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ORIGINAL ARTICLE

Analysis of energy efficiency obligation scheme implementation in Turkey

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Abstract To achieve energy efficiency and to develop supporting policy tools have become priorities worldwide. In this respect, one of the important energy efficiency policy tools is Energy Efficiency Obligation Scheme (EEOS). Turkish Government, dealing with regulations about energy efficiency since 2007, has placed EEOS in the current agenda in parallel with the global improvements. The authorities agree that EEOS could be a proper mechanism for Turkey to achieve its targets on energy efficiency. This study aims to propose a possible basic EEOS structure for Turkey as well as to present a comparative analysis of the design and implementation of the EEOS's best practices and key issues. Hence, in addition to the review of the EEOS, currently active in the European Union (EU), proper alternatives for Turkish EEOS were enlightened through expert analysis. In order to evaluate the expert opinions, Bayesian Belief Network (BBN) is implemented as a framework for uncertainty. The possible basic structure of Turkish EEOS, involving responsible authorities, related parties, support mechanisms, and basic properties of the scheme, is constructed according to experts' opinions. Related BBN analysis reveals the success probability of this structure as about 84%. Moreover, for the improvement of this success, the following implications can be considered from the best practices in the EU: the scheme must be compatible with the country's specific circumstances and have flexibility in application, promotive opportunities, and deterrent penalties and should be open for improvement.

Keywords Energy Efficiency Obligation Scheme · Bayesian Belief Network · White certificates

Introduction

Energy efficiency is a commitment reflecting sustainability comprising monetary saving, energy consumption reduction, environmental, and social benefits. In this respect, energy efficiency is a priority for countries willing to meet their energy policy goals according to global, international, and national agreements. Efficiency is central for making progress on decarbonization while also fostering energy security as well as economic, technical, and social developments, and it is recognized as the "first fuel" by the world (Rosenow et al. 2017).

The EU is dedicated to develop a sustainable, competitive, secure, and decarbonized energy system. In 2007, the European Council adopted ambitious energy and climate change objectives for 2020 to reduce greenhouse gas emissions by 20%, to increase the share of renewable energy to 20%, and to reach 20% energy efficiency as compared with 1990 levels. To make a significant contribution to meet the EU's 2020 energy efficiency target as well as to set a common framework to promote energy efficiency in the Union beyond 2020, Energy Efficiency Directive (EED) 2012/27/EU entered

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into force on December 4, 2012. The EED presents legally binding measures for all Member States to increase efficiency at all stages of the energy chain. Article 7 of the Directive requires Member States to establish Energy Efficiency Obligations Scheme (EEOS) or alternative policy measures, such as energy/carbon taxes, financial incentives, and voluntary agreements that lead to increased use of energy-efficient technology, etc., to reduce final energy consumption. EEOS is a mechanism obliging the energy companies (distributors, suppliers, retailers, etc.) to sell energy to end-users, to perform energy efficiency actions on consumers. This scheme requires energy companies to achieve yearly energy savings of 1.5% of annual sales to final consumers. To reach this target, companies need to carry out measures that help final consumers to improve energy efficiency. This may include improving the heating system at consumers' homes, installing double glazed windows, or better insulating roofs to reduce energy consumption. From the energy supplier to the distributor, from material and equipment manufacturers to energy service providers, EEOS can activate all the rings of the energy supply chain (Directive 2012).

Towards the end of the 2020 goals period, the Energy Union Strategy established ambitious objectives for 2030 which are to reduce greenhouse gas emissions by at least 40%, to increase the share of renewable energy to at least 32%, and to improve energy efficiency at least 32.5% as compared with 1990 levels (European Commission 2019). The amended EED Directive ((EU) 2018/2002) establishes a headline target of at least 32.5% energy savings at the EU level by 2030. In other words, the amended EED requires member states to achieve cumulative end-use energy savings at least equivalent to new savings each year from January 1, 2021 to December 31, 2030 of 0.8% of annual final energy consumption, averaged over the most recent 3-year period before January 1, 2019 (Directive 2018).

The EED 2012 requires Member States to prepare national energy efficiency action plans (which state how Member States will meet their EED savings targets) and renew by reviewing once every three years periodically (Directive 2012). Turkey, being an official EU candidate state since 1999, has closely followed developments in international conjuncture (Republic of Turkey Ministry of Foreign Affairs 2020). Similar to the EU, 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. The National Energy Efficiency Action Plan (NEEAP) of Turkey was prepared in compliance with the template set in the EED 2012 which allows for comparing and monitoring studies with the EU countries, in 2018 (Republic of Turkey Ministry of Energy and Natural Resources 2018). The introduction of the NEEAP of Turkey is a significant step in harmonizing with the EU in terms of energy efficiency policies. Moreover, the NEEAP of Turkey is prepared as consistent with principles in 2023 goals and national target policy documents (such as strategy papers, development plans) (Republic of Turkey Ministry of Energy and Natural Resources 2018).

EEOS was mentioned clearly in the NEEAP of Turkey (Republic of Turkey Ministry of Energy and Natural Resources 2018). EEOS is a new and hot topic for Turkey. In this context, the core objective of this study is to provide an approach to introduce EEOS in Turkey by presenting and comparing the existing best practices in the EU Member States. Moreover, this study aims to develop recommendations to help policymakers in Turkey and to create a new vision for researchers. Besides, this work intends to contribute to the literature by proposing a possible EEOS structure alternative based on experts' opinions. Furthermore, this study could provide an example for other countries that would like to establish the EEOS. With this aim, an expert survey was conducted and Bayesian Belief Network (BBN) method was used for evaluating the survey results. BBN is a useful tool for modelling uncertainty, and it has a dynamic approach that is inevitable to analyze the complex system. BBN combines the probabilistic and causal semantics and it allows us to investigate a problem in a wide frame by causal relations. It is also helpful in integrating expert knowledge and data. The main reason for selecting this method for the analysis is that BBN enables to construct possible structures, to create scenarios, and to observe basic consequences of any strategic change (Cinar and Kayakutlu 2010). At the end of this study, the basic structure of possible Turkish EEOS, how successful the scheme could be, and which parameters would be more important for the scheme was revealed based on the experts' opinions.

Consequently, in "Review of EEOS studies" details of EEOS applications are examined and summarized. In "Current status of energy efficiency in Turkey," current energy efficiency studies in Turkey are explained. In "Analysis method: Bayesian Belief Networks," the methodology of the study is stated and the structure of

the possible Turkish EEOS is discussed in "Case study: Turkey." "Results and discussion" comprises a discussion by comparing the obtained results and the best practices in the EU Member States. As a conclusion, in "Conclusion," final remarks and suggestions for further studies are listed.

Review of EEOS studies

EEOS is a legislative mechanism that places requirements on obligated parties to meet quantitative energy savings targets across their customer portfolio. But it is also a market-based instrument that does not prescribe the measures to be deployed obligated parties through given freedom to choose the measures and delivery routes that work best for them within the constraints defined by the scheme administrator (EBRD 2019).

In the United States of America (USA), utility end-use energy efficiency schemes, which are defined as EEOS in Europe, were first implemented following the energy crisis of 1973. Although the motivation for EU schemes has a strong focus on the environmental benefits from energy savings, the USA focuses more on energy security and economic efficiency concerns. Both schemes include end-use savings and typically in all end-use sectors (Waide and Buchner 2008). In Europe, the United Kingdom (UK) is the first country that established EEOS as Supplier Obligations. Italy, Denmark, France, and Bulgaria implemented their EEOS after the UK. With EED in 2012, other EU countries started to implement their country-specific EEOS (Broc et al. 2015). Currently, 15 EU Member States (Austria, Bulgaria, Croatia, Denmark, France, Greece, Ireland, Italy, Latvia, Luxemburg, Malta, Poland, Slovenia, Spain, and the UK) are implementing the EEOS. Besides, Estonia decided to use only alternative measures to meet its target for Article 7 in EED and Lithuania voted a new energy efficiency law in November 2016 reinforcing the Voluntary Agreement together with the energy companies started in 2010 (Deconninck et al., 2017). In addition, the law for regulating the EEOS in Cyprus is under legal vetting by the Law Office of the Republic of Cyprus. The adoption of EEOS in Cyprus is expected to be in 2020 (Broc et al. 2020).

