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Implementations of energy performance contracts in the energy service market of Turkey

Hande Nur Akkoç, Sermin Onaygil *, Ebru Acuner, Rabia Cin

Istanbul Technical University, Department of Energy Science and Technology, Ayazaga Campus, 34469, Maslak, Istanbul, Turkey

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ABSTRACT

Energy performance contracts (EPC) are important tools to spread energy efficiency (EE) applications in the energy service market of countries, encourage large-scale projects by overcoming the risk on the customer side, and provide financing on the projects implemented by energy service companies. This study aims to analyze the level of market participant knowledge, present the experiences of EE projects with and without the utilization of EPCs, evaluate the main market barriers, and draw policy recommendations for the expansion of the market in Turkey. For this purpose, an online survey was conducted on energy service company representatives, facility workers, and independent energy managers. The Chi-Square (χ^2) test, which is preferred in the analysis of non-parametric and qualitative data, was used in the statistical evaluation of the answers. Survey results show that there are no significant associations observed between projects with and without using EPC. Results show that EPC applications in Turkey do not meet certain EPC requirements. The study revealed that obtaining financing is the most difficult stage for both projects. For the correct and widespread implementation of EPCs in Turkey, there is still a need for more development including improving sector coverage, stakeholders' knowledge, and market conditions.

Introduction

Efficient use of energy is a critical issue in our age. Considering the increasing energy demand, limited energy resources, and climate change, energy efficiency (EE) is not a choice but a necessity. With the Sustainable Development Goals (SDGs) in 2015, the Paris Agreement that entered into force in 2016, and European Green Deal in 2019, EE issues gained more importance and awareness in society.

In the EE market, one of the most important players are Energy Service Companies (ESCOs), which are real/legal entities that accept a certain degree of financial risk while providing energy services and guaranteed efficiency improvements. In Turkey, the term "Energy Efficiency Consulting Company" (Enerji Verimliliği Danışmanlık Şirketi - EVD) is used for representing. ESCO. However, EVDs do not fully meet the ESCO standards, especially in size, capacity, and financial aspects. In the study, the term ESCO will be used for the world, and the term EVD for Turkey.

In an ideal energy service market, potential customers are familiar with the concept of an ESCO, and training is available to facilitate customer decision-making. The ideal market is demand-driven, transaction costs are low, and there are advanced and viable contract alternatives. Government policies are supportive and ESCOs and customers have access to grants and financing. ESCOs establish a long-term partnership based on mutual trust and conclude contracts, i.e., Energy Performance Contracts (EPCs), for guaranteeing the energy-saving and also financing, if it is desired. The fact that countries have different trade laws and this has led to the emergence of various alternatives for EPCs. However, Guaranteed and Shared Energy Saving Contracts are the ones with the highest familiarity (Carbonara & Pellegrino, 2018). Moreover, there are various contract types such as Build-Operate-Transfer, Leasing, Chauffage, First-In, and First-Out. There are also Energy Supply Contracts (ESCs) used by ESCOs as an alternative to EPCs (Backlund & Eidenskog, 2013; Bertoldi & Boza-Kiss, 2017; Kostka & Shin, 2013; Qin et al., 2017). But in all those contracts, ESCOs improve the customer's EE, presume most of the investment risk, and the customer does not need to have more technical knowledge.

The energy service market, which has developed in Turkey since 2009, continues to grow and has not reached its full potential. Besides the market, EPCs are much newer and the number of applications is less. With the increase in EPC applications in Turkey, it may be easier for

* Corresponding author.
E-mail address: onaygil@itu.edu.tr (S. Onaygil).

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EVDs to reach ESCO standards, the development and growth of the energy service market, and eventually it may be easier to reach an ideal energy service market. Therefore, the research question of this study is what are the current usage, obstacles, and future potential EPC in the Turkish energy service market. This study first aims to provide an overview of the Turkish energy service market and investigate the energy efficiency knowledge and awareness of the market participants. Secondly, it is aimed to analyze energy efficiency project experiences according to EPC usage. The final purpose of this study is that investigate the approach of the market participant to the EPC.

An online survey was prepared to target three different groups that are EVD representatives, independent energy managers, and facility workers (facility/factory/business/organization energy managers). By legislation, industrial facilities consuming 1000 toe/annual and more energy and commercial and service buildings consuming 500 toe/annual and more energy are required to have an energy manager. Therefore, the energy managers of these facilities are responsible for EE studies. On the other hand, facilities, do not have an obligation to hire energy managers and have different titled employees deal with EE studies. In this study, "facility workers" represent the customer side inclusively.

While each group's questions are mostly identical, certain questions are special to some groups as well. In the survey, there are questions to categorize the participants, assess awareness, query the participants' experience with EE and EPC projects, investigate the implementation challenges, and participants' EPC approach.

To evaluate the survey results descriptive statistics and the Chi-Square (χ^2) test were used. Firstly, the survey answers were summarized and presented visually. Then, it was tested whether there is a statistically significant association between the practices carried out during the project and the type of contract (with or without EPC) used with the Chi-Square test.

This study is the first academic publication investigating EPC applications in Turkey and contributed to the literature by providing an overview of a local energy service market with real applications, analyzing differences in the perspectives of different implementors and contract types in the market, identifying challenges and needs, and making recommendations on how to improve the market and EPC applications in Turkey. The results of this study will show the current situation of the Turkish energy service market and its applications to market participants, policymakers, and researchers. It will also set an example for countries similar to Turkey.

Accordingly, the rest of the study is structured as follows: the second section provides an overview of Turkey's EPC legislation, and the third section describes the methodology. The study's fourth section looks at the survey results, and its fifth section discusses them. Finally, the conclusion and final remarks are given in the sixth section.

Energy performance contracting in Turkey

In the Turkish energy service market, there are two important key players, namely energy managers and energy efficiency consulting companies (EVDs), concerning EPC applications. The General Directorate of Energy Efficiency and Environment (EVCED), under the Ministry of Energy and Natural Resources, is the responsible public institution to carry out studies regarding energy managers, EVDs, and EPCs.

Energy managers are certified by EVCED as well as chambers of engineers and EVDs, authorized by EVCED. Industrial enterprises with an energy consumption of 1000 tone oil equivalent (toe) and above, and commercial buildings, service buildings, and public sector buildings with a total construction area of at least twenty thousand square meters or an annual energy consumption of 500 toe or more must assign energy managers to carry out energy management activities. In addition, these responsible industrial enterprises and buildings must submit the requested energy efficiency-related information to EVCED every year until the end of March, with the format which is determined by EVCED.

In the EVCED database, there are over 10,000 experts who got energy manager certificates. On the other hand, according to the information taken from the responsible director of EVCED only 2000 of them are active in the market currently.

The second important players are EVDs (Turkish ESCOs). They are certified by EVCED and authorized institutions (chambers of engineers, universities) to carry out energy efficiency services, within the framework of the authorization agreement. A five-year authorization certificate is given to an EVD company to operate in the industry and/or building and services sectors. In the current market, there are 56 EVD companies of which 23 of them work for buildings, 11 for industries, and 22 of them serve both. For more information about the Turkish energy service market, see https://doi.org/10.1007/s12053-021-09973-w.

EPC, as a financial tool for energy managers and EVDs acting in the energy service market, is defined in Turkey with Energy Efficiency Law No. 5627 as "a contract based on the principle of guaranteeing the energy-savings to be achieved after the implementation project and paying the expenditures with the savings that will occur as a result of the implementation" (Republic of Turkey, 2007). In other words, Turkish ESCOs (EVDs) become a partner in the project risk by guaranteeing a certain energy-saving to its customer at the beginning of the project. Since the EVD payments are made based on savings, it puts less strain on the customer financially.

It is crucial to legally define the concept of the EPC to be recognized and understood by all stakeholders. After stating as a policy, to develop a strategy to push the applications in the market, the National Energy Efficiency Action Plan (NEEAP) of Turkey determined actions on a sectoral basis to achieve the cumulative 23.9 Mtoe reduction target in Turkey's primary energy consumption in the 2017–2023 period (Republic of Turkey, 2018). The 4th action of the NEEAP under "Horizontal Issues" is about guiding EE projects in terms of technical, legal, and financial issues, and type of contracts and aims to encourage EPCs to standardize ESCO activities, strengthen the financing side, increase the quality of service they provide, and facilitate easier financing and dissemination of EE services. Additionally, under the "Building and Services Sector Issues", the 10th one titled improving energy performance in existing public buildings is aimed to realize the legal regulations that will allow public buildings to make long-term contracts, establish a standard contract structure for EPC, increase the technical and financial capacities of EVDs, and to establish a control and verification mechanism. Furthermore, within the scope of "Increasing Energy Efficiency in General Lighting", action 7 is aimed to encourage the application of EPCs, as well. It is worth mentioning that these strategies just attempt to improve the market by means of EPC applications and the NEEAP is not legally binding.

Besides the NEEAP, legally binding EPC-related legislations have been published. For example, in Presidential Decree No. 1, published in the Official Journal (OJ) dated 10 July 2018 and numbered 30474, the task of "providing consultancy and technical support for the realization of EE investments, including energy performance contracts" is specified (Presidency of Turkey, 2018). Moreover, the Presidential Decision No. 2850 published in the OJ No. 31220 dated August 21, 2020, the procedures and principles regarding the EPC to be executed by public institutions and organizations are indicated (Presidency of Turkey, 2020). Although it is based on the EE Law, some new definitions are also included in this decision. One of them is the standards that the savings verification report to be carried out during the monitoring of the project, which starts from the date of acceptance of the project and continues throughout the contract period. This report will be prepared by the contractor that implements the EE measures in line with the contract signed with the public administration. Communiqué on the public sector implementation of energy performance contracts, which entered into force in the Official Gazette No. 31455 on April 2021, aims to explain the procedures and principles regarding the EPCs to be made by public institutions in detail (Presidency of Turkey, 2021). Additionally,

Communiqué on the implementation of energy performance contracts in the public sector entered into force by the OJ dated April 15, 2021, and numbered 31455. These legislations are very important for Turkey and the market since the public buildings are open to the private sector to evaluate the existing energy-saving potential and to provide best practices by clarifying numerous technical, financial, procedural, and legal issues to be addressed on the public sector EPCs.

Although these stated legislations and strategies aim to direct the energy service market with the help of EVD activities and specifically through EPC projects. In the current situation, EVDs in the market are not at the desired level in terms of capacity and creditability to apply EPC in their implementation projects. In addition, the EPC concept could not be well understood especially by the customers and financing institutions due to the lack of best practices. As a result, it is crucial to reflect the legislation in practice. This study will give an analysis of the current situation of the market from market participant's points of view in order to pave good examples targeted by legislation.

Methodology

This section explains the survey's preparation stage with the use of literature references and provides information on the survey's analysis method.

