International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 06 | June -2018 www.irjet.net p-ISSN: 2395-0072

Cost Benefit Analysis of a Roof Top Solar PV System at a Domestic Apartment in Kolkata

Pallav Dutta[1], Ushnik Chakrabarti[2]

[1]Assistant Professor, Dept. of Electrical Engineering, Narula Institute of Technology, West Bengal, India
[2] Assistant Professor, Dept. of Electrical Engineering, Narula Institute of Technology, West Bengal, India

---

Abstract - *Using of roof top PV system can be rapidly deployed on various apartments with a large roof top area in the city. The paper shows an investigation on variation of energy consumption from distributors of a domestic consumer while using solar power or maintains conventional system. The paper also explores the coast benefit analysis of an implementing PV system in an apartment. The impacts of various economic parameters are also taken into consideration.*

***Key Words*: Rooftop PV cell, Block tariff, irradiation factor, insulation factor, Cost analysis, AMI.**

1. INTRODUCTION

There is a necessity to hasten the development of clean energy technologies in order to address the global challenges of energy security and sustainable development. Solar PV cell technology is the easiest option to reduce the excessive usage of non-renewable energy sources. As India is located in the equatorial sunbed of the earth, the territory receives plenty radiant energy from the sun. Most part of India is experiencing over 250-300 days a year of clear sunny weather, where the annual global radiation varies from 1600-2200 kWh/m^2 having equivalent energy potential about 6000 million GWh energy per year, which is quite higher than the countries total annual energy consumption[1]. The paper describes a cost analysis between a domestic (urban) consumer category of rate G in normal tariff scheme and running with a PV rooftop panel at a domestic apartment in Kolkata.

2. ENERGY CONSUMPTION ANALYSIS OF THE APARTMENT

Kolkata is a developing metropolitan with population of about 45 lakh, which is increasing rapidly and so the energy consumption. Accommodation is a huge problem the city is facing right now and as some result apartments are in trend these days. In order to provide electricity throughout the city the generation and distribution companies meet huge challenges over the years. Now a days the thermal power generation sectors are experiencing several challenges like excessive hike of fossil fuel cost and the maintenance cost during transmission and distribution encourages several consumers to shift from conventional energy systems to non-conventional renewable energy systems like rooftop PV solar cell generation[2-3]. Here the detailed monthly and annual energy consumption of an apartment in Kolkata consisting 14 households. The detail of the gross payable amount to the electricity company is also taken into account. In this calculation the cost due to load power factor, fixed monthly charges and meter charges are not taken into consideration. Only the monthly unit (kWh) consumption of each household is considered and the current tariff rate consumer category of rate G in normal tariff scheme of CESE ltd. Thus, in this paper we have taken the energy consumption of a whole apartment into consideration for a year long.

Table -1: The energy consumption and considerable amount of charges monthly and annually.

Month	LOAD 1	LOAD 2	LOAD 3	LOAD 4	LOAD 5	LOAD 6	LOAD 7	LOAD 8	LOAD 9	LOAD 10	LOAD 11	LOAD 12	LOAD 13	LOAD 14
	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT	UNIT
March	76	31	21	66	126	113	203	192	86	91	49	167	395	270
April	119	75	50	131	371	334	264	230	187	93	80	203	490	437
May	143	79	48	143	442	269	243	212	233	47	90	190	455	446
June	129	85	66	108	319	192	262	233	219	49	87	179	496	452
July	103	60	116	58	230	203	248	242	207	60	79	166	401	440
August	127	64	142	64	339	156	242	266	210	62	79	152	507	475
September	113	63	119	52	300	192	246	261	53	63	37	91	516	334
October	127	66	122	66	264	157	291	225	98	25	40	93	336	283
November	66	7	53	52	115	93	159	177	65	25	39	56	169	220
December	52	8	44	47	60	60	150	157	62	23	17	60	107	219
January	47	9	48	52	90	55	148	166	34	3	13	57	313	199
February	60	11	50	48	76	67	142	150	53	15	20	71	305	203
Annual consumption	1162	638	886	896	2723	1871	2602	2509	1463	526	600	1474	4066	3974
Avg energy consumption	96	44.83	74.83	73	227.75	155.91	216.83	209.08	121.91	43.83	50	122.83	413.83	331.16

Table – 2: Monthly energy consumption and Monthly gross payable amount.

Month	Monthly Energy Consumption	Monthly Gross Payable Ammount
	UNIT	Rs.
March	1883	11934.21
April	3005	20451.36
May	3039	20750.89
June	2895	19517.12
July	2702	18090.31
August	2874	19508.27
September	2430	16112.83
October	2112	13436.37
November	1462	9860.19
December	1266	7720.81
January	1233	7476.66
February	1275	7687.83
Annual	26182	172546.85
Avarage	2181.79	14378.9

3.ROOF TOP SOLAR PANEL PERFORMANCE

Now the 14 house hold of the apartment decided to install the roof top solar panel around the 120 square foot of unshaded area of the roof. is as follows.

