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Analysis of Solar Energy Development Strategies for a Successful Energy Transition in the UAE

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Abstract: The United Arab Emirates (UAE) is making significant progress in improving its economy by attracting tourists and trade. In the short run, however, economic activity will continue to be more based on oil, natural gas, and related industries. Rising demand for natural gas for power plants and industrial users, such as petrochemicals and steelmakers, has made the UAE a net gas importer, prompting the country to launch multibillion-dollar investments in nuclear and renewable energy. This study addresses the trend of solar energy production and consumption in the UAE. The strengths, weaknesses, opportunities, and threats (SWOT) analysis was performed on the different types of solar energy in the UAE, and some strategies were developed based on it. The SWOT analysis reveals promising strategies for the UAE's solar energy transition that would reduce fossil fuel demand, mitigate greenhouse gas emissions through solar energy production, and transform the UAE into the carbon market centre of the Gulf Cooperation Council countries.

Keywords: solar energy; SWOT analysis; energy policy; photovoltaic; concentrated solar power; energy transition; fossil-fuel-based economy

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1. Introduction

The United Arab Emirates (UAE) is a federation of the seven emirates of Abu Dhabi, Dubai, Ras Al Khaimah, Sharjah, Ajman, Al-Fujairah, and Umm Al-Quwain. With its vast oil resources, the UAE is developing as one of the world's major financial institutions and a central trading hub in the Middle East [1]. The country is located at 22°30′–26°10′ north latitude and 51°–56°25′ east longitude, indicating an excellent exposure to solar energy [2]. The UAE receives an average of more than 10 h of sunshine a day. The average annual 350 sunny days in this country are significant with total solar energy [3]. According to the report on global solar radiation in 2007 in Abu Dhabi, the average daily energy input is 48.18 MJ/(m^2 day) [4].

The UAE supplies 3.8% of the world's consumed oil and has nearly 6% of the world's crude oil reserves, which are expected to be fully depleted by 2100 [5]. The demand for electricity in the UAE, almost supplied exclusively by fossil fuel power plants, had increased by about 9% per year by 2019 [6]. It should also be noted that the UAE has been a net importer of natural gas since 2007. Annual local energy consumption has increased significantly in recent years [7]. The energy demand in 1990 was less than 20 TWh and rose to more than 120 TWh in 2020. Almost every year, the electricity demand in the UAE has grown from 1990 to 2019. Knowing that local electricity generation is based on natural gas and 35% of oil and 65% of natural gas are used to generate power, the country must adopt alternative energy sources for its energy security. Compared to other countries with similar characteristics, a relatively high energy consumption per capita was observed in the UAE, causing the country to have some of the world's highest CO_2 emissions [8]. The primary sources of emissions are electricity generation, water supply, and transportation [9].

The high concentration of dust particles in the air and high humidity affects the emission and solar radiation intensity. Satellite images and ground measurement data show that the magnitude of these impacts is site dependent and seasonal, making it possible to select solar technologies according to the data of satellite images. Based on solar radiation parameters, including artificial intelligence techniques, the UAE has the highest annual solar energy rate in the Middle East and North Africa [10]. The southern parts of the UAE have considerable potential for photovoltaic (PV) power generation, with more than 1826 kWh/kWp in most areas of the country (Figure 1). The UAE has plans, initiatives, and strategies to develop energy-efficient systems with renewable resources that ensure future socio-economic growth and expand the UAE's place as a reliable supplier of crude oil by lowering domestic fossil fuel demand.

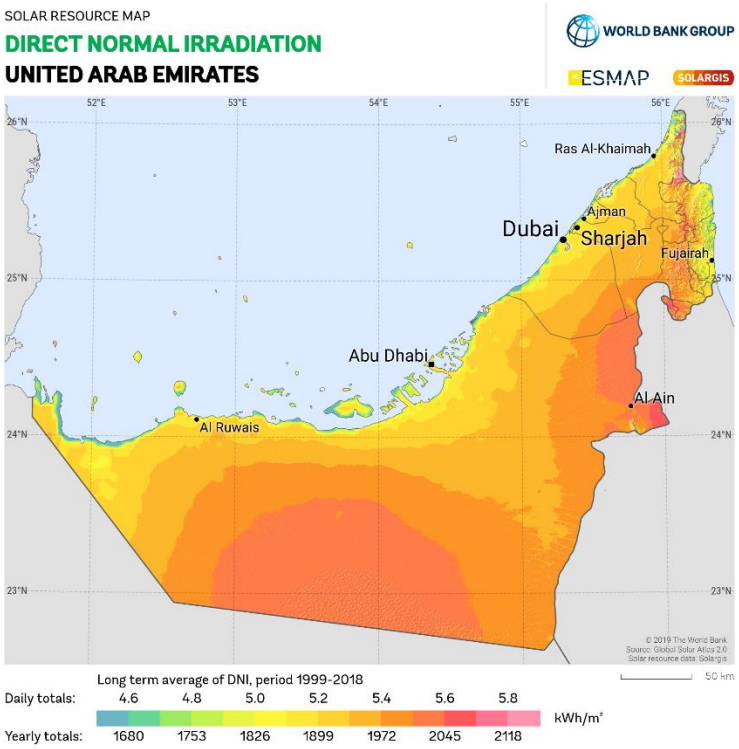


Figure 1. PV solar power generation potential map of the UAE [11].

This study examines the strengths, weaknesses, opportunities, and threats (SWOT) of the solar energy transition for governments and shifting the energy investment to solar energy. Using SWOT analysis, governments, companies, projects, and other entities can determine whether their long-term goals will be achieved by looking at internal and external elements [12]. Analysis of the internal characteristics of a sector shows what advantages (strengths) or disadvantages (weaknesses) it has over others and the external features of the sector that can be used as an advantage (opportunity) or create a problem in achieving the goal (threats) [12]. In SWOT analysis, only verifiable factors were considered for the assessment. In this study, based on the strengths, weaknesses, opportunities, and threats of the solar energy industry in the UAE (as a case study for the fossil-fuel-based economy in the Middle East), strategies for the future development of solar energy are proposed.