Preparation stage of the survey

Survey studies are crucial tools for understanding the issues in the EPC sector and developing recommendations for improvement. For preparing the appropriate EPC survey for Turkey, firstly, relevant studies in the literature were examined in detail. With a survey, Vine (2005) revealed the market situation for ESCOs in terms of various countries and identified the country-specific barriers to ESCO development. He argued that actions like standardizing contracts and measurement systems, raising awareness, developing a third-party financing network and an ESCO accreditation system, and realizing promotion were necessary (Vine, 2005). By interviewing 63 companies that use EPC, Goldman et al. (2005) collected data on the annual number of projects, revenue, products, and services for each ESCO. They noted that one of the reasons why EPC projects are typically larger projects may be that the customer wants to share this risk with the ESCO as the risk increases. Moreover, their research indicates that the typical 10-year project duration for EPC projects is beginning to shrink. Although corporate firms typically use longer EPC periods, they claimed that the private sector requested shorter repayment periods because of challenges like the high-interest rates. They claimed that one of the most significant reasons for the inefficiency of ESCOs in implementing EPC is the expectation of the return of the private sector in the short term, and they emphasized that businesses typically concentrate on offering EPCs to larger clients (Goldman et al., 2005). Lee et al. (2015) conducted a survey to identify potential risks in the life cycle of EPC projects, analyze the risk distribution of EPCs from the ESCOs' viewpoint, and investigate the concerns of parties regarding the EPC implementation. They argued the distrust of measurement systems, an increase in installation costs, and payment default after installation are the three main risk factors in their projects. The long payback period, the intricate nature of the contract, the inability of energy service providers to deliver on their savings promises, and issues with third-party financing companies were found to be the primary concerns for building owners (Lee et al., 2015). The market for ESCOs was examined by Pätäri et al. (2016) using a Delphi study with panelists to determine its drivers and constraints. Results indicate that potential customers still have a limited understanding of energy service providers. The panelists also identified the economic climate and high transaction costs relative to potential savings as challenges, but they also saw active information sharing as a factor supporting the work of ESCOs (Pätäri et al., 2016). Garbuzova-Schlifter and Madlener (2016) conducted a survey to investigate the main risk factors and causes associated with EPCs in Russia. They concluded that sector-specific contracts for EPC projects are necessary after concluding that there is no suitable risk management approach in EPC projects and that the project risks are mostly regulatory and financial (Garbuzova-Schlifter & Madlener, 2016). Deng et al. (2017) prepared a survey targeting EE experts, policymakers, and ESCO managers. As a result of the survey conducted with a small pilot group, indicators were determined and these indicators were shared with the entire test group. Determined measures as a result of the study are standardization of contracts, the establishment of an energy-saving certification system, supporting EE innovations, providing awareness-raising training to the personnel performing the applications about EE and ESCOs, determining energy prices in a way that supports efficiency needs, and ensuring a better understanding of EPCs (Deng et al., 2017). Bertoldi and Boza-Kiss (2017) examined the European energy service market through surveys carried out regularly by The European Commission Joint Research Centre and stated that the driving forces of the ESCO market are similar in different countries, but the obstacles differ. They also presented policy recommendations for the development of the ESCO market and identified the characteristics to be found in an advanced market. According to their study, the concept of an ESCO in a developed energy service market is known and understood by potential customers; the market is demand-driven, there are advanced and viable contract alternatives; transaction costs are low, access to grants and finance is available; government policy is supportive rather than obstructive, training are available to facilitate customers' decision making (Bertoldi & Boza-Kiss, 2017). Jiang and Zhao (2021) investigated the key factors for building trust and its effects on development of the EPC from the perspective of ESCOs with a survey. At the end, they revealed that competence, honesty, communication and a transparent contract have positive effects on mutual trust (Jiang & Zhao, 2021).

For this study, the infrastructure for the EPC survey was prepared by examining the literature. Afterward, the prepared infrastructure was improved by taking the sector stakeholders' opinions, and the EPC survey was finalized. Three different participant groups were targeted in the survey facility workers (facility/factory/business/organization energy managers), ESCO representatives, and independent energy managers. The final group will be briefly referred to as “facility workers” in the following sections.

The survey consists of four parts (Fig. 1). In the first part, there are questions to evaluate the respondent's experience. The second part aims to demonstrate the respondent's level of awareness and practices regarding EVDs, EPCs, and EE supports in Turkey. In the third part, to analyze the project experience, the respondents were asked whether they had been involved in an EE implementation project before, and with this question, the diffraction of the survey began in different directions. The respondents, who answered “No” to this question and stated that they had not been involved in the EE implementation project before, continued directly from the fourth section. Respondents who answered “Yes” were asked questions about their experiences in EE implementation projects by continuing to the third part. The EPC experience is another diffraction point of the survey. While the EPC experiences of the respondents who implement EPC were questioned, the EE project experiences of the respondents who stated that they did not use EPC were examined. In the fourth part, which is the final part of the survey, the respondents were asked whether they would prefer to use EPC in future projects and they were asked to evaluate the factors affecting their decisions on a five-point Likert scale.

Data collection

On the Ministry of Energy and Natural Resources website, all authorized EVD's information is publicly available. There is also the Energy Efficiency and Management Association (EYODER) in Turkey and some of the EVDs and energy managers working independently or in a facility are registered to EYODER. We sent the survey to all authorized

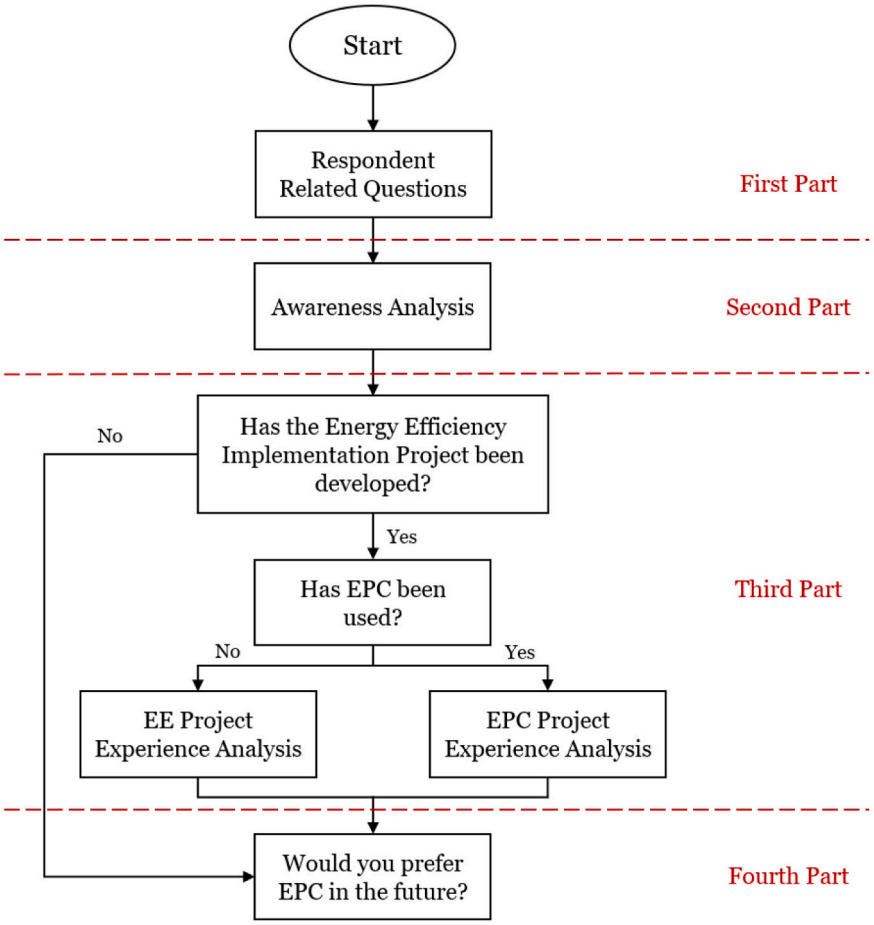


Fig. 1. The structure of the survey.

EVDs in Turkey and EYODER via email. EYODER forwarded the survey to all their members via mass e-mail. When the online survey was sent to EVDs, they were kindly asked to share the survey with their customer base. Survey responses were accepted between February and April 2021. During this period, reminder emails were sent every two weeks.

It takes 10–15 min to answer the survey. All participants were informed that the survey results would be used anonymously for academic purposes. No personal data or tracking information was obtained from any participant in the online survey. We tried to make the survey reach as wide an audience as possible. Answering the survey was completely voluntary, at the end of three months, a total of 123 responses were obtained. One of the respondents submitted the survey twice within seconds. This was detected thanks to displaying the online survey response date and time data, and the duplicate response was excluded from the analysis. In the survey, it is obligatory to answer all the questions except the project budget question. Thus, the validity of the survey responses was not impaired due to the missing answers. Finally, analysis was done with 122 valid responses.

Analysis stage of the survey

While analyzing the survey results, first of all, descriptive statistics were used to summarize and visualize the answers. Then, it was investigated whether there is a statistically significant association between the practices carried out during the project and the type of contract used. The Chi-Square (χ^2) test, which is used in the analysis of non-parametric and qualitative data, was employed to analyze the survey.

The Chi-Square test is based on determining whether the difference between the observed and expected frequencies is significant. It compares the frequencies observed in certain categories to the frequencies that might be expected in those categories by chance. Chi-square tests can be used for three different purposes: the test of fit, the test of homogeneity, and the test of independence. To ascertain whether one categorical variable is related to another (H_0 and H_1), the Chi-Square independence test is utilized.

H_0. Variables are independent (there is no association between variables).

H_1. The variables are not independent (there is an association between the variables).

To investigate the effects of EPC usage on various steps of the energy efficiency implementation projects carried out by the participants, 2×2 contingency tables and the Chi-Square independence test were applied. Simple tabular representations of categorical data, called contingency tables, display the frequencies of discrete variables for particular sets of values. Column and row totals of the contingency tables are used for calculating the expected frequency (Field, 2013).

$$Expected\ frequency = \frac{row\ total \times column\ total}{table\ total} \tag{1}$$

The contribution of each cell in the contingency table of the Chi-Square independence test based on these hypotheses to the test statistics is calculated according to Eq. (2):

$$\chi^2 = \sum_{i=1}^{n} \frac{(f_0 - f_i)^2}{f_i} \tag{2}$$

Here f_0 is the frequency observed in the contingency table (frequency of the observation); f_i corresponds to the expected frequency (the frequency with which the observation is expected to occur according to the calculations) in the contingency table. Finding significant differences between the observed frequency and the expected frequency indicates that the variables are associated to each other.

The probability that a particular statistical measure, such as the mean or standard deviation of a putative probability distribution, is greater than or equal to the observed results, is expressed by the *p*-value. Depending on the data type and traditional practices, various values are available. A p-value >0.05 in the commonly used terminology indicates that the association is not significant, that is, the observation occurred by chance. Within the scope of this study, the value of 0.05 in traditional usage was chosen as the threshold value. In other words, if the significance value is $P > 0.05$, H_0 cannot be rejected and it is concluded that the variables are independent.

The Chi-Square test is based on the assumptions that the groups are independent of each other and that the frequency of each cell in the 2 × 2 contingency table is greater than five. When the expected frequencies are greater than five, the sampling distribution is close enough to perfect the chi-square distribution. However, when the expected frequencies are too low, it probably means that the sample size is too small and that the sampling distribution of the test statistic is deviant from a chi-square distribution. At this point, Fisher Exact Test comes up to compute the exact probability of the chi-square statistic which is accurate when the sample size is small. If >20 % of the expected frequency was still below five, we need to check the minimum expected value. If the minimum expected value is less than five, the results of the Fisher's Exact test are considered (Field, 2013).

The SPSS program was used to perform the calculations. To get accurate results with a small sample size, we tried to increase the frequency by combining rows in the tables where the frequency condition was not met. Throughout the analysis, appropriate results were obtained for the Chi-square test, but there was also a case where Fisher's exact test was used. Our hypotheses during the analysis are given below:

H_0: There is no association between the mentioned topic (project payback period, budget, energy savings, etc.) and whether EPC is used or not.
H_1: There is an association between the mentioned topic (project payback period, budget, energy savings, etc.) and whether EPC is used or not.

Survey results

A total of 122 valid responses were received. Of the 122 responses, 86 are facility workers, 9 are independent energy managers, and 27 are EVD representatives. The survey's results are provided in this section by grouping each survey question under a distinct heading.

First part – respondent-related questions

In the first part of the survey, there are three questions to get to know the respondents:

1. Indicate your position within your institution.
2. Indicate your total work experience (in years).
3. Specify the sector you serve.

The first question was intended to see whether the respondent was an energy manager, and if not, what position she/he was in. Independent energy managers were not questioned in this manner.

Of the 86 facility workers, 41 are energy managers or in a comparable position and the remaining 45 have a variety of roles including general manager, an officer in charge of maintenance and repairs, or an R&D engineer.

The second question is the total duration of work experience. When comparing the work experience of respondent groups, it seems that the most experienced group is independent energy managers with an average of 26 years of work experience. The average work experience of facility workers is 18 years, and the average work experience of EVD representatives is 14 years.

Finally, the question of the sector served aims to analyze how the EE studies will diversify according to the sectors. In Fig. 2, sectoral distributions of different respondent groups are given.

It can be seen in the figure that the industry sector is the most served sector by independent energy managers. When EVD representatives are the case, it is seen that 48 % of them provide services in both the industry and building sectors. Facility workers specified that only 11 % have been serving the building and service sector and the remaining for different sub-sectors of the industry. When sectors are examined in three groups “industry”, “building and service” and “other sectors”, it is understood that 85 % of the participants are from the industry and 12 % from the building and service sectors (Fig. 3).

Second part - awareness analysis questions

In this section, firstly, yes or no inquiries were posed to analyze respondents' awareness and practices regarding EVDs, EPCs, and EE supports in Turkey with the following subjects:

1. Being aware of EE incentives
2. Benefited from EE incentives
3. Being aware of EVD companies (excluding EVD representatives)
4. Being aware of EPC
5. Realization of EE project
6. Usage of EPC

Fig. 4 presents the results both in the number and percentage of independent energy managers, facility workers, and EVD representatives.

