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RESEARCH ARTICLE

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Evaluation of renewable energies production potential in the Middle East: confronting the world's energy crisis

Abstract Oil and fossil fuels, the main source of energy in the Middle East have obviously the most destructive effects on the environment and public health. The developed countries of the Middle East are faced with the crisis and energy security. This paper is about evaluating the energy demand /consumption in the Middle East. First, the position of energy consumption in the world and the Middle East is discussed. Next, the evaluation of the current potential of clean energy production from renewable energies is explained. Finally, according to related maps, charts and information presented for the condition of renewable energy which has been approved by the countries of the Middle East, the greatest places in some countries of this region are introduced and discussed.

Keywords Middle East countries, renewable energy, fossil fuels, energy crisis

1 Introduction

The Middle East and the Persian Gulf include the lands between the Mediterranean Sea and the middle part of the Africa-Eurasia or Asia, that occasionally covers part of North Africa [1]. The Middle East, because of having huge resources of oil, has been counted as the world source of energy. The Kingdom of Saudi Arabia (KSA), Iran, Iraq, Kuwait, and the United Arabian Emirates (UAE) are the countries with the largest oil reserves in the world [2]. The Middle East also has large reserves of natural gas [3]. Iran and Qatar have the first and second largest natural gas reserves in the world respectively. The economy of Middle East countries is mainly single-product and more dependent on oil exports and less dependent on applying oil and its derivatives in the industry sector [4].

Petroleum and energy crises in the Middle East are the two subjects, which have engaged the countries in this region for more than 70 years [5]. Most governments have managed the balance of Petroleum and energy crisis scheme for their countries. Production and selling of petroleum-based products have been the most important business in the Middle East for more than 70 years [6].

These countries have been chosen based on four main characteristics: the fuel energy crisis in approach of fuel leakage and pollution; the existence of ambitious national targeting and planning, supporting the policies and achievements; the strong local potentials and experiences in renewable energy projects; and the local industrial investment dedicated to renewable energies.

As long as the main governed equation in the Middle East is about the energy crisis and petroleum, there would be no stability and security in this region [7].

In the case of the Middle East, which includes a number of countries, some geographers also consider countries of the North and East Africa such as Pakistan, Afghanistan and some other Middle Eastern countries as Middle East countries [8].

War, insecurity, population growth and energy involving the Middle East are the main issues. In recent years, great advances have been made in the field of renewable energy application in some countries of the Middle East. The high potential of this region in using of renewable energies

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according to the number of sunny days, the wind and sea power, and the great lakes in this area can make this region as an important center for energy production from renewable energies [9].

In addition, with regard to the damaging effects of fossil fuels challenging in public health and the tension and disputes made between countries in global prices of oil and gas, it seems that the use of renewable resources in this area can act as a peace maker and give stability in the Middle East [10]. In Figs. 1 and 2, the net and major domestic oil production of the countries is shown. It can be observed from Fig. 1 that a huge amount of the world's oil supply has been produced in the Middle East. Following this trend, more extraction of these resources in the Middle East will cause the evacuation of oil resources in the next few years, which will create problems and serious crisis [11].

The charts, maps, and tables in this paper present a serious warning to the completion of fossil resources and the enormous financial crisis in this region.

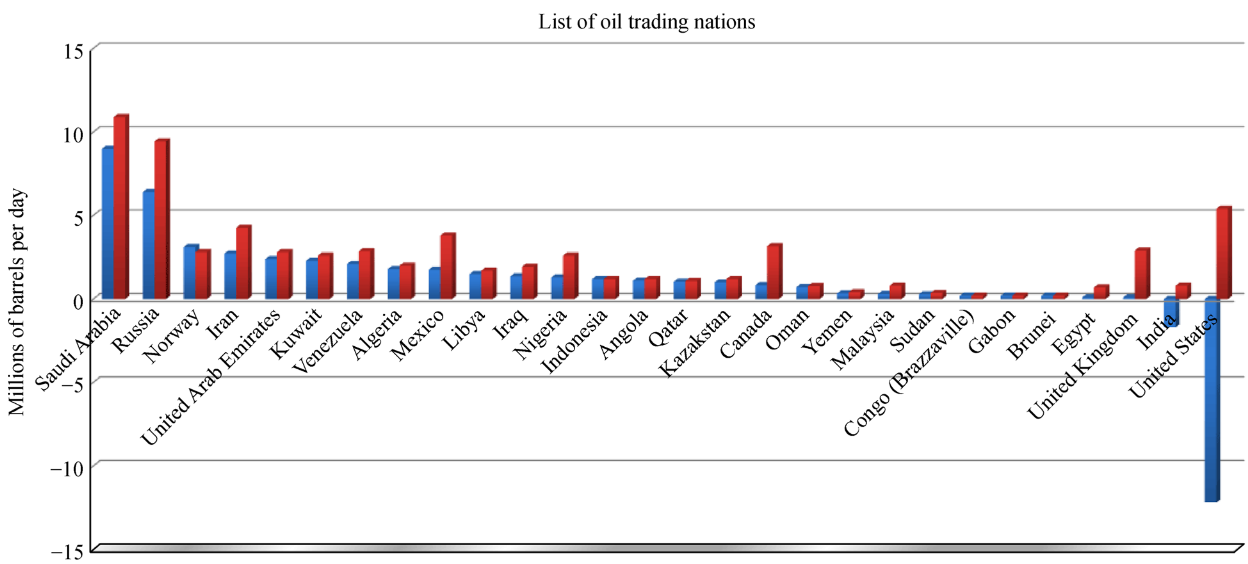
Other factors for extracting more oil and fossil fuels in the Middle East are the competition for more sale and oil prices. The economy of the world deeply depends on crude oil exports from the five countries, especially the KSA, Iran, and UAE). Figure 3 shows crude oil exports of the first five countries in the field of crude oil exports from 1980 to 2012 [12].

The electrical power generated from fossil fuels and renewable energies, the share of each of them, and the prediction of the trend of increasing consumption of fossil fuels for electricity production in 2030 in the Middle East are illustrated in Fig. 4[1].

A significant amount of gas and oil has been produced by Middle East countries. The released CO_2 in this area is significantly higher than that in the rest of the world. Figure 5 shows the amount of carbon production in various countries in the Middle East [13] while Table 1 depicts the extraction of natural gas in this area against North Africans countries, which is the proof of the effective role of the Middle East in producing dry gas.

Power generation is one of the most important factors in polluting the region of the Middle East [14]. The Middle East and North Africa has a population of about 2.4 billion with a 5.5% growing rate annually between 1981 and 2009. The average annual rate of electricity production in the Middle East is 7.2%. This production rate is higher than other regions such as East Asia which has an annual rate of electricity production of 6.2% and Latin American countries who have an annual rate of electricity production of 4.5% [15].

