , sharing mobility. Use, E.V. mobility, etc.); (d) implementing Power Electricity Distribution (D.S.O.) in smart grids key technology factor for distributed energy production and smart services to citizens.

In order to achieve the energy consumptions and CO_2 emissions reduction according with the Covenant of Majors S.E.A.P. strategic plan it will be necessary adopting the principle of energetic invariance, constructing new buildings with almost zero consumption, nZEB, and refurbishment of existing building stocks.

Xavier Normand Smart energy solutions are undoubtedly a strategic part of future city development, in the perspective of a better management of natural resources and CO_2 emissions, as well as to move towards more inclusive and participatory cities. 50% of the population live in urban areas, which are responsible for more than 80% of energy consumption and CO_2 emissions. Cities are therefore on the front line when it comes to the latest challenges: fuel poverty affecting 4.5 million people in France, tackling global warming, reducing greenhouse gases, optimizing, rationalizing and managing consumption, improving the energy efficiency and performance of buildings, etc.

The city and territory of the future will need to be sustainable, in other words: Eco-responsible (Sensible, managing consumption of water, electricity, gas, heat, etc., enhancing energy efficiency and protecting the environment); Efficient (quality and performance of public services in a context of budget rationalization and constraint); Champions of fairness and social cohesion; Connected (ease of access to information and communication infrastructures and new technologies, and to digital services); Open to a new type of governance (more participatory, uniting the many stakeholders, local participants and citizens).

Making the city more sustainable means, in addition to responsible urbanization, being smart about how resources are produced, managed and used.

The value created by a Smart City and territory is inextricably linked to its capacity to pool, organize, and release data from various urban systems. This is currently difficult because these activities have historically been designed, managed and operated individually by public or private operators.

Over recent years, new information technologies have been increasingly integrated in the various utilities in the city and territory which can therefore be deemed "smart": electricity, gas, water, heat, cold, street lighting, mobility, etc.

The rollout of smart devices in these systems, especially with the arrival of smart meters, is generating profound change and opportunities in the management of infrastructures and hence of the city. This is because it opens the door to an unprecedented amount of data and hence potentially of information and new services to meet the needs of the community and its inhabitants.

Rasmus Reeh I tend to disagree, at least in part. Cities are using the bulk of global energy, and stand as a central must win battle in order to transition from a fossil economy. But smart cities are not the only solution. Rather it is a systemic change where all parts need to be redirected in use and energy usage.

First of all must be considered that in CPH we do not advance the "Smart City" as a concept: this do entail that we do not work within the space of smart cities but we do not approach from the inclination of building a Smart City. Rather we develop to be liveable, efficient, green and we develop solutions to work to fulfil these ends.

The emphasis here is that we work from a demand-led perspective all along. These demands can have short and long time horizons, they include technology in the design, but we do have goals of implementing Smart City technologies per se: I believe this perspective runs against the presuppositions questioned, which infers some challenges answering them.

In CPH like the rest of EU smart meters are being installed, providing new arms to optimise energy systems. 98 per cent of heat consumption is district heating. As a result changing the energy mix on the supply side of heat is a major part ingredient in changing CPH in to a CO_2 neutral capital by 2025.

Along the same logic in transport; busses are being electrified or fuel changed to biogas. The building of new metro lines are also solutions that change the physics, rather than just digitisation.

Renovation of existing building are also key elements in achieving a CO_2 neutral city.

Paolo Civiero *Did your city support participatory processes and structured information campaigns for citizens to increase people's awareness on the idea of what a Smart City is?*

G.A. In the context of the (citizen) participation processes, the City of Linz was already taking steps in the direction of a Smart City at a very early date.

At the beginning of the 1990s special citizen participation processes were established concerning the construction of an HBL production plant (for producing a precursor substance for so-called "slimming pills") at the Linz chemical industry park and also for a high-temperature gasification plant (HTG) for the company *voestalpine*. This all happened at a time when Austria was still not a member of the EU.

Another point to be equally stressed is the energy utilisation plan for Linz and also the waste management concept based on the avoidance of waste, which was produced with the participation

of the citizens of Linz. The local development concept was also submitted to a citizen participation process.
Further to this, it is a standard in Linz, for the population to be included in the planning of parks and children's playgrounds. This very direct cooperation between politics, business and civil society that counts as one of the characteristics of a Smart City and is already introduced in here Issue 1 and it can be seen that it already has a long tradition in Linz.
Following this course, Linz took on a pioneering role in Europe with the "Open Commons Region Linz" project that was started in 2009. The aim of this, amongst others, is to provide data from the internet free of charge. This "open-access asset" includes photos (also aerial views), statistics, maps, specialised scientific works and presentation documentation all for free use.
Online portals are also currently available, such as the look at Linz platform ("Schau auf Linz"), offering the people of Linz the opportunity to report or comment on problems, inadequacies and improvement possibilities for their neighbourhoods using a very easy electronic method. This shows the date when the report was made and how long it has taken for it to be dealt with.
In addition to this, there is also the "My Linz" portal ("Mein Linz"): here the best ideas for important future issues in the city are regularly searched out commented on and evaluated. Following the live phase, these ideas and suggestions are summarized in a concluding report and handed over to the politicians to help them in their decision making. "Mein Linz" is also an archive. Projects which have already been wrapped up and concluded are kept permanently accessible and can be continuously accessed, read and researched.
P.C. Our city has adopted a participatory approach on Smart City design in particularly in urban planning process, social inclusion and educational activities, promoting energy consumption awareness and renewable supplies.
In this context City of Bari has organized several workshops with stakeholders and citizens within a participatory process prior adoption of Sustainable Energy Action Plan as also workshops in schools to raise awareness of energy efficiency and use of renewable energy sources concepts, and the adoption of energy refurbishment measures or the installation of PV systems.
Nowadays Bari is planning his new General Urban Plan in a participatory path activated by the Department of Urban Planning of the Municipality of Bari and that will design the city of the future. Called the "Neighborhood Walks", the new instrument has opened the path for the definition of the new Urban Plan starting from the places perception of the community, enhancing the skills of the inhabitants in the form of widespread knowledge and opening up to the citizens the "decision fields" involved in the new General Urban Plan. The aim of the walks was to expand the system of territorial knowledge, by collecting the decisions on the future spatial structure of the city of Bari, and opening, through participation, a new way of building the city. The "Neighborhood walks" has always been an instrument of urban participation and democratization able to activate new forms of knowledge about the city, opening the urban plan to a shared reading of the places we live, offering an opportunity for "active listening" of the territory through experiential knowledge, in a dimension of direct relationship between inhabitants and institutions.
The walks are accompanied by special guides and the walkers were joined by institutional representatives, with the aim of returning different points of view in an unpublished image of the city of Bari, which mixes with that of the designers in charge taking into account the communities of places, enhancing the skills of the inhabitants and the practices of use of the places.
In addition the "Urban center" has been established: it represents a physical place where citizens, planners and experts discuss the General Urban Plan: citizens can send their proposal for the future of Bari by filling in a thematic form online and in territorial centers.
X.N. Grenoble's Smart City initiative has been designed from the beginning as a deeply participative process. A very powerful filter is applied to every proposed innovation, made of two questions: will it bring new functions that really benefit to citizens? will it be possible to design the solution/service with the people who will use it?
This was the case for instance with "Vivacité", developed by GEG and Atos Worldgrid, which is a collaborative integrated software platform for real-life data from production and consumption of electricity, gas, heat, water, etc. It consists of interactive, educational interfaces and feedback applications for decision-makers and elected officials in the territory; technical managers of public buildings; managers of collective housing (social landlords, shared ownership schemes, etc.); local authority officers responsible for land use and planning in the territory; citizen-consumers. In concrete terms, the expansion of Vivacité relies on technical and software infrastructures installed in tester consumers' homes, in new or existing residential homes, in public buildings, and collective housing: multi-fluid smart meters (electricity, gas, water), sensors (hot water cylinder, heating, etc.), data displays, etc. combined with energy management services. Another example is "Grenoble Ville de Demain", which is the sharing and anticipation platform of the city of Grenoble to gather around the challenges of the 21st century and all the talents that put the city on the move. Participants are all kind of citizens: residents, students, athletes, scientists, retirees, entrepreneurs, cultural actors, scientific and economic, by joining Grenoble, city of tomorrow, everyone can help make Grenoble a city where the common good is co-built and shared. The lines of inquiry concerning all areas related to the transition: demographic change, social jus-

tice, energy transition, nature in the city, sustainable urban planning, soft mobility, sharing economy, short circuits, new forms of solidarity, citizen participation or boom digital, etc. These themes are divided into three fields: sustainable cities, the city emancipatory and inclusive city.
R.R. No. But we work very hard to transfer citizens in to the digital era.

Paolo Civiero *How much your idea of a Smart City refers - from a technological and cultural point of view - to peri-urban area management and social regeneration aspects?*
G.A. With solarCity which was built on the south-eastern periphery of Linz in the nineteen nineties an exemplary sustainable city district was created and furthermore solarCity was already a pioneer model of a Smart City back then.
Renewable energy is the principle built on here together with short distances for the community in this housing development, taking account of public transport links and with an implemented open-space concept that provides for an intensive coexistence of people and nature.
Furthermore an own neighbourhood office was established in solarCity serving some 3,000 residents of this suburb, and providing an important interface between the living environment in the community and that of official policy and administration, institutions and enterprises. Interdisciplinary and inter-departmental work is perceived here as being essential for efficient regional and district development is perceived as being essential.
The needs and concerns of the people are the point of departure for the community work. The interests of the people who live here determine the issues that are taken up and dealt with. In this process, the people are supported and activated themselves to make their issues a matter of public concern and to work on achieving results for them.
The neighbourhood office is a part of the City of Linz municipal administration. The main objective of the neighbourhood management is to establish all the different, and to some extent contradictory, needs and interests of the residents, and of the local economy, associations, administration and official policy, to bundle these and also frequently to mediate between conflict parties; and furthermore to do this with the firm perspective of always pursuing the development and improvement of the living conditions in this city community.
The biggest single and coherent urban renewal plan in Linz has been implemented in the green centre with an area of 85,000 m².
A residential settlement developed on the site of a former freight railway station in low-energy construction consists of 800 apartments, with the inclusion of a nursery school. The high quality of life here is based not least on the central green area with an integrated children's playground.
A district management including a neighbourhood office has also been set up for this green centre in Linz.
Neighbourhood community work on the basis of district managements is also provided in the city communities of Franckviertel and Auwiesen.
The former Ebelsberg barracks area in the south of Linz is currently in new use development as a settlement with 3,000 new homes with the inclusion of infrastructure and commercial uses. The urban development approach that is being assembled here is a cooperation approach with the inclusion of all stakeholders. This area will also include an own district management.
P.C. Transforming a city in a Smart City represents an opportunity for urban regeneration global model to improve quality of life of inhabitants in surrounding urban areas. Urban regeneration is a tool for transforming degraded parts of city from both a physical and social and economic point of view through redevelopment, promotion of social and economic inclusion activities, and improvement of civic services available to include parts of the population often far from development process of city.
The City of Bari has employed dedicated Regional Funds promoting these activities, as required by Regional Law n. 21/2008, carrying out urban redevelopment interventions in peri-urban neighborhoods e.g. S. Girolamo, S. Paolo, Carrassi Japigia and in Urban Re-qualification Programme "S. Paolo Lama Balice".
The experience of the Urban Regeneration Project "P.I.R.P. S. Marcello" refers to a complex project with public governance, which includes agreements with private entrepreneurs for the construction of public buildings, social housing and urban infrastructures in exchange for building volumes for private market .
The area was characterized by a strongly degraded public housing stock and poor social cohesion. The program will equip the district with services, infrastructures and greenery, both increasing its attractiveness, e.g. enhancing existent excellence such as the University Campus, by the implementation of Regeneration Plans (PIRP). The district showed all the signs of the marginalization of the "inner" urban suburbs, devoid of squares and real places of socialization, yet with the negative characteristics of the periphery. Despite the emergencies highlighted, the district has built, over a period of 50 years, also its strength: a sense of belonging with a strong identity connotation of the residents, which makes this piece of town a sort of "urban village" with a precious system of relations, not to be forget in the renovation process. The choice proved to be founded in light of the participation of the inhabitants and of the intense collaboration in the construction of an Intervention Program that redeveloped the district, without however distorting it[1].
The respect of the environmental characters of the territory is also the guide idea of the "San Girolamo seafront and Fesca program". The municipal administration wanted to "open" to pos-