Table – 3: The performance of solar panel at standard condition

PERFORMENCES AT STANDERED TEST CONDITION*			
Nominal Power	P_{MPP}	[W]	250
Short Circuit Current	I_{SC}	[A]	8.62
Open Circuit Voltage	V_{OC}	[V]	37.32
Current At Minimum Power	I_{MPP}	[A]	8.13
Voltage At Maximum Power	V_{MPP}	[V]	30.76
Maximum System voltage	V_{SYS}	[V]	100 (IEC) 600(CSA/UL)
Weight	M	[Kg/lb]	19.0 / 41.89

*AM 1.5 Spectrum Data are given (nominal) values.

To calculate the annual solar energy output of a photovoltaic system the global formula to estimate the electricity generated in output of a photovoltaic system is [4-6]:

$$E = A * r * H * PR$$

E = Energy (kWh)

A = Total solar panel Area (m2)

r = solar panel yield or efficiency (%) given by the ratio: electrical power (in kWp) of one solar panel divided by the area of one panel.

H = Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75).

It is a very important value to evaluate the quality of a photovoltaic installation because it gives the performance of the installation independently of the orientation, inclination of the panel. It includes all losses.

Example of detailed losses that gives the PR value (depends on the site, the technology, and sizing of the system):-

-Inverter losses (4% to 10 %)

- Temperature losses (5% to 20%)

- DC cables losses (1 to 3 %)

- AC cables losses (1 to 3 %)

- Shadings 0 % to 80% (specific to each site)

- Losses at weak radiation 3% to 7%

- Losses due to dust, snow... (2%)

- Other Losses

Table – 4: the amount of energy generation from installed roof top solar panel Considering above parameters,

Month	Area (Sq. m.)	Solar Panel Yields (%)	Annual Avg Irradiation (kWh/M2/Day)	Performance Losses &Co-eff of Losses	Inverter Losses	Temperature Losses	DC Cable Losses	AC Cable Losses	Shadings	Avg. Losses Due to Weak Irradiation	Losses Due to Dirt & Snow	Energy	Energy With Losses	Monthly Energy Generation	Monthly Consumption	(Consumption – generation)	Monthly Generation Cost	Monthly Total Consumption Cost	Monthly Profit
January	120	0.15	4.26	0.75	0.06	0.10	0.01	0.01	0.02	0.03	0.02	57.51	43.16	1294.84	1233.00	-61.84	7911.46	7476.66	-434.80
February	120	0.15	4.93	0.75	0.07	0.09	0.01	0.01	0.02	0.03	0.01	66.56	50.14	1504.28	1275.00	-229.28	9191.13	7687.83	-1503.30
March	120	0.15	5.66	0.75	0.07	0.08	0.01	0.01	0.02	0.03	0.09	76.41	52.74	1582.15	1883.00	300.85	9666.91	11934.21	2267.30
April	120	0.15	6.11	0.75	0.08	0.05	0.01	0.01	0.02	0.03	0.09	82.49	58.42	1752.48	3005.00	1252.52	10707.63	20451.36	9743.73
May	120	0.15	5.82	0.75	0.08	0.05	0.01	0.01	0.02	0.03	0.09	78.57	55.16	1654.68	3039.00	1384.32	10110.12	20750.89	10640.77
June	120	0.15	4.51	0.75	0.09	0.02	0.01	0.02	0.02	0.03	0.01	60.89	48.89	1466.72	2895.00	1428.28	8961.66	19517.12	10555.46
July	120	0.15	4.11	0.75	0.09	0.02	0.01	0.01	0.02	0.03	0.01	55.49	44.70	1340.96	2702.00	1361.04	8193.27	18090.31	9897.04
August	120	0.15	3.99	0.75	0.10	0.05	0.02	0.02	0.02	0.03	0.01	53.87	40.98	1229.25	2874.00	1644.75	7510.74	19508.27	11997.53
September	120	0.15	3.94	0.75	0.10	0.06	0.02	0.02	0.18	0.03	0.01	53.19	30.99	929.65	2430.00	1500.35	5680.19	16112.83	10432.64
October	120	0.15	4.24	0.75	0.11	0.07	0.02	0.02	0.02	0.03	0.01	57.24	41.56	1246.86	2112.00	865.14	7618.31	13436.37	5818.06
November	120	0.15	4.36	0.75	0.11	0.11	0.02	0.02	0.02	0.03	0.02	58.86	39.52	1185.56	1462.00	276.44	7243.76	9860.19	2616.43
December	120	0.15	4.13	0.75	0.12	0.12	0.02	0.02	0.04	0.03	0.02	55.76	35.52	1065.48	1266.00	200.52	6510.07	7720.81	1210.74

