Financing models for energy-efficient street lighting

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Abstract
Investment in the upgrade of urban street lighting infrastructure may offer energy savings up to 80%. It is also very cost-efficient and has a short payback period. Despite these arguments, a large share of the infrastructure in many European countries requires refurbishment. The budgetary constraint of its owners, who are often municipalities, is a common reason. To overcome it, creative business models are required to attract other investors and overcome the barrier of high up-front investment costs.

The paper summarizes the results of a piece of research, which aims to find suitable models to finance urban street lighting infrastructure. The geographical focus is on the countries of Central Europe, namely Austria, Croatia, the Czech Republic, Germany, Hungary, Italy, Poland, Slovakia, and Slovenia. The research represents one of the tasks of Dynamic Light project, which aims to promote dynamic, intelligent and energy efficient urban lighting. The project is supported by the Interreg Central Europe platform.

The paper provides a review of existing financing models, including self-financing, debt-financing, third party financing, and project finance. The paper further analyses these models using a common framework. In particular, it provides the overview of each model, identifies the projects to which it could be applied, specifies its advantages and disadvantages, and provides a case study. The paper concludes with recommendations for decision-makers on finding a suitable financing model.

Introduction
Investment in the upgrade of urban street lighting infrastructure offers energy savings and carbon dioxide (CO_2) emission reduction up to 80 %. It is also very cost-efficient and has a short payback period. Despite these arguments, a large share of the infrastructure in many European countries requires refurbishment. The budgetary constraint of its owners, who are often municipalities, is a frequent reason. To overcome it, creative business models are required to attract other investors and overcome the barrier of high up-front investment costs.

The paper identifies, reviews, and analyses financing models used to finance the upgrade of the urban street lighting infrastructure. These include different alternatives of self-financing, debt-financing, third party financing, and project finance. Among these, the paper in particular discusses the models, which minimize the burden on the public budget.

The paper builds on one of the deliverables of the Dynamic Light project, which aims to promote dynamic, intelligent, and energy efficiency urban lighting in the countries of Central Europe. These countries include Austria, Croatia, the Czech Republic, Germany, Hungary, Italy, Poland, Slovakia, and Slovenia. The project is co-financed by the Interreg Central Europe platform.

The main target group of the paper are the organisations, which own, operate, and make decisions on the modernisation of the street lighting infrastructure in Central Europe, e.g. municipal governments, municipally owned utilities, as well as private or partially private companies delivering these functions. The second target group of the paper are the organisations, which are involved in the financing of the street lighting upgrades, such as the operators of the European Union (EU) funds, the operators of the federal support schemes, public and commercial banks, energy service companies, manufacturers of advanced lighting solutions, as well as institutional investors (pension funds, insurance funds, investment funds, and other agents on the capital market) interested in diversifying their portfolio.

After the introduction, the paper describes the methodology for the collection of financing models and the common framework against which they were analysed. Then, the paper provides an overview of each model, identifies the projects to which it could be applied, specifies its advantages and disadvantages, and provides a case study. The paper concludes with recommendations on identifying a suitable financing model.

Methodology

There have been several data collection approaches, which we relied on. Thus, we interviewed the organizations which own, operate, and make decisions on the modernisation of the street lighting infrastructure in Central Europe. These include municipal government structures, companies owned by municipality, e.g. utilities, and private or partially private companies delivering these functions. We also interviewed the organisations in Central Europe, which are involved in the financing of the modernisation of the street lighting infrastructure. These are energy service companies, manufactures of advanced lighting solutions, public and commercial banks and institutional investors.

Further, we gathered information available in the public domain, e.g. from publication databases and the project websites. Above all, we identified the projects, which have already conducted similar studies in the past. From our review, we concluded that so far there has been no recent comprehensive catalogue of the business models and best practices for efficient street lighting in Europe. Therefore, we identified individual case studies from the countries of Central Europe through online search and personal interviews. However, when a useful model was identified but was available outside Central Europe, we include such case studies prioritizing ones from the EU, then from Europe, and finally worldwide.

Then, each business model was analysed in a common framework. First, we provided a model overview drawing its schematic structure e.g. its key actors and their roles. Second, we analysed the types of projects, which could be financed using these models. Third, we argued about the advantages and disadvantages of the models. Finally, for each business model we provided a selected case study, for which we went even into deeper details of the model context, scope, stakeholders, implementation experience, and outcomes. In our analysis of the financing models, we relied on the definitions developed by the OECD and Climate Policy Initiative for the analysis of energy and climate finance (Buchner et al. 2011; OECD 2016).

After the information gathered was analysed, the conclusions were distributed for comments among the key stakeholders interviewed, when they had a chance to recommend outstanding business models and case studies.

Financing models for energy-efficient urban lighting

SELF-FINANCING

The most straightforward way to finance the upgrade of the street lighting infrastructure is to pay for it from own funds. In a few developed countries of Central Europe, e.g. Germany and Austria, using municipal budget and dedicated national or federal funding sources is very common for funding municipal infrastructure projects. The financing model of such upgrade project is rather simple, e.g. a municipality identifies the investment need, prepares a request for financing, obtains its approval, and issues a tender to select a contractor, e.g. an energy service company, who conducts the upgrade.

To minimize the burden on tax payers, the public sector could design and implement additional schemes which help raise the funds for the budget. These funds are then specifically channelled to the upgrade of the street lighting infrastructure. For instance, a municipality could invest in street lighting upgrades and once it accrues saved energy costs, it could re-invest them in new upgrade projects. The example includes for instance the municipality of the Hague[1].

