INSMART - TOWARDS THE NEW DSO POTENTIAL ROLES IN LOW CARBON FUTURE AND INTEGRATED FRAMEWORKS FOR SMART CITIES

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ABSTRACT

With the increasing amount of big data available from high temporal resolution from smart meters and with the increasing digitalization of the customer expectation of digital service brings forward new business models, which might request significant improvement ICT capabilities for the DSO, as well as new decision support tools and new challenges to procure flexibility services from distributed generation, EV charging network, demand response or storage. Active network management and distributed generation along with the changing market structures are drivers for change towards the future cities. This paper will provide a better understanding on the actual state of the art for utilities and DSOs seeking their new role as Market Facilitator and Data Manager with additional insights from market segmentation as well as the potential role of the DSO in the integrated framework for smart cities. The InSmart project developed a mix of sustainable energy measures to improve the energy efficiency of each partner city, identified with specialised tools and models.

INTRODUCTION

More than two thirds of the European population live in urban areas. Cities are places where both problems emerge and solutions found. They are fertile ground for science and technology, for culture and innovation, for individual and collective creativity. Cities consume most of the energy today and their energy demand will continue to increase in the future. Buildings and Transport are the two largest energy-consuming sectors, cities are Europe´s power and traffic centres since they represent 75% of EU population, ¾ of EU energy consumption and CO_2 emissions is in cities. Urban areas have therefore a pivotal role in climate change mitigation.

As active and concerned citizens, we all aim to meet a more sustainable energy system and climate change goals. Cities should act in planning their future development in an integrated way considering energy needs and environmental impacts: cities must go “smarter” and provide a secure, affordable and climate-friendly energy. Wiser energy use while addressing climate change and providing the transition to a low-carbon secure and competitive economy will drive to improved competitiveness to cities environments and citizens’ way of living.

With increasing trends of energy consumption and global warming constraints, cities need to demonstrate integrated solutions for smart connections between homes, grids (electricity, heat and cool, gas, telecommunications, water, etc.), energy storage, EV and their charging infrastructures using the latest generation of smart ICT solutions that help to manage a successful transformation towards intelligent, user-driven and demand-oriented city infrastructures and services. There is strong need for energy efficiency measures and the use of very high shares of renewables namely in decarbonized economies and with increased electrification. Towards a carbon-free, digital and electrified society that deeply rely on resilient, secure and enabling distribution systems, DSOs need to ensure the integration of the distributed resources, managing data in a secure and non-discriminatory way and also need to promote new added value services. This means that DSOs need to overcome their primary challenges in quality of service and security of supply and need enhance their new role in a new customer centric approach, with empowered customers and prosumers, distributed generation, distributed storage, with increasing EV charging and active network management, in a time of changing market structures.

The European research project INSMART (EU 7th FP under GA 314164) has the objective of identifying the optimum mix of short, medium and long term measures for a cities sustainable energy futures through the use of specialised tools and models. The project addresses the efficiency of energy flows across all the energy consuming sectors (buildings, transports, water and waste management, lighting, etc.) evaluating economic, environmental and social criteria intended to pave the way towards actual implementation of priority actions, involving different stakeholders from city planning bodies to private services [1].

The work was developed in four European cities (Évora, Cesena, Trikala and Nottingham) targeting innovative methods to city energy planning (Fig. 1). Through an integrative and multidisciplinary planning approach, we looked in depth for each energy consuming city sector, while using the city of Évora in Portugal for depicting the results.

In this paper, we focus on presenting the several approaches used to address renewable energy potential and consumer segmentation issues at city level understanding how those results can be beneficial from a DSO perspective. We address the DSOs new role as Data Manager and active Market Facilitator. DSOs will be enablers of new services and play its potential role in cities low carbon pathways, fulfilling the main challenges in driving energy transition. Smart Grids are needed more than ever to deliver on the EU´s Energy Union, alongside a renewed focus on innovation as a centrepiece of the market design reform – INSMART vision [2] [3].

METHODS

This section depicts the methodological process and the datasets used to conduct the different analysis for renewable energy potential identification and consumer segmentation.

A) Solar Energy Potential

Southern Europe is a solar radiation top region, with high number of hours of daylight (2200 to 3000h) and high daily solar insolation (around 5000 W/m^2/day), and hence very keen to take full advantage of solar resource.

