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Generation electricity with hybrid energy (solar and wind energy) in Iran: A Review

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Abstract

Generating electricity in Iran with fossil energy is much more than the usage of renewable energy. Iran is one of the leading non-renewable energy producers in the world due to its plentiful fossil fuel resources. The utilization of natural gas and petroleum in transportation and industrial sectors has been developed vastly in Iran because of their low prices. Consequently, the increasing rate of pollutant formation and depletion of non-renewable fuels have emerged as new challenges in the energy scenario of this country. The utilization of renewable resources is growing, in part due to the environmental impacts caused by fossil fuels. The most significant sources of renewable energy are wind, and solar and many predict that these energy sources will be used increasingly for distributed generation. In this paper, a review study of electricity generation by using solar and wind energy by 2020 is presented.

Keywords: Renewable energy, solar radiation, Wind speed, Iran

Introduction

Iran has an area of 1,648,195 km2, with a population of about 85 million based on the latest census in 2016 [1]. The country is a member of OPEC (Organization of Petroleum Exporting Countries) that controls about 78% of the world oil reserves and produces about 45% of the world oil production. Iran is one of the major exporters of energy, such as crude oil and natural gas, with approximately 11% of world oil reserves (136 billion barrels). It has the second-largest reserves of natural gas in the world, with approximately 19.7% of the world's proven natural gas reserves, which are about 28,080 billion cubic meters [2]. Recently, due to the advantage of renewable energy technologies, increasing three times the cost of fossil fuels, and its global warming effect, the use of distributed energy four sources has been growing [3–4]. Regarding the environmental problems created by fossil fuel consumption, renewable and sustainable energy resources should be taken into consideration by different countries in the world. The contribution of RES resources in the transportation system and power generation has been projected to be increased by 7% and 29%, respectively, by the year 2030 [5]. The primary energy demand in the year 2011 in Iran was reported to be 228.6 MT, which had a 2.5% increment compared to the year 2010. Electricity demand in Iran is reported to be 50,000 MW, which is around 80% of what, which has been generated by fossil fuel consumption. It is projected that Iran′s electricity demand will be 200,000 MW in 2030. Fossil fuel resources will not cover this percentage in 2030 [6]. Iran will meet this increasing trend of energy demand by becoming the importer of energy in the future, and some new strategies should be taken into account by the Iranian government in the case of the energy mix. Some important feasibility study and application investigations were investigated, now described, and many of them were conducted in different regions in Iran. In 2012, Essalaimeh et al. evaluated the economic feasibility of using a hybrid power system for cooling and heating in Amman, Jordan, concluding that it is feasible from technical and economic perspectives [7]. Shan Ngan and Wei Tan analyzed the implementation of hybrid systems using simulations obtained with the HOMER software in Johor Bahru, Malaysia. They showed that the economic and environmental performance of a PV/wind/diesel/ battery configuration is advantageous and it is a convenient replacement for a stand-alone diesel system [8]. Asrari et al. [9] used HOMER to design a hybrid energy system for a rural village in the north-west of Iran. They evaluated the feasibility of various hybrid diesel-RES and grid-RES energy systems. Fazelpour et al. [10] studied the feasibility of satisfying electrical energy needs of a medium-sized hotel on Kish Island, south of Iran, by employing renewable energy resources of wind and solar. They used HOMER for simulation and showed that the most economical system is the diesel-battery system. Still, they suggested that the wind-diesel-battery hybrid system appears to be superior to the diesel-battery system, as it achieves a 14% reduction in emissions of carbon dioxide and only a 0.3% rise in net present cost (NPC).In the present investigation, we determined whether the required energy of a medium-size hotel with a capacity of 125 rooms in Kish Island, Iran, can be met economically with hybrid energy systems for which four hybrid scenarios were considered. A hybrid energy system is defined as a system in which different energy resources (solar, wind, Hydro, diesel generator, etc.) are used to supply the energy load demand [11]. The most important advantage of hybrid systems is, when the variety of energy productions are used together, the reliability of the system improves. Moreover, the reduction in renewable energy technologies' costs as a result of R&D and accelerated deployment makes them more attractive to investors. We can refer to the availability of these energies as another privilege of them in a remote and rural areas where other energy resources such as electricity and natural gas grid are not available. Renewable Energy resources like the photovoltaic plate and wind turbine for generating electricity are inherently stochastic in nature of Iran in which they are reliable power sources by itself in many locations). Many kinds of research to generate electricity in Iran with solar energy [12], and with wind energy (Rezaei, Naghdi-Khozani and Jafari 2020) have been analyzed. Mostafaeipour et al. [13] studied the analysis of wind energy for the city of Zahedan in the southeast part of Iran. Their result showed that obtained wind power was 89 W/m^2, and turbines generated 2.5 kW in the region, which is the most cost-efficient option. The best comparison between Iran and the Middle East was analyzed [14] assessed the wind energy for four locations in Bushehr province of Iran. This result found that the annual wind power density for Borskhum was about 265 W/m^2 for wind turbines of 40 m and twelve wind turbines with generating capacities ranging from 1 kW to 100 kW. In 2012 following a similar approach, a wind-diesel-battery hybrid system was determined to be the most advantageous choice for the village of Sheikh Abolhassan, Iran, where only a diesel generator was providing electrification of the village. The proposed system attained around a 32 percent reduction in carbon dioxide emissions, with a rise in NPC of only 44 percent [15]. Li et al. determined using HOMER software that load and PV module tilt angle are closely connected in a PV-wind-battery hybrid system [15]. In Istanbul in 2011, Turkey and Telli compared renewable energy sources with hydrogen systems economically and technically with HOMER software, where the hydrogen was utilized to decrease the intermittency of PV and wind [16]. Khorasanizadeh and Mohammadi [17] empirically tested a model for prediction of daily global solar radiation in four Iranian cities of Bandarabass, Isfahan, Kerman and Tabass. A solar chimney power plant was proposed to be built as the first national solar chimney power plant in central regions of Iran [18]. Results showed that clear the solar chimney power plants could produce from 28 MWh/month of electrical power. Dincer [19] optically and thermally analyzed parabolic through solar collectors for the production of thermal energy in different climates in Iran with a comparison between the conventional nanofluids. Simulation with MATLAB software resulted in that city of Shiraz with an average annual thermal efficiency of 13.91 % and annual useful annual energy of 2213 kWh/m^2

