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Exploring the role of servitization to overcome barriers for innovative energy demand reduction technologies – the case of public LED street lighting in German municipalities

Friedemann Polzin[*,1,2], Paschen von Flotow[2] & Colin Nolden[3]

Abstract: In this paper we analyse the case for public application of LED street lighting. Drawing from the energy services literature and transaction cost economics, we compare modes of lighting governance for modernisation. We argue that servitization can accelerate the commercialisation and diffusion of end-use energy demand reduction (EUED) technologies in the public sector if third party energy service companies (ESCo) overcome technological, institutional and economic barriers that accompany the introduction of such technologies resulting in transaction costs. This can only succeed with a supportive policy framework and an environment conducive towards the dissemination of specific technological and commercial knowledge required for the diffusion process.

Keywords: energy efficiency, public policy, servitization, contracting, ESCo, modes of governance, LED, lighting

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1. Introduction

Energy efficiency is increasingly considered the cheapest and most effective way of addressing issues such as climate change and energy security (EC, 2014; IEA, 2014a, 2014b; IPCC, 2014). However, investments in associated technologies remain below the optimal level as the markets for energy efficiency are subject to severe system failures (IEA, 2013a). Consequently, the rate of adoption and diffusion is low as structures and incentives for application are missing (Jaffe et al., 2005; Schleich, 2009; Sorrell et al., 2004). In this paper we analyse the case of public sector application of LED (light-emitting diodes) street lighting in Germany as an example of a market where some of the barriers are being addressed through servitization.

The lighting industry has recently undergone major shifts from traditional lamps towards LED with significant savings in terms of finance and energy possible under laboratory conditions but limited experience in real world settings (IEA, 2013b). As a result, application of this technology is proving to be challenging for both manufacturers and customers (Bergek and Onufrey, 2013; Sanderson and Simons, 2014; Smink et al., 2013), despite forecasts of LED market shares increasing from less than 10% to 70% by 2020 (McKinsey, 2012). Public procurement is considered a significant driver in the innovation and diffusion process (Edler and Georghiou, 2007; Edquist and Zabala-Iturriagagoitia, 2012) and in this paper we analyse the role of different governance arrangements available to German municipalities for LED street lighting.

Street lighting in Germany represents a major cost factor, accounting for almost one third of municipal electricity budgets (DStGB, 2010). This provides a strong incentive for municipalities to take the lead in the diffusion of more efficient technologies (Radulovic et al., 2011; Schönberger, 2013). Municipalities, however, are typically short in budgets although they need to invest in energy efficiency not only to alleviate financial constraints but also to meet their own as well as national climate change targets (Bennett and Iossa, 2006; dena, 2015; Hartmann et al., 2014; Hendricks, 2014). Energy service companies (ESCos) can help overcome some of these barriers by ‘servitising’ public sector LED street lighting using energy service contracts. ESCos have primarily been analysed in the context of markets (Bertoldi et al., 2014; Marino et al., 2011, 2010) while 'servitization' is commonly analysed from a business perspective through product-service systems (Steinberger et al., 2009).

This paper merges these areas of research by drawing from the energy services literature based on transaction cost economics and arguing that 'servitization' involving third-party contractors can accelerate the commercialisation and diffusion of energy efficiency technologies and help overcome systemic barriers. Compared to the traditional in-house approach to energy management, alternative approaches primarily imply the establishment of hybrid forms of economic organisation or more market based solutions through outsourcing (Pint and Baldwin, 1997; Toffel, 2002; Williamson, 1985). The example of Germany is particularly revealing as municipal independence and its federal state structure have lent themselves to the establishment of diverse governance mechanisms for the provision of public services. Additionally, Government launched an energy service contracting initiative by providing standardised contracts (SBI, 2013). Hence our research questions reads as follows: *What is the role of energy service contracting in addressing the barriers to commercialisation and diffusion of LED street lighting in Germany?*

Combining a longitudinal archival document analysis and 40 semi-structured interviews, our analysis points towards energy service contracting contributing to LED street lighting diffusion in German municipalities under specific institutional conditions. Section 2 introduces the main literature streams, theoretical framework and research design including the qualitative research approach and the data. Section 3 displays the results which form the basis for discussion (Section 4) and conclusion (Section 5), including policy implications.

2. Literature review and theoretical framework

2.1. Challenges facing adoption of novel end-use energy demand technologies

One way to address climate change by uncoupling economic growth from the use of finite resources is low-carbon innovation (Foxon et al., 2008; Popp, 2010). Compared to supply side low-carbon technologies, end-use energy demand reduction technologies (EUEDs)[1], which could contribute significantly to reaching climate change targets while reducing costs and dependency on fossil fuels, have been marginalised (IEA, 2014a, 2014b; Mickwitz et al., 2008; Sovacool, 2009). Wilson et al. (2012) attribute this to the nature of these technologies, such as diversity and widespread application, small scale and low visibility.

Barriers to the diffusion process arise from complex interdependent factors that relate to the nature of innovation and environmental externalities. **Technological factors** comprise uncertainty about the dominant design, quality, increased complexity of innovative technologies and application (Jackson, 2010; Schleich, 2009; Sorrell et al., 2004; van Soest and Bulte, 2001). **Institutional barriers** such as path dependent technological application due to investments into corresponding infrastructure, low acceptance among the local population or unanticipated or reoccurring changes in the policy design and administrative approval also impede the technological diffusion process (Foxon et al., 2008; Iyer et al., 2013; Klein Woolthuis et al., 2005; Steinbach, 2013; Wilson et al., 2012). Volatile or artificially low energy prices and incomplete carbon markets represent **economic barriers** to diffusion by increasing uncertainty and rendering investments in novel EUEDs unprofitable, which lead to slow capital stock turnover and corresponding long payback periods as upfront costs are high (Gallagher et al., 2006; Jaffe et al., 2005; Sorrell et al., 2004). To examine these factors, potential users require enhanced **competencies and capacities** (Jacobsson and Karltorp, 2013; Klein Woolthuis et al., 2005; Schleich, 2009; Sorrell et al., 2004). Hence customers often 'wait' for future improvements and fail to harness current savings. This is referred to as 'energy efficiency paradox' (van Soest and Bulte, 2001). The above mentioned factors represent key barriers for a range of EUEDs, including lighting (Mills and Schleich, 2014), which this paper seeks to address.

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[1] An 'end-use energy demand reduction technology' can be defined as 'the reduction of the absolute consumption of primary energy' (e.g. electricity, fuel) (Herring, 2006; Wilson et al., 2012); see also: http://www.eued.ac.uk/whatiseued

To support the uptake of novel technologies, scholars highlight the importance of demand side measures, among which public procurement is one key element (Edler and Georghiou, 2007; Guerzoni and Raiteri, 2014). Public procurement can also contribute to satisfying unsatisfied human needs and solving societal problems, such as climate change, if appropriate innovations are supported (Edquist and Zabala-Iturriagagoitia, 2012). However, this process is subject to a set of barriers perceived by suppliers of innovative goods, such as the lack of interaction with procuring organisations, the use of over-specified tenders as opposed to outcome based specifications, low competences of the procurers and a poor management of risk during the procurement process (Uyarra et al., 2014).