It is seen that the rate of benefiting from EE incentives of the participants is 33 %, 51 %, and 37 % for independent energy managers, EVD representatives, and facility workers, respectively. The participants who have completed an EE project have EPC usage rates of 22 %, 40 %, and 6 %, correspondingly. The fact that EPC is used in only 6 % of the realized projects by the facilities suggests that the advantages of EPC may not be fully understood, even though 76 % of facility workers are aware of it.

In this part, secondly, a multiple-choice question was asked to only the facility workers to analyze the EE agenda of facilities. According to the answers, the majority of the respondent facilities have been keeping EE studies on their agenda and almost half of the facilities have been doing this for >10 years (Fig. 5).

Third part - experience analysis questions

In the experience analysis part, firstly participants were questioned about previous EE projects. While the participants who did not carry out an EE project were continued in the fourth part of the survey, the participants who stated that they carried out such a project were asked whether they used EPC or not. After that, the project experience of EE projects with and without using EPC was questioned. 78 of the 122 participants stated that they implemented previously an EE project. EPC was used in 19 of the realized projects, and it was not used in 59 of them (Fig. 6).

While evaluating this part of the questionnaire, the questions are examined sequentially. It is statistically examined whether the responses to experience analysis questions are differentiated significantly on projects with or without using EPC.

Participants who use and do not use EPCs in their EE project were asked mostly similar questions for experience analysis, only three questions differ. These differing questions are respectively the reason for choosing EPC, the type of EPC used, and the stakeholder party where the

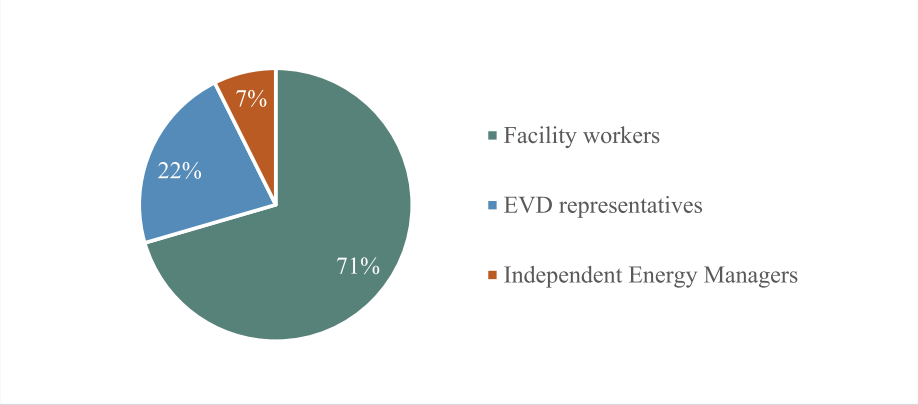


Fig. 2. Survey respondents' profile.

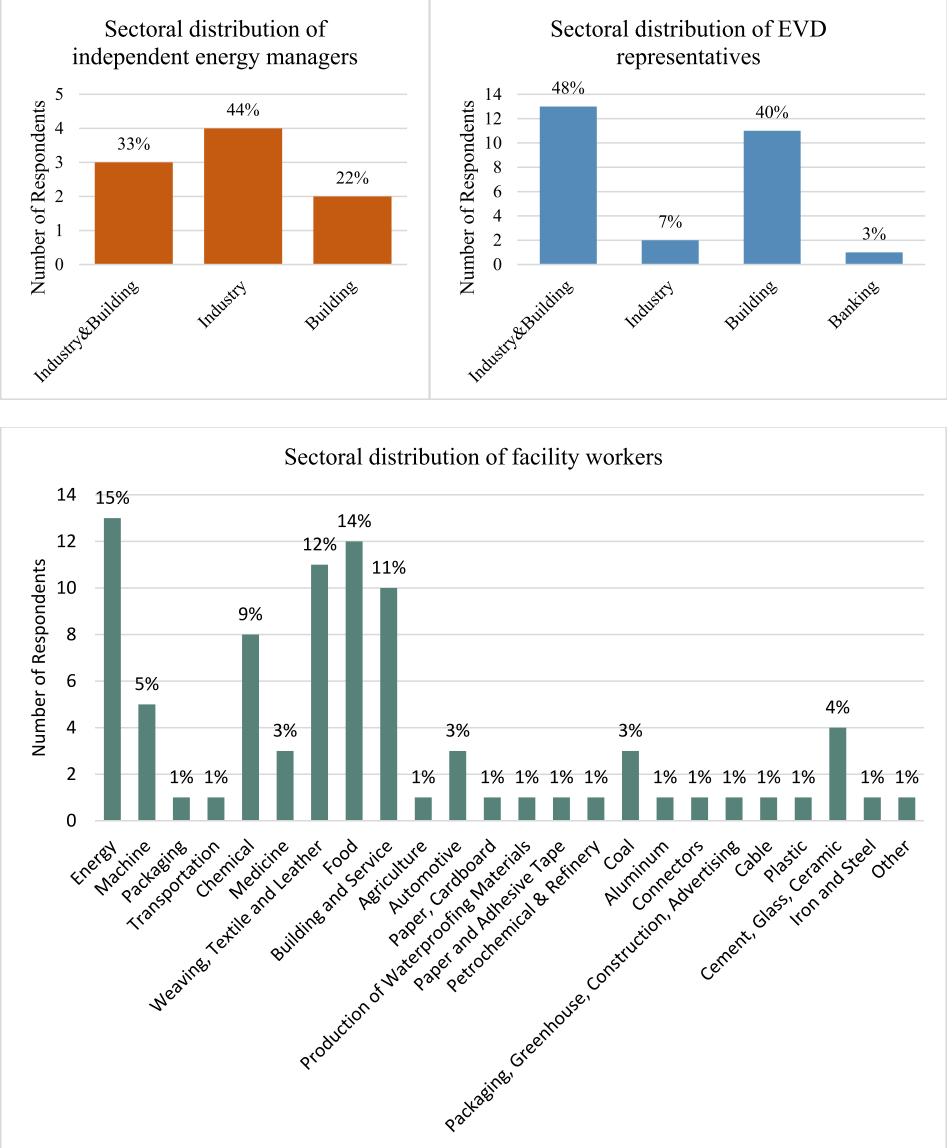


Fig. 3. Sectoral distributions of different respondent groups.

EPC is performed.

1. What are your reasons for choosing the EPC? (only asked EPC users)

The most common answer given to this question by the participants was “energy-saving guarantee” and this is followed by “the factors of utilizing existing supports” and “finding external financing”.

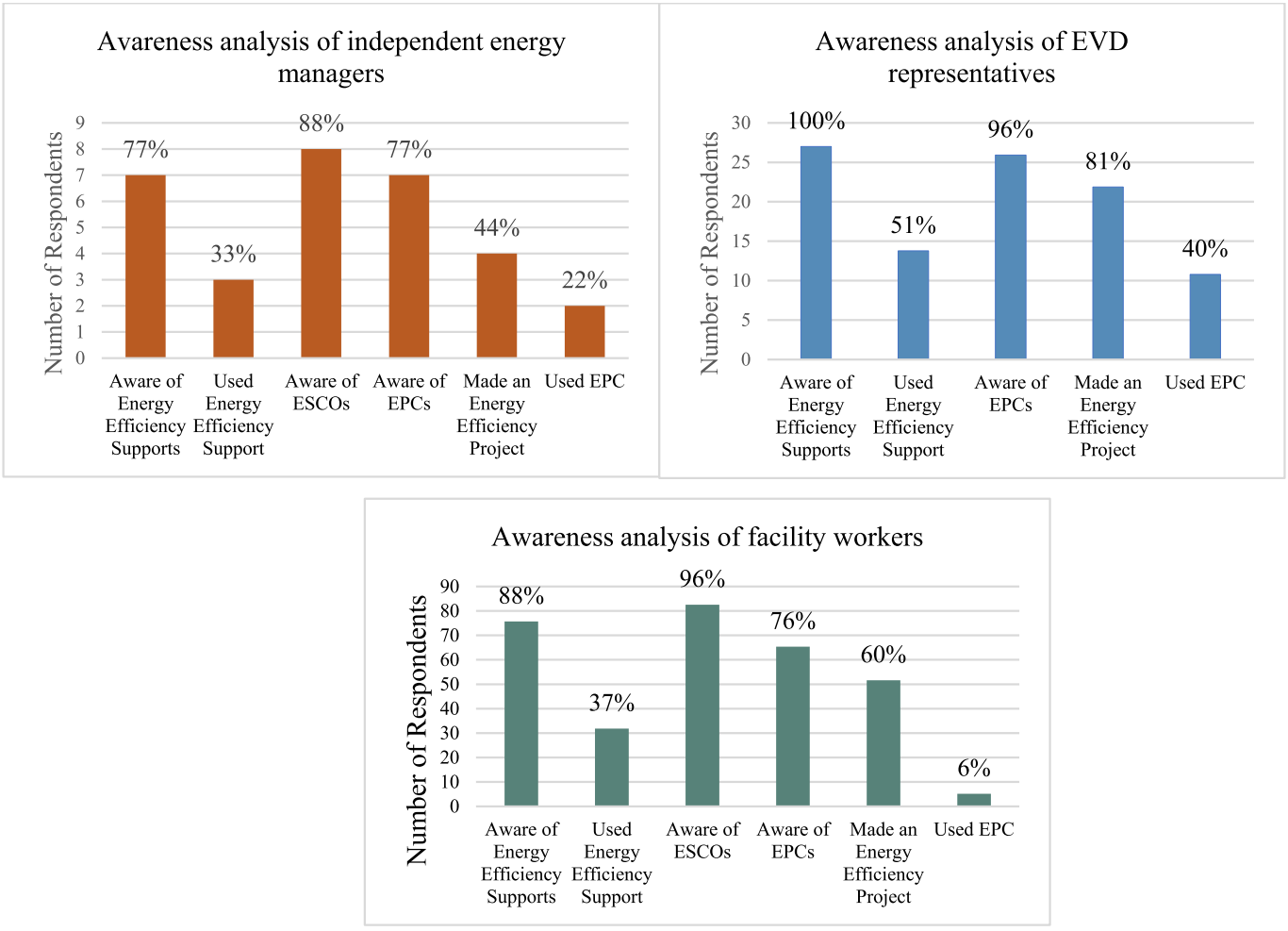


Fig. 4. Awareness analysis results.

