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Redefining Urban Players

in partnership with ENGIE

CONTENT

3 Chloé Gaspari, Jean Danielou
Editorial

4 Louis-Frédéric Robin
Engaging with local stakeholders to create social and environmental value in urban (re)development

8 Yolène Berrou, Prof. Eddie Soulier, Dr. Philippe Calvez
Identification of smart city development strategy's profile for use case simulation

15 Maria Giorda, Olga Kavvada, Jean Daniélou
Using a Network-theory based approach to identifying, mapping and classifying civil society actors in urban communities

24 Marc Daumas
Reinventing ENGIE's positioning on urban activities

29 Nicolas Hatem, Jean Daniélou
Opportunities and challenges in urban infrastructures management: How to procure and implement large and digitalized infrastructure systems?

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Publication Director | Prof. Matthias Finger

Editor of this Issue | Chloé Gaspari

Publishing Manager | Chloé Gaspari

Designer of this Issue | Ozan Barış Süt

Publishers | Chair MIR, Matthias Finger, director, EPFL-CDM, Building Odyssea, Station 5, CH-1015 Lausanne, Switzerland (**phone:** +41.21.693.00.02; **fax:** +41.21.693.00.80)

Email | iglus@epfl.ch **Website** | www.iglus.org

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The rise of the smart city expression in the early 2010's had a dramatic impact on the representation of the city as a global market. Consultancy firms played a key role in turning this market horizon in a ready-to-hand business opportunity, announcing through market forecasts that smart city market segment weighted up to trillion US dollars.

One striking element was the sudden apparition in the urban fabric of players coming from the ICT industry, like IBM, competing with historical private players, like Engie, to equip cities with infrastructures and solutions. If ICT players and digital technology-oriented solutions gained momentum during the first half of the 2010's, second half of 2010's witnessed both the backflow of ICT players, that culminated this year with the cancellation of the controversial 'Sidewalk Toronto' lead by Alphabet/Google, and the digitization of historical players capabilities and offers.

From an academic perspective, lot of attention has been given to the tormented story of these newcomers that, in 10 years, got kicked out of an urban market that they first helped to create. But almost no research efforts have been done to explore how historical players have transformed their traditional businesses to conciliate this digital impetus with their existing capabilities and cities' new needs for a more sustainable and more inclusive development of urban projects.

Taking advantage of the relationship IGLUS developed with Engie since 2018, this Quarterly aims at presenting some aspects of Engie research streams and positions in the urban fabric to fix this academic asymmetry and also open a perspective on how private players translate and interpret urban challenges. The articles of this special issue have been written by the research teams of Engie Computer Sciences and Artificial Intelligence (CSAI) Lab. Two interviews are complementing them, giving an operational perspective of the transformations undertaken by Engie to position itself on the urban market. The words of Louis-Frederic Robin, Director in charge of Cities, Public Lighting & Safety Solutions at the Global Industrial Hub, Acceleration Task Force, opens this publication to explain the crucial issue of addressing local stakeholders while implementing new urban models to create social and environmental value.

The first article then introduces a digital tool supporting public decision making currently under development at CSAI; while the second one presents a methodology developed by the CSAI to assess local urban contexts by mapping stakeholders. It aims at representing their relations and filtering their relevance thanks to criteria like activity, legitimacy or representativity.

In the second interview, Marc Daumas, CEO of ENGIE Solutions Aire Nouvelle, analyses the reconfiguration of business models through the development of real-estate activities within the Group.

The last article focuses on the contractual relations between public and private players when implementing large and digitized infrastructure projects. If digital solutions are transforming urban infrastructures management, they may challenge the traditional governance of urban infrastructures and provoke contractual innovations.

We hope you will enjoy reading this issue on the transformation of urban development models, co-produced with our partner ENGIE. At IGLUS, we aim at providing a platform to our partners and contributors to encourage debates on approaches to city-making and are looking forward to continuing the discussion, especially in this very specific context of the (post-) COVID-19 crisis. Would you be willing to contribute, we encourage you to contact us at **chloe.gaspari@iglus.org.**

Jean Danielou, ENGIE

Chloe Gaspari, IGLUS

The IGLUS Quarterly Issue has been edited in partnership with ENGIE.

Engaging with local stakeholders to create social and environmental value in urban (re)development

Louis-Frederic Robin

Interviewee's Profile

After an initial path of his career in major energy groups, where Louis-Frederic Robin held several managing positions especially in energy network activities and renewables in particular onshore winds farms, he was requested to join the Corporate body of ENGIE.

Within the group Performance plan, he held the role of Director in charge of operational categories to improve the procurement of operational activities delivering more than 1,8 bn EUR recurring savings.

In 2016, ENGIE set a new corporate body to support the 24 business units called "metier" where Louis-Frederic Robin was appointed as Vice President of the Midstream Gas Chain activities to support their expansions including new gas such as biogas and hydrogen.

In 2019, Louis-Frederic Robin became the Head of Smart Cities and infrastructure for ENGIE Group. He leads the strategy, the development and the urban innovation activities towards decarbonising territories and make them sustainable.

How did ENGIE develop its strategy to support the energy transition in the territories?

ENGIE works along with regions and territories through various offers addressing street lighting, mobility, energy efficiency in public buildings, video protection and heating and cooling networks. Overall, this panel of offers was the Group's spearhead in the territories.

Today, there are two factors that are changing the situation: on the one hand, the climate emergency and, on the other, the will of elected officials to transform territories and make them sustainable. For the Group, such change has several implications. First, it questions the ability to compose and assemble these mature offers in a unique way, linked to the territory's needs. Then, it is how to integrate these offers by developing a digital infrastructure that will help the city integrate these traditionally-separated markets.

Within ENGIE, it also means working on our ability to talk to each other and work together, to make the link between the offers, to demonstrate that each one has value for the other, with the digital layer that makes the link between them. The reconfiguration of the external landscape will also have an impact on the offers we will be able to bring to the territories.

The climate emergency and the desire to leave a sustainable footprint the territory is something that is claimed by elected representatives and is expected by citizens. We see that there is an alignment between the public entity and consumers. They are ready to make efforts, they are ready to invest and to change their behaviour to achieve these objectives of environmental preservation. It was not the case until recently. The tendency was rather to green and decarbonise the offers, to make them more efficient, but there was no such willingness to change.

How does this willingness to change impact your offers?

The impact is significant since effectively decarbonising a territory requires to articulate a technical roadmap of solutions that complement each other while engaging with the stakeholders involved to a greater or lesser ex-

tent, depending on the impact of the solution. For instance, the inconvenience generated from changing a light bulb or from regenerating infrastructure will affect the users' everyday life differently. It must be taken into account. Let's take the example of an elected representative who wants to create a tramway: it becomes a public transport infrastructure, developed to have a positive impact on the carbon emissions of transport. The elected representative must ensure that it will have users. If residents keep using their private car, without changing their habits, it is because this very stage of engaging with the parties has not been considered properly.

For ENGIE, this paradigm shift leads to a reconfiguration of our external landscape. We now encounter urban customers who are ready to create integrated offers with a player such as us. It questions our ability to become owner or co-owner of infrastructure with the city as well as our financing capacities. Our goal is to position the Group as a strategic partner and not just a technical partner of the territory.

In terms of stakeholder engagement, for ENGIE, it implies key partnerships with local players and a specific way of organising our teams. The local partner should help us to engage as closely as possible to the field and develop tools to understand this ecosystem. It is a very sensitive subject and the example of Sidewalks in Toronto is emblematic, on these aspects of data management and stakeholder engagement. We need to rethink this partnership model to get them on board. This is becoming almost the major criterion of success, especially because the technical solution is often already available on the market. We build this positioning to address local needs and develop projects with a positive impact.

Where is this innovative positioning already being implemented?

In France, which is ENGIE's historical territory, we have a contract with the city of Angers, which aims at developing a smart territory[1]. Only a small number of French cities have initiated this move. Some countries are faster: in the United Kingdom, for example, there are around fifteen cities that have affirmed the climate emergency and the desire to decarbonise their territory by 2050. They use a contractual model which consists of building a public-private company into which the city brings its assets, with a strategic partner and a financier as co-shareholders. It has a very clear governance, with the public authority's lead. Local governments are willing to maintain their sovereignty, so the management of their assets is not completely delegated to the private sector. They ensure a neutral use of infrastructure on the territory and therefore, must keep control over it. Such positioning can be translated into shares held by the municipality into the company created, but it has overall control of it in any case. The UK has long been accustomed to delegate public services to private or third parties under this form of governance.

For instance, the city of Bristol is planning to achieve carbon neutrality[2] through its City Leap Programme. The municipality is currently seeking strategic and financial partners to co-construct the technical roadmap that will decarbonize the territory, through the revamping of its major infrastructure in the energy or mobility sectors. The city provides bidders with a very exhaustive set of data that allows us to imagine the solutions we could implement and is expecting an actor having the capacity to engage with local stakeholders to ensure that the technical roadmap gets local support. Overall, the city expects a capacity to develop social return on investment. It means that, beyond their technical value, solutions will create value on the territory in terms of the environment, resource management and economic creation, especially regarding jobs. It is an emblematic project, which plays a pioneering role in initiating territorial transformation.

In other parts of the world, the movement is slower. There is a political will and an expectation, but the contractual models have not yet been developed. For the time being, many smart city projects are linked to technology and equipment, especially sensors, and we are monitoring them with vigilance. For ENGIE, what we call a "smart city" is much more than that.

[1] http://www.smartcitymag.fr/article/458/le-projet-de-territoire-intelligent-dangers
[2] https://www.energyservicebristol.co.uk/wp-content/pdf/City_Leap_Prospectus%204-5-18.pdf

How does this positioning differentiate ENGIE from its competitors?

Our competitors are building consortiums to challenge us on these integrated offers. We are also bidding in consortium when we are missing some skills like water or waste management, that are the core business of Suez for instance.

