Departmental Energy Syndicates: key stakeholders in smart street lighting for rural areas

Embedded case study of two French departments

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Abstract

These embedded case studies took place within two French departments and carried out an analysis of the "intelligent" street lighting stakeholder system. The article considers the departmental energy syndicates' capacity to act as a key stakeholder while facing governance and coordination challenges as well as competition between public and private bodies. Drawing upon a literature review of "smart city" stakeholders and energy syndicate history, the article demonstrates how the governance model supports the key role that this public organisation plays. Indeed, this model positions elected members, that is to say town mayors, at the centre of the "smartization" process and establishes strong links between the political stakeholder and the technical expert which facilitates the political decision-making process as well as decisions about technology. Furthermore, widening the stakeholder system to incorporate the digital dimension forces the energy syndicates to develop skills across the digital technology chain. Finally, by drawing upon business ecosystems theory, the article demonstrates the energy syndicate's ability to play an essential role in the street lighting market - that of coopetition, the subtle combination of cooperation and competition that occurs between public organisations and private operators. By highlighting the multiple interactions and complex stakeholder coordination challenges, the study deduces that departmental energy syndicates play a key role within a diverse stakeholder system working on smartization in rural areas. This article calls for further exploration into the governance of "smart city" stakeholder systems and, in particular, more complex cases involving several local services (energy, transport, waste, security).

Keywords: intelligent street lighting, governance, smart infrastructure, departmental energy syndicates, stakeholder system.

Introduction

There is a great deal of literature relating to research into smart city stakeholders. This is mainly focused on large cities and fails to mention rural areas. This lack of interest is in no way justified because what takes place in rural areas provides just as much insight into the complex nature of stakeholder leadership and interactions within the smart city process. In rural areas, "regional and local authorities have full governance in matters of energy policy" and face energy transition challenges (Poupeau, 2015a). They have recently become involved in the smartization of the street lighting technical system in order to fulfil those requirements. This recent initiative involves a wide range of organisations, stakeholders, politicians and technical and digital system experts whose governance models are brought into question. Governance, which is defined by Le Galès P. (2014) as "a process of coordinating stakeholders, social groups and institutions with a view to meeting objectives which have been collectively defined and discussed", refers to a "more flexible form of political power" and consists of "being in interaction within a plurality of "governing" stakeholders that are not all part of the state, or even public organisations (Leca, 1996).

"Smart infrastructure" (Anthopoulos, 2017) is one of the sectors within the "smart territories" remit. It involves optimising technical systems and connected infrastructure at an operational level (Daniélou, Ménard, 2014) in order to conserve resources such as water and electricity, to mention only the main ones. Optimisation makes use, inter alia, of the opportunities provided by digitisation in terms of the availability of data and the development of algorithmic innovations in software applications (Picon, 2018). Here, we are referencing "Optimising operational features in the governed city according to the smart city vision of integrated flow control (vehicles, energy, water, waste)" (Ménard, 2017).

It involves a diverse **stakeholder system** (Bernoux, 2001) which is made up of public and private organisations, based both within and outside the area (Baraud-Serfaty, Fourchy, Rio, 2018). This is rapidly evolving with an influx of new players from the digital world. (Courmont, 2018). Objectives that seek to conserve resources, adapt, and optimise the service, while working with the changing nature of the stakeholder system, cause political, economic and technological tensions (Lorrain, 2018). This situation can even overthrow market stakeholders' strategic or competitive rationale (Attour, Rallet, 2014). It forces the key players, whether they are public or private, to rethink their governance and organisational models and collaborative approaches, expanding their areas of expertise. According to Dominique Lorrain (2018) "when faced with the reshaping of the stakeholder system, coordination and skills-based challenges become central. This raises the question of an organisation's capacity to oversee this stakeholder system".

Several theoretical frameworks served as models in this case study. Initially, it drew upon theoretical literature that could be described as discussion based, identifying large **"smart city"** stakeholder groups (Picon, 2013), as well as lesser developed literature that looked at the historic role of **departmental energy syndicates** in the energy and public lighting systems in France (Poupeau, 2019). Lastly, it draws upon two other tools-based, theoretical fields: **theory of business ecosystems** (Moore, 1993), (Koenig, 2012) and **organisational sociology** (Crozier, Friedberg, 1977). In the past ten years, the concept of business ecosystems has become an area of growing interest in academic circles and has been increasingly called upon when studying collaborative innovation governance in a number of both private and public organisations. In order to supplement this ecosystemic approach and to look at the interactions as individual strategies, the study made use of **organisational sociology** tools and in particular strategic analysis of the concepts of power and concrete actions systems developed by M. Crozier and E. Friedberg.

The field study was carried out in **rural areas in two French departments** that had been tasked with switching **the technical street lighting system** to "smart". This technical system is becoming one of the main infrastructures to be optimised in order to save energy within regional and local authorities (Ademe, 2019). In these rural departments, **joint departmental energy syndicates** operate the technical system and street lighting infrastructure on behalf of the municipalities and EPCIs (Boyer, 2019).

The study's research topic explores the **governance challenges (Le Galès, 2014) within the stakeholder system involved in implementing "smart infrastructure" Anthopoulos, 2017) in rural areas.** More specifically, we will be looking at **the organisation's ability to adopt the role of key player within this stakeholder system.** Our research question examines what capacities the departmental energy syndicates have to play the central stakeholder role within the "intelligent" street lighting stakeholder system for rural areas.

Conceptual framework

According to ADEME (2019), the street lighting service amounts, on average, to 41% of energy consumption in France and 37% of the local and regional authorities' electricity bill (Ademe, 2019). The technology involved in street lighting provides real opportunities to optimise services such as LED and digital information. Within the context of technological opportunities, analysing how key players are coordinated when implementing terms of use and technological innovations, contributes towards a better understanding of the challenges involved in meeting "smart" and energy transition objectives.

The smartization of street lighting

The aim when contemplating the switch to "smart" street lighting is to save energy, adapt the service according to need, and indirectly to save regional and local authorities money. These objectives create scope for considerable interaction between political stakeholders and technical experts: the first involves meeting national objectives related to energy efficiency and the environmental impact of street lighting in accordance with the 2015 Energy Transition Law and the 2018 decree issuing from the 2010 Grenelle 2 Act. These laws and regulations oblige local and regional authorities to take concrete action in terms of energy savings and stipulate that measures be taken to protect biodiversity and prevent light pollution. At a local level, town mayors are responsible for street lighting in accordance with the General Code on Local Authorities. The political decision to switch to a "smart" technical street lighting system is made by local authorities. Ultimately, it is about establishing the right balance between the levels of service in terms of security, quality, comfort and aesthetics, and the anticipated energy and costs saving and reduction in environmental impact. Technically speaking, this means street lighting being switched off at certain times and the technical system being optimised at an operational level. The technical expert intervenes in implementing these changes in operating methods and the required changes in the infrastructures and networks of the main operational components of street lighting which are the energy system (resources), the technical system (street lighting infrastructure), the digital system (data collection network, data platform and remote management software applications).

The aim of the document is to raise questions about the role of the energy syndicates based upon three aspects of the street lighting stakeholder system, observed in two French departments: **Politico-technological relations between political stakeholders and technical experts, new digital stakeholders and public/private relations within the market.** (Figure 1: "Intelligent" street lighting stakeholder system).