Wind and solar energy status in Iran

Iran has a high capacity to deploy a variety of renewable energy sources. This vast country is located in southwest Asia and the Middle East with the latitudes between 24° and 40° N, and longitudes between

44° and 64° E with an area of 1,648,195 km^2. Iran is a large country (1,648,195 square kilometers in area) located in the Middle East, with latitude of 35410 3900 North and longitude of 51250 1700 East. There is a diverse climate throughout the country, and more than half of it is mountainous. Iran has begun using wind energy for electricity production since 1994. Although the country has fossil fuel resources such as oil and gas, the utilization of renewable energies, especially the wind power, has expanded significantly in recent years due to their numerous environmental benefits and advantages. Wind is the second source of renewable energies for power generation in Iran [32]. Wind speeds are generally high in many regions of the country, hence, making wind farm projects attractive and reliable for its power generation application. According to the country's fifth economic development plan (2010e2015), 1650 MW of wind power generation capacity along with 5000 MW of combined solar and wind power generation capacity, should be installed and in operation by 2015.

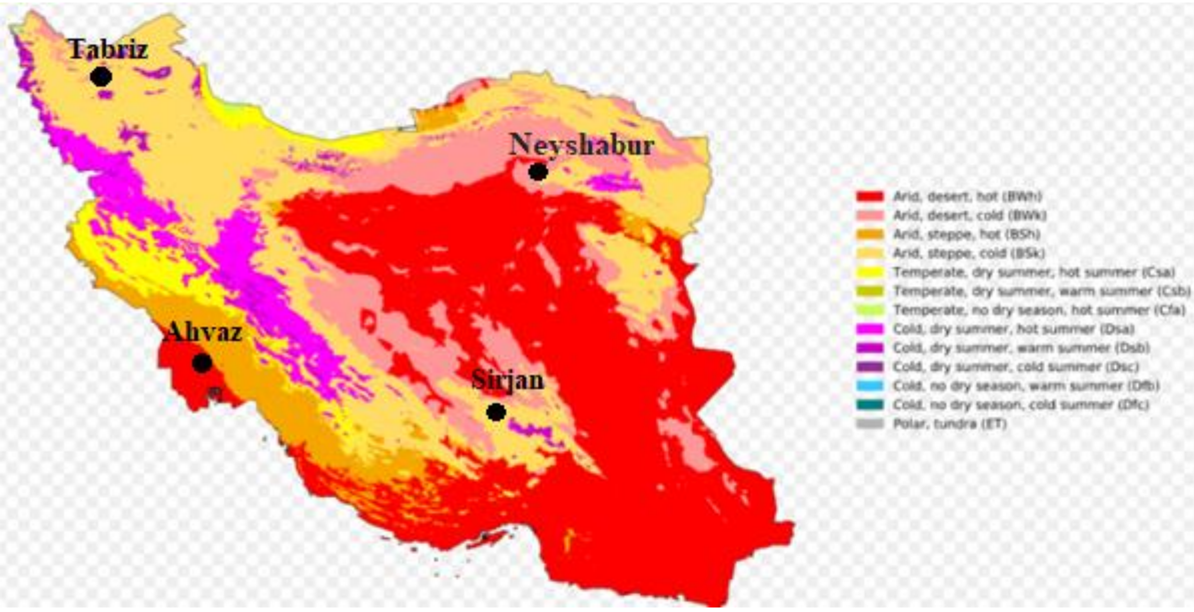

Figure 1: Cities of study in this paper [20]

The complete information of their wind speed and solar irradiance are shown in Figure 2.

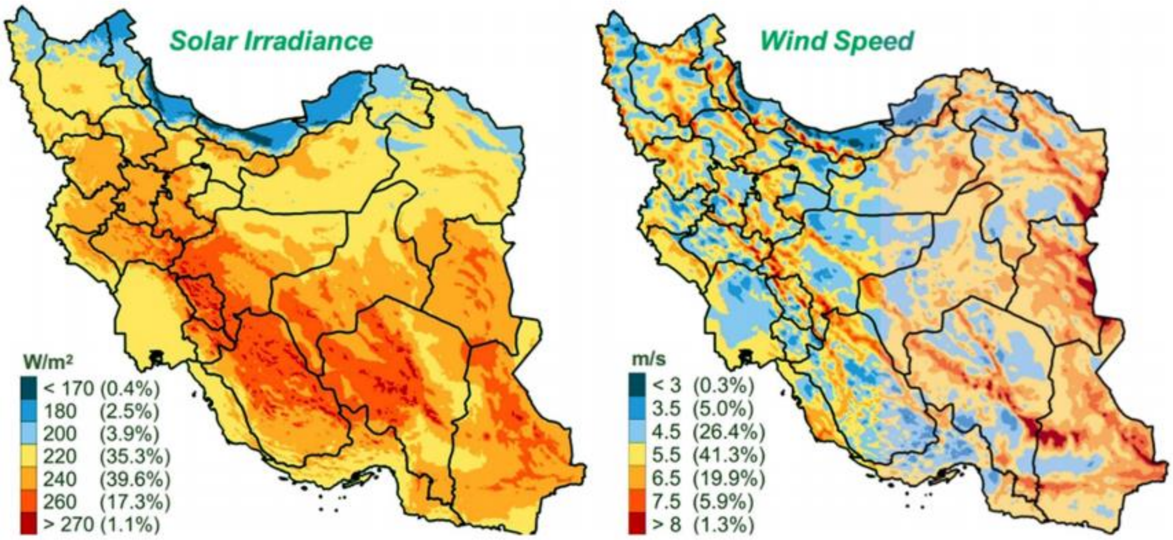

Figure 2. Distribution of solar and wind energy resources in Iran [21]

The viability of a grid-independent system applied for a medium-sized hotel in Kish Island, Iran, is discussed in this paper. Also, economic optimization is included in the evaluation by using the Homer program as the optimization method [22]. Sensitivity analyzes are conducted to assess the effect of several critical parameters on performance: wind speed, solar radiation, and fuel costs. The aim site in this analysis is a hotel with 125 rooms with an annual total electrical energy usage of 2,628,000 kWh, and a peak demand of about 620 kW. The study results show that the wind-diesel hybrid system with battery storage is the most efficient energy solution for providing the electrical needs of the hotel. With five typical 20 kW wind turbines, one 600 kW diesel generator, and 35 batteries, the wind-diesel-battery hybrid device has a gross NPC of $7.236, 000 and a COE of $0.318/kWh.

