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Feasibility Construction of a 4 MW PV Power Plant to Provide Sustainable Electricity to Bandar Abbas Industrial Estate

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Abstract

The upward increases in electricity consumption in the last decade and excessive use of electricity in these years have challenged the electricity industry and related industries. The blackout caused by this increase in consumption leads to losses for manufacturing companies and workshops. The location of Hormozgan province has created this mentality for researchers that due to high humidity and dust, it is not possible to use PV power plants. The possibility of installing a 4 MW PV power plant in Industrial Estate No 2, has been investigated, and the simulation results with PVSol, PVSyst, and RETScreen software have shown that the location is a suitable place to install the power plant, and there is a possibility of obtaining suitable energy and supporting the industrial estate. In the selected position, it is possible to get suitable solar energy for more than eight months of the year, and solar energy could be used for more than 10 hours a day. The output of the simulations also showed that the construction of the PV power plant in this location with a performance factor of 0.7 and an average output power of 3.2 MW would be good efficiency. Since the hours of solar energy production correspond to the electricity peak hours of consumption, the PV power plant can be used as a suitable alternative for producing stable electricity and preventing power outages during peak hours of production units and factories. The use and comparison between south-facing panels and delta wing and the use of these types of equipment in the hot and humid climatic conditions of Hormozgan province have been done for the first time in this research.

Keywords: Computer Simulation, PVSol, PVSyst, Renewable Power Plant, Solar Energy, Sustainable Electricity

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1. Introduction

Considering that energy is one of the determining indicators in economic development, the development and optimization of renewable energy can play an effective role in economic growth and protection of environmental conditions. They point to the policies that ultimately determine the priority and necessity of using some of them for the country and explain why and how to use them. Using solar energy to supply hot water to homes and industrial centers is one of the most cost-effective ways to use solar energy in oil-burning villages in Iran. For scattered users far from the grid who need relatively little power, photovoltaic is almost a competitive or low-cost technology. Photovoltaic has a strong and modular structure and requires little

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maintenance, and is, so, very suitable for remote rural users. For older users, it seems best to hybridize with wind or fossil fuels [1]. The importance of electricity in the production and economy of Iran comes from the fact that the electricity industry has a high value in the national economy and provides economic and social welfare to countries, and is one of several great infrastructure industries. Especially in industries, electricity has a particular grade because, in most cases, electricity drives the machinery of factories and makes all operations and production activities possible, and for this reason, some experts have considered the electricity industry as the mother of industries. The optimum time for a preventive replacement of renewable energy devices varies from one geographical location to another because each geographical location has its climatic fluctuations. The higher the occurrence of climatic fluctuations in a geographical location, the shorter the optimal time for preventive replacement of the device. The higher the average occurrence of climatic fluctuations, and as a result, the greater the optimal time for the protective replacement of the device. It was also indicated that the better the industrial qualifications (that is, a greater tolerance limit for the device), the greater the optimal time for a preventive replacement for the device. Therefore, companies that export these devices must study the geographical location where the device is exported and the climate in which it is distinguished to develop plans and programs to protect the device [2]. One of the major challenges faced in photovoltaic technology is the ability to harvest as much energy as possible from the sun. The peculiarity in geographic location and the sun’s movement has made it hard to get maximum irradiation from the sun. [3].

Based on research by Khazaee et al, most Asian countries have the capacity for renewable energy, including solar, hydro, wind, etc. Asian countries are geographically placed in an area with various climatic circumstances including tropical, and humid. Hence, easy access is provided to various renewable energy sources. Studying the years 2000 to 2019 comprehensively, the results revealed that China, India, and Japan had the most renewable energy capacity in Asia with 790000 MW, 133000 MW, and 120000 MW in 2019 respectively. Also, the energy produced by renewable energy for these countries in 2019 was 1739400 GWH, 288622 GWH, and 190587 GWH respectively [4]. The use of renewable energy in residential buildings has main environmental and social effects. Noorollahi et al researched energy consumption in buildings. According to this research, 89% of thermal demand in the building section of Iran is supplied by natural gas, but it can be used more in the current industrial infrastructure if renewable resources supply buildings' thermal demand. Different scenarios were discussed for this research by considering the amounts of CO_2 emission and total energy cost. The results showed all procedures led to CO_2 emissions reduction due to reducing natural gas consumption. Based on the results, using solar thermal collectors decreased the average total cost by about 13%. In conclusion, considering the current national natural gas distribution network in Iran, using solar thermal collectors was the best alternative solution [5]. Reducing greenhouse gas (GHG) emissions-induced environmental hazards is one of the most important goals of future research on the energy economy and the environment. This study aims of Pourarshad et al, to visualize emissions from electricity generation in Khuzestan province, southern Iran. Khuzestan's electricity supply and demand system was simulated and examined under green scenarios till 2050 by assessing the existing situation and choosing a suitable low-carbon energy system for the future. One of the results of this research is to reduce emissions in terms of energy management strategies in the short term and the ineffectiveness of development strategies regardless of consumption management strategies. Electricity supply optimization scenarios are attractive in the long term, which indicates the costly implementation of development strategies. Combining solutions to balance the energy economy and environment is more effective. The OKEP scenario as a combination of consumption management and development strategies showed that it would maintain its positive impact in the short and long term and successfully reduce emissions. In this scenario, the net present value (NPV) attractiveness is over $ 6706 million and saves the emission of 179 MtCO2e. Compared to the business as usual (BAU) scenario, more than 90 Bm3NGe savings and a 3.62% increase in renewables share are other benefits of this scenario [6]. Similar research was also done in Poland on the effect of building and using photovoltaic renewable power plants on the reduction of harmful gas production by Lew et al. Poland is one of the European leaders in photovoltaic development, and according to estimates for 2021–2025, it will continue to be. The results obtained from the survey allowed us to draw conclusions, which include the following: (1) a lack of general conviction of respondents about the effectiveness of Poland’s decarbonization policy on reducing global CO_2 emissions, especially among those who show a higher willingness to use PV installations, (2) the willingness to use PV installations is motivated by rather than environmental benefits, (3) the need for more widespread public campaigns aimed at promoting the benefits of decarbonization and renewable energy sources, and (4) the finding that the respondent's region of residence (with a different degree of insolation) mattered for the willingness to use PV installations [7].

