Energy Efficiency (2021) 14: 62
https://doi.org/10.1007/s12053-021-09973-w

ORIGINAL ARTICLE

Energy service market evaluation by Bayesian belief network and SWOT analysis: case of Turkey

Ebru Acuner · Rabia Cin · Sermin Onaygil

Received: 25 November 2020 / Accepted: 14 June 2021 / Published online: 7 August 2021

Abstract In Turkey, the energy service market has been growing since 2008 and one of the main actors is energy efficiency consulting (EVD) companies. As of January 2020, 45 EVD have been active in the market. To analyze the current situation of the energy service market, a questionnaire was prepared and sent to all EVD companies and 13 of them responded. In the questionnaire, the main contents can be listed as control authority, sub-sectors for the energy efficiency audits and implementation projects, possible measures determined after audits, the main focus of implementation projects, and main financing sources in audits and implementation projects. The obtained answers were explored by Bayesian belief networks (BBN) through Netica modelling program. According to BBN analysis, in the current situation, the success of the energy service market is about 58%. Considering both the improvements in the regulations and the results of the survey together with BBN, SWOT analysis of the Turkish energy service market was made. Depending on the strengths, weaknesses, opportunities, and threats, in order to improve the success, it is clarified that implementation projects should be increased both in number and quality. National Energy Efficiency Fund should be formed and it is declared that energy performance contracts (EnPCs) should be more actively used together with measurement and verification for more reliable market formation.

Keywords ESCOs · Energy efficiency audits · Implementation projects · Bayesian belief · Energy service market policy

Introduction

As a rule of thumb, energy efficiency is the "first fuel" of all energy transitions. Energy efficiency has become one of the crucial concerns of many industries due to the climate change, economic developments, fluctuating energy prices, technological innovations, and increasing demand for renewable energy (Yanmaz et al., 2018). Hence, energy end users have been looking for new ways to manage and monitor their energy consumptions. As a result, the energy service company (ESCO) concept was established in North America at the beginning of 1980s (Okay & Akman, 2010).

In parallel to this development, European Union (EU), which is always willing and pioneering in energy efficiency, ESCOs have started to operate from the late 1980s to early 1990s (Marino et al., 2011) within the EU member states. Especially after the Directive, 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy

E. Acuner (✉) · R. Cin · S. Onaygil
Energy Institute, Istanbul Technical University, ITU Ayazaga Campus, Energy Institute, 34469 Sarıyer, İstanbul, Turkey
e-mail: acuner@itu.edu.tr

End-use Efficiency and Energy Services (Energy Services Directive), ESCO and related terminology was established, officially. As it can be derived from the main purposes of this Directive, the following issues can be stated with regard to energy service market and ESCO:

- "to enhance the cost-effective improvement of energy end-use efficiency in the Member States by providing the necessary indicative targets as well as mechanisms, incentives and institutional, financial and legal frameworks"
- "to remove existing market barriers and imperfections that impede the efficient end-use of energy creating the conditions for the development and promotion of a market for energy services and the delivery of other energy efficiency improvement measures to final consumers"

On this basis, the term ''Energy Service Company'' can be defined as ''a company that delivers energy services and/or energy efficiency improvement measures in a user's facility or premises, by accepting some degree of risks (performance or financial) in its activities. The payment for the services is based (either whole or in part) on the achievement of energy efficiency improvements and the other agreed performance criteria'' (Directive, 2006). Energy services can include various activities such as energy analysis and audits, energy management, project design and implementation, maintenance, operation, monitoring and evaluation of savings, property management, and energy and equipment supply (Bertoldi et al., 2006). Therefore, ESCOs offer comprehensive contracts that include energy information and control systems, energy audits, installation, operation and maintenance of equipment, competitive finance, and fuel and electricity purchasing (Sorrell, 2007). Besides, ESCOs offer an opportunity to restrain increasing energy demand and control carbon dioxide (CO_2) emissions while capturing market benefits by decreasing clients' energy costs and making profit for themselves.

Similar to the EU, Turkish energy sector and policies need to evolve to meet rising energy demand, foster sustainable economic growth for its cities and industries, and ensure the energy security needs of an emerging market located at the crossroads between Europe, Asia, and the Middle East in a period of significant geopolitical turmoil (IEA, 2016). In this process, due to tight supply and demand relation, energy efficiency has arisen as one of the most important agenda items in the energy service sector, in terms of sustaining economic growth and reducing environmental impacts, particularly in relation with the climate change. For example, The Eleventh Development Plan (2019–2023) can be accepted as the main road map to meet the basic values and expectations, to raise the international position of the country and to increase the welfare, by revealing country's development vision with a long-term perspective. In the plan, within the framework of these policy areas, main energy-related issues can be summarized below with specified targets:

- Providing energy continuously with high quality and minimum costs
- Meeting the increasing energy demand, by a competitive investment environment
- Continuity of an energy service market that is financially strong, stable, transparent, predictable, by taking sustainability into consideration (Republic of Turkey, 2019).

Considering these targets, improving energy efficiency at all stages of the energy chain and hence, reduction of energy intensity are important components of the energy and climate policies of Turkey. Similarly, the energy efficiency (EE) law (2007) is expected to achieve 25–30% savings in total energy consumption. The law utilized efficient use of energy and covered administrative structuring, energy auditing, incentives, awareness raising, and the establishment of an ESCO market for EE services. A Turkish ESCO, namely EE consulting (EVD) companies, is defined as an EE service/consulting company, with additional benefits of being state-approved ESCO (Akman et al., 2013).

Various studies related with the ESCOs in Turkey have been published in the literature. Onaygil and Acuner give an overview of energy service contracting and ESCOs and provide policy suggestions for the forthcoming Turkish ESCO market (Onaygil & Acuner, 2007). Okay et al. review the ESCO literature and its financing mechanisms in the world, and present their views with regard to the funding and related risks that are likely to be associated with the forthcoming Turkish ESCO market (Okay et al., 2008). Okay and Akman use a literature data

on the activities and the sectors targeted by ESCOs in 38 countries in terms of the age of ESCO market, number of ESCO companies, and the total value of ESCO projects (Okay & Akman, 2010). In that study, the relationships among these ESCO Indicators and the country indicators (per-capita GDP, energy consumption, CO_2 emission) are investigated. Akman et al. provide an outlook through the timely legal statements and present barriers, enabling factors, and opportunities, supported by country's financial and economic facts and review the status of the ESCO market in Turkey (Akman et al., 2013). Dursun and Bertoldi examine the market for ESCO services in Turkey and compare Turkey with the EU member states as a candidate country (Dursun & Bertoldi, 2015). In addition, Bertoldi and Boza-Kiss stated that between 2010 and 2013, the growth of Turkish ESCO market can be regarded as moderate as compared to other EU countries (Bertoldi & Boza-Kiss, 2017). Several studies are suggesting a systematic approach to analyze the causal relationships between factors shaping the ESCO market with Fuzzy cognitive mapping (Asan et al., 2004), fuzzy time cognitive mapping (Kadaifci et al., 2014), and DEMANTEL (Basak et al., 2012) methods. Besides these, Yanmaz et al. show the effectiveness of the ESCO market of Turkey by using a new systematic approach of analyzing the key barriers and drivers by examining the direct and indirect causal relations (Yanmaz et al., 2018).

Although there are informative studies on the Turkish energy service market, as explained above, a study concerning the analysis of the market with respect to EVD companies is not available. This study aims to update the literature by presenting and analyzing an overview of the current situation from the viewpoints of EVD on emerging EE policies in the energy service market of Turkey and with its outputs develop recommendations for policymakers. For this purpose, an energy service market survey was conducted in 2019 and analyzed by using the Bayesian belief network (BBN) method which enables a theoretical framework for uncertainty and integrates principles from graph and probability theory as well as computer science, and statistics. BBNs are generally used in various fields comprising environment and energy in order to reflect and explain the complex system, under discussion with expert knowledge and data mining and artificial intelligence-oriented solutions. In addition, BBN is very effective when there are no enough data or insufficient size of data. BBNs allow to create scenarios and observe the current structure and basic consequences of any strategic change, meaning that it is helpful for decision makers to analyze the effects of different scenarios (Cinar & Kayakutlu, 2010). Hence, the novelty of this study is not only looking the energy service market from the viewpoints of Turkish ESCOs but also designing a survey based on BBN analysis and evaluating the results by using BBN and SWOT analyses to estimate the market success and to determine the current situation of the market with pros and cons for developing future prospects, respectively. Accordingly, the paper is structured as follows: In Section "Energy service market in Turkey," current information and new regulations about the energy service market in Turkey are given. In Section "Methodology," the methodology of the study is introduced as survey, BBN, and SWOT analyses. ESCO survey study and related analyses are presented in Section "The survey: case of Turkey." The obtained results of the study are discussed in Section "Results and discussion." Section "Conclusion" gives final remarks and concludes the paper.

