Collaborative Innovation Projects Engaging Open Communities: a Case Study on Emerging Challenges

Laurent Dupont, Alex Gabriel, Mauricio Camargo, Claudine Guidat
ERPI laboratory
Université de Lorraine
Nancy, France
l.dupont@univ-lorraine.fr

***Abstract*—This paper presents a case study on emerging challenges within collaborative innovation projects engaging open communities. Innovation driven by open communities has proven to have a significant potential, in particular for open source software. However, tools and methodologies enabling the supervision of collaborative innovation involving open communities, in the perspective of creating open hardware to solve societal issues, remains at the early stages. This paper seeks to pinpoint the potentialities and challenges of such projects toward defining methods to better support a multi-stakeholders open source collaboration context. The experimental field of this research concerns the smart electricity distribution, and more precisely a public driven project of the diffusion of smart-meters in France and their appropriation by open source communities, with the involvement of the university and a public industrial company. The project seeks to study how these communities of users develop in a collaborative manner, new products and services using the smart-meter as a support technology. The first results show that the open community makes natural connection on specific environments such as Smart buildings to materialize usages of smart meters.**

Keywords—open hardware; collaborative innovation; community of practice; project management; user-driven innovation; co-creation

I. Introduction

The French public electricity distribution network is currently in transition mode with the implementation of “Linky” program, the French networked or smart meter program. By years 2021-2022, according to the “Linky” program manager [1], the industrial system will evolve from a mass power plan to a distributed network managing renewable sources (Fig.1) and new suppliers (e.g. individual & irregular); new technologies (e.g. electricity storage, networked meter); new sources of electricity consumption (e.g. electric vehicle, digital devices, etc.).

In order to manage the environmental challenge and notably reduce the CO_2 emissions, the European commission has set in 2009 that 80% of all Europeans households would have access to electric smart meters before 2020 [2]. Based on this agenda, in 2013, the French Prime Minister restarted the French program in that direction by implementing of 3 million of smart meters between 2015 and 2016 [3]. The distribution company plans to replace 90% of the old electrical meters in 35 million of households by the end of 2022. However, this program of networked meters implementation met some resistances and contestation since it began [4], in particular for economical, environmental, security, or health reasons [1]. Nevertheless, there is a fact that as a consequence of the project deployment, the French distribution network will be completely reconfigured in the coming years. The setup of this new technological platform of smart meters network, will leads to the emergence of new uses, and innovations that still yet unknown.

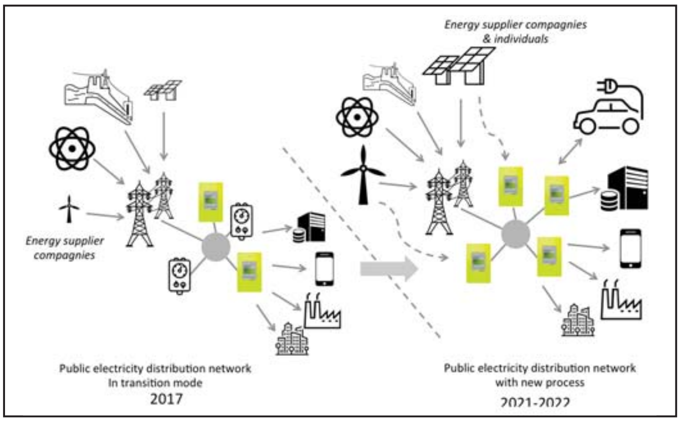


Fig. 1. Evolution of the French context of electric energy (production, distribution, consummation)

Furthermore, the “Linky” program has been created by engineers and focused on solving a huge technical stake. Nevertheless, from the industrial point of view, there still a number of challenges that must be considered, such as: (1) Which technological, organizational, societal innovations will emerge from the networked meter program? (2) How many types of new users will appear? (3) How to interact with them? However, in this project, the integration of the communities of makers (type of lead-users) occurs at the phase of “product launching”, which is currently the end of the innovation process. Instead, real-use situations are almost unknown yet.

As any complex object, the networked meter “appears simultaneously as a technological device, a public policy tool, and a socially invested object” [5]. According Bertoldo et al. [6] “it would be prejudicial that these technical challenges retain the whole attention at the expense of the social object.” In this framework, we suggest to adopt another point of view. Networked meters constitute also a socio-technological

Chaire REVES and the NIT Foundation of Université de Lorraine support this project.

ecosystem with a potential to involve all the stakeholders for a win-win strategy. With this approach we focus on the use of the functions of the technological system. Thus, the challenge is to study how adopt a user-centric design process on the services during the product-launching phase (Fig. 2).

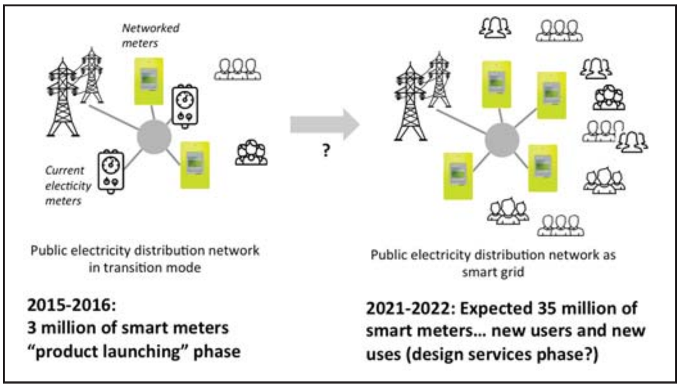


Fig. 2. Predicted shift from technological system to socio-technological ecosystem

In the light of the difficulties encountered in implementing European smart meters [7], this paper explores the development of a user-driven innovation supporting smart electricity distribution network. The purpose is to establish the firs requirements of the design of a smart (public) electricity distribution network supported by citizens.

In this context of a national action in order to respect the European agenda and act in large scale for sustainable development, user centric approach could have several numbers of interests. The fact of involving open communities in the innovation process enables the access to potential innovation as between 3.7% to 6.1% of the UK, US and Japanese citizens generates innovation [8]. Higher innovation rates can be reached in engaged and active consumers' community [9]. Moreover interact with user communities during the design process is more efficient for different aspects. It permits to the user to have a new representation of the overall environmental issue easing its future adoption. The fact of involving users in the process limits, in some way, the rejection as it is closer to expectation of the market [10]. It is also an opportunity for the electricity distribution company to observe the potential of new operating mode of organizations for coming years [11].