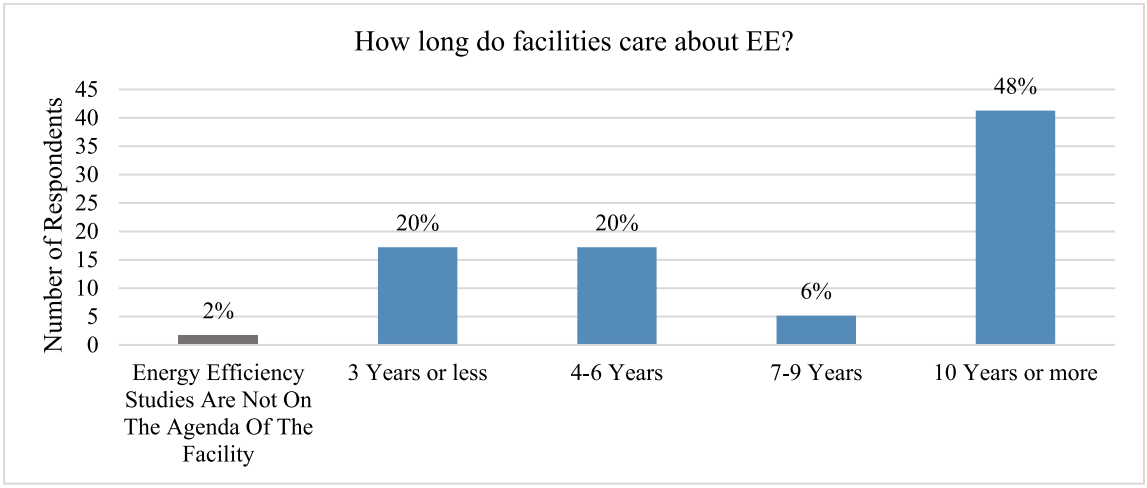


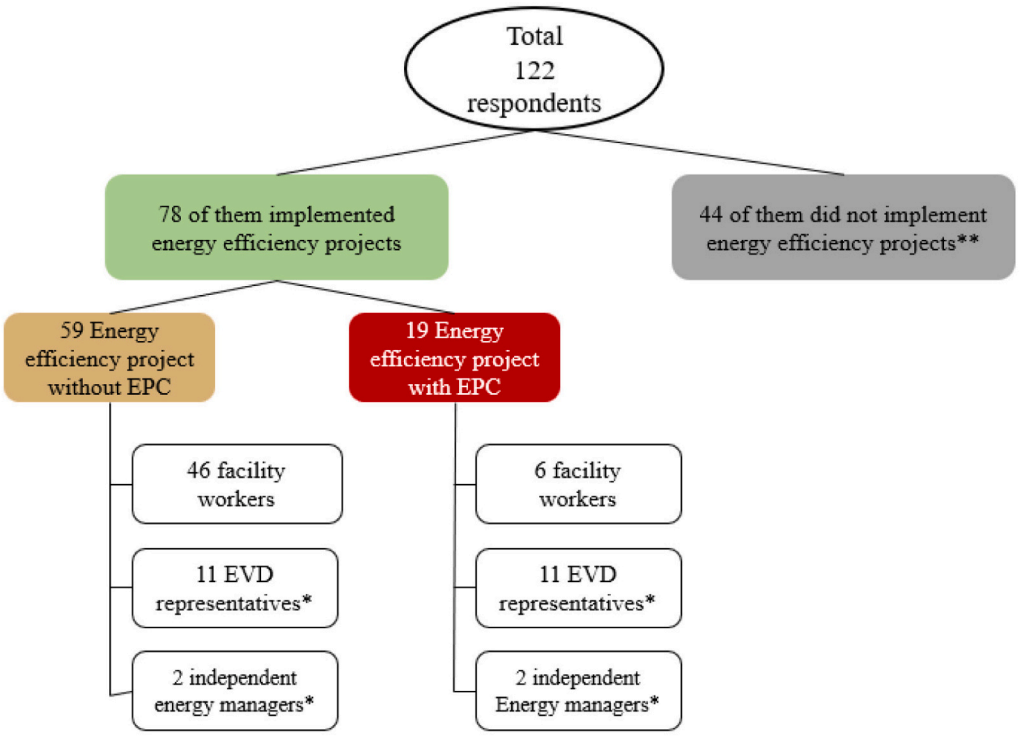
Fig. 5. Facilities agenda for EE studies.

2. What types of EPC did you use? (only asked EPC users)

Guaranteed savings is the most preferred EPC model by the participants and this is followed by sharing savings model.

3. With whom did you carry out the EE project? (only asked facility workers)

According to the results, 47.83 % of the facility workers carried out the project by themselves. Facilities receiving service from EVD are in second place with a share of 43.48 % (Fig. 7).



*The similarity of the number of projects with and without EPC carried out by EVDs and independent Energy managers is random/coincidental

**There are 34 facility workers, 5 EVDs and 5 independent energy managers who have no energy efficiency implementation project experience.

Fig. 6. Number of energy efficiency projects implemented by respondents.

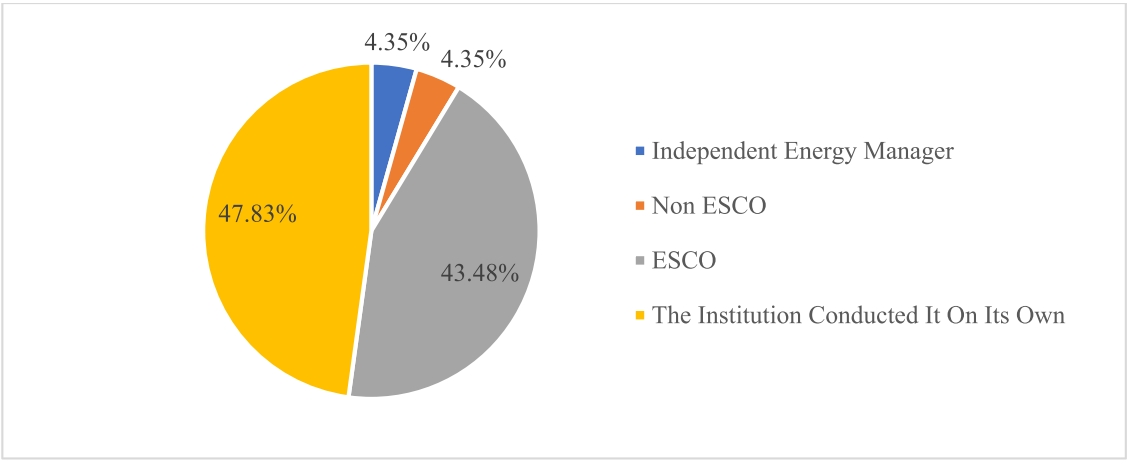


Fig. 7. Service procurement for the EE project of the facilities.

4. How was energy use measured at the beginning of the project?

To determine the real energy-saving potential, the measurement of energy consumption at the beginning of the project is very important.

According to the responses, while long-term measurements and detailed audit rates are slightly higher in EPC projects, traditional methods, and short-term measurements are dominant in EE projects without using EPC (Fig. 8).

5. Which EE measures were used in projects?

Another important point to differentiate is EE implementations within the project. According to Fig. 9, different EE measures are applied at similar rates in both project types. However, while the rate of application of lighting systems in non-EPC projects is slightly higher, the rate of waste heat recovery applications is higher in EPC projects.

6. How long was the payback period of the project?

In the survey, six payback period options were presented to participants "1 year and below, 2–3 years, 4–5 years, 6–7 years, 8–9 years, 10 and above". When looking at the descriptive statistics, it is seen that

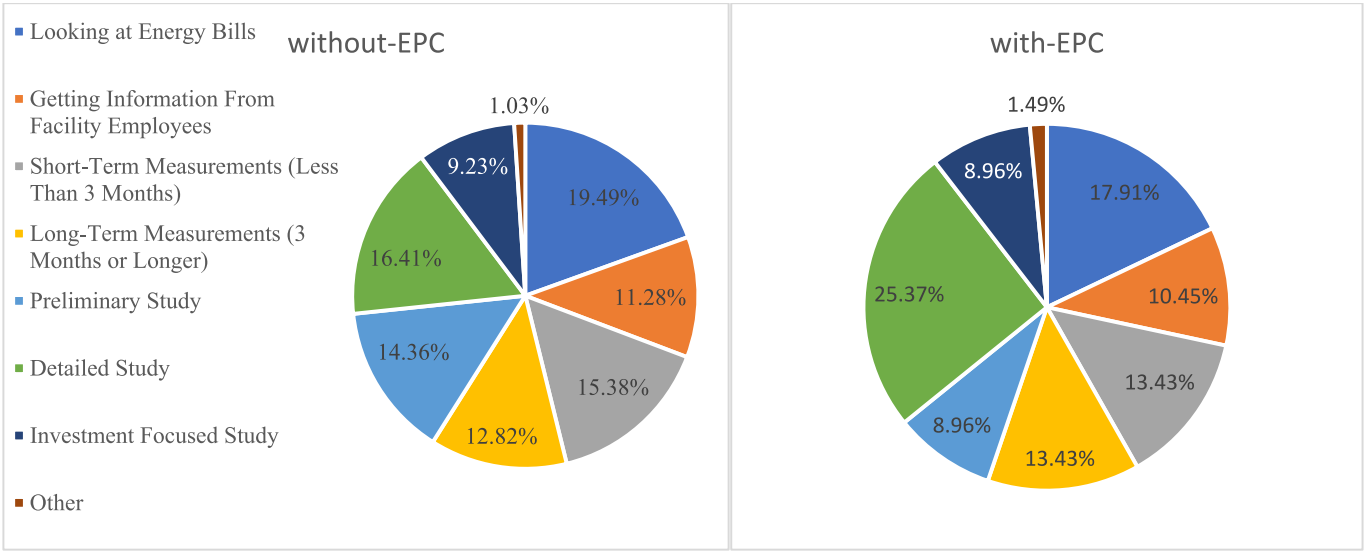


Fig. 8. Energy consumption measurement methods at the beginning of the project.

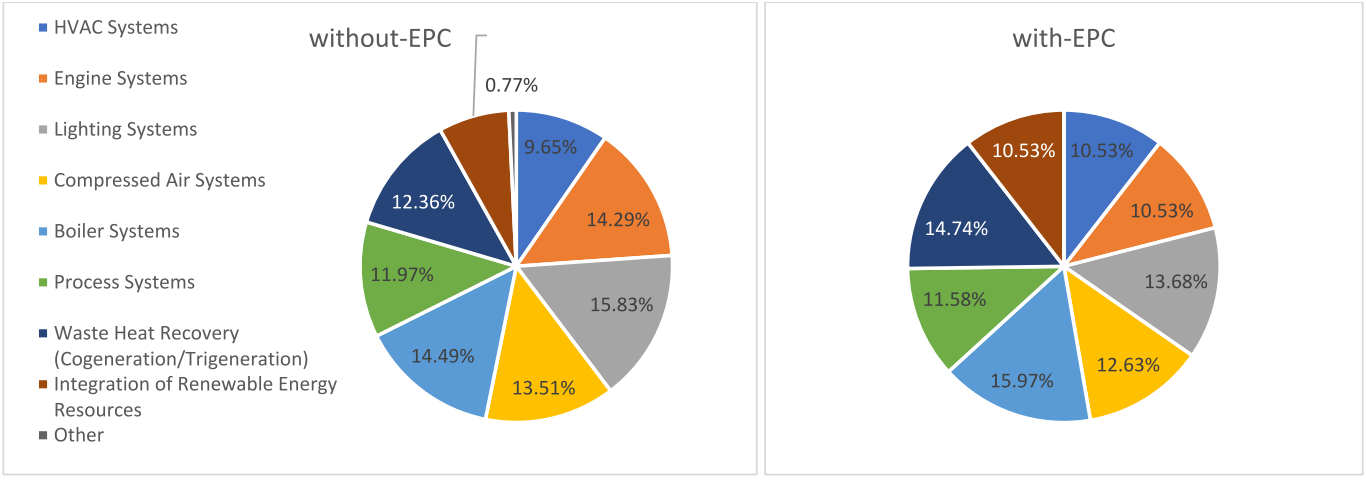


Fig. 9. EE measures used in implementations in the projects.

89.1 % of the projects without using EPC and 94.7 % of the EPC projects have a duration of <5 years. Fig. 10 shows the distribution of the average payback periods of the projects.

Fig. 10 shows that both with or without using EPC projects have a payback period of two to three years followed by four to five years. Though without-EPC projects can also have a payback period of less than a year or as long as six to seven years. It is important to note that the payback periods for both types of projects that take longer than 10 years are 5 % and 3 %, respectively, with and without using EPC projects.

To increase the frequency to apply the Chi-Square analysis, the answers were compiled in 2 classes as "5 years and below, over 5 years" (Table 1). In addition, the outputs of the performed Chi-Square analysis are shown in Table 2.

Since the frequency was expected to be <5 above 20 % of cells, the Fisher's Exact Test was considered. The value of 0.424 is bigger than 0.05, we cannot reject the null hypothesis and say that there is no statistically significant association between the project payback period and whether EPC was used or not.

7. What was the targeted energy-saving rate at the beginning of the project?

The participants were asked about the amount of energy savings they targeted at the beginning of the project. There are 6 different answer options in the questions "10 % or less, 11 %–20 %, 21 %–30 %, 31 %–40 %, 41 %–50 %, over 50 %". Fig. 11 shows the distribution of the answers.

It seems that energy savings of 11 %–20 % are aimed mostly at both projects with and without using EPC.

To reach sufficient frequency for the Chi-Square analysis, the answers were grouped into 3 classes "10% or below, between 11% and 20%, and above 20%" (Table 3). The results of the applied Chi-Square test are shown in Table 4.

The Chi-square value of 1.476 is bigger than 0.05 and we cannot reject the null hypothesis and say that there is no statistically significant association between the amount of targeted energy savings and whether EPC is used or not.

8. What was the energy-saving rate achieved at the end of the project?

Similarly, there are 6 different answer options in the questions "10 % or less, 11 %–20 %, 21 %–30 %, 31 %–40 %, 41 %–50 %, over 50 %". Fig. 12 shows the distribution of the answers.

