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Original Article

Solar Energy Development: Study Cases in Iran and Malaysia

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Abstract *- Solar energy is one of the most important renewable energy sources worldwide. The solar cell is the device that converts solar radiation into electrical energy through the photovoltaic effect. The main objective of this work is to report the development of solar energy in Iran and Malaysia. Malaysia and Iran were situated north of the equator and showed very high temperatures and a rainy environment. These countries receive from average to high solar radiation throughout the year. Research findings showed that several solar power plants (the solar panel was made using thin film materials and crystalline silicon) were built and successfully delivered electricity to end users. Researchers also highlight that the government should give several policies and initiatives to increase the number of solar power plants and installation of solar panels in these countries.*

Keywords **-** *Solar energy, Solar radiation, Renewable energy, Energy sources.*

1. Introduction

Energy sources could be divided into two groups: renewable and non-renewable (figure 1). The advantages and disadvantages of solar, hydropower, biomass, wind and geothermal were highlighted in Table 1. The solar cell is the device that converts solar radiation into electrical energy via the photovoltaic effect [1]. When sunlight falls on the solar cell, the sunlight transfers heat energy [2], and electrons freely start moving in a semiconductor material, finally producing electric current [3]. Solar energy, due to its high potential, is one of the most important renewable energy sources and is widely spread worldwide [4]. It is a good way to provide energy regarding environmental compatibility [5] and sustainable development [6]. Solar energy has several applications, including solar ventilation systems [7], solar water heating [8], solar lighting [9] and portable power supplies.

This work reported the development of solar energy in Iran and Malaysia. Several aspects such as solar energy development, policies, strategies and challenges were highlighted. Lastly, a solar power plant project and a literature review related to solar energy were reported.

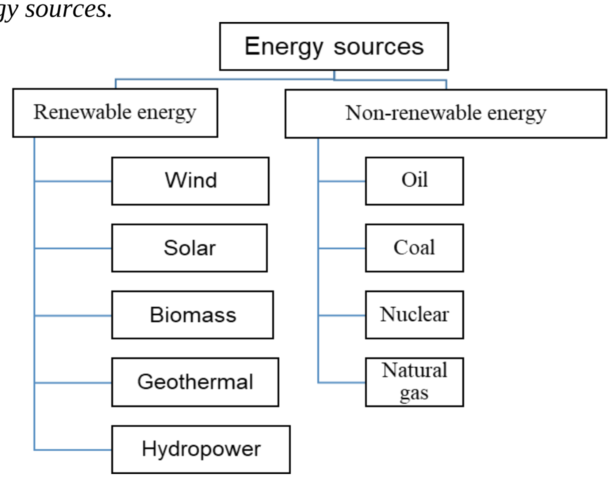

Fig. 1 Examples of non-renewable resources and renewable resources

Table 1. Advantages and disadvantages of renewable resources

	Advantages	Disadvantages
Solar	Pollution-free and reduced electricity bill	No solar power on cloudy days and night
Wind	Wind energy – low operating expenses	Wind turbines – expensive to install Wind blades – safety concern
Biomass	Clean sources of energy and biomass energy could be stored	Required more land and sustainable management

Geothermal	High efficiency with minimal maintenance	Location restricted and very high costs
Hydropower	Green energy sources and low level of pollution	Destruction of habitats and water quality degradation

2. Current status of solar energy development

With 300 sunny days a year, Iran is one of the countries with high and rich potential in the field of solar energy [10]. Central, southern, eastern, and southeastern regions of Iran (Zahedan, Kerman, Yazd, and Khorasan provinces) showed high solar radiation throughout the year, and solar panel installation could be invested in these areas [11]. Solar radiation in hot and dry weather in the central part of Iran is recorded at 3200 hours of solar radiation per year [12]. As reported by researchers, the average daily sunlight, especially in the central regions [13,14], is about 5.5 to 8.5 kWh/m^2. On the other hand, the average daily solar radiation potentials in the south and north of Iran [15] are 5.4 kWh/m^2 and 2.8 kWh/m^2, respectively. Solar energy reached the highest growth rate (43%) if compared to wind energy (25.1%) and biogas (15.4%) [16,17]. Ministry of Energy has announced that the biomass, solar, geothermal and wind energy rates were IRR 6930, IRR 8918, and IRR 7644, respectively, for power plants [18] which produced less than 10 MW in 2021. The potential of different types of renewable energy sources is shown in Table 2. Solar energy achieved the largest contributor to electricity generation (86198 MW) in Iran, ahead of hydropower (26000 MW) and wind energy (18000 MW). Figure 2 shows the potential of electricity generation by photovoltaic systems. As seen in figure 2, some regions (especially the southern region) receive very high solar radiation throughout the year, causing more electricity to be produced in the solar energy plant.

Malaysia is situated near the equatorial zone. The large-scale solar project could be carried out in Malaysia because the average solar radiation was about 400 to 600 MJ/m^2 per month [21]. Figure 3 shows the photovoltaic power potential in Malaysia [22]. Kota Kinabalu (1900 kWh/m^2), Bayan Lepas (1809 kWh/m^2), George Town (1785 kWh/m^2) and Taiing (1768 kWh/m^2) showed the highest solar radiation compared to other cities in Malaysia. Several agencies, such as Malaysia Energy Centre, Tenaga Nasional Berhad (TNB), and Sustainable Energy Development Authority Malaysia, have contributed to solar energy development [23]. Based on Table 3, the installed capacity of solar energy has increased to 1493 MW (in 2020) if compared to 166 MW (in 2014), indicating the solar market has grown significantly because of supportive government policies and initiatives at various end-user segments.

On the other hand, photovoltaic manufacturers (local and international companies) also play an important role in developing solar energy. In 2014, Malaysia accounted for the third biggest manufacturer of photovoltaic equipment around the globe. Several international companies were located in Malaysia, as highlighted in Table 4, due to some reasons such as supportive banking loans, fair regulation, good tax breaks, competitive labor costs, and excellent infrastructure and facilities.

Table 2. The potential of different types of renewable energy sources in Iran [19]

Renewable Energy	Potential (MW)
Solar energy	86198
Hydropower	26000
Wind energy	18000
Geothermal energy	187.0
Biomass and biogas	19.04

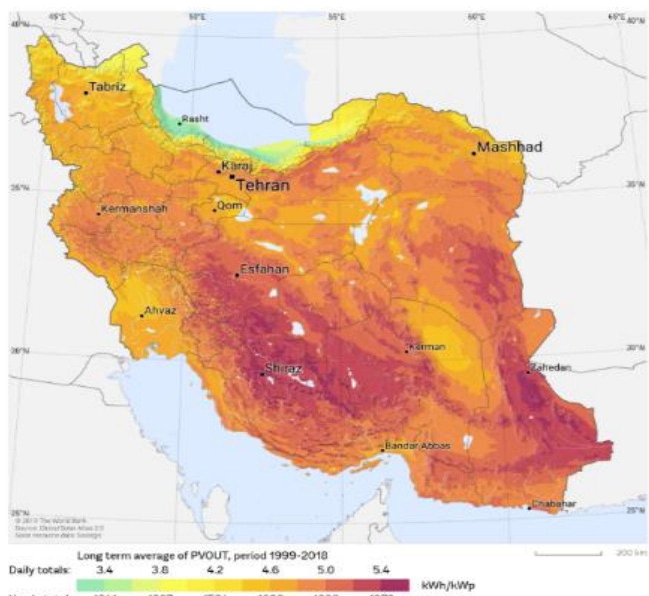

Fig. 2 The potential of electricity generation by photovoltaics systems in Iran [20]

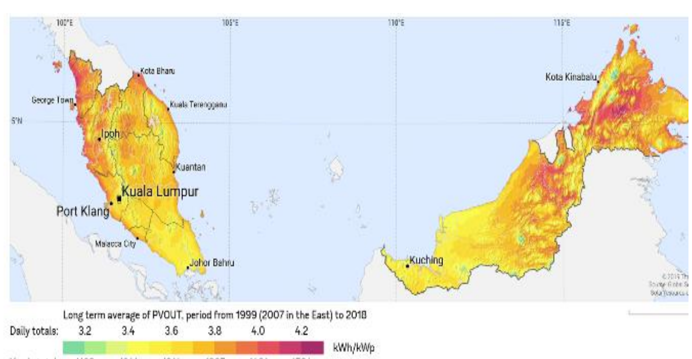

Fig. 3 Photovoltaic power potential in Malaysia [22]

