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From potential forecast to foresight of Turkey's renewable energy with Delphi approach

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ABSTRACT

A Delphi Survey is a series of questionnaires that allow experts or people with specific knowledge to develop ideas about potential future developments around an issue. The Delphi questionnaires were developed throughout the foresight process in relation to the responses given by participants in bibliometric and SWOT analysis conducted prior to the Delphi survey. In this paper, Turkey's renewable energy future is evaluated using the Delphi method. A two-round Delphi research study was undertaken to determine and measure the expectations of the sector representatives regarding the foresight of renewable energies. First and second round of Delphi study were carried out by using online surveys. About 382 participants responded in the first round of the Delphi questionnaire yielding a respond rate of 20.1%, whereas 325 participants responded at the second round yielding a respond rate of 84.9%. About 50% of Turkey's energy demand was foresighted to be met by renewable energies around 2030. The results showed that all types of renewable energies would not only provide economic and environmental benefits but also improve living standards.

1. Introduction

New technological advances are the most important driving force behind growth and renewal in such fields as information technology, energy supply and genetic engineering that are predicted to provide increasing quality of life [1]. Thinking about the future and future events has a long history. People at all times wanted to know what was lying ahead. That was the basis for the 'success' of the Greek oracles in ancient times when forecasting the future was less predicting than making politics and shaping present-day decisions [2]. Technology foresight is the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging of generic technologies likely to yield the greatest economic and social benefits [3,4].

Many emerging market countries such as Brazil, China, Hungry, India, Korea, Poland, South Africa and Taiwan have recently adopted the foresight technique, including the use of Delphi surveys, in research and development planning [5]. The technology foresight is very different from the forecasting [2,6–9]. The technology foresight does not attempt to predict what future technologies are most likely to be. Rather, foresight is about describing the variety of potential futures, in order to allow players, especially stakeholders, to prepare for this variety and to contribute to shape the outcomes. As such, foresight lies at the heart of the management of technology and innovation [9].

Renewable energy technologies, which produce energy without using fossil fuels, contribute to a small but rapidly growing portion of the world's energy portfolio. According to Renewables Global Status Report [10], the modern renewable energy industry has been hailed by most analysts as a "guaranteed growth" sector, and even "crisis-proof," due to the global trends and drivers underlying its formidable expansion during the past decade. Policy makers have reacted to rising concerns about climate change and energy security by creating more favorable policy and economic frameworks, while capital markets have provided ample finance for development and deployment. The recent growth of the sector has surpassed all predictions, even those made by the industry itself.

Many researchers [11–24] have made some important contributions to renewable energy technology foresight studies.

This study attempts to explore and define the Turkey's renewable energy future and research priorities likely to be demanded by the Turkish renewable industry and contribute to the achievement

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of strategic goals in the renewable energy sub sectors vital for the national wealth creation, environmental effect and improvement of the quality & security of life. The ultimate objective of the research was to provide advice on renewable energy R&D priorities, based on sound expert knowledge with a time horizon of 2050. This expert questionnaire provides a useful perspective on long-term developments of Turkey's renewable energy future. Also Identify research needs in the renewable energy field which helps to promote a sustainable development. On the other hand, the study was to describe trends in the development of energy technologies and to elicit research and development needs in order to reach the priorities identified in the renewable energy fields.

2. Methodology

There is no single set of methods used in all foresight activities. The methods used need to reflect the resources available and the objectives of the exercise. The choice of methods is critical, though it often appears to be based upon what is fashionable or which practitioners have experience in. The methods may be organized and interrelated in different ways, but there is little advice on the sequencing of methods. There are various guides to available methods and tools, for instance Miles and Keenan [25].

The Delphi method is a method of consolidating respondents' views by repeatedly giving the same questionnaire to a large number of participants. In the second and subsequent questionnaires, respondents received a feedback of the results of the previous questionnaire so that they could reassess their answers to the questions in the light of the overall trend of views. This is the major characteristic that sets the Delphi method apart from ordinary survey methods. Respondents who are not confident in their answers will generally tend to support the majority view, so it is possible to consolidate their views [26].

The Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise. The technique is designed as a group communication process which aims to achieve a convergence of opinion on a specific real-world issue. The Delphi process has been used in various fields of study such as program planning, needs assessment, policy determination, and resource utilization to develop a full range of alternatives, explore or expose underlying assumptions, as well as correlate judgments on a topic spanning a wide range of disciplines. The Delphi technique is well suited as a method for consensus-building by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects [27].

In this study, three different methods are used for a multitude of purposes, including: Bibliometric analysis, SWOT analysis and two-round Delphi survey. Bibliometric analysis study [28] was conducted to find out the development trends of the scientific studies in the field of renewable energies in Turkey. In the SWOT analysis [29], different information gathering strategies have been applied for the analysis of Turkish renewable energy technologies, market and policies. Delphi statements were developed by using the results obtained from the bibliometric and SWOT analysis. The Survey was thus able to give a comprehensive view of the future of renewable energy technologies from basic research to social impact and from subjective and normative points of view to objective and extrapolative perspectives.

The Delphi poll was created by the outcomes of bibliometric analysis [28] by which researchers working in this field were elicited. Moreover, experts and various actors in renewable energies were identified by screening the people working in governmental, non-governmental organizations and industry which was reflected in the quadratic helix approach [29].

The Delphi survey was comprised of two sections, where the first section was designed to cover participants' demographic properties and the second section was dedicated to questioning of six Delphi statements. The foresight period was ascertained as 40 years from today to 2050.

The web-based questionnaire was developed and designed using PHP and MySQL databases. The survey was structured and functionally designed as a web-based, flexible, scalable, analogical and analyzable format which had a user-friendly interface. It was pre-tested with 9 expert participants from Ege University. Subsequent to considerable refinements made to the survey tool, particularly to the navigational structures, the survey was validated.

Some definitions used in structuring the Delphi questionnaire are given in Table 1. Respondents were asked to assess the time occurrence of Delphi statements for seven time intervals from today to 2050 and never. Regarding times of technological realization, the earliest and latest quarters of the answers were discarded and the half in between was used to obtain a value. The quartile including the top statistically ranked members is called the

Table 1
Some definitions about the Delphi questionnaires.

The terms	Indicate
1	The first round of the questionnaire
2	The second round of the questionnaire
E	High degree of expertise in the second round of the questionnaire
Expert	If participant consider yourself to belong to that community of people who currently dedicate themselves to this topic
Knowledgeable	If participants once engaged in research or work related to the topic
Familiar	If participant know most of the arguments used in discussions on the topic, participants have read about it, and have formed an opinion about it. Or has read technical books or literature about the topic or has listened to experts connected with the topic
Unfamiliar	Has no expertise
Wealth creation	Is defined as the economic growth of the European economy measured in GNP/capita
Environment	Is defined as the natural environment, biological diversity, air and water
Quality of life	Is defined as major advancement in health and safety, education, employment, affordable housing, and cultural and recreational opportunities for most people
Security of supply	Is defined as robustness of security of energy supply to ensure that European citizens are not exposed to shortages of energy supply and that Europe is not affected by international policy and conflicts in this area
Standard deviation	Is a measure of the variability or dispersion of a time occurrence between 1st and 2nd round of Delphi participants expectations. A low standard deviation indicates that the data points tend to be very close to the same value (the mean), while high standard deviation indicates that the data are spread out over a large range of values.
Time of occurrence	The mean, median, and quartiles are single numbers that help describe how the individual scores in a data set are distributed in value. A data set consists of the observations for some variable is referred to as raw data or ungrouped data.
High importance degree	Extremely important
Medium importance degree	Important
Low importance degree	Somewhat important
Unnecessary importance degree	Not important

first quartile and denoted Q1. The center half (Q1–Q3) is used as the range of answers and the median (Q2) is used as the representative value for achievement. An average time of occurrence of the statements was evaluated after the second round of Delphi. First and third quartiles were used respectively for the evaluation of the time of occurrence.

Standard deviation is a measure of the variability or dispersion of a time occurrence between first and second round of Delphi participants' expectations. A low standard deviation indicates that the data points tend to be very close to the same value (the mean), while high standard deviation indicates that the data are spread out over a large range of values.