Intracting

Intracting is a model of internal energy performance contracting within the municipality's organisational units without external financiers. Energy saving measures are financed through energy bill savings. The initial financing is provided from the municipal budget, for example, through establishing a dedicated revolving fund or trust (Figure 1). The fund or trust will finance energy efficiency or other emission reduction measures at zero interest rate and without any extra charges. Creating such a fund or trust requires political support and commitment from the department(s) responsible for the budget (EnergyCities 2016).

Another administrative unit, e.g. environmental agency, street lighting department or municipally owned company, will serve as the "intractor", fulfilling the role of energy service company (ESCO, please see the section on financing by a private contractor for more details). Namely, it will assess the energy savings potentials, calculate the investment costs and payback period, and plan the project. Here it is important that the "intractor" department has the right skills and expertise to be able to prepare and implement successfully such projects. Once the project is implemented, the achieved energy cost savings are paid back to the fund or trust until the investment has been paid off. The paid pack resources are then used again for financing new energy saving projects (German Watch 2015; EnergyCities 2016).

Municipal infrastructure projects such as building energy efficiency retrofits, street lighting, combined heat and power plants, and renewable energy can be financed with this model. The maximum project size will depend on the size of overall funding available from the finance department (Zirkwitz 2016; German Watch 2015).

The advantage of this model is that intracting enables financing of measures with achieved saved energy costs by the municipalities without involvement of external financiers. In

1. http://citynvest.eu/content/energy-fund-den-haag.

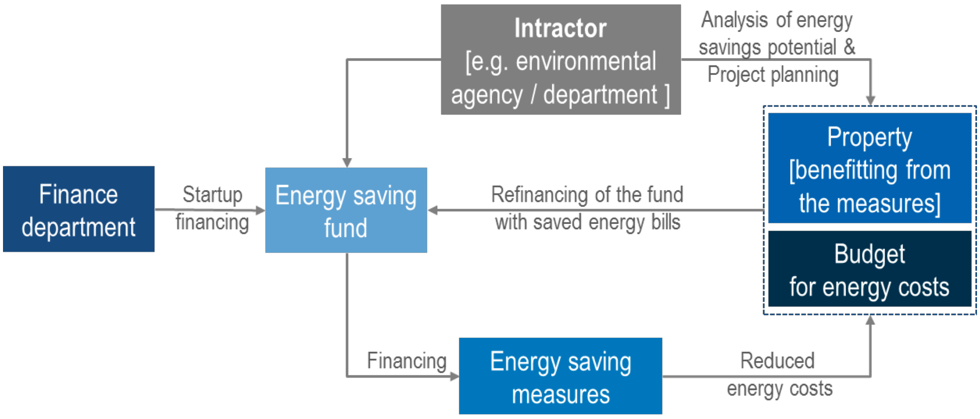

Figure 1. Intracting model (German Watch 2015; EnergyCities 2016).

this way, cooperation between municipality's units helps to overcome the obstacle of separated municipal investment and operational budgets. Projects that are too small or not interesting for private investors can also be covered with this model. Intracting also implies no interest rate on investment capital, reduced transaction and administration costs (EnergyCities 2016).

This model has the limitations that come with self-financing. Namely, municipality has to provide the upfront capital. Municipalities use different approaches how to sustain the fund and increase the funding available. Also the projects will be carried on the municipality's balance sheet and it will bear all related investment risks. Finally, projects financed by the municipalities only may have less efficient structure as compared to those where private investors are involved (German Watch 2015; Seifried 2011).

Intracting was conceptualised and adapted in Germany, namely, by Stuttgart, Lörrach and Kiel. Other European cities, i.e. Agueda and Almada in Portugal, Udine in Italy and Koprivnica in Croatia are currently testing intracting in their jurisdictions (German Watch 2015; EnergyCities 2017).

DEBT-FINANCING

Many municipalities, whose own funding resources are limited, obtain debt which will be paid back from the municipal budget, e.g. tax revenue of municipalities and/or saved energy costs. The financing model of such projects would include obtaining the debt, e.g. taking the loan or issuing bonds, and issuing a tender to select a contractor, who conducts the upgrade.

Most commonly, municipalities obtain low-interest (soft) loans. Low-interest rate lending programs offered by a national development bank, dedicated funds, or by the European banks and funds such as the European Investment Bank (EIB), European Bank for Reconstruction and Development (EBRD) or the European Energy Efficiency Fund, in cooperation with local commercial banks, are widely used for energy efficiency investments by municipalities in Central Europe. In Germany, a dedicated programme of KfW bank for municipalities, supported by the Government of Germany, offers loans for sustainable urban infrastructure and public buildings investments at interest rates close to 0 %. It is the main source of funding available for municipalities in Germany. In Croatia and Lithuania, the revolving funds are set up from the federal budget that provides loans and guarantees to municipal governments for energy efficiency investments. As loans and guarantees are returned, the funds are re-invested again in new projects.

In many countries, where public lending programs have limited budgets or do not exist, municipalities obtain commercial loans at a market rate from commercial banks. For instance, in Hungary, the Erste bank provides tailored loans to municipalities to finance street lighting projects. In case of commercial loans, the interest rate under which the loan is awarded does not depend on saved energy costs but on the credit record of a borrower.