Also, in another research in Turkey and a climate similar to the climate of southern Iran with high humidity, the variable albedo effects on bi-facial PVs in different ground conditions were examined. The results were compared with monofacial PV panels in the same conditions for the Konya region. Bifacial PV panels were analyzed under white, sand, and asphalt ground conditions. Simulations were made by the PVsyst program, and the results were compared by global radiation value, the performance ratio (PR), and the produced energy results. An capacity of 54,6 kWp bifacial and monofacial installed PV panels with a horizontal angle of 35°, azimuth angle of 0°, and 6m intervals for roof installation is considered [8].

Climatic conditions are a very effective factor in the construction of photovoltaic power plants. according to this in colombia, Narvaez and et al present the first study of the long-term climate-change impact on photovoltaic power potential in Nariño, Colombia. Their results suggest that changes in photovoltaic power potential, by the end of the century, will have a maximum decrease of around 2.49% in the central zone of Nariño, with some non-affected areas, and a maximum increase of 2.52% on the south eastern side with respect to the pessimistic climate change scenario [9]. Ibrahim and et al monitor the trend of extreme temperature and analyze its impact on solar power plants in Malaysia. The basic energy parameters of the solar photovoltaic module are calculated to find out the relationship between ambient temperature and power generated. It is found that the output power of the solar photovoltaic module is reduced about 0.3 to 0.5 % for every 1 °C ambient temperature increases [10]. Although research in hot and dry climates has shown that a portion of this power can be used to cool solar panels through various means to keep their efficiency high, such as running air fans or running pumps to cool them with coolant [11].

In new research Considering Iran's potential in the field of solar energy and the country's need for this type of energy, it is necessary to locate and identify suitable sites for the use of solar energy. In this research, the potential of generating power from solar energy on the ocean coasts of south-eastern Iran has been investigated. The geographical data of the solar radiation map of Iran was used to estimate the power of electrical energy from spatial limiting criteria for the feasibility of installing photovoltaic panels at the power plant scale. The total power of electricity that can be extracted from suitable places in the region was calculated, which shows the high potential of the south-eastern coast of Iran in benefiting from renewable energy, which can be a driving force for the industrial, economic, and social development of the Makran region. Calculations show that only with the construction of photovoltaic power plants with a total capacity of 3,000 megawatts in the study area, which covers only about half a percent of very good land, the total electricity generated by the current power plants in Sistan and Baluchestan can be replaced the year 2016. This is a good indication of the high potential of solar energy in the Makran region, which has been neglected so far [12]. In similar studies with the southern climate of Iran, acceptable results have been obtained from the use of renewable solar energy. In the analysis for Chandigarh in India, a 100-kW photovoltaic plant is analyzed for the selected area with different PV panel combinations for finding the optimal solution for power generation. This selected area is having a good solar radiation reception potential of 5.07 $kWh/m^2/day$ annually at an annual 25.4°C temperature. The plant is designed with fixed axis orientation and has a tilt of 31°. The plant has the potential to export 156120 kWh of electricity to the grid with a performance ratio of 76% [13].

The importance of using solar energy in the Persian Gulf countries is well understood. Despite the existence of abundant oil and gas resources, the countries of the Persian Gulf have made appropriate investments in this area and have long-term plans. Now all GCC countries had conducted, relatively, large project in solar and wind energy, especially Kuwait (currently about 70MW among a plan of 2000MW by 2030), UAE (currently about 300MWamong a plan of 2500MWby 2030) and Saudi Arabia (with an ambitious renewable energy target of 3450MW by 2020 with a further 6000GW envisioned by 2023 and to 200 000MW by 2030) [14].