To reach sufficient frequency for the Chi-Square analysis, the answers were grouped into 3 classes "10 % or below, between 11 % and 20

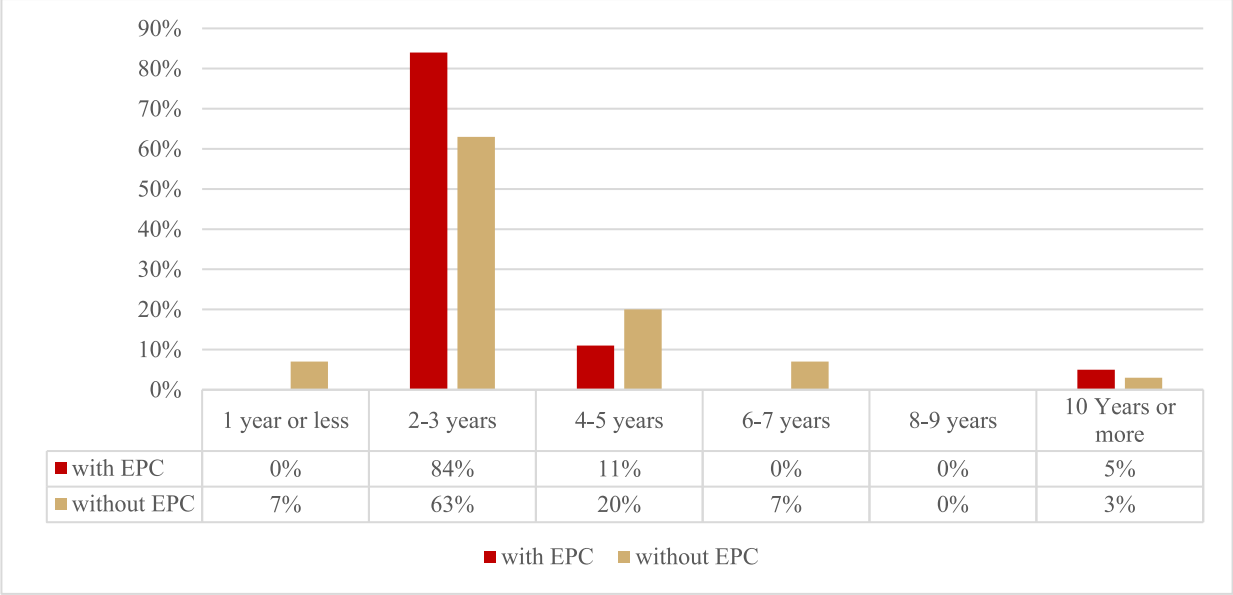


Fig. 10. Impact of contract type (with or without using EPC) on project average payback period.

Table 1
The effects of the contract on the payback periods of the project.

			Have you used EPC in your projects?		Total
			Yes	No	
Time	5 years or less	Observed counts	18	53	71
		Expected counts	17.3	53.7	71
	More than 5 years	Observed counts	1	6	7
		Expected counts	1.7	5.3	7
Total		Observed counts	19	59	78
		Expected counts	19	59	78

Table 2
Examination of the effects of the contract on the payback periods with the Chi-Square test.

	Value	df	Asymptotic significance (2-Sided)	Exact sig. (2-Sided)	Exact sig. (1-Sided)
Pearson chi-square	0.424[a]	1	0.515		
Continuity correction	0.036	1	0.85		
Likelihood ratio	0.471	1	0.493		
Fisher's exact test				1	0.453
N of valid cases	78				

[a] A single cell (25,0 %) has expected count <5. The minimum expected count is 1.71.

%, and above 20 %". The results of the Chi-Square test are shown in Tables 5 and 6.

The Chi-square value of 1.266 is bigger than 0.05 and we cannot reject the null hypothesis and say that there is no statistically significant association between the amount of realized energy savings and whether EPC is used or not.

Fig. 13 shows that some EE projects fall short of the targeted energy savings while projects using EPC always achieve the targeted energy savings, and some EPC projects even go beyond the targeted energy savings.

9. What was the project budget?

Although answering is not mandatory, the project budget question was answered by 77 of the 78 participants. The budgets with and without-EPC projects are given in Fig. 13. From the figure, it is seen that the budget is concentrated in the range of 51–150 thousand €for both types of contract.

There are 4 options for this question in the survey: "50 thousand € and below, 51–150 thousand €, 151–300 thousand €, over 300 thousand €". While the options were included in the Chi-Square analysis, to increase the frequency, they were reduced to 3 classes "50 thousand € and below", "51–150 thousand €", and "151 thousand € and above". Accordingly, the results obtained from the Chi-Square test are shown in Tables 7 and 8.

The Chi-square value of 2.394 is bigger than 0.05 and we cannot reject the null hypothesis and say that there is no statistically significant association between project budget and whether EPC is used or not.

Projects having a difference between the targeted and the realized energy savings are examined, and the project-based evaluation of the energy savings targeted at the beginning of the project and the energy savings reached at the end of the project, including the payback period and budget of the project, are given in Table 9.

The targeted and realized energy savings appear to be the same in all responses given by independent energy managers. However, in projects conducted by EVD representatives and facility workers, there are differences between the targeted and achieved energy savings. As another diversion, it was discussed whether the project was implemented with or without using EPC. It seems that the energy savings obtained in the EPC projects are higher than the targeted energy savings. On the other hand, three of the projects without using EPC reached higher than targeted energy savings, and 4 of them reached lower energy savings.

10. How was the maintenance/repair of the equipment installed during the project period?

Answers show that there seems to be a moderate difference between the party undertaking the maintenance and repair of the equipment installed. While the maintenance and repair of the equipment installed in the EPC projects are done by EVDs, the facility tends to carry out these works in-house in projects without using EPC (Fig. 14).

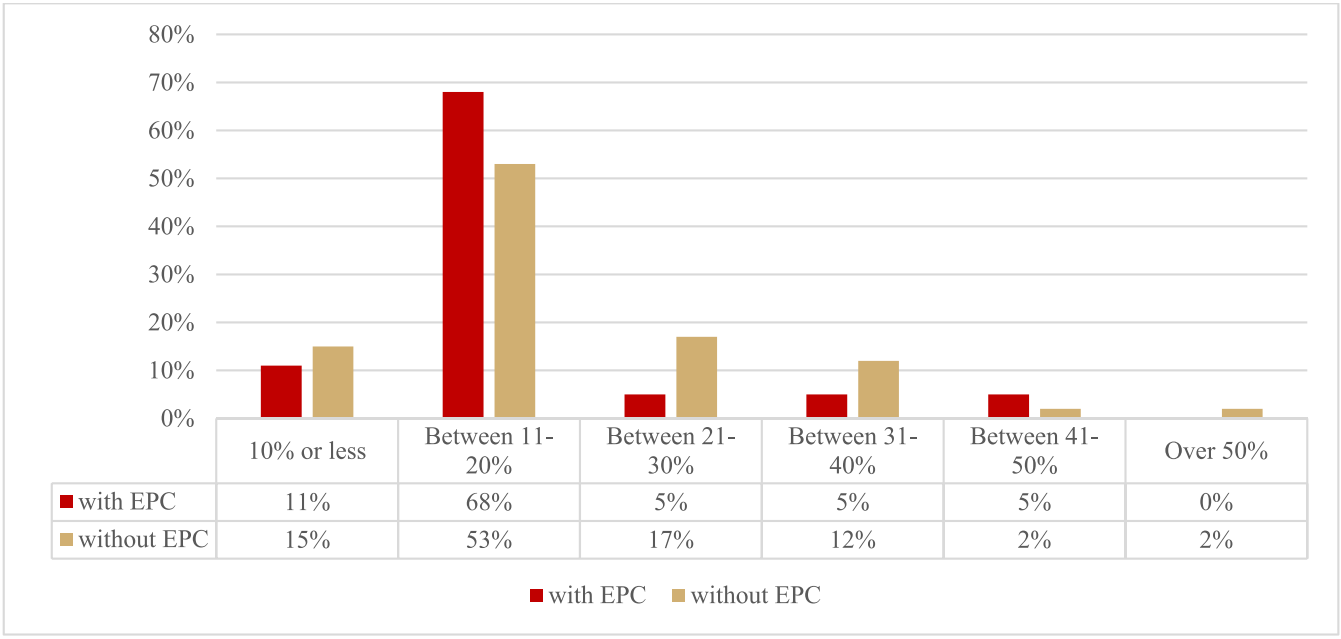


Fig. 11. Impact of contract type on targeted energy-savings.

Table 3
Effect of contract on targeted energy-savings.

			Have you used EPC in your projects?		Total
			Yes	No	
Targeted savings	10 % or less	Observed counts	2	9	11
		Expected counts	2.7	8.3	11
	Between 11 and 20 %	Expected counts	13	31	44
		Expected counts	10.7	33.3	44
	Over 20 %	Observed counts	4	19	23
		Expected counts	5.6	17.4	23
Total		Observed counts	19	59	78
		Expected counts	19	59	78

Table 4
Effects of the contract on the targeted energy-savings with the Chi-Square test.

	Value	df	Asymptotic significance (2-Sided)
Pearson chi-square	1.476[a]	2	0.478
Likelihood ratio	1.511	2	0.47
N of valid cases	78		

[a] A single cell (16,7 %) has expected count <5. The minimum expected count is 2.68.

11. Which stakeholder owned the equipment installed in line with the project?

In both cases, ownership is mostly in the facility where the project is implemented (Fig. 15).

12. The basic steps of the EE implementation project are listed below. You are expected to evaluate the problems/difficulties you encounter in these steps.

The survey questioned the difficulties that occurred over the entire project cycle. Participants were asked to rate the difficulties they experienced at various stages of the project on a three-point Likert scale (There were no problems, some problems have occurred, many problems have happened).

Results show that financing is the most difficult phase for both projects (Fig. 16).

13. Please indicate if you have encountered any of the following problems during the project.

The participants were questioned regarding the problems that they ran across with the projects. In Fig. 17, the distribution of problems encountered with and without using EPC projects is given. Facility workers' unfamiliarity with newly installed technology is the most occurred problem on the without-EPC projects. On the other side, facility workers' unfamiliarity with newly installed technology, uncertainties within the scope of the contract, and failure to complete the project on time are the most common obstacles on with-EPC projects.

Fourth part – future EPC preference questions

In the fourth and last part of the survey, participants were asked the question of whether they would prefer to use EPC in their future EE projects. While 94 % of the responses indicated that they were considering using EPC, only 6 % stated that they would not prefer the EPC application (Fig. 18).

Then, the participants were asked to evaluate the effects of these decisions on a five-point Likert Scale. The factors underlying the decisions of the participants who stated that they would or would not prefer EPC in the future are shown in Figs. 19 and 20, respectively, with their importance rates.

Figs. 19 and 20 indicate that the energy-saving guarantee is the most important factor to consider while choosing EPC. Conversely, lack of knowledge about EPC, a lack of understanding of the structure of EPC (risks, interests, and credit conditions), a lack of an accepted standard

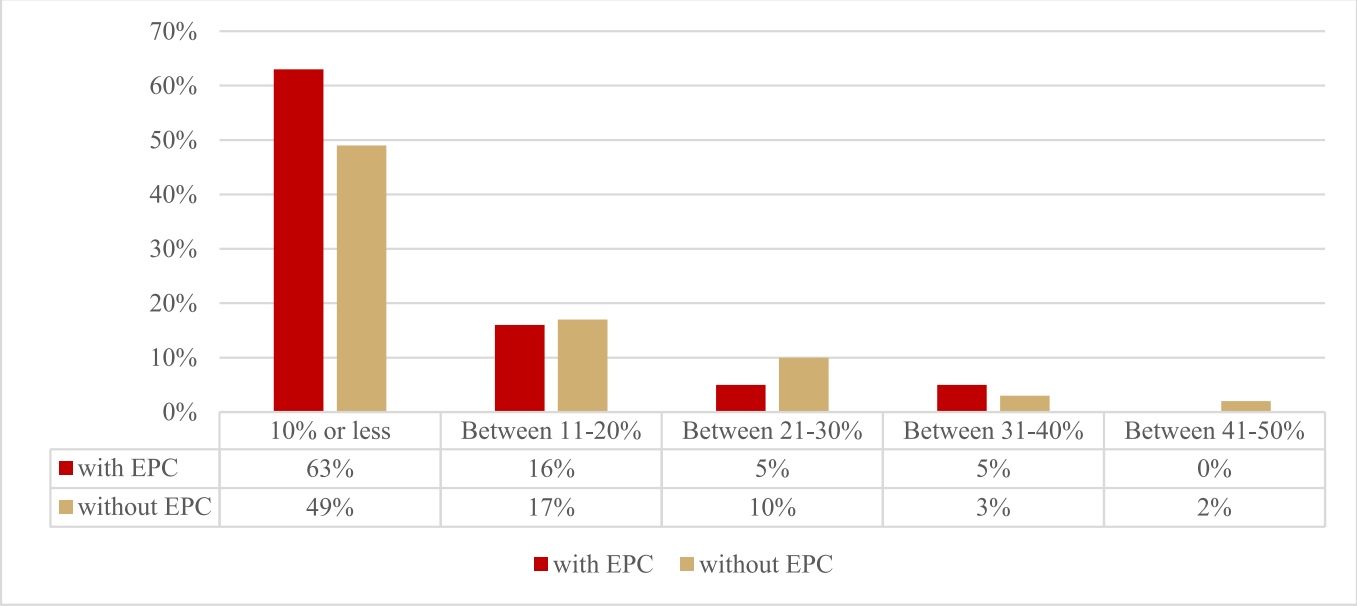


Fig. 12. Impact of contract type on achieved energy-savings.

