Energy performance contracting as an innovative tool for financing the building renovation in Slovakia, Central Europe

Veronika Gombošová [a], *Michal Krajčík* [b]

[a] Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Slovakia, veronika.gombosova@stuba.sk

[b] Faculty of Civil Engineering, Slovak University of Technology in Bratislava, Slovakia, michal.krajcik@stuba.sk

Abstract. The possibilities of using Energy Performance Contracting (EPC) are presented for Slovakia, Central Europe, including a case study performed for a building in Bratislava. The case study contained an inspection of the building, an energy audit with a proposal of energy efficiency measures, and profitability calculations for the measures. A package of suitable measures was created, and its suitability for financing by EPC was evaluated. The net present value quotient (NPVQ) was used to indicate the profitability of energy-saving measures. However, for EPC projects, the number of years in which the investment is returned is the most important. Therefore, payback was considered to be a more relevant indicator of profitability for EPC projects. With an adequate combination of energy efficiency measures, a payback period of 15 years was reached. This was acceptable considering that the building belonged to a municipality. The potential drawback of EPC is that it may not be feasible for complex renovations.

Keywords. Energy performance contracting (EPC), energy audit, energy efficiency, net present value (NPV), payback.
DOI: https://doi.org/10.34641/clima.2022.72

1. Introduction

One of the worldwide problems that need to be addressed is high energy consumption. Of all sectors, the most energy is consumed by buildings [1]. As a result, solutions have been researched to reduce energy use by improving the design and operation of building envelope and HVAC systems. The European Directives set minimum requirements and a common methodology to improve the energy performance of newly built and renovated buildings in the EU [2][3]. A significant part of the energy-saving potential in buildings is attributed to building retrofit. Countries within the European Union have made commitments to build energy-efficient buildings between 2019 and 2021 [4]. Especially new buildings are targeted, promoting nearly zero-energy buildings [5], but existing buildings should also be improved with energy retrofits [6][7].

In Slovakia, a substantial part of the building stock was built decades ago. Complex or in-depth renovation of such a building is typically carried out 30 to 40 years after its construction. Based on these facts, special attention must be paid to the quality of current construction or renovation of buildings now, so that they can provide their users with a safe and healthy environment under economically affordable conditions even in 2050.

The biggest obstacle to investing in quality renovation or building construction is, among other things, funding. The most common source of financing is a bank loan. In fewer cases, the financing comes from own capital. However, alternative financing methods exist such as Energy Performance Contracting (EPC). In several countries, a strong commitment of the government to the use of EPC has been observed [8]. In Europe, the European Commission launched an EU-Energy Performance Contracting Campaign (EPCC) to help member states develop a legal and financial framework for the EPC market [9]. The main advantage of EPC is that financing and related risk are taken over by an Energy Service Company (ESCO), which is a company that implements the EPC project. ESCO not only provides clients with upfront capital for project implementation but also monitors the actual performance of newly installed equipment and provides staff training for better system operation and control [10]. In a popular EPC model, the ESCO guarantees the host a certain level of energy savings and compensates for the losses in the event of a shortfall in savings [10].

This study presents the principle of EPC, including related profitability indicators and a case study focused on the possibilities of using EPC for building retrofit in Slovakia. It illustrates the principles to evaluate the suitability of energy-saving renovation measures for EPC, including the maximum payback durations tolerated for an EPC project.

2. Energy service

An energy service is a service provided under a contract concluded between an energy service provider and a recipient of the energy service. The energy service can be provided as an energy support service and as an energy service with guaranteed energy savings, also called Energy Performance Contracting. The result is a verifiable, measurable, or estimable energy saving which improves energy efficiency and allows for a financial or material advantage for all parties involved due to the more energy-efficient technology or activity. This activity includes the operation, maintenance, or control necessary to provide an energy service [11]. This study focuses mainly on EPC and its principles.

2.1 Legal framework

The energy services provided in Slovakia are based on Act no. 321/2014 Coll. on Energy Efficiency [11], where Energy Performance Contracting is defined. Following the Slovak law, EPC entails an energy service provided under an energy efficiency contract, which must be in written form, with guaranteed energy savings. The specific guidance on how to perform the actions as required by Act no. 321/2014 Coll. are defined in Decree no. 99/2015 Coll. [12]. For example, the Decree provides a sample application for a proficiency test needed to obtain permission to provide EPC. An important part of each EPC project is an energy audit, as it describes the actual state of the objects, the proposal of energy savings measures, and the profitability calculations. The procedure to elaborate the energy audit is provided in Decree no. 179/2015 Coll. on energy audit [13].

