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Proposal for 1KWp Roof-Top Solar PV Plant

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Abstract - *Energy demand in Karnataka state is increasing, however the electric utilities failed to meet this load demand. Photovoltaic (PV) solar power plant is used for larger development of solar power generation. In a solar roof top system, the solar panels are installed on the roof of any residential, commercial, institution and industrial building. The solar roof top system may come up with storage facility using battery or grid connected. The roof top system with storage facility has a battery to store solar electricity and can be utilized during night when sunlight is not available. In this research paper, it is aimed at providing technical details of 1KWp with 1.5KVA off grid solar roof top power plant on turnkey solutions and Simulation analysis is carried out using PV Syst for Davangere city location and simulation results of energy output of PV module, energy supplied to the load and unused energy are presented*

***Key Words*: Grid, Roof top system, solar photovoltaic panel, solar radiation, Energy.**

1. INTRODUCTION

Solar energy is a clean, pollution free renewable source of energy. Karnataka state being located between 11° 40′ and 18° 27′ North latitude and the geographical location favors the harvesting and development of solar energy. Karnataka state is having 300 sunny days with good solar radiation of 5.4 to 6.2 KWh / square-meter /day. Davangere city comes under Karnataka state in India which is 250KM from the Bangalore, the capital city of Karnataka state. The yearly average solar radiation on horizontal surface of Davangere city is 5.24 KWh/m^2/day at latitude of 14.4384 ^{0}N and longitude of 75.956082 ^{0}E [6].

Electric utilities are finding it difficult to meet rise in peak demand and as a result, most of cities and towns are facing severe electricity shortages. Most of commercial establishments use one or more diesel generator for back-up power. In order to utilize the existing roof space of buildings, the scheme proposes to promote rooftop solar PV systems on buildings to replace diesel generator sets.

2. OFF-GRID ROOF TOP SOLAR POWER PLANTS

Solar PV cells converts sunlight to generate electricity through a photovoltaic process. There are two types of solar PV systems: standalone and grid connected. Standalone solar PV systems work with batteries [5].

In off Grid rooftop solar power plant, the DC power generated from solar photovoltaic (SPV) panel is converted to AC power using inverter and is fed to the load through single phase lines and at the same DC power is stored in Battery during day time and loads are served by Battery back in night hours. A schematic sketch of a typical off grid solar rooftop photovoltaic power plant is shown in Fig1 [7].

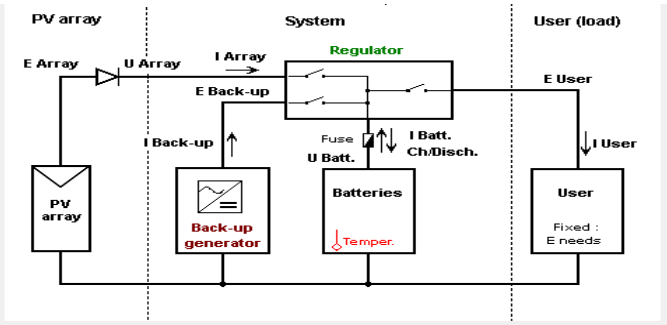


Fig1. A Schematic sketch of a typical 1KWP off Grid Solar Roof Top Photo Voltaic Power Plant

3. COMPONENTS OF SOLAR PV SYSTEM

A Grid-connected solar PV system consists of following main components [1]:

A. Solar photovoltaic (PV) modules

Solar PV modules are mounted on the roof of buildings and convert sunlight into direct current. To achieve a required voltage and current, a group of PV modules are wired into large array called PV array.

B. Solar PV array support structure

These are galvanized steel structures secure the solar PV modules on the roof of building. The mounting structures require roof to be penetrated and mounting solar panels correctly is part of maximizing power generation

C. Solar Off-grid inverter

Solar Off-grid inverter converts generated direct current into alternating current which is required for all electrical appliances through a charge controller. It also regulates battery charging if required

D. Balance of system

All other components considered for solar rooftop power plant are cables, junction boxes, fuses etc.
The size of solar plant require depends on requirement of electrical load, number of KWh consumption

4. REAL TIME SYSTEM DESIGN

The main target is to design and install 1KWP solar rooftop solar power plant [4].

