Complexity and energy performance contracting: the case of street lighting

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Abstract

There has been a renewal of public-private partnership (PPP) in France after 2004. Until 2013, this procedure was relatively popular to deliver integrated solutions to public authorities who were demanding for packaged product and service delivery. Street lighting projects aiming at reducing electricity consumption are dominant among PPP. These projects are a category of energy performance contracting (EPC). The question is why EPC is dominant for street lighting projects and not for buildings. A case study focusing on a street lighting project indicates that they are less complex. Uncertainty is limited and beneficiaries have no influence on the end result whereas occupants can have a strong impact on the energy consumption of a building. Moreover, formal contracts are adapted to this type of projects with limited uncertainties and relational governance can be limited.

Keywords: PPP, complexity, governance, public lighting, energy performance contracting

1. Introduction: private finance procurement in France

France has a long experience in private finance procurement. It concerns mainly infrastructure projects where an asset (such as a road) is provided for which users pay directly. The first concession arrangement was signed in 1554 for the construction and maintenance of a canal over a period of ten years (Bezançon, 2005). During the 19th century, the concession system was dominant for all public works. Contractors were systematically associated to maintenance works for six to ten years. More recently, during the sixties, concessions mainly concerned public infrastructures such as bridges, tunnels, urban facilities and roads (motorways). Under this scheme, the concessionaire is partly paid by the users of the public service conceded.

During the late eighties, some schools and prisons were delivered under a Design, Build, Operate and Finance scheme. However, the procurement method was opaque and it led to illicit agreement practices between contractors. Thus, public private partnership (PPP) for buildings was banned for about ten years and the development of the market in France was delayed. However, most large French contractors were able to benefit from the PFI experience in the UK.

At the beginning of the 21st century, there was a strong debate for the renewal of PPP in France. Architects were strongly opposed to any kind of PPP for buildings. They considered that contractors would become relatively more powerful and that financial issues will took over architectural matters. Conversely, large contractors saw PPP as an opportunity to modify their traditional business models and to move into new kinds of value-added activities. Between 2002 and 2004, several ministries (home Affairs, Justice, Health and Defence) introduced a new legal framework for projects concerning facilities such as prisons, police stations, and healthcare facilities. Finally, in June 2004 a new law was enacted to spur partnership contracts ("Contrats de partenariat"). It was strongly influenced by the Private Finance Initiative in the UK. From June 2004 to December 2013, 194 contracts were signed representing an investment of approximately 14 billion euros (table 1).

Table 1: Economic value of Partnership contracts at the end of 2013[1]

Actors	*Projects signed*	*Investment (million €)*	*Global value (million €)*
Local authorities	*145*	*4 119*	*10 185*
State	*49*	*10 346*	*26 436*
Total	*194*	*14 465*	*36 621*

Source : CEF-OPPP (2014)

Knowing that public investment reaches about 90 billion euros every year, the vast majority of investments in the French public service is still procured through conventional means. Partnership contracts were mostly used for buildings at the State level, and for urban facilities, at the local level (table 2).

[1] After 2013, the number of deals collapsed. 9 and 6 projects were respectively signed in 2014 and 2015.

Table 2: Sectoral breakdown of partnership contracts signed at the end of December 2015

Actor / *Type*	*Local authorities*	*State*	*Total*
Building	*34*	*32*	*65*
Sports and cultural infrastructure	*22*	*2*	*25*
Energy / waste	*11*	*11*	*22*
Urban facilities	*63*	*0*	*63*
Information and communication technologies	*13*	*4*	*17*
Transport	*10*	*6*	*16*
Training	*0*	*1*	*1*
Total	*153*	*56*	*209*

Source : MAPPP (2015) - http://www.economie.gouv.fr/ppp/contrats-signes

Among urban facilities, street-lighting is dominant. These contracts aim at refurbishing street lighting in order to reduce the electricity consumption of local authorities. As such, they can be associated to energy performance contracting (EPC). According to the European Parliament's definition (2012), "*energy performance contracting means a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings*".

Partnership contracts have seldom integrated issues dealing with energy performance in buildings. Conversely, cutting energy consumption was the main target of PPP focusing on street-lighting. The aim of this paper is to understand this gap.

To launch a partnership contract, it is necessary to prove that the project is "urgent" or "complex" or brings value for money. More than 90% of PPP projects were considered as complex.[2] Thus, the paper will examine the notion of complexity in construction and its impact on project governance. Then, a case study focusing on street lighting will be presented. The aim of the discussion will be to understand why energy performance contracting is dominant in street lighting projects and frequently omitted in building projects.

