Iranian (Iranica) Journal of Energy & Environment
Journal Homepage: www.ijee.net
IJEE an official peer review journal of Babol Noshirvani University of Technology, ISSN:2079-2115

Review paper

A Comparative Analysis of Solar Energy Strategies in Middle East with Rich Fossil Resources

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P A P E R I N F O

Paper history:
Received 15 March 2023
Accepted in revised form 15 March 2023

Keywords:
Feed in tariff
Photovoltaic
Power purchase agreement
Renewable energies
Solar energy

A B S T R A C T

With countries throughout middle east and north Africa pursuing ambitious targets for a transition to renewable energies, the political economy of a region predominantly analyzed through the prism of fossil fuels is on the verge of radical change. As hydrocarbon prices decline, the low-cost producers of Middle East have an advantage and should be the last to leave the market. The world will demand proportionally more of the region's oil and gas. Nearly half of the world's oil is located in Middle East, which has long been referred to as the "energy axis" of the planet. In the meanwhile, as the nations of this area progress towards the future, they have realized the need of supplying energy from these other sources, such that the utilization of renewable energy sources, such as the sun, has attracted considerable interest. This study analyzed and assessed these attractions in addition to five middle eastern nations and Turkey, which is located in middle east, close proximity to this area. The approach of comparing government incentives in the development of renewable power plants was used in this study. The final findings revealed the current status of this energy in the target nations. This study may give the target countries and other nations in the middle east with a wealth of information for the formulation of effective policies for the use of renewable resources.

***doi**: 10.5829/ijee.2023.14.03.09*

NOMENCLATURE

FIT	Feed in Tariff	*GWh*	Gigawatt hours (10^9Wh)
ME	Middle East	*MWh*	Megawatt hours (10^6Wh)
PPA	Power Purchase Agreement	*$/kWH*	USD kilowatt hours ($/$10^3$Wh)
IEA	International Energy Agency	*TWh*	Terawatt hours (10^{12}Wh)
RET	Renewable Energy Technology	*USDcent*	10^{-2} $
SPP	Solar Power Plant	*tJ*	Terajoules

INTRODUCTION

The depletion of fossil fuels has prompted middle east (ME) nations to contemplate broad plans for the adoption of Renewable Energy Technology (RET) sources, and certain nations have even discussed long-term objectives. The governments of Middle East are definitely seeking to diversify their energy supplies beyond oil; therefore, they have studied the combination of RET and oil and gas products. ME nations' interest in RET is not only a

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Please cite this article as: M. R. Hayati, S. Ranjbar, M. R. Abdar, M. Molaei Nasab, S. Homayounmajd, M. Esmaeili Shayan, 2023. A Comparative Analysis of Solar Energy Strategies in Middle East with Rich Fossil Resources, Iranian (Iranica) Journal of Energy and Environment, 14(3), pp.271-288. Doi: 10.5829/ijee.2023.14.03.09

question of combining energy sources, but also a worldwide commitment in the area of climate, and the same problem will influence the price of fossil fuels. In addition to the most recent estimate, ME nations have a 200 billion dollar plan for the development of renewable energy technologies [1]. According to a report published by the International Energy Agency (IEA) in Table 1, the Middle East is comprised of 12 countries with a combined population of approximately 248 million people: Iran, Afghanistan, the United Arab Emirates, Syria, Qatar, Jordan, Oman, Bahrain, Iraq, Lebanon, Kuwait, and Yemen. There are 12 countries in Middle East, and the total installed capacity of RET in these nations is 3873 TJ by the end of 2022 [2].

Figure 1 shows the installation and investment plan in the solar energy sector in MENA region. As this figure shows, Research focusing on Middle East and Africa (MEA) has forecast solar installations to skyrocket by 170% this year and continue accelerating to install more than 83 gigawatts (GW) of new solar capacity between 2018 and 2023. The recent increase in the usage of RET in ME is a remarkable aspect of the evolution of RET in the region. According to the data published by the IEA until the end of 2019, the share of RET in the final consumption of these nations was approximately 0.6% (see Figure 1), and the dispersion of the technology of using these resources is also significant, so the share of using from solar power plant (SPP), including photovoltaic, was approximately 10,189 GWh until the end of 2020.

The availability of fossil resources unquestionably threatens the attractiveness of interest in the development of RET, and in this case, the employment of different incentives may be the answer to these resources' circumstances. In the meantime, numerous nations, including the United States, Germany, China, Japan, England, the European Union, and several European

Table 1. Total energy consumption in 2022 ME region [3]

Total ME	Total	Natural gas	Solar, wind, etc.
Iran	11035889	7673101	3873
Saudi Arabia	9624183	3378669	2803
Emirates	3444896	2342439	21550
Iraq	1911381	618336	206
Qatar	1762654	1588394	
Kuwait	1622907	945630	1938
Oman	1079535	939404	459
Bahrain	669228	567203	
Syrian	365980	105183	
Jordan	354630	134662	24408
Lebanon	292965		2668
Yemen	120841	4690	1763

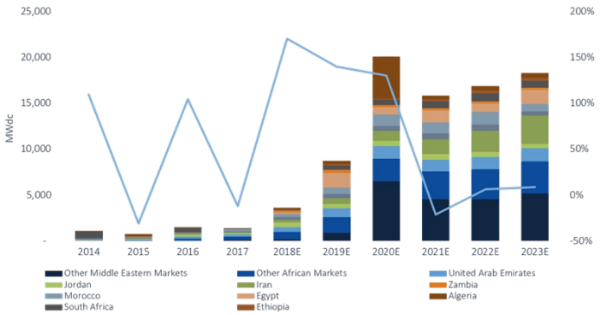


Figure 1. Forecasting installation and investment in solar energy sector in the MENA region [2]

nations, have detailed plans for the development of renewable energy technologies (RET), which include incentives such as Feed in tariff (FIT), guaranteed purchase contracts (GPC), green certificates, and various tax exemptions and investment incentives.

This study investigates the most recent policies and incentives of six nations in ME over seven categories. These nations are including: Emirates, Turkey, Oman, Saudi Arabia, Iraq. It should be mentioned that the selection of these nations is predicated on their efforts toward the use of renewable energy and their proximity to Iran. Significant findings about the number of incentives and policies are reported in the seventh part. Therefore, based on literature [4-7] there have been scattered studies about the policies of other countries in ME and North Africa in the field of RET.

MATERIALS AND METHODS

The RET and conventional fossil energy policies of each nation are individually presented, followed by the assessment metrics and policy instruments for each country. In the conclusion, a comparative analysis of countries and policy recommendations have been provided. Also, the sources extracted from the scientific articles of the last few years have been internationally recognized.

United Arab Emirates

The United Arab Emirates is one of Iran's neighbors. According to published statistics, almost 98% of the nation's energy is derived from two frequently used materials: gas and oil [8]. So it may be claimed that this country's policy is centered on these fossil fuels. However, the UAE, like many other nations, is seeking an environmental approach, minimizing the usage of oil and gas resources, and using renewable energy sources, like solar systems, which have been extensively explored [9,10]. However, one of the most significant aspects of energy consumption in the UAE is the variable nature of power consumption rates. This is the case despite the fact

that this tariff may be different in other places. The tariffs of various locations, which effect investments in solar panels, are shown in Table 2. The following is unquestionably one of the most alluring aspects of investing in the solar energy area in terms of power consumption costs.

But what is the forecast for the RET sector in the United Arab Emirates? According to the RET regulations in this nation, which were released in 2011 under the name of Dubai's 2030 Integrated Strategy Program, the target is to attain 5% of the energy sector from renewables. In 2015, the rate rose to 15%. In the meanwhile, so-called guaranteed purchase initiatives are launched in the UAE to strengthen the motivation of individuals to use RET. In addition, modest rooftop power plants and other incentive schemes are implemented in this nation. These policies are described in the aforementioned sources [5, 6, 8, 11].

The UAE utilizes price fluctuations to better regulate energy. For instance, the price of gasoline in the middle of this nation is around $0.50 per liter, which was cheaper than the price of Brent crude oil until 2014. Of course, there are further facets to this problem, such as the tiered structure of the household power bill in Dubai. That the first 2000 kW will incur a fee of 6.2 US cents per kilowatt, and this tariff will increase to 10.4 US cents per kilowatt when the consumption exceeds 6,000 kilowatts [12]. Obviously, this legislation will not discriminate against low-income individuals, since decreased water and power use would lower prices. According to the IEA's estimate of fuel consumption subsidies provided by governments, the UAE paid 21.8 billion dollars in fuel subsidies in 2011. Obviously, this number is smaller for the UAE than for other ME nations, such as Iran [10]. Prior to 2008, the UAE did not have a RET organization (Table 3), but since then, around 150 megawatts of SPPs have been installed and constructed [13]. With these numbers, the UAE has a greater total contracted capacity and installed capacity than other Persian Gulf cooperation nations [14].

Figure 2 shows a comprehensive comparison of power capacity based on Reference Case and RE map 2030. Each of the seven provinces of the United Arab Emirates is ruled by its own ruler. The seven provinces are: Dubai, Ras Al Khaimah, Sharjah, and four smaller cities, if Abu Dhabi is considered the capital. This nation has an area of around 84 thousand square kilometers and a coastline of about 700 kilometers. It has borders with Saudi Arabia and Oman [9]. This nation shares a center with Saudi Arabia and Oman, has a 650-kilometer coastline, and an area of 83,600 square kilometers [15].