The other approach to obtaining debt finance is to issue municipal bonds. Bonds are less common in Europe, but widely used in the United States. The European examples include Gothenburg, the second largest city in Sweden. Gothenburg has started the Gothenburg Green Bond Program, which provides funding for sustainable investments in the city infrastructure. The American examples include for instance federal and state level programs Qualified Energy Conservation Bonds (QECBs) as well as initiatives by the individual cities. Some examples include Detroit and San Diego cities, where bonds were used to raise finance for modernisation of street lighting (LBNL 2012; Kinzey 2015).

FINANCING BY A PRIVATE CONTRACTOR

Alternatively, municipal actors could reallocate the burden of financing street lighting infrastructure on third parties, e.g. contracting an energy service company. The next section focusses on those models, where the financing is covered by a private partner, for instance an energy service company (ESCO), who delivers the upgrade works and who usually is not responsible for energy supply and therefore cannot use energy savings for his financing needs. The private partner finances the street lighting project from its own funds or it obtains the funds from third parties. For its services, the contractor receives the payment from municipalities. If the contractor obtains financing from further third parties, it returns the debt to them. The municipal payment to the contractor and the contractor's payments to a lender are not contingent on energy savings occurring.

Simple contracting model

In a simple contracting model, shown below (Figure 2), the contractor can have several responsibilities, but its main activities are usually planning, financing and execution of the investment into a new, energy efficient street lighting infrastructure. Optionally, the contractor could also be responsible for the operation of this infrastructure. There are, however, several reasons, why this usually is not the case. First of all, the city usually either has its own resources for the operation of the street lighting infrastructure, potentially supported by subcontractors, or already has assigned an external operator with this task in a contract, usually running over a longer period. Such contracts often do not cover modernisation using new technology. For this reason, the city either has to wait until the end of the contract, in order to tender a different contract including modernisation, or a different partner has to be found for the modernisation. Since the most suitable timing of the investment usually does not coincide with the end of an existing operation contract, the latter case, namely finding a different partner for the modernisation, often makes sense.

In a simple contracting model, the contractor directly receives a contracting fee, which covers the costs of planning, financing and execution of the investment, and obviously includes a margin. The length of such a contract may vary, depending on the size of the investment, its relation to energy costs etc., but it typically is in the range of ten years or more. The contract usually has to be put out to tender, and there are different options how to evaluate the offers received by various bidders. The city might define the framework conditions like minimum energy savings to be achieved, details about the luminaires to be used, warranty conditions, standards to be met, etc. In addition, the procedure at the end of the contract needs to be defined. Theoretically, the contractor should have the opportunity to remove the luminaires at the end of the contract. Due to the long running time of such contracts, however, it is very unlikely that this will take place, because relatively old luminaires are of no use for the contractor, since he will not be able to sell them again.

Typically, tenders are evaluated based on the savings the city achieves. Such savings can be significant, particularly in countries with relatively high energy prices. The contracting fee, to be paid by the city to the contractor, in such cases usually is much lower than the energy savings achieved. In addition, costs of maintenance are reduced due to the low maintenance costs of modern light-emitting diode (LED) luminaires.

Projects need to have a sensible minimum size, in order to justify the set-up of the model by the contractor, who often involves a bank for co-financing. There is no fixed threshold, but EUR 0,5–1 million may be the minimum project volume. A higher level would be needed, if the contractor also becomes responsible for carrying out the operations, because in this case it is necessary to establish an office with personnel and equipment in – or close to – the city.

The key advantage is that the model is off-balance sheet for the city. It makes contracting models different from loans, since the latter are normally on-balance sheet for the city. It is therefore recommended to clarify this issue with the responsible authority, which the city has to report to. A further advantage is that specialised companies can be selected via the tendering process, who have corresponding know-how and experience, and who will offer more attractive prices than the city itself or the existing operator might achieve.

A disadvantage, from a city viewpoint, is the high financing costs of such model. Costs of the contractor's capital – either directly if equity is used, or via re-financing through a bank – is usually significantly higher than in the case of direct financing from the city's budget, or in case of financing through models with low interest rates. A further disadvantage can be that there are restrictions in the availability of grants. This has to be checked within the specific programme. For example, in Germany the grants currently available from the German federal government cannot be used for contracting models. From a contractor's viewpoint, it is a disadvantage that this model is on-balance sheet, while typically, private investors favour off-balance sheet models.

Simple contracting models are being widely applied in street lighting, although both partners (city and contractor) usually search for ways to reduce the financing costs by applying more complex models like the one described in the following section.

Contracting model with forfeiting and waiver of defence

In this more complex model, the roles of the city and the contractor are similar to the simple contracting model described above. The major difference is that the involvement of a bank is a central element of this model, and that the bank enters into agreements both with the contractor and with the city (Figure 3). The contractor sells part of the receivables to a bank, which means that the city has to pay part of the contracting fee to the contractor, and another (typically larger) part directly to the bank. The part of the receivables, sold to the bank, corresponds to the value of the equipment installed, and therefore is higher than the part for planning, installation and warranty.

By applying forfeiting and waiver of defence, the payments from the city to the bank are guaranteed, regardless of the performance of the equipment, which falls under the responsibility of the contractor. This allows the bank to reduce the interest rate to a level, which typically is available for municipalities only. While the difference of a few percentage points might seem low, this could add up to quite a sum over the running time of a contract.

In terms of the projects that could be financed with this model, there is no big difference to the simple contracting model, as far as minimum project size is concerned. Due to the higher complexity of the model, it might be a bit more difficult to find a bank financing projects below EUR 1 million. There is limited experience with the application of this model in street lighting so far.