Furthermore, the Delphi survey participants were asked to qualify their expertise level for each Delphi statement based on four categories; expert, knowledgeable, familiar and unfamiliar. The respondents were also invited to assess each statement in terms of its impact on the four following elements: Wealth creation, Environment, Life quality and Energy supply safety. The results of the impacts were subsequently weighted using the weights attributed to a particular level. The particular expertise categories and corresponding weight are calculated as (High (expert) responses $\times$ (2) + Knowledgeable responses $\times$ (1) + Familiar responses $\times$ (0) + Unfamiliar responses $\times$ (−1)) ÷ total responses on impacts (non-responses not included). Finally, overall impact was calculated as overall impact index = [(index of wealth creation impacts)^2 + (index of environmental impacts)^2 + (index of life quality impacts)^2 + (index of Energy supply safety impacts)^2]$^{0.5}$.

Actions needed to enhance the likelihood of occurrence were depicted as the percentage of respondents selecting each of the 11 items (Table 2) as effective measures that the authority (initiative) should adopt in Turkey to promote R&D aimed at the realization of the topic in question.

The degree of importance of the statements to Turkey was reflected as a percentage breakdown of respondents who indicated "high," "medium," "low" or "unnecessary". The index was worked out from the following equation; the index was accepted as 100 when all respondents indicated "high" and 0 when all indicated "unnecessary". Degree of importance index was calculated as:

Degree of importance index = (number of "high" responses $\times$ 100 + number of "medium" responses $\times$ 50 + number of "low" responses $\times$ 25 + number of "unnecessary" responses $\times$ 0) ÷ total number of degree of importance responses.

Finally, all the outcomes of the Delphi survey were evaluated using Access, Microsoft Excel and macros software tools.

3. Results and discussion

A two-round Delphi research study was undertaken to determine and measure the expectations of the sector representatives regarding foresight of renewable energies. First and second round of Delphi study was carried out by using online survey, among experts representing different entities of the energy sector. Totally 456 experts participated in the whole Delphi questionnaire process which shaped out the future of renewable energies in Turkey. Averagely 325 experts have responded to this survey from 49 different locations in Turkey and 12 from abroad. The list of experts was composed of representatives from industry, science and technology institutes, academia and governmental authorities as well as non-governmental organizations corresponding to all Turkish renewable Energy actors.

Over 1900 experts in the field of all Turkish renewable energy sectors were directly invited to participate in the two-round Delphi questionnaire. Experts who accepted the invitation to participate were asked to complete two questionnaires. The link of the questionnaires was sent to respondents consecutively between March and May of 2009. The second questionnaire included the results of the first one and was identical to the first questionnaire.

The overall response rate for the first round of the Delphi process was (382/1900) 20.1%, this improved to (325/382) 84.9% in the second round questionnaire. The majority of the Delphi survey respondents were from universities and industries (Fig. 1). The respondents were classified into 5 different age groups (Fig. 2) and the gender distribution was 80.6% male and 19.4% female.

The time of occurrence was evaluated on the data from the second round of the Delphi results which is presented in Fig. 3. The Delphi statements and their time of occurrence were assessed by all participants. The number of the respondents and the distribution (%) were displayed on the left side of the figure. The answers obtained in the second round and experts for all those participants claiming to be either experts, knowledgeable or at least familiar with the topic were displayed on the right hand side of the figure. The bars indicate the statistical distribution of the responses. The distribution gets narrower from the first to the second round, as intended with the Delphi method, thus signifying a higher reliability of the results. However, for many statements the difference between the lower and upper quartile still surpasses 15 years, thus the mean value should not be referred to as an exact prediction. The shares of respondents evaluating the corresponding statement to be totally unlikely and classified it to happen never were displayed on the far right hand side of Fig. 3.

There are other forecast papers that exist in renewable energy studies using different methodologies. For example, Terrados et al. [30] conducted a study using a similar methodology. According to this study, Delphi techniques have also been a popular tool for preparing forecasts and planning purposes. In recent years, it is being used as an effective method in long-term planning related to sustainable development.

Table 2
Actions needed to enhance the occurrence.