After the EU Energy Efficiency Directive, Croatia has preferred an alternative approach including a combination of alternative policy measures (carbon taxes, energy renovations, energy management, etc.) and energy efficiency obligation schemes. Up to now, alternative policy measures were implemented in Croatia (Republic of Croatia 2017). In April 2019, the ordinance on EEOS has been additionally adopted, fully prescribing the functioning of the EEOS. In the period from 2021 until 2030, as envisaged in the draft National Energy and Climate Plan, the EEOS will continue its operation to deliver 50% of Article 7 target in Croatia (Broc et al. 2020).

Malta's obligation scheme is a very special case since it has a single electricity distributor, the small size of petroleum distribution companies, and no natural gas or district heating and cooling networks. This situation considerably limits the range of measures available to meet the energy savings obligations in Malta. Enemalta Corporation is the only distribution system operator and the only licensed electricity supply company in Malta. Malta preferred to achieve its Article 7 target by establishing an obligation scheme on Enemalta for certain measures including on its commercial interests and that are more appropriately carried out through its own structure. The first obligation was set on Enemalta to roll out smart meters between 2009 and 2015. Then, Enemalta has been required to implement complementary measures for raising households' awareness about their electricity consumption and savings potentials. Since 2018, this obligation has been started to be applied as an incentive in the residential electricity tariff system (Broc et al. 2020).

EEOS is a flexible system and thus the application of each country is unique. EEOS gives its parties the freedom to choose how to achieve their goals, so ensures to optimize the cost/benefit of energy efficiency actions. The structures of EEOS for the countries that implement the system are given in Table 1 (Bertoldi and Rezessy 2008; Bertoldi et al. 2010; Crossley et al. 2012; Giraudet et al. 2012; Pavan 2012; Bertoldi et al. 2015; Broc et al. 2015; ENSPOL 2015a, b; ENSPOL 2016; Deconninck et al. 2017; European Commission 2017, 2018; Fawcett et al. 2019; Broc et al. 2020). Briefs in Table 1 present the below findings about EEOS structure and implementation methods are given below:

- Each EEOS has a responsible authority that determines its objectives and general rules and these are usually related ministries in the country. There is also a managing authority that is in charge of the operation. Managing authorities are often energy agencies of countries or institutions affiliated to the

Table 1 Structures of European EEOS implementations

Countries	Founding year	Responsible authority	Managing authority	Obligated parties	Target sectors	Threshold value	Possibilities in scheme
UK	1994	Department for Business, Energy & Industrial Strategy (BEIS)	Office of Gas and Electricity Markets (Ofgem)	Electric and natural gas suppliers	Residential	Having more than 200,000 domestic customers	Transfer of savings
Italy	2005	Ministry of Economic Development	GSE (Gestore dei Servizi energetic)	Electric and natural gas distributors	All end-use sectors	Having more than 50.000 customers	Certificate system
Denmark	2006	Ministry of Climate, Energy and Utilities	Danish Energy Agency (DEA)	All energy distributors	All end-use sectors except transport	No threshold value	Transfer of savings
France	2006	Ministry of Ecology, Sustainable Development and Energy (DGEC)	National Pole for White Certificates (PNCEE) and The French Energy Agency (ADEME)	All energy suppliers	Residential, service and transport	No threshold value	Certificate system
Bulgaria	2008	Ministry of Energy	Sustainable Energy Develop-ment Agency (SEDA)	All companies selling energy to final customers	All end-use sectors	Selling more than; Electric and heat: 20 GWh/year, natural gas 1 million m^3/year, liquid fuel 6500 ton/year and solid fuel 13.000 ton/year	Transfer of savings and Energy Efficiency and Renewable Sources Fund
Poland	2013	Ministry of Energy	Energy Regulatory Office (URE)	Energy suppliers and traders selling electricity, heat, or natural gas to end-users, except for heating companies	All end-use sectors except transport	No threshold value	National Fund of Environment Protection and Water Management, Certificate System and Voluntary parties
Ireland	2014	Department of Communicatio-ns, Climate Action & Environment (DCCAE)	Sustainable Energy Authority of Ireland (SEAI)	All energy suppliers	All end-use sectors	Selling more than 600 GWh/year	Transfer of savings
Spain	2014	Ministry for the Ecological Transition	Institute for Diversifica-tion and Saving of Energy (IDAE)	Suppliers of electricity and natural gas and wholesale retailers of oil products and LPG	All end-use sectors	No threshold value	Energy Efficiency National Fund
Austria	2015	Federal Ministry for	Austrian Energy	All energy suppliers	All end-use sectors	Selling more than 25 GWh/year	Transfer of savings, Voluntary

Table 1 (continued)

Countries	Founding year	Responsible authority	Managing authority	Obligated parties	Target sectors	Threshold value	Possibilities in scheme
		Sustainability and Tourism	Agency (AEA)				parties and pay to save
Luxemburg	2015	Ministry of the Economy	Ministry of the Economy	Electric and natural gas suppliers, based on their sales in the residential, service and industry sectors	All end-use sectors	No threshold value	Transfer of savings
Slovenia	2015	Ministry of Infrastructure	Slovenian Energy Agency (SEA)	All energy suppliers	All end-use sectors	No threshold value	Eco Fund and Voluntary parties
Greece	2017	Ministry of Environment and Energy	Centre for Renewable Energy Sources and Energy Savings (CRES)	Electric, natural gas and oil, and oil product suppliers and retailers	All end-use sectors	Market share is higher than 1% for 2017 reference year	Transfer of savings and National Energy Efficiency Fund
Latvia	2017	Ministry of Economics	Ministry of Economics	Electric retailers	All end-use sectors	At least 10 GWh more sales than the previous year	State Energy Efficiency Fund
Croatia	2019	Ministry of Environmental Protection and Energy	National Energy Efficiency Authority (within the Ministry)	Energy suppliers of electricity, natural gas, heat, and oil products	All end-use sectors	Selling more than 300 GWh/year (for 2019), 100 GWh/year (for 2020), and 50 GWh/year (for 2021)	Environmental Protection and Energy Efficiency Fund

ministries. Besides, other institutions can provide technical support for the sake of the successful operation of the system.

- Both responsible and managing authorities can form a partnership with more than one institution. Also, the presence of energy market regulators is noteworthy in the system.
- The main actor of EEOS is the obliged parties to perform energy efficiency actions. The obliged parties can be suppliers, distributors, or retailers of all types of energy (electricity, natural gas, petroleum products, LPG, and heat) that exceed certain thresholds (none, annual energy sales, number of customers, etc.). Obligations are determined for certain periods such as 1, 2, 3, or 5 years. In addition, voluntary parties who do not have any obligation can also join the scheme at their request. In all end-use sectors (residential, services, industry, transport), energy efficiency actions can be applied.
- The obliged parties can directly implement the energy efficiency/saving actions themselves or conclude partnership or agreement with third parties such as energy service companies, local authorities, or manufacturers.
- Costs of energy efficiency actions are supplied by obliged parties or provided by the states with various incentives (subsidies, tax rebates, tax exemptions, unit price contracts, etc.). Also, countries implementing EEOS can establish their national energy efficiency funds. The national energy efficiency funds are important tools for achieving the objectives of the obliged parties. To achieve savings targets, obliged parties can pay to national energy efficiency funds rather than making energy

efficiency actions. Funds can be used to finance technical assistance, training, and information plans for energy efficiency actions, as well.