2.2 Process of the EPC project

Figure 1 illustrates the principle of an EPC project. In the beginning, the building has a certain energy consumption, also called the baseline, which may be considered too high by the owner. The building owner can see EPC as an option to reduce energy consumption and achieve financial savings. In such a case, the owner bids through public procurement, and the ESCO responds. If the owner is satisfied with the offer from ESCO, they subscribe to the contract. A model contract for Slovakia is published on the website of the Ministry of Economy of the Slovak Republic [14]. The next step is an energy audit of the building, where efficiency measures are proposed, evaluated, and recommended. The contract is usually signed for 6 to 10 years [15]. However, if there is a reliable investor, such as the government or a municipality, the duration of the EPC project can be longer, even up to 15 years. The main principle is that during this period, ESCO guarantees savings and takes all risks that may arise. These savings reduce the energy consumption of the building and pay the initial investment costs paid by ESCO. At the end of the contract period, the building has substantially lower energy consumption compared to the baseline, and the owner now acquires savings, better technologies, services, and a retrofitted building.

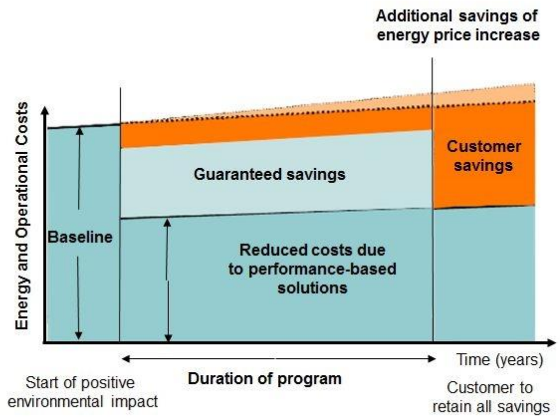

Fig. 1 – EPC project process [11].

2.3 Energy Service Company (ESCO)

Usually, the EPC is provided by an ESCO, which could be a person or a legal entity that provides energy services. At the same time, ESCO assumes the technical and financial risk that arises from the design of energy efficiency measures, their implementation, and operation throughout the project. The project funding can vary; but usually, the ESCO or investors choose a bank loan.

3. Profitability indicators

Economic evaluation is an important part of building retrofit projects. The aim of this evaluation is to find the profitability of individual energy-saving measures and to determine the cash flow of the proposed financing option. The economic parameters that enter into the evaluation are investments, annual savings, economic lifetime, and nominal interest rate. Among the most commonly used profitability indicators are the simple payback, discounted payback, internal rate of return, net present value, and net present value quotient. This study focused on the net present value coefficient and the payback period.

Equation (1) is used to calculate the net present value (NPV) based on the ratio of financial savings per year to the end of the economic life of the equipment (B_{1-n}) and the real interest rate (r), minus initial investments (I). A positive NPV indicates a profitable investment [16].

$$\mathrm{NPV} = \left(\frac{B_1}{(1+r)^1} + \frac{B_2}{(1+r)^2} + \cdots + \frac{B_n}{(1+r)^n}\right) - I \qquad (€)\ (1)$$

A practical way to express the profitability of the measure is the Net Present Value Quotient (NPVQ). It is the ratio of the net present value (NPV) to the value of the total investment (I) [16]. The NPVQ method is suitable for ranking energy-saving measures in terms of profitability.

$$\text{NPVQ} = \left(\frac{\text{NPV}}{\text{I}}\right) \quad (€)\ (2)$$

The discounted return expresses the return of the measure, also considering the discount of the savings over time. According to EN 15459-1, discounted payback (PB_{disc}) is the time when the difference between the initial investment cost for the optional and reference case is balanced with the cumulative discounted annual costs difference in each individual year. It is calculated using eq. (3). The calculation considers the initial investment (CO_{INT}) and the initial investment of the reference solution ($CO_{INT,ref}$). If nothing is done, the value of the reference solution is 0 [17]. In this calculation, the difference in annual costs between the actual solution and the reference solution (CF_t) must also be considered. For better understanding, it can also be explained as the difference in cash flows. The resulting value of the payback period is also affected by the discount rate (RAT_{disc}). The payback period must be lower than the economic lifetime of the energy efficiency measures. In this study, a discount rate of 3% was chosen, as recommended in the Guide to Cost-Benefit Analysis of Investment Projects [18], and 5% for comparison.