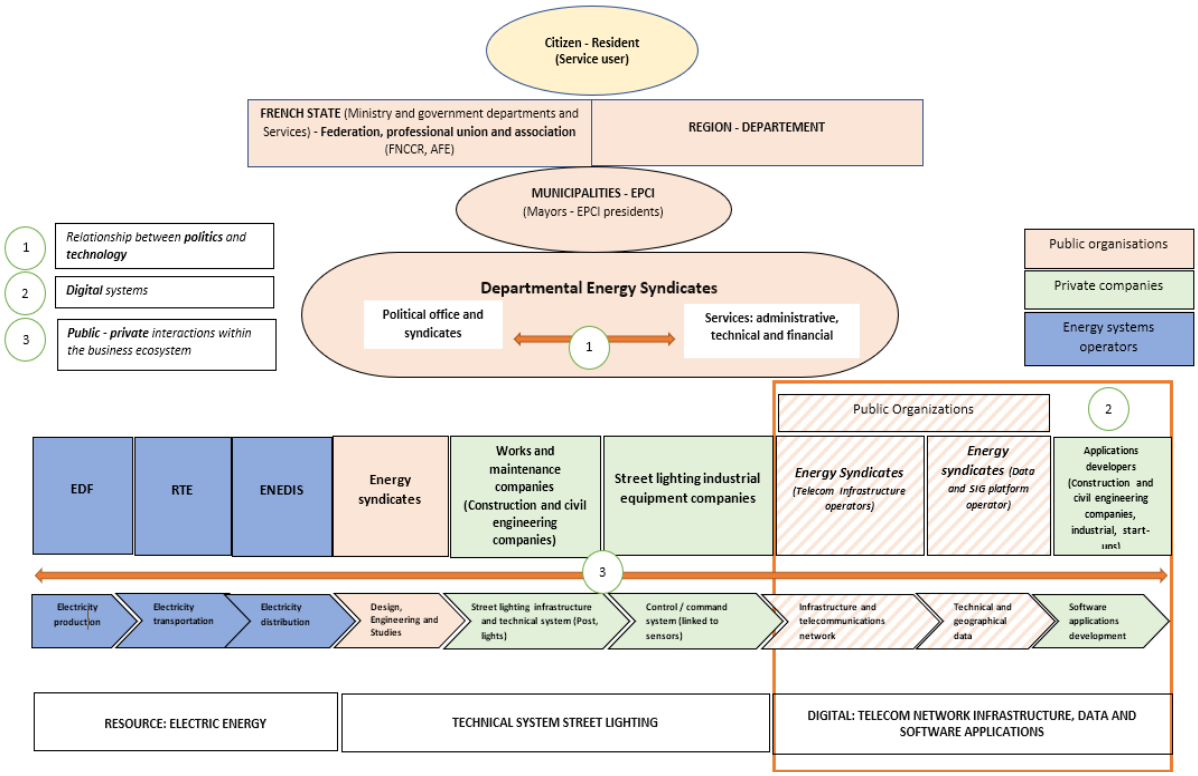


Figure 1: "Intelligent" street lighting stakeholder system – January 2020 – author's own diagram

Departmental energy syndicates: background, governance and competition for this public structure that links local authorities

The first aspect addresses governance (Le Galès, 2014) and the organisation itself of energy syndicates, looking at the key role of the political stakeholder, town mayors (Marzloff, 2016) and relationships with technical experts. How do the governance and organisational structures of departmental energy syndicates contribute to them securing the role of key stakeholder within the local authority leadership stakeholder system?

In the rural areas of the Maine et Loire and Vendée departments, much like in the majority of other French departments, it is the departmental energy syndicates that ensure the management of street lighting projects and oversee street lighting operations and maintenance on behalf of EPCIs and local authorities who have delegated their territorial jurisdiction for this. The first question examines the structure of the departmental energy syndicate itself, as a key stakeholder with a historic understanding of rural electrification and street lighting in French departments (Poupeau, 2015a). This organisation, which is not very well known to the general public, has "spearheaded energy transition for local authorities in France." (Boyer, 2019). Throughout their long history, these organisations have always adapted and are currently attempting to diversify their areas of expertise at departmental level (Poupeau, 2020). By analysing their governance model and competition, as well as the support that they receive, we were able to reflect upon their leadership role within the local authorities' system.

In addition to analysing energy syndicate structure, we have observed individual strategies for two key players in street lighting "smartization", namely the political stakeholder and the technical expert. We have analysed and given consideration to the relationships between these two stakeholders, drawing upon tools from organisational sociology. (Crozier, & Friedberg, 1977). This approach meant we could "look for" the informal (Bernoux et al., 2001) individual strategies, interactions and collaboration between the two players within the local authority and energy syndicate structures.

The digital system: new entity in the "intelligent" street lighting stakeholder network

In the second section, the article looks at the syndicates' capacity to wider their areas of expertise when faced with the arrival of new stakeholders from the digital system (Courmont, 2018). How do the energy syndicates use skills acquisition and experimentation to preserve their key stakeholder position within the intelligent street lighting digital system ?

The “intelligent” street lighting stakeholder network has integrated **a third new entity, that of the digital system (telecommunication, data, algorithm and software applications networks).** Indeed, setting up an “intelligent” street lighting project involves collecting and storing data, such as energy consumption, technical data about government infrastructure, geographic data, as well as that of presence sensing sensors. Dependent upon the planned sequence for switching lights on and off, this data enables programmed lighting management by integrating gradation and simple lighting algorithms according to a schedule or an event, such as people or vehicles passing. The access to this data then becomes essential in order to develop software applications (remote management software). This new entity changes the historical set-up of the stakeholder system and mastering these different levels – namely telecommunications networks, data management and digital platforms (SIG and remote management software) (Courmont, 2018) – can call into question the role the key stakeholder plays. In order to maintain their leadership, stakeholders within public organisations are required to engage with experiential ways of working and acquire new skills (Guéranger & Fritz, 2019) when integrating this new digital system.

The “intelligent” street lighting market as a business ecosystem

The third and final aspect explores the interactions between energy syndicates and intelligent street lighting market operators through a business ecosystem lens (Attour, Rallet, 2014). How do departmental energy syndicates strengthen their leadership position within the intelligent street lighting business ecosystem?

Drawing upon **business ecosystem theory** (Moore, 1993), in which the notion of key stakeholder is central (Donada & Fournier 2014; Ben Letaifa & Rabeau 2012; Gueguen & Torres 2004), the stakeholder system in the “intelligent” street lighting market is approached as **a business ecosystem**. The business ecosystem approach involves a particularly interesting

structural analysis of a system of stakeholders involved in a collective innovation process such as “intelligent” street lighting. Indeed, the main characteristics of the business eco system are the “heterogeneity of the stakeholders, the range of industrial sectors involved, the variety of inter-organisational relationships (collaboration, competition, coopetition), the skills enlisted through the process of innovation and, of course, the role of new digital technologies (platforms)” (Isckia, 2011). This business ecosystem theory will be put into practice, in this case study, as part of a unique approach to “smart infrastructure” - to be more precise, a street lighting service in which the key stakeholder, the energy syndicate, is considered to be the leader of this ecosystem as well as a public body. Drawing upon different aspects of business ecosystems, the third hypothesis looks at energy syndicate leadership through a **coopetition** lens, which is, at once, cooperative and competitive (Mira-Bonnardel, Géniaux, & Serrafo, 2012) and exists between organisations involved in “intelligent” street lighting, whether they are public or private organisations.

By developing three questions that relate to the role and leadership of energy syndicates in terms of their governance; their experiential dynamics, digital skills acquisition - and also looking at how this is coordinated within the business ecosystem - we will be able answer the core research question of the study of leadership of departmental energy unions, public organizations play what of the system of actors of public lighting «intelligent» in rural areas.

Literature review

Dialogue theory: "Intelligent city" stakeholders and governance – departmental energy syndicates

In the first section, we limited ourselves to outlining the main categories of stakeholders and the governance challenges tackled in the "smart city" literature, retaining anything relating to the "smartization" of street lighting. Then, in the second section, we looked at the energy syndicate literature which, despite their historic and essential role in the electric system for street lighting in France, has been the object of little interest in comparison to the "smart city" theme. This section throws light on the background and evolution of these public organisations and indicates that their role in the "smartization" process has not yet been addressed in academic research.

The main stakeholder categories in the "smart city"

Politics, local authorities and the urban governance system. The "intelligent city" or "smart city" is perceived as a political topic and something to be considered a model, if not an ideal (Picon, 2014). The fact that it is a "technology" is secondary to this. (Picon, 2016). The political stakeholder role is therefore the object of "particular attention" in the literature (Picon, 2018) and cites public organisations (Marzloff, 2016) and "mayors, in particular" (Picon, 2018). The political role is indeed described as key in the "intelligent city" stakeholder system. In a publication about new resource management models in cities, Lorrain (2018) cites two main players "urban government and big urban companies that become drivers for change". In addition to the political stakeholder role, the influence of the city (or regional) government system on the frugal management of resources is also examined. In a November 2018 report which aimed to outline the governance of ecosystems in the city of tomorrow, Baraud-Serfaty, Fourchy and Rio

(2018) again focus on governance within this rapidly evolving stakeholder system within local authorities. Their role must be expanded to include the regulation and coordination of this complex stakeholder system in order to ensure public interest and to maintain a value system while enabling the optimisation and development of new services. (Baraud-Serfaty, Fourchy, & Nicolas Rio, 2018).

Digital system stakeholders. "The *smart city* refers to a city that is "in the grips of digitalisation" rather than a supposedly intelligent city" (Rio, 2018). In an initial report on intelligent city stakeholders, Daniélou (2012) created a stakeholder map that highlighted digital stakeholders' leading role in the reconfiguration of urban public organisations' traditional activities. (Daniélou & Ménard, 2014). IBM and Cisco (Picon, 2018) (Courmont, 2018) are considered to have instigated the creation of the smart city concept. The digital companies' arrival is one of the key features in the reconfiguration of the stakeholder system for "smart area" projects.