2. Background and Current State of Solar Energy Development in the UAE

Figure 2 demonstrates the renewable power generation percentage trend between 1990 and 2020 in the UAE. As can be seen, the renewable power generation before 2015 was negligible. Due to technological advances and policy shifts in recent years, the share of renewable power increased to more than 3.5% in 2020 [13]. It should be noted that solar energy is the predominant source of renewable power in the UAE.

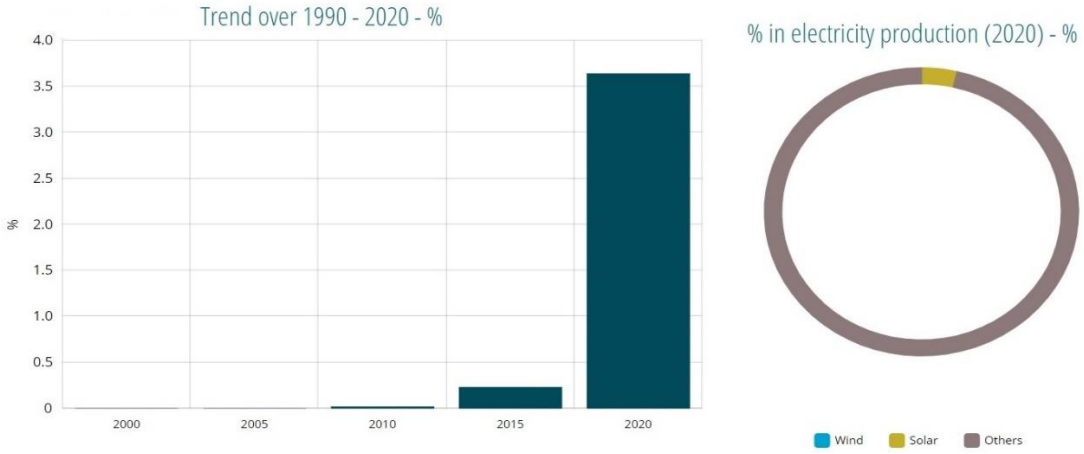


Figure 2. UAE renewable power generation percentage (1990–2020) and power generation mix in 2020 [13].

Figure 3 shows the considerable rise in installed capacity of solar energy in the UAE. The installed capacity of solar energy before 2013 was almost zero. After 2018, the installed capacity increased dramatically and reached more than 2500 MW in 2020. The total installed solar energy generation capacity was from PV panels [14].

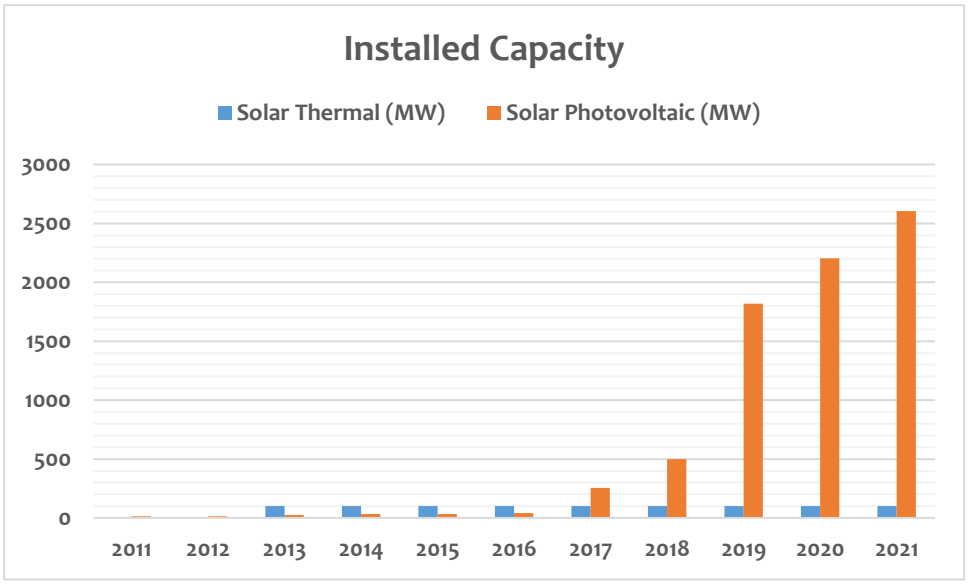
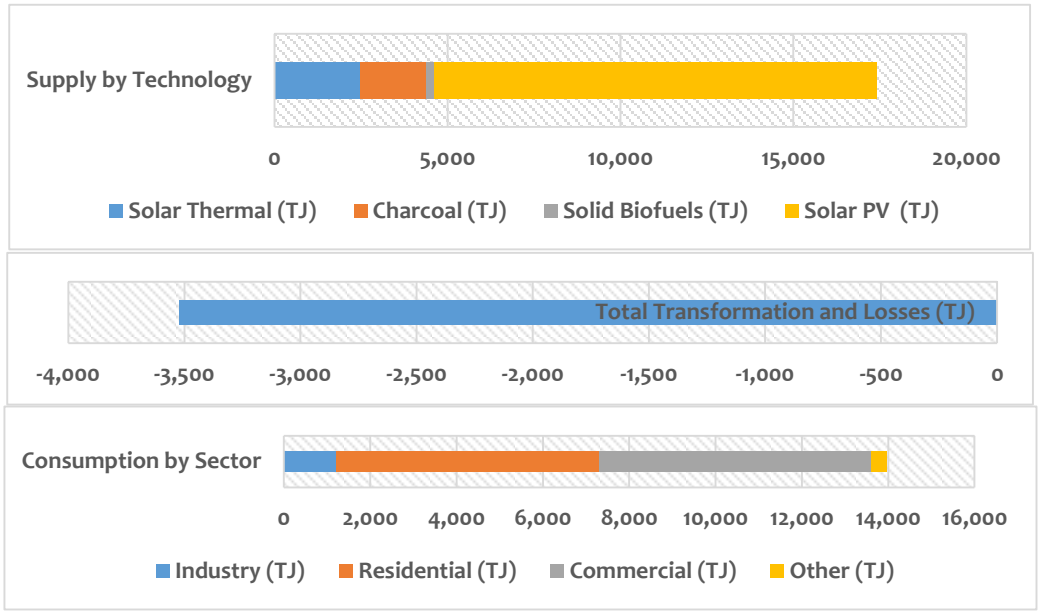


Figure 3. UAE solar energy generation installed capacity (2011–2021). Data were collected from [14].