Table 3. Total solar energy installed capacity (megawatts) in Malaysia [24]

Year	Installed capacity (MW)
2014	166
2015	229
2016	279
2017	370
2018	536
2019	882
2020	1493

Table 4. The photovoltaics companies in Malaysia [25]

Company name	Description
Malaysian companies	
TS Solartech	• It was located in Penang Science Park. • This company has 7 production lines, a capacity of about 500 MW (solar cells)
Foreign companies	
First Solar	• It was located in Kulim Hi-Tech Park • This company has 24 production lines, a capacity of about 2000 MW (solar cells)
JA Solar	• It was located in Penang. • Its capacity is about 400 MW (solar cells)
Jinko Solar	• It was located in Penang • This company has 7 production lines, and its capacity is about 500 MW (solar cells)
Panasonic Energy Malaysia	• It was located in Kulim Hi-Tech Park • Its capacity is about 300 MW
Q-cells Malaysia	• It was located in Cyberjaya • It has 4 production lines and a capacity of about 1100 MW (solar cells)
SunPower	• It was located in Malacca • 28 production lines could be observed, and its capacity was about 1400 MW (solar cells)
LONGi Solar	• It was located in Kuching, Sarawak • Its capacity is about 600 MW

3. Policies and strategies

In terms of strategy policies, a 20-year contract Feed-in-Tariff has been offered by the Iranian Ministry of Energy for renewable energy to the final consumer [26]. Under National Renewable Energy Development Policy [27], the minister accounted for all renewable energy issues, including the development and planning process [28]. Iran's main policy in renewable energy is that the contract for purchasing electricity is guaranteed. The fifth and sixth five-year development plans of the Iranian government state that 77000 m^2 of solar power plants built in Iran up to 1000 MW per year are to be added to the solar power generation capacity [29]. But, this goal has not been achieved due to the existing challenges [30]. The construction of 134 power plants has been one of the effects of the Ministry of Energy's policies on renewable energy in recent years [31]. The private sector's share in electricity production increased successfully in 2015 (8.71 MW) compared to 2018 (300.86 MW), which is the result of adopting the policies of the Ministry of Energy of the Iranian government [32]. The SATBA (Iranian renewable energy and electricity efficiency organization) has 78 power plants in Iran. The construction of these power plants has increased government tax revenues [33] and created jobs and revenue for renewable energy businesses [34].

In Malaysia, several programs such as feed-in tariff, net energy metering, peer-to-peer, large-scale solar, Malaysia's National Renewable Energy Policy and Action Plan were discussed under strategies and policies. Feed in tariff is a tool to promote investment in renewable energy [35]. It means that distribution licensees will buy the electricity produced from Feed-in users at home for a specific duration. For example, all the new approved FiT applications will be paid the FiT for 21 years for renewable energy production [36]. The Net energy metering 1.0 program was introduced in 2016. It allows customers to offset some or all energy produced by their solar system at the utility rate [37]. It means that the consumer offsets the photovoltaic system's energy with a cost of MYR 0.50/kWh [38], and then any excess is exported to the utility grid with the selling cost of MYR 0.31/kWh [39]. Customers need to buy a bidirectional meter that spins in both directions. Clockwise and opposite directions represented customer exports energy to the utility and consumed power from the utility, respectively [40]. Since 2019, the sale of excess power to the grid could be carried out via a program called "Net energy metering 2.0". As a result, more and more customers were registered to install a solar plant (up to 500MW) on the rooftop [41]. Every kWh exported to the grid is compensated from the next electricity bill with the value of kWh [42].

The Net Energy Metering program was introduced in 2020 and encourage consumers to install a photovoltaic system on the roof to save on electricity bill. This program will be effective from 2021 to 2023, and the total quota allocation of 500MW. This program could create many new jobs and indirect connections to the grid [43]. Under Malaysia's National Renewable Energy Policy and Action Plan, the renewable energy targets [44] were 1% in 2011, 6% in 2015, 10% in 2020, 13% in 2030, 24% in 2040. Another program was called large-scale solar. It is a solar plant project and could be applied via competitive bidding to reduce energy costs [45]. The energy commission and large-scale solar plant were the agency for this policy. Large-scale solar must have a 30 MWac capacity to be connected to the transmission network [46]. Reduction of carbon emissions was achieved, and a great return on investment could be observed in this scheme. Perlis obtained 87% or 3996 MW in the first and second rounds of the LSS project because it received the highest solar irradiance compared to other states. The peer-to-peer program is a business model (virtual market) designed on an interconnected platform [47]. Consumers can buy electricity directly from the producer without needing a middle party to handle the transaction [48]. Under these activities, the government expects to improve solar cell efficiency, increase the number of solar power plants and install solar panels at home in Malaysia.

4. Literature review

Afrouzy and co-workers [49] analyzed a new integrated structure for liquefied natural gas production. They successfully installed a solar panel in Chabahar and the specific energy consumption improved by 0.2293 kWh/kg.LNG. Some scientists, such as Edalati et al. [50] and Gorjian et al. [51], concluded that several factors, such as technology conditions, bad weather conditions, and the unclear roadmap were the most important obstacles to the development of photovoltaic systems. Najafi and co-workers [13] highlighted that 9 million MWh of energy could be produced daily. However, only 10% efficiency of the system harnesses solar energy. Dehghani and co-workers [52] analyzed some solar plants indicated in Iran. They found that monocrystalline and polycrystalline solar panels were successfully installed in different locations such as Yazd, Razavi Khorasan and Shiraz province in Table 5. Payam and co-workers [53] revealed that Iran's land management was another big issue. They pointed out that Iran's barren fields and lands cover 60% of Iran's area, which has a reasonable amount of sunlight. Based on Table 6, we can observe that research can develop the solar industry, reduce solar energy production costs and mitigate climate change.

Table 5. The photovoltaic system manufacturer in Iran [52]

Company name	Description
Hedayat Noor Solar Energy	• It is situated in Yazd province. • This company produced monocrystalline and polycrystalline panels • Several projects were completed, such as 45 kW, 50 kW and 20 kW in Taleghan, Kish and Yazd.
Solar Sanat Firouzeh	• It is located in Razavi Khorasan. • This company produced monocrystalline and polycrystalline panels • Solar power plant projects were built in rural and regional areas.
Pak Atieh	• It is located in Razavi Khorasan. • This company produced monocrystalline, mini solar panels and polycrystalline panels. • Several projects were completed, such as 540 kW, 130 kW, 220 kW, 137.5 kW and 50 kW in Mashhad, Khorasan regional, south of Khorasanr Razavi, Yazd and Fars.
Taban Energy	• It is situated in Shiraz. • This company produced monocrystalline and polycrystalline panels • Annual production capacity reached 130 MW.

