Social sciences and technical innovation projects.

Insights from the DIMMER project

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***Abstract*— Social scientists are more often asked to contribute to the development of effective technical innovations. The aim of this paper is to present the social research activities that have been carrying out within the DIMMER project. DIMMER aims at creating a system to visualize, compute and simulate data about energy consumption and production at the district level, in order to consistently reduce both energy consumption and energy-related CO2 emissions.**

***Keywords*— co-design approach, smart grids, district heating, ICT**

I. Introduction

To manage the energy transition towards more sustainable systems, a new highly complex, self-balancing energy system called "Smart Grid" has been initiated. It entails processes of definition and development of intelligent control technologies aimed at flexibly coordinating consumption in order to maintain a balance between production and consumption in energy systems.

Even if the current visions of smart grids depict a future characterized by new perfectly deployed devices and perfectly enrolled actors, the deployment of "smartness" is at the moment far from being satisfactory. There is still a gap between the visions of the future smart grid system and the practical realisation of these visions. Many actors operate in energy grids, all having different and sometimes diverging roles, interests and objectives. Conflicts may emerge, as well as betrayals, so that mediations and adjustments are required. The integration of information technologies and of sensors of many kinds allows the collection of an increasing amount of data. However, finding the appropriate places and roles for data, sensors, actuators, displays and so on is the other key challenge to deal with if the deployment of smartness in energy systems is to be achieved.

Could technical improvements alone be sufficient? They could lead to improvements, but it is less clear whether they could also be sufficient or not. Users (i.e. a part of the "social" world) have to be involved, both in order to weaken open aversions to innovation and in order to modify how users behave or the ways they perform practices.

In one of his writings, Michel Callon (1989) describes what he refers to as "engineer-sociologists":

"[…] engineers who elaborate a new technology as well as all those who participate at one time or another in its design, development, and diffusion constantly construct hypotheses and forms of argument that pull these participants into the field of sociological analysis. Whether they want to or not, they are transformed into sociologists, or what I call engineer-sociologists" [1].

Nonetheless, as we know, not all new technologies are successful. Indeed, not all engineers are sociologists at the same extent, or they are not sociologists at all. In this latter case, innovations might even be perfectly functioning, although not in the world outside the laboratory.

In research funding frameworks such as FP7 and H2020, social scientists are asked to contribute to the development of effective innovations. It means that they are not asked to create seeds, but rather to contributing to grow sprouts ready to be transplanted somewhere. Indeed, the effectiveness of an innovation can be assessed in three different ways: if it is used; if it is correctly used; if it helps in reaching some desired objectives. This is because social scientists are not only asked to collect information that are useful for the understanding of the "social" world (social research). They are also asked:

- to remove barriers and conflicts or act as mediators in case of conflicts (social accompaniment)

- to act as mediators or facilitators between users and engineers (co-design)
- to act as mediators or facilitators between different expert spheres (interdisciplinarity).

II. The DIMMER project

District Information Modelling and Management for Energy Reduction (DIMMER) is a project that received funding from the European Union's Seventh Framework Programme for research (FP7-SMARTCITIES-2013, Technological development and demonstration, Grant agreement n° 609084). The project started in October 2013 and there is still one year in front to complete it.

DIMMER focuses on:

- Interoperability of district energy production and consumption
- Exploitation of effective visual and web-based interfaces for user feedback
- Integration of Building Information Model (BIM) with real time data, and extension to the District level (DIM)
- New business models for energy providers, ESCos, facility managers, etc.

The DIMMER system integrates BIM and district level 3D models with real-time data from sensors and users feedback. The main idea is to analyze and correlate buildings utilization and provide real-time feedback about energy-related behaviors. DIMMER system allows open access to personal devices and Augmented Reality (A/R) visualization of energy-related information. Another goal is the development of client applications for energy and cost-analysis, tariff planning and evaluation, failure identification and maintenance, energy information sharing.

In order to validate the DIMMER innovative system, both public (university, schools, public offices) and private buildings included in urban districts are considered in two different cities: Turin (IT) and Manchester (UK). The project is focused on to existing buildings. Furthermore, the expected result is a consistent reduction in both energy consumption and CO_2 emissions by enabling more efficient energy distribution policies. Another aim is the more efficient use and maintenance of the energy distribution network.

In this paper, the Turin case study will be described. This pilot main focus is on district heating.

III. Mapping the heating socio-technical system

In Turin, almost two thirds of the population is served by district heating. Heated volumes almost doubled between 2004 and 2014. At present, heated volumes are close to 56 millions of cubic meters, having almost reached the maximum capacity given the current infrastructure.

The heat provider in Turin faces some of the same obstacles and challenges that electric energy providers face. This is partly because it too produces electric energy that is delivered to the national grid. On the other side, even for what refers to heat production and delivery, it has to reduce the seasonal and daily peak-to-average ratios, to postpone or avoid costly infrastructural integrations, implementations and empowering, to balance production and consumption.

Our research activity was structured in two phases, roughly corresponding to the first and the second half of the project.

The first phase was dedicated to mapping the heating socio-technical system(s). Fifty semi-structured interviews were carried out with public administrators, energy utilities professionals, building managers, householders, employees, students. They were aimed at understanding:

- the features of the human actants currently playing a role in the overall heating network or in the heating systems of the buildings they are users or managers of;

- the current as well as the imagined technical apparatuses;

- the relations linking all actors with each other;

- the problematizations actors are carriers of.