The UAE is situated between, it is situated at around 26100 minutes north latitude and 56000 minutes east longitude, which is favorable for solar radiation. This country's high pollution levels and atmospheric humidity diminish the quality of sunlight. The overhead imagery demonstrates that UEA has a greater potential to use solar energy than other renewable sources. Consequently, the rate of solar energy absorption in the UAE may be determined using four indicators: 1. Ground measurements, 2. Artificial intelligence networks, 3. Correlational analyses, and 4. Satellite processing [18, 19]. In addition, Figure 3 depicts the expenses

Table 2. Tariff in Emirates [11]

Types	Rate ($/kWh)
Domestic national	0.01
Foreign national	0.06
Commercial use	0.04
Application of industries	0.04
Agricultural application	0.04

Table 3. RET projects for power generation in UAE [8]

Period	Dhabi	Dubai
2014	Masdar PV—11MW in 2009 Sir Bani Wind—30 MW Shams 1CSP—100 MW	Mohammad Rashid Maktoum Solar park PV, Phase 1–13 MW Roof top PV installations 4 MW
2021	Noor1PV—100 MW (in planning) Noor 2PV—150 MW (in planning) Energy losses —101 MW in 2016	Mohammad Bin Rashid Al Maktoum Dubai Solar park PV Phase 2–130 MW
2031	Without announcement	Mohammad Rashid Al Maktoum Solar Park PV, Phase 3–1000 MW
Total	488.8 MW	1004 MW

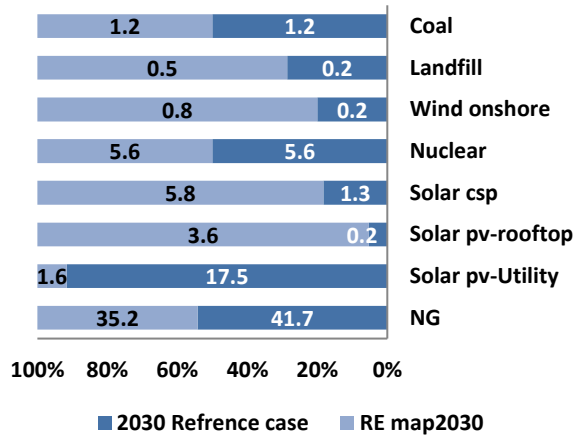


Figure 2. Power capacity break down comparison for reference case and RE map 2030 [14]

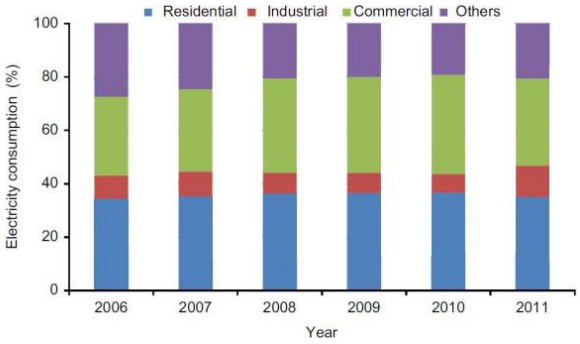


Figure 3. Separate expenses in a period of up to 5 years [16]

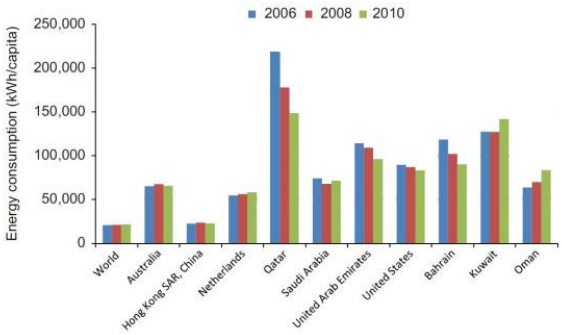


Figure 4. Comparative gross domestic product of several countries [16]

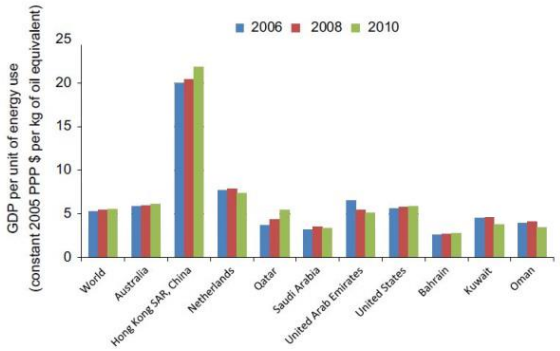


Figure 5. Per capita rate in several countries [17]

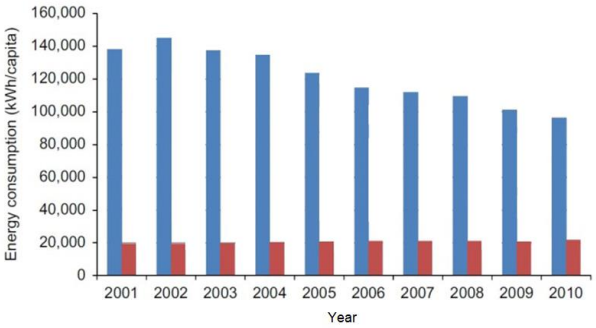


Figure 6. Per capita consumption in several countries [16]

disaggregated over five years. Figure 4 illustrates the per capita rate in different nations. Figure 5 depicts the gross domestic product, and Figure 6 depicts per capita consumption. Obviously, Figure 7 identifies important aspects of the development of solar power plants. As shown in Figure 8, the UAE has the potential to construct power plants with a capacity of 50 kW or more.

Over the years, the UAE has encountered several difficulties. The daily reliance on oil, the use of foreign power, and the decline in the worldwide price of oil have resulted in several threats and concerns, including the budget deficit. In the last decade, the UEA has made considerable investments in the use of RET, and as a result, it has placed 2300 megawatts of RET, including solar, into service, and around 4000 megawatts are in the tender stage [20, 21]. Therefore, the UAE intends to spend 160 billion dollars in the renewable industry over the next two decades. According to this problem, 68 firms in the Emirates are extensively engaged in SPPs. The United Arab Emirates lacks an integrated system or service, yet three centers individually address energy challenges. Abu Dhabi Electricity Company, Dubai Electricity Company, and Sharjah Electricity Authority are subsidiaries of the Ministry of Energy [22]. Based on this, Dubai and Abu Dhabi now contribute just about 10% of your gross energy from RET, but as part of a national plan, they are expected to get about 25% and nearly 50%

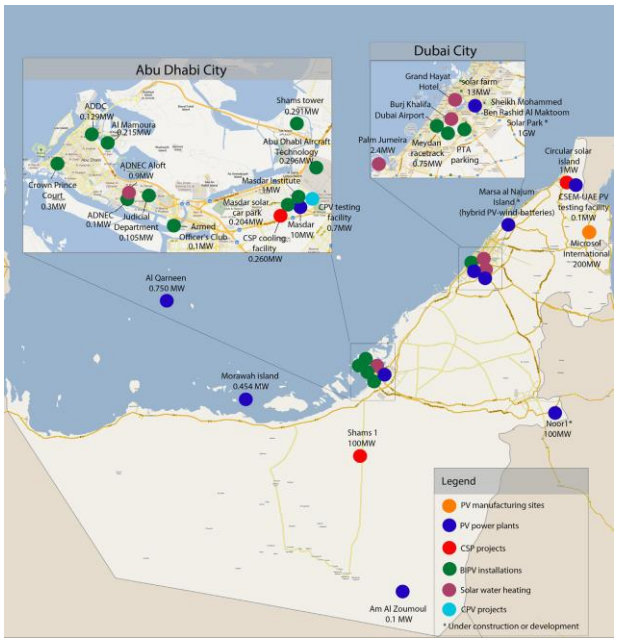
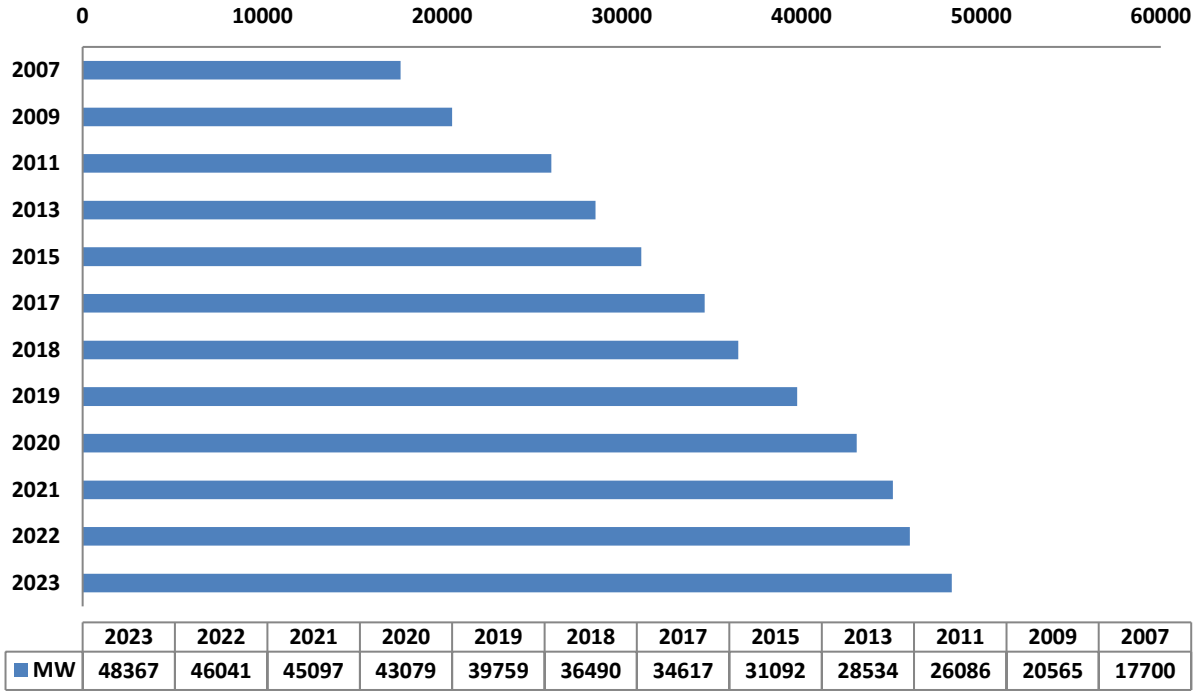


Figure 7. The development program of SPPs in the UAE [14]



	2023	2022	2021	2020	2019	2018	2017	2015	2013	2011	2009	2007
MW	48367	46041	45097	43079	39759	36490	34617	31092	28534	26086	20565	17700

Figure 8. UAE electricity generation and consumption (TWh) [14]

of their energy through RET by 2030 and 2050, respectively [۲۳]. Currently, this country has about 2.4 GW of total renewable capacity, which is expected to reach 9.1GW by 2025, which is mostly solar [24]. The demographic makeup of men and women working in SPPs is a serious concern. In the major RET nations, women comprise up between 20 and 25% of the workforce. In the UAE, about 90% of the labor force is male. This represents 25% of the female population in the UAE [25-27]. However, between 2010 and 2016, the price of solar panels, which were mostly imported from China, fell by 80%, making the development of these power plants more viable [28]. In contrast, now that the planning is complete, the 2 GW Al-Dhafra SPP will shortly be linked to the country's grid. The Al Dhafra Project (IPP) is being constructed by a collaboration consisting of a French firm and Jinko Power Technology Co. The development contract for this facility was granted to the consortium in July 2020 [۲۹]. In the UAE, power consumption has climbed dramatically during the last two decades. Beginning in 2000, this nation produced 40 terawatt hours of energy, which increased to 110 terawatt hours by the end of 2013, indicating a 15% growth in power consumption from customers. The United Arab Emirates ranks 25th in the world for CO_2 emissions. Consequently, this nation was the second most polluting in the world from 2000 to 2004, but in 2013 it was rated eighth and currently it is placed 25th [30]. In general, the average irradiation in this nation is approximately 10 hours, which might be a decent ranking from the point of view of irradiation in the globe. Obviously, the middle of this nation has high humidity and a substantial dust particle concentration [31]. In 2009, the UAE government established its first significant policy in the area of RET, and in its vision, it set a goal of at least 7% of the city of Abu Dhabi's electrical capacity came from RET sources in 2020 [32, 33]. According to the steps taken in the UAE, there are still several impediments, including a lack of legislation and regulations in the area of renewable energy technologies (RET) [34]. These barriers exist within the area of RET:

1. The UAE's power network is managed independently by seven provinces, and its integration would upset the country's upstream laws.
2. Electricity consumption tariff in this country is very low due to subsidized consumption. For example, the electricity tariff in Dhabi is approximately 3.9 US cents.
3. In UAE, there is no direct tax system to support RET.
4. Requirements for using RET are not defined [35].