This model has similar advantages to the simple contracting model. Furthermore, contracting with forfeiting and waiver of defence will have a lower interest rate, included in the contracting fee. The disadvantage of this model is that although the interest rate is lower than in a simple contracting model, it still is much higher than in the case of financing through models with low interest rate lending programmes, such as the KfW loans currently available in Germany at close to 0 % interest rate. A further disadvantage is the higher complexity of this model, as well as the fact that a large part of the city's payments, namely the payments to the bank, have to be guaranteed, regardless of the performance of the new street lighting infrastructure.

Case study: the city of Dillenburg, Germany

In 2011, the German city of Dillenburg tendered the contracting of part of their street lights, based on a structure with a high share of some 73 % of all luminaires using high pressure mercury (HPM) lamps. The energy efficiency of these lamps is low, and it had already been decided at that time by the EU to phase out the utilisation of HPM lamps through a directive banning sales as from 2015. A contracting model for Dillenburg was interesting, because replacement of HPM based street lights was urgent, while there were budgetary constraints on financing this replacement in the short term. The main goal therefore was to spread the costs over a 12-year period, and to find a specialist for the modernisation task, while the responsibility for operations should remain with the utility of Dillenburg.

The contract was tendered in 2011 in a process with multiple steps, including an indicative analysis and concept to be presented by bidders, followed by a preliminary contract and a detailed analysis and concept, which then were used for the final contract. The final decision was mainly based on the maximum reduction of annual costs for the city, consisting of the contracting fee and energy costs of the street lighting infrastructure.

Some 70 % of receivables were sold by the contractor to a bank, which then became a third partner to the contract in order to enable forfeiting and the waiver of defence. The 12-year contract started in September 2012, and the replacement of some 2,450 luminaires took place in less than three months.

An additional element of this particular contract is that the successful bidder guaranteed a certain level of energy savings (minimum 52 %), contributing to the reduction of the city's annual costs. If the contractor achieves higher savings than guaranteed, the additional savings are split between the city of Dillenburg and the contractor. The exact split was part of the successful offer and leads to an additional contribution towards the reduction of the city's annual costs. In total, annual energy savings amount to some 1 GWh or EUR 160,000, which is much more than the payments to the contractor and the bank.

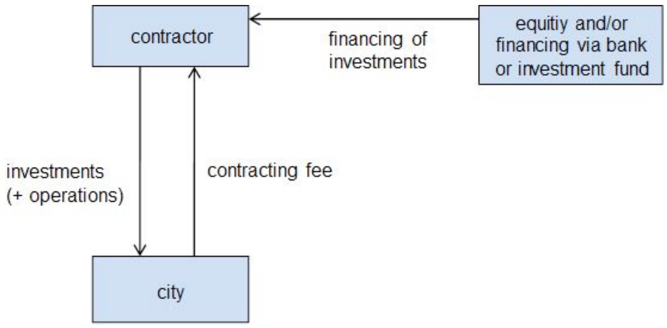

Figure 2. Simple contracting model.

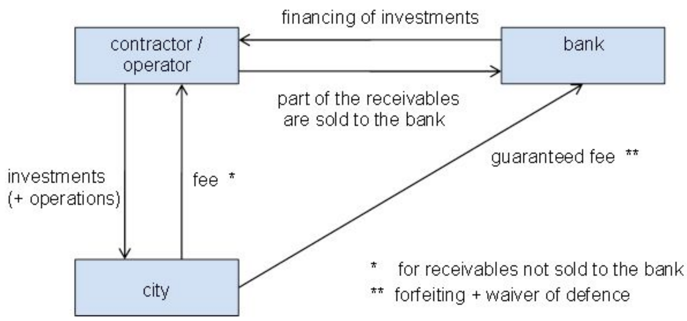

Figure 3. Contracting model with forfeiting and waiver of defence.

FINANCING BY PRIVATE PARTNER THROUGH ENERGY SAVINGS

Energy Performance Contracts (EPC) are used to finance municipal infrastructure projects by private partner, usually an Energy Service Company (ESCO) through energy savings. There are different descriptions and models of EPCs. The basic element of all EPC models, however, is that cost savings achieved via a reduction of energy consumption, are used to finance the investment. EPC models work in both cases with the municipality or the private partner being responsible for energy supply. In the end, however, it always will be the municipality paying for the service of operations including energy supply, plus planning, financing and installing the new equipment, either directly for each of these services, or in a lump sum.

Two elements can categorise the EPC models. The first is the EPC provisions on energy savings to be achieved and how they are to be shared between the contractor (ESCO) and the municipality. Here municipalities can choose between the guaranteed savings model and shared shavings model. The second element is how the upgrades or modernisation works will be distributed over time, e.g. whether all modernisation will take place in the first years of the contract to achieve maximum energy savings, or rather stretched over time. In this case, municipalities can choose either modernisation contract with immediate savings of energy costs or EPC with staggered modernisation. All four EPC models are discussed on the following sections.

Energy Performance Contract – guaranteed savings model

EPC with guaranteed energy savings implies that the ESCO designs and implements a project, and obliges to achieve a certain level of energy savings. If ESCO fails to deliver guaranteed level of energy savings it has to cover the shortfall. In case ESCO delivers higher energy savings than guaranteed, they fully benefit the municipality. The municipality pays a fixed fee over the contract term from the saved energy bills.

Energy savings should, however, be sufficient to pay for the modernisation in a reasonable time. This already shows a potential problem of this model. In countries with low energy prices, the payback period can be too long to find private partners willing to enter into such contracts. Experience has shown that this was the case in some Eastern European countries, with energy prices far below 10 EUR-Cent/kWh. It leads to theoretical lengths of energy performance contracts of more than 20 years, whereas in a typical Western European country with energy prices close to or even beyond 20 EUR-Cent/kWh, much shorter contract lengths are possible.