There is however a specific positioning for ENGIE, which is unique in the variety of its activities. We are therefore able to take risks on different steps of the project's value chain: upstream, on commodity since we are an energy producer, on urban planning and design thanks to our affiliates Tractebel and ENGIE Impact, and downstream, with our project delivery competences. Our activities are disparately distributed worldwide, thus we must sometimes combine local skills with expertise from other entities within the Group. Sometimes located in other country. It is changing since ENGIE has begun decentralizing its activities a few years ago to strengthen its local subsidiaries.

What about the ability to finance? Can you tell us more about that?

There is a lot of money available worldwide, with large investment funds seeking to finance carbon neutral project in cities. The difficulty is rather to find a client – local government - that can propose bankable projects allowing to transform infrastructure in a sustainable way, with an appropriate level of digitalization, to obtain, 15 years later a high-performance and decarbonised asset that improves the services provided on the territory. The levels of return on investment, particularly on heating and cooling networks as well as renewable energy, are lower than what these funds are used to. Improving profitability is possible through strengthening the assets' overall performance, while creating social and environmental value.

In terms of urban development, what changes need to be made?

There is a need to propose new models of urban development that will reconcile decarbonation with quality of life in the city. It is obviously possible to improve local performance by forbidding car use in urban area, with minimal street lighting at night… But this is not what urban space is about. Cities have been originally created for human beings to live together in better conditions in a given place. So we need models and strategies for city development that integrate this aspect of better living, together with technology and financial resources. Such sustainable strategy is quite new and represents a significant change from the last 30 or 40 years of urban sprawl.

There are urban spaces with sizes preventing the combination of quality of life and decarbonation to be resolved. Take the example of Santiago de Chile, which is six times the size of Paris. Switching to decarbonising mobility solutions in this type of space is impossible! We will no longer be able to develop massive infrastructures corresponding to these gigantic cities. We will have to choose a smaller scale – perhaps the neighbourhood scale - to recreate coherence and the condition for people to live together. It works well for mature territories but also for developing countries. On the African continent, there is great population growth, a strong climate emergency, high poverty, sub-Saharan developing megacities and, alongside this, infrastructure development plans that are only dotted lines. They will not be developed because it is no longer possible to create them. We need to think about the mid-grid, about the scale of a sustainable, energy self-sufficient neighbourhood. And it is the aggregation of these neighbourhoods that will make a sustainable system. It means thinking on a human scale and strengthening resilience locally.

We will need public policies that address two dimensions: a macro-level that envisions the city as a large and complex object, coupled with a micro-level that coordinates the multitude of small sub-systems so that they live together, avoiding disparities and segregation. The only actor who can decrease them is the public authority since it can modulate its actions according to the territory's needs. For instance, we see local governments reaffirming their powers over the distribution of economic activities, allowing corporations to establish their activities according to local needs in terms of job creation, to ensure the creation of local value. It is fundamental for urban policies.

How do you view urban policies in France?

I believe that there is a difference to be made between urban policy and strategy. In terms of policy, for the last thirty years or so, the elected representatives have above all been keen to make their city grow to receive subsidies. It was about exceeding the 10,000 inhabitants threshold to obtain them. We can talk about mixed results, particularly in terms of the quality of infrastructure that has supported these developments. On the other hand, there have been development strategies that have worked well. I can talk about Houdan, a town in the west of Paris. The Mayor Jean-Marie Tétart, who worked on the development of cycling policy in France, had a policy in his town that only favoured local businesses. National or international chains cannot rent a space in the city center. As a result, it is today a city with one of the lowest unemployment rates in France, because this local value creation. Infrastructure have been developed to support this policy, such as specific free car parks for business owners with charging stations for electric vehicles, thus leaving spaces in front of the stores for potential customers. He created this type of virtuous loop, which is also the result of a vision and political courage.

Today, both the climate emergency and the will for better living conditions are becoming very strong: the next emblematic mayors will manage to reconcile these issues within their vision and strategy, with citizens ready to change. In Paris, Parisians are relatively satisfied with the measures taken to limit the number of cars within the city, particularly on the pedestrianisation of riverside streets. There will be no turning back as residents have now reclaimed those spaces that were initially designed solely for cars. The municipal team had a strong strategy on this issue and did not negotiate despite the protests, due to the necessary adjustments in residents' behaviour. But the citizens are ready to change if they receive support, such as subsidies or an extension of public transportation. Both sides must meet. The COVID crisis has also forced people to give up on some things, and city dwellers have discovered new benefits in having car-free cities for instance. It is interesting to see how this will sustainably transform our habits.

Identification of smart city development strategy's profile for use case simulation

Yolène Berrou, Prof. Eddie Soulier, Dr. Philippe Calvez

Abstract: *The ability to offer energy-centric solutions that are adapted to cities and at the same time take into account the particular context of urban environments remains complex when it comes to addressing challenges such as the ecological transition to sustainability. Indeed, activities or projects developed in cities are not all coherent due to heterogeneous city components, different political orientations across time or available budgets. To help identify city's situation and projects to be implemented to improve city strategy coherence, a novel computation method is proposed. Based on research literature and field cities feedbacks collected during workshops we organized, a model of smart city profile characterization is given, as well as a smart city model to ensure an implementation of relevant activities through a new use cases methodology.*

Authors' Profile

Yolène Berrou is a PhD student in informatic, Computer Science and Artificial Intelligence laboratory, ENGIE Lab CRIGEN, and affiliated to the department of Technologies for Cooperation, Interaction, and Knowledge in Collectives, University of Technology of Troyes, email: yolene.berrou@engie.com

Eddie Soulier is a professor on the department of Technologies for Cooperation, Interaction, and Knowledge in Collectives, University of Technology of Troyes, email: eddie.soulier@utt.fr

Dr. Philippe Calvez is research a lab manager at Computer Science and Artificial Intelligence laboratory, ENGIE Lab CRIGEN, email: philippe.calvez1@engie.com

Introduction

To help companies and local authorities in their transition towards carbon-neutral economy, ENGIE offers sophisticated global solutions to customers and develops integrated energy solutions[1] . Indeed, companies and local authorities play a key role in this transition: in France in 2018, 46% of the energy was consumed by buildings (housings and tertiary), and 32% by transports (French Commissioner-General for Sustainable Development, 2019). Local authorities also have goals to reach, given by the government, and thus have needs to lower their carbon emissions. Based on its experience in the energy field that guarantees an investment source to develop customers solutions, ENGIE offers to local authorities, solutions to provide energy solutions, improve energy efficiency, city places and mobility service[2].

These solutions are present on all energy services value chain, and include digital solutions for smart cities in varied domains: energy supply, heating and cooling, green mobility, digital systems and platforms including dashboards, lighting and security. Local authorities can take advantage of this digitalization, including the associated data to optimize their systems, and thereby the city itself. To offer solutions to local authorities, it is essential to characterize the context: its governance, its morphology and its energetic systems. However, it can be difficult to define the needs and to characterize cities, particularly in smart city projects. The aim is to have a broad approach of the city: to know what the city is and what are its systems, and how some of those systems are smart city oriented. This can allow operators to have a better knowledge of the city and to address their needs in an optimal manner. Two types of solutions are pro-

[1] https://www.engie.com/en/group/our-vision/our-strategy
[2] https://www.engie.com/villes-et-territoires

posed in the paper:

- a city overview situation;

- solutions and their positioning to improve coherence in city's activities and ongoing projects.

A method to characterize a city profile has been developed by ENGIE Lab CRIGEN CSAI, based on scientific literature and feedbacks of cities that took place during workshops (end of 2019/early 2020) about city and data. The city is characterized by a list of descriptors, and their analysis allow to have an overview of it. The comparison of actual state with reference city model allows to identify a roadmap based on best practices to implement. The descriptors distribution helps to identify if the city's activities are coherent. Smart city implies ICT-driven activities, which have to be described by use cases, specifying interactions between the actors and the different functions. Inspired by the SGAM frame of reference, a Smart City Model is proposed where use cases can be mapped, to guarantee their effective implementation.

Profile types modelling

Four smart city profiles have been identified from the literature and from feedbacks of different cities' cases.

From the bibliometric analysis of documents published between 1992 and 2018, (Mora & Deakin, 2019) analysed the state of the art about smart cities, assuming that a city is smart when there is an ICT platform that provides solutions to reach urban sustainability. Two main groups or profiles are distinguished: one that is techno-centric and one that advocate a more holistic approach to smart city development, both being ICT-driven.

A cluster of European scientific literature about smart cities appeared during the analysis. The common feature of this cluster is the focus on low carbon technologies and environmental activities. The authors identified four European smart cities (Amsterdam, Barcelona, Helsinki and Vienna) considered as "leading examples". They follow this path, with a more poly-dimensional point of view: their activities include other dimensions, as social aspects, activities that relate to e-government or quality of life. Nevertheless, activities to fight climate change still take an important part: a majority of their activities is related to energy networks, air, mobility and transports, and buildings and districts, as ENGIE's activities segmentation. The study of cities activities helps identify best practices. To define them more accurately, a classification system was elaborated, leading to three categories: activities' category, application domains of the activities and categories of actors. These categories lead to four dichotomies, represented as the strategy type (techno-led or holistic), the approach type (top-down or bottom-up), the intervention logic type (mono-dimensional or integrated) and the model of collaboration type (2 or 4-helix model).

Based on this work, a first list of descriptors of a smart city has been made. To complete the two profiles identified (techno-centric and holistic) with a less ICT-driven view of the smart city, a third one has been considered, characterised by its social aspect, and inspired by the book of (Green, 2019), which promotes the idea that a city can be smart even without systematically using technology to solve its problems. Other descriptors have thus been added, based on this profile.

The last added profile, which is in-between the social profile and the holistic profile, is inspired from a study conducted by the French National Agency of Territories' Cohesion and the University of Technology of Troyes (UTT), in collaboration with ENGIE Lab CRIGEN CSAI, the University of Le Havre and Chronos group. It aims to achieve two goals:

- To produce a state of the art of data projects cities based on private public partnerships;

- To analyse their organizational and economic models to promote territorial innovation.