Table 6. Recent solar energy research and development in Iran

Researcher(s)	Experimental results
Hadi and co-workers	• More energy could be absolved by using phase change materials such as $NaNO_3$, KNO_3 and H250. • Zahedan City received the highest solar fraction (68.%) compared to other cities [54].
Sadat and co-workers	• Dust particles comprised aluminium oxide, calcium oxide and silicon oxide [55]. • Experimental results showed dust deposition could reduce the output power of solar cells (by 98.13%) by increasing the dust thickness (0.001 to 0.033 g/cm^2).
Bahareh and co-workers	• Several barriers could be classified as technical, institutional, political & regulatory, economic & financial and social, and cultural & behavioural [56]. • Government and policymakers should pay more attention to fostering the adoption of solar energy technology
Maryam and co-workers	• The researcher concluded that minimize the number of policy documents leads to the

	success of solar energy [57] • Solar energy technology could be carried out nationally and on an urban scale.
Mahya and co-workers	• It is noted that the success of solar energy relied on policy stabilization, the attraction of foreign capital and long-term technology acquisition programs [58].
Shahsavari and co-workers	• There, 180 million tons of carbon dioxide gas will be released from fossil-fueled power plants [59]. • Solar energy could reduce greenhouse emissions; each kilowatt per hour can save 715g of carbon dioxide.
Madvar and co-workers	• Based on the triple helix approach, the industrial sector, government, and institutions play a very important role in solar energy development [60].
Mostafa and co-workers	• The solar density in Jask was 2255.7 kWh/m^2.year [61]. • A photovoltaic system was built, and the efficiency values range from 14.4% to 21.16%.
Dehghan	• The solar power plant supplied electricity (12kW off-grid system) to Dorbid village in Yazd Province [62]. • The gas-steam-solar power plant, located in the Middle East, Yazd province, has a capacity of 467 MW.
Hiva and co-workers	• Principal solar cell technology issues include a lack of a sustainable road map and technical gaps [63]. • The main barriers in the solar electricity sector include the financing and licensing process complexity.
Lari and co-workers	• Integrating solar combined cycle systems (ISCCS) and standalone solar electricity generating systems were investigated. • The electricity output
	successfully increased by 39 MWe at high daytime temperatures, high insolation coincident by using ISCC [64].
Mehdi and co-workers	• The researcher pointed out that generating electricity without consuming water in Iran is due to suffering from a severe shortage of water sources [65]. • Findings revealed that the price of $0.75/kWh from solar-diesel generator battery is located in Darab station.
Ghaemi and co-workers	• Strengths, weaknesses, opportunities and threats (SWOT) and DEMATEL were used to study the development of solar energy technology [66]. • Several factors caused the underdevelopment of this technology, such as lack of effective policies, motives for entering the private sector and lack of understanding of the necessity of renewable energy development.
Hossin and Ali	• Thermal will be supplied to the smart building via a heat pump (produced electricity through solar energy). • Research findings showed average investment costs of 6453, 8125 and 7007 in Zahedan, Tehran and Tabriz, respectively [67]. • It was observed that Zahedan and Tehran need a photovoltaic array with nominal power of 1343 and 1989, respectively.
Mehdi and co-workers	• The average monthly mean daily solar irradiance was found to be 5.92 $kWh/m^2/day$ and 0.54 $kWh/m^2/day$ by using Guilan Meteorological and EU PVGIS, respectively [68]. • Guilan can use a photovoltaic pumping system in a rice paddy ($5000m^2$) due to the mean monthly clearness index

	being 0.54 to 057 during the irrigation period.
Majid and co-workers	• Researchers have reported various models were used to predict monthly mean diffuse solar radiation in Isfahan [69]. • Research findings confirmed that the best performance could be reached via sunshine duration compared to other models.
Amir and co-workers	• Predicting monthly, hourly and daily diffuse solar radiation as carried out • The yearly average diffuse fraction of solar radiation was 12.4, 9.04, 7.65, 8.99 and 9.93 in Bandarabbas Kermanshah, Mashhad, Tabriz and Zahedan, respectively [70].
Seyed and co-workers	• Solar energy technologies reached stable revenues because of establishing strong relationships with targeted customers and government-supportive actions [71]. • This project was carried out based on interviews and questionnaires (experts in renewable energy fields).
Yousefi and co-workers	• A fuzzy logic model was used to identify the suitable site for the solar power plant in Markazi. • Based on the Boolean-Fuzzy integration, the best place was observed on the border between Saveh and Zarandieh [72].
Jahangiri and co-workers	• Wind solar system has the highest capacity (38818 kWh/y) if compared to biomass (14612 kWh/y) in Sarakhiyeh, Khuzestan [73]. • The solar cell/diesel generator system indicated the lowest cost ($0.561) than diesel alone ($0.802) and wind turbine/diesel generator ($0.833).
Saman and co-workers	• The particle swarm optimization (PSO) and decision tree were used to identify the best location for a solar power plant [74]. • The decision tree (0.29) could be the highest prediction rate compared to PSO (0.13).
Khalil	• Small-scale solar systems (1,5 and 10 kW) could be designed on optimum fixed tilt angles in 15 selected cities because of the temperature changes [75]. • The financial assessment included the rate of return, the present worth of benefit, Levelized cost of energy and the present worth of cost.
Ali and co-workers	• The solar energy potential for free trade and industrial zones in Kish, Chabahar and Salafchegan was studied [76]. • Research findings revealed that semi-yearly tilt angles of south-facing solar collector adjustment were suggested (two periods of cold and warm).
Fathi and co-workers	• The sunny hours were found at 700 h, 1050 h, 830 h and 500 h in spring, summer, autumn, and winter, respectively [77]. • Electricity production supply was observed in Semnan (20000-83300 kWh), Taleghan (10000-45000 kWh), and Yazd (8900-18000 kWh) from 2004 to 2013.

In Malaysia, researchers have highlighted that solar panels have been installed in the home to save electricity bills successfully. The airport-based solar plant was done in Kuantan Airport, Malaysia, which covered a 0.2677 km2 area. The solar plant was made from 57143 crystalline silicon photovoltaic modules and can produce 26304 MWh annually. This plant consisted of 40 inverters and 20 transformers [78]---54]. The photovoltaic plant was built at the University Malaysia Pahang Pekan campus and the University Malaysia Pahang Gambang campus in Malaysia. The Yingli Solar panel (crystalline silicon) was chosen for this project. Under this project, 1390 Megawatt hours of energy could be generated [79]--55] and successfully saved about 173318 tCo2 (carbon dioxide gas) in a lifetime. The use of solar energy in Sarawak was also highlighted. Based on the research findings, solar energy contributed to 25% of energy demand because Sarawak has four hours of average sunshine per day [80]--56]. Solar panel made with cadmium telluride (1370k Wh) showed the highest energy output produced if compared to crystalline silicon (1220k Wh) and copper indium selenide (1250k Wh) for the irradiation of 1710 kWh/m^2. Many scientists have studied solar energy technology, incentive and the role of renewable energy sources. Research findings, observations and conclusions are described in Table 7.

Table 7. Recent solar energy research and development in Malaysia

Researcher(s)	Experimental results
Salleh and co-workers	• The grid photovoltaic electric boat charging station was built in Kuala Terengganu to achieve green technology in the commercial sector. • Research findings showed the payback period, and net present cost were 8.2 years and RM 759098, respectively [81].
Johari and co-workers	• Energy consumption is increasing to support tourism, industry, population growth and urbanization. • They highlight solar radiation intensity, feed-in-tariff, and the role of renewable energy sources [82].
Ayu and co-workers	• Average minimum solar radiation was increased from 1982 (3.07 kWh/m^2), 1992 (3.373 kWh/m^2) to 2006 (4.21 kWh/m^2), indicating solar radiation for most areas was found to be increased. • The highest solar radiation in Northern and East Malaysia could be observed annually [83].
Gomesh and co-workers	• Malaysians accept solar energy technology; They are ready for any policies that could enhance the use of solar energy in Malaysia [84].
Maricar and co-workers	• It was observed that solar cell technology could increase its local energy utilization index due to effective and reliable energy technology [85].
Solangi and co-workers	• Solar energy can be considered as environmental friendly electricity generation. • The highest average daily radiation was 6.8 kWh/m^2 in November and August [86].
Tamer and co-workers	• The accurate artificial neural network (ANN) models, such as mean absolute percentage error of 5.3% and diffuse solar energy of 1.53%, could be used to predict solar energy in Malaysia [87].
Lau and co-workers	• Feed-in tariffs could be introduced in the higher photovoltaic array (costs up to $2320/kW). • The grid-connected photovoltaic installation is very suitable for low arrays [88] due to the production cost ($1120/kW or lower).
Mekhilef and co-workers	• Large allocation was handled by the 9th Malaysia Plan, which provides support for solar power installations [89]. • Malaysian Building Integrated Photovoltaic project was implemented from 25th July 2005 until 2010.
and co-workers	• Green Technology Financing Scheme was implemented for individuals (soft loan scheme with interest rate is 5% or less) and companies (financial sources). • The feed-In-Tariff scheme can enhance the installation of solar cells in rural and urban areas [90].
Solangi and co-workers	• Survey results indicated that 80% of the respondents could accept solar energy and incentives can attract solar energy usage, while 70% believe that government must lead the development of solar energy technology [91].
Firdaus and co-workers	• The experimental results showed that Malaysians' awareness levels are low, and they were unwilling to invest (in the Feed-In-Tariff scheme) due to lower returns than investment schemes. • Research findings confirmed a higher return for solar installation in residential houses compared to the United Kingdom [92].
Hussain and	• Solar energy systems must be