[2] A new law will be enacted soon. The aim is to simplify all sector-specific legislation and to comply with the European directive on public markets. According to the first draft (July 2015), partnership contracts will only be signed if they offer value for money.

2. The impact of complexity on governance

2.1 Complexity in construction project

It is widely recognised that construction projects become progressively more complex (Baccarini, 1996). This complexity is also put forward by Hobday (1998) who introduced the notion of complex products and systems (CoPS) to characterise one-off projects. While the focus is on the production process with goods and services, the emphasis with CoPS is on design, project management, systems engineering and systems integration. Several dimensions characterise complexity: the degree of technological novelty, extent of embedded software in product, quantity of sub-systems and components, feedback loop from later to earlier stages, uncertainty/change in user requirements… As construction is moving away from its production-based focus and is developing new service activities (financing projects, operating and maintaining systems…), interfaces are multiplied, and project complexity becomes stronger. Project management does not anymore concentrate on the internal project team and external supply chains. It also integrates downstream service delivery. (Alderman et al., 2005).

This move from the building activity to the service provided by the built environment (Carassus, 2002) is accompanied by a change of procurement. Traditional design and build contracts based on input specifications are more and more replaced by service-led contracts where the output to be delivered is specified. The competitive dialog procedure is particularly adapted to these situations since it helps to match the demand of the client with the possible solutions that contractors can offer (Hoezen et al., 2010). According to Lewis and Roerich (2009), it is possible to assess the complexity of the procurement process in terms of two dimensions: performance complexity and infrastructural complexity. The first refers to "*a function of characteristics such as the level of knowledge embedded in the performance*" (p.127). The second refers to "*the complexity of the infrastructure through which performance is enacted*" (p.128). According to this framework, traditional design and build contracts based on input specifications would be considered as less complex in terms of performance than service-led contracts which go further than design and build and encompass operation and maintenance.

Complexity can change over time. Wang and von Tunzelmann (2000) show that each functional area of the firm (technology, markets and products, production processes, administration and management) is in interaction with each other and that the evolution of the complexity of one function will impact other functions. Complexity will also depend on the competencies developed by public authorities. This issue is central for the European Commission (2004) who considers that a public contract is particularly complex when the contracting authorities*: "(1) are not objectively able to define the technical means (…) capable of satisfying their needs or objectives, and/or (2) are not objectively able to specify the legal and/or financial make‑up of a project*."

2.2 Complexity in EPC

Simple building constructs cannot be associated to CoPS. Conversely, EPC for buildings are complex on several dimensions:

1. Design based on collection of information and data, and dynamic thermal modeling and simulation: Dynamic thermal modeling and simulation is a complex activity as illustrated by the frequent gap between predicted energy performance of buildings and measured energy use once buildings are operational (de Wilde, 2014).
2. Works such as the removal and installation of efficient heaters, measurement and monitoring equipment, insulation of buildings, cover a broad range of activities and usually involve subcontractors. Moreover, works usually concern buildings with different architectural style, different year of completion…and require the development of specific technical solutions. Works are also done in occupied buildings and they have to take into account the occupants to avoid disturbances and conflicts.
3. Operation and maintenance of buildings: the performance of these activities is based on day-to-day maintenance but also on occupancy conditions. To reduce the impact of users during the operation of the building, the operator may develop actions to promote environmental awareness. The complexity is due to the necessary cooperation between two actors (the operator and the occupants) with antagonist goals.
4. Project financing: The financial arrangement is very complex. There are mainly two financing approaches: self-financing or third-party financing (Lee and al., 2015). In some cases, project financing is made with a mix between debt and equity. Public authorities who are not familiar with these complex financial schemes regularly receive the support of lawyers and financial consultants.
5. Measurement and verification: they are the cornerstone of EPC since it is used to allocate risks between the ESCO and the client, to assess energy savings and reckon penalties / bonuses, to monitor equipment performance and to improve operations and maintenance (USDE, 2015). There has been effort to standardized M&V by developing protocols. Moreover, technological development in monitoring and data mining techniques have contributed to improve performance predictions and building energy management decision-making (Ahmed et al, 2011). However, this is still complex since it is difficult to get reliable building operation data before the signature of the contract and to monitor behavioural changes during the project life time.