Digitalisation within local authorities: socio-technical brokerage and "data sovereignty". Working within a context in which both processes and structures are being transformed by the digital system, local authorities face internal and external challenges which require them to adopt different aspects of digitalisation. A case study about services in a large city provided evidence of socio-technical brokerage, where local authorities officers are stakeholders facing new challenges in data management, data repository harmonisation and information systems, as well as having to implement the expansion of a transversal infrastructure network within the "business departments" (Guéranger & Mathieu-Fritz, 2019). Implementing data collection infrastructure across the entire area involves gaining consensus and adoption at different levels - across information system security services and business department services – and this must get final approval from elected members who remain the

decision-makers. Groups of individuals convene to exchange ideas, experiment with working transversally, informally and, sometimes, invisibly (Guéranger & Mathieu-Fritz, 2019). Services within local authorities must simultaneously manage the changes to their internal information system and bring together the interests and expectations of each of the services within the local authority. This interplay between stakeholders is not limited to internal interactions and is extended to power relations around data management between local authorities and large urban operators. Data assets are considered a "sovereignty" factor for the local authority. These include knowledge of the area and even the ability to set out public policy (Guéranger & Mathieu-Fritz, 2019).

Repositioning private firms within the digital economy of the "smart territories" market and benefiting local urban service provider businesses. Even if the large digital companies had forecast a large share in the cities' information systems market, their lack of knowledge in the complexities and singularity of each individual area forced them to regularly reposition themselves so as to be in partnership with urban service operators (Courmont, 2018). "An innovative technology is not sufficient in its own right to gain a foothold. You need to be able to insert it into a pre-existing social, technical and economic environment" (Courmont, 2018). What we can take from this analysis is, firstly, the understanding that digital stakeholders are key in the reconfiguration of historic stakeholders. In addition, new technologies need to take the local regional context into consideration in order to be integrated. The limitations that the large digital stakeholders encountered can become an opportunity for both the local authorities, in terms of their stakeholder leadership, but also businesses and operators whose regional presence is an asset to the regional service "smartization" market.

The "smart territories" business ecosystem.

According to Attour and Rallet (2014), in an eco-systemic case study of "smart territories" only three main stakeholder categories remain: network operators, global digital companies and local authorities. (Attour & Rallet, 2014). The local area is therefore considered to be a "technical or economic platform and the only cooperative framework that is likely to instigate a collective innovation dynamic" (Attour & Rallet, 2014). The local authorities have the infrastructure and produce their own local data. They are stakeholders in the urban ecosystem, managing flow and facilities in the area as well as tackling the challenge of developing new services (Attour & Rallet, 2014) and being responsible for keeping the area attractive. Issues of strategic and competitive rationale between private companies are dealt with by evaluating competitive advantages on the market according to their expertise with the technical system and infrastructures, their ability to capture and process information and data, their capacity for innovation and their connections with local public stakeholders. According to Attour and Rallet (2014), the network operators' strength lies in the fact that they have a locally embedded technical platform and are able to invest in intelligent sensors to create new services. (Attour & Rallet, 2014). Thereafter, global digital companies are introduced. They have other advantages such as an innovation-based strategy, substantial capacity to invest and access to user information. Their main weakness currently lies in their connections with local public organisations, with whom they have no direct contact (Attour & Rallet, 2014) and no established ways of relating. This case study looking at the "smart" market as a business ecosystem captures the extensive range of stakeholder categories and, more importantly, the strategic challenges for private companies that are working with local authorities. It highlights the importance of service operators having a foothold in the local area, being able to work innovatively and having proficiency and skills in digital systems.

Departmental energy syndicates

An established stakeholder in the energy system in France. The energy syndicates have not been studied very much despite their important, if not decisive, role in the history of street lighting and the electric energy system in rural areas in France. According to Poupeau (2020), there have been four major periods in their history, punctuated by threats and opportunities. At the beginning, when electricity was first introduced in France, the 15 June 1906 law, accorded all cities licensing authority status with the ability to grant electricity operator contracts. From the 1930s, the energy syndicates went through a period of fast growth as pioneers of shared services between municipalities in France (Poupeau, 2020). The local authorities formed an opportunity-based strategy based around the Facémechanism and awarded the energy syndicates the works and financial management linked with these investments. The FNCCR, created by the syndicate's presidents during this time, will emerge from Facé, and will give a real impetus to rural electrification. The second period, from the 1950s to the 1980s, takes place within the context of the set-up of EDF (8 April 1946 nationalisation law). With the electrification works coming to an end, the energy syndicates find themselves having to negotiate with a single concession holder on a national scale and this marks the beginning of a period of slow decline (Poupeau, 2020). The 1990s see a resurgence among the energy syndicates which is linked to the privatisation of the energy sector driven by Europe and the French state. This privatisation process brings into question EDF's monopoly and, during this period, it will have to secure its position in relation to its customers and accommodate the energy syndicates who will therefore benefit from more favourable financial terms. The energy syndicates levy two charges: The first (R1) enables them to boost their resources in order to take on concession contracts and the second (R2) will allow them to carry out their own works. With FNCCR's agreement, a subsidy provided by EDF will enable the energy syndicates to pursue departmentalisation.

Departmentalisation and diversification (2000 - 2020). Since the 2000s energy syndicates have faced a less advantageous context as communities have grown in strength, particularly inter-council partnerships (Poupeau, 2019). These can be potential competitors. Within this shifting institutional context, both the rules around local jurisdiction and the role local authorities play in energy transition have changed. Local stakeholders can be mapped out into two sections: the large agglomerations with awarding authority status on one side and the energy syndicates on the other (Poupeau, 2020). At present, energy syndicates are diversifying and moving into facilities and services sectors, but this is not standardised across all geographical areas. New areas of activity and skill are arising within the energy syndicates, such as electronic communications, electric mobility, geographic information systems and urbanism (Boyer, 2019).

Tools-based theory: theory of business ecosystems and organisational sociology tools

***Business ecosystem theory*:** Business ecosystem theory emerged from the transposition of the definition of an ecosystem in ecological science (relating to the natural world and biodiversity) into the business world by Moore (1993). Beyond, the metaphorical limitations of this theory (Koenig, 2012), a business ecosystem is defined as:

> "An economic community supported by a foundation of interacting organisations and individuals - the organisms of the business world. This economic community provides products and services of value to the customer, who are themselves members of the ecosystem". (Moore, 1993).

A business ecosystem is a vast community of stakeholders (competitors, suppliers, customers, users, public organisations, training centres, etc.) belonging to several sectors, and a value system which is initiated, run and structured by a leading company. This dynamic draws

upon shared tools (collaborative platforms), rules around creating shared values and, especially, a shared strategic vision for innovation (Moore, 1993; Gueguen & Torres, 2004).

A diverse stakeholder system overseen by a key player: leadership as a core concept within the business ecosystem. A business ecosystem is characterised by the diverse parties involved (Daidj, 2011) and the range of relationships that exist within the stakeholder system (Isckia, 2011). The relational complexity comes out of the variety and diversity of the coexisting organisational systems (Mira-Bonnardel, Géniaux, & Serrafo, 2012; Iskia, 2011). The concept of a business ecosystem refers to a vast community (Moore, 1993) or network of stakeholders (Iansiti & Lieven, 2004) that can be companies (producers, suppliers, competitors), customers, but also users, institutional groups, public organisations, and associations (Gueguen & Torres, 2004). Peripheral stakeholders, such as public stakeholders, are included as players that have a key role in the innovation process. (Ben Letaifa, Rabeau, 2012). The benefit of this concept lies in an expanded vision of the environment, in which diverse stakeholders, with specific and complementary competencies, are likely to be able to participate, to differing degrees, in a creative process led by a key stakeholder (Mira-Bonnardel, Géniaux, & Serrafo, 2012). The complementary nature of the relationships between stakeholders creates a service that none of the partners would have been able to create on their own. The synergy is the cement in the ecosystem (Mira-Bonnardel, Géniaux, & Serrafo, 2012). The key stakeholder channels the most strategic resources and skills. In other words, the leadership position always reverts back to the stakeholder that is the best able to manage the key resources in the value chain. (Ben Letaifa & Rabeau, 2012). Its role must be to build the ecosystem, by developing the most collaborative possible route towards a strategic intention that will encourage as many as possible to sign up for the project. (Gueguen, & Torres, 2004). The leader will therefore have to constantly manage the tension between value creation and

harnessing the value created. (Isckia, 2011). The technological remit is one of the aspects that is explored in business ecosystems theory. The role of the leader can sometimes involve imposing technology (Daidj, 2011). The aim of the business ecosystem and its leader would be to push for innovation among members, pursuing a fresh technological trajectory that is sustainable in terms of profitability (Edouard, & Gratacap, 2011).

Multi-sector organisational model within a value network: the coopetition concept. Business ecosystem stakeholders belong to several sectors (Daidj, 2011). The business ecosystem draws in stakeholders from different sectors who must collaborate as part of a value chain or, rather, value network. The notion of a business model is substituted by a value network - a combination of several different business models that takes into consideration the specifics of each economic model (Attour and Burger-Helmelchen, 2014). This feature in multi-sector relationships within business ecosystems brings into play a combination of business models which gives rise to strategic, competitive and economic tensions within the value network. The key organisations within the business ecosystem do not constantly progress in a cooperative way: they must maintain their capacity to alternate between collective and competitive strategies (Mira-Bonnardel, Géniaux, Serrafo, 2012). In order to be able to co-innovate, move beyond tensions and keep a level playing field around competition, a hybrid version of collaboration takes shape in which cooperation and competition are blended: coopetition (Isckia, 2011).