$$\text{PB}_{disc} = \sum_{t=1}^{TPB} CF_t \cdot \left(\frac{1}{1+\text{RAT}_{\text{disc}}}\right)^t - CO_{INT} + CO_{INTref} = 0 \quad \text{(a) (3)}$$

where TPB is the number of years when the sum becomes equal to 0. When calculating the investment in an EPC energy efficiency measure, it is necessary to take into account the additional costs of financing by EPC by increasing the investment in the measure. During the duration of the EPC project, ESCO guarantees energy savings for the entire renovation package. For this reason, additional costs related to risk, management, insurance, or repairs must be reflected in investment costs. These additional costs are expressed as a percentage of the initial investment per measure. These percentages are chosen according to the experience of the entity providing the EPC. A simple payback taking into account the additional investment-related to EPC is calculated as follows:

$$EPC_{SimplePB} = \frac{EPC_{Investment}}{(EPC_{savings} - EPC_{costs})} \quad \text{(a) (4)}$$

4. EPC projects funding

An essential part of an EPC project is the Energy Performance Contracting Business Model (EPCBM). EPCBM determines the type of contract for EPC projects that has a significant impact on project performance [19]. However, each of the types of EPCBM impacts the EPC project at a different level because various types of EPCBM have their characteristics related to financing and risk-sharing [20][21][22]. EPCBM identifies the roles of the energy customer and the ESCOs and defines the responsibility and risk-sharing of the participants in an EPC project [23][24]. It also clarifies the allocation of cost savings [25]. EPCBM determines the type of contract of the EPC project and has an essential impact on energy savings performance [26].

4.1 Credit and leasing financing

One of the most commonly used financing methods is credit financing. Credit financing means that a lender (financing institution) provides a borrower (customer) with capital for a defined purpose over a fixed period of time. Borrowers in this case can be either ESCO or client. A credit is settled over a fixed period of time with a number of fixed instalments (debt service). These instalments must cover the amount borrowed, plus interest rates, as well as other transaction costs such as administrative fees. Loans are disbursed against proof of purchase in order to secure the earmarked use of the funds. The other often used financing method is leasing. Leasing is a way to obtain the right to use an asset, not the possession of this asset. Assets in our case mean investments in energy conservation measures. When leasing an energy conservation investment, you do not buy it. You only pay for the exclusive right to use it [26].

4.2 Authority/government participation in financing

It is common for the Authority (or other government entities) to participate in the financing of an EPC arrangement. The reasons for an Authority to participate in the financing vary from EPC to EPC, as do the ways in which it may choose to do so. The most common examples are milestone payments (non-refundable) and/or direct provision of EPC assets to the Partner during or at the end of the Construction Phase, loans to the Partner, equity participation in the Partner, financing guarantees and financial incentives (e.g., reduced energy tariffs) and/or exemptions from liabilities (e.g., corporate tax, value-added tax) that the Partner would otherwise incur. But it is necessary to know that European Union financing (e.g. grant, loan) is not counted as government financing [26].

4.3 Funding for EPC projects in Europe and Slovakia

In general, EPC is a financing solution with guaranteed savings, regardless of the funding form. Customers can opt for EPC, regardless of funding [15] to achieve guaranteed savings, thus ensuring the predictability of the economic results of the project, or to use the competitiveness of EPC procurement in the case of complex solutions, so that the best solution for finding a provider can be found to find the most cost-effective solution in terms of cost-benefit.

Based on research carried out by the European market, the most used method was a loan taken by the ESCO. The least-used method in selected European countries as financial leasing. In the case of the Slovak Republic, the most used method was also a loan taken by the ESCO. The least used method, in this case, was the operating lease [27].

5. Case study – an apartment building in Bratislava

5.1 Building description

The apartment building studied is located in Bratislava, the capital of Slovakia. The built-up area is 1 636 m² and the heated volume is 29 135 m³. The building consists of 2 parts, the entrance building with 3 storeys and the accommodation part with 9 above-ground storeys and one underground storey. The average storey construction height is 2.9 m. Both parts have a simple rectangular shape. Between 2003 and 2005, the building underwent a partial retrofit, consisting of the construction of a single-story vertical extension of the accommodation part and the construction of a two-story superstructure of the entrance building.