- Energy efficiency and saving actions also vary from country to country. While some countries accept all energy efficiency actions (including consultation) where savings can be proven, some countries have set a limited number of standard energy efficiency and savings actions. Slovenia, Luxembourg, and Poland are the countries that set standard actions. Slovenia adopts measures to improve the efficiency of cogeneration, district heating, and cooling installations as well as the standard actions that are specified. The main standard actions set by Luxembourg are wall, window, roof insulation, efficiency in air conditioning systems, efficiency in home appliances and office equipment, efficiency in lighting systems, efficiency and energy management in motor, pump, steam, boiler, and cooling systems. For Poland, energy-efficient home appliances, equipment, and installations used in industrial processes, lighting, insulation of industrial installations, reconstruction and refurbishment of buildings, heating or cooling with renewable energy resources, cogeneration and waste heat recovery in industrial processes, reducing power loss and other activities of energy companies are eligible.
- EEOS requires a compliance regime to determine whether obligated parties have met their energy-saving targets and to apply sanctions if they fail. Usually, obligated parties that fail to meet their targets are required to pay a financial penalty.
- In some EEOS, verified energy savings of the obliged parties are certified. These certificates are generally called "white certificates" or "energy efficiency certificates." Obligated parties can earn white certificates with their energy efficiency and saving actions, purchase certificates from other parties, or sell their excess certificates to other parties to achieve their energy-saving goals. Depending on the size of the certificate trade, a market platform can be established to provide bilateral or multilateral trade of certificates between parties. Eligible and/or voluntary parties that are not subject to an obligation can also be allowed to certify the energy savings from eligible projects implemented and sell the white/energy efficiency certificates. In this way, eligible and/or voluntary parties generate an additional stream of revenue for themselves, increase the certificate market liquidity, and allow the parties under obligation to reach their obligations at a lower cost. For the effectiveness of white/energy efficiency certificates, standardized calculation methods are used. There are three countries (France, Italy, and Poland) that use the white certification system and have a trading market. Spain also wants to include tradeable energy efficiency certificates in the second phase of its scheme. In some countries without a certificate system, it is allowed to trade energy savings between parties. The main logic to include in the scheme some form of trading is that the combination of an obligation with a market mechanism lets competition in the delivery of energy services towards the targets and should guarantee that the energy savings will happen where it is more economic.

Based on the existing obligation schemes, some research groups have identified best practices and key issues in designing and implementing EEOS as explained below:

- Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes Report prepared by The Regulatory Assistance Project and published by the International Energy Agency explains the best practices in designing and implementing an EEOS categorically. According to the report, the policy objective of an EEOS must be simple and clear and focussed on achieving energy savings and it must be applied by means of a carefully selected combination of legislation, regulation, and administrative processes. When deciding the fuel and the end-use sector coverage, the choice must be made according to the overall policy objectives for the EEOS and estimates of energy efficiency potentials for the different fuels and the different sectors. The level of the energy-saving target for the EEOS must be set according to the overall policy objectives for the scheme and aimed to balance the cost to consumers of meeting the target, and what is practically possible based on an assessment of energy efficiency potential. The obligated parties in the EEOS must be determined concerning the fuel coverage of the scheme and the type of energy provider

that can manage the delivery and/or procurement of eligible energy savings. It is crucial to establish a penalty to be charged on obligated parties that fail to meet their energy-saving targets. The level of the penalty must be set high enough to mobilize energy providers to achieve their targets. For rewarding obligated parties that exceed their targets, performance incentives could be also included in the EEOS. A list of pre-approved energy efficiency measures with deemed energy saving values must be established in the EEOS, but the measures must not be limited to only those on the list. As an integral part of the EEOS, it must be established as a robust system for measuring, verifying, and reporting energy savings and other activities that contribute to EEOS targets. It must enable trading of energy savings among both obligated parties and eligible parties and a proper regulatory mechanism in the EEOS to enable recovery of the costs incurred by obligated parties in meeting their targets should be covered (Crossley et al. 2012).

- ENSPOL (Energy Saving Policies and Energy Efficiency Obligation Schemes - EU-funded project targeting the effective and proper implementation of Article 7 of the Energy Efficiency Directive in all Member States and beyond) emphasizes some strong characteristics and areas for the improvement of EEOS. Many of the existing EEOS have started with low targets but were increased over time, allowing a "learning" period for the subject under the obligation. In general, the majority of savings have come from relatively low-cost energy efficiency measures in the buildings and residential sector. This has meant that the EEOS has delivered very cost-effective savings. The approach has been different in Denmark and Italy, where most savings have come from the industrial sector. This shows the flexibility of EEOS as a policy instrument and its adaptability to national conditions and policy precedencies. The challenge of EEOS is to adapt itself to continue delivering energy savings even if the low-cost mass-market saving opportunities decrease. Denmark and Italy have realized strong savings in the industrial sectors; France is one of the few states that obliges automotive fuel suppliers to achieve energy savings. This allows targeting a more ambitious saving objective while increasing the competition between obligated parties and the diversity of business models that are developed to reach final consumers. In some countries, the EEOS is still pretty unknown or misunderstood by end-users. It is crucial to improve communication among potential scheme beneficiaries. Public campaigns and consulting do not directly affect energy savings, but they can be accepted as preconditions to increase the awareness and understanding of energy efficiency. An effective EEOS needs to achieve a balance between rules and procedures that are simple enough for obliged parties to work with while needs to be complex enough to meet requirements for additionality, flexibility, suitability, and transparency. Having a standardized action catalogue listing best practices comprising energy efficiency measures can be very effective. These saving actions can be fundamental during the first years of the EEOS. Besides, it is significant to work with a continuous improvement approach (re-design) and to monitor the evolution of the scheme and the market. Increasing the transparency (e.g., calculation methods, detailed results per sector), also an appropriate evaluation of the scheme (cost-effectiveness), can provide higher effectiveness. Moreover, Member States which are later adopters of EEOS can benefit from other countries' experience and lesson-learned by the applications (ENSPOL 2015a).
- As mentioned before, EEOS is a market-based instrument. In the market-based instruments (MBIs) for Energy Efficiency Policy Choice and Design Report published by the International Energy Agency, key policy design issues of MBIs are examined and explained. First, MBIs must work within existing policy frameworks. They require supporting measures such as technical standards and should interact with other policy instruments to improve the overall policy mix. Second, when the rules are well crafted, obligations can be successful. Another key issue is a flexible program design permitting savings to be delivered across a wide range of customers and fuels. Providing more choice to obligated parties increases the probability that the most cost-effective options will be discovered. Also, MBIs should be designed to achieve specific policy goals through incentive structures including minimum energy savings' requirements, limits on the installation of technologies with shorter lifetimes, greater rewards for deeper savings, and the use of additional funding streams. Moreover, monitoring, verification, and evaluation are essential for

the integrity of programs. Finally, program rules should be as simple as possible but as complex as necessary (Rosenow et al. 2017).

Current status of energy efficiency in Turkey

The first step taken for energy efficiency in Turkey is the enactment of the Energy Efficiency Law in 2007 (Fig. 1). The main objectives of the Law are defined as efficient usage of energy, preventing energy losses and wastes, reducing the burden of energy costs on the economy, and improving the efficiency for the protection of the environment (Law 2007). Additionally, within the Turkish Climate Change Strategy Paper and National Climate Change Action Plan, for the years 2010–2020, Turkey's national vision of climate change was identified and energy efficiency was highlighted (Republic of Turkey Ministry of Environment and Urbanisation 2010; Republic of Turkey Ministry of Environment and Urbanisation 2011). Afterward, to state strategies required for the efficient usage of energy, The Energy Efficiency Strategy Paper, covering the years 2012–2023 and consisting of strategic objectives as to reduce energy intensity and losses as well as related carbon emissions in industry, building, and transportation sectors, to provide market transformation of energy-efficient products; to increase efficiency in production, transmission, and distribution of electricity; to strengthen institutional capacities and collaborations among the related governmental, private, and non-governmental institutions; and to increase awareness activities, and to develop financial mechanisms, was prepared (Republic of Turkey Ministry of Energy and Natural Resources 2012).

"Energy Efficiency Improvement Program" was comprised in the Tenth Development Plan, covering the years 2014–2018 (Republic of Turkey Ministry of Development 2013). Under the title of "Energy Efficiency and Energy Saving" in the Strategy Document of the Ministry of Energy and Natural Resources for 2015–2019, targets, such as raising public awareness on energy efficiency, developing and revising the regulatory framework concerning energy efficiency, increasing the effectiveness of the current incentives, establishing joint work step and interaction plans between the associated institutions, and establishing a well-operating energy efficiency sector, have been defined (Republic of Turkey Ministry of Energy and Natural Resources 2015).