As a first step, as shown in Fig.3, we propose to analyze the current situation, i.e. the technological system focused on the device functions. This industrial and political strategy is currently limited by other unsolved problem: stakeholders have to tackle new technological challenges. Based on this analysis and building upon the achievements already accomplished, we suggest a protocol adopting an multi-disciplinary approach crossing industrial, societal and research issues to design a participatory research involving professional stakeholders and citizens. First results of this study show that time and resources are needed to build a distributed collaborative engineering involving specific Community of Practice (CoP) [12], [13]. Furthermore, it seems particularly relevant to focus on the environment where uses of smart meters are relevant and connected to the every day life. For example, Smart building development brings together transversal issues.

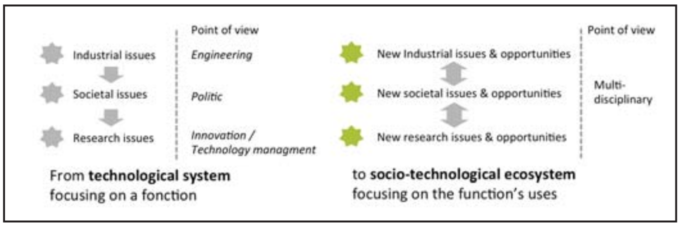


Fig. 3. Smart meter development as an opportunity to design an ad hoc participatory research involving professional stakeholders and citizen.

The next section provides further details on the context of this project and several concepts of the theoretical framework. Then the third section presents in details the design research and the context of this project. The fourth session formalizes the challenges associated to this project. Finally, the last section provides conclusion and perspective of this on-going project.

II. Previous Works

A. *Context of the smart meter implementation*

In the context of the energy transition, Europe community established in 2005 the European Technology Platform for Electricity Networks of the Future that work on the creation of a joint vision of European networks for 2020 and onward [14]. It identified clear objectives and proposes a strategy for the development of future electricity networks. In 2014, the European commission organized the smart meter rollout [2]. The objective is to deploy the smart grids at the European scale in order to harmonize the standards and develop the internal market for energy [15].

The national electrical distribution company designed a smart meter based on power line carrier technology that would be the cornerstone of the smart grid [16]. The smart meter is a final product designed by engineers for at least 20 years (for industrial challenges). It would permit a better adaptation of the production based on the instantaneous demand. But the introduction of smart meter as a feed-back provider on the consumption behaviors, would induce an autonomous regulation of the consumption of individuals [17]. The conditioning induced by these information feedbacks is a best manner to save energy than incitation, awareness or education campaigns [18].

TABLE I. Comparison between current electric networked and the expected smart grid including smart meters

Characteristics of current electric networks	Expected characteristics of smart grid supporting by network meter
Analogic	Digital
Unidirectional	Bidirectional
Centralized production	Decentralized production
A part of the network communicates	The overall network communicates
Management of the electricity system balance by supply-demand	Management of the electricity system balance by demand-consumption
Consumer	"Smart consumer"

As shown Table 1, the future technological system requires lot of technological evolutions and should provide new capabilities such as decentralized production and management of the electricity distribution network. However, this technological deployment is also a territorial deployment, which needs financial resources, time and a global coherence. Furthermore, in transition mode until 2021/22, the new meters are, for the moment, imitating the current electricity meters' function. Indeed, to access private dwelling, new smart meter providers inform consumers as they change their meter, but in practice that changes nothing for consumer. Moreover, in order to avoid monopolistic situations, the law mandates a disconnection between the company in charge of the public electricity distribution network and the consumers. Finally, potential uses of smart meters stay unknown.

Although this smart meter responds to the requirements to anticipate evolution of the electrical network and its potential as a tool for the autonomous regulations of individuals' electricity consumption, the acceptation of the smart grids by consumers was not rightly anticipated [6] despite the warning of the social dimension as central [19]. The French national electrical distribution company was faced to resistance and contestation from people who rejected the installation of this specific smart meter and its associated technological choices [1]. This resistance is, among other causes, the symptoms of a lack of involvement of the users and different stakeholders. Smart meter as a new product on the market and private life generates large area of uncertainty and anxiety. Finally, there is inordinate amount of concerns for health, security, economy, etc. So Smart meters are like a "fear generator", this fear driven more by stakeholders' representations than by scientific observations or studies.

The ways to increase consumer acceptance are: ease-of-use and simplicity of the technology, information about the clear benefits of the technology and reducing the concerns of people by increasing the observability of pilot projects [20]. The fact that focus group facilitates the owners of smart meter to perceive it as a technical innovation and transform it to a social innovation, by better control the electrical consumption, support this lack of involvement [6]. Given this situation, the concern is to involve people in 'active' acceptance [19] and in an energy usage optimization [15] mainly through user co-creation.

B. Review of the co-creation approach

Collaborations are ignited due to the insufficiency of individual work for reach expected results [21]. People create organizations to achieve a shared goal but actually the problem these organizations are facing is so complex that it requires to enlarge the collaboration to others actors and with new modalities. The issue of sustainability is the perfect example; it can't be solved neither by one person or one organization. It requires involving people in the process of development. New paradigms such as web 2.0, open innovation, human-centered design, Living Lab and FabLab act for the integration and creation of value by users. In the perspective of the human centered design, the stakeholder company is directly in contact with the users. This interaction is characterized through two dimensions: design research approach (research-led to design-led) and the mind set (expert mind-set to participatory mind-set) [22]. However, this approach implies that the organizations are able to mobilize its user communities with the mandatory to contribute and create value. There are others forms of value creation from the user. The user community is not homogenous from this perspective; a small range of this community is composed by lead users who appropriate the product up to modify it to better respond to their usage and needs [8]. It is innovation by users and for users and demonstrates that companies are not the unique place for innovation [23]. The emergence and the increase of open source software development is the best example of the production of value based on volunteers' work. It is so much interesting that some companies achieve hybrid structure to integrate contributions of developers outside the corporate [24]. This open source software development has to be related to the peer to peer approach related to the re-localization and added value generation by a community [11]. Peer production refers to open collaborative innovation and creation, performed by diverse, decentralized groups organized principally by neither price signals nor organizational hierarchy, harnessing heterogeneous motivations, and governed and managed based on principles other than the residual authority of ownership implemented through contract [25]. The peer production is characterized by three organizational dimensions [25]:

- Decentralized conception and execution
- Diverse motivations
- Organization (combining participatory, meritocratic and charismatic models) is separated to the property (commons property regimes)

The peer production can notably be observed in third places such as Fabrication Laboratories (FabLabs) [26]. FabLabs are collective and distributed experimentations of the open innovation without the imperative profitability [26]. They are facilitating the interactions with various stakeholders in order to contribute to the local innovative community. If the FabLabs are places for open innovation, the concept of peer production should be distinguished from open innovation but also crowdsourcing, innovation contest, and open collaborative innovation [25]. These are models of decentralized production and innovation but have different characteristics on task conception and execution, social motivation and governance/ownership separation [25]. However, open innovation, crowdsourcing and lead user communities are part of the Living Lab landscape that empower users for creating content and value [27]. Living labs are open research and innovation ecosystems involving user communities (application pull), solution developers (technology push), research labs, local authorities and policy makers as well as investors [27]. It aims to explore new ideas and concepts, experiment new artifacts and evaluate breakthrough scenarios that could be turned into successful innovations. The environment of a Living Lab needs to have a specific technology platform, science and innovation service, and user communities [27]. If all the elements are gathered, theoretically members of the community can be able to generate value. The potential benefits of Living Lab approach, considered as a user-centric research methodology, are mainly a wide and rapid spread (viral adoption phenomenon) of innovative solutions, a reliable market evaluation and a reduction of technology and business risks [27]. It remains that the integration of the user in an active development dynamics is not as easy and several challenges were identified [28]. Authors explain that the LEGO Company have experimented the user innovation and highlights four mains challenges:

- Moderating effect of users' deep knowledge and specialization,
- Finding the best user innovators,
- Integrating user innovations with firm systems,
- Untangling intellectual property issues.

These challenges were considered in the case of the project with the energy distributor company. However the situation was slightly different and new challenges appear that will be detailed as follows:

1) Operational Challenge: From a public electricity distribution network in transition mode to a Smart public electricity distribution network

a) Initial situation: an industrial issues mainly solved by engineering point of view. Engineers chose their processes and technologies. Thus, an answer is already developped, however, several failures appear at another level.

b) This industrial issues involve or crystallize societal issues. They became clearly apparent since the deployment's beginning. Even if it is more the representation of the stakeholders than real objective observations, from a political point of view, legitimate questions have to be adressed:

- Which is the electric energy origin? (Environmental crisis)
- Which are the potential impacts of smart meters, in particular for health and security (private life)?
- Misunderstanding of the technology by neophyte
- Why a future decentralized system is developed in top-down approach? Furthermore, some local authorities are also electricity suppliers and distributors. In France, there are some local different electricity distribution networks. In these cases, how the smart meter deployment will be managed?
- In the current economic crisis, some consumers fear this new technology increase the global price of the energy. How anticipate some consumers' difficulties?

c) Company managing distribution network suggest research issues. Innovation & Technology management are particularly adapted to:

- Evaluate technology substitution and appropriation impacts
- Support acceptance of the new technology (lunching product)
- Develop a real appropriation of this new technology (use of the lunching product and integration into specific environments)
- Identify who are the potential users (use cases and profiles)
- Generate economical developments or new business-model (e.g. create start-up, suggest partnerships?)
- Experiment new research applications (e.g. Living Lab approach)

2) Multi-disciplnary research challenge: Considering the list of previous challenges generated by the distributed and sequential initial approach, how a scientific approach could successfully transform a technological system (involving mainly engineers) into socio-technological ecosystem (involving all the stakeholders for a win-win strategy)? According the expected situation in 2021-2022, the available network of 35 millions of smart meters can be viewed as a part of scientific or participatory system involving citizens on the design of smart environements (electricity distribution network, building, city, etc.) (Fig.2). From this point of view, which scientific disciplines could be engaged (e.g. engineering, economy, sociology, digital science, etc.) in a (national or european) long term project? How could be manage a such multi-disciplinary strategy working with various users. Which are the issues (use, data, security, environments, health, etc.) and how are connected?

The next section describes our methodological approach to tackle the described operational and multi-disciplinary research challenges for the case of the smart meters deployment.

III. METHODS

A. Integrating makers communities (FabLabs) in a Living Lab project

As described in the previous section, a huge number of research challenges have to be undertaken. So this paper focuses on an open source hardware collaborative project from a micro-level perspective, i.e. following the current project deployment activities. The main goal of the proposed model is to achieve a better understanding of this type of co-creation projects underlying phenomena so that it can be effectively managed. In this work, attention has been directed towards a detailed description of the project's stages in order to propose a model that overcomes some limits of theoretical models identified in the literature review.

So the decision was to follow the project dynamics, from the point of view of an observer. As a consequence, a register of the main activities, intermediary objects, milestones and outcomes of the project was established. Within this exploratory approach we assume that the communities of Makers act as early-adopters for this emerging technology.

Based on the assumed benefits of the Living Lab approach, the energy distribution company collaborates within the "Scientific Body" ("Chaire" in French) named REVES project [29] and the Lorraine Fab Living Lab® [30] in order to integrate users' community in the development process of the smart meters. The objective of the project was to experiment the mobilization of users' communities to create the usage and the technology associated in order to adopt more responsible and sustainable energy consumption habits permitted or eased by the implementation of smart meters. Instead of being focused on the smart meters, the intent of this approach is to create innovation related to user needs. As the appropriation is a prerequisite to innovation, the creation of innovative artifacts, as additional objects related to smart meter, will permit a better adoption and appropriation of the smart meter. To achieve this, the research team involved in French FabLabs network asked to communities of makers, of different geographic areas of the country, to create new products and services based on the information and new functionalities of the smart meter. After a preliminary verbal agreement between five French FabLabs and ERPI Laboratory, the "Linky by makers" project (LbM) was officially launched the 30th January 2016 (http://linkybymakers.fr/). The value produced by the makers is not dedicated to the company but to commons under the principle of the open hardware.