To that end, three workshops were organized: the first one presented six city cases, the second one analysed statements and issues identified in city cases, and the

last one presented some digital solutions to cities needs and issues. These workshops involved different kind of actors, from public actors (with representatives from the cities of La Rochelle, Prats-de-Mollo-la-Preste, Nice Côte d'Azur Metropolis, Paris, Lyon Metropolis through the Tuba association, and the Occitanie region) to researchers and experts in geography, to private actors as GFI group, Lexcity Avocats or GrDF.

Then, we propose to retain four ideal-type profiles which are: techno-centric, techno-social centric (holistic), socio-technical centric, and social-centric profiles.

Although relevant the analysis of Mora and Deakin, focused on "business" level (or "public action" level, when related to the city), do not identify "systems" level that could led the city to become concretely "smart".

In our own model, activities play a key role in profile characterisation. In a smart city perspective, which imply ICT, activities related to systems have to be described by use cases. They depict in detail the interactions between different actors and different functions. We propose to define goals in order to specify systems features, and a method that can be applied on both "business level" and "system level". Goals could be: to reduce energy consumptions of buildings and infrastructures, to reduce the environmental impact of buildings and infrastructures, to improve the energy efficiency of the technological systems or to move towards a carbon-neutral economy. Those goals point towards systems like energy production, distribution or storage, heating, cooling, air quality, lighting, transport, or energy services.

Use cases modelling

To define a proper use case can be difficult, as it was mentioned several times during the workshops. In 2015, a standard of the International Electrical Commission on a use case methodology for complex systems has been released (IEC 62559-2, 2015), which focus on power systems, followed by a book describing how to apply this standard to smart grids (Gottschalk, Uslar, & Delfs, 2017), via a Smart Grid Architecture Model (SGAM), developed by the Smart Grids Coordination Group (CEN -CENELEC - ETSI, 2012). The SGAM is a model in three dimensions composed of five vertical layers (business, function, information, communication and component layers), inspired by the interoperability layers defined by the GWAC (GridWise Architecture Council, 2008). Each layer has two axes, one for the zones that represent the hierarchical model of power system management (from energy production process to market), and the other for the domains describing the electrical energy conversion's chain. Another model named Smart City Infrastructure Architecture Model (SCIAM) were developed by the German DIN/DKE Smart Grid Standardization roadmap, which uses the same architecture layers (Gottschalk et al., 2017). SGAM framework is used as well in the H2020 Project PLATOON that ENGIE LAB CSAI is coordinating. PLATOON will deploy **distributed edge processing** and **data analytics** technologies for optimized real-time energy system management in a simple way for the energy domain expert[3].

In software engineering, use cases are scenarios that aim to reach a goal. They describe a system and its functional requirements, as well as the interactions between the actors (humans or not) and the activities to be implemented. The process to describe them in a structured way is called *Use Case Methodology*, and led to a *Use Case Template* (IEC 62559-2, 2015). In PLATOON, energy oriented use cases for each pilot (Energy efficient building, Energy Management System, Predictive maintenance, …) will use the IEC 62559-2 Use case Methodology.

In the context of smart grids, the SGAM allows to represent the use cases in accordance with the Use Case Template. The layers and axes of the architecture make it possible to map the different viewpoints that stand out from the use cases scenarios, and the interactions according to the interoperability layers of the GWAC (Gottschalk et al., 2017; GridWise Architecture Council, 2008).

Inspired by the SGAM and SCIAM layers, we elaborate a Smart City Model (SCM) which can be seen on Figure 1.

[3] https://platoon-project.eu/

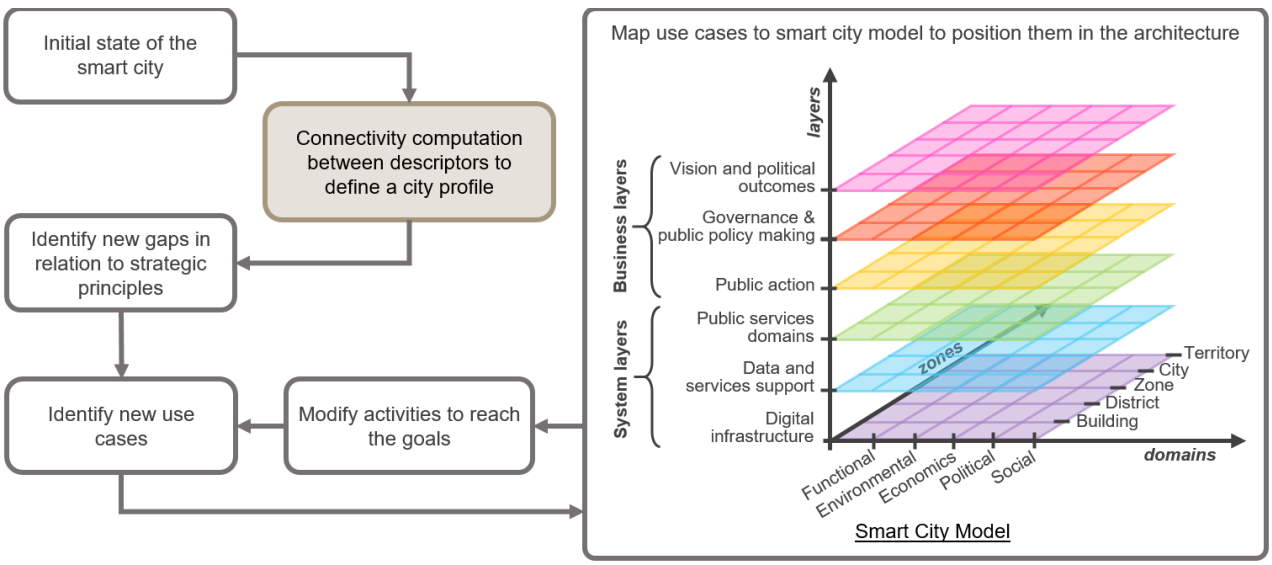

Figure 1. Identification of use cases and mapping into the Smart City Model.

Those layers can be divided in two types : the business layers (vision and political outcomes, governance and public policy making, public action), and the system layers (public services domains, data and services support, digital infrastructure).

The goals "systems" oriented are positioned on the public action layer of the SCM. Those goals point towards solutions on system layers which can be declined in use cases and mapped on each layer of the SCM. The figure below represents the use cases identification process and the Smart City Model, where use cases can be mapped.

Novel computation method based on SCM.

The identification and grouping of a multiplicity of descriptors, for each use case and at all levels of the SCM, require automated calculation. We experiment simplicial complex method as a relevant method.

Unlike networks which link pairs of things, the reality is often more complex. Such a complexity may be modelled by what is called relational simplices, that can be visually represented by polyhedra. Considering n elements $x_1, x_2, \ldots, x_n$ of a set X, this subset of X can be seen as the vertices of the polyhedron, all of them linked to each other by a relation R. The dimension of the relational simplex is given by the number of vertices it contains minus one (Johnson, 2012). Polyhedra that share p vertices are said to be q-near, with $q = p-1$, which means that they have a "face" of dimension q in common. Two simplices – or polyhedra – are said to be q-connected if there is one or more q-near polyhedra between them, and several simplices q-connected form a simplicial complex, noted $K_X(Y,R)$, with Y the set of vertices. A way to analyse these structures consist to identify the q-connected components for each dimension of the simplicial complex. Such an analysis is called a Q-analysis.

To perform these calculations on simplices, a software application has been developed through a collaboration between the UTT Lab, ENGIE LAB CSAI and Data Nostra. The main objective of HYPE is to build model for simplicial complexes representation and perform on it, a Q-Analysis.

An example of Paris city profile characterization is given below. This characterization focuses on business goals, not on system goals. The chosen city is Paris because

of the amount of available data through the DataCity program (Numa & Ville de Paris, 2015) that list all the projects developed, completed by other data available on the Paris city's website[4].

A Q-analysis has been performed, that helps to determine to which smart city profile it is closer to: by analysing the simplices or descriptors and how they connect to each other, it is possible to compare them with the four ideal profiles identified. Examples of descriptors are: *actor: research*, *development of a data platform or infrastructure*, *citizen participation at the beginning* or *use of public data*.

The figure below gives a visualisation of the simplices and their connections, at a q-dimension of analysis of 42. At this dimension, there are three groups of simplices (or components) that stand out: green circles (or simplices) (*government actor* and *development of an application or service*), a red simplex (*industrial actor*) and an orange simplex (*evaluation measures of progress*). Those are the highest simplices, that reflects the DataCity program which aims to develop innovative applications for the city or its citizen. A deeper analysis leads to the conclusion that Paris comes within the scope of the techno-social centric profile, even though it is not an unmitigated profile. However, it has to be noted that this profile characterization is only based on information publicly available on two websites, and thus do not include all the activities developed by Paris; if so, the results may have been quite different. Yet, this techno-social centric profile is coherent with what came out of the Paris presentation at the first workshop.

Conclusion

Many cities implementing activities related to a smart city have to face the issue of defining a proper use case. However, the identification of relevant use cases has to take into account the developmental profile of the city.