Managing knowledge and competencies. Another characteristic of business ecosystems, mentioned in the literature, is the management of knowledge and competencies. The concept of an ecosystem refers to an expanded vision of the environment, in which diverse stakeholders, with specific and complementary competencies, are likely to be able to get involved, to differing degrees, in a collective value creation process led by a key stakeholder (Mira-Bonnardel, Géniaux, Serrafo, 2012). Teece et al (1997) developed the notion of dynamic

capabilities which describe, on the one hand, the necessity for companies to quickly update their competencies in order to deal with changes in their environment, and on the other, the management's ability to integrate, develop and reconfigure internal and external competencies to face these same changes (Isckia, 2011), (Fréry, Gratacap and Iskia, 2012). This aspect of business ecosystems requires both sharing knowledge between the players and the dynamic management of competencies within the stakeholder system.

The concept of technological platforms. Technological platforms play an essential role within business ecosystems. The de-structuring of industries' firm boundaries coincides with a pulling together of companies from different sectors to produce new value propositions within new ecosystems. The digital age will trigger parallel and simultaneous changes between businesses belonging to very diverse industrial sectors. (Gueguen & Torrès, 2004). If the notion of platforms brings up technical questions, there will also be relational considerations embedded within that (Isckia, 2011). The businesses that have such platforms therefore play a key role in ensuring the coordination of stakeholders and in encouraging value creation (Isckia, 2011). The configuration of technical platforms is one of the necessary conditions in order to structure communities such as these, that share the same strategic destiny. These platforms take the form of interfaces but also standards (Edouard & Gratacap, 2011).

This theory draws in aspects of the analysis grid and examines key stakeholder roles in a case study which views the stakeholder system through the lens of a business ecosystem comprised of a diverse range of public and private organisations working competitively in a significantly technological field.

Organisational sociology and the concept of the organised collective action system.

Thanks to the input provided by Crozier and Friedberg's (1977) organisational sociology, the stakeholder system can be explored not just in terms of its being a system of organisations but also in terms of the impact of the individuals' strategy on that of collective organised action. Strategic analysis theory revolves around key empirical concepts that have come out of business and management based organisational sociology studies and then been theorised in several pieces of work such as Actors and Systems (Crozier & Friedberg 1977). These concepts look at power, uncertainty and the link between the idea of power and the concrete action system playing out between actors and their strategy within organisations.

The concepts of power, uncertainty and the concrete action system. According to Crozier (1977) organisations are structured according to power relations. "An actor's power resides in his/her ability, when in relationship with other people, to ensure that the terms of the exchange are favourable to him/her" (Bernoux et al., 2001). There are four sources of power: technical expertise, mastering organisation-friendly relationships with the environment, communication and information management, and proficiency in general organisational rules such as the allocation of funds. (Crozier & Friedberg, 1977). These different sources of power correspond to different sources of uncertainty. In strategic analysis, uncertainty is not exclusively defined by external and internal events that occur but particularly relates to interactions in actors' sometimes "hidden" games (Bernoux et al., 2001). The concrete action system represents the third concept in strategic analysis. It includes formal and informal rules but also alliances between different groups of actors. "It refers to the way actors regulate their relationships, the rules that they impose upon themselves (formally or otherwise) to enable the organisation to function" (Bernoux et al., 2001). Power, uncertainty and action systems are the tools used to analyse organisational operations within the context of strategic analysis. (Bernoux et al., 2001) They provide another approach to the analysis of a stakeholder system,

which no longer alludes to an organisation but to the individuals with their own ways of thinking in their interactions and interconnections with other actors or groups of actors.

The choice to draw upon this theory when analysing the street lighting smartization stakeholder system was based upon one of its main features: the involvement of the political stakeholder and the technical expert. Analysing the organisations with which they are collaborating alone would limit the results of the study to the organisational environment without touching upon their actions, leadership and the specific challenges of the "smartization" process.

Research Methods

An embedded case study, using a pragmatic, action research approach to look at either a single case or several combined, is particularly fitting when it comes to studying dynamic phenomena and complex organisational processes such as, in our case, the stakeholder system and its interactions within the "smart infrastructure" process. Given the individual nature of studying a single case, there will be more focus on comparing analysis and literature (Eisenhart, 1989; Yin, 2017). Studying a combination of several cases generally requires additional methods and resources (Yin, 2017) particularly in terms of data gathering but, once you've carried out targeting on each analysed case, it does enable you to draw conclusions by comparing with other cases (with similar or contrasting results) (Musca, 2006). The embedded case study also draws upon several sub-units and therefore allows for new points of view to emerge and come up against each other, testing out how they fit alongside other units, which in turn further validates it both internally and externally. (Yin, 2017; Musca, 2006). This type of research which draws upon embedded case studies aims to link the detailed and varied collected data so that innovative theoretical results can emerge (Yin, 2017).

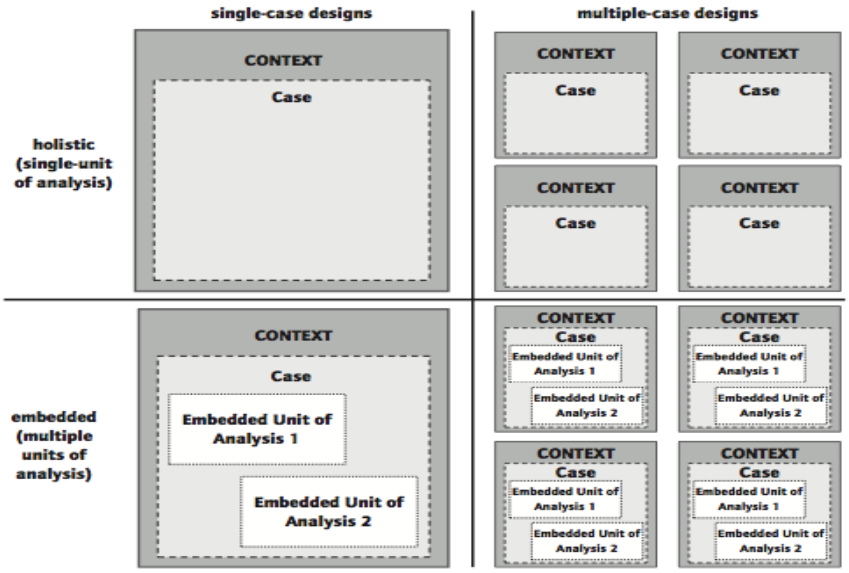


Figure 2 : Basic types of Design Studies (Yin, 2009).

Choosing the cases: Case boundaries, quantity and selection criteria

The case boundaries must be the same as they are within the social system being referenced, where the studied phenomena– ie: the stakeholders and the way that they are interacting within their environment – is embedded. The case study was influenced by the selection criteria within the local authority - which is simultaneously the object of the study and its backer - and the technical system. In addition to criteria based on the ability to access information, the two observed areas need to be geographically close and, in this case specifically, need to be predominantly rural. As for the technical system, it must be able to be embedded within a "smart infrastructure" type process and provide scope for innovations so as to become "intelligent". One individual technical system was identified: street lighting. It has a range of features which can be integrated within the "smart infrastructure" process. Switching to an intelligent system involves implementing aspects of a "smart" project. It is a local service for citizens and it creates challenges for local authorities in terms of energy and cost savings. It also features disruptive technology, such as LED lighting, which enables energy saving opportunities. There is also a need to develop light control applications which can then be customised according to use. The service is then optimised, either by customising the way it is

used and how it is run politically, or by implementing digital applications or disruptive technologies such as the LED, or a combination of these different options.

Research structure	
Strategy for practical and field applications	Embedded case studies
Case boundaries	Local authorities: a French department and a technical system: street lighting.
Unit of analysis	Stakeholder system that includes town councils, energy syndicates that are responsible for street lighting installation, maintenance and works, resource (electricity) operators, street lighting private sector companies and street lighting federations and associations.
Analysis purpose	To identify stakeholders (mapping, profile, role) and study the interactions between public and private (ecosystemic) organisations and (sociological) individuals involved in an innovative initiative to switch the technical system to "intelligent", in the sense of a "smart territories"
Number of cases selected	**Two French departments Maine et Loire (49) and Vendée (85).**
Case selection criteria	A (rural) local authority with access to information, involved in an innovative and reflective initiative which is ongoing or has already been rolled out, featuring a smart infrastructure and technical system: Street lighting.

