# ENERGY TRANSITION ENHANCED BY SHARING ENERGY MANAGEMENT SYSTEMS ON LOCAL ENERGY DISTRICTS

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## ABSTRACT

*The Distribution System Operator (DSO), as the owner of critical infrastructure, is at the core of any smart city solution design. An increasingly digitalized infrastructure (with the rollout of smart grid infrastructure and increase of cloud based services) is the driver for the creation of novel digital services, able to cope with the high-level demands of the end users. This brings forward new business models, which might require significant development of Information and Communication Technologies (ICT) capabilities for the DSO, as well as new decision support tools to allocate flexibility services from distributed generation, EV charging network, demand response or storage.*

*The new DSOs' roles are extremely connected with their increasing need of flexibility. DSOs should procure flexibility through market-based solutions or use other direct flexibility alternatives, such as grid reinforcements or storage. The different alternatives should always be assessed on an economic/societal perspective and must always guarantee security and quality of supply, under the supervision of the Regulator.*

*Presently, several European Union projects with a focus on the use of flexibility resources for grid management are currently taking place in the city of Lisbon, namely Sharing Cities Lighthouse program and Suscity project. These projects will enable the creation of new business models for the stakeholders across the value chain.*

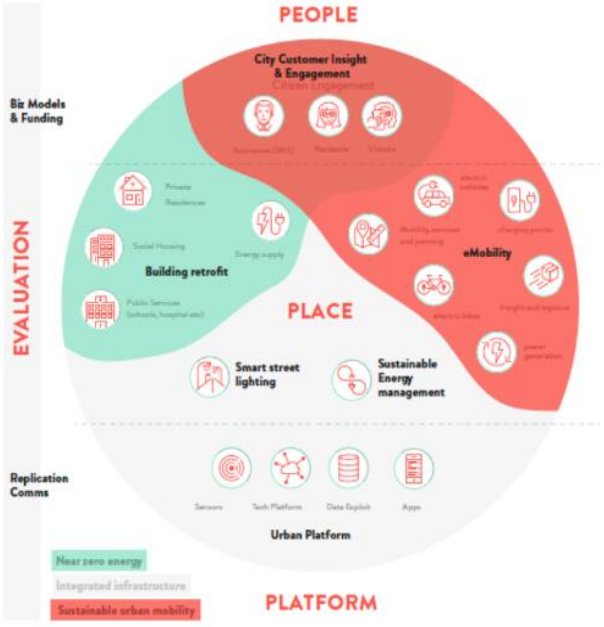


*Figure 1: Sharing Cities Concept*

## INTRODUCTION

DSOs, as neutral market facilitators, with direct access to consumers, have a key role in promoting customer engagement by making the most out of the interactions that take place during smart meter deployment and through the development of new customer oriented processes and solutions, such as Home Energy Management Systems (HEMS). The Portuguese DSO (EDP Distribuição) and a Portuguese University - Instituto Superior Técnico (IST) are currently taking part in several projects that have as one of the objectives the development of new business models arisen from new services developed.

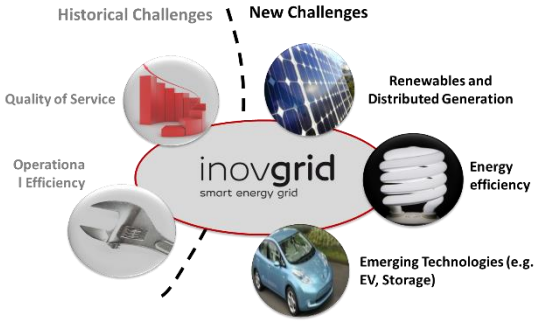


*Figure 2: InovGrid challenges*

In this paper, three research projects and business models are presented.

InovGrid is EDP's umbrella project with a strong focus on smart grids, aiming to address several challenges, including: the need for increased energy efficiency; the pressure to reduce costs and increase operational efficiency; the integration of a large share of distributed generation; the integration of electric vehicles and the desire to empower customers and support the development of new energy services [1].

Sharing Cities Project (Figure 1) [2] has a major objective: to adopt a digital first approach which proves the extent to which ICT integration can improve and connect existing infrastructure, as well as the design and management of a new city infrastructure. This also

allows the creation of a new set of next stage digital services which will engage the citizens in making better choices around energy efficiency, such as HEMS and the adoption of adequate behaviours. Another key objective is to accelerate the market to understand, develop and trial new business, investment and governance models, essential for the successful aggregation and replication of smart city solutions in cities of different sizes and maturities.