Figure 4a shows the renewable energy balances of the UAE in 2019. As can be seen, most of the renewable energy is utilized in the residential and commercial sectors. The industrial sector is the third consumer of renewable energy. Transformation losses of renewable energy in the UAE were about 3500 TJ in 2019. Figure 4b shows the demand percentage for the UAE's commercial, residential, industrial, and other sectors. Further, 13,975 TJ final renewable energy demand is divided between the mentioned sectors 45%, 44%, 9%, and 3%, respectively. Figure 4c demonstrates the final renewable energy demand divided by energy generation technology in 2019.



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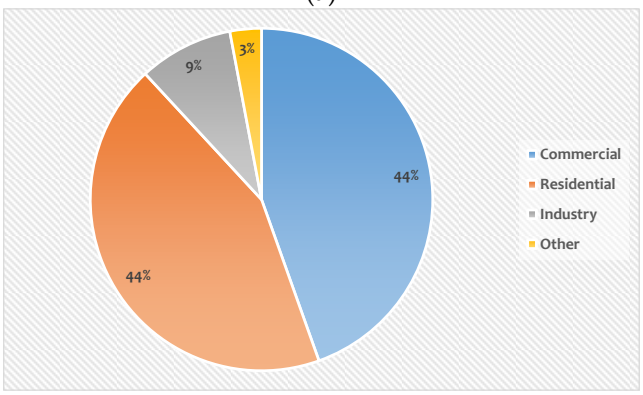

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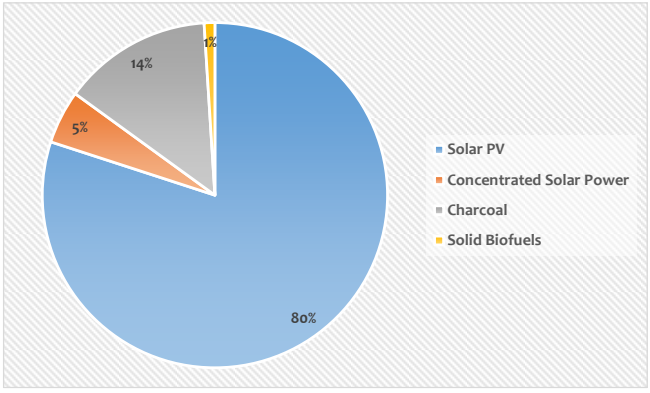

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Figure 4. (**a**) Renewable energy balance in the UAE (2019). Data were collected from [15]; (**b**) final renewable energy demand by UAE economic sector (2019). Data were collected from [16]; (**c**) final renewable energy demand by energy generation technology (2019). Data were collected from [16].

3. Situation in the UAE in the Field of Different Types of Solar Energy and Its Applications

This section addresses the UAE's small-scale solar facilities and programs.

3.1. Solar Rooftop Plan

The solar rooftop plan (SRP) in Abu Dhabi is a state financial incentive scheme aiming to make solar PV deployment on rooftops more feasible for the owners of commercial buildings [17]. Masdar and the Abu Dhabi Water and Electricity Authority (ADWEA) lead the effort. The 500 MW of solar PV on rooftops will be generated by this effort in the next two decades [18]. The UAE's SRP began in 2017 with about 4 MW of installed capacity at the beginning of the year [19]. By the end of 2017, 20 MW of solar power was installed. As a result of the scheme, 11 government buildings with a combined roof capacity of 2.3 MW have been constructed, resulting in annual electricity output of 4.025 GWh and mitigation of 3220 tons of CO_2 emissions. Abu Dhabi's unique environmental conditions necessitate a pilot project to test the performance of PV plants and devise a financial incentive strategy [20].

3.2. Parking Lot Solar Canopy Installations

Due to the high temperature, installing canopy structures for cars in outdoor parking lots in the UAE is common. Several PV installations have been installed on the roofs of these canopy structures to generate, accumulatively, 1.65 MW of energy [2]. One of these systems is installed at the temporary Masdar offices with a capacity of 204 kW. The project is supposed to be expanded to 343 MWh/year with 300 units of CO_2 savings per year. Designed and built by Enviromena, the project includes 105 parking spaces that protect cars against solar heat and provide shade for outdoor paths [2].

3.3. Facilities in Remote Islands

The islands cover about 7% of the UAE's lands. Several islands host oil refineries, natural gas processing units, and other activities, and their fuel needs are met by air or sea. Two islands currently have PV installations to provide more reliable energy and a cumulative capacity of 1.24 MW [2].

3.4. Domestic Solar Water Heating Facilities

It is not just the four most famous skyscrapers in the country with domestic solar water heating systems: the Aloft Hotel in Abu Dhabi, the Masdar Institute in Abu Dhabi, the Burj Khalifa in Dubai, and the Palm Jumeirah in Dubai. The Al Bustan Tutana Hotel in Dubai, the Sea Palace in Abu Dhabi, and the Ajman Pine Hotel in Ajman are examples of hotels with medium and large water heating facilities installed. The 4 MW of solar water heating capacity is estimated for the entire country [4].

4. Solar Energy Industry in the UAE and Its Practical Programs on Its Development

4.1. Solar PV Cell Production

Microsol International is the only solar cell company in the UAE and the largest in the Middle East because of its PV cell production. Since its inception in India, Microsol International has operated in the Fujairah. It has a production capacity of 200 MW and focuses on poly-crystalline and mono-crystalline silicon cell production. When the company was founded in 2006, it had a 15 MW capacity; now, it has a capacity of 200 MW. The company has a semi-automatic line constructed on a 5000-square-foot plot of land and employs 2000 people. There are several rooftop facility installers in Abu Dhabi; however, Enviromena is the biggest rooftop facility installer and has erected a 10 MW PV facility in Masdar [21].