In that context, and based on what was found in the literature and what was discussed during the workshops, a conceptual model of smart city development have

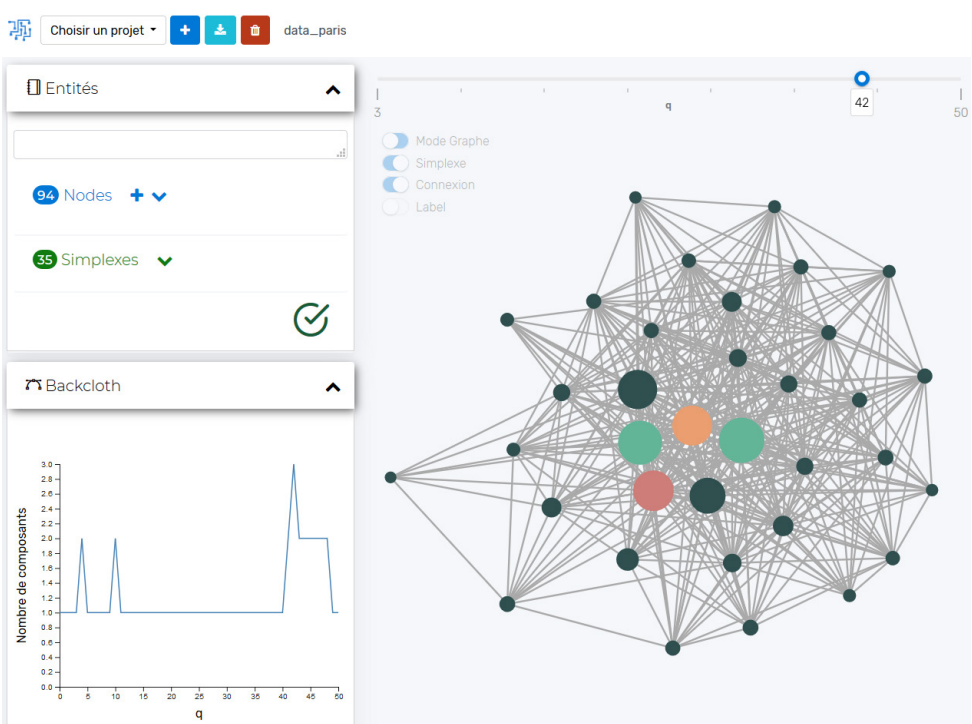

Figure 2. Screenshot of the HYPE application and the graph of the Q-analysis' result.

[4] https://www.paris.fr/

been created, and two kind of analysis are proposed: an overview of the situation of the city; solutions and their positioning to improve coherence in city's activities and ongoing projects.

Inspired by the SGAM and SCIAM, a Smart City Model is proposed, in which system goals and the resulting use cases can be mapped to ensure their optimal implementation.

In the end, a smart city profile computation based on simplicial complexes is presented, based on activities and descriptors corresponding to the business type.

These different elements (methodology, models, tools) already allow ENGIE Lab CRIGEN CSAI to address territorial issues and particularly those related to urban infrastructure with a strong digital component. Whether in response to calls for tender in connection with urban renovation projects, but also to develop operational performance tools that support the activities of the actors, experts at ENGIE.

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Using a Network-theory based approach to identifying, mapping and classifying civil society actors in urban communities

Maria Giorda, Olga Kavvada, Jean Daniélou

Authors' Profile

Maria Giorda is a political sciences intern at ENGIE. She completed a BSc in Business Management at King's College London, specializing in Marketing and Product Innovation. Maria gained her first professional experience in UK companies: she was involved in launching and troubleshooting a web-based startup and worked in the application of geolocation data solutions. She is currently completing the Master program Governing the Large Metropolis at Sciences Po Paris. During her time as a graduate student, Maria has acquired expertise in urban governance and, together with a team of fellow graduate students, won second place at the 2019 Geneva Challenge for Advancing Development Goals, pitching for a digital tool that improves urban disease surveillance by leveraging mobile technology and informal healthcare providers. She also received funding from French NGO Urbanistes du Monde to carry out research on practices of urban resilience in Quito, Ecuador.

Olga Kavvada is a Research Scientist at the Computer Science and Artificial Intelligence Lab of Engie. She got her PhD from the University of California, Berkeley in 2017 in Civil and Environmental Engineering. Her research interests revolve around geospatial data science, databases and systems-level modeling as well as developing software tools that assist in decision-making processes

Jean Daniélou is urban policies analyst at Engie, PhD candidate at PSL-Mines ParisTech (Centre de Sociologie de l'innovation) and member of the scientific board of the chaire « villes et numérique » at Sciences Po.

Introduction

Private companies looking to participate in large-scale urban infrastructure projects are increasingly aware of the importance to include the local community in the planning process. As Mok and Shen (2016) point out with regards to major construction projects: "a project environment can be perceived as network systems composed of interconnected stakeholders, and of interrelated stakeholder issues". However, when it comes to designing a community engagement strategy, it may feel tempting to just fulfil the legal consultation requirements by organizing a few public meetings, sending out surveys and distributing flyers. Moving away from considering public outreach as a simple 'check-the-box' activity, to actually connecting with the local population through meaningful and genuine community engagement may feel like an expensive and time-consuming investment, but is a crucial factor to ensure the long-term success of an infrastructure project. Failure to design a customer/end user-centric approach to infrastructure delivery means that a company's resources are not adequately allocated to achieve value-for-money and maximise local benefits from the project. Moreover, it is more cost-effective to engage with residents early on in the process, as the costs of doing so later in the project lifetime are higher, especially when lack of adequate consultation causes public backlash and people's trust in the company is compromised. Finally, no one knows the local context better than the local community itself does. It is therefore important to tap in residents' expertise and make them early in the definition process, valuable service co-producers. The first step to develop an authentic community engagement strategy is to have a clear picture of the local community. Urban populations are heterogenous systems characterised by overlapping geographical, socio-demographic and cultural layers. For this reason, the challenge for private companies is not to understand a single community, but to map a community of communities and, crucially, to

identify the most relevant stakeholder groups in the context of a specific infrastructure project. We developed a two-step approach strongly based on network theory to community mapping that supports the development of an effective engagement strategy. Firstly, the community organizations and not-for-profits mediating access to the broader urban population are represented in the form of nodes in a network and connected to each other based on their current and past collaborations. Secondly, each node is attributed a measure of relative importance. We developed three criteria, Activity, Representativity and Legitimacy, calculated using four different types of data sources: financial statements, annual impact reports, social media data and hyperlinks scraped from actors' websites. The result is an interactive webtool allowing users to detect urban communities, highlight their interactions with one another, and to identify key community spokespersons. This first iteration also forms the basis for the development of a broader approach that will aim at assessing how to identify and engage with the right stakeholders on new infrastructure projects.

Problem Statement

Over two-thirds of the world's population is expected to live in cities by 2050 (UNDP, 2017). Rapid urbanisation presents both opportunities and challenges. The spatial concentration of people and activities can bring significant efficiency gains, such as lower production costs, and increased innovation, thanks to faster knowledge and information exchange. However, quickly expanding urban centres also need to cope with the additional pressure brought to bear on local infrastructure (UN/DESA, 2013). Good services are essential to the wellbeing of residents, as well as to the functioning of cities. Deficient infrastructure can ultimately offset the productivity gains brought about by urbanization, as it increases production costs and discourages private investment. The ability of local governments to maintain and improve basic infrastructure therefore plays an essential part in harnessing the growth potential of urbanization (UNDP, 2017). Considered city councils' limited access to expertise and finance, private companies can support the public sector in taking advantage of the opportunities and alleviating the threats of rapid urbanisation (World Economic Forum, 2016). An important challenge for firms looking to participate in large-scale urban infrastructure projects is to understand and engage with the local community. Decrypting an urban population's DNA, its unique characteristics and concerns, is crucial for three reasons. Firstly, infrastructure services should be designed and tailored to answer the distinctive needs of the community. Since citizens are the direct infrastructure users, engaging them in the planning process can help companies improve service outcomes without allocating more inputs, thereby increasing value-for-money. An outcome is the end result of a service, provided the service performs effectively. Planning in terms of outcomes rather than services means turning investments into something that citizens actually value (LARCI, 2010). If, for example, a city decides to expand its water infrastructure by 20%, but the investment does not generate improved health outcomes amongst its citizens, then it has failed to maximise the impact of the planned outputs. Secondly, it is essential to obtain early stakeholder buy-in to reduce the possibility of future conflict. Analysing data on 200 infrastructure projects in Latin America and the Caribbean, the Inter-American Development Bank (2017) found that lack of adequate consultation led to conflicts in 74% of the cases. The cost of conflict can be significant and goes from delays and budget overspending all the way to project withdrawal. When conflicts arise in the early stages of a project, as it is often the case, the consequences are even more serious. It is therefore important to provide citizens with effective communication venues through which they can articulate their concerns, without feeling the need to turn to public protesting. Community engagement can build trust and engender a local sense of ownership amongst users, therefore increasing the value of the project in the eyes of the population (OECD, 2017). Thirdly, as urban systems become increasingly complex and interconnected, a wider range of resources and actors need to be mobilised. Developing an innovative and inclusive urban infrastructure requires a shift from a silo-based approach to project delivery to a holistic view of infrastructure. This means looking for

opportunities to generate additional value from infrastructure interdependencies by leveraging local stakeholders' knowledge of the local context (Ersoy, 2017; Rosenberg & Carhart, 2013). Instead of passive service users or beneficiaries, urban communities can therefore become relevant co-creators planning for such services. The integrated infrastructure development resulting from the process will be more likely to consider broader socio-economic and environmental needs and therefore trigger positive synergies, boosting human capital and supporting local economic development (Avis, 2016). In summary, there are both intrinsic and instrumental benefits to community engagement. Intrinsic benefits encompass greater trust and acceptance on the part of citizens. Instrumental benefits derive from the improvement of service outcomes by taking advantage of the expertise of future service users and from tailoring the offering to the needs of the community.