SusCity project [3] is focused on developing and integrating new tools and services to increase urban resources efficiency with minimum environmental impacts while contributing to promote economic development in cities.

**InovGrid Experience in HEMS :** The new energy ecosystem enables new products and services. EDP Distribuição assessed the increased value and the increment in the engagement of the end users of an energy management system. This initiative was tested with 16 home energy management service in Oporto and Lisbon. As a result, it was possible to identify two key learnings from HEMS:1) Although there are segments of heavy users that take advantage of a HEMS service, others only take advantage of the extracted information in a reactive way. These are the "Observers"; 2) Heavy users want more functionalities, Basic Users want guidance to take greater advantage of their HEMS service and the Observers want reports with actionable insights that they can act on.

**The Sharing Cities Project** main focus are: (1) the people, through citizen engagement; (2) the place, through deployment of a series of actions that can promote energy efficiency and; (3) the platform, through the development of an urban sharing platform that collects and analyses data.Among the actions taking place, two are especially relevant for ICT integration as a way to improve and connect existing infrastructure and to run new city infrastructure resulting in energy efficiency improvements by changing citizen behaviour. These actions are: A) optimization of building energy consumption and B) integrated energy and mobility management.

**A) Optimised energy building consumption (EV charging and flexible loads within buildings) to better match microgeneration (photovoltaic (PV) panels).**

The optimization of building energy consumption as a way to maximize the self-consumption of building integrated solar production is achieved via two main actions:

1) At building level by testing in a service building the consumer-producer paradigm. This is done at two levels, technical and analytical:

1.1) Within a building, smart meters with power limitation capabilities (able to reduce the maximum electricity inflow) and equipment control plugs are installed to enable a better energy management by the building/household owners through an online control system. The equipment installed will enable the monitoring and/or control of building consumption, HVAC consumption, PV generation, water heaters and smart plugs. EDP Distribuição is currently in the process of installing The test building within the Sharing Cities Project will provide valuable information on how to develop business models that can maximize the benefits from the installation of such equipment, for both the building users and the DSO.

1.2) A sustainable energy management system at the building level (SEMS-BL) that integrates an optimisation algorithm is being coupled with the equipment installed in the test building (Figure 3). Through the coupling of these equipment with the SEMS-BL, it is possible to optimize the use of variable loads in order to optimize self-consumption and reduce peak loads, thus reducing the energy consumption and minimize the renewable energy not being used on premises. The testing of such a system will allow the DSO to identify the benefits of such systems for the building owner and will provide useful inputs on how to enlarge its set of services to the stakeholders, enhancing and enlarging its role of market facilitator.

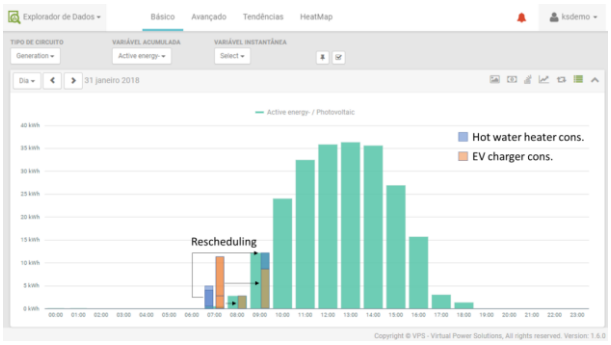


*Figure 3 - SEMS-BL mock up. (Source: VPS)*

2) At city level by creation of a Sustainable Energy Planning System (SEPS). This system will be able to account for all electrical energy flows within the city for the main infrastructures (solar production estimations for most buildings and real energy data for municipal buildings, EV charging stations and public lampposts). SEPS will be developed has an online platform that uses electrical energy data provided by the DSO from its substation and thus respecting the building owner's privacy. The building level values are then estimated analytically. The solar production estimations at building level will be done using data from Lisbon's Solar Chart. This will be done by integrating historical data with weather forecasting. This platform will provide urban planners with a holistic view of the urban energy system that has the potential of making fundamental contributions for the development of initiatives that can reduce and optimize the energy consumption at urban level.

The implementation of these measures will enable the

creation of a billing/accounting system, online portal for consumer management (specifying his production and consumption separated by house and mobility if possible), dashboard for city-wide energy consumption and production (integrated in the urban platform), Energy prosumer guide/manual.

