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Cities – what smart grids can tell us about resilient infrastructure design

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Abstract:

The dependency on reliable infrastructure planning and layout is crucial for resilient urban areas. In this context a lot of innovation is focusing on smart systems. What can urban administrators learn from this, as municipal authorities have to keep the balance in-between individual interests of investors and the general interest of providing a place of urban environment and resilience for inhabitants? Leaving “smart” developments completely to the market stakeholders might result in economic welfare during ordinary operation, but could lead towards infrastructure breakdowns and its consequences – in emergency cases. Reminding the role and the legitimacy of municipal authorities as keeper of the general interest in charge of local crisis management will explain why – and how – cities should take part to the design processes of infrastructures, in order to secure their resilience. This paper gives an insight from research towards understanding resilience measures in planning and metropolitan smart infrastructure.

Keywords:

Infrastructure, Strategies and approaches, Urban planning

Introduction

Cities are more dependent on their infrastructures than any other area due to the concentration of population, building and activities. In order to manage these as well as the interdependencies in the urban supply chain, municipal authorities work within a well-known functional segregation of administration fields. In a context of global competition, the reliability of infrastructures has a major impact on the reputation and the macroeconomic attractiveness of modern cities. For example in rankings and indexes, the nexus between energy and water supply, waste management, lighting, telecommunication and transportation, is essential in order to attract investments. The provision of such reliable environment and business friendly surrounding are therefore strategic concerns for urban resilience. There are many legal frameworks and business models to develop and to run these city systems. However, municipalities face more and more exceptional situations - the dramatic earthquake and tsunami in Japan in 2011, the hurricanes Katrina (2005) and Sandy (2012) in the USA or the typhoon Haiyan (2013) in the Philippines have proved how vulnerable critical supply systems can be, even in highly developed countries. The statistical observation of many smaller events, such as storms, hails, extreme temperatures waves, shows that any network is vulnerable. The chains of consequences following the black-outs are reminding that one severe event can lead to a complete collapse of urban infrastructures and processes, within very little time. This fragility and the resulting interruptions have always been a thread to economic activities, but nowadays their cost became even more damageable for our highly integrated and globalized economies. Such events may also affect the quality of life for residents, sometimes even leading to destabilization of the social equilibrium.

On the field of city supply, questions arise: which innovations have been undertaken in the past years on a grand scale? And as resilience appears to be crucial for the future of metropolitan areas: is this concern taken into consideration by research efforts? Are there available returns on experience? What can urban administrators learn from this for the future?

”Smart grids” is one of the main research and innovation topics of the past years in the field of supply infrastructures, which provided many results. A general overview will be used here to provide first answers to these questions.

1. ICT meets urban infrastructure: the example of smart grids

Numerous national and international funding programs, demonstration projects, involved stakeholders representing most parts of the society and business explorations show how much attention has been paid to this topic since the mid 1990’s. The massive roll-out of new and cheap communication technologies is

seen as an opportunity to change the paradigms of infrastructure management. With the help of new ICT, spatially distributed and communicating metering is expected to allow real-time monitoring and even real-time action, such as load management. As the idea seems quite convincing and promising, many demonstration projects have been launched and funded by national or continental administrations. Companies have started tests in Asia, Europe and Northern America.

1.1 The local context as driver for a smart grid

Smart grid projects have now been running long enough to allow a critical observation of their outcomes. Europe concentrates a large panel of case studies with major differences in understanding and implementation. The member states of the European Union have agreed on common targets about energy efficiency and carbon emissions, but their national contexts differ. Some of the structural differences between their energy supply paradigms are linked to:

- Variations in the regulatory frameworks and agencies (e.g. centralized versus federal organizations)
- National and local legislation
- Stakeholder structures (number and size of energy suppliers and level of competition between them)
- Cultural aspects (level of environmental awareness, acceptance to certain types of energy production technologies)
- Social preferences (community or individual driven societies)
- Economic situation

Hence, grids and urban infrastructures differ from a country or city to another and adaption to local situations might require more or less radical variations in their concept and planning. Knowing the intention behind these approaches reveals what makes a smart grid radically different from another one.

1.2 European demonstrators

Since the 1990's, several research funding programs such as Germany's e-Energy, or the European Framework Program (FP6 and FP7) brought up experimentations, while some large electricity suppliers including Vattenfall, Fortum or EDF came up with their own approaches. Field tests of all sizes and types have been conducted, including smart metering, load management, renewable and/or decentralized energy sources integration and management, load simulation, load aggregation, new ICT devices and

other innovative designs. In order to sort this information, simplified groups of countries can be defined, to which main drivers can be considered:

- Eastern EU newcomers still have major infrastructure upgrades to achieve: smart grids are not yet a priority there.
- Nordic countries (Finland, Sweden) developed metering roll-outs to improve their grid monitoring, mainly in order to prevent winter-storm black-outs. In this case, resilience issues are more important than efficiency.
- North and Baltic Sea neighbors set their focus on massive renewable energy integration in order to adapt to the rapidly growing offshore wind power capacities surrounding them, with Denmark as a leader.
- Central European countries (Spain, Germany, Austria, France) are mainly exploring innovative technologies and business models while tackling local issues (grid structure, local potentials, cooperation with specific industries, aggregators, electric vehicle).

