

A Case study of one unit of 250 MW in Rewa Ultra Mega Solar Park 750 MW (Mahindra Teqo Private limited)

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ABSTRACT:- India's energy crisis as seen today can be solved by using reliable source of renewable resources like solar energy with minimum undesirable conservation impacts, along with alleviating energy security concerns. Several photovoltaic projects based on rooftop model and land-based solar parks have been approved for the purpose to improve the solar electricity. Energy production and various input parameters are analyzed to evaluate the Efficiency, capacity Factor (CF), Performance Ratio (PR) for augmenting Solar Power. Availability of electricity is very important in economic development as well as attracting investment in solar energy. Madhya Pradesh is also one of the fastest growing states in the country in the field of energy. Madhya Pradesh's largest solar plant is located in Rewa and Rewa Solar Power Plant Project which increases the power of MP Power Sector. Mahindra Renewable, a wholly owned subsidiary of Mahindra Systems, has already completed its project by providing Yes Bank loans for \$7.5 billion and \$2 billion to other financial institutions. As a loan from IFC, the World Bank's financial arm for the Rewa project, in support of the 250 MW solar project construction, development, financing, operation and maintenance of Rewa Solar Park, ACME Jaipur Solar Energy Pvt. Ltd. wholly owned by ACME Solar is an ACME Solar subsidiary.

Key Word :- Rewa Ultra mega solar power plant, Percentage Performance Ratio (PR%), capacity Factor

Introduction :- Rewa Ultra Mega Solar Limited (hereinafter referred to as 'RUMSL'), a joint venture company through an agreement signed between Solar Energy Corporation of India (SECI) and Madhya Pradesh Urja Vikas Nigam Limited (MPUVNL) was incorporated in 2015 for implementation of solar park(s) and ultra mega solar power plant(s) in the State of Madhya Pradesh. As an initial Endeavour of the agreement, development of a 750MW Ultra Mega Power Plant has been proposed in Gurh Tehsil, Rewa District. RUMSL intends to install the 750MW capacity in Gurh Tehsil, Rewa District, and Madhya Pradesh (hereinafter referred to as the 'Project'). The project is proposed to be developed in an area measuring approximately 1500 hectares, with 2MW capacity to be installed on one hectare of land. Rewa Ultra Mega Solar Power Park is a 750MW solar PV power project. It is located in Madhya Pradesh, India. The project is currently active. It has been developed in multiple phases. Post completion of construction, the project got commissioned in 2018. RUMSL has been given the responsibility of identifying the required land for the proposed project. The development of the project will be undertaken as per package size of 250 MW each (250x3) through an open competitive bidding process conducted by the New and Renewable Energy Department (NRED) under the Government of Madhya Pradesh. Power evacuation would be transmitted to 33/220 kV pooling sub-stations linked to a 400/220 kV Power Grid sub-station to be set up within the project location by Power Grid Corporation of India Limited (PGCIL) through the Intra-State Transmission System (ISTS). Project cost infrastructure work is proposed to be funded 50% by World Bank through MNRE, INR 75

Cr. as financial assistance from MNRE while the remaining amount would be raised through solar project developers. Each unit of 250 MW would be developed by solar project developer (SPD) under investment mode. SPD would be selected by e-bidding-auction process. International Finance Cooperation (hereinafter referred as IIFC) is providing advisory services to RUMSL on selection of SPD(s). In order to ensure that the project is established in a manner that is socially responsible and reflects sound environmental management practices, RUMSL intends to carry out an Environmental and Social Assessment (ESA) study for the Project, in accordance with World Bank's Operational Policies; Performance Standards (PS) on Social and Environmental Sustainability, 2012; and World Bank's Environment, Health and Safety Guidelines, 2007. The aim of the study is to provide an assessment of the ability of the project to comply with the requirements of the above mentioned guidelines as required by financial investors. This ESA report has been prepared on the basis of a reconnaissance survey, baseline environmental monitoring, review of secondary data and consultation with relevant stakeholders. Based on the requirements of the World Bank's Operational Policies and IFC PSs, adequate management plan are also expected to be developed as part of this assessment. There are some important point about the Rewa ultra mega solar limited . 1. The Rewa Ultra Mega Solar Limited (RUMSL) project is Asia's largest single-site solar power plant with a total solar installed capacity of 750 megawatts. 2. It has three solar generating units of 250 MW each spread over 500-hectare land, in a 1590-hectare solar park. 3. The mega solar plant has been designed in a joint venture of Madhya Pradesh Urja Vikas Nigam Limited (MPUVN) and Solar Energy Corporation of India (SECI). It will cater to the needs of



