Contracting Energy Efficiency Projects using PPPs

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Abstract

Due to the high energy consumption and exaggerated emission of greenhouse gases (GHG), the construction sector of buildings (public and private) is one of the largest contributors for pollution in the European Union (EU). In this paper we analyze the importance of Energy Performance Contracting (EPC) for the improvement of energy efficiency in buildings. A research was conducted on the different models of contracting Energy Service Companies (ESCOs), from traditional models to alternative models, to expose not only the versatility of the new contracting models, but also the main risks associated with them. In order to identify the main characteristics that led to the successful implementation of these contracts, several applications of energy performance contracts already implemented in other European countries were studied. The previously mentioned study, associated with the research carried out for the elaboration of the Literature Review, allowed the analysis of the application of energy performance contracts to a public building that seeks to reduce its annual energy consumption. Therefore, a sensitivity analysis was performed considering different scenarios, to understand which of the three types of energy performance contracts would be the most suitable to apply in the building in question. Additionally, to identify which contract would be the most favorable for both the company and the client, an evaluation was assembled considering analysis criteria based on financial discounting, namely NPV and IRR. In the end, the paper presents the conclusions obtained as well as some proposals of possible approaches for future research concerning the analyzed theme.

Keywords: Energy Performance Contract; contract; Energy Service Company; First-Out Contract; Guaranteed Savings; Shared Savings; PPP

Introduction

Buildings currently consume about 40% of the European Union's (EU) total energy consumption and generate approximately 36% of Europe's greenhouse gases (GHGs), figures that make the building sector one of the most polluting on this continent. About 75% of buildings are energy inefficient and, depending on the member state, only between 0,4% and 1,2% of the building stock is renovated every year (Boza-Kiss et al., 2017).

To improve the energy performance of buildings and consequently decrease energy consumption and emissions of pollutant gases into the atmosphere, Energy Performance Contracts (EPCs) are proving to be a good tool for this purpose, as they allow the speed of energy renovation of existing buildings to be increased, and the implementation of energy-efficient measures in buildings yet to be constructed (Lugarić et al., 2019).

The existence of different types of EPCs makes it necessary to prepare them well before they are signed so that it is possible to choose the type of contract that favors not only the customer but also the ESCO (Energy Service Company).

The main objective of this document is to analyze the various types of EPCs. As such, it is intended to identify the risks associated with the application of these contracts, as well as their respective major and minor values to understand which one best meets the needs of both parties involved.

The study developed in this dissertation is considered relevant since through sensitivity analyses with different scenarios it is intended to provide public entities (customers) and private entities (companies) with guidelines on the most important aspects and risks to be considered when executing an EPC. To reach this goal, the analysis of EPCs applications in various municipalities across the European continent was carried out, which was later complemented with sensitivity analyses performed for the application of EPC in a public elementary school.

I – Literature Review

EU funding programs for energy efficiency improvements in buildings

Over the years, the EU has created several funding programs to support and promote research in various areas, including construction. In 2007, the Framework Programme 7 (FP7) was created with a funding of about 55 billion euros, which ended in 2013. This programme was followed by the Horizon2020 (H2020), which is the largest research and innovation project ever created by the EU, with funding of about 80 billion euros over 7 years (2014 to 2020) (ECTP, 2018).

Since buildings consume about 40% of the EU total energy consumption, and generate approximately 36% of the European continent's GHGs, the building sector turns out to be crucial to the EU's environmental and energy policies (ECTP, 2018).

Due to the need to lower the previously mentioned indicators, a project called Energy-efficient Buildings (EeB) cPPP emerged in 2008, consisting of a partnership between the European Commission (EC) and the private sector. With the implementation of this project, the EU aims to:

- Increase private investment in research and innovation by 3% until 2020;
- Create 10 new types of specialized jobs, with training and knowledge sharing among professionals;
- Develop appropriate technological solutions to reduce energy consumption by 50%, and CO_2 production by 80%, concerning the values verified in 2010;

To be able to quantify the evolution of the EeB cPPP inserted in the Framework Programmes (FP7 and H2020), key performance indicators (KPIs) were designed, such as the average duration per project, the average reduction of consumption due to innovations, the average reduction of CO_2 emissions due to innovations, etc.