The rapid growth of power generation poses a major environmental challenge to the Middle East and North Africa, because 96 % of power generation capacity in the Middle East is dependent on fossil fuels. Renewable energies (including hydropower energy) only account for 3% of electricity generation in the Middle East. It seems that the use of renewable energies is a suitable solution for eco-friendly power generation. The using of renewable energy sources is recommended, especially for countries



Net exports	9	6.4	3.1	2.721	2.4	2.3	2.1	1.8	1.756	1.5	1.367	1.3	1.2	1.1	1.04	1	0.832	0.714	0.333	0.3	0.25	0.2	0.2	0.2	0.1	0.1	−1.7	−12.2
Production	10.9	9.44	2.8	4.259	2.8	2.6	2.855	2	3.791	1.7	1.942	2.6	1.2	1.2	1.08	1.2	3.151	0.781	0.41	0.8	0.36	0.2	0.2	0.2	0.7	2.9	0.8	5.4

Fig. 1 Net production and export of oil in 2014

1) Available at the website of bunkerportsnews

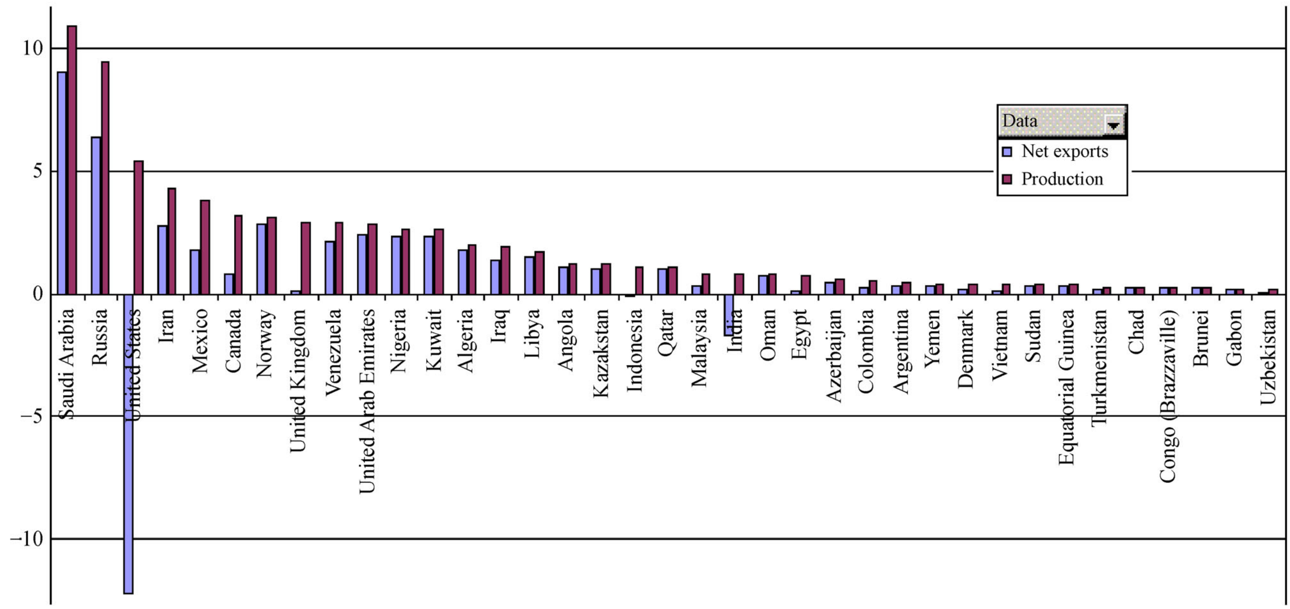


Fig. 2 GDP in oil exports in 2014

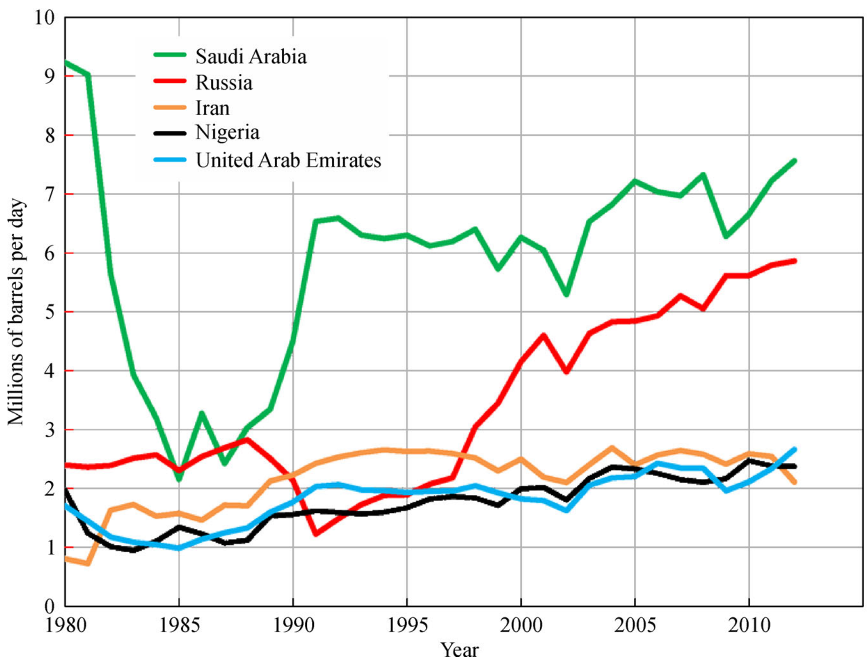


Fig. 3 Top five crude oil-exporting countries

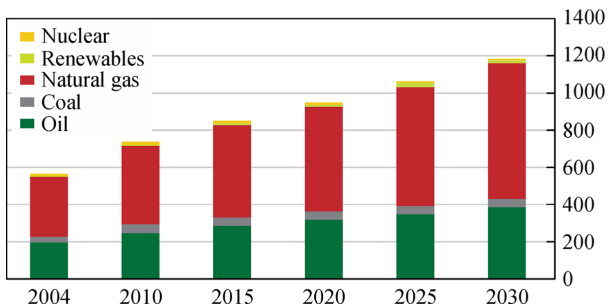


Fig. 4 Net electricity generation in the Middle East using fossil fuels form 2004 to 2030 (in billion kilowatts- hours)