In Table 3, the reported expenses include yearly, periodic, initial, and device depreciation charges. The cost estimate, building, and operation of an SPP are shown in Table 4. As stated in the chart for comparative purposes, the price of solar panels per watt is $5.50, and the overall cost of the equipment is $55.5 million.

According to Table 4, yearly expenditures include both operating and inverter repair expenses. The anticipated annual running expenses are $334,500, which is less than thermal power plants [37]. Table 5 as well simplifying the financial index of a SPP in the UAE it has been shown.

Turkey

The FIT technique is a realistic strategy for encouraging investment, particularly in the sector of SPP construction. The terms of these incentives range from 10 to 25 years. This technique of incentives may be used in many ways based on the markets of each nation. This topic has been well explored in earlier studies [38, 39]. The price of solar energy generation is one of the elements driving investor interest in this sector. Between 2009 and 2020, for instance, the cost of constructing a megawatt SPP decreased from 351 US$/MWh to 50 US$/MWh, which is less than other renewable energy (Figure 9).

In August of 2020, the nominal capacity of the country's power plants has reached 93022 megawatts, according to statistics from the Turkish Ministry of Interior. The distribution of power plants established in Turkey is shown in Figure 10 as 49.7% thermal power plants, 32% hydro power energy sources, 6.8% solar and 8.8% wind energy sources [40]. According to the preceding data, this nation has 8934 power plants at the end of 2020, the solar plant was 6435. Due to its geographical position, this nation has a significant solar energy potential (Figure 11). The average yearly length of sunshine is 2741 hours, while the average daily duration of sunlight is 7.5 hours. Until the end of 2020, the installed capacity in this nation was around 300 megawatts.

Table 6 displays the production tariff for renewable power sources. The nation gives large incentives for building and RET in general, including a range of tax exemptions, a discount of 85% on transmission line costs, and a 10-year purchase guarantee of 13.3 US cents per +69. As seen in Table 7, the nation has also provided incentives for the use of indigenous manufacturing equipment.

Among the United States and France, Turkey has the shortest guaranteed purchase time for renewable power,

Table 4. Important indicators in evaluating a solar system [36]

Type	$USD (In thousands)	% of initial costs
FS	$200	0.22%
outspread	$165	0.18%
Inverter replacement cost	$2000	Period 5 years
Installation	$9000	
Balance of plant costs	$36,500	39.67%
Electrical	$7000	
Inverters	$10,000	
Tracking system	$10,500	
Equipment	$55,000	59.77%
Total initial costs	$92,015	100%
Engineering	$150	0.16%
O&M	$335	Period 1 year
Salvage value	$9202	10%

Table 5. Simplifying the financial index of a SPP in the UAE

Net value	$/50.9 million
Energy cost	16.18 cent/kWh
Profit to money ratio	0.46
Save money	$3.3 M
internal efficiency	٥.٤%
Payback time	55.٥ years
Course to the right cash flow	30 years

Table 6. FIT

RET Tariff power plant	USDcent/kWh
Wind	7.3
Bioenergy	13.3
Hydroelectric	7.3
Solar (PV)	13.3
Geothermal	10.5

Table 7. Internal construction incentives

Types Plant	Native	USDcent/kWh
PV	Inverter	0.6
PV	Cell	3.5
PV	Module	1.3
PV	Structure	0.8
PV	Other items on the module	0.5

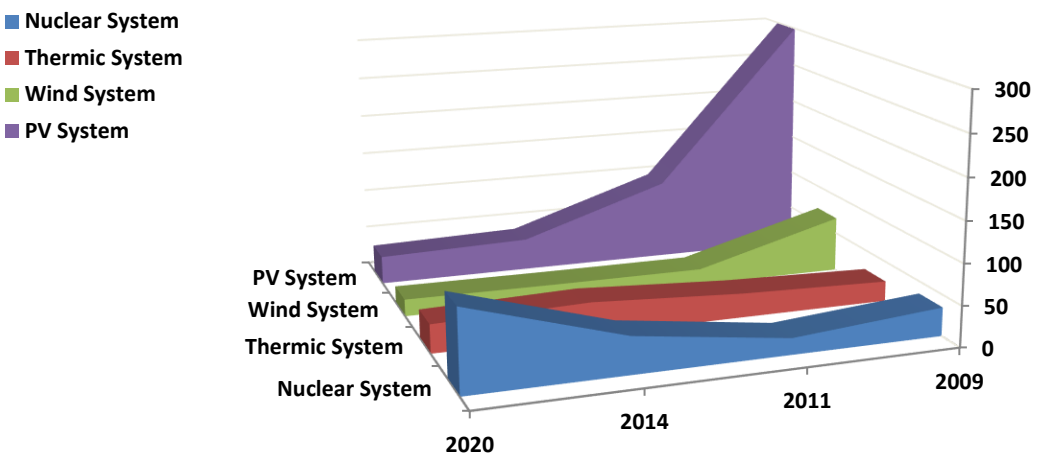


Figure 9. The cost of building a SSP [38]

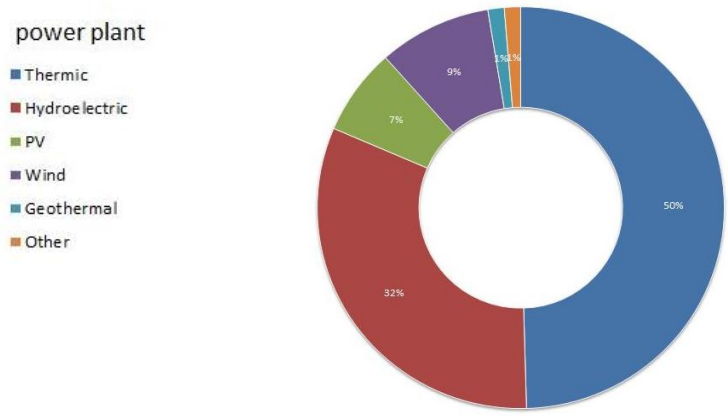


Figure 10. The amount of installed capacity in Turkey with different sources [40]

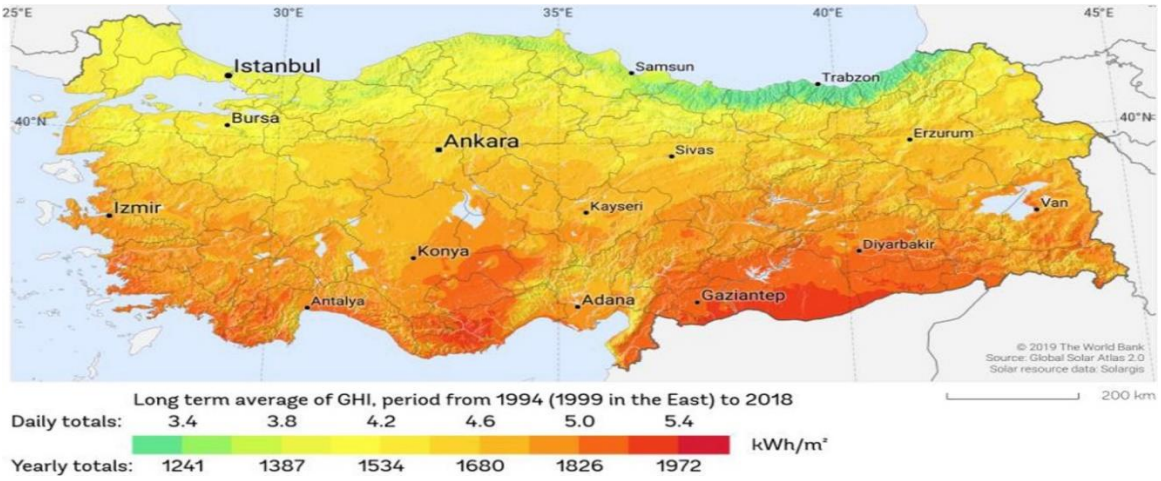


Figure 11. Turkey's Solar Energy Potential Atlas [40]

with a 10-year guarantee. This problem has diminished its appeal to investors. Notable was Turkey's new policy for the building of renewable power plants, which, after 2019 and with the elimination of subsidies for rooftop power plants, would render rooftop power plants unattractive. The building of large-scale SPPs was put out to bid, which accelerated the development of SPPs and maximized the use of non-agricultural and underutilized land [41, 42]. Moreover, with the actualization of energy costs in Turkey at the end of 2012, the trend of attractiveness and interest in investing in the area of RET has been reevaluated. Alternatively, the natural potential of this nation has garnered considerable interest in the subject of RET [43]. Obviously, these numbers were rather intriguing in 2010, when the percentage of RET in total consumption was 1%, while other fuels such as oil accounted for 26% and coal for 31%. Assuming hydroelectric power facilities, the percentage of RET would cover around 11% of the nation's overall demand. According to data, the installed capacity of SPPs in 2000 reached 400 kilowatts in the same year, and 600 kilowatts in 2010 (Figure 12).