sible designs that were able to configure new public spaces on the coast, intended as a land-sea interface, in order to expand and redevelop the areas designated for public bathing (e.g. complementary structures and equipment), to the free time, to the walk, to the stop and to the restoration, isolating them from the polluting actions of the traffic.
The prized project meets, in a complete and original way, all the issues such as urban relations, the configuration of new public spaces with designated areas bathing, the balance with pre-existences, the reorganization of the routes and the insertion in urban area of the road, the articulated planning of public horizontal spaces, creating the necessary conditions for the desired elevation of the role of the area in the most general urban context and the conditions for a successful public-private partnership[2].
X.N. Grenoble initiated the "City-Zen, New urban energy" project with the city of Amsterdam and a pool of public and private partners in 2014 within the framework of the EC-FP7 "Smart Cities and Communities" program.
The main goal is to explore the conditions of the transition to renewable energy in urban and peri-urban contexts, especially in disadvantaged districts. Such a transition must be based on a strong involvement of all stakeholders: industries, decision makers, knowledge partners and citizens. All infrastructures can play a role in a zero-energy solution, but it all needs to be decided through transparent and cooperative processes. What is noticeable is that different infrastructures are today mixing, supplementing and even substituting for each other. And it isn't just for domestic heat system and gas grids, but also for electricity, fuels, sewage, drinking water, ICT and solid waste.
Social participation is crucial for this process. By applying (technical) innovations in the city, we learn how to overcome barriers, how to build business models and how to make technology both user-friendly and attractive. These innovations are both on system level (smart grids, district heating) as well as on household level (renovation, citizen engagement, home batteries and games).
Social monitoring is a major part of the project. The monitoring strategy in Grenoble are based on the results of the previous European project, "Empowering", which raised the importance of considering the energy profile of the users. To determine the behaviour and relationships involved among different parties such as: users, co-owners, social housing, public services, the municipality of Grenoble has decided to focus on the empowerment of stakeholders with the Spiral methodology, which aims to determine indicators for progress and well-being of citizens and communities.
This is a good illustration of how we think that Smart City solutions must first and foremost be applied to the most critical social situations, to tackling fuel poverty.
R.R. We do not have a Smart City idea. We have political goals for the city as a whole where technology plays a part in the solution.

Paolo Civiero *Is your municipality/city/administration prepared, under a cultural and technical point of view, to face governance challenges thanks IoT and Big Data?*
G.A. The City of Linz is committed to working on the technological level for a transformation into a Smart City.
Current examples of this include the Smart City square street lighting being tested at the Pfarrplatz in Linz: motion sensors here increase the illumination level whenever pedestrians, cyclists and cars approach and the light is also adjusted automatically to the weather conditions.
In addition to this environment sensors in have been integrated in the lighting systems. These measure the temperature, air humidity, fine dust pollution, noise levels and many other values. These continuously supply all current sensing data to a control centre, where the data is processed to give instant forecasts and compile long-term analyses. The work of traffic management is supplemented by environmental aspects and optimised by this means.
Furthermore the urban public utility LINZ AG operates its own project LORA (low range): an infrastructure network in the scope of which devices and equipment can be controlled online with own IP addresses and which also have the capability of submitting data to a central unit. The data can be further processed at this point, for example in the course of energy monitoring work for a specific facility. Energy advice can be provided for example, through the use of this database.
At present LINZ AG is still only using this system within its own service area, but there is already a plan concept to create a noise register for Linz, with data available and provided for the population and which is intended for interactive operation in a further development phase - and thus with participation as an integral element of the concept.
The big data issue is thematically linked to this: the vast quantity of data produced needs to be aggregated and analysed, with cross-links then established to other data and with the IT technical requirement in this context for appropriate object-oriented databases - and Linz intends to move ahead in this direction.
It is a matter of course that data protection will be given top priority in all of this.
P.C. Iot and Big Data require technical competences which are hardly available in municipality/city administration. Italian cities often refer to external technical expertises and promote innovative funding mechanisms and new business models: it calls for a review of public procurement codes for services which represent a tricky problem in our country.
Anyway IOT and Big Data analytics represent important drivers for understanding city thanks to real time data.
The Digital Agenda 2016-2018 adopted by the City of Bari endorses a set of actions and standards to be put in place to exploit the potential of digital technologies in order to boost innovation

and economic growth in the city. The aim is to lay the foundations, through a precise and clear path, for a series of activities and projects to be implemented in the next three years according to the needs of the citizen.
The document represents an update of the IT strategy for the next years with a program of initiatives addressed to a participatory model of both administration and citizens, for the development of a Digital Citizenship, e.g. the Breakdown of Technological Innovation, through actions involving the citizens themselves to encourage and support a participatory construction of the agenda. The guidelines adopted with a view to participation and collaboration are: (a) Co-planning participatory and collaborative path with citizens; (b) Exploring user needs, trying to understand the context; (c) Services and rights demanded by the citizen; (d) Change of perspective that leads to the creation of knowledge networks through a wide collaboration between Local Authorities and citizenship.
The implementing paths to be pursued in the execution of the main projects planned for the next three years will have as reference the following thematic areas: (a) Digital Citizenship: foundation for a new digital Bari, open and accessible to citizens through the creation of a civic platform; (b) Intelligent Cities (Smart City): conversion of urban reality into a "smart" format through the implementation of interventions aimed at improving the quality of life of citizens while making the city more sustainable from an energy point of view; (c) Citizen services and eGovernment: improving the delivery of online services to the citizen in terms of efficiency and effectiveness; (d) Smart Administration: improvement of sectoral information systems and municipal digital infrastructures.

X.N. We consider IoT and data processing systems as very powerful tools to move towards much more efficient management solutions for urban systems. This is done through the EcoCité and City-Zen projects, which are real scale innovation laboratories, to test a new approach to managing urban utilities that is better integrated, covers more disciplines and is more participatory, thanks to the involvement of several local participants.
Their aim is to prove that it is possible to make a city more attractive, more environmentally-friendly and in particular less wasteful of energy and water, facing several challenges at the same time: Social (developing effective communication methods and tools to raise citizens' long-term awareness of the challenges and the impact of consumer behavior on energy and water resources); Methodological (implementing a collaborative working approach between partners and the parties involved in these projects); Technical (the concept of the smart city is still very new. Consequently, one of the aims of these trials is to define common national and European standards relating to data exchange, especially from the perspective of Open Data); Organizational (these programs offer the opportunity to try out a way of organizing and working collaboratively across a range of disciplines. These projects can be used to propose a governance model which involves the community in the administration of this data management platform); Conceptual (many questions are asked about the benefits of digital technologies for citizens and communities, especially at a time when smart meters are being rolled out. These projects explore all the possible ways to use these devices, especially collected data which can offer real "added value" for the different parties in the city).
R.R. IoT is a moving target as tech evolves all the time. We are fully compliant with GDPR and are investing in finding optimal ways to reap the benefits of IoT while remaining within the governance frameworks.

Paolo Civiero *How Smart City plays a key role in promoting innovative and sustainable economies or processes of economic transformation and sustainability?*
G.A. Sustainable enterprise management or corporate sustainability (CS) means successful operating of *core business* while taking full account of social and ecological responsibility.
Companies that are managed sustainably ensure that their employees and suppliers receive fair payment. They use resources efficiently and avoid using any contents that are harmful to health or the environment. Their products and services contribute to sustainable development insofar as they assure a basis for life and the livelihoods of future generations.
These enterprises build on the basis of the "cradle to cradle" concept, according to which all material used must either be compostable or must stay in an industrial closed circuit.
Innovations play a crucial role in all of this and so too does the cooperation capability of the stakeholder in politics, business and civil society (as already mentioned in Issue 1). Against this background, it can be clearly seen that the Smart City has a key role in promoting sustainable forms of business.
The Linz City Administration has begun to give direct support to sustainable enterprise management in the city; it does this by promoting innovative young companies such as those seeking a move to the Linz Techcenter or to the Tabakfabrik.
In addition to this, a new business location strategy for Linz is currently being developed with six action plan areas: the service sector; business, real estate property and infrastructure; location marketing and internationalisation; employment and qualification; research, technology and innovation and also cooperation and networking.
Taking account of a number of fundamental sustainable business principles as outlined above is intended in establishing the content for each of these action plan areas.

P.C. Holistic and global approach to next city challenges appear to be the best way to transform our cities in cities of tomorrow.
Transforming energy systems in decarbonized systems produce important economic development in terms of investments promoting ICT technologies, digital services, IOT and sensors device in city life, and new sustainable technologies for urban transportation. This stimulate private companies and innovative start up. Innovation in governance can attract talents and skills which can contribute to the urban development of the city in cultural and social terms.
The Municipality of Bari, in collaboration with the Apulia Region and with the technical support of Capitale Lavoro S.p.a. (In-house public company) has launched the experimental service "Porta Futuro Bari" funded by PON Governance and System Actions 2007-2011: an innovative Job Center of 500 sq. meters, already successfully tested in the City of Rome since 2011 and promoted as a pilot model on the regional capital. The aim of this service is to adequately link the metropolitan users with the labor market, running as an aggregator able to mobilize resources, information, skills and opportunities in the service of autonomy, social innovation and local development.
The center hosts the necessary skills and resources to perform its function as a platform for orientation and meeting between the demand and supply of work, operating in continuity with the current headmasters and agencies active in the territory, engaged on issues of employability and self-employment.
X.N. Since 1998, Grenoble hosts every year the "Forum 5i", where the 5 "i" stand for Innovation, Industry, Inclusive, Investment and International. This is a big event which involves all the companies which deal with technical innovation as well as universities and research centers. As one can observe, topics linked with the Smart City issues are more and more important in this arena, since the titles of the previous editions are as follows: The Industry of the Future: what stakes for tomorrow? (2017); Enernet: a new paradigm to manage energetic transition (2016); Internet of things: what impact on economy and society? (2015); Silver Economy: autonomy, a new field for innovation (2014); Smart mobility, use and innovations (2013); EcoCity, innovation accelerator (2012).
Smart city is not only a question of technology, and that is why it is so deeply connected with many fields. As far as business models are concerned, there are many ways to promote a more sustainable development scheme, as collaborative or functional economy.
These different aspects are also explored by the city of Grenoble, which organizes international events like the "Biennale of the transition cities" of the "International forum about well-living" for the first time in June 2018, and Smart City is always shown as a multi-faceted concept which can be first put in service of citizens.
R.R. We work steadily to increase the efficiency of the city administration while improving service levels. IoT and technology play substantial roles in achieving these ends.

