Scientific Program "The Future of Energy"

Qualitative and Quantitative Assessment of New Paradigms and Challenges for Urban Energy Systems

Final report

Authors

Mélodie Mistré, Sylvain Cail

Enerdata, Global Energy Forecasting

consulting@enerdata.net

January 2017

Enerdata

47, avenue Alsace Lorraine

38000 Grenoble, France

SAS au capital de 294 250 Euros

489 319 111 RCS Grenoble

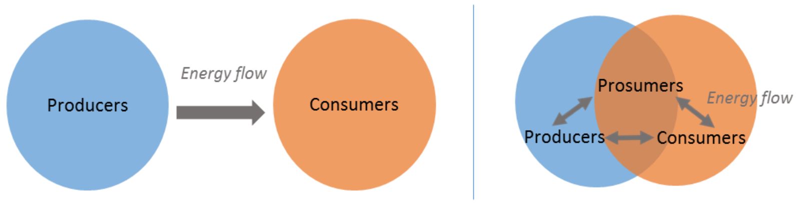
www.enerdata.net

Executive Summary

With this study, the authors address the question of paradigm shifts and challenges which urban energy systems may face in the mid to long term. The role of cities and more broadly urban areas is increasingly gaining importance in the current context of sustainability. Most recent studies see cities as a major contributor to the efforts required to reduce global GHG emissions.

The question of the future of urban energy systems and how these may undergo new paradigms and challenges has been answered through a two-pillar qualitative and quantitative approach.

As a first step, the qualitative approach consisted in a thorough literature analysis to identify, understand and assess ongoing and future paradigms shifts likely to impact urban energy systems engaged in sustainability efforts. While this has allowed to track ongoing trends and possible future developments in terms of innovative solutions, technologies and expected impacts for the energy future of cities (including the increasing role of prosumers, i.e. consumers acting to some extent as self-producers), further lessons were learnt with regards to the prerequisites for a suitable assessment of urban energy systems and their sustainability. In particular, a crucial aspect is to perform such analyses with a fine granularity, i.e. considering specificities of districts' and buildings' types, which enables a representation of possible synergy and optimisation effects, as well as the simultaneous consideration of multidisciplinary requirements, including technical, economic, environmental, social and political aspects. The identification of such key aspects is of utmost importance both to develop and assess adequately strategic plans of urban areas, and, as a logical corollary, to precise which system components need to be addressed in any modelling exercise aiming at providing prospective insights for the long-term planning of urban energy systems.



In the second pillar of this study, Enerdata's EnerCity model has been described and applied for the calculation of three scenarios, with the aim to understand the possible energy pathways of the urban area of Grenoble Alpes Métropole. The model, covering a time horizon of 20 years until 2035, already fulfils some of the prerequisites identified in the literature review, and is based on a three-scale approach: the buildings level, the districts scale and finally the observation of the city/agglomeration as a whole, with a focused consideration of potential synergies and linkages at each step of aggregation. This approach allows in particular to address specific challenges identified in the literature analysis, such as the development of innovative solutions (photovoltaics, combined heat and power, electricity storage), the consideration of "prosumption" flow patterns, energy efficiency potential at the buildings level, and synergy potentials for the energy system through solutions such as district heating and the integration of mobility through the development of electric vehicles.

The EnerCity model has been used to calculate and assess three contrasted scenarios to explore the possible future of Grenoble's energy system: a baseline scenario (BAU) with current policies implemented, an energy efficiency scenario (EE) and a scenario with increased expansion of decentralised energies (DER). The results show that in the BAU case, energy consumption of the agglomeration is expected to increase slightly

(+0.1%/year over 2015-2035), even if the energy mix evolves towards a slight development of district heating and solar thermal equipment in buildings. The implementation of additional energy efficiency measures (EE scenario) could lead to substantial cumulated savings, reaching about 9% over the period compared to the baseline scenario, where demand reduction would be primarily achieved in the residential and tertiary sectors. Setting the effort on decentralised energies (DER scenario) shows promising opportunities for the whole urban area, where specific solutions such as the coupling of photovoltaics with storage solutions, solar thermal as well as geothermal technologies and heat pumps could meet together up to 16% of total energy needs of the metropole by 2035. Such an increase in decentralised means would be ideally coupled with flexibility management tools, leading to a shifting ad smoothing of the consumption load curve in the different districts.

The analysis performed in this study shows both limitations and promising perspectives. The main limitation of such a model-based assessment is the important requirements in terms of data collection and quality. Indeed, running such models requires an extensive amount of very disaggregated input data, e.g. at buildings scale. One of the main recommendations of this work is to further promote the openness of historical energy market data at districts' and buildings' level (e.g. energy consumption per building type, drivers of energy demand in the various sectors, use of district heat in the various quarters, emissions levels, etc.), and ideally at households' level in order to integrate a further socio-economic dimension in the city's assessment.

The work shows great perspectives in terms of further model developments likely to be performed in the future. Although the model already allows to consider urban energy systems as integrated entities and is very descriptive and granular up to the buildings scale, further research can be envisaged to increase its scope and reliability. Such developments include e.g. the consideration of the future potential role of gas and biogas technologies, the development of social indicators (e.g. to better track and tackle energy poverty) in a context of progress towards more sustainability, and more largely, the development of enhanced multi-dimensional indicators, including a systemic-technological dimension to depict how smart solutions can help stabilise the system. Last but not least, an emissions and climate module would capture the underlying dynamics between economic growth, energy consumption and GHG emissions. This could provide a promising model upgrade to help local authorities in their decision-making processes and urban strategies related to energy and climate policies.

List of Figures