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Buildings Thermal Retrofit Investement under ESCO Formula - A Case Study from Poland

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Tomasz Łukaszewski[1]

Abstract:

Purpose: *The goal of analyzing investments carried out under the ESCO formula is to determine, implement and apply an optimal set of retrofitting technologies in order to reduce facility's energy costs borne by its public owner, maintain a satisfactory level of building thermal parameters while upholding the economic profitability of the investment for the private partner. The purpose of this article is to show the investment evaluation process, which consists of determining the scope and method of investment undertaken to achieve the goals mentioned above.*
Design/Methodology/Approach: *A case study approach has been used to assess the profitability of building retrofit investment. The research procedure includes: (1) assessing the characteristics of the selected buildings; (2) collecting data; (3) developing retrofit alternatives, (4) evaluating project profitability of the project.*
Findings: *The empirical results show that the monthly costs of energy supply to buildings that would be borne by the municipality in case of realizing term modernization investment in ESCO formula would be lower than the cost of commercial loan taken for the total value of the investment in case the municipality would conduct the thermal retrofit on its own.*
Practical Implications: *Research findings may be relevant for those municipalities in Poland which for some reason, have not decided to improve the technical condition of their buildings on their own.*
Originality/Value: *The empirical results presented in this paper show that thermal modernization of buildings carried out in the ESCO formula can make this investment financially profitable for the private partner while reducing the cost and risks of the public partner.*

Keywords: *ESCO model, economic efficency, energy efficiency, investment appraisal.*

JEL classification: *C13, C22, C53, F31, G11.*

Paper Type: *Research study.*

[1]*Institute of Economics and Finance, University of Szczecin, Poland,*
tomasz.lukaszewski@usz.edu.pl;

1. Introduction

The climate targets adopted by the European Commission as part of the Green Deal policy oblige all EU member states to reduce greenhouse gas emissions by 55% (as compared to 1990), increase the share of renewable energy, and improve energy efficiency. The EU's goal is to achieve climate neutrality by 2050, which is expected to bring a range of tangible economic, social and environmental benefits. Appropriate measures have to be taken in order to increase energy efficiency in various sectors of the economy. The building sector has a particularly significant potential for it. According to researches, buildings are responsible for almost 40% of the EU's final energy consumption and 36% of its greenhouse gas emissions (Ma *et al.,* 2012). Implementing energy-efficient technologies in new facilities and improving existing ones is vital for the savings and the reduction of CO2 emissions, and the potential growth and employment in this sector (Congedo *et al.,* 2016).

Also, in Poland, improving building energy efficiency is one of the most critical challenges of the upcoming energy transition. According to statistics, the number of buildings in Poland exceeds 6 million, of which more than 5.5 million are residential homes. The energy standard of the majority of them is low or even very low, more than 70% of single-family buildings and the same percentage of non-residential buildings, and more than half of multi-family buildings do not have sufficient thermal insulation. At the same time, nearly 70% of the buildings are heated with coal-fired boilers, with almost a third of them being more than ten years old (Europe, 2016). The lack of adequate thermal insulation combined with outdated heating technology results in the annual consumption of over 9 million tons of coal, which, per capita, is the highest figure in the EU and thus contributes to considerable air pollution.

The article addresses the problem of the thermal retrofitting of public buildings. The maintenance of municipal facilities and their renovation and modernization are the statutory responsibilities of local authorities, which are also responsible for the creation of local energy policies to ensure the optimal use of resources and saving money. According to the report published by the Central Statistical Office containing the results of 2007-2013 surveys, out of more than 6000 public buildings (including almost 4000 belonging to municipalities), the vast majority (over 90%) were constructed before 2000 using the large-panel system, which has low energy efficiency (GUS, 2015). The same study showed that more than 65% of public administration buildings had undergone some modernization. The scope of modernization included: replacement of electrical equipment (55.4%), insulation (22.3%), replacement of woodwork (22.2%), as well as modernization of ventilation (5.5%) and air conditioning systems (2.7%).

