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Design and Analyze of 20 MW Photovoltaic Solar Powerplant in Iran

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A B S T R A C T

It is well known that the rapidly growth of business and population are putting more and more pressure on world energy resources. Photovoltaic Solar Power plant price will play a vital role in the larger development of solar power generation. Therefore, it is most important to develop new methodology and techniques for reduced cost of solar power plant. This paper shows the result of designing of a solar power plant in SHAHRYAR area. A total production of about 3900 MWh yearly showed favourable conditions for the development of photovoltaic solar power systems, due mainly to the high average daily radiation in this area. In this research, PVSYST software was used to calculate and design all part of this power plant.

1.Introduction

Iran has a big solar energy potential. Development of solar energy systems requires precise knowledge of Iran solar radiation. With increasing awareness of sustainability and the increasing demand for renewable energy sources, the solar industry plays an essential role in providing such a solution.

In fact solar energy presents the opportunity to generate clean electricity, which can lead to a sustainable life style. Solar radiation arriving on earth surface is the most fundamental renewable energy source. In recent years, solar energy utilization in various applications has increased significantly.

One of the most important which you can see in Figure 1 is the most suitable countries for using solar power in 300 latitude. Solar energy is one of the most important sources of renewable energy.

Solar radiation is variable in different parts of the world and in the Earth Sun Belt has the highest value. Iran is located in this area and studies show that the use of solar equipment in Iran is very suitable and can easily provide part of the energy that nation needs. Figure 2 shows Iran solar energy potential.

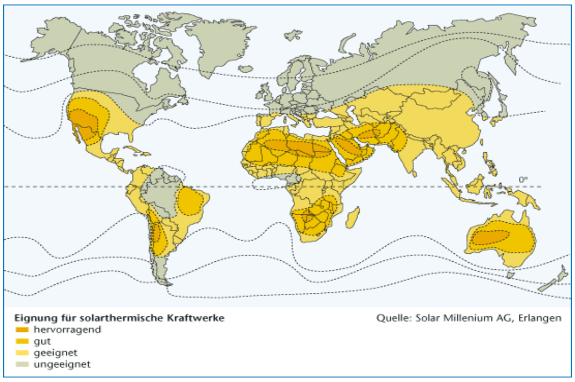

Figure 1. Best countries for using solar power [1]

According to international standards, if the average daily solar radiation energy is above 3.5-kilowatt hours per square meter (3,500 kW / h) the use of solar modules such as solar collectors or photovoltaic systems are very economical and affordable. In many parts of Iran, solar radiation energy is much higher than the international average and in some places is measured higher than 7 to 8kWh/m2. However, the average of the solar energy radiation on the surface of Iran is about 4.5kWh/m2. Iran, having 300 sunny day in a year is one of the best countries for solar energy potential.The average solar radiation for the whole Iran is about 19.23 Mega joules per square meter, and this data is even higher in the central part of Iran [1].

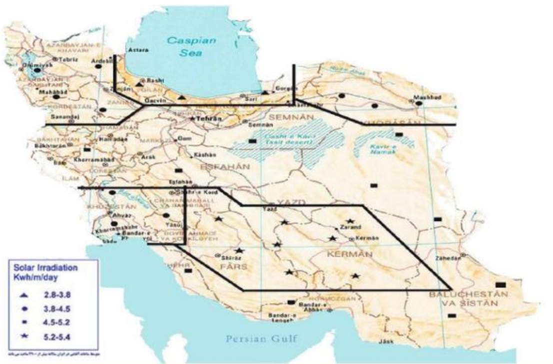

Figure 2: Solar potential in Iran [1]

2. About Site Location

Shahriar County is a county in Alborz Province in Iran. The capital of the county is Shahriar. At the 2006 census, the county's population was 1,044,707, in 273,826 families; the population was 516,022, in 134,378 families. The county has one district: the Central District. The county has seven cities: Shahriar, Sabashahr, Vahidieh, Shahedshahr. Ferdowsieh, Baghestan, and Andisheh [2].

3. Components of Solar PV System

Solar PV system includes different components depending on system type, site location and applications. The major components for solar PV system are solar charge controller, inverter, battery bank, auxiliary energy sources and loads. Major Components of PV System include:

1. PV Module
2. Solar Charge Controller
3. Inverter
4. Battery Bank

4. Solar PV Module

It is an assembly of photovoltaic (PV) cells, also known as solar cells. To achieve a required voltage and current, groups of PV modules wired into large array that called PV array. A PV module is the essential component of any PV system that converts sunlight directly into direct current (DC) electricity. PV modules can be wired together in series and/or in parallel to deliver voltage and current in a particular system. Table 1 shows the information of PV modules which have been selected for this power plant.