The Dubai Supreme Council of Energy has made initiatives to assure the reliability and availability of energy supply by conserving natural resources through operational practices to meet the problems of climate change and by adopting and developing renewable energy technologies [22,23]. The council designed the Dubai Integrated Energy Strategy to ensure that sustainable energy sources support the country's economy. This strategy aims to boost renewable energy sources in the UAE to 5% by 2030 by diversifying the UAE's energy resources [24]. Solar power plants and user-owned solar power generators are two

methods for introducing renewable energy into Dubai's energy mix. This solar park is a component of Dubai's effort to diversify its energy supply to meet its renewable energy goals. Siah al-Dahl has a 48 km^2 solar park with enough land to develop a 1000 MW PV and concentrated solar power (CSP) plant by 2030. The largest solar park in the region will be built, the Siah al-Dahl. In the first stage, the 13 MW thin-film PV plants have already been operated [24].

4.2. Power Generation

4.2.1. Large-Scale PV Power Plants

Proper solar radiation and the ability to supply high capital costs are critical in developing large PV power plants to meet the growing electricity demand that the UAE enjoys. The development of large PV power plants has several cost and environmental benefits. From an environmental point of view, it was found that 10,000 tons of greenhouse gases could be offset annually by generating 24 GWh of renewable electricity. Another incentive to establish solar power plants is to increase oil taxes and reduce the price of solar modules in the international market [25].

Constructed by Enviromena, the Masdar Power Plant was formally launched in June 2009. About 17,500 MWh of electricity is generated annually by the 218,000-square-meter power plant, which has 87,336 PV modules mounted on lightweight steel tracks and 200 km of wiring. This is the MENA region's first and largest grid-connected solar PV power plant.

4.2.2. Large CSP Plants

When CSP power plants are replacing gas-fired power plants, the reduction in CO_2 emissions will be about 398 g/kWh. However, this comes with several challenges that must be addressed first. For instance, renewable energy is relatively novel to the UAE market, which places it at a disadvantage [23]. There may be a need for a comprehensive value chain strategy because the workforce, agencies, and infrastructure may not be geared for this transition. Over time, the difference between policy expectations and implementation may outweigh CSPs' anticipated benefits [26].

Shams 1 is the first CSP in the Middle East and one of the world's largest CSPs. A joint venture involving Masdar, Total, and Abengoa Solar, Shams 1, was officially unveiled in the first half of 2013. An additional 100 MW of power can be generated by expanding Shams 1 to 2.5 km^2. Abengoa Solar prepared 768 parabolic collector units for the solar field. This idea uses parabolic mirrors to generate solar thermal power from sunshine to produce the high-pressure steam required to run a traditional steam turbine [27].

4.2.3. PV Installations in Buildings and Complexes

High temperature, especially in summer, is a major technical problem, reducing average efficiency by 5 to 6%. As expected, angling the modules to the south expedites higher performance than placing them horizontally on the roof, while placing them vertically to the south has the lowest efficiency. It can be concluded that there are two solutions to make the PV installations in buildings more cost effective: increase electricity tariffs or drastically reduce installation costs [28]. Dubai is now planning to install solar panels on every roof by 2030. Those who opt for net metering can install solar panels on their roofs to generate their electricity, which they may sell back to the power grid when they have excess.

4.2.4. Solar Coolers

Due to the hot climate in the UAE, HVAC is vital in any built environment; therefore, electricity consumption is high in the residential sector. The cooling load accounts for 40% of buildings' annual power demand [29]. In a study, a ten kWc ammonia–water absorption chiller was presented, powered by evacuated tube collectors. The size and cost of solar collectors are essential parameters for improving the economic justification of the solar-

powered absorption cycle. The specified system size consumes approximately 47% less power than the prevalent vapor-compression cycles with the same cooling capacity [30].

4.3. Desalination Plants

As the second-largest desalination capacity globally, the UAE holds a 14% share of global desalination capacity [31]. Between 2006 and 2011, the capacity of desalination facilities in the UAE expanded by 6% each year to cover around 40% of the total water demand. Climate change's impact on rainfall and groundwater access, rising irrigation demands, and rapid population and industrial growth contribute to a predicted rise in this proportion in the coming years. Desalination plants in the Persian Gulf that use solar power and reverse osmosis technology are becoming increasingly affordable, and Dubai and Abu Dhabi are taking advantage of this trend [32]. Hitachi solar-powered desalination units supply fresh water in distant desert places in Abu Dhabi to save the endangered Arabian Oryx [33].

4.4. Street Lighting

Certain areas in the UAE utilize PV panels to light the streets. For instance, in Masdar, Abu Dhabi, street lighting is powered by solar panels installed on poles and battery storage systems [2].

4.5. Independent Transportation Strategy

By 2030, Dubai aims to have 25% of its transportation completely self-sufficient. Recharging, parking, and registration fees for electric vehicles are all now free, thanks to the efforts of the Dubai High Energy Council. In February 2017, Tesla hosted an exhibition in Dubai, a city in the UAE. The UAE has 103 charging stations and three supercharging stations as of 2019. Abu Dhabi National Oil Company and Emirates National Oil Company Group national service stations will receive hundreds more employees in the next few years [34]. In water transportation, the Dubai Roads and Transport Authority has introduced a 20-seat electric water taxi with a 20 kW motor and solar panels on top [35].

4.6. Construction of Floating Solar Power Plants in the Persian Gulf

Dubai is looking to build floating solar power plants in the Persian Gulf. DEWA (Dubai Electricity and Water Authority) and Dubai Municipality will install a floating solar PV system in deep-water drainage lakes. In 2019, DEWA launched a call for consultants to evaluate, design, and construct floating solar power facilities in the Persian Gulf [36]. As of 2020, a partnership led by France and China will be developing the Al-Dhafra Solar PV project in the UAE at a cost of USD 0.7934 per kWh. The project is capable of powering approximately 160,000 households across the UAE. According to the 2020 Solar Vision Report, Abu Dhabi can target up to 6 GW of additional capacity [36]. Further, in March 2019, Shurooq, the Sharjah Investment and Development Authority, and Diamond Developers began building a sustainable city in Sharjah that is entirely based on solar energy.