Paolo Civiero *Which key stakeholders and key actions better deploy transition to Smart Cities?*
G.A. The internationally established term "Stakeholder" incorporates various interest groups such as corporate target groups. It was intended as a counterpart to "shareholder", the owner of business stock.
Business and enterprises play a decisive role in the transformation process for becoming a Smart City. The stakeholders of a company are in essence the staff, the suppliers and the customers, but also academic and scientific institutions and non-governmental organisations (NGOs). It is above all the latter of these that demonstrates ever and again the demands of those affected and that can also influence the social acceptance of a company.
NGOs not only influence the behaviour of companies, however, but also that of politics and of society in general:
A clear example of this is how Linz already joined the 1991 *International Climate Alliance* in 1991 as a response to a suggestion by the environmental NGO GLOBAL 2000 - an action that was a milestone by the City of Linz on the path to becoming a Smart City.
Further to this, a working group for the creation of a City of Linz sustainability programme - the "Linz Agenda 21" - was established at the turn of the new century by the Linz City Administration. This public body is comprised of a series of different stakeholders:
In addition to the *Linz City Administration* the *political parties* are represented amongst others including the Linz *Johannes-Kepler-University*, the Linzer *energy supply utilities*, the city *public transport authority*, the *Chamber of Commerce*, the *Institute for Economic Development*, the *Chamber of Labour*, the *Chamber of Agriculture*, the *Conservation Association* and the *Climate Alliance for Upper Austria*.
Each of these stakeholders is a typical Smart City stakeholder.
The first municipal sustainability report Europe-wide was produced for the City of Linz in 2004/2005 under the auspices of the Austrian sustainability group the *Österreichischen Instituts für Nachhaltige Entwicklung (ÖIN)*.
A further milestone on the way to a Smart City was set by Linz in 2014 when the city became a Fairtrade Town in the scope of the EU TRINET project with powerful support from the development NGO *Südwind Agentur*.
P.C. The holistic approach is extremely important to deploy transition to smart cities as is a booster of various stakeholder types.
A national framework to smart cities transition could be a key element even if City government need to assume leadership role in the process promoting and facilitating private initiatives.

Key Government Stakeholders could be referred to administrative Ministers, members of parliament - MPs, local authorities, consultants contractors, NHS, other government departments and agencies, Emergency services, Regulatory authorities, lobbyists, media.

X.N. The City of Grenoble is aware of the necessity to protect its environment which participates in its own prosperity. Political actions in favour of sustainable development has been set put, emphasizing the strong political will of local authorities on this issue. As a major player in the Local Climate Plan since 2004 and as Covenant of Mayors member since 2008, the city of Grenoble is committed to reduce energy consumption, encourage the use of renewable energies, promote social solidarity, set up alternative forms of transport and develop Environmental, Architectural and Urban quality. The main objectives of Grenoble Local Climate Plan, launched in 2004, recasted in 2009, remain to divide local greenhouse gas (GHG) emissions by factor 4 by 2050. In Grenoble, between 2005 and 2012, energy consumption decreased by 3.7% and GHG emissions were reduced by 17%. The final energy consumption per Grenoble inhabitant in 2011 was 19.7 MWh. To go further and to offer a future and Smart City to inhabitants, Grenoble has presented its ÉcoCité project on the north side of the town. The Grenoble innovative concept of smart integrated city has been selected, with 13 other advanced Cities in France by the French Government in 2009, to receive grant on some innovative actions. Among inspiring cities, Grenoble is at the first place, because EcoCité project is gathering private and public stakeholders around demonstrations projects for which political decisions have already been taken in the fields of mobility, building and energy. The objective is to transform the ÉcoCité area into a positive energy and carbon neutral district.

R.R. Cities and citizens.

NOTES

[1] The participatory process started with the drafting of a Preliminary Intervention Program, followed by a Public Notice where the municipal Administration invited the public and private subjects concerned to propose themselves as actors for the realization of the P.I.R.P. of San Marcello. The private interventions proposals received were publicly presented to citizens and residents together with the framework of public interventions. Then a single integrated project proposal was designed with the contribution of citizens. Thanks to the coordinated action of the Municipality, Region, IACP and building contractors, distinct redevelopment interventions will be implemented in the future, i.e. the restructuring of 240 existing public housing and the creation of 8 new housing units, new meeting areas, new public offices, energy saving actions, primary and secondary urbanization, and further 55 apartments.
The overall investment on the district will be around 23 million euros, 80% of which by private funds.
List of Public Entities involved in the PIRP program: the Municipality of Bari, the Province of Bari, the Autonomous Institute of Popular Houses of the Province of Bari (IACP).

[2] The project involves the construction of a pedestrian plaza at high altitude, that is, raised above the level of the sea, which hides two parking lots and is crossed by a cycle path. At one extreme a large amphitheatre, at the other an aquarium of 6 thousand square meters (the first of the south center, able to attract tourists who can be accompanied directly by the port by sea taxi). Also envisaged bars and restaurants hidden from the road but with an enviable view of the sea, a nautical basin and two beaches. All the interventions, except the aquarium and the enlargement of the square are included in the European funding by Region Apulia for a total of 18 million euros.

RESEARCH STAKEHOLDER GROUP

Interview by **Elena Guarneri,**
Technical University of Denmark and Secretariat of the European Energy Research Alliance

Urbanization, globalization and climate change are major issues that affect and will affect the way we live. At the same time, they encourage us to create new solutions that can lead to a healthier and more sustainable urban life. Research and innovation (R&I) play a big role into this process, which combines technological, environmental, physical, economic and social aspects and calls for new mechanisms for adapting, applying and developing solutions. However, these challenges require increasingly coordinated strategies and actions, with the involvement of stakeholders at all levels, and cooperation within and amongst countries and across sectors and disciplines. R&I networks are essential in this context, not only to facilitate research development and knowledge exchange, but also to get a better understanding of the complexity of the challenges and of how to replicate solutions, coordinate priorities and, whenever possible, find a common voice in the dialogue with policy makers, consumers, industry and other key stakeholders.
What is the role of R&I to supporting the development of a smart city? Can researchers, and R&I networks, facilitate social participation? What is, and can be, the added value of R&I networks in the governance of smart cities? These are some of the questions addressed by this round table, which gathers the contribution of representatives of the largest energy research network in Europe, the European Energy Research Alliance (EERA).

Elena Guarneri *Smart grids, residential microgrids, smart home, sustainable mobility and e-mobility, big (open) data and IoT, building integrated PV, storage in PV systems and new grid architectures are some of the smart technologies which will support the transition towards smart cities. What would be the best way to integrate current research and innovation into processes that can limit the drastic increase in urban energy consumption and related* CO_2 *emissions?*
Luciano Martini Cities should pursue an integrated approach to significantly reduce their overall energy consumption, thus limiting their greenhouse gas emissions and other pollutants. Research and innovation (R&I) and the related generated know-how will allow cities to progressing towards their full sustainability. In this respect, there is the need to demonstrate innovative technologies, algorithms and tools for an optimized management of energy systems in cities, with mixed solutions that take into account sector coupling, weather and demand forecasting, market frameworks, prosumer interest and new business models, with the goal to maximize consumption of locally generated renewable energy.
R&I solutions to increasing the flexibility of the system in the short and long-term are key. This would allow minimizing the mismatch between load and supply profiles of alternative energy sources (electricity, heat, etc.) and in turn reducing the use of fossil fuels in peak load. Other concrete measures that would enhance the mass deployment of low-carbon technologies at city level are the labelling of city efficient buildings, according to their energy consumption, and the decarbonisation of the city transport sector through the full adoption of hybrid and battery electric vehicles (EVs). The lack of appropriate infrastructures is certainly slowing down the electrification of transport - other reasons are e.g. inappropriate business models. Solutions to foster the rollout of EVs in cities are needed to move towards a decarbonised transport sector - for example, having a number of real fast-charging infrastructures spread appropriately in the streets to allow users to be less dependent of battery capacities. Appropriate business models, as well as regulatory changes, should be proposed to make EV infrastructures deployment possible.
However, in many cases cities may have to prioritize their actions according to their particular needs and means, as it may not be manageable or be economically feasible to carry out actions in all areas of urban life at the same time and to the same extent. Hence, this may call for a certain prioritization in the efforts made by cities to tackle energy and transport challenges.

Luciano Martini
Director, Ricerca sul Sistema Energetico, RSE, Italy, Coordinator European Energy Research Alliance Joint Programme Smart Grids

Prof. Dr. Mathias Noe
Karlsruhe Institute of Technology, KIT, Germany, Coordinator of European Energy Research Alliance Joint Programme Energy Storage

Dr. Isabelle Johanna Südmeyer
KIT, Manager of National Research Programme Storage and Cross-linked Infrastructures

Dr. Myriam E. Gil Bardají
KIT, Manager of European Energy Research Alliance Energy Storage

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Daniela Velte There is probably not a "unique" or "best" way to integrate research and innovation processes, since our cities differ largely in terms of untapped energy efficiency potential of the building stock, organization of mobility, cultural practices, capacity for social innovation and potential for the use of renewables. Each local solution probably requires the combination of all these factors to achieving a lasting effect on urban energy emissions.

Mathias Noe, Isabelle Johanna Südmeyer, Myriam E. Gil Bardají The deployment and system integration of energy technologies in Europe depend to a large extent on the strength of R&D efforts. A better design, planning and behavior aiming at greater energy efficiency gains are key elements to reducing the overall energy needs in Europe. For instance, by proposing new regulatory frameworks, business models, services and applications that enable a mass behavioral shift towards a proactive and sustainable relation of the prosumer to energy.

One of the key elements for the success of the energy transition is to raise the awareness and understanding of the public about the energy system of the future and the diversity of technologies and solutions (e.g. rural *versus* urban solutions, wind in the north, sun in the south, increase of e-mobility in cities, car sharing etc.).

The development of demonstration projects that are replicable and scalable, and that contribute to the overall system design at different community levels, is also a good option to integrate current research to reduce energy consumption, thus reducing emissions in general, and carbon in particular. Nevertheless, nowadays the demonstration of first of a kind real-scale technologies faces regulatory barriers. In addition to the support of technical innovation and demonstration, the proof of the practicability and commercial viability plays a very important role. Demonstration projects allow for gathering valuable knowledge about market applications and commercial arrangements for the energy system design: in fact, in these projects the complexity of the interface involving regulatory and commercial risks provides a sufficient route to push new technologies into commercialisation. In addition, new business models - such as shared mobility, seamless mobility and transactive mobility concepts - would also dramatically reduce the energy consumption in the transport sector.