Table 1 : Research structure

Choosing analysis units

The rule, when selecting analysis units, must be to achieve contrast (Doughterty, 2002). It's in the search for contrasts that it becomes possible to find a potential theoretical theme. Eisenhart (1989) also states that the main selection criteria must be set out within the study's initial framework (Musca, 2006). The stakeholder system was selected as the analysis unit. This analysis unit can be broken down into three sub-units: public organisations, namely energy syndicates (elected members and street lighting operators), energy operators (a key resource where street lighting is concerned), private companies in the street lighting sector and federations and associations that are stakeholders in the street lighting ecosystem.

Table 2 : Features of the embedded case studies.

Features of the two embedded case studies		
Department name	Job/Function	
Maine et Loire department (49): (Elected and operational) staff.	Town mayors	The towns that are part of the Maine et Loire study, are all members of the departmental energy syndicates.
	President of the joint energy syndicates (SIEML)	
	Infrastructure department director (SIEML)	
	Head of street lighting service (SIEML)	
	Street lighting works and maintenance companies (SPIE CityNetworks)	
Vendée department (85): (Elected and operational) staff.	Town mayors	The towns that are part of the Maine et Loire study, are mostly members of the departmental energy provider union.
	President of the joint energy provider union (SYDEV)	
	Infrastructure department director (SYDEV)	
	Head of street lighting service (SYDEV)	
	Head of the union street lighting service (SYDEV) or town council technical service. (Challans).	The head of service at Challans town council, which is not a member of the energy syndicates, was interviewed for this study.
Private national and/or regional companies (Directors and operators).	Area director for Vendée and large-scale project lead for Pays de Loire (Energy operator - ENEDIS)	
	Street lighting operations lead (Street lighting works and maintenance companies - SPIE CityNetworks) in Maine et Loire and Vendée.	
Federations and national associations	FNCCR	
	AFE (Regional presence)	

Data collection

Data collection involved carrying out semi-structured interviews with elected members and heads of services within two joint energy syndicates in Maine et Loire (49) and the Vendée (85). Across these two departments, the energy syndicates are in charge of managing, operating and maintaining the street lighting portfolios for a significant portion of the municipalities or intercommunal authorities by delegated local authority as set out in the General Code on Local Authorities (article L. 212-2). These interviews were carried out individually with the exception of the interview with the infrastructures director and the street lighting head of service within the Maine et Loire joint energy syndicates which took place in the presence of two directors. The interviews with political leaders and operators from the two energy syndicates were carried

out by a street lighting head of service from Challans council in Vendée, which was not a member of SYDEV (the Vendée department's energy and facilities provider syndicate) when the interview took place. Thereafter, there are interviews with private sector company representatives: the area director for Vendée and head of major projects for Pays de Loire for Enedis, which is a subsidiary of EDF and concessionary energy operator across the two Vendée departments, and the operations managers for civil engineering company, SPIE CityNetworks, a subsidiary of the SPIE group and contractor for the street lighting works and maintenance contract across specific geographical areas in Maine et Loire and Vendée, on behalf of two joint syndicates and municipalities across these two departments. Finally, interviews were carried out with the AFE (French lighting association) across the Pays de Loire region as well as on a national level with the FNCCR (The National Federation of Licensing Local Authorities).

Table 3 : Description of the local authorities observed, the features of the street lighting

Area	**Maine et Loire department**	**Vendée department**
Geographic profile and local authorities' structure	The Maine-et-Loire department (49) covers a surface area of 7,106 km², that is to say, 22% of the Pays de la Loire region with 810,934 inhabitants across the department (legal population as of 1st January 2019). Angers, the largest town (151,229 inhabitants), La Lande-Chasles is the smallest (118 inhabitants), it is the 2nd most populated departments in the Pays-de-la-Loire region, and has 21 districts, 177 town including 38 new ones.	The Vendée department (85) is spread across a surface area of 6,720km² with 655,606 inhabitants. The density of population is therefore 98 inhabitants/km². The department is split into 3 boroughs and 17 districts. It has 269 towns and is connected to the Pays de la Loire region. Its prefecture is La-Roche-sur-Yon (52,732 inhabitants) and its sub-prefecture are the towns of Sables-d'Olonne (14,253 inhabitants) and Fontenay-le-Comte (13,647 inhabitants).
Energy syndicates	**Energy Syndicate of Maine et Loire: SIEML**	**Energy Syndicate of Vendée: SYDEV**
Governance	The SIEML, Syndicat intercommunal d'énergies de Maine-et-Loire, is a joint syndicate run by a syndicate committee and an office. The syndicate committee has 54 members. 36 representatives are appointed by 8 constituencies based on the perimeter of the EPCIs. 18 representatives represent the communauté urbaine Angers Loire Métropole, or Angers Loire metropolitan borough council (since Loire Authion was incorporated within the metropolitan borough in 2018, ALM has an additional seat without the total number of commissioners having changed). A president, 10 vice presidents and a member who is assigned the role of syndicate officer. SIEML implemented new governance as of 1st January 2016 to improve its workings and in order to take into account new departmental cooperation between municipalities as well as the creation of numerous new municipalities in Maine-et-Loire. There used to be 380 delegates representing all of the municipality and EPCI members. However, the union committee now has 54 members elected within the constituencies. These electoral constituencies are made up of elected representatives selected by each borough council and each EPCI.	SYDEV, Syndicat départemental d'énergie et d'équipement de la Vendée, is a closed, joint syndicate, which is run by a syndicate committee and an office that is made up of representatives elected by members via the local energy committees (CTE - comités territoriaux de l'energie). Local energy committees: each member of the SYDEV selects two regular representatives and two deputies to represent it within 31 local energy committees which are both consultative organisations and electoral constituencies. The syndicate committee is the SYDEV's deliberative assembly. It is made up of 81 representatives that are elected by the local energy committees. The syndicate committee is the SYDEV's deliberative assembly. It is made up of 81 representatives that are elected by the local energy committees. The syndicate committee delegates another part of its remit to the Office, the deliberating body made up of 24 members including the president and vice-president.
Technical system	The syndicate oversees 100,000 lights and 4,450 lighting meter boxes across 159 towns in Maine et Loire. 90% of those decided to switch off in the middle of the night. The timing of the switch off is determined by bylaws.	More than 90% of local authorities in Vendée transferred the maintenance of their lighting installations across to SYDEV. That represents approximately 140,000 lights in 2017.

Discussions and results

The role of energy syndicates is analysed by exploring three aspects that characterise intelligent street lighting stakeholder systems. Firstly, it examines how the governance (Le Galès P., 2014) and running of the street lighting service succeeds in creating interactions between politicians and technological experts. What kinds of support does it have and what are its strengths and weaknesses as key stakeholder when facing competition within the local authorities' stakeholder system? In the second section, the question of leadership within the digital stakeholder system is considered. How do organisations experiment and position themselves in order to preserve their role as a leader within the stakeholder network? And, finally, the third section looks at the business ecosystem (Moore, 1993) for construction and civil engineering companies and energy operators. How does the energy syndicate coordinate the stakeholders in this market using a coopetition rationale (Edouard, Gratacap 2011 ; Isckia 2011 ; Mira-Bonnardel, Géniaux, Serrafero, 2012)?

Model of governance and organisation of the services of departmental energy syndicates

By drawing upon a governance model (Pierre Le Gales, 2014) that includes elected representatives, town mayors and the EPCI president, as well as the expert street lighting technical service, these organisations are creating a close local partnership and interactions between political stakeholders and technical experts involved in the "smartization" of street lighting. Close ties between the political and the technical enable an intrinsic response to political, societal, economic and technological challenges within the "smartization" process.

A democratic and interdependent governance structure that positions the political, locally elected, stakeholder at the heart of the "smartization" of the street lighting technical system

These public organisations have a governance structure that works around a political office and a syndicate committee. The mayors or municipal councillors in each member town or EPCI appoint regular representatives and deputies that represent them within the local energy committees. These committees are both consultative organisations and electoral constituencies. The energy syndicate committee is made up of delegates that are elected by the local energy committees. Each one of them has a vote in syndicate council deliberations. The political office is elected and made up of a president and several vice-presidents who are in charge of commissions including finances, works related to concession holders, innovation and large-scale projects, as well as cooperation and fuel poverty. The energy syndicates regularly adjust their governance to meet changes in the area.

In addition to its democratic function, this energy syndicate governance brings together town mayors. This creates a kind of solidarity between political stakeholders and elected members from small and medium-sized rural communities as they carry out responsibilities and statutory obligations relating to street lighting in the area. The 'sobriety' objectives that came out of the "smart" process and the technological complexities are not always easy to grasp for rural town mayors, for whom decisions are to be taken in borough councils. In Vendée and Maine et Loire, the two energy syndicates recommend street lighting being switched off at certain times dependent upon the type of road. More than 75% of Vendée cities partially switch off street lighting and more than 90% in Maine et Loire. Rolling out a form of moderation across the energy syndicate street lighting service at a regionalised level also provides support for these elected members when faced with some taxpayers' reluctance at having street lighting provision changed. Particularly as it is a recent and radical change in stance, as pointed out by one of the infrastructure directors at one of the energy syndicates: "*2 or 3 terms ago, mayors*

were getting elected by promising that they would bring lighting to villages. Now that's not what it's about. Now they are saying I'm going to switch it off and it will cost less - despite some residents' reluctance." (Interviewer, personal communication, April 26, 2019)

Energy syndicate technical services as longstanding experts in street lighting providing support and help with elected members' decision-making processes.

