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Article

Techno-economic assessment of fixed solar panels and sun-tracking technology in solar farms in the districts of Tehran and Qazvin in Iran

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ABSTRACT

Energy is regarded as one of the most pressing issues confronting the world, particularly in Iran. However, Iran depends mostly on fossil fuels, alternative energy sources are gradually being replaced to cover its energy needs. The efficiency and performance of two types of solar panel systems, fixed and sun-tracking, were evaluated in this study in two different regions: Tehran and Qazvin. According to this investigation, the Qazvin solar farm generates 16,763 MWh with fixed panels and 18,017 MWh when sun-tracking technology is used. Tehran solar farm yields 15,380 MWh with fixed panels and 16,528 MWh when sun-tracking technology is used. The sun-tracking technology increases solar power generation by 7.5 percent. However, due to the high irradiation in Iran, fixed PV systems operate well enough and appear to be considerably more cost-effective than sun-tracking systems. Financial analysis was conducted, taking into account all expenditures, losses, profits, Return On Investment (ROI), payback timeframes, Internal Rate of Return (IRR), and Net Present Value (NPV). Net Present Value (NPV) at the discount rate of 12% of Tehran solar farm is calculated 724,771.4 USD, and for Qazvin's one is calculated 810,471.4 USD. In addition, the normal payback time for Tehran and Qazvin are 7.35 and 6.78 years, respectively. The analysis sensitivity has been done based on three main features, sales revenue, costs of assets, and operating cost, which massively affect the project for instance, considering Tehran's solar far, when the costs of assets increase by 12%, the IRR will drop by 1.71%. On the other hand, when the costs of assets decrease by 12% the IRR will increase by 2.13%.

1. Introduction

According to prognoses, the number of global residents may reach 13 billion by the 22nd century [1]. This upward tendency designates a massive growth in energy demand [2]. One possible way to confront the dearth of energy is to replace renewable sources with conventional ones [3, 4]. Funding for the expansion of renewable energy foundations can be regarded as a feasible option for this concern and increase sustainability [5]. The International Energy Agency (IEA) provided the information that roughly one-fifth of the entire world investment is correspondent to renewable energies in 2018 [6], where approximately half of them is corresponding to solar power generation [7]. To deal with the energy concern, areas with high solar irradiation also have significant importance in miscellaneous social-wise and in the matter of economics. Considering Economics aspects, there are various investment possibilities, such as the building of local solar panel zones and, therefore, the vending of power to the ministry of energy (MOE) in Iran [8]. In the solar farm, numerous employment positions would pop up considering social aspects, which are massively more than the available careers made by gas, oil, and coal plants [9]. Since Iran has a considerable irradiance which enhances its possible potential to invest in solar energy section but encounters some problems in exploiting this energy. The most significant possible challenges fronted are the dearth of technology and funds. Moreover, the lack of an expert workforce is another challenge. Government can stimulate local entrepreneurs to invest in productive sectors in this regard. Photovoltaic systems are not straightforward in terms of design, multiple features and factors should be counted as the criteria of decisions, such as solar radiation angles (tilt, azimuth), the orientation of installation, and the causes of energy loss possible in PV panels like dust blockage, shadows blockage, etc. [10, 11]. It was explained that the critical levels that confine the collection of great portions of dirt and dust on the photovoltaic panels are the average wind velocity above 4 m/s and the relative humidity is lower than fifty percent [12]. The substantial overlap solves between the peripheral factors that affect the accumulation of dirt and dust on the PV panels and to measure of dusty and clean samples simultaneously in the same circumstances, so the only variable is the agglomeration of dust on the photovoltaic panels' area and the neutralization of the other weather conditions [13]. Concerning the depletion of fossil fuel resources proposes the development of renewable energy to meet the requisition for electricity from industrial enterprises. Moreover, the increase in utilizing fossil fuels resulting in more CO_2 emissions leads to global warming, a more irreversible problem for the planet, and causes severe climate change in the future [14]. It is momentous to count the possibility of electricity supply from renewable energy sources and for ports, which will lead to a reduction in harmful emissions and saving of fossil resources. Employing versatile hybrid power systems in renewable energy origins would present a cost-effective option solution to existing present-day energy in areas [15].

During the Covid-19 pandemic, renewable energy positioned a history in new energy capacity in 2020 and was the only source of power generation to make a recorded net climb in the whole potential. For the third consecutive year, investment in the renewable power area went up, although gradually, and companies and corporations consistently continued to pass records for providing renewable electricity [16]. Firstly, Proximate up to 25% of Iran's lands are deserted, which fetches high solar irradiation of about 5.5 kWh per square meter per day; secondly, on average, it has 300 sunny days per annum. The annual average sunny hours in Iran are around 2900 [17]. Figure 1 illustrates the irradiation in Iran; as it can be seen, most areas in Iran receive massive amounts of irradiation which a total daily amount is about 5 kWh/m^2 to 6.2 kWh/m^2 and the total yearly amount is approximately 1826 kWh/m^2 to 2264 kWh/m^2 [18]. According to that survey, solar energy is the main source of power in Iran. The active development of solar power engineering in recent years has contributed to significant progress in the field of technology for the design and manufacture of equipment for solar farms. Monocrystalline cells are a kind of solar cells made by using silicon crystallized into a single crystal. The efficiency of this kind is roughly 15%–24%, but the process of producing them is complex and expensive.