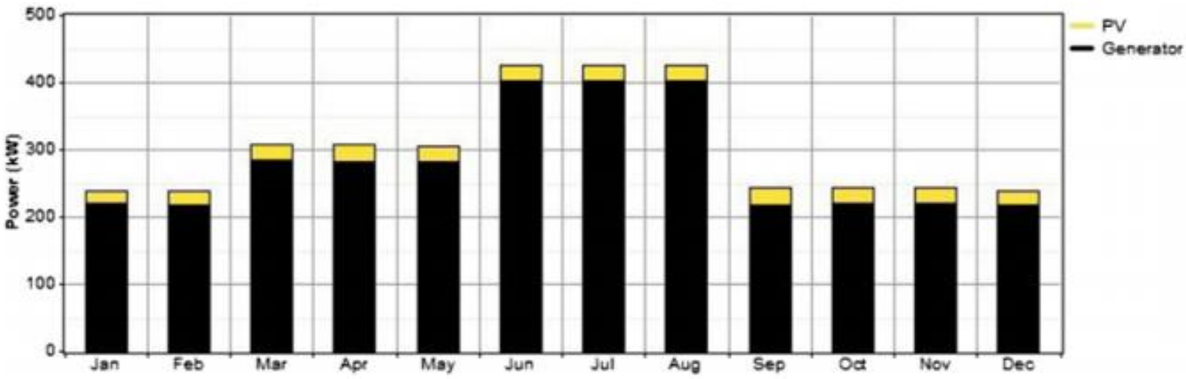

Figure 3 Monthly average electricity production of the PV-diesel system with battery storage

This report explores the degree to which renewable energy sources are used for generating electricity i n Iran, an East Asian country [23]. Based on the country's total electricity production in 2001; Just 8.9% of the power generated by renewable energy resources was gathered from hydroelectric po wer (8%), i.e., the share of other energy sources such as solar, wind, etc. amounts to around 0.9%, sug gesting that we only took initial steps in the process of using renewable energy resource- s compared to other countries and that much more work would be needed.

Table 1: A total list of power production with renewable energy sources up to 2001

No.	The type of renewable energy	MW	Million kW h
1	Hydroelectric power-Dept. of Energy	1998.5	3587.13
2	Hydroelectric power-Dept. of Agr.	7.7	13.82
3	Wind powered generator	10.8	34
4	Solar energy	4.442	11.1
5	Geothermal	–	–
6	Other sources	–	–
Total		2021.442	3645.05

The goal of this paper is to perform a technical economic analysis on the common use of solar and wind power in two Qom and Yazd towns [24]. To achieve this goal, we first gathered the required data from the regional meteorological organization .We then used Homer tools to perform technical and economic analyzes on the two considered sites. Solar and wind analyzes on Qom and Yazd reveal that both cities have great potential for producing solar energy. Only Qom has the energy properties appropriate for generating wind power. The diagram of horizontal radiation for Qom town shows that the peak solar radiation level reported in July is 5,380 kWh / m2/day, and the lowest amount is 0,860 kWh / m2/day. Also It was calculated that the maximum amount of solar radiation for Yazd was reported in June at 8,142 kWh / m2/day, and the lowest level was reported in December at 3,455 kWh / m2/day. In Qom, the maximum daily 27 kW generation of electricity will be in July, and the minimum daily 3 kW generation of power will be in December. In Yazd, the average regular electricity production of 25 kW will be reached in July, and in November, it will fall to its average minimum output of 7 kW. Therefore, it can be found out that investment in both cities ' solar energy sector would be economically justified, but only investment in Qom's wind energy field would be sustainable in the case of wind energy.

Because hydrogen is adopted as the future fuel in the last few years, the purpose of this study is to assess wind and solar energy capacity for hydrogen production in vulnerable areas o f Iran via the Weibull Distribution Function (WDF) and the Angstrom-Prescott (AP) equation. Manjil and Zahedan with annual densities of wind and solar energy of 6004 (kWh / m2) and 2247 (k Wh / m2), respectively, have the maximum volume of electricity among the other cities. Three separate types of commercial wind turbines and photovoltaic (PV) systems were investigated,and it became evident that using one collection of Gamesa G47 turbine, 91 kg/ d of hydro gen, which provides 91 car/week electricity, could be generated in Manjil and will save around 1347 L of gasoline a week.

By installing 1000 sets of X21345 PV systems in Zahedan, 20 kg / d of hydrogen can be produced, wh ich is enough for 20 cars per week, and 296 L of petrol can be saved.

This analysis aimed to identify the lowest cost of hybrid solar wind energy production in 103 stations in Iran utilizing data from NASA and HOMER [24]. Since the construction sector accounts for 45 percent of Iran's energy consumption, our goal was to supply the electricity of an off-grid residential building. Results showed that there is a strong potential for using solar and wind renewable resources in Iran, so the lowest and highest percentages of renewable energy usage were reported in Darab with 87 percent and 100 percent use of Jask stations. In comparison, a solar-diesel

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generator-battery system at Darab station at $0.75/kWh and a wind-diesel generator-battery system at Bandarabbass station at $0.586/kWh were considered to be the maximum and lowest cost per kWh of the produced electricity.