different type of power off-takers, including Power Management Company, Madhya Pradesh, as well as Delhi Metro Rail Corporation.

Rewa Ultra Mega Solar is an operational solar park spread over an area of 1,590 acres (6.4 km²) in the Gurh tehsil of Rewa district of Madhya Pradesh. The project was commissioned with 750 MW capacities in July 2018 Rewa Ultra Mega Solar Limited (RUMSL), the implementing agency of the project, is a joint venture between the Madhya Pradesh Urja Vikash Nigam Limited (MPUVNL) and the Solar Energy Corporation of India (SECI). Minimum tariff of the time for solar projects received from Rewa Solar Project: 2.97 per unit for first year (without Viability Gap Funding) Revenue land allotted for the project: 1255.68 ha Private land purchased under the 'mutual consent policy' of the state government: 300 hectares Amount received by the state as registration from developers: Rs 7.5 crore.

Table 1 The project Rewa Ultra Mega Solar Limited (RUMSL).

Project Type	Total Capacity (MW)	Active Capacity (MW)	Pipeline Capacity (MW)	Project Status	Project Location	Project Developer
Solar PV	750	750	–	Active	Madhya Pradesh, India	ACME Solar Energy Private; Mahindra Renewable; Rewa Ultra Mega Solar; Spring Energy

In online bidding, 3 Solar Project Developers (SPD), namely, Mahindra Renewables Private Ltd., Acme Jaipur Solar Power Private Ltd. and Arinsun Clean Energy Private Ltd were selected for developing 250 MW Unit each. The project boasts of a unique structuring and is having two power procurers, namely, Madhya Pradesh Power Management Company Ltd. (MPPMCL) and Delhi Metro Rail Corporation (DMRC). MPPMCL, which supplies power to the state DISCOMs, will get 76% of the power produced from Rewa Solar Power plant, while the Delhi Metro Rail Corporation (DMRC) will benefit from the remaining 24%. Rewa solar plant has started production from June 2018 and has been in commercial production from July 2018. Total 750 MW capacity has been commissioned on 3rd January 2020. An indicative location of the project site is presented in Figure 1.



Fig .1:- Inductive Location Of the Project Area The power generation from the project is being purchased by the MPPMCL to the extent of 651 MW and DMRC to the extent of

99MW. The project has been commissioned to full capacity of 750 MW on 03rd January 2020. The Government of India has set a target of installing of installing 175 GW of renewable energy capacity by the year 2022, which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power.

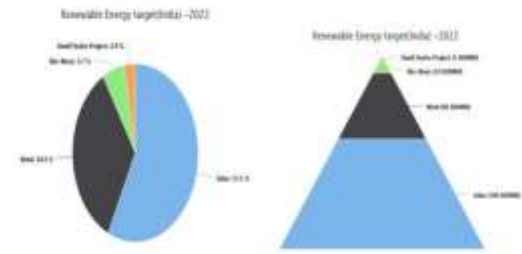


Fig.2 India Target Renewable energy Generation in 2022

The Fig 2 shown Pie diagram for renewable energy target India in 2022 is 57.1% energy generation from solar power plants, 34.3% energy generation from wind power plant, 5.7% energy generation from Biomass system, and 2.9% energy generation from small hydro projects. The triangular diagram shown the total target of renewable energy India 2022 is 100000 MW electricity generation from solar power plant, 60000MW electricity generation from wind power plant, 10000 MW electricity generation from Biomass, 5000MW electricity generation from small hydro project.