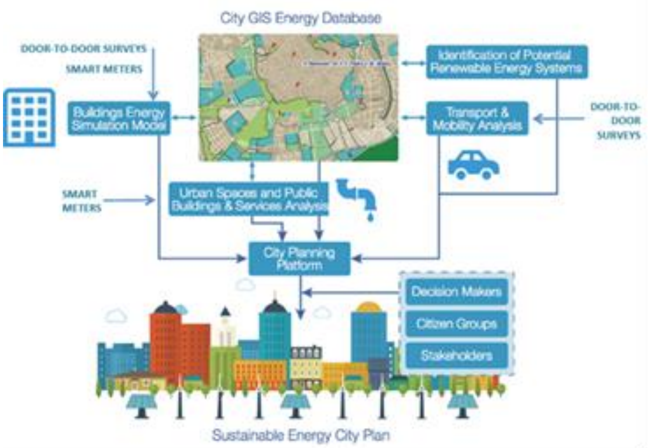

Figure 1 - Integrated City energy Planning Framework

For a comprehensive analysis of an energy system, the knowledge of the supply system and energy resources potential is paramount. Therefore, we identified the potential of solar photovoltaic for utility scale and residential buildings rooftop in three different analysis, making possible to maximize PV production without grid feed-in injection and this way preventing over estimating of capacity and investment costs:

1) Assessment of the technical potential of utility-scale solar PV projects (>1MW) while taking advantage of GIS systems and spatial planning regulations [4];
2) Residential building's technical rooftop PV potential differentiated by city districts and buildings typologies suing the surveys data and GIS [5];
3) Use off-peak consumption from smart meters data as a proxy for the minimum base load of electricity consumption of Évora households in order to find adequate PV capacity [6].

B) Consumer Segmentation and Typification

InSmart project developed another set of analysis to understand and typify the demand side. For these assessments, we use a combination of household door-to-door survey data with details on socio economic details, builds structure and equipment ownership and use, a smart metering dataset, daily registries of temperature and buildings energy simulation modelling.
In addition, we conducted three different analysis to understand the different types of electricity consumers in Évora:

1. Clustering methods to derive distinct consumer groups from their yearly consumption patterns [7];
2. Identification of fuel poverty consumers and calculation of the thermal comfort gap on heating and cooling for these households [8];
3. Leveraging the role of smart meters' data, while assessing the influence of different external air temperature thresholds, evaluating maximum daily temperatures (25°C, 30° and, 35°C) and minimum daily temperatures (18ºC, 15ºC, 10ºC and 5ºC) on daily synthetic electricity consumption profiles.

All these assessments serve as support for tailor made policies, detailed analysis for ESCOs intervention and increased DSO knowledge on the different type of consumers.

RESULTS AND HOW CAN DSOS BENEFIT FROM INSMART APROACH

A) From RES potential to grid integration

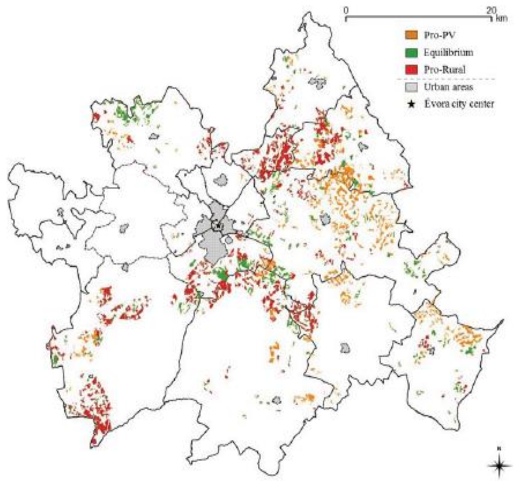

Figure 2 - Utility scale solar PV potential in Évora

Portugal achieved 70% of renewable energy in the first quarter of 2014, and energy spot price was around ZERO for about a week. This brings new challenges to the DSO, such as a large and growing amount of renewable energy integration injected far from consumption. With intermittency and uncertainty, this will call for flexibility in the layer between supply and demand: the Smarter Grids will allow the control, the DG Mix management, Storage Back Up and DSM.

Using the first method (solar energy potential), and in the most ambitious PV adoption scenario, the potential installed capacity of 1 MW project (near 2500 MW full potential capacity) represents around five times the 2015 national PV installed capacity (451 MW [9]) and 40% of the total country currently installed capacity of coal and gas power plants (5890 MW).

For PV rooftop, the technical potential in the city identified was 59MW. The results of the analysis using smart meters' data related to consumption bring forward a more conservative number more aligned with current polices on auto production (12.7MW).

