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Research Article

The evaluation of factors in utilizing the potential of solar energy: the case of Turkey

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ABSTRACT

The importance of energy which has a significant role in socio-economic development of countries is increasing because of a fast-growing population and industrialization. The fact that the fossil resources are insufficient to meet the demand if new reserves cannot be found in the near future and the threat to human and environmental health lead the countries to seek renewable clean energy resources. Turkey, which is dependent on foreign energy due to being poor in terms of fossil fuels as a country, has high solar energy potential but cannot utilize this potential fully. In this paper, the importance and potential of solar energy in Turkey, the problems encountered in utilizing solar energy have been studied. In this study, semi-structured interview was used as qualitative data collection technique. The experts to be interviewed were selected from people with at least five years of academic or sector experience in solar energy. As a result of the research, it was reached by all experts interviewed that Turkey need to increase the benefit from solar energy for Turkey's social and economic development and there are various obstacles in front of utilizing this benefit. However, it is seen that expert opinions vary in terms of solutions.

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INTRODUCTION

The importance of energy in the development of countries is increasing with the growth in population and industrialization all around the world. Fossil energy has been used extensively to meet the energy need of nations for centuries because of the ease and availability of these resources. However, renewable resources gained a significant attention recently as there is a scarcity in fossil energy resources to meet the needs in the near future, and the effects of fossil fuel on the environment and human health such as global warming, acid rain and nuclear radiation wastes threat human life.

Solar energy is one of the most common renewable energy among various types of renewable energy resources currently used. It was used for the first time in the solar water pump made by Belidor in 1725. Later, in 1860, Mohuchok worked on solar radiation steam engines, solar pumps and

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solar cookers using parabolic mirrors. With the emergence of oil during the First World War, the importance given to solar energy decreased. Today, solar energy has gained importance again due to the availability of solar power, the depletion of fossil resources and the damage it causes to the environment [1]. The effects of solar energy technologies on the environment were analyzed in the study of [2]. It has been concluded that solar energy technologies have almost no harm to the environment compared to fossil resources. If due importance is given to the land and existing vegetation during the installation of technologies, to the location selection that does not harm the living area, and to keeping the toxic substances to be used in the system under control, the effects of solar energy can be minimized. With these benefits, solar power increased at a rate more than total renewable supply in 2018 [3].

Energy, which is of great importance in terms of growth and social development, is more important in developing countries such as Turkey. Turkey ranks first among developing countries in terms of foreign dependency in energy. It met approximately 72% of its energy consumption from abroad in 2019 [4]. According to the data of 2020 in the TCMB balance of payments, a total of 24211 million dollars in our current account deficit is due to energy imports [5]. Only 17% of energy consumption in Turkey is met by renewable energy [4]. It is known that Turkey has an annual solar energy potential of 2741 hours due to its geographical location [6]. It is seen that Turkey, which has a wide geographical opportunity to benefit from solar energy in factors such as the slope status of the land, transportation status, agricultural status, topographic structure, network connection, geological structure, property status, distance to the sea, cannot obtain the expected benefit from its solar energy potential [7]. Although Germany, the world leader in electricity generation from solar energy, has an annual solar energy potential of 1300–1900 hours and Turkey and Germany use the same solar energy technologies, as of 2019 Germany produces 47517 GWh from solar energy, while Turkey produces 9578 GWh [8–9]. This situation has caused us to draw attention to the problems encountered in electricity production from solar energy in Turkey.Renewable energy projects necessitate significant investment in both research and manufacturing capacity, which frequently surpasses the capabilities of the private sector. Therefore, governments play a significant role in the expansion of this industry, trying to enhance the international competitiveness of domestic manufacturers through their economic policies. Government support and education are of great importance in the evaluation of the current potential in the production of electrical energy from solar energy in Turkey. Yılmaz [10] mentioned in his study that studies in the field of renewable energy gained momentum with the entry into force of the Renewable Energy Law (YEK) in Turkey in 2005. It has been analyzed that general incentive applications, regional incentive applications, incentives for large-scale investments, and incentives for strategic investments are provided in the regulation made in 2012 due to the lack of fixed price guarantee and unlicensed production right in YEK 2005. In the study of İraz and İsa [11], the solar energy policy implemented by the European Union (EU) in 2007 was shown as an example for the government to intervene in the renewable energy market. It has been stated that the role of government support and incentives is among the reasons why EU has developed in solar energy. It has been determined that the tariff guarantee, investment support and quota systems applied in Turkey are the most effective methods applied in sixty-three countries. It has been concluded that the regulations regarding obstacles to the use of solar energy in Turkey have not been used yet and concrete strategies have not been formed. Dinçer [12] conducted a comparative analysis of financial, technological barriers and incentives in electricity generation and use from solar energy between Turkey and EU countries. It was determined that Turkey's thermal solar energy potential is in the fourth place after China, US, and Japan. As a result, although EU countries have less solar energy potential than Turkey, it has been seen that they gain more benefits with the development of financial and technological incentives. It suggested to increase incentives in Turkey, spread the use of solar energy to the base, and improve inter-ministerial coordination and cooperation. It was stated that although they do not have a high solar energy potential compared to Turkey, the point reached by countries such as Germany and France, which have achieved higher values in electricity generation from solar energy, is remarkable.