Theoretical Approach

Any solid community engagement strategy needs to be built on an in-depth understanding of the local context. Traditionally, stakeholder analysis takes the local community as a homogenous stakeholder group, evenly affected by a private company's operations. This perspective does not recognise the fact that cities are heterogenous systems characterised by several geographical, socio-demographic and cultural layers (Guo et al., 2018). Extensive work in the field of socio-anthropological studies has revealed that these layers can be broken down in fairly well defined and coherent sub-units. Yet people identify with different sub-groups depending on their socio-economic status, political beliefs, religion, values and interests, and any one person can belong to multiple sub-units. Because of this intersection in membership, we approached cities as a web of interrelated actors and groups, rather than a cluster of separate units (Scott, 2000). Private companies are therefore faced with the challenge of acquiring an understanding not of a single generic community, but of a collection of interconnected communities, and selecting the most relevant groups to engage with for a specific infrastructure project. We developed a two-step approach to community mapping that recognizes the need to adopt a multi-stakeholder perspective and is both comprehensive, in the sense that it reflects a city's make-up in terms of socio-demographic, ethnic and interest groups, and pragmatic, in that it supports the development of an effective engagement strategy. While the analysis of census data allows finding dominant urban ethnic, religious and occupational clusters, it provides no information on relevant communities of interest, such as people interested in environmental issues, and offers no insight on how communities are connected with each other. Considering the specific demands of a community engagement strategy, which requires not only to uncover the underlying structure of an urban system, but also to help firms reach any one group in particular, we adopted a network perspective. A network is a graph composed by a set of nodes/actors and links/relations that connect them. Network analysis can be an important tool to develop a community engagement strategy, as it identifies centrality, namely which actors have the largest number of connections to other actors, and which groups are rather isolated. Drawing from communities studies (Scott, 2000), we chose to consider as our 'nodes' not-for-profit organizations and community groups that comprise two different types of non-kin groups: groups of people who share an identity or experience, such as the South-Asian community, and groups of people who share a concern or an interest, such as environmental organisations. Not-for-profit organizations are valid network nodes as they represent proxies for the broader civil society and also important community spokespersons and gatekeepers, advocating the needs of and mediating access to specific communities.

Step 1: Identifying and connecting Actors

The first step consisted of identifying and connecting the not-for-profits that are present in a city. As previously mentioned, the local population can play the role of partner, opposer or user. We mirrored this in our mapping approach, by dividing actors in three different categories: potential partners, potential controversy instigators and potential users/beneficiaries. To do this, we combined three different methods, one for each actor type, thus reducing the risks associated with any one

particular approach.

1. To identify potential community engagement partners, we borrowed the concept of action arena from institutional analysis (Dragos Aligica, 2006). In the context of a specific infrastructure project, not all actors will be relevant supporters. We therefore need to identify not-for-profits operating in a pre-defined field, or action arena, such as transport, energy, water. To draw the boundaries of our arena of interest, namely the set of actions and initiatives to consider in order to find relevant actors, we analysed publicly available municipal reports. These contain the set of actions undertaken by a city council in a given timeframe concerning a specific infrastructure sector and represent a solid starting point to investigate organisations that are currently supporting or have supported public action in the past. Once a list of relevant projects and initiatives was drafted, we identified the community actors involved in the delivery of these projects through desktop research.

2. To find potential opposers, we employed controversy mapping, a method to scrutinise public disputes and the actors taking part to them (Venturini, 2012). This technique was chosen based on the assumption that not-for-profits that already mobilized in the past are likely to mobilize again in the future. We first reviewed the municipal Local Plan and other relevant environmental or transport policies listing ongoing and planned infrastructure works and the city's broader ambitions in terms of urban development. Having compiled a list of current target neighbourhoods and infrastructure sectors, we consulted the local and national press to identify controversies surrounding recent projects and trace the actors that animated them.

3. Finally, to identify those user communities that should be the priority beneficiaries of a community engagement strategy, we used snowballing sampling in combination with geodemographic classification. Since potential partner or opposing organizations often have a direct relationship with, or represent the demands of, smaller community groups, we followed the hyperlinks found on their webpages to map additional actors. We retained those organisations that were located in deprived areas, represented priority communities according to census-based categories, or advocated for particularly relevant subjects (for example, BAME community organizations, immigrants support networks, homeless rights) (Singleton & Spielman, 2014). This methodology also allowed us to understand which actors from the other two groups were connected to the greater number of smaller community organizations and therefore generally played the role of "brokers" in the network.

Once identified relevant actors, the nodes of the network, we connected them through standardized links or edges. A single link only connects two actors and can be directed, going from one actor to another, or undirected, simply linking the two actors. Networks can vary along multiple dimensions, in the sense that any two actors can share several kinds of links. In the social sciences, links can be categorized into four types: 1) affinities based on shared characteristics, location (people living in the same neighbourhood), or membership (the South Asian community); 2) social relations (for example who trusts or knows whom); 3) interactions; and 4) exchanges (of information, money, etc…) (Vicsek et al., 2016). The relational data we chose to use is information concerning collaborations or partnerships between actors. Reviewing official reports and actors' websites, we connected any two actors that were involved in a common initiative or had an established partnership, for example, they referred service users to one another or regularly organized events together.

Step 2: Attributing Relevance to Actors

After visualising community actors based on their connections to other stakeholders, the second step was to

attribute to each node a measure of relative importance. A network visualization can contain more information than just simple nodes and connections, such as insights on the nature of vertices/actors. In other words, elements like nodes' size and colour can be modified to increase the final visualization's effectiveness in supporting decision-making. In our case, we decided to change the size of actors' nodes to show a synthesized assessment of community organizations' relevance. There is no objective measure of relevance, as a stakeholder that is important for one issue is not necessarily relevant in another one. For this reason, we categorized and ranked actors in a way that reflected their relative 'worth' in the context of a community engagement strategy. Since the project's goal was to identify those community-based groups and not-for-profits that had substantial relationships with broad segments of the population, we chose to calculate relevance as the aggregate measure of three criteria, Activity, Representativity and Legitimacy, each underscored by two complementary metrics to strengthen overall reliability.

1. ***Representativity***

Number of Members: This metric corresponds to the number of members a community organization has or the number of people positively impacted by a not-for-profit. Considering the fact that this measure means different things depending on the type of not-for-profit (a community arts venue will reach more people in a year than a homeless charity) and membership data is not always available or up-to-date, we enriched the criteria by also adding social media followers.

Social Media Followers: This metric corresponds to the number of followers an organization has on Facebook and Twitter. It complements the other Representativity metric, as it gives a good idea of an organization's 'reach' beyond its registered members. However, since some organizations representing Black, African and Ethnic Minorities (BAME) or elderly people do not rely on social media followers to reach their target audiences, it was not advisable to consider this representativity metric alone.

2. ***Activity***

Number of Connections: This metric defines the number of actors an organization is connected to. Since having partnered with several other not-for-profits does not necessarily mean that an organization is particularly active, we complemented this metric with the number of grant-funded projects carried out in a given year.

Number of Grant-funded Projects: This metric measures the number of grant-funded projects undertaken by an actor in the last available financial year. The government, businesses and foundations award grants for specific purposes and their number gives a good understanding of how active an organization is in pursuing partnerships with public and private organizations.

3. ***Legitimacy***

Number of Funders/Supporters: This metric defines the number of funders/supporters an organization lists on its website and its latest financial statement. It provides an idea of how reputable an organization is. However, many large charities do not list all of their supporters/sponsors on their website, as they do not need to advertise themselves or get funding only from a few large grant-making organizations or the government. Conversely, smaller local organizations often list several supporting organizations on their website to assert their legitimacy. For this reason, we complemented this metric with the total amount of grant funding or donations received by a not-for-profit in a given year.

Amount of Grant funding/Donations: This measure is the sum of amount of grants and donations obtained by an organization in the last financial year available. Both grants and donations symbolize the legitimacy of an organization in that we can assume that the more donations or grants an organization receives the more it is considered trustworthy. For this reason, even though many not-for-profits earn money from dispensing services or from other activities, we chose to use this as a metric of Legitimacy rather than an organization's annual income or turnover.

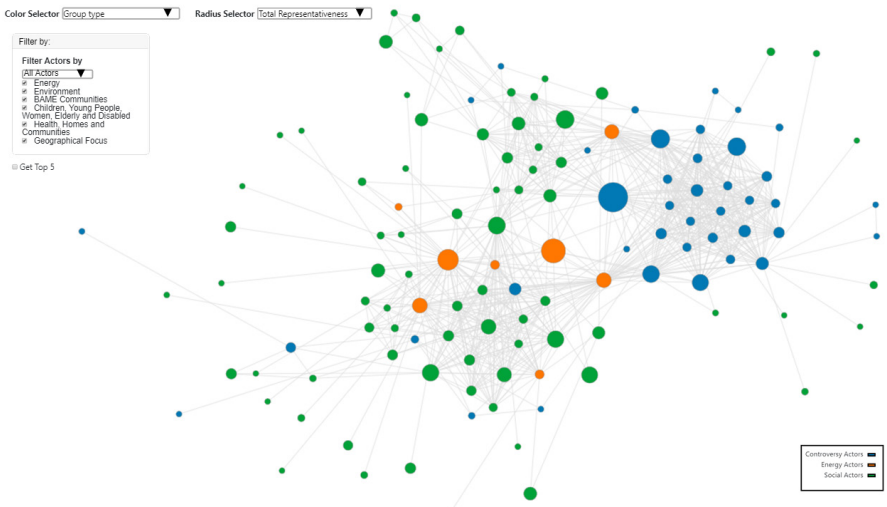

Figure 1. The Stakeholder Engagement Tool developed by the Engie Computer Science and Artificial Intelligence Lab (CSAI). Actors' names have been hidden for confidentiality reasons.

We visualized the final dataset as a network of actors/nodes of different sizes depending on their aggregate relevance: the more relevant the actor, the larger the node. The aggregated relevance is a custom metric that combines the normalized importance of all the previously mentioned metrics. Nodes are coloured differently depending on the group they belong to: potential partners are coloured in orange, potential opposers in blue, and potential beneficiaries in green. The network visualization is modelled as a force graph which clusters the nodes into groups based on their connectivity. The closer the nodes are in the network, the higher the degree of connectivity between them (Figure 1).

As we can see in Figure 2, actors' colour can be modified to reflect their mission: whether they support the elderly and youngsters, or Black, Asian and minority ethnic communities, or specific neighbourhoods within a city... Hovering over a node, its direct connections are highlighted and additional information on the actor displayed.