co-workers	used in plantation projects and homes to replace fossil fuels in the future. • Researchers suggest they fed in tariffs and net energy metering should be implemented because these policies were applied in 80 countries [93].
Dut and co-workers	• Solar irradiance was observed to be increased with time, reached the maximum (afternoon), and finally dropped from evening to night based on the Davis Vantage Pro2 Weather station. • The lowest solar energy (0.4215 MJ/m^2) was observed in June compared to other months in Perlis [94].
Syafawati and co-workers	• Ulu Pauh was located in Perlis (6.462 °N, 100.351 °E) and received sunlight on average 12 hours per day [95].
Aghaei and co-workers	• Electrical power generation (solar energy) will be built in Pulau Perhentian Besar Island. • The highest irradiation rate could be observed in February and March, while the minimum irradiation rate was in November and December. • In this project, solar energy contributed to 100% of the building in zero-energy buildings design. • The clearness index values range from 0.488-0.567 from January to December [96].
Mohd and co-workers	• Highlight RM 469 million for the rural electrification program in the 7th Malaysia Plan [97].
Vaka and co-workers	• In 2020, the government opened a tender for a 1400 MW solar power project • Malaysia spent US$ 2.9 billion to install rooftop solar panels, LED street lights and new grids [98].
Shing and co-workers	• MBIPV, government institutions, incentives and foreign investments encourage solar cell development [99].

5. Solar power plant projects

In Iran, Kerman showed the highest solar radiation compared to other provinces. Therefore, eight solar power plants were built in Kerman, with a total capacity successfully reaching 48.7 megawatts, which can supply clean energy to villagers. Several advantages could be observed in this plant, such as attracting foreign investors, saving natural gas (3.95 million cubic meters), reducing the consumption of water (3060 cubic meters), reduce environmental pollutants (9598 tons) annually. The Mahan Solar Power Plant is the largest solar plant in Kerman, which can produce 20 megawatts per day. This solar plant consisted of 76912 solar panels, and the construction cost was US27 million. Ten solar plants were made in Fars, with a 67.6MW cumulative production capacity. Lastly, several solar plants with a maximum capacity of 20 MW have been built in Tehran, Isfahan, Yazd, Khuzestan and Hamedan.

On the other hand, Shiraz solar power plant was located in Shiraz, Iran and started in 2008. It has a 500 kW capacity and uses a concentrating parabolic mirror to produce electricity. The Yazd solar power station was situated in Yazd, Iran. This plant used concentrating solar power to produce electricity (about 467 MW). The Nika Energy Solar Farm contained 37000 modules, was located in Fars, Iran, and spread over 20 hectares. This plant was developed by Banian Sanat Persian Holding, spent about $32.936m, and is owned by Nika Energy. It can produce a 10 MW capacity, supply energy to 2700 households, and reduce 22000 tons of carbon dioxide emission annually. A solar power plant was built in Khorasan Razavi (Ali Abad village and Khaf city) and had a 5MW capacity. It spent about 350 billion Rials and spread over 11 hectares.

Solar energy is one of Malaysia's important renewable energy resources [100---[57]. The government expects that solar energy will account for 20% of renewable energy by 2025. Therefore, many solar plants were built. The Quantum Solar Park was considered a large-scale solar plant [101---58], located in Kedah, the northern part of Malaysia. This power plant, 2019 grid-connected to produce 284 GWh annually, sold to Tenaga Nasional Berhad (sufficient to power about 93,000 households). These types of solar panels require little maintenance for a long time (about 21 years) and successfully reduce 188000 tons of carbon dioxide emissions. Another solar plant (Redsol plant) was built [102---59] and is located in Northwest Malaysia. This power plant (2020 grid-connected) can produce 67 GWh annually (21000 households powered) and reduce about 44000 tonnes of carbon dioxide annually. Tenaga Nasional Berhad and BNP Parbas contributed to this plant [103-----60]. The Sepang solar plant was operated by TNB, located in Kuala Langat, Selangor [104], and consisted of 38140 solar panels that can produce 110000MWh of energy. Also, prevented 76000 tons of carbon dioxide emissions annually.

[a] [b] [c]

Fig. 4 Solar power plant in Malaysia [a] Quantum Solar Park [b] Redsol solar plant [c] Sepang solar plant

6. Challenging issues

Reluctance to using renewable energy sources is one of the major challenges in Iran. Forough and workers [105--61] have highlighted that managers, government employees, artisans, and consumers showed little interest in renewable energy sources because of the cheaper price of fossil fuels (about 6US cents per litter). In 2016, the cost of producing 1MW was $1.5 million. However, it dropped to $600000 in 2018 [106]. There are many challenges facing investors in this field. One of the most important challenges in recent years was banking sanctions against Iran in 2018, as well as the shock of fluctuations in the USD exchange rate. Another issue is subsidies given to fossil fuels, and this causes renewable energy to be neglected [107-62]. We observed that the amount of photovoltaics installed in 2019 reached 367 MW (approximately 8.5 times more than in 2016). However, only accounted for 0.05% of total renewable energy production [108-63]. Another problem is the lack of technicians and specialists in providing post-installation services [109-64]. The large-scale use of solar energy could be challenged, such as inadequate policy-making of the Ministry of Energy, training problems and preparation of specialized experts and pointed to international financial sanctions [110-65].

In Malaysia, the big problem is purchasing land and land use change. The government will buy land (a very large area needs to be cleared) to build a large-scale solar power plant. Table 7 shows the world's eighth largest solar power plant, with a large area [111]. Also, solar panels require a huge amount of space and cause environmental impact (plants and animals can be disturbed). The construction and manufacturing process of the solar plant could produce air pollution, dust pollution, and soil erosion. In terms of commercial perspectives, developing solar energy needs very high investment values [112-66]. Investors required incentives from the Government, such as the FiT scheme, at the very beginning of the stage. Table 8 indicates the estimation for solar panel price. Most solar installers included Jinko, JA Solar, Canadian Solar, and Hanwha Q Cells [113]. Average costs are based on warranty duration, power efficiency, and manufacturer. Regarding maintenance fees, most solar panels and solar inverters have 25 to 30 years and a 5 to 10-year warranty, respectively. Generally, maintenance will be carried out every 3 to 5 years, and the charges are about RM 320, which includes a clean solar panel and tests on breakers and inverters.

Regarding technical issues, the key success criteria depend strongly on pilot projects. Table 9 exhibits some pilot projects that were implemented in Malaysia. The output obtained from these projects could be used to develop solar energy technology in future. Lastly, the power conversion efficiency of the obtained materials. Based on Table 10, average module efficiency values were 6.87%, 5.14%, 3.99% and 2.23% in monocrystalline, polycrystalline, CIS and amorphous silicon films, respectively, under Malaysian climates. The silicon was produced into the bars and cut into wafers to prepare a monocrystalline panel. The manufacturer melted many silicon fragments to produce the wafer to synthesise polycrystalline solar panels.