Governments, like municipalities, are typically running on a very tight budget, which limits their abilities to procure innovative EUEDs (Edquist and Zabala-Iturriagagoitia, 2012; Hartmann et al., 2014). In this case third-party contracting, a specific form of public procurement and public-private-cooperation, can be a solution (Bennett and Iossa, 2006; Hartmann et al., 2014; Helle, 1997; Hypko et al., 2010a; Roehrich et al., 2014). The literature has highlighted the design of contractual arrangements (*mode of governance*) regarding contract duration and responsibilities as a critical factor to address the complexity in the procurement process, especially with regard to public infrastructure (Hartmann et al., 2014; Roehrich and Lewis, 2014). It has been suggested that public agencies need to 'identify the procurement level and the contractual and relational challenges involved' in a public-private partnership (PPP) to increase the economic viability for both parties (Hartmann et al., 2014, p. 174).

2.2. Energy service contracting of end-use energy demand technologies

Third-party contractors such as ESCos can be efficient suppliers, especially when it comes to energy-related services (Helle, 1997; Sorrell, 2007). This paper focuses on energy performance contracts (EPCs). The ESCo assumes control over the secondary conversion equipment and associated control equipment. This allows the ESCo to identify, deliver and maintain savings using guarantees for certain standards (of lighting service) at a particular cost, which is typically lower than its customers' current or projected energy bill (Hannon et al., 2013; Marino et al., 2011; Sorrell, 2007, 2005).

A tendency towards outsourcing, rising energy prices, continuing market liberalisation and environmental concerns benefit ESCo markets (Bertoldi et al., 2006; Marino et al., 2011). As an ESCo assumes control over conversion equipment during an EPC (see Sorrell, 2007 for more details) it could also accelerate the uptake of innovative EUEDs by addressing the aforementioned barriers, especially technological, competency and economic or investment barriers. For example, an ESCo may be able to reduce the cost for energy by deploying (novel) EUEDs and management systems, which usually require enhanced competencies and high upfront investments. However, this process might be hampered by barriers to EPC itself. In the public sector in particular these include a lack of awareness, low priority, lack of confidence in standardised measurement and verification (M&V) of energy savings and general uncertainty regarding energy efficiency investments, legal complexities, volatile energy prices, missing energy cost information, difficult access to finance, business risk and mistrust against ESCos (Marino et al., 2011; Pätäri and Sinkkonen, 2014).

Despite the barriers to EPC, the public sector EPC market is expected to grow in the coming years as ESCos co-evolve with a transition towards a more sustainable energy system (Hannon et al., 2013). Pätäri and Sinkkonen (2014) highlight difficulties with ESCos in the public sector, such as lack of knowledge, skills and resources for EPCs. Furthermore, Hannon and Bolton (2014) analysed the strengths and weaknesses of energy service contracting (with a focus on energy supply contracts) for municipalities. They conclude that the decision for a municipality to establish a partnership with a third-party ESCo will depend on its risk-aversion, the extent to which it wants to retain strategic control and the resources it has at its disposal.

2.3. Research gaps identified in the literature

With our analysis we address the calls for research by Pätäri and Sinkkonen (2014), Roehrich et al. (2014) and Hannon and Bolton (2014) into successes and failures of energy service contracting in order to derive success factors for the ESCo solution in the context of PPP and public procurement. Energy service contracts have been shown to be suitable for reducing energy costs for some energy services (Helle, 1997; Pätäri and Sinkkonen, 2014; Sorrell, 2007) and to exhibit elements of a transformative power towards an alternative market design of a performance-based economy (Haas et al., 2008; Hannon et al., 2013; Steinberger et al., 2009). LED lighting has been analysed at industry level (Sanderson and Simons, 2014; Smink et al., 2013) and household level, focusing specifically on adoption (Mills and Schleich, 2014), while the distinct context of public application has been neglected, although this provides opportunities to combine climate change mitigation with alleviation of budget constraints The specific potential of energy service contracts to accelerate the commercialisation and diffusion of *novel* EUEDs has been neglected in the literature (Hypko et al., 2010a; Roehrich et al., 2014; Steinberger et al., 2009).

2.4.Analytical Framework: Transaction cost economics

Transaction cost economics (TCE) represent the most prominent theoretical perspective to analyse modes of governance and institutional structures between hierarchies (internal) and markets (external) (Delmas, 1999; Selviaridis and Wynstra, 2014; Williamson, 1985). ‘Servitization’ refers to the outsourcing process as governance modes shift from hierarchies (in-house provision) to markets. Transaction costs depend on how the transaction is organised through governance structures and TCE makes ‘several key assumptions about managerial behaviour when determining which governance structure is most efficient for a particular transaction’ (Pint and Baldwin, 1997; Toffel, 2002, p. 2).

Transaction costs (TC) are incurred within organisations through managing and monitoring personnel, procuring inputs and capital investment, in the word of Sorrell (2007: 512) *“the costs associated with organising (‘governing‘) the provision of […] streams and/or services“*. When the same streams and/or services are sourced from an external provider, transaction costs are associated with source selection, contract management and performance monitoring., dispute resolution (Pint and Baldwin, 1997) and opportunistic behavior (Sorrell, 2007). Transactions are governed through structures, which are located on a spectrum with hierarchical organisations (internal) at one end and spot markets at the other with hybrid mechanisms in between (Pint and Baldwin, 1997; Toffel, 2002) (see Figure 1).

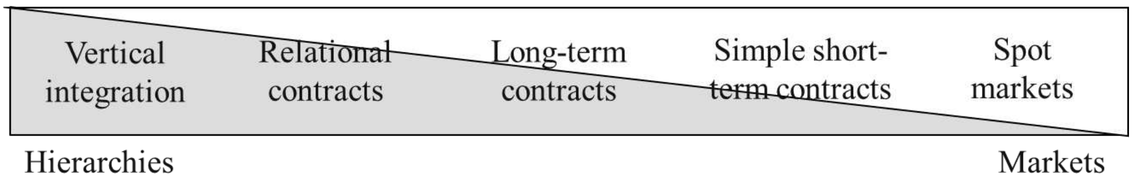

Figure 1: Spectrum of governance structures (adapted from Pint and Baldwin (1997, p.4)

With increasingly complex customisation of services, long-term contracts and more hierarchical governance structures are required, allowing for adjustment clauses to respond to contingencies (such as the emergence of more efficient technologies) over the life of a contract (Pint and Baldwin, 1997). According to TCE, the choice between long-term contracts (EPCs) and hierarchies (in-house provision) depends on the magnitude of associated transaction (TC) and production costs (PC). We employ a model originally developed by Williamson (1985) and specified by Toffel (2002), Pint and Baldwin (1997) and Sorrell (2007). Sorrell's model in particular focuses on the economics of energy service contracts, which allows the analysis of EPC vis-à-vis other modes of governance in Germany's municipal street lighting market and their capacity to diffuse innovative EUEDs and enhance modernisation.

