School of Architecture, Civil and Environmental Engineering
Environmental Engineering Institute
Laboratory on Human-Environment Relations in Urban Systems

PhD Project: Modeling Demand and Supply Dynamics in Socio-technical Energy Systems

Matteo Barsanti (matteo.barsanti@epfl.ch)

Motivation and goals: Meeting the new ambitious target of a fully decarbonized European economy by 2050 requires a deep transformation of the power sector. In this regard, a change in paradigm is envisaged as a key strategy to "achieve decarbonization at the lowest possible cost": from supply following demand whenever it occurs to demand following generation when it is available. Demand Side Management (DSM) programs enclose all practices that allow demand to take part in actively managing the grid. In this perspective, as repeatedly stated in the European Green Deal, the active involvement of the residential sector is crucial. Although relatively easy from a conceptual standpoint, the effective implementation of DSM programs faces a general aversion of consumers, whose acceptance and engagement remain fundamental, in both manual and automated mechanisms.

This research is part of a joint research project, named Modelling the socio-technical Multi-level architecture of the Energy system and its Transformation (MoMeEnT).

The aim is to investigate the active role(s) of residential consumers in the Smart Grid paradigm, in order to assess how residential demand flexibility can support the energy transition, looking at multi-criteria performance indicators.

Research approach: Key factors and dynamics are investigated for characterizing the diversified and interlinked energy consumer decision makings: (i) *Participation* as long-term choice to enroll in a smart energy contract, (ii) *Response* as short-term response to multi-modal DSM stimuli and (iii) *Persistence* as interaction and change of Participation and Response over time. The multiplicity of individual actors, their multi-criteria objectives and the multidimensionality of the relevant factors make Agent Based Modeling (ABM) approach the best suited for this application. The interaction between individual agents is examined considering individual and social dynamics. In this regard, the Consumat approach, due to its deliberative, social, normative and learning characteristics, gives the conceptual structure to the *Participation* model, while a Random Utility Model (RUM) operationalizes the consumer *Response* model, making it possible to consider the marginal utility resulting from multimodal DSM stimuli and to integrate personal, contextual and situational factors.

Outcomes and significance: The parametrization and integration of the two models allows to run large-scale long-term Smart Grid (SG) simulations. Scenario and sensitivity analysis are used to investigate the emergence of certain situations, event/path sequences and spillover effects among the sub-models. Moreover, lifestyle specific interventions, innovative DSM business models and appropriate governance interventions are developed, their effects simulated and their robustness assessed using multi-criteria performance indicators. This research will contribute to the understanding of the role of resident demand in energy transition, as a competitive and/or complementary source of flexibility to industrial facilities or generation power plants (e.g. hydroelectric power plants, gas power plants).