According to another estimate, between 2006 and 2013, more than 60,000 non-residential buildings in Poland (this category also includes administrative buildings) underwent thermal upgrading, but in more than 70% of cases, this was limited to upgrading or replacing the heat source (Europe, 2016). Money spent on low-emission investments by municipalities and local governments in 2014-2019 amounted to PLN 9.5 billion. Approximately 80% of this amount was spent on projects improving energy efficiency in buildings, with the rest spent on replacing energy generation sources. The financial resources for these purposes came both from public and private sources. The analysis of the financing structure of retrofitting investments carried out in 2006-2019 shows that the primary sources of financing were European funds, which accounted for more than 60% of the value of completed works (WiseEuropa, NewClimate Institute, I4CE - Institute for Climate Economics, 2020).

The figures quoted indicate that many municipalities have not decided to carry out thermal modernization of their buildings, despite being aware of their unsatisfactory condition and having a possibility to apply for funds for this purpose. The following reasons were mentioned:

- Lack of own funds - the municipality has to obtain debt financing for the whole amount of the investment, as the costs are reimbursed only several months after the project has been implemented and only if the costs are deemed eligible. Moreover, the grant amount does not cover all expenses, the municipality is obliged to contribute, which may be a problem in the case of municipalities already in debt.
- Lack of competence and knowledge in obtaining, implementing, and accounting for external funds combined with complicated procedures for EU funds. This problem concerns mainly tiny municipalities that do not have competent administrative staff.
- Unwillingness to take political, legal, technical, and organizational risks associated with implementing investments financed by external funds.
- Simultaneous involvement in the implementation of multiple infrastructural projects, requiring choosing between them.
- The need to adopt a Low-Emission Management Plan, prepare energy audits of buildings, enter planned investments into long-term financial forecasts.

An alternative solution for municipalities is to implement infrastructural projects through the ESCO model. ESCO (Energy Service Company) is a particular type of public-private partnership (PPP) in the form of an agreement between a private partner (ESCO company) and a public partner (municipality) in which the private entity invests its financial resources in the municipality's assets by implementing solutions that reduce energy consumption and energy production costs in its properties. The investment is paid back through savings made on energy sources such as hot water, heating, steam, electricity, technological process, lighting, etc., (The European PPP Expertise Centre (EPEC), 2018). Signing an ESCO contract is preceded by carrying out an investment evaluation process, which includes analyzing the technical condition of buildings and current costs. The audit indicates proposed technical and organizational solutions, presents related estimated investment expenditures and the expected cost reduction, and also determines the profitability of each planned modernization and the entire project.

Given the scale of thermal retrofit needs reported by public entities and the reasons for not deciding to implement thermal investments on their own, the following question can be asked: is the ESCO model a natural alternative for municipalities that have not undertaken such actions far? The article attempts to answer this question by comparing the benefits of implementing a project under the ESCO formula (associated additional costs that a municipality must incur) to carry it out with the municipality's funds. By conducting a case study of a natural thermal retrofitting project proposal for a small municipality in central Poland, this article empirically compares the economic effects of an investment performed under the ESCO formula with standard financing using the municipality's own money and bank loan.

2. Research Methodology

Companies select investment opportunities and choose from those that ensure a rate of return higher than the threshold at an acceptable risk level. The article characterizes the pre-investment process carried out by ESCO companies, consisting of finding and evaluating potential projects. The purpose of this process is to assess the feasibility and economic efficiency of the investment at hand, and the result obtained serves as the basis for a decision to (or not to) join the tender procedure. The process model consists of four stages, each of which is carried out using specific tasks, using data from various sources (Thewes *et al.*, 2014; Ma *et al.*, 2012). Its conclusions are the basis for the business decision whether to proceed to call for tenders and determine the terms of the offer (Figure 1).

The pre-investment process consists of four stages. The first stage is to verify the investment preconditions. The company only undertakes projects for which it is possible to obtain financing from external funds. As funds from Regional Operations Programs are distributed to regions, only those in which calls for tenders were organized can be the subject of the company's activities. The next step is selecting municipalities and counties: surveys are conducted to exclude entities that do not have the needs in terms of thermal modernization of their buildings. The final step is to arrange an information meeting, during which the local government agrees to conduct an assessment of its facilities. The second phase is collecting the necessary data. The activities performed at this stage consist mainly of an on-site inventory of buildings and data acquisition on energy consumption and costs.