Considering the solar power situation in Turkey, this study is important for comprehending and finding experts' perspectives on the factors affecting the use of solar energy. The main question of this study is what experts in the energy field think about solar power industry in Turkey and the problems encountered in utilization of solar power. Sub-questions to find the answer to the main question are listed below.

1. What are your thoughts on Turkey's energy mix and what do you think about the low share of solar energy in this mix?
2. What are your thoughts on what should be done or developed to increase the share of solar energy in Turkey?
3. Do you find the studies of universities on solar energy (research and development (R&D), project, plan, program) sufficient? What are your thoughts?
4. Are there departments teaching solar energy in vocational and technical high schools, and universities in Turkey and are the trainings oriented to the needs of the sector?

5. Are there any issues in the energy legislation regarding solar energy that you think should be improved or changed?
6. What do you think about the problems and impacts Turkey faces on solar energy transportation, customs, expertise, technology supply and other issues?
7. What are your thoughts about the impact of solar technology supply on the low share of solar energy?
8. Do you find the current transmission capacity and transformer share for electrical energy produced from solar energy sufficient?
9. Do you think that small-scale YEKA areas should also be determined next to the large-scale YEKA areas for the dissemination of small-scale YEKA projects (solar energy projects)?

THE STATUS OF SOLAR ENERGY

Solar energy is a most available energy in the world. It is reachable from most countries which have days with sunshine. Solar energy is used in two ways, electrical and thermal energy. The earlier use of solar energy was mostly thermal energy for heating water. Technological development in solar energy has led to use it as electrical energy. There are two types of technology to transform solar energy to electrical energy: Concentrating solar power (CSP) and Photovoltaic power (PV).

CSP is a solar energy technology which generates electricity by using first concentrators to transform sunlight to heat and second heat engines to transform heat into electricity with Rankine, Brayton, and Stirling cycles [13]. CSP may be used as a heat storage alone or with fossil fuels which have a back-up role for the times there is no sunshine. There are several types of CSP in use. In the Figure 1, the development of CSP technology was shown according to receiver temperature (~250–450 °C, ~500–565 °C, ~720 °C, and >700 °C), plant type (parabolic trough collector-PTC, solar power tower-SPT, linear Fresnel reflector-LFR, power dish collector-PDC), heat transfer material (oil or steam, steam or salt, gas, salt, particle), thermal energy storage capability, power cycle (Small Rankine cycle, Stirling, and Brayton cycle), cycle peak temperature (~240–440 °C, ~480–550 °C, ~720 °C, and >700 °C), efficiency of design cycle (~28–38%, ~38–44%, ~38%, and >50%), solar electricity generation efficiency per year (~9–16%, ~10–20%, ~25%, and ~25–30%).

Solar photovoltaics (PVs) allow direct transformation of solar energy to electricity. They are formed from semi-conducting material layers. It is a significant electricity source for fulfilling energy demand in developing nations, particularly in rural and isolated areas, without polluting the environment. PV systems' improved efficiency and further cost reductions suggest that solar producing systems will play a key role in the future. Among renewable energy technologies, photovoltaics provides the most flexibility. The lack of moveable components, the extremely gradual deterioration of sealed solar cells, and the great ease of their usage and maintenance are the most appealing aspects of solar