So far, many studies have been done to analyze the energy output efficiency of photovoltaic systems, however, the absence of research to address all aspects of energy efficiency and financial analysis simultaneously is salient for both regions. In this investigation, meteorology data such as global horizontal irradiance (GHI) has been employed to measure the power output of photovoltaic systems for both districts of Tehran and Qazvin. In the first step, the energy output of fixed panels is compared to panels with solar tracking technology. Moreover, the performance of the PV panels for the assessment of the feasibility of solar energy in Iran is provided in comparison. Furthermore, the specific technical features of photovoltaic systems have also been optimized in addition to effectual financial features, which indicate the amount of the return on investment (ROI), the net present value (NPV), the internal rate of return (IRR), and payback time, have been considered to assure the feasibility of these systems in both regions. The novelty of comparing and contrasting the convincible potential in the matter of technical-wise and financial-wise simultaneously for employing photovoltaic systems in both regions is presented. The meteorology data extracted from the database of PVsyst illustrate the Global Horizontal Irradiation (GHI) in each region according to Figure 2. It can be seen that each month the GHI of Qazvin is approximately 5% more than the GHI of Tehran therefore based on this, it is anticipated that Qazvin solar farm will eventuate in the much preferable functioning.

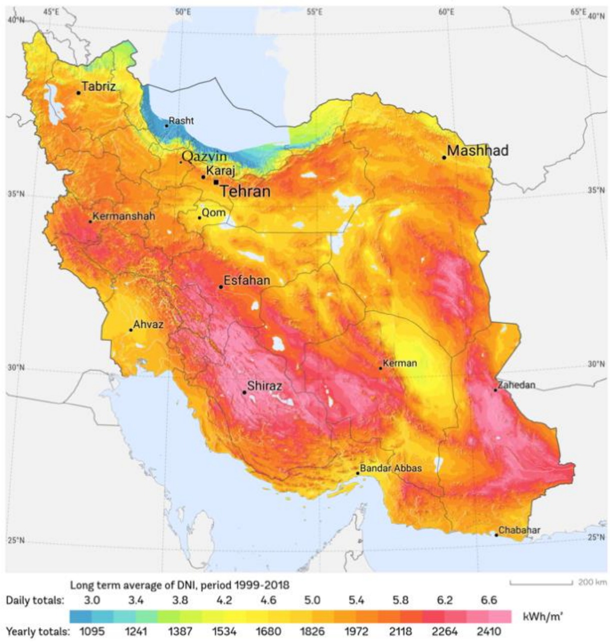

Figure 1. Irradiation in Iran [18]

