International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

Design of solar parabolic trough plant for a village in Rajasthan

Vikrram Singh Meena[1], G.D Agrawal[2]

Centre for Energy and Environment, Malaviya National Institute of Technology, Jaipur 302017, India

---

Abstract-*To fulfill the need of electrical energy and also cut down the dependency on state distribution company for power supply, a solar parabolic trough power plant is proposed for village Mansarkheri situated in district Jaipur. Electrical energy demand of the village has been found by surveying the village and also from electricity Distribution Company. Energy requirement is found to be 584.60 MWh/annum and 557.12 MWh/annum according to survey data and bill data respectively for year 2014. Solar parabolic trough power plant is designed to fulfill the energy need of year 2015, 2019 and 2024. Electrical energy demand and capital cost for year 2019 and 2024 has been achieved by linear regression based forecasting. Energy demand for year 2015, 2019 and 2024 have been calculated as 638.25 MWh/annum, 821.27 MWh/annum and 1072.01 MWh/annum respectively. Solar parabolic trough power plant capacity is calculated as 312.61 kW 451.24 kW 641.88 kW for year 2015, 2019 and 2024 respectively. According to these required capacities, the other designed parameters of solar parabolic trough plant are calculated.*

Key words: Solar parabolic trough plant, Survey, Electrical energy demand

1. INTRODUCTION

In Bassi sub division of Jaipur district, Mansarkheri village is situated at (latitude 26˚83'N, longitude 76˚05'E**,** altitude 351 m. Population of the village is 3662 and total number of households are 513 according to census 2011 data. Need of electricity in the village is both for household purpose and agricultural purpose for which the villagers completely depends on local electricity distribution company. The tariff of the electricity is the major issue for the villagers according to their opinion. Therefore there is need for a economical and sustainable energy source in order to supply desired power demand.

Chandel et al. [1] proposed one on-site solar photovoltaic power plant and one off site solar photovoltaic power plant in order to provide required electricity to the garment zone located in Jaipur in Rajasthan state. The internal rate of return (IRR), net present value (NPV) at 10% discount rate, simple pay-back period, discounted pay-back period at 10% discount rate and Levelized cost of energy at 10% discount rate are 11.88%, 119.52 million INR, 7.73 years, 15.53 years and 14.94 Rs. Per kWh for on-site power plant and 15.10%, 249.78 million INR, 6.19 years, 10.14 years and 11.40 Rs. Per kWh for off-site power plant. **Agrawal et al. [2]]** proposed one on-site solar parabolic trough power plant and one off site solar parabolic trough power plant in order to provide required electricity to the garment zone located in Jaipur in Rajasthan state. The internal rate of return (IRR), net present value (NPV) at 10% discount rate, simple pay-back period, discounted pay-back period at 10% discount rate and Levelized cost of energy at 10% discount rate are 19.21%, 372.77 million INR, 5 years, 7 years 4 months and 9.41 Rs. Per kWh for on-site power plant and 27.85%, 550.55 million INR, 3 years 6 months, 4 years 7 months and 6.89 Rs. Per kWh for off-site power plant. **Kobayakawa and Kandpa [3]** proposed a methodology in order to maintain balance between financial viability of any rural electrification project and the affordability of the electricity generated by the project by considering tariff as an important parameter. **Hrayshat [4]** designed an optimal hybrid system involving photovoltaic, diesel generator and battery storage system which is not connected to grid (off grid) for the purpose of providing electricity to a house located in remote area of Jordanian territory. It is observed that when the electricity is generated by using this hybrid system the operating hours of diesel generator system are decreased by 19.3% and in turn it reduced the consumption of diesel by 18.5% as compared to the case when electricity is generated by only diesel generator system. **Poullikkas [5]** showed his study on the feasibility analytics of a solar parabolic trough based solar thermal technology installation for the purpose of generation of electricity in the selected location of Mediterranean region. He concluded his study that solar parabolic trough power plants are economical as well as profitable in certain conditions. **Muneeret al. [6]** suggested that future energy security can be confirmed by using electricity generated by solar photovoltaic facilities. Six important cities of India i.e. Mumbai, Delhi, Chennai, Kolkata, Trivandrum and Jodhpur are selected in order to exercise modular approach on these for fulfillment of energy demand of those cities in 2025. **Ishan and Pallav [7]** evaluated the solar power generation based on concentrating technology (CSP), technically as well as financially in India. They concluded that CSP based power generation facilities are financial feasible for selected part of India like north-western part especially Rajasthan and Gujarat states. **Celik [8]** evaluated a small scale hybrid type of energy generation facility which involved photovoltaic system and wind energy system, techno-economically. They found that hybrid combination of photovoltaic