Table 2: Details of selected stations [24]

Station	Components	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Production (kWh/yr)	Excess electricity (kWh/yr)	Hours of operation (hr/yr)	Battery Losses (kWh/yr)	Inverter/ Rectifier Losses (kWh/yr)
Bandarabbass	Wind Turbine	0.28	0.33	0.43	0.49	0.49	0.49	0.6	0.57	0.45	0.36	0.29	0.22	3,630	1,232	7,543	131	235/15
	Generator	0	0	0.05	0.01	0.01	0	0	0.02	0	0.04	0.03	0.05	147		191		
Jask	PV Panel	0.43	0.48	0.52	0.54	0.52	0.51	0.5	0.5	0.54	0.54	0.5	0.44	4401	1,765	4,381	233	8753/0
	Generator	0	0	0	0	0	0	0	0	0	0	0	0	0		0		
Darab	PV Panel	0.2	0.24	0.28	0.34	0.38	0.41	0.4	0.37	0.34	0.28	0.22	0.17	2,648	378	4,387	235	8329/417
	Generator	0.04	0.02	0.13	0.03	0.01	0	0	0.05	0.06	0.06	0.06	0.09	405		444		

The study [25] focuses on defining a cost-optimizing 100 percent renewable energy system in Iran by 2030 using a model of hourly resolution. The optimum sets of renewable energy technology, low-cost electricity source, the combination of capacities and modes of service were measured, and the function of storage technologies was investigated. In this analysis, two scenarios were evaluated: a country-wide scenario and an optimized scenario. Renewable energy production and energy management systems meet the need for electricity in the country's power market, in the country-wide scenario. The renewable energy generated in the integrated scenario was able to satisfy both the power sector's demand for electricity and the substantial demand for water desalination and industrial gas sy nthesis. The total electricity costs decreased from € 45.3 to € 40.3/MWh by adding integration into the sector. The energy infrastructure focused on RES generation and energy storage technology covers the need for electricity in the country's power market, in the country-wide scenario. The estimated operating expense and the minimum sum expected to produce 377.7 TWh is € 15 and € 167, respectively. The combined scenario entails not just producing power but also desalination from SWRO and industrial SNG. Because of the strong demand for water and industrial SNG in Iran, overall annual costs and overall CAPEX rose from the country-wide scenario to the consolidated scenario, respectively, by 693 and 589 percent. It was observed that the market for RE capacities and electricity produced increased significantly to cover two additional sectoral demands. However, an integration advantage may be obtained as such integration brings additional stability to the energy system, especially for seasonal fluctuation reimbursement, in parallel with supplying the demand. In the optimized case, the LCOE of 40.3 € /MWh is very competitive and reasonable relative to other low-carbon options such as CCS and nuclear power, which cost considerably more.

This paper [25] first offers a summary of earlier attempts at energy policy in Iran, which indicates that adequate attention to long-term energy preparation may have avoided such significant problems in a realistically. Nonetheless, the previous research has some shortcomings about the usage of suitable forecasting resources, detailed assessments, and the description and classification of scenarios. This paper, therefore, introduces an energy forecasting system for evaluating the viability of potential power scenarios for the 2015–2050 timeframe. The MESSAGE model was used as a modeling framework, ten scenarios identified for the share of non-hydro-clean technology, eighteen specific techno-economic, environmental, and social parameters established for sustainability evaluation and MCDM metrics used for scenario classification. The route in the Cl 32 case, where the share of non-hydro clean technologies is rated highest at 32 percent. In this way, the risk for global change will be 23 percent smaller than the reference case for 2050.

The goal of this paper [26] is to identify renewable energy off-grid solutions, including solar panels, wind turbine, and batteries as potential zero-emission stand-alone power generation options at KhshU Location, a renewable energy laboratory in Iran. The findings showed that the most economical configuration of different renewable energy systems (RES's) was the PV-battery, which had a gross net present cost of US$ 8.173 (NPC) and an energy cost (COE) of $0.546/kWh, accompanied by the PV/wind/battery combination. Sensitivity analysis found that increasing discount levels will raise energy prices by while the net present cost of the whole program will decrease by at any rate of inflation. The study also found that the difference in wind speed from 3 to 6 m / s has no important impact on both NPC and COE. Photovoltaic power generation systems are more cost-effective for the central part of Iran and superior to wind systems. Table 6 reveals that COE and NPC are lower for a photovoltaic device than the estimates for a hybrid solar wind network. Compared to other areas of the world, especially developed countries, COE is less in Iran. Yet, in other parts of the world, such as Malaysia, fossil electricity tariffs are lower than renewables, in terms of Iran's simpler access to coal fuels, and this problem threatens the viability of renewable energy systems in Iran. The first and most cost-effective option was found to be the PV-battery system, with 1.2kW PV arrays and 6-unit batteries, each supplying 3 kW of 16 for a combined NPC of $8.173 and a COE of $0.546/kWh. To satisfy the electric demand safely, the second ideal option, which consisted of a wind / PV / battery group network of 1.6 kW PV racks, a 0.5 kW wind turbine, and 43 kW battery modules. Nevertheless, relative to the PV-battery system, it will raise the overall NPC and COE by 10 percent and 20 percent, respectively.

This paper [27] measured the capacity of CSP and PV power plants in the province of Sistan and Baluchistan, in southeast Iran. Multi-criteria decision-making approaches were performed using GIS as a digital spatial computing device to estimate the theoretical and technological capacity of the non-constructed region. The research applied a mixture of GIS and MCDM methods to pick the best-suited region of solar power plant capacity.

The final [28] production maps show that the environment parameter has a considerable impact on the solar power capacity. About 14 percent and 12 percent of the region chosen to host the most suitable area for solar PV and CSP production. Around 49766 TWh / year in the PV case and 37093 TWh / year in the CSP case is the theoretical capacity of solar energy production in the most suitable region. The solar power capacity of the best-fit area was estimated and decided to be 8758 TWh / year and 7419 TWh / year for PV and CSP systems based on the scientific framework for determining the solar energy.

The option of the solar photovoltaic farm provides a strong potential in meeting the market for electricity relative to solar CSP plants.