In the model shown in Figure 4 (left), future costs for the municipality, consisting of energy costs plus regular payments to the private partner, are identical to the energy costs paid by the municipality before modernisation took place. Since energy savings in those cases, where rather old technology will be replaced by state-of-the-art LED luminaires, can be up to 80 % or more, when dynamic lighting is installed, using "intelligent" controls, this leaves a significant part of the costs for payments to the private partner. This can be used in two ways: either to shorten the length of the contract, or to reduce regular payments of the municipality, allowing immediate savings, even during the term of the contract, as shown in Figure 4.

For all models, subsumed under the term EPC, a basic element is the guarantee of the private partner, to achieve a certain level of energy savings. For the municipality, this is helpful to calculate future costs with a high reliability, because the risk of achieving the energy savings is transferred to the private partner. Typically, there also is an arrangement, under which payments to the private partner will be cut, if he does not meet the guaranteed savings. While theoretically this constitutes a risk for the private partner, he might include a buffer in his calculation of energy savings and include this in his offer.

This model is suitable for projects with a high energy (cost) savings potential. Otherwise, the contract length could be too long to attract private partners. Moreover, municipalities should have sufficient financial resources to pay the same – or a slightly reduced - amount of money in total over the length of the contract, although now split between energy costs and payments to the private partner.

The key advantage is that the city will receive a new, energy efficient street lighting infrastructure, without any peaks in public spending. Payments are constant, possibly even on a slightly reduced level than before, and after expiry of the contract, the city owns an energy efficient infrastructure and benefits from the low operating costs. A further advantage for the city is the wide-ranging transfer of risks to the private partner.

Some disadvantages have been described above, related to low energy prices and/or the efficiency of the existing lighting infrastructure being not too bad. While old technologies using HPM lamps enable savings of up to 80 %, when changed to LED luminaires, in some countries including a lot of Eastern European countries, high pressure sodium (HPS, yellow light) lamps dominate the existing street lighting infrastructure, enabling lower – while still significant – energy savings of up to 60 %, depending on the age of the technology in use. Unfortunately, this often coincides with low energy prices. A further disadvantage of this model is a missing incentive for the private partner to reduce energy demand more than guaranteed in the contract. This problem can be solved with the "shared energy savings" model presented in the next section.

EPC – shared savings model

In this model, both partners, a municipality and a private partner, benefit from additional energy savings, realised on top of the guaranteed savings level. The contract includes typically a certain level of guaranteed energy savings, as well as a malus agreement, cutting payments to the private partner if the guaranteed savings are not met. In addition, the municipality and the private partner share any additional savings, achieved on top of the guaranteed level (Figure 5). The bonus payment to the private partner either can be a certain amount in EUR/MWh, or a share of the saved energy costs, based on an electricity price agreed upon by both partners. The split might be 50 %/50 %, but it can also be a different one. It is possible to ask bidders in the tendering process to propose a split in their offers. The model is a "win-win-situation", when both a contractor and a municipality are interested in as high energy savings as possible, and is found more often than the models described above.

A big advantage with this model is that there is an incentive on both sides to consider and realise additional energy savings, even if these were not planned or foreseen in the first instance. Since municipalities receive a share of additional energy cost savings, this allows them making additional investment into energy efficiency projects. The model also possesses the advantages of the model described previously.

While the disadvantage of guaranteed energy savings models without sharing additional savings, namely lack of incentive to reach energy savings beyond guaranteed levels, has been solved, the other disadvantages related to low energy prices and therefore long payback periods still exist.

Case study: the city of Nauen, Germany

In 2010, the German city of Nauen tendered a 5-year contract for the operation of their street lighting infrastructure, consisting of some 2,350 luminaires, some 45 % of which were equipped with HPM lamps, whereas the rest were HPS lamps. Targets set by the city were a complete replacement of HPM based luminaires by more efficient technology (not necessarily LED), energy savings of at least 40 %, and a limitation of investment needs due to budgetary constraints. Alternative bids with varying details were invited too.

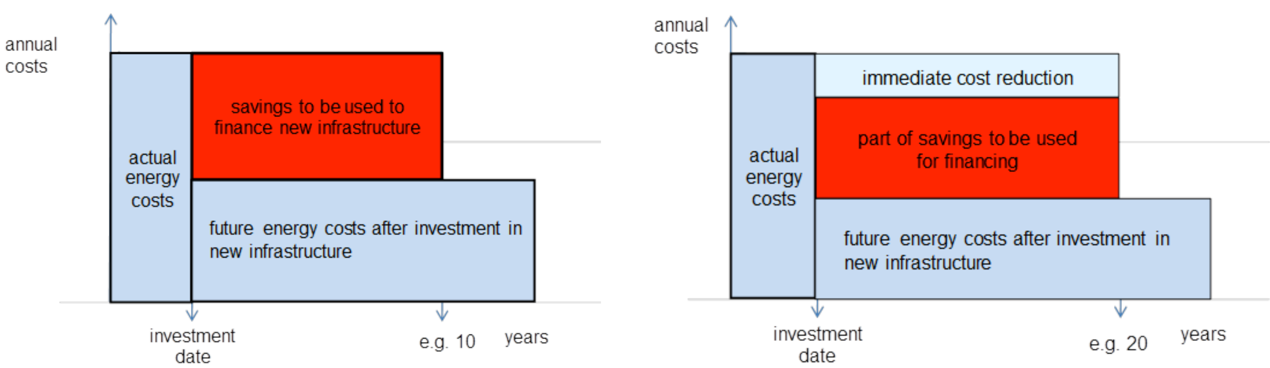

Figure 4. EPC – guaranteed savings time-optimised model and EPC – guaranteed savings model with immediate cost reductions.