Laurens de Vries A systemic approach is key. The EERA Joint Programme Energy System Integration (ESI) is working on improved modeling techniques for addressing problems that span different energy carriers, network levels and time frames. In addition, we need models that bridge the gap between technical and socio-economic models. In terms of research organization, I think more mission-based calls that explicitly embrace a multidisciplinary and innovative research approach would help.

Elena Guarneri *Smart Cities combine diverse technologies to reduce environmental impact and offer citizens better lives. This is not, however, simply a technical challenge. Making a city smart is a multidisciplinary challenge, bringing together city officials, innovative suppliers, national and EU policymakers, academics and civil society. Do Research and Innovation networks play a leading role to tackle this challenge?*

L.M. Yes, in smart cities the implementation of smart and integrated energy systems is not only a technological practice, but also a social, cultural, commercial and political practice where networks play an important role, since cooperation and coordination are pivotal ingredients.

Daniela Velte

Programme Director & Senior Researcher, Tecnalia, Spain
Coordinator European Energy Research Alliance Joint Programme Economic, Environmental and Social Impacts

Laurens de Vries

(contribution on question 1)
Associate Professor
Delft University of Technology, Netherlands, Coordinator, European Energy Research Alliance Joint Programme on Energy Systems Integration

D.V. I don't see researchers leading the process of social participation. Their natural role is that of supporting engaged citizens and communities, who are the real drivers of social innovation.
M.N., I.J.S., M.E.G.B. The use of renewable energy sources, as well as the development of new concepts of circular economy and bioeconomy and interdisciplinary and societal factors, are all crucial elements to successfully implement the energy transition. Through the exchange of experiences and best practices of research and innovation, the development of the energy transition can be tackled not only in terms of technology but also of regulation and civil society. European countries can mutually learn R&I experiences and best practices, although a solution in one country is not directly transferrable to another. General public and civil society play a key role and R&I networks can support by seeding information and the understanding of the several R&I activities and novelties in the frame of the energy transition.
Research and Innovation networks play an important role at gathering the main actors of the energy landscape. At the moment there are many projects and platforms collecting research knowledge and experiences as well as end-user involvement - for instance, the BRIDGE project (www.bridgeproject.eu), which aims at building a system to support interoperability - both technical and social - in large-scale emergency management. The system will serve as a bridge between multiple First Responder organisations in Europe, contributing to an effective and efficient response to natural catastrophes, technological disasters, and large-scale terrorist attacks.

Elena Guarneri *Do you think that Living Labs or incubator experiences could still play a key role to pave the pathways towards Smart Cities?*
L.M. Living labs could be seen as a variation of experimental Test Facilities, but with an important difference: they are completely exposed to external factors that could impact real-life performance. Thus, a living lab could still play a significant role towards smart cities since it could represent real-life operating conditions, failures, behavior and misuse of technical solutions in order to detect their intended impact, but also weaknesses, learnings and opportunities for improvement.
M.N., I.J.S., M.E.G.B. Current energy systems are operated and controlled with a focus on only one form of energy, such as electricity or heat. Future energy systems will be operated in highly integrated ways and must be controlled in smart ways in order to optimise the use of various forms of generation and storage technologies. Operation and control strategies for so-called hybrid energy systems currently exist only on a conceptual stage such as Living Labs.
Scientists in research facilities or in energy companies throughout Europe are collecting information in these test areas and feed them into their simulation software. However, every researcher uses his or her own simulation software, and no one knows exactly if different simulation methods fed with the same dataset come to comparable conclusions. Currently, various modelling tools and methods to simulate multi-energy systems with storage are under development (e.g. SmILES project, www.ecria-smiles.eu). In the SmILES project various application cases and test scenarios are being collected, simulated and compared by six project partners to find the best approach on how to integrate different types of energy and their storage systems into one energy grid. These cover different types of local systems, including urban neighborhoods, a rural village, office buildings, and a small industrial production site. Thus, there is much to learn from an exchange of experiences, and from better coordination of these approaches.

Elena Guarneri *Current governance structures in most countries usually require limited involvement of citizens in decision-making. The development of efficient and effective governments is a prerequisite for the development of smart cities. In which way R&I networks can represent an added value for governance?*
L.M. R&I networks could represent an added value for the city governance in many ways, for example by promoting and supporting the use of digital technologies to enable improved communication and engagement between citizens and Council, thus fostering the capacity for community and citizens to influence decision-making. In particular, the adoption of digital technologies and service platforms across the whole city could significantly improve Council planning, asset management and service delivery.
M.N., I.J.S., M.E.G.B. R&I networks are needed to bring together recent innovations and best practices of European smart cities solutions, so that a common understanding of R&I for smart cities across Europe is achieved while keeping the end-user in focus. New promising technological developments can be taken into consideration, evaluating the relevance in comparison to the existing targets. Still, experts from industry and research must certainly provide the expertise and propose the needed knowledge about new breakthrough technologies and developments. The R&I networks can help to seed and facilitate awareness raising towards the need for R&I activities, new technologies and understanding of CO_2.
For a fruitful long lasting framework for research and innovation exchange within these networks, the integration of national representatives of city councils, leading European research organizations together with end-users, is essential in order to avoid that industry and research organizations follow exclusively their own interests.

Elena Guarneri *Smart business models are needed for smart cities. Can you identify which innovative ones adequately support the transition towards smart cities?*
M.N., I.J.S., M.E.G.B. Renewable energy, energy efficiency, energy storage technologies and smart grid technology, as well as the interaction of these energy technologies, are the pillars of the energy transition concept. A few good examples of small to medium scale projects addressing smart business models for smart cities are:

- In Germany
  - The LAMP project, which connects 20 residential households in the area of Lazarettgarten in Landau and supports the trade of locally produced renewable energy among them. This pilot and research project is based on the Brooklyn Microgrid and a is one of a kind implementation of a local energy market in Germany. Therefore, LAMP is already trying out today the decentralized energy future of tomorrow
  - The research project RegEnKibo (Regionalisation of energy supply on the distribution grid level using the model location Kirchheimbolanden), which exemplarily models the electricity and gas network of Kirchheimbolanden based on real-time data, then validated and reconciled. The project partners use optimisation algorithms and take into account electricity from renewable energy sources fed into the medium and low-voltage levels.
- In Denmark: EnergyLab Nordhavn - New Urban Energy Infrastructures, which develops and demonstrates future energy solutions. The project uses Copenhagen's Nordhavn as a full-scale smart city energy lab and demonstrates how electricity and heating, energy-efficient buildings and electric transport can be integrated into an intelligent, flexible and optimized energy system.

Elena Guarneri *Which key stakeholders and key actions would better support - from a programmatic point of view - the transition to smart cities?*
L.M. Even though all stakeholders don't have the same relevance with regards to decision making, the effective transition to smart cities requires the involvement of all different stakeholders in a coordinated manner. Key stakeholders certainly include citizens and their community as well as research and innovation networks. In fact, demonstrators have shown that end-user behavior and interaction is at least of the same importance than technical aspects. Moreover, research and innovation networks could for example support the development of guidelines, methods and tools on collection, processing and storage of energy data in districts and cities to enable optimized planning, implementation, and monitoring of sustainable regional energy systems.
M.N., I.J.S., M.E.G.B. The energy transition involves changing policies, market design, regulatory frameworks and people consumption behaviours. It will profoundly affect the relation of every citizen to energy (e.g. the prosumers) and will require a profound transformation of behaviors and lifestyles. In that respect R&I networks (such as the European Energy Research Alliance, the European Technology and Innovation Platforms…) are essential to bring the main actors together and foster the exchange of key players and stakeholders.
In terms of stakeholders, a high level governance needs to be established including all relevant stakeholders, i.e.: national agencies, EU regulation experts, EU industry, TSOs and DSO (storage technologies, conversion technologies, transport…), representatives of EU networking platforms (e.g. ETIPs, EERA, EASE), city councils, citizens, consumers and end-users of multimodal forms of energy (electricity, gas, heat, fuels…), public transport stakeholders. With regards to actions, it is key to:

- Establish a sufficient grid infrastructure not only for electricity, but also for gas and heat, where reasonable
- Establish sufficient individually adapted storage capacities
- Foster balancing energy consumption
- Increase clean mobility options for urban areas as well as for long-distance travel and transportation (e. g. sharing transport)
- Scale-up technologies, including the reduction of materials consumption
- Implement the Circular Economy Strategy at all stages
- Develop innovation laboratories for citizen-inspired technology development (combining demand pull and technology push)
- Support education and training.

DESIGN/CONSTRUCTION AND REAL ESTATE STAKEHOLDER GROUP

A dialogue between **Paolo Civiero** and **Eugen Pănescu, Daniele Russolillo, Graziella Roccella, Luca Talluri**

In the last ten years of economic disease, architects, engineers and construction companies had been facing many and more revolutions to sustain growth and lead innovation in urban areas. Most of this innovations concern design, planning and P&CM as well as tools, regulations upgrade and protocols. All these innovations promote sustainability, efficiency and security, technological advances in materials and products, according with a 4.0 industrial revolution towards industrialized building systems. The Smart Cities lighthouse projects already demonstrate that solutions to integrate smart homes and buildings, smart grids (electricity, district heating, telecom, water, etc.), energy storage, electric vehicles, smart charging infrastructures and ICT platforms based on open specification, are feasible though expensive.
On the other side different approaches are possible in built environment: urban regeneration and/or urban regeneration through cultural creativity and social inclusion, transition to ZEED, rehabilitation, reconstruction, recovering.
The participants in the VRT are key note representatives of three European Design, Construction and Real Estate promoters of cities of tomorrow (Architects Council of Europe[1], Federcasa[2], and Planet Idea[3]).

Paolo Civiero *Housing is probably the main construction sector able to face human healthy living conditions and - due to its impact on cities - it represents the way to limit the drastic increase in urban energy consumption associated with CO_2 emissions. Which strategies and solutions for cities of tomorrow?*
Eugen Pănescu European housing stock faces a dual situation. The clear majority of existing residential units is not fit to provide a healthy comfort without using too much energy. New units are already better equipped, but insufficient in numbers. Main future efforts are regarding the huge demand to upgrade old stocks, in relation to the social context, not only technological. All efforts must start with the integrated design of contemporary solutions, balanced in investment vs. effect. As for the existing cities, a step-by-step approach is very much sustained by developing efficient tech solutions, funded in broad research programs (Horizon2020 for example). Affordability of all solutions is key for a massive impact in the future years, sustained by European and national policies.
At urban level, the European compact city is a model for short distances, mixed areas, social balance and public transit. Ecological approach comes in place at every level of the design, building and use of cities. All these aspects provide best conditions to further improve the circular economy, lower emissions and public support, to tackle climate change causes and effects.
ACE promotes quality based approaches in acquiring professional services of architects, which bring considerably advantages for the entire life cycle of buildings, from economic, social, environmental and cultural points of view. Value of design is paying back every time.
Daniele Russolillo, Graziella Roccella Energy, together with air, soil, water and natural ecosystem, is one of the target areas in which cities of tomorrow can have a positive impact in terms of different approaches to consumption, being one of the crucial areas of urban life, in the broad framework of ecosystem resources.
When it comes to define strategies for reducing emissions, it is necessary to make a first distinction between greenfield and brownfield projects. In the first case it is somehow easier - even if not always economically feasible - to adopt the most effective methods starting from the right choices in urban planning (such as density, localization of the houses near the production plants, choice of renewable sources for energy production, correct orientation of the buildings, closure of productive cycles in a systemic vision), in Brownfield projects it is harder to define an efficient and effective roadmap that can gradually lead to a more sustainable energy management.