The goal [29] of this analysis is to evaluate the potential of wind energy for the city of Zahedan in the southeastern part of Iran. Wind data was collected for five years (2003–2007) to obtain wind density and demand for wind energy. The method Weibull density was used to calculate the region's wind power density and strength.
The parameters for Weibull, k and c, were 1.155 and 3.401 (m / s). The wind power and energy densit ies reported are 89,184 W / m2,
respectively, and 781,252 kWh / m2. In brief, in this paper, we discuss economic assessment and stud y of four separate wind turbines.
The average hourly wind speed is equivalent to 5.52 m / s based on an average of whole years and occurs at noon.
The results show that the average wind and wind power corresponds to 106,525 W / m2 and 933,159 kWh / m2 in 2003, whereas the lowest figures were 72,777 W / m2 and 637,527 kWh / m2, respectively in 2006. The minimum energy cost is achieved using Proven 2.5 kW, which is equivalent to 0.1225 $/kWh and 0.1187 $/kWh, respectively, at hub heights of 20 m and 30 m. On the other hand, Bergey XL.1 kW achieves the maximum energy efficiency. The energy costs at 20 and 30 m hub heights for this wind turbine model are 0.3059 $/kWh and 0.2967 $/kWh, respectively. The Bergey Excel-R model with a rated power of 7.5 kW produces the most
significant amount of electricity, while the Tested 2.5 kW model is the most economical model for wi nd turbines. The presented article [31] studies the optimum feed-in tariff of solar-generated electricity in Iran regarding climate conditions. Across the country, solar radiation varies from 380 to 578 wm^{-2}.Based on the both governmental and current study of feed-in tariff, ARDEBIL and KOHKILUYEH AND BOYER-AHMAD are the riskiest and best places for a solar project.

To adopt a solution for investor inaction, some rules are needed to be set which can be seen in TABLE 1.Until 2015 the capacity of PV power plants were 5 megawatts which then increased to 45 MW in 2018.

The aim of this study [32] is to present both the technical and theoretical potential of the best region in Iran for solar generation and considering the feasibility of the selected place. To fulfill this desire the SISTAN AND BALUCHISTAN province is selected, and two approaches are used (MCDM &GIS) in which by utilizing them, many factors such as environment, orography, and so on can be studied. Both PV and CSP (concentrated solar power) generation plants are investigated. Figures 8 and 9 show solar power potential in each city. The theoretical potential of solar energy generation in the best suitable area is about 49766TWh/year in the PV case and 37093TWh/year in the CSP case. The solar power potential of the best suitable area based on the technical method for estimating the solar energy was calculated and determined to be 8758TWh/year and 7419TWh/year for PV and CSP systems.

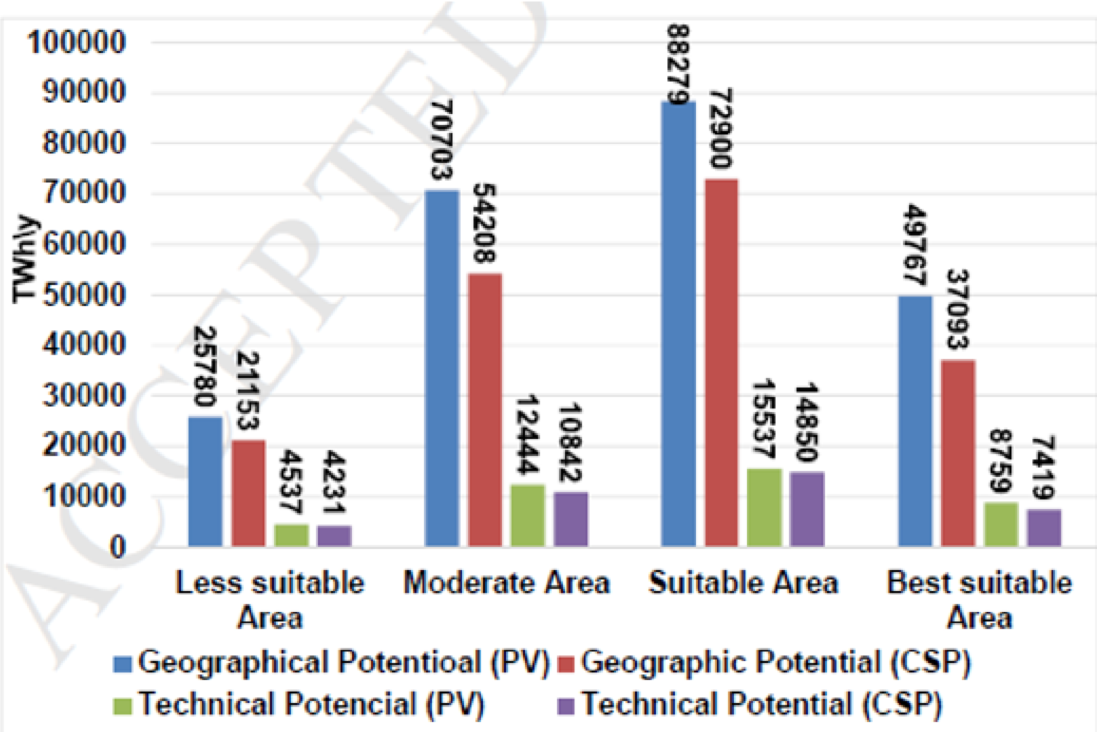

Figure 4 solar energy potential in classified suitability land area

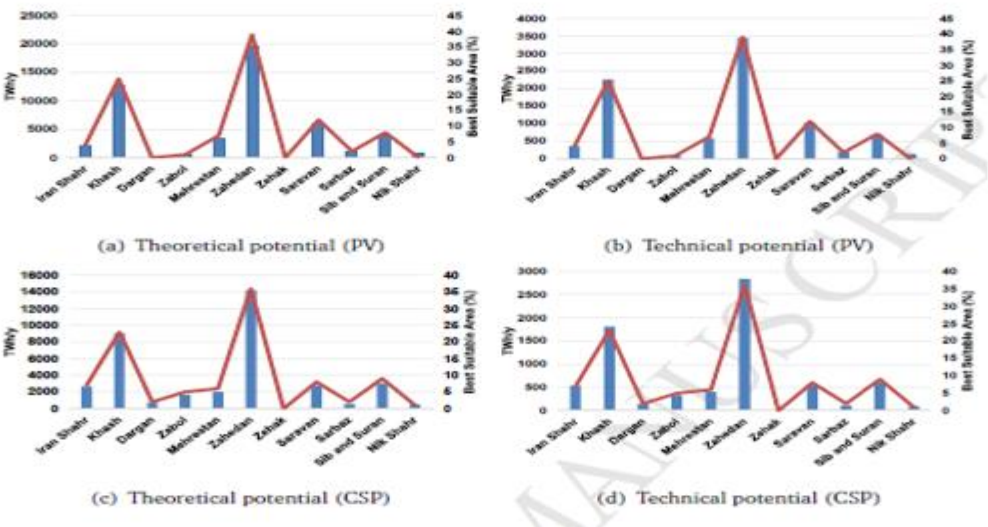

Figure 5 solar power generation in each city

As Iran faces many problems both in energy and water consumption, this study aims to find the lowest cost of generating electricity without consuming water.45% of energy consumption in Iran is dedicated to the building sector [33]. Among all 103 studied stations, DARAB with 87% and JASK with100% usage were the highest and lowest usage of renewable energies. Table 3 shows consumption and generation. Despite having a great opportunity for renewable energy production in Iran, the greatest barrier is the cheap energy in Iran. Based on international standards, if average solar energy received daily is 3.5 kWh/m2, using solar energy is highly cost-effective. In Iran, this is more than 7 to 8 kWh/m2 in some areas, and on average, daily solar radiation is 4.5 kWh/ m2 (Jahangiri et al.). Figures 5 and 6 show the global capacity of wind & solar energy.