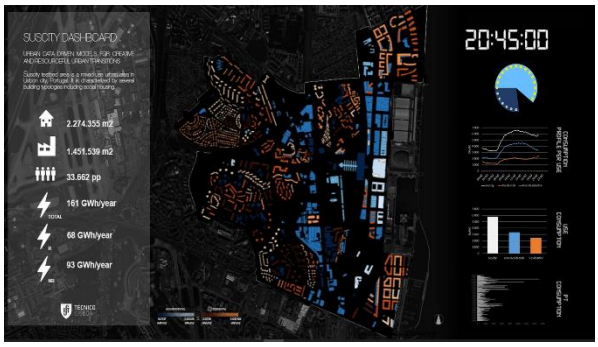


*Figure 4: Mock-up of the SEPS online platform*

**B) Outdoor spaces integrated energy and mobility management**

Within the scope of the project several urban monitoring equipment will be installed in public lighting lampposts. These sensors can monitor temperature, humidity, atmospheric pressure, particles, chemical pollutants, traffic (both vehicles and pedestrians) and noise.

These data can then be used to optimize public lighting schedules by accounting with the flux of pedestrians and vehicle lighting, traffic management using not only traffic but also air quality and noise as factors.

**The main outputs of the installation of smart lampposts will be valuable data and guidelines for urban systems optimization.** The implementation of these measures will lead to the deployment of a public lighting self-control system and a traffic control system based on environmental parameters.

The Sharing Cities project is supporting the deployment of innovative ICT than can enable the development of new business models that can create value not only for the DSO but also for institutions that deploy energy systems and most importantly for the citizen. By integrating a consortium that includes 3 leader cities and 3 follower cities and by developing outputs providing valuable insight on new energy related business models, the project can have a significant contribution for the development and scalability of viable services that can contribute for the financial sustainability of innovative smart city solutions.

**The Major Broad Impact of SusCity Project** consists on advancing emerging business models for energy solutions in a rich data and ICT driven context, with increasingly customized alternatives to the citizen, empowering him to an active role in urban design. The use of renewable energy contributes to "net-zero energy" cities enabling new business models associated with the concept of energy supply and demand "aggregation", which is the process of linking small groups of industrial, commercial, and residential customers into a larger virtual power unit to make them "visible" from the electric system point of view. An effective management of "aggregators" requires advanced models and distributed control systems, with fine time and spatial resolution due to challenges linked to "intermittency" and "variability" of renewables and also the dynamics of energy consumption (consumer behavior) in urban functions such as mobility or housing. Two main products/services are described in this paper: A) Urban area building energy modelling and B) Energy measurement in buildings.

**A) Urban area building energy modelling**

The software prototype for urban building energy modelling (UBD) developed in SusCity provides a quantitative assessment of the environmental performance of multiple buildings through three main actions:1) Identification of city related information and integration to generate an Urban Building Database – UBD. This allows to keep an updated platform of the city building stock and provide summary statistics to be used by the municipality, researchers, citizens and companies. For example, the information provided in this database can serve as a marketing tool for local companies related to real estate or building construction. Also, this platform can be a revenue source for the municipality or the companies that owns the data, as part of the information could be available to everyone free of charge but the access to further data would only be possible upon payment. 2)Modelling of the buildings' energy consumption at the neighbourhood scale to determine the current electricity consumption per end-use. This allows to establish pre energy performance certification schemes of buildings that can serve as a supervision tool for the Energy Agency or for the homeowners. Furthermore, the identification of critical areas for urban rehabilitation is possible allowing municipalities to better manage their financial resources and direct them to priority areas. Financial targets as the property taxes can be studied taking into consideration building energy performance parameters.3) Scenarios for buildings' retrofit to test different energy saving strategies and create environmental awareness. This enhances citizen engagement and participation to promote knowledge production by local and non-governmental groups and gives to the citizens a cost-benefit analysis of adopting different refurbishment options. Also, it promotes political transparency to justify decisions regarding urban rehabilitation helping to take the better decision on the urban planning side. Tax incentives can be studied towards the target of carbon emissions reduction imposed by the European Commission. Providing data to consumers and private sector companies would also promote the growth of the EER market by driving both the demand and supply side and make effective use of H2020 funding opportunities, allowing suppliers of EER seeking to adopt shared savings contracts similar to energy service companies.