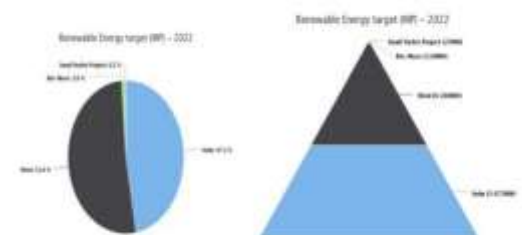


Fig. 3 Madhya Pradesh (M.P.) Target Renewable energy Generation in 2022

The Fig 3 shown Pie diagram for renewable energy target Madhya Pradesh (M.P.) in 2022 is 47.2% energy generation from solar power plants, 51.6% energy generation from wind power plant, 1.0% energy generation from Biomass system, and 0.2% energy generation from small hydro projects. The triangular diagram shown the total target of renewable energy Madhya Pradesh (M.P.) 2022 is 5675 MW electricity generation from solar power plant, 6200MW electricity generation from wind power plant, 118 MW electricity generation from Biomass, and 0.2% energy generation from small hydro projects.

generation from Biomass, 25MW electricity generation from small hydro project.

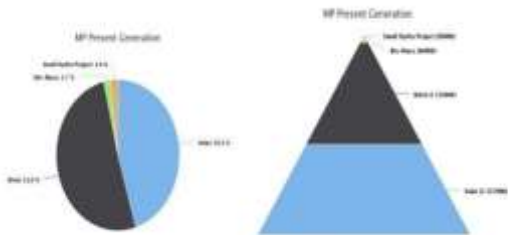


Fig. 4 Madhya Pradesh (M.P.) Present Generation

The Fig 4 shown Pie diagram for presently renewable energy generation Madhya Pradesh (M.P.) is 45.3% energy generation from solar power plants, 51.0% energy generation from wind power plant, 1.7% energy generation from Biomass system, and 1.9% energy generation from small hydro projects. The triangular diagram shown the total presently renewable energy Madhya Pradesh (M.P.) is 2237 MW electricity generation from solar power plant, 2520 MW electricity generation from wind power plant, 85 MW electricity generations from Biomass, 96MW electricity generation from small hydro project.

Project Overview

Solar energy systems produce energy by converting solar Irradiation Into electricity or heat. For the proposed PV power facility, RUMSL will utilize photovoltaic (PV) technology to generate electricity. PV technology consists of the following components:

Project Components:- It is envisaged that the proposed Solar Plant will be grid connected system which will also include monitoring of the system and the grid and switches which can off the system in case of faults. Developers will be scrutinized based on the technical guidelines of the proposal and with the best available technology.

Technology evaluation was performed by SECI in the preliminary stages of the project to assess the land requirement. SECI has shortlisted four commercially established solar PV technologies — Mono Crystalline, Poly Crystalline, Amorphous Silicon (a-Si) and Cadmium Telluride (CdTe) for the proposed site. Considering an initial assessment of about 1500 hectares of land, technologies requiring beyond 2 hectares/ MW may not be feasible for generating an output of 750 MW as proposed.

Table 3.1 Comparison of various solar panel Technologies

Technology	Lab Efficiency	Module Efficiency	Cost (\$/wp)	Approx. Area required/ MW (hectares)
Mono Si	25%	13-23%	1.1-1.3	1.72
Multi Si	20%	17-19%	0.55-1.0	1.97
Amorphous Si	12.5%	8-10%	0.8-0.9	3.7-3.9
Cd Te	16.7%	11%	0.9-1.0	2.5-3

Source : Draft Prefeasibility Report submitted by SECI As per the evaluation, Polycrystalline (or multi-crystal) silicon panels are made by using polycrystalline wafers which Is the most preferred technology. Crystalline technology has got a proven track record of over 30 years in commercial operation as compared to approximately 7 years for thin film technologies. Further, considering the mega-size of the proposed solar park, PV modules with a power rating of more than 240 Wp will be shortlisted.