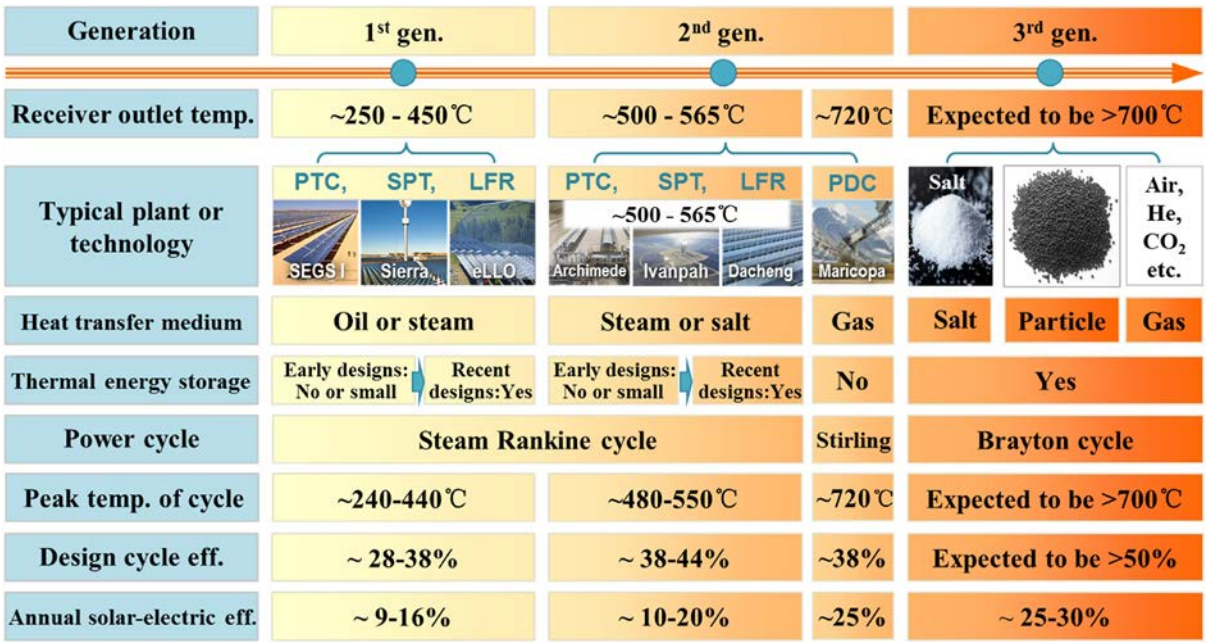


Figure 1. The development of CSP technology [14].

panels. Another benefit is that it is modular. All generating sizes, from milliwatts to megawatts, may be achieved [15]. Main materials used in PV cells are crystalline materials, thin films, organic and polymer cells, hybrid solar cells, dye-sensitized solar cells, and nanotechnology [16]. PV power plants can be categorised into four groups in terms of implementation. These are [17]:

- Domestic solar systems that are not connected to the grid: These plants supply energy to families and villages in distant areas that are not linked to the national grid. Light, cooling, and other low-power demands are often supplied by these plants.
- Non-domestic solar systems that are not connected to the grid: These plants were the first commercial use of solar panels. They are suitable for situations where a little quantity of power has a high value such as telecommunication, pumping for water, and cooling for vaccine.
- Distributed photovoltaic systems that are connected to the grid: These plants provide electricity to a dwelling linked to the grid. Residential, commercial, and industrial buildings may all be served with these plants. These are less expensive than off-grid installations since they do not require battery storage devices because they are directly linked to the grid.
- Centralized photovoltaic systems that are connected to the grid: These are used as a replacement for traditional centralized power generator or to improvement of the utility distribution network.

Solar PV has been a cheaper option compared to new fossil fuel plants in most countries in the last decade therefore it had seen a rapid increase in the recent years around the world. From 2014 to 2019, total PV production increased almost by four time as seen in Figure 2a and the most capacity in PV belongs to China as show in Figure 2b.

China is the world leader in solar PV module production, as seen in Figure 3. Other Far East countries such as South Korea and Malaysia follow China with %6 shares. Then, US comes with %3 and Europe with %2.

The current energy supply in Turkey is mostly dependent on fossil fuels as shown in Figure 4. Even though Turkey is poor in terms of fossil fuels therefore importing mostly from Russia and Iran, it has considerable renewable energy resources, particularly wind and solar.

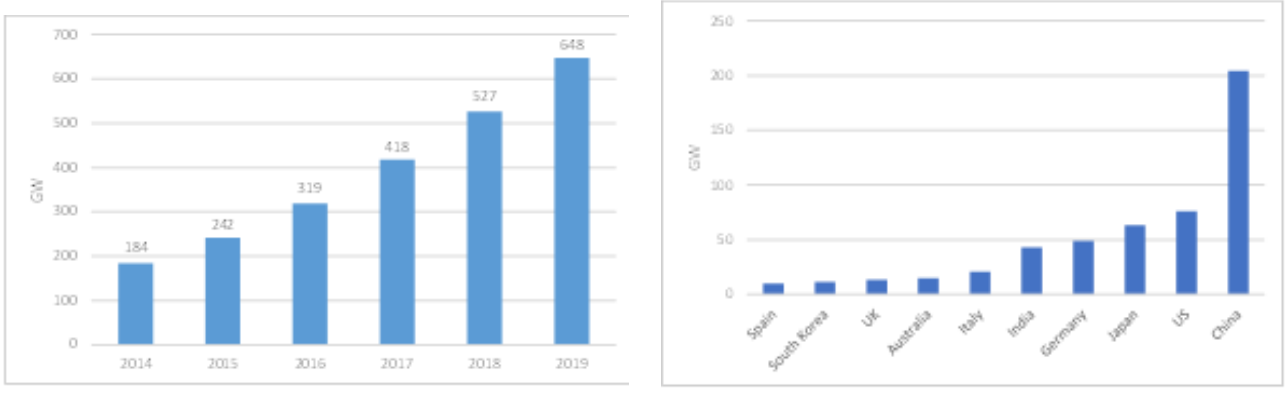
According to the Turkish Solar Energy Potential Atlas (GEPA) as seen in Figure 5, the total sunshine duration is 2741 hours in a year and the total radiation intensity is 1.527 kWh/m² in a year [21].