Several bids were received and evaluated based on the total operating and investment costs. From the successful bidder, the city of Nauen received two offers, one for a period of 5 years, the other one for period of 10 years. While the first one guaranteed energy savings of at least 43 %, but with limited modernisation measures and not including LED technology, the second one went a step further in terms of more advanced technology, leading to energy savings of at least 47 %. After considering all offers received, as well as the budgetary situation, the city decided to accept the first offer, mainly because of the lower investment volume.

The city did, however, want to keep the option open for additional investments in more efficient lighting technology, in case the city's budget would allow this in later years. Therefore, an agreement was reached that additional energy savings, on top of the 43 % being guaranteed, should be split 50 %/50 % between the city of Nauen and the private partner. Based on an electricity price per kWh fixed at the beginning of the contract, any additional energy savings were measured once a year, with 50 % being paid to the private partner. As a result of this agreement, some additional investments in energy efficient technology were carried out, proving the "win-win" character of the model.

EPC – modernisation with immediate savings of energy costs

In reality, investments in new, energy efficient street lighting infrastructure could be carried out in the space of a few months, unless the total volume is too large. It then might be stretched over a slightly longer period, which, however, should be as short as possible, in order to benefit from the energy savings as soon as possible. The EPC models described in the previous section also fall under this category.

The key advantage of this model is the maximisation of energy savings. Moreover, as the new technology in general, and LED technology in particular, is characterised by reduced maintenance needs, corresponding costs are lower too, which should be reflected in the price offered by the private partner.

the main disadvantage of this model is that if the city is paying directly for the modernisation, then investment costs in the initial phase might be a big burden. Moreover, there will be a lot of modernisation activity in the city at the same time. It has to be considered, if this is acceptable in terms of traffic congestion and public acceptance, particularly if poles are to be replaced, not just luminaires.

Particularly in long running contracts, the early realisation of the investment means that the entire street lighting infrastructure at the end of the contract is "old" again and needs to be replaced again. Until then, no modernisation takes place, so that there is no chance to modernise at a constant rate – typically 3 % of the existing infrastructure per year – always using the most advanced technology. All luminaires will be modernised at the same time, regardless of their age, although some still might be in a reasonable condition. These disadvantages are eliminated in the model described in the next section, realising a time optimised – meaning stretched over a longer period – modernisation and utilisation of energy savings.

EPC – model with staggered modernisation

In this model (Figure 6), modernisation is stretched over a longer time period, avoiding the disadvantages of the previous model. There could be a modernisation time schedule, agreed upon between city and private partner, or a definition of maximum age of luminaires (and poles if these are included in the modernisation programme) at certain times during the term of the contract and at the end of the contract.

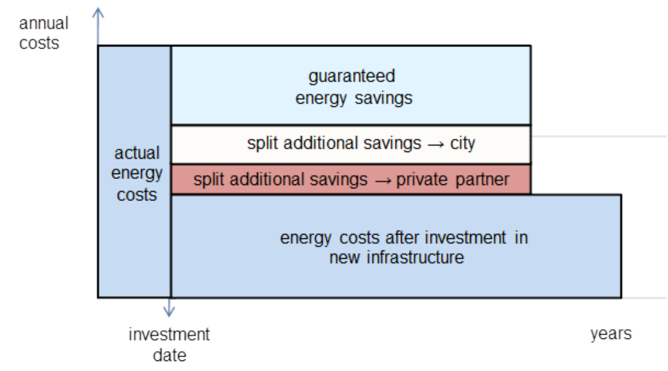

Figure 5. Energy performance contracting – shared savings model.

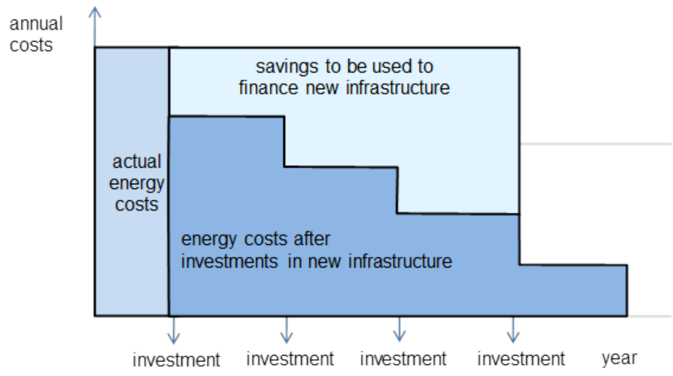

Figure 6. EPC – Model with staggered modernisation.

The advantage of this model is a more regular investment regime, so that the city always has a reasonably modern street lighting infrastructure, and that peaks in investment needs and building activity are avoided. The model also helps avoid the situation that all luminaires are replaced at the same time. In this model, it is possible to focus on those luminaires with the worst energy efficiency first. The major disadvantage is that energy savings, as well as the benefit of lower maintenance costs, will be achieved at a later stage than in the previous model.