Energy service market in Turkey

In the EE law of Turkey, "ESCO" was referred to as "EVD companies" in Turkish; a direct translation for Energy (E) Efficiency (V) Consulting (D) companies. This Turkish acronym sounds as if Turkish ESCOs have been conceived primarily as state-licensed energy auditing firms. However, it can be assumed ESCO and EVD are equivalent with respect to the law. That means any company delivering EE services/consulting can become ESCO if and only that company fulfills the requirements stated in the law and related by-law as "Regulation on Increasing Efficiency in the Use of Energy Resources and Energy" (ENVER regulation) in 2008 and 2011. In Turkey, ESCOs have to be state-authorized and they operate under state regulations (Akman et al., 2013).

Following the EE law, the energy service market has started to develop and EVD companies have begun to establish one by one. Figure 1 shows the change in the number of EVD companies, acting in the market,

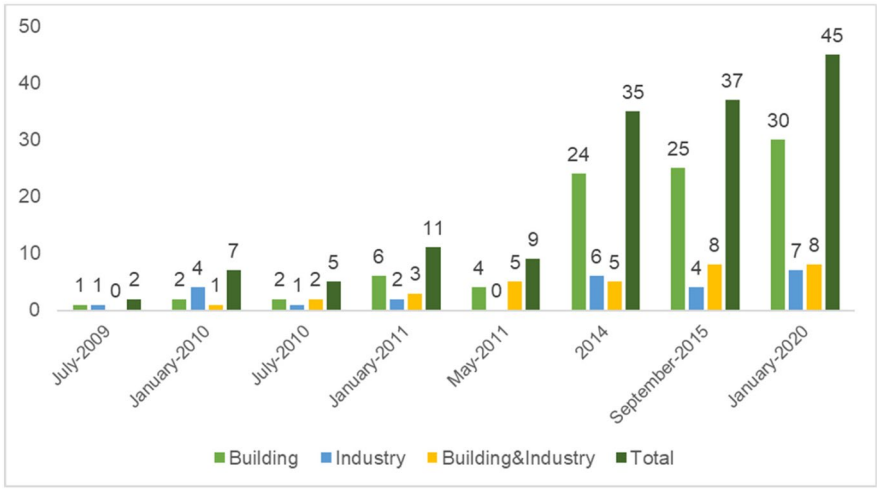

Fig. 1 Number of EVD companies acting in the market between 2009 and 2020

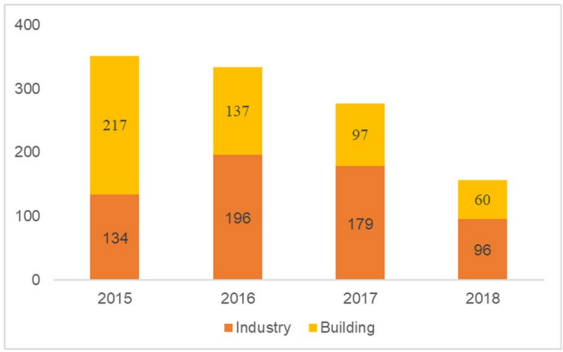

Fig. 2 Energy efficiency audit studies between 2015 and 2018

in Turkey between 2009 and 2020. In 2020, there are 45 companies certified as EVD. Among these companies, 30 serves in the building sector; 7 is in the industry sector and 8 is active in both sectors. As can be seen from the figure, especially between 2014 and 2020, there is a sharp increase in the number of EVD companies. It is worth to mention that in 2011, due to changes in the structure of the related general directorate, issuing EVD licenses, under the Ministry of Energy and Natural Resources (MENR), the authorization of companies had been ceased and started after 2012 (DEEE, 2019).

Within the scope of the legislation, EE studies such as audits through service agreement and application projects by implementation agreement are envisaged to be carried out through EVD companies. Figure 2 represents the number of EE audit studies for the industry and building sectors between 2015 and 2018. While the number of audits performed by EVD companies in the industry was 134 in 2015, it increased by 46% in 2016. The increase in the number in 2017 is 34% compared to 2015, and the number of services is 179. In 2018, 96 energy studies were conducted in the industrial sector (DEEE, 2019).

While the number of audits provided by EVD companies in the building sector was 217 in 2015, it was 137 in 2016 with a 36% decrease. In 2017, the number decreased by 30% compared to the previous year and reached 97. The number of energy studies conducted in the building sector in 2018 is 60, although most of the EVD companies have been serving for the building sector.

Energy management services consisting of training, auditing, measurement, monitoring, planning, and implementation activities are carried out to ensure the efficient use of energy. Within this scope, the following services are provided to commercial and service buildings by EVD companies:

- Establishing an energy policy defining goals and priorities in energy management
- Establishment of energy management systems in buildings in accordance with TS ISO 50,001 Energy Management System-User Manual and Conditions Standard
- Determining measures for improving consumption behaviors, preventing unnecessary use, and organizing training programs to increase the level of knowledge and awareness of employees

- Monitoring and evaluating energy consumption and costs with periodic reports
- Making audit studies, preparing and implementing EE projects
- Identification and implementation of modifications on energy-consuming systems, processes, or equipment
- Monitoring the efficiency of energy-consuming equipment and systems considering required maintenance and calibration on time
- Allocation, installation, and calibration of measuring devices needed to monitor energy consumption on time
- Preparing and implementing measures to protect the environment, reduce harmful emissions, and not exceed the limit values by changing the energy mix and to investigate the possibilities for alternative energy sources
- Preparation of risk mitigation plans to reduce the use of oil and natural gas to be implemented in case of energy shortages
- To send annual information on energy use and energy management to MENR until the end of March every year.

Energy efficiency projects (VAPs) cover studies such as the use of energy-efficient equipment and systems, modification, rehabilitation, and process regulation, including solutions on issues such as preventing or minimizing unnecessary energy use, waste energy, energy losses, and leakages. To date, 5.72 million EUR have been paid to 210 projects in total by MENR as a grant. While the total investment amount of these projects was 23.92 million EUR, an annual financial saving of 20.82 million EUR was achieved (DEEE, 2019). Please note that the EUR exchange rate was accepted as the average for the years 2015–2018.

In addition to VAPs which were prepared by EVD companies and supported by MENR, other special projects are prepared and implemented between either industrial enterprise or building management and EVD companies. Hence, the total number of EE projects can be seen from Fig. 3 with an increasing trend.

With the energy performance contracts (EnPC) signed between the contractor and the customer, a financing mechanism is established based on the reimbursement of the first investment costs of EE or renewable energy projects with the savings to be

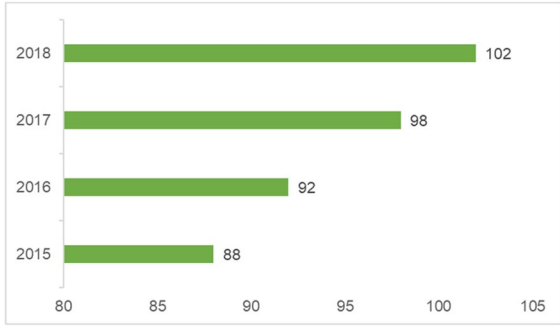

Fig. 3 Number of energy efficiency projects conducted by EVD companies

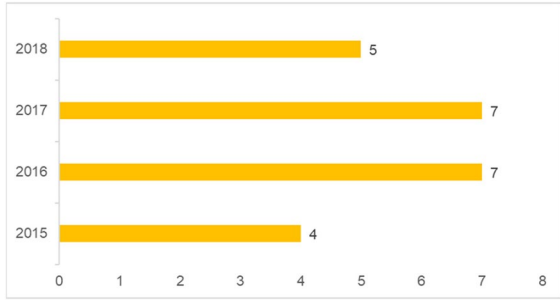

Fig. 4 Number of energy performance certificates made by EVD companies

provided in the following years. The EE project is based on the principle of making payments to the contractor as much as the difference between the reference energy consumption and the actual consumption for a certain period. Savings are guaranteed with the contract and the savings are left to the customer at the end of the contract period. With EnPC, the first investment costs are provided by the contractor and the savings to be achieved with the project implemented is guaranteed. Since the comfort conditions and production quality are defined in the contract, the risks that may occur in the project implementation are secured on behalf of the customer. The number of EnPC made by EVD companies is given in Fig. 4 (DEEE, 2019). The regulations concerning EnPC have been renewed and the governmental buildings are included for such studies of EVD companies. Additionally, measurement and verification standards will be improved to increase both the number and the quality of the EnPCs.