Table 5
Effects of the contract on the realized energy-savings.

			Have you used EPC in your projects?		Total
			Yes	No	
Achieved savings	10 % or less	Observed counts	2	11	13
		Expected counts	3.2	9.8	13
	Between 11 and 20 %	Expected counts	12	29	41
		Expected counts	10	31	41
	Over 20 %	Observed counts	5	19	24
		Expected counts	5.8	18.2	24
Total		Observed counts	19	59	78
		Expected counts	19	59	78

Table 6
Effects of the contract on the realized energy-savings with the Chi-Square test.

	Value	df	Asymptotic significance (2-Sided)
Pearson chi-square	1.266[a]	2	0,531
Likelihood ratio	1.311	2	0,519
N of valid cases	78		

[a] A single cell (16.7 %) has an expected count of <5. The minimum expected count is 3.17.

for EPC, a lack of independent auditor structures (arbitration committee), and the inadequacy of current legislation are predominating factors among the participants' opinion who said they would not prefer EPC in the future.

Discussion

This section provides the interpretation and discussion of the survey results. The survey tried to reach its target audience widely through different channels and reminder emails sent in three months and 122 responses were received. It is worth to point that one-third (44/122) of the respondents stated that they did not implement EE projects. Although the key participants in the energy service market are the survey's target group, that situation offers a critical hint about the state of the market. As mentioned before, facilities that exceed a certain annual energy consumption must have an energy manager and they have to submit their annual energy consumption to the Ministry of Energy and Natural Resources by legislation. Therefore, they make non-detailed audits and some of them take only small-scale measures. The motivation of facilities like this is to avoid punishment by complying with the regulations. There are also small-scale EVDs in Turkey, which were established only to issue building energy performance certificates or to conduct energy audits, which do not carry out any implementation projects. Therefore, the facility or EVD that does not develop an implementation project is not a surprise in Turkey. On the other hand, the low number of EPC implementations makes it difficult to make a statistical evaluation, the results of the study are compatible with the realities of the Turkish energy service market. This is the first study to focus on EPC applications in Turkey and the results should be presented with all the facts of the current situation. It is very important to understand the current situation, to see the awareness and approaches of the market participants, and to show whether the EPC projects carried out so far differ from the standard energy efficiency projects. When all these results are digested, steps can be taken for the development of the EPC market.

Two-thirds of the participants (78) implemented EE projects either with or without using EPC. Therefore, the main discussion points belong to these two-thirds. According to the survey results, projects are mostly implemented in the industry sector. Despite the significant energy-saving potential, policies and incentives for building-based EE studies in Turkey have only just begun to be defined. Initial studies were concentrated on the industry because there is a larger possibility of finding a budget and qualified experts there. The implementation preferences in EPC-based projects are also affected by this situation.

According to the survey, the most common reason for choosing EPC is to provide an energy-saving guarantee. The most widely used contract

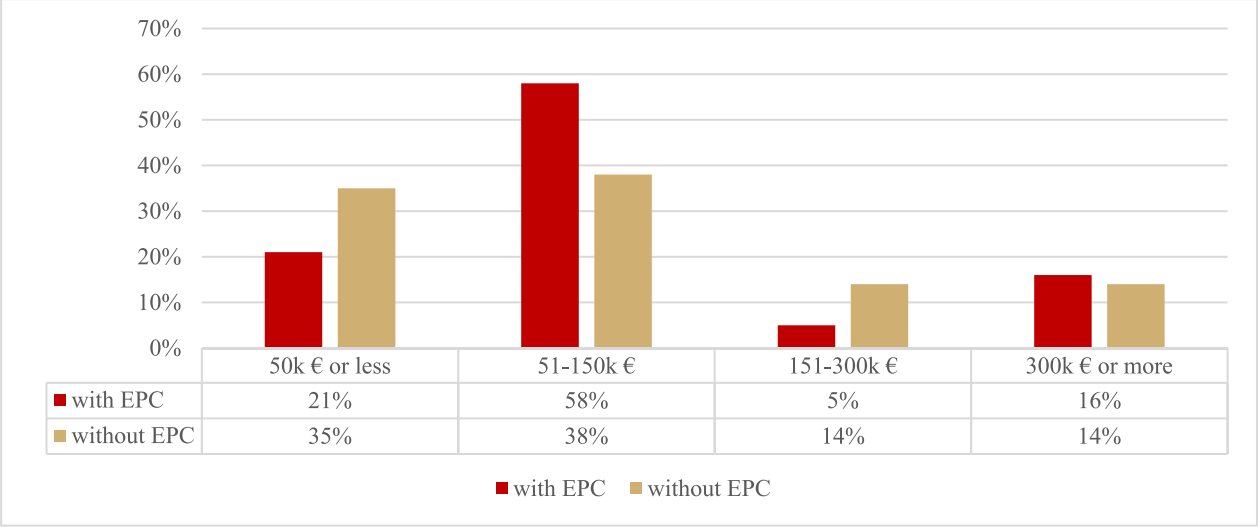


Fig. 13. Impact of contract type on project budget.

Table 7
Representation of the contract effects on the project budget.

			Have you used EPC in your projects?		Total
			Yes	No	
Budget	50k € or less	Observed counts	4	20	24
		Expected counts	5.9	18.1	24
	51–150k €	Expected counts	11	22	33
		Expected counts	8.1	24.9	33
	151k € or more	Observed counts	4	16	20
		Expected counts	4.9	15.1	20
Total		Observed counts	19	58	77
		Expected counts	19	58	77

Table 8
Examination of the effects of the contract on the project budget with the Chi-Square test.

	Value	df	Asymptotic significance (2-Sided)
Pearson chi-square	2,394[a]	2	0.302
Likelihood ratio	2.393	2	0.302
N of valid cases	77		

[a] Cell (16,7 %) has expected count <5. The minimum expected count is 4.94.

type is the guaranteed-savings contract. Most of the financing for the equipment to be installed in guaranteed-savings contracts is covered by the customer. The fact that the financing is mostly provided by the customer can be seen as a reason why the budgets of the projects carried out by the survey participants are mostly within the same range (51–150 thousand €). If different EPC types are correctly used, it will be possible for the customer to implement projects with higher budgets.

Since a certain energy-saving is guaranteed in EPCs, the project must be designed cautiously. Such designing is only possible with the correct execution of detailed on-site investment-oriented energy audits. When evaluating the survey answers in this context, it is seen that the most common answer given to the methods used in energy audits in without-EPC projects is to look at energy bills, while the option of "detailed audit" comes to the fore in with-EPC projects. This is a natural consequence of EPC's structure that guarantees savings. On this basis, when comparing the targeted and achieved energy-savings, the targeted energy-savings rate for both groups is concentrated in the range of 11–20 %, and the energy-savings obtained may be lower in without-EPC projects, while there is no result below the target in with-EPC projects. It is seen that in some projects, energy savings above the target can be achieved in with-EPC projects.

In the literature, it is emphasized that the payback period of EPCs is long and this is a factor that hinders the development of the sector in countries with a dynamic market structure such as Turkey. However, when evaluating the survey answers in the context, it is seen that both EPC and non-EPC projects have mostly 2–3 years payback periods. This situation raises the question of whether the EPCs used in Turkey fully meet the EPC criteria for financing. However, a definitive conclusion can only be reached by examining all contracts in detail. On the other hand, target energy-saving rates, project budgets, and payback periods do not meet EPC usage purposes and expectations. The realization of the targeted savings is directly related to the correct use of the installed equipment and the timely maintenance and repairs. When looking at the projects realized with EPC, the party that undertakes maintenance repair is predominantly EVD companies. The ownership of the installed equipment is predominantly with the customer for both groups. This preference is the result of the widespread use of the guaranteed-savings type of EPCs. When all these results are evaluated together, we can say

Table 9
Comparison of targeted and realized energy-savings on a project basis.

Participant	Contract type	Targeted energy savings	Realized energy savings	Payback period	Project budget
EVD representatives	With-EPC	11–20 %	21–30 %	2–3 years	51–150k €
	Without-EPC	21–30 %	11–20 %	4–5 years	51–150k €
	Without-EPC	31–40 %	41–50 %	2–3 years	51–150k €
	Without-EPC	31–40 %	21–30 %	4–5 years	51–150k €
Facility workers	Without-EPC	21–30 %	31–40 %	1 year or below	50k € or less
	Without-EPC	11–20 %	10 % or less	4–5 years	50k € or less
	Without-EPC	11–20 %	10 % or less	2–3 years	50k € or less
	Without-EPC	11–20 %	21–30 %	2–3 years	300k € or more

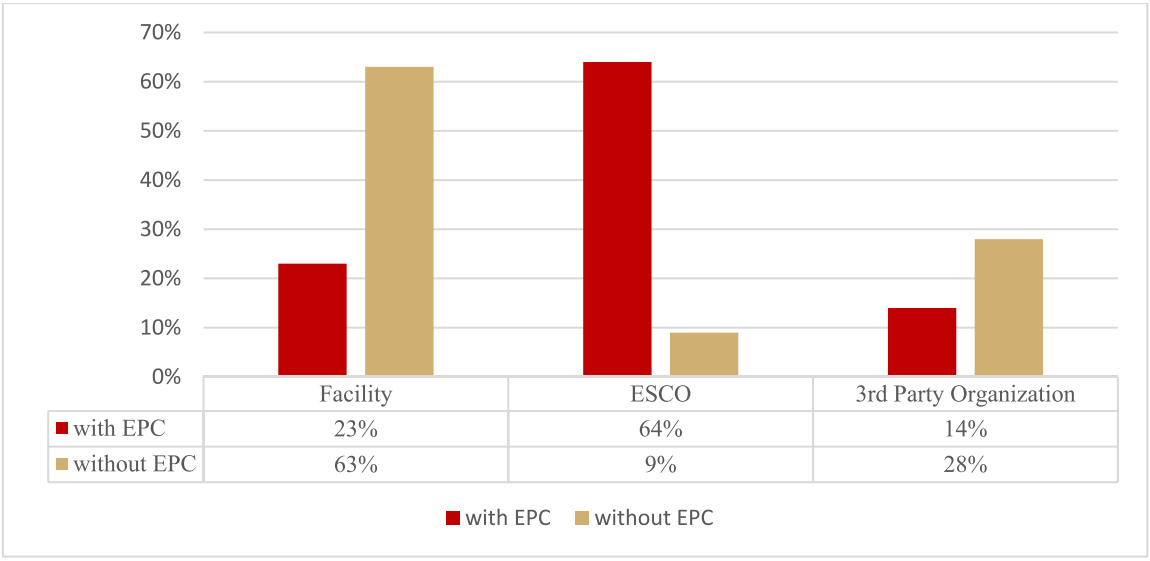


Fig. 14. The party that undertakes maintenance and repair according to the contract type during the project.