Moreover, project complexity is influenced by the experience of the stakeholders with EPC projects. Energy Service Companies (ESCOs) which are at the core of EPC are not equally developed among countries. Bertoldi and al. (2006) classified French ESCOs in the “second European league”. Similarly, public authorities who have a great experience with delegating the management of public services are still not familiar with performance contract and performance procurement process. As indicated by Hartmann et al. (2010), public authorities need to develop capabilities to contract for service-led projects and manage the relationships with their service providers. Developing simultaneously contractual and relational capabilities is difficult since contractual documents are still the main references.

2.3 Governance issues

Developing a transaction cost analysis, Winch (2001) considers that low asset specificity, low transaction frequency, and high uncertainty characterise construction. According to this theoretical framework, hierarchy should be preferred to drive construction procurement because of the uncertainty surrounding the project (unknown natural conditions, temporary coalition between actors, unique features of each project). However, market governance is the most adapted to clients' preferences since asset specificity is low (resources required are available from a large number of suppliers and contractors) and transactions are not frequent (even experienced clients do not procure many buildings every year). The move toward service-led projects modifies this framework and requires more contractual safeguards to mitigate the uncertainty (Hartmann et al., 2010). According to Bijlsma-Frankema and Costa (2005), the effectiveness of control of formal contracts depends on three elements: (1) the codification of the tasks and the behaviours, and the measurability of outcomes; (2) the monitoring of the actions performed by the parties; (3) the creation of a structure that enforce the contract.

However, formal contracts are difficult to specify for service-led projects since outcomes are frequently intangible. Moreover, service-led projects have a longer lifespan and are subject to technological changes. Specifying everything ex-ante would raise transaction costs and render the contract difficult to enforce. Indeed, it would be necessary to create a specific structure in charge of monitoring opportunistic behaviour and applying contractual clauses. This would be costly and would create additional complexity. Consequently, it is more efficient to accept incomplete contracts, to introduce some contractual flexibility and to rely on relational governance and trust between partners to avoid conflicts. "*Relational governance refers to those inter-organizational exchange mechanisms that are not sanctioned through formal contractual positions (…) but are manifest in custom and practice*" (Roehrich and Lewis, 2010, 1157). Relational governance has its own enforcement mechanisms such as threat of social sanctioning and reputation effects. Formal contracts and trust are complementary. The negotiation process that leads to the contractual agreement is frequently at the origin of a common understanding between parties. The contract also offers protections necessary for the creation of a relationship based on trust. It is a solution to enforce the trust between partners and to limit opportunism.

3. Case description: the EPC dealing with street-lighting in two municipalities[3]

3.1 The project and its context

The PPP project concern two municipalities: city A and city B hosting respectively 117 000 and 23 000 inhabitants. Most street lighting facilities of city A were outdated (more than 45 years

[3] Since there is apparently nothing in the literature about street lighting the case study approach appears appropriate. It is based on face-to-face interviews with the client, the legal consultant, and two people representing the private partner. A report comparing the conventional public procurement process and the PPP option was also used as complementary source of information.

old) and highly inefficient. In 2007, 26% of the 5298 lights would have required to be replaced within five years and 40% within two years. The power of the lighting system was also defective. Consequently, the network was not anymore safe and reliable. Operation and maintenance were entrusted to municipal employees and outsourced to one company who signed a one year contract renewable three times. The situation of the neighbouring city (B) was less dramatic. Only 25% of its 2 647 lights had to be replaced in the short run. One private partner was in charge of operating the network. Indeed, in 1994, this city signed a PPP including financing, operation, maintenance and renewal of street lighting and traffic lights.

Annual operating costs were different between cities. City A spent about EUR 335,000 each year. City B with a network twice as small spent EUR 400,000. In 2004, competencies dealing with street light were transferred to a regional community. PPP was seen as the solution to modernise the lighting network and to introduce environmental criterion and energy performance objectives. City A had a limited borrowing capacity and was not able to borrow €30 million for the modernisation of its public lighting network.[4] City B already experienced PPP and was also looking for a solution to finance, renovate and operate its network.

The criterion of complexity has been put forward to justify the PPP procedure. Both municipalities did not have the technical know-how to refurbish street lighting. Moreover, the regional community who represented both municipalities and took in charge the project had no expertise to assess the level of investment and to operate and optimize the energy related installations.