Table 3 Rough share of renewable energies in global final energy consumption

			All renewables				
			Modern renewables				
Year	Fossil fuels	Nuclear power	Power (wind, Solar, Biomass, geothermal)	Biofuels	Heat (biomass, Geothermal, solar)	Hydropower	Traditional biomass
2017	79.5%	2.2%	1.7%	0.9%	4.1%	3.7%	7.8%
2018	79.7%	2.2%	2%	1%	4.2%	3.6%	7.5%

Table 4 rough share of renewable in global electricity generation

Year	Non-renewables	Renewable electricity				
		Hydropower	Wind	Bio-power	Solar PV	Geothermal, CSP and ocean
2017	73.5%	16.4%	5.6%	2.2%	1.9%	0.4%
2018	73.8%	15.8%	5.5%	2.2%	2.4%	0.4%

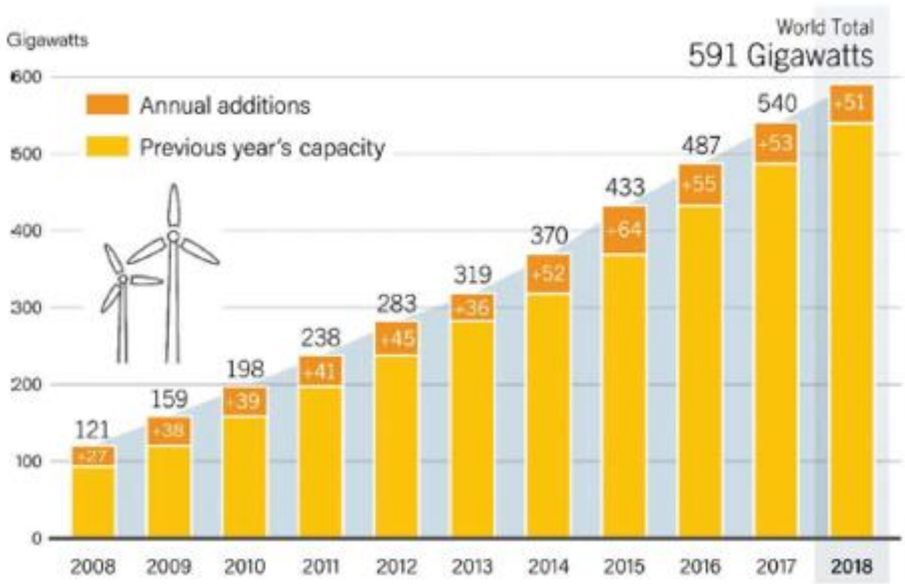

Figure 5 global wind power capacity

[34] This study mostly concentrates on job opportunities that can be gained from wind power plants and sectors related to this sector. Its data is mainly compared with European countries and pioneers in this sector. It is predicted that 12 GW will be added to the Middle East wind power capacity between 2018 and 2027. Saudi Arabia, Iran, and Jordan would be the leaders of wind capacity growth in the Middle East region, and 70 percent of the capacity growth will be installed in these countries (Stankiewicz 2018), which can be seen in figure 2. Usually, 144420 person-day will be required to develop a 50 MW wind farm. Table 1 illustrates the collected data of 7 wind power plants in Iran, which had precise and information.

In this paper [35], the potential renewable energies were studied through 3 strategies in which the third one seems to be the most rational. Alongside the usage of renewable energies, pollution and water shortage also were taken into consideration. Statistics show that fossil resources generate 98% of the energy demand in Iran. As can be seen from figure 1, energy consumption until 2050 is expected to increase by five times. In table 3, solar and wind potential in Iran's province are shown. Geothermal, hydropower, and biomass energies are also investigated, but only solar and wind technologies are chosen. For storage systems, batteries were preferred rather than dams due to the problems mentioned above of water shortage in Iran.

Table 5 solar potential power in Iran's province

Province Name	Area (km^2)	Percent of Usable Area	Usable Area (km^2)	Annual Average Irradiation (kWh/m^2)	Absorbed Energy by the Panels (TWh)	Electricity Produced With 15% Efficiency (TWh)	Produced Power (MW)
Kerman	183,193	0.1%	183	2000	366	55	15057
Sistan & Balouchestan	181,785	0.1	182	2200	400	60	16435
Southern Khorasan	140,634	0.1	141	2100	295	44	12137
Fars	122,608	0.1	123	2100	257	39	10581

Table 7 wind potential power in Iran's Province

	Installable Capacity in Each Province (MW)			
Province	Wind Class 1	Wind Class 2	Wind Class 3	Sum of Capacity (MW)
Eastern Azerbaijan	0	50	700	750
Western Azerbaijan	0	10	400	410
Ardebil	0	0	100	100
Kordestan	0	0	150	150
Zanjan	0	10	350	360
Gilan	200	250	650	1100
Qazvin	0	100	1500	1600
Hamedan	0	0	250	250
Alborz	0	0	200	200
Markazi	0	0	500	500
Qom	0	0	100	100
Lorestan	0	0	20	20
Kermanshah	0	0	250	250
Ilam	0	20	1000	1020
Khouzestan	0	0	600	600
Boushehr	0	0	300	300
Isfahan	0	0	200	200
Yazd	0	0	500	500
Fars	0	0	950	950
Kerman	500	350	2000	2850
Hormozgan	0	0	250	250

In this article [36], a one-axis tracker PV power plant with10 MW capacity in 2 provinces of Iran located in the southeastern part of it was investigated. Ten cities were chosen and 6 factors including LCOE (level cost of energy), IRR (internal rate of return), PP (payback period), CF (capacity factor), annual electricity production-c ratio (benefit-cost) and GHG (greenhouse gas) reduction were studied, by using RET screen software. The usage of the one-axis system increased the capacity factor of the power plant by 33%.as can be seen from Table 3, among all selected cities, JASK port is the best place to be chosen regarding all factors.