Eugen Pănescu
Architect, Architects Council of Europe

Daniele Russolillo
Senior Programme Manager
Planet Idea Smart Engineering

Graziella Roccella
Chief Operating Officer
Planet Idea Smart Engineering

Luca Talluri
Engineer, President of Federcasa

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Multicriteria analysis tools together with CIM (City Information Modeling) and DIM (District Information Modeling) can help supporting decision makers to determine short and medium term strategies.
Designing smart grids, starting from *smart metering* and even experimenting demand-response based processes, can help energy providers to manage peaks in energy consumption promoting peak-shifting and/or peak-shaving.
When it comes to list vertical solutions for the neighborhood of tomorrow, if decision-makers want to understand and manage the wide offer in terms of products, they must operate with an integrated and systemic approach. For instance, regarding the issue of public lighting, starting by substituting traditional lamps with LED ones is surely not enough. New generations of smart lighting systems can integrate a number of diverse sensors and devices such as wi-fi connection, cameras and audio systems that can significantly improve performances in the quality of urban life in public spaces, that's why it is vital to keep an integrated approach that also helps to avoid the technology lock-in.
Besides those solutions, that can instantly and rapidly reduce consumptions, there is also a need for spreading best practices to activate virtuous behavioral changes. In this perspective, cities could encourage the implementation of intelligent equipment in their public spaces, creating "Living Labs" with e.g. gym equipments that produce energy through physical exercise, active playgrounds where children can touch, hear or see the energy they produce are just two examples of what the cities of tomorrow can put in place to promote a so called "smart citizenship".
Luca Talluri The challenge is to regenerate what already exist, to work on what was built. A project of the building is necessary in order to have high performances in energy efficiency and high living comfort but it is also essential a urban planning that takes into account social needs as use of commons, social cohesion, possibility of self-realisation and emancipation of the individual. Families who live in public social housing have an average rent of about 110 €/month and spend more than 10% of their income on energy consumption. Reducing energy costs would help the fight against "energy poverty", therefore it is necessary to intervene right where the need is greatest.
Considering that the dwellings built before 1981 are certainly lacking of adequate insulation, there are about 400 thousand apartments with consumption over 150 kWh/sqm/year which need urgent intervention. The serious maintenance deficit in which a portion of the managed assets is experiencing absorbs a large part of the total amount of the resources allocated: these resources activate extraordinary maintenance interventions on about 7 thousand dwellings each year, less than 1% of the assets. Currently public social housing benefits from Italian financial incentive (Conto Termico, D.M. 16/02/2016) and tax deduction (DL 63/2013, art. 14) but they cover only part of the cost of an energy efficiency intervention (from 30% to 75% of the total). Therefore it is possible to activate energy efficiency interventions only by an integration with regional funding and own funds of the public housing company.
The public housing sector is particularly suited to meet the challenge that Europe has launched on energy efficiency, because its features facilitate intervention more than in private assets: there are many apartment building with centralized systems which allow greater economies of scale. Larger scale interventions, small district heating networks or building complex ones, combinations of interventions to improve the thermal behaviour of the building envelope associated with systems optimization and use of renewable energy are possible.
For these reasons, the public social housing sector has a role of experimentation of innovative methods and technologies also thanks to the possibility of monitoring the results and of intervention on the behaviour of both the operator and the users, by:
- the development and implementation of low-consumption urban, building and construction models;
- the development and innovation in the sector of systems engineering in order to reduce energy consumption, as research of materials to increase their durability and consequently to reduce management costs;
- the implementation of almost Zero Energy pilot projects for public social housing, to be constantly monitored: results can be used as good practices;
- the transfer of process and procedural models to the private rented sector.

Despite the current constraints, energy requalification activity demonstrates that public social housing companies have technical and planning skills able to implement and manage interventions in a perspective of deep redevelopment of entire buildings, up to demolition and reconstruction of almost zero energy buildings. The public social housing sector is therefore ready to launch an energy redevelopment plan based on funding targeted to the specificity of the subject and that can be combined with incentives and tax deductions, with the aim of combine upgrading and recovery interventions of the assets with energy efficiency measures and improvement of seismic safety of buildings and entire neighbourhoods.
In particular, the role of public housing operators can be qualifying in energy efficiency improvement programs. Through the redevelopment of public housing assets, it is indeed possible to achieve both the reduction of the emissions and help the fight against "energy poverty", considering that a high percentage of families that live in there are in disadvantaged economic conditions and currently spend on the bill energy equivalent to twice the rent. Last

but not least: in some national contexts energy efficiency must be linked to the improvement of the seismic performance.

Paolo Civiero *How social inclusion, social participation and demographic change will be faced by buildings and built environment in the next future?*

E.P. The relation between urban context, buildings and their occupants is a continuous preoccupation in the European cities. Still enjoying the advantages of social mixed environments, either in historical centres or in peripheral mass living neighbourhoods, we must defend increasing effects segregation and urban poverty. Well planned cities and buildings bring people together, not keep them apart. Short distances and efficient public transports make people meet and spend more time together instead of commuting in private cars.

Social policies are key in balancing an ageing population. Generations are communicating easier, integrating their needs and using the built environment in a flexible way.

D.R., G.R. By 2025, 440 million affordable households will be needed around the world (62 million in China, 28 million in India, 11 million in Brazil, 11 million in Nigeria and 7 in Indonesia, only to quote the first 5 countries in the ranking)[4]. New population will settle in urban context and will need to dwell in affordable houses. To face this growth, trying to reduce inequalities and offer the same opportunities to everybody, it is important to define internationally valid guidelines and set up minimum requirement standards for smart infrastructures and services. A global action carried out by governmental bodies and in general by the public sector is strongly needed and welcome.

Being directly involved in the planning and construction of *Smart City Laguna*, a newly built settlement in São Gonçalo do Amarante, near Fortaleza in Brazil, Planet Idea has defined the Social Smart City Matrix, a new evaluation tool for measuring how much "smart and social" a project is. The matrix, elaborated with Arup and RECS Architects, works both on the urban and on the architectural scale and is based upon a framework operating with two components: people and technology. These dimensions are expressed through qualities: from the "social" point of view, a project must be attractive, healthy and inclusive; to be technologically smart, a project should be informative, efficient and digital. *Smart City Laguna* will feature various sharable spaces such as a social kitchen, a Library of Things, shared gardens where people shall grow their vegetables, spaces for book crossing, to help the spontaneous creation of *Smart Communities*. The Planet App, a digital tool, where data are made available to citizens, is encouraging the birth of the community of inhabitants who will live in the city that will be ready by 2020. There would be no Smart City without active citizens therefore it becomes more and more clear that social participation is one of the drivers of change.

L.T. Federcasa is the association which provide over 850,000 social dwellings to low and middle income households. They are specialized in the construction and management of housing assets, implement interventions of recovery, restructuring and maintenance and promote and implement urban regeneration programs, providing also the services necessary to improve social cohesion and inclusion.

The efficient management of public social housing is affected by the general context of reference but also by the socio-economic conditions of the families that live there. According to the Bank of Italy survey on household budgets, the profile of the typical family living in public housing is characterized by a significant presence of retirees (43.9%) over 65 years (38.3%). It is a population with a deep economic vulnerability: more than half of the families pays a monthly rent of less than 100 euros (51.1%), as its income is below 10 thousand euros per year (37.8% of households). They are unable to save money, 83.3% of households claims to spend all their income. Households are mostly Italian citizens, and the percentage of foreigners represents 5.8%. More often they are single-family or two-component families, while the largest families (with more than 3 members) represent a residual percentage. Young families (up to 34 years) reach only 12.5% of the total.

Considering the picture above, the public social housing companies needs new tools and skills to foster integration and social cohesion, to manage neighborhood conflicts, to ensure compliance with the rules of cohabitation and coexistence with the goal of integrating the skills of housing policies with those of social mediation in order to prevent illegality and to overcome the degradation of neighborhoods and suburbs, including through partnerships with institutions, social and health services, voluntary work.

Public social housing companies now come to awareness that it is the time of complex programs and integrated approaches between construction activities and social interventions in order to be effective and efficient toward households. The ongoing challenge on which we are working is managerial and organizational: it is crucial to introduce offices and services that recognize tenants as persons, understand their fragility and carry them in the search for answers to their problems, to be received from the territorial socio-health institutional network. This creates social cohesion.

Interventions of reallocation and fractionation of dwellings increase available units and allow a wider response to the current size of families. At the same time, it is very important to sustain and strengthen all the initiatives of co-housing, for disabled and vulnerable people, students and families, and the development of a network of care services and local protection of the elderly, through monitoring and prevention services.

Paolo Civiero *New technologies and materials will facilitate renovation and reconstruction in urban areas: citizen's participation in the planning and design phases could be an added value for urban regeneration?*

E.P. Smart City can help boost residents interest in their close living environment and participation in the decisions affecting their living standard. Already such framework is present and design has become inclusive and democratic.

Open Data and effect based decisions in design are supported by new technologies, ready-to-use by citizens.

Urban regeneration has become a general topic throughout Europe, but is still an unclear approach unless the issues to tackle are not clearly defined. Focus on an integrated intervention will prevent limitations in solving single issues.

D.R., G.R. The most critical issue that the concept of "smart" city generally raises is that it is mainly based on the technocratic paradigm and it is probably leading to social exclusion of people who are not able to use or who can not afford digital technology. For this reason, a new concept of "human Smart City" is gaining attention on the international scene.

From this perspective, every process which encourages active citizenship's engagement is the perfect counterpart to the innovation carried out in the technological field. Truly smart and social neighborhoods should include public spaces to be interpreted like pluralistic arenas where active citizens can meet, organize and realize public events and activities.

Co-design processes for the urban regeneration, especially of existing suburban areas, are effective strategies to build a new identity for those places, certainly different from the "mousetrap identity" criticized by architects, that imprisons places and resists to renewal[5] but rather a new bottom-up participatory process of identity building. Many cities have already started this kind of approach by adopting innovative and light forms of participated administration such as the Regulation of the Common Goods and the possibility for the citizens to take care of public spaces through Collaboration Agreements. Besides, since 2001 participation could also be adopted starting from local funding operations such as Participatory Budgeting.

In short, the main objectives that a truly participatory budget pursues are:

- facilitating the confrontation with the citizens and promote shared choices and decisions, also reducing conflicts;
- responding more effectively to the needs of citizens, and ensure greater correspondence between needs to be met and available resources;
- involving citizens in the process of public management through forms of direct democracy;
- rebuilding a relationship of trust between institutions and citizens.

L.T. Citizens participation is an inherent need of urban regeneration and is fully part of the smart governance tools. Talking about urban regeneration means tackling the problem of social exclusion, which is always associated with physical and functional marginalization of the district, widespread poverty, lack of services and unemployment.

Since the nineties, many legislative measures (integrated programs, urban recovery and urban redevelopment programs, neighborhood contracts, programs of sustainable development of the territory) allowed the integration of real estate valorisation processes with improvement of urban conditions, employment development and improvement of quality of residential building. Companies of public social housing have been able to join national, regional and European calls by participating in local partnerships on cross-sector projects, supported by participatory planning processes, which allowed to renew and increase managed assets and to improve the quality of life of the inhabitants.