The use of PV in setting up industries and workshops is increasing rapidly today. Kim and et al study, a comparative economic analysis was conducted for typical greenhouses, plant factories with natural and artificial light, and those with only artificial light, based on the insulation, artificial light, and photovoltaic (PV) installation costs. the case of the installed PV systems exhibited large reductions, of 424% and 340%, in terms of primary energyconsumption and GHG emissions, respectively [15]. Bangladesh has a considerable number of large manufacturing plants with appropriate roofs that could be used for deploying solar energy conversion systems at scale. Talut and et al, in Bangladesh presented which identified and assessed 6045 such plants, which have roof areas ranging from 100 m^2 to 50,000 m^2, and modelled the deployment of solar photovoltaic (PV) technology that can provide power through site available grid infrastructure. The results showed that around 7.4 GWp of PV capacity can be achieved on such roofs with a corresponding annual electricity generation of 11 TWh [16]. Desai and et al To overcome the problem of continuous grid supply of electricity and diesel generator sets, solar based refrigeration system for milk cooling at society level is quiet feasible. The results showed Use of solar energy has great scope for its commercial use in the dairy processing operations as well as to design and develop solar based refrigeration systems for dairy industry [17]. Solar energy has also been used to run mining equipment. The copper mineral processing industry faces complex scenarios with increased demand, highly variable energy prices, falling ore grades that increase energy consumption, and increasing concern about the industry’s carbon footprint. To reduce the risk imposed by these scenarios, the industry is looking at the use of renewable energy sources. Behar and et al investegated use of solar thermal and solar photovoltaic technologies to produce power and heat for the copper mining processes. Results showed the use of solar energy in the copper mineral processing industry could solve present energy-related problems particularly GHG emissions. To fully utilize the solar potential, toward all-solar-powered mining industry in Chile, innovative and cost-optimized processes and operations should be introduced [18]. Farjana and et al, investigated this issue in lead mines. Comparative analysis among seven miner countries is conducted by considering a few cases based on solar industrial process heating system design. The analysis results showed that buffer tank system with solar loop heat exchanger but without flow heater would be the most beneficial in terms of solar fraction, emission reduction, and annual fuel savings. These results showed that evacuated tube collector installation in the industrial processes would be the most beneficial irrespective of the cost of solar energy [19]. Site selection to build a renewable solar power plant and going through this process helps to optimize the final result and reduce costs. Researchers and scientists in institutes and research centers around the world mainly used a combination of AHP, WLC, and IDW methods in a GIS environment[20-24].

The geographical location and weather conditions of Hormozgan province, in the south of Iran, are such that the supply of sustainable water and electricity for domestic, agricultural, commercial, and production purposes have been one of the constant challenges for the managers of Hormozgan province. Every year, especially in recent years, as the hot season begins, the concern about the lack of electricity, followed by widespread blackouts throughout the country, is intensified. This issue has become an important challenge, especially in the first six months of every year, when the temperature rises rapidly, the annual decisions in this matter mainly push the priority of consumption to the home consumers. It causes scheduled or unplanned interruptions for industries and makes their production difficult. Based on the specific conditions of production costs, the price of subscribers increases by 20% in the summer. The problem of not providing stable electricity in industries, in addition to creating costs on production and the final product, will lead to a delay in delivering products to customers and as a result losing a part of the market.

Due to the noticeable increase in temperature in the first six months of the year in Hormozgan province, the conditions for using electricity for government executive bodies, organizations, and industries have become stricter and are subject to blackouts, most of which are during peak consumption hours, it is from 13:00 to 17:00. The great heavy industries of Hormozgan province, especially in the metal field, are located in the west of Bandar Abbas city and the special economic zone of the Persian Gulf, mining and metal industries, which use very high energy due to their type of work. Other industries, and workshops are in 15 industrial estates. Seven industrial areas are located throughout the province. One of the ways to use stable and separate electricity from the national grid for production units in these industrial estates is to use renewable energy, especially solar energy. Due to the view that the climate of the province has high humidity and dusty conditions, the use of solar energy in Hormozgan province is not well-understood, but the results of different research have shown that solar cells in tropical regions also have an acceptable performance [25]. Many people's idea of solar energy is focused on turning on traffic lights or weak electricity generation from it. Because they think that since electricity is produced by sunlight, it cannot have enough power to supply large power. It is possible to produce up to megawatts of electricity through solar panels, and make it ready to be used for various purposes or to contribute to national electricity. Supplying three-phase electricity through solar energy or battery banks can be a solution for many industries that are either unable to supply electricity from the national grid or their required power exceeds the maximum power of the grid. In this research, as a pilot, the possibility of generating electricity from a solar power plant near Bandar Abbas Industrial Estate No 2 has been investigated, and its results have been presented.