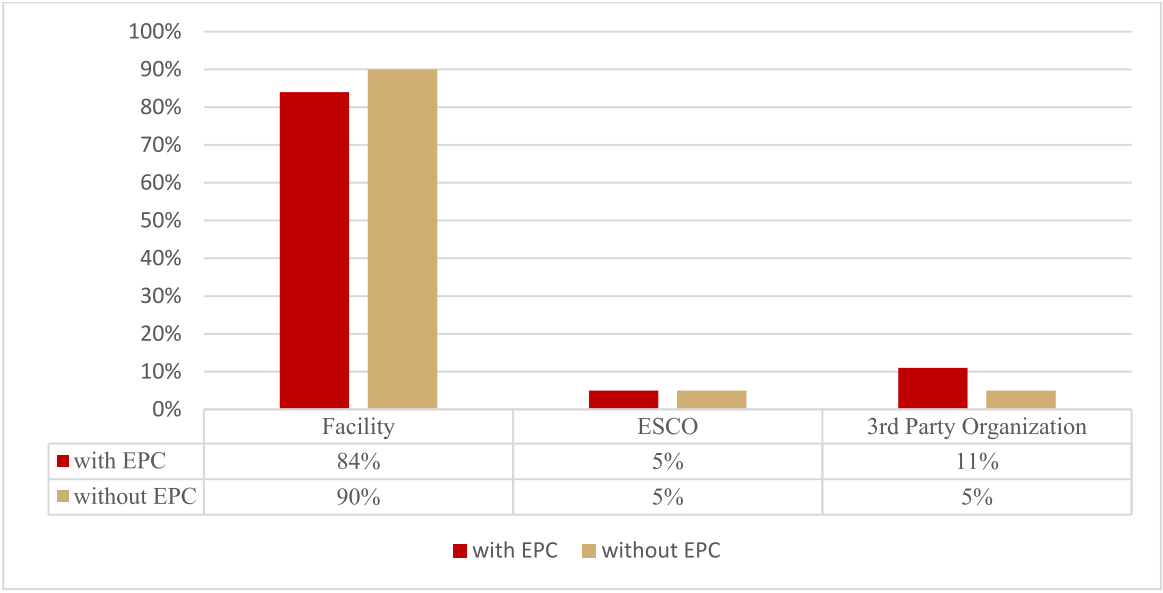


Fig. 15. Ownership of the installed equipment according to the contract type.

that the EPC projects realized so far in Turkey meet the EPC requirements only to a certain extent.

EE projects consist of audit study, project development, contracting, financing, installation, operation & maintenance, and measurement & verification (M&V) steps. According to the results, in both types of projects with or without using EPC, financing is the most difficult stage. Since savings are guaranteed in EPC projects, in which M&V is emphasized, the percentage of problems that occurred in the M&V phase has increased. Nonetheless, to fulfill the savings guaranteed in EPC projects, more emphasis should be given to operation and maintenance activities. As a result, the percentage of difficulty in these issues decreases in EPC projects.

As standard contracts are not yet available in Turkey, there are difficulties in the contract phase in projects that with and without using EPC. However, the difficulty is higher in EPC projects, the scope of which needs to be prepared more carefully. This can show that the EPC structure is not fully understood by the actors in the market and trust between these actors has not emerged, yet.

We can say that almost all respondents' EPC using preference for the future is positive and this can be interpreted as the market is open to development. However, although a few respondents have negative approaches to using EPC in the future, their reasons are worth examining. When we look at the EPC literature, since its inception, EPCs have faced certain obstacles from different parties. The most important ones were investors' reluctance to accept EPC as a means to finance their investments, the lack of the public sector's openness to EPC, and the low numbers of ESCOs (Backlund & Eidenskog, 2013; Brown, 1988; Painuly et al., 2003). Similar to the literature, our study shows that the most important obstacles to EPCs were a lack of information and understanding of the EPC structure in Turkey. We can say that this situation reveals the current inadequacy of EPC projects in the developing Turkish energy service market.

Risk sharing problems, complexity in contracts, inflation, incorrect pricing, insufficient support for EE, lack of established regulations for EPC projects, unexpected changes in the customer's working schedule, equipment failures, and decrease in guaranteed efficiency are some

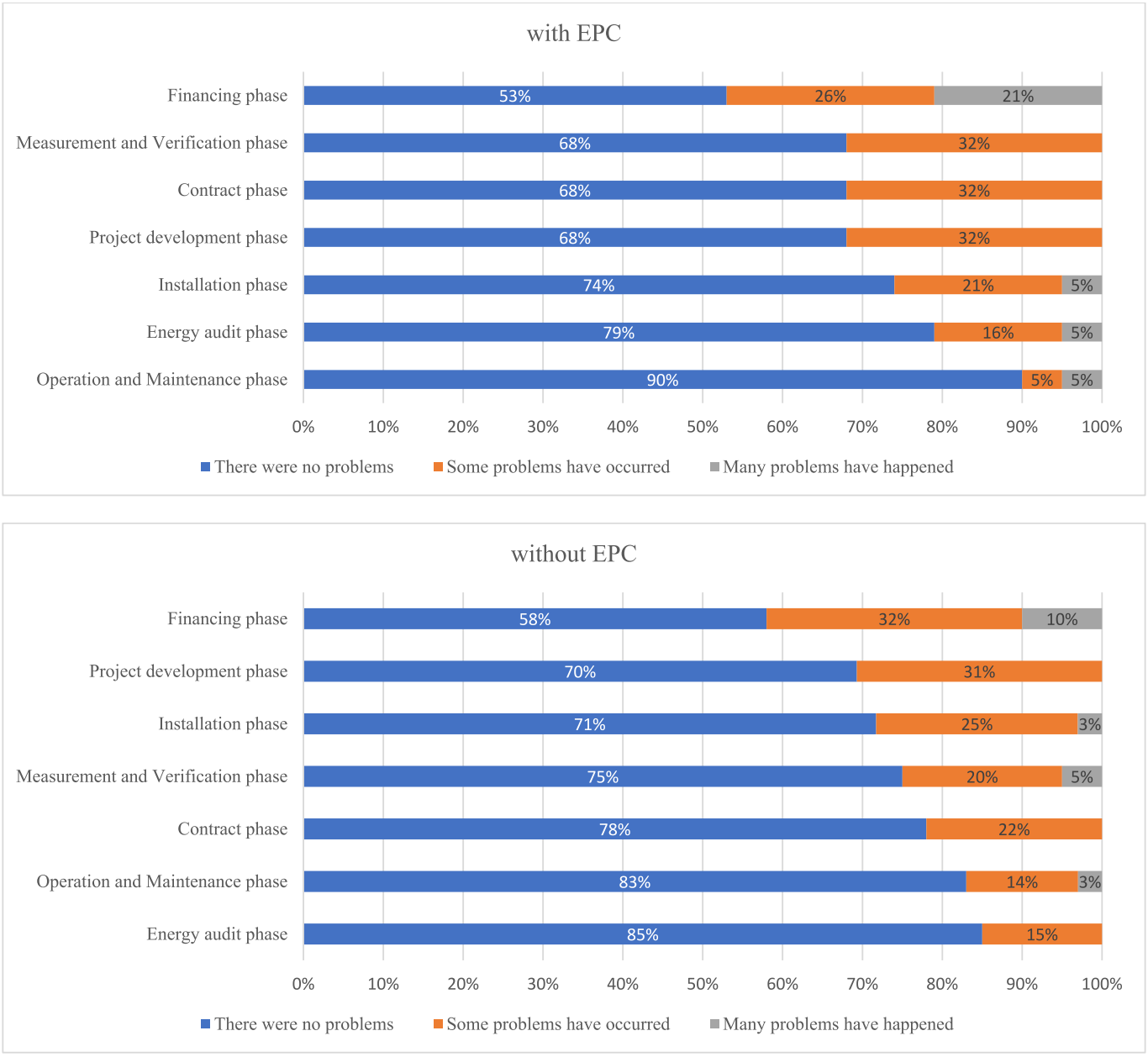


Fig. 16. The difficulties encountered during the project stages.

examples of such risks (Brown, 1988; Kostka & Shin, 2013; Qin et al., 2017). Also, when we look at it from the customer's side; insecurity in measurement systems, increase in installation costs, incomplete understanding of the contract due to its complexity, fear of ESCOs not being able to achieve the savings they guaranteed, length of contract periods, problems with financing companies and the lack of arbitration in case of disputes are also obstacles that slow down the development of EPCs (Backlund & Eidenskog, 2013; Guo et al., 2021; Zhou et al., 2020). Moreover, the impacts of these barriers may differ among countries as economic, political, and cultural characteristics are changeable (Labanca et al., 2015; Painuly et al., 2003; Zhou et al., 2020). Likewise, obstacles faced by EPCs such as lack of standards, independent audit and arbitration, and inadequacy of legislation, are still issues for Turkey and need to be solved. Although, in Turkey, significant and detailed EPC legislation has been established for the public sector, special studies are still needed for the private sector in Turkey. On the other hand, Boza-Kiss, Zangheri, Bertoldi, & Economidou (2017) says that public EPC projects might increase the market's demand. By growing the EPC market's demand side, suppliers will be quick to respond to offers and create new models, and the entire EPC market will begin to thrive (Boza-Kiss, Zangheri, Bertoldi, & Economidou, 2017). In Turkey, public sector EPCs, if implemented successfully, might serve as a guide for the private sector.

Last but not least, monetary issues such as exchange rate fluctuations and difficulties in accessing financing are the leading issues that hinder the Turkish energy service sector.

Conclusions

By investigating the energy service sector, this study attempted to examine the current market environment, experiences in EE projects with or without using EPC, obstacles faced, and the sector's approach to EPC in Turkey. An online survey was conducted on participants from three groups: facility workers, EVD representatives, and independent energy managers. After presenting the survey response visually, the Chi-Square test was then performed to see whether there is a significant

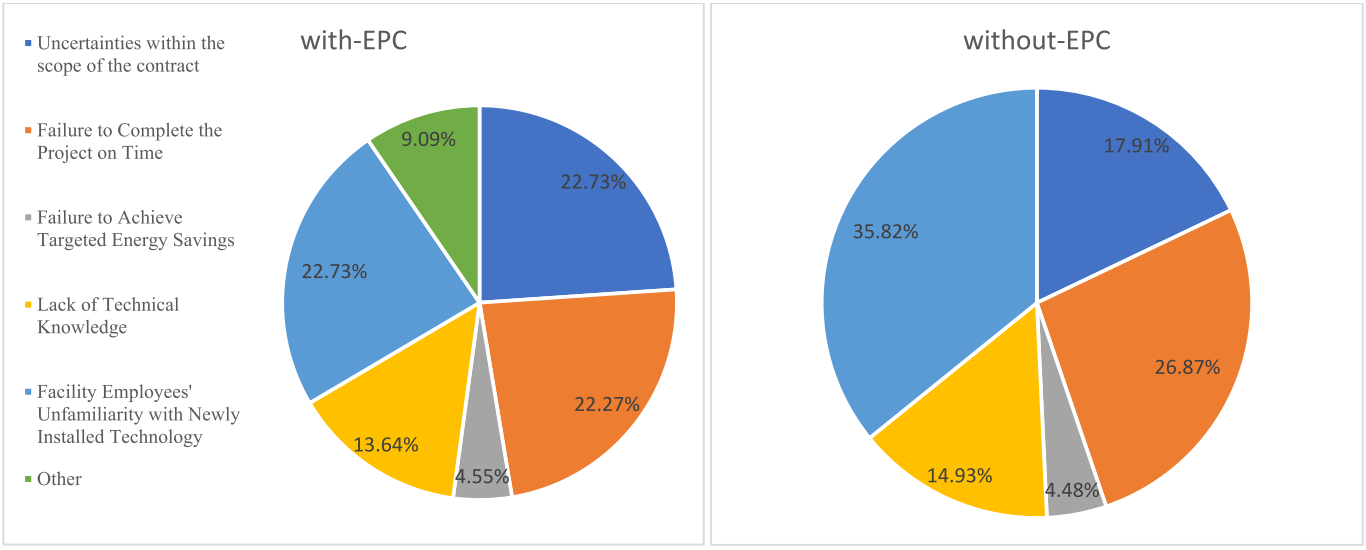


Fig. 17. Problems encountered during the project.

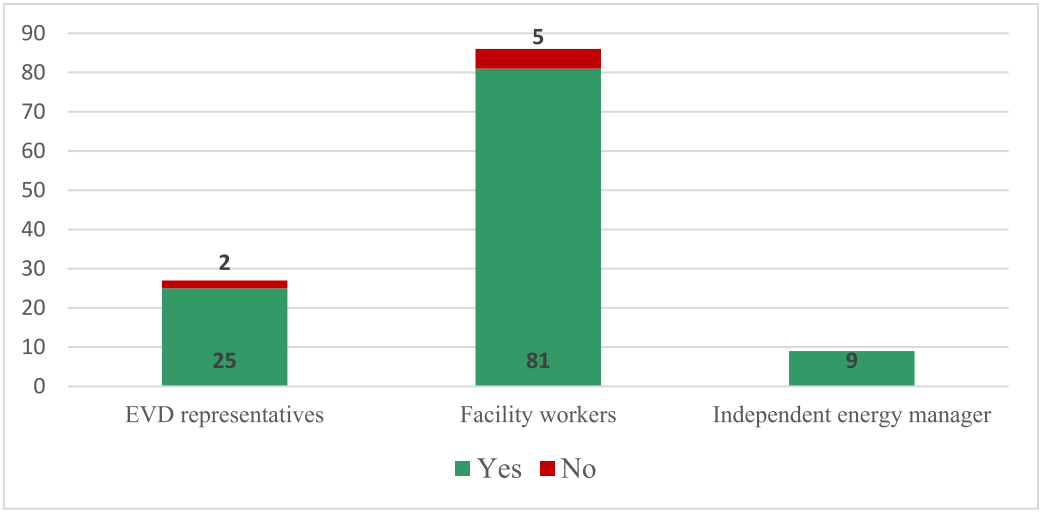


Fig. 18. Future EPC preference of participants.