1	Increase in basic R&D
2	Increase in applied R&D
3	A well qualified teaching workforce
4	Fiscal measures (supports, incentives)
5	Increase in R&D supports and R&D infrastructure
6	Internationalization of R&D studies
7	Increase in University–industry–government grid cooperation
8	Encourage of multidisciplinary studies
9	Legal arrangements (adjust relevant regulations, standards, etc.)
10	Increase social awareness (public acceptance)
11	Other

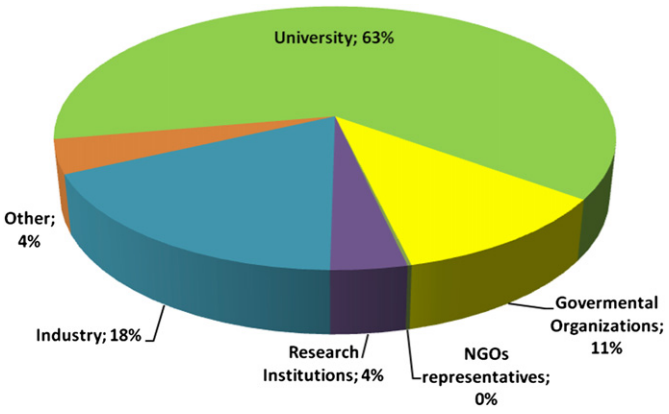

Fig. 1. Distribution of the Delphi survey participants according to foundations.

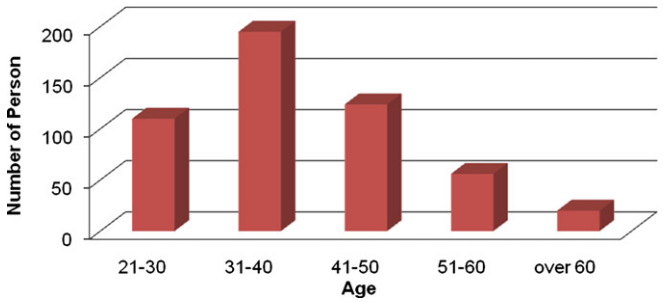

Fig. 2. Age classification of the Delphi survey participants.

Renewable energy sources have been facing a growing importance in the European and global energy markets due to various benefits associated with their use: Renewable energy technologies help decreasing import dependency, diversifying sources of production, and contribute to a sustainable development. According to International Energy Agency's recent *alternative policy* scenario (as of 2007) it can be expected that 28.7% of total electricity will be generated by using Renewable Energy Sources by 2030 at global level [31]. On the other hand, according to Verbruggen and Lauber [32] a full transition of power generation from renewable energy sources is expected in the EU by 2050. which is in accordance with our findings where the Delphi statement "Total installed capacity from renewable energy sources in Turkey reaches 50,000 megawatts (MW)" was ranked to be reached in the long term, sometime after 2020. As, Turkey's current total installed power capacity has reached 40,835 MW at the end of 2007. Otherwise, increased energy consumptions and the demand in parallel, will create an energy bottleneck. This was one of the main drivers behind the power sector investigation process [33,34].

In recent years, the Turkish economy has displayed a high growth performance due to decisively implemented structural reforms and successful macroeconomic policies; it has become one of the fastest growing economies in the world. The annual average real GDP growth rate, which was 0.8% during the period 1998–2002, reached 7% in the period 2002–2007 [34].

According to Turkey Water Report [35] which is prepared by General Directorate of State Hydraulic Works, annual energy consumption per capita in Turkey has reached 2900 kilowatt hours (kWh) which is above world average of 2500 kWh. The average energy consumption for the developed countries is 8900 kWh, but it varies from 12,322 kWh in the USA to 827 kWh in China. Annual increase in energy consumption in Turkey is 8–10% since 1985 parallel to economic growth, industrialization and urbanization except for the recession years (Fig. 4). Total energy generation in Turkey in the 1950s was 800 Gigawatt hours (GWh), this figure has increased by about 256 times, reaching 191,555 GWh/year today. As of 2008, the current installed capacity could generate an average of 250 terawatt hours/year by utilizing 87% of the energy from thermal plants and 70% from hydroelectric power plants. According to the present supply-demand trends, 19% of energy generation depends on hydroelectric power and the remaining 81% on thermal power. A special emphasis has recently been placed on alternative energy sources such as wind and geothermal power. The share of geothermal and wind power in total energy generation has reached 2%. According to TEIAS estimates (Fig. 5), Turkey needs approximately 17,570 MW additional capacity which corresponds to 5600 MW hydraulic & wind, and 11,970 Megawatts-thermal (MW_{th}) energy, from 2007 till 2016 based on low-demand scenario [33].