According to TCE, the choice of governance structure also depends on characteristics of transactions as investment in transaction-specific (dedicated) assets may improve the efficiency of some transactions (Pint and Baldwin, 1997). An ESCo specialising in lighting, for instance, may already have acquired skills and established links with manufacturers and appropriate equipment for both operation and maintenance (O&M) and measurement and verification (M&V). Acquired skills and the buyer-seller relationship can be classified as *human capital specificity* while specialised equipment falls under *technical asset specificity*. Site or location specificity, another characteristic of transactions, is less of an issue in relation to street lighting. *Dedicated resources* is the degree to which institutions support a particular (Pint and Baldwin, 1997; Toffel, 2002).

The assumption is that transactions featuring *high technical asset specificity* and *dedicated resources* are less likely to operate efficiently within market transactions as the party that has not invested, in this case the municipality, may threaten to cancel the contract to expropriate some of the invested value as it may assume that the ESCO would be unlikely to remove the lighting once installed. This is knows as *opportunism*, in the words of Williamson (1985, p. 4), 'self-interest seeking with guile'. A further interference with the efficient operation of transactions is *bounded rationality* as decision-making is subject to constraints on time, attention, resources and the ability to process information (Pint and Baldwin, 1997; Sorrell, 2007, 2005; Toffel, 2002) (see Table 1).

Table 1: Overview of characteristics and behaviours that can affect transaction costs (TC) (Pint and Baldwin, 1997; Toffel, 2002; Sorrell, 2007)

Affect	Competencies	Examples
Increase or reduce TC	Human capital specificity	Dedicated human resources for lighting
	Dedicated resources	Specialisation in a particular area
Increase TC	Bounded rationality	Limited time and capacity to analyse options
	Opportunism	One party taking selfish advantage of circumstances

Additional factors that influence the transaction costs of contracting are the *complexity of the task* (both replacing street lights or lamp posts and the complexity of monitoring performance according to contractual terms and conditions), the *competitiveness of the energy service market* and the *institutional context* in which contracting takes place (Sorrell, 2005). The institutional context can be affected by standardised tendering and procurement procedures and standardised M&V and projects such as the German 'LED Lead Market Initiative' (BMBF, 2014). Clients such as municipalities are only likely to enter an energy service contract if useful energy streams and final energy services can be supplied at a lower *total* cost compared to in-house provision. Total cost are the sum of firstly production costs (PC), *"the expenditures for inputs such as fuel and electricity"*, which depend on technical and operational efficiency of the equipment and secondly transaction costs (TC) as outlined in this section (Sorrell, 2007, p. 512).

To summarise, the viability of energy service contracts is assumed to be determined by the following factors affecting TC (Pint and Baldwin, 1997; Sorrell, 2007; Toffel, 2002):

1. Technical asset specificity;
2. Human capital specificity;
3. Dedicated resources;
4. Task complexity;
5. Competitiveness of the market;
6. Institutional framework.

As we have identified the institutional framework as a factor also affecting the diffusion of EUEDs it is not included in our TC factors of the analysis in section 3.

3. Methods and research design

We apply the TCE framework to help understand the relationship between the uptake of energy efficiency technology and energy service contracts. Our analysis covers the intersection of LED and ESCo markets (where ESCo models are employed for LED diffusion) as a case study (Miles and Huberman, 1999; Patton, 2002) using a longitudinal, multi-level analysis of key market players and key policy initiatives.

3.1. Case study: LED street lighting and EPC in German municipalities

As pointed out earlier, LED is currently on the path towards maturity in the technology life cycle, although LED lighting still features high upfront costs, especially compared to conventional technologies. In Germany, LED sales are growing due to numerous initiatives at the federal level. Until 2013 the 'National Climate Initiative' provided subsidies to municipalities for switching to LED, which covered on average 30% of the costs. The 'LED Lead Market Initiative', founded in 2009, brings together market players and policy decision-makers to identify barriers for the municipal diffusion of LED. These activities take place in the context of a wider Ecodesign context which phases out several energy-related products, such as many conventional lighting products in 2015, as a result of low efficiencies (Schischke et al., 2008).

9.5 million public outdoor lights installed in Germany consume approximately 4 billion KWh of electricity per year, which corresponds to energy costs of about 750 Mio €. This number represents approximately one third of municipal energy costs. The potential savings by using new energy efficient lighting systems (especially innovative LED) amount to 400 Mio. € per year (dena, 2012; DStGB, 2010), although numbers regarding refurbishments of old lighting systems are missing (dena, 2012). Germany's market for public street lighting is highly dispersed, consisting of more than 11000 municipalities with individual decision-makers.

An important feature of public street lighting in Germany is the prominence of local multi-utility companies (MUCo) known as 'Stadtwerke' providing municipal lighting services. Although strong local embedding ensures near monopolies on most supply and waste streams, providing incentives for integrated solutions (Betsill and Bulkeley, 2006), this arrangement can represent a barrier for competition. The primary motivation for municipalities to engage with suppliers such as ESCos is the promise of final energy services such as lighting at a lower cost compared to in-house or MUCo provision.

The German energy service contracting market, one of the largest, most heterogeneous and most mature in Europe with approximately 250-500 active companies, experienced stable growth over recent years. Among the dominant companies are EUCos[2], MUCos[3] and ESCos (Bertoldi et al., 2006; Marino et al., 2011). EPCs are gaining more acceptance among customers although the market has reached only 10% of its potential (Duscha et al., 2013). We identified 10 companies that offer lighting services to municipalities, which include subsidiaries of EUCos or infrastructure providers.

Historically, different forms of governance in the provision of lighting have emerged. 27% of the municipalities provide street lighting in-house, 35% outsourced the management to EUCos, another 10% to MUCos and 25% partially outsourced services such as maintenance. 3% of the municipalities employ an ESCo to manage their street lighting (dena, 2012). Figure 2 depicts the main actors that take part in the process. Regulatory bodies oversee municipal finances and partially have to approve budgets, especially when the municipality is in financial turmoil. Financiers mostly consist of (government-owned) banks.

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[2]EUCos stands for a national Energy Utility Company, which typically engage in energy generation and supply. They may also engage in distribution and transmission (see Hannon et al., 2013, p. 1036).