In Table 1, the total saving potentials determined in the industrial and building EE audits and EE projects are given in toe/year and TRY/year and EUR/year, and the investment amounts required for realizing these savings are shown, as well.

In the evaluation made over the energy-saving potential *for the industry* and the projected investment amounts, it can be stated that it was 859.27 EUR/toe (2595 TRY/toe) in 2015, 989.82 EUR/toe (3306 TRY/toe) in 2016, 953.15 EUR/toe (3927 TRY/toe) in 2017, and 728.62 EUR/toe (4124 TRY/toe) in 2018. In this context, the most important reasons for the change in the amount of investment required per unit of energy-saving are the increase in initial investment costs due to the increase in exchange rates, the inclusion of projects with long payback periods according to the needs of the industrial enterprise, and the difference in the project composition (heat/electricity) within the scope of the study.

The building sector energy-saving potential determined in 2015 was approximately 20 thousand toe/year and 29.14 million EUR/year, the amount of investment required to achieve these savings was 68.97 million EUR. After a decrease in 2016 and 2017 about 44% and 66% in terms of energy-saving potentials as compared to 2015, respectively, there was an 11.5% slight increase in the 2017–2018 period. While the simple payback period of investments for 2015 and 2018 is close to 3 years, it is about 2 years for 2016 and 2017. The amount of investment needed to save one toe energy can be calculated as 3530.8 EUR/toe (10,663 TRY/toe) in 2015, 2635.6 EUR/toe (8803 TRY/toe) in 2016, 2533 EUR/toe (10,436 TRY/toe) in 2017, and 1838.9 EUR/toe (10,408 TRY/toe) in 2018. The same reason stated for the industry sector can be accepted for the building sector for explaining the changes in the required investment per unit of energy saved.

According to the total savings potentials in the applied *energy efficiency projects* and the investment amounts required to realize these savings, while the simple payback period of investments for 2015, 2016,

Table 1 Saving potentials and investment requirements

Industrial energy efficiency audits with saving potentials and investment requirements					
	Saving potential		Investment requirement		Energy saving potential
Years	(Million TRY/year)	(Million EUR/year)	(Million TRY)	(Million EUR)	(ktoe/year)
2015	260.53	86.27	518.8	171.67	199.9
2016	295.66	88.52	632.5	189.37	131.3
2017	137.7	33.42	334.4	81.16	85.2
2018	154.4	27.28	306.3	54.12	74.3
Building sector energy efficiency audits with saving potentials and investment requirements					
2015	88	29.14	208.3	68.97	19.5
2016	51	15.27	96.8	28.98	10.9
2017	30.4	7.38	68.4	16.60	6.6
2018	29.5	5.21	80.2	14.17	7.7
Energy efficiency projects with saving potentials and investment requirements					
2015	17.60	5.83	29.84	9.88	9.26
2016	23.06	6.90	47.90	14.34	14.27
2017	28.05	6.81	53.40	12.96	21.62
2018	19.79	3.50	51.81	9.15	10.16
EnPCs with saving potentials and investment requirements					
2015	1.14	0.38	2.13	0.70	0.98
2016	2.15	0.64	3.80	1.14	0.96
2017	3.39	0.82	7.24	1.76	1.75
2018	8.13	1.44	3.90	0.69	0.29

2015: 1 EUR = TRY 3.02;
2016: 1 EUR = TRY 3.34;
2017: 1 EUR = TRY 4.12;
2018: 1 EUR = TRY 5.66

and 2017 is close to 2 years, this is around 2.5 years in 2018. One of the main reasons for this difference can be concentrating especially in the building sector in 2018. The total amount of savings potential determined in *EnPCs* issued is also given in Table 1 with the investment amounts required for realizing these savings. In 2016, the monetary equivalent of the amount of energy savings potential detected was 643,712 EUR/year (2.15 million TRY/year) with an increase of 89%. Between 2015 and 2017, saving potentials determined in EnPCs was increased, sharply about 196%. On the other hand, there is a severe decrease between 2017 and 2018 and the saving potential decreased by nearly 76%. Though the simple payback period of investments for 2015 and 2016 is less than 2 years, this period is slightly above 2 years for 2017, and in 2018, this period exceeds 4 years due to the increase in the investment costs of the projects.

In line with the data obtained from EVD companies, along with the increasing number of companies, the number of technical staff working on EE has also increased over the years. The number of employees, which was 222 in 2015, was 269 with an increase of 21% in 2016 and 326 in 2017 with an increase of 21% compared to the previous year. In 2018, the number of technical personnel working on EE in companies was 329. It can be stated that the increase in the number of technical staff could be accepted as evidence that the market is growing.

For the harmonization of the legislation with the EU, the Turkish National Energy Efficiency Action Plan (NEEAP) was prepared and published in 2018. Under the NEEAP that is going to be implemented between 2017 and 2023, it is aimed to reduce the primary energy consumption of Turkey by 14% by 2023 through 55 actions defined in 6 categories namely buildings and services, energy, transport, industry and technology, agriculture, and cross-cutting (horizontal) areas. It is also projected to achieve savings of 23.9 Mtoe cumulatively by 2023, for which 10.9 billion USD of investment will be made. The cumulative savings by 2033 will be 30.2 billion USD at 2017 prices, where the effect of certain savings will continue through 2040. The average payback period for actions is 7 years (NEEAP, 2018). Depending on the first development report, between 2017 and 2018, 1.35 billion USD was invested and 900 ktoe was saved (NEEAP, 2019). In the second development report for 2019, analyses revealed that a total of 1.182 billion USD was invested in EE, thereby achieving 858 ktoe of primary energy savings, valued at 300 million USD (NEEAP, 2020). In NEEAP, the actions that are needed to be improved and related to EVD companies can be summarized in Table 2.

Taking this analysis of the energy service market between 2015 and 2018 and the targets specified in the NEEAP into account, ENVER Regulation (2011) was revised in 2020. Table 3 demonstrates the main differences between these two versions (ENVER, 2011, 2020).

As can be understood from all these improvements for both regulatory and implementation points, the success of the energy service market in Turkey is crucial. Since EVD companies can be stated as the major players in the market, their opinions about the current situation as well as future improvements should be taken and analyzed for the sake of a strong and reliable energy service market.

Table 2 Actions related to EVD companies stated in NEEAP

Sector	Action
Cross-cutting areas	Establish and increase the efficiency of energy management systems (TS ISO 50,001)
	Develop guides, standard contracts, measurement and verification tools and similar bases containing technical, legal and financial aspects for energy efficiency projects
	Perform more energy efficiency audits
Building sector	Improve energy performance of existing public buildings
Industry sector	Mapping energy-saving potential
	Improve voluntary agreements
Energy sector	Improve energy efficiency in public lighting

Table 3 Main differences between ENVER Regulation 2011 and 2020

Subject	Change
Measurement and verification definition is added	TS ISO 50,006—Energy management systems—measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI)—general principles and guidance by using either TS ISO 50,015—energy management systems—measurement and verification of energy performance of organizations—general principles and guidance or the International Performance Measurement and Verification Protocol
ENVER portal definition is added	To disseminate energy efficiency studies, increase their efficiency, and monitor the development of energy efficiency; the energy management information system of the MENR, which includes features such as information collection, storage, analysis, and reporting
TS ISO 50,001 is mandatory	Public buildings, commercial and service buildings, power generation facilities, and industrial enterprises, and organized industrial zones responsible for establishing an energy management unit should establish TS ISO 50,001 Energy Management System by the end of 2023
Employees of EVD companies can act as an energy manager	In cases where it is not possible to assign the job among its employees, energy manager services are obtained by making contracts with energy managers or EVD companies. Each energy manager or energy audit-project specialist working within the companies can provide energy management services for up to three buildings or industrial enterprises in total. The energy manager, who is assigned among his employees, cannot provide energy manager services other than the building or industrial enterprise he/she is responsible for
Measurement-verification training is started	In addition to the energy manager and audit-project training, the MENR may organize or have a training, examination, and certification program for measurement verification expertise
Energy efficiency audits are closely monitored	If necessary, the MENR may have EVD companies conduct audits in the sectors or sub-sectors. Among the measures determined with these studies, implementation projects for which the payback period is less than three years are prepared by the institutions, organizations, or businesses being audited, and the implementation plans for these projects are sent to the MENR. Within the first year after the termination of the project, the related data is going to be entered into the energy efficiency portal
	Industrial enterprises with annual total energy consumption of 1000 toe (previously 5000 toe) and above conduct energy efficiency audit either by their sources if their employees have industry audit-project certification or by means of EVD companies and audits will renew every 4 years
	The management of commercial and service buildings with a total construction area of 20,000 square meters or annual total energy consumption over 500 toe, in the absence of building management, the owner of the building do energy efficiency audits by either their staff with a building audit-project certificate or EVD companies and the audits will renew every 7 years