The third phase is to analyze the current state of the facilities, assess the potential for improvement, and propose technological solutions that will allow using of this potential. This stage includes identifying the elements most responsible for the poor thermal condition of individual buildings. For each of them, alternative technological solutions are evaluated with the help of models for assessing the energy efficiency, which allows determining possible energy savings depending on set input parameters. Then, after selecting acceptable alternatives, thermal modernization options are chosen, which have the most favorable ratio of possible benefits compared to the amount of expenditure. The last stage is the effectiveness analysis of the selected technological solution for various values of selected parameters of the financial model, such as the share of own funds in financing the investment, the duration of the contract, or distribution of savings between the parties of the ESCO contract.

Figure 1. *Process for assessing investment opportunities*

Stage	Verification of pre-conditions	Data acquisition	Analysis and development of technical solutions	Assessment of project efficiency
Activities	• Region selection • Municipality selection • Authority approval	• On-site buildings inventory • Collect energy consumption and cost data	• Performed energy consumption analysis, • Development of technical solution • Energy savings estimations	• Performance of ROI calculations • Decision to join the tender procedure
Data	• Terms and conditions of the announced ROP • List of buildings to be retrofitted • Adopted Low Carbon Economy Plan	• Energy, heating, water bills • Services and repairs invoices • Maintenance costs	• Specification of building retrofit technologies • Materials and workforce cost estimates • Model of building energy efficiency	• Expected financial performance • Financial model data • Macroeconomic factors
Source	• Calls for proposals for ROP • Municipality website	• Acquired from the accounting department of the municipality	• Manufacturers data • Studies and expert opinions • Own calculations	• Own calculations • Banking and financial data

Source: *Own creation.*

Data from multiple sources are used in the evaluation process. To verify the initial investment conditions, publicly available data on the number of funds allocated to thermal modernization activities and the dates and principles of their distribution are used. Data on tenders announced by municipalities are also analyzed; it is checked whether the municipality has adopted Low Carbon Economic Plan and its provisions. When preparing the characteristics of facilities, construction designs, building logbooks, and on-site inventories are used. Data on energy consumption and costs are obtained from invoices and bills for heating fuel, electricity, and water obtained from the municipal accounting department. The accounting systems also provide information on the costs of servicing, repairs, and maintenance of heating devices in the facilities. Technical data necessary to develop a method of thermal modernization (such as equipment parameters, efficiency, tariffs, calorific values for various sources, insulation coefficients of building envelopes, etc.) are generally available. They are calculated by or collected from manufacturers and available studies and expert opinions. Data on the degree days or solar radiation energy use efficiency come from the nearest weather station. Data used for making financial models depends on funding conditions and the ESCO company's internal knowledge.

3. Results and Discussions

3.1 Preconditions

An ESCO company is considering thermal modernization of public facilities belonging to a municipality in central Poland. The verification of preconditions showed the following:

- The region in which the municipality is located is covered by the EU program dedicated to improving the energy efficiency of buildings in the public sector, which will allow the company to apply for funds.
- The municipality has no major heating plants which would cover large groups of buildings or institutions. Most administrative and school buildings use coal-fired boiler houses, while a few have fuel oil heat sources. In the coming years, a steady increase in energy consumption is predicted.
- The municipality has adopted a Low Emission Management Plan, which aims to reduce energy consumption by increasing the number of public buildings undergoing thermal modernization, improving existing heating systems, implementing technologies using renewable energy sources, and replacing lighting systems in public buildings energy-efficient ones.
- Municipality authorities are open to cooperation in modernizing public utility buildings, but the decision to sign the contracts depends on the results of the project’s economic assessment.Building verification

After the identification and pre-evaluation of the municipal infrastructure, three buildings were selected for modernization: Municipal Office with adjacent boiler house, Social Welfare Centre building, and School Complex. The following paragraphs present the characteristics of the selected buildings, based on available documents and the inventory.