Rating of a solar modules :- The output of the solar depends upon some condition Such as (i) Ambient Temp. (ii) Incidence Light Intensity. The maximum output of a solar module can be obtained under ideal condition – (Standards test condition) 25 0 Temperature (i) 1000 W/M2 light radiation (ii)

Rating of PV module can be given with their I. Short circuit current (Isc) II. Output open circuit voltage (Voc) III. Peak Power (Wp) IV. The standard test condition may vary with location and time at site.

Short circuit current of a PV module (Isc) :- At Short circuit test condition (+ve) and (-ve) terminals of a solar modules , short circuited and gives Short circuit current The bigger value of Isc denoted bitterness of PV Modules. This deepens on area of modules that expressed to sun radiation. The Short circuit current per unit area is called Current density (Jsc)

$$J_{sc} = \frac{I_{sc}}{A} \dots \dots \dots (1)$$

Open Circuit Test (Voc) :- The Voltage output of PV modules when not connected to load under standard test condition is Open Circuit Test (Voc). This Mainly depended upon the technology used to manufacture the solar cell .More Voc indicates better modules , but depends upon the operating temperature of modules.

Maximum Power Point (Watt Peak) – (Wp) :-The maximum amount of power which can be delivered by PV modules under standard test condition is maximum power point (Wp or Pm) For fix dimension of modules higher Wp denotes better modules. The PV modules can be operated in any voltage and current combination up to Voc and Isc .If we observe VI curve we see power output increase with respect to current but often certain current it falls down to zero . so the power is maximum at a current which is less then Isc ; called Imax

$$I > I_m > I_{sc} \dots \dots \dots (2)$$

Similarly the Pmax occurs at a voltage lower then Voc which is called Vmax

$$V > V_m > V_{oc} \dots \dots \dots (3)$$

$$P_{max} \text{ Or } W_p = I_m \times V_m \dots \dots \dots (4)$$

Vm and Im are voltage and current at maximum power point Fill factor of solar PV module:-The ratio of Pmax to the product of Voc and Isc

$$\text{Full Factor (FF)} = \frac{P_m}{V_{oc} \times I_{sc}} = \frac{V_m \times I_m}{V_{oc} \times I_{sc}} \dots \dots (5)$$

Higher the fill factor better the solar module. Efficiency of PV Modules :-The ratio of maximum output power to the input power at standard test condition . Input power is solar radiation which is standard condition = 1000 W/m² So actual input power = 1000 w*A A= area of PV module exposed to sun light

$$\text{Efficiency} = \frac{P_m}{1000 \times A} \times 100 \dots \dots (6)$$

$$\text{Efficiency \%} = \frac{V_m \times I_m}{1000 \times \text{Area}} \times 100 \dots \dots (7)$$

Result: Rewa Ultra Mega Solar Power Project 250MW is made by Mahindra, it is fitted with Total number of Inverter is 183 and the total number of panels is 1120774, it has three inverters 1) ABB inverter 2) TEE inverter 3) String inverter 1) ABB inverter :- There is an inverter of total 2MVA capacity in ABB inverter and total 94 inverter is installed then 2*94=188MVA ABB inverter has been installed in it, there is 12 combination box and 12 string is installed in one combination box and in one string there are 62