Turkey has begun to assess the potential in this area in recent years, focusing on solar energy and taking efforts to capitalize on its benefits. As a result, the share of solar energy has increased in recent years. As presented in Figure 6a and 6b, 9250 GWh electricity is generated from solar energy and installed capacity reached to approximately 6000 MW in 2019.

DATA AND METHODOLOGY

The case study technique, which is one of the qualitative research methodologies, is utilized in this study. The purposeful sampling approach was used to identify the study's sample group which consists of six experts who have more than five years' experience in energy subject in general and solar energy in particular. The information of the interviewed experts is shown in Table 1. During the data collecting procedure, a semi-structured interview method was used.

In the semi-structured interview method, which is a qualitative research technique, the researcher prepares an



(a) (b)

Figure 2. (a) Worldwide solar PV growth (GW) [18]. (b) Solar PV capacity of countries in 2019 (GW) [19].

interview protocol that includes questions that he/she plans to ask about the subject he/she is researching. In addition to these questions, the researcher can affect the course of the interview with other questions or sub-questions according to the flow of the interview. The researcher may ask the interviewee to elaborate on their answers, and this gives the researcher the opportunity to explore the subject in depth. Semi-structured interview technique provides convenience in research because it offers a certain level of standardization and flexibility in the questions prepared by the researcher in the interview protocol [23] (Türnüklü, 2000). Besides, being able to communicate directly with people while interviewing is an important advantage. It provides instant feedback to the data obtained during the interview process. Since the researcher asks the questions in a conversational manner during the interview process, they are more likely to get answers to their questions. Being able to control the different conditions that arise according to the progress of the interview process allows the researcher to advance the interview as desired. Since it is an oral process, it can be applied to illiterate people and to all small and large groups [24].

Nine open-ended questions were asked in the semi-structured interview form to the experts selected by purposeful sampling approach. Questions to reveal why Turkey cannot produce electricity from solar energy at the expected level despite being a country with high solar potential were asked questions through face-to-face interviews.

Content validity of the data, as well as detailed profiles of the subject and experts in the study, have been used to assure the validity and reliability of the research. Furthermore, reliability was evaluated according to Miles and Huberman's [25]'s reliability calculation. It was found that it is 91%. As this value is over %70, it meets the reliability.

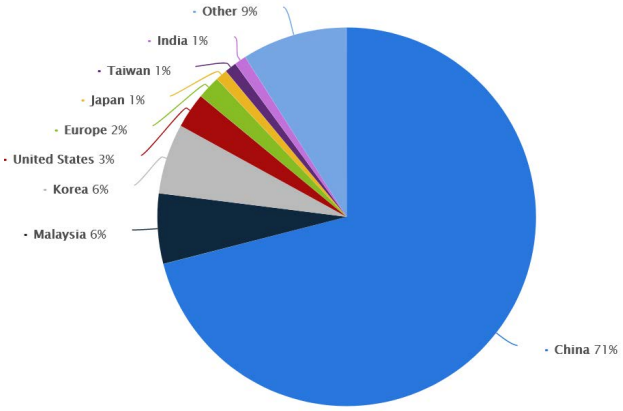


Figure 3. Distribution of solar PV module production worldwide in 2019 [19].

RESULTS

The findings derived from the answers to the semi-structured interview questions gathered from experts are presented in this part.

Table 2 shows the experts' answers to the first sub-question "What are your thoughts on Turkey's energy mix and what do you think about the low share of solar energy in this mix?".