The two energy syndicates in Maine et Loire and Vendée have dedicated street lighting services that include engineers and officers that are experts in the technical system. They have huge roles and remits, incorporating regulatory monitoring and managing works and maintenance across the lighting portfolio. These technical services have developed tools to support local authorities that wish to embark upon the switch to "smart" street lighting in making their decision. The two syndicates' street lighting services suggested running a study to develop Schémas Directeurs d'Aménagement Lumière (SDAL - public lighting installation action plans). These action plans involve auditing a town or local area's technical street lighting system and then putting forward a proposal to change the way the street lighting service is delivered according to the town's different uses, replacing worn out equipment with better performing items such as LEDs until a remote management system, which is separate from the infrastructure, can be fitted.

One of the energy syndicates heads of street lighting and operations services pointed out: "*The first stakeholders are the applicants, the members. That's who we are working for. So, towns and groups of towns. When it comes to this subject, they are the main stakeholders. It will be them asking us for a service or a project. And when it comes to innovation, currently, they don't make too many demands really That comes from us, as professionals, who have the expertise to know what can be done, so we'll suggest things*." (Interviewer, personal communication, April 26, 2019)

He elaborated by pointing out the benefits cities experience as a result of joining an energy syndicate: "*Ultimately cities were very pleased to devolve responsibility (for street lighting) to the syndicates and for the syndicates to provide a steer on this because they didn't necessarily have the resources required to do this internally. So, they get the benefit of our experience by devolving responsibility to us."* (Interviewer, personal communicate, April 26, 2020).

The energy syndicates developed their expertise over a long period of time by adapting to technological changes in street lighting and then bringing this to elected members who then embark upon the "smartization" of the technical system in their cities. As well as the technical skills, the energy syndicates manage the financial investments, such as the cost of the operations involved in switching to "smart" street lighting, whether in terms of work phases or maintaining the infrastructure and systems that are set up. The syndicates pool these skills and expertise to benefit all of the towns, on the basis of providing equal, high quality services to all of the local authorities who have signed up for street lighting.

Politico-technological leadership

Energy syndicate leadership within departments can also be supported and strengthened by a more personal leadership style from the president, vice-president and energy syndicates service directors. The Sydev syndicate is very well known and recognised among other Loire valley syndicates, and beyond the regional boundaries. This more personalised energy syndicate leadership style, as demonstrated by Sydev, draws upon a particularly well-developed innovation culture, put in in place by the energy syndicate presidency but, equally, the elected members and president taking ownership and mastering the different systems being implemented (energy, technical, digital). This innovative leadership style in Vendée also benefits other syndicates that interact with Sydev. It would be interesting to further explore the politico-technological profile of public body leaders working with the challenges of energy

transition, digitalisation and mobility and street lighting use in more detail could be an extension of this study.

Support and competition within local authorities

Between support of the National Federation of Licensing Local Authorities and France's lighting association as well as the emergence of an informal group of energy syndicate technical experts. Within the stakeholder system, FNCCR, the national federation of licensing local authorities are strongly represented and the AFE, France's lighting association, plays a supportive role in connecting different stakeholders. The FNCCR's street lighting service runs a national network of experts, organises working groups and develops training for elected members and for staff working for syndicates that are in charge of street lighting. The FNCCR is a very active national organisation but does not have a regional presence. The AFE is a national association with regional outreach, which brings together all of the stakeholders from both the public and private sectors. These organisations are a real source of support to energy syndicates in terms of developing skills and sharing experiences as part of the innovation process. The FNCCR runs several commissions that take a specific interest in intelligent street lighting which overlap with others with a more generalised approach (for whom "smartization" of technical lighting systems is just one element of the work). One of the Infrastructure directors explains that the digital aspects that the FNCCR "smart" commission addresses are also relevant to street lighting: "*The smart working group that they (FNCCR) had created is very focused on communications protocols such as LoRa etc. Actually, that can be used for street lighting too."* (Interviewer, personal communicate, April 26, 2020).

Running alongside these official organisations, informal exchange groups take place between energy syndicates in order to share experiences. The different energy syndicate heads of street lighting services get together in an informal manner as a network of experts in order to share experiences, difficulties and successes as they experiment with the "smartization" of

street lighting. These have come about as a result of these public organisations not having a nearby space or location in which to meet in order to discuss their innovation projects without needing to mix with stakeholders from other working environments.

One of the operations and maintenance heads of services at one of the energy syndicates explained that: "*We know each other within the energy syndicate world and we are sharing more and more. As far as I'm concerned, that was not happening 5 or 10 years ago. These days we are always exchanging information... We have to work together on quite a few issues. For the past two years now, we have a working group that is specifically for street lighting in Pays de Loire, working with other Loire valley and Calvados syndicates. These 5 syndicates form the core the group and now we have almost all of Brittany and la Manche joined us two years ago... It enables us to share information and skills and that's been quite a new development...!"* (Interviewer, personal communication, April 26, 2019)

FNCCR and AFE, as well as informal regional groups act in a supporting capacity and take part in skills development initiatives within energy syndicates. These organisations participate when energy syndicates want to give feedback on their experiences, and they provide backing for energy syndicates to position themselves as leaders in the public organisations' ecosystem.

A public organisation in competition with other local authorities (municipalities, EPCIs that aren't part of the syndicates, cities). Does the governance of the Maine et Loire and Vendée energy syndicates and the experience that they have acquired over a long period of time (Poupeau, 2015) give them legitimacy in the eyes of departmental municipalities and EPCIs? Energy syndicates are not unanimous and are still in competition with other local authorities within the department (Poupeau, 2019). First among those are municipalities that are not members of the energy syndicates and have their own street lighting service. They want to retain political, financial and technical independence where street lighting services are

concerned. It is difficult to accurately set out the reasons and trends for not taking part in an energy syndicate. This could be the object of a more in-depth study. Unlike the municipalities that do join an energy syndicate, they do not benefit from the pooling of expertise at departmental level and seem isolated when facing the complexities of the "smartization" of street lighting, which requires developing a new set of skills.

In the case of Maine et Loire another type of competition appeared when the Angers Agglomeration launched their intelligent spaces project in 2019. Although Angers Loire Métropole is a member of the Sieml energy syndicate, the municipalities within the outer suburbs of Angers, which had been energy syndicate members up until that point, got absorbed within this large metropolitan "intelligent spaces" project which reduced the number of lights that were then managed by the energy syndicates. More than 23,000 lights went over to being managed by the Angers city project, that is to say almost a quarter of the street lighting facilities managed by Sieml. The towns of Saint-Gemmes sur Loire and Trélazé which are part of the Angers Agglomeration, but are in favour of being integrated within an energy syndicate in the Metropole project. It's therefore Engie Solution, a private company that is part of the consortium that won the "Angers Intelligent Spaces" bid that will operate the street lighting facilities for these lights rather than the energy syndicate.

This democratic and inclusive governance, which is combined with the technical expertise of their operations services, plays a part in the departmental energy syndicates' leadership within the public sector stakeholder system involved in street lighting "smartization". These public organisations include the two stakeholders involved in the interaction: the political stakeholder, who is represented by the elected member with regulatory responsibility for street lighting services (also the link with taxpayers, inhabitants and service users across the local area) and the technical stakeholder because the energy, technical and digital systems within the service need to be modified both in terms of their operational

procedures and their technological innovation. When implementing "smartization" across a localised service, these two stakeholders must synchronise the political decision-making process as well as technological decisions, so as to meet the objectives of the smart process, namely saving (energetic and financial) resources. Despite this wide range of benefits the energy syndicates can get into competition with other public organisations such as some municipalities, EPCIs and large agglomerations (Poupeau, 2019) that want to retain their autonomy during the "smartization" of their city.

Digital skills and experimentation: From data collection networks to GIS platforms and public lighting remote management

Energy syndicates are getting organised by integrating new digital expertise within their services in order to be skilled in the digital elements of intelligent street lighting. This becomes strategic in the context of the stakeholder system.