The entrance building and most of the accommodation part of the building is built as an aerated concrete wall panel system with a thickness of 300 millimetres. The single-storey superstructure of the accommodation part consists of reinforced concrete with a thickness of 150 millimetres. The perimeter walls of the separate extension consist of full bricks. The roof of the main building is built as an aerated concrete roof panel system. The roof of the separated extension is built as a reinforced concrete roof panel system. All peripheral structures are non-insulated. The opening structures are designed mainly as windows and doors with insulating double glazing and a plastic frame. A small part of the opening structures is still in their original state and does not meet today's normative requirements.

The heating source for the building is a gas boiler room, located on the ground floor in a separate extension with three low-pressure gas boilers. Two boilers operate in alternate operations. The third boiler is outdated and non-functional. The total heat output of the boiler room is 2 190 kW. The efficiency of one boiler is approximately 80%. The heating system is controlled by an equithermal regulation, i.e. based on the external temperature. There are 334 cast iron heaters in the heating system; only a small part of them have a thermostatic head. Horizontal distribution pipes are insulated, but the free risers are uninsulated.

The lighting system has undergone a partial reconstruction. It consists of luminaires with linear fluorescent lamps and classic and electronic ballasts, LED bulbs, or old luminaires with ordinary bulbs, and one halogen lighting. The preparation of domestic hot water is centralized using one storage heater with a volume of 2 000 litres.

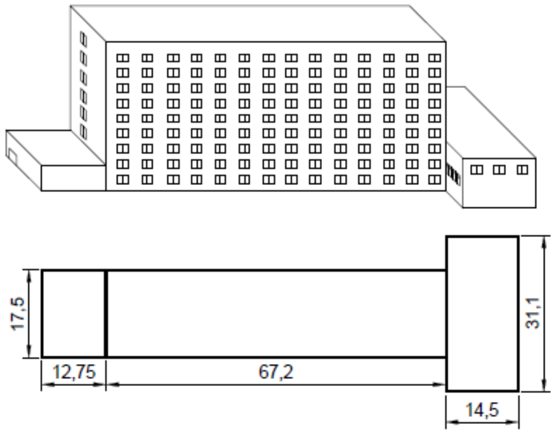

Fig. 2 - The case study apartment building

5.2 Energy inputs

Figure 3 shows the average annual energy costs for the building over three years (2016-2018). The share of energy carriers in annual energy consumption is shown in Figure 4. The average annual electricity consumption was 308.3 MWh, in monetary terms 41 179 € per year. The average annual consumption of natural gas was 129 562 m³ per year, in monetary terms 54 105 € per year.

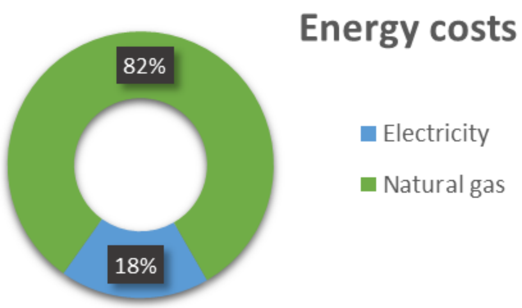

Fig. 3 - Share of energy carriers in average annual energy costs

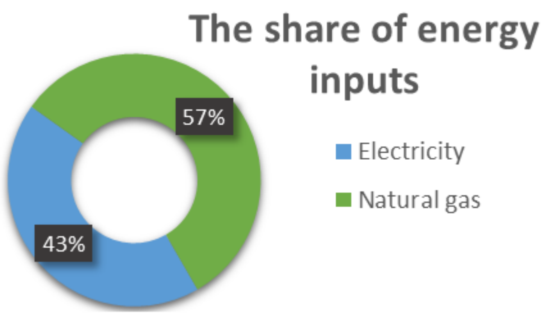

Fig. 4 - Share of energy carriers in annual energy consumption

5.3 Energy calculations

An important part of the EPC project is energy calculations to determine the energy-saving potential of energy-saving measures. The European Committee for Standardization (CEN) provides a set of standards containing procedures for energy balance calculations. The important part is the link between the energy needs of the building and the energy delivered for space heating and cooling, and the energy requirements for ventilation, domestic hot water, and lighting. For space heating, there is a set of standards EN 15316 with the input of energy need for heating according to EN 52016-1. In addition, national standards and legislation documents provide the specific requirements and input data for the national context and give recommendations and guidelines to specify the methods and inputs for energy balance calculations [28].