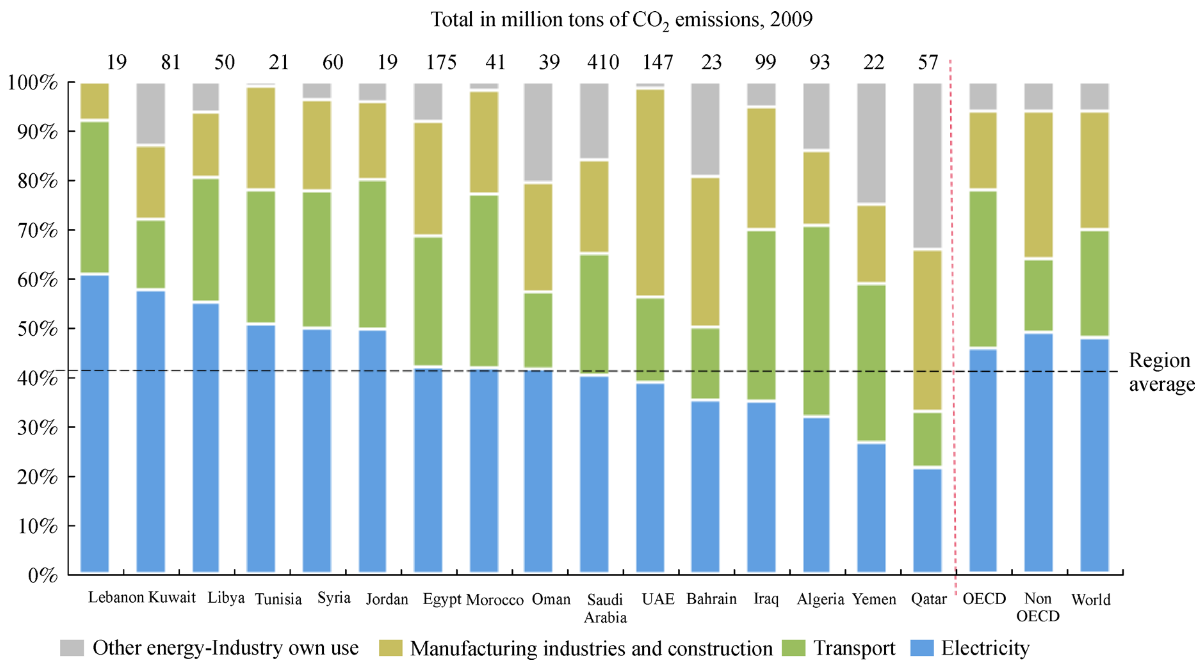


Fig. 5 CO_2 released in the Middle East

Table 1 Dry gas production in the Middle East and North African countries

Countries	Dry gas production/(Bcf·d^{-1})
Iran	12.69
Algeria	7.88
Saudi Arabia	7.59
Egypt	6.07
Qatar	8.64
United Arab Emirates	4.73
Oman	2.40
Bahrain	1.22
Kuwait	1.11
Libya	1.54
Syria	0.60
Iraq	0.11
Jordan	0.02
Israel	0.15
Tunisia	0.35
Yemen	0.05
Morocco	0.01
Sudan	<0.01

Notes: Bcf/d = billion cubic feet per day; World 2009 dry gas production = 291.70 Bcf/d; MENA 2009 dry gas production = 55.14 Bcf/d; MENA share of world 2009 dry gas production = 18.9%

that the share of oil in electricity production is more than 50%. Such countries include Yemen (100%), Lebanon (94%), Iraq (92%), Kuwait (71%), the KSA (55%) and Syria (50%) [16]. Figure 6 shows the use of fossil fuels and renewable sources in different regions of the world. It can be observed from Fig. 6 that the Middle East has the largest share of using energy from fossil fuels.

The use of renewable energy as a solution to overcoming energy crisis as well as the appropriate use of the potential of the Middle East in the production of renewable resources in recent years is one of the focuses of the regional governments [17]. In Table 2, the increased share of renewable energy in energy production in the Middle East is listed. However, increasing the utilization rates of these resources over the past this time is very minimal with a slight increscent of government attention to the use of renewable energy[1)].

From 2008 to 2011, according to the positive approach of the government to use of renewable energy, the growth rate of using renewable energy sources, instead of fossil fuels, has significantly increased. Figure 7 displays the annual average growth rate of electricity production by using different sources in the Middle East and North African countries. Although the percentage of using renewable energy is increasing, yet, having a little share in the energy production in the Middle East makes this growth inconsiderable toward the use of fossil fuels[1)].

In this paper, the problems of using fossil fuels in the

1) World net electricity generation from renewable power by fuel. 2012, available at the website of eia

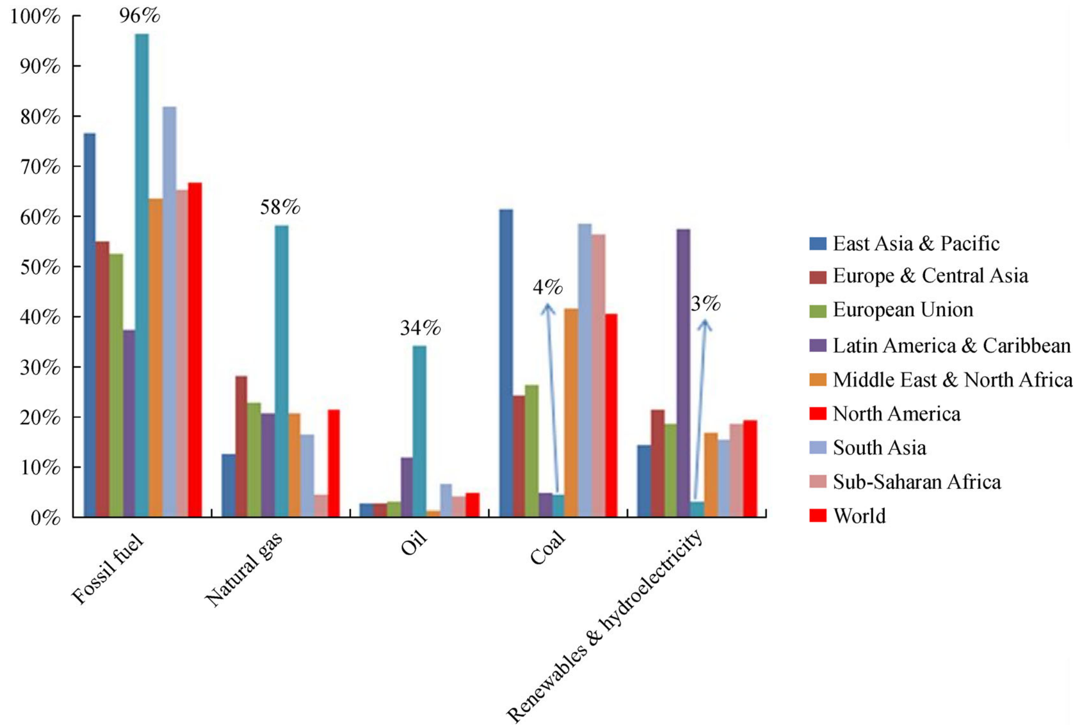


Fig. 6 Word development indicator

region of the Middle East will be reviewed, the proposal of replacing renewable energy to solve the problem of energy crisis in the Middle East will be presented, and the activities that are currently being used or going to be used in several countries will be described.