Two factors emerge as essential in order to reverse the escalation triggered in the degraded neighborhoods: the resumption of a relationship of trust between the local administration and the inhabitants (who felt excluded from the process of growth of the city for too long) and the launch of a process of taking-in-charge by the inhabitants of the maintenance of the results of the regeneration process.

This practice can lead to a change of culture: in those neighborhoods where any form of active democracy has not been promoted and the same democracy has been questioned, a bottom-up participation in land transformation processes can be the premise for restoration of legality and social cohesion.

Paolo Civiero *Rules and burocratic obligations, lack/difficult access of funding financing (private and public) are some of the main aspects to be overcome in everyday activities. Which governance model would better support urban regeneration?*

E.P. Best cases of Urban Regeneration schemes are including a balanced mix in providing arguments, data, participation and decisions: citizens, independent specialists, city administrators and local politicians.

Urban Quarter/Districts management frameworks offered optimal results when they included continuous professional support as part of the scheme - facilitators, architects, sociologists, landscapers and urban planners.

Participatory budgeting schemes are proven to increase the trust and participation of citizens, thus bringing closer decision makers with the populations and providing transparency in managing public funding. Often smart open digital platforms are key in social progress, increasing common understanding brings empathy and supports interest in raising the overall standards. Smart Cities rely on connected infrastructure, but the real in-

novation is being driven by citizens, in the most democratically manner available.
D.R., G.R. The most successful development models for Smart Cities seem to be characterized by the wide participatory approach of a strong and formally established governance structure. Such a governing body can really get into the details of the executive decisions related to projects timeline and of the procurement and investment decisions often realized in the context of public-private-partnerships[6].
The constitution of such a strong governance requires a comprehensive alignment of incentives among the actors with regards to the Smart City programme. This requirement is surely not sufficient to ensure a successful implementation of smart city processes, but it is necessary[7]. The alignment of incentives in turn requires a comprehensive knowledge of the system of actors, as well as a deep understanding of each actor's incentives before the start of any Smart City programme.
Thus the first step is certainly the identification of salient stakeholders for which a three-layered scheme made of infrastructure, digitalization layer and services is surely helpful. Indeed such layers should be carefully looked into, to mitigate the risk of leaving some actors out of the game. For instance, the service layer in a Smart City can be exploded in sub-layers such as legacy services and innovation services and the latter can be even further explored analyzing on-demand/sharing economy services and specific social innovation services aimed at social inclusion or at updating the welfare system in place.
Then, in order to start building an effective and efficient governance structure of the Smart City, it is relevant to:
- analyze the set of relationships among all the local and sometimes national (it depends on the regulatory framework in place) stakeholders, and
- analyze in detail the information flow in place amongst the actors.

L.T. As the "Parliamentary Commission of Inquiry on Suburbs" recently highlighted, first of all there is the need to define a strategic plan for cities and then it is necessary to start a structural policy on the regeneration of suburban areas. So far the call for inner peripheries collected a widespread planning not able to realize a mass critical enough to reverse regressive tendencies.
In particular, in order to have more effective housing policies in urban regeneration processes we consider necessary:
- to define a national strategy for housing and urban regeneration and to decide a national department or agency as reference point on the matter for public bodies and operators;
- within urban regeneration programs, to have subsidies specific in favor of public social housing;
- to provide permanent funding for public social housing in order to ensure an adequate maintenance of the assets and to have the possibility to increase the assets itself in cities and municipalities where the housing deprivation is more severe;
- to redefine responsibilities and duties of State, Regions and municipalities and prepare a framework legislation on tasks and functions of Public Social Housing Companies in order to establish uniform criteria for the entire national territory concerning the treatment of households;
- to redefine the above-mentioned Companies and their role in order to recover administrative and financial efficiency and to ensure them to be the leading actor in the social housing sector;
- to oppose the squatting through new procedures that involve local authorities, court and law enforcement;
- to launch a program that support the development of social infrastructure in the suburbs, a program that put first the creation of services, trials of immaterial actions, the diffusion of sustainable management models, the support for projects of social inclusion, cultural production, new welfare and innovative living services.

Paolo Civiero *How the Smart City paradigm plays a key role in promoting innovative and sustainable economies?*
E.P. Smart Cities are better working with urban open data, with broad population inclusion and transparent decision making. In this regard, urban and architectural design is benefitting from an integrated growing framework of awareness. Diversity of the European context is asking for diverse solutions, so less big scale approach as opposed with matching answers, provided by small scale dynamic economies.
The digital transition affects most aspects of daily life and will have significant impact on all levels, making most of us adapt and benefit from it. Smart City toolkit should increase cooperation of the public and private sectors. City and community management are depending but also generating better economical instruments, based on cross financing and incentives. Sustainability can be achieved by opening access to technological solutions and sustaining SMEs.
D.R., G.R. The most relevant factors of the Smart City paradigm to promote innovation and sustainability for the local economy are indeed the connectivity and the local social innovation.
The first element, i.e. the availability of a widespread and reliable broadband connectivity, both available in private and public premises in open spaces, is key for instance to enable the set of new enterprises that can be developed onto such technology layer: the most known example are surely the sharing economy services (also called on-demand services) blossoming everywhere. In fact they are substantially match-making platforms that require an always-online state and geolocation services in order to provide the expected results. Such a requirement might sound outdated, but reliable broadband connectivity is still a challenge in most minor urban centers and is widely known that the digital divide can halt

any smart city programme. Moreover is still the first challenge to meet in emerging and developing countries worldwide.
The second key element is the social innovation process. The Smart City paradigm shift is at risk of being non-inclusive by design when excessively techno-centric, whereas user-centricity insures that the real needs of all citizens are met in the urban innovation process. It is very relevant at the urban level that competent stakeholders trigger social innovation first of all analyzing the main collective interests of the urban society with a bottom-up approach. The risk in fact, especially when social innovation is bound to impact finance, is to foster the interest of social entrepreneurs only to the low-hanging fruits.
The social innovators in a Smart City or Smart District must aim at promoting new models of civic participation, with a constant eye to inclusion and social protection, that are able to meet effectively the social needs with an updated capacity[8].
L.T. Increase in the world population, a gradual decline in energy resources and the consequent increase in their cost, climate changes and air pollution are the main problems cities will have to face to survive, transforming themselves into smart cities and focusing on green building and smart mobility.
Cities must necessarily be ready and able to sustain enormous social and environmental changes, becoming the focus of the fight against global warming and catalyzing investments and policies oriented towards sustainability and efficiency in a smart perspective.
A Smart City is a city able to improve the quality of life of its citizens by offering a lasting opportunity for cultural, economic and social growth in a healthy, safe, stimulating and dynamic environment, focusing essentially on digital technology, environmental sustainability, civic initiatives, mobility and businesses.
Concerning the housing sector, a Smart City is therefore a city able to guarantee a smart living: quality of life, health and safety, culture, social structures, quality of dwellings, educational facilities, social cohesion, tourist attraction.

Paolo Civiero *Which key stakeholders and key actions better deploy transition to Smart Cities?*
E.P. Smart City is an unavoidable trend, but also a flexible approach, which should be tailored-to-fit for any community. Key actions are first hand expected from the public sector managing cities and regions. Responsibility will be met more efficient using new tools. Nevertheless, obtaining real time data, using it in an open transparent and accessible way is possible with private sector support and citizen's access and involvement. In a diverse social and economic mix, Universities can play a decisive role, providing not only specific research and solutions, but also urban vitality, without which Smart City has only a softer grip.
Architects Council of Europe is promoting several topics that will need a smart approach in their implementation throughout Europe: European Urban Agenda is integrating all key topics for the common future and Smart City can provide help for every aspect. As architects can play a role in fighting Climate change, the complex relation between context, materials, form and cultural approach gives better results as only concentrating on technological solutions. Quality driven output is achieved if "Value" of design is recognised in its complete benefit. Fair architectural competitions are one of the main tools in providing quality.

D.R., G.R. Sound examples such as Copenhagen or Amsterdam have succeeded in developing strong management stakeholder platforms that succeeded to deploy effective transition to Smart Cities.
Such stakeholder cooperation models are characterized by really broad participation, executive powers over investment decisions, high reputation and of course the ability to influence the political and policy making arena. Furthermore they speed up the project execution[9].
The inner core of effective stakeholder platforms should surely include the municipality, the public companies participated by the municipality, the local private or public incumbents with regards to the local public services (such as waste, energy and transport utilities). The public or private nature of the incumbents depends on the regulatory framework in force and on the maturity of the privatization and unbundling process achieved on the territory. The outer circle of stakeholders should indeed include the private operators directly involved in realizing infrastructures and implementing smart solutions, such as real estate developers, system integrators, competence centers and technology providers.
Another set should include the academic institutions and the start-up community and last but not least the organizations involved in social innovation and the associations of active citizens.
The best initial actions to trigger the required paradigm shift are related to a structured dialogue aimed at discovering the real needs of the citizens, in order to avoid to develop an excessively techno-centric approach to the Smart City. The level of the district (starting from 600-800 households) is indeed the most suitable for experimentation and realizing pilot projects whose hopefully positive results can spread to the rest of the urban territory.
L.T. Public social housing assets represents an important opportunity to create increasingly inclusive, sustainable and Smart Cities, more commonly called Smart Cities.
When we talk about Smart City we are not referring just to hyper-technological or hyper-connected urban centers but to cities that pursue an idea of sustainable development based on the conciliation between environmental, social and economic sphere, where the citizen's well-being is central.

With this logic, housing is the fundamental issue: the house is the minimum space unit in the city where social relationships develop and where habitual behaviors are formed but it is also a physical space, that has to be salubrious, functional and energetically efficient.

Managing public social housing assets means to have the possibility of identifying guidelines and developing projects on a consistent and extended system of residences, both on the "software" level (relationships, behaviors, inclusiveness, services, etc.) and the "hardware" level (building, applied technology, energy efficiency, plant engineering, etc.). And it means to be able to influence the future of our cities and their inhabitants.

Therefore public social housing companies can be considered among the main stakeholders to build the future policies of the Smart Cities, together of course with the Public Administrations and the other companies that deal with public services (from water management to waste management, from public transport management, to parking, to pharmacies, etc.).

There are therefore many actions to be developed on public social housing that can lead to the transition to Smart Cities: actions on the building with an immediate impact on environmental sustainability (construction of new Near Zero Energy Buildings, energy redevelopment of existing real estate, system integration for energy efficiency and use of renewable energy sources, bio-architectural solutions, etc.); action for householders (preventive matching of families in order to foster relationships and minimize conflict, services for inclusion and interculture, spaces for integration and recreation, co-housing experiments, etc.); action for the neighborhood (development of services and activities shared with the surrounding urban and social fabric as for example sharing mobility services, neighborhood carers, etc.). It is necessary to deploy all this to create more and more cohesive communities and to design the cities of the future.

NOTES

[1] The Architects' Council of Europe (ACE) is the representative organisation for the architectural profession at European level. Its membership consists of regulatory and professional representative bodies throughout Europe. Through them, the ACE represents the interests of over 560,000 architects from 31 countries in Europe, with the aim of fostering Cross-Border Cooperation, facilitating European Practice and supporting Sustainable Development of the Built Environment.