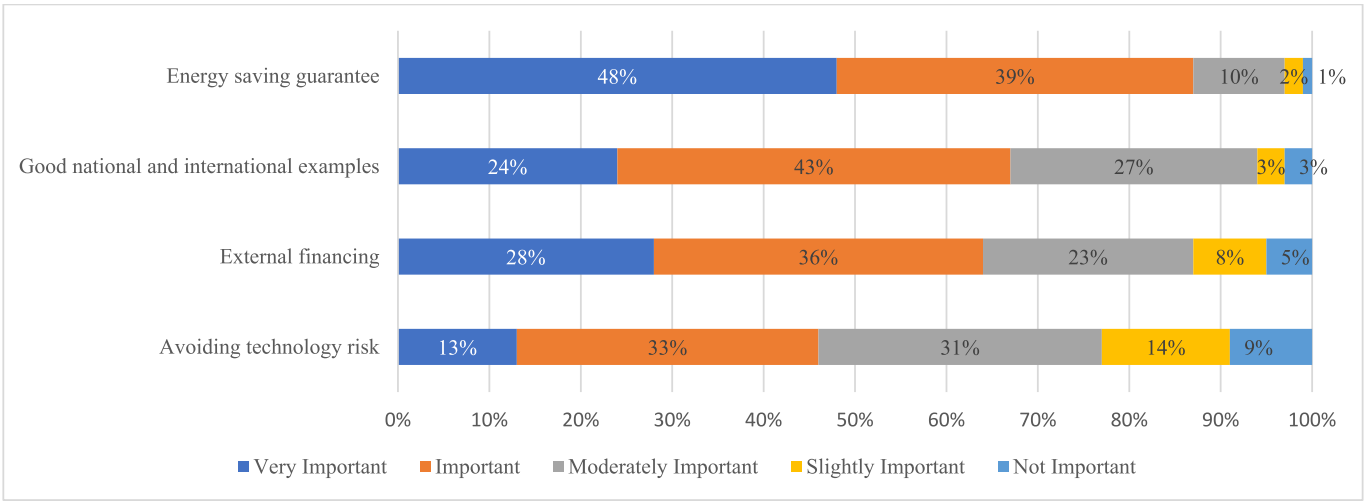


Fig. 19. Participants' future EPC preference factors.

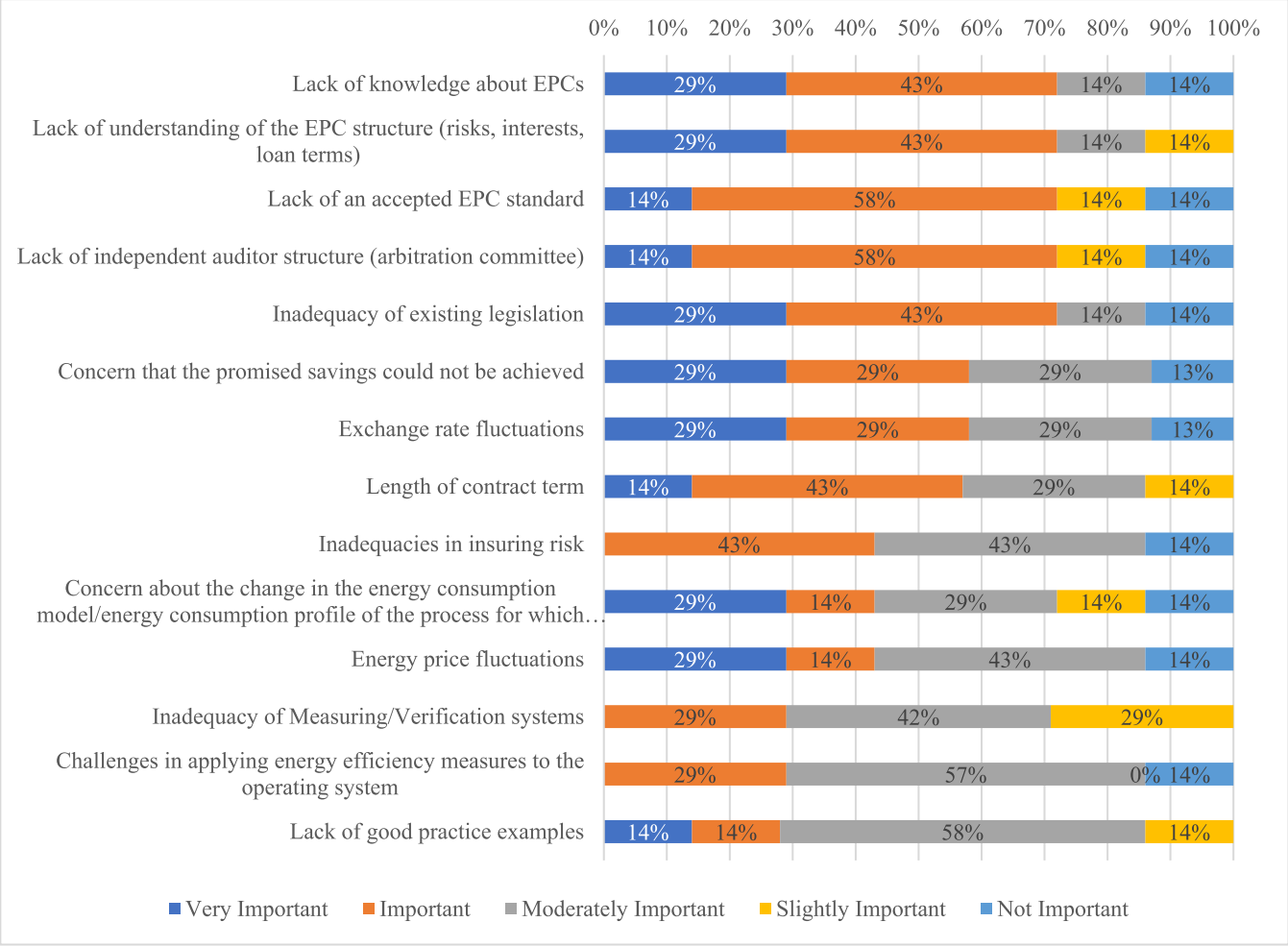


Fig. 20. Factors of participants not preferring EPC.

association between the project procedures and the type of contract (EPC or not) used.

In the survey study, no statistically significant associations were observed between project details and whether EPC was used or not. It shows that there are no EPC applications at the desired size and quality in Turkey yet and EPC projects could not go beyond ordinary energy efficiency projects. To improve this, it is known that the correct and widespread use of EPCs will strengthen the energy service sector by especially contributing to the formation of reliable ESCOs, having more expertise, and it can be regarded as a solution to the financing problem in EE projects.

For the future, EPC stands out as an important tool in terms of the development of the energy service market in Turkey and the realization of existing energy-saving potentials. For the dynamic and volatile energy service market of Turkey, the following steps should be taken:

- increasing the level of knowledge of all market actors,
- the transformation of existing EVDs into ESCOs according to their capacities,
- the development of guarantee mechanisms such as insurance in contracts in terms of increasing implementation and financing opportunities,
- preparation and usage of standard contract types considering all legal issues and technical specifications as additions to the main contract,
- increasing successful EPC usage as best practices, with different methods rather than only guaranteed-saving types to ensure the development of the trust of third parties can be mostly financiers,
- expanding EPC usage to cover the building and public sectors in addition to the industry.

Declaration of competing interest

Authors declare that they have no conflict of interest.

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References

Backlund, S., & Eidenskog, M. (2013). Energy service collaborations—it is a question of trust. *Energy Efficiency, 6*, 511–521.

Bertoldi, P., & Boza-Kiss, B. (2017). Analysis of barriers and drivers for the development of the ESCO markets in Europe. *Energy Policy, 107*, 345–355.

Boza-Kiss, B., Zangheri, P., Bertoldi, P., & Economidou, M. (2017). Practices and opportunities for energy performance contracting in the public sector in EU Member States. In *EUR 28602 EN*. Luxembourg: Publications Office of the European Union. https://doi.org/10.2760/49317, JRC106625. SBN 978-92-79-68832-4,JRC106625.

Brown, I. (1988). European energy performance contracting. *Energy Policy, 16*(3), 297–301.

Carbonara, N., & Pellegrino, R. (2018). Public-private partnerships for energy efficiency projects: A win-win model to choose the energy performance contracting structure. *Journal of Cleaner Production, 170*, 1064–1075.
Deng, X., Zheng, S., Xu, P., & Zhang, X. (2017). Study on dissipative structure of China's building energy service industry system based on brusselator model. *Journal of Cleaner Production, 150*, 112–122.
Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). SAGE Publications Sage UK: London, England.
Garbuzova-Schlifter, M., & Madlener, R. (2016). AHP-based risk analysis of energy performance contracting projects in Russia. *Energy Policy, 97*, 559–581.
Goldman, C. A., Hopper, N. C., & Osborn, J. G. (2005). Review of US ESCO industry market trends: an empirical analysis of project data. *Energy Policy, 33*(3), 387–405.
Guo, H., Wang, B., & Jin, C. (2021). Research on the effect of market mechanism for industrial energy conservation. *IOP Conference Series: Earth and Environmental Science, 634*(1), 12021.
Jiang, W., & Zhao, X. (2021). Trust and the intent to cooperate in energy performance contracting for public buildings in China. *Engineering, Construction and Architectural Management, 28*(1), 372–396.
Kostka, G., & Shin, K. (2013). Energy conservation through energy service companies: Empirical analysis from China. *Energy Policy, 52*, 748–759.
Labanca, N., Suerkemper, F., Bertoldi, P., Irrek, W., & Duplessis, B. (2015). Energy efficiency services for residential buildings: market situation and existing potentials in the European Union. *Journal of Cleaner Production, 109*, 284–295.
Lee, P., Lam, P. T. I., & Lee, W. L. (2015). Risks in energy performance contracting (EPC) projects. *Energy and Buildings, 92*, 116–127.
Painuly, J. P., Park, H., Lee, M.-K., & Noh, J. (2003). Promoting energy efficiency financing and ESCOs in developing countries: mechanisms and barriers. *Journal of Cleaner Production, 11*(6), 659–665.
Pätäri, S., Annala, S., Jantunen, A., Viljainen, S., & Sinkkonen, A. (2016). Enabling and hindering factors of diffusion of energy service companies in Finland—Results of a Delphi study. *Energy Efficiency, 9*, 1447–1460.
Presidency of Turkey. (2018). Presidential Decree No. 1. Official Journal, 30474. July 10 https://www.mevzuat.gov.tr/mevzuatmetin/19.5.1.pdf.
Presidency of Turkey. (2020). Presidential Decision on the procedures and principles regarding energy performance contracts in the public sector. Official Journal, 31220. August 21 https://enerji.gov.tr/Media/Dizin/ETKB/Duyurular//144d684a-1672-4aa9-a928-1e116c3ec010_Karar.pdf.
Presidency of Turkey. (2021). Communiqué on the implementation of energy performance contracts in the public sector. Official Journal, 31455. April 15 https://www.resmigazete.gov.tr/eskiler/2021/04/20210415-6.htm.
Qin, Q., Liang, F., Li, L., & Wei, Y.-M. (2017). Selection of energy performance contracting business models: A behavioral decision-making approach. *Renewable and Sustainable Energy Reviews, 72*, 422–433.
Republic of Turkey. (2007). 5627 Energy Efficiency Law. Official Journal, 26510. April 18 https://www.mevzuat.gov.tr/mevzuatmetin/1.5.5627.pdf.
Republic of Turkey. (2018). National Energy Efficiency Action Plan. https://enerji.gov.tr//Media/Dizin/EVCED/tr/EnerjiVerimliliği/UlusalEnerjiVerimliliğiEylemPlanı/Belgeler/NEEAP.pdf.
Vine, E. (2005). An international survey of the energy service company (ESCO) industry. *Energy Policy, 33*(5), 691–704.
Zhou, Y., Evans, M., Yu, S., Sun, X., & Wang, J. (2020). Linkages between policy and business innovation in the development of China's energy performance contracting market. *Energy Policy, 140*, Article 111208.