Actions needed were evaluated on the basis of the Delphi results for all statements (Fig. 6). The two items with the highest degree of consensus among the respondents were "Fiscal measures" and "Strengthened industry-academic-government collaboration" items, whereas, "Internationalization of R&D activities" has been pointed out by few respondents.

According to Renewables Global Status Report [10], annual renewable energy investment has increased four-fold reaching $120 billion in 2008. In the four years from the end of 2004 to the end of 2008, solar photovoltaic (PV) capacity increased six-fold to more than 16 GW, wind power capacity increased 250% to

No	Statements	Round	Respondent(s)	Expertise degree (%)				Time of occurence												Standart Deviation (S)
				Expert	Knowledgeable	Familiar	Unfamiliar	2011-2020	2021-2030	2031-2040	2041-2050	2010'dan önce	2011-2020	2021-2030	2030-2040	2040-2050	2050 Sonrası	Never	
1	Total installed capacity from renewable energy sources in Turkey reaches 50.000 MW.	1	456	49	41	9	1					7	64	18	7	2	1	0,4	8,2
		2	353	57	35	8	0					3	62	18	8	7	2	0,3	10,1
		E	201	100								3	62	18	6	9	2	0,0	
2	Renewable energy replaces fossil fuels in all energy sector.	1	424	50	42	7	1					4	45	19	9	7	13	2,6	14,6
		2	341	59	34	6	1					2	43	18	9	9	17	3,2	15,6
		E	202	100								2	43	15	11	9	18	1,5	
3	Relating to renenewable energy's standards and regulations are implemented for energy security of supply and sustainability.	1	373	38	40	21	1					7	62	22	5	3	1	0,3	8,7
		2	325	48	33	19	1					6	64	20	5	3	2	0,3	8,9
		E	155	100								6	63	19	7	4	1	0,0	
4	50% of Turkey's energy demand is met by renewable energies	1	357	41	42	15	2					3	29	27	18	11	8	2,5	13,1
		2	317	50	37	13	1					3	27	28	17	13	9	2,2	13,4
		E	157	100								3	22	31	15	17	11	1,9	
5	Renewable energy technology researches takes 10 % from Turkey's national R&D budget.	1	346	34	40	23	4					5	42	25	14	4	3	5,8	11,0
		2	310	44	33	19	4					5	43	23	13	5	5	6,8	11,6
		E	137	100								4	45	20	15	4	6	5,8	
6	Overcome to grid connection of renewable energy system which ensure to reliable energy supply	1	336	35	35	25	5					4	51	29	10	2	4	0,0	10,2
		2	301	43	30	22	5					3	52	28	11	2	4	0,0	10,1
		E	130	100								3	56	25	11	2	2	0,0	

Fig. 3. The Delphi statements and their time of occurrence.

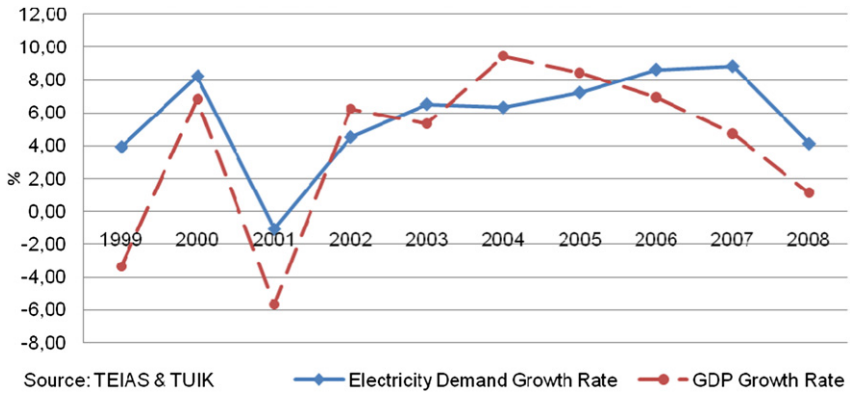

Fig. 4. Growth rate of GDP & electricity demand (%).