The strength of this approach lies in the possibility of

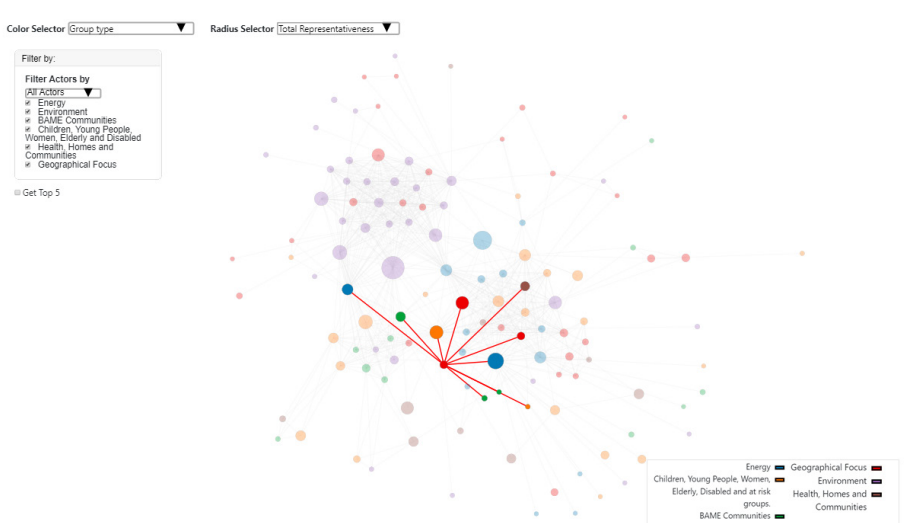

Figure 2. Interacting with the Stakeholder Engagement Graph

moving from complexity to simplicity, allowing users both to visualize the full range of community organizations and to reduce the clutter in the network and make it more interpretable. In fact, by applying different filters and queries to the visualization, we are able to generate multiple actor maps that help identifying priority partners to develop and implement a community engagement strategy, depending on the requirements of the project. For example, Figure 3 shows the top 5 most active not-for-profits in the city working with children, women, the elderly and the disabled. Top actors are highlighted in yellow. The organizations they are directly connected to are also displayed, whereas the rest of the network is blurred out. If we select different actor types or different Relevance criteria, for example Representativity instead of Activity, the resulting visualization changes. This kind of static maps offer users the opportunity to 'interrogate' the tool on the basis of their needs and export the results in the form of an image.

Conclusion

The article provides a mixed-method approach to the identification and visualization of urban communities in their multi-fold nature of future users, potential opposers and valuable partners. The final scale-free map visualizes, as interconnected nodes in a network, the community organizations and not-for-profits present in a city. Organizations' relative power is represented by nodes' size, while interests are represented by nodes' colours. The goal is to offer users a decision-support tool that indicates the relative priority to be assigned to different stakeholders and assesses their importance to the success of community engagement. Civic organizations are important community gatekeepers and identifying the most active, representative and legitimate ones is crucial to reach broader groups of residents. The methodology and tool present multiple advantages. Firstly, as actors are not a priori defined, the approach is able to find and include less established organizations. Secondly, the relational data used to connect actors can be modified depending on the priorities of the firms or availability of the data. Thirdly, the visualization is interactive to maximise its flexibility and allow users to explore freely the ecosystem depicted. This first approach is a key founding step in the broader development of a tool that will be able to meet the theoretical challenges of community mapping at the urban scale, and handle complex queries, therefore providing a seamless user experience. Considering the difficulty of finding and processing data sources that vary from city to city, future iterations of the tool will aim at facilitating automatic data ingestion and transformation. One option is using Natural Language Processing (NLP) techniques to automatically extract keywords and identify stakeholders from official reports and websites. Additionally, knowledge representation structures, such as ontologies, are

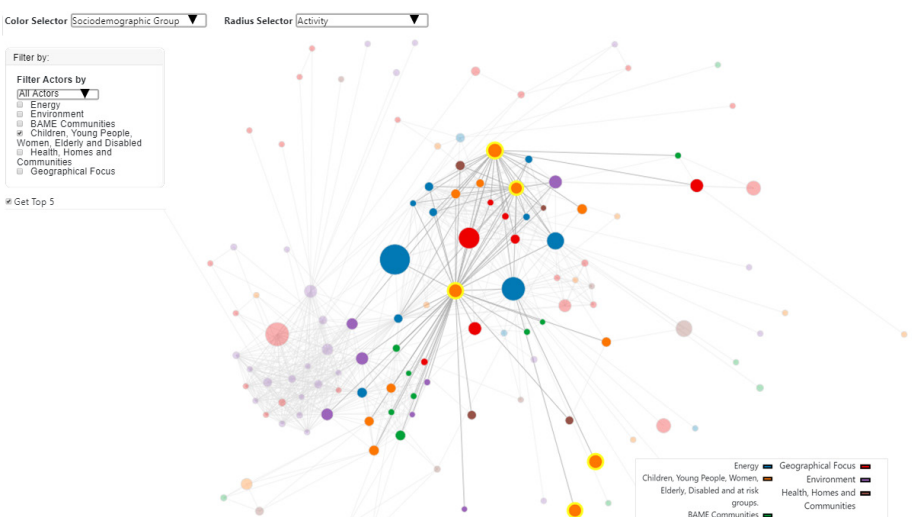

Figure 3. Interactive querying of the tool for a static display of results. Selected top 5 nodes from the user defined query are highlighted with a yellow background.

already being considered to achieve formal abstract representation of urban information. These techniques can enhance decision-support tools capabilities by inferring additional knowledge from existing data and providing a better understanding of the local context and its challenges. Overall, there is great potential for firms to establish mutually beneficial long-term relationships with NGOs and community groups operating in urban areas, provided that they are willing to invest time and resources in developing a strong understanding of cities and their communities, and to use that knowledge to work in a more inclusive and proactive way on the ground.

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Reinventing ENGIE's positioning on urban activities

Marc Daumas

Interviewees' Profile

Convinced by the need to design zero-carbon real-estate projects, Marc Daumas co-funded ENGIE Solutions Aire Nouvelle in 2017, and is currently its CEO. He is also Chairman of the Advisory Board of the Smart Building Alliance for Smart Cities.
With 18 years of experience in the energy, services and real-estate sectors, Marc Daumas aims at developing projects with positive impact on the well-being of citizens and on the environment.

Marc Daumas holds a double degree from Ecole Nationale Supérieure des Arts et Métiers and ESCP-EAP, completed with a degree in strategy and financial expertise at the CNAM.

Can you introduce ENGIE Solutions Aire Nouvelle to the IGLUS readers?

We are a land and property developer, with a specific positioning which consists of being the developer of the ENGIE group and more specifically of ENGIE Solutions. Our leitmotiv is to create very low carbon buildings or neighbourhoods, well beyond the standards. We position ourselves on projects with high environmental or social added value. We work on all types of programmes: offices, shops, housing, activities or even turnkey factories! We currently work only in France, but there are many international subsidiaries where the model is of interest. This activity will surely develop within ENGIE internationally in the years to come.

The second key characteristic of our positioning is that we always partner with another developer. Building a good project requires two legs: an environment and social leg as well as a finance and market-adequacy leg. We manage these subjects together. ENGIE Solutions Aire Nouvelle is a leader on the environmental, social and innovation aspects and we are challenged by our partner on these issues, while we challenge our leading partner on the financial aspect. Both topics are closely linked but each complements the other.

How do you articulate ENGIE's skills on your projects? How does this differentiate you on the market?

ENGIE Solutions Aire Nouvelle is a developer insofar as we provide the Group with activities on issues of works, operation and maintenance, financing of renewable energies and mobility solutions. This is precisely our particularity: ENGIE Solutions Aire Nouvelle is not a competitor of other players but rather a partner of developers because we offer a wide range of expertise. On the environment side, ENGIE is present across the entire value chain from development, construction, operation and distribution of electricity from renewable energies. We are also present in the field of mobility, from the design of solutions. By being involved in the entire course of a project on these themes, we find ourselves hitting the traditional real estate value chain, which normally includes various types of partners on successive vertical silos (land servicing, property development, construction, operation and maintenance). We are horizontally present on the whole value chain, which breaks the classic pattern. So far, it is rather well accepted.

What are ENGIE Solutions Aire Nouvelle's flagship projects?

ENGIE Solutions Aire Nouvelle has been created three years ago. We now have a dozen projects in France's major cities and nearly 450,000 m2 under development for future offices, housing, commercial activities..

Among the emblematic projects, we have "Les Lumières Pleyel", a project in Saint-Denis (north-east of Paris) around the new train station. It is a major railway hub and will be one of the main train stations for the Olympic Games in 2024. We are developing 170,000

Source: Palais du Commerce de Rennes : Groupe FREY Citizers ; Engie Solutions Aire Nouvelle (promoteurs) MVRDV ; Bernard Desmoulins (architectes)

sq.m., including three office towers for 110,000 sq.m., 500 housing units, shops, a student residence and a hotel.

On the environmental side, ENGIE Solutions Aire Nouvelle proposed a multi-energy smart-grid, which means that heat, cold and renewable electricity are produced on site, interconnected to the wider urban networks. Thermal energy is bought and sold to these networks. It's an interconnected system, producer, consumer, and could potentially do on-site storage. On the mobility aspect, we will develop a mobility hub, linked to this station and which will be used for the last-mile mobility, either from the station to the district or vice versa, with a range of mobility services. It also deals with last-mile logistics, since a dispatch platform is planned there. Delivery trucks will be brought only to this location and then dispatch by green vehicles to the neighbourhood.

ENGIE Solutions Aire Nouvelle acts as an ecosystem creator: we have our own energy production and distribution solutions and we link them with external one to create a system. Regarding mobility, the sector is developing fast, so it is difficult to predict which solutions will work in 3 or 4 years. It rather expected that we will adapt the solutions and services to achieve the project's goals on this matter. It is a long-term project. We won it at the end of 2017 as part of inventing the metropole of the Great Paris 1 and it should be completed in 2030.

ENGIE Solutions Aire Nouvelle also won a project in Rennes, in the west of France, on a former post office building, listed as heritage monument. We are involved in a complete refurbishment project to ensure a 80% reduction in energy consumption compared to existing regulations, which means that the building will be very efficient. We will create an extension to the current building, which will be energy-positive (producing more than its needs). We will produce heat, cooling and electricity and sell it to the neighbourhood. Thanks to this project, we are reaching the highest environmental standard. It will hopefully be certified E4C2, which is the holy grail regarding environmental certifications and very rare to obtain in an urban environment.