Legal, financial and technical consultants assisted public authorities during the redaction of the comparative analysis and the competitive dialog. According to the public sector comparator, PPP offered the best value for money both in terms of costs and service quality. The call was launched in December 2006. The first round for the competitive dialog was organised in September 2007 and the second in November. The contract was awarded in June 2008 and signed in July for 20 years. The company, who won the competition for the deal, covers the entire value stream of public lighting, from design, to renovation works and operation. Consequently, there was no need to create a Special Purpose Vehicle as for most PPP projects. The company borrowed money to one bank. The initial costs of the deal reached EUR 92.3 million. However, it was renegotiated during refurbishment works due to a decrease of interest rates. Thus, the final deal reached EUR 86 million over the 20 year period.

[4] At that time, PPP was still seen as a way to account public investments as off the balance sheet. According to the Eurostat rule in 2004, it was possible to classify investments made through PPPs as non-governmental if the construction risk and either availability or demand risk were transferred to the private operator. Thus, debt hiding was a motivation for PPP. Since 2011, both existing and new projects have to be considered as public debt. "*On the balance-sheet, the capital value of the investment is recorded within the assets, while the already-paid investment and the remaining debt are recorded within the liabilities*" (Buso and al, 2013).

3.2 The complexity of the project

According to Wang and von Tunzelmann (2000), complexity covers several dimensions: the technology, the markets and products, the production processes, and the administration and management. The complexity of this project mainly concerned the technological and organisational dimensions:

- A large part of civil engineering was performed with micro slicers[5] in order to reduce both the time in which roads cannot be used and the quantity of excavated volume. The private partner also anticipated future works by performing all civil engineering during the first three years of the contract. In the future, when a cable will be laid, no additional trench will be opened. This approach minimised the environmental impact and the nuisance caused by the construction sites.
- The use of the micro slicers completely changed the organization and the conduct of the project. The work was closely coordinated with private companies in charge of managing the gas network and relevant community services. The objective was to avoid interventions from municipal employees shortly before or after the action of the private partner. A specific team was also created to inform residents about the works in progress. Moreover, to optimise the micro slicers, trenches had to cover a length of 500 meters for one week. Such length was unusual and required further communication.
- The installation of a centralised control station was another major innovation. It is commonly used for building but it was the first time for public lighting. Moreover, a wireless network was set up to link luminaires to the central station. This solution aimed at monitoring the intensity of every light[6] and providing complementary services to local authorities (such as video protection, tricolour stop lights).

3.3 Results

The private companies renovated 70% of the street lighting system on time (at the end of the contract, 95% of the park will be renovated).[7] By concentrating most of the renovation works on the first three years, the goal of the company was to reduce as soon as possible the power of the network by 38% and to reach its energy performance objectives on the long run. Over the 20 year period, total energy consumption has to reach 94 GWh. If the savings are not achieved, the private partner will pay compensation. Conversely, gains will be invested in energy performance works. However, there are no yearly milestones. The private partner just needs to write a report every year in order to present how contractual obligations are respected. Public

[5] With the traditional approach, the company digs a trench of 80 cm deep and 40 cm width while with this technique, the hole is limited to 35 cm deep and 15 cm width. This technology is traditionally used for the installation of fiber optics in the countryside.
[6] Lights can be shut down in streets that do not need to be lighted in the middle of the night.
[7] The competitive dialog helped the laureate to improve its initial offer. His first proposal was to renovate 62% of the candelabra over a period of five years. In addition, at the end of the twenty years contract, only 88% of the Park would have been renovated.

authorities also hired a subcontractor who ensures that the private company adheres to the performance and standards stipulated in the contract.

After two years, the energy consumption was slightly over its target. However, the private partner was still optimistic since the centralised control station was not operational in both cities during the first years of the contract. Moreover, life cycle costing approaches were not neglected because the operator contributed to the elaboration and he success of the deal. According to Swaffield and Mc Donald (2008) and Rintala (2005), this issue is frequently ignored in PPP projects because budgets are constrained, clients are unable to understand the maintenance requirements and the associated costs, and there is a lack of information about the different options and about the past performance of products. Moreover, operators have usually less influence on the service provision solution than contractors. Consequently, operational solutions are not frequently optimised.

Both partners considered that the contract lacks flexibility, particularly to resolve unforeseen actions. For example, the contract does not mention that the private partner is responsible for exceptional lighting events such as the National Day or the "Night of the Stars". So far, the private partner accepted to support these costs. However, he would like to open a special account for financing contingencies that were not anticipated and to introduce information disclosure for this account in order to preserve the stability of the agreement.

The public person in charge of following the contract was satisfied with the service quality. However, he was sceptical about the length of the contract. Even if the best technology available were selected[8], several technological changes may affect street lighting system and the actual contract may create a lock-in effect.