121 GW, and total power capacity from new renewables increased 75% to 280 GW, including significant gains in small hydro, geothermal, and biomass power generation. During the same period, solar heating capacity doubled to 145 Gigawatts-thermal (GWth), while biodiesel production increased six-fold to 12 billion liters per year and ethanol production doubled to 67 billion liters per year.

According to the same report, renewable energy industries boomed during most of 2008, with large increases in manufacturing capacity and diversification of manufacturing locations. Many leadership changes and milestones in renewable energy markets and policy took place in 2008. The United States became the leader in new capacity investment with $24 billion invested, or 20% of global total investment. The United States also led in added and total wind power capacity, surpassing long-time wind power leader Germany. Furthermore, Spain added 2.6 GW of solar PV, representing a full half of global grid-tied installations and a five-fold increase over Spain's 2007 additions. China doubled its wind power capacity for the fifth year in a row, moving into fourth place worldwide. Another significant milestone was that for the first time, both the United States and the European Union added more power capacity from renewables than from conventional sources (including gas, coal, oil, and nuclear).

European Renewable Energy Centres Agency (2002) stated the renewables will play a significant role in the energy systems between 2020 and 2030 [36]. According to the EurEnDel Delphi [37], renewable energy sources will cover 25% of Europe's total energy supply by 2028 (first quartile 2020–third quartile 2033). The share of renewables is expected to rise from 5.8% (2000) to 8.6% by 2030. Thus, renewable energies were considered to be overall the most beneficial in the four areas considered which wealth creation, environment, quality of life and security of supply. In addition to the positive ecological impact, the respondents highlighted the strong contribution to security of supply.

On the other hand, in March 2007, the European Union defined a target of 20% renewable energy for year 2020. A target of 30% renewable energy for year 2025 has just been proposed by the Danish Government [38]. The Chinese government is making favorable policies for the middle and long-term development of renewable energy resources [39]. Poland will fulfill EU standards concerning the share of renewable energy sources in the energy market approximately in 2021 [11].

However, fossil fuels remain the dominant source of primary energy, accounting for 84% of the overall increase in global demand between 2005 and 2030. Oil remains the single largest fuel, though its share falls from 35% to 32%. Oil demand is expected to reach 116 million barrel/day (mb/d) in 2030 from 32 mb/d in 2006. The biggest increase in demand for coal will be between 2005 and 2030, jumping by 73% and pushing its share of total energy demand up from 25% to 28%. On the other hand, the share of natural gas increases more modestly, from 21% to 22%. However, electricity use almost doubles, its share of final energy consumption rising from 17% to 22%. Some $22 trillion of investment in supply infrastructure is needed to meet projected global demand is stated in the 2007 edition of the World Energy Outlook which is pressed by International Energy Agency [40].

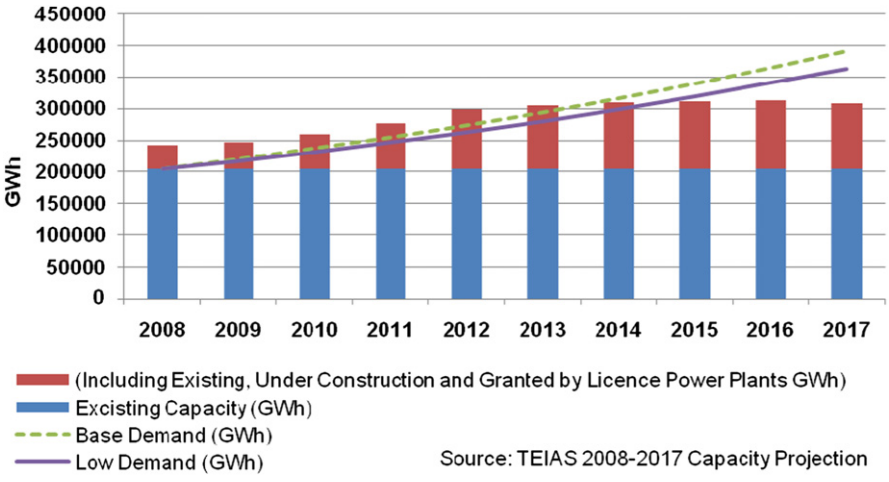

Fig. 5. Turkey-electricity demand projections.