Municipal Office Building: The two-story administrative building built in the 1990s, with a cubic capacity of 2100 m3 and a usable area of 540 m2, is covered with an attic roof. The walls and roof are not insulated. Old type PVC windows have a total area of 110 m2. The building is heated by a handmade coal boiler located in a boiler room adjacent to the building and used as a fuel storage facility. Moreover, the building has additional separate premises used as subsidized housing and commercial premises. These premises have no heat meters, and their heating costs are calculated proportionally to their cubic capacity. Cast iron radiators are inside the building.

Social Welfare Centre (GOPS) building: The Social Welfare Centre is located on the ground floor of a detached building from the 1960s; there is a subsidized housing unit on the first floor. The cubature of the GOPS building is 500 m3, with an area of 150 m2. The building is covered with an uninsulated roof with an area of 140 m2. The window area is 16 m2. The building is heated from the same boiler room as the Community Office and has no heat meters. The cost of heating is calculated proportionately to its cubic capacity.

School Complex: The School Complex consists of three independent buildings joined by connectors, which have been used in recent years as an elementary school, a junior high school (gymnasium), and a sports hall. The oldest building was built in the 1960s; the other two were built at the beginning of the 21st century. They were built using hybrid technology; each of them has a basement. A school complex is a two-story object. Its total cubature is 33,000 m3, and the total heated area is 6625 m2. External walls are made of three layers with a 5-cm foamed polystyrene insert. In the walls of the buildings, there are over 280 PVC windows, with a total area of about 780 m2. A large part of the sports hall walls is made of glass, which - according to the headteacher - significantly increases heating costs. The buildings are covered with a ventilated roof with a total area of almost 4,000 m2; the roof above the sports hall is insulated with pre-cellular panels, while the remaining part is uninsulated and covered with a bituminous waterproofing system. Heat is supplied to the facility from a boiler room and comes from two oil-fired boilers manufactured in 1998, with a total capacity of 300 kW. The general technical condition of the buildings in terms of construction is good. The condition of the building envelope is also good. The main concerns are the technical condition and efficiency of the heat source and the economic viability of the technological solution consisting of supplying heat to three large buildings from one source, thermal insulation of windows and ceilings, and old, energy-consuming interior lighting systems.

Receipts, statements, invoices, and bills for coal, heating oil, electricity, and utility costs for the last 12 months before the time of analysis were obtained from the Municipality. The collected data were input into the model and processed in order to estimate total energy consumption. The results per building and per type of energy consumed are shown in Table 1.

Table 1. *Final energy consumption in municipal facilities*

	Facility	Total energy consumption before retrofitting kWh/year			**Total**
		Central heating	Heated water	Electricity	
1	Municipal Office	299 650	1 651	11 960	**313 260**
2	Social Welfare Centre	95 046	371	234	**95 652**

3	School Complex	561 787	65 897	69 440	**697 124**
	Total	956 483	67 919	81 634	**1 106 036**

Source: *Own creation.*

The data presented in Table 1 indicate that the largest share in the structure of final energy consumption is heating, with the highest amount of energy consumed by the School Complex. Excessive energy consumption causes high maintenance costs of the analyzed buildings. The municipality spends over PLN300,000 per year, most of which (over 70%) on heating. The results presented in Table 2 are not surprising, considering the size of the heated area of the School Complex, the type of fuel used for heating, the lack of insulation of walls and roofs, and the large-surface glass walls in the sports hall. The data presented indicates that there is considerable potential for thermal upgrades in the municipality.

Table 2. *Annual cost of energy consumption in municipal facilities.*

	Facility	Annual cost of energy (PLN/year)			**Total**
		Central heating	Heated water	Electric Energy	
1	Municipal Office	62 836	794	14 381	**78 011**
2	Social Welfare Centre	31 286	223	587	**32 095**
3	School Complex	125 876	19 427	49 101	**194 404**
	Total	219 998	20 444	64 069	**304 511**

Source: *Own creation.*

The analysis aims to find solutions that reduce energy consumption and operating costs for each building while ensuring their proper performance parameters (temperature, amount of light). The range of possible modifications includes several different measures, e.g., insulating building envelopes, replacing or modernizing the heating system, installing renewable energy supply systems, replacing lighting systems, etc. Moreover, for each variant, several technically feasible retrofit alternatives differ in terms of performance, maintenance costs, the capital investment required, and that offer different amounts of potential savings. Therefore an energy-efficiency model had to be applied to select the optimal combination of technologies for each building.