4.7. Solar Energy and Its Application in the Oil and Gas Industry

The oil and natural gas industry will play an important role in supplying the rising global energy demand for decades to come. A fact that is sometimes overlooked is that the industry is also a significant energy consumer and increases greenhouse gas emissions. Conventional thermal power plants require a large amount of hydrocarbon fuel to produce steam, and the amount of CO_2 produced by burning hydrocarbon fuel is very high. CSPs produce steam without using hydrocarbon fuel or emitting greenhouse gases [18]. However, solar-generated steam has challenges for power plants, such as the need for significant investments, the lack of permanent availability of solar energy, and the adverse effects of sandstorms and dust on concentrators. In 2011, the first commercial use of solar energy was in the oil and gas industry in Kern County, west of Bakersfield, to supply steam to

the McKittrick Oil Field, California; a 300 kW thermal project uses solar energy instead of gas to produce steam [37]. Another application of solar energy in the oil and natural gas industry is the heating of heat transfer fluid (synthetic oil), which circulates through a twisted tube by solar concentrators [18]. In the following, we will get acquainted with some other solar energy applications in the oil and gas industry of the UAE.

4.7.1. Supplying Electric Power for Oil and Natural Gas Production Operations

PV panels for power generation for specific field applications are a key use of solar energy in the oil industry. Alarm lights for offshore projects are the most critical use of these devices. As early as the early 1970s, Exxon was among the first businesses to utilize this technology in these applications. All major oil companies swiftly embraced PV panels due to the large savings in capital investment and operational costs [38].

4.7.2. Supplying the Thermal Energy Requirements of the Oil Production Industry

It is possible to utilize solar thermal energy with several technologies, such as a central receiver and parabolic dish. Some of these technologies have been thoroughly tested and confirmed to be commercially feasible to produce electricity, steam, or heat for industrial or domestic consumption. Concentrated solar thermal technologies are currently the focus of attention [39]. In 1977, the IEA—Implementing Agreement for Solar Power Generation and the IEA—developed Chemical Energy Systems to encourage the development of solar thermal technologies (SolarPACES13). With 19 nations participating, the UAE is a member of SolarPACES13, which focuses on standardizing solar heating for industrial applications, solar water treatment [31], and optimizing the cost of solar thermal systems [38].

Other applications in the oil industry include:

- Solar thermal applications at low and medium temperatures for heating processes;
- Applications of high-temperature solar heating in oil production for enhanced oil recovery.

5. SWOT Analysis

Identifying SWOT is essential as it can help individual plans for achieving goals. Given the SWOT analysis, decision-makers must often assess whether the goal is achievable. Assuming a goal is unattainable, another goal must be decided, and the process is repeated to achieve the best result. SWOT analysis is a strategic planning method utilized to analyse the strengths, weaknesses, opportunities, and threats related to a project or a business [12,40–42]. The SWOT analysis identifies:

- Strengths of a business or project that makes it superior to others.
- Weaknesses that make a business or project vulnerable.
- Opportunities that the project can take advantage of.
- Threats to the project that can cause trouble for the business or project.

The compatibility of solar energy with the environment, the minimum cost in the long run, and multi-functionality are just a few of the significant benefits of this energy source, which seeks to replace fossil fuels. Reducing the expected cost over time as technology advances will also provide an opportunity to utilize solar energy. However, solar energy has weaknesses and threats that still need more attention. Low efficiency, high initial cost, and the need to save energy are challenges. In addition, changing industrial energy sources from fossil fuels to solar energy remains a significant challenge due to facilities already operating on conventional fuels. Despite the weaknesses and threats of using solar energy, technological advancement will solve most problems in the future [12,43]. Based on the information we collected from the UAE on renewable energy, especially different types of solar energy, we will perform a SWOT analysis and examine the strengths, weaknesses, opportunities, and threats for the future solar energy transition in the UAE.

5.1. Strengths

The strengths of the solar energy development in the UAE are as follows:

- The UAE government is committed to developing renewable energy resources, especially solar energy.
- Required infrastructure and industrial bases in the UAE are developing.
- This type of energy is limitless, and the UAE is rich in radiation and has enough land to use solar energy.
- There are attractive places in the UAE with high potential for renewable energy, especially solar energy.
- The UAE has some of the highest political stability in the Middle East.
- The UAE obtains some of the largest investments in this field, which motivates the private sector globally.
- Due to the high amount of land available, the UAE government provides the required space for solar energy.
- In the city of Masdar, several universities offer engineering programs and active research centres related to renewable energy. The country provides sufficient funds for research and development in the solar energy field.
- Most operational projects in this country have been successful [3].
- The UAE is also known for its commitment to the global GHG mitigation agenda and plans to mitigate its CO_2 emissions by 30% by 2030 [44].
- The International Renewable Energy Agency (IRENA) headquarters is located in Abu Dhabi, a good research opportunity for the UAE.

The renewable energy generation sector will create many jobs in 2020. Solar PV, CSP, and other renewable technologies created 6500, 1000, and 300 sustainable jobs in the UAE economy in 2020 (Figure 5) [45].