While certain topics were emphasized, according to interviewees' roles and competences, discussions were in general about: their working/heating practices; their opinion and attitude about changing thermal-related practices; the energy information and data they use/receive related to their work/consumption practices; the habits and the time patterns in their buildings/offices/apartments; their knowledge and perception about the functioning of the heating systems and network; their perception and definition of thermal comfort; their opinion about the role ICTs might play.

Three focus groups were also carried out in this first phase. They were aimed at testing - participants were recruited among the users and managers of three different buildings – the presence of conflicts and agreements about thermal issues.

Some of the main results of the first phase can be summarized as follows:

1) *Differences between energy (electrical) grid and thermal grid*. It should be taken into account, that the differences are related to many aspects starting from the "mere" physical qualities of electricity and heat to consumption practices and infrastructures. These differences are listed below, not in order of importance:

- Radiators gradually lose and gain heat. For example, indoor temperature continues being comfortable even after the radiators have been switched off;
- For centralized heating systems, while radiators can be switched on and off at any moment, these actions are ineffective when enacted outside of the building heating time.
- For what refers to centralized heating systems in residential buildings, households can modify the thermal settings (heating time and set-points temperature) only to a very limited extent and only by means of complex decision procedures (e.g. meetings of house owners).
- While electric energy is used for many purposes, thermal energy is mainly used for thermal comfort purposes only.
- Contrary to what happens in public buildings, the heating time schedule in residential buildings only partially corresponds to the moments when the "awake occupancy

level" is the highest. It means that the heating time schedule for residential buildings might instead be considered as the most appropriate way to simultaneously perform two functions: provide thermal comfort for those who come back home and provide thermal comfort for those who stay at home (e.g. the elderly, sick persons, part/full-time unemployed). It derives that even if late morning and afternoon heat use in residential buildings is inefficient (in terms of delivered thermal energy per person) it is nonetheless effective in giving the possibilities to all people to have comparable levels of thermal comfort during mornings and afternoons. Would the efficiency issues prevail, "thermal equity" will be damaged.

2) *Different districts coexist*. DIMMER is aimed at creating a system to visualize, compute and simulate (where real data is not available) data about energy consumption and production at the district level. A district is not a universally recognizable and well-defined entity. The district level can be defined as the level situated above the building level. However, such a definition does not make clear enough yet how much "above" a district is situated, so that districts vary according to the actors involved in them. For professional building managers a district is composed by the buildings they manage. For public (town) administrators a district is a neighbourhood or whichever already recognizable section of the town. For the energy provider a district is composed by all the buildings connected to a given sub-ramification of the transmission lines / pipes.

3) *Access to information / Lack of trust*. The strength of an assemblage is given by the strength of its weakest part. Many interviewees complained about limited, or not transparent, access to heat supplier data. Users' engagement will stay weak unless transparency, and thus trust, increase.

4) *Energy system literacy.* This concept describes a part of the energy literacy concept. In particular, it refers to the widespread lack of knowledge about how district heating currently functions, let alone know what "smart grid" means. Consequently, the most part of the interviewees see their buildings as isolated entities that are not affected by what the other isolated entities do.

5) *Building managers as mediators.* The relationship between end-users and heat supplier is at present characterized by a low level of dynamicity that could prevent demand-response schemes to be implemented Building managers could play an important role as mediators/intermediaries between end-users and heat supplier. However, the difficulties this role implies are not taken into due account by the heat supplier and by the public authorities.

IV. Target users identification and co-design activities

The second phase is more evidently characterized by continuous interactions among sociologists, IT project partners and target users. The three following steps can be identified:

1) Target users identification. Discussions took place among partners about who the target users could or should be. Target users are intended as those whose daily actions have an impact on the energy systems and/or on the dynamics of energy consumption and savings and that could take advantage of enhanced energy management tools. Three categories of users have been identified:

- Public administrators. People being part of the public administration, whether they are elected representatives, employees or managers, having among their tasks those of reducing energy consumption, energy expenses, emissions due to energy consumption and production, with reference to the territorial level the institution they belong to operates.
- Building managers (private and public). People who are in charge of guaranteeing and improving the operability of the building(s) according to its/their intended use. The management of the aspects related to energy (consumption, emissions, costs and maintenance of energy systems) may be, or may not be, part of their tasks.
- Energy utilities professionals. Professionals working in institutions managing, the more efficiently and effectively as possible, energy production and/or energy supply and/or, partly or in its entirety, the distribution infrastructure.

2) Development of scenarios and identification of user requirements. Scenarios are hypothesis about possible interactions between target users and the tools under development. They are preliminary inputs for the development of DIMMER's tools and applications and serve as guidance instrument. They were built based on the information needs as they were expressed by the target users in the first year of the project. Then, user requirements have been identified for each scenario, as well as the related input data.

3) Tools development and assessment. The tools and innovations the consortium is developing have been submitted to the evaluation of target users representatives during three co-design meetings. These were lively and allowed the project partners to collect many suggestions and comments. More co-design meetings and other usability assessment methods will be taking place in the next few months. Indeed, the core of this activity is expected to start not before the next 15th October, i.e. the day when the "heating season" will start in Turin and, thus, when the applications and tools will be used in a "live" environment with real-time data.

V. Conclusions

Having one more year in front to complete the project, it is still too early to say whether the contribution of social scientists will have helped in reaching the objective of creating effective tools or not. Moreover, even at the end of the project, it will be almost impossible to understand whether the outcomes would have been better or worse than they would have been would the contribution of social scientists had never occurred. However, what can be asserted now, without fear of refutation, is that nothing came to contradict the analysis that emerged from the first phase. It can also be asserted that the co-design meetings and the meetings among project partners have been useful and lively moments of discussion. Partly, further developments of DIMMER project will be based on the interviews, workshops and co-design meetings outcomes.

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