A. Key facts of solar rooftop power plant

Plant capacity in Wp : 1KWp Rooftop Solar power plant
PV Technology/Module: Poly crystalline modules
Power conditioning unit: 1.5KVA
Power evacuation : 230V AC, Single phase, 50HZ

B. Number of PV panels for the system

Capacity of each module: 250WP
Number of PV panels or modules required = 04

Module area = 7.5m^2
Nominal PV Power = 1KWP
Maximum PV Power =1KWdc
Fixed Tilted plane = Tilt :30^0 ; Azimuth :0^0
The maximum power of this module is 1KWP; hence it requires 04 modules to design 1KWP PV system. The selected PV is manufactured by Alfa Solar Ltd.
The PV module parameters and ratings are given in Table 1[2].

Table1. PV module parameters and ratings

Electrical Characteristics	
Rated Maximum power (Pmax)	250Wp
Maximum power voltage (Vmp)	30.84 V
Maximum power current (Imp)	8.15A
Open circuit voltage (Voc)	37.26V
Short circuit current (Isc)	8.907A
Module efficiency	15.37%
Operating temperature	- 40°C to +85°C

The PV module specifications and dimensions are given in Table 2[2].

Table 2. PV module specifications and dimension

Specifications and Dimensions of PV module	
Solar cells	Multi crystalline solar cells
Solar cell size	156 mmx156 mm(6 inx6 in)
Number of cells(pieces)	60 (6x10)
Module dimensions	1644 mm x994 mm x50 mm
Weight	18.8 kg
Front glass	3.2 mm tempered glass
Frame	Anodized aluminum alloy
Protection degree	IP 65
High efficiency	17.4%
Grid connection	OFF grid
No. of PV modules/panels	04

C. Solar off- Grid Inverter rating

For this system, solar off grid inverter designed is 1.5KVA. The inverter parameters are given in Table 3

Table 3. Inverter parameters [3]

Inverter specifications	
1-phase inverter chosen	1.5KVA off grid inverter
Maximum efficiency	90%
Maximum ac output power	1000W
Rated ac power	900W
Rated ac off grid voltage	12V

D. Battery Back up

The battery maker is Electrona has following ratings.
Each Battery rating : 150 Ah
Total Number of batteries: 04
Total Capacity : 600Ah
Battery Voltage : 15V

E. Daily House Hold Consumptions

The daily house consumptions are given in Fig.2

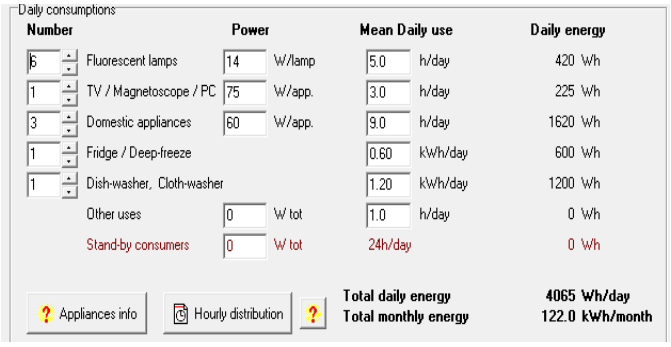


Fig.2 The daily house consumptions

Total daily house hold energy needed = 4065Wh/day
Total monthly house hold energy needed =122 KWh/month

5. SIMULATION ANALYSIS RESULTS

For simulation purpose, the considered PV module capacity is 1KWP, 15V Si-Poly with array current of 56.1A from Alfa Solar. The Considered battery capacity is 600Ah, 12V with stored energy of 7.2KWh from Electrona. Due to non- availability of correct make, it is considered from other manufacturers with appropriate ratings. The global system configuration of the PV array is shown in Fig.3 [7]