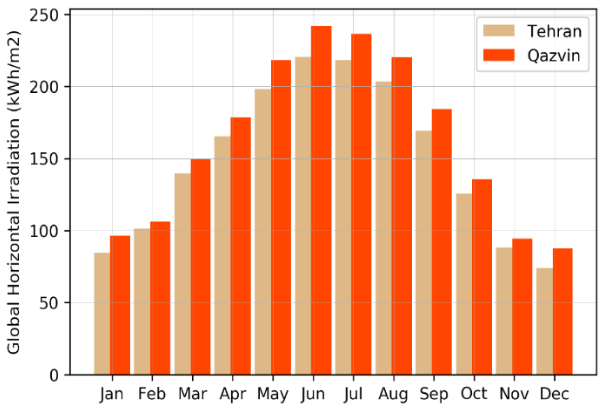

Figure 2. Global horizontal irradiation in Tehran and Qazvin

2. Photovoltaic energy systems

In the calculation of solar energy, different variables involve, which makes them not straightforward, and therefore the matter of these computations has emerged to reach the peak of the possible privilege. Photovoltaic power systems are transforming solar power into electricity with the main aid of semiconductor materials found in them. The interaction of semiconductors in the system with a determined ratio of sunlight eventuates in electron activation, which is called the Direct Current (DC) [19]. The emitted rays from the sun are assimilated by the PV panels transforming into electrical power as no fossil fuel is burned then no greenhouse gases are released during electricity production. Therefore, they are comprehended as completely environmentally friendly systems, as no air pollution is caused. One of the major features of PV panels is that, without any requirements for complex mechanical integration, can transform sunlight into electrical power [20]. The most basic part of such a system is photovoltaic cells. Cells are considered as very thin silicon and thin-film cell technologies into two basic categories. The most conventionally employed technology in the usage of PV panels is Crystal Silicon Cell technology [21]. In the process of manufacturing crystalline silicon cells, Silicon is utilized probably because it is one of the most available elements and semiconductors on the earth after oxygen [22]. The photovoltaic market mainly develops solutions produced with this technology. Crystal silicon cells have two categories: Single Crystalline Silicon and Multi Crystalline Silicon [23]. Thin-film technology, with a 1 mm thickness, is an ingenious technology that superlatively assimilates sunlight. The significance of the sector has risen as its low price and less supply time [24]. Manifold paddings of photovoltaic material are combined with a dorsal material to produce thin-film modules. Four various kinds of thin-film modules are available: Amorphous silicon, Cadmium Telluride, Copper Indium Selenide, and Multi-link cells [25]. However, this technology is cost-effective compared to the crystalline silicon cells because of the lower-cost usage of the PV materials and fewer expenditures in terms of manufacturing, it provides lower output [26]. In grid-connected systems, the required energy is fetched from the sun [23]. PV power plants are considered in scale of large systems that consist of abundant PV arrays and multiple grid-connected inverters, all coupled to produce power. The voltage is needed to step up from low to medium level by Transformers, which is efficient for power transmission. The concept of such systems is illustrated in Figure 3. The PV array may have contained thousands of PV modules in parallel and series connections.

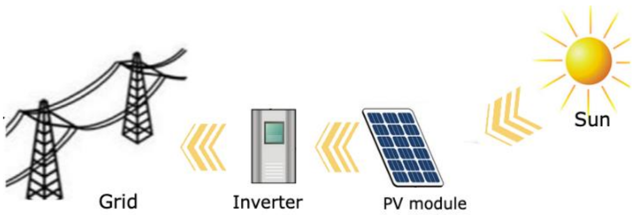

Figure 3. Grid-connected system

The PV modules with the same electrical features should be employed to make a perfect solar array. A place without shading barriers should be considered for installation however, sometimes, it is inevitable. Some conditions like shading due to cloudy weather, tall building, and trees' shadow, dusting blockage, irregulate temperature distributions and defectively manufacturing eventuate in PV module mismatches. In addition, there are some other unpredictable and unavoidable shading and mismatch conditions, such as bird dropping and bird perching [27]. In order to obtain the sought power and specify the required panel necessities, it is necessary to estimate loss during the transformation of solar energy to electrical power for the system's efficiency [28]. Multiple technical and environmental perspectives involve in the proficiency of the system [29, 30], such as:

- Temperature factor: The modules during the hot days of the year are overheated leading to lower efficiency. To clarify this, loss of performance occurs due to high temperature eventuates in lessening the power generation, so a standard factor of 0.89 is recommended [29].
- Sun angle factor: The sun angle indicates consistent alteration within the day. When the variance in sunbathing timeframes in each individual region is considered, it is essential to install the PV panels at the optimized angles to reach the maximum production of energy at the considered locations [29].
- Dust factor: PV panels' function is interrupted by dust accumulation. The dirt and dust factor that recurs over time eventuates the production of energy reduction; the standard produced energy reduction coefficient is given as 0.93 [30].
- Incongruence losses and Wiring: The highest amount of energy that the PV array can generate could likely be lower than the maximum energy output of a single module because of inconsistencies between the modules and the incompatibilities of the assembling being made. The standard loss factor for wiring and mismatch losses should be considered 0.95 [29, 30].
- Transformation dissipation in Direct Current to Alternating Current (DC-AC): While the generated direct current is transforming into an alternating current in the inverter, power losses ensue. The standard transformation loss coefficient due to these operations should be considered 0.90 [29, 30].

3. Methodology

3.1 System specification

The utilization area of the solar farm is considered 285,180 square meters. For the execution phase, the size of the system is computed for a specified zone which consists of 5 sectors and covers an area of 199,626 square meters which is 70% of the whole area. The total nominal installed power of each solar farm herein is 9,660 kWp. Every detail of production and financial performance of the system provided that the equipment used in the size of the system and the employed workforce considered the same; comparing has been done in both the cities of Tehran and Qazvin by considering that condition. As Iran is located in the North Hemisphere the azimuth angle is considered zero. The tilt angle ranges from 0 to 90 degrees, giving both seasonal and mean values that were considered to decide the best possible angle. In this computation, the mean of all seasons' angle quantity is 35°. The PV panels employed in the system are polycrystalline solar panels with a power of 250 W. The size of the 60-cell panel is 1.642 × 0.952 m, so the module area is 1.627 m^2. The module area is used in the calculation. The module panel is to be used with a width of 10 m and a length of 3.3 m. The inverters employed in the system are 20 kW 50