It is noteworthy that both programs managed to achieve respectable values in terms of reductions in CO_2 emissions, energy consumption and also in the use of material resources. Moreover, it is relevant to note that in the last 7 years the participation of SMEs has increased from 28% to 34%, which shows that the private entities are willing to make investments in improving the energy efficiency of buildings (ECTP, 2018; ECTP, 2019).

Thus, in the last 15 years the EU has maintained a proactive stance about improving energy efficiency in buildings, making considerable investments in research and innovation, and encouraging investment and participation of private entities, including SMEs. Through this attitude, very positive results have been achieved, showing that if the investment continues to be well applied, the EU goals for the coming years will be achieved.

Energy Performance Contracts (EPCs)

While new energy-efficient buildings may be constructed, existing buildings will continue to be responsible for the majority of energy consumption, making it extremely important to improve the energy efficiency of these buildings (Tan, 2020). Due to the need for energy efficiency improvements in existing buildings, Energy Performance Contracts (EPCs) have emerged.

Stemmed from the oil crisis in the 1970s, EPCs appeared as an innovative model of financing to reduce energy consumption by compensating the costs of installing and managing energy-saving equipment (Okay & Akman, 2010). Today, EPCs are seen as a market mechanism or financing tool to encourage building owners, both public and private, to undertake energy retrofits (Xu et al., 2011)

According to the European Commission (2012): "Energy performance contracting means a contractual arrangement between the beneficiary and the supplier of an energy efficiency improvement measure, verified and monitored throughout the contract, where investments (work, supply or service) are paid for concerning a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial savings."

Energy Service Companies (ESCOs)

As mentioned earlier, EPCs are signed between customers and companies, with the former consisting of public or private entities, and the latter consisting of companies that are titled Energy Service Companies (ESCOs) (Bougrain, 2017).

According to the European Commission (2006), an ESCO is: "A natural or legal person that provides energy services and/or other energy efficiency improvement measures in a users' facility or facilities, and accepts some degree of financial risk in doing so. Payment for the service provided is based (in whole or in part) on the achievement of energy efficiency improvements and compliance with other agreed performance criteria." The type of service provided by ESCOs has been identified by several experts and scholars as a high-potential alternative for meeting consumers' energy needs in a more sustainable way than is currently the case (Hannon & Bolton, 2015).

Typically, an ESCO (which must be selected through a public tendering procedure) is responsible for the implemention of measures providing the knowledge required for effective energy efficiency improvements, and also for monitoring the contract during the respective period. If it does not guarantee the energy savings set out in the contract between both parties, the ESCO may not receive payment for the services rendered (ENERJ, 2017). The investment made by ESCOs can be made through funds from the companies themselves or through mechanisms provided by a financial institution (ENERJ, 2017).

Guaranteed Savings Contracts

In guaranteed savings contracts, the ESCOs are responsible for the "design and implementation of the project but not for its financing", i.e., the projects are financially supported mostly by the customers (Martiniello et al., 2020; Huimin et al., 2019). In this case, as the savings performance risks are accepted by the ESCOs, the EPC should include clauses specifying the ESCOs' obligation to guarantee the energy savings and pay the difference if they are not achieved (Figure 1). Therefore, it is recommended to require a savings guarantee on energy costs at constant base-year prices, making it easier to compare different proposals (ENERJ, 2017). If the savings exceed the guaranteed level, the excess is divided between the customer and the ESCO according to the provisions specified in the contract (usually, the customer receives at least 50% of the excess savings) (ENERJ, 2017).