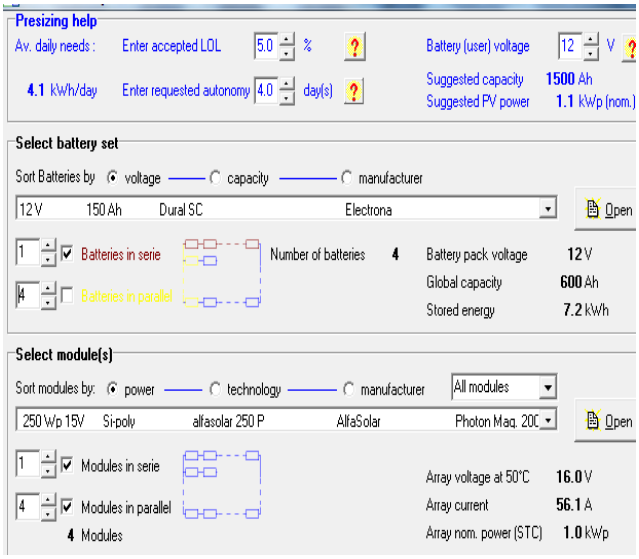


Fig.3 The global system configuration of the PV array

The mateo for Davangere, synthetic data is shown in Fig. 4[7]

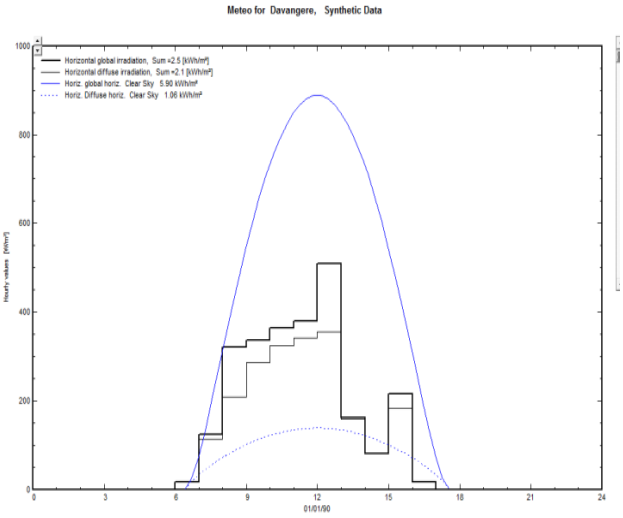


Fig.4 Mateo for Davangere city.

The simulation input and the main results of standalone 1KWP project are shown in Fig.5 [7]

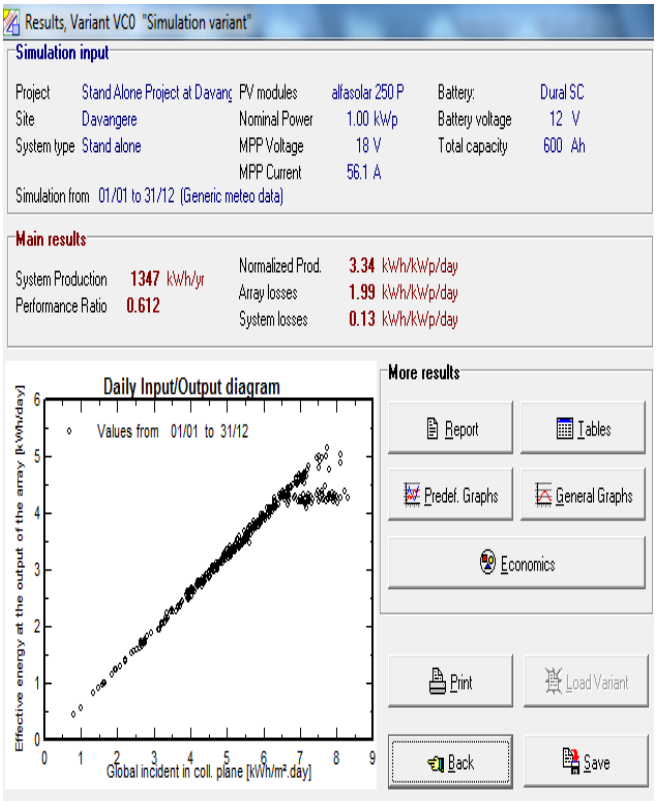


Fig.5 The simulation input and the main results of standalone 1KWP project

The standalone simulation parameters of 1KWP project are shown in Fig.6 [7]