ENGIE Solutions Aire Nouvelle represents an important shift in terms of positioning for ENGIE. What is at the origins of its creation?/ What was the basis for its creation?

ENGIE Solutions Aire Nouvelle is an idea that arose from several strategic reflections. The first one was that ENGIE sells energy and does work on buildings and roads but operates at late stages of the development cycle of real estate and urban projects. We created ENGIE Solutions Aire Nouvelle to move up the value chain and partake in strategic environmental choices. This development strategy was supported by the fact that we were losing value because of this former positioning at the last stages of the projects.

Creating ENGIE Solutions Aire Nouvelle was also the result of a market trend: for the past four or five years in France there has been a significant increase in environmental awareness, which has been reflected in the demand of citizens and local governments for urban and real estate development. For us, it was a sign that the market was going to value environment-friendly solutions and even digital technologies. Our jobs as techni-

cians were going to be valued. What was also positive - and without it we wouldn't be here - was the materiality of this market trend favouring the environment thanks to the projects Reinventing the Metropole, Reinventing Paris, which included an environmental criterion in the decision-making process. It started 3 years ago and was extended to other projects, as a new way of developing cities. ENGIE Solutions Aire Nouvelle was born from this trend.

What internal dynamics and restructuring did the creation of this company give rise to?

We suggested new intervention models for the Group and the management gave us the opportunity to do it. We succeeded by winning the flagship projects I mentioned with strong environmental values. We can say that it was a rapid movement from testing an extension of activity to accelerate its development. It has indeed gradually become a very interesting growth lever for ENGIE Solutions.

We had few skills in the real estate sector, stemming from the team's past experiences. It was a wise move to partner with experienced developers to start on the market. We are rather a minority partner on projects, since our share does not exceed 40%. We used to have a limit of 20% but it has been lifted. However, we remain a minority partner and our share on each project results from a discussion with the developer. This model suits us for the moment.

In terms of competences, we have sought to develop the team with young people who are very committed to environmental values and bring dynamism to the project, alongside more senior people with strong experience of calls for tenders. We have also hired external people from the real estate sector to increase the team's capacities on this topic and have discussions between equals with our partners. We have a specific recruitment process during

Source: Les Lumières Pleyel : Sogelym ; Engie Solutions Aire Nouvelle ; Crédit Agricole Immobilier (promoteurs) Snohetta ; Baumschlager Eberle Architekten ; Chaix & Morel et Associés ; Ateliers 2/3/4 ; Mars Architectes ; Maud Caubet Architectes ; Moreau Kusunoki (architectes)

which we test the candidates' convictions, their leadership and their ability to federate. It is important for us to recruit people able to build support with our partners on environment-friendly solutions. Technical skills are rather secondary for us, since we can find them in other teams within the Group or in engineering consultancies. ENGIE Solutions Aire Nouvelle acts more as an orchestra conductor.

We position ourselves on projects that are much more creative than the calls for tenders ENGIE traditionally responds to, which follow well-established specifications. Most of the time, on the contrary, we have a blank sheet of paper and few starting rules. Based on this, we must invent the project that fits into the urban landscape.

What does ENGIE Solutions Aire Nouvelle bring to its partners? What would encourage a developer to partner with you?

If we are talking only about financial matters, then a promoter has no interest in partnering with ENGIE. The reality is more complex, since we have for example noted that some private land sourcing companies are very happy to have us around the table: there are projects on brownfield sites for example, where having a partner with environmental expertise reassures the seller about the reality of the project. Land parcels are sold in two stages: there is first a sale agreement then, there is a request for authorisations and when they are obtained, the sale takes place. There are several milestones, especially regarding environmental regulations, to obtain the authorisations and having a stakeholder like us helps during the process.

At the end of the development cycle, there is another stakeholder which is increasingly concerned about environmental issues: I am talking here about investors, especially the large institutional organisations which are buying more and more green buildings. Not only to green up their financial portfolio but also because this type of building will lose less value over time : environmental buildings being more "future proof" than others.

Developer thus understand that it takes a wide range of skills to complete a project and therefore see an interest in the association. Regarding the other stakeholders, urban planners and architects are quite interested in these environmental issues and are getting involved. Engineering consultancies were initially afraid that a Group like us would do their work, but we clarified our positioning at early stage of ENGIE Solutions Aire Nouvelle's development. Project after project, we built trust.

Who are your competitors?

For the time being, we are the only one with this model and it should last for a while. This positioning is a chance as much as an opportunity and we are now being requested to participate in projects. There are other ways to be positioned in this environmental building niche. Woodeum, for example, is a real estate developer specialized in wood-based real estate projects. It has internalized part of the engineering on wood, part of the sourcing of materials as well. For a local government, it doesn't make a difference when the goal is to get a green building. Another competitor, REI Habitat, has more or less the same positioning.

We also have a close look at EDF, whose positioning is to help developers early enough in the cycle to develop projects with high environmental quality. It's always interesting for us to compare ourselves with EDF, which is our big competitor, to see how and how fast they move.

ENGIE is a private player and urban development in France is historically a public prerogative. How does the presence of a private company change the urban fabric and what is the impact on the relation between public and private space?

Thanks to the Group's historical activities of public service delegation contracts, we already had long-term relations with municipalities, operating urban infrastructure rather than designing the services.

What is happening is that the public/private and planner/developer boundaries are disappearing, and activities are becoming intertwined. Recent competitions on urban redevelopment projects are also changing the

approach and breaking down historical silos. It changes the French tradition of long-term strategic planning and brings more flexibility and agility. We are moving towards a much more iterative model, with small movements at more local scale. It is the contribution of decentralization laws which is fundamental to the way we now take decisions on land-use strategies. The other critical aspect is the protection of the environment. In this context, it is rather well-perceived on both sides that we have more to gain by working together. As private stakeholder, we are more involved in the co-construction of the urban project. It is a real evolution in the urban development sector.

Regarding co-construction, are citizens involved in the projects you are working on?

The public land-developers were already consulting citizens and more naturally had this inclination than we do, as private developers.

As regards to citizen consultation, I tend to question how well the local population is represented by the sample of citizens who participate. Time scales in urban development projects are long, 10 or 20 years, and thus managing citizens involvement is complicated. During this period, expectations will change. However, it is very important to understand how they evolve at different stages of the project. We consult local populations, especially through competitions, we question the project's neighbours, whether they are citizens, businesses, associations or companies.

Around the world, we can see cities, entirely private, that are developing. This model has an impact on the governance of urban space, which will also be the responsibility of the company. Does this seem to you to be a possible model in France?

I don't think so. As far as I'm concerned, city life is public, there is public governance with elected officials, there are laws that govern public life. The construction of European cities is the fruit of a long history and the ability to make cities work cannot be reinvented overnight. I do not believe that we can be governed by private CEOs. After the question of public/private subcontracting already exists but the municipality, in terms of elected representatives, remains in charge of the decision-making process. Regulations are implemented to allow each actor to be sanctioned in case of problems. It is a governance that works very well, and I wouldn't be interested in living in a private city.

Opportunities and challenges in urban infrastructures management: How to procure and implement large and digitalized infrastructure systems?

Nicolas Hatem, Jean Daniélou

Summary: *This article presents opportunities and challenges to implement large and digitalized infrastructure systems. The first challenge concerns the feasibility of merging and aggregating several infrastructures domains in one project. The second challenge relates to the business models and governance schemes that are needed to organize these infrastructures. These projects must fit local contexts and overcome inefficiencies in public administration. Hence, the last challenge is to adapt public-private contracts in order to formalize new organizational models and overcome barriers to the development of digital infrastructures.*

Authors' Profile

Nicolas Hatem is currently Phd candidate at Paris School of Economics (PSE) in partnership with Engie. He holds a Bachelor in Civil engineering and a Master in Energy Management and Sustainability from Ecole Polytechnique Fédérale de Lausanne (EPFL), obtained in 2020. During his master's degree, Nicolas acquired interdisciplinary knowledge of energy and environmental systems in a sustainability framework. He acquired a first professional experience in the circular economy and public services, while working at the Waste Management Authority of Ras Al Khaimah (United Arab Emirates). He then completed his Master's thesis at Engie corporate as an analyst of sustainable and smart energy infrastructures for cities and territories.

Jean Daniélou is urban policies analyst at Engie, PhD candidate at PSL-Mines ParisTech (Centre de Sociologie de l'innovation) and member of the scientific board of the chaire « villes et numérique » at Sciences Po.

Opportunities and challenges in urban infrastructures management: How to procure and implement large and digitalized infrastructure systems?

Public services management is territory specific and results of complex processes. It first depends on the local public authority's organization for public services. It is also constrained by specific legal and fiscal frameworks, guiding public actors in structuring and modeling their public services management. Public authorities experience three levels of public services management and mix their usage to organize their territory. They can make and manage the public service internally, buy and control the services by contracting out the services delivery/operations to a private entity, or privatize and externalize the public service while framing and regulating the market. This article focuses on the second level of public management where the public entity contracts out the services or the asset (Staropoli Thirion, 2019).

1. *Public services management and development of public-private contracts*

Public services management on private initiation is a concept that has evolved throughout time. While the first forms of private involvement were mostly privatization, public-private cooperation has become more complex and have increasingly used public-private contracts to structure itself. First private initiatives arose in the 17th century in various infrastructures. In Holland, private individuals purchased plots of land from the State and were obliged to ensure various works for the community in return for tax exemptions. In France, the construction of navigation canals (for example the Briare Canal in 1642) was initiated by private parties for their grain trade, under the agreement of the State. In the 19th century, the deployment of network infrastructures has driven more specific kinds of public-private cooperation. Highways and toolroads for instance were

managed in forms of early concessions in England and the United States - sections of roads were entrusted to private companies to ensure the maintenance and renovation of the road network in exchange of turnspikes, a kind of tool (Vries, 2013). After a period of nationalization and strong state-driven infrastructure development during the second half of the 20th century, defined and framed public procurement frameworks have emerged in the 1980s (Loi MOP in France 1985, SoPC in UK 1997). Countries have developed defined procurement tools and procurement processes to standardize and facilitate contracting with private entities.