2 Exploring the use of renewable energy in various countries of the Middle East

This section examines potentials, projects, facilities and major sites of energy production from renewable sources in Middle East countries.

2.1 KSA

The KSA is located at a latitude of 16.33 degrees North and a longitude of 34.56 degrees East [18]. Petroleum sources are used mainly for energy production [19] while the use of oil reserves for domestic purposes is the reason for pollution of the environment. Geo model investigations estimate the model by measuring the DNI (Direct Normal Irradiance) per month in the KSA. The amount of radiation has been recorded in the southern region with a maximum average of 7004 Wh/m^2 [20]. In this regard, the top 10 solar projects in the KSA are presented in Table 3 [21].

The ability to use hybrid solar/wind energy in the south-western part of the KSA (Yanbu) has been evaluated [22]. The survey relies on the use of solar photovoltaic (PV) cell and wind turbines as a hybrid system. Uncalculated and unfulfilled additional electricity has been considered in this study. The annual solar radiation is about 5.95 kWh/m^2, and the average wind speed is 3.53 m/s.

According to the results of the PV cell simulation to generate electricity, wind turbines have a greater share in terms of size, though wind turbines and the PV arrays used in hybrid wind/solar are identified effectively. However, using the combined total for energy purposes has been effective in the area of south-western the KSA. Wind turbine and batteries in a hybrid system play an important role in energy supply in the evening hours, although both components are part of a costly hybrid systems [23]. The result of the study shows that the KSA has a great amount of geothermal energy for direct applications. Underground aqueduct, hot springs and geothermal reef system in this country are the most important geothermal resources.

According to many studies, hot springs and volcanic regions along the south-western coast of the Red Sea have a large geothermal potential in the KSA.

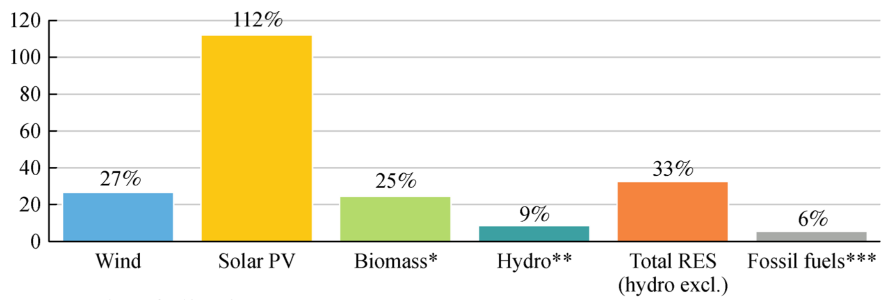
2.2 UAE

The UAE is rich in oil and gas resources. However, since 2006 unprecedented various efforts have been made in the renewable energy sector [24]. Because of the geographical location, this country is always under the sunshine.

Table 2 Installed renewable energy capacity in the Middle East and North African countries Unit: MW

	Solar		Wind	Biomass and waste	Geothermal	Hydro	Total
	PV	CSP					
Algeria	7.1 [c]	25 [a]	0 [a]	0 [b]	0 [b]	228 [a]	260.1
Bahrain	5 [b]	0	0.5 [a]	0 [b]	0 [b]	0 [b]	5.5
Egypt	15 [a]	20 [a]	550 [a]	0 [b]	0 [b]	2800 [a]	3385
Iran	4.3 [c]	17 [b]	91 [a]	0 [b]	0 [b]	9500 [a]	9612.3
Iraq	3.5 [d]	0 [b]	0 [b]	0 [b]	0 [b]	1864 [a]	1867.5
Kuwait	1.8 [c]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	1.8
Libya	4.8 [a]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	4.8
Oman	0.7[c]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0.7
Qatar	1.2 [c]	0 [a]	0 [a]	40 [a]	0 [a]	0 [a]	41.2
Saudi Arabia	7(2013)	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	7
Syria	0.84 [c]	0 [b]	0 [b]	0 [b]	0 [b]	1151 [c]	1151.84
UAE	22.5 [a]	100(2013)	0 [b]	3 [a]	0 [b]	0 [b]	125.5
Yemen	1.5 [a]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	1.5
Total NOEC	75.24	162	641.5	43	0	15543	16464.74
Djibouti	1.4 [c]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	1.4
Israel	269 [a]	0 [b]	6 [b]	27 [a]	0 [b]	7 [d]	309
Jordan	1.6 [a]	0 [b]	1.4 [a]	3.5 [a]	0 [b]	10 [a]	16.5
Lebanon	1 [a]	0 [b]	0.5 [a]	0 [b]	0 [b]	282 [a]	283.5
Malta	12 [b]	0 [b]	0 [b]	0 [b]	0 [b]	0 [b]	12
Morocco	15 [a]	20 [a]	291 [a]	0 [b]	0 [b]	1745 [a]	2017
Palestinian Territories	1 [a]	0 [b]	0 [b]	0 [b]	0.023 [a]	0 [c]	1.023
Tunisia	4 [a]	0 [a]	154 [a]	0 [b]	0 [b]	66 [a]	224
Total NOIC	305	20	452.9	30.5	0.023	2110	2918.42
TOTAL MENA	380.24	182	1094.4	73.5	0.023	17.653	19383.16

Notes: a—2012, b—2011, c—2010, d—2009



Source: See Endnote 6 for this section
In 2010, Iran and Morocco started to operate the first CSP plants in the MENA region, and in 2011, Algeria and Egypt started to operate their first CSP plants; therefore, it is not possible to calculate the average annual growth rate for CSP power generation from 2008 to 2011.

*Average annual growth rate for biomass power generation is from 2009 to 2011.
**Average annual growth rate for hydropower generation includes 2010 data for Lebanon and Syria.
***Average annual growth rate for fossil fuel power generation includes 2010 data for Lebanon, Syria, and Yemen.