Finally, the National Energy Efficiency Action Plan (NEEAP) for the years 2017–2023 has been prepared. Under the 2012/27/EU Directive, Member States are obliged to prepare national energy efficiency action plans (Directive 2012). Therefore, Turkish NEEAP is an important step for Turkey in terms of compliance with the Directive. Within the scope of the Turkish NEEAP, 55 actions are specified on buildings and services, energy, transportation, industry and technology, and agriculture. In NEEAP, it is stated that a 14% reduction in Turkish primary energy consumption is going to be realized until 2023. In this way, it is aimed to achieve 23.9 million tonne oil equivalent (Mtoe) cumulative savings during 2017 and 2023. To realize this saving, it is predicted that US$10.9 billion should be invested. In Turkish NEEAP, a newly defined action is about the establishment of Turkish EEOS and it is specified that the national energy efficiency target is given to the related energy (electricity, natural gas, petroleum) companies in proportion to the market share and the companies are accustomed to achieve this target by developing various projects for the end-users or by increasing the energy efficiency of their

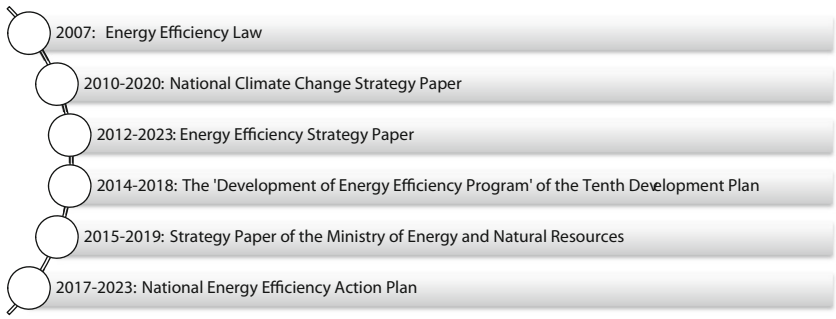

Fig. 1 Chronological energy efficiency legislation in Turkey

activities. Moreover, energy companies will be able to reflect the cost of the efficiency services they provide to their customers to the end-users under favorable conditions. On the other hand, energy companies that fail to meet their obligations will pay their remaining liabilities in cash and will be transferred to the newly formed "National Energy Efficiency Fund." For these purposes, in NEEAP, the preparation of a guidance document has been stated to standardize information such as energy-saving potential and cost for energy efficiency projects, and obligated companies (distributors, suppliers, etc.) will present energy efficiency projects to their customers to realize their energy savings. The costs of the realized projects will be reflected in the end-user within certain programs. According to the NEEAP, the EEOS will be active in 2022 (Republic of Turkey Ministry of Energy and Natural Resources 2018). Currently, Turkey is still in the preparation phase for the implementation of EEOS and continues to work on this issue.

Analysis method: Bayesian Belief Networks

BBN method was used for the analysis of the survey study in which expert opinions were taken to reveal the structure of the possible Turkish EEOS. Bayesian Belief Networks or Bayesian Networks (BBN) are "directed acyclic graphs that represent probabilistic relationships among variables." The variables may be "discrete" or "continuous" (Heckerman 1997; Heckerman and Wellman 1995). The structure of the network involves two sets, namely, the set of nodes and directed edges. The nodes represent variables. The edges signify direct dependence among the variables and are drawn by arrows between nodes. An edge from a node to another node shows a statistical dependence between the corresponding variables. These conditional dependencies in the graph are often estimated by using known statistical and computational methods. Thus, BBNs comprise principles from graph and probability theories as well as computer science and statistics (Ben-Gal 2008). Ultimately, Bayesian networks provide a theoretical framework for dealing with uncertainty using the graphical structure and the probability calculus (Holmes 2008).

The theory of Bayes reveals from the work of Thomas Bayes in 1763. Mainly in the theorem, conditional probabilities of events of interest have been computed from known probabilities. Consequently, to understand the Bayes Theorem, the conditional probability concept should be understood well (Neapolitan 2004). For example, 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 Eqs. (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, and $P(X \cap Y)$ and $P(Y \cap X)$ represent the probability that both X and Y events occur. When multiplying Eqs. (1) and (2) by the denominator on their right side, it shows 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.

In the literature, BBNs can be utilized in many different fields for various purposes. Larrañaga and Moral (2011) reviewed the purpose of probabilistic graphical models in artificial intelligence with an emphasis on BBN. According to this paper, BBNs are important tools for solving real problems and can be used for forecasting (Tang et al. 2016; Bassamzadeh and Ghanem 2017), diagnosis (Cai et al. 2017), classification (Moore and Zuev 2005), clustering, abductive reasoning (Zarei et al. 2018), and decision-making

(Gindele et al. 2015) purposes. Constantinou et al. (2016) presented a generic and repeatable method for developing real-world BBN models that combine both expert knowledge and data (questionnaires and interviews with patients) for medical decision support. Nadkarni and Shenoy (2004) explain a procedure for constructing BBNs from data-based and knowledge-based (domain knowledge of experts) approach using the causal mapping (CM) method. Cinar and Kayakutlu (2010) analyzed the structure of the energy sector by running an expert survey and using data. They developed scenarios for renewable energy investment in Turkey by using CM and BBN. Taking advantage of the flexibility of BBNs to create a causal structure based on expert judgment, Hosseini and Barker (2016) developed a BBN model for evaluating the performance of candidate suppliers to select the best. In this paper, BBNs are used to evaluate the results of the expert survey study for determining the basic structure of Turkish EEOS.

Case study: Turkey

Within the scope of this study, an expert survey was conducted to establish the possible structure of Turkish EEOS. The steps of the survey study are given in Fig. 2.

While preparing the EEOS expert survey, for more practical and understandable analysis, ten variables were determined based on the structures of the EEOS applied by the EU States considering the current situation of the Turkish energy market structure as well as possible improvement points which are available in EU schemes but does not exist in Turkey like national energy agency, energy efficiency fund, etc.. Then, ten variables as "responsible authority," "managing authority," "obligated parties," "obligated parties in relation with certain energy type," "target sector," "threshold value," "voluntary parties," "financial support," "penalty system," and "certificate trading" are presented with their options in the survey that are given in Table 2.

For each variable, the stated options are explained below, in detail:

Responsible authority In Member States implementing EEOS, energy, environment, industry, and economy ministries are generally preferred as the responsible authority of the scheme. In some states' schemes, there is also cooperation between different ministries as a responsible authority. The options of the responsible authority variable were determined considering the ministries that are responsible institutions in EU systems and appropriate ministries available in Turkey. Accordingly, in the survey, the Ministry of Energy and Natural Resources of Turkey, Ministry of Environment and Urbanization, Ministry of Treasury and Finance, and Ministry of Science, Industry, and Technology were presented as options.

Managing authority In Member States implementing EEOS, managing authorities are mostly national energy agencies. In some states, institutions affiliated to the ministry, which is the responsible authority, can become a managing authority. Currently, no national energy agency exists in Turkey. However, to reveal a possible need for the Turkish Energy Agency, the new energy agency option was added together with the ministerial institution.