Next section (B) will provide details on the project organization and the different stakeholders involvement.

B. Characteristics of the stakeholders

Since electricity is delivered to a large proportion of the population, the users' communities concerned can be really huge, however the mandate of the project was to produce prototype related to smart grids and smart use of energy. Although the mission of Living Lab is to support collaborators in the concretization of innovations, in this case the users involved had to being able to produce electronic prototype as artifact enhancing smart meter's use. Since FabLab has similar aspects to the mission of Living Labs and is constituted by lead users, the addressed users' community was first composed by the members of the following Regional FabLabs (RFL): NyBi, FOL, Artilec, and FacLab (the fifth FabLab stopped to participate after five months). If the direct community related to the FabLab was not sufficient up to them to enlarge range of collaborators. In order to be in accordance with the value of the FabLab, it was clearly defined that all the ideas production and prototypes have to be open source. In this situation, the different stakeholders could be identified into three different roles: the industrial partner, the academic stakeholder and the associative partner, as most of the FabLab are associations.

A project description based on the different aspects of innovation, living lab approach and user centric design approach as previously described will allow us to get a better understanding of the project. According to the innovation process, even if the smart meter is not a commercial good, as its installation it in every household is mandatory, it remains it can be considered in the step of the product launching. Concerning the user centric design approach, it is both a participative approach and a user centered design with lead-users, as everybody is an electricity user, and is concerned by the smart meter implementation and the member of the participating FabLabs are relevant for producing technological value.

However, as the collaboration is semi-structured, this project can be considered as mix between open innovation and group dynamic in a user content creation approach. Moreover, according to the novelty character of the project (new technology, new potential business models, new uses and maybe new users, new societal impacts, new research protocol, etc.), the learning dimension is fundamental in the LbM project. Furthermore, participants have to share among other competences and a common vocabulary around several concepts: smart meter and smart grid, criteria for competence, and at least one domain of interest (e.g. develop energy efficiency, create open hardware object, hake smart-meters, etc.)

Thus, as Fig.4 shows, we assume to observe LbM project as a "social learning system" where participants can joint activities and discussions, share information, and make relationships that enable them to learn from each other. We have therefore decided to use the concept of Community of Practices (CoP) that Wenger et al. describe as a groups of people who share a concern for something they do and learn how to do it better as they interact regularly [12], [31]. CoP can appear inside an organization (like a company) or its members can be part of several organizations. In LbM project, the group comes from different cultures and organizations. The interaction process is not natural and has to be made. As indicated before, FabLab values, context and practices energize the core group of this "informal" organization. Beside, in this specific case, there are one public big company, several RFL, and a research team. Furthermore RFL can also involve Local FabLabs (LFL) from their surrounding geographical area. In other words, there are several CoPs with their own boundaries and own practices. In this "open" environment, with fuzzy roles and rules between stakeholders, how manage the CoPs generating an open innovation context and open source hardware "framework"? To facilitate understanding and representation, we also adopt the concept of Community of Interest (CoI) as the convergence of several CoPs on one shared interest.

FabLab community is heterogeneous even if the FabLabs join the Fab Foundation's charter. Their resources, motivation, origin, organization and users are not the same. They are independent from one another in terms of management, staff and all operations. This process involves different experts, from different culture. In the same time, we have to deal with the (traditional) hierarchical organization and a transversal approach that is horizontal, mutual, regularly negotiated, often tacit and informal.

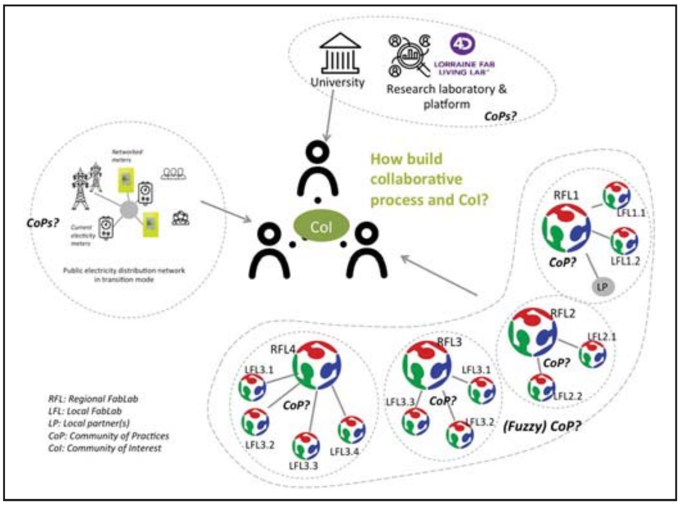


Fig. 4. Representation of the collaboration context based on the CoP concept

In fact, to paraphrase Wenger [32], participants have to find a "*right balance between enough formality to give them legitimacy*" in their own organizations and "*enough informality to let them be peer-oriented, self-governed learning partnerships*" and earn legitimacy in LbM.

The next session (IV) describes the observations and feedbacks from this original operational experimentation based on CoP and CoI representation. Findings highlight how distributed collaborative design model enriches the process and the results.