Required output power = 312.61 kW

Solar intensity at Jaipur (Rajasthan) = 617 W/m^2

Overall efficiency of plant = 21.15%

Solar collector area = $\frac{312.61 \times 1000}{617 \times 0.2115}$

= 2395.56 m2 ~ 3000 m^2

5.3 Solar field elements

Number of loop required = $\frac{\text{solar collector area}}{\text{area of one loop}}$

Area of one loop = 2624 m^2

Number of loop required = $\frac{3000}{2624}$ = 1.14 ~ 2 loops

Number of solar collector assemblies required = $8 \times 2 =$ 16 SCA

Number of solar collector elements required = 16 X 8 =128 SCE

Number of Receiver tubes required = 128 X 3= 384 Receiver tubes

5.4 Land requirement

Length of one SCA = 115 m

Length of one SCA loop = 2 x Length of one SCA

= 2 x 115 =230 m

Length of the field = Length of one SCA loop = 230 m

Width of one SCA = 6 m

Width of one SCA loop =

(2 x Width of one SCA) + Separation between two SCAs

Separation between two SCAs = 12 m

Width of one SCA loop = (2 x 6) + 12 = 24 m

Width of the field =

(4 x Width of one SCA) + (3 x Separation between two SCAs)

Width of the field = (4 x 6) + (3 x 12) = 60 m

Total area required =

Length of the field x Width of the field

Total area required = 230 x 60

= 13800 m^2 = 3.41 Acre

6. SOLAR PARABOLIC TROUGH PLANT DESIGN FOR YEAR 2019 AND 2024

In this section solar parabolic trough power plant is designed for village Mansarkheri with the considerations of 2019 and 2024 year energy requirements. All the design parameters are calculated and has been tabulated in table-11.

Table-11: Design parameters of SPV plants for year 2019 and 2024

Design parameters	SPT 2019	SPT 2024
Rating of SPT plant (kW)	451.24	641.88
Solar collector area (m^2)	3460	4920
Number of loops	2	2
Number of solar collector assemblies	16	16
Number of solar collector elements	128	128
Number of receiver tubes	384	384
Land required (Acre)	3.41	3.41

7. PROJECT COST

Project cost of SPT power plants have been calculated according to the capital cost of the SPT plant in respective year. Capital cost from 2012 to 2015 are taken from order of central electricity regulatory commission and tabulated in Table-12. [10], [11], [12], [13], [14], [15], [16], [17], [18]. Capital cost pf SPT plant for year 2019 and 2024 has been obtained by forecasting which are 1101.50 Rs.lakh/MW and 1012.03 Rs.lakh/MW for year 2019 and 2024 respectively. According to these capital costs, project cost of spv plant for year 2015,2019 and 2024 have been calculated and tabulated in table-13.

Table-12: Capital Cost for SPT Power plant in Rs. Lakh/MW for years 2012-2015

S.No.	Particulars/Years	2012	2013	2014	2015
1	Collector	572.00	528.00	528.00	528.00
2	Storage	234.00	216.00	216.00	216.00
3	Contingencies	156.00	144.00	144.00	144.00
4	Electricity generation	130.00	120.00	120.00	120.00
5	Consultancy	78.00	72.00	72.00	72.00
6	Balance of plant	52.00	48.00	48.00	48.00
7	Heat exchangers	39.00	36.00	36.00	36.00
8	Structures	20.06	20.50	20.88	21.25
9	Land	10.03	10.25	10.44	10.63
10	Total capital cost	1291.09	1194.75	1195.31	1195.88

Table-13: Project cost of SPT plants in Rs. Lakh/MW

S.No.	Particulars/Years	SPT2015	SPT 2019	SPT 2024
1	Collector cost	165.06	218.40	283.31
2	Storage cost	67.52	89.35	115.90
3	Contingencies cost	45.02	59.56	77.27
4	Electricity generation cost	37.51	49.64	64.39
5	Consultancy cost	22.51	29.78	38.63
6	Balance of plant cost	15.01	19.85	25.76
7	Heat exchangers cost	11.25	14.89	19.32
8	Structures cost	6.64	10.38	16.69
9	Land cost	3.32	5.19	8.34
10	Capital cost	373.84	497.04	649.60
11	Capital cost with 30% capital subsidy	261.69	347.93	454.72

8. CONCLUSION

In this study Electrical energy required by the village Mansarkheri is estimated for year 2015, 2019 and 2024 and solar parabolic trough power plant is proposed and design parameters are calculated accordingly. Following conclusions can be drawn from the study.

(i).Total electrical energy demand of village Mansarkheri is found to be 638.25 MWh/annum, 821.27 MWh/annum and 1072.01 MWh/annum for year 2015, 2019 and 2024 respectively.

(ii).According to this electrical energy demand solar parabolic trough power plant of capacity 312.61 kW 451.24 kW 641.88 kW are proposed and designed for year 2015, 2019 and 2024 respectively.