This product may be a driver for local economy by promoting both the creation of new EER-related companies and the expansion of business activities of the existing companies that will take advantage of EER opportunities.

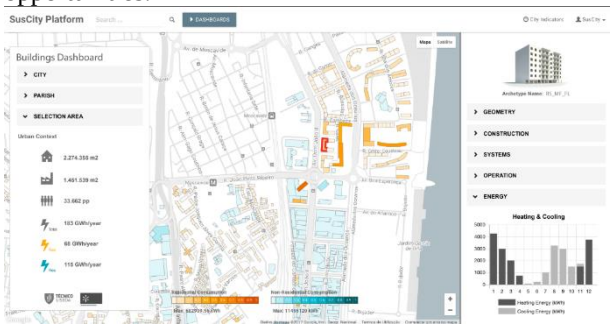


*Figure 5: Buildings Dashboard (ref )*

**The output of these actions are:**

Online platform - Buildings Dashboard – for data exploration and acquisition, scenario analysis and public participation in urban planning (Figure 3).

**B) Energy measurement in buildings (EnergyOT)**

The energy measurement in buildings provides the development of decision-aid tools for different stakeholders in the buildings sector to help them adopt more efficient energy practices. These include predicting, monitoring and controlling buildings performance, innovating buildings design, construction, and maintenance, recommend new policies, regulations and practices focused on the Southern European reality.

EnergyOT is a range of devices that measure remotely certain physical parameters that allow monitoring and managing energy consumption with 15 seconds of resolution by placing sensors near the energy meters.

These devices measure, processes and deliver data to the cloud, so it requires the existence of a wireless internet network near the device so that it can communicate with the cloud. EnergyOT customers have access to detailed information about their consumption by freely accessing their personal account at www.myeot.pt. Three versions of EnergyOT devices are available: EnergyOT Optic for monitoring electricity consumption, for temperature & relative humidity monitoring and for temperature monitoring. To implement this product and services, three main action are necessary: 1) Developing value-added services in the short term or in targeting special low-voltage consumers for which the detail of information is essential. This allows to communicate information through the client's wi-fi network. 2)Provide information to support the switch between electricity and gas depending on the tariffs. Companies of energy management could use this tool to advise their clients. Also, new tariffs can be designed tailored to the client consumption pattern or home automation systems created to work in several energy dimensions. 3)Monitor and predict energy consumption and PV generation forecast. This allows the consumer to have a better idea when their systems is producing and manage their own consumption. Also, local governments can use this tool to manage energy consumption in public buildings. Moreover, retailers can improve or create their own forecast system based on demand flexibility or develop algorithms to be incorporated both in existing systems and new applications.

The output of these actions is a metering system coupled to a real-data online platform for consumer management and analytics.

## FINAL REMARKS

This paper provides a discussion on a set of topics driven by research carried out in the InovGrid, Sharing Cities and Suscity projects. Through consortiums of several stakeholders with broad backgrounds it is possible to generate results supported by scalable and viable business models that can contribute for the financial sustainability of innovative smart city services.

These projects are supporting the deployment of innovative ICT than can enable the development of new business models able to create value for three key players: i) the DSOs, ii) the institutions that deploy energy systems and iii) most importantly, for the citizens.

The paper presents a better understanding on the actual state of the art of HEMS on a district level and these devices can be used to increase energy efficiency and manage the resources (either at a building level or at a district level) in an optimised manner.

Acquired knowledge can be used to target energy consumption reduction policies and optimize self-consumption capacity investment costs and electricity production surplus. There is a strong need for knowledge sharing, innovation and know how in business models, finance and funding.

**Acknowledgements**

The authors acknowledge Fundação para a Ciência e Tecnologia for the SusCity Project (MITP-TB/CS/0026/2013) financial support. The study was developed within the framework of the project SHAR-LLM, which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691895. Support from the IN+ strategic Project UID/EEA/50009/2013 is gratefully acknowledged.

## REFERENCES

[1] GridInnovation-on-line, «InovGrid Project - EDP Distribuição (Portugal),». Available: http://www.gridinnovation-on-line.eu/articles/library/inovgrid-project---edp-distribuicao-portugal.kl. [Acessed 22 March 2018].

[2] Sharing Cities, «Sharing Cities - Programme. Available: http://www.sharingcities.eu/. [Acessed 22 March 2018].

[3] Suscity, «Suscity Project». Available at http://www.suscity-project.eu [Accessed 22 March 2018]