Table 3 (continued)

Subject	Change
VAP projects application is changed	For both VAP and Voluntary Agreements, the industrial enterprise is registered in the ENVER portal and has 50,001 certificates
	Industrial enterprises that want to benefit from VAP supports submit their project applications, prepared in accordance with the application procedures and principles by EVD companies, to the MENR whenever it is convenient
	If deemed necessary, an on-site preliminary examination is carried out on the project component by the personnel of the MENR or the real or legal persons determined by the MENR for receiving the service. In the case of on-site pre-examination by real or legal persons, service costs, as well as the cost of VAP project preparation, are covered by industrial enterprises
	Within the scope of the implementation report, the project or project components whose applications are made different from those specified in the project, and the project or project components, whose implementation has been made in accordance with the project, but which have been determined less than ninety percent of the amount of component energy gain at the end of the implementation, are not supported
Public buildings should do energy efficiency audits and implementation projects	Public buildings with a total construction area of at least 10,000 m^2 or annual total energy consumption of 250 toe and above have to be audited, and if they have audit-project certified personnel, they can do it themselves (energy manager certificate is not enough) every 7 years (previously 10 years). It is necessary to prepare implementation projects for those whose payback period is 3 years or less and to implement these projects within 4 years
Energy Performance Contracts in the Public Sector	The decision on the procedures and principles of energy performance contracts in the public sector was published in the Official Journal (No:31220, Date: 21 August 2020) of Turkey

Methodology

In this section, firstly survey method, then BBN and SWOT analyses are explained in order to clarify the selection reasons for the three-step methodology, applied in the study.

Survey

Surveys represent one of the most often used techniques of collecting information from or about people to describe, compare, explain, or predict their knowledge, attitudes, or behaviors (Phillips, 2013). Surveys can be used to provide information about opinions and behaviors of the targeted people for decision-making. They are important to understand the motivations behind actions. There are numerous studies in the literature comprising survey study to analyze the energy service market and ESCOs. Table 4 summarizes some of these studies, dealing with either in a specific country or internationally.

ESCOs are one of the main actors in the energy service market and their opinion is valuable for assessing the market situation. As can be shown in Table 4, to evaluate the energy service market, interviewing ESCOs or conducting surveys for ESCOs has an importance in the literature. Similarly, in this study, the opinions of ESCOs were taken to evaluate the situation in the operation part of the Turkish energy service market.

Bayesian belief networks

BBN can be described as a probabilistic graphical model for integrating both quantitative and qualitative data, particularly for data-limited circumstances. BBN is quite strong in modeling and analyzing a complex problem that is characterized by direct/

Table 4 Literature review on survey analysis of energy service market and ESCOs

Study	Objective	Method
Vine et al., 1999	How ESCOs are currently interacting and planning to interact in the future	(1) Review of the published and unpublished literature on ESCOs (2) Phone interviews with Super ESCOs and utility companies in the USA (3) presentations at the conference on November 1997 by the National Association of ESCOs and (4) informal discussions with ESCO and Super ESCO experts in the USA
Vine, 2005	Examine the current level of ESCO activity internationally discuss possible actions that countries can take to promote the ESCO industry in their country and provide examples of recent ESCO activities around the world	A questionnaire for key ESCO contacts in countries known for their ESCO activity
Goldman et al., 2005	Represents the first systematic attempt to estimate US ESCO industry trends and performance empirically	(1) A survey of national and regional ESCO firms, supplemented by interviews with ESCO executives and industry experts (2) draw on roughly 1500 completed ESCO projects to analyze target markets and typical project characteristics, costs, savings and economics from the customer's perspective
Marino et al., 2011	Present the European ESCO industry between 2007 and 2010	Combination of stakeholder interviews and a large-scale survey carried out 2009–2010 in 39 European countries
Roshchanka & Evans, 2016	Scale up the ESCOs in Russian Federation based on the current market status	(1) Reviewed official public database (2) conducted structured interviews with ESCOs in Russia and (3) supplemented with online research
Bertoldi & Boza-Kiss, 2017	Focused on market development between 2010 and 2013 present a comprehensive overview of the ESCO industry in EU Member States and neighboring countries	Online survey for a pool of around 900 ESCO representatives, energy efficiency experts with knowledge on the ESCO market, national energy efficiency policy makers, and financial institutions supporting ESCO projects and 300 replies received comprising 43 European countries
Liu et al., 2018	Present the status of the building ESCO industry in China and proposed alternative strategies	A SWOT analysis with the analytic network process (ANP), to select the best strategy to promote the development of the building ESCO industry
Nurcahyanto, 2020	Understand and verify SWOT of developing markets for energy service companies in Indonesia	(1) Literature survey for about ESCOs, (2) surveying to determine factors for SWOT analysis (3) SWOT with analytic hierarchy process (AHP) to determine the level of perception of SWOT

indirect effects and uncertainty. BBN consists of a set of random variables and their causal relations. In the network topology, a node represents a random variable while an arc denotes the dependence relation between nodes. It can be used for many applications, for example, to determine the relations among variables, to represent expert opinions, and also to identify significant uncertainties because of the highly flexible general network structure. BBN makes the effects of various scenarios possible to be examined by utilizing the prior knowledge from domain experts and performing causal inference (Jensen, 2001; Cheon et al., 2008, Lee et al., 2010; Hanea et al., 2010; and Landuyt et al., 2013). BBN has been used in diverse research areas such as medical diagnosis (Wang et al., 1999), reliability assessment (Gran & Helminen, 2001), forecasting (Abdoli & Choobineh, 2005), threat evaluation in air surveillance (Johansson & Falkman, 2008), energy-efficient network management (Bashar et al., 2010), scenario analysis in the energy sector (Cinar & Kayakutlu, 2010), fault detection and diagnosis (Zhao et al., 2013), environmental modeling (Kayakutlu et al., 2017), and classification (Yang et al., 2018).

The theory of Bayes originates in the work of Thomas Bayes in 1763. Mainly in the theorem, conditional probabilities of events of interest have been computed from known probabilities. Let X and Y be two events and their probabilities are different from zero ($P(X) \neq 0$ and $P(Y) \neq 0$), then the conditional probabilities are given in Eq. (1) and (2) as Bayesian theory states (Neapolitan, 2004):

$$P(X|Y) = \frac{P(X \cap Y)}{P(Y)} \tag{1}$$

$$P(Y|X) = \frac{P(Y \cap X)}{P(X)} \tag{2}$$

where $P(X|Y)$ is the conditional probability of X given Y, $P(Y|X)$ is the conditional probability of Y given X, $P(X \cap Y)$ and $P(Y \cap X)$ represent the probability that both X and Y events occur. When multiplying Eq. (1) and (2) by the denominator on their right side to show that:

$$P(X|Y)P(Y) = P(Y|X)P(X) \tag{3}$$

because of $P(X \cap Y)$ equal to $P(Y \cap X)$. When X and Y are independent, inner probability of the combination of variables $P(X \cap Y)$ and $P(Y \cap X)$ are equal hence the $P(X|Y) = P(X)P(Y)$. Finally, dividing the Eq. (3) by $P(Y)$, basic Bayes theorem is obtained as shown Eq. (4).

$$P(X|Y) = \frac{P(Y|X)P(X)}{P(Y)} \tag{4}$$

$P(Y|X)$ indicates the probability that Y will occur in a condition where X occurs. It is accepted that when event X occurs, so does event Y. The theorem shows how much of event X is caused by event Y. The theorem provides to compute $P(X|Y)$ if $P(Y|X)$, $P(X)$, and $P(Y)$ are known.

As a result, BBNs can be beneficial for the involvement of a high level of uncertainty, which means having limited or incomplete data; for integrating numerous system components and for requiring expert or stakeholder engagement in the modeling, where the relations among variables are non-linear or complex (Aguilera et al., 2011). In this paper, BBNs are used to evaluate the results of the EVD survey study for determining the current situation and opportunities of the Turkish energy service market.