[3] MUCos stands for Multi-Utility Company. In the German context this refers specifically to local 'Stadtwerke', which tend to provide a wide range of utilities such as gas, electricity and municipal waste management. Strong local embedding ensures that these MUCos enjoy near monopolies on most supply and waste streams which can provide incentives for integrated solutions (Bulkeley and Betsill, 2006)

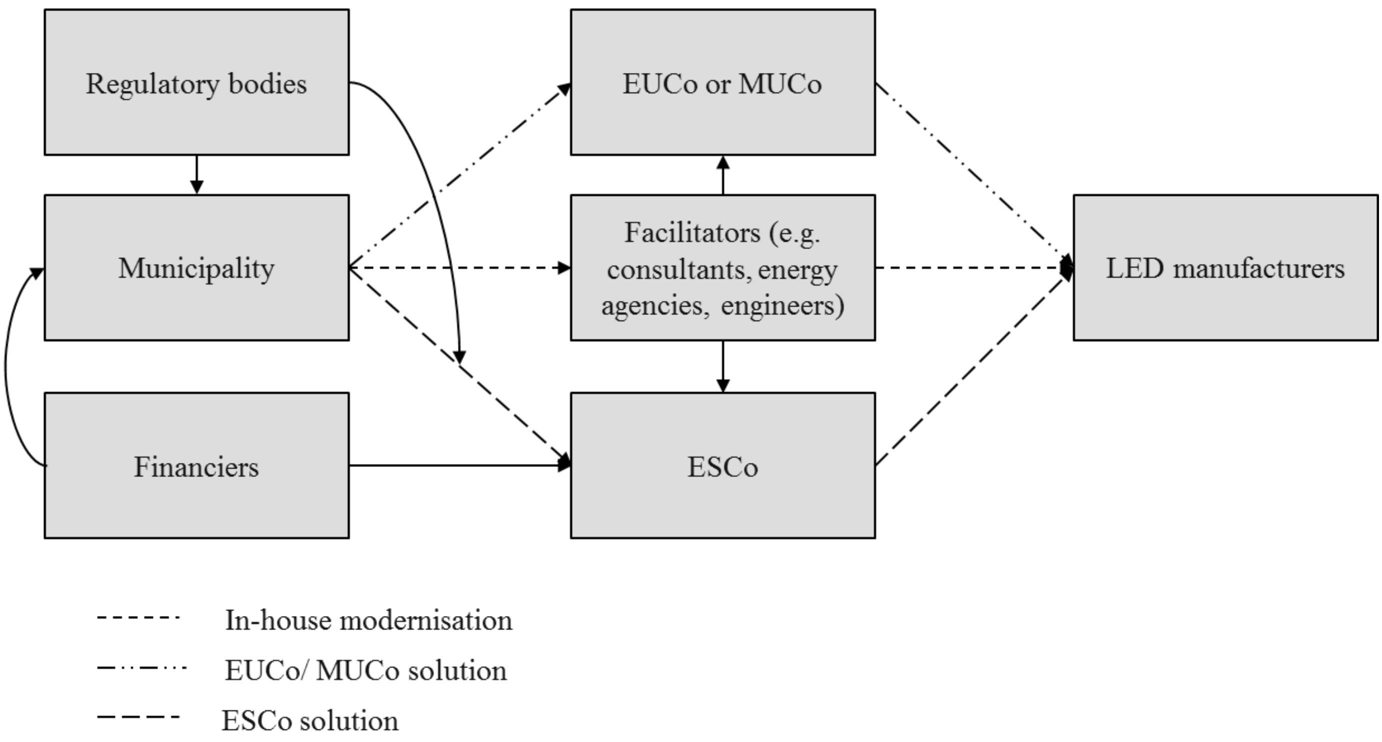

Figure 2: Overview about actors and modes of lighting governance

As established in 2.1.4, the choice of supplier represents a choice of governance structure. In-house provision represents a hierarchical governance structure. EUCo contracts can be considered relational contracts as they focus on the terms of the relationship, while MUCo contracts fall under the same category although they their contractual relationship can be more dynamic as their business model may shift towards privatisation (market) or 'recommunalisation' (hierarchy) of municipal enterprises. In fact, Germany is witnessing a trend towards 'recommunalisation' with 1/3 of respondents to one study indicating interest in more hierarchical approaches specifically for energy supply (PublicGovernance, 2011). ESCo provision represent long-term contracts, the most market-based governance structure.

Table 2: Spectrum of Governance Structures (adapted from Pint and Baldwin (1997, p. 4))

Vertical integration	—	Relational contracts	—	Long-term contracts	—	Simple short-term contracts	—	Spot markets
Examples								
In-house lighting provision	—	MUCo or EUCo contract for lighting provision	—	Energy performance contracts for lighting with ESCos	—	Lighting arrangement for a recurring event	—	Lighting arrangement for a one-off event

ESCos may be able to provide certainty over savings in PC for a specified quantity and quality (performance) of lighting if replacement LED EUEDs can be financed, operated and maintained over the duration of a contract at lower cost compared to in-house or EUCo/MUCo provision. The complexity of long-term energy service contracts compared to relational contracts or conventional in-house procurement of equipment increases the TC of negotiating and managing the relationship with the (energy) service provider or manufacturer (combination of human capital specificity and bounded rationality). Consequently, production costs (PC) resulting from the physical characteristics of the energy system and the technical efficiency of organisational arrangements need to be lower for this model to be economically viable (Sorrell, 2007).

The case of energy service contracting for public sector LED street lighting provides a good example as potential savings are high (for example, LEDs are ten times more efficient than halogen for the same light output (Bennich et al., 2014)), the capacity of municipalities to invest in these EUEDs is, as mentioned above, limited (Hartmann et al., 2014), while the DStGB streamlines the outsourcing process by offering standardised contracts (SBI, 2013). Municipal benefits of abandoning the in-house approach in favour of energy service contracting may arise out of reductions in energy costs, less exposure to energy price fluctuation and the transfer of risk, allowing the municipality to focus on core activities. EPCs are only possible if the ESCo succeeds at addressing technology factors, competency and capacity factors, as well as institutional factors which will be analysed in more detail in the results section.

3.2. Data Collection

Data was collected through an extensive longitudinal archival document analysis (i.e. context of lighting and ESCo markets from 2008-2013) and interviews which permits us to reflect upon changes in the industry and institutional context. The documents consist of industry reports for lighting, energy services and public procurement from industry experts such as energy agencies, official government bodies or industry associations. In addition as two of the three authors participated regularly in meetings of the German 'LED Lead Market Initiative', we also analysed the minutes of meetings regarding important topics for each of the participating stakeholders (i.e. manufacturers, government officials, ESCos and others).

The main empirical focus of this paper lies on the analysis of 40 semi structured interviews with key stakeholders. The interviews took place from October 2013 until January 2014. We selected interview partners according to an approach suggested by Seawright & Gerring (2008). After an initial screening we selected the most influential stakeholders in the process of LED application in German municipalities by consulting experts from the 'LED Lead Market Initiative'. Thus we selected stakeholders that directly engage in the process of modernisation (see Figure 2). For each of the modes of governance we compiled typical cases that are representative. Hence we combined snowball sampling and purposeful sampling strategies. An overview of our sample can be drawn from Table A.1. The interviews lasted between 30 minutes and 1,5 hours and were conducted face-to-face or via telephone with one to two researchers present. The interviews have been recorded (for later verification) and notes have been taken. Representative quotes have then been translated into English. Questions during the interviews revolved around two main topics, notably modernisation of public street lighting (participating actors, processes and facilitators) and the role of energy service contracts (see appendix for detailed questions).