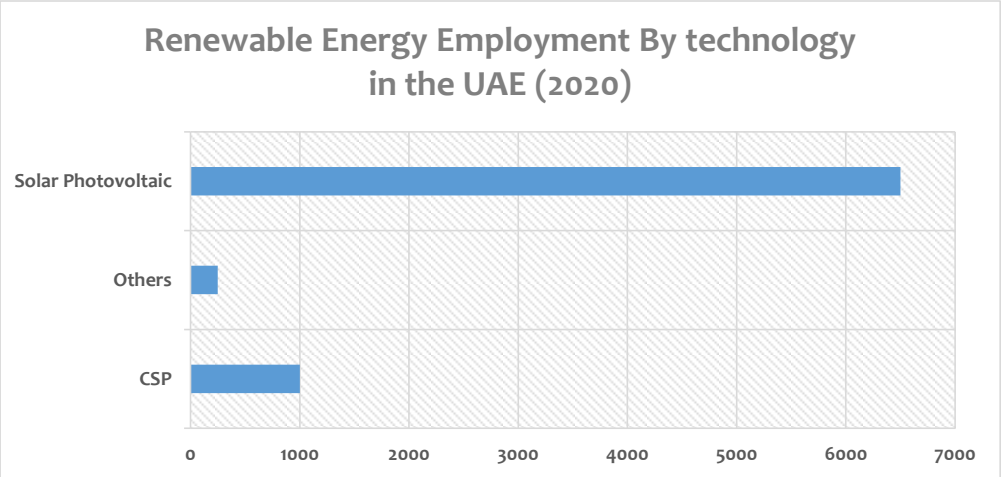
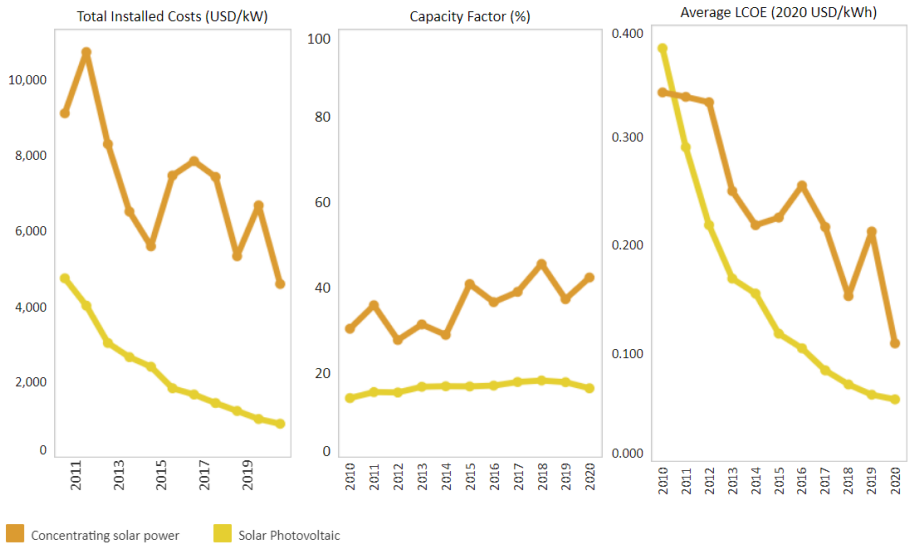


Figure 5. Renewable energy job creation in the UAE (2020). Data were collected from [45].

Figure 6 shows the declining global trends in total installation costs and average LCOE of PV and CSP. These trends help the strategies to expand solar power generation capacity in the UAE.



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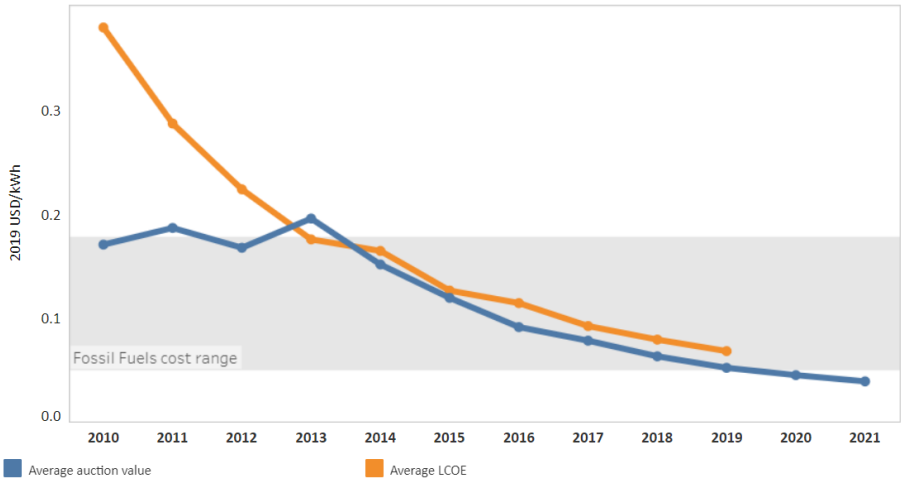

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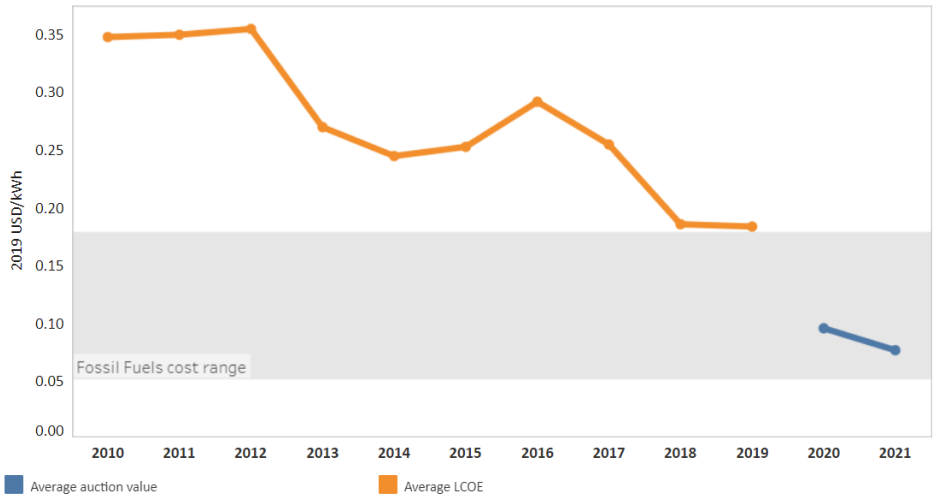

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Figure 6. (**a**) Global weighted average total installed costs, capacity factors, and LCOE (2010–2020) [46], (**b**) Global weighted average LCOE and auction values of solar PV power (2010–2021) [47], (**c**) Global weighted average LCOE and auction values of concentrated solar power (2010–2021) [47].