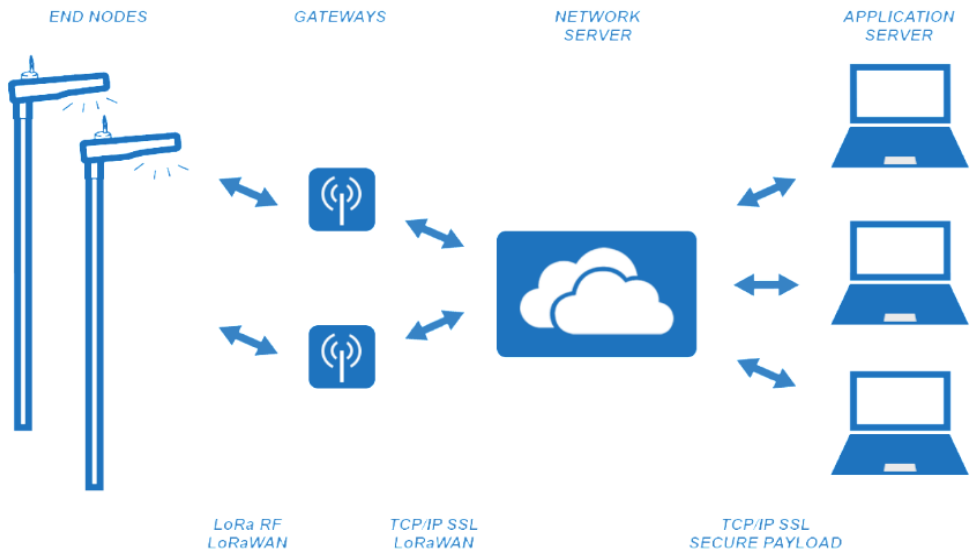


Figure 2: EP Intelligent digital system structure - MI System 2018

Energy syndicates are required to gain skills in telecommunications networks for data collection

Choosing a telecommunications network for data collection is the first technological challenge within the digital system when implementing a "smart" street lighting solution. Initial pilots were considered to have somewhat failed due to reliability issues in communicating data as well as operations and maintenance costs, particularly in terms of radio and GSM network solutions. One of the EP operations and maintenance heads for one of the energy syndicates points out that: "*In the examples that we have been able to test, street lighting works well with remote management systems, but it is often the communications that fail. And these systems really heavily on either PLC, or GSM. There are several different communications systems linking the different devices. But the aim is to be able to send commands from a web platform to the lights telling them to switch off or dim and vice versa, and there must be a back and forth of information."*

One of the two energy syndicates networks carried out several pilots with different telecommunications networks technology. The syndicate's head of street lighting services explained: "*The low-power telecommunications networks such as Lora seemed to provide more appropriate solutions. We are carrying out quite an involved pilot project. We'd already put four remote management systems out to try in the control cabinets using GSM solutions and we installed two Lora ones just over a year ago. We're considering rolling out our own network".* Talking about communications networks infrastructures, he adds: *I think that throughout its history the syndicate has proved that it can pool facilities with local authorities, EPCIs and municipalities. And that is a string to its bow."*

These telecommunications networks are not limited to just gathering street lighting data and will be able to be used to gather data with a view to using it for the "smartization" of other technical systems managed by the energy syndicates.

The other energy syndicate is awaiting feedback about its Lora network piloting scheme from an energy syndicate in Brittany which was the result of an informal expert information exchange. "*A syndicate that joined us (an informal information sharing group for syndicates) recently is testing the Lora network on quite a large scale. With regards using the Lora network, I'm actually going to, above all, wait and see as they are quite far along in the pilot scheme. We've decided that they are going to feed back on the experience at our next meeting and we are going to have a discussion around it."*

Although making these decisions about telecommunications networks requires energy syndicates to increase their digital expertise, it strengthens their positioning as leader. It even provides an opportunity to further advance this leading position within the street lighting stakeholder system in other technical systems within their fields of expertise that could make use of this same data gathering network.

Interoperability between remote management systems and SIG platforms.

Selecting a remote management system that is connected to the SIG geographical data platform plays a determining role in the "smartization" of the street lighting technical system. These applications can provide geolocation for infrastructures and lights in order to create the synoptic visualisation of its operating order. This image mapping then enables the control of "smart" technical system operations. It is complicated for energy syndicates to have several remote management solutions coexisting, particularly as they are managed by different stakeholders working within the same area. In fact, the companies that provide remote management systems are either construction and civil engineering groups or lighting suppliers and sometimes have different technologies.

Head of operations and maintenance for one of the energy syndicates explains that: "E*verybody was suggesting their system, saying we've got this company or that manufacturer's system. Then we have Philips offering us theirs, and me as an operator, operating more than*

150,000 lights, I can't have 5 or 6 different platforms. It's not manageable... What's lacking in all of these manufacturers' offers, is that all of these systems need to be open and able to be integrated with SIG... so they can be interoperable." This difficulty forces the energy syndicates to play a key role as system aggregators while maintaining control over the data for their lighting facilities and imposing system interoperability (Courmont, 2018).

The energy syndicates' maintenance expertise is widened to include digital system infrastructure and software

Infrastructure maintainability challenges become more complex due to the need to organise maintenance for these new infrastructures and digital system software applications (SIG: geographical data, remote management: working order, maintenance and asset management: listing the facilities, breakdowns and call-outs). The energy syndicates' role is broadened as it coordinates infrastructure technical systems maintenance stakeholders in working with these new digital systems that are integrated within the smartization process. Mastering the maintenance operations procedures for digital devices becomes a new asset for energy syndicates in this role as stakeholder system leader.

Energy syndicates compete by gaining control of the street lighting digital system

Whoever is in charge of data control the digital system's operational optimisation process. Even if this has not taken place in the Maine et Loire and Vendée departments, it should be noted that in other adjacent departments, digitisation syndicates[1] took the initiative to put Lora type data gathering networks in place locally, including for street lighting. In this case, the digitisation syndicates take part and become a stakeholder in the street lighting "smartization" process. If these pilots become widespread among other technical systems, the digitisation

[1] Digitalisation syndicates are public bodies that must ensure that all stakeholders involved in rolling out high speed broadband across the department.

syndicates will then become a competitive stakeholder in its role as key energy syndicate stakeholder because it has control of a strategic part of the digital system (data gathering and data management networks).

The expertise that is in the process of being developed by two energy syndicates from Maine et Loire and Vendée (acting as both data gathering network operator and remote management "systems aggregator" connected to the SIG data platform) will enable them to control all of the components of the digital system within the technical system smartization process. Controlling the digital system and data (Courmont, 2018) with a view to switching to smart street lighting plays an essential part in their role as leaders of the "intelligent" street lighting stakeholder system.

Coordination and cooperation of the business ecosystem by departmental energy syndicates.

The key business ecosystem stakeholder is in control of the key resources (Donada & Fournier, 2014; Ben Lataifa & Rabeau, 2012) and must be able to coordinate stakeholders and enable them to collaborate (Gueguen & Torres, 2004). It ensures that value creation is reallocated (Iskia, 2011) while maintaining a competitive mindset on the market. In the case of intelligent street lighting, it is the energy syndicates that provide that coordinate stakeholders throughout this innovative process while also maintaining a competitive mindset on the market. They enable a type of coopetition within the business ecosystem which is a combination of collaboration, coordination and competition (Iskia, 2011). The departmental energy syndicates interact with all of the market stakeholders, have experience coordinating (public and private) stakeholder networks involved in technological innovation and are able to offer private companies a competitive environment.

Energy syndicates interacting with all private sector stakeholders are in a central position: from energy operators, to digital players via construction and civil engineering companies (works and maintenance)

The departmental energy syndicates are in a contractual relationship with all of the market stakeholders across the three functional components of the street lighting service.
For the first component, energy, three stakeholders are involved: EDF, RTE and ENEDIS hold contracts with energy syndicates. The high/low voltage distribution network, which is wired into the street lighting system electrics, is a concession contract (Poupeau, 2015b) which is negotiated with the operator ENEDIS over several decades for both the Maine et Loire and Vendée departments.

In terms of the street lighting technical system, construction and civil engineering companies operate technical system facilities and infrastructure on a long-term, 3 or 4-year, contract based upon geographical divides. The department is split into several geographical areas for street lighting infrastructure works and maintenance operations. Another category of stakeholders in this ecosystem are lighting equipment and technical system control cabinet suppliers. In the vast majority of cases, construction and civil engineering companies purchase lighting equipment.

For the third component of the operational system, energy department syndicates have often contracted with the construction and civil engineering company that is in charge of that geographical area and the borough council that is experimenting with a switch to “smart” street lighting. It is therefore this stakeholder that carried out the works and rolled out the equipment and remote management applications. The energy syndicates then played a coordinating role between all of the stakeholders. ENEDIS also attempted to position itself within the digital system by offering to take part in developing a SIG platform in partnership with a syndicate, working in the maintenance and installations field and providing applications related to energy

consumption data. This application which was called “Linky Lux” was able to identify malfunctions on the network linked to energy consumption anomalies recovered by the Linky meter. ENEDIS’s strategy would enable it to increase its influence - which is already quite substantial within the energy system - even further across the whole ecosystem. The unfortunate experience of a syndicate which got involved in a pilot following the collapse of a start-up due to financial difficulties, should also be noted. This company had developed equipment that enabled lighting to be managed at a distance with a remote management system. This created difficulties for the syndicates. The system is still in place but there is no longer any maintenance equipment.