The resulting analysis leads to the following conclusions:

- The power of the current heating boilers is oversized about the needs, and their efficiency is low. Therefore they should be replaced. When choosing new heat sources, it must be considered that the energy demand will be significantly lower after modernization. After comparing the alternatives, electric ground/water heat pumps were considered the best heat supply technology. To increase the system's efficiency, the proposed solution has been complemented with an energy management system.

- It is proposed to install photovoltaic panels to supply the heat pump, the power of which should be adjusted to the increased demand in the future.
- External walls in administration buildings should be insulated with an 18 cm layer of EPS foamed polystyrene, and the flat roofs over the Municipality Office and School Complex buildings - with 20 cm granulate layer.
- Insulating the walls of the School Complex building, was deemed uneconomical. For the same reasons, the idea of replacing door frames and insulating basement ceilings was also abandoned.
- In all analyzed buildings, windows should be replaced with energy-efficient ones; the changes concern only some of the windows in the School Complex.
- In all buildings, it is proposed to change the lighting fixtures to 12W and 15W LED lamps.

The detailed scope of the proposed retrofits for each building is presented in Table 3.

Table 3. *Scope of proposed retrofits in municipal facilities*

Scope	**Technology**	**Municipal Office**	**Social Welfare Centre**	**School Complex**
Heat source	Electric ground/water heat pumps	**40 kW**	**1,7 kW**	**82 kW**
		Implementation of an EMS		
Electricity	Installation of photovoltaic panels	**40 kW**	**10 kW**	**120 kW**
Insulation	Walls with 18 cm EPS foamed polystyrene layer	**452 m^2**	**170 m^2**	-
	Flat roofs with 20 cm granulate layer	**345 m^2**	-	**3170 m^2**
Windows	Replacement of windows	**113 m^2**	**16 m^2**	**210 m^2**
Lighting	Replacement of the lighting fixtures with 12W and 15W LED lamps	**26**	**12**	**591**

Source: *Own creation.*

For each of the facilities the expenditures were calculated as following:

- Municipal Office - PLN543,927.00
- Social Welfare Centre - PLN194,903.00
- School Complex - PLN1,460,673.00

The total estimated cost of the investment amounts to PLN2,199,502.00. Once all technical and economic parameters have been identified, economically optimal choices can be determined by comparing the investment expenditures with expected cost savings from energy conservation using standard engineering economics methods.

3.2 Assessment of Project Efficiency

In order to assess the profitability of a project, expected revenues need to be estimated. In the case of retrofit investments, profits result from the reduction in total energy consumption and service costs. Using the efficiency model, the expected energy consumption and the amount of potential savings were determined. The results are presented in Table 4 for each building separately.

Table 4. *Estimated energy savings after retrofits in municipal facilities*

	Facility	Final energy after retrofitting kWh/year			Savings of final energy kWh/year			**Total**
		C.H.	H.W.D	Electricity	C.H.	H.W.D	Electricity	
1	Municipal Office	12 277	1 651	6 643	287 373	0	5 317	**292 690**
2	Social Welfare	2 538	371	144	92 509	0	90	**92 599**
3	School Complex	52 971	15 723	41 753	508 816	50 174	27 687	**586 677**
	Total	67 785	17 745	48 540	888 698	50 174	33 094	**971 965**

Source: *Own creation.*

The expected reduction in total energy consumption and operating costs as a result of the thermal retrofit should result in financial savings. Estimated values are presented in Table 5.

Table 5. *Estimated cost savings after retrofits in municipal facilities*

	Facility	Energy costs after retrofitting PLN/year			Saving of cost PLN/year			**Total**
		C.H.	H.W.D	Electricity	C.H.	H.W.D	Electricity	
1	Municipal Office	4 226	246	3 420	58 610	548	10 961	**70 120**
2	Social Welfare	2 589	28	181	28 697	195	406	**29 298**
3	School Complex	15 274	2 753	10 577	110 602	16 674	38 524	**165 800**
	Total	22 089	3 026	14 178	197 909	17 418	49 891	**265 218**
		39 292			**265 218**			

Source: *Own creation.*

The following additional assumptions were used to determine economic efficiency:

- CPI: 2%
- VAT rate: 23%
- CapEx is financed in 25% by equity, in 25% by debt and in 50% by subsidy
- Loan margin: 6%
- Applied cost of capital: 8%
- Investment period: 10 years.