As solar energy is the most abundant type of renewable energy, its proper usage is essential to be considered [37]. This article studies exergoeconomic and exergoenviornmental maps to take all factors into consideration better. At first, some useful refereeing is mentioned, such as ALAMDARI [15] and BESARATI [16] (introduction part). Alongside irradiation, there are some other factors to be taken into consideration, such as ambient temperature, wind speed, soiling, and so on, which neglecting them may lead to misunderstanding in solar plant's proper placement. In this study, a 100KW solar power plant is simulated by PVsyst software. Through figures 2-10, all the above-mentioned factors are investigated, and six significant conclusions are found, which show how all elements are needed to be gathered together so that a more rational approach can be achieved.

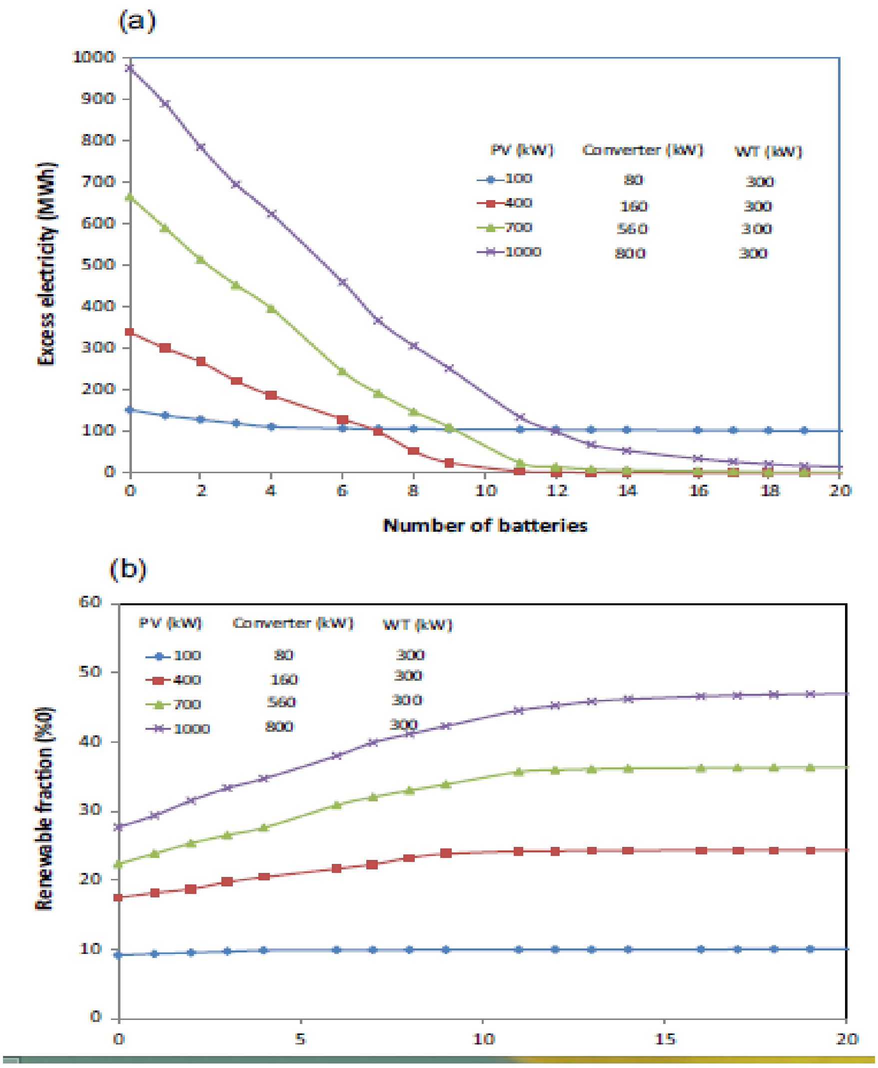

Figure 6 Impact of adding batteries to off-gird systems on (a) excess electricity, (b) renewable fraction

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Conclusion

Iran is a rich country in terms of solar and wind energy. In some villages in Iran, there is no electricity. The best way to generate electricity in these areas is to use solar energy. This paper is a brief study of previous articles on electricity generation using solar and wind energy.

Table 55 summarizes the results of these articles.

Table

Ref	Year	Type of energy	Result(s)
Firozjaei, H. K et al.[32]	2020	solar	1) Across the country solar radiation varies from 380 to 578 wm^{-2}. 2) Based on the both governmental and current study of feed-in tariff, ARDEBIL and KOHKILUYEH AND BOYER-AHMAD are the riskiest and best places for solar projects. 3) During the last three years, through adopting new supportive policies, the capacity of fewer than five megawatts in 2015 has been increased to more than 45 MW in 2018.
Golara Ghasemia et al. [33]	2019	Solar	1)The theoretical potential of solar energy generation in the best suitable area is about 49766TWh/year in the PV case and 37093TWh/year in the CSP case 2) The solar power potential of the best suitable area based on the technical method for estimating the solar energy was calculated and determined to be 8758TWh/year and 7419TWh/year for PV and CSP systems.
Mehdi Jahangiri et al. [34]	2019	Hybrid	1) Among all 103 studied stations, DARAB with 87% and JASK with100% usage were the highest and lowest usage of renewable energies. 2) Based on international standards, if average solar energy received daily is 3.5 kWh/m2, using solar energy is highly cost-effective. In Iran, this is more than 7 to 8 kWh/m2 in some areas and, on average, daily solar radiation is 4.5 kWh/ m2 (Jahangiri et al)
Teeka Sohrab et al. [35]	2019	wind	1). It is predicted that 12 GW will be added to the Middle East wind power capacity between 2018 and 2027. Saudi Arabia, Iran, and Jordan would be the leaders of wind capacity growth in the Middle East region, and 70 percent of the capacity growth will be installed in these countries (Stankiewicz 2018)