Hz. The calculation is done to determine the number of inverters required for each unit of the PVsyst simulation program to obviate dissipation in production or dissipation due to overload. The features of the inverter directly affect the inverter efficiency of a large system. Moreover, the loaded energy into the inverter is also very momentous. The inverters quantity without DC/AC overload dissipation is given in Table 1. The regions' Global Horizontal irradiation data and optimized solar panel angles were exported from the website of renewables.ninja [31], and annual production relevant literature, data computation were made for the designated cities of the system. For each region, the amount of productions per annum has been calculated, and the cost analysis was made for 25 years of lifespan. After that, the cost analysis, such as the return on investment periods and investment returns, was given comparatively. Moreover, the specified area and the number of PV modules and inverters units are provided in Table 2, also the size of power for the system is given in Table 3. Various variables have been employed in the computation, such as flat areas without any natural or artificial barriers, resulting in shading or blocking sunlight in order to preclude overload loss and provide cost privilege, and to accede precise outcomes. The efficiency of the solar farm with the same specifications in both districts was financially investigated. The PVsyst software was utilized for simulation development at the University of Geneva, Switzerland [32]. For this simulation; meteorology data, detailed solar radiation, surface reflection rate (Albedo) data, regional pollution rate for each region; PV brand model, productivity, efficiency reduction relative to solar panels, and other system vehicles use a database containing any other technical and physical specifications.

Exclusive simulations were performed regarding the system dissipations to be confronted in the meteorological areas in the inaugurated system.

4. Results and discussion

4.1 Technical analysis

The normalized monthly production of each region is illustrated in Figure 4. For the polycrystalline modules, 5 g/m^2 of dust contamination causes the deterioration of 3%. To minimize the losses caused by the dust it is recommended to consistently cleanse the PV panels. Another main loss in power generation was the energy loss in solar panels. Moreover, the amount of power injected into the grid per day was auspiciously superior when the sun tracker technology was employed however, it imposed prodigious expenses on the projects. It can be seen that Normalized productions per installed kWp in Qazvin is much higher in both fixed and sun-tracking panels than the same ones in Tehran. For instance, when the fixed panels were employed in Qazvin, the Normalized production in each month fluctuated between 4 to 5 kWh/kWp per day, while with the same technology employed in the Tehran area, the Normalized production in each month fluctuated between 3.5 to 4.5 kWh/kWp per day. Moreover, when the sun tracking technology was employed, the Normalized production increased by 0.5 kWh/kWp per day for both regions. Therefore, considering the extremely high irradiation in Iran and the much lower price of the fixed solar panels, it is highly recommended to apply to fix solar panels to obviate additional expenses.

Table 1. System features for both solar farms

	Tehran fixed plane	Tehran sun tracking plane, horizontal E-W axis	Qazvin fixed plane	Qazvin sun tracking plane, horizontal E-W axis
Altitude (m)	1,200	1,200	1,278	1,278
Global horizontal irradiation (kWh/m^2)	1,788	1,788	1,949	1,949
PV module model	Poly 250 Wp 60 cells	Poly 250 Wp 60 cells	Poly 250 Wp 60 cells	Poly 250 Wp 60 cells
PV Nominal power (kWp)	9,660	9,660	9,660	9,660
Number of PV modules (unit)	38,640	38,640	38,640	38,640
Inverter model	SE50K-JP unit	SE50K-JP unit	SE50K-JP unit	SE50K-JP unit
Inverter Nominal power (kWac)	24.8	24.8	24.8	24.8
Number of inverter modules (unit)	403	403	403	403

Table 2. Solar farm features

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Total
Specified area (m^2)	17,105	27,990	44,473	51,937	58,157	199,626
Module area (m^2)	5,466	8,980	14,291	16,342	18,585	63,664
Number of Modules (unit)	3,274	5,388	8,671	10,041	11,206	38,640
Inverter (unit)	34	56	90	105	118	403

Table 3. Power measure

System	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Total
Nominal PV power (kW_p)	833	1,372	2,196	2,511	2,867	9,660
Nominal inverter power (kW_{ac})	842	1,386	2,277	2,549	2,896	9,974
P_{nom} ratio (PV power/inverter power)	0.99	0.99	0.99	0.99	0.97	0.97

