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ANALYSIS FOR INSTALLATION OF STAND- ALONE PV SYSTEM IN HOUSEHOLD IN RADOVIS

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Abstract
PV Systems are promising technology that is increasingly being used as a solution that meets electricity requirements for households especially in remote locations. In this paper analysis for setting a PV system on the rooftop of household in Radovish will be represented.

Keywords: PV System, sun isolation, production of electricity.

INTRODUCTION

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Photovoltaic (PV) systems use solar panels, either on rooftops or in ground-mounted solar farms, converting sunlight directly into electric power.

Concentrated solar power (CSP, also known as "concentrated solar thermal") plants use solar thermal energy to make steam that is thereafter converted into electricity by a turbine. The production of electricity from PV system reduces harmful effects on the environment, especially the emission of CO2.

Republic of Macedonia has a favorable geographical position [1] for the production of electricity with the construction of photovoltaic systems connected to the existing power grid. The steady decline in the price of photovoltaic panels, and feed-in tariff of purchase price of electrical energy would spur investment and construction of photovoltaic power plants.

One of the objectives of this paper is to estimate the potential of solar photovoltaic power system in rural or urban areas taking for example, Radovish.

In this paper will be performed analyzes for setting photovoltaic panels on household in Radovish. The first part will be given a description of the characteristics of the PV system and details of all the components that will be used in the PV system. The third part will be an analysis of radiation intensity and solar energy.

STAND-ALONE PHOTOVOLTAIC SYSTEM

A Solar cell or photovoltaic cell (PV) is a major part of the photovoltaic system. One solar cell is quite small with dimensions from 1 to 15cm and produces relatively low power from 1 to 2 W. Because the output power is very small, it connects to photovoltaic modules in order to provide greater output power. Photovoltaic modules can be connected in series or network. According to desire power PV modules are connected in series, parallel or combination connection. When PV modules are connected serial the voltage is increased and when the connection is parallel current is increased. Therefor to be increased output power the connection in PV array should be combination of parallel and serial linked modules [3].

Stand-alone photovoltaic system is a collection of interconnected electrical components, using which we can generate electricity from sun light and satisfy our daily energy requirement without worrying about any interval when the sunlight may not be available. This type of system is useful only when there is requirement of load to run in night time or in other time when sunlight is unavailable for some period.

Depending on load requirement and radiation intensity at the location, the components of the system will have to be specified.

PV systems can work stand-alone or connected in electricity grid. Figure 1 gives a schematic model of proposed grid-connected PV system. Figure 2 gives a schematic diagram of interconnection of components of a typical stand-alone photovoltaic power system [3].

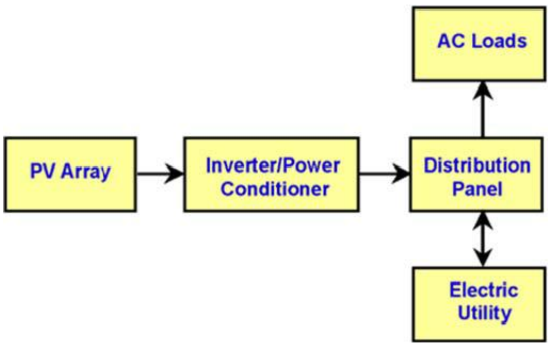

Fig. 1. *Model of proposed grid-connected PV system*

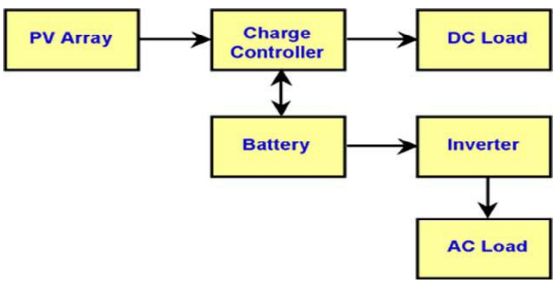

Fig. 2. *Model of proposed stand-alone PV system*

Stand-alone PV system does not require connection to the electricity grid. When electric power is needed during the night or in a period with low sunlight a battery is necessary for proper function of the system. In that case, a regulator should be added to the system for controlled charging of the battery, and by adding a converter (=12V/~230V) all the connected consumers can be supplied. This kind of systems can be used in rural areas as well as individual objects (signalization, alerts, and systems for monitoring lighthouses, telecommunication transmitters, etc.) where there is no electricity grid.

DESCRIPTION OF PV SYSTEM

The PV system will be mounted on the rooftop of household in Radovish with 14 panels, one DC switch, 3 blocking diodes, DC/AC inverter, charge controller, cable PP 001x6mm2 for connecting the strings, 12 batteries and 10 automatic fuses 1R type B 10A. Schematic of the stand- alone PV system is represented on Figure 3.