Case study: the city of Hilden, Germany

In 2014, the city of Hilden tendered a contract with a term of twenty years. The contract included all operations, including energy supply, and the modernisation of more than 5,000 luminaires, which is the vast majority of all existing luminaires, as well as the modernisation of some 2,400 poles. A key condition of this contract was a definition of a maximum average age, as well as a maximum age of any single luminaire and pole at fixed times (after 5, 10, 15 and 20 years). The costs of electricity were split between the private partner (direct costs) and the city (indirect costs such as taxes, dues and grid access costs). This means that both partners benefit from energy savings, and the task of bid-

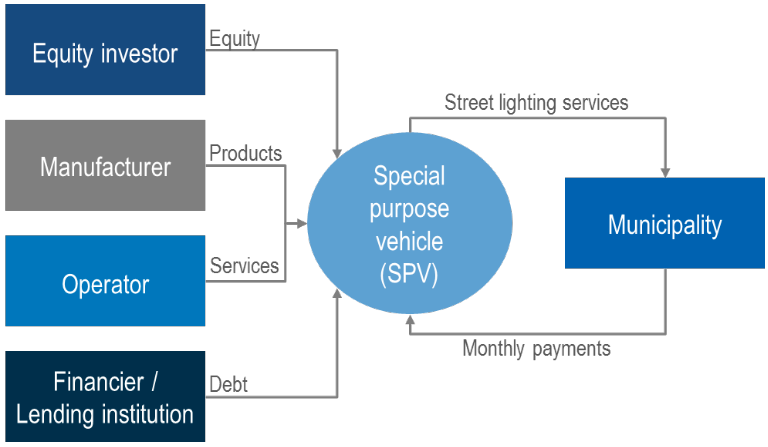

Figure 7. Example structure of SPV model.

ders was to select the right luminaires to be modernised at the right time, while taking the age restrictions into account. Based on the total price over the 20-year-period and several organisational and technical concepts, offered by several bidders, the contract was awarded and started on 1 January 2015.

PROJECT FINANCE

The project finance model is another model for municipalities to leverage limited public funds and raise private capital. In this model, a special purpose vehicle (SPV) is established, which carries the investment project on its balance sheet (Figure 7). It is financed with the equity from private investors, debt from lending institutions, and contributions from the municipality (De Marco et al. 2016). The project finance has a proven track record in large transportation and energy infrastructure projects (Esty and Sesia 2010). There is a growing interest and cases of applying this model for urban-scale energy efficiency projects, but no standardized approach has been developed yet (Limaye and Limaye 2010).

In the SPV model, there are one or several private sector partners, e.g. equity investors, manufacturer, debt providers and asset operator. The SPV is responsible for design, installation, operation and management of the street lighting infrastructure at its own cost for a specified contract period. The private sector partners bear the majority of risks associated with the assets ownership over the contract life (De Marco et al. 2016).

The contracts are typically for 20–25 years. The contract price is based on the required investment, cost of capital, and operation and maintenance cost. The municipality pays monthly unitary charges to private sector partners, based on the contract price. These payments represent the key security for funders (Scottish Futures Trust 2013; WBG 2016).

The model is suitable for large projects with capital costs over ~EUR 20 million. The projects have to be able to attract private investors and therefore, be financially sustainable. Financial sustainability depends on the revenues and profit to be generated during the contract term and is also linked to the municipality's credit profile. Supporting public instruments such as grants, tax exemptions, tax-free bonds, or credits can significantly improve project viability and facilitate private sector involvement. This model also implies long term contracting of private actors for operation and maintenance of street lighting assets (Scottish Futures Trust 2013). The simple regulatory structure, clear legislative provisions, as well as fast and transparent bidding process are prerequisites for successful project implementation (Mendoza et al. 1999; Spillers 2000; De Marco et al. 2016).

The key advantage of this model for the municipalities is an opportunity to leverage private capital and carry out project implementation off the municipality's balance sheet. Another advantage from the perspective of both public and private sectors is isolating the project risks within the SPV, which enhances the attractiveness of the investment. Long time frames of the contract will provide stability of the operations and maintenance of the assets (De Marco et al. 2016; Link 2012). An additional benefit for the municipalities is that if private sector partners fail to deliver the services agreed in the contract, there are foreseen deductions or withholding of payments or even penalties by the municipality.

The main challenge of using the model is high transaction costs related to the preparation and implementation of the SPV. This model is not suitable for small projects. Creating a consortium of several municipalities can be one option to create a scale sufficient for SPV and diversify investment portfolio and risks. However, it will bring in additional costs related to the governance and structure of the consortium. Project finance might also imply long time frames from project start to actual development (De Marco et al. 2016;; ESMAP 2016).

Project finance has been widely used for street lighting investments across the United Kingdom (UK) under the Private Finance Initiative (PFI) and Private Finance 2. As of March 2016, 32 UK jurisdictions applied SPV models for street lighting infrastructure investments of an average capital value of £45 million (EUR 57 million)[2] (HM Treasury 2016).

Case study – City of Birmingham, UK

The Birmingham LED street lighting project is part of a larger public private partnership on modernization of the city's streets, roads, tunnels and other assets – the Birmingham Highway Maintenance and Management Private Financing Initiative

2. Here and further, currency conversion according to the exchange rate as of 31 March 2016 published by the European Central Bank: GBP 1 = EUR 1,2633.