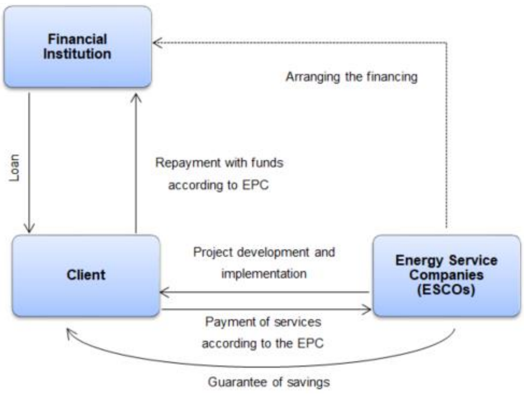

Figure 1: Guaranteed Saving Contract

Shared Savings Contracts

In shared savings contracts (Figure 2), the ESCOs are responsible for the design, implementation, and financing of the project, and a pre-established percentage of energy savings is shared between the public and private partners over a fixed contract period (Martiniello et al., 2020). Performance in this type of contract is related to the percentage of energy cost savings. Based on the cost of the project, the duration of the contract, and the risks assumed by the ESCO and the customer, a percentage of the cost savings is pre-determined and divided between the two actors over a predefined period (Pätäri & Sinkkonen, 2014). In a standard shared savings agreement, in addition to the financing, project development, and implementation of the performance risks, the ESCOs are also responsible for the interest rate risk and the risk of increased service costs, as well as the readjustment clause agreed upon by both parties (ENERJ, 2017).

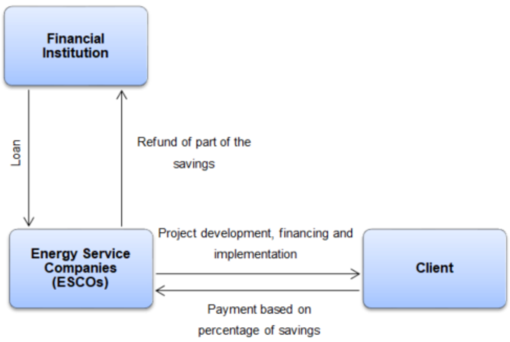

Figure 2: Shared Saving Contract

First-Out Contracts

First-Out Contracts stand out because the ESCOs finance the investments and retain all energy savings for a given contract period (Martiniello et al., 2020). Although the contract period is defined when it is signed, if the ESCO covers the project's entire costs and profits before the end of the contract, it ends on that date, and the energy savings are retained subsequently by the customer (Taylor et al., 2008). Therefore, the main characteristic of this type of contract is that its duration is influenced by the amount of savings achieved, and the greater the energy savings, the shorter the contract duration (Martiniello et al., 2020).

Main risks of the CDEs

Despite growing worldwide, energy services markets are still far from realizing their potential (Huimin et al., 2019). Previous studies reveal that some key barriers, such as technological, financial, and political barriers, must be overcome for energy services markets to reach their full potential (Huimin et al., 2019).

The risks associated with EPCs need to be properly considered and studied by both parties when entering into these contracts, as the greater the knowledge regarding the risks, the easier it is to mitigate them. Lee et al. (2015) identified the critical risks in energy efficiency improvement projects, such as the possible lack of payment by EU after the execution of the project, errors in baseline measurement, and increased installation cost. In turn, Qian & Guo (2014) highlighted that the risks and uncertainties in these projects are largely related to energy prices, equipment usage, unexpected events, and contractual risks, among others. In addition, it is relevant to highlight that the lack of knowledge and awareness in the development of these types of projects, as well as technical hindrances, and the insufficient political support for the implementation of these projects are other risks that deserve consideration by decision-makers. (Zhang & Yuan, 2019).

To sum up, Wang et al. (2019) state that the risks arising from this type of agreement can be divided into five major groups: financial and market risks, operational and management risks, technological risks, customer risks, and external environmental risks (Figure 3).

