“Designing and Simulation using Software’s PV SYST & HELIOSCOPE for Mitigating Challenges of Grid Connected PV Based Solar Plant”

Nilesh Rohankar, Jithin C.J, Shashikant Bakre, Sachin Shelar, Ashpana Shiralkar

Abstract: India is having large potential of renewable energy for which Govt of India has a plan to develop 100GW solar generation. Out of which commissioning of 60 GW Distributed RE generation has been the beginning of an era of de-licensed generation. Paper emphasis on the need for active involvement of distribution companies (DISCOMS) for strong scalability of pilot projects concept under clustered solar agriculture feeder in rural areas and its power evacuation with high degree of performance indicators. In this paper we have discussed various issues regarding grid connected ground mounted solar plant with its energy generation, solar insolation, project sizing/designing tools like PV SYST & HELIOSCOPE software with simulation analysis. Paper covers analysis of above software results for critically study annual energy generation & to mitigate its challenges.

Keywords: RE, DER, DG, SLDC, MSEDCL, MSPGCL, CEA, MERC, PV SYST, DISCOMS, HELIOSCOPE

I. INTRODUCTION

In today’s changing scenario of development of power market, integration of Renewable Generation and increase in transmission congestion, there is a need for active involvement of distribution companies (DISCOMS) in Transmission Planning process, keeping in view the spirit of National Electricity Plan and National Tariff Policy. A change is taking place, or will to take place from large power generation units towards small generation connected to distribution areas. The term “distributed generation” (DG) is being used to refer to this small generation. The paper example is referred to as “centralized generation”.

Electricity consumption by agriculture consumers constitutes almost 1/5th of total electricity consumption in India. In most of the agriculture dominant states, the sale of electricity for agriculture is reported to be in the range upwards of 30%.

The per unit gap (ABR - ACoS) for AG consumer is in excess of Rs. 2 per unit in most of the states, thus appropriate accounting of energy catered to AG consumption has great influence on the financial health and on the cash flows of the distribution utility. Agricultural demand for electricity is one of the largest burdens on India’s power sector as irrigation systems are largely undeveloped, and farmers are dependent on electricity to power the pumps. Solar can mitigate this entire portion of demand by generating power at the source and converting users into suppliers. In India as a vital part of all schemes, rural electrification which bringing electricity to remote and rural areas, results into the development of the rural areas. So to cater challenges head-on, looking at past challenges, and creating opportunities, govt. of Maharashtra has launched project for MSEDCL consumers which feeds electric power to agricultural pumps consumers and some rural domestic consumers.

Pilot project scalability under solar PV based agriculture feeders policy can also be helpful for newly launched Central government scheme KUSUM for farmers. Farmers can development solar power projects on their barren land and can utilise the generated energy. For that subsidy will be provided by government. Farmers can also sell the excess power to local discoms through grid to generate additional income.

Paper consist of five sections. Section I comprises of Introduction, Section II of 1.6MW Solar Plant & its Evacuation/ Grid Connectivity ideology, section III discusse Photovoltaic array modeling & manual analysis of performance indicators, Section IV is all about PV SYST V6.81 Software designing & simulation, Section V discusses HELIOSCOPE Software designing & simulation results, Section VI tells us about conclusion.
II. EVACUATION/GRADE CONNECTIVITY IDEOLOGY OF 1.6MW SOLAR PLANT.

Basically grid connected PV based project under clustered solar agriculture feeder at Ralegan Siddhi consist of HT power supply at 11kv level with Start Up power having contract demand of 40KVA for purpose of solar generation evacuation and also having installation of special Import/Export ABT meter having continuous communication facility with SLDC & to provide real time visibility of electricity generation to MSEDCL. Regarding grid connectivity, committee was formed for incorporation of private company as a start up power in association with MSPGCL. Also connectivity to the distribution network was governed by CEA (Technical Standards of Grid Connectivity ) Regulation 2007 & MERC (Distribution Open Access ) Regulation 2016. Likewise MSPGCL has tendered 750 MW of grid-connected solar photovoltaic (PV) projects to cater to the agricultural (AG) feeder load of various substations across the state. MSPGCL has fixed Rs. 3.25 (~$0.0477)/kWh as the upper tariff ceiling for this tender. A single bidder can bid for the entire capacity tendered. The scope of work includes the design, engineering, manufacture, supply, installation, testing and commissioning of the grid-connected solar PV projects.

III. PHOTOVOLTAIC ARRAY MODELING

WAAREE WS260[4] panels are used. Panels connections are in series and parallel to obtain required amount of power. -40 to 85 degree Celsius is Operating temperature range. The electrical characteristics of the panel is mentioned below in figure.

**ELECTRICAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Model</th>
<th>Voc(V)</th>
<th>Isc(25)</th>
<th>Pmax</th>
<th>Fill Factor</th>
<th>Module Efficiency (%)</th>
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<tbody>
<tr>
<td>WS260</td>
<td>34.5</td>
<td>3.2</td>
<td>780</td>
<td>0.74</td>
<td>15.0</td>
</tr>
<tr>
<td>WS256</td>
<td>34.5</td>
<td>3.2</td>
<td>750</td>
<td>0.74</td>
<td>15.0</td>
</tr>
<tr>
<td>WS252</td>
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<td>3.2</td>
<td>720</td>
<td>0.74</td>
<td>15.0</td>
</tr>
<tr>
<td>WS262</td>
<td>34.5</td>
<td>3.2</td>
<td>780</td>
<td>0.74</td>
<td>15.0</td>
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<tr>
<td>WS270</td>
<td>34.5</td>
<td>3.2</td>
<td>780</td>
<td>0.74</td>
<td>15.0</td>
</tr>
</tbody>
</table>

No of Panels ( size 1.640m x 0.990 m ) =5960 nos.

Total plant Capacity = Inverter 1 ( 100 strings) + Inverter 2
(148 strings)
= (270 watts x 2400 nos. + 260 watts x 3552 nos.)
= 1571520watts
= 1.57 MW

(**24 modules =1 string**)

*Annual Energy Generated = A x r x H x PR
A = Total solar Panels Area (sq.m)= 1.640m x 0.990 m
=1.623 sq.m.
r = Solar Panel Yield or Efficiency (16.1 %)
H= Annual Average Solar Radiation on Tilted Panels
= 5.61 kwh /sqm / day x 365 days

*Performance Ratio (PR) = Total Energy generated by solar PV plant / Estimated energy generated by solar PV plant
= Total Energy generated by solar PV plant in kwh

Solar insolation in kwh per sq. Meter x Net active area in Sq.
Meter x Efficiency (%) = Total Energy generated by solar PV plant in kwh

*Solar Insolation at Proposed site :
Ralegan sidhi, Ta. Parner Dist. Ahmednagar India.
Latitute : 19.1N    Longitude: 74.8 E

**Fig.2 PV module Electrical Characteristics**

**MANUAL ANALYSIS**

**Performance Indicators ;**

* Manual calculations :

**Fig.1 Site photos of S/Stn Yard & PV Solar plant at Ralegan sidhidi Area**

**Fig.2 PV module Electrical Characteristics**

**MONTH** | **MWH**
--- | ---
JAN 19 | 197.28
FEB 19 | 169.52
MAR 19 | 150.69
APRIL 19 | 190.90
MAY 19 | 226.48
JUNE 19 | 159.60
JULY 19 | 140.60
AUG 19 | 156.21
SEPT 19 | 146.85
OCT 19 | 165.00
NOV 19 | 182.82
DEC 19 | 166.36

**TOTAL 2052.31**

*Actual Energy Generation chart : Jan 2019 to Dec 2019*
Table:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>APR</td>
<td>5.81</td>
<td>6.97</td>
</tr>
<tr>
<td>MAY</td>
<td>5.69</td>
<td>7.03</td>
</tr>
<tr>
<td>JUN</td>
<td>3.62</td>
<td>5.66</td>
</tr>
<tr>
<td>JUL</td>
<td>2.35</td>
<td>4.81</td>
</tr>
<tr>
<td>AUG</td>
<td>2.21</td>
<td>4.56</td>
</tr>
<tr>
<td>SEP</td>
<td>3.82</td>
<td>5.20</td>
</tr>
<tr>
<td>OCT</td>
<td>4.80</td>
<td>5.41</td>
</tr>
<tr>
<td>NOV</td>
<td>5.22</td>
<td>5.02</td>
</tr>
<tr>
<td>DEC</td>
<td>5.56</td>
<td>4.84</td>
</tr>
<tr>
<td>AVG.</td>
<td>4.69Kwh/sqm/day</td>
<td>5.61 Kwh/sqm/day</td>
</tr>
</tbody>
</table>

(Source :NREL)

*Losses Analysis :*
- Shadow loss 1-3%
- Module Mismatch loss 1%
- Module Quality Loss 1.5%
- Temp. Loss 10-15%
- Cabling Losses 1-3%
- Soiling Losses 1-2%
- Inverter loss 1-3%