Table 7. The eight largest solar power plants in the world [111]

Location	Name of power plant	capacity
Sahar Desert, in Draa-Tafilalet, Morocco	Noor Complex Solar Power Plant	• It was a concentrated solar power plant; it had a capacity of 580 megawatts in 2020 and could supply 1 million people • Size area: 2500 hectares
India	Kamuthi Solar Power station	• It consists of 2.5 million solar panels, has a capacity of 648 MW, and can supply 750000 people • Size area: 2500 acres
Rosamond, California, United States	Solar Star Solar Farm	• It consists of 1.7 million solar panels and can supply 255000 homes. • Size area: 13 square kilometres
Cixi city, eastern Zhejiang, China	Longyangxia Dam Solar Park	• It produces 220-gigawatt hours and can supply 100000 houses. • Size area: 300 hectares

Kurnool district, Andhra Pradesh, India	Kurnool UltraMega	• It generates 1000 MW, it consists of 4 million solar panels • Size area: 5932.2 acres
Viesca, Coahuila, Mexico	Enel Villanueva Photovoltaic plant	• It was a solar photovoltaic power plant successfully launched in March 2018. It consists of 2.3 million solar panels and can generate more than 1,7000 GWh annually. • Size area: 2400 hectares
Datong, Shanxi, China	Datong solar power is the top runner base	• It can generate 870 million watts. • Size area: 47000 acres
Zhongwei, Ningxia, China	Tengger Desert Solar Park	• It was the world's largest solar array • Size area: 36700 km

Table 8. Estimate of the overall solar panel price in Malaysia [113]

	Number of solar panels	System	Installation area	Average cost
Terrace	20	8 kWp	45 sqm	RM 45000
Semi-detached	30	12 kWp	70 sqm	RM 60000
Bungalow	50	20 kWp	110 sqm	RM 95000

Table 9. Solar power pilot project in Malaysia

• Petronas Power Sdn Bhd completed the Rays of Hope project with other collaborators (Orang Asli Welfare Department and SOLS24/7). The main purpose was providing free energy (6W prtable micro grid solar system with LED lamps) to Orang Asli in Kampung Tibang (Perak), KampungTanjung Sepat (Selangor) and Kampung Ulu Piong (Perak). • Four community-based centres (orphanages and old folks' homes) will be supplied 10 kW solar system [114].
• TNB pilot floating solar farm project was built in ash dump pond, Sultan Azlan Shah Power Station, Manjung, Perak. • The pilot plant consisted of 288 solar panels installed at a 175 ha pond. It can produce 100 MW, supply 30 houses, and reduce 7.9 tonnes of carbon dioxide emission per month [115].
• KUB-Berjaya Enviro and Berjaya Solar Sd Bhd will produce a solar power plant (about RM 3 to RM 5 million, a capacity of 100 kW) in Bukit Tagar, Selangor [116].
• Kuala Lumpur City Hall (DBKL) has launched Wangsa Maju (section 1) Pilot Project. It was the first eco-conscious township (low carbon) in Kuala Lumpur. This project could encourage stakeholders to move to green technology and solve climate change [117].
• The solar power station was built in Kampung Denai, Rompin, Pahang. This is a rural area, and the Orang Asli Residents used candles, kerosene or generator to get electricity. This pilot consisted of a 10 kW inverter, 10kW solar panel, and 150 kWh battery. The highest capacity, about4195.35 kW, can supply electricity to home and school appliances such as television, video, small lighting unit, and radio [118].
• Polygreen PMJ, Politeknik Mersing, Johor has installed solar panel in campus. It has a capacity of 1kW, which can be used for corridor light and agricultural projects [119].

Table 10. Photovoltaic panel performance under various climate conditions [120]

Solar cell technology	Average output efficiency (%)	Performance ratio	Average module efficiency (%)
monocrystalline	30.1	0.933	6.87
polycrystalline	30.34	0.941	5.14
Copper Indium Selenide	35.31	1.094	3.99
Amorphous silicon films	33.74	1.046	2.23

7. Conclusion

Malaysia and Iran, located north of the equator, received high solar radiation throughout the year. Therefore, several solar power plants have been successfully built to generate electricity and supply it to people. However, several barriers could be identified, including technical, institutional, political & regulatory, economic & financial, social, and cultural & behavioral. Government and policymakers should pay more attention to fostering the adoption of solar energy technology. Researchers concluded that minimize the number of policy documents and maximising the incentive lead to the success of solar energy

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References

[1] Steven, G.; Joshua, W.; Rebecca, R, “Solar Energy Development Impacts Flower-Visiting Beetles and Flies in the Mojave Desert,” *Biological Conservation*, 2021. https://doi.org/10.1016/j.biocon.2021.109336, 2021.

[2] Srinivasan C, “A Study on Energy Crisis and Social Benefit of Solar Energy,” *International Journal of Environmental Science and Development*, vol. 5, pp. 404-411, 2014.

[3] Tarujyoti B, “Impact of Solar Energy in Rural Development in India,” *International Journal of Environmental Science and Development,* vol. 3, pp. 334-338, 2012.

[4] Ali, M., Marzieh, A., Alibek, I., Najafi, F, “Identifying Challenges and Barriers for the Development of Solar Energy by using the Fuzzy Best-Worst Method: A Case Study,” *Energy,* vol. 226, 2021. https://doi.org/10.1016/j.energy.2021.120355.

[5] Hoi T, “Potential for Solar Energy Development in Vietnam,” *International Journal of Environmental Science and Development,* vol. 11, pp. 358-364, 2020.

[6] Shahsavari, A., Yazdi, F., Yazdi T, “Potential of Solar Energy in Iran for Carbon Dioxide Mitigation,” *International Journal of Environmental Science and Technology,* vol. 16, pp. 507-524, 2019.

[7] Sansaniwal, S., Sharma, V., Mathur J, “Energy and Exergy Analyses of Various Typical Solar Energy Applications: A Comprehensive Review,” *Renewable and Sustainable Energy Reviews,* vol. 82, pp. 1576-1601, 2018.

[8] Minier Q, “Opportunities for Alternative Energies Deployment in Iran,” 2022. [Online]. Available: https://www.sciencespo.fr/kuwait-program/wp-content/uploads/2021/02/Quentin-MINIER-Opportunities-for-alternative-energies-deployment-in-Iran.pdf.

[9] Ghasemi, G., Younes, N., Hamed, A., Mousa, M., Mahmoud S, “Theoretical and Technical Potential Evaluation of Solar Power Generation in Iran,” *Renewable Energy*, vol. 138, pp. 1250-1261, 2019.

[10] Taghavi, M., Salarian, H., Bahram G., “Thermodynamic and Exergy Evaluation of a Novel Integrated Hydrogen Liquefaction Structure Using Liquid Air Cold Energy Recovery, Solid Oxide Fuel Cell and Photovoltaic Panels,” *Journal of Cleaner Production,* vol. 320, 2021. https://doi.org/10.1016/j.jclepro.2021.128821.

[11] Khalil G, “Assessment of Small Scale Solar PV Systems in Iran: Regions Priority, Potentials and Financial Feasibility,” *Renewable and Sustainable Energy Reviews,* vol. 94, pp. 267-274, 2018.

[12] Norouzi, N., Fani M., “The Prioritization and Feasibility Study over Renewable Technologies using Fuzzy Logic: A Case Study for Takestan Plains,” *Journal of Energy Management and Technology,* vol. 5, pp. 12-22, 2021.

[13] Najafi, G., Mamat, R., Azmi, H., Yusaf, T., Ghobadian, B., “Solar Energy in Iran: Current State and Outlook,” *Renewable and Sustainable Energy Reviews,* vol. 49, pp. 931-942, 2015.

[14] Dehghan A., “Status and Potentials of Renewable Energies in Yazd Province Iran,” *Renewable and Sustainable Energy Reviews,* vol. 15, pp. 1491-1496, 2011.

[15] Hosseini, S., Amin, M., Mazlan, A., Bagheri G., “A Review on Green Energy Potentials in Iran,” *Renewable and Sustainable Energy Reviews,* vol. 27, pp. 533-545, 2013.

[16] Fathi, S., Arash M., “A Review of Renewable and Sustainable Energy Potential and Assessment of Solar Projects in Iran,” *Journal of Clean Energy Technologies*, vol. 5, pp. 126-130, 2017.

[17] Aien M., Omid M., “On the Way of Policy Making to Reduce the Reliance of Fossil Fuels: Case Study of Iran,” *Sustainability,* vol. 12, 2020. https://doi.org/10.3390/su122410606.

[18] Solaymani S., “A Review on Energy and Renewable Energy Policies in Iran,” *Sustainability*, vol. 13, 2021. https://doi.org/10.3390/su13137328.