Fig. 7 Annual average growth rate of electricity production by source in the Middle East and North African countries from 2008 to 2011

Nevertheless, the dust particles in the air with a high moisture lead to the decreasing permeability and dilution intensity of solar radiation. Satellite imagery and ground-based calculations show that the intensity of this effect depends on seasons and the location [25,26]. Therefore, this reason causes solar technologies predominance toward

Table 3 Solar projects in the KSA

No.	Name	Current size	Com. date
1	Saudi Aramco Solar Car Park	10.5 MW	2012
2	Princess Noura Bint Abul Rahman University	25 MW	2012
3	King Abdulaziz International Airport Development Project	5.4 MW	2013
4	KAPSARC Project	3.5 MW	2013
5	KAUST Solar Park	2 MW	2010
6	Pilot Project	500 kW	2011
7	King Abdullah Financial District Project	200 kW	2012
8	Al Khafji Plant	10 MW	2015
9	KAPSARC II Project	1.8 MW	2014
10	Solar Energy Project (Mecca)	100 MW	2018

other countries in this region. As noted above, the UAE have a high accumulation of atmospheric dust on solar energy collectors [27–29]. This leads to a decrease in energy efficiency, the difficulty of predicting the output power, and additional costs for cleaning them. To solve this issue, two ways has been proposed. One is the consideration of the optimal frequency for cleaning the wet (such as water), and the other is the addition of a self-cleaner cover to the PV module (PV) [30]. Figure 8 shows the distribution of solar energy projects in the UAE including PV stations, concentrated solar power projects, concentrated solar power (CSP), building-integrated PV (BIPV), solar water heaters projects, and concentrating PV (CPV) designs [31]. The UAE is the top 6 of CSP in the world in 2015. The top 5 countries are Spain, USA, India, Morocco, and South Africa.

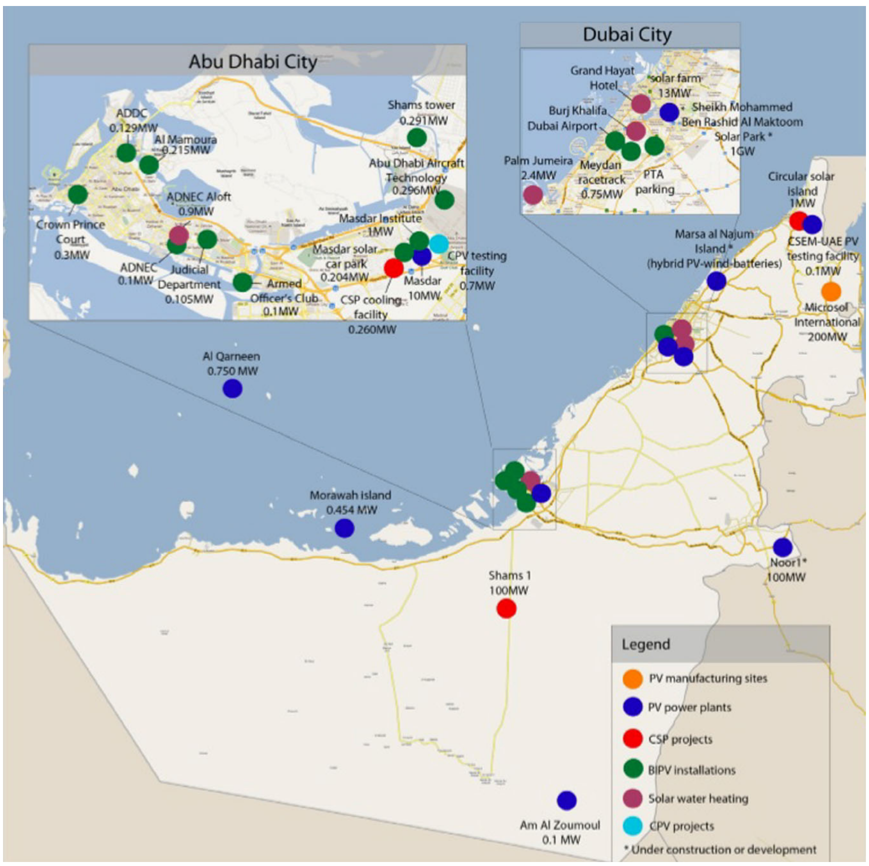


Fig. 8 Solar installations in the UAE

A study in Sharjah shows that the wind speed in some seasons can reach up to 13 m/s. Anajereh et al. [32] have steadily measured the wind speed in the city of Masdar (Abu Dhabi) for a number of months at various altitudes between 0 and 50 m. It is concluded that in this part of Abu Dhabi, the amount of wind speed is low and the balance area is type 1. Thus wind turbines with a low angular momentum and a low wind carrier can be used. The amount of wind speed has also been examined in the emirate Fojereh. Based on its analysis, the capacity of wind power is between 130 and 200 MW [33]. So the wind power cannot be used widely as a viable option because of its low speed. The UAE produces 3.8% of the total global consumption of oil and 5.9% of the world's oil reserves, which are expected to be fully finished in the next 80 years. It is also noted that the UAE has become the importer of gas since 2007. Domestic demand increases by 5.2% per year and electric energy demand is as much as 10.08%. Knowing the fact that 35% oil and 65% of energy production is based on natural gas, the adoption of alternative energy sources seems necessary [31]. The country is also among the top five of CSP in the world.

2.3 Egypt

According to the International Energy Agency (IEA) the annual primary energy demand has been grown 2.6% in Egypt and in 2030 it will be 109 Mtoe, whereas the production of electricity in 2030 is approximately 188 TW. This country normally receives an electric energy of about 2000 to 3200 kWh/m^2/year from direct solar radiation. The sun exposure time ranges from 9 to 11 h/day from the north to the south [34].

The first solar thermal power plant is built in the area of Korbamat situated in the south Ghahereh with a solar thermal generating capacity of 140 MW [35]. This power plant has gas turbines with a capacity of 40 MW, steam turbines with a capacity of 50 MW, and a solar field of parabolic type with a capacity of 200 GWh per day from solar energy. Totally, the plant is capable of producing 62 MW of solar heating at a temperature of 393°C [36]. The overview of Kuraymat Integrated Solar Combined Cycle Power Plant (ISCC) is shown in Table 4.

Egypt has two coastal regions for promising significant exploitation of wind energy. The northern shore of the Mediterranean Sea and the eastern coast of the Red Sea have been known to have a high wind potential relative to the rest of Egypt and many regions in north African desert [37,38].

According to Ref. [39], the two areas have a significant economic scale of wind energy. Figure 9 demonstrates the distribution of meteorological stations in Egypt. Area A, including Zafran, Bodrka, Hor Al Qaeda, and Ras Banas, has an annual wind speed of respectively 7.3, 7.2, 4.4, and 5.5 m/s at a height of 10 m. So this is a proper region for big-scale installation of turbines with a capacity of 1000 kW. Area B, including Kassir and Suez, has a moderate wind speed of respectively 4.6 and 4.4 m/s at a height of 10 m, which is suitable for installing medium-sized (150–600 kW) wind turbines and can be used to connect other resources to meet the electrical needs.

As a result, Egypt is a country rich in renewable energy sources, particularly in solar and wind energy. Of course, the operation and use of renewable energy sources depends on political developments in Egypt with the consideration of sustainable development.