3.3. Data Analysis

We systematically evaluated the collected archival documents from 2008 onwards. We then analysed the interview protocols and reflected these against the bulk of documentations. We analysed the material according to the research question concerning barriers to the uptake of innovative end-use energy demand technologies as well as the possible role of EPC for accelerated uptake of public LED street lighting. In this process we identified the following main topics:

- Technological drivers and barriers
- Institutional drivers and barriers
- Economic and financial drivers and barriers
- Competency and capacities as both are required to examine and technological, institutional and economic/financial barriers and to enhance the diffusion of innovative EUEDs

These were reflected against concepts of TCE (technical asset specificity, human capital specificity, dedicated resources, task complexity and competitiveness of market) in an 'abductive' process (Mantere, 2008), i.e. the back and forth between theory, interview transcripts and archival documents. We then compared the modes of lighting governance, highlighting the suitability for each in different situations (financial situation, competency and capacity of actors, institutional set-up) to derive policy implications for municipalities and government.

4. Results: Factors affecting the diffusion of LED street lighting and EPC

This section gives an overview about factors affecting the uptake of EUEDs and the corresponding TCE interpretation. Hence we present the drivers and barriers that increase or lower the TC and PC for different modes of governance (see Table 3 for an overview).

4.1. Technological factors

LED lighting provides a technological advantage over conventional lighting which is a main driver for its use: higher energy efficiency. Thus this technology exhibits a high potential for energy (and PC) savings, which would suit an outsourcing solution. The first set of barriers to the modernisation comprises technological aspects such as the maturity of the products, complexity and uncertainty regarding energy savings and lifetime. '*There is tremendous uncertainty regarding new measures to evaluate the performance of LEDs, for example maintenance factors and payback periods.' (Manufacturer)* LED customers such as municipalities and ESCos in particular further highlighted the missing standardisation and short warranties of LED due to the early stage in the innovation cycle as well as technological path-dependency relating to less innovative and less efficient lighting systems which are currently being installed. '*Many sales people from LED manufacturers have been to our town. There are too many standards and warranty mechanisms.' (Municipal representative)* As this municipal representative suggests, technical change and the lack of standardisation may increase opportunism on behalf of the technology providers. These barriers translate into higher TC as the both technical asset specificity of LED lighting and the task complexity of both assessing technology offers up-front and M&V for potential savings .

4.2.Competency and capacity factors

A push for open-book accounting was a robust success factor for lowering TC as the availability of consumptions figures lowers the risk of opportunism on behalf of the municipality since anticipated cost-savings are one of the main drivers for municipalities to modernise their lighting infrastructure. This lowers the human capital specificity of EPC as it reduces the ESCo's need for acquiring information to perform the contract. *I think one of the main barriers is the municipal accounting system. Usually the overall costs for running their lighting system are higher than what we estimate during the planning process. (ESCo)*

The interviewees further highlighted the positive role of facilitators (e.g. energy agencies) and other consultants as well as best practice examples during the tender and implementation process as they provided the necessary lighting and planning expertise. Facilitators hold a critical position as they are able to reduce the risk of opportunism by making the task of determining cost savings less complex. These success factors lower the TC both for in-house modernisation and ESCo solutions, as independent advice provides a more concrete overview of available options, thus reducing search costs and the human capital specificity required to search for alternative options. If, on the other hand, intermediaries and facilitators between ESCos and municipalities suffer from a lack of lighting competence, a bias towards established technologies and a lack of understanding about the complex tendering processes, the task of determining savings may remain complex. *The building and energy context require a lot of expertise. Energy consultants are lacking the competence for lighting functional tendering. So manufacturers and their tools to calculate savings dominate the market.*

(Energy consultant) Low human capital specificity of facilitators increases the danger of opportunism by suppliers, which increases TC for ESCo solutions.

Cost transparency and cost management systems increase the tendency towards an EPC solution for modernisation as the procuring agency can compare baseline and future scenarios. *The main preconditions for effectively modernising the lighting systems lie in a lighting database and a clear guideline. So you turn that into a functional, neutral tender. (Municipal representative)* In addition, the early involvement of decision makers from local government and administration further facilitate their use. Neutral tenders ensure technology-free bidding and realisation and are more likely to be an ESCo competence. Manufacturers enter into competition for the collaboration with an ESCo, which results in lower prices and higher quality lighting products, which then can be implemented in ESCo projects. These factors reduce human capital specificity and task complexity as potential savings can be anticipated and adequate tenders be set up, thus lowering TC for ESCos as services provided by the contract are well defined.

Competency barriers relate to the capacity of the actors to overcome technological, market and institutional barriers. *Many people simply ignore the risks and do the modernisation on their own. (ESCo)* On the one hand municipal representatives often fail to evaluate the market for LED lighting concerning quality, energy savings and risks. *The implementation of the modernisation is demanding. You need to know the technical details and test examples in practice. (Municipal representative)* On the other hand, municipal representatives lack the administrative competency to design tenders to reflect appropriately their quality and endurance criteria and carry out comprehensive budgeting and cost management throughout the procurement process of modern LED street lighting. *Usually they [municipal representatives] don't know about their own costs for lighting. Data about the old lighting systems in terms of energy costs, investments etc. is missing. (Manufacturer)* These competencies were not necessary in the past, as more efficient technologies evolved slowly. In the case of low human capital specificity dedicated towards municipal energy management, outsourcing may be sensible option but the difficulty of designing tenders may provide too complex a task for a municipality to consider, translating into high TC and a difficult choice between realisation of modernisation and possible outsourcing options. Our results show that the responsible decision-makers tend to ignore or reject these solutions as the perceived human capital specificity is too high.

4.3. Institutional factors

From the analysis we derive institutional drivers which have a varied effect on the TC involved for different governance modes to modernise municipal lighting. These include an alignment of interests between different administrative bodies that are responsible for lighting, acceptance for the new lighting technology by the local population and the procuring organisation. Additionally, financial service providers act as drivers of energy efficiency projects, since they provide necessary risk and return structures.

Barriers on the demand side relate to institutional problems such as the property situation (many municipalities sold their street lighting to national EUCos) and specific structural arrangements for the provision of public street lighting which has historically been a task for MUCos. *Existing contracts with national EUCos often run for a very long time and the national EUCo only complies with the legal minimum when it comes to efficiency. A switch to LEDs, which would make sense, does not happen, they use less efficient technologies. (ESCo)* The interviewees also referred to the inadequate infrastructure for the new LED technology. Time consuming and costly procedures to switch to another contractor translate into human capital specificity and increase TC for EPCs as a favourable institutional context is needed.

Experts also referred to problems on the supply side (i.e. in the ESCo market) as only few ESCos exist that target the lighting market. *Street lighting does not receive the attention it deserves in terms of potential cost savings and improvements in quality of light. (Energy agency)* Manufacturers (OEMs), which could also act as ESCos did not show willingness to enter the service based market segment as they perceived the margins as low and complexity as high, although they act as providers of secondary conversation equipment. Specialised ESCos gain a competitive advantage in the field of lighting, although the low competitiveness in the ESCo market increases TC as it reduces the likelihood of municipalities considering outsourcing using EPCs.