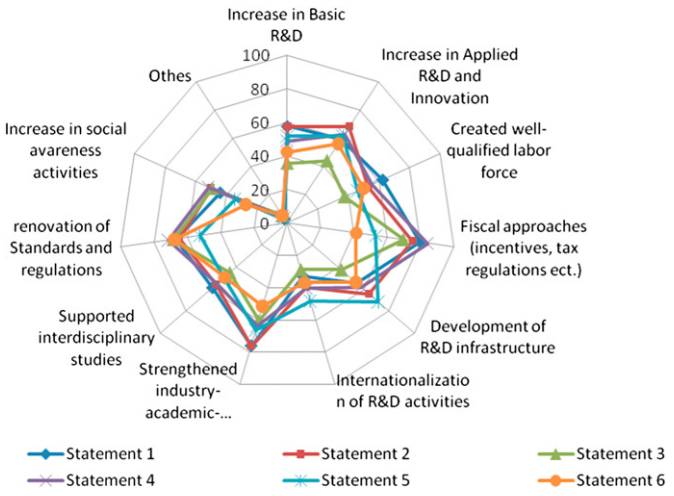

Fig. 6. Comparison of actions needed to enhance the Delphi statements.

Despite, fossil fuels play a crucial role in the world energy market and the world's energy market worth around $1.5 trillion dollars is still dominated by fossil fuels [41] and many countries move away from fossil fuels with the Kyoto protocol, it is obvious that the Turkish energy experts are much more optimistic for the "renewable energy replaces fossil fuels in all energy sector". According to experts, the mean value of the time of occurrence for the second statement lies between 2014 and 2042.

The integrated index of importance is calculated according to four indicators such as wealth creation, environmental impact, life quality and energy supply safety. Implementation of renewable energy standards and regulations for the security of supply and sustainability was the most important message from the experts and renewable energy community. This expectation was the highest on the list of priorities (Table 3).

Apart from the technology and technophysical data also socio-economic (e.g. employment, turnover) data and R&D expenditures are of critical relevance. Concerning Research and Development (R&D), in most EU countries, the R&D for RES is funded with 20–40% of the total energy research budget [42].

Considering the survey results, respondents strongly believe that "Renewable energy technology researches will take 10% from Turkey's national R&D budget". When focusing on some of the indicators for Turkey, it is necessary to mention that the share of GDP in R&D expenditures has doubled between 1998 and 2007 from 0.37 to 0.71%. The increase in R&D financing during the last 10 years has raised hopes for the development of renewable energy technologies [29]. According to the energy experts, this statement would be implemented by the end of the 2023 if the R&D infrastructures are developed. Regarding effective results that should be taken by authority towards technological realization, the ratio for expansion of R&D funding is high in this field, followed by strengthened industry–academia–government and increase in applied R&D and innovation. On the other hand the statement has the less importance degree for Turkey among other statements (Table 3).

According to Energy Revolution report [43], The power grid network must also change in order to realise decentralized structures with a high share of renewable energy. Whereas today's grids are designed to transport power from a few centralized power stations out to the consumers, a future system must be more versatile. Large power stations will feed electricity into the high voltage grid but small decentralized systems such as solar, cogeneration and wind plants will deliver their power into the low or medium voltage grid. In order to transport electricity from renewable generation such as offshore wind farms in remote areas, a limited number of new high voltage transmission lines will also need to be constructed. These power lines will also be available for cross-border power trade. Within the energy [r]evolution scenario, the share of variable renewable energy sources is expected to reach about 30% of total electricity demand by 2020 and about 40% by 2050.

While reviewing the Eurendel final report [37], a large consensus was reported that the trend towards a more decentralized electricity supply would prevail. A 30% share of decentralized generation is expected by 2020. In contrast there is quite a controversy when and if all large international grids allow for an energy transportation of regionally produced renewable energy. It is worth to mention that the results of our Delphi survey in regards to the six statements are almost parallel to the results outlined in Eurendel.

Finally, "Overcome to grid connection of renewable energy system which ensure to reliable energy supply" statement was foresighted to be realized between 2020 and 2025. The need for actions addressing renovation of standards and regulations was supported by a majority of respondents (67.7%). The other actions picked up by the respondents were R&D, innovation and

Table 3
The degree of importance of the Delphi statements to Turkey.