Figure 3: Relations between risks

II - ENERGY PERFORMANCE CONTRACTING APPLICATIONS

Guidonia Montecelio - Italy

The Municipality of Guidonia Montecelio is located about 29 km from Rome in a northeasterly direction and has a surface area of 79.06 km2, consisting mostly of flat terrain and a hilly area just above 300 meters. In this municipality, the largest energy consumption comes from civil heating and fuel production activities, fuel transport, and electricity use. Between 1990 and 2008, the per capita consumption of an inhabitant of this region for the use of electricity, thermal energy and transport was 17.57 MWh/year. The average consumption of the same resources by a citizen living in Italy amounts 25.11 MWh/year, as such the consumption of an inhabitant of Guidonia Montecelio was lower than the national average (Cusano et al., 2011).

To improve energy performance and renew the street lighting network, the municipality used public-private partnerships to carry out these interventions. To this end, the Municipal Administration published a public tender in 2008 for the concession of the municipality's public lighting service. This service also included the implementation, management and maintenance of an IT system to manage the entire network. The total amount to be paid to the concessionaire was estimated by the municipality at 28,454,500€ (plus VAT), to be paid over a contractual period of 20 years (Colella et al., 2013).

The selected consortium was then responsible for the economic and financial viability of the project, as well as for the planning and execution of the necessary works, operation, and maintenance of the facilities and financial provision. The ESCOs financed the investments from their own resources, recovering the investment through a shared savings contract lasting 20 years, where most of the energy savings were used to repay the investment (ENERJ, 2017). With this intervention, it was possible to reduce electricity consumption by 45% (Table 1) and total installed power by 33%, allowing the municipality to achieve savings of 1.5GWh/year of energy savings 1 (ENERJ, 2017).

A shared savings contract was also signed for the complete replacement of all lighting fixtures in the interior spaces of public buildings with more energy-efficient systems. This contract allowed the municipality energy savings of 57% (Table 1), and the reduction of all the electrical energy installed.

Koper – Slovenia

The Municipality of Koper occupies an area of 303.2 km2 along the coast of the Adriatic Sea, and it is located in the Coastal-Karst region, which despite being one of the smallest regions in Slovenia, is classified as one of the most advanced regions concerning economic development (GOLEA, 2019).

In order to improve energy performance, reduce energy costs and achieve a significant reduction in the use of primary energy in 31 public buildings, the municipality of Koper launched a public tender to select an ESCO to perform the necessary interventions. Under a 15-year shared savings contract, in which a 3% reduction in the final energy used for heating was expected to be achieved, the investment was fully financed by the contractor, and it was stipulated in advance that the municipality of Koper was entitled to receive 10% of the total savings achieved. If in any period the guaranteed savings are exceeded, the municipality receives 50% of the value of the additional savings (ENERJ, 2017).

The implementation of all the necessary interventions, good energy management, and the application of some additional measures in the technical has enabled the municipality of Koper to achieve an annual reduction of 100.000€ (Table 1) in energy costs (ENERJ, 2017).

Sant Gulat des Vallès – Spain

Located in Catalonia, more precisely in the comarca of Vallés Occidental, the municipality of Sant Gulat des Vallès has an area of 48,2 km2. According to Spain's National Institute of Statistics, the municipality's population reached 90.664 inhabitants in 2018, which translates into a population density of 1880,9 hab/km2.

In 2013, the municipality of Saint Gulat des Vallès launched a public tender for interventions to improve the energy performance and maintenance of the sports facilities of the High-Performance Centre of Saint Gulat des Vallès (CAR). This set of interventions was awarded to an energy services company (ESE) called COMSA Service for the contract value of 3,184,347€, and included the energy renovation of the facilities, maintenance and monitoring of consumption of the CAR, and also the management of the facilities. (LEITAT, 2015). The 10-year shared savings contract between the parties involved, where the financing of all improvements and interventions was fully allocated to ESE, has allowed the municipality to reduce electricity and thermal consumption by 39% (LEITAT, 2015).