When, on the other hand, municipalities are willing to engage in ESCo solutions, experiences tend to be positive. *The risks taken by the ESCo surpass the amount of financial savings I have when I do the modernisation on my own (Municipal representative)*. In this case the human capital specificity associated with lowering the risk of in-house EUED retrofit is too high, which reduces TC for long-term contracts and more market-based governance structures.

Efforts required to govern the relationship relate to the task complexity and human capital specificity of negotiating and monitoring contracts. *There is a complexity problem. Many contract documents are longer than 50 pages (Financial service provider)*. Regarding energy service contract design, the experts highlight transparency, comprehensibility and a distinct guarantee for energy savings as beneficial. *Guidelines, transparency of the energy service contract and an ESCo that selects high quality products turned out to be successful. (Municipal representative)* Increasing know-how and enabling structures for the modernisation process could significantly reduce task complexity of outsourcing particularly if contractual arrangements align interests by providing transparency and flexibility.

Regarding the energy service contract design, municipal actors in particular also emphasised the need for flexibility (e.g. to change or improve lighting systems) and a fair balance of interests during the contract as a prerequisite for EPCs. *We need flexibility regarding, short- medium- and long-term developments in the markets. (Municipal representative)* An exact definition of the baseline, however, often proves difficult. *Complexity of EPC leads to high TC. Exact numbers are needed. (Energy agency)* EPCs also need to be checked by the regulatory bodies when municipalities run on a very tight budget in need of consolidation. *The regulating authorities need to approve the energy service contract. The financing over the contract duration need to be assured (Municipal agency)*. Administrative approval represents a dedicated institutional resource to mitigate against bounded rationality on behalf of the municipality.

Additionally, long-term partnerships with manufacturers are often in place, which create technological and product-related lock-in effects. Manufacturers possess a lot of market power. They dictate the tenders because they have long lasting partnerships and thus can charge individual prices for each customer, for example ESCos, MUCOs or EUCos. *The manufacturers are the winners in this market. They often have long lasting partnerships with the municipalities, they supply analyses for free. Many tenders thus specify one product. (ESCo)* Contractual barriers also relate to lighting arrangements with national EUCos, which prevents ESCos from entering the public lighting market. *The contracts [with national EUCos] run for a very long time. The municipal representatives do not have expertise any more. (Energy agency)*

In sum, the institutional complexity of opening up lighting provision towards EPCs as well as partnerships with manufacturers, MUCOs and EUCos tend to increase the task complexity and in turn TC for outsourcing as they complicate the distribution of responsibilities among the actors involved.

4.4. Economic/ investment factors

Economic drivers result from PC savings, which EUCos and MUCOs can realise by lowering the cost for energy and better procurement conditions thanks to long lasting contracts with manufacturers. However, these companies might be subject to a conflict of interests, as they engage in selling electricity as opposed to providing energy efficiency services. Finally, traditionally conservative attitudes towards innovative technologies may also prevent them from deploying LED. ESCos, on the other hand, possess better procurement conditions for lighting equipment, which potentially favours an outsourcing solution.

Economic barriers stem from the relatively high upfront costs of LED street lighting, particularly for municipalities as they typically run on a tight budget, in some cases tightly controlled by regulatory bodies with budgetary control powers (see Figure 2). Volatile energy prices and uncertain price developments for LED further constrain the payback of investments. These factors prevent municipalities from realising significant production cost savings, a prerequisite for using any mode of governance for modernisation.

EUCos and MUCos on the one hand possess knowledge about the current lighting system and experience in providing maintenance services for the municipality. Hence a EUCo/MUCo solution may exhibit lower aggregate PC for the provision of the energy service. ESCos on the other hand often lack finance as they are not well established among financial service providers. *ESCos need to* *refinance themselves. However, forfeiting is not accepted by many municipalities. This leads to financial constraints on ESCos side. (Financial service provider)* Thus an ESCo solution might exhibit higher financing costs, which lowers its potential to cut PC.

Factors affecting uptake of LED and choice of governance model		**Transaction cost perspective**	**Actions and human behaviour**	**Specific TC for governance model**	
				Lowering TC	Increasing TC
Technical factors	***Measurement and verification of savings***	**Technical asset specificity and task complexity**	Increases opportunism on behalf of the manufacturer		For ESCo solution
	Lack of standardisation	**Technical asset specificity and task complexity**	Increases opportunism on behalf of the manufacturer		For general outsourcing
	Uncertainty regarding warranties	**Technical asset specificity and task complexity**	Increases opportunism on behalf of the manufacturer		For general outsourcing
Competency and capacity factors	***Open-book accounting***	**Human capital specificity**	Reduces opportunism on behalf of the municipality	For ESCo solution	
	Expert facilitators	**Human capital specificity**	Reduces opportunism on behalf of the municipality	For ESCo solution	
	Cost transparency and neutral tenders	**Human capital specificity and task complexity**	Reduces time-consuming and costly search for alternatives	For ESCo solution	
Institutional factors	***Lock-in contracts with existing suppliers***	**Human capital specificity**	Time-consuming and costly search for alternatives to in-house, MUCo or EUCo solution		For ESCo solution
	Low ESCo market competitiveness	**Competitiveness of the market**	Time-consuming and costly search for alternatives to in-house, MUCo or EUCo solution	For in-house solution	For ESCo solution
	Risk transferral	**Human capital specificity**	Risk taken by ESCo surpasses financial savings of in-house provision	For ESCo solution	
	Transparency of outsourcing procedure and contracts	**Human capital specificity and task complexity**	Transparency enables municipalities to consider ESCo solution	For ESCo solution	
	Administrative approval procedure	**Dedicated resources**	Mitigates against bounded rationality on behalf of the municipality	For in-house solution	

Economic/ investment factors	***EUCos and MUCos potentially selling and saving energy***	**Competitiveness of the market**	ESCo independence from selling energy reduces conflict of interest	For in-house or ESCo solution	
			Allows ESCos and MUCos to reduce overall PC by reducing electricity tariffs for lighting	For EUCo or MUCo solution	
	Volatile energy prices and uncertain technological development trajectories	**Human capital specificity and task complexity**	Time-consuming and costly search for alternatives		For in-house solution
	Experience of current lighting system and providing maintenance	**Dedicated resources**	ESCos lacking experience	For EUCo or MUCo solution	

Table 3: TCE perspective - Factors affecting the governance of novel EUEDs

5. Discussion

5.1. Factors affecting the diffusion of LED street lighting and associated services

Previous research points towards technological, economic, competency and institutional factors influencing the diffusion of novel EUEDs (Klein Woolthuis et al., 2005; Rogers, 1995; Schleich, 2009; Sorrell et al., 2004; Wilson et al., 2012). We confirm these findings although our results show that these factors are especially strong in the case of public sector application due to specific institutional set-ups/ regulations and lower competency compared to private actors, which limits their ability to carry out a mission-oriented procuring policy or tenders (Edler and Georghiou, 2007; Edquist and Zabala-Iturriagagoitia, 2012; Uyarra et al., 2014).