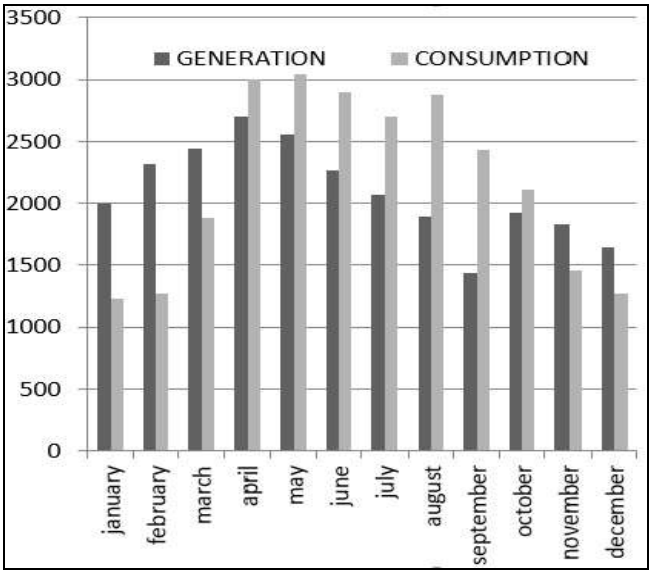

Chart -1: Comparison chart between monthly generation and consumption

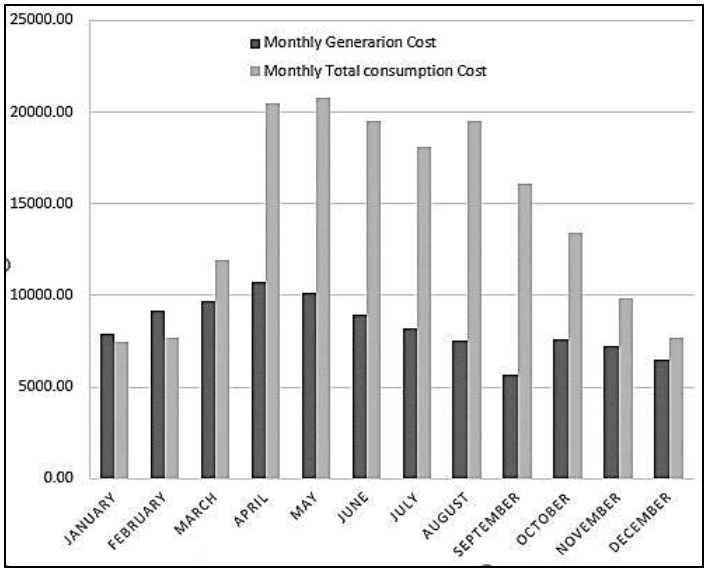

Chart -2: Comparison chart between monthly generation cost and monthly total consumption cost

Table – 5: Different cost analysis

Annual Total Generation Cost (Rs.)	**99305.24**
Annual Avg Generation Cost (Rs.)	**8275.44**
Annual Total Consumption Cost (Rs.)	**172546.85**
Annual Avg Consumption Cost	**14378.90**
Annual Total Profit (Rs.)	**73241.61**
Monthly Profit	**6103.47**
Annual Cost Before Using Solar Cell (Rs.)	**172546.85**
Monthly Cost Before Using Solar Cell (Rs.)	**14378.90**

3. CONCLUSION

Here we can conclude that instead of using conventional method of power generation to justify the annual load demand, the hybrid system is much more relevant from both the suppliers and consumers side. It not only reduces the generation cost but also very helpful to manage several challenges of the recent power market. Here we can clearly see the difference between the monthly energy consumption of a domestic consumers between using conventional system and hybrid system. Such an arrangement is economical for the both the suppliers and consumers perspective. In future this arrangement can be applicable for official and industrial consumers also.

REFERENCES

[1] Performance Of Solar Power Plants In India, Central Electricity Regulatory Commission, New Delhi, February 2011.

[2] K. S. Reddy, T. K. Mallick and D. Chemisan; "Solar Power Generation"; Hindawi Publishing Corporation, International Journal of Photoenergy, Volume 2013, Article ID 950564.

[3] Christoph Maurer, Christoph Cappel and Tilmann E.Kuhn,"Progress In Building-Integrated Solar Thermal Systems"; ELSEVIER, Solar Energy, Volume 154, 15 September 2017, Pages 158-186

[4] Jai Singh Arya, Aadesh Kumar Arya and Sanjeev Aggarwal, "Recent Trends in Solar Energy Generation", ACEEE, proc. of Int. Conf. on Emerging

Trends in Engineering and Technology. DOI: 03. AETS.2013.3.303

[5] Kraemer, D; Hu, L; Muto, A; Chen, X; Chen, G; Chiesa, M (2008), "Photovoltaic-thermoelectric hybrid systems: A general optimization methodology", Applied Physics Letters, **92** (24): 243503, doi:10.1063/1.2947591

[6] PragyaNema, R.K.Nema and Saroj Rangnekar, "A Current And Future State Of Art Development Of Hybrid Energy System Using Wind And PV-Solar: A Review" , ELSEVIER, Renewable and Sustainable Energy Reviews**,** Volume 13, Issue 8, October 2009, Pages2096-2103, Https://Doi.Org/10.1016/J.Rser.2008.10.006.