IV. Findings

The way to analyze and evaluate an open hardware approach between several organizations is the first important result. Indeed, LbM project have to design, animate and participate in a task force around open hardware production, i.e. build new links and shared knowledge between participants. Due to the distributed dimension of this project and the need of collaboration between stakeholders, we decide to use the "distributed collaborative design model" as proven method [33], [34]. Thus, the creation and management processes of the CoI need to take into account four potential barriers: geographical, conceptual, technological, and temporal. These four aspects give a useful framework to describe the context and experiment a first interaction between identified CoPs inside LbM. Based on these different perspectives to observe, and the nature and the relations of the stakeholders, several numbers of challenges other than those presented previously emerged from the implementation of this complex project. The challenges are among others the creation of a shared representation of the project, the interaction with

TABLE I. Issues in collaborative innovation with industrial, academic and association partnership on smart meter usages

	Geographical	Conceptual	Technological	Temporal
1-Initial Diagnosis	- One industrial strategy: national technological deployment via private providers ("Product Launching" phase)	- Different stakeholders and (potential) users (associations, public company, university, citizens, providers, etc.) -Shared societal engagement (energetic transition law) - 3rd wave of DIY [36] - Electricity: heart of our technological Society	- New smart meters (Unopened Hardware - not modifiable by the user) with new skills and know-how - Technical & scientific knowledge - Cost of the technology - FabLabs use the same technologies (Fab Foundation charter)	- Waiting period of 4 or 5 years before a global Smart Grid with 35 Millions of Smart meters - Smart meter in just-in-time production and delivery - Anticipate future societal trends
2-LbM: a first experiment	- One project: 7 teams and around 70 expected participants (10 by team) - Four cities / regions - Decentralized organization, decisions and budget - Occasional virtual meetings -Internet collaborative tools	- A maker inside the research team - A shared contract between RFL & University - Open hardware production - University as interface between company & Makers (Chaire REVES [29])	- Makers as early-adopter - Shared collaborative tools ("Slack" a collaborative platform, 48h Innovation makers, LbM website) - Shared mock-ups / artifact - Smart meter emulators - ENEDIS company hotline - Funds for raw materials & equipment	- Literature review - Informal interviews - Capitalization tools (Mind map, "idea grid of description", report, sc. Papers, etc.) - Asynchronous work - Selection of the best ideas by makers (vote on the most interesting ideas)
3-Specific Challenges	-Lack of face to face interactions (lack of spontaneity) - Different culture between different Regional FabLabs	- Structured organization vs. (very agile or) fuzzy organization - Conceptualization skill vs. materialization skill (different way of representation) - Contract vs. liberty - Governance vs. non-governance. Master the project without been directive (intrusive)	- Different learning time - Build share technical knowledge - Smart meter a specific function for Smart Grid vs. use of the smart meter in potential smart building - Find the adapted communication tools between CoPs	- LbM an initial short time project (6 months) vs. complex societal and research issues… - Administrative rules vs. Agile methods - Interaction with communities at the right moment of the project
	- Horizontal and vertical processes - Volunteers (auto motivation) vs. hired (mission) - How give concrete expression to intangible elements (energy, electricity, trust, data, communication, etc.)?			
4-Explanation	When dealing with distributed teams. The process of animating communities of users (makers) innovations may be complicated.	A heterogeneous set of profiles and motivations may difficult to find the project dynamics among the participants	Immaterial object: Electricity (energy); Network (grid, stakeholders, communication, etc.); Ideas (conceptual and abstract); Time	Integration of users too late on the project ("Product launching" phase) when strategic decision have been already made will inhibit their auto-determination, so their motivation
5-New hypotheses and perspectives	- Make travel one animator/facilitator (researcher?) between places - Organize some physical meeting / events will all the participants - Connect Local FabLabs to public electricity distribution network	- Adopt a "technological transfer" methodology [37]? - Identify personal motivation (FabLabs depend of volunteers) - Develop Several CoIs around different topic rather than an unique CoI (e.g. Smart Environment) - Adopt a larger issue - Identify (a) mediator(s) between CoPs	- Develop and shared pedagogic tutorials - Dedicated tools to manage this type of projects still to be developed. - Define / prepare "real" early-adopters / lead-users: e.g. maker-environmentalist- electrician?	- Develop a long term research project and build a 2021-2012 vision - Create & animate different rhythms around the CoIs and CoPs

communities at the right moment of the project, the adoption of the adapted governance compatible to all roles, the adoption of the adapted communication tools.

The Table 2 describes step by step all the observations and results. First, the initial diagnosis presents some significant elements known at the beginning of the project. The second line presents the first scientific and operational answers. Then, the line "specific challenges" exposes the new challenges generated, some are linked to one barrier, and others are transversal. The main challenges are individually detailed in the following paragraphs but the fourth line gives a summary. The last line suggests the new ways of research.

A. Common representation of the project

Since the smart meter was object of debate and rejection, the representation related to this subject was not partial and new. Moreover the fact that the installation of the smart meters was in progress, the perceived degree of freedom was low to null to modify anything on the smart meter. The issue had to be switch to a larger issue related to the management of the energy in households and smart environments.

It is known that a badly formulated problem does not permit to solve rightly the problem by totally missing the critical aspect.

B. Interaction with communities at the right moment of the project

As it has been introduces in the previous sections, the public electricity distribution company involved lately the users in the development process after a long period of engineering development. And makers, regional manager of the company and researchers launched together LbM project after few exchanges (but as part of a global and ongoing collaboration between the public company and the university [29]). This open Innovation project asked for new tools, methodologies, skills, know-how, knowledge and rhythms between new partnerships without previous common collaboration. If the kick-off event succeeded to mobilize FabLabs members (volunteers), professionals and researchers (Fig.5), no other collective event was organized. RFL were not involved in a self-organization dynamic generating collective events.