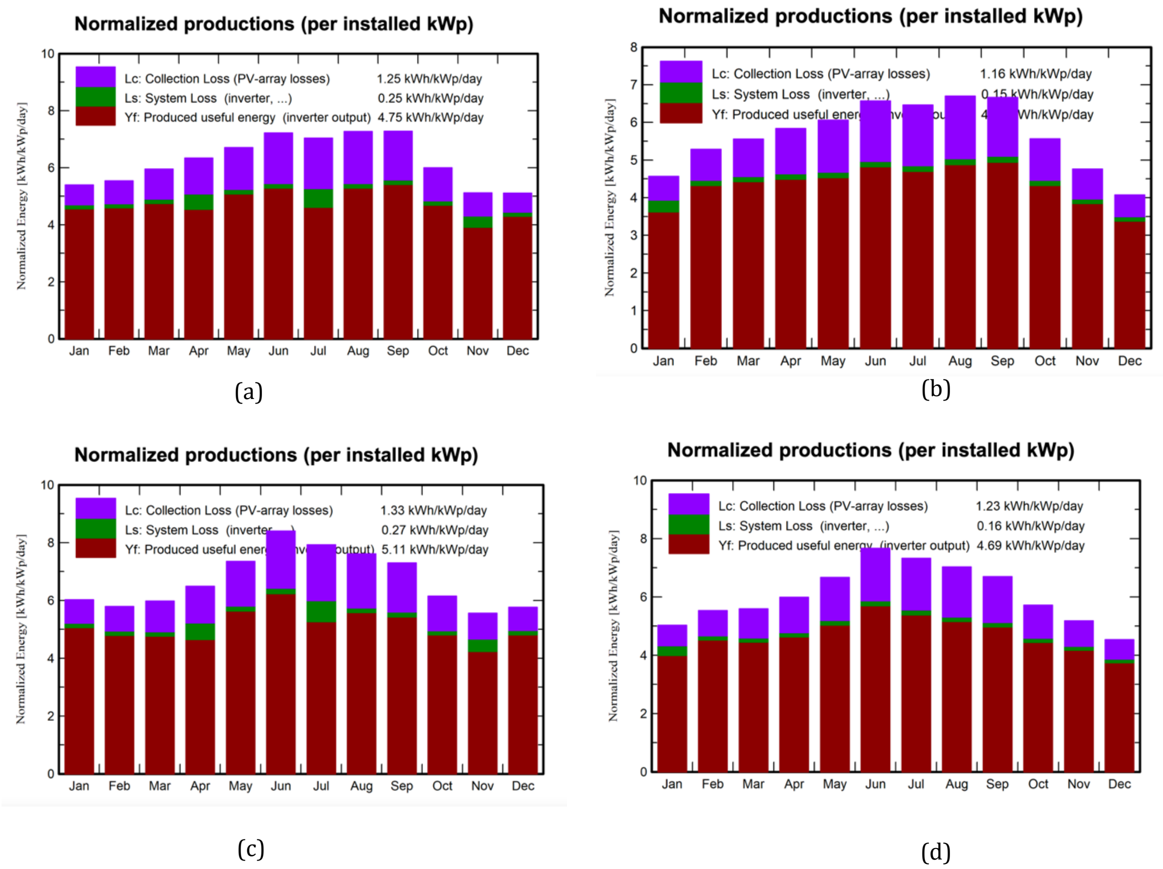

Figure 4. (a) Fixed panels in Qazvin (b) Fixed panels in Tehran (c) Sun-tracking panels in Qazvin (d) Sun-tracking panels in Tehran

The results indicate that Qazvin solar farm, which has higher solar radiation with fixed panels, generates 16,763 MWh and when the sun tracking technology was employed it reached 18,017 MWh. Tehran solar farm with fixed panel generates 15,380 MWh and when sun tracking technology was employed, it reaches to 16,528 MWh. Also, 3% annual production dissipation is anticipated from the systems. The tracking system increases solar power generation by 7.5 percent. However, due to the high irradiation in Iran, fixed PV systems operate well enough and appear to be considerably more cost-effective than sun-tracking systems.

4.1.1 The privilege of photovoltaic power to the region's energy demand

The generated power in Tehran and Qazvin can satisfy each household's power demand at the regional level. The results given in Table 4 indicate benefits to be provided according to the simulation. In 2015, the Ministry of Energy of Iran reported that the average daily power consumption in Iran was about 10,000 MWh [33]. On the 11th of July 2015, the power consumption peaked at 50,000 MWh. In 2022, the Iran Electrical Industry Syndicate reported that during the 2021 summer, the power consumption peaked at 67,000 MWh, and in the 2022 summer, it will pass 70,000 MWh [33]. Therefore, the average monthly power consumption per household is roughly 186 kW, and the average yearly per household is 2,232 kW [34]. The government has highly recommended saving 10% to 20% on power-out prevention [33].