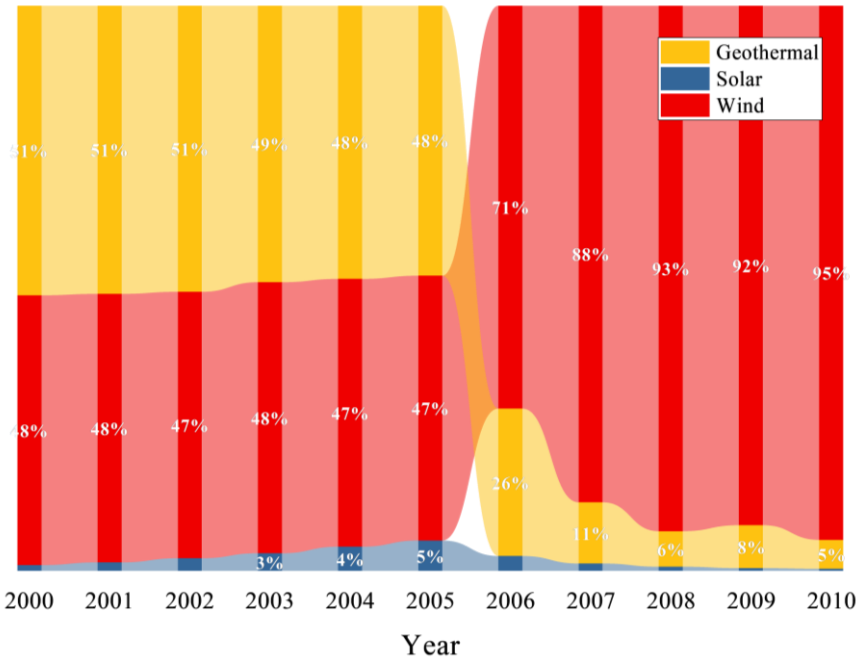


Figure 12. Summary of the capacity of power plants built in Turkey during 10 years [43]

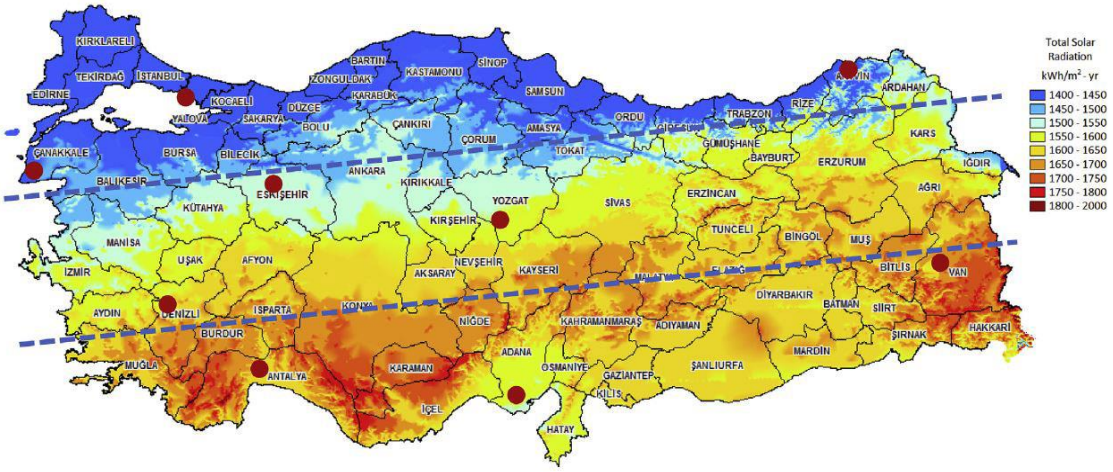


Figure 13. Capacitance measurement of solar radiation in different parts of Turkey [46]

Table 8. Incentive policies in Turkey

Changing market rules	Amount
R&D	Incentives up to 100 expenses incurred and tax relief
Connect to the network	Clearly distribution companies
FIT	Creating a mechanism to sell electricity in the energy market at different prices
Guaranteed purchase	Easing rules for distribution companies
Fix the problem of multiple licenses	Determination of capacity up to 0.5 MW
Costs related to the construction of the land	Use of land incentives for free or discounted up to 90%
Issuance fees	Exemptions known as 1% and the first eight years

Existing hurdles to the development of renewable power plants include the absence of an accurate evaluation of renewable resources and a data repository for the renewable industry. In recent years, 5 kW rooftop systems have been one of Turkey's support options. For example, if we take a Profitability index, payback duration, and internal rate of return for one of these units, the extracted indicators are as follows: The findings indicated that the aforementioned values fall between the ranges of 13.68 to 6.87 %, 7.75 to 14.43 years, and 2.02 to 1.28, respectively. This example demonstrates the need to improve incentives (Table 8) for the building of residential SPPs in Turkey and create a regional support network [44].

However, there have been little research on residential SPPs in Turkey. So that the installed capacity of rooftop systems accounts for 5 percent of the overall installed capacity of solar power plants in the nation (Figure 13). By the end of 2017, the installed capacity of SPPs in Turkey had reached around 3,42,000 megawatts, placing it among the top five countries worldwide in terms of SPP construction. Of course, 200 megawatts have been put on the rooftops of industrial and commercial buildings as a portion of this capacity [45]. It should be mentioned that the price of domestic power in this nation, including taxes and fees, is 10.60 dollars per kilowatt hour.

Another highlight is the development made in the area of renewable resources in this nation, with roughly 48% of the country's total power output coming from renewable sources from 2019 to the present, while water resources were the cause for this statistic [46]. The Energy Organization of this nation reported the breakdown of Turkey's energy resources at the end of 2019: 22% coal, 6% solar, 31% hydro, 28% natural gas, and 8% wind [47].

Oman

The use of solar energy in Oman is in its early stages, and government institutes have conducted extensive research and initiatives on the subject [48]. Solar energy in Oman has problems such as power price subsidies, natural gas prices, laws, and public education among the country's people [49]. For example, the city of Dhofar in the nation of Oman is one of the towns with highly adequate sunshine, with the highest solar flux in this city being 1360 watts per square meter in the month of March, according to the records supplied. This potential has enticed investors to employ SPPs instead of fossil fuel power facilities. Interestingly, temperature is also important in this nation; for example, in Muscat, the air temperature reaches 48 degrees Celsius, while in the desert, it reaches 54 degrees Celsius [50]. Oman is a royal kingdom in the southwest of Asia and the east of Arabia. This country's economy is mainly reliant on oil and gas [51]. Solar energy is now used in this nation for street lighting, traffic lights, and low-capacity public usage. The Omani government, of course, has just announced a short list of six renewable power plant building projects, four of which are SPPs [52]. Although no extensive study has been conducted, statistics reveal that solar energy was the sole adequate capacity of RET in Oman in 2017. This nation offered thorough plans and strategies to facilitate the building of major SPPs beyond 2017. The current target for RET share is at 30% by 2030, with a goal of 40% by 2040 [50]. In recent years, Oman has seen the biggest rise in power usage by roughly 23% when compared to other Persian Gulf countries [17]. This is a critical concern since this country's power consumption is increasing at a quicker pace than nations such as America, Germany, and Spain [53]. The north of the nation is desert, whereas the south is subtropical. The radiation length of sun light ranges from 8 to 15.5 hours, and it is noteworthy to note that the average sun radiation is close to 5.2 kilowatt hours per square meter. Summers in this nation are often hot and humid [54]. These figures are noteworthy since Oman has a radiation of around 2500 to 6000 Watt hours per square meter owing to the bright sky, which is mostly attributable to Oman's placement on the solar belt [55, 56]. According to United Nations figures, Oman's population distribution in 2022 is about 5.5 million people. Based on these estimates, Oman's population in 2020 is expected to be 5106626 persons in the middle of the year. According to the same data, this country's total population is equivalent to 0.08% of the global population. In terms of population, this nation ranks 120th out of 120. The recorded population density is 17 persons per square kilometer, urbanization accounts for almost 88% of the population, and the average age is around 31 years [57]. The country's electrical status is such that all domestic demands are covered, and some is even exported. The utilization of solar systems is hampered by humidity, dust, and coastal areas [58]. In general, and based on studies, solar power plants are appropriate in Oman's northern areas. This method is useful for producing energy in arid locations that are not connected to the power grid. Of course, the effectiveness

of these cells will vary depending on temperature, humidity, and dust [59].

Saudi Arabia

Saudi Arabia's economy relies on the sale of fossil fuels, yet strangely, the government is exploring selling solar energy to Europe [60]. In other words, the Kingdom of Saudi Arabia is situated in the heart of the most solar-productive regions, with an average yearly radiation of 2200 kilowatts per square meter [61]. In 1960, the French erected and activated the first photovoltaic light at Madinah Al Manwarah Airport [62], if we are to investigate the historical usage of solar energy in Saudi Arabia (Table 9). After the French, research began in 1969 with a small-scale university initiative, but the ruler of this nation announced the development of RET technology in 1977.

Table 9. List of completed development projects in Saudi Arabia

Period or year conducted	Location	Description of projects	
		Type	Capacity
1990	Solar village	Long-term performance of PV	3kW
1993-1995	Solar village	Internal combustion engine	-
1993-2000	Solar village	Fuel cell development	1kW
1994-1999	Sadous village	PV water desalination	4kW
1994-2000	5 stations	Wind energy measurement	4 kW
1996	Muzahmia	PV in agriculture	6 kW
1999-2000	Solar village	Solar refrigeration	2 kW

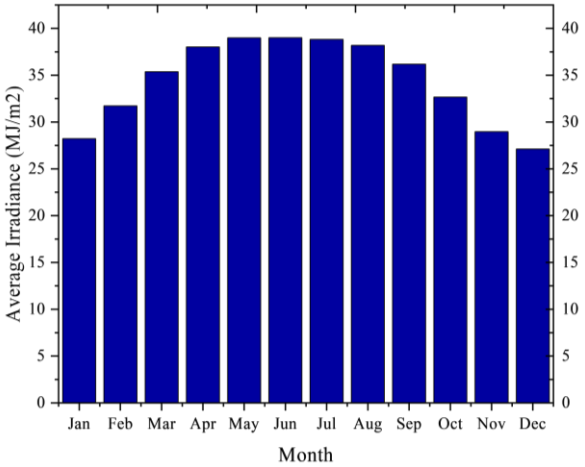


Figure 14. Average Sunlight in one of the provinces of Saudi Arabia– Najran [61]

In contrast to its neighbor Iran, Saudi Arabia only experiences summer and winter. Because of this, solar radiation is in excellent condition throughout the whole year. According to official figures, the average solar radiation in Saudi Arabia is two kilowatt hours per square meter, which is a substantial amount. Figure 14 depicts the average sun radiation in Saudi Arabian city of Najran.

In the last decade, Saudi Arabia has expanded its renewable energy technology (RET) research initiatives and collaborated with nations such as the United States and Germany, who have been engaged in this sector for over three decades. This nation has designated SOLERAS for this collaboration [61]. In1998, the beginning of large-scale solar projects in this nation, northwest of Riyadh was observed. This project produced around 1.5 megawatt hours and cost 18 million dollars. If we want to determine the worth of constructing renewable power plants, we may consider the rise in the price of oil fuel. In general, one ton of oil is equivalent to 6.9 barrels and can generate 11,630 kilowatts of energy. Currently, a barrel of oil costs around $100, and this price is growing annually; this indicates that the cost of generating power from fossil fuels is daily increasing [61, 63].