[19] Rezaei, R., Marjan G., “Rural Households' Renewable Energy Usage Intention in Iran: Extending the Unified Theory of Acceptance and Use of Technology,” *Renewable Energy*, vol. 122, pp. 382-391, 2018.

[20] Global Solar Atlas, 2022. [Online]. Available: https://globalsolaratlas.info/map.

[21] Ho, S.M., Lomi, A., Edmund, C., Urrego R., “Investigation of Solar Energy: The Case Study in Malaysia, Indonesia, Colombia and Nigeria,” *International Journal of renewable Energy Research*, vol. 9, pp. 86-95, 2019.

[22] 2022. [Online]. Available: HTTP://GLOBALSOLARATLAS.INFO.

[23] Ho, S.M., Edmund, C., Adewale, G., Hammed, B., Ahmed Y, “Advanced Research in solar energy: Malaysia, UAE and Nigeria,” *Eurasian Journal of Analytical Chemistry*, vol. 13, pp. 312-331, 2018.

[24] 2022. [Online]. Available: https://www.mordorintelligence.com/industry-reports/malaysia-solar-energy-market.

[25] 2022. [Online]. Available: https://en.wikipedia.org/wiki/Photovoltaics_manufacturing_in_Malaysia.

[26] Kordvani, A., Hassan, M. Renewable Energy in Iran, 2019. [Online]. Available: http://www.satba.gov.ir/suna_content/media/image/2017/02/5196_orig.pdf?t=636219021775330000.

[27] Aghahosseini, A., Breyer, C., Ghorbani, N., Bogdanov, D., “Analysis of 100% Renewable Energy for Iran in 2030: Integrating Solar PV, Wind Energy and Storage,” *International Journal of Environmental Science and Technology*, vol. 15, pp. 17-36, 2018.

[28] Alamdari, P., Omid, N., Ali A., “Solar Energy Potentials in Iran: A Review,” *Renewable and Sustainable Energy Reviews*, vol. 21, pp. 778-788, 2013.

[29] Khojasteh, D., Davood, K., Kamali, R., Gregorio I., “Assessment of Renewable Energy Resources in Iran: with a Focus on Wave and Tidal Energy,” *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 2992-3005, 2018.

[30] “The First Document that Highlighted the Achievement of a Specific Target for Renewable Energy is the Law of the Sixth Five-Year Economic Development Plan, 2017-2021,” *Ministry of Energy*, Iran, 2022. [Online]. Available: https://www.moe.gov.ir.

[31] ‘Energy Statistics and Charts of Iran and the World,” *Ministry of Energy, Iran*, 2022, [Online]. Available: https://www.moe.gov.ir.

[32] An Overview of 30 Years of the Country’s Energy Statistics, *Ministry of Energy*, Iran, 2020, [Online]. Available: https://www.moe.gov.ir.

[33] “Annual Report on Renewable Energy and Employment,” *Renewable Energy and Energy Efficiency Organization of Iran SATBA*, 2022. [Online]. Available: http://www.satba.gov.ir.

[34] Azadi, P., Nezam, A., Shirvani, T., “The Outlook for Natural Gas, Electricity, and Renewable Energy in Iran; The Stanford Iran 2040 Project,” *Stanford University, USA*, Working Paper No. 3, 2017. [Online]. Available: https://www.researchgate.net/publication/316560095_The_Outlook_for_Natural_Gas_Electricity_and_Renewable_Energy_in_Iran.

[35] Couture, T., Gagnon, Y., “An Analysis of Feed-In Tariff Remuneration Models: Implications for Renewable Energy Investment,” *Energy Policy*, vol. 38, pp. 955-965, 2010.

[36] 2022. [Online]. Available: http://www.seda.gov.my/reportal/fit/

[37] Amran, M., Muhtazaruddin, N., Muhammad, F., Bani, A., Ahmad, Z., Ardila, A., “Photovoltaic Expansion-Limit through a Net Energy Metering Scheme for Selected Malaysian Public Hospitals,” *Sustainability*, vol. 11, 2019. [Online]. Available: https://doi.org/10.3390/su11185131.

[38] Tan, R., Chow, T., “A Comparative Study of Feed in Tariff and Net Metering for UCSI University North Wing Campus with100 kW Solar Photovoltaic System,” *Energy Procedia*, vol. 100, pp. 86-91, 2016

[39] Sulaima, M., Dahlan, Y., Yasin, M., Rosli, M., “A Review of Electricity Pricing in Peninsular Malaysia: Empirical Investigation About the Appropriateness of Enhanced Time of Use (ETOU) Electricity Tariff,” *Renewable and Sustainable Energy Reviews*, vol. 110, pp. 348-367, 2019.

[40] Husain, A., Phesal, H., Kadir, M., Ungku, A., “Short Review on Recent Solar PV Policies In Malaysia,” *E3S Web of Conferences*, vol. 191, 2020. [Online]. Available: https://doi.org/10.1051/e3sconf/202019101002.

[41] 2022. [Online]. Available: https://www.mordorintelligence.com/industry-reports/malaysia-solar-energy-market

[42] Zahurul, S., Othman, M., Id, M., “Photovoltaic Modules Evaluation and Dry-Season Energy Yield Prediction Model for NEM in Malaysia,” *PLoS ONE*, vol. 15, 2020. https://doi.org/10.1371/journal.pone.0241927

[43] Guo, Y., Zhang, X., Zhao L., “*Feasibility Study on New Energy Multi-Feed Direct Current Grid Connection*,” Proceedings of the Institution of Civil Engineers-Energy, vol. 174, pp. 57-66, 2021.

[44] 2022. [Online]. Available: https://policy.asiapacificenergy.org/node/1218

[45] Shafie, S., Mahlia, T., Masjuki, H., Andriyana A., “Current Energy Usage and Sustainable Energy in Malaysia: A Review,” *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 4370-4377, 2011.

[46] Shen M., “A Review on Battery Management System from the Modeling Efforts to its Multi-Application and Integration,” *International Journal of Energy Research*, vol. 43, pp. 5042-5075, 2019.

[47] Ushar, W., Member, S., Saha, T., Yuen, C., “Peer-to-Peer Trading in Electricity Networks: An Overview,” *IEEE Transactions on Smart Grid*, vol. 11, pp. 3185-3200, 2020.

[48] Huang, H., Nie, S., Lin, J., Wang, Y., Dong, J., "Optimization of Peer-to-Peer Power Trading in a Microgrid with Distributed PV and Battery Energy Storage Systems," *Sustainability*, vol. 12, 2020. https://doi.org/10.3390/su12030923.

[49] Afrouzy, Z., Masoud, T., "Thermo-Economic Analysis of a Novel Integrated Structure for Liquefied Natural Gas Production Using Photovoltaic Panels," *Journal of Thermal Analysis and Calorimetry*, vol. 145, pp. 1509-1536, 2021.

[50] Edalati, S., Ameri, M., Masoud, I., Sadeghi, Z., "Solar Photovoltaic Power Plants in Five Top Oil Producing Countries in Middle East: A Case Study in Iran," *Renewable and Sustainable Energy Reviews*, vol. 69, pp. 1271-1280, 2017.

[51] Gorjian, S., Babak, N., Ludger, E., Redmond, R., Yasaman, A., "Solar Photovoltaic Power Generation in Iran: Development, Policies, and Barriers," *Renewable and Sustainable Energy Reviews*, vol. 106, pp. 110-123, 2019.

[52] Dehghani, M., Nazari, A., Jamal, T., Ahmadi, H., Roghayeh, G., "Analysis of Stakeholder Roles and the Challenges of Solar Energy Utilization in Iran," *International Journal of Low-Carbon Technologies*, vol. 13, pp. 438-451, 2018.

[53] Payam, F., Taheri, A., "The Role of Energy Policy on Sustainable Development in Iran, the Role of Energy Policy on Sustainable Development in Iran," *Journal of Energy Management and Technology*, vol. 1, pp. 1-5, 2017.

[54] Hadi, M., Pourfallah, M., Shaker, B., "Simulation of a Solar Power Plant with Parabolic Receivers in Several Parts of Iran in the Presence of Latent Heat Thermal Energy Storage System," *Thermal Science and Engineering Progress*, 2022. https://doi.org/10.1016/j.tsep.2022.101249.