SWOT analysis

SWOT analysis has been widely used over the last five decades in the field of strategic management and it is a useful supporting tool for planning and decision-making. SWOT consists of four components which are Strengths (S), Weaknesses (W), Opportunities (O), and Threats (T) (Table 5) (Gürel

Table 5 The components of SWOT analysis

Strengths The characteristic that adds value to something and makes it more special than others	Weaknesses Not having the required format and competence for something
Opportunities Advantages and the driving forces for an activity to take place	Threats Situation or condition that endangers the realization of an activity

& Tat, 2017). SWOT analysis has two dimensions as internal (organizational) and external (environmental) strengths and weaknesses are internal factors that can be controlled. Otherwise, opportunities and threats are external factors that cannot be controlled. Additionally, strengths and opportunities are helpful aspects and they assist the success. weaknesses and threats are the harmful aspects and they block success (Sarsby, 2016).

SWOT analysis is a practical, common, and popular tool for strategic planning and management, business, marketing, etc. Because of its simplicity and memorable acronym, its usage has been sustained as a tool for assessing alternatives and complex decision situations (Helms & Nixon, 2010).

The survey: case of Turkey

In November 2019, an online survey study was conducted to determine the current energy service market situation in Turkey from the viewpoints of EVD companies. Out of 45 EVD, active in the market, 13 companies participated in the survey study. Table 8 in the Appendix represents the details of EVD companies participating in the survey.

In the survey, to reveal the current situation of the energy service market and to evaluate the energy service market success, EVD companies were asked about their opinions and practices on; control authority of the Turkish energy service market, sectors and sub-sectors carrying out the audit and implementation projects, possible measures and energy-saving potentials determined after audits, the main focus of implementation projects, and major financing sources in audits and implementation projects. Survey questions and obtained responses are given in Table 6.

In the survey, open-ended questions were also asked to understand EVDs' general views on the energy service market. In this part of survey, EVD companies state their opinions about the market and recommendations for the market success. Key thoughts of EVD companies are listed below:

- EVD-1 (Building and Industry): For strategies and targets in NEEAP to be realized, the relevant institutions and customers must become willing to receive EE services, except for legal obligations, and understand their importance.
- EVD-2 (Building): The work done so far has neither revitalized the sector nor increased awareness.
- EVD-3 (Building): It mostly serves in commercial and public buildings. Among the facilities, it can be stated that hospitals consume more energy than various small industrial enterprises and they need external support for energy management. However, it is not possible to do anything other than cost-free projects within the scope of EE projects in commercial buildings like hospitals. These customers often postpone the issue of energy efficiency audits every year, stating that they have no budget. Unfortunately, EVDs have to depend on customers for financing.
- EVD-4 (Building): EE law must be fully implemented. This market should be strengthened by the audits and implementation projects to be systematic, controlled to have a common voice and common purpose.
- EVD-5 (Industry): There are still customers who do not have clear information. Solutions should be found to eliminate the problems of measuring savings, investment financing, and guaranteeing the permanence of savings. ESCOs will not exist without a direct savings business model. Instead of legal enforcement, market compliance and win–win strategy must be considered. Besides, studies should be carried out for EVDs to communicate with each other and to increase their knowledge and skill sharing.
- EVD-6 (Industry): Considering the EE potential in the industrial sector, it can be observed that EVD companies work successfully. However, the work of EVD companies should be audited to maintain the service quality.
- EVD-8 (Building): The key problems in the market can be listed as; the lack of EE awareness and insufficient incentives / financing for the implementation projects.
- EVD-9 (Building): While public support is provided to the industrial sector, there is no specific support for the building sector. In this sense, providing such a support to the building sector will benefit the development of the energy service sector.
- EVD-10 (Building & Industry): Most EVD companies are not capable of making implementation projects. In this respect, the potentials that arise as a result of audits may not be realistic.

Table 6 Survey questions and replies by the experts

Survey questions	Answers	
What are the main *sectors* that you are interested in as EVD?	• Building: 54% • Industry: 15% • Multiple: 31%	
What are *energy efficiency measures* determined as a result of the industry and/or building sector studies you have conducted? (from most to less)	*Building* 1. Heat insulation 2. Use of EV Technologies 3. Efficiency in lighting systems 4. Efficiency in heating, cooling and air conditioning (HVAC) systems 5. Integration of renewable energy sources 6. Efficiency in motor systems 7. Awareness and behavior change	*Industry* 1. Efficiency in motor systems 2. Use of EE Technologies 3. Integration of renewable energy sources 4. Efficiency in lighting systems 5. Heat insulation 6. Awareness and behavior change
What is the main focus of your *implementation projects*? (from most to less)	1. Efficiency in HVAC systems 2. Efficiency in motor systems 3. Efficiency in lighting systems 4. Heat insulation 5. Integration of renewable energy Sources 6. Awareness and behavior change 7. Use of EV Technologies	
What are the energy-saving potentials that can be realized as a result of the audit studies you have conducted?	*Building* 20–70%	*Industry* 20–90%
What are the achieved savings in implementation projects you have made?	*Building* 10–50%	*Industry* 15–30%
What is your primary *financing* source for energy efficiency implementation projects?	• EVDs' resources: 38% • Customer resources: 54% • No implementation projects: 8%	
Which financing methods would you *recommend for implementation projects*?	• Energy efficiency fund: 54% • Energy performance contracting: 31% • Public supports: 15%	
Who should *control* the energy service market?	• MENR: 31% • Possible energy agency: 46% • An Umbrella Organization that includes EVDs: 23%	

- EVD-11 (Industry): EE and management studies in the industry are not effective except the big scale industrial facilities. The majority of projects in the market are done reluctantly to meet certain requirements.
- EVD-12 (Building & Industry): Customers want qualified EE service; however, they cannot take the risk to allocate a budget for this. For this reason, solutions directed to financing will activate the market by the realization of projects that guarantee high efficiency and will convince end users to receive EE services from a professional company like an EVD.
- EVD-13 (Building): Building sector is an important player in the energy service sector, but the current legislation has excluded the buildings from the scope of supports /incentives.

After exploring the obtained responses from the survey, in order to estimate the energy service market success, BBN and to determine the current pros and cons of the current market situation for

developing future prospects, SWOT analysis are used.

BBN analysis

The main purpose of the BBN analysis is to reveal the current success of the Turkish energy service market and to identify the main factors affecting this success. While analyzing the energy service market survey, for more practical and understandable analysis the structure of energy service market of Turkey was examined on five factors which are sectors to be served, control authority/mechanism of the market, EE measures determined after audit studies, implementation projects, financing methods for both audits and implementation projects. In the survey, EVD companies were asked the impact of these factors on the energy service market success and each other. According to the survey results, factors that can have an impact on the energy service market success and interrelationships among factors were identified and their relations are shown in Fig. 5.

The causal map shows the following points:

- The financing method is affected by the control authority of the energy service market
- EE measures are affected by sectors
- Implementation projects are affected by EE measures and sectors
- All factors affect the system success

While causal map shows all relations/effects among factors BBN presents only direct effects. "Netica Bayes Network Modelling Program" was used as a tool for BBN analysis and how these factors affect the success of the energy service market was investigated (Fig. 6).

Considering BBN results based on the survey, in the current situation of the energy service market in Turkey, the success of the market is 57.7%. In other words, the energy service market of Turkey, under the control of the MENR, with its focus sectors, EE measures, and implementation projects is approximately 58% successful. In the BBN analysis, the energy service market success was observed by changing the probability values of the factors and options (observed from Fig. 6) by means of scenario analysis, and the factors having more impact on the success were determined. Therefore, it can be concluded that financing methods together with the number of the implementation project are identified as the main factors affecting the energy service market success. Besides, increasing implementation projects in the building sector, diversification of the implementation of EE measures, especially energy-efficient technology use, renewable energy integration and behavior change, and activating efficient financing are important to achieve higher market success.