Iraq

In 1991, the Iraqi power grid had a severe outage. After this occurrence, Iraq's power output increased from 5,000 megawatts in 2005 to over 14,000 megawatts in 2016 [64]. Obviously, power losses and rising consumption demand have resulted in an average of 15 hours of electricity per day for the citizens of this nation throughout the whole year [65]. Figure 15 depicts the distribution of fuel sources used for the generation of electricity consumed in Iraq. In this nation, gas plants and liquid fuels account for the majority of power production [66].

Geographically, Iraq is placed inside the world's solar belt of significance. This nation receives 3000 hours of irradiation every year, with an average of 11 hours in the summer and 8 hours in the winter, which is sufficient for using this technique. According to the study, the sun intensity in Baghdad in January is around 415 Watts per square meter and in June it is approximately 830 Watts per square meter. It is intriguing that the majority of nations do not have this level of light intensity. It is notable that Iraq has more bright winter days than other countries [68]. In reality, Iraq lacks an electricity grid and electricity sales to the grid; however, in 2018, the Iraqi Ministry of Energy began discussions with international organizations regarding electricity sales and purchase tariffs (FIT) and grid measurement models in the presence of renewable power plants. In the meanwhile, several studies have been undertaken on guaranteed purchase rates and power sales; for instance, Aziz et al. [69] reported the three electricity purchase prices for low load, medium load, and peak load were 0.0084 dollars per kilowatt hour, 0.0293 dollars per kilowatt hour, and

$0.0672 per kWh, respectively. In contrast, the price of power sold is considered 50% of the purchase price in this study. Figure 16 shows a map showing radiation levels in Iraq based on 2018 NASA data. This nation is bordered on the north by Turkey, on the west by Syria and Saudi Arabia, on the south by Lebanon and Kuwait, and on the east by Iran. In 2022, Iraq's size is around 436 thousand kilometers and its population is approximately 43 million. It is intriguing that the area between the Tigris and Euphrates in the heart of Iraq is the most irradiated. Notable is the southern area of this nation, which is recognized as one of the places with the highest levels of solar radiation in the globe. Figures 17 and 18 depict the energy balance in Iraq for 2019 and 2036. It is evident that the proportion of renewables will undergo significant changes in 25 years.

Iran

Iran is a nation with immense natural resources; in addition to oil and gas deposits, it also boasts a range of renewable energy sources, including solar, wind, water, geothermal, etc. According to meteorological statistics, Iran has 299 bright days with an average daily radiation of around 5 kilowatt-hours. According to the research undertaken, this nation will employ almost 3,000 megawatts of renewable energy sources to generate power by 2030 [71]. According to Iran's sixth development plan, around 5% of the country's power, or roughly 5,000 megawatts, came from renewable sources at 2020. This seems to be related to the country's economic issues and sanctions. By 2025, the nation will accomplish its ambition. Obviously, this nation provides the highest level of gasoline subsidies in the world.

Iran is among the top nations in ME for RET organization. The government founded the RET Organization in 2000, and in 2016, after a name change by the Ministry of Energy, the organization's activities were expanded. Its name is SATBA, and its responsibilities include the focused promotion of RET, as well as enhancing network productivity and decreasing losses. Until 2022, Satba's contracts took the form of PPAs, which were designed for purchasers as a 20-year guaranteed purchase with a complex tariff whose annual price was announced [72]. The intention of SATBA's move was to attract investors, and the 20-year purchase time might assist attract local and international investment [73, 74] outlines, in accordance with SATBA regulations, the rate for the guaranteed purchase of power under a PPA contract until the end of 2022(Table 10).

Obviously, the number of sub 200 kilowatt power plants (Table 11) has increased by 20 to 60 percent during the last several years. In accordance with an announcement made by the Ministry of Energy in November 2022, the guaranteed electricity purchase rate from SPPs with a capacity of less than 20 kW increased by 20%, from 14,560 Rials to 17,500 Rials, while the guaranteed electricity purchase rate from SPPs with a capacity between 20 and 200 kW increased by 30%, from 12,740 Rials to 16,500 Rials. The rate of rip has risen. In addition, the purchase price per kilowatt-hour of energy generated by small-scale branch wind power plants with a capacity of less than 250 kW will rise by 60 percent to 16,600 Rials, and wind power plants with a capacity of 250 kW to 1 MW will increase by 20 percent to 12,400 Rials. This report indicates that new prices are subject to change at the time of bill payment.

Iran has a strong solar radiation potential, with a radiation capacity of 5.5 kilowatt hours per square meter, which allows the building of any SPP feasible and cost-effective. In its development plans, Iran has

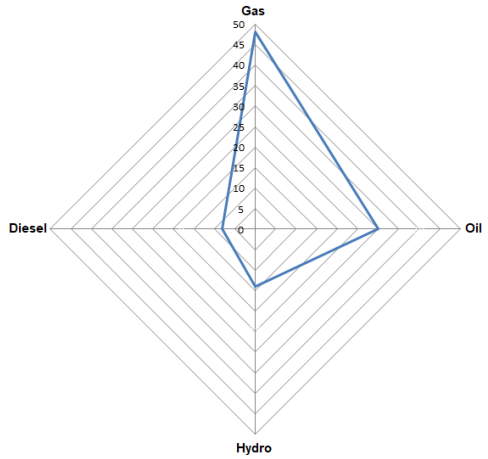


Figure 15. Iraq electricity generation profile [65]

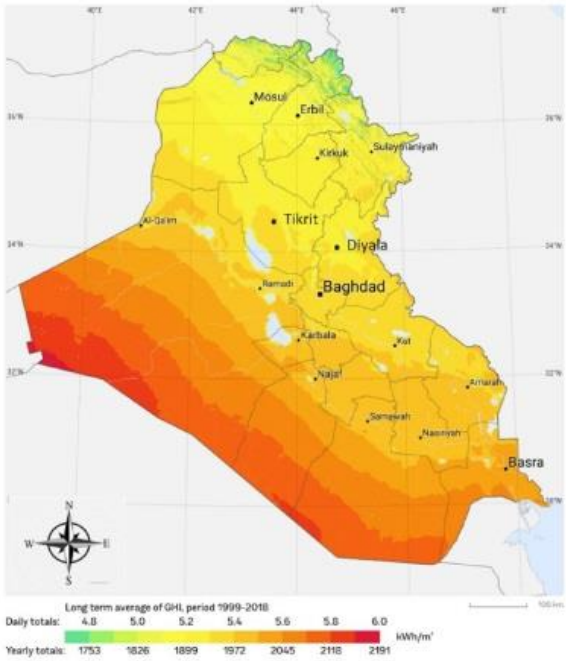


Figure 16. Solar map of Iraq [67]

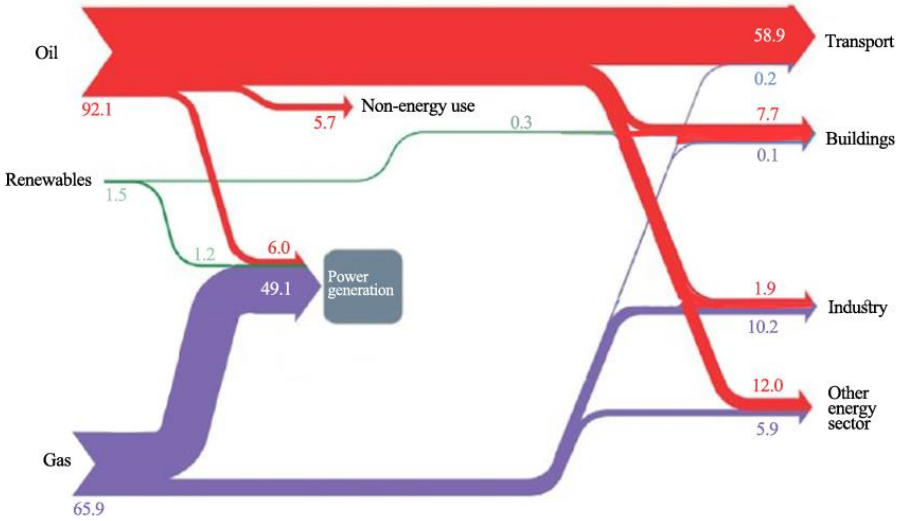


Figure 17. Iraq's internal energy balance until the beginning of 2036 [70]

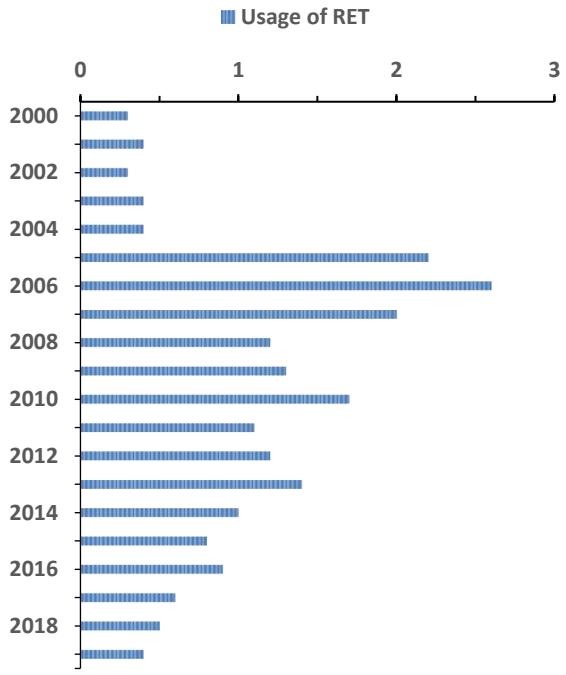


Figure 18. Chart of RET use in Iraq until 2019 [65]

Table 10. Satba's guaranteed purchase tariff until the end of 2022

Types of power plants		Base rate of guaranteed purchase of electricity (Iran Riyals per kWh)
Biomass	Landfill	5670
	Other biological processes	7350
	All thermal processes	7770
Wind farm (with a capacity of 10 MWh)		7644
Solar farm (with a capacity of 10 MWh)		8918
Geothermal		8918
Electricity generation (CHP)		5278
Small Blue (with a capacity of 10 MW and less)	On rivers (river or stream)	6916
	On water and sewage pipelines	5915
Fuel cell system		9004
Expansion turbines		2912

envisioned several scenarios and possibilities for the use of renewable energy; for instance, in its fourth five-year growth plan between 2005 and 2010, renewables accounted for 1% of the country's power system capacity. Alternatively, the 55-year development plan predicts the installation of 5,000 megawatts of SPPs and a 15% decrease in grid losses. Or, in the sixth development plan,a greater emphasis was placed on these figures. So that the percentage of renewables in Iran's total power generation by the end of 2030 is 10%, it seems to be quite challenging for Iran to accomplish these numbers [75]. According to statistics published on the SATBA website,

the installed capacity of renewable power plants in Iran should be nearly 984 megawatts by the end of 2022, of which 42% is SPPs with a capacity of 416.16 megawatts and the rest, including wind, Hydroelectric power, biomass, etc., are in the next place. The distribution of RET in Iran to the end of 2022 is shown in Table 12.