2. Materials and Methods

The method used in this research started with the preliminary study of similar articles and experiences in the energy field. Considering that energy is needed for industries and workshops, based on that, the land required for the power plant needed and the amount of consumption have been determined. The climatic conditions and weather of the region as well as the radiation in the region have been investigated. These data are taken from meteorological databases, articles as well as international online databases. Based on the relevant standards and technical and legal requirements, a suitable place for the construction of the photovoltaic power plant has been located. After determining the amount of electricity consumed, the site selection for the construction and simulation of the solar power plant has been determined. This location is based on technical requirements using the site selection feature in ArcGis software. The capability of this software and entering appropriate data to choose the location is the appropriate capability of this software. After determining the required energy consumption and suitable location, a simulation has been done using the software. Finally, the effects and environmental results of the construction of this photovoltaic power plant have been calculated by the RETScreen software. Since the analysis of statistical results is important, the results have been analyzed using the hypothesis test using the Minitab software.

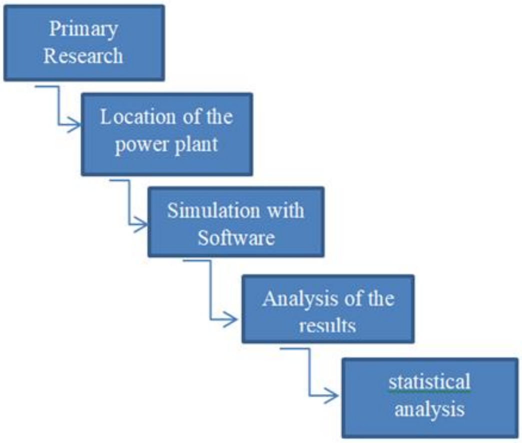


Figure 1. Schematic of the research method

2.1. ESTIMATING THE AMOUNT OF ELECTRICITY CONSUMPTION IN THE PILOT LOCATION

Bandar Abbas Industrial Estate No 2 is located on an area of about 70 hectares, 20 km from Bandar Abbas city and in the position 27.20 N longitude and 56.20 E latitude in the north of this city (Figure 2). This industrial estate has 20 factory units and workshops. Of these 11 units are generally working permanently and other workshops and units are seasonal and temporary. According to the statistics obtained from the Hormozgan Electrical Company as well as the industrial settlements company, according to the size of the area, the electricity requirement of this place to run the units and provide lighting and other related services is on average about 3 MW. Of course, the amount of consumption is higher in the hot seasons of the year, and the main challenge is to provide stable electricity in these seasons.

Figure 2. The location of the industrial Estate and surrounding lands

2.2. DETERMINIG THE INSTALLATION LOCATION OF PV POWER PLANT

To construct a PV power plant, two plots of flat area in the east of the industrial estate with an area of 5 hectares and west of it with an area of 10 hectares were considered and selected to investigate other effective factors. The weather information of the region obtained from international climatological authorities shows that the proposed location has suitable conditions for temperature, radiation, pollution, and reflection coefficient throughout the year (Table 1) [26,27].

Table 1. Environmental conditions of the study area

	GolbHor KWh/m^2	DiffHor KWh/m^2	T_amb ºC	Globinc KWh/m^2	GlobEff kWh/m^2
January	125.5	35.9	17.23	183.6	172.4
February	122.4	56.5	19.41	153.5	142.1
March	157.7	80.1	23.05	175.4	160.4
April	183.1	85.0	27.28	184.8	170.3
May	215.5	92.1	31.97	199.3	184.2
June	216.1	97.5	33.81	192.3	177.5
July	207.7	102.6	34.92	188.8	174.2
August	191.8	99.5	34.36	186.7	172.3
September	172.9	74.4	32.14	186.7	171.8
October	160.3	56.0	29.73	198.7	183.0
November	128.3	37.9	23.64	179.6	169.1
December	115.4	35.0	19.00	172.7	162.6
Year	1996.6	825.3	27.26	2202.2	2039.8

The study and field visit of two pieces of land, east, and west, near the industrial estate, have almost the same topography conditions. Due to the absence of tall or low-rise buildings in the area, the shading effect on the installed panels due to the topography is zero. After estimating the soil samples, standard penetration test, triaxial resistance, direct cutting, hydrometry, and granulation tests were performed on the samples [28, 29]. According to the results of the tests, the ground in this area is of hard soil type and therefore it has suitable conditions for installing the base structure of the panels and making them stable. The soil in the area will have the necessary strength, and in case of a strong storm, the pollution of soil and sand is low [25,30]. In terms of access to the industrial town as well as the national electricity network, the location of the western flat land has more suitable conditions, and therefore this land was chosen as a pilot site for the installation of equipment.

Figure 3. The open areas selected for the installation of the PV power plant in (a) east and (b) west of the industrial estate

Another point about this part of the selected lands is the lack of cultivation capability due to their soil type, and therefore, in terms of environmental permits, and government organizations, this place will not have any problems. Using ArcGIS software, the location of the land and its area has been calculated. After Geo referencing the plot of land, its exact location and topology status were examined .