[55] Sadat, A., Jamal, F., Abbas, K., Mohammad N., "The Experimental Analysis of Dust Deposition Effect on Solar Photovoltaic Panels in Iran's Desert Environment," *Sustainable Energy Technologies and Assessments*, 2021. https://doi.org/10.1016/j.seta.2021.101542.

[56] Bahareh, O., Koo, Y., Rezania, S., Shafiee A., "Barriers to Renewable Energy Technologies Penetration: Perspective in Iran," *Renewable Energy*, vol. 174, pp. 971-983, 2021.

[57] Maryam, N., Mansour, Y., Yusaf T., "Landscape Framework for the Exploitation of Renewable Energy Resources and Potentials in Urban Scale (Case Study: Iran)," *Renewable Energy*, vol. 163, pp. 300-319, 2021.

[58] Mahya, G., Taji, M., Sadat, A., Seifi C., "Developing a Perspective on the Use of Renewable Energy in Iran," *Technological Forecasting and Social Change*, 2021. https://doi.org/10.1016/j.techfore.2021.121049.

[59] Shahsavari, A., Yazdi, T., Yazdi F, "Potential of Solar Energy in Iran for Carbon Dioxide Mitigation," *International Journal of Environmental Science and Technology*, vol. 16, pp. 507-524, 2019.

[60] Madvar. M., Nazari, M., Tabe, A., Aslani, A., Ahmad H, "Analysis of Stakeholder Roles and the Challenges of Solar Energy Utilization in Iran," *International Journal of Low Carbon Technologies*, vol. 13, pp. 438-451, 2018.

[61] Mostafa, R., Ali, M., Jafari, N., Nafiseh N., "Wind and Solar Energy Utilization for Seawater Desalination and Hydrogen Production in the Coastal Areas of Southern Iran," *Journal of Engineering, Design and Technology*, vol. 18, pp. 1951-1969, 2020.

[62] Dehghan, A., "Status and Potentials of Renewable Energies in Yazd Province-Iran," *Renewable and Sustainable Energy Reviews*, vol. 15, pp. 1491-1496, 2011.

[63] Hiva, G.; Babak, Z., Eltrop, L., Redmond, R., Yasaman, A., "Solar Photovoltaic Power Generation in Iran: Development, Policies, and Barriers," *Renewable and Sustainable Energy Reviews*, vol. 106, pp. 110-123, 2019.

[64] Lari, R., Shahnazari M., "Modeling of a Solar Power Plant in Iran," *Energy Strategy Review*, vol. 18, pp. 24-37, 2017.

[65] Mehdi, J., Omid, N., Ahmad, H., Ali, R., Akbar, A., "An Optimization of Energy Cost of Clean Hybrid Solar-Wind Power Plants in Iran," *International Journal of Green Energy*, 2019. https://doi.org/10.1080/15435075.2019.1671415.

[66] Ghaemi R., Arash S., "Development of Solar Energy Technologies in Iran: Swot and Dematel Methods," *Journal of Energy Planning and Policy Research*, vol. 2, pp. 97-130, 2017.

[67] Hossein, J., Ali, K., "Using solar Energy to Meet Thermal Demand in Smart Buildings Due to Different Climate Conditions: Cases of Iran," *International Journal of Ambient Energy*, 2019. https://doi.org/10.1080/01430750.2019.1670260.

[68] Mehdi, N., Mayeli, P., Mohammad, N., Amin, H., "Techno-Economic Feasibility of Off-Grid Solar Irrigation for a Rice Paddy in Guilan Province in Iran: A Case Study," *Solar Energy*, vol. 150, pp. 546-557, 2017.

[69] Majid, S., Kasra, M., "Establishing New Empirical Models for Predicting Monthly Mean Horizontal Diffuse Solar Radiation in City of Isfahan, Iran," *Energy*, vol. 69, pp. 571-577, 2014.

[70] Amir, H., Ali, H., Alireza, K., "Assessment and Categorization of Empirical Models for Estimating Monthly, Daily, and Hourly Diffuse Solar Radiation: A Case Study of Iran," *Sustainable Energy Technologies and Assessments*, 2021. https://doi.org/10.1016/j.seta.2021.101330.

[71] Seyed, M., Sara, S., Naser, A., Negar, J., "Promotion of Solar Energies Usage in Iran: A Scenario-Based Road Map," *Renewable Energy*, vol. 150, pp. 278-292, 2020.

[72] Yousefi, H., Hamed, H., Amin Y., "Spatial Site Selection for Solar Power Plants Using a GIS-Based Boolean-Fuzzy Logic Model: A Case Study of Markazi Province, Iran," *Energies*, 2018. https://doi.org/10.3390/en11071648.

[73] Jahangiri, M., Haghani, A., Heidarian, S., Alidadi, S., Pomares, M., "Electrification of a Tourist Village Using Hybrid Renewable Energy Systems, Sarakhiyeh in Iran," *Journal of Solar Energy Research*, vol. 3, pp. 201-211, 2018.

[74] Saman, N., Najmeh, N., Foad, M., Mehdi, H., Ali, D., Hamzeh, K., "A Decision Model Based on Decision Tree and Particle Swarm Optimization Algorithms to Identify Optimal Locations for Solar Power Plant Construction in Iran. Renew," *Energy*, vol. 187, pp. 56-67, 2022.

[75] Khalil F, "Assessment of Small-Scale Solar PV Systems in Iran: Regions Priority, Potentials and Financial Feasibility," *Renewable and Sustainable Energy Reviews*, vol. 94, pp. 267-274, 2018.

[76] Ali, M., Majid, S., Kasra, M., "Wind-Solar Energy Potentials for Three Free Trade and Industrial Zones of Iran," *International Conference on Industrial Engineering and Operations Management*, 2015. DOI: 10.1109/IEOM.2015.7093792.

[77] Fathi, S., Arash, M., "A Review of Renewable and Sustainable Energy Potential and Assessment of Solar Projects in Iran," *Journal of Clean Energy Technologies*, vol. 5, pp. 126-130, 2017.

[78] Sreenath, S., Yusop, A., Sudhakar, K., Solomin, E., "Solar PV Energy System in Malaysian Airport: Glare Analysis, General Design and Performance Assessment," *Energy Reports*, vol. 6, pp. 698-712, 2020.

[79] Nallapaneni, M., Sudhakar, K., Samykano, M., "Techno-Economic Analysis of 1 Mwp Grid-Connected Solar PV Plant in Malaysia," *International Journal of Ambient Energy*, vol. 40, pp. 434-443, 2019.

[80] Mujahid, T., Saad, B., Bazlul, M., "Feasibility of Using Photovoltaic (PV) Technology to Generate Solar Energy in Sarawak," *International Conference on Computer and Drone Applications (IConDA)*, 2017. Doi: 10.1109/ICONDA.2017.8270391.

[81] Salleh, A., Muda, W., Umar, R., "Optimization and Economic Analysis of Grid-Photovoltaic Electric Boat Charging Station in Kuala Terengganu," *MATEC Web Conferences*, vol. 74, 2016. https://doi.org/10.1051/matecconf/20167400022.

[82] Johari, A., Siti, S., Ramli, M., Hashim, H., "Potential use of Solar Photovoltaic in Peninsular Malaysia," *IEEE Conference on Clean Energy and Technology*, 2011. DOI: 10.1109/CET.2011.6041446.

[83] Ayu, W., Sopian, K., Azami, Z., Ghoul, M., "A New Approach for Predicting Solar Radiation In Tropical Environment Using Satellite Images – Case Study Of Malaysia," *WSEAS Transactions on Environment and Development*, vol. 4, pp. 373-378, 2008.

[84] Gomesh, N., Daut, I., Irwan, M., Fitra, M., "Study on Malaysian's Perspective towards Renewable Energy Mainly on Solar Energy," *Energy Procedia*, vol. 36, pp. 303-312, 2013.

[85] Maricar, M., Lee, E., Lim, H., Sepikit, M., Maskum, M., Ahmad, M., Mahmo, M., "Photovoltaic Solar Energy Technology Overview for Malaysia Scenario," *Proceedings National Power Engineering Conference*, PECon, 2003. DOI: 10.1109/PECON.2003.1437462.