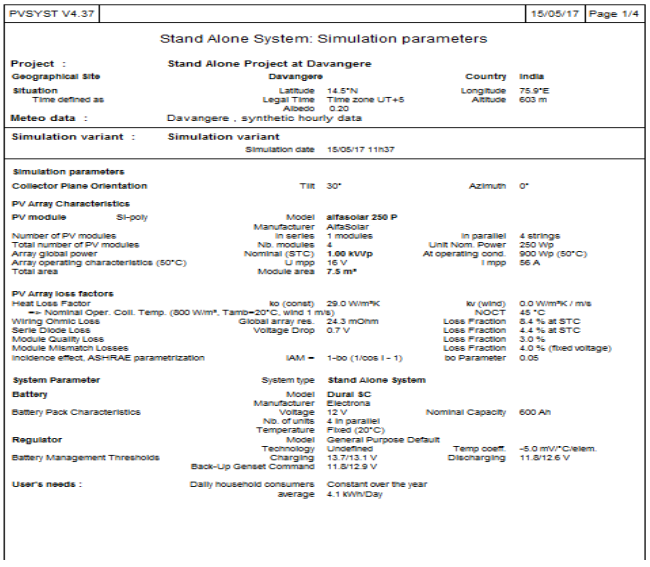
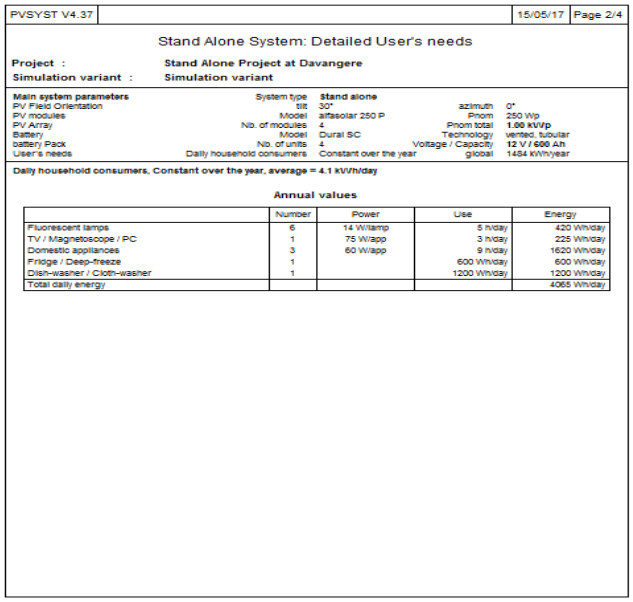


Fig.6 The standalone simulation parameters of 1KWP project

The standalone system details of user's needs of 1KWP project are shown in Fig.7 [7]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Stand Alone System: Detailed User's needs

Project : Stand Alone Project at Davangere
Simulation variant : Simulation variant

Main system parameters		System type	Stand alone		
PV Field Orientation		tilt	30°	azimuth	0°
PV modules		Model	alfasolar 250 P	Pnom	250 Wp
PV Array		Nb. of modules	4	Pnom total	1.00 kWp
Battery		Model	Dural SC	Technology	vented, tubular
battery Pack		Nb. of units	4	Voltage / Capacity	12 V / 600 Ah
User's needs	Daily household consumers		Constant over the year	global	1484 kWh/year