4. Discussion

The main objective of this paper was to understand why energy performance contracting was dominant in public lighting projects following a PPP procurement process and frequently omitted in building projects. To answer to this question, it appears first necessary to compare the complexity of EPC for buildings and public lighting. The five aforementioned dimensions can be examined: design, works, operation and maintenance, project financing, and measurement and verification.

Design: design is usually integrated in order to achieve higher energy savings. Lots of data are frequently missing in these types of projects even when the preferred bidder is selected. Time and money spent for data collection (information on buildings / current state of street lighting) are probably similar. However, dynamic modelling and simulation are more complex for buildings since the users (operational hours, behaviours…) have a strong influence on the results. Conversely, user will not interfere with the operation of street lighting system.

[8] At this time LED technology was not considered as the most interesting option. It was twice as expensive as other technology available. Moreover, there was a lack of feedback studies for LED.

Moreover, architectural issues are omnipresent in building projects but limited for street lighting.

Works: in both cases, it is necessary to coordinate a large number of subcontractors. Before and during the works, communication with the residents / the users of the buildings is a key action. In the case study, technologies used during the refurbishment of street lighting were innovative. Moreover, 70% of the park was renovated over a three year period. All these elements increased the complexity of the works. The implementation of a centralised control station appears as complex for buildings as for street lighting systems.

Operation and maintenance: in the case of public lighting, it is a standardised process. Unforeseen events are limited (e.g.: light time can be anticipated for the length of the contract). In buildings, it is harder to anticipate the evolution of the activity. For example, occupancy may vary according to the activity from one year to the other. Thus, uncertainty is stronger.

Project financing: there is a large spectrum of financial arrangements. Complexity varies from one project to the other. Apparently, it is as complex for buildings as for street lighting. However, the risk supported by the financing party is probably stronger for buildings because of the frequent gap between predicted energy performance of buildings and measured energy use once buildings are operational.

Measurement and verification: establishing the baseline is probably the most difficult task of EPC for buildings. The conceptual framework published by the U.S. Department of Energy (2015) for quantifying the savings resulting from energy efficiency equipment, improved operation and maintenance, is complex. Even if the steps are well defined, each item is subject to interpretation and several options are available. The public lighting project presented in this paper does not reflect such a high level of complexity.

Table 3 summarises complexity of EPC projects in the cases of street lighting and buildings.

Table 3: Complexity of EPC: public lighting versus buildings

Dimensions	*Level of complexity on a scale going from 1 to 5*	
	Public lighting	*Buildings*
Design	*3*	*5*
Works	*4*	*4*
Operation and maintenance	*2*	*5*
Project financing	*3*	*4*
Measurement & Verification	*1*	*4*

According to table 3 based on the author's experience with EPC in buildings (Bougrain and al. 2014) and the case study, street lighting projects integrating design, works, operation and maintenance, appear much less complex at the operational level than building projects. The

absence of users who interfere with the operator and the predictability of most events occurring during the life of the contract, limit the risk. Moreover, the codification of the tasks and the measurability of outcomes are easier to implement. Thus, the control is more effective. Formal contracts seem adapted. Conversely, uncertainty is strong for EPC in buildings. Actions performed by private partners such as ESCO, are difficult to monitor. Users can adopt opportunistic behaviour. To mitigate these aspects, cooperation based on trust is essential for the success of a project.

The limited complexity of street lighting projects at the operational stage, probably explains why these projects represented about 40% of partnership contracts signed by local authorities (table 2). The paradox is that complexity was frequently cited by public authorities to justify PPP for street lighting. Conversely, the high level of complexity of EPC for buildings in operation and the uncertainty attached to this contract, explained probably the infrequent use of EPC in building projects.

5. Conclusions

The case study indicates that EPC for street lighting are very complex during design and construction phases. This complexity decreases when one moves downstream to the operation of the public network. This is due to a diminution of uncertainty: most events having an impact on the performance of the network in operation are predictable. Conversely, EPC in building projects tend to face unforeseen events during the operation: cooperation between occupants and operators is subject to tensions; protocols to measure and verify energy consumption are standardised but their implementation is still complex. This difference of complexity has an impact on the governance of each project. While pure contractual relationships may be adapted to EPC in street lighting projects, relational governance needs to be introduced in EPC for buildings. Trust can compensate the uncertainty surrounding these projects.

By investigating only one case study, the research has limitations. Further research is required to extend applications to this field. It would be interesting to examine how complexity evolves over time and impacts on governance.

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