Public-private contracts allow the transaction of services (supply, works, services) between the private and the public. The public authority specifies the terms of the transaction, the private delivers services and bears certain risks related to the project, providing resources and expertise. Public-private contracts when complex and at large scale (global markets, PPPs) are constrained and limited by environment uncertainties, bounded rationality from the actors (prone to opportunistic behaviors) and strong asset specificities. These may involve incomplete contracts, create asymmetries between public and private entities and increase the risk of costly contract endorsements (Saussier, 2018) (Tirole, 2015). Public-private-partnerships for instance are contracting schemes where the private entity finance the infrastructure and is remunerated on a long-term period according to the service availability or market demand (Yescombe, 2007) (Vries, 2013) (Finger, 2018). In this scheme, forecasting long term payments in an uncertain environment is a major source of disputes between the public and the private, furthermore the private operator can profit from information asymmetries (expertise and residual control on the infrastructure) to take advantage in the contract arrangement. In France for example, multiple PPPs went under important failures and costly contracts endorsements (Eaux de Paris, Caen tramways, Velib's).

2. *Evolution of infrastructure planning and the predominance of city areas*

Infrastructure planning and governance are currently framed at varying scales and levels which have evolved throughout time. While the industrialization drove the expansion of network infrastructures at the national level – state owned enterprises with strong market power to profit from economics of scale and network effects (monopolies) [1], the globalization and an economic slowdown in the 1980s have constrained the infrastructure networks industry. Nation-states reduced their capacities to invest in retrofits, maintain or expend infrastructures. In turn, the period saw a multiplication and complexification of governance levels. Network industries changed their organization from monopolies to an unbundled organization, i.e. horizontal and vertical separation of monopoly infrastructures and services (for instance the electricity market liberalization as of 1997). Besides, technology complexification and an innovation push (notably due to ICTs and the climate pressure) has created more distributed and decoupled infrastructure systems (for instance smart grids in electricity).

Hence, energy services companies now focus on delivering competitive services for downstream infrastructures driven by efficiency, sustainability and resiliency criteria, dealing with lower levels of government: cities and territories (Finger, 2018) (Hoppmann, 2018). That trend is reinforced by the global market demand for infrastructures. On one hand, cities must improve the quality of life offered to citizens and decarbonize their infrastructure under financial constraints. On the other hand, investors have strong appetite for infrastructures favoured by low interest rates and good returns. Academics use the term "infrastructure turn" to describe the current global effort to boost infrastructure developments (multi-levels policies and frameworks) and attract investments (Dodson, 2017). The infrastructure investment demand would range between $57 and $67 trillion worldwide according to the New Cities Foundation (Kim, 2016).

3. *From urban infrastructures to large and digitalized urban infrastructure systems*

From recent literature, it is considered that the relevant unit are large urban systems (Finger Razaghi, 2017)

[1] Network effects, strong economics of scale, market power and concentration

(Finger, 2019), being aggregated urban and metropolitan areas. Large urban systems must be considered as complex socio-technical systems. They are systems because can be represented as dynamic multi-factor and inter-related networks[2]. They are socio-technical because citizens' activities are enabled and inter-related with infrastructures. Hence, urban infrastructures are addressed at the same scale and tackled as dynamic socio-technical systems. Indeed, there exist interrelations and similar characteristics between different urban infrastructures (such as energy dependency, public good characteristics, network effects, sunk costs, …) and there are levels of coordination when considered as a system. The penetration of cities by information and communication technologies (ICTs) have pushed that paradigm further, increasing the potential coordination between infrastructures systems. ICTs enable data collection, aggregation and analysis for infrastructures, adding a data layer on infrastructures systems that create new coordination (digitalization). Applications of that data layer on infrastructures are called smart urban data applications and are embedded in the concepts of "*smart cities*". Smart urban data applications are based on the use of connected Internet of Things, to collect data on digital platforms in order to visualize and monitor urban space and public services. For instance, it allows remote maintenance, control and management of urban networks (water, energy, telecoms, transport, waste) for more efficient resource and energy management. Besides, this creates new digital public services for consumers such as demand responsive traffic monitoring, or remote management of home appliances (Gérando Avocats, 2015) (Finger, 2018).

4. *Challenges for procuring large and digitalized urban infrastructure systems*

From the above it can be seen that, on the one hand, urban infrastructures are increasingly delivered and managed as large and digitalized urban infrastructure systems in order to profit from synergies and coordination, notably provided by digitalization. On the other hand, the level of public management is more granular and distributed. Infrastructures are planned in different environments and with varying resources (case by case) and delivered with public private contracts. This section presents four challenges to procuring and implementing large and digitalized urban infrastructures[3].

The first challenge is to understand and define new scopes for urban infrastructure systems. What will be the new models of urban systems with digitalization and the limits of public services' mutualization? To answer that, one must assess technical and organization factors. First, core infrastructure domains should be identified has "entry keys" to combine and aggregate other infrastructures or components in a single project. For instance, starting from public lighting poles, one could add connection (*Internet of Things*). An extension to mobility would include road signalization as well, then a digital *hypervision* platform could be added and visualize public spaces with the aggregation of a security cameras network for instance. To assess the feasibility of merging all these components in a single project, one must look at the value generated and performance gains from the project. Secondly, one must assess the administrative and governance feasibility to implement such projects. Some specific local administrations present strong barriers to merge and mutualize public services. The main issue is the transfer of responsibility from one entity to another and hence, the loss of sovereignty on the service. In order to establish a proper governance for public services, key features are the risks allocation between private and public actors translated by adapted business models. That is the next challenge explained below.

Indeed, a second challenge is to build a business model that best reflects the services and objectives of the infrastructure and establish the level of responsibility and implication of each stakeholder. It has been seen that there is a clear interrelation between the economic model implemented (risks taken by the private operator related to the project cash flows) and the asset deconsolidation, i.e. the economic transfer of the project to the private

[2] Also strategic for the country's economic development and profitable for governments drove some companies' nationalization as of the 1930s

[3] Resources used to develop the section are derived from the contract assessment of 9 complex projects in 5 different infrastructure domains (public lighting, video-protection, smart platforms, district heating and cooling, transportation infrastructures) done at Engie: Master thesis with Engie corporate's business development unit: "how to implement asset based models in complex urban infrastructures"

actor (Eurostat, 2016) (IGD, 2019). Hence, when the infrastructure has a natural merchant business model, remuneration on end users, risks and responsibilities are easily transferred to the private operator. For non-merchant infrastructures (for instance public lighting), business models based on energy efficiency and performance incentives emerge, such as *intracting schemes* (payments on energy savings compared to the original energy bill). In that context, digitalization plays a strategic role and ICTs could be a key infrastructure to unlock large infrastructure systems as well as new merchant models and revenues streams. Indeed, a data layer allows centralized monitoring and new coordination for infrastructures. First, centralized monitoring allows the large scale vision on the whole infrastructure system and new performance incentives. Secondly, the coordination of infrastructures creates new services and potential revenues streams from the infrastructure system (for previously non-merchant infrastructures). Hence, digitalization would enable the implementation of hybrid business models for infrastructure systems, aggregating remunerations on performance in addition to established business models. For instance, one could aggregate the energy savings from public lighting and the traffic congestion management efficiency monitored by a digital platform (traffic lead times or pollution monitoring as performance targets). In addition, new services could be added such as revenues from electric vehicles charging (infrastructure added around some public lighting poles) or smart park billing.

Even if a clear scope has been identified for digital urban infrastructures, the public locality remains the key actor that selects, appraises and implements the project. Each locality is specific and might have strong procurement, financing and governance barriers as well as political biases. The next challenge is on addressing and adapting local contexts in order to reduce and overcome those barriers. Specific frameworks organize urban infrastructure development from strategic planning to procurement. These frameworks aim to maximize projects socio-economic impacts and collective value (ex-ante socio economic assessments), to help public actors manage financial resources, and guide them in a transparent and non-collusive procurement process. However, public authorities present strong critical paths in delivering and managing public services and assets, using similar contract schemes by experience or political bias for instance. That leads to inadequate and badly conceived contracts. Either procurement frameworks are not incentivizing properly localities or local administrations present too important barriers and inefficiencies to enable transparent and lean processes for projects developments (Tirole, 2015) (Saussier, 2018). New innovative tools could improve that and provide more practical and specific decision-aid frameworks that facilitate projects business cases. SOURCE for instance is a tool developed by multilateral banks that frames and records PPP's appraisals and structuring in emerging countries[4].

The last challenge pertains to adapting public-private contracts to these new concepts of digitalized infrastructures. New governance schemes must be found to monitor and incentivize the private operator. Public sector's organization and frameworks must also be adapted in order to overcome public sector's inefficiencies and help public authorities select the best contract model.

[4] 800+ questions specific to the infrastructure domain

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Our Group is a global reference in low-carbon energy and services. In response to the urgency of climate change, our ambition is to become the world leader in the zero-carbon transition "as a service" for our customers, in particular global companies and local authorities. We rely on our key activities (renewable energy, gas, services) to offer competitive turnkey solutions.

With our 170,000 employees, our customers, partners and stakeholders, we are a community of Imaginative Builders, committed every day to more harmonious progress.

Turnover in 2019: EUR 60.1 billion. The Group is listed on the Paris and Brussels stock exchanges (ENGI) and is represented in the main financial indices (CAC 40, DJ Euro Stoxx 50, Euronext 100, FTSE Eurotop 100, MSCI Europe) and non-financial indices (DJSI World, DJSI Europe and Euronext Vigeo Eiris - World 120, Eurozone 120, Europe 120, France 20, CAC 40 Governance).

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