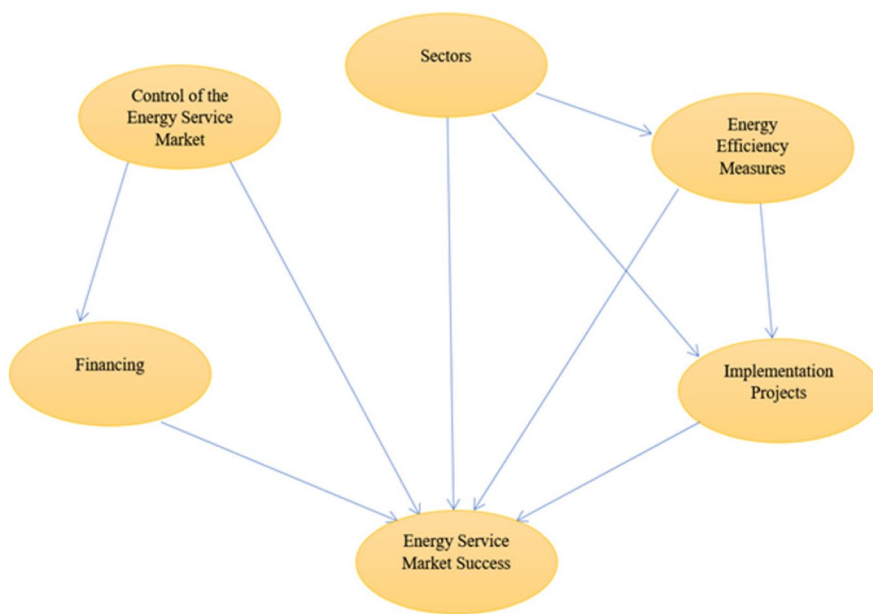

Fig. 5 Causal map of energy service market in Turkey

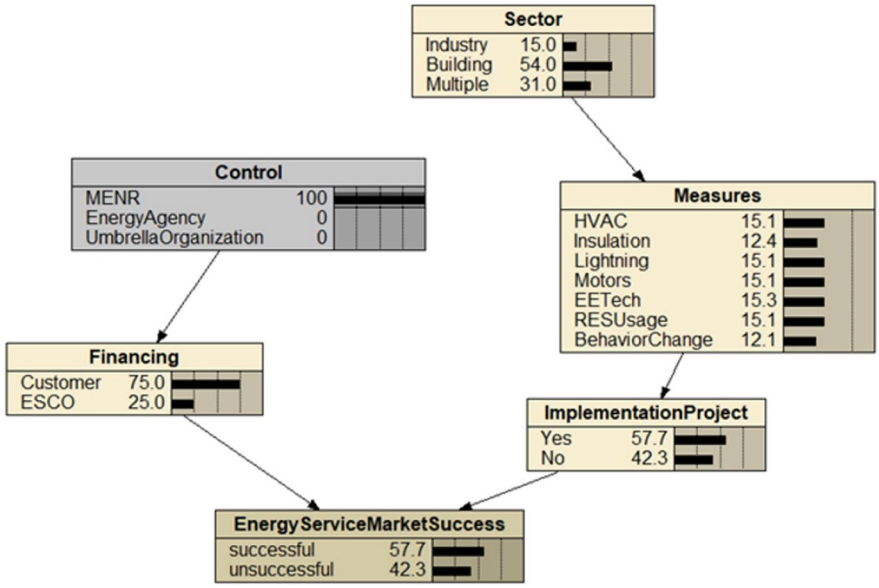

Fig. 6 BBN analysis for the energy service market in Turkey

SWOT analysis

Considering the development of the EVD market starting from 2010, the conducted EVD survey and the SWOT analysis were made to analyze the current situation of the Turkish energy service market and to develop recommendations for policymakers to make strategic planning. Table 7 summarizes the SWOT analysis of the current Turkish energy service market.

Results and discussion

Within the scope of this study, research and survey studies were conducted to understand, analyze, and present to the literature the current status of the Turkish energy service market.

When the evolution of Turkey's energy services market, its existing legal rules and regulations, and the actions in the market are examined, it seems that the market is mostly affected by economic changes and uncertainties. Turkey is dependent on foreign EE technologies and unfortunately, fluctuations in currency exchange rates had a negative impact on energy efficiency EE actions. On the other hand, being dependent on the imported energy resources can indicate the importance of using energy, efficiently. Hence, changing the dynamics of the market has been a significant uncertainty factor for the market stability. However, new and updated regulations have been prepared for the energy service market and NEEAP actions involving EVD companies have been determined. These are encouraging policies that can strengthen and develop the Turkish energy service market.

When the survey results are examined, EVD companies stated that the control of the ESCO market would be crucial to energy service market success and they want that the main control of the energy service market should be a possible National Energy Agency. Currently, the control authority of the Turkish energy service market is MENR. But, EVD companies want an energy agency as a control authority instead of a governmental institution. Although the number of EVD companies serving in the building sector is higher, the projects have not developed much due to the lack of financing. EVD companies mostly use their or customers' resources for the financing of audit studies and implementation projects. According to the survey, EVD companies want a National Energy Efficiency Fund and EnPC applications for the major financing source. According to EVD companies' calculations, the difference between calculated and realized energy savings in audit studies and implementation projects, respectively, is quite high and it should be reduced immediately. Also, the quality of audit studies and implementation projects needs to be improved. To

Table 7 SWOT analysis of Turkish EVD market

Strengths: • Presence and revision of legislation • Mandatory energy efficiency audits • Mandatory ISO 50,001 Energy Management System establishment for governmental incentives • Defined incentives for at least the industry sector • In the market, about 25 EVD companies continuously acting since 2009 meaning sustainability • Training of technical staff through EE manager, EE audit-project topics • Presence of concrete NEEAP targets • The presence of ENVER Portal which is mean of properly collected, analyzed, and used as a data bank and reference studies for specific sectors to determine EE measures easily • The decision on the procedures and principles of energy performance contracts in the public sector • Learning not only from know-how but also by doing	Weakness: • Wide scope energy efficiency legislation which is very difficult to implement • Lack of governmental incentives for the building sector • National energy efficiency fund is desired but not in the scope of new revisions • Due to economic fluctuation, high investment cost for the initial development (currency issues) • Not very efficiently utilized EE evaluation tools (i.e., building energy performance) • EE projects are considered "high risk" • Insufficient capacity of financing institutions • Lack of measurement and verification experts • Due to the need for monitoring after the termination, long implementation periods of EE projects (10–15 years) which is unusual for Turkey (i.e., max. 3–5 years in Turkey) • Lack of awareness by the customers (they usually want to see best practices as real examples of gains) • Lack of project financing and other requirements for EnPC • Lack of understanding behavior changes and non-energy benefits towards energy efficiency • The dependency on imported energy-efficient technologies
Opportunities: • Variety of international financial institutions allocating funds for Turkish market improvement • If best practice projects can be possible for the new EE technology applications, there is a big chance to widespread easily • Very few examples of the studies including an increase in buildings' energy performance hence it is an open area • Opportunity for a good example of EnPC especially in public buildings with minimum 15% energy saving target in 2023 by Presidency Circular dated 15/08/2019 and No. 2019/18 • Revisions regarded measurement and verification protocols • Presence of national smart cities strategy and action plan by Ministry of Environment and Urbanism towards 2023 • Improvements to reach the NEEAP targets	Threats: • The economic situation in Turkey • Due to not effective usage of international funds, the threat of resignation of related institutions for the Turkish market • Risk of large companies to finish their EVD activities in the market due to economic fluctuations • Risk of inaccurate evaluation of energy efficiency performance because of inefficient tools, (current energy performance evaluation tools could not cover all types of buildings not only in Turkey but also in Europe) • In NEEAP, for some applications, the duration for the realization is very close could bear risks of not performing them • Not yet fully formed independent control bodies for measurement and verification of the implementation projects

solve these issues, EnPC applications should be brought along with measurement and verification and independent control bodies (Nolden & Sorrell, 2016). Thus, reliability, quality, and common standards are ensured in the energy service market.

Instead of getting the benefit of the EE potential and measures that emerge in the audit studies, it is seen that EVD companies are more prone to making familiar and less costly implementation projects. For this reason, new projects that integrating renewable energy, EE technologies, and behavior change should be disseminated, in addition to application projects such as efficiency in HVAC systems, efficiency in motor systems, and efficiency in lighting systems, which EVD companies mostly apply.

To interpret the key thoughts of EVD companies, it is seen that there is a general dissatisfaction. Many EVD companies complain about the lack of awareness of the customers. Moreover, EVD companies desire to be understood, appreciated, and supported in many ways. EVD companies think that the current situation of the energy service market is not sufficient, as the potential of the market does not be utilized. When the general views of EVD companies are surveyed, the issue about the quality of audit studies and implementation projects draws attention. For the EE audit and implementation projects, EVD companies hope for the quality to be enhanced, controlled and adhered to a common standard. Besides, one of the main problems of EVD companies is financing

especially for the building sector. It is an important reason for dissatisfaction in the market that there are financial supports for the industrial sector but not for the building sector by addressing the underexplored potential for not only improvements in operational building energy performance but also assessing the high energy saving potentials (Papachristos, 2020).

As a result of the BBN analysis, the current success of the Turkish energy service market has been revealed as 58% and the financing mechanisms and implementation projects have been identified as the most important factors. The survey results reflecting the views of EVD companies and the BBN analysis are consistent indicating the accuracy of the analysis. The obtained responses and the results of the BBN are presented by means of SWOT analysis reflecting the current situation of the energy service market.