2.4 Lebanon

Lebanon is almost dependent on imports of fossil fuels to meet its energy needs. However, Lebanon is rich in solar radiation because it has nearly 300 sunny days per year. This leads to an average solar radiation of about 4.8 kWh/m^2 [40,41]. The solar water heating systems (SWH) has only included about 3% of home water heaters installed in Lebanon [42]. Most of the Lebanese homes are surely equipped with an electrical water heater. Table 5 tabulates the percentage distribution of the household water heater. Clearly, the dependence on production hot water with electrical heaters has imposed unstable electrical power on power lines of Lebanon [43,44].

Hydropower has been introduced in Lebanon for a long time and various units have been built for this propose. In 2009, approximately 4.5% of the electrical energy was obtained with this method. However, only 205 MW electricity generation is considered with this method because the production priority is for irrigation. Table 6 expresses the outlook of the hydroelectric power generation plans in the future in Lebanon [45–48].

With regard to wind energy, Houri [50] and Beheshti [51] have reported that the wind speed in some parts of the country, particularly the north and south, has appropriate values. The study of wind speed per month in different parts of Lebanon reflects the low average wind speed in most parts of the country [52]. Figure 10 shows the density of wind power at a height of 80 m in coastal and offshore areas of the country.

Finally, it should be noted that Lebanon is a country dependent on oil imports to meet its energy needs. To reduce the growing dependence on energy, to reduce environmental pollution, and to increase energy efficiency, renewable energies should be adopted and be certified in the field of electricity production and consumption [53].

2.5 Iran

Although with enormous opportunities for value creation from the deployment of large-scale solar and wind energy in this region, Iran's energy is dominated by hydrocarbons. Huge reserves of natural gas and oil have caused about 98% of Iran's total energy demand to be supplied by fossil

Table 4 Overview of Kuraymat Integrated Solar Combined Cycle Power Plant (ISCC)

Kuraymat Integrated Solar Combined Cycle Power Plant		Description
Background	Technology	Parabolic trough
	Status	Under commissioning
	Country	Egypt
	City	Al Kuraymat
	Lat/Long location	29.16 degrees north and 31.15 degrees east
	Electricity generation	34000 MWh/a (expected)
	Company	New and Renewable Energy Authority (NREA)
	Explanation:	expected generation is based on solar fraction of anticipated total generation of 852000 MWhy/a.
Construction	Break ground	January 1, 2009
	Start production	December 30, 2010
	Developer	NREA
Plant configuration	Solar-field aperture area	131.000 m^2
Power block	Turbine capacity (Gross)	150.0 MW
	Turbine capacity (Net)	150.0 MW
	Output type	Steam Rankine
Project data	Project name	Kuraymat ISCC power plant
	Plant location	Al Kuraymat Egypt
	Customer	Iberinoo S.A.U Bilbao
	End user	New and renewable energy authority
	Year of operation	2011
Gas turbine	Number of units	1
	Type: GE	Frame 6FA
	Fuel	Natural gas
Heat recovery steam generator	Number of units	1
	Type	Modular HRSG (hybrid)
	Pressure levels	2
	Special feature	Solar heat as energy source
Steam	Steam flow/($kg \cdot s^{-1}$)	69.4
	Steam pressure/bara	95
	Steam temperature/°C	500–560

fuels. The 2% remaining of the hydropower, nuclear, biofuel, and other energies are included in renewable sources [54]. Figure 11 exhibits Iran's total primary energy consumption in 2014 [55].

Studies have shown that there are at least 26 regions across the country for the construction of the wind power generators, which produce about 6500 MW of power generation capacity [56], but at the end of 2014, these generators had just a production capacity of 118 MW although it is about 18% more in comparison to that of 2013 [57]. Out of the electricity producers from 11 wind farms, 7 are located in the region of Gilan, Manjil [57]. More than 90% of Iran's land averagely have more than 280 days of sunshine annually, which have an amount of solar radiation higher than the global mean (1800–2200 kWh/m^2 per year). Therefore, obviously Iran has a high solar energy potential [58]. The amount of electricity produced by Iran PV sites has contributed slightly to the total produced electricity in recent years [59]. Figure 12 shows the PV capacity in Iran.

The largest solar thermal power plant in Iran has been installed in Shiraz, which now has a capacity of 250 kW of electrical energy [60].

More electricity generated from renewable sources of energy in Iran is from hydropower, which is due to the proper geographical position of Iran. A capacity of 10000 MW of electricity has been generated with hydropower. Therefore, it can be included that about 6% of