Obliged parties European Commission recommends that "determination of the obligated parties in the EEOS according to the fuel coverage of the scheme and the type of energy provider that has the infrastructure and capability to manage the delivery and/or procurement of eligible energy savings, bearing in mind the requirement that designation of the obligated parties must be based on objective, non-discriminatory criteria" (European Commission 2019). Different types of licenses must be owned to operate in the Turkish energy markets, which vary according to different energy types. In the electrical energy market, suppliers are producers providing electricity and/or capacity, and companies with a supply license, distributors are private companies that generally

Fig. 2 Steps of expert survey study for Turkish EEOS

Table 2 Variables and options

Variable	Options
Responsible authority	• Ministry of Treasury and Finance (MoTF) • Ministry of Energy and Natural Resources (MENR-ETKB) • Ministry of Environment and Urbanisation (MoEU-CSB) • Ministry of Science Industry and Technology (MoSIT)
Managing authority	• Ministerial Institution • National Energy Agency to be established
Obligated parties	• Energy distributors • Energy sellers • Energy suppliers • All
Obligated parties in relation with certain energy type	• Natural gas • Electricity • Oil and oil products • All
Target sector	• Service • Household • Industry • Transport • All
Threshold value	• The amount of sales in the energy unit • The share in the energy market • The number of customers • No threshold value
Voluntary parties	• Municipalities • Industrial facilities • ESCOs • Non-governmental organizations (NGO) • All • None
Financial support	• Energy Efficiency (EE) Fund • Incentive • Both • None
Penalty system	• The ones not to achieve the targets • The ones not to achieve the determined percent of the targets • Cancel the certificate in case of unsuitable applications • No penalty system
Certificate trading	• On the stock market • Under the control of the managing authority • No certificate trading

perform installation, maintenance, repair, and operation tasks in their distribution regions. In the past years, distribution companies have also been supplying electricity in the region they are in charge of. Due to changing practices over time, the electricity supply task was separated from the distribution companies and sales authorization was taken from electricity distribution companies, and the power to sell consumers was transferred to electricity supply companies (sellers). It is worth to mention that some companies can have both distribution and selling licenses at the same time. In the natural gas market, distribution, wholesale, import, export, and storage licenses exist. Oil and oil product market has distribution, supply, bunker delivery, refinery, etc. licenses. To be inclusive for all energy types, licenses that are related to the end-use sectors are selected. Hence, for the obligated parties variable, in the survey, energy distributors, suppliers, and sellers are presented as options.

Energy type For the energy type of obliged parties, all available energy types that serving by energy companies in Turkey are given as options. Similarly, for the target sector variable, all end-use sectors are selected.

Threshold value In the Member States implementing EEOS, various threshold values, such as the amount of sales in the energy unit, the number of customers, and the share in the energy market, are used. These threshold values are stated in the survey together with no threshold value option.

Volunteer parties in some Member States implementing EEOS, voluntary parties are also included in the scheme. Municipalities, industrial facilities, ESCOs, non-governmental organizations, etc. appear as voluntary party types and all are listed in the survey with no voluntary party option.

Financial support For the financial support variable, energy efficiency (EE) fund, the incentive (subsidies), and both options are listed.

Penalty system One of the important variables of EEOS is the penalty system. The penalty for the obliged parties who cannot reach its target, or who cannot reach a certain percentage of its target, and the cancellation of certificates in case of problems faced in the inspection of the obliged parties are in the penalty systems of Member

States implementing EEOS. All penalties are offered as options in the survey.

Certificate trading The acquisition of certificates as a result of energy efficiency actions and the trade of these certificates constitute another important part of the scheme, although it is not seen in all Member States implementing EEOS. Whether or not to place certificate trading in Turkish EEOS, three options are chosen for this variable as trading under the control of the managing authority, on the stock market, and also with no certificate trading.

Afterward, five local and four foreign energy experts who know EEOS and Turkey's energy market and policies were selected. In the survey, energy experts were asked to select the best options for variables of the Turkish EEOS and it is possible to select more than one option for the responsible authority, managing authority, voluntary parties, and penalty system variables. Besides this, for the BBN analysis, energy experts were asked to evaluate the potential importance of their selections on the system success from 1 to 9. In other words, first, experts chose the option(s) which is/are proper in their opinion and after that, they scored their selected option(s) for the general system success. The selected options for each variable by the energy experts participating in the survey are given in Table 3.

In order to determine the causal relations among the variables, energy experts were asked to evaluate the interactions between variables of EEOS, as well. "1" refers to a positive effect meaning the increase in the row variable causes an increase in the column variable. "0" means there is no interaction between variables. The whole pairwise comparison matrix that includes interactions between the described variables is given in Table 4.

Subsequently, causal maps (CM), also called cognitive maps, which can be defined as the directed graphs that represent the cause-effect relations embedded in experts' thinking (Nadkarni and Shenoy 2004), were drawn (Fig. 3). In CMs, there are three major parts, namely, "causal concept, connection, and value." A causal concept can be an attribute, issue, factor, or variable and shown by a node. The causal connection is presented by an arrow and expresses the direction of the connection. It describes a cause-effect relation between two concepts. Hence, a causal connection can be positive or negative. Causal value, on the other hand, is the strength of the causal connection (Cinar and Kayakutlu 2010).

Bayesian Network can be described as an artificial intelligence method that uses CM to make inferences for decision making (Cinar and Kayakutlu 2010). For this purpose, the "Netica Bayes Network Modelling Program" was used to evaluate the survey results. Thus, The Bayesian network, expressing the views of experts, is presented in Fig. 4.

As a result of the analysis, the following observations can be stated:

- Responsible authority should be Ministry of Energy and Natural Resources.
- Managing authority should be an energy agency that should be established soon.
- Obligated parties should be energy distributors and suppliers.
- Obligated parties should service in all energy types.
- Target sectors should be all end-use sectors.
- Threshold value should be the annual sales amount in the specific energy unit.
- Voluntary parties should be municipalities, industrial facilities, ESCOs, and non-governmental organizations (NGOs).
- In the penalty system, obligated parties who are unable to reach a certain percentage of their energy-saving targets should be punished.
- Financial support should be an incentive mechanism defined and applied by the government.
- Certificate trading should be on the stock market.

With this structure, the success probability of Turkish EEOS will be 83.6%.

Using the Netica, two different scenarios have been implemented namely the "optimistic scenario" where the system is 100% successful and the "pessimistic scenario" if the system fails 100%. The purpose of these scenarios is to determine which variables play a key role in success. The optimistic and pessimistic scenarios are shown in Figs. 5 and 6, respectively.

With optimistic and pessimistic scenarios, the probability changes of the variables chosen by the experts are observed when the scheme transitions from 100% successful to 100% unsuccessful. When looking at the probability changes between scenarios, the most effecting variables are financial

Table 3 Selections of energy experts

Variables	Turkish experts			Foreign experts	
	Academia (2)	Public authority (2)	Public and private institution (1)	Academia (3)	Researcher at the non-profit research organization (1)
Responsible authority	MENR	MENR	MENR and MoEU	MENR (× 2) MENR and MoEU	MENR
Management authority	New Energy Agency	Ministerial Institution	New Energy Agency	New Energy Agency	New Energy Agency
Obligated parties	Distributors Distributors and suppliers	Distributors and suppliers All	Distributors and suppliers	Distributors and suppliers	Sellers
Energy type Of obligated parties	Natural gas and electric	Natural gas All	All	Electric Natural gas and oil All	All
Targets sectors	Industry and service Industry, service, and transportation	All	Residential, industry and transportation	Industry and transportation All (× 2)	All
Threshold value	The amount of sales in the energy unit	The market share The amount of sales in the energy unit	The amount of sales in the energy unit	Number of customers	The amount of sales in the energy unit
Voluntary parties	ESCOs and industrial facilities Municipalities, ESCOs, and NGOs	All	All	Municipalities and ESCOs Municipalities, industrial facilities, and NGOs All	Municipalities and ESCOs
Financial supports	Both	Incentive EE Fund	EE Fund	Incentive (× 2) Both	EE Fund
Penalty system	The ones not to achieve determined percentage of the targets The ones not to achieve the targets and cancel the certificate in case of unsuitable applications	The ones not to achieve the targets The ones not to achieve determined percentage of the targets	The ones not to achieve determined percent of the targets	The ones not to achieve the targets (× 2) The ones not to achieve determined percentage of the targets and cancel the certificate in case of unsuitable applications	The ones not to achieve the determined percent of the targets
Certificate trading	On the stock market Under the control of the managing authority	On the stock market Under the control of the managing authority	On the stock market	On stock market (× 2) Under the control of the managing authority	No certificate trading

support-incentive, target sector-all, threshold value-amount of energy sales, obligated parties—distributors and suppliers, and energy type of obligated parties-all. The Bayesian Network, which is formed as a result of increasing the probability of these variables to 100%, is shown in Fig. 7. In this case, the probability of system success reaches to 99.8%.