Conclusion

This study can be regarded as pioneer research including analysis of the current situation of the Turkish energy service market and examination of the market success from the viewpoints of EVD companies. As a decision-making tool with limited data, Netica Bayes Network Modelling Program was used for the analysis of the survey results. As a practical tool for strategic planning and management, SWOT analysis was also used to evaluate the Turkish energy service market from different sights. When outputs of the study are considered together with the recent improvements in the regulations, the following advances in the Turkish energy service market can be indicated:

- 25 EVD continue their activities in the market starting from 2009.
- The building sector is mostly preferred due to diversified characteristics, such as residential, commercial, service, and public buildings. Moreover, EVD companies are active in the energy performance certification of the buildings. And also, industrial enterprises, especially the larger ones, have their energy managers. On the other hand, in the new revision of ENVER Regulation, it is declared that certified experts of EVD companies can serve as an energy manager for industry and building sectors, this means for small and medium-sized enterprises, EVD can be more active, as well.
- In 2020, the amount of governmental incentives (VAP and voluntary agreements) are increased. This is also important for more varied projects including a combination of different measures, process changes for being more efficient, and integration of renewable energy.
- EnPC was started to be applied in various projects. Governmental/public buildings are included in audit and implementation projects' scope by the revision of the related regulation. Additionally, audit obligation is stated in 2020, implying their energy-saving potentials can be determined and more implementation projects can be made.
- For controlling the quality of the audits and implementation projects, measurement and verification training is going to be started by MENR.
- The energy efficiency portal by MENR has started to be used more actively and more publicly available reports are produced by the government to see the changes in the market on a sectoral basis.

Considering the progress and the potential of the Turkish energy service market, to be evaluated, it should be noted that criticizing constructively is always better than being destructive. All strengths, weaknesses, opportunities, and threats should be integrated based on planning, doing, controlling, and acting phases of the management for further improvement of the Turkish energy service market. Moreover, energy efficiency together, current hot topics such as "carbon neutrality," "circular economy," "big data," "digitalization," and "industry 4.0," can be regarded as the central driver of innovation for the energy service market. Therefore, it presents not only a central challenge but all opportunities considering the following concerns:

- New sufficient policy strategies based on measurement, data analysis, verification, and continuous monitoring for sustainable business areas along the value chains
- A clear direction for major technology and infrastructure investments in the market
- The establishment of climate-neutral and circular value chains in the energy service market

- An integrated comparative climate, energy, economic, and social policies as a central component of sustainability.

For further improvement of the energy service market in Turkey, the outputs of the study can be used to improve the related regulations and the NEEAP actions, especially the establishment National Energy Efficiency Fund as well as National Energy Agency. Moreover, to increase the success in the market, best practices with regard to EnPC and different financial instruments like cooperative financing and crowdfunding usage in EVD companies' applications for various sub-sectors will be presented, verified by the measurement and verification tools and disseminated within the country. Insurance systems are also significant for the reliability of the energy efficiency implementations. With all of these, a more stable market could be possible. Also, for the countries having a new ESCO market, the outputs of the study could be beneficial to establish regulations, standards, implementations, and the market itself. Achievements of this study will open a new work field to academics, energy sector participants, especially ESCOs, and energy policy-makers. Thus, the success of the energy service market is prompted.

Acknowledgements This study was performed under a European Union project entitled "Strengthening Communication and Data Sharing Network among Energy Efficiency Stakeholders" is leaded by Energy Efficiency and Management Association (EYODER) under EuropeAid//139044/ID/ACT/TR.

The authors declare that they have no conflict of interest.

Appendix

Table 8 Details of EVD companies participating in the survey

EVD	Sector	Sub-sectors
EVD-1	Industry and Building	Energy, Metal, and Trade (Sales and Marketing)
EVD -2	Building	Residential
EVD -3	Building	Automotive, Health and Social Services, Community and Personal Services, Tourism, Hospitality, Food and Beverage Services
EVD -4	Building	Construction and Residential
EVD -5	Industry	Energy
EVD -6	Industry	Woodworking, Paper, Glass, Cement and Soil, Energy, Food, Chemical, Petroleum, Rubber and Plastic, Mining, Metal, Automotive, Textiles, ready-made clothing, Leather, Tourism, Hospitality, Food and Beverage Services
EVD -7	Building	Construction
EVD -8	Building	Energy and Residential
EVD -9	Building	Information Technology, Residential
EVD -10	Industry and Building	Woodworking, Paper, Glass, Cement and Soil, Education, Electric—Electronics, Energy, Food, Chemical, Petroleum, Rubber and Plastic, Mining, Metals, Automotive, Health and Social Services, Textiles, ready-made clothing, Leather
EVD -11	Industry	Glass, Cement and Soil, Education, Energy, Metal, Automotive, Textiles, Clothing, Leather
EVD -12	Industry and Building	Woodworking, Paper, Glass, Cement and Soil, Electric—Electronics, Energy, Food, Business and Management, Chemical, Petroleum, Rubber and Plastic, Mining, Metal, Automotive, Textiles, ready-made clothing, Leather
EVD -13	Building	Information Technology, Energy, Residential, Culture & Arts, and Design, Health and Social Services, Tourism, Hospitality, Food, and Beverage Services

References

Abdoli, M., & Choobineh, F. F. (2005). Empirical Bayes forecasting methods for job flow times. *IIE Transactions*. https://doi.org/10.1080/07408170590948495.

Aguilera, P. A., Fernández, A., Fernández, R., Rumí, R., & Salmerón, A. (2011). Bayesian networks in environmental modelling. *Environmental Modelling & Software*. https://doi.org/10.1016/j.envsoft.2011.06.004.

Akman, U., Okay, E., & Okay, N. (2013). Current snapshot of the Turkish ESCO market. *Energy policy*. https://doi.org/10.1016/j.enpol.2013.04.080.

Asan, U., Bozdağ, C. E., & Polat, S. (2004). A fuzzy approach to qualitative cross impact analysis. *Omega*. https://doi.org/10.1016/j.omega.2004.02.006.

Basak, E., Asan, U., & Kadaifci, C. (2012). Analysis of the energy service market in turkey using the fuzzy dematel method. In *Proceedings of the 10th International FLINS Conference on Uncertainty Modelling in Knowledge Engineering and Decision Making*. https://doi.org/10.1142/9789814417747_0010.

Bashar, A., Parr, G. P., McClean, S. I., Scotney, B. W., Subramanian, M., Chaudhari, S. K., & Gonsalves, T. A. (2010). Employing Bayesian belief networks for energy efficient network management. In *2010 National Conference on Communications, IEEE*. https://doi.org/10.1109/NCC.2010.5430172.

Bertoldi, P., Rezessy, S., & Vine, E. (2006). Energy service companies in European countries: Current status and a strategy to foster their development. *Energy Policy*. https://doi.org/10.1016/j.enpol.2005.01.010.

Bertoldi, P., & Boza-Kiss, B. (2017). Analysis of barriers and drivers for the development of the ESCO markets in Europe. *Energy Policy*. https://doi.org/10.1016/j.enpol.2017.04.023.

Cheon, S. P., Kim, S., Kim, J., Kim, C. (2008). Learning Bayesian networks-based diagnosis system for wastewater treatment process with sensor data. *Water Science and Technology*. https://doi.org/10.2166/wst.2008.839.

Cinar, D., & Kayakutlu, G. (2010). Scenario analysis using Bayesian networks: A case study in energy sector. *Knowledge-Based Systems*. https://doi.org/10.1016/j.knosys.2010.01.009.

DEEE. (2019). *Enerji Verimliliği Danişmanlik Şirketleri 2015–2018 Dönemi Faaliyet Raporu. Enerji ve Tabii Kaynaklar Bakanlığı Enerji Verimliliği ve Çevre Dairesi Başkanlığı*. Can be downloaded at http://www.yegm.gov.tr/duyurular_haberler/document/EVD_2015_2018_Donemi_Faaliyet_Raporu.pdf. Accessed 05 Apr 2020

Directive. (2006). 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC. Can be downloaded at https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32006L0032.

Dursun, E., & Bertoldi, P. (2015) ESCO market in Turkey: Challenges and opportunities. In *2015 IEEE 15th International Conference on Environment and Electrical Engineering (EEEIC)*. https://doi.org/10.1109/EEEIC.2015.7165532.