4.2 Financial analysis

One of the major representatives that alter the ratio of cost on production in investments in the solar farm area is expenditures that range belonging to both social and economic conditions in the land of the investment for example, the price of land around Tehran is almost 10 times more than Qazvin. Therefore, selecting land far outside of the city makes a useful contribution to lessening the capital costs of solar farms. The net present value (NPV) was estimated using Iran's 10% inflation and 12% interest rates [35]. While launching a 10 MW solar farm in each region costs 7.5 Million USD, the government has guaranteed to buy 100 percent of the power generation with at least 0.05 USD per kW for the first 10 years and 70 percent of the power generation for the later 20 years [36]. According to Table 5 data, Qazvin's solar farm brings a better IRR than Tehran's solar farm. Therefore, the solar farm in Tehran should be considered as the second option, as it provides a lower return. By considering the costs in Table 5, the return on investment and also the payback period was computed for both cities, as it is shown in Table 6. Return on investment (ROI); can be estimated by dividing the whole project's net income by the total cost. Tax and interest are not added to the net income here. The cost here consists of the inventory, equipment, and cash receivables so the return on investment is as follows [37].

$$ROI = \frac{Whole\ project\ (income - cost)}{Total\ cost} \times 100 \quad (1)$$

Table 4. Simulation for both solar farms

	Tehran fixed plane	Tehran sun tracking plane, horizontal E-W axis	Qazvin fixed plane	Qazvin sun tracking plane, horizontal E-W axis
Global incident in coll. plane (%)	15.9	24.1	17.0	25.5
IAM factor on global (%)	-2.53	-2.05	-2.48	-1.99
Soiling loss factor (%)	-3	-3	-3	-3
Module Degradation Loss for year #10 (%)	-3.8	-3.8	-3.8	-3.8
PV dissipation due to irradiance level (%)	-0.39	-0.39	-0.39	-0.39
PV dissipation due to temperature (%)	-7.41	-7.41	-7.41	-7.41
Spectral correction (%)	-0.83	-0.83	-0.83	-0.83
Optimizer efficiency dissipation (%)	-0.95	-0.95	-0.95	-0.95
Module quality dissipation (%)	-1.3	-1.3	-1.3	-1.3
Light-induced degradation (%)	-2	-2	-2	-2
Ohmic wiring dissipation (%)	-0.98	-0.98	-0.98	-0.98
Inverter dissipation during operation (efficiency) (%)	-2	-2	-2	-2
Medium voltage transformer loss (%)	-1.05	-1.05	-1.05	-1.05
System unavailability (%)	-0.37	-0.37	-0.37	-0.37
Effective energy at the output of the array (MWh/year)	15,926	17,101	17,638	18,955
Energy injected into the grid (MWh/year)	15,380	16,528	16,763	18,017

Table 5. Investment costs (USD)

	Tehran	Qazvin
Cost PV panels system	7,368,997	7,368,997
Cost of land	-	-
Operating Maintenance costs	71,428.6	71,428.6
Energy production cost	0.05	0.05
Annual energy sales revenue	796,300	881,900
Net Present Value	724,771.4	810,471.4

Table 6. Return on investment and payback timeframe

	Tehran	Qazvin
Internal Rate of Return %	20.88	22.71
Normal Payback Time (years)	7.35	6.78
Dynamic Payback Time (years)	11.12	9.84

The normal payback period is represented in the following formula [38].

$$normal\ payback\ time = \frac{Initial\ investment}{Annual\ Cash\ Flow} \quad (2)$$

The payback period method exclusively provides construable marks for specifying the time of the investment operation so it is not employed to measure the profitability. Generally, as the payback timeframe of these projects lessens, the risks to investors are anticipated to reduce, and liquidity will climb. As the information provided in Figure 5 and Figure 6, the propensity of lucrativeness of both projects is illustrated in their lifespan. In Figure 5, the first six years of launching the Tehran solar farm are overwhelmed with debt, while it starts making profits after the 7th year. In the 15th year, it will make 20 Million USD and at the end of the lifespan, it will reach a peak at just as close to 79 Million USD. In Figure 6, the first five years of launching the Qazvin solar farm are not prolific, while it starts gaining profits after the 6th year. In the 15th year, it will make roughly 23 Million USD and at the end of the lifespan, it will reach a peak at 85 Million USD, approximately. In comparison with Figure 5, that the Qazvin solar farm at the end of its lifespan will make almost 6 million USD more profit than the Tehran solar farm. While launching this solar farm with the nominal power of 9,660 kW in both regions' costs 7,368,997 USD. For Tehran and Qazvin solar farms the revenue per annum is equal to 796,300 USD and 881,900 USD, respectively and the amount of NPV at the discount rate of 12% for Tehran and Qazvin are 724,771.4 USD and 810,471.4 USD, respectively. As can be seen in Figure 7 the maximum rate of profit can be 20.88% for the Tehran Solar Farm meaning that the desired discount rate which was 12% is easily satisfied and the additional gain is 8.88%. On the other hand, if the entrepreneur seeks more gain than 20.88%, something like 30%, then this project would not satisfy their wish meaning the loss will outweigh.