The syndicate is interacting with all of the private sector stakeholders working across the three-street lighting operational components within the sector. This stakeholder system, which is rolling out an innovative street lighting optimisation service, is still evolving, and is perhaps even unstable. Indeed, there are risks such as the economic fragility of innovators as well as possible reconfigurations should Enedis strategically position itself in the digital domain.

Expertise and experience in coordinating a network of public and private stakeholders that are part of a technological innovation dynamic

The responsibility for street lighting was transferred to energy syndicates in 1998 for Sieml and at the beginning of the 1990s for Sydev. For several years, Vendée and Maine et Loire energy syndicates have been gaining experience in coordinating a network of stakeholders involved in innovative processes in other areas of competence such as, more recently, rolling out intelligent electric networks solutions, monitoring and infrastructure solutions and electric vehicle charging stations for electric mobility. These experiences in other areas of expertise enabled the energy syndicates to strengthen their skills in coordinating a varied stakeholder

network which is involved in an innovative process embedding technological complexities within three types of street lighting system (energy, technical and digital).

Business ecosystem positioning which can compete in the street lighting market

The syndicate is coordinating this stakeholder network, which includes energy operators and construction and civil engineering companies, while remaining competitive within the street lighting market. It sets the competition rules (Gueguen & Torres, 2004). Where the energy system is concerned, the competition between concessionary markets in electricity distribution and supply appears to be very unbalanced between the national energy operator ENEDIS and the departmental energy syndicates. Despite this, however, the latter manage to negotiate with the long-standing operator on long term investment commitments, the quality of the energy service and principles such as fair and cooperative services and fuel poverty. Furthermore, even if pilots are still limited, the development and local production of energy, as well as renewable energy, can strengthen the autonomy of energy syndicates in energy production. In Vendée, over the past few years, Sydev has taken part in several pilots such as Vendée "Smart Grid". This project involved establishing the active management of locally produced energy on a large scale, in particular to supply street lighting installations (1,250 lights involved). This demonstrator project was a real laboratory for regional experimentation in the guided (or intelligent) management between energy production and energy consumption, incorporating several sources of energy production. The Vendée energy syndicate was one of the main stakeholders in this project. The energy syndicate also tested the installation of solar panels on lights in remote areas. All of these experiments demonstrate the key, and leading, role that energy syndicates play in setting up competition at a local level both in terms of energy production solutions and energy system stakeholder contracts.

The street lighting infrastructure works and maintenance markets, are subject to consultation and competitive procedures with construction and civil engineering companies every four years by the energy syndicates. These markets are not limited to street lighting and include several other activities such as landfill works and electricity network extensions. These companies are usually local operational branches of large national construction and civil engineering groups or regional companies. They have the resources and expertise to operate the energetic, technical and digital street lighting systems. Despite this, the technological complexities of the "smartization" process involve investments, innovations and experimentation as well as these construction and civil engineering companies developing competencies which they won't all have the financial resources to do. This situation could bring about a reconfiguration of the stakeholder system for the construction and civil engineering companies involved.

The central positioning of energy syndicates within the street lighting market ecosystem enables them to be in a position to collaborate with all of the stakeholders and to coordinate the varied stakeholder network in this innovative "smartization" process while maintaining competition with market stakeholders. The energy syndicate can then play the role of leader and develop a type of coopetition within the intelligent street lighting ecosystem and within the three-component energetic, technical and digital systems.

Limitations of the study

"System of stakeholder systems" for one service only

In order to carry out an in depth and detailed "smart infrastructure" stakeholder analysis, the study focused on just one service alone, a single technical system, that of street lighting, which has real "smartization" potential (energy saving, providing new technologies). Drawing upon its process and the three services (energetic, technical, digital), the study's originality lies in its three stakeholder categories and the interactions between them: the political and the technical occurring within local authorities, digital system stakeholders, whether public or private, as well as those from the business ecosystem. Ultimately, the "smart" system could correlate with a "stakeholder system" (whether that's political - technical expert, local authorities, digital stakeholders and business ecosystems) that is interactive, if not interdependent.

The hidden assets of a rural environment in the "smartization" context

The second unique aspect revolves around the profile of the area involved in the study. The "intelligent city" literature is primarily focused on the challenges faced by big cities that have experienced an unprecedented migration flow. This situation requires a rethink in order to reorganise different aspects of town life by drawing upon digital opportunities. Due to the over-representation of the urban environment in the literature, it seemed pertinent, to us, to take the multiple current studies available about cities, which look at the current energy transition, digital, uses and services challenges, and apply it to rural areas. Especially since an extended approach to "smart places" is nevertheless starting to make an appearance. This focuses on a range of both urban and rural spaces, while maintaining the city as the basic unit on a regional scale.

Citizens - Residents and Users

It might have seemed an oversight not to mention the position and role of the "end user", that is to say the citizens or resident, in a study of the "smart" process. Indeed, citizen partnership in the changes and developments in new services as users, as well as their involvement in the process of making the service" intelligent, are features of the smart places stakeholder system. In our case, this area was not expanded upon because the citizen for whom the street lighting is provided, is of course an important stakeholder but does not directly get involved in the process of transforming the service and rendering it smart. Citizens are not really associated with it and their influence lies in the uptake of their mayors' decisions.

Future research

The themes of governance (Le Galès P., 2014) and coordinating the "smart infrastructure" (Anthopoulos, 2017) stakeholder system still seem deficient and will need to be examined in further depth in line with objectives around saving resources in urban and rural areas. Smartization turns the roles that each of the stakeholders have played in previous organisations on their heads, going as far as to bring into question the local authorities' sovereignty in the face of large services and digital operators. The allocation of roles in the implementation of energy transition has seen institutional changes relating to previous stakeholders and shared authorities such as energy syndicates and city councils. This was brought in by the MAPTAM and NOTRe laws (Poupeau 2015a), (Poupeau 2020). A comparative study of the stakeholder system of these different local authority profiles would offer a key to understanding the governance in place and the way that each approaches the substantial "smart infrastructure" challenges. A second approach could involve focusing on the services and uses. The study of stakeholders involved in a "smart" process across several sectors

could enable the analysis of the real benefits and risks of horizontal integration across a city's different silos and flows of direction: energy, water, waste, transport. (Daniélou, J. & Ménard, P, 2014).

Conclusion

Street lighting "smartization" brings into a play a diverse stakeholder system and a variety of interactions. This raises the question of an organisation's capacity to oversee this stakeholder system. The combination of stakeholders requires complex coordination which involves both political stakeholders and digital technology experts as well as all public and private stakeholders in the street lighting market.

In the first instance, the energy syndicate literature and the case studies carried out in two rural areas show that the political governance and organisation model of this public body's services help with its role. In fact, it places **political and technical experts within a politico-technical interaction, if not interdependence.** This democratic governance, and the interactions between the political and technological environments, allow the rural areas to commit to concrete energy transition action while developing a form of solidarity among local authorities and the mayors of these towns. Despite their assets, the energy syndicates are subject to competition within their departments' public organisations such as the EPCIs and towns that do not want to rely upon the energy syndicate's services and want to maintain their autonomy.

Secondly, drawing upon studies of smart city digital stakeholders, the article demonstrates that the digital world reinvents operative processes and involves key historic stakeholders in **experiential ways of working and digital skills acquisition.** Strategically choosing autonomy and independence from telecommunications data collection networks and street lighting remote data management platforms enables them to strengthen their leadership

position within the stakeholder system. The coexistence of diverse digital solutions for remote management across one area positions the departmental energy syndicates as “systems aggregators” and requires interoperability on the part of the stakeholders. When it comes to the digital aspect of “smartization”, energy syndicates also face competition. Digitisation syndicates are another type of public stakeholder that could aspire to play a leading role in the smartization of rural areas.

The third aspect refers to the economic stakeholders in the market and its business ecosystem. Finally, energy syndicates that have historically coordinated this stakeholder network, from energy operators to civil engineering companies, **maintain a competitive edge** in their respective markets. The experience of coordinating a network of public and private stakeholders working on technological innovation strengthens the energy syndicates’ leadership position. Consequently, they take on the role of key stakeholder in a type of coopetition within the business ecosystem involved in street lighting “smartization”.

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Acronyms

ADEME	The French Environment and Energy Management Agency
AFE	French lighting association
EPCI	Public Establishment of Intercommunal Cooperation
FACE	Electrification Charges Depreciation Fund
FNCCR	The National Federation of Licensing Local Authorities
GSM	Global System for Mobile communications
LORA	Long Range Technology
LED	Light Emitting Diodes
PLC	Power Line Communication

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