With this information, the solar panels perform at optimum capacity when placed in direct sunlight. Try to position the photovoltaic array directly under the noontime sun for maximum efficiency from the photovoltaic units are so important. Remove all items unnecessary items or trim branches that may be blocking sunlight to your solar unit. Trace the path of the sun in the sky to determine if an object is casting a shadow over your solar photovoltaic panels. For this project, we do not have to remove any object. The panels must be installed faced to north and 15-degree angle with the horizon in the spring and summer. In the autumn and winter, it must be around 56 degree.

5. Solar Charge Controller

Charge controller is used in the solar application and solar battery charger. Its function is to regulate the voltage and current from the solar arrays to the battery in order to prevent overcharging and over discharging. There are many technologies which have been included into the design of solar charge controller. For example, MPPT (maximum power point tracking) charge controller includes an algorithm to optimize the production of PV cell or module. Solar charge controller – regulates the voltage and current coming from the PV panels going to battery, preventing battery overcharging, and prolonging the battery life.

Table 1. Information of PV modules

Type	**Poly crystal**
The total number of panels	80000
The size of Array	20×4000
The number of parallel strings	4000
The number of panels in each series string	20
Rated power of each panel	250 W
The total arrays rated power	20 MW
Total power array in working conditions(50 ° C)	17993
The voltage at the maximum power point	542 V
The total flow at maximum power point	33191 A
Arrays Area	130150 m^2

6. Inverter

Inverter converts DC output of PV panels, wind turbine into a clean AC current for AC appliances, or fed back into grid line. Inverter is a critical component used in any PV system where alternative current (AC) power output is needed. It converts direct current (DC) power output from the solar arrays or wind turbine into clean AC electricity for AC appliances. Inverter can used in many applications. In PV or solar applications, inverter also is called solar inverter. To improve the quality of inverter's power output, many topologies are incorporated in its design such as PWM (Pulse-width modulation) inverter. The parameter of selected inverter for this study is shown in table2.

Table 2. The parameter of selected inverter

Number of inverters	960
Voltage	300-800 V
Rated power	20 kw AC
Total rated power of inverters	19200 kw AC

7. Battery

In stand-alone photovoltaic system, the electrical energy produced by the PV array not always can be used when it is produced because the demand for electric energy does not always coincide with its production. Therefore electrical storage batteries are commonly used in PV system. The primary functions of a storage battery in a PV system are:

1. Energy Storage Capacity and Autonomy: to store electrical energy when it is produced by the PV array and to supply energy to electrical loads when needed or on demand.
2. Voltage and current Stabilization: to supply power to electrical loads at stable voltages and currents, by suppressing or smoothing out transients that may occur in PV system.
3. upply surge currents or high peak operating currents to electrical loads or appliances.

8. Simulation Results

Interconnection requirements for reactive power, voltage, and ramp rate control and the characteristics of solar power require unique solutions for optimal plant design. To ensure that large solar plants can be connected successfully to the grid without impacting on grid stability or reliability, the design process must include the development of suitable models for transient and dynamic simulation. Simulation tools and models can then be used to determine special requirements to deal with issues such as daily plant energization, low voltage ride-through, temporary overvoltage and feeder grounding, etc. The result shows the system yearly production is about 39000 MWh with 83.5 % efficiencyas the simulation output shows power losses in the system, Figure 3 shows the yearly power losses in the whole system.

Weather and climate on earth are determined by the amount and distribution of incoming radiation from the sun. For a steady-state climate, global mean outgoing longwave radiation (OLR) necessarily balances the incoming absorbed solar radiation (ASR), but with redistributions of energy within the climate system . Incoming radiant energy may be scattered and reflected by clouds and aerosols or absorbed in the atmosphere. The transmitted radiation is then either absorbed or reflected at the earth’s surface. Radiant solar energy is transformed into sensible heat, latent energy, potential energy, and kinetic energy before being emitted as long wave infrared energy. Energy may be stored, transported in various forms, and converted among the different types, giving rise to a rich variety of weather or turbulent phenomena in the atmosphere and ocean. Moreover, the energy balance can be upset in various ways, changing the climate and associated weather.