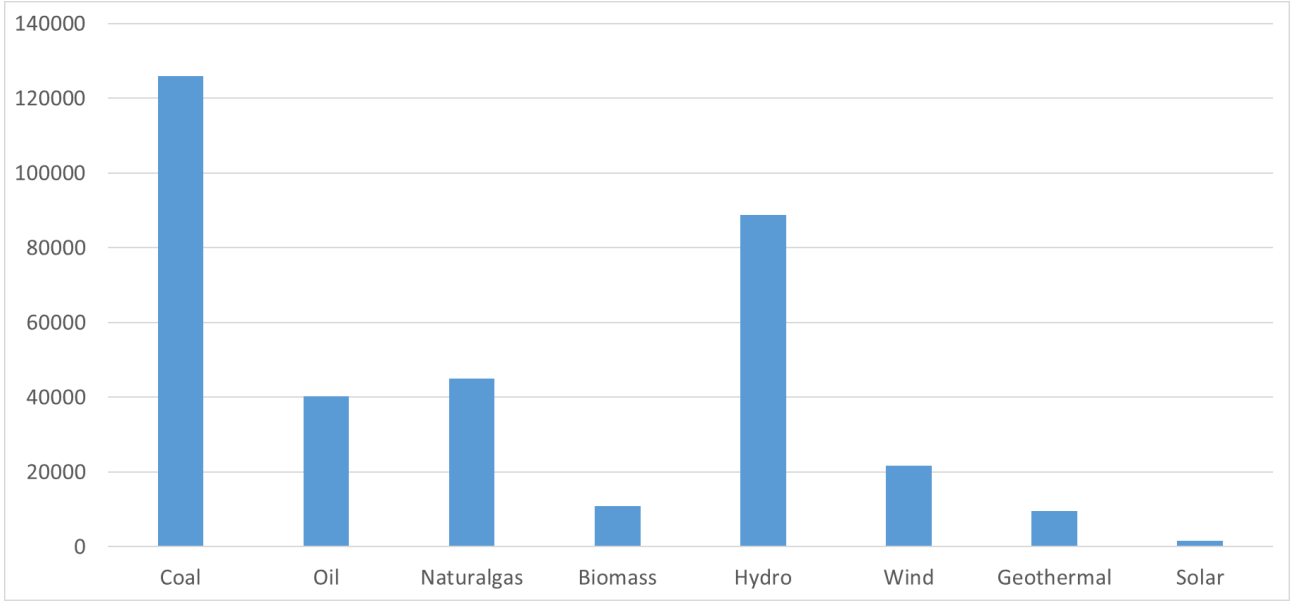


Figure 4. Energy supply of Turkey in 2019 [20].

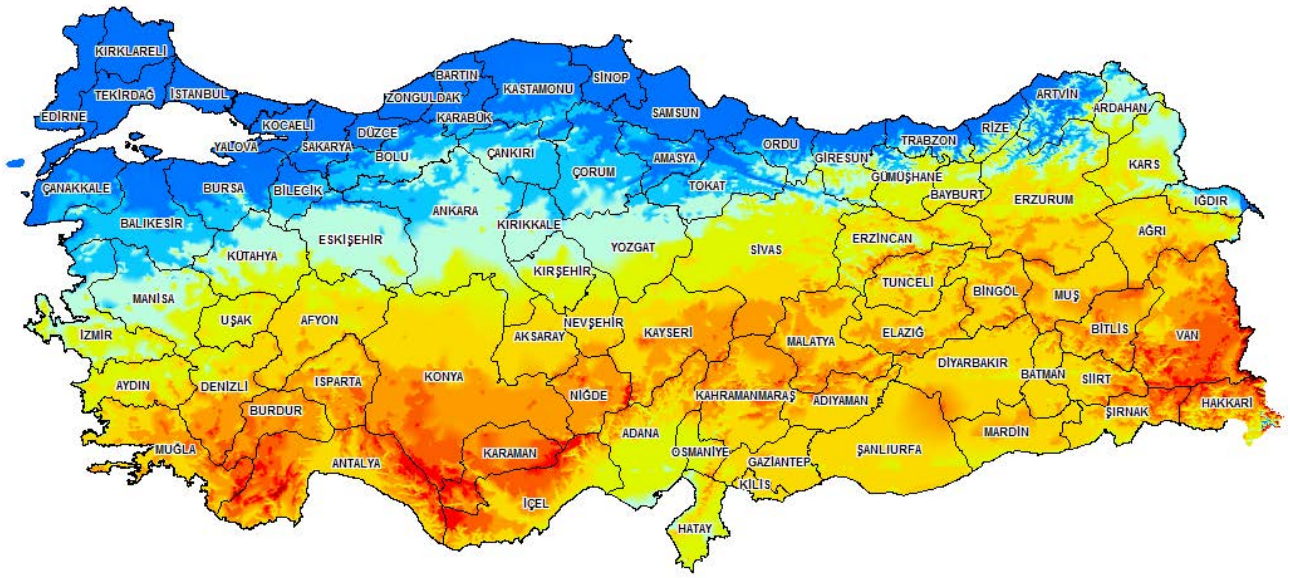


Figure 5. City based solar energy potential atlas [22].