ENVER. (2011). *Enerji Kaynaklarının ve Enerjinin Kullanımında Verimliliğin Artırılmasına dair Yönetmelik, Resmi Gazete No: 28097, 27 Ekim 2011*. Can be downloaded at https://www.resmigazete.gov.tr/eskiler/2011/10/20111027-5.htm.

ENVER. (2020). *Enerji Kaynaklarının ve Enerjinin Kullanımında Verimliliğin Artırılmasına dair Yönetmelikte Değişiklik Yapılmasına dair Yönetmelik, Resmi Gazete No: 31019, 25 Ocak 2020*. Can be downloaded at https://www.resmigazete.gov.tr/eskiler/2020/01/20200125-27.htm.

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*. https://doi.org/10.1016/j.enpol.2003.08.008.

Gran, B. A., & Helminen, A. (2001). A Bayesian belief network for reliability assessment. In *International Conference on Computer Safety, Reliability, and Security*. https://doi.org/10.1007/3-540-45416-0_4.

Gürel, E., & Tat, M. (2017). SWOT analysis: a theoretical review. *Journal of International Social Research*, *10*(51). https://doi.org/10.17719/jisr.2017.1832.

Hanea, D. M., Jagtman, H. M., Van Alphen, L. L. M. M., Ale, B. J. (2010). Quantitative and qualitative analysis of the expert and non-expert opinion in fire risk in buildings. *Reliability Eng. & System Safety*. https://doi.org/10.1016/j.ress.2010.02.011.

Helms, M. M., & Nixon, J. (2010). Exploring SWOT analysis–where are we now? A review of academic research from the last decade. *Journal of Strategy and Management, 3*, 215–251. https://doi.org/10.1108/17554251011064837

IEA. (2016). Energy Policies of IEA Countries: Turkey 2016 review. Can be downloaded at https://webstore.iea.org/energy-policies-of-iea-countries-turkey-2016-review. Accessed 15 June 2020

Jensen, F. V. (2001). *Bayesian networks and decision graphs*. Springer-Verlag.

Johansson, F., & Falkman, G. (2008). A Bayesian network approach to threat evaluation with application to an air defense scenario. In *2008 11th International conference on information fusion, IEEE*. https://doi.org/10.1109/ICIF.2008.4632368.

Kadaifci, C., Kucukyazici, G., Asan, U., & Bozdag, E. (2014). Dynamic modelling of critical factors in energy service contracting using fuzzy time cognitive mapping. In *Proceedings of the Global Conference on Engineering and Technology Management 2014 (Istanbul, Turkey),* June pp. 23–26.

Kayakutlu, G., Daim, T., Kunt, M., Altay, A., & Suharto, Y. (2017). Scenarios for regional waste management. *Renewable and Sustainable Energy Reviews*. https://doi.org/10.1016/j.rser.2016.11.147.

Landuyt, D., Broekx, S., D'Hondt, R., Engelen, G., Aertsens, J., Goethals, P. L. M. (2013). A review of Bayesian belief networks in ecosystem service modelling. *Environmental Modelling & Software*. https://doi.org/10.1016/j.envsoft.2013.03.011.

Lee, C., Song, B., Cho, Y., & Park, Y. (2010). A Bayesian belief network approach to operationalization of multi-scenario technology roadmap. In *PICMET 2010*

TECHNOLOGY MANAGEMENT FOR GLOBAL ECONOMIC GROWTH, IEEE, pp. 1–6.

Liu, G., Zheng, S., Xu, P., & Zhuang, T. (2018). An ANP-SWOT approach for ESCOs industry strategies in Chinese building sectors. *Renewable and sustainable energy reviews*. https://doi.org/10.1016/j.rser.2018.03.090.

Marino, A., Bertoldi, P., Rezessy, S., & Boza-Kiss, B. (2011). A snapshot of the European energy service market in 2010 and policy recommendations to foster a further market development. *Energy Policy*. https://doi.org/10.1016/j.enpol.2011.07.019.

Neapolitan, R. E. (2004). *Learning Bayesian networks (Vol. 38)*. Pearson Prentice Hall.

NEEAP. (2018). *National Energy Efficiency Action plan 2017–2023. Department of Energy Efficiency and Environment*. Can be downloaded at http://www.yegm.gov.tr/document/20180102M1_2018_eng.pdf. Accessed 15 June 2020

NEEAP. (2019). *2017–2018 Development Report of National Energy Efficiency Action Plan. Department of Energy Efficiency and Environment*. Can be downloaded at https://www.enerji.gov.tr/File/?path=ROOT%2f1%2fDocuments%2fSayfalar%2fUlusal+Enerji+Verimlili%c4%9fi+Eylem+Plan%c4%b1(2017-2018)+Geli%c5%9fimi+%c3%96zet+Raporu.pdf. Accessed 15 June 2020

NEEAP. (2020). *National Energy Efficiency Action Plan 2019 Progress Report, Department of Energy Efficiency and Environment*. Can be downloaded at https://enerjiapi.etkb.gov.tr//Media/Dizin/EVCED/Raporlar/Ulusal%20Enerji%20Verimlili%C4%9Fi%20Eylem%20Plan%C4%B1/NEEAP%20Progress%20Report%202019.pdf. Accessed 15 June 2020

Nolden, C., & Sorrell, S. (2016). The UK market for energy service contracts in 2014–2015. *Energy Efficiency, 9*, 1405–1420. https://doi.org/10.1007/s12053-016-9430-2.

Nurcahyanto, Simsek, Y., & Urmee T. (2020) Opportunities and challenges of energy service companies to promote energy efficiency programs in Indonesia. *Energy*. https://doi.org/10.1016/j.energy.2020.117603.

Okay, N., & Akman, U. (2010). Analysis of ESCO activities using country indicators. *Renewable and Sustainable Energy Reviews, 14*(9), 2760–2771. https://doi.org/10.1016/j.rser.2010.07.013.

Okay, E., Okay, N., Konukman, A. E. Ş., & Akman, U. (2008). Views on Turkey's impending ESCO market: Is it promising? *Energy Policy*. https://doi.org/10.1016/j.enpol.2008.02.024.

Onaygil, S., & Acuner, E. (2007). Energy efficiency consulting companies: An overview of the current situation in the world. *Energy Efficiency Congress, 6*, 41–54.

Papachristos, G. (2020). A modelling framework for the diffusion of low carbon energy performance contracts. *Energy Efficiency, 13*, 767–788. https://doi.org/10.1007/s12053-020-09866-4.

Phillips, P. P., Aaron, B. C., Phillips, J. J. (2013). *Survey: basics*. Series: ASTD training basics series. American Society for Training & Development.

Republic of Turkey. (2019). *The eleventh development plan*. Can be downloaded at http://www.sbb.gov.tr/wp-content/uploads/2019/07/OnbirinciKalkinmaPlani.pdf. Accessed 10 Aug 2020

Roshchanka, V., & Evans, M. (2016). Scaling up the energy service company business: market status and company feedback in the Russian Federation. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2015.05.078.

Sarsby, A. (2016). *Swot analysis: A guide to Swot for business studies students.* Leadership Library.

Sorrell, S. (2007). The economics of energy service contracts. *Energy policy*. https://doi.org/10.1016/j.enpol.2005.12.009.

Vine, E. (2005). An international survey of the energy service company (ESCO) industry. *Energy Policy*. https://doi.org/10.1016/j.enpol.2003.09.014.

Vine, E., Nakagami, H., & Murakoshi, C. (1999). The evolution of the US energy service company (ESCO) industry: from ESCO to Super ESCO. *Energy*. https://doi.org/10.1016/S0360-5442(99)00009-2.

Wang, X. H., Zheng, B., Good, W. F., King, J. L., & Chang, Y. H. (1999). Computer-assisted diagnosis of breast cancer using a data-driven Bayesian belief network. *International journal of medical informatics*. https://doi.org/10.1016/S1386-5056(98)00174-9.

Yang, C. C., Soh, C. S., & Yap, V. V. (2018). A systematic approach in appliance disaggregation using k-nearest neighbours and naive Bayes classifiers for energy efficiency. *Energy Efficiency*. https://doi.org/10.1007/s12053-017-9561-0.

Yanmaz, Ö., Kadaifci, C., Asan, U., and Bozdag, E. (2018). A systematic approach to the analysis of barriers and drivers of the ESCO market in Turkey. In *Energy Management—Collective and Computational Intelligence with Theory and Applications* (pp. 405–426). Springer. https://doi.org/10.1007/978-3-319-75690-5_18.

Zhao, Y., Xiao, F., & Wang, S. (2013). An intelligent chiller fault detection and diagnosis methodology using Bayesian belief network. *Energy and Buildings*. https://doi.org/10.1016/j.enbuild.2012.11.007.