Given the expected values of savings, financial expenditures and assumptions listed above, a preliminary evaluation of the investment efficiency was carried out. Calculations are presented in Table 6.

Table 6. *Estimated savings after retrofits in municipal facilities*

Facilities		Investment [net PLN]	Equity [net PLN]	NPV [net PLN]	IRR of Equity	EE
1	Municipal Office	543 927	135 982	160 850 zł	30,99%	93,43%
2	Social Welfare	194 903	48 726	73 791 zł	36,67%	96,81%
3	School Complex	1 460 673	365 168	252 496 zł	22,15%	84,15%
	Total	**PLN2 199 502**	**549 876**	**487 137**	**29,94%**	**91,47%**

Source: *Own creation.*

The implementation of thermal modernization works in the scope proposed by the ESCO company would cost PLN2,199,502 and reduce the buildings' energy costs to PLN39,292 per year. The investment NPV for those parameters over ten years would be PLN549,876. Considering that the project would be financed in 25% from the municipality's resources, this would give an IRR for equity of 29.94%. The average EE value for the buildings exceeds 90%, which means that the project has met the conditions for obtaining a subsidy from the EU.

Having calculated the level of the investment profitability, the ESCO company presents the municipality with a proposal in which they evaluate the price of their services and proposed share of savings. The offer is based on the current energy cost in the analyzed buildings, which amounts to PLN304,511 per year, which is the average monthly cost of PLN25,376. After the modernization, the annual maintenance costs of the buildings would be PLN250,510, which means a reduction of ca. PLN54,000 in comparison with the previous year.

The presented costs would be the sum of fixed monthly payments of PLN20,876, which is the price for the service of the ESCO company. The service would include designing, preparing, and implementing the thermal retrofit and supplying and managing energy in the buildings for ten years. After that period, the buildings would be managed again by the municipality.

In order to check whether the offer is attractive for the municipality, a simulation was prepared. Monthly costs incurred if the investment was performed under the ESCO formula were compared with the financial costs of the commercial loan taken for the investment by the municipality itself. Two variants were analyzed. In the first one, the municipality finances the investment fully from the loan, and in the second, the share of the loan financing is 50%. The simulation results are presented in Table 7.

Table 7 *Comparison of building maintenance costs by investment financing method.*

Source of financing	Investment	Energy cost after retrofit	Annual loan cost	Total cost for the municipality	
				annually	**monthly**
Loan for 100% of investment value	2 199 502	39 292	283 632	**322 924**	**26 910**
Loan for 50% of investment value	2 199 502	39 292	141 816	**181 108**	**15 092**
ESCO services	2 199 502	39 292	-	**250 510**	**20 876**

Source: *Own creation.*

4. Results and Discussion

The presented results indicate that the cost to be borne by the municipality, which has decided to invest using the ESCO formula, falls between the two presented variants of taking a loan. Therefore, it can be concluded that the ESCO formula is an attractive alternative for public entities. At the same time, it should be noted that for many municipalities, an expenditure of PLN2.2 million does not constitute a significant burden on their budget, and they can carry out works with their funds. In this case, it should be remembered that the ESCO contract allows public entities to avoid several risks: The municipality does not bear the costs of obtaining and servicing the loan, nor does it have to secure it, for example, on real estate. An additional advantage is the fact that the costs connected with investment service can be qualified as operational costs and thus the municipality does not increase its debt.

- Comprehensive investment by one partner means that the municipality does not bear technical risks connected with the investment process. At all stages, the municipality cooperates with one entity interested in the proper execution of works.
- Funds from the municipality's budget may be allocated for the implementation of other activities.
- The scope of investment and applied technologies are selected to achieve optimum effects in the long term, and the private partner ensures that the objects are maintained in good condition for the duration of the agreement.
- Mitigated risk of failure to meet project objectives declared in the grant application.

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