SATBA cancelled all PPAs in the middle of 2022 and contracted the building of renewable and specifically SPPs in Iran based on the Economic Council's approval of the issuing of an investment authorization for the construction of a 4000 megawatt SPP [77]. The Economic Council of Iran will reimburse the new contracts of these power plants from the savings income and schedule the implementation based on Article (12) The law on improving the financial system and the law on removing obstacles to production and its Executive Regulations as well as Note (3) of Article (61)) Law on the amendment of the energy consumption pattern, reviewed and approved subject to compliance with the relevant laws and regulations. 1. This plan calls for the building and operation of 4,000 megawatts of solar power plants in vulnerable regions of the nation. 2. The organization of RET and Electricity Efficiency (SATBA) is required to run an auction to pick the investor businesses executing the project in accordance with the tendering regulations. The firm that provides the lowest price per kilowatt-hour of power generated wins each bid. 3. The ceiling price per kilowatt-hour of electricity in the tender is based on the weighted average value of the fuel saved; it is a maximum of 6.9 cents and is unaffected by fuel price fluctuations. 4. The technical characteristics of solar panels must comply with national and international standards authorized by the Energy Ministry. 5. The repayment period of the government subject to this project from the savings related to Article (12) of the law on improving the financial system and the law on removing obstacles to production is a maximum of six years, which if the investor requests and provides a guarantee letter for the fifth and sixth years, it will be possible to receive the total value of fuel saved in the last two years during the first four years following the operation of the power plant. The value of the saved gasoline will be repaid to the investor in accordance with the quarterly measurement and validation process, the currency exchange rate declared in the ETS system at the time of payback, and the savings limit established during the repayment term. According to this decision, the SATBA tender was conducted in two phases through the end of 2022, and out of a total of 4,000 megawatts, roughly 1,700 megawatts have been awarded building permissions and are in the process of acquiring land and other construction permits. Considering the limit on the price of each kilowatt-hour of power in the tender of 6.9 cents in this resolution made it appealing to investors, and it seems that this strategy, which has legal backing, will lead to the expansion of renewable energy capacity in this nation. Obviously, the Iranian government's support for RET has not resulted in guaranteed purchase contracts. For instance, the government of this country in late 2022, in a resolution titled Article 16 of the Executive Regulations of Danesh-Banyan, emphasized that industries with a consumption power of more than one megawatt are obligated to provide the equivalent of one percent (1%) of their annual electricity needs through the construction of SPP, and that this amount will reach five percent (5%) by 2025. Otherwise, the power company, a part of the Ministry of Energy, must compute this amount from the industrial plant's renewable energy tariff consumption [78]. Considering that 34% of Iran's energy consumption is accounted for by the industrial sector, this notice might be quite important.

Table 11. Guaranteed purchase tariff for RET below 200 kW

Type of technology	Power plant capacity	FIT (Iran Riyals)/2020	FIT (Iran Rials)/2022
Solar	20 kW and less	14560	1750
	Between 20 kW and 200 kW	12740	16500
Wind	250 kW and less	10374	16600
	Between 250 kW and one megawatt	10374	12400

Table 12. The share of renewable power plants in Iran at the end of 2022 [76]

Technology	Capacity(MW)	Share in percent(%)
Hydropower sources	100.78	10.4
Wind sources	337.39	34.8
Expansion turbine	9.6	1
Biomass sources	12.5	10.3
Solar sources	416.16	42.9
Total	983.02	

This study examined the most recent advancements in the area of RET in the ME nations. In this study, six nations, including Iran, Iraq, Saudi Arabia, Oman, and the United Arab Emirates, as well as Turkey, were analyzed and their incentives, policies, and prospects in the area of solar power plant building were provided (Table 13). After the introduction, the status of solar power plants in the UAE was studied in the first section. As indicated in Table 14, this nation has adopted comprehensive plans and expanded the capacity of its SPPs during the last several years. The trustee of this country's government has not stated the guaranteed purchase method and tariffs because of the country's modest size. In the second section, Turkey was investigated as one of the Middle

eastern nations' neighbors (Table 14). This country's predicament is more extraordinary than that of other nations studied in this sector. Guaranteed purchase tariffs, guarantee contracts, tax advantages, and government backing are the country's most significant distinctions. Tables 13 and 14 outline policies and incentives. In the third section, Oman is studied as an important middle eastern nation (Table 14). In recent years, this country's measures to minimize reliance on fossil fuels have included considerable projects for the development of RET. Tables 13 and 14 illustrate the most essential policies and incentives. In the fourth and fifth portions, Iraq and Saudi Arabia (Table 14) are studied. Although these two nations have been investing in RET for a number of years, their investments are substantial in

Table 13. RET incentives in six ME countries

Countries	FIT	Categorized incentives policy	Subsidy	Tax exemption	Funding and interest discount	Tendering and project incentives
Iran	*	*	*	*	*	*
Turkey	*	*		*	*	*
Arabic Emirates		*		*	*	
Oman		*				
Saudi Arabia		*		*		
Iraq		*				

Table 14. RET policy and incentives in the UAE

Countries	Incentive and policy
Arabic Emirates	• Based on the RET policies in this country, which was announced in the name of Dubai's 2030 Integrated Strategy Program in 2011, the goal is to reach 5% of the energy sector from renewables, which is this number. In 2015, it increased to 15%. • The UAE did not have a RET organization until 2008, but from that year until the time of writing this article, about 150 megawatts of SPPs have been installed and built • Currently, this country has about 2.3 gigawatts of total renewable capacity, which is expected to reach 9 gigawatts by 2025, which is mostly solar. • In this country, there is no direct tax system to support RET
Turkey	• incentives for the construction of SPP and RET in general, including a variety of tax exemptions, an 85% discount on transmission line costs • Guaranteed purchase period of 10 years • Holding a tender for the construction of large-scale SPPs • The difference in the tariff value of electricity produced in RET • Ten-year guaranteed purchase, and use the attractiveness of bilateral contracts • Tax exemptions up to 100% • Incentive for the construction of facilities below 10 kW
Oman	• The current goal of the share of RET is about 30% by 2030 and this amount will reach about 40% by 2040 • Tax waivers • Implementation of the smart incentive plan in recent years • Low interest loan • Exemptions for transmission line fees • Providing at least one hundred percent of electricity from RET until the beginning of 2026. • Planning the so-called hydrogen economy until 2041. Including this vision of building wind and SPP with a capacity of 25,000 megawatts.
Saudi Arabia	• Achieving a 50% share of RET by the beginning of 2031. • The prospect of building RET with a capacity of 54,000 megawatts at the beginning of 2033 and operating 40,000 megawatts of SPP by the beginning of 2031. • Creating new rules for solar power plants up to 2 megawatts to facilitate construction In 202. • Construction of SPPs with the mechanism of holding tenders
Iraq	• Approval of the facility of about 700 million dollars of the Central Bank of Iraq for the development of RET. • According to the agreements signed, nearly 7.5 gigawatts of renewable electricity will be produced in this country in the coming years. • In 2021, this country has signed a 1 GW contract. • The contract of 525 megawatt SPP in Karbala and Babol province in the south of Araf, worth 500 million dollars.
Iran	• Guaranteed purchase tariff in dollars

- Guaranteed purchase contract for 20 years for power plants under 200 kilowatts and 6 years for megawatt power plants
- 5-year tax discounts
- Higher purchase rate of produced energy compared to thermal power plants
- Paying bills earlier than thermal stations
- The mechanism of participation in the tender
- Incentive payment in the form of saved fuel
- Requiring industries to use 5% of energy consumption from RET
- According to the Sixth Development Plan of this country, the share of RET in Iran should be 55% of the country's total electricity capacity

comparison to those of other Middle eastern nations. In Table 14**,** the building plans and strategies of these two nations **are** depict**ed**. In addition, it has been explored in the last region of Iran. Due to the pre-planning of its national electrical infrastructure, this country, like Turkey, has made substantial precautions addressing its RET sources. According to Table 19, this nation's rules and incentives for the construction of solar power plants are extensive and supported in a number of ways. Table 13 depicts the comparative results of these six nations' incentives and policies for the construction and support of solar power plants.

CONCLUSIONS

Finally, it can be concluded that policy making in the field of renewable energy in Middle East is still in its infancy, although countries like Iran and Turkey have taken significant measures in the last few years in the area of reforming the energy tariff rate, increasing investment attractiveness and real They have made the rate of fossil energy, but it seems that despite the abundance of fossil energy in this region, policy making and the importance of this industry are in the next priorities.