5.2. Weaknesses

The weaknesses of the solar energy development in the UAE are as follows:

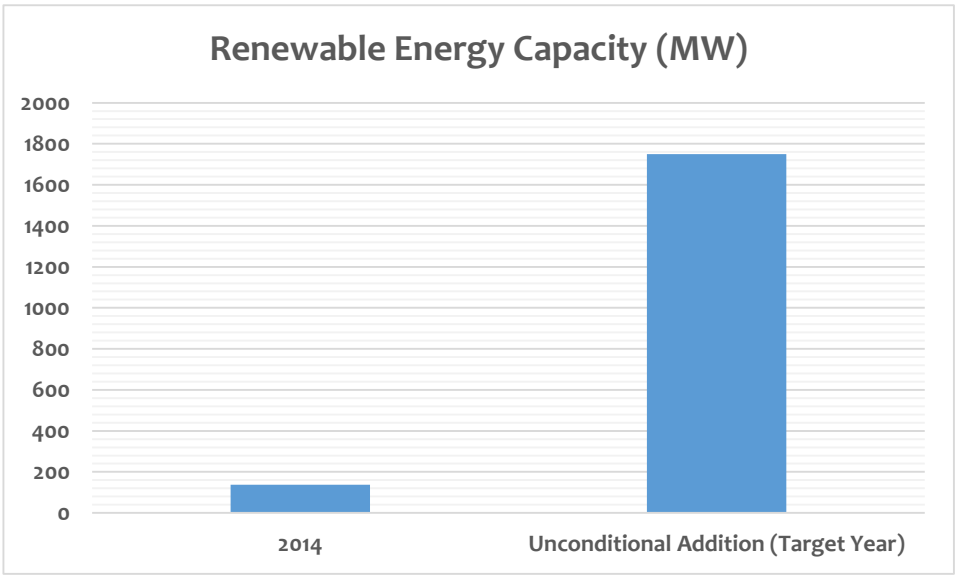
- The initial capital cost of solar energy development is still high compared to fossil fuel technologies.
- Some solar technologies, such as CSPs, are still expensive.
- Lack of awareness among people and users about solar energy needs to be cultured quickly.
- Power for households and the commercial sector still depends on fossil fuels.
- The applied research results on commercial solar energy are not yet considered [28].
- Solar energy is only available during the day and must be stored for night use with a storage system and battery, which increases costs [12].
- The UAE has an opportunity to establish rooftop solar energy units on a small and home scale, namely the solar roof market, which has its drawbacks in terms of beauty and safety.
- Large-scale storage of solar power is not feasible.

5.3. Opportunities

The opportunities for solar energy development in the UAE are as follows:

- Investment in the UAE is uncomplicated and profitable.
- The UAE promises profitable renewable energy markets, especially solar hydrogen [48].
- The UAE government strongly supports the solar energy industry and labour market [49].
- There is a growing trend for private sector participation in solar energy in the UAE, and private companies have established most of Abu Dhabi's power and water-producing capacity [23].
- The UAE has implemented an auction mechanism to support giant solar energy projects [50].
- Focus and invest in a variety of energy storage technologies.

Figure 7 demonstrates renewable energy in the nationally determined contributions (NDCs) of the UAE. To achieve the UAE's carbon mitigation goals, USD 4.5 billion will be needed by 2030.



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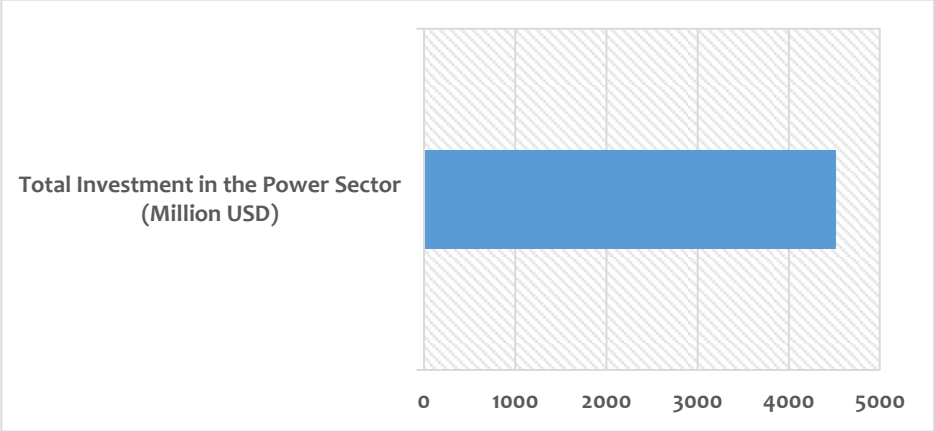

Figure 7. Renewable energy in the NDCs of the UAE. Data were collected from [51].

In 2018, emissions of 0.5655 million tons of CO_2 equivalent were avoided due to the installed capacity of solar energy in the UAE (Figure 8).

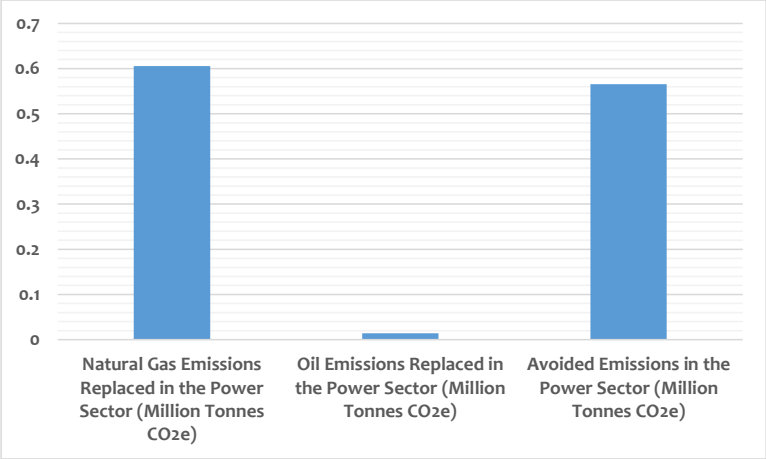

Figure 8. Avoided emissions of solar energy for the UAE (2018). Data were collected from [52].