The first step is the calculation of the energy needs that represent the only theoretical amount of heat, needed e.g., to keep the room temperature or the water in the tank at a certain level, without considering the losses of the technical systems. The energy need for heating is calculated as defined in EN 52016-1. It is necessary to define the space heating boundaries and calculation method. In this case, a monthly calculation step was used. It is necessary to calculate the specific heat loss by heat transmission and ventilation. Part of the calculation refers to heat gains, which include internal gains and solar gains. According to the national standard STN 73 0540-2, internal heat gains are characterized by the average heat outputs of the internal heat sources. Solar gains depend on the location of the building [29].

To determine the detailed current condition of the building, it was necessary to calculate heat losses by heat transmission through the structures and heat losses through ventilation. The monthly method was used for the calculation, where a different internal temperature was considered for each month. The heat loss of the building is also to some extent influenced by the infiltration rate, which was also considered different for each month. Heat transmission losses were calculated as follows:

$$H_T = \sum b_{x,i} . U_i . A_i + \Delta U . \sum A_i \qquad \text{(W/K) (4)}$$

Heat loss through ventilation was calculated based on air density, specific heat capacity, building volume, and air change rate. The following formula was used for the calculation:

$$H_V = \frac{V}{V_b} . \rho_a . c_a . n_{inf} . V_b / 3600 \qquad \text{(W/K) (5)}$$

The next step was the calculation of solar heat gains, which mainly depend on the type of opening structure and internal gains. After calculating the heat losses by heat transmission and ventilation and calculating the heat gains of the building, it was possible to calculate the energy need for heating:

$$Q_H = Q_{ht} - n_{gn} . Q_{gn} \qquad \text{(kWh) (6)}$$

The next step is to calculate the additional energy losses of the technical systems. These consist of heat emission (EN 15316-2 [30]), distribution losses (EN 15316-3 [31]), storage losses (EN 15316-5 [32]), and generation losses (EN 15316-4-1 for boilers [33]). When calculating the energy demand, the calculation process follows a reverse order, from the energy need for heating towards the generation and storage subsystem. For the calculation of the energy demand for heating, the following formula was used (7).

$$Q = Q_H + Q_{em,ls} + Q_{H,dis,ls,an} + W_{H,dis,aux,an} + Q_{s,ls+} Q_{g,ls} \qquad \text{(kWh|(7)}$$

Annual energy saving is the difference between the energy demand before implementation and after implementation of the saving measures. Annual energy savings should also be expressed in monetary terms.

The energy audit also included the calculation of the energy demand for domestic hot water preparation, as well as the energy demand for lighting. Calculating the energy demand for domestic hot water was based on the standards 15316-3 [31] and EN 15316-5 [32] and consisted of the calculation of the energy need for domestic hot water, heat loss from distribution, heat loss from accumulation, and the heat loss from heat generation.

The electricity consumption for lighting was not measured separately. To be able to assess the impact of the lighting system on energy consumption in the building, it was necessary to determine the approximate electricity consumption for lighting based on the individual number of lighting elements and their power consumption and based on the number of lighting hours.

5.4 Energy saving measures considered

After determining the energy demand of the building, energy-saving measures were proposed. These measures focused on the insulation of the perimeter structures of the building, the modernization of the lighting system, the reconstruction of the boiler room and the heating system, and the use of a solar system for domestic hot water. Profitability indicators such as net present value, EPC simple payback, and discounted return were calculated for each of the proposed measures. The proposed measures are shown in Table 1.

To calculate the net present value, formula (1) was used. After calculating the NPV, the net NPVQ was calculated using formula (2). Following EN 15459-1, equation (3) was used to calculate the discounted payback for each of the energy-saving measures [17]. Discount rates of 3% and 5% were selected. Table 2 shows the values of NPV, NPVQ and PB calculated on the basis of a discount rate of 3%. Table 3 shows the values of NPV, NPVQ and PB_{disc} calculated on the basis of a 5% discounted rate. In the calculation of NPV, an economic lifetime of 20 years was considered.