models so that total 12*62=744 solar panels are installed in a one combination box, thus total 12*744=8928 solar panels are installed in 12 combination boxes, so total 94 inverter of ABB is 94*8928=839232 solar panels is engaged. A total of 47 transformers is connected to ABB inverter, total of ABB is 94 inverter and each inverter is of 2MVA capacity so thus total inverter of ABB inverter is 94*2=188 MVA capacity, for this 47 transformers of 4MVA capacity have been installed (188/4=47 Transformer) 2) TEE inverter :- There is an inverter of total 2.55MVA capacity in TEE inverter and total 20 inverters have been installed, then TEE inverter of 2.55*20=51MVA has been installed, it has 14 combination boxes and 14 strings are installed in one combination box and There are 62 models in a string, then total 14*62=868 solar panels are installed in a combination box, thus total 14*868 = 12152 solar panels are installed in 14 combination boxes, so total of TEE inverter is 20 inverters, so it has 20*12152 = 243040 solar panels installed. Total 10 transformers are connected to T inverter, total is 20 inverters of TEE and each inverter is of 2.55MVA capacity, thus total inverter of TEE inverter is 20 * 2.55 = 51MVA capacity, for this 10 transformers of 5MVA capacity are installed is (51/5=10.2~10 transformer) 3) String Inverter :- String inverter has one inverter of total 160KVA capacity and total 60 inverters are installed then 0.160*69=11.04MVA string inverter has been installed, it has 1 combination box and 9 strings have been installed in one combination box and one string I have 62 models, total 9 * 62 = 558 solar panels are installed in a combination box, thus total 1 * 558 = 558 solar panels are installed in 1 combination box, then total 69 of the string is inverter, then 69 * 558 = 30502 solar panel is installed. Total 3 transformers are connected to string inverter, total of string inverter is 69 inverter and each inverter is of 160KVA

capacity, thus total inverter of Abb inverter is 69*0.16 = 11MVA capacity inverter, for this 3 transformers of 3.5MVA capacity have been installed. (11/3.5=3.14~3 transformer) Now ABB Inverter, TEE Inverter, String Inverter got all the three types of inverter, the total number of inverter is 94+20+69 = 183 Inverters. Similarly total number of transformer is installed at Rewa Ultra Mega Solar Power Project is including ABB Inverter, TEE Inverter, String Inverter are connected 47+10+3 =60 transformer. Similarly total number of solar panels is 839232 + 243040 + 38502 = 11,20,774 solar models are installed at the location of Rewa Ultra Mega Solar Power Project 250MW. The Table 5.4 shown a ABB Inverter, TEE inverter and String inverter configuration, table 5.5 shown Area occupy by solar system. This graph is drawn between active power and irradiation on date 15.3.22. In this graph we have seen that the curve line of irradiation and active power is running overlapping each other, in this graph red line is between active power and time and green line is between irradiation and time. In this graph is drawn between active power and time and between irradiation and time, at 5 AM in the morning there was no irradiation, then the generation of that time was 00 KW, this is the highest in the graph Irradiance 991.24W/m² was received at 11:40AM and the generation at this time was 246639.59KW. We saw that the irradiation in the graph is constant but the generation is decreasing, but after some time the graphs of both irradiation and generation become together.

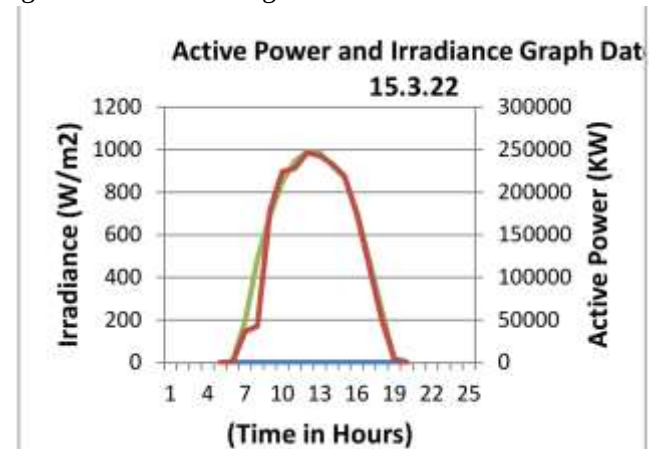


Fig. 5 shows an active power and irradiance graph on date 15.3.22. In a 250 mega watt solar power plant, we have made this graph between the electricity generated per minute of every hour and its Mega Watt (MW) and Mega Volt Ampere Reactive (MVAR) power, in this graph the blue line is the total megawatt produced and the red line is the total mega volt ampere reactive power, on looking at this graph it appears that power is increasing all the time and mega volt

ampere reactive power is decreasing all the time. Fig. 6 shown MW and MVAR one day per hour graph at 6.00 o'clock.