REFERENCES

1. Esmaeili Shayan, M., Najafi, G., Ghobadian, B., Gorjian, S., and Mazlan, M., 2022. A novel approach of synchronization of the sustainable grid with an intelligent local hybrid renewable energy control. *International Journal of Energy and Environmental Engineering* , pp.1–12. Doi: 10.1007/S40095-022-00503-7
2. Esmaeili Shayan, M., Najafi, G., Ghobadian, B., Gorjian, S., Mazlan, M., Samami, M., and Shabanzadeh, A., 2022. Flexible Photovoltaic System on Non-Conventional Surfaces: A Techno-Economic Analysis. *Sustainability*, 14(6), pp.3566. Doi: 10.3390/SU14063566
3. Esmaeili Shayan, M., Najafi, G., Ghobadian, B., Gorjian, S., and Mazlan, M., 2022. Sustainable Design of a Near-Zero-Emissions Building Assisted by a Smart Hybrid Renewable Microgrid. *International Journal of Renewable Energy Development*, 11(2), pp.471–480. Doi: 10.14710/IJRED.2022.43838
4. Rathore, P.K.S., Chauhan, D.S., and Singh, R.P., 2019. Decentralized solar rooftop photovoltaic in India: On the path of sustainable energy security. *Renewable Energy*, 131, pp.297–307. Doi: 10.1016/J.RENENE.2018.07.049
5. Griffiths, S., and Mills, R., 2016. Potential of rooftop solar photovoltaics in the energy system evolution of the United Arab Emirates. *Energy Strategy Reviews*, 9, pp.1–7. Doi: 10.1016/J.ESR.2015.11.001
6. Solangi, K.H., Islam, M.R., Saidur, R., Rahim, N.A., and Fayaz, H., 2011. A review on global solar energy policy. *Renewable and Sustainable Energy Reviews*, 15(4), pp.2149-2163. Doi: 10.1016/j.rser.2011.01.007
7. Kural, D., Ara, S., Tasarımının, O., and Analizi, B., 2020. An Analysis of the Optimal Design of Feed-in Tariff Policy for Photovoltaic Investments in Turkey. *Sosyoekonomi*, 28(46), pp.425–444. Doi: 10.17233/SOSYOEKONOMI.2020.04.20
8. Sgouridis, S., Abdullah, A., Griffiths, S., Saygin, D., Wagner, N., Gielen, D., Reinisch, H., and McQueen, D., 2016. RE-mapping the UAE's energy transition: An economy-wide assessment of renewable energy options and their policy implications. *Renewable and Sustainable Energy Reviews*, 55, pp.1166–1180. Doi: 10.1016/J.RSER.2015.05.039
9. Mokri, A., Aal Ali, M., and Emziane, M., 2013. Solar energy in the United Arab Emirates: A review. *Renewable and Sustainable Energy Reviews*, 28, pp.340–375. Doi: 10.1016/J.RSER.2013.07.038
10. Sgouridis, S., Griffiths, S., Kennedy, S., Khalid, A., and Zurita, N., 2013. A sustainable energy transition strategy for the United Arab Emirates: Evaluation of options using an Integrated Energy Model. *Energy Strategy Reviews*, 2(1), pp.8–18. Doi: 10.1016/J.ESR.2013.03.002
11. Kılıç, U., and Kekezoğlu, B., 2022. A review of solar photovoltaic incentives and Policy: Selected countries and Turkey. *Ain Shams Engineering Journal*, 13(5), pp.101669. Doi: 10.1016/j.asej.2021.101669
12. Sgouridis, S. and Csala, D., 2014. A framework for defining sustainable energy transitions: principles, dynamics, and implications. *Sustainability*, 6(5), pp.2601-2622. Doi: 10.2139/SSRN.2361603
13. Patlitzianas, K.D., Doukas, H., and Psarras, J., 2006. Enhancing renewable energy in the Arab States of the Gulf: Constraints & efforts. *Energy Policy*, 34(18), pp.3719–3726. Doi: 10.1016/J.ENPOL.2005.08.018
14. Mokhtar, M., Ali, M.T., Bräuniger, S., Afshari, A., Sgouridis, S., Armstrong, P., and Chiesa, M., 2010. Systematic comprehensive techno-economic assessment of solar cooling technologies using location-specific climate data. *Applied Energy*, 87(12), pp.3766–3778. Doi: 10.1016/J.APENERGY.2010.06.026
15. Kazim, A.M., 2007. Assessments of primary energy consumption and its environmental consequences in the United Arab Emirates. *Renewable and Sustainable Energy Reviews*, 11(3), pp.426–446. Doi: 10.1016/J.RSER.2005.01.008
16. Lee, C.C., and Chang, C.P., 2007. Energy consumption and GDP revisited: A panel analysis of developed and developing countries. *Energy Economics*, 29(6), pp.1206–1223. Doi: 10.1016/J.ENECO.2007.01.001
17. Alnaser, W.E., and Alnaser, N.W., 2011. The status of renewable

energy in the GCC countries. *Renewable and Sustainable Energy Reviews*, 15(6), pp.3074–3098. Doi: 10.1016/J.RSER.2011.03.021

18. Eissa, Y., Chiesa, M., and Ghedira, H., 2012. Assessment and recalibration of the Heliosat-2 method in global horizontal irradiance modeling over the desert environment of the UAE. *Solar Energy*, 86(6), pp.1816–1825. Doi: 10.1016/J.SOLENER.2012.03.005
19. Dorvlo, A.S.S., Jervase, J.A., and Al-Lawati, A., 2002. Solar radiation estimation using artificial neural networks. *Applied Energy*, 71(4), pp.307–319. Doi: 10.1016/S0306-2619(02)00016-8
20. Rahman, F., 2021. UAE's renewable energy capacity set to increase to 9GW by 2025. Update: Feb 11, 2021, Available at: https://www.thenationalnews.com/business/energy/uae-s-renewable-energy-capacity-set-to-increase-to-9gw-by-2025-1.1164561
21. Esmaeili Shayan, M., Hayati, M.R., Najafi, G., and Esmaeili Shayan, S., 2022. The Strategy of Energy Democracy and Sustainable Development: Policymakers and Instruments. *Iranian (Iranica) Journal of Energy & Environment*, 13(2), pp.185–201. Doi: 10.5829/IJEE.2022.13.02.10
22. National Grid project, 2020. URL: https://u.ae/en/information-and-services/environment-and-energy/water-and-energy/electricity/national-grid-project
23. Esmaeili Shayan, M., Najafi, G., Ghobadian, B., and Gorjian, S., 2022. Modeling the Performance of Amorphous Silicon in Different Typologies of Curved Building-integrated Photovoltaic Conditions. *Iranian (Iranica) Journal of Energy & Environment*, 13(1), pp.87–97. Doi: 10.5829/IJEE.2022.13.01.10
24. Esmaeili Shayan, M., and Hojati, J., 2021. Floating Solar Power Plants: A Way to Improve Environmental and Operational Flexibility. *Iranian (Iranica) Journal of Energy & Environment*, (4), pp.337–348. Doi: 10.5829/IJEE.2021.12.04.07
25. Esmaeili Shayan, M., Esmaeili Shayan, S., and Nazari, A., 2021. Possibility of supplying energy to border villages by solar energy sources. *Energy Equipment and Systems*, 9(3), pp.279–289. Doi: 10.22059/EES.2021.246079
26. Pearl-Martinez, R., 2015. All Hands On Deck: Who's Missing in the Clean Energy Workforce. In The Fletcher Forum. URL: http://www.fletcherforum.org/home/2016/8/23/fs3vy011ir50otfufof0lxe89wawap
27. Dicce, R.P., and Ewers, M.C., 2021. Solar labor market transitions in the United Arab Emirates. *Geoforum*, 124(April), pp.54–64. Doi: 10.1016/j.geoforum.2021.05.013
28. Irena, I.P., 2021. End-Of-Life Management: Solar Photovoltaic Panels, ISBN: 978-92-95111-99-8. Available at: https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels
29. Shayan, M.E., Najafi, G. and Nazari, A., 2021. The Biomass Supply Chain Network Auto-Regressive Moving Average Algorithm. *International Journal of Smart Grid*, 5, pp.15-22. Doi: 10.20508/IJSMARTGRID.V5I1.153.G135
30. Juaidi, A., Montoya, F.G., Gázquez, J.A., and Manzano-Agugliaro, F., 2016. An overview of energy balance compared to sustainable energy in United Arab Emirates. *Renewable and Sustainable Energy Reviews*, 55, pp.1195–1209. Doi: 10.1016/j.rser.2015.07.024
31. Esameili Shayan, M., Najafi, G., and Esameili shayan, S., 2021. Design of an Integrated Photovoltaic Site: Case of Isfahan's Jarghouyeh photovoltaic plant. *Journal of Energy Planning And Policy Research*, 6(4), pp.229–250. Available at: http://epprjournal.ir/article-1-858-en.html
32. Mezher, T., Dawelbait, G., and Abbas, Z., 2012. Renewable energy policy options for Abu Dhabi: Drivers and barriers. *Energy Policy*, 42, pp.315–328. Doi: 10.1016/J.ENPOL.2011.11.089
33. Choucri, N., Goldsmith, D. and Mezher, T., 2010. Renewable energy policy in an oil-exporting country: the case of the United Arab Emirates. Renewable Energy Law and Policy Review, pp.77-86. Available at: https://www.researchgate.net/publication/291159310_Renewable_energy_policy_in_an_oil-exporting_country_The_case_of_the_United_Arab_Emirates (accessed Dec. 17, 2022)
34. Al-Amir, J., and Abu-Hijleh, B., 2013. Strategies and policies from promoting the use of renewable energy resource in the UAE. *Renewable and Sustainable Energy Reviews*, 26, pp.660–667. Doi: 10.1016/J.RSER.2013.06.001
35. Ghasemzadeh, F., Esmaeilzadeh, M., and Esmaeili shayan, M., 2020. Photovoltaic Temperature Challenges and Bismuthene Monolayer Properties. *International Journal of Smart Grid*, 4(4), pp.190–195. Doi: 10.20508/ijsmartgrid.v4i4.131.g109
36. Harder, E., and Gibson, J.M.D., 2011. The costs and benefits of large-scale solar photovoltaic power production in Abu Dhabi, United Arab Emirates. *Renewable Energy*, 36(2), pp.789–796. Doi: 10.1016/j.renene.2010.08.006
37. Shayan, M.E. and Ghasemzadeh, F., 2020. Nuclear power plant or solar power plant. In Nuclear Power Plants-The Processes from the Cradle to the Grave. IntechOpen. Doi: 10.5772/intechopen.92547
38. Shayan, M.E., 2020. Solar energy and its purpose in net-zero energy building. Zero-Energy Buildings—New Approaches and Technologies, pp.14. Doi: 10.5772/intechopen.93500
39. Ghasemzadeh, F. and Esmaeili Shayan, M., 2020. Nanotechnology in the Service of Solar Energy Systems. Nanotechnology and the Environment. IntechOpen. Doi: 10.5772/intechopen.93014.
40. Turkey Ministry of Energy and Natural Resources. URL: https://www.enerji.gov.tr/homepage/
41. Azadbakht, M., Esmaeilzadeh, E., and Esmaeili-Shayan, M., 2015. Energy consumption during impact cutting of canola stalk as a function of moisture content and cutting height. *Journal of the Saudi Society of Agricultural Sciences*, 14(2), pp.147–152. Doi: 10.1016/j.jssas.2013.10.002
42. Couture, T., and Gagnon, Y., 2010. An analysis of feed-in tariff remuneration models: Implications for renewable energy investment. *Energy Policy*, 38(2), pp.955–965. Doi: 10.1016/J.ENPOL.2009.10.047
43. Esmaeili shayan, M., Najafi, G., and Banakar, A. ahmad, 2017. Power Quality in Flexible Photovoltaic System on Curved Surfaces. *Journal of Energy Planning And Policy Research*, 3(7), pp.105–136. [In persian]
44. Duman, A.C., and Güler, Ö., 2020. Economic analysis of grid-connected residential rooftop PV systems in Turkey. *Renewable Energy*, 148, pp.697–711. Doi: 10.1016/j.renene.2019.10.157
45. Tech, T., 2018. Final Report Turkey: Rooftop Solar PV Market Assessment. Available at: https://documents.worldbank.org/curated/en/318801537299381731/pdf/123784-PUBLIC-repl-A2I.pdf
46. Önder, H.G., 2021. Renewable energy consumption policy in Turkey: An energy extended input-output analysis. *Renewable Energy*, 175, pp.783–796. Doi: 10.1016/j.renene.2021.05.025
47. Enerji ve Tabii Kaynaklar Bakanlı gı Elektrik, Energy and Natural Resources. URL: https://enerji.gov.tr/bilgi-merkezi-enerji-elektrik
48. Kazem, H.A., 2011. Prospects of potential renewable and clean energy in Oman. *International Journal of Electronics, Computer and Communications Technologies*, 1(2), pp.25–29. Available at: https://journal.uniten.edu.my/index.php/ijecct/article/view/13
49. Kazem, H.A., Albadi, M.H., Al-Waeli, A.H.A., Al-Busaidi, A.H., and Chaichan, M.T., 2017. Techno-economic feasibility analysis of 1MW photovoltaic grid connected system in Oman. *Case*