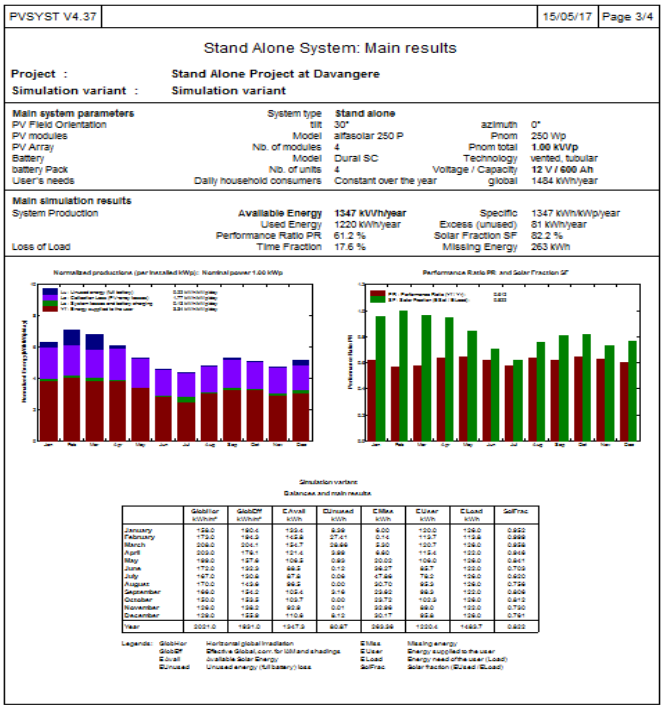
Daily household consumers, Constant over the year, average = 4.1 kWh/day

Annual values

	Number	Power	Use	Energy
Fluorescent lamps	6	14 W/lamp	5 h/day	420 Wh/day
TV / Magnetoscope / PC	1	75 W/app	3 h/day	225 Wh/day
Domestic appliances	3	60 W/app	9 h/day	1620 Wh/day
Fridge / Deep-freeze	1		600 Wh/day	600 Wh/day
Dish-washer / Cloth-washer	1		1200 Wh/day	1200 Wh/day
Total daily energy				4065 Wh/day

Fig.7 The standalone system details of user's needs of 1KWP project

The standalone system main results of 1KWP project are shown in Fig.8 [7]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Stand Alone System: Main results

Project : Stand Alone Project at Davangere
Simulation variant : Simulation variant

Main system parameters		System type	Stand alone		
PV Field Orientation		tilt	30°	azimuth	0°
PV modules		Model	alfasolar 250 P	Pnom	250 Wp
PV Array		Nb. of modules	4	Pnom total	1.00 kWp
Battery		Model	Dural SC	Technology	vented, tubular
battery Pack		Nb. of units	4	Voltage / Capacity	12 V / 600 Ah
User's needs	Daily household consumers		Constant over the year	global	1484 kWh/year

Main simulation results

System Production					
	Available Energy	1347 kWh/year	Specific	1347 kWh/kWp/year
	Used Energy	1220 kWh/year	Excess (unused)	81 kWh/year
	Performance Ratio PR	61.2 %	Solar Fraction SF	82.2 %
Loss of Load	Time Fraction	17.6 %	Missing Energy	263 kWh

Normalized productions (per installed kWp): Nominal power 1.00 kWp

Performance Ratio PR and Solar Fraction SF

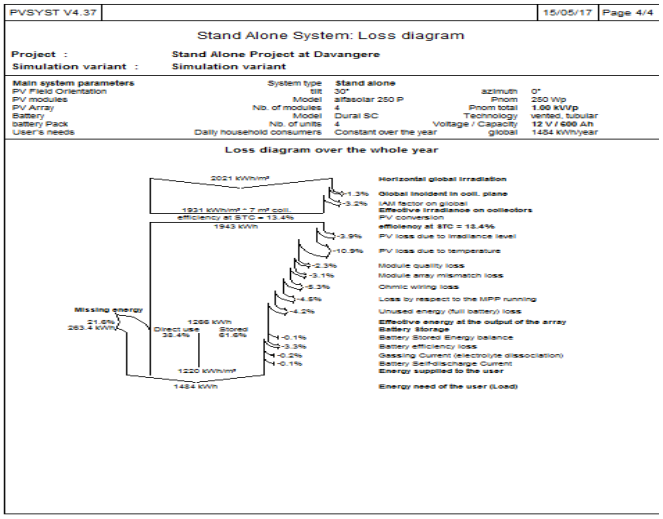
Simulation variant
Balances and main results