Fig. 5. 30th Jan. 2016: kick-off of the Linky by Makers project on 4 places

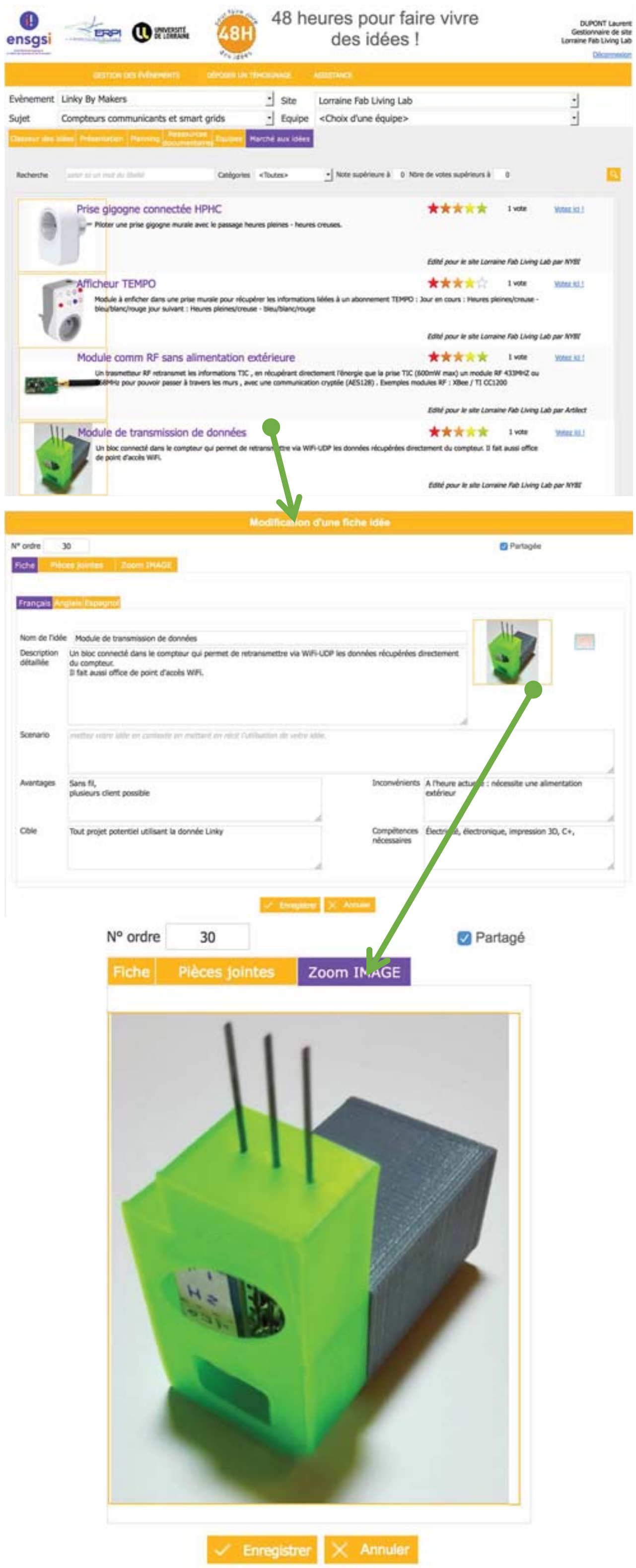
C. Compatibility of the mode of governance / Horizontal and vertical processes

Initially scheduled for the first six months of 2016, in accordance with the FabLab short-term logic, the LbM project stared with stakeholders in different level of information and groundwork. Furthermore, open hardware approach as a shared value between stakeholders call for some common behaviors. Thus, on the one hand, participants need to learn together, from the others, and accept they are all dependent of the others' knowledge and motivation, but on other hand, the process must generate one skillful and reputable coordinator inside each CoP, and between CoPs.

Time is necessary and it is a fundamental parameter to generate a "regime of accountability" for each CoP [13]. Each mode of governance need time to understand other values and accept it could be interesting to transform its practices for a higher interest. Furthermore, LbM project shows that it could be relevant to organize several CoIs (health, energy efficiency, technological development, etc.) involving the different CoPs. After many misunderstandings, which could have resulted in the end of the project, it is still running after 1,5 years. The public company also changed his strategy and developed recently a web site with an interactive 3D tool to describe the smart meter functioning (Fig. 6) and allow a better understanding.

http://compteurs-enedis-3d.squareglasses.net/ (14/04/2017)

Fig. 6. Screenshot of an interactive 3D tool generating different views of the French smart meter and comments (available on internet only in French since the beging of 2017)



http://ensgsi.kalanda.info/ENSGSI (20/04/2017)

Fig. 7. Digital platform to materialize, share, capitalize and select ideas.

D. Communication

The community-driven development model would have been impossible in the absence of design/knowledge commons and digital platforms. Peer production requires collaborative socio-technological digital platforms that permit collaboration of everyone on joint of individual project on global basis [11]. In the case of open source software development, there is a bunch of platforms that ease the collaboration process as the version control system Git[1], Mercurial[2] or Bazaar[3], and several amount of platforms as notably GitHub[4], or SourceForge[5]. The efficiency of these tools associated to several others to create open hardware artifact can be argued. For LbM participants adopt several collaborative tools to communicate and capitalize their interactions. In particular, generated ideas from CoPs are described and stocked in a platform designed by the university (ENSGSI). This digital platform allows shared idea cards between CoPs and each participant can vote for is favorite idea (Fig. 7). Idea cards describe suggested solution to improve smart meter or enrich them with new services. Each idea card can be developed or increased by all the participants. These communication tools generate an open assessment systems that permit to contribute to the maturity of the project [11].

E. Give concrete expression to intangible elements

Topics as energy, electricity, trust, data, communication, geographical distribution, and collaborative distributed creativity, etc. generate many immaterial and abstract elements around smart grid and smart meters. Furthermore, as shows Fig. 8 many issues can be explored around our main subject. The figure only shows the first level and each 14 topics have several sub-topics and potential open hardware artifacts can be designed.

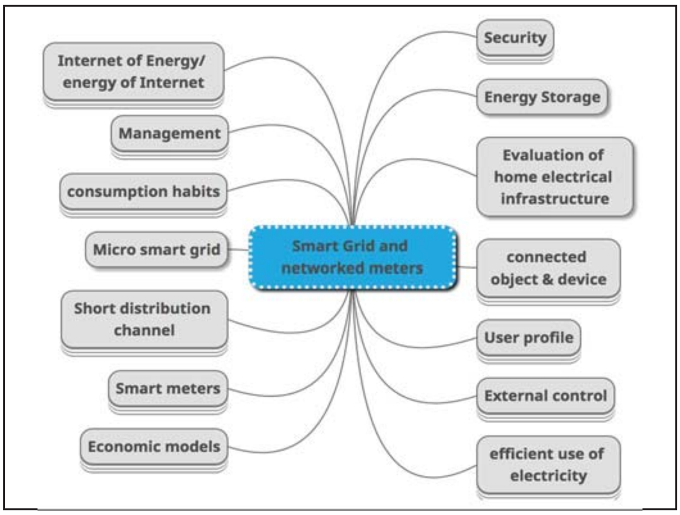


Fig. 8. 1st level of an online-shared mindmap genereted by the interaction between participants during a workshop (11/02/2017).