Table 1: Main results from the study of the application of CDEs

	Contract Type	Contract Value	Contract Duration	Annual Reduction of Energy Consumption	Reduction of CO_2 Emissions
Guidonia Montecelio (Public Lighting)	Shared Savings	25.877.281€ (plus VAT)	20 years	45%	
Guidonia Montecelio (Public Lighting)	Shared Savings	≈1.250.000€	15 years	57%	410,9 ton/year
Koper (Public Buildings)	Shared Savings		15 years	24% (100.000 €/year)	
Saint Gulat des Vallès (CAR)	Shared Savings	3.184.347€	10 years	39% (296.000 €/year)	1.036 ton/year

III – Case Study

Located in the Autonomous Region of Madeira (RAM), in the municipality of Santa Cruz, Caniço Basic School is a school that has 1172 students, 145 teachers, and 61 non-teaching staff members. Annually, this infrastructure has an average monthly energy bill of about 2630€.

In order to reduce its annual energy consumption, the school used 3 ESCOs to perform energy audits to the buildings, so that they could collect all the necessary data to present possible energy-efficient solutions to reduce energy consumption (Table 2).

Based on the data and solutions obtained, it is intended to find out in this paper which of the three types of EPCs turns out to be the best for this type of public buildings.

IV – Results and Discussion

CDE Sensitivity Analysis

To find out which of the EPCs is the most economically and financially advantageous to the Caniço Elementary School and the ESE that will provide the service, a sensitivity analysis considering different scenarios was carried out based on the information and results obtained through the study of the proposals prepared by the three ESEs, and also on the information collected during the literature review and the conclusions drawn from the study of the application of EPCs in EU countries.

Sensitivity analysis studies the impact that changing an input parameter can have on the final results (outputs). The identification of the variables that determine the success of the project is very useful for minimizing the risks associated with the project, since it allows reducing the uncertainty associated with them (Luheto, 2018). Through the research carried out, it was concluded that the most critical input parameters for the preparation of the sensitivity analysis are the contract duration and the annual energy savings.

The contract periods vary between 10 and 20 years for large infrastructures. In the energy audits carried out on the object of study, the contractual durations are between 5 and 10 years. Combining the data from both studies, the duration of 5, 10, and 15 years were defined for the sensitivity analysis regarding the implementation of photovoltaic panels at Caniço Elementary School.

For the definition of the values of annual energy savings, it was only considered the values presented by the energy audits carried out at the school. Observing that the energy savings are comprised in the 10% - 25% range, it was defined for the sensitivity analysis in question the values of 15%, 20%, and 25% for the annual energy savings obtained by the solution installed on the roof of the school.

Multiplying these percentages by the school's annual electricity bill, we obtain values of 4728.79€ for a 15% saving, 6305.05€ for a 20% saving, and 7881.31€ for a 25% saving.

Regarding the solution to be installed, we chose to consider the solution that corresponds to a self-consumption of about 30kW. According to the company RC Automação, to achieve the desired power it is necessary to install 90 panels of 330W, which totals a cost of 36.000€, and in

Table 2: Main results from the energy audits

		Occupied coverage area (m^2)	Annual Savings (€)	Initial Investment without VAT (€)	Payback Period (years)	CO2 Emissions Reduction (ton/year)
AREAM	6 kW Solution	45 a 50	1111,00	10200,00	9,1	10,20
RC AUTOMAÇÃO	30 kW Solution	≈ 300	6941,78	35410,35	5,1	17,48
	45 kW Solution	≈ 300	10277,23	52265,21	5,09	26,22
FACTOR ENERGIA	52,7 kW Solution	289	7541,98	40628,02	5,39	

this value is included the maintenance of the panels (375€ per semester).

Therefore, for the sensitivity analysis, we also considered a profit margin for the ESCO of 15%, thus setting a total value of 41.400€ for the implementation of the 30kW solution.

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To verify which contract is the most viable for the parties involved, analysis criteria based on financial discounting should be considered, such as the Net Present Value (NPV) and the Internal Rate of Return (IRR). This values result from calculations performed based on cash flows, represented by annual revenues and expenses updated over the project horizon (Luheto, 2018).

Comparative Analysis of Results

Once the sensitivity analyses and respective simulations have been carried out for different scenarios, namely in terms of contract duration and annual energy savings, a study is conducted to understand which energy efficiency contract is more beneficial for both parties involved.

