INTERTWINING SECTORAL ELECTRICITY LOAD PROFILES AT CITY LEVEL

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Overview

New production and business models are emerging in the power sector driven from a complex system and entailing pathways on the advances of smartgrid technologies and functionalities (*e.g.* EC, 2014, ETP SG, 2015): increase data availablilty of detailed load profiles for different sectors; decrease of costs of solar photovoltaic (PV) systems making them competitive in many countries (*e.g.* Feldman et al., 2015); penetration of electric vehicles (*e.g.* Rathore and Roy, 2016) and expected use of electricity storage technologies (*e.g.* IEA, 2014). This organizational environment is far from understood, in particular how the role of energy consumers might be crucial through collective entreperneuship.

Several authors have carried out work on these topics using diferent countries, sample sizes, economic sectors and level of detail (spatial and temporal). As examples, Munkhammar *et al.* (2013) quantify self consumption potential of on-site PV power generation in households with plug-in electric vehicle home charging; Luthander *et al.* (2015) examined battery energy storage and demand side management in residential buildings for PV self consumption; Gouveia *et al.* (2015), assessed different profiles of households electricity consumption based on socio economic factors and evaluated the PV potential for the baseload consumption; Macedo *et al.* (2015) typifyies load curves for demand side management in Brazil.

As identified by B.A.U.M (2012) there is limited, potential of residential consumers to change their load profile with estimates of electricity reduction potential of around 5%. However, this is in sharp contrast to the potential for consumption reduction in other city sectors (20% reduction in services and industry).

In this study we aim to better undertand the different electricity demand profiles (annual to daily) of the city economic sectors (e.g. residential, services, retail, public lighting, industry) to assess the potential for complementarity amongst them. Power demand complementarity is key to depict the possibility of local power markets, mainly when local PV production is taken into account. The knowledge on the different consumers load profiles enables systems cost minimization allowing a better definition of distributed energy resources penetration and makes the diferent sectoral consumers more aware of their energy consumption fostering potential savings. We use the city of Évora as a case study, which has a massive smart metering system providing 15-min interval electricity data (EDP Distribution S.A., 2015), and a recognized potential for a city sustainable energy transition.

Methods

To look at how the sectoral demand varies over the course of a typical day we performed a set of data analysis over 15min electricity consumption registries of 2014. A sample data of more than 3000 meters from the 33000 installed in the city were retrieved for three types of consumers: normal low voltage (*i.e.* less or equal to 13.8 kVA), special low voltage (*i.e.* from 13.8 kVA to 100kVA) and special medium voltage (*i.e.* higher than 100kVA) for Évora. The work presented here is being partly developed under the EU InSMART – Integrative Smart City Planning project (www.insmartenergy.com). Table 1 depicts the economic sectors under analysis and the number of meters assessed.

Table 1 – Characterization of the electricity database sample regarding the energy consuming sectors assessed

Sectors	Number of Meters (#)	Percentage (%)
University and schools	28	0,9%
Agriculture, Animal Stock and Animal Production	130	4,2%
Hotels and Restaurants	48	1,6%
Residential	2252	73,2%
Public Administration	107	3,5%
Health	8	0,3%
Industry	56	1,8%
Services	223	7,3%

Retail	134	4,4%
Public Lighting	79	2,6%
Water and Electricity Distribution	5	0,2%
Energy Production	5	0,2%
Leasure	5	0,2%
Transports	5	0,2%
Total	3085	100%

Results

From Figure 1 we can recognize the diferences of the daily electricity load profiles between two selected city energy consuming sectors, demonstrating the complementarity potential in a restricted local market and for electricity peer to peer schemes. Further analysis with the 12 other energy consuming sectors and combined with the PV production profile for Évora unfolds relevant complementarities.

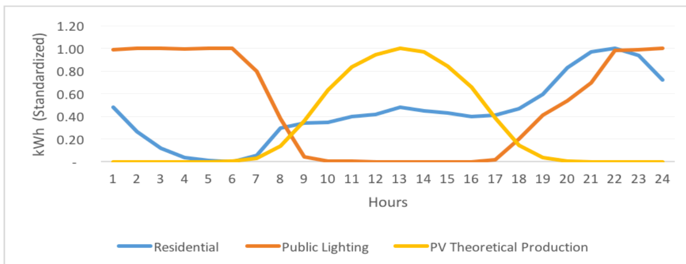

Figure 1 – Daily average profiles (2014) for the Residential and Public Lighting Sector and PV theoretical production

Conclusions

The deployment of a smart grid environment generates large volume of data, that carries important knowledge to support new functions and models. Transforming big data into useful information that may help to improve efficiency in the management, planning and operation of the power grid as well in resolving the issues of sustainability and energy conservation is a key scientific challenge. The complementarity of the power demand of different types of consumers in the city is a major factor to support changes in peak demand, the integration of DER for local markets and to new business models based on peer to peer schemes, requiring additional attention from the city distribution operators. This paper provides an improved understanding of electricity consumption profiles of different city consuming sectors, based on high granularity of power registries.

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