Due to this rich context, and the fact that smart meters are set up in each building, the creativity of LbM participants

[1] Git: https://git-scm.com/ (20/03/2017)
[2] Mercurial: https://www.mercurial-scm.org/(20/03/2017)
[3] Bazaar: http://bazaar.canonical.com/en/ (20/03/2017)
[4] GitHub : https://github.com/ (20/03/2017)
[5] SourceForge : https://sourceforge.net/ (20/03/2017)

naturally focus on the usages of electricity for building and networks or objects inside buildings.

V. Discussions

Based on the identified challenges (Tab. II), several aspects can explain the actual difficulties met in governance of the community and the production of innovation. According to the advice suggested by the experience of LEGO [28], several elements could explain this situation. Vitality of the community has been certainly dried by an administrative overload for the establishment of contract in order to receive the funding and several misunderstandings between participants. A lack of real initial common vision of the project generates incomprehension and stress among partners. Furthermore, vertical project management tools are not so relevant for most associative forms of communities. A least one mediator between CoPs is necessary and maybe a real operational coordinator at the beginning could support collective momentum.

This research project is still on-going for overcoming faced difficulties and challenges. And it is currently a long-term process involving multi-stakeholders with limited resources; many participants, such as volunteers, can easily loose their motivation. Furthermore, uncertainty (political, environmental, economical, etc.) stays strong around the industrial project. There are some limits but LbM project was an opportunity to experiment in an iterative dynamic several scenarios around open hardware approach. Beside, with these new and fuzzy dimensions, a systematic programming of its activities was impossible.

The relevance of the selected user community involved can also be discussed; perhaps the choice was not well adapted, but more specifically, CoPs were not enough prepared. After one and a half year, LbM allows a better characterization of the stakeholders, their motivations and the development process notably the institutionalization phase of the Fab Lab [26]. Currently, 24 participants follow and participate through collaborative digital platforms and local face-to-face meeting. We observe and analyze the process as involved researchers in this case study. As a consequence, we observed that a true co-creation started after one year. Thus, in the subsequent three months 29 ideas of potential innovation projects were formalized on the digital platform. Furthermore, makers and researchers transformed about 10 idea cards into functional mock-ups.

VI. Conclusions

This presented case study comes from a – geographically, culturally, technologically and temporally - distributed Public–Private–Population Partnership (4P). It generates practical implications within an operational protocol driving open hardware projects with societal implications; because companies attempt to reduce the risk of technology acceptability in adopting a user-driven innovation strategy. This study, building from this practical experience, strengthens also the expectations of energy efficiency, thanks to the connection between communities of practices and their ability to share knowledge and build new know-how. Table II summarizes these findings and challenges and provides a better comprehension to deal with such emerging projects.

Institutions and organizations could think they understand what drives innovation and how to manage these type of open projects as they do in "controlled" environments [35]. However, using traditional project management codes lead to fail. In order to make rise of collaborative innovation between organizations of different nature, it requires defining a hybrid approach to manage this kind of project.

Desktop manufacturing and peer production, that are the tools of the maker communities, are the means of the commons-based economies. The exploration of the field by the electricity distribution company is the low signal in this direction. Similarly to the green-washing, which consists to influence the consumer by promoting the environmental performance of product or a service, there is certainly a mistrust of lead user from the maker community for a peer-washing or maker-washing. This project is somehow an experimentation of a public-private-commons triad [11].

The issue of the organizational governance and management of communities (users or peer) is an actual issue [25] in which this article provides some elements. User-driven approaches and notably their implementation through "third space" or Living Lab projects can be virtuous, whereas it occurs at the early stage of the product of process conception.

The future success of the smart grid will critically depend on the overall functioning of the energy system as a socio-economic organization, not just on individual technologies. Smart environments could be explored as the place of materialization of these societal issues. There is, most probably, a lack of model to support these multi-stakeholder collaborative innovation projects, involving industry, research institutions and users' community engaged into solving a societal issue.

As the LbM is a on-going project, further works and dynamics are under construction and should be continued in order to properly disclose new perspectives, such as: (1) development of local economical development with start-up; (2) use of feedbacks as new way of increase for the company managing the public electricity distribution network; (3) evolution from national project to European Union strategy involving citizens in industrial innovative process. Indeed, this reported study suggests some basis for a protocol turning a technological system into to a socio-technological ecosystem.

Acknowledgment

This project benefit from the Chaire REVES funds. Furthermore ERPI research team thanks for their valuable contributions and efforts: Manuel Zurita, ENEDIS, Regional FabLabs (NYBI, Artilect, FOL, FacLab) and all the involved makers, GSI Lab, Lorraine Fab Living Lab® team. Authors also thank Emmanuel Del Sordo, Hakim Boudahoud, Joëlle Mastelic and Marc Pallot for their advice and support.

References

[1] Assemblée Nationale, "Mission d'information commune sur l'application de la loi n°2015-992 du 17 août 2015 relative à la

transition énergétique pour la croissance verte," Assemblée Nationale, Paris, France, May 2016.

[2] European Commission, "Smart grids and meters," *European Commission*, 2017. [Online]. Available: https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters. [Accessed: 14-Apr-2017].

[3] O. Schneid, "Linky, c'est parti… or, des zones d'ombre demeurent," *la gazette des communes*, 2013.

[4] N. Stiel, "Compteur Linky : le jackpot que EDF veut faire payer aux usagers," *Challenges*, 2013.

[5] T. M. Skjølsvold, "Back to the futures: Retrospecting the prospects of smart grid technology," *Futures*, vol. 63, pp. 26–36, 2014.

[6] R. Bertoldo, M. Poumadère, and L. C. Rodrigues, "When meters start to talk: The public's encounter with smart meters in France," *Energy Res. Soc. Sci.*, vol. 9, pp. 146–156, 2015.

[7] European Commission, "Smart Metering deployment in the European Union," *JRC Smart Electricity Systems and Interoperability*, 12-Apr-2017. [Online]. Available: http://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union. [Accessed: 14-Apr-2017].