(iii).For Solar parabolic trough plant 2015, 3000 m^2 of solar collector area, 2 loops, 16 solar collector assemblies,128 solar collector elements, 384 receiver tubes and 3.41 acre area required.

(iv).For Solar parabolic trough plant 2019, 3460 m^2 of solar collector area, 2 loops, 16 solar collector assemblies,128 solar collector elements, 384 receiver tubes and 3.41 acre area required.

(v).For Solar parabolic trough plant 2024, 4920 m^2 of solar collector area, 2 loops, 16 solar collector assemblies,128 solar collector elements, 384 receiver tubes and 3.41 acre area required.

(vi).Capital cost solar parabolic trough power plants are found to be 1195.88 Rs.lakh/MW, 1101.50 Rs.lakh/MW and 1012.03 Rs.lakh/MW for year 2015, 2019 and 2024 respectively.

(vii).According to these capital costs, the project cost of the solar parabolic trough plants are calculated which are 373.84 Rs.lakh, 497.04 Rs.lakh and 649.60 Rs.lakh for year 2015, 2019 and 2024 respectively.

REFERENCES

[1]M. Chandel, G.D.Agrawal, S.Mathur and A.Mathur, Techno-economic analysis of solar photovoltaic power plant for garment zone of Jaipur city, Case Studies in Thermal Engineering 2 (2014) 1–7.

[2]M. Chandel and G.D.Agrawal, Techno-economic analysis of solar parabolic trough type energy system for garment zone of Jaipur city, Renewable and Sustainable Energy Reviews 17(2013)104–109.

[3]T.Kobayakawa and T.C.Kandpa, A techno-economic optimization of decentralized renewable energy systems: Trade-off between financial viability and affordability—A case study of rural India, Energy for Sustainable Development 23 (2014) 92–98.

[4]E.S. Hrayshat, Techno-economic analysis of autonomous hybrid photovoltaic-diesel-battery system, Energy for Sustainable Development 13 (2009) 143–150.

[5] A. Poullikkas, Economic analysis of power generation from parabolic trough solar thermal plants for the Mediterranean region—A case study for the island of Cyprus, Renewable and Sustainable Energy Reviews 13 (2009) 2474–2484.

[6] T. Muneer, M. Asif and S. Munawwar, Sustainable production of solar electricity with particular reference to the Indian economy, Renewable and Sustainable Energy Reviews 9 (2005) 444–473

[7] I. Purohit and P. Purohit, Techno-economic evaluation of concentrating solar power generation in India, Energy Policy 38 (2010) 3015–3029

[8] A.N. Celik., Optimization and techno-economic analysis of autonomous photovoltaic–wind hybrid energy systems in comparison to single photovoltaic and wind systems, Energy Conversion and Management, 43 (2002) 2453–2468

[9] Population census data of village Mansarkheri website, http://censusindia.gov.in/, accessed on March 2015.

[10] Solar Capital Cost Norm, Central Electricity Regulatory Commission, New Delhi, Petition No. SM/354/2013 (Suo-Motu).

[11]Terms and Conditions for Tariff determination from Renewable Energy Sources Regulations, Central Electricity Regulatory Commission, New Delhi, No.: L-1/94/CERC/2011.

[12]Solar Capital Cost Norm, Central Electricity Regulatory Commission, New Delhi, Petition No. SM/353/2013 (Suo-Motu).

[13]Solar Capital Cost Norm, Central Electricity Regulatory Commission, New Delhi, Petition No. SM/004/2015 (Suo-Motu).

[14]Solar Capital Cost Norm, Central Electricity Regulatory Commission, New Delhi, Petition No. SM/005/2015 (Suo-Motu).

[15]Solar Capital Cost Norm, Central Electricity Regulatory Commission, New Delhi, Petition No. 243/SM/2012(Suo-Motu)

[16] Solar Capital Cost Norm, Central Electricity Regulatory Commission, New Delhi, Petition No. SM/354/2013 (Suo-Motu).

[17] CERC revises capital cost of solar photovoltaic power plant, website, http://re-solve.in/, accessed on Jan 2015.

[18] S.A. Maiyya and P. Poondla, Indian Institute of Technology Madras, CSP White Paper, for Energy Alternatives India, 2015.

BIOGRAPHIES

Vikrram Singh Meena
M.Tech- Renewable Energy
Malaviya National Institute Of Technology, Jaipur, India
B.Tech- Electrical Engineering
Jamia Millia Islamia, New Delhi, India

Dr. G. D. Agrawal
Associate Professor
Dept. of Mechanical Engineering,
Malaviya National Institute Of Technology, Jaipur, India
Ph.D.-Energy Recovery From MSW
M.Tech.-Thermal Engineering
B.E.-Mechanical Engineering