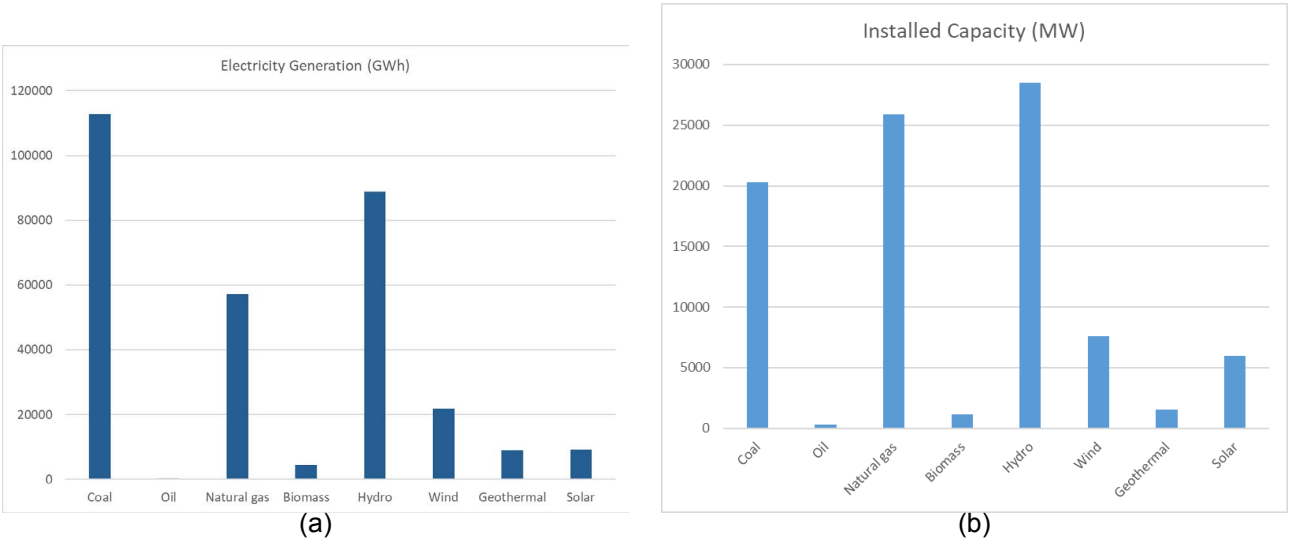


Figure 6. (a) Electricity generation of Turkey in 2019 [20]. (b) Installed capacity of Turkey in 2019 [20].

Table 1. Code and characteristics of experts

Code	Position	Industry
EXP 1	CEO	Energy
EXP 2	General secretary	Media
EXP 3	Academician	Education
EXP 4	Education specialist	Education
EXP 5	Project planning specialist	Government
EXP 6	Engineer	Manufacturing

It can be observed from Table 2 that all experts agree with the low share of solar energy in Turkey energy mix. They all expressed that the share is low compared to high solar potential in Turkey. Also, Expert 1 and Expert 6 stated that there is high fossil fuel use, particularly coal and natural gas. In addition to these statements, Expert 1 also expressed that fossil fuel-based energy imports have accounted for the majority of current account deficit and the lack of public awareness is responsible for low solar energy demand from consumption viewpoint.

Table 2. Experts' views on Turkey energy mix and the share of solar energy

Answers	Experts	f
Low solar share in the mix	EXP 1, EXP 2, EXP 3, EXP 4, EXP 5, EXP 6	6
High coal and gas use	EXP 1, EXP 6	2
Budget deficit due to fossil fuel export	EXP 1	1
Low demand for solar energy due to the lack of public awareness	EXP 1	1

Table 3. Experts' views about increasing the share of solar energy

Answers	Experts	f
Incentives	EXP 1, EXP 2, EXP 3, EXP 4, EXP 5, EXP 6	6
Encouraging distributed systems (on-site generation and on-site consumption)	EXP 1, EXP 2	2
Mandatory roof solar panels for new buildings	EXP 1, EXP 2	2
Large capacity solar power plants	EXP 1	1
Energy storage systems	EXP 1	1

Table 4. Experts' views about university engagement in solar energy

Answers	Experts	f
Insufficient	EXP 1, EXP 2, EXP 3, EXP 4, EXP 5, EXP 6	6
Insufficient solar energy research	EXP1, EXP 2, EXP 3, EXP 5	4
Not innovative	EXP 1	1
Fossil fuel-based studies common	EXP 1	1
Lack of financial support for R&D	EXP 4	1
Lack of human resources at universities	EXP 6	1

Table 3 presents the experts' answers to the second sub-question "What are your thoughts on what should be done or developed to increase the share of solar energy in Turkey?".

Increasing incentives currently given or introducing new ones was the main suggestion given by all experts. Expert 1 stated that it is necessary to encourage the construction of large-capacity solar power plants to rapidly reduce the share of fossil fuels. It is necessary to build solar power plants (SPPs) in all provinces with the capacity to meet their needs. It is also necessary to add energy storage systems to all these SPPs so that energy supply and demand are balanced. Expert 1 and Expert 2 told that encouraging distributed systems and making installation of solar panels mandatory on the roofs of all new buildings are suggested to increase the share of solar energy.

Table 4 shows the experts' answers to the third sub-question "Do you find the studies of universities on solar energy (R&D, project, plan, program) sufficient? What are your thoughts?".

University engagement in solar energy was found to be insufficient by all experts. Reasons for insufficiency vary. Expert 1, Expert 2, Expert 3, and Expert 5 stated that there are very few researchers who have been trained and have done scientific studies on solar energy. Expert 1 claimed that universities are not innovative as they stay behind of recent developments and the studies promoting fossil fuels are still common practice in academic settlings. Expert 4 told that scientific institutions such as TUBITAK have insufficient R&D establishment and support projects. Expert 6 pointed to the insufficient numbers in people working on solar energy at universities therefore less productivity.

Table 5 shows the experts' answers to the fourth sub-question "Are there departments teaching solar energy in vocational and technical high schools, and universities in Turkey and are the trainings oriented to the needs of the sector?".