Our results also show that at the interplay between services and technologies, institutional factors such as established relationships, flexibility or balance of interests are crucial to advance the uptake of EUEDs. Hence the interactions between procurer and innovator are critical to address the increasing complexity in procuring services and infrastructure (Hartmann et al., 2014; Roehrich and Lewis, 2014). Further barriers to EPC and EUED, such as the low priority of energy efficiency projects, uncertainty, legal and institutional problems, access to finance and difficulties defining baseline consumption figures (see Pätäri and Sinkkonen (2014); Marino et al. 2011) also prevail throughout our case study.

Additionally, we highlight interdependencies among the barriers. Assessing these technological, institutional and economic barriers requires enhanced competencies on the municipal side and our analysis (see Table 3) reveals this missing capacity as a key element which has previously been ‘hidden’ in other factors such as ‘dedicated resources’ or ‘task complexity’ throughout the TCE literature (Pint and Baldwin, 1997; Sorrell, 2007). Technological, economic and competency barriers can be addressed through a change in the governance structure. Analysed through the lens of TCE, drivers and barriers that constitute a factor relate to higher or lower TC depending on the mode of governance (see Table 3). With this analysis we partially integrate literature on the diffusion and adoption of EUEDs and TCE that have previously been used for the analysis of barriers to energy efficiency (Sorrell, 2005; Sorrell et al., 2004).

5.2. Modes of governance for novel end-use energy demand technologies

As highlighted by Roehrich et al. (2014); Schleich (2009) and Sorrell et al., (2004), the tendency of customers to 'wait' for technological improvements provides an incentive for outsourcing solutions for innovative products. Depending on the institutional set-up and country characteristics, municipalities possess various options.

First of all municipalities could manage the modernisation of the street lighting installations in-house. This requires significant technical and commercial know-how to evaluate technologies, markets and the institutional background to achieve an economically viable solution. These translate into high TC for modernisation as the human capital and technical asset specificity for the innovative technology are high. There is also a danger of lower PC savings by deploying inefficient products. On the other hand, municipalities are able to significantly lower the TC a more market based solution would incur through open book accounting and transparent tendering. However, the task complexity for managing the contract, especially with a private third-party ESCo should not be underestimated (See Table 3).

Second, municipalities in Germany tend to choose relational contracts with EUCOs or MUCos. Historically, MUCos in particular have been contracted to manage municipal street lighting in Germany. As these trusted relationships feature interwoven knowledge of existing technologies and infrastructure (Backlund and Eidenskog, 2013), the task complexity for contract management and the human and technical asset specificity of EUCo or MUCo solutions for modernisation are likely to be low (see Table 3). Relational contracts particularly with a MUCo could therefore have an advantage over a third-party ESCo solution. On the other hand, these companies usually sell final energy to the municipality as well, which reduces their incentive to apply novel EUEDs technologies.

Third, with an ESCo solution, customers are able to achieve cost savings from the beginning of the contract and additional cost savings due to freed personnel capacity. They can transfer risks and uncertainty regarding technological components and development. One representative of a facilitating organisation precisely framed the potential role of EPC: '[Energy performance] *contracting is a means to accelerate the diffusion and adoption of innovative energy efficiency technologies.'* We thereby confirm earlier research suggesting that PPPs can foster innovation, technical knowledge and skills as well as managerial efficiency (Roehrich et al., 2014).

We also confirm the view of previous studies (Hypko et al., 2010a, 2010b) that performance-based contracts lead to lower costs in the provision of energy services, although customers demand high flexibility during the contract duration as they fear a lock-in into unknown new technologies. In that case, scholars suggest an emphasis on the establishment of trusting relationships, particularly during the set-up of the contract (Backlund and Eidenskog, 2013; Roehrich and Lewis, 2014), which may again benefit a MUCo solution. To fully exploit this potential in the municipal context, we can confirm the need for tenders not to over-specify to allow technology neutral bidding originally proposed by Uyarra et al. (2014).

To address these barriers and to reduce TC our research highlights experienced consulting services and the early involvement of decision-makers from local government and administration to ensure a transparent process and open tenders. Other possible institutional barriers such as regulations concerning lighting and maintenance and existing partnerships with MUCos or EUCos might jeopardize ESCos' potential to accelerate the diffusion of EUEDs. Our findings thereby concretise earlier work by Hannon et al. (2013), Hannon & Bolton (2014) and Marino et al. (2011).

5.3. TCE provide a useful lens to study the product-service relationship for novel end-use energy demand technologies and EPC

Many of our case study participants considered the energy service fee comparatively low compared to the risk and complexity associated with in-house search for new products and services. In the absence of MUCos, ESCos can therefore reduce human capital specificity required to perform modernisation in-house and contribute to reducing opportunistic behaviour towards the municipality (Pint and Baldwin, 1997). Table 3 suggests that standard procurement rules, model contracts as well as facilitators could help lower TC for ESCo solutions, which coincides with earlier findings by (Bleyl et al., 2013; Roehrich and Lewis, 2014).

Above all, our major contribution revolves around the TCE perspective on the uptake of innovative EUEDs and the different modes of governance. Factors influencing the diffusion of EUEDs (technology, competency, institutional and economic) have been related to factors influencing the TC of different governance modes (technical asset and human capital specificity, dedicated resources, task complexity, competitiveness) , taking into account human behaviours relevant to TC (opportunism and bounded rationality) to compare the viability of EPCs vis-a-vis other modes of governance. Public sector LED street lighting is likely to fulfil several preconditions hypothesized by Sorrell (2007) for outsourcing using EPCs, although some assumptions about municipal street lighting do not hold as competence and institutional problems prevail.

EPCs might even be a means to reduce occurring TC and thus accelerate the diffusion and application, especially when a trusted MUCo is absent and the municipality features low in-house competence and a tight budget. Based on our results we argue to include the notion of competencies (quality and quantity) which tend to be 'hidden' behind 'dedicated resources' and 'human capital specificity' in TCE frameworks (Pint and Baldwin, 1997; Sorrell, 2007; Toffel, 2002).

6. Conclusions and policy implications

6.1.Conclusions

An accelerated uptake of innovative EUEDs among public actors such as municipalities is economically and socially desirable for a number of reasons. First, it bears a huge (mostly untapped) potential for realising CO_2 emission reductions. Second, it reduces energy dependency and provides a relief for public budgets. Third, it may increase economic growth in the (domestic) EUEDs industry. On the one hand, our results show that ESCos represent a vehicle for the commercialisation and diffusion of innovative EUEDs by addressing barriers to technological diffusion through EPCs. This could be a public-private arrangement when procuring innovative products in a public context. On the other hand, high associated TC might hinder the diffusion of the ESCo solution and need to be addressed specifically.

However, we also highlight the discrepancy between theoretical fit of EPC and actual slow diffusion. As mentioned above, only 3% of the municipalities use this mode of governance, which points towards the existence of strong interdependencies between actors and a conservative institutional environment. This ‘lock-in’ may be a reason for the slow diffusion of LED lighting and/ or EPC. Our study therefore also points towards an institutional environment in Germany that appears to favour relational contracts over long-term contracts. A German municipality with a MUCo may want to strengthen its local capacity to manage energy and benefit from the diffusion of innovative EUEDs, rather than outsourcing.