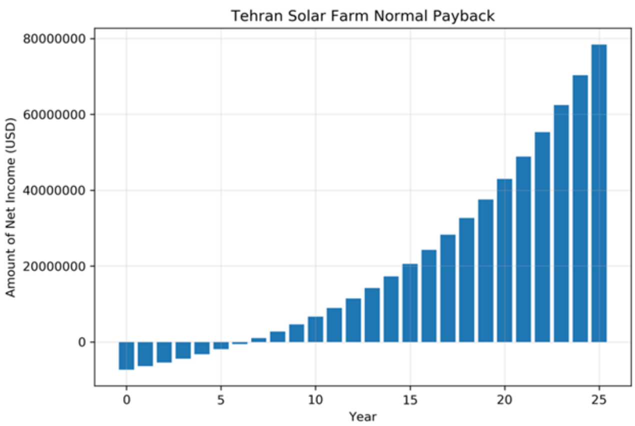

Figure 5. The total net present value for Tehran solar farm

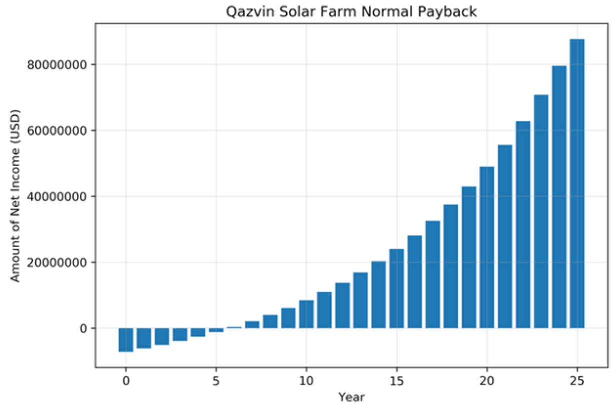

Figure 6. The total net present value for Qazvin solar farm

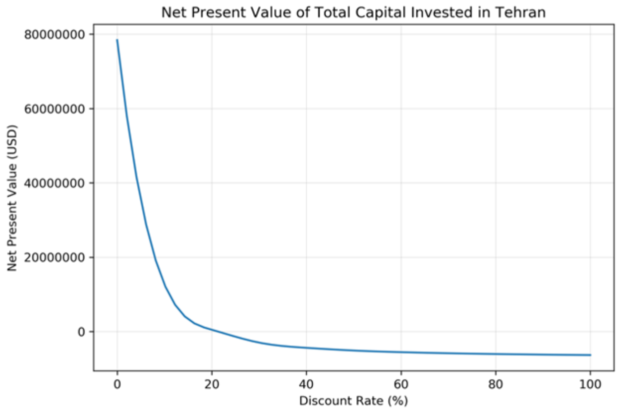

Figure 7. NPV of Tehran solar farm on the discount rate

As can be seen in Figure 8 the maximum rate of profit can be 22.71% for the Qazvin solar farm meaning that the desired discount rate which was 12% is easily satisfied and the additional gain is 10.71%. On the other hand, if the entrepreneur seeks more gain than 20.88%, something like 30%, then this project would not satisfy their wish meaning the loss will outweigh. Comparing both projects in Tehran and Qazvin we can easily conclude that the Qazvin project will make 1.83% more profits.

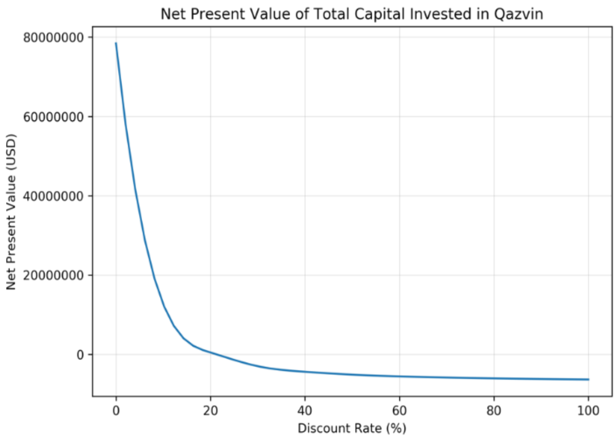

Figure 8. NPV of Qazvin solar farm on the discount rate

4.2.1 Sensitivity analysis

According to Figure 9 and Figure 10, based on the three main features, sales revenue, costs of assets, and operating cost, the analysis sensitivity has functioned, and these parameters mainly affect the project profitability. Considering Figure 9, in Tehran's solar far, when the costs of assets increase by 12%, the IRR will drop by 1.71%. On the other hand, when the costs of assets decrease by 12% the IRR will increase by 2.13%. Moreover, when the sales revenue increase by 20%, the amount of IRR will reach a peak at 24.28%, which is a prodigious climb. when there are 8% increases in the sale revenue, the IRR will increase by 1.36% and when it increases to 12%, the IRR then will increase by 2.04. On the other hand, when the costs of assets go up at 8% the IRR will decline by 1.18% and when it goes down at 8% the IRR will incline by 1.36%. In addition, when the operating costs fall by 20% the amount of IRR will increase only at 21.19%. Looking at Figure 10, it is clear that the pittance changes in each parameter in the sensitivity analysis can make a significant impact on the project perspective. For instance, when there are 8% increases in the sale revenue, the IRR will increase by 1.51% and when it increases to 12%, the IRR then will increase by 2.26. On the other hand, when the costs of assets go up at 8% the IRR will decline by 1.29% and when it goes down at 8% the IRR will incline by 1.51%. On the other hand, when the operating costs fall by 20% the amount of IRR will increase only at 23.02%.