Studies in Thermal Engineering, 10, pp.131–141. Doi: 10.1016/j.csite.2017.05.008

50. Alhousni, F.K., Ismail, F.B., Okonkwo, P.C., Mohamed, H., Okonkwo, B.O. and Al-Shahri, O.A., 2022. A review of PV solar energy system operations and applications in Dhofar Oman. AIMS Energy, 10(4), pp.858-884. Doi: 10.3934/energy.2022039
51. Ministry of National Economy, 2023. URL: http://www.moneoman.gov.om/
52. The Authority for Electricity Regulation Oman, 2023. URL: http://www.aer-oman.org
53. Al-Saqlawi, J., Madani, K., and Mac Dowell, N., 2018. Techno-economic feasibility of grid-independent residential roof-top solar PV systems in Muscat, Oman. *Energy Conversion and Management*, 178, pp.322–334. Doi: 10.1016/J.ENCONMAN.2018.10.021
54. Kazem, H.A., and Khatib, T., 2013. Techno-economical assessment of grid connected photovoltaic power systems productivity in Sohar, Oman. *Sustainable Energy Technologies and Assessments*, 3, pp.61–65. Doi: 10.1016/J.SETA.2013.06.002
55. Al-Saadi, S., and Krarti, M., 2015. Evaluation of Optimal Hybrid Distributed Generation Systems for an Isolated Rural Settlement in Masirah Island, Oman, *Distributed Generation and Alternative Energy Journal*, 30(2), pp.23–42. Doi: 10.1080/21563306.2015.11431662
56. Abdul-Wahab, S., Charabi, Y., Al-Mahruqi, A.M., Osman, I., and Osman, S., 2019. Selection of the best solar photovoltaic (PV) for Oman. *Solar Energy*, 188(June), pp.1156–1168. Doi: 10.1016/j.solener.2019.07.018
57. Oman Population in 2022. URL: https://www.worldometers.info
58. Yu, T.C., and Chien, T.S., 2009. Analysis and simulation of characteristics and maximum power point tracking for photovoltaic systems. *Proceedings of the International Conference on Power Electronics and Drive Systems*, , pp.1339–1344. Doi: 10.1109/PEDS.2009.5385670
59. Kazem, H.A., 2011. Renewable energy in Oman: Status and future prospects. *Renewable and Sustainable Energy Reviews*, 15(8), pp.3465–3469. Doi: 10.1016/j.rser.2011.05.015
60. Shayan, M.E., Najafi, G., Ghobadian, B., Gorjian, S., Mamat, R., and Ghazali, M.F., 2022. Multi-microgrid optimization and energy management under boost voltage converter with Markov prediction chain and dynamic decision algorithm. *Renewable Energy*, 201, pp.179–189. Doi: 10.1016/J.RENENE.2022.11.006
61. Hepbasli, A., and Alsuhaibani, Z., 2011. A key review on present status and future directions of solar energy studies and applications in Saudi Arabia. *Renewable and Sustainable Energy Reviews*, 15(9), pp.5021–5050. Doi: 10.1016/j.rser.2011.07.052
62. Tabassum, S., Rahman, T., Ul Islam, A., Rahman, S., Dipta, D.R., Roy, S., Mohammad, N., Nawar, N., and Hossain, E., 2021. Solar Energy in the United States: Development, Challenges and Future Prospects. *Energies*, 14(23), pp.8142. Doi: 10.3390/EN14238142
63. US Energy Information Administration, 2010. URL: http://tonto.eia.doe.gov/country/%0Aindex.cfm
64. Al-Douri, Y., and Abed, F.M., 2016. Solar energy status in Iraq: Abundant or not - Steps forward. *Journal of Renewable and Sustainable Energy*, 8(2). Doi: 10.1063/1.4947076
65. World Bank Group, 2018. Iraq Economic Monitor, Spring 2018: From War to Reconstruction and Economic Recovery. World Bank., Washington, DC. Available at: https://www.researchgate.net/publication/325514557_Iraq_Economic_Monitor_From_War_to_Reconstruction_and_Economic_Recovery_With_a_Special_Focus_on_Energy_Subsidy_Reform (accessed Dec. 25, 2022)
66. Khatteeb, L. and Istepanian, H., 2015. Turn a light on: electricity sector reform in Iraq. Brookings Institution. Brookings Doha Center. Available at: https://www.researchgate.net/publication/273949491_Turn_a_Light_on_Electricity_Sector_Reform_in_Iraq (accessed Dec. 25, 2022)
67. Esameili Shayan, M., Najafi, G., and Esmaeili Shayan, S., 2023. Smart Micro-Grid Electrical Energy Management: Techno-Economic Assessment. *Engineering and Energy Management*, 13(1), pp.90–101. Available at: https://energy1.kashanu.ac.ir/article_113605_fad303eec3aa22b2d08f8a932d595f46.pdf?lang=en [In persian]
68. Hussein, I.I., Essallah, S., and Khedher, A., 2022. Improvement of the Iraqi Super Grid Performance Using HVDC/HVAC Links by the Integration of Large-Scale Renewable Energy Sources. *Energies*, 15(3), pp.1142. Doi: 10.3390/EN15031142
69. Aziz, A.S., Tajuddin, M.F.N., Adzman, M.R., Mohammed, M.F., and Ramli, M.A.M., 2020. Feasibility analysis of grid-connected and islanded operation of a solar PV microgrid system: A case study of Iraq. *Energy*, 191, pp.116591. Doi: 10.1016/j.energy.2019.116591
70. Esmaeili Shayan, M., Najafi, G., and Lorenzini, G., 2022. Phase change material mixed with chloride salt graphite foam infiltration for latent heat storage applications at higher temperatures and pressures. *International Journal of Energy and Environmental Engineering*, 13(2), pp.739-749. Doi: 10.1007/s40095-021-00462-5
71. Esmaeili Shayan, M., and Hayati, M.R., 2023. Thermal Performance and Heat Dynamics Energy and Exergy of Integrated Asphalt Collector Storage: Sources of Thermal Energy, and Thermoelectric Energy. *Iranian Journal of Energy and Environment*, 14(1), pp.17–25. Doi: 10.5829/IJEE.2023.14.01.03
72. Eslami, M., and Nahani, P., 2021. How policies affect the cost-effectiveness of residential renewable energy in Iran: A techno-economic analysis for optimization. *Utilities Policy*, 72(July), pp.101254. Doi: 10.1016/j.jup.2021.101254
73. Mostafa Nosratabadi, S., Hemmati, R., Bornapour, M., and Abdollahpour, M., 2021. Economic evaluation and energy/exergy analysis of PV/Wind/PEMFC energy resources employment based on capacity, type of source and government incentive policies: Case study in Iran. *Sustainable Energy Technologies and Assessments*, 43, pp.100963. Doi: 10.1016/j.seta.2020.100963
74. Ghorashi, A.H., and Maranlou, H., 2021. Essential infrastructures and relevant policies for renewable energy developments in oil-rich developing countries: Case of Iran. *Renewable and Sustainable Energy Reviews*, 141(May 2020), pp.110839. Doi: 10.1016/j.rser.2021.110839
75. Esmaeili shayan, M., Najafi, G., and Esmaeili Shayan, S., 2023. Microgrids Energy Management System Based on Renewable Energy. *Amirkabir Journal of Mechanical Engineering*. Doi: 10.22060/mej.2023.20755.7346
76. SATBA, 2022. The share of renewable power plants in Iran, Available at :https://www.satba.gov.ir/fa/satba/information
77. Council, E., 2022. Investment permit for the construction of a solar power plant, [Online] Available at: https://qavanin.ir/Law/TreeText/297472
78. Parliament, 2022. The Executive Regulations of Article 16 of the Knowledge-Based Production Jump Law, Available at: https://dotic.ir/news/12847

Persian Abstract

چکیده

با توجه به اینکه کشورهای خاورمیانه و شمال آفریقا اهداف بلندپروازانه‌ای را برای گذار به مصرف انرژی‌های تجدیدپذیر دنبال می‌کنند، اقتصاد سیاسی منطقه‌ای که عمدتاً از طریق منشور سوخت‌های فسیلی تحلیل می‌شود در آستانه تغییر اساسی است. با کاهش قیمت سوخت‌های هیدروکربنی، تولیدکنندگان ارزان قیمت کشورهای غرب آسیا (خاورمیانه) از مزیت‌های اقتصادی برخوردار بوده و باید آخرین افرادی باشند که این بازار را ترک می‌کنند. این درحالی است که سایر کشورهای جهان به نسبت بیشتری از نفت و گاز این منطقه تقاضا خواهند نمود. قریب به نیمی از ذخائر نفت جهان در منطقه غرب آسیا قرار دارد که از دیرباز به عنوان محور انرژی کره زمین از آن یاد می‌شود. در این میان، با پیشرفت و آینده‌گری کشورهای این منطقه، این کشورها اهمیت تامین انرژی از سایر منابع انرژی را به خوبی دریافته‌اند؛ به گونه‌ای که استفاده از انرژی‌های تجدیدپذیر مانند خورشید، توجهات گسترده‌ای را به خود جلب کرده است. این مطالعه علاوه بر پنج کشور غرب آسیا و نیز ترکیه که در مجاورت منطقه خاورمیانه واقع شده است، این جاذبه‌ها را تحلیل و ارزیابی کرده است. در این پژوهش از رویکرد مقایسه مشوق‌های دولتی در توسعه نیروگاه‌های تجدیدپذیر استفاده گردیده است. یافته‌های نهایی وضعیت فعلی این انرژی را در کشورهای هدف نشان می‌دهد. شایان توجه است که این مطالعه می‌تواند برای تدوین سیاست‌های مؤثر برای استفاده از منابع تجدیدپذیر اطلاعات فراوانی را در اختیار قانون‌گذاران کشورهای هدف و سایر کشورهای منطقه بگذارد.