[86] Solangi, K., Lwin, W., Rahim, N., Hossain, M., Saidur, R., Fayaz, H., "Development of Solar Energy and Present Policies in Malaysia," *IEEE Conference on Clean Energy and Technology*, 2011. DOI: 10.1109/CET.2011.6041447.

[87] Tamer, K., Azah, M., Sopian, K., Marwan, M., "Modeling of Daily Solar Energy on a Horizontal Surface for Five Main Sites in Malaysia," *International Journal of Green Energy*, 2011. https://doi.org/10.1080/15435075.2011.602156.

[88] Lau, Y., Arief, Y., Muhamad, A., Tan, W., Yatim, M., "Grid-Connected Photovoltaic Systems for Malaysian Residential Sector: Effects of Component Costs, Feed-In Tariffs, and Carbon Taxes," *Energy*, vol. 102, pp. 65-82, 2016.

[89] Mekhilef, S., Safai, A., Mustaffa, S., Saidur, R., Omar, R., Younis, A., "Solar Energy in Malaysia: Current State and Prospects," *Renewable and Sustainable Energy Reviews*, vol. 16, pp. 386-396, 2012.

[90] Sukki, M., Abu, B., Roberto, R., Hajar, M., Scott, G., Siti, H., Brian, G., "Solar photovoltaic in Malaysia: The Way Forward," *Renewable and Sustainable Energy Reviews*, vol. 16, pp. 5232-5244, 2012.

[91] Solangi, K., Luhur, R., Saidur, R., Aman, M., Kazi, S., Lwin, N., Rahim, N., Islam, M., "Social Acceptance of Solar Energy in Malaysia: Users' Perspective," *Clean Technologies and Environmental Policy*, vol. 17, pp. 1975-1986, 2015.

[92] Firdaus, M., Roberto, R., Siti, H., Scott, G., Brian, G., "An Evaluation of the Installation of Solar Photovoltaic in Residential Houses in Malaysia: Past, Present, and Future," *Energy Policy*, vol. 39, pp. 7975-7987, 2011.

[93] Hussain, A., Ahmad, P., Kadir, M., Ungku, A., "Short Review on Recent Solar PV Policies in Malaysia," *The 3rd International Conference on Renewable Energy and Environment Engineering REEE*, 2020. https://doi.org/10.1051/e3sconf/202019101002.

[94] Dut, I. Irwan, M., Razliana, N., Farhana, Z., "Analysis of Solar Irradiance and Solar Energy in Perlis, Northern of Peninsular Malaysia," *Energy Procedia*, vol. 18, pp. 1421-1427, 2012.

[95] Syafawati, A., Daut, M., Farhana, Z., Shema, S., Razliana, N., "Potential of Solar Energy Harvesting in Ulu Pauh, Perlis, Malaysia using Solar Radiation – Analysis Studies," *Energy Procedia*, vol. 14, pp. 1503-1508, 2012.

[96] Aghaei, M., Hanum, M., Imamzai, M., Paria, P., Amin, N., "Design of a Cost-Efficient Solar Energy Based Electrical Power Generation System for a Remote Island-Pulau Perhentian Besar in Malaysia," *IEEE 7th International Power Engineering and Optimization Conference (PEOCO2013)*, Langkawi, Malaysia, pp. 203-208, 2013.

[97] Mohd, A., Yaaseen, R., Nor, M., "Prospective Scenarios for the Full Solar Energy Development in Malaysia," *Renewable and Sustainable Energy Reviews*, vol. 14, pp. 3023-3031, 2010.

[98] Vaka, M., Rashmi, W., Abdul, R., Khalid, M., "A Review on Malaysia's Solar Energy Pathway towards Carbon-Neutral Malaysia Beyond Covid'19 Pandemic," *Journal of Cleaner Production*, 2020. https://doi.org/10.1016/j.jclepro.2020.122834.

[99] Shing, C., Oh, T., "Solar Energy Outlook in Malaysia," *Renewable and Sustainable Energy Reviews*, vol. 16, pp. 564-574, 2012.

[100] Mekhilef, S., Safari, A., Mustaffa, W., Saidur, R., Younis, A., "Solar Energy in Malaysia: Current State and Prospects," *Renewable and Sustainable Energy Reviews,* vol. 16, pp. 386-396, 2012.
[101] 2022. [Online]. Available: https://www.itramas.com/quantum-solar-park-malaysia-qspm-launched-50mwac-solar-power-plant-in-pendang/.
[102] 2022. [Online]. Available: https://scatec.com/locations/malaysia/#redsol-malaysia-45-mw.
[103] 2022. [Online]. Available: https://renewablesnow.com/news/scatec-solar-opens-47-mw-redsol-plant-in-malaysia-716163/.
[104] 2022. [Online]. Available: https://www.smart-energy.com/renewable-energy/malaysia-pioneers-large-scale-solar-project/[sepang
[105] Forough, A., Nima, N., Fani, M., "Investigation of the Optimal Model for the Development of Renewable Energy in Iran using a Robust Optimization Approach," *World Journal of Electrical an Electronic Engineering*, vol. 1, pp. 1-20, 2021.
[106] 2022. [Online]. Available: https://financialtribune.com/articles/energy/95642/cost-of-renewable-power-falling-rapidly-in-iran.
[107] Pourkiaei, S., Moosavi, S., Khalilpoor, N., Pourfayaz, F., "Potential, Current Status, and Applications of Renewable Energy in Energy Sector of Iran: A Review," *Renewable Energy Research and Applications,* vol. 2, pp. 25-49, 2021.
[108] *International Renewable Energy Agency IRENA,* Irena Data Query Tool, 2020. [Online]. Available: https://www.irena.org/
[109] Shokri, K., "Iran's Transition to Renewable Energy: Challenges and Opportunities," *Middle East Policy*, vol. 26, pp. 62-71, 2019**.**
[110] "Technology and Engineering Capacities Development Program for Photovoltaic Solar Power Plants In Persian," Vice President for Science and Technology of Iran, 2016. [Online]. Available: https://www.irena.org/.
[111] [Online]. Available: https://solarvest.my/2019/02/28/largest-solar-power-plants-world/
[112] Wan, S., Osman, M., Mohd, Z., Renuga, V., "The Potential and Status of Renewable Energy Development in Malaysia," *Energies*, vol. 12, 2019. Doi:10.3390/en12122437.
[113] 2022. [Online]. Available: https://getsolar.ai/blog/solar-panel-installation-maintenance-price-malaysia/
[114] 2022. [Online]. Available: https://themalaysianreserve.com/2022/04/15/petronas-power-completes-free-solar-power-pilot-project/.
[115] 2022. [Online]. Available: https://www.tnb.com.my/assets/newsclip/05032022a.pdf.
[116] 2022. [Online]. Available: https://www.thestar.com.my/business/business-news/2011/02/22/kbe-bsolar-in-solar-project.
[117] 2022. [Online]. Available: https://www.thestar.com.my/metro/metro-news/2021/05/17/shaping-kls-first-div-low-carbon-townshipdiv.
[118] Iszuan, S., Azmi, O., Hamdan, H., "Pilot Solar Hybrid Power Station in Rural area, Rompin, Pahang, Malaysia, Proceedings of the *International Symposium on Renewable Energy: Environment Protection and Energy Solution*, Malaysia, pp. 762, 2006.
[119] 2022. [Online]. Available: https://pmj.mypolycc.edu.my/greenpmj/index.php/projects/11-landscaping/35-summer-workshop.
[120] Tofael, A., Saad, M., Shah, R., Nadarajah, M., "An Assessment of the Solar Photovoltaic Generation Yield in Malaysia using Satellite Derived Datasets," *International Energy Journal*, vol. 19, pp. 61-76, 2019.
[121] Poonam Gurjar, Saira Banoo, "Status and Potential Utilization of Solar Energy in India," *International Journal of Economics and Management Studies*, vol. 6, no. 7, pp. 54-58, 2019. *Crossref*, https://doi.org/10.14445/23939125/IJEMS-V6I7P108