Over the past years, DSOs made several investments in both technology and communications to offer the grid more autonomy and flexibility. In fact, smart meters are enablers towards the real-time management of the low voltage grid. This new paradigm will contribute to level up the grid's automation grade as well as the remote management capacity of all network devices. By doing so, the grid becomes equipped with highly adaptable and dynamic behaviour components, which tends to reduce the operational and maintenance costs and will improve both quality and reliability of supply. To do so, DSOs will need to build front line systems to manage the incoming data from smart meters. These new information systems, with highly adaptable architecture, are crucial for the functioning of the electricity market. These flexible capacities allow DSOs to provide relevant data for retailers and for the system operator. In addition, it can benefit the DSO since in the detection of commercial losses it will be possible to compare consumptions of homologous periods for a particular installation. Moreover, this new approach also allows DSOs to study the allocation of clients by bus, i.e., verify the current's balance by phase at the bus. The DSOs will have a deeper view of the electrical system and will be able to check voltage level and current values in buses and secondary substations. Additionally, the DSO will also be able to acknowledge the energy balance at the secondary substation level, which is a major improvement regarding costs control.

B) From consumer typification to Demand Management

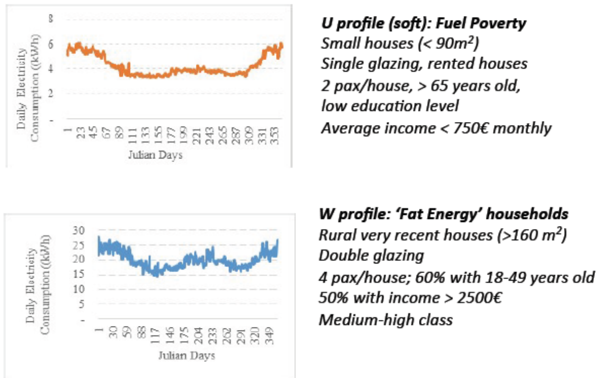

Figure 3 - Residential sector electricity consumer groups in Évora

Linking the results of the above-mentioned surveys with the remote metering data from smart meters, DSO has access to valuable information that will be key in areas such as demand response, peak demand management or operational efficiency. This data details will allow DSO a deeper understanding about consumption profiles, any time of the year. Therefore, it´s easier to anticipate possible emergency interventions or to delay financial investments, due to the acknowledgment of the grid´s expected demand. With smart meters and distributed generation, some areas may become auto sufficient in terms of energy and that may pose also a challenge for the DSO. Grid investments will be subject of deeper analysis and this is one of the main findings regarding the grid planning.

C) Customer Relationship Manager, ESCOs, Municipalities and new market players

Smart metering, distributed generation and smart cities set a new paradigm for the electricity framework: a new customer centric approach where the customer is the centre and the market players should come up with new products and value added services. Smart meters have empowered the customer to such extent that we are witnessing new business models being born at a faster pace than in all previous years before the smart metering era. New digital services are under construction by DSOs and since end-users are becoming more digital, EDPD has recently launched its renewed digital platform available for PCs, tablets and smartphones, where these new empowered end-users are free to choose new tariffs and to digitally command the electrical devices. As one may imagine, such requirements pose an ocean of challenges to the DSOs and to the market agents as a whole. New disruptive business models are emerging among a smart energy environment and with IoT based customer relationship, DSOs are becoming an information Hub. Storage and EV charging

will also demand more flexibility from the grid and a secure, resilient and digital smarter grid has to be set in place.
DSOs are electricity market facilitators and need to ensure this role in the future market design.
The current regulatory framework for DSOs does not provide the right incentives for DSOs to act as retail market facilitator. It is necessary to revise the tariff structure in order to recognize the benefits of demand response with the system´s sustainability. Regulatory frameworks should leave sufficient scope for DSOs to design network tariffs that can enable a more efficient and participative customer behaviour since they will positively affect with the electricity market agents' as they will contribute to a smoothing of the demand curve. This will benefit many players of the electricity market:

- Retailers will be able to make better forecasts of consumer´s consumption profile;
- Since retailers will have more accurate forecasts, the TSO will have less energy to adjust in the system's auxiliary markets (deviations);
- DSO will manage a smoother demand curve with fewer peaks, meaning that operational benefits;
- The spot price will tend to decrease, as the TSO does not need to provide large amounts of energy from the secondary markets;
- A more efficient and participative customer behaviour will be assisted by these benefits.

FINAL REMARKS

This paper provides a discussion on a set of topics driven by research carried out in the INSMART project. It presents a better understanding on the actual state of the art for utilities and DSOs seeking their new role as Data Manager and Market Facilitator. It provides additional insights from market segmentation and within regions with a high renewable energy potential as well as the prospective role of the DSO in an integrated framework for smart cities. Acquired knowledge can be used to target energy consumption reduction policies and optimize self-consumption capacity investment costs and electricity production surplus.

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