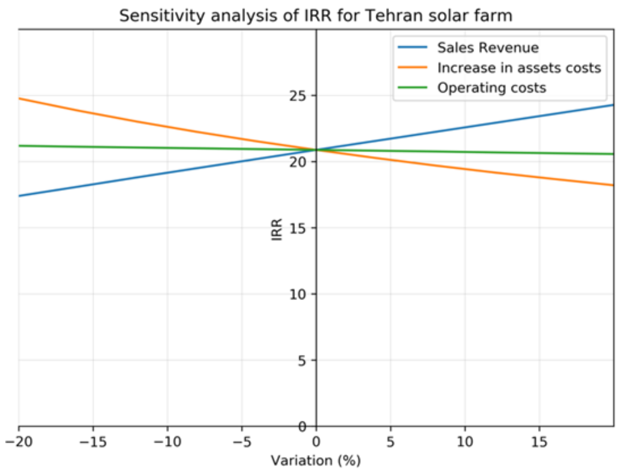

Figure 9. Sensitivity of IRR For Tehran Solar Farm

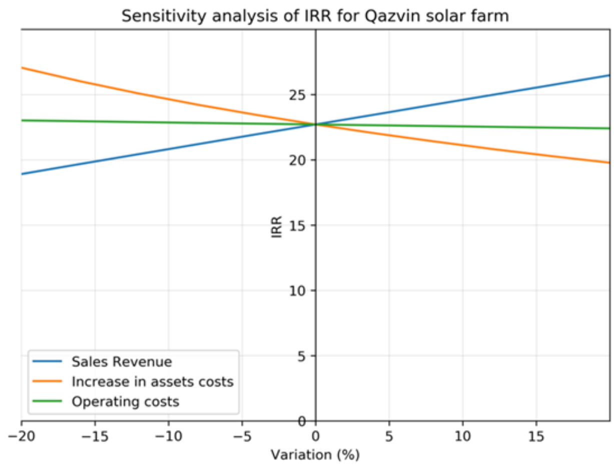

Figure 10. Sensitivity of IRR for Qazvin Solar Farm

5. Conclusion

In this work, the implementation of polycrystalline PV modules was figured out for a lifespan of 25 years in Tehran and Qazvin, Iran. Respect that, the efficiency of the production for both fixed and sun-tracking technology of PV modules was gained according to the evaluated data for each region. Based on this simulation, a financial analysis was carried out to measure the cost and benefit of establishing a 10 MW PV solar farm in each region. The primary outcome of the investigation can be outlined as follows:

- The sun tracking technology moderately increases production in each region.
- Qazvin receives a higher amount of GHI which eventuates in the much preferable functioning of the solar farm.
- Due to the high irradiance in Iran, the fixed panels still function perfectly to produce the desired amount of energy.
- The higher irradiance in Qazvin, in addition to its less air pollution, eventuate in a higher amount of energy production.
- Annual module quality dissipation, light-induced degradation, and DC wiring dissipations were measured to be 1.3%, 2%, and 1.5%, respectively, based on analyzing and comparing the monthly mean temperature corrected PR of a clean PV module for both regions.
- The maximum power dissipation of dusty PV modules per month was in August (3.5%±2.3%) and the minimum was in March (1.1%± 1.2%).
- Allocating loans for the investment section in the PV industry could lessen the Levelized cost of electricity by up to 45.5%.
- Delegating lands for the investment section in the PV industry can expedite the payback duration from roughly 15 years to 7 years.

The economic results are summed up as follows:

- Tehran's solar farm payback is in 7.35 years, and it also provides a return of 20.88 percent in a useful lifetime.
- Qazvin's solar farm payback is in 6.78 years, and it also provides a return of 22.71 percent in a useful lifetime.
- Land price could make a massive impact on the capital cost and lengthen the payback timeframe; therefore, it is highly recommended to the government to delegate lands to entrepreneurs to reduce the capital costs as much as possible.
- Many variables such as PV kit technology, price of land, area solar radiation, annual sunbathing timeframes, legitimate infrastructure, and country motivation mechanism affect the payback timeframes of PV systems, annual power generation, and efficiencies. For the production project, it is very important to consider the area's solar radiation, the size of the system, expenses for the allocation of the used solar panel modules, and inverter technology. Meticulously considering these variables and factors with well-trained conscious management will expedite the refund of the investment.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically concerning authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no potential conflict of interest.

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