Tab. 1 – Energy-saving measures and investments

Energy-saving measure	Investment (€)
1) Perimeter walls insulation	397 211
2) Heat source reconstruction	82 822
3) Lightning system modernization	61 416
4) Solar system implementation	45 100
5) Reconstruction of DHW distribution	20 630

Tab. 2 – Profitability indicators assuming a discount rate of 3%

Measure	$NPV_{3\%}$	$NPVQ_{3\%}$	$PB_{disc3\%}$
1)	-3 059 626	-6.7	15.0
2)	-1 480 893	-13.3	82.0
3)	+166 705	+14.5	7.0
4)	-551 688	-10.7	27.0
5)	+691 077	+34.5	2.0

* For explanation of the measures 1 to 5 see Tab. 1

Tab. 3 – Profitability indicators assuming a discount rate of 5%

Measure	$NPV_{5\%}$	$NPVQ_{5\%}$	$PB_{disc5\%}$
1)	-3 704 214	-8.3	24.0
2)	-1 512 424	-17.3	<100
3)	+573 753	+10.3	8.0
4)	-646 911	-11.9	40.0
5)	591 337	+29.6	2.0

* For explanation of the measures 1 to 5 see Tab. 1

Tables 4 and 5 describe the EPC simple payback calculation for each of the energy efficiency measures considered. EPC simple payback was calculated using formula (4).

Tab. 4 – EPC Simple payback

	EPC investment with funding (€)	EPC saving (€/year)	EPC project costs (€/year)	EPC simple payback (year)
1)	476 654	17 903	15 888	236.5
2)	99 386	7 863	4 141	26.7
3)	73 699	8 294	3 070	14.1
4)	54 120	1 664	2 255	-91.6
5)	24 756	5 214	1 031	5.9

* For explanation of the measures 1 to 5 see Tab. 1

Tab. 5 –EPC project duration

EPC Investment with funding (€)	EPC savings (€/year)	EPC costs (€/year)	EPC simple payback (year)
728 616	40 940	26 387	50.1

Table 5 reports the duration of the EPC project when all energy efficiency measures are considered. By combining these measures, we obtained an EPC simple payback of more than 50 years. As mentioned in Chapter 2.2, the duration of the project is usually 6 to 10 years, sometimes up to 15 years. In this case, a maximum project duration of 15 years was considered. Therefore, it was necessary to find a combination of measures that would fulfil this criterion.

5.5 Suitability of the saving measures for EPC

The basis of an EPC project is the selection of appropriate energy-saving measures. Therefore, in the next step, the measures that had the most significant impact on energy consumption and operating costs were selected while having reasonable profitability. In some cases, the annual cost of the EPC energy efficiency measure may be higher than the related annual savings, resulting in a simple negative return on the specific measure. However, this problem could be solved by using a suitable combination of individual energy efficiency measures to obtain a favourable overall payback for the EPC project. Tables 6 and 7 summarize the energy efficiency measures that were considered appropriate for the case study EPC project.

Tab. 6 – Energy efficiency measures for EPC project

Energy-saving measure	Investment (€)
2) Heat source reconstruction	82 822
3) Lighting system modernization	61 416
5) Reconstruction of DHW distribution	20 630

Tab. 7 – EPC Simple payback

	EPC investment with funding (€)	EPC saving (€/year)	EPC project costs (€/year)	EPC simple payback (year)
2)	99 386	7 863	4 141	26.7
3)	73 699	8 295	3 070	14.1
5)	24 756	5 124	1 031	5.9

* For explanation of the measures 1 to 5 see Tab. 1

5.6 EPC project duration

The financial summary of the project without the costs associated with EPC is shown in Table 8. It indicates that based on this initial investment, it is possible to propose financing for the EPC project. Table 9 shows the key parameters of the project, including the associated EPC costs. The EPC simple payback doubled compared to the simple payback in Table 8. None of the selected measures had a negative EPC simple payback. Their combination met the 15-year payback limit. The owner of this building is the city and therefore has several buildings under management. Therefore, it can presumably commit itself to continue to pay the same costs and to ensure that there is no downtime. This reduces the risk to the ESCO and allows for a longer duration of the project. Therefore, in this case, the duration of the EPC project of 15 years was allowed.