5.4. Threats

The threats to solar energy development in the UAE are as follows:

- Despite the relatively good advancement in solar energy, local investors may still recognize it as an unreliable and risky investment.
- The global behavior of oil reserves and the fluctuations and challenges in this field can be a serious threat.
- The fossil fuel market will continue to be volatile and out of control.

6. Strategies Based on SWOT Analysis

We presented solutions and strategies according to the principal and influential factors identified by the analysis performed in Section 5. We attempted to make the SWOT analysis tables in this section comprehensive, and the solutions could be executable to an acceptable extent. First, we formed the SO array (Table 1); that is, we use strengths to take advantage of opportunities. We organised the items mentioned in Section 5 to develop appropriate strategies based on them.

Table 1. SO array of the matrix.

S1	Existence of developed infrastructures and industrial bases	SO1	Construction of solar power plants with higher capacities and reduction of fossil fuel consumption in the country
O1	Having a very open and attractive investment climate		
S2	Extensive private sector investments	SO2	The private sector can take over the market for renewables, especially solar, and its investment will pay off over a short time.
O2	Increasing trend of private sector participation in the field of solar energy		
S3	Existence of several universities offering engineering programs and several active research centres related to the development of renewable energies	SO3	Proposals of funds and research projects on energy storage systems by the government
O3	Focus and investment on different types of energy storage systems		

Then, we formed the WO array, taking advantage of opportunities to eliminate weaknesses (Table 2).

Table 2. WO arrays of the matrix.

W1	Lack of awareness among people and users	WO1	Granting special facilities and privileges to users to install solar panels on the roof and selling electricity to the grid in case of surplus production
O1	Having the opportunity to deploy solar units on a small and home scale		
W2	Available only during the day	WO2	Research and development on storage facilities to store electricity generated by solar energy and use it when supply and demand do not match
O2	Focus and investment on different types of energy storage systems		
W3	High initial cost	WO3	Cooperation of government with panel production companies to provide funds for the private sector
O3	Increasing trend of private sector participation in solar energy development		
W4	Most technologies are new emerged	WO4	By advertising on national media, the government can address the challenges associated with the emergence of these technologies
O4	Government support for the industry		
W5	Some solar technologies are not yet used and are expensive	WO5	Participation and presence of investors in the auctions and the development of solar power plants
O5	Executing an auction mechanism to support the establishment of solar projects		

In the next step, we formed the ST array. We attempted to use the strengths to avoid potential threats (Table 3).

Table 3. ST array of the matrix.

S1	The political stability of the government	ST1	Encouraging global companies to invest in the UAE's solar power generation value chain
T1	The global behaviour of oil reserves strongly influences the solar energy market		
S2	Existence of several universities offering engineering programs and several active research centres related to the development of renewable energies	ST2	Cooperation of graduates in the field of energy economics with centers for access to up-to-date information on improving and developing energy investment forecasts
T2	Accurate forecasts and predictions are possible for the industry		
S3	Extensive private sector investments	ST3	Using financial methods to encourage a reduction of fossil fuel demand and mitigation of greenhouse gas emissions by solar energy production
T3	Local investors recognize solar energy as an unsafe and risky investment		
S4	A 30% reduction in CO_2 emissions by 2030	ST4	Transforming the UAE into the carbon market center of the Gulf Cooperation Council countries
T4	The fossil fuel market will continue to be volatile		

The UAE could become an influential country supporting the Paris Agreement and reducing greenhouse gas emissions (Table 4).

Table 4. WT array of the matrix.

W1	Dependence on fossil fuels	WT1	- Using the technologies that reduce the dependence of solar power plants on fossil fuels - Using recycled materials in making the panels to avoid further consumption of fossil fuels
T1	The global behaviour of oil markets strongly influences the solar energy market		
W2	Lack of awareness among people and users	WT2	Attract investors to the industry by raising awareness and seeking help from experts to estimate the return on investment
T2	Local investors recognized it as an unsafe and risky investment		
W3	Some solar technologies are not yet used and are expensive	WT3	Giving special discounts to local investors for the construction of solar power plants
T3	Local investors recognized it as an unsafe and risky investment		

7. Conclusions

The UAE, home to some of the world's greatest hydrocarbon reserves, intends to expand its use of non-hydrocarbon energy sources, such as solar energy, in its energy mix. In recent years, the UAE has taken good steps in using solar energy and constructing several power plants. Several projects are underway in Dubai and Abu Dhabi. Because the general public's willingness to move to renewable energy resources and initiatives is unknown, no assessment has been made of how to better raise awareness within the local community. In the first step, we discussed the current situation and the potential of the UAE in solar energy. Then, we used the SWOT approach to analyze the status of solar energy technologies, including PV and CSP, in the successful energy transition in the UAE. Using strategies based on SWOT analysis, solutions were provided by studying the strengths, such as plentiful solar resources, a considerable amount of available land, and suitable end-use applications for decentralized solar energy systems; the weaknesses, such as incomplete solar industrial value chain, lack of widespread knowledge about social, economic, and environmental advantages of solar energy; opportunities of reducing the widening gap between energy demand and supply, heightening awareness of the impacts of climate change, and a sharp decline in the cost of solar technology, as well as the threats of fossil fuel's dominant position, potential environmental effects related to the solar technologies' life cycle, and instability of renewable energy policies. The below strategies are presented using SWOT analysis:

- The construction of solar power plants with higher capacities should be supported. Investing in large-scale renewable energy, particularly solar, can pay off in a relatively short period for the private sector. In addition, government research grants for energy storage systems should be made available for companies and universities.
- Allowing users to put solar panels on their roofs and selling any excess electricity back to the grid was successful in the UAE. The government and panel manufacturing businesses should collaborate to give the private sector green funding.
- The government should facilitate investment in the UAE's solar power generation value chain for international corporations. In addition, energy investment forecasting for solar energy projects should be encouraged.
- Making solar panels out of recycled materials, for instance, should be encouraged because it will help reduce the amount of fossil fuel needed for the life cycle of solar power.

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