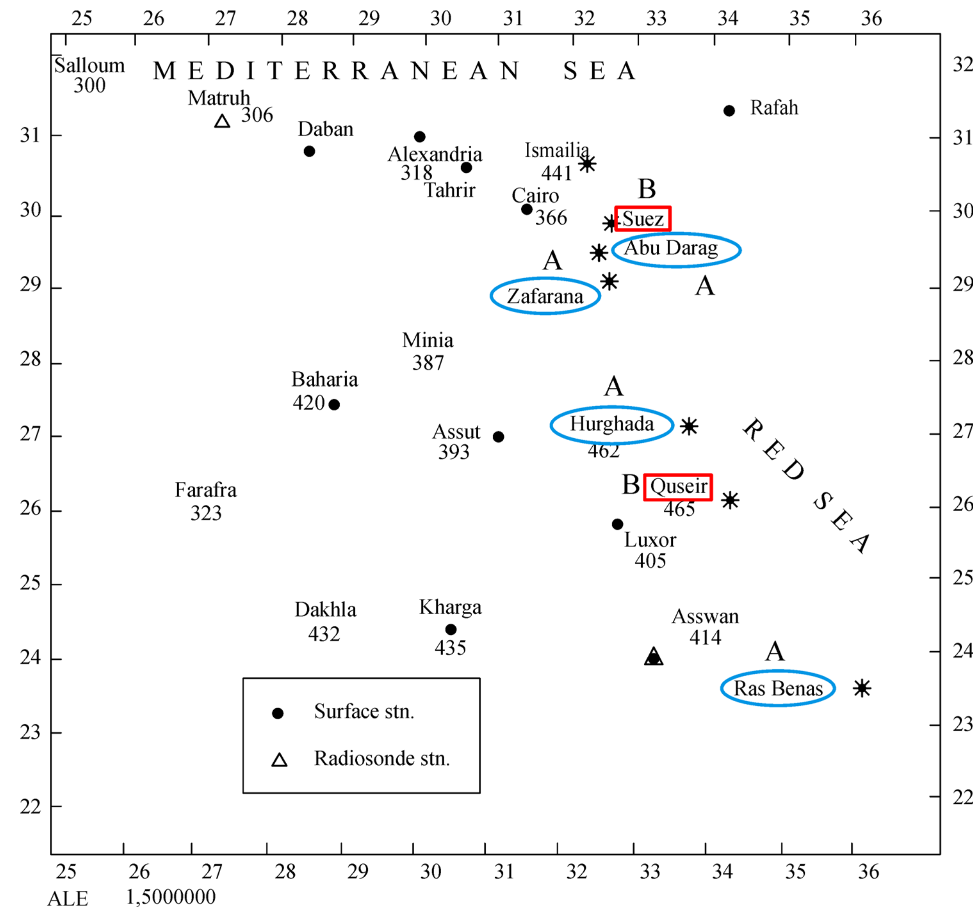


Fig. 9 Distribution of meteorological stations in Egypt

Table 5 Distribution of water heater by type

Electric/%	Gas/%	Oil/%	Wood/%	Solar/%
60	8 (+ wood)	31	8(+ gas)	1
82	125 (+ oil and wood)	152 (+ gas and wood)	152 (+ gas and oil)	28
70	10	10	5	1
70	5 (+ wood and solar)	25	5 (+ gas and solar)	5 (+ gas and wood)
75	22 (+ oil and wood)	22 (+ gas and wood)	22 (+ gas and wood)	3

the electricity is produced from this source. As a result, Iran ranks the 30th globally in the use of renewable energies [61].

2.6 Turkey

In Turkey, more than 35% of the electrical energy comes from natural gas. Therefore, this country has been heavily depended on gas which is mainly imported from Russia. According to Turkish government approval, electricity generation will be doubled from 2013 to 2023. This policy should have persuaded the Turkish authority to reduce dependence on gas. The result of this strategy will be an investment in clean energy. Now, more than 30% of electricity is produced from renewable sources that are mainly in the field of hydropower [62]. Figure 13 illustrates electricity generations by type in Turkey in 2015 [63].

In 2014, 1352 MW of power generation have been added to the hydropower capacity of Turkey, which is the fourth largest in the world. Including this new capacity, a total capacity of 23661 MW of power generation has been increased in Turkey [60]. Theoretically, Turkey has the capability of power generation up to the capacity of 88GW through wind energy [64]. In recent years, by greater investment in this field, Turkey has obtained the position in

Table 6 Future hydropower plants [49]

River	Plant	Capacity/MW	Conditioned to dam erection
Litani	Bisri	6	No
	Khardah	20	Yes
Safa	Zibli	45	No
	Richmaya	45	No
	Damour	45	No
Ibrahim	Hneidi	20	No
	Jannah	40	Yes
Assi	Yammouneh	10	Yes
	Hermel	50	Yes
Bared	Boumoussa	12	No
	Hamra	16	No
	Kasim	5	No
	Kottine	175	No
Abu Ali	Bchenine	4	No

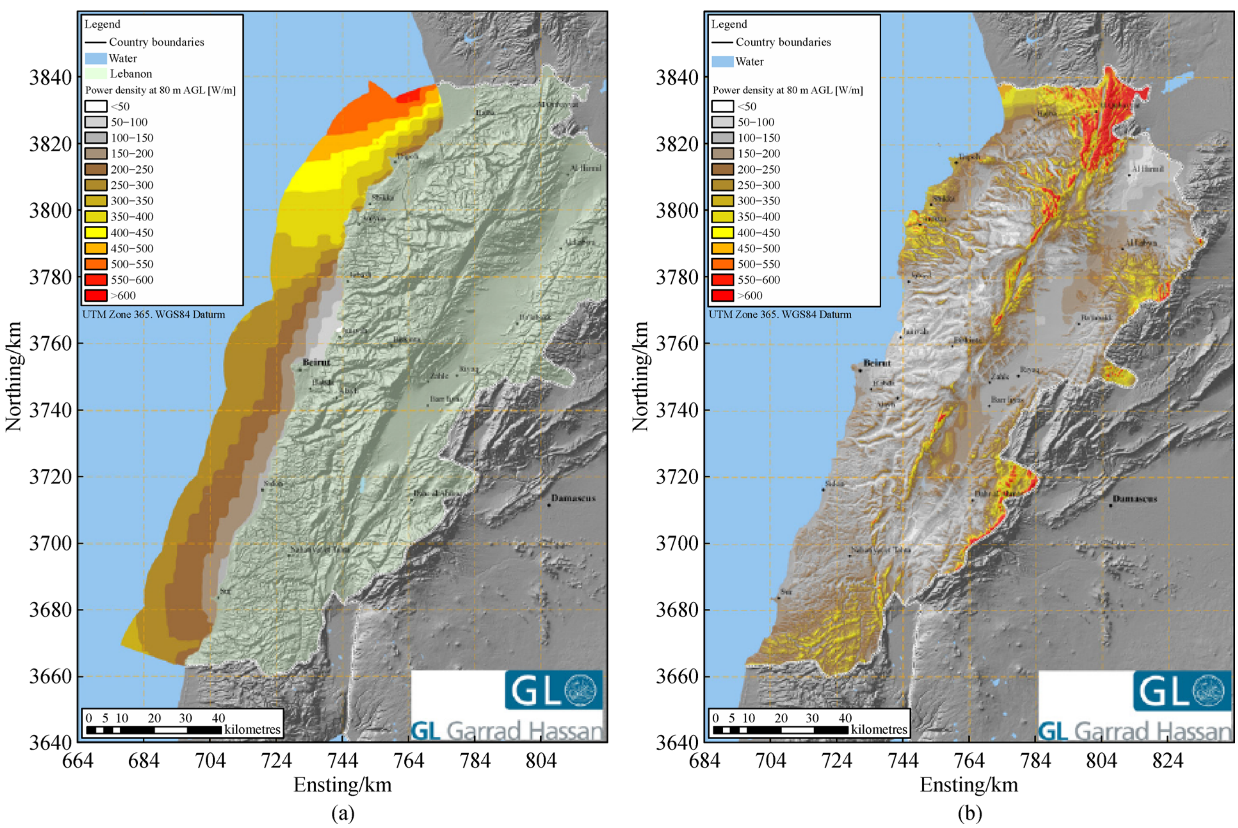


Fig. 10 Density of wind power in Lebanon
(a) Offshore wind power density map of the region lying up to 20 km from the coast of Lebanon at 80 m above the ground; (b) wind power density map of Lebanon at 80 m above the ground [52]