Tab. 8 – Simple payback of project without EPC costs

Investment (€)	Savings (€/year)	Simple payback (year)
164 868	21 373	7.7

Tab. 9 – Simple payback of project including EPC costs

EPC Investment (€)	EPC savings (€/year)	EPC costs (€/year)	EPC Simple payback (year)
197 842	21 373	8 243	15.0

6. Conclusion

The case study on an EPC project for an apartment building confirmed that the renovation of technical systems is often more feasible than the renovation of building structures. Therefore, EPC can be a suitable funding method mainly for the reconstruction of technological systems of buildings. However, in some cases, it is possible to combine it with the reconstruction of building structures. With a suitable combination, it is possible to achieve a return that will be acceptable for the ESCO company as well as for the customer. It also depends on the duration of the contract signed at the begging of the EPC project. In this way, the EPC can be a suitable financing tool even for complex building renovations.

The case study has also shown the important impact of variability in the selected input data, such as, for example, the discount rate. Tables 8 and 9 showed that the additional costs associated with EPC can considerably increase the payback period. The profitability of individual energy efficiency measures can be expressed through various profitability indicators. NPVQ can be used to distinguish the main differences between measures for building structures and measures for technology systems. However, for EPC projects, the number of years in which the investment is returned is the most important. This indicates that PB can be a more relevant indicator for EPC projects than NPVQ.

Nomenclature

Symbol	Definition (Unit)
NPV	Net present value (€)
NPVQ	Net present value quotient
B	Yearly financial savings (€)
r	Real interest rate
n	Economic lifetime (year)
I	Investment (€)
PB_{disc}	Discounted payback (year)
CF_t	Cashflow (€)
RAT_{disc}	Discount rate
t	Time (year)
CO_{INT}	Initial investment (€)
$CO_{INT,ref}$	Initial investment to reference solution (€)
$EPC_{SimplePB}$	Simple payback incl. EPC costs (year)
EPC_{Invest}	Investment to EPC project (€)
$EPC_{savings}$	Financial savings by EPC (€)
EPC_{costs}	Costs associated with EPC (€)
H_T	Heat loss by transmission (W/K)
H_V	Heat loss by ventilation (W/K)
$b_{x,i}$	Factor considering loss to unheated space
U_i	Heat transfer coefficient (W/(m^2.K))
A_i	Area of the building structure (m^2)
ΔU	Loss by thermal bridges (W/(m^2.K))
$\sum A_i$	Total area of building envelope (m^2)
V	Internal volume of building (m^3)
V_b	Outer volume of building (m^3)
ρ_a	Density of air (kg/m^3)
c_a	Specific heat capacity of air (kJ/(kg.K))
n_{inf}	Air change rate in building (1/h)
Q_H	Energy need for heating (kWh)
Q_{ht}	Thermal losses of building (kWh)
n_{gn}	Heat gain utilization factor
Q_{gn}	Heat gains of building (kWh)
Q	Energy demand for heating (kWh)
$Q_{em,ls}$	Heat loss of emission system (kWh)
$Q_{H,dis,ls}$	Heat loss of distribution system (kWh)
$W_{H,dis,aux}$	Auxiliary energy for distribution system (kWh)
$Q_{g,ls}$	Heat loss of generation system (kWh)

7. Acknowledgement

This work was supported by the Ministry of Education, Science, Research and Sport of the Slovak Republic through grants VEGA 1/0303/21 and 1/0304/21 and KEGA 005STU-4/2021.

The datasets generated during and/or analysed during the current study are not available because of the page limit but the authors will make every reasonable effort to publish them in near future.

8. References

[1] Dipasquale, Ch., Fedrizzi, R., Bellini, A., Gustafsson, M., Ochs, F., Bales, Ch. Database of energy, environmental and economic indicators of renovation packages for European residential buildings. Energy & Buildings. 2019;203:1-2.

[2] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

[3] Energy Performance of buildings Directive, Directive 2010/31/EU of the European Parliament and of the council of 19 May 2010 on the energy performance of buildings.

[4] EC, EPBD Recast (Directive 2010/31/EU). http://www.eceee.org/policyareas/buildings/EPBD_Recast. 2010.

[5] Marszal A.J., Heiselberg P., Bourrelle J., Musall E., Voss K., Sartori I., Napolitano A. Zero energy building - a review of definitions and calculation methodologies. Energy and Buildings. 2011; 43:971-979.