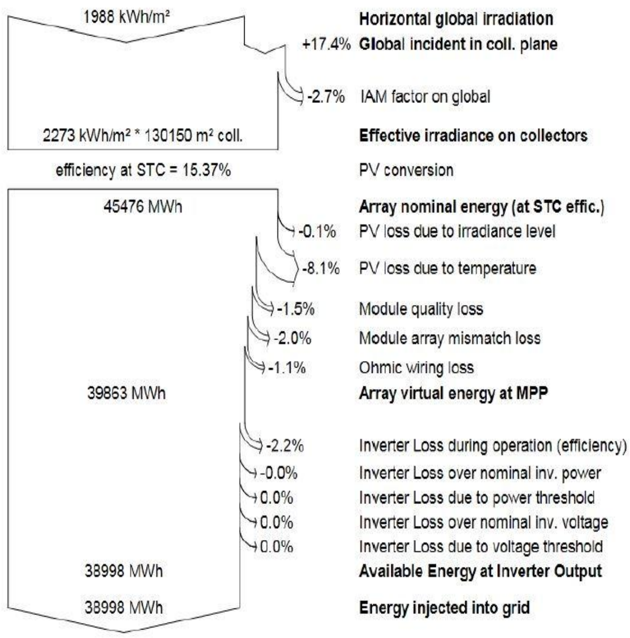

Figure 3: Annual losses of system diagrams

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Figure 4 and Figure 5 show the references incident energy in collector plane and normalized production (per installed kWp). The result shows in the 20000 KWp nominal power, that the PV losses are about 0.94 KWh/day and average system losses are 0.12 KWh/day.

In addition, as shown in table 3, the maximum result obtained by simulation of annual array efficiency is about 14.18 % and maximum system efficiency calculated in December is about 13.79 %.

9. Conclusions

How to reasonably utilize green energy and keep sustainable development is the most important challenge for the future. We should grasp the opportunity to build the most suitable environmental friendly PV power , and welcome a better tomorrow. Shahryar with havin good irradiation choose for solar power plant because there are exist large yards and its suitable for this power plant. On the other side Shahryar is closed to Tehran and Alborz which are the biggest cities in Iran with high population. It can reduce the pollution in those provinces. 20 MW power plant can be suitable for this aim and maximum demand in grid to support for future response.

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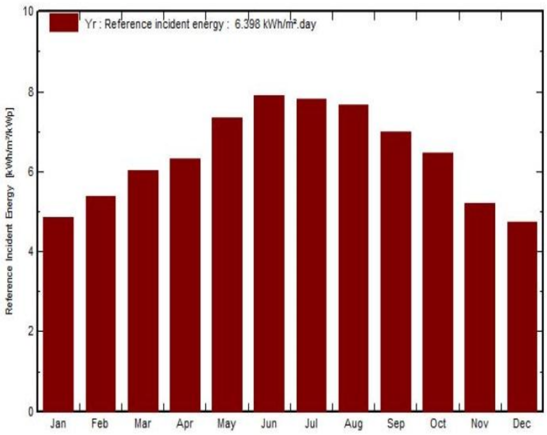

Figure 4: references incident energy in collector plane

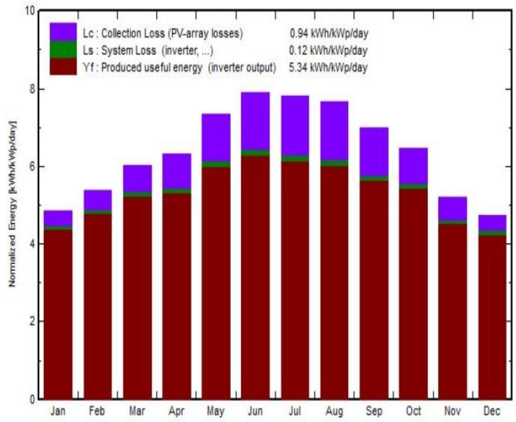

Figure 5: normalized production (per installed KWp)

Table3. simulation variant, balanced and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	EffArrR	EffSysR
	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	%	%
January	88.4	0.60	150.1	147.0	2770070	2709655	14.18	13.87
February	105.6	1.70	150.5	147.1	2739015	2679408	13.98	13.68
March	160.3	5.60	187.1	181.6	3320338	3248484	13.63	13.34
April	179.7	12.70	189.5	183.6	3267021	3196250	13.25	12.96
May	226.9	17.60	227.5	221.1	3804695	3722654	12.85	12.57
June	243.3	21.80	237.3	230.6	3864306	3780141	12.51	12.24
July	245.8	23.90	242.3	235.3	3896905	3812055	12.36	12.09
August	230.0	23.80	237.4	230.4	3825552	3742786	12.38	12.11
September	188.7	19.70	209.6	203.2	3462292	3387445	12.69	12.42
October	144.5	13.80	200.5	195.6	3446197	3372177	13.21	12.92
November	95.1	7.80	156.4	153.2	2772947	2712842	13.62	13.33
December	80.0	2.60	146.8	144.0	2692833	2634445	14.09	13.79
Year	1988.3	12.69	2335.1	2272.7	39862171	38998342	13.12	12.83

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