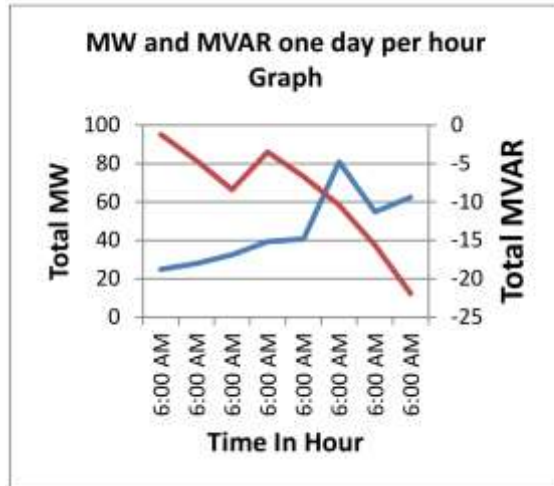


Fig. 6 shown MW and MVAR one day per hour graph at 6.00 o'clock. Monitoring the average daily generated energy from the PV array is responsible for calculating the final yield, which largely depends on the quality factor of the PV plant, i.e. Performance Ratio (PR). The Performance Ratio evaluated for the monitoring period of 20 days. The PR is responsibly maintain at e a constant measuring average value of 78.47% over 20 days, Percentage Performance Ratio (PR%) in which percentage performance ratio from 10.3.202 to 30.3.222 has been taken and according to this table we have prepared bar graph in which lowest percentage performance ratio 30.3.22 got 77.71%. And the highest percentage performance ratio was achieved at 25.3.22 with 87.19%. Fig. 7 shown Percentage Performance Ratio (PR%) and Date wise Bar graph.