6.2.Policy implications

In terms of policy implications we want to highlight the benefits of market transparency regarding both novel EUEDs and ways to source them. This can be done by either encouraging competitiveness among governance structures, which may benefit EPC solutions, or by supporting facilitators.

The design and content of tenders emerged as a key phase during the adoption of LED technologies and outsourcing options. To address competency and capacity barriers, criteria to design these tenders should be widely diffused in order to increase competition among organisational (governance) structures. This could be done by introducing statutory obligations for tendering to include outsourcing options on a national or federal level. Additionally, institutional support could include the provision of documentation and guidelines or instruments to calculate baseline and savings (e.g. with standard tendering processes). Similarly technological standards or enhanced warranties to address technological complexity as well as standard contracts to address legal complexity (monitoring contractual terms and conditions) facilitate the use of EPC for innovative technologies, which could be established on a national level.

Finally, policy makers need to address institutional barriers by providing the infrastructure necessary to make the transition towards EUEDs for example by rethinking long-term partnerships with MUCos or EUCos at the municipal level. Depending on the institutional set-up, establishing an EPC with a MUCo could also be a way to lower the costs and risk associated with modernisation.

To foster the ESCo market, policy makers need to support facilitators (e.g. consultants or energy agencies) to disseminate specific technological and commercial knowledge at the state/ regional level. These intermediaries emerged as a key driver throughout our analysis. This could be done either by subsidising consultancy services or by supporting the market for energy consulting by establishing remunerations schemes to provide incentives for consultants to enter the market.

EPC for lighting also faces a lack of finance, which represents a significant economic barrier. Government owned banks (such as Germany's KfW) or governments themselves could provide guarantees for credits to increase the access to finance to increase the competitiveness of the LED street lighting market as a policy response on the national level.

6.3. Limitations and future research

Our use of TCE in exploratory qualitative research, as opposed to rigorous model testing, exhibits limitations regarding the measurability of the constructs. We nevertheless believe that our analysis uses TCE appropriately. Conclusions derived from this study, however, do not represent generalizable assumptions about the usefulness of EPC for the diffusion of EUEDs as this process is usually not linear. More factors than those analysed in this paper influencing the diffusion of innovative EUEDs need to be taken into account (e.g. behavioural factors).

Additional markets could be valuable to explore as the viability of an ESCo solution is dependent on the institutional context. Another factor which determines the application of EPC is technology. Smart grids or smart homes could serve as another case study to explore the suitability of the ESCo solution for commercialisation and diffusion of EUEDs.

Finally, the conditions for ESCos to maintain a competitive position vis-à-vis other actors (EUCos, MUCos, manufacturers, etc.) provide an interesting field of future research (Hannon et al., 2013). In relation to that, scholars could further explore why the creation of a market for EPC in a public context did not achieve its potential so far (Pätäri and Sinkkonen, 2014).

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9. Appendix

9.1. Interview guide

Modernisation of public street lighting

- How does the process of modernisation unfold in the municipalities?
- Which technologies have been applied in the modernisation process?
- What role did the participating actors (EUCos, MUCos ESCos, manufacturers and financial service providers) play?
- What factors influence their decision making?
- How does the regulatory or political environment influence the modernization process?

Role of energy service contracts (EPC)

- What are perceived specific success factors and barriers of EPC for LED street lighting in a municipal context?
- How is technological and financial risk treated in these arrangements?
- Can EPC accelerate the diffusion of eco-innovations?

9.2. Interview participants

Table A.1: Sample

Nr	Category	Position	Format	Date	Interviewer
1	Municipal representatives	Lighting engineer	Via telephone	Oct 2013	FP, PvF
2	Municipal representatives	Member of parliament	Via telephone	Oct 2013	FP
3	Municipal representatives	Technical manager	Via telephone	Oct 2013	FP
4	Municipal representatives	Energy efficiency manager	In person	Jan 2014	FP
5	Municipal representatives	Building authority	Via telephone	Oct 2013	FP
6	Municipal representatives	Building authority	Via telephone	Nov 2013	FP
7	Municipal representatives	Lighting manager	In person	Nov 2013	FP
8	Municipal representatives	Building authority	Via telephone	Nov 2013	FP
9	Municipal representatives	Lighting manager	Via telephone	Nov 2013	FP
10	Municipal representatives	Lighting manager	Via telephone	Nov 2013	FP
11	Municipal representatives	Lighting manager	In person	Jan 2014	FP
12	LED Manufacturers	Engineer	Via telephone	Oct 2013	FP, PvF
13	LED Manufacturers	Business developer	In person	Nov 2013	FP
14	LED Manufacturers	Business developer	Via telephone	Dec 2013	FP
15	LED Manufacturers	CEO	In person	Jan 2014	FP
16	LED Manufacturers	Chief marketing officer	In person	Nov 2013	FP
17	Energy service companies ESCos	Business developer lighting	Via telephone	Oct 2013	FP
18	Energy service companies ESCos	Business developer lighting	Via telephone	Oc 2013	FP
19	Energy service companies ESCos	CEO	Via telephone	Nov 2013	PvF
20	Energy service companies ESCos	Business developer lighting	Via telephone	Nov 2013	FP
21	Energy service companies ESCos	Chief marketing officer	Via telephone	Oct 2013	FP
22	Multi-utility companies MUCos	CEO	Via telephone	Oct 2013	PvF
23	Multi-utility companies MUCos	Lighting manager	Via telephone	Nov 2013	FP
24	Multi-utility companies MUCos	Lighting manager	Via telephone	Dec 2013	FP
25	Multi-utility companies MUCos	CEO	Via telephone	Dec 2013	FP
26	Multi-utility companies MUCos	Lighting manager	In person	Jan 2014	FP

27	Financial service providers	Key account manager for municipal clients	Via telephone	Nov 2013	PvF
28	Financial service providers	Expert on financing energy efficiency projects	Via telephone	Jan 2014	FP, PvF
29	Financial service providers	Key account manager for municipal clients	Via telephone	Jan 2014	FP, PvF
30	Regulatory bodies	Municipal budgetary expert	Via telephone	Jul 2013	FP
31	Regulatory bodies	Municipal budgetary expert	Via telephone	Jul 2013	FP
32	Regulatory bodies	Municipal budgetary expert	Via telephone	Jul 2013	FP
33	Regulatory bodies	Municipal budgetary expert	Via telephone	Oct 2013	FP
34	Facilitators	Energy agency	Via telephone	Oct 2013	FP
35	Facilitators	Energy agency	Via telephone	Oct 2013	FP
36	Facilitators	Public property manager	In person	Dec 2013	PvF
37	Facilitators	Energy consultant	In person	Nov 2013	FP
38	Facilitators	Energy consultant	Via telephone	Dec 2013	FP
39	Facilitators	Municipal agency	Via telephone	Dec 2013	FP
40	Facilitators	Energy agency	Via telephone	Nov 2013	FP

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