Also, according to the topological map, the western land is far from the plain, and the probability of the area getting waterlogged due to seasonal rains is less than the eastern part [27,28]. In the final stage of determining the location of the power plant, the DEM[a] data of the area was collected. After that, this data is drawn by Global mapper software. The result of this data mining showed that the height of the area is higher than the surrounding areas. As a result, in case of rain or flood, this area will not be affected by them (Figure 4).

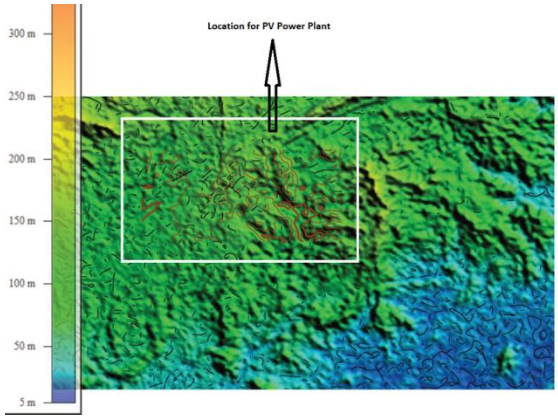


Figure 4. The topography of the west area location

2.3. CLIMATE AND SUN PATH OF LOCATION OF PV INSTALL

Examining the path of the sun from scientific and international sources [31], showed that the selected geographical location has a good conditions in terms of the time of effective radiation and the amount of radiation (Figure 5). Also, the amount of radiation and the environmental conditions of the installation location have a considerable amount of direct and return radiation (Figure 6).

According to climatological calculations, in terms of average solar energy, the location of Bandar Abbas Industrial estate No 2 has a good condition (Figure 6). The average amount of solar radiation energy is 1729.5 Kwh/m^2. The clear sky and direct sunlight as a divine gift for Hormozgan province is a necessity to exploit in the production of cheap wealth in the form of setting up solar energy panels. Because, producing electricity with sunlight reduces people's costs. Between 340 and 350 days a year, Hormozgan province has the best capacity to use clean and pollution-free energy from the sun and produce electricity from this energy source, which is one of the unique capacities of this southern region in the country and even the world. The use of new and clean energies such as solar energy in provinces like Hormozgan, where 95% of the days of the year benefit from the blessing of sunlight, can also be an inspiring and income-generating event for people, especially those in need.

[a] Digital Elevation Model

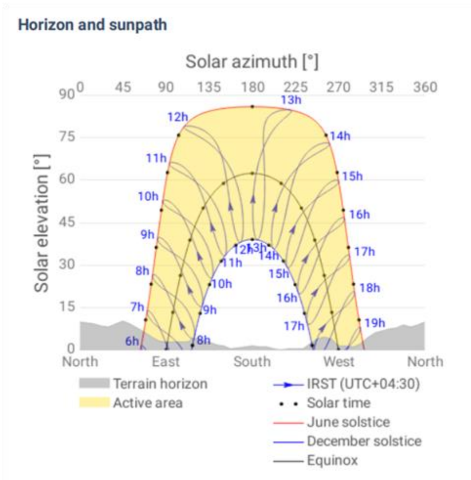


Figure 5. The sun path during the year in the desired position to install the equipment of PV power plant

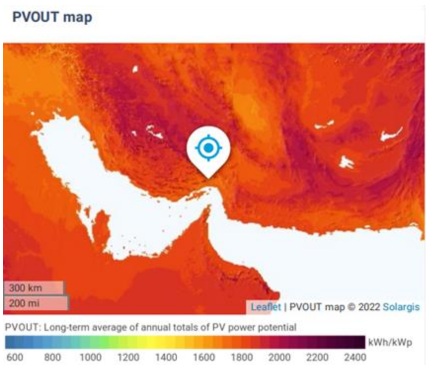


Figure 6. Average annual PV power potential in industrial estate location [31]

The windrose of Bandar Abbas station is shown in Figure 7. The prevailing wind in this station is south, then the south-southwest, north, and north-northeast directions have the highest frequency of the wind. The speed is greater than 12 m/s only in the south direction and with negligible frequency. In most directions, the wind speed is lower than 10 m/s. The northwest direction has the lowest frequency [32]. From the south to the northwest, the wind frequency has a decreasing trend, then it increases to the north, and after it has a decreasing trend to the east. In Figure 6, the monthly winds of Bandar Abbas station are presented for comparison. In this figure, it can be seen that the prevailing wind direction is south in all months except for December and January. In the two mentioned months, the prevailing wind direction is north since mid-winter. Speed over 10 m/s starts from the south and continues until the beginning of autumn. The highest frequency in these months is related to the speed range. It is 6-10 m/s, which blows from the south. The western winds have weakened since the middle of spring and until the end of autumn, almost no wind blows to the Bandar Abbas area. The general trend of changes in the different speeds is almost the same in different seasons of the year. The difference is that the speed values decrease a little from early spring and increase a little from October onwards. Speeds over 4 m/s have a probability of 50% in different months [32].