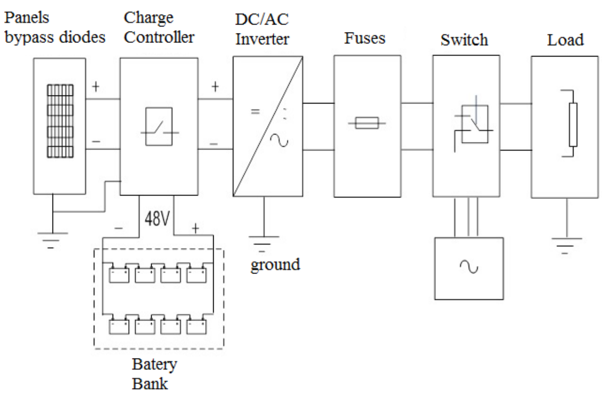

Fig. 3. *Schematic representation of stand- alone PV System*

The panels will be connected into two strings with 7 panels each. The total length of the array is 15.5m. The roof of the household has a slope $\alpha=17^{o}$. The tilted panels ($\beta=32^{o}$) are placed on metal construction (Figure 4) with an optimal slope for the location ($41^{o}47'08''$ N, $22^{o}14'22''$ E).

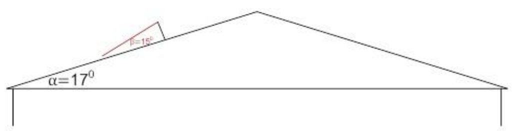

Fig. 4. *Optimal panel placement*

The system uses microamorhous silicon solar panels which characteristics are given in Table I. The operating temperature range is -40°/85°. The current- voltage characteristic at different temperature and irradiation is given on Figure 5.

TABLE I. MODULE CHARACTERISTICS

P_{mpp}	125W
Tolerance	±2.5%
U_{mpp}	56.6V
I_{mpp}	2.21A
U_{oc}	74.1V
I_{sc}	2.71
η	8.9%
Power	87.4W/m²

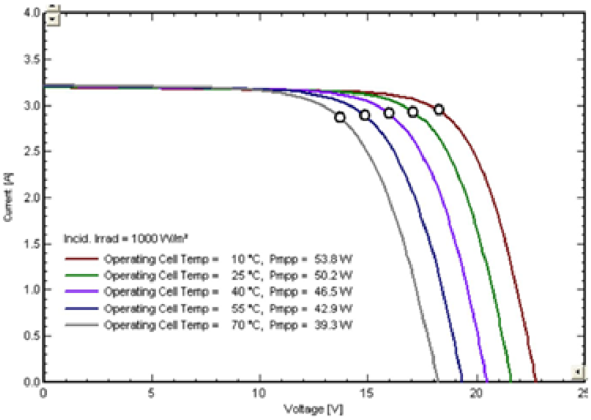

Fig. 5. *Current- Voltage Characteristic*

The controller (PWM 12V 30A, Verdenergia) regulates battery charging and discharging. When the battery is charged to a certain level, the controller cut off current, and when the battery is depleted to a certain level the controller exclude the load. The regulation is performed based on the point of maximum power (MPPT). The characteristics of the controller operating in MPPPT are given in Table II.

TABLE II. CONTROLLER CHARACTERISTICS

Maximum output power	40A, to 500°C temperature of environment
Battery voltage	12V, 24V, 36V or 48V
Maximum input current	30A
Input voltage	16 -192 V 240V maximum voltage at open circuit
Maximum string power	5200W
MPPTcharacteristics	Optimal utilization in periods without Sun
Status Display	Display of input voltage and current, output voltage and current, mode of charging and battery status
Data record	Data record for 90 days

TABLE III. INVERTER CHARACTERISTICS

Nominal battery voltage	48V
Input voltage	38-68V
Power at 25°C	2000VA
Power for 30 min at 25°C	2600VA
Power for 5 sec at 25°C	6.5KVA
Maximum load	Till short circuit
Cos φ	0.1-1
Maximum efficiency	96%
Output voltage	AC sin 230V (+/- 2%)
Output frequency	50Hz (+/- 0.05%)
Harmonic distortion	<2%
Overload and protection from short circuit	Automatic shutdown with 3 attempts to restart
Overload from overheating	Warning before shutdown with automatic restart

Batteries (type 12V-100Ah DIN100M, Verdenergia) are composed of 6 cells with 2V nominal power each. The battery bank has 8 batteries 12V /100Ah as shown in Figure 6.

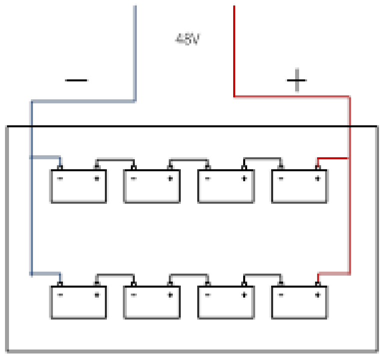

Fig. 6. *Battery Bank*

The inverter (KS-2000-248, Verdenergia) converts direct current into alternating and is set to 48V input DCvoltage. The output is 230V/ 50Hz AC sine voltage. The output power is 2000W.