According to experts, it is clear that the most important variables are financial support mechanism, target sector, obligated parties, and energy type of obligated parties. It can be seen that obliged parties should be energy (electricity, natural gas, etc.) distributors and suppliers with strong financial support by the government, targeting all end-use sectors. While the Turkish EEOS is to be

Table 4 Pairwise comparison matrix

	Responsible authority	Management authority	Obligated parties	Energy type of obligated parties	Targets sectors	Threshold value	Voluntary parties	Financial supports	Penalty system	Certificate trading	System success
Responsible authority	0	0	0	0	0	0	0	0	0	0	+ 1
Management authority	+ 1	0	0	0	0	0	0	0	0	0	+ 1
Obligated parties	0	0	0	0	0	+ 1	0	0	0	0	+ 1
Energy type of obligated parties	0	0	0	0	0	0	0	0	0	0	+ 1
Targets sectors	0	0	0	0	0	0	0	0	0	0	+ 1
Threshold value	0	0	0	0	0	0	0	0	0	0	+ 1
Voluntary parties	0	0	0	0	0	0	0	0	0	+ 1	+ 1
Financial supports	0	0	0	0	0	0	0	0	0	0	+ 1
Penalty system	0	0	0	0	0	0	0	+ 1	0	0	+ 1
Certificate trading	0	0	0	0	0	0	0	0	0	0	+ 1
System success	0	0	0	0	0	0	0	0	0	0	0

established, these four variables and their relations must be considered by policymakers.

Results and discussion

This study is prepared to review the different structures of EEOS that are planned to be constructed in Turkey and to reveal a basic structure based on energy experts' opinions. Therefore, an expert survey study was carried out involving not only the domestic but also foreign energy experts, knowledgeable about EEOS, and Turkey's energy market and policies. Netica Bayes Network Modelling Program is used for the analysis of the expert opinions. Based on survey results, the proposed structure of Turkish EEOS is shown in Fig. 8. Accordingly, the generally accepted structure which is suggested composes of the following: Ministry of Energy and Natural Resources as the responsible authority, a new energy agency as managing authority, all energy distributors and suppliers as obliged parties, all end-use sectors as target sectors, annual sales amount in the specified energy unit as threshold value, governmental incentive mechanism as financial support, and obligated parties who are unable to reach a certain percentage of their energy-saving targets as penalty application and stock market formation for certificate trading. It should be noted that information flows, monitoring verification and control system, independent auditors, and third parties were not included in the survey but stated in EEOS structure, as can be seen from Fig. 8, since they can be crucial for the management of EEOS, properly.

As mentioned before, five local and four foreign energy experts participated in the EEOS survey. Two of the local experts are from the public authority, one is from public and private institution and the remaining two are academics. The three foreign experts are academics, and one is a researcher in the non-profit research organization. The main thought of the majority of both local and foreign energy experts is that the *responsible authority* of the possible Turkish EEOS should be MENR. Only one local and one foreign expert selected that MENR and MoEU should cooperate. Additionally, except the experts from the local public authority, others agree that *managing authority* of the possible Turkish EEOS should be a new energy agency. Experts from local public authority think that a ministerial institution should conduct the managing studies of the Turkish

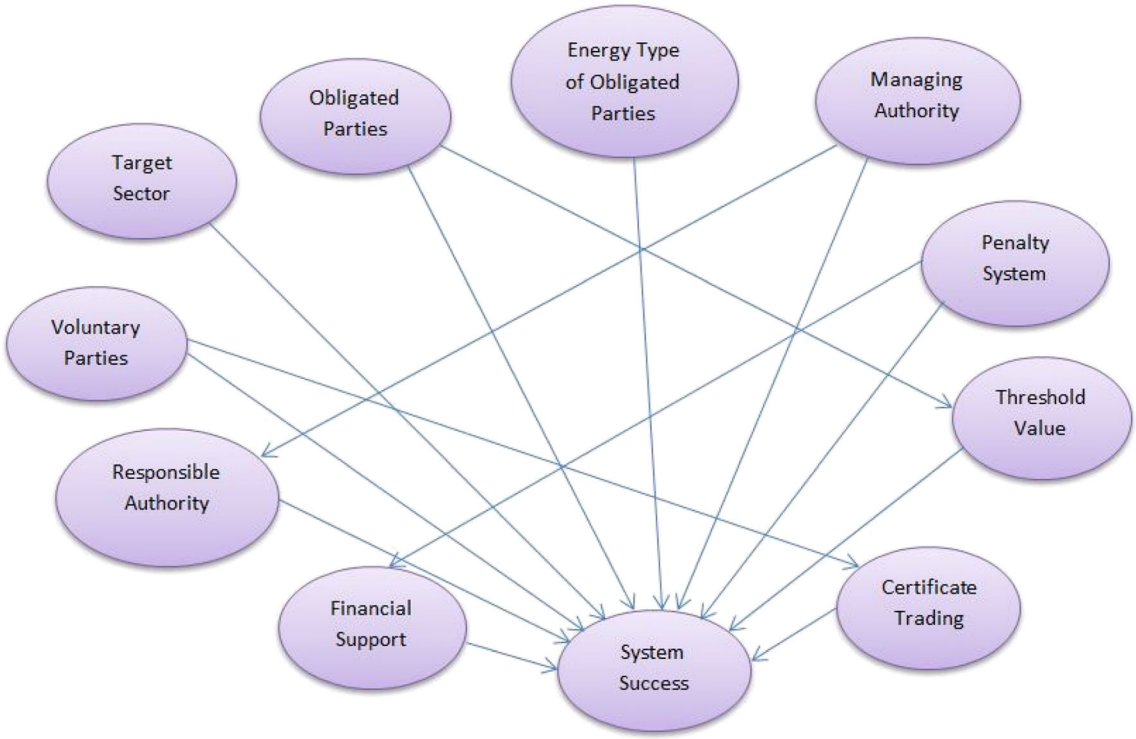

Fig. 3 Causal map of expert survey

EEOS. According to the majority of both local and foreign energy experts, the *obligated parties* should be energy distributors and suppliers. The majority of experts want to include *all types of energy* to identify obligated parties in the EEOS. Furthermore, all end-use sectors are mostly chosen answers for the *target sector* of the Turkish EEOS. Except for experts from foreign academia and one from the local public authority, it is stated that the *threshold value* should be the annual sales amount in the specific energy unit. As