No	Statements	Round	Respondent(s)	The degree of importance to Turkey				
				(%) High	(%) Medium	(%) Low	(%) Unnecessary	Index
1	Total installed capacity from renewable energy sources in Turkey reaches 50,000 MW	1	456	79.61	15.35	2.41	2.63	0.88
		2	353	79.55	15.63	1.99	2.84	0.88
		E	201	79.50	14.50	2.00	4.00	0.87
2	Renewable energy replaces fossil fuels in all energy sector	1	424	77.83	16.27	2.83	3.07	0.87
		2	341	80.65	15.25	1.76	2.35	0.89
		E	202	84.16	12.38	1.98	1.49	0.91
3	Relating to renenewable energy's standards and regulations are implemented for energy security of supply and sustainability	1	373	77.21	16.89	5.09	0.80	0.87
		2	325	80.66	15.12	3.09	0.93	0.89
		E	155	87.66	9.09	1.95	1.30	0.93
4	50% of Turkey s energy demand is met by renewable energies	1	357	80.67	13.17	3.92	2.24	0.88
		2	317	82.02	12.93	3.15	1.89	0.89
		E	157	82.80	13.38	1.27	2.55	0.90
5	Renewable energy technology researches takes 10% from Turkey's national R&D budget	1	346	62.72	22.83	12.43	2.02	0.77
		2	310	63.23	23.55	11.61	1.61	0.78
		E	137	70.80	18.25	8.76	2.19	0.82
6	Overcome to grid connection of renewable energy system which ensure to reliable energy supply	1	336	68.75	23.21	5.65	2.38	0.82
		2	301	71.43	21.59	5.32	1.66	0.84
		E	130	76.15	19.23	3.85	0.77	0.87

strengthened R&D infrastructure. Only 26.9% of the respondents pointed towards public acceptability as a required action. This may be related to the long-term realization perspective of this statement.

When the respondents were asked to assess which actions could promote early occurrence of the statements, the issues with the highest degree of consensus among the respondents were the necessity of fiscal approaches and university-industry-government collaboration. Considering the spider graph (Fig. 6) which was based on the responses from experts, necessity of fiscal measures was agreed on with the highest degree of consensus for statement 4 (84.1%) and statement 1 (79.6%), while few respondents pointed towards an increase in social awareness as a required action for realizations of statement 6 (29.6%) and statement 5 (34.3%). Increase in university–industry–government collaboration was the category that was considered most relevant by the respondents for all statements. Likewise, the need for actions addressing increase in basic and applied R&D action was supported by a great majority of respondents in the case of all statements. Additionally, more than 70% of the respondents agreed on the need for fiscal approaches for realization of statements 1–4.

4. Conclusion

This paper was the first attempt to provide a Delphi analysis of the Turkish renewable energy. The web-based survey was developed and designed using PHP and MySQL databases. Information gathered from the two-round Delphi survey was used to foresight Turkey's renewable energy futures. The participants chosen for the survey played key roles in the sector and the fact that all the actors such as academicians, policy makers, politicians, industrialists and representatives of civil society organizations were represented, the outcome was very fruitful.

The most important findings obtained from the Delphi survey can be summarized as follows:

- Turkey will reach 50,000 MW total installed capacity from renewable energy sources in about 2020.
- Renewable energy replaces fossil fuels in all energy sectors that are expected to be realized in the period of 2014–2042.
- Standards and regulations for energy security of supply and sustainability would be implemented at the end of the next decade.
- About 50% of Turkey's energy demand would be met by renewable energies around 2030.
- The budget of researches in renewable energy technologies would be 10% from Turkey's national R&D budget through 2023.
- "Overcome to grid connection of renewable energy system which ensure to reliable energy supply" expectation could be realized around 2020.

All renewable energies are expected to play an important role for reaching a major advancement in health and safety, education, employment, interrelationship, cultural and recreational opportunities for most people. Consequently, the renewable energies will bring not only economic and environmental benefits but also improved living standards. Therefore, we hope that this study can shed a light on the future use of renewable energies, especially for policy makers.

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