ANALYSIS OF SOLAR RADIATION

Radovish is located altitude of 380m with average of 112 summer and 49 tropical days. Summer days are from March to October with peak in July and August. The average annual air temperature is 12.3°C with the warmest month July with average temperature 22.9°C while the coldest month is January with an average temperature 1.1°C. Radovish belongs to areas with increased duration of sunlight with annual average of 2320 sunny hours which on average is 6.3 hours per day. The maximum is in July with an average of 324 sunny hours or 10 hours per day.

TABLE IV. MONTHLY SOLAR INCLINATION

Month	S_c	G_{opt}(Wh/m)	I_{opt}(^{o})	T_D(^{o}C)
January	101	3735	62	1.1
February	119	4477	55	3.4
March	149	4876	41	6.7
April	186	6072	27	11.6
May	218	6578	14	16.6
June	261	6762	8	20.7
July	324	7371	12	22.9
August	310	6980	23	22.6
September	249	6244	39	18.4
October	187	4841	51	12.9
November	116	3266	60	7.8
December	100	2219	61	3.0
Total	3220	5186	32	12.3

The minimum insolation is in December with an average of 100 hours of radiation which is 3.2 hours per day. The monthly solar insolation for Radovish at optimum angle of inclination 32^o (G_{opt}(Wh/m)), recommended slope of solar panels for given month (I_{opt}), monthly sunny hours and average temperature are given in Table IV. Figure 7 shows solar insolation on a horizontal surface with optimal angle and angle of 90^o during the year.

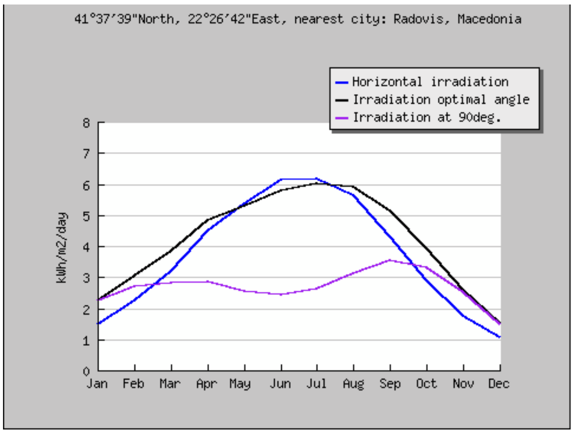

Fig. 7. *Solar insolation on a horizontal surface at optimal angle and angle 90^o*

The nominal power of PV system is 1750W. The data used for this paper is obtained by PVGIS Solar Data [4] which provides large and accurate solar irradiation free database for Europe, Africa Mediterranean Basin and South-West Asia. The solar PV energy output of the PV System is calculated by:

$$E = A \cdot r \cdot H \cdot PR \qquad (1)$$

Where *A* is total solar panel area (m^2), *r* is solar panel yield (%), *H* is annual average irradiation on tilted panels and *PR* is performance ratio (range between 0.5 and 0.9).

After analyzing the data for solar insolation [4] it is expected the total system of losses to be 13.1% from which 4.4% are expected loses due temperature variations, 2.7% due angular reflectance effect and 6% other losses (cables, invertor etc.). The system will be placed under fixed tilt of 32^o and orientation -10^o.

Under this conditions from [4] data are obtained for average daily production of electricity (E_d), average monthly production of electrical energy (E_m), average daily sum of global irradiation per square meter received by the modules and average sum of global irradiation per square meter received by the modules of the given system. These data are summarized in Table V. The average daily production of electricity would be 5.81kWh while the average monthly production of electricity would be 177kWh.

TABLE V. ESTIMATED ELECTRICITY GENERATION

Месец	E_d (kWh)	E_m (kWh)	H_d (kWh/m^2)	H_m (kWh/m^2)
January	3.06	94.9	2.19	67.9
February	4.11	115	2.94	82.3
Marc	5.23	162	3.75	116
April	6.76	203	4.85	145
May	7.45	231	5.35	166
June	8.22	247	5.91	177
July	8.41	261	6.03	187
August	8.17	253	5.86	182
September	7.08	212	5.06	152
October	5.45	169	3.89	121
November	3.62	108	2.58	77.5
December	2.13	66.1	1.53	47.4

CONCLUSION

PV Systems have numerous advantages primarily because solar energy is free and inexhaustible and provide clean green energy. Residential solar panels are easy to install on rooftops without interface to residential lifestyle.

This paper presents a study about installing a PV system for household usage. The system will be fixed with optimal slope angle of the panels. The average annual production of electricity is expected to be 21.24MWh.

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