	GlobHor kWh/m²	GlobEff kWh/m²	EArray kWh	EUnused kWh	EMiss kWh	EUser kWh	ELoad kWh	SolFrac
January	156.0	160.4	139.4	8.99	6.00	120.0	126.0	0.952
February	173.0	180.3	143.8	27.41	0.14	113.7	113.8	0.999
March	209.0	224.1	141.7	29.66	2.50	120.7	126.0	0.958
April	203.0	174.1	121.0	9.89	6.90	115.4	122.0	0.946
May	199.0	137.6	104.2	0.83	20.00	106.0	126.0	0.841
June	173.0	130.3	98.2	0.10	36.27	85.7	122.0	0.703
July	147.0	100.6	87.8	0.04	47.98	78.2	126.0	0.620
August	170.0	143.4	96.2	0.00	30.70	95.3	126.0	0.756
September	199.0	154.3	103.4	0.19	23.62	98.3	122.0	0.806
October	180.0	139.3	109.7	0.00	23.73	102.3	126.0	0.812
November	156.0	156.0	92.8	0.01	33.96	89.0	122.0	0.730
December	139.0	133.6	110.8	8.12	20.17	95.8	126.0	0.761
Year	2021.0	1951.0	1347.9	80.47	263.36	1220.4	1483.7	0.822

Legends: GlobHor Horizontal global irradiation; GlobEff Effective Global, corr. for IAM and shadings; EArray Effective Solar Energy; EUnused Unused energy (full battery); EMiss Missing energy; EUser Energy supplied to the user; ELoad Energy need of the user (Load); SolFrac Solar fraction (EUsed / ELoad)

Fig.8 The standalone system main results of 1KWP project

The standalone system loss diagram over the whole year of 1KWP project are shown in Fig.9 [7]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Stand Alone System: Loss diagram

Project : Stand Alone Project at Davangere
Simulation variant :

Main system parameters		System type	Stand alone		
PV Field Orientation		tilt	30°	azimuth	0°
PV modules		Model	alfasolar 250 P	Pnom	250 Wp
PV Array		Nb. of modules	4	Pnom total	1.00 kWp
Battery		Model	Dural SC	Technology	vented, tubular
battery Pack		Nb. of units	4	Voltage / Capacity	12 V / 600 Ah
User's needs	Daily household consumers		Constant over the year	global	1484 kWh/year

Loss diagram over the whole year

2021 kWh/m²
-1.3%
-3.2%
1931 kWh/m² * 7 m² coll.
efficiency at STC = 13.4%
1943 kWh
-3.9%
-10.9%
-2.3%
-3.1%
-9.3%
-4.5%
-4.2%
Missing energy
21.8%
263.4 kWh
Direct use
38.4%
1266 kWh
Stored
61.6%
-0.1%
-3.3%
-0.2%
-0.1%
1220 kWh/m²
1484 kWh

Horizontal global irradiation
Global incident in coll. plane
IAM factor on global
Effective irradiance on collectors
PV conversion
efficiency at STC = 13.4%
PV loss due to irradiance level
PV loss due to temperature
Module quality loss
Module array mismatch loss
Ohmic wiring loss
Loss by respect to the MPP running
Unused energy (full battery) loss
Effective energy at the output of the array
Battery storage
Battery Stored Energy balance
Battery efficiency loss
Gassing Current (electrolyte dissociation)
Battery Self-discharge Current
Energy supplied to the user
Energy need of the user (Load)

Fig.9 The standalone system loss diagram over the whole year of 1KWP project

The standalone system energy output of array of 1KWP project are shown in Table 4[7]

Simulation variant
Energy Use

	EArray kWh	E Load kWh	E User kWh	SolFrac	T LOL Hour	Pr LOL %
January	125.0	126.0	120.0	0.952	34	4.6
February	118.4	113.8	113.7	0.999	0	0.0
March	126.0	126.0	120.7	0.958	30	4.0
April	117.4	122.0	115.4	0.946	38	5.3
May	105.6	126.0	106.0	0.841	116	15.6
June	88.3	122.0	85.7	0.703	213	29.5
July	87.8	126.0	78.2	0.620	280	37.7
August	96.5	126.0	95.3	0.756	179	24.1
September	102.3	122.0	98.3	0.806	138	19.2
October	103.7	126.0	102.3	0.812	139	18.7
November	92.9	122.0	89.0	0.730	193	26.9
December	102.5	126.0	95.8	0.761	176	23.6
Year	1266.4	1483.7	1220.4	0.822	1538	17.6