All experts stated that educational institutions are not capable to meet the human resources needs of the sector. Universities should work on R&D and processes while vocational high schools should train blue-collar intermediate staff. Vocational and technical high schools should open departments for the needs of the sector and provide required training. Expert 1 and Expert 6 claimed that except for few technical high schools, most of the educational institutions are only teaching theoretically and this is leading the lack of

Table 5. Experts' views about solar energy education

Answers	Experts	f
Education sector do not meet the human resources needs of the solar energy sector	EXP 1, EXP 2, EXP 3, EXP 4, EXP 5, EXP 6	5
Too theoretical education	EXP 1, EXP 6	2
Need to train teachers	EXP 2, EXP 5	2
Specialization is needed	EXP 1	1
Lack of training instruments	EXP 2	1
A common platform for vocational and technical high schools regarding solar energy	EXP 2	1
Need for highly educated professionals	EXP 3	1
Lack of foreign language (English)	EXP 6	1

practical skills in students. Expert 2 and Expert 5 presented that there is a need to train teacher and lecturers to increase the efficiency of solar energy courses or programs given in educational institutions as solar energy is a dynamic subject it requires to update study materials periodically. Expert 1 found that it is necessary to open new departments in educational institutions catering to solar energy sector for specialization in profession. Expert 2 expressed that there are 44 vocational high schools which have solar energy programs, but almost none of them have the tools and equipment to provide training in accordance with the sector. Only small materials among necessary training equipment are provided by the school authorities themselves. Expert 2 also stated that constructing a common platform for vocational and technical high schools regarding solar energy will be beneficial. On the other hand, Expert 3 said that the sector needs not only intermediate technical staff, but also manpower at undergraduate and postgraduate level however efforts on this subject are insufficient. Additionally, Expert 6 stated that there is a need for using English at a sufficient level as solar energy sector is operating globally however most of the educational institutions in Turkey is not capable to teach English.

Table 6 shows the experts' answers to the fifth sub-question "Are there any issues in the energy legislation regarding solar energy that you think should be improved or changed?".

Most experts stated that incentives need to be increased. There should be incentives for energy cooperatives and unions. A certain price mechanism should be created for the electricity produced on the roofs such as a feed in tariff or as a purchase guarantee. This should be a price that will facilitate investment increase and overcome the obstacles in front of investment decisions. Also, exemption from certain taxes such as VAT for a certain period will reduce the costs around 21% and consequently will reduce the amortization period approximately 1 year and this will encourage investors for solar energy investments. Three experts (Expert 2, 4 and 5) have suggested to create new regulations for getting more benefits from roofs such as introducing a regulation for roof renting, electricity subscription for roof and energy contracting. Expert 1 also suggested to use mechanisms that restrict fossil fuels in addition to the incentives encouraging renewable energy. Expert 2 added that regulations for encouraging R&D in industry/universities and solar technology production will be beneficial. Expert 6 suggested to establish a special unit in the Energy Ministry to follow all the current developments in solar energy globally.

Table 7 shows the experts' answers to the sixth sub-question "What do you think about the problems and impacts Turkey faces on solar energy transportation, customs, expertise, technology supply and other issues?".

Table 6. Experts' views about solar energy legislation

Answers	Experts	f
More incentives for renewable energy (such as feed-in tariffs, purchase guarantee, VAT exemption)	EXP 1, EXP 2, EXP 3, EXP 4, EXP 5	5
Regulation for roof panels and distributed systems	EXP 2, EXP 4, EXP 5	3
Restrictive measures on fossil fuel imports	EXP 1	1
Regulation for R&D in industry and universities	EXP 2	1
Regulation for encouraging solar technology production	EXP 2	1
Need for a special unit in Energy Ministry for solar energy regulation	EXP 6	1

Table 7. Experts' views about problems encountered in solar energy technology supply

Answers	Experts	f
Problems due to low market potential of Turkey	EXP 3, EXP 4, EXP 5	3
Need to increase the number of customs control centres	EXP 4, EXP 5	2
Vibration problem in transportation	EXP 4, EXP 5	2
Need for competent human resources	EXP 3, EXP 5, EXP 6	2
There is a problem in the implementation of legislation	EXP 1	1
Nothing goes as planned; disruptions on supply of technology	EXP 1	1
A serious decrease in productivity and flow of work	EXP 1	1
Technology import from Far East	EXP 3	1
Long transportation time	EXP 5	1
Lack of coordination between institutions	EXP 6	1

Table 8. Experts' views about the effect of solar energy technology supply on low solar share

Answers	Experts	f
High import cost > low solar energy use	EXP 1, EXP 2, EXP 3, EXP 4, EXP 5, EXP 6	6
Technology production inside the country will decrease the cost	EXP 1, EXP 2	2

Table 9. Experts' views about the effect of solar energy technology supply on low solar share

Answers	Experts	f
Low transmission and distribution capacity for solar energy	EXP 1, EXP 3, EXP 4, EXP 5	4
Enough capacity till 2023	EXP 2, EXP 6	2
Need for microgrids	EXP 1	1
More off-grid systems	EXP 1	1