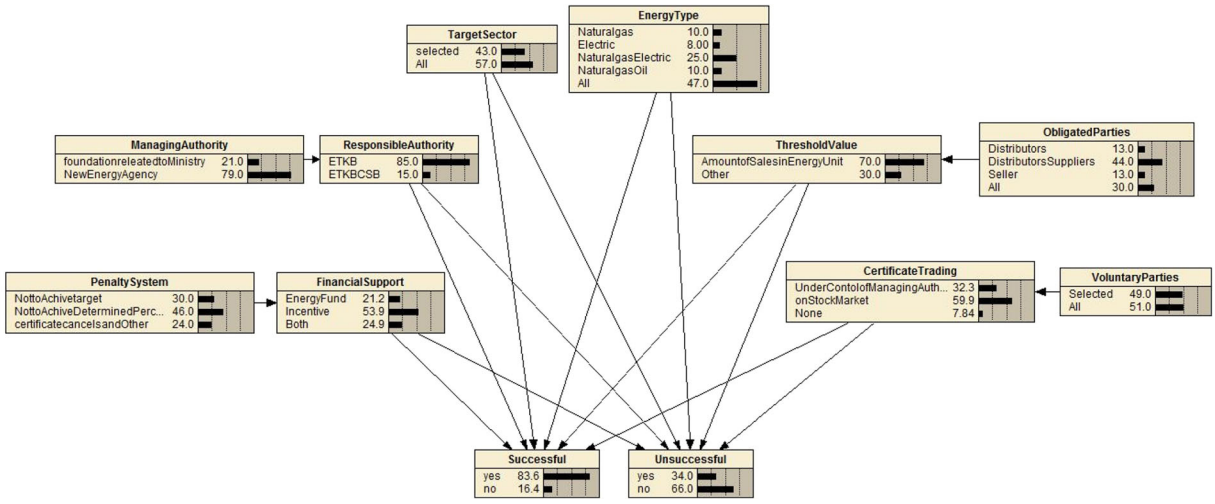

Fig. 4 Bayesian network expressing the views of experts

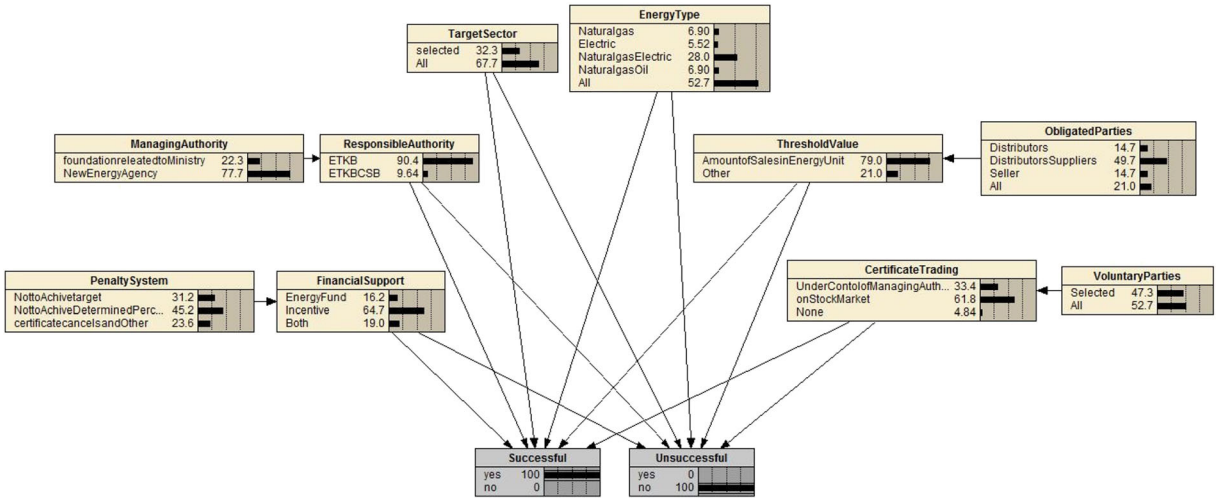

Fig. 5 The optimistic scenario for 100% success of Turkish EEOS

mentioned before, it is possible that selecting more than one option for the variables in the survey. For the *voluntary parties* variable, experts combined some of the options. The mostly stated parties by both local and foreign experts are municipalities and ESCOs. Moreover, the common decision of the experts can be specified that all types of voluntary parties (municipalities, industrial facilities, ESCOs, and non-governmental organizations (NGOs)) should participate in the Turkish EEOS. For the *penalty system* variable, "obligated parties who are unable to reach a certain percentage of their energy-saving targets" option which is a more tolerant penalty than other penalty options are selected by the majority. All local and foreign expert groups gave different answers to the *financial support* variable. It can be derived that energy efficiency fund and incentive options were chosen, equally. As previously mentioned, experts were asked to give a score for their selected option(s) about its/their effect(s) on the general system's success. According to the results obtained, the incentives option has more score than an energy efficiency fund. The outcome of this result argues that obligated parties should be financially supported by incentive mechanisms defined and applied by the government.

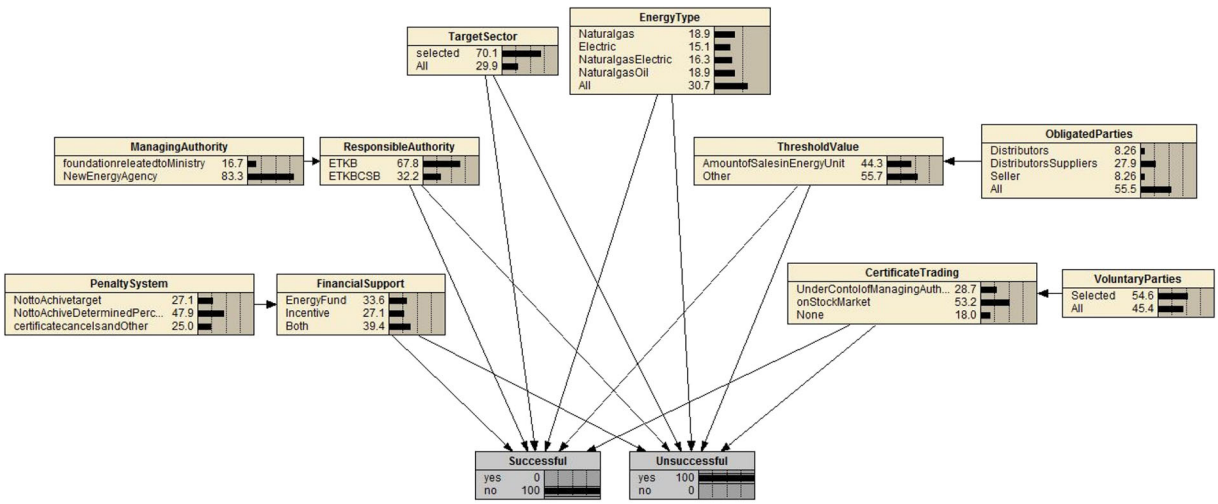

Fig. 6 Pessimistic scenario for 100% failure of Turkish EEOS

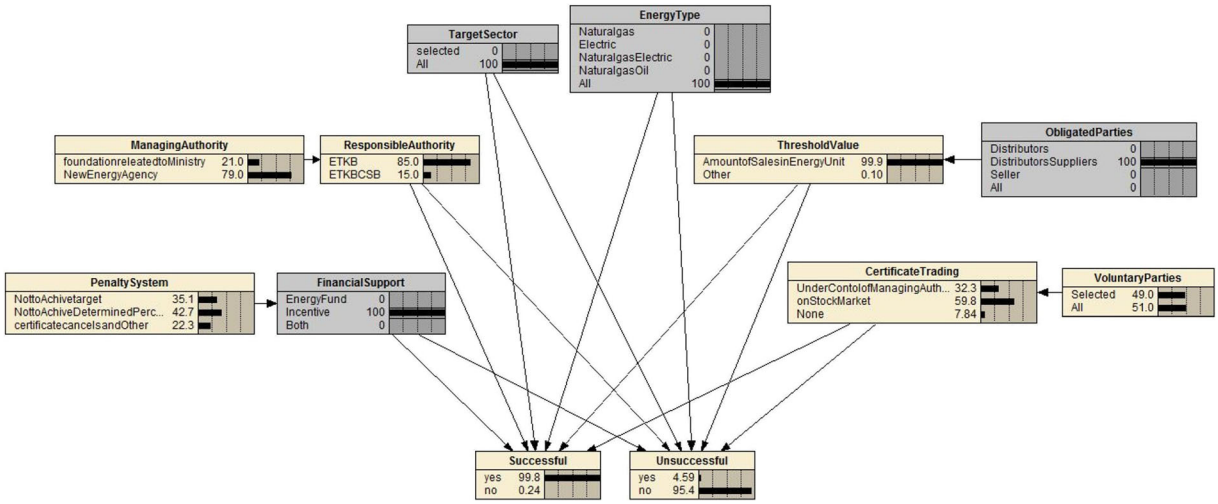

Fig. 7 Bayes map consisting of 100% application of important variables

The common answer for the *certificate trading* variable is that verified energy-saving actions of obligated parties should be certified, and the trade of these certificates should be on the stock market.

When the selected options of the energy experts are considered, it can be observed that for most of the variables, although local and foreign academics tend to select similar options, the choices of two experts from the local public authority differed between themselves. Also, it can be derived that there is a consortium among the experts on the selection of responsible authority, managing authority, and threshold value variables. On the other hand, the decision about financial support, energy type of obligated parties, target sectors, and voluntary parties are mostly varied issues. At this point, best practice examples and success stories of mature EEOS schemes should be followed and inspired.