Table 4. The standalone system energy output of array of 1KWP project

The Global irradiation and array energy output and unused energy/day are shown in Fig.10 [7]

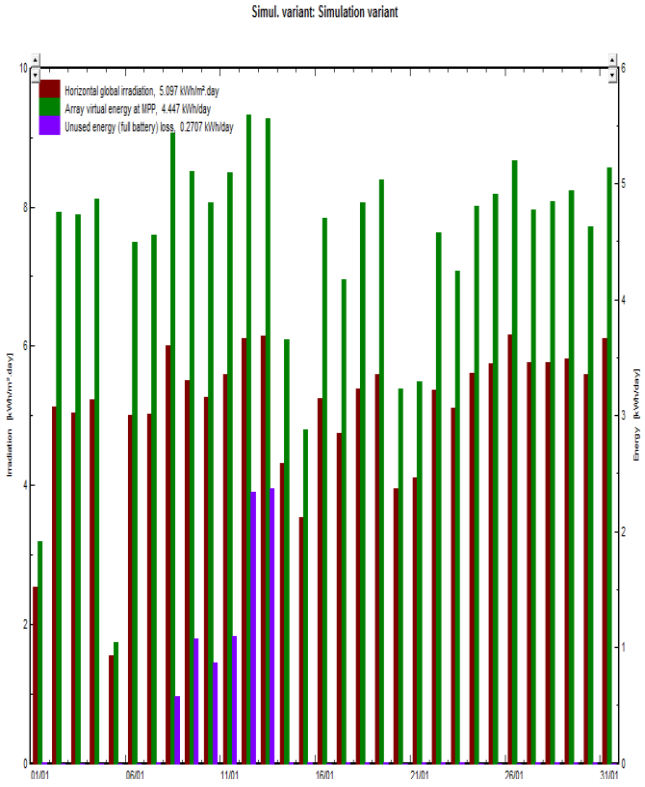

Fig.10 The Global irradiation and array energy output and unused energy/day

The balances and main Simulation results of 1KWP Project are given in Table 5[7].

Simulation variant
Balances and main results

	GlobHor kWh/m²	GlobEff kWh/m²	E Avail kWh	EUnused kWh	E Miss kWh	E User kWh	E Load kWh	SolFrac
January	158.0	190.4	133.4	8.39	6.00	120.0	126.0	0.952
February	173.0	194.3	145.8	27.41	0.14	113.7	113.8	0.999
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August	170.0	143.6	96.5	0.00	30.70	95.3	126.0	0.756
September	166.0	154.2	105.4	3.16	23.62	98.3	122.0	0.806
October	150.0	153.5	103.7	0.00	23.72	102.3	126.0	0.812
November	126.0	138.2	92.9	0.01	32.96	89.0	122.0	0.730
December	129.0	155.9	110.6	8.12	30.17	95.8	126.0	0.761
Year	2021.0	1931.0	1347.3	80.87	263.36	1220.4	1483.7	0.822

Table 5 The balances and main Simulation results of 1KWP Project

6. CONCLUSIONS

The research paper aimed providing technical details of 1KWp with 1.5KVA off grid solar roof top power plant on turnkey solutions and Simulation analysis is carried out using PV Syst at Davangere city location. From the simulation results, the horizontal global irradiation is 5.097 Kwh/m².day in different months in a year and the available energy at inverter output is 4.447 Kwh /day and energy demand is 4.065 KWh/month. In Jan-March, the PV module output is more than the load demand so we get excess energy in these months and in remaining months PV module output is equal to or slightly more than the demand. The energy demand is 120.7KWh/month in March month while energy output of PV module is 154.7 KWh/month and excess energy is 28.6 KWh / month and energy loss is 5.30KWh/month. The simulation results of energy output of PV module are presented. These outputs of PV module vary with respect to irradiation. The future growth can be enhanced to larger scale PV modules

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