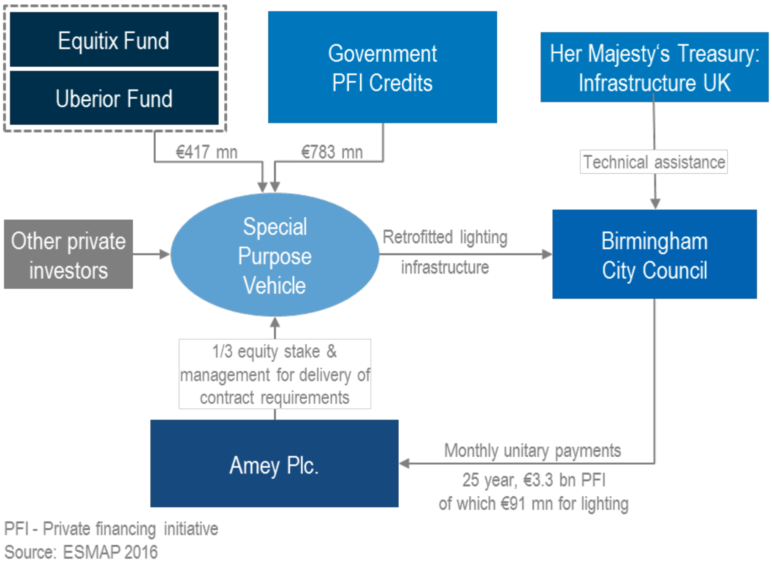

Figure 8. Simplified structure of Birmingham LED street lighting project.

(HMMPFI) implemented in 2007–2035. The project was implemented under the Private Financing Initiative (PFI), which is a national government support in the form of credits or grants to facilitate private sector investment. Birmingham's Sustainable Community Strategy 2026, endorsed in 2008, was an additional driving force to implement the project. The total value of the HMMPFI is £2,6 billion (EUR 3,3 billion) of which approximately EUR 91 million is assigned for lighting (ESMAP 2016).

The project included upgrade, maintenance and management of 97,000 streetlights. It was a Europe's first LED street light project financed through project finance. The program is expected to achieve energy cost savings of 50 % or up to £2 million (EUR 2,5 million) annually (ESMAP 2016).

Amey plc was contracted by Birmingham City Council as the main service provider for 25 years. Infrastructure UK[3] provided technical assistance to structure the PFI deal. An SPV was created for project implementation with oversight by Birmingham City Council and Amey Plc. The total project value is £2,6 billion (EUR 3,3 billion), the lighting part is around EUR 91 million. This includes £620 million (EUR 783 million) of PFI credits from the UK government in the form of a grant, £330 million (EUR 417 million) from the Lloyds (Uberior Fund) and the Equitix Investment Fund, as well as other investors and debt providers (ESMAP 2016).

Over the contract life time Birmingham City Council pays to Amey Plc. monthly unitary payments for the initial investment and maintenance and operation cost. For the first 5 years of the contract, an independent certifier approves increases of monthly unitary charges by approximately 4 %. The contract foresees cases for deductions in payments by the city. The simplified structure of the project is presented in Figure 8.

The project is implemented in two stages. The core investment (replacement of 57,404 luminaires) is made in the first five years and the rest of the luminaries are updated in the following twenty years. All assets are operated and maintained over the contract period of twenty-five years. Through the SPV, Amey Plc. is responsible for selection, purchase, installation and maintenance of luminaires. It takes the full asset technology and performance risks. Birmingham City Council can audit the performance of Amey Plc.

The final outcomes of the investment are still to be seen but the project is already considered to be a positive case of modernizing urban infrastructure with private capital. Key drivers of the project success are availability of national framework or support such as the PFI credits, availability of technical assistance to make sure the contract is well structured and clear municipality policy priorities.

Conclusion

Even though the upgrade of street lighting offers high energy savings, its upgrade rate is low in many geographical jurisdictions in Central Europe. High up-front investment costs are among the highest barriers for municipalities to upgrade street lighting. Under the Dynamic Light project, the authors of the paper reviewed and analysed different financing options placing special focus on the third-party financing.

The most straightforward financing model is to pay for street lighting upgrade from the own funds of municipalities. To minimize the burden on tax payers, the public sector could design and implement additional schemes which help raise the funds to the budget, in particular the revolving scheme. Many municipalities, whose own funding resources are limited, obtain debt which is then be paid back from the tax revenue of municipalities and/or saved energy costs. Thus, the municipalities could obtain a low interest loan from a public lending program, a commercial loan from a commercial bank, or it could issue municipal bonds.

Another alternative for the municipal actors is to reallocate the burden of financing street lighting infrastructure on third parties, e.g. contracting an energy service company. There is a wide variety of such contracts. In a simple contracting model,

3. Infrastructure UK (IUK) was a body within Her Majesty's Treasury which focused on long term infrastructure priorities and facilitation of private sector.

the contractor directly receives a contracting fee, which covers the costs of planning, financing and execution of the infrastructure upgrade, as well as its margin. The city is not involved into the contractual relationships with a bank providing the funds. In a more complex model with forfeiting and waiver of defence, the roles of the city and the contractor are similar to the simple contracting model, but the bank enters into agreements both with the contractor and with the city.

The other configuration is a set of energy performance contracting models, which could be applied when either a municipality or the contracted party pays for energy supply. In this model, the energy cost savings achieved via a reduction of energy consumption are used to finance the street lighting upgrade. Typically, the contracted energy service company guarantees an energy saving level to be achieved. In some models, additional energy savings achieved on top of the guaranteed level are shared between the municipality and the contractor.

Each of the models has its advantages and disadvantages as well as constraints to do with the economic, market, and legal conditions in which it could be applied. Therefore, the choice of model should be made according to the specific conditions in each municipality.

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