*Location and PV System Details:*

1. Lat(deg N): 17.45
2. Long(deg E): 78.55
3. Module Type: Standard
4. Array Type: Fixed (open rack)
5. Array Tilt (deg): 20
6. Array Azimuth (deg): 180
7. System Losses: 14.08
8. Invert Efficiency: 96
9. DC to AC Size Ratio: 1.2

**IV. PV SYST SOFTWARE DESIGNING & SIMULATION:**

**PV SYST Software V6.81**

PVSYST V6.81 is the software to study, sizing and analyzing of grid connected, stand alone, pumping and DC grid solar system. It is facilitated with technical, economical and environmental analysis of solar system. It consist of three stages ie. Preliminary design, Project Design & Measured data analysis. Preliminary design involves quickly pre-sizing step of a project with few system characteristics. & a rough estimation of the system cost. Project Design consist of thorough system design using detailed hourly simulations & can perform different system simulation runs and comparison. Effects like incidence angle losses, horizon (far shading), or partial shadings of near objects on the array, thermal behavior, wiring, module quality, mismatch can also be find out. Results including several phases of simulation variables & "Loss Diagram" is useful for identifying the weaknesses of the system design. In Measured data analysis close comparisons with the simulated variables is possible with analysing the real running parameters of the system, and identifies even very little misrunnings.
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Grid-Connected System: Simulation parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>New Project</td>
</tr>
<tr>
<td>Geographical Site</td>
<td>Raigad, Maharashtra</td>
</tr>
<tr>
<td>Time zone</td>
<td>172.60°E, 11.68°N</td>
</tr>
<tr>
<td>Altitude</td>
<td>1500 m</td>
</tr>
<tr>
<td>Wind data</td>
<td>Raigad, Maharashtra, 172.60°E, 11.68°N</td>
</tr>
<tr>
<td>Simulation variant</td>
<td>New simulation variant</td>
</tr>
<tr>
<td>Simulation case</td>
<td>System type</td>
</tr>
<tr>
<td>Outdoor Plane Configuration</td>
<td>W</td>
</tr>
<tr>
<td>Models used</td>
<td>Transmission, Diffuse</td>
</tr>
<tr>
<td>Pollution</td>
<td>None</td>
</tr>
<tr>
<td>Users need to simulate</td>
<td>Unlimited user</td>
</tr>
</tbody>
</table>

PV System Characteristics:

- Number of PV modules: 2000
- Total number of PV modules: 2000
- Array power: 1000 kW
- Array efficiency: 15%
- Array lifetime: 25 years

Fig. 5. Grid Connected System: Simulation parameters

Fig. 6. Geographical Site configuration

Fig. 7. Global irradiance of site
Fig. 8. Grid Connected System: Main Results

Fig. 9. Grid-Connected System: Special graphs: System output Power Distribution
V. HELIOSCOPE SOFTWARE DESIGNING & SIMULATION:

HelioScope software involves all the features of PV Syst and adds the design functionality of AutoCad, allowing designers to do a complete design with one package. When using HelioScope, user selects the roof area for the array, specifies a PV module, and chooses an inverter model and also user enters the location’s address. You can use Google Earth for a free drawing program. Based on that 3D model, HelioScope will perform its shading analysis. Site assessment and design without setting foot on the actual property is also possible. HelioScope uses the same models that PV Syst uses, so they’re not reinventing the wheel with the simulation algorithms.
A performance and Simulation analysis of grid connected solar PV power plant installed at Ralegan siddhi was evaluated on annual basis using PV SYST & Helioscope Simulation software with high degree of performance indicators like maximum energy been generated in the month of March is 254.6 MWh and minimum energy generated in the month of Aug is 142.1 MWh. The available energy obtained through software after the inverter losses at the inverter output is 2616 MWh/year with overall simulation output of 2512 MWh/Year. DC wiring losses between PV and inverter are 1.5%, and the performance ratio is 0.77. Both PV SYST & Helioscope Simulation softwares are applied through common data irradiation Meteonorm 7.2. Hence Production probability forecast in energy generation is 90% at STC 16.08%. But actual site real time measured energy over all output of solar grid connected roof top power plant was 2052.31 MWh/year with maximum energy generated in the month of May 226.48 MWh and minimum energy generated in the month of July 140.60 MWh. Actual site values vary by 15% due to Grid availability/ Grid failure factors. By using tools like PV SYST & Helioscope software for grid connected system simulation parameters, graphs, losses and results including annual production reports can help DISCOMS to critically analyze and match the actual energy generation of solar plant with software simulations leading to benefits like reduction in T & D losses of the Solar Plant located near to the selected feeder, giving supply to the agriculture sector in day time & last but not the least increasing overall efficiency of a solar plant with improvement in the revenue recovery with minimizing the cross-subsidy burden.

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