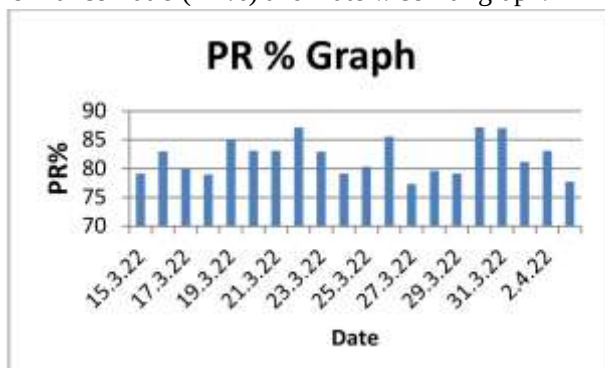


Fig. 7 shown Percentage Performance Ratio (PR%) and Date wise Bar graph

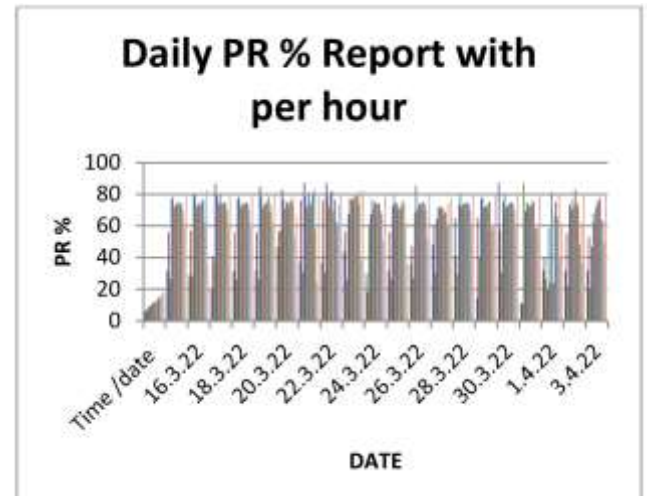


Fig. 8 shown Daily PR%, Sun shine time per day per hour and Date wise Bar graph

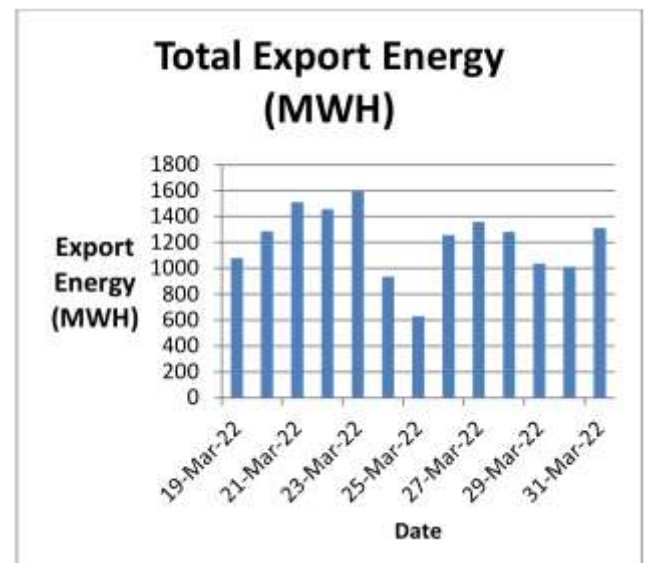


Fig. 9 shown Export energy (MWh) on Date wise bar graph

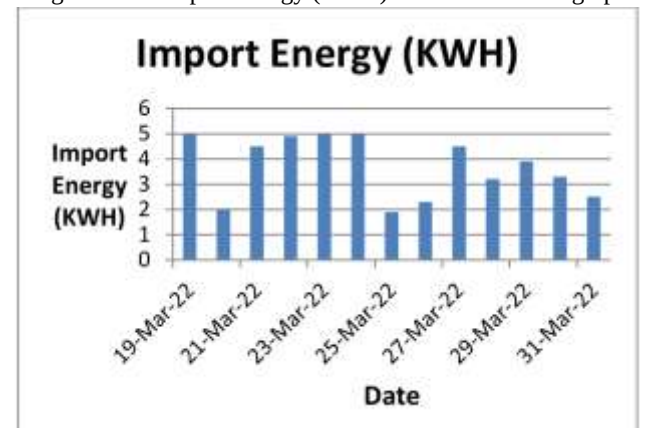


Fig. 10 shown Import energy (KWh) on Date wise bar graph

Conclusion :- We saw in the plant that when there are clouds, then the production of electricity is less and when the weather is good then the solar rays are faster, at that time the production of electricity is more and when the rays are more than 1000 W/m² then at that time solar generation exceeds 250MW. Rewa solar project started the power supply 6 July 2018. With an exceptionally low rate of RS 2.97. The project provided environmentally friendly power to the states. Which was marked to be less than its average power procurement cost. In the first year along with an increase provision of RS 0.05 per year for the coming 15 year which leveled the tariff to RS 3.30/unit, were set on the tariff of RS 2.97/unit. Rewa Ultra Mega Solar (RUMS) Park, the largest grid connected solar power plant the time in India.