The Guaranteed Savings Contract turns out to be attractive for the ESCO, because it receives in year 0 the payment that covers its investment, also guaranteeing the intended profit. The only risk associated with this part is having to guarantee the annual energy savings defined in the contract, under penalty of paying an indemnity to the client if it does not comply with this condition. From the client's point of view, it is observed that for different contract lengths (5, 10, and 15 years) and different energy savings (15%, 20%, and 25%), the results obtained for NPV and IRR are very favorable. Through the sensitivity analysis for this type of contract, it can be seen that increasing the length of the contract does not have much impact on the analysis parameters, with the NPV of the 5-year contracts relative to the NPV of the 15-year contracts suffering an increase of only 4000€ on average, and the IRR an increase of 1%. However, Guaranteed Savings Contracts carry a very high risk for the client, as he/she is fully responsible for the investment, and although the company must indemnify the client in case of breach of contract, it is a risk that ends up driving entities away from opting for this type of contract, being much more attractive a contract where the investment risk is on the side of the company that presents the solution.

On the contrary, First-Out Contracts on the client's side end up being quite attractive, since the financial risk is totally assumed by the ESCO. From the sensitivity analysis performed on this type of contract, it is worth highlighting the fact that during the contractual period the client does not receive any type of remuneration nor has any type of expense. The client only keeps the equipment, the total energy savings, and also the responsibility of assuming the maintenance costs when the contract ends. The greater the energy savings defined in the contract, the shorter the duration of the contract, and the greater the NPVs obtained by the client. When it comes to ESCO, First-Out Contracts turn out not to be as appealing as Guaranteed Savings contracts, because it accumulates the financial and energy risk. If the ESCO does not guarantee the minimum energy savings specified in the contract, it will take the company much longer to recover the money invested. Furthermore, while the minimum NPV obtained for the client, which is associated with an energy savings of 15%, is 19.317,44 euros, the maximum NPV obtained by the company, which is associated with an energy savings of 25%, is only 4900,40 euros. Thus, this type of contract turns out not to be very advantageous for ESCOs, with the clients benefiting the most.

Thus, the type of energy efficiency contract that emerges as the best alternative for both parties involved turns out to be the Shared Savings Contract, which consists of both parties sharing energy savings for their own benefit, with the financial and energy risk being, like First-Out Contracts, associated with the energy service company. In the sensitivity analysis performed, it was considered during the contract period that the energy savings received by the ESCO would be 80% of the total savings, so that the ESCO would recover its investment, leaving the remaining 20% for the client. At the end of the contract, the client receives 100% of the savings, assuming also the maintenance costs. Analyzing the tables constructed for the analysis in question, it can be seen that the customer, by not having any expenses, always guarantees a positive NPV whatever the energy savings or the contract period. However, it is of interest to the customer that the contract duration is short because it is in these contracts that he/she can optimize his/her benefits. For example, in a 5-year contract with the most pessimistic savings scenario (15%), the customer can guarantee an NPV of 37.346,04€, whereas for the most optimistic scenario, he/she can guarantee an NPV of 60.946,61€, for the same contract duration. By increasing the duration of the contract, this NPVs fall to 16.854,64€ and 28.963,39€ respectively, thus proving that shorter contracts represent a greater benefit for the customer.