Experts 3, 4 and 5 claimed that the market share of Turkey in global solar energy technology is low therefore the priority is given to the countries with high shares. This causes the loss of several incentives such as volume and time guarantees or special discounts. Turkey mostly supplies technological parts from Far East countries such as China and Thailand (Expert 3) and this increases lead time (45 days) of orders (Expert 5). Experts 4 and 5 stated that imported solar energy technology orders are checked at the customs control centers in Gebze and Ankara in Turkey and obtain a certificate of origin. Since there are two control centers to control these technologies, reports can be obtained from here in 3 months. For acceleration in customs, there should be an increase in the capacity of legislation, quality control centers, existing quality control centers. These experts also told that imported technologies should arrive without vibration in transportation however this is not taken care of in most cases. This affects the efficiency obtained from technologies. More importance needs to be given to the logistics of solar energy technology. Experts 3, 4 and 5 told that the technologies we purchase should not have contact with hand or air, which can cause faults in the supply, therefore a separate unit should be created at the customs, unit personnel should receive training in solar energy technologies. Expert 1 claimed that legislation is efficient on the paper but there is a problem in implementation therefore disruptions occur in supply of technology and a serious decrease in productivity and workflow happens. These necessitate conducting more inspections. Also, lack of coordination between institutions has been mentioned by Expert 6.

Table 8 shows the experts' answers to the seventh sub-question "What are your thoughts about the impact of solar technology supply on the low share of solar energy?".

All experts have agreed on that high import costs lead to low solar energy use. This is more prevalent in recent years because of decrease in Turkish lira value. Experts 1 and 2 told that increasing local production of technology will lower the cost therefore will increase the use of solar energy use in the long run.

Table 9 shows the experts' answers to the eighth sub-question "Do you find the current transmission capacity and transformer share for electrical energy produced from solar energy sufficient?".

Table 10. Experts' views about the dissemination of solar energy projects

Answers	Experts	f
All scales should be encouraged	EXP 1, EXP 3, EXP 4, EXP 6	4
More importance must be given to small scale projects	EXP 2, EXP 5	2

It is stated by Experts 1, 3, 4, and 5 that transmission and distribution capacities need to be increased to develop solar energy ratio in Turkey energy mix. Experts 2 and 6 claimed that there is enough capacity until 2023. Expert 1 told that there is a need for microgrids and off-grid systems in Turkey to increase the use of solar energy by public.

Table 10 shows the experts' answers to the nineth sub-question "Do you think that small-scale YEKA areas should also be determined next to the large-scale YEKA areas for the dissemination of small-scale YEKA projects (solar energy projects)?".

Experts 1, 3, 4 and 5 told investments for all scales need to be supported and small-scale areas need to be determined in YEKA areas in addition to large-scale areas. This will expand the solar energy sector and therefore increase the share of solar energy. In addition, Experts 2 and 5 stated that more importance must be given to small scale projects to disseminate solar energy use to public.

CONCLUSION

It is seen that Turkey has a high solar energy potential, but the expected benefit in electricity generation cannot be obtained from this potential. Semi-structured face-to-face interviews were conducted with the participants selected according to their fields of expertise, on which factors are effective in not benefiting from Turkey's solar energy potential sufficiently.

It has been found from the interviews that Turkey does not benefit from the solar energy potential at the expected level due to importing technologies because of lack of competent personnel, low market potential in the global technology supply, encountering problems in supply chain (transportation, customs, and expert workforce), insufficient small size solar energy projects, transmission and distribution capacity being an obstacle to the development of the sector in terms of volume, inadequate legislation, lack of training in the field of solar energy to meet the needs of the industry, insufficient R&D studies at universities.

Various suggestions have been made by experts to solve these problems.

- Increasing the support given to R&D in industry and universities,
- Supporting universities to create a workforce that will work on R&D,
- Opening of departments in vocational schools for the needs of the sector,
- Increasing customs control centers and creating a separate unit in customs, providing special training to the employees in this unit,
- Requesting logistics companies to take the necessary care in transportation of solar technology,
- Increasing the current share in the transmission and distribution capacity,
- Make the necessary arrangements in the legislation to facilitate the operations,
- Increasing public awareness about solar energy,
- Encouraging the use of solar energy technologies on roofs and having to transfer the remainder to the transformer,
- Abolition of VAT and OTV in the legislation for domestic use,

Coordination of the Ministry of Energy and Natural Resources with the Ministry of Customs and Trade regarding the problems in customs, with the Ministry of Transport and Infrastructure regarding the problems in transportation, with the Ministry of Education regarding the problems in education, and with the Ministry of Environment and Urbanization regarding the solar energy use in buildings.

In order to accelerate its economic and social development, increase its welfare level, and reduce foreign dependency on energy, which is the primary item in the current account deficit, Turkey needs to increase its electricity production from solar energy. Considering the problems encountered in the use of electricity from solar energy and evaluating the solution proposals will increase the rate of benefiting from the solar energy potential in Turkey.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

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