In winter, systematic westerly winds, whose directions have become southwesterly winds following the coastline and the mountains aligned with it, and have been weakened by the effect of the mountains, in the daytime, combined with sea breezes, have created dominant southerly and southwesterly winds in Bandar Abbas. The north and northeast winds in this season are caused by the rule of the Siberian cold high-pressure system over this region and in this season, but these winds are weak during the day due to the direction opposite to the daily breeze and strengthen at night due to the alignment with the night breeze. As a result, what has appeared as the prevailing wind in this season in windrose is completely the land and sea breeze intensified by the mountains behind this region [33].

Figure 7. Average Monthly windrose Bandar Abbas from the synoptic station [30]

2.4. MODELING THROUGH SOFTWARE

After obtaining the initial field data and determining the appropriate location for installing the said power plant, PVsyst and PVsol software were used to simulate 4 MW PV. PVsol software has high power in 3D simulation and it is possible to obtain suitable output data from it. Also, to ensure the output results and data control, PVsyst software has been used. To simulate, 550 Watt panels were used in two rows and 50 panels in each row. To reduce the design costs, fixed angle panels, and 24 degrees angles were placed on the ground. The determined angle after monitoring the software and finding the optimal angle corresponding to the latitude of the installation location, which leads to the best output performance of the power plant, is selected and determined in the software input. To prevent the panels from shading each other and according to the height of the panels, the appropriate distance between the panels was determined using equation (1) of about 6 meters [29].

$$\beta_N = L - \delta \quad (1)$$

Where L is the Azimuth, is the δ height angle and β_N is the tilt angle of the sun to the latitude of the region. Hofmann algorithm is used for diffuse radiation [34]:

$$E_{clear} = 0.78 E_{ext} \ \sin(\gamma_S)^{1.15} \quad (2)$$

Where γ_S elevation of the sun and Eext is the extra-terrestrial irradiation. The Hey&Davies algorithm for radiation equations on inclined surfaces. An anisotropy index, A_i, is defined is [35]:

$$A_i = \frac{DNI}{E_a} \quad (3)$$

Where DNI is the direct normal irradiance and E_a is extraterrestrial radiation.

Regarding the power of the panel, the inverter used to produce 4 MW power, both softwares suggested the number of 8000 panels. The 3-phase electricity production and the power output of the power plant were estimated to be about 2.3 MW based on the simulation. To increase the efficiency of the process, the used panels are of single crystal type and have an efficiency of 21.29 and consist of 144 cells, a filling factor of 78.74%, and 50 KW inverters.

The advantage of Iran and especially the southern provinces is the existence of vast lands for building solar power plants, but it should be noted that the optimization of the area required for the installation of equipment, their control and monitoring will make it easier, and will lead to the reduction of other current costs. Based on the simulation, the amount of land required for this power plant is around 20000 square meters. This is the amount of area used in the case of fixed south-facing angle panels.

Due to the same initial conditions and the use of similar panels and inverters, the output of PVsyst and PVsol software were similar and did not differ statistically. According to the prepared outputs, in another simulation using the same panel and inverter, the efficiency of the power plant in the east-west delta installation has been entered, and the calculations have been checked. In this case, the installation angle is 25 degrees and simulation algorithms, the Hofmann algorithm for diffuse radiation and the Hey&Davies algorithm were used [29]. The simulation output results show that 7500 panels are needed in this case, and in terms of the required land area, this amount is significantly reduced compared to the previous case and about 9700 square meters are needed. In terms of the performance ratio, there was no significant difference between the delta mode and the south mode, and both simulations were in the same working range. Tables 2 and 3 show the technical specifications of solar panels and inverters used in the simulation. To achieve acceptable results, it has been tried to use the highest quality panel and inverter in this simulation.

Table 2. Characteristic of solar panel at STC[b] [36]

Irradiance in W/m^2	200
MPP Voltage in V	40.2
MPP Current in A	2.66
Open Circuit Voltage in V	46

[b] Standard Test Conditions (STC)

Short-Circuit Current in A	2.8
Fill Factor in %	83.02
Relative Efficiency in %	97.19
Width in mm	1134
Height in mm	2279
Surface in m^2	2.58
Depth in mm	35
Output coefficient in %K	0.036
Maximum System Voltage in V	1500
Incident Angle Modifier (IAM) in %	98

Table 3. characteristics inverter at STC [36]

DC nominal output in kW	50
Max DC Power in kW	66
Nom DC Voltage in V	860
Max Input Voltage in V	1100
Max Input Current in A	90
AC Power Rating in kW	50
Max AC Power in kVA	50
Number of Phases	3
Min Feed in Power in W	250

3. Results & Discussion

The performance ratio is a parameter that can be used to obtain appropriate information about the performance of the solar power plant. Based on the results of the software simulation, the performance ratio in the case of south panels with a fixed base for all months of the year is 0.7 or more, which is considered a suitable ratio (Figure 8).