On the other hand, short contract durations are extremely detrimental to ESCOs in this type of contract. It can be observed that for a contract duration of 5 years, regardless of an optimistic or pessimistic scenario for energy savings, the company always obtains negative NPVs and IRRs, since it does not have enough time to recover its investment. Increasing the contract duration to 10 years, if we consider an energy-saving scenario of 20%, the intermediate between the pessimistic (15%) and the optimistic (25%), the NPV and IRR become positive, the NPV equals 3055,39€. Compared to the NPVs obtained by the client in this type of contract, the NPV obtained by the company is much smaller, and adding this aspect to the fact that the ESCO must assume the financial and energy risks, this contract again ends up not being attractive to companies. However, when increasing the duration of the contract to 15 years, it can be observed that the NPV values for the company and for the client start to get closer, specially in the most optimistic scenario, associated with an annual energy saving of 25%, being the client's NPV 28.963,39€ and the company's NPV 28.191,37€. Another aspect that reveals itself as an indicator that this is the most favorable energy efficiency contract for both parties is that for 15 years, considering the intermediate energy savings scenario (20%), the client and the company achieve NPVs that are quite advantageous for both sides, being the client's NPV 22.909,02€ and the company's NPV 15.353,11€. Tables 3 and 4 summarize the main results obtained in this study.

Table 3: Main results from sensitivity analysis – Guaranteed Savings and Shared Savings Contracts

		NPV (€)			
		Guaranteed Savings		Shared Savings	
Contract Duration (years)	Annual Energy Savings (%)	Customer	ESCO	Customer	ESCO
5	15	9814,06		37346,04	-19168,17
	20	28706,68		47664,58	-13557,58
	25	47599,30		60946,61	-7946,98
10	15	12201,90		24310,30	-6708,44
	20	31094,50		33439,14	3055,39
	25	49987,20		42597,94	12819,22
15	15	13969,50		16854,64	2514,82
	20	32862,10		**22909,02**	**15353,09**
	25	51754,80		**28963,39**	**28191,37**

Table 4: Main results from sensitivity analysis – First-Out Contracts

		NPV (€)	
		First-Out Contract	
Annual Energy Savings (%)	Contract Duration (years)	Customer	Company
15	9	19317,4	614,45
20	7	34510,3	1115,16
25	6	49373	4900,40

V – Conclusions

The fact that buildings consume about 40% of total energy consumption in the EU and generate approximately 26% of greenhouse gases (GHGs) on the European continent, has led the EU to create various funding programs to support and promote research in the construction area, launching the Framework Programme 7 (ended 2013), Horizon2020 (ended 2020), and the Energy-efficient Buildings (EeB) cPPP project.

Consequently, energy performance contracts (EPC) emerged, which consisting in a contractual agreement between a beneficiary and a supplier of an energy efficiency improvement, verified and monitored over the contractual horizon. Alongside these contracts, energy service companies (ESCOs) have surged. These are entities contracted to implement the energy efficiency improvement measures. Of the EPCs, Guaranteed Savings Contracts, Shared Savings Contracts, and First-Out Contracts are the most proeminents.

However, the EPCs still face some difficulties when it comes to implementation, namely the drafting of contracts and the launching of public tenders. The emergence of these contracts, associated with the new contracting models, has led to the need to adapt and improve the procedures for public tenders, including the possibility of energy audits by ESCOs before the initial bidding stage. In the case of energy efficiency, the specifications should give special importance to the technical quality of the proposal and its value.

In addition to tendering and contracting difficulties, with EPCs there are also several risks associated with their implementation, namely financial and market risks, operational and management risks, technological risks, customer risks, and external environmental risks.

Through the analysis of the positive application of GPP in European countries, it was possible to perform a sensitivity analysis to verify which contract is the most appropriate to apply to a school (Caniço Elementary School).

After selecting the solution to implement (30kW), several simulations were then performed with different values for the critical input parameters. From the analysis of the simulations, we conclude and recommend the conclusion of a Shared Savings Contract for this case study, as it allows both the client and the company to obtain high and balanced NPVs (28.963,39€ for the company and 28.191,37€ for the client) for a 15 year contract. In addition, the Shared Savings contract allows the customer not to assume any type of financial or energy risk, which is mitigated for the company, which consequently receives a higher remuneration during the contract period.

The present work also provides all the foundations for the next step, as the obtention of the optimal solution, using software designed for this purpose. Other possible paths to study the EPCs would be to consider all the aspects involved in the EPCs that were not considered in the simulations present in this dissertation, such as the case of having excesses or gaps in energy savings throughout the contract period, and what impacts these effects would generate for the customer and the company.

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