Alireza Tavana et al. [36]	2019	Hybrid	1) Iran is internally highly reliant on its non-renewable energy resources and Statistics show that 98% of the energy demand in Iran is generated by fossil resources. 2) In tables 3 and 5 solar and wind potential in Iran's province are shown (both so important).
Mahyar Mirzaei Omrani et al [37]	2019	Solar	1) In this article, a one-axis tracker PV power plant with10 MW capacity in 2 provinces of Iran located in southeastern part of it was investigated. 2) 10 cities were chosen and 6 factors including LCOE(level cost of energy),IRR(internal rate of return),PP(payback period),CF(capacity factor),annual electricity production-c ratio(benefit-cost) and GHG(greenhouse gas)reduction were studied, aided by RET screen software. 3) Among all selected cities JASK port is the best place to be chosen regarding all factors.
Ehsan Rahnamaa et al [38]	2019	Solar	1) Alongside irradiation, there are some other factors to be taken into consideration such as ambient temperature, wind speed, soiling and so on which neglecting them may lead to misunderstand in solar plants proper placement. 2) The central, south, southeast, and some west parts of Iran are the most exergoeconomically and exergoenvironmentally suitable locations for implementing photovoltaic power fields in that country.
Mehdi Baneshi and Farhad Hadianfard [39]	2016	Hybrid	1) Results show that for off-grid systems the cost of electricity (COE) and the renewable fraction of 9.3–12.6 ₵/kWh and 0–43.9%, respectively, are achieved with photovoltaic (PV) panel, wind turbine, and battery sizes of 0–1000 kW, 0–600 kW, and 1300 kWh, respectively' and for on-grid system these numbers were 5.7-8.4 and 0-53%.
Farivar Fazelpour et al [22]	2014	Hybrid	With five common 20 kW wind turbines, one 600 kW diesel generator, and 35 batteries, the wind-diesel-battery hybrid device has a gross NPC of $7.236,000 and a COE of $0.318/kWh. The combined PV-diesel battery system with a 100 kW PV module, a 600 kW diesel generator and 35 batteries has a gross NPC of $7,429,000 and a COE of $0.326/kWh.

			With a 100 kW PV array, two common 20 kW wind t urbines, one 600 kW diesel generator and 35 batterie s, the PV-wind-diesel- battery hybrid system has a cumulative NPC of $7,45 4,000 and a COE of $0.327/kWh.
Dawud Fadai [23]	2005	Hybrid	Based on the country's total electricity production in 2001; Just 8.9% of the power generated by renewable energ y resources was derived primarily as hydroelectric po wer (8%), i.e. the share of other energy sources such as solar, wind, etc
Ali Razmjoo et al [24]	2017	Hybrid	In Qom the maximum daily 27 kW generation of electricity will be in July and the minimum daily 3 kW generation of electricity will be in December. In Yazd the average regular electricity production of 25 kW will be reached in July and in November it will fall to its normal minimum output of 7 kW.
Mostafa REZAEI et al [25]	2019	Hybrid	Manjil and Zahedan with annual densities of wind an d solar energy of 6004 (kWh / m2) and 2247 (kWh / m2), respectively, have the maximum volume of elec tricity among the other cities. 91 kg/ d of hydrogen, which provides 91 car / week e lectricity, can be generated in Manjil and will save ar ound 1347 L of gasoline a week. In Zahedan, 20 kg / d of hydrogen can be produced, e nough for 20 cars per week, and 296 L of petrol can be saved.
Mehdi Jahangiri et al [26]	2019	Hybrid	The lowest and highest percentages of renewable energy usage were registered in Darab with 87 percent and 100 percent use of Jask stations. In comparison, a solar-diesel generator-battery system at Darab station at a price of $0.75/kWh and a wind-diesel generator-

			battery system at Bandarabbass station at a price of $0.586/kWh were correlated with the maximum and lowest price per kWh of the produced electricity.
A. Aghahosseini et al [27]	2017	Hybrid	The total levelized electricity costs decreased from € 45.3 to € 40.3/MWh by adding integration into the se ctor. The energy infrastructure focused on RE generation and energy storage technology covers the need for electricity in the country's power market, in the country-wide scenario. The estimated operating expense and the minimum sum expected to produce 377.7 TWh is € 15 and € 167, respectively. The combined scenario entails not just producing power but also desalination from SWRO and industrial SNG.
Vahid Aryanpura et al [28]	2019	Hybrid	-
Mojtaba Haratian et al [29]	2018	Hybrid	The first and most cost-effective option was found to be the PV-battery system, with 1.2kW PV arrays and 6-unit batteries each supplying 3 kW of ACCEPTED MANUSCRIPT 16 for a combined NPC of $8.173 and a COE of $0.546/kWh. To satisfy the electric demand in a safe way, the second ideal option, which consisted of a wind / PV / battery network of 1.6 kW PV racks, a 0.5 kW wind turbine and 4 3 kW battery modules. Nevertheless, relative to PV-battery system, it will raise the overall NPC and COE by 10 per cent and 20 per cent respectively.
Golara Ghasemi et al [30]	2019	Hybrid	The solar power capacity of the best fit region was estimated and decided to be 8758 TWh / year and 7419 TWh / year for PV and CSP systems based on the scientific framework for estimating the solar energy.

			The option of solar photovoltaic farm provides a strong potential in meeting the market for electricity relative to solar CSP plants.
Ali Mostafaeipour et al [31]	2013	Wind	The results show that the average wind and wind po wer corresponds to 106,525 W / m2 and 933,159 kW h / m2 in 2003, whereas the lowest figures are 72,777 W / m2 and 637,527 kWh / m2 respectively in 2006. The minimum energy cost is achieved using Proven 2.5 kW which is equivalent to 0.1225 $/kWh and 0.1187 $/kWh, respectively, at hub heights of 20 m and 30 m. On the other hand, Bergey XL.1 kW achieves the maximum energy efficiency. The energy costs at 20 and 30 m hub heights for this wind turbine model are 0.3059 $/kWh and 0.2967 $/kWh, respectively. The Bergey Excel-R model with a rated power of 7.5 kW produces the l argest amount of electricity, while the Tested 2.5 kW model is the most economical model for wind turbin es.

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