[8] E. Von Hippel, S. Ogawa, and J. P. De Jong, "The age of the consumer-innovator," *MIT Sloan Manag. Rev.*, vol. 53, no. 1, p. 27, 2011.

[9] E. Von Hippel, *Democratizing innovation*. Cambridge: MIT Press, 2005.

[10] C. Hienerth, E. von Hippel, and M. Berg Jensen, "User community vs. producer innovation development efficiency: A first empirical study," *Res. Policy*, vol. 43, no. 1, pp. 190–201, Feb. 2014.

[11] V. Kostakis, V. Niaros, G. Dafermos, and M. Bauwens, "Design global, manufacture local: Exploring the contours of an emerging productive model," *Futures*, vol. 73, pp. 126–135, Oct. 2015.

[12] E. Wenger, *Communities of Practice: Learning, Meaning, and Identity.* Cambridge: Cambridge University Press, 1998.

[13] E. Wenger and B. Trayner-Wenger, "Communities of practice: a brief introduction," 2015.

[14] M. Sánchez-Jiménez, "European technology platform SmartGrids: vision and strategy for Europe's electricity networks of the future," Office for Official Publications of the European Communities, Luxembourg, 2006.

[15] M. Sanchez Jimenez, "European task force for the implementation of smart grids into the European internal market: mission and work programme." pp. 1–15, 2011.

[16] Jixuan Zheng, D. W. Gao, and Li Lin, "Smart Meters in Smart Grid: An Overview," in *2013 IEEE Green Technologies Conference (GreenTech)*, 2013, pp. 57–64.

[17] M. Poumadère, R. Bertoldo, À. Boso, J. Espluga-Trenc, C. Mays, C. Oltra, A. Prades, and N. Schneider, "Entre consommation durable et vie quotidienne: Les premiers balbutiements du compteur communicant en France et en Espagne," in *Beslay C., Zélem, M.-C. (dirs) La sociologie de l'énergie*, CNRS, collection Alpha, 2015.

[18] G. Moser, *Psychologie environnementale. Les relations homme-environnement*. Bruxelles: De Boeck, 2009.

[19] A. Mengolini and J. Vasiljevska, "The social dimension of smart grids: consumer, community, society.," Publications Office of the European Union, Luxembourg, 2013.

[20] S. M. Stern, "Smart-grid: technology and the psychology of environmental behavior change," *Chi.-Kent L. Rev.*, vol. 86, no. 1, p. 139, 2011.

[21] S. K. Levan and J.-P. Vickoff, *Travail collaboratif sur Internet : concepts, méthodes et pratiques des plateaux projet*. Paris, France: Vuilbert, 2004.

[22] E. B.-N. Sanders and P. J. Stappers, "Co-creation and the new landscapes of design," *CoDesign*, vol. 4, no. 1, pp. 5–18, Mar. 2008.

[23] E. Von Hippel, "innovation by user communities: learning from Open-Source Software," *MIT Sloan Manag. Rev.*, vol. Summer, pp. 82–86, 2001.

[24] N. Bettenburg, A. E. Hassan, B. Adams, and D. M. German, "Management of community contributions - A case study on the Android and Linux software ecosystems," *Empir. Softw. Eng.*, vol. 20, no. 1, pp. 252–289, Feb. 2015.

[25] Y. Benkler, "Peer production and cooperation," in *Handbook on the Economics of the internet*, Edward Elg., Johannes M. Bauer; Michael Latzer, 2016, pp. 91–119.

[26] É. Lhoste and M. Barbier, "FabLabs," *Rev. d'anthropologie des connaissances*, vol. 10,1, no. 1, p. 43, 2016.

[27] M. Pallot, B. Trousse, B. Senach, and D. Scapin, "Living Lab research landscape: from user-centred design and user experience towards user co-creation," in *First European Summer School "Living Labs"- 25-27 Août.*, 2010.

[28] Y. M. Antorini and A. M. Muñiz, "Invited Article: The Benefits and Challenges of Collaborating with User Communities," *Res. Manag.*, vol. 56, no. 3, pp. 21–28, May 2013.

[29] L. Dupont, L. Morel, and C. Guidat, "Innovative public-private partnership to support Smart City: the case of 'Chaire REVES,'" *J. Strateg. Manag.*, vol. 8, no. 3, pp. 245–265, Aug. 2015.

[30] L. Dupont, L. Morel, and P. Lhoste, "Le Lorraine Fab Living Lab : la 4ème dimension de l'innovation," in *Actes des sessions du colloque Science & You, France*, 2015, pp. 230–235.

[31] E. Wenger, R. McDermott, and W. M. Snyder, *Cultivating communities of practice: a guide to managing knowledge.* Boston, Mass.: Harvard Business School Press, 2002.

[32] E. Wenger, "Communities of practice and social learning systems : the career of a concept," in *Social Learning Systems and communities of practice*, C. Blackmore, Ed. Springer Verlag and the Open University., 2010, pp. 225–246.

[33] L. Dupont, V. Gholipour, L. Morel, J.-C. Bignon, and C. Guidat, "From Urban Concept to Urban Engineering: The Contribution of Distributed Collaborative Design to the Management of Urban Projects," *J. Urban Des.*, vol. 17, no. 2, pp. 255–277, May 2012.

[34] L. Dupont, L. Morel, J. Hubert, and C. Guidat, "Study case: Living Lab Mode for urban project design: Emergence of an ad hoc methodology through collaborative innovation," in *2014 International Conference on Engineering, Technology and Innovation (ICE)*, 2014, pp. 1–9.

[35] D. Dougherty, "The Maker Movement," *Innov. Technol. Governance, Glob.*, vol. 7, no. 3, pp. 11–14, Jul. 2012.

[36] S. Fox, "Third Wave Do-It-Yourself (DIY): Potential for prosumption, innovation, and entrepreneurship by local populations in regions without industrial manufacturing infrastructure," *Technol. Soc.*, vol. 39, pp. 18–30, Nov. 2014.

[37] L. Dupont, "Transfert du génie industriel vers l'ingénierie urbaine : vers une approche collaborative des projets urbains," Institut National Polytechnique de Lorraine - INPL, Nancy, France, 2009.