[2] FEDERCASA is the main Italian Association representative of national public social housing companies and housing bodies, involved in different activities (e.g. construction, management, training, design competition) and in broad scientific research programmes at European level.

[3] PLANET IDEA is a multidisciplinary competence and service center that designs and integrates innovative smart solutions into the urban context at various scales. Planet Idea operates based on four macro-areas: built environment, technological systems, ecosystem resources, and society. It international clients are presented with a list of smart solutions that are sub-categorized within each area.

[4] McKinsey Global Institute, A blueprint for addressing the Global Affordable Housing Challenge, October 2014, pages 27.

[5] Koolhaas, R., Generic City, 1995, Sikkens Foundation, ISBN 9789074957038.

[6] E&SG (Energy&Strategy Group of the Polytechnic of Milan, Italy), Smart city report, 2015. Available online at http://www.energystrategy.it/assets/files/SCR_15.pdf

[7] D. Russolillo, *Knowing the Field for Infrastructure and Service Regulation at the Local Level: Players, Information, Incentives*, featured in the volume *The Political Economy of Local Regulation. Theoretical Frameworks and International Case Studies*, Palgrave Macmillan 2017, pages 77-94, ISBN 978-1-137-58827-2.

[8] Such a definition and framework related to collective actions has been presented by Planet Idea Srl to the working groups of the initiative of the City of Turin named Torino Social Impact, soon online.

[9] Mosannenzadeh Farnaz, Maria Rosaria Di Nucci, Daniele Vettorato, Identifying and prioritizing barriers to implementation of smart energy city projects in Europe: An empirical approach, Energy Policy, volume 105, June 2017, pages 191-201, ISSN 0301-4215.

SOCIAL AND CIVIL STAKEHOLDER GROUP

Interview by **Paola Clerici Maestosi,**
Coordinator for Scientific and Editorial Board of European Energy Research Alliance on Smart Cities,
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
paola.clerici@enea.it

Smart Cities require innovative governance approaches to facilitate the increasingly self-initiating civil society and to exploit the potential of ICT. City policy-makers need to revisit the approaches they adopted to combat urbanization challenges. Traditionally, the provision of urban infrastructure and services to meet people's basic needs, local economic development and environmental protection has been the exclusive province of the public sector. But Urbanization dynamics have evolved over time and call for a transition to a more collaborative approach enabling the private sector, civil society and academia to participate and be a partner in bringing about the desired transformation. This calls for new roles, new skills, new cooperation and new policy models.
The participants in the VRT are key note representatives of two major European networks (Eurocities[1], Urban Europe Stakeholder Involvement Platform[2]). Main findings in this VRT refers to the fact that there is not one transition pathway towards sustainable development and that cities need to drive towards a more open and experimental approach as well as innovation does not only manifest in urban infrastructure but also requires changes in urban governance!

Paola Clerici Maestosi *The development of sustainable and energy-efficient "smart cities" appears to be the way to move the energy system towards a more sustainable path and to limit the drastic increase in urban energy consumption associated with CO_2 emissions. Do you think this is the only way?*
Margit Noll Urban areas are responsible for approximately 40 percent of the CO_2 emissions worldwide. Given the fact that over 50% of the world population lives in cities we have to acknowledge that urban areas actually have one of the biggest potentials for reducing CO_2 emissions. For meeting the sustainability goals cities play a key role. Transforming our urban energy systems by increasing the share of renewable energy and enhancing energy efficiency is an essential aspect in this regard. However, the potential of such transitions and new technological solutions can only be fully exploited when considering aspects of behavioural change, the socio-economic consequences of "smart city" approaches or the resulting demands for urban governance and management.

Margit Noll
Austrian Research Promotion Agency, JPIUE Management Board Chair

Nikolaos Kontinakis
EUROCITIES, Senior projects coordinator

Nikolaos Kontinakis Tackling the energy system issue is an important factor for implementing sustainability targets in cities. Nevertheless, we should not forget the high costs of intervening in the existing built environment and the complex business models involved that - practically - are hindering a substantial energy transition. In addition, total energy consumption in a city depends in energy consumed for public infrastructure and transport, the second one proving to be especially resistant to any short - or mid-term solutions. In Eurocities we try to help cities tackle these challenges through initiatives like the Covenant of Mayors, the Green Digital Charter, the European Mobility Week, etc.

Paola Clerici Maestosi *The best way to prepare for smart cities in the future is not by trying to predict what exactly the cities will be like, but rather by making way for different possibilities. Do you think that research and innovation network adequately support this approach?*
M.N. Yes, there is not *the* one transition pathway towards sustainable urban development. Cities have to develop their specific strategies according to their characteristics, their specific situations defined by, amongst others, geographical, social, economic, cultural, infrastructure dimensions. Thus, there is a wide range of urban approaches, strategies, targets and stakeholder interests defining and influencing transition pathways. Such strategies are often developed and implemented in parallel, some of them reinforcing one another, others competing or conflicting. While many cities for example have laid out their "smart city" strategies, the interrelationship with and mutual influence of their "digital agendas" should not be neglected.
In this sense, research and innovation is needed to create evidence not only for specific transition pathways but also to create

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knowledge regarding the interrelationship of different strategies and pathways. Research and innovation networks can provide important environments to share such experiences, validate good practice solutions against different urban situations and to improve our understanding of urban transition pathways. To create robust evidence on all these issues the involvement of stakeholders and societal actors is increasingly important. Research and innovation can act as a facilitator in this sense, connecting different stakeholders, co-designing new solutions and by that enhancing its impact.

N.K. I wouldn't consider the first sentence as granted. With regard to innovation management it seems that, indeed, cities need to develop a more open and experimental approach. In general, though, the discussion of how much of the future cities should plan or facilitate and enable is still open. Experience shows that many of the needs and reservations coming from the citizens can find their way via typical city, state or European functions like planning and regulating. Even more important, these organization can facilitate the creation of local ecosystems in some form of triple/quadruple helixes.

In this sense, research and innovation networks are not able to support this approach alone. They need to be part of the wider ecosystem that brings together not only the R&I sector (by definition a proponent of innovation and experimentation) but also industry, public organisations and citizens as the final users and beneficiaries of the future cities. Working with major European cities for many years and through our peer-to-peer activities we have tried to exhibit the virtues of such an approach, especially to cities that struggle to catch-up and create innovation networks and ecosystems.

Paola Clerici Maestosi *How legitimate for municipalities the use of innovative ICT technologies to implement social processes and municipality tasks?*

M.N. Urban transition does not only manifest in urban infrastructure investments but also requires changes in urban governance and management. The need to involve stakeholders and society at large in urban transition process is widely acknowledge. This consequently results in changing roles of city administration, the development of new public services, anticipating new business models.

The new dynamics of public services and the involvement of civil society in urban processes are taking new forms which facilitate the opportunity to a new set of play in governance. The top-down and bottom-up approaches are changing, leading to participatory and co-creative approaches which have the potential to address and solve pressing urban challenges. Manifold efforts are taken to enhance society's ability to act and to identify new ways of engaging civil society and urban stakeholders in urban discourses for ensuring a continuous dialogue. Digital technologies, advancements in low-threshold ICT solutions, the spread of social media use, all this creates potential for involving societal actors and communities in urban development. Many research and innovation projects are exploring the potential of new digital technologies and tools to drive behavioural change, let civil society participate in urban planning and development and create new partnerships among urban stakeholders.

N.K. I don't see why innovative ICT technologies are different from any other type of technologies used by local authorities. In all cases, the latter needs to examine and determine two parameters: (1) what is this technology will bring to the city and the citizens - results, benefits, possible problems or new exclusions, etc. and (2) what are the conditions to use this technology - cost, the legal, privacy and security issues, contingency planning in case of negative outcomes, etc. Of course, the results of innovative technologies are sometimes hard to predict, that's why early adopters of innovative ICT technologies need to have a truly agile mindset and approach.

Paola Clerici Maestosi *How do you renew the municipal organization in order to implement new cooperation and new policies model?*

M.N. Sustainable urban development calls for integrated urban governance. As mentioned earlier the interrelationships of different targets and strategies can on the one hand provide synergetic potential for boosting transitions but on the other hand mutually hamper progress towards sustainability. New business models are emerging for services for the public. New forms of cross-sector cooperation within the municipality and with stakeholders are consequently needed.

To develop such cooperation or governance models Urban Living Labs is seen as a promising method of social innovation and co-creation. Urban Living Labs are experimental areas where municipal organisations, researchers, civil society actors and business can work together to co-create and test new solutions and policies. Manifested in physical spaces they support the establishment of urban innovation eco-systems. Such transdisciplinary and co-creative research and innovation support also the development of new models of urban governance.

N.K. Eurocities has developed many networking and peer-to-peer learning activities that aim to help and support cities in adopting new cooperation models that suit the current challenges and opportunities. Eventually though each city has to evaluate its starting point and priorities and select the methods it will use and the speed of change that better serves it.

Paola Clerici Maestosi *How smart city plays a key role in promoting innovative and sustainable economies or processes of economic transformation and sustainability?*

M.N. According to estimates of Roland Berger the global market for smart city solutions is expected to expand by 13% per year over the coming decade, from just under USD 13 billion in 2017 to a forecast USD 28 billion in 2023. At the same time we are all aware that business models and urban economies are changing - citizens are no longer just end-users and consumers, but becoming prosumers, providing data and content, taking new roles in the smart and sustainable city. Social entrepreneurs, community-led initiatives, new partnership models in delivering business, all such approaches are contributing to creating new urban economies. Many of these developments are enabled by digital technologies through which a much wider potential for economic transformation is created.

N.K. By definition, one of the aims of a smart city is to create a growing economy or an economy that does more with the same. In my opinion, this second part seems to be the promising for the moment. Under the labels of sharing and/or circular economy, the reduction of idle infrastructure (e.g. cars, roads, built spaces, etc.) or the minimisation of waste can offer quick wins with the use of existing technologies.

Paola Clerici Maestosi *Which key stakeholders and key actions better deploy transition to smart cities?*

M.N. As experiences demonstrate we need all stakeholders on board to realise urban transitions. None of the actors - municipalities, business nor society - will be able to achieve smart or sustainable cities without support from the other stakeholder groups. Municipalities have of course a key role in driving change through their investment decisions, the implementation of new public services or innovative governance models, in many cases based upon innovative products and business solutions. But as urban transition pathways impact people's everyday life and thus depend on their choices regarding mobility, energy use, consumption, etc. society needs to act accordingly. In this sense one of the key issues is to understand how good practice cases can be mainstreamed, how living lab experiences can be exploited in a wider scale.

N.K. We need to invert this question and ask if a transition to smart cities is possible without the participation of some stakeholders and the answer is negative. The development of a smart city can be described in both terms of process and outputs. All key stakeholders of a city need to be on-board if any successful transition is to be realised. The recent examples of the smart specialisation strategies or the digital transformation blueprint give proof of this. In both cases, no single stakeholder is identified as more important than the others but all of them are identified as necessary ingredients for success.

NOTES

[1] Eurocities is the network of major European cities, founded in 1986. Today, Eurocities brings together the local governments of over 130 of Europe's major cities from 35 different countries, representing the interests and needs of 130 million citizens.