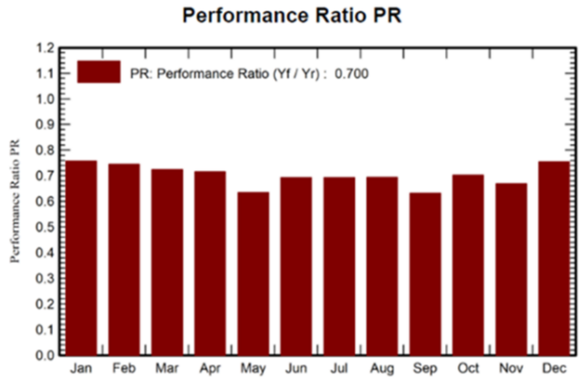


Figure 8. Performance ratio of the installed power plant during the year

For the final monitoring of the process, the simulation performed for the construction of the power plant was evaluated using RETScreen software [32]. Based on the output of the software, the average monthly direct radiation at the installation site is in the range of 120 to 170 kilowatt hours per square meter, which is a suitable value for the start-up and efficiency of the power plant (Figure 9).

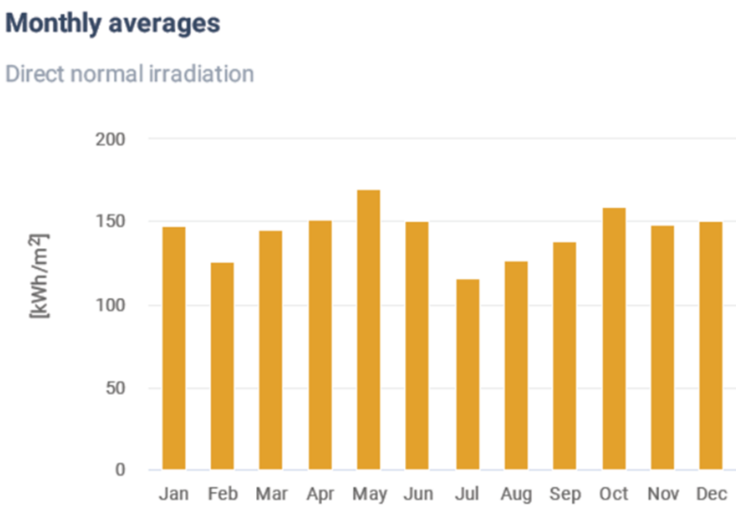


Figure 9. Average direct radiation in the installation position

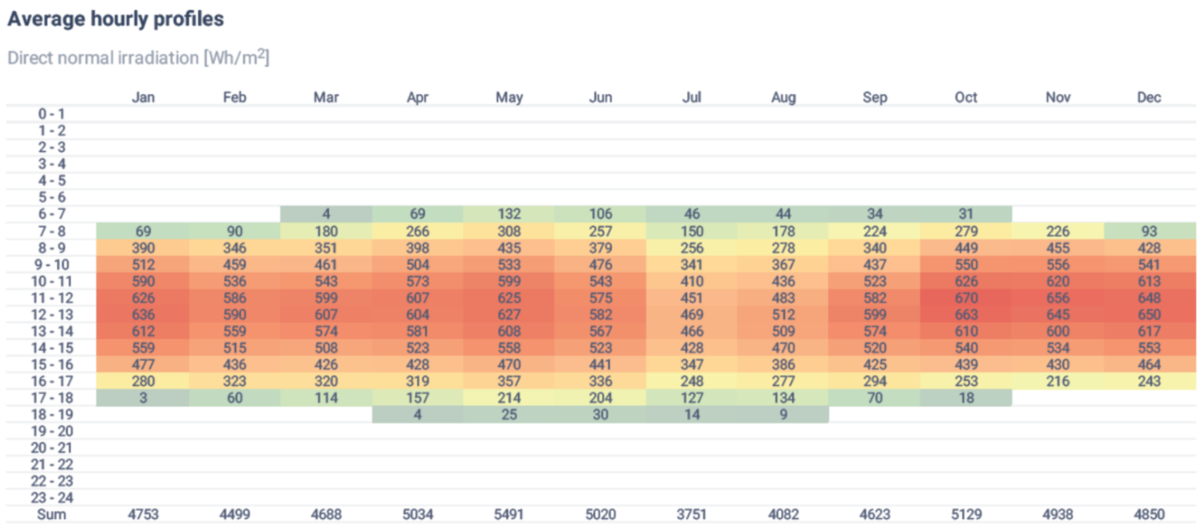
According to the output and monitoring of the amount of radiation at the site, it was possible to obtain energy from 6:00 AM to 7:00 PM for more than eight months of the radiation year in the installation site, but most of the radiation power in the year is between 8:00 AM and 5:00 PM (Figure 10). Considering that these hours are the peak time for electricity consumption, this is a suitable advantage for the power plant in question. According to the economic estimate made by the software, the investment return time for the installation of this power plant is in the fourth year, and as a result, after four years, the project investor will get a good profit.