[6] Brown N.W.O., Bai W., Bjork F., Malmqvist T., Molinari M. Sustainability assessment of renovation for increased end-use energy efficiency for multi-family buildings in Sweden. In: Proceedings of SB11 Helsinki World Sustainable Building Conference, Helsinki. 2011;132-133.

[7] Kurnitski J., Saari A., Kalamees T., Vuolle M., Niemelä J., Tark T. Cost optimal and nearly zero energy performance requirements for buildings in Estonia. Estonian Journal of Engineering. 2013; 19:183-202.

[8] Marino A., Bertoldi P., Rezessy S., Boza-Kiss B. A snapshot of the European energy service market in 2010 and policy recommendations to foster a further market development. Energy Policy. 2011;39(10):6190–6198.

[9] European Commission, Energy Performance Contracting Campaign (EPCC), 2014. Accessed from: http://ec.europa.eu/energy/efficiency/financing/campaign_en.htm

[10] Sorrell S. The economics of energy service contracts. Energy Policy. 2007;35(1):507–521.

[11] Act no. 321/2014 Coll. on Energy Efficiency and on Amendments to Certain Acts, 2014.

[12] Decree of the Ministry of Economy of the Slovak Republic no. 99/2015 Coll.

[13] Decree of the Ministry of Economy of the Slovak Republic no. 179/2015 Coll.

[14] Ministry of Finance of Slovak Republic, EPC contract template [online]. 2020. [cit. 2020-10-05].

[15] The definition of EPC [online]. [cit. 2020-10-05].

[16] Dahlsveen T., Petráš D. Energetický audit budov [Energy audit of buildings], ISBN 80-88905-85-0, 2005; 167-168.

[17] STN EN 15459-1, Energy performance of building – Economic evaluation procedure for energy systems in building – Part 1: Calculation procedures, Brussels, 2017.

[18] Guide to Cost-Benefit Analysis of Investment Projects, ISBN 978-92-79-34796-2, 2015.

[19] Shang T., Zhang K., Liu P., Chen Z. A review of energy performance contracting business models: Status and recommendation. Sustainable Cities and Society. 2017; 203-210.

[20] Lu Z. J., Shuai S. Impacts of government subsidies on pricing and performance level choice in Energy Performance Contracting: A two-step optimal decision model. Applied Energy. 2016;106.

[21] Lee P., Lam P. T. I., Lee W. L. Risks in energy performance contracting (EPC) projects. Energy and Buildings. 2015,92;116–127.

[22] Lee P., Lam P. T. I., Yik F. W. H., Chan E. H. W. (2013). Probabilistic risk assessment of the energy saving shortfall in energy performance contracting projects-A case study. Energy and Buildings. 2013;66:353–363.

[23] Bertoldi P., Rezessy S. Energy service companies in Europe. Status report. 2005;1–72.

[24] Rezessy S., Dimitrov K., Urge-Vorsatz D., Baruch S. Municipalities and energy efficiency in countries in transition – Review of factors that determine municipal involvement in the markets for energy services and energy efficient equipment, or how to augment the role of municipalities as market players. Energy Policy. 2006,34;223–237.

[25] Xu P. P., Chan E. H. W., Qian Q. K. Success factors of energy performance contracting (EPC) for sustainable building energy efficiency retrofit (BEER) of hotel buildings in China. Energy Policy. 2011,39;7389–7398.

[26] Comparison and Evaluation of Financing Options for Energy Performance Contracting Projects, Graz Energy Agency Ltd. 2008.

[27] Project QualitEE, market research. 2019. [cit. 2020-10-05]

[28] STN EN 15316-1:2017, Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 1: General and Energy performance expression, Brussels, 2017.

[29] STN 73 0540-2, Tepelnotechnické vlastnosti stavebných konštrukcií a budov. Tepelná ochrana budov. Časť 2: Funkčné požiadavky, SÚTN, Bratislava, 2002.

[30] STN EN 15316-2:2017, Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling), Brussels, 2017.

[31] STN EN 15316-3:2017, Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 3: Space distribution systems (DHW, heating and cooling), Brussels, 2017.

[31] STN EN 15316-5:2017, Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 5: Space heating and DHW storage systems (not cooling), Brussels, 2017.

[32] STN EN 15316-4-1:2017, Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space distribution systems: Space heating and DHW generation systems, combustion systems (boilers, biomass), Brussels, 2017.