As it is understood from the applications of the EU Member States and the variance of the options for the selected variables, EEOS is a flexible policy and market

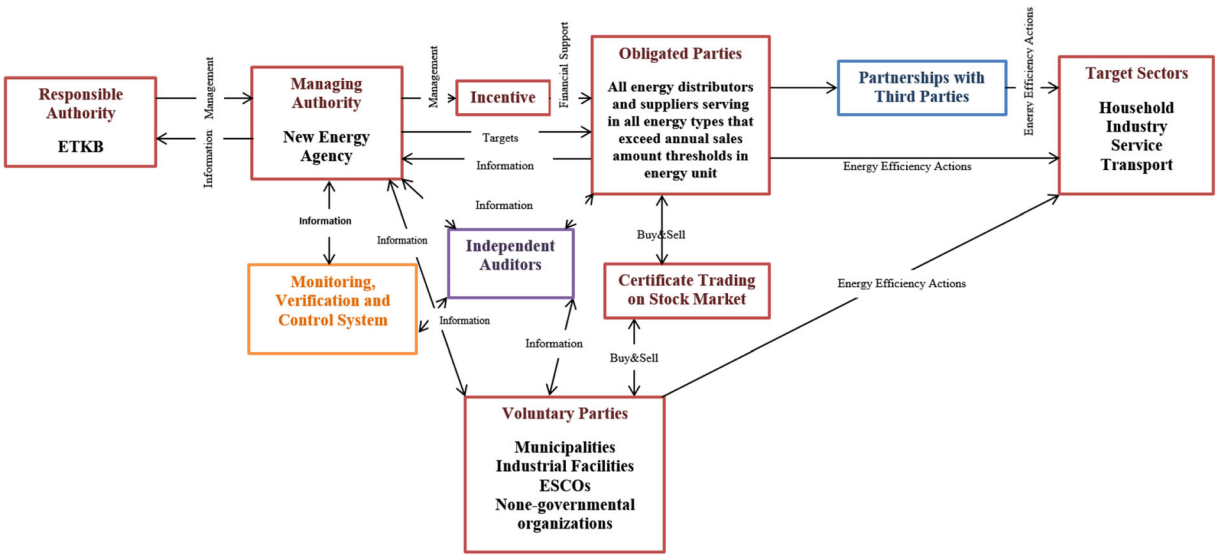

Fig. 8 The proposed structure of Turkish EEOS

mechanism that has no strict rules and offers freedom in its implementation. These flexibility and freedoms enable countries to adopt the scheme and implement it according to their local characteristics. While preparing the survey, different implementation methods of the EEOS are examined and proper alternatives for variables were selected according to local conditions of Turkey. All experts participating in the survey were carefully selected, according to their background and expertise.

In the "Review of EEOS studies" section, best practices and key issues in designing and implementing EEOS were explained. To summarize, for establishing and implementing a successful EEOS, policy objectives, structure, and rules of the scheme must be as simple as possible but as complicated as needed. For example, the fuel type and the end-use sector coverage must be determined concerning the overall policy objectives of the EEOS and estimating energy efficiency potentials. EEOS with flexible program design allowing savings to be provided across a broad range of customers and fuels enables more choice to obligated parties and increases the probability that the most cost-effective options will be found. Besides, including industry and transport sectors in the scope of the EEOS allows more ambitious objective, as increasing the competition between obligated parties. It is crucial to improve the communication among the scheme participants and to comply with the conditions required by the system such as flexibility, suitability, and transparency. Moreover, financial support and rewarding obligated parties improve the success of the EEOS. It is also important to ensure the participation of eligible parties (voluntary parties) in the system and enable trading of energy savings among both obligated and eligible parties (Crossley et al. 2012; ENSPOL 2015a; Rosenow et al. 2017).

In this study, the EEOS structure described for Turkey based on experts' opinions matches some of the best practices and key points for designing and implementing an EEOS. These are the coverage of all energy types and all end-use sectors, the participation of volunteer parties in the system, allowing the trade of savings with certificates, and providing financial support through incentives. Similar to the key points in the EU, financial support mechanism, target sector and fuel coverage (energy type of obligated parties), and obligated parties were stated as the most important parameters in the EEOS of Turkey.

In Turkey, important steps have been taken in both the preparation and implementation of energy efficiency policies and legislation since 2007 (e.g., Energy Efficiency Law including voluntary agreements, environmentally responsive design of energy-related products, energy performance regulation for buildings, energy labelling of home appliances, procedures and principles regarding increasing energy efficiency in transportation, Energy Efficiency Strategy Paper, NEEAP) (EVÇED 2020). The primary energy intensity index, which is a significant indicator of energy efficiency, decreased cumulatively by 23.1% between 2000 and 2015 by the measures taken and resulted in an average annual improvement of 1.65%. The end-use energy intensity index was also reduced by 21%, corresponding to an average annual improvement of 1.5% in the same period. However, Turkey is in the category of high external dependency countries with the import rate of 75.9% in energy resources for primary energy supply. Therefore, one of the main objectives of Turkey's energy policy is to increase efficiency in all processes from energy generation to end-use consumption to ensure energy supply security and environmental protection. Under the NEEAP of Turkey that is under implementation starting from 2017 to 2023, it is aimed to reduce the primary energy consumption of Turkey by 14% (23.9 Mtoe cumulative saving). To reach NEEAP goals, the establishment of EEOS in Turkey is defined as one of the important tools. EEOS must work within existing policy frameworks in Turkey, and it requires supporting measures to improve the overall policy mix. To overcome this, some goals have been set, such as "developing national financing mechanism for energy efficiency," "developing guides, standard contracts and similar bases containing technical, legal and financial aspects for energy efficiency projects," "developing registration, database and reporting systems for energy efficiency activities," and "conducting activities of awareness-raising and training on energy efficiency" (Republic of Turkey Ministry of Energy and Natural Resources 2018).

EEOS would be a beneficial tool in the existing energy policy mix and energy-related targets of Turkey as setting quantitative targets to increase energy efficiency, being legally binding, defining energy-saving actions, and confirming that the energy savings achieved by these actions are realized through measurement, verification, and reporting. Also, EEOS may trigger the success of the energy service market in Turkey. Through EEOS, the energy performance contracts would also be promoted

by the third-party agreements and energy service companies' participation in the scheme. EEOS would provide competition among energy efficiency market actors in Turkey for the benefit of end-users. However, it should be considered that EEOS is a purchase subsidy (as they usually involve a financial contribution from the obligated parties to the overall investment cost of energy-saving actions) and there is a potential risk that EEOS would overlap with some policy instruments such as grants, financing mechanisms, or voluntary agreements. For this reason, a more detailed examination of policy mix design could be beneficial for reaching energy efficiency targets (Rosenow et al. 2016).

Conclusion

This study can be regarded as a pioneer research since it aims to introduce the EEOS concept in Turkey by comparing existing experiences in the EU, to present a possible basic structure of EEOS that can be successful in Turkey and to develop recommendations for Turkish policymakers by using expert opinion survey and Bayesian Belief Network analysis.

When Turkey successfully adopts the EEOS which is defined as one of the specified targets in Turkish NEEAP, it will be a significant step for improving energy efficiency, reaching energy-related goals defined in NEEAP cost-effectively, and harmonizing with the EU. In favor of the successful implementation of Turkish EEOS, the scheme must have a flexibility in application, promotive opportunities, deterrent penalties, and should be open for improvement, as well. For this purpose, Turkey must follow the best practices of the EEOS in the EU, try to obtain the know-how and lesson learned of these schemes, and adapt the scheme to its specific circumstances. Besides, Turkey should motivate the possible scheme participants and prepare them for the scheme. At this point, communication, collaboration, and transparency are the most crucial issues.

Achievements of this study will open a new work field to academics, energy sector participants, and energy policymakers also set an example for the other countries which are willing to adopt the EEOS and have similar conditions with Turkey.

For further study alternatives, how the EEOS will be added to the Turkish economy and how the Turkish energy market will be affected by this implementation should be analyzed. Besides, it should be considered that EEOS can interact with other policy measures (voluntary agreements, possible carbon/energy taxes, regulations, etc.) and how EEOS will fit into the wider policy mix in Turkey should be examined in detail. For this purpose, the opinions of other participants (possible obligated and voluntary parties, etc.) about the scheme should be taken and a more advanced structure can be proposed, in this way. It would also be valuable to investigate different degrees of the interactions among variables of EEOS in a more comprehensive study. After the basic structure of EEOS is determined, how the system will be applied, how to determine incentives and penalties, which specific actions and calculation methods will be used, investment costs, and cost-benefit analyses of actions should be examined for the further studies. Furthermore, a multi-disciplinary approach of social scientists, economists, and engineers should be combined and technical, financial, environmental, socio-political aspects of the Turkish EEOS should be evaluated in these further studies.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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