In order to obtain the reduction of harmful greenhouse gases, the amount of energy produced by the 4 MW power plant is obtained and compared with the amount of fuel consumed in gas or diesel power plants that produce the same amount of energy a 4 MW. The amount of greenhouse gas produced from the diesel power plant is calculated and expressed as the prevention of greenhouse gas emissions due to the use of the solar power plant. The amount of greenhouse gases removed due to the construction and operation of the mentioned power plant is about 3500 tons (Table 4). Based on the guaranteed purchase price of renewable electricity, the amount of electricity produced by the 4 MW photovoltaic power plant can be calculated by multiplying the amount of electricity produced and the amount of money saved due to the construction and operation of this power plant (Table 4).

The results of the RETScreen environmental simulation have shown that the construction of this solar power plant will lead to a reduction in the production of more than 3500 tons of carbon dioxide. The continuation of the construction of this power plant will have a significant impact on reducing pollution for other industrial estates (Table 4).

Table 4. The amount of carbon dioxide decreased and the income from electricity production

Summary		
	Electriccity export revenue IRR	GHG emission reduction tCO_2
Proposed Case	108,378,851,430	3,499



Average hourly profiles

Direct normal irradiation [Wh/m²]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6												
6 - 7			4	69	132	106	46	44	34	31		
7 - 8	69	90	180	266	308	257	150	178	224	279	226	93
8 - 9	390	346	351	398	435	379	256	278	340	449	455	428
9 - 10	512	459	461	504	533	476	341	367	437	550	556	541
10 - 11	590	536	543	573	599	543	410	436	523	626	620	613
11 - 12	626	586	599	607	625	575	451	483	582	670	656	648
12 - 13	636	590	607	604	627	582	469	512	599	663	645	650
13 - 14	612	559	574	581	608	567	466	509	574	610	600	617
14 - 15	559	515	508	523	558	523	428	470	520	540	534	553
15 - 16	477	436	426	428	470	441	347	386	425	439	430	464
16 - 17	280	323	320	319	357	336	248	277	294	253	216	243
17 - 18	3	60	114	157	214	204	127	134	70	18		
18 - 19				4	25	30	14	9				
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	4753	4499	4688	5034	5491	5020	3751	4082	4623	5129	4938	4850

Figure 10. Average daily radiation per year

4. Conclusions

Based on the simulation results, it can be said that it is possible to install this power plant with suitable efficiency and output power of about 3 MW. Adequate radiation in the study area and relatively low rainfall in this area are the advantages of the desired location. The absence of local high-speed winds, as well as dust, makes this location a good place to install a power plant

Based on the output of the software, installing the panels of this power plant in the form of an east-west delta will be more cost-effective in terms of finance and also reduce the required surface area compared to the south-facing panel.

The results of the statistical test at the confidence level of 95% between the data output of PVSol and PVSyst software showed that there is no significant difference between the data of the output results, and both software achieved the same answers. The proposal of both soft wares for panel installation was Delta wing panels.

Considering that the purpose of installing and operating this power plant is to use it during peak consumption hours, especially in the hot seasons of the year and the first half of the year, the simulation output shows that the peak efficiency of this power plant is a suitable adaptation. It has peak consumption hours and will eventually help to prevent blackouts in the industrial town. Also, for more than 8 months of the year in this place, it is possible to use this power plant for more than 12 hours, which is also a good advantage for the proposed location. The use of this amount of renewable solar energy in the location of this industrial town will have a significant impact on reducing the amount of pollution. Also, if panels are installed on the roofs of the buildings and sheds in this industrial town, it is possible to obtain the energy needed for current purposes such as lighting, running cooling devices, and security and camera systems. Etc. and this process will also prevent disruptions in the current processes of companies and workshops in the event of a power outage.

The most important challenge and limitation in this research have been the justification of the government to establish renewable systems. Considering the climatic conditions of the southern region of Iran, verifying this research and justifying government managers' investments in the renewable energy sector is a difficult task.

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Nomenclature

L	Azimuth
δ	height angle
β_N	tilt angle
Ea	extra-terrestrial radiation.
Eext	extra-terrestrial irradiation.
γ_S	Elevation the sun
A_i	anisotropy index
AHP	Analytical Hierarchy Process
IDW	Inverse Distance Weighting
WLC	Weighted Linear Combination
DNI	direct normal irradiance
DEM	Digital elevation Model
STC	Standard Test Conditions
PR	Performance Ratio
GHG	Green House Gas
IRR	Internal Rate Return
MPP	Maximum Power Point
Nom	Nominal
amb	ambient
GCC	Gulf Cooperation Council

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