REFERENCE

- [1] Maria Malvoni, Nallapaneni Manoj Kumar, Shauhrat S Chopra, Nikos Hatziaargyriou "Performance and degradation assessment of large-scale grid-connected solar photovoltaic power plant in tropical semi-arid environment of India" solar energy 203, Elsevier, 2020 pp 101-113.
- [2] Deepak Bishoyi, K. Sudhakar "Modeling and performance simulation of 100 MW PTC based solar thermal power plant in Udaipur India" Case Studies in Thermal Engineering 10, Elsevier, 2017 pp 216-226.
- [3] Vikrant Sharma, S.S. Chandel "Performance analysis of a 190 kWp grid interactive solar photovoltaic power plant in India" Energy 55, Elsevier 2013 pp 476-485.
- [4] B. Shiva Kumar, K. Sudhakar, "Performance evaluation of 10 MW grid connected solar photovoltaic power plant in India" Energy Reports, 2015, pp 184-192.
- [5] T. Bogaraj, Dr. J. Kanakaraj "Indian Renewable Power Sector: Potential, Policies, Barriers, And Its Prospective" Journal of Electrical Engineering ISSN 1582-4594 Vol. 21 No 3 2021 pp 109- 124.
- [6] Brijesh Kumar Vyas, Ambuj Adhwaryu, Kalyan Bhaskar, "Planning and developing large solar power plants: A case study of 750 MW Rewa Solar Park in India" Cleaner Engineering and Technology 6, Elsevier, (2022) 100396 PP 1-8.
- [7] Anil Kumar, om Prakash, Akarshi Dube, "A rivew on Progress of Concentrated solar power in India" Renewable and Sustainable Energy Reviews, 79 (2017) PP 304-307.
- [8] Kante Visweswara, "An Investigation Of Incremental Conductance Based Maximum Power Point Tracking For Photovoltaic System" 4th International Conference on Advances in Energy Research 2013, ICAER 2013 Energy Procedia 54 (2014) PP 11 – 20.
- [9] Amita Ummadisingu, M.S. Soni, "Concentrating solar power – Technology, potential and policy in India" renewable and sustainable energy reviews 15 (2011) Pp5169– 5175
- [10] Pankaj Kalita, Pallab Borgohain, Anupam Dewan, "Feasibility study of installation of MW level grid connected solar photovoltaic power plant for northeastern region of India" Indian Academy of Sciences (2019) 44:207 pp 1-24 . <https://doi.org/10.1007/s12046-019-1192-z>
- [11] M. Ganga Prasanna, S. Mahammed Sameer, G. Hemavathi, "Financial Analysis of Solar Photovoltaic Power plant in India" IOSR Journal of Economics and Finance (IOSR-JEF) e-ISSN: 2321-5933, p-ISSN: 2321-5925 PP 09-15.
- [12] Atul Sharma, "A comprehensive study of solar power in India and World" Renewable and Sustainable Energy Reviews Elsevier 15 (2011) 1767–1776 .
- [13] Aashish Jaiswal, Garima Sikka, "Future Scope and Potential of Solar Energy in India An Overview" International Journal of Innovative Science and Modern Engineering, ISSN: 2319-6386, Volume-4 Issue-10, April 2017 pp 18-23
- [14] Utkarsh Mohan, Priyanka Singh, Krishna Mohan Agarwal, Sanjeev Kumar Sharma, Ashish Yadav, Chinmay Sharma, "Solar power generation, utilization and management for facilitating sustainable development in India : Review" IOP Conf. Series: Materials Science and engineering CEME 2020, 2021 pp.- 1-14.
- [15] Ritu Sharma, Dr.P.V.Rao "Review On Madhya Pradesh Power Sector Reforms" International Journal Of Research And Analytical Reviews (IJRAR) June 2019, Volume 6, Issue 2 pp 122-126
- [16] Satish Kumar Yadav, Usha Bajpai, "Performance evaluation of a rooftop solar photovoltaic power plant in Northern India" Energy for Sustainable Development (2018) pp 130–138.
- [17] Nallapaneni Manoj Kumar, Ramjee Prasad Gupta, Mobi Mathew, Arun kumar Jaya kumar Neeraj Kumar Singh "Performance, Energy Loss, And Degradation Prediction Of Roof integrated Crystalline Solar Pv System Installed In Northern India" Case Stuies In Thermal Engineering 2019 100409 Elsevier Pp. 1-9.