Without describing each of them, European tests have proven a variety of possible drivers conducting to smart grids implementation, for which resilience as such is only one among many others. Local authorities might contribute to bring up this issue by taking part to the planning discussions in order to make sure it will be addressed, even when companies may be driven by own interests. Before discussing the role of cities, some attention should be paid to possible impacts on resilience of other approaches.

2. Smart infrastructures: chance or thread for urban resilience?

“Smart” concepts basically imply a large use of ICT-driven solutions to an existing system. The constant improvement of possibilities accelerated by falling prices has generated all sorts of expectations. Infrastructures matters were no exceptions and when it comes to them, urban areas are prior targets for “smart” projects. Densely built places concentrating activities, consumptions and exchanges are ideal to reach and promote substantial results. Nevertheless electronic devices and a computing architecture remains an appliance, which can be dedicated to various goals.

2.1 ICT will change the way infrastructures work

As a matter of fact, “smartization” trends can be observed: as efforts are being made to extend the principles of smart grids to all the other urban infrastructures, they are paving the way to “upscale” this

approach to the entire city. ICT-driven management seem to be comparable from one system to the other. The trend to switch to more and more ICT tools has already started.

It is not too early to question whether such an ICT-based design increases the vulnerability and reduces the resilience of facilities which used to be independent. Increasing numbers of computer-driven systems are submitted to growing risks of cyber-attacks. A comprehensive interconnection of several, maybe even all urban systems also means the next step of extensive interdependence: all parts of the city are growing together in one single powerful, but very woundable body. Chain reactions are capable to cause simultaneous collapses of infrastructures that were almost independent from each other before. Beside the possible gain of overall efficiency, which is at the heart of most European energy policies, the risks of integrated management must be questioned.

2.2 Is smart resilient?

The paradigm of lean production shows a high vulnerability to unexpected occurrences, which is even higher when talking about electricity by the way. The optimization of electricity supply achieving the matching between demand and production aims at maximizing the consumption of irregular production and avoiding expensive oversized grid capacities. In other terms, the grid tolerance towards unexpected loads is being reduced. If smart infrastructures are set up this way, they will be less resistant to extreme climatic events and become a higher risk for the functioning of cities.

As a consequence for decision-makers at the city scale, this hypothesis premises a careful design of urban equipments and their management. With resilience in mind, smart grids and connected facilities provide new opportunities: the considerable investment efforts in new technical potentials and the multiplication of participating stakeholders provide cities and their surroundings with new options. If well-planned, new infrastructure interconnections and interdependencies can offer extended abilities in the emergency case, higher buffering potential or more flexibility. To reach this, a “resilience hypothesis” including a balance between bottom-up and top-down design of smart infrastructures should be discussed.

Conclusion: Cities have a new role to play

The history of smart grids experience is now sufficient in both duration and number of demonstration projects to come up with results and some extrapolations about the future of strategic urban planning. The diversity of approaches in Europe demonstrates that infrastructure concepts are delivering answers to local challenges: very different ideas share the same name.

With such variations, resilience is not automatically coming with smart concepts, but as one possible option. The trend towards ICT solutions, interconnection and the optimization of grid costs can either lead to a reduction of the tolerance towards unexpected events or provide new management options. The future of cities will rely more than ever in the quality of planning.

To that purpose, it might be helpful to keep the respective functions of public and private stakeholders in mind. On the business side, urban facilities upgrades mean huge hardware investments, which imply important investments. Companies and suppliers are the most likely to provide these capacities and it is logical that such investments must be business-oriented in order to repay themselves. On the regulation side, public authorities are responsible for ensuring the quality of transformations in the urban area. Those two drivers must not collide with each other or come up with a perfect “win-win” business for both sides. While some demonstration projects tried to redefine this balance by exploring new business models, it is also possible to consider different levels when assessing a smart infrastructure, to which different indicators of success can be affected.

Local authorities have a clear interest in seeing innovation, investments and improvements happen on their territory. Benefitting from them in terms of reputation, infrastructure quality or economic dynamism does not imply to become business actors themselves. It will be in their hand to find ways to encourage smart investments that are not only focusing on new business opportunities, but which embed resilience improvements, maybe for everyday operations and definitely for crisis management. Response capacities such as emergency islanding, prior affectation of local production to critical amenities (e.g. neighborhood solar panels to hospitals) or other exceptional event management protocol must be defined and set up in advance: local authorities will have to adapt and to gain expertise (internally and/or with external support) on this field in order to tackle properly the evolutions coming with ICT innovation and to make sure these will not affect, but improve urban resilience. Companies will find their interest in such regulation too. It will provide a frame for innovation and business, a reliable situation protected by legal commitments and better chances for social acceptance.

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