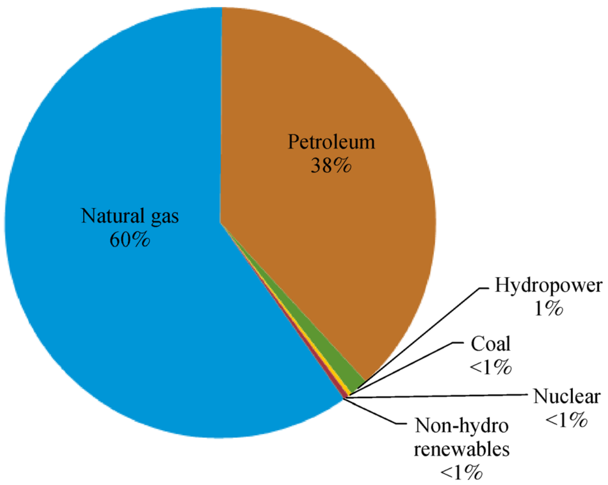


Fig. 11 Iran's total primary energy consumption in 2014

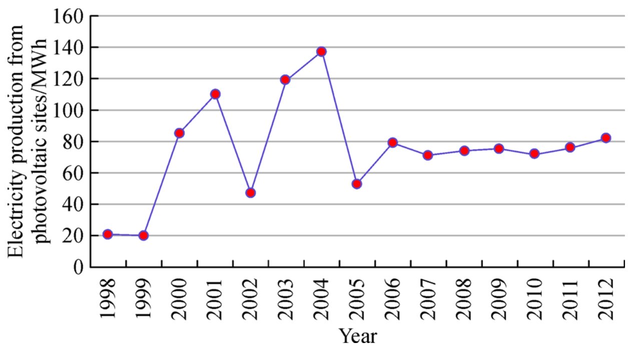


Fig. 12 Total solar electric generation in Iran from 1998 to 2012

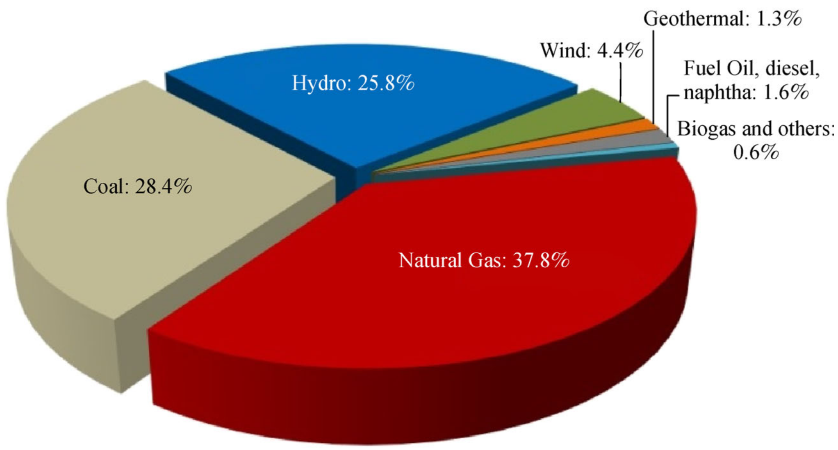


Fig. 13 Electricity generations by type in Turkey in 2015

the top ten countries in the world in terms of new capacity in the field of energy [65]. The growth of wind energy in this country seriously started in 2006 and remain increasing up to now [66]. Figure 14 shows the growth of electricity production by wind in Turkey from 1998 to 2015.

Turkey also has a good potential for using solar energy. An average solar radiation of 3.6 kWh/m^2 per day has been confirmed. But the share of solar energy in electricity production in this country is still negligible.

In 2013, the power generating capacity in this field was just 8.5 MW. However, according to reports, this amount will reach 3 GW in 2019 [64]. One of the capabilities of Turkey in clean energy is geothermal energy. As far as the receiving power, the direct heat of solar energy, and investment affairs are concerned, Turkey is considered as one of the superior countries in the world. Adding 107 MW to power generation capacity in 2014, Turkey has acquired the second place in global ranking. In direct heat field, Turkey has acquired 12.2 TWh energy and has taken the second place after China. Other countries except for Iran, Turkey, Iraq, Egypt, the UAE, the KAS, and Lebanon which have been briefly reviewed in this paper in the field of renewable energies, countries such as Yemen and Oman in the Middle East could be the ones in this region that have very a high potential for clean and renewable energies. Besides, the potential of countries such as Qatar, Bahrain, Jordan and Kuwait should not be overlooked for installation of solar panels, wind turbines, and hydroelectric equipment [67].

3 Discussion

This paper investigated the potential of using renewable energy sources in the Middle East. It also discussed the rising energy demand and eventually introduced several countries in the Middle East who have high potentials in

- End 1998: 9 MW (–%)
- End 1999: 9 MW (–%)
- End 2000: 19 MW (+111.2%)
- End 2001: 19 MW (–%)
- End 2002: 19 MW (–%)
- End 2003: 21 MW (+10.6%)
- End 2004: 21 MW (–%)
- End 2005: 20 MW (–4.7%)
- End 2006: 65 MW (+225%)
- End 2007: 207 MW (+218.5%)
- End 2008: 333 MW (+60.9%)
- End 2009: 801 MW (+140.6%)
- End 2010: 1329 MW (+66%)
- End 2011: 1799 MW (+35.4%)
- End 2012: 2312 MW (+28.6%)
- End 2013: 2959 MW (+28%)
- End 2014: 3763 MW (+27.2%)
- End 2015: 4718 MW (+25.4%)

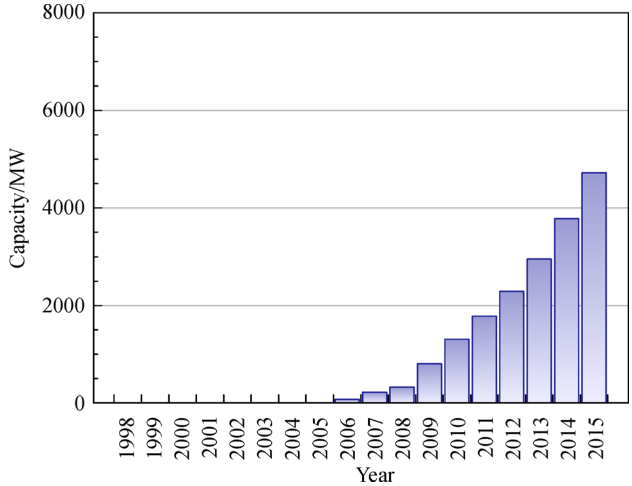


Fig. 14 Growth of electricity production by wind in Turkey

the use of their renewable sources for energy production. Due to the climate conditions in this region, particularly due to the use of solar and the wind energy, and with regard to the existence of rivers, lakes, and dams, it is strongly recommended that special attention be paid to the use of renewable sources of energy to overcome the energy crisis and unemployment in the Middle East. Of course, using renewable resources is in the prospect of most of the countries of this region and it is depended on investment of governmental and private organizations which are moving forward at different rates. To confront with the energy crisis in this region, a long-term planning should be applied as the main duty of the governments against the deficiency of fossil fuels. The Middle East, as a major fossil fuel supplying center, is always considered as an important region in the world. The potential of energy production of renewable sources and clean energies can make this region remarkable among the various regions of the world as another aspect once again.

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