[2] JPI UE SIP comprises a wide spectrum of urban stakeholder involved, thanks to CSA EXPAND, in the co-creation approach of JPIUE Strategic Research and Innovation Agenda.

[3] Berger, R. (2017), Think: Act. The rise of the smart city, available at: https://www.rolandberger.com/en/Publications/pub_smart_city_smart_strategy.html

Authors

Mario Losasso
SITdA and TECHNE Director
2014-2017
Full Professor of Architectural Technology, Head of DiARC - Department of Architecture, University Federico II of Naples, Italy

Emilio Faroldi
Editor in Chief
Vice-Rector of Politecnico di Milano, Full Professor at Department of Architecture, Built Environment and Construction Engineering of Politecnico di Milano, Italy

Paola Clerici Maestosi
Coordinator for Scientific and Editorial Board of EERA JPSC, Senior Researcher DTE-SEN, ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy

Brigitte Bach
European Energy Research Alliance Executive Committee vice-chair

Hans-Martin Neumann
Member for Scientific and Editorial Board of EERA JPSC, Senior Research Engineer, Sustainable Buildings and Cities, Austrian Institute of Technology, Austria

Annemie Wyckmans
Member for Scientific and Editorial Board of EERA JPSC, NTNU Norwegian University of Science and Technology, Faculty of Architecture and Design, Norway

Mauro Annunziato
Member for Scientific and Editorial Board of EERA JPSC, Head for Smart Energy Networks Energy Technologies Department, ENEA -Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Italy

Miimu Airaksinen
Member for Scientific and Editorial Board of EERA JPSC, Managing Director and CEO, Finnish Association of Civil Engineers, Finland

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Ambrosio Liceaga

Member for Scientific and Editorial Board of EERA JPSC, Institute of Smart Cities, Universidad Pública de Navarra, Spain

Ernesto Antonini

Full Professor of Technology of Architecture at the Department of Architecture of the University of Bologna, Director of Second Cycle Degree of Engineering of Building Processes and Systems

Elena Mussinelli

Full Professor at Department of Architecture, Built Environment and Construction Engineering of Politecnico di Milano, Italy

CONTRIBUTIONS
Authors

Alessandra Barresi,
Department of Architecture and Territory, Mediterranean University of Reggio Calabria, Italy

Maurizio Sibilla,
School of the Built Environment, Oxford Brookes University, United Kingdom

Esra Kurul,
School of the Built Environment, Oxford Brookes University, United Kingdom

Roberta Pinna,
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Intern at Energy Technologies Department - Smart Energy - Smart Cities and Communities, Bologna, Italy

Ezilda Costanzo,
ENEA - ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Energy Efficiency Department, Rome Italy

Sabrina Romano,
ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Energy Technologies Department, Rome, Italy

Ornella Iuorio,
University of Leeds, School of civil engineering, Leeds, United Kingdom

Luca Lanini,
Department of Energy Engineering, Systems, Land and Buildings, University of Pisa, Italy

Eleona Barsanti,
Toscana Energia, Italy

Angelo Frascella,
Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, Bologna, Italy

Arianna Brutti,
Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, Bologna, Italy

Nicola Gessa,
Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, Bologna, Italy

Piero De Sabbata,
Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, Bologna, Italy

Cristiano Novelli,
Italian National Agency for New Technologies, Energy and Sustainable Economic Development, ENEA, Bologna, Italy

Martin Burns,
National Institute of Standards and Technology, Gaithersburg, United States

Vatsal Bhatt,
United States Green Building Council, Washington DC, United States

Raffaele Ianniello,
Department of Computer Science and Engineering, University of Bologna, Italy

Linghao He,
United States Green Building Council, Washington DC, United States

Ali Hainoun,
Center for Energy, Sustainable Buildings and Cities, AIT Austrian Institute of Technology GmbH, Seibersdorf, Austria

Ghazal Etminan,
Center for Energy, Sustainable Buildings and Cities, AIT Austrian Institute of Technology GmbH, Seibersdorf, Austria

Massimiliano Condotta,
University Iuav of Venice, Department of Design and Arts, Italy

Giovanni Borga,
University Iuav of Venice, Department of Design and Planning in Complex Environments, Italy

Silvia Soutullo,
Energy Efficiency of Buildings R&D Unit 7 Renewable Division, CIEMAT, Madrid, Spain

Jose Antonio Ferrer,
Energy Efficiency of Buildings R&D Unit 7 Renewable Division, CIEMAT, Madrid, Spain

Maria del Rosario Heras,
Energy Efficiency of Buildings R&D Unit 7 Renewable Division, CIEMAT, Madrid, Spain

Maria Beatrice Andreucci,
Department of Planning, Design, Technology of Architecture, Sapienza University of Rome, Italy

Fabrizio Tucci,
Department Planning, Design, Technology of Architecture, Sapienza Università di Roma, Italy

Daniele Santucci,
Chair of Building Technology and Climate Responsive Design, Technische Universität München, Germany

Elisabeth Endres,
IB Hausladen Engineering Firm, Kircheim-München, Germany

Gerhard Hausladen,
Emeritus, Technische Universität München, Germany

Andrea Boeri,
Department of Architecture, University of Bologna, Italy

Jacopo Gaspari,
Department of Architecture, University of Bologna, Italy

Valentina Gianfrate,
Department of Architecture, University of Bologna, Italy

Danilo Longo,
Department of Architecture, University of Bologna, Italy

Edi Valpreda,
ENEA, Italian national agency for new technologies energy and sustainable economic development, Italy

Lorenzo Moretti,
ENEA, Italian national agency for new technologies energy and sustainable economic development, Italy

Maria Anna Segreto,
ENEA, Italian national agency for new technologies energy and sustainable economic development, Italy

Francesca Cappellaro,
ENEA, Italian national agency for new technologies energy and sustainable economic development, Italy

ACKNOWLEDGMENTS OF VALUE
Stakeholders

William Brunelli,
Confindustria Emilia - Area Centro, Italy

Barend van Engelenburg,
TNO, Netherlands

Nienke Maas,
TNO, Netherlands

Laura Ricci,
Department of Planning, Design and Technology of Architecture, Sapienza University, Rome, Italy

Carmen Mariano,
Department of Planning, Design and Technology of Architecture, Sapienza University, Rome, Italy

Marco Padula,
National Research Council of Italy, Institute for Construction Technologies

Francesca Picenni,
National Research Council of Italy, Institute for Construction Technologies

Roberto Malvezzi,
CertiMaC

Luca Laghi,
CertiMaC

José Manuel Salmeròn Lissén,
Universidad de Sevilla, Spain

Francisco José Sanchez de la Flor,
Universidad de Sevilla, Spain

Carolina Mateo-Cecilia,
Intituto Valenciano de la Edificaciòn, Spain

Laura Soto-Francés,
Intituto Valenciano de la Edificaciòn, Spain

Maragarita-Niki Assimakopoulos,
National and Kapodistrian University of Athens, Greece

Theoni Karlessi,
National and Kapodistrian University of Athens, Greece

Michela Toni,
Department of Architecture, University of Ferrara, Italy

Maddalena Coccagna,
Department of Architecture, University of Ferrara, Italy

Alessandro Claudi de Saint Mihiel,
Department of Architecture, University Federico II of Naples, Italy

Eliana Cangelli,
Department Planning Design Architecture Technology, Sapienza University of Rome, Italy

Giovanna Franco,
Department of Architecture and Design, University of Genoa, Italy

Paola Gallo,
Department of Architecture, University of Florence, Italy

Rosa Romano,
Department of Architecture, University of Florence, Italy

DIALOGUES
Virtual Round Table Participants

Magdalena Andreea Strachinescu Olteanu

Head of Unit, New energy technologies, innovation and clean coal, Directorate General for Energy, European Commission

Eddy Hartog

Head of Unit Smart Mobility and Living, Directorate General Communications Networks, Content and Technology, European Commission

Paolo Civiero

Associated Participant and Assistant Editor EERA JP on Smart Cities, Sapienza University of Rome

Gunter Amesberger

Municipality of LINZ, Austria, and Director Urban planning, Technics and Environment

Pasquale Capezzuto

Municipality of Bari, Italy, and Head of Energy and Plants Office in Urban Planning and Private Building Department, Former Coordinator of Bari Smart City Project

Xavier Normand

City of Grenoble, France, and Former program manager "Sustainable Urban Development", Founder and CEO of "XN conseil", consulting and expertise in the field of sustainable urban development projects

Rasmus Reeh

Municipality of Copenhagen, Denmark, and Senior Advisor of Copenhagen Solutions Lab and Project Leader of the project Innovatorium Nordhavn

Elena Guarnieri

Technical University of Denmark and Secretariat of the European Energy Research Alliance

Luciano Martini

Director, Ricerca sul Sistema Energetico (RSE, Italy) and Coordinator European Energy Research Alliance Joint Programme Smart Grids

Daniela Velte

Programme Director and Senior Researcher, Tecnalia, Spain, and Coordinator of European Energy Research Alliance Joint Programme Economic, Environmental and Social Impacts

Mathias Noe

Karlsruhe Institute of Technology, Germany, and Coordinator of European Energy Research Alliance Joint Programme Energy Storage

Isabelle Johanna Südmeyer

Karlsruhe Institute of Technology,Germany, and Manager of National Research Programme Storage and Cross-linked Infrastructures

Myriam E. Gil Bardají

Karlsruhe Institute of Technology,Germany, and Manager of European Energy Research Alliance Joint Programme Energy Storage

Laurens de Vries

Associate Professor at Delft University of Technology, Netherlands, and Coordinator of European Energy Research Alliance Joint Programme on Energy Systems Integration

Eugen Pănescu

Architect, Architects Council of Europe

Daniele Russolillo

Chief Business Development Officer Planet Idea Smart Engineering, Italy-Brazil

Graziella Roccella

Chief Operating Officer Planet Idea
Smart Engineering, Italy-Brazil

Luca Talluri

Engineer, President of Federcasa,
Italy

Margit Noll

Austrian Research Promotion
Agency JPIUE Management
Board Chair

Nikolaos Kontinakis

EUROCITIES, Senior projects
coordinator

EERA JOINT PROGRAMME ON SMART CITIES - Full Members and Associated Partners

Participant	Associated participant	Associated participant	Associated participant	Associated participant
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Associated participant

Associated participant

SP Coordinator,
Participant

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Associated participant

Participant

Associated participant

NTNU Norwegian University of Science and Technology	JP Coordinator, Participant
tecnalia Inspiring Business	Participant
TNO innovation for life	Participant
ECN	Associated participant
CTU Czech Technical University in Prague	Participant
UKERC Loughborough University	Associated participant
UKERC The University of Nottingham	Taskforce leader, Associated participant
UKERC De Montfort University	Associated participant
UKERC King's College London	Associated participant
UKERC Newcastle University	Associated participant
UKERC northumbria University	Associated participant
UKERC University of Strathclyde	Associated participant
UKERC uclan	Associated participant
UKERC Heriot Watt University	Associated participant
VTT	Participant
Warsaw University of Technology	Participant
IEN	Associated participant
IMP PAN Gdańsk	Associated participant
Alma Mater Studiorum A.D. 1088	Participant
Università di Pisa	Participant
Universitat de Girona	Participant