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Integration of solar generation for reduction of auxiliary power consumption (APC) in thermal power plant

Introduction

Auxiliary power consumption (APC) is a major concern for power plant since % APC is one of the components for tariff determination. The selling cost of one unit of electrical energy (tariff) increases with the increase of % APC.

Since Indian power sector is moving towards tariff treading mechanism for selling out the generated power, it is going to be compulsory for each generating station to keep the tariff as low as possible in order to evacuate the generated power to the grid. Under this circumstance, reduction of % APC is one of the options for maintaining the tariff as low as possible.

On the other hand, thermal power plant has to comply with some statuary environmental regulation for handling dry ash, emission of SO_x, NO_x, SPM and handling effluent. To comply with these environmental norms, considerable amount of electrical energy is consumed for operating these systems and it leads to further increase in % APC.

In view of the above, utilization of solar energy for APC is one of the options which can be implemented for reducing auxiliary power consumption in thermal power plant.

The objective of this paper is to study the technical and financial feasibility for setting up of solar panel in thermal power plant for the purpose of reduction in % APC.

Auxiliary power consumption (APC)

During operation, thermal power plant consumes some power for operating its auxiliary's. This power is drawn from its own generation as well as from grid. The power which is drawn from own generation is known as unit auxiliary consumption (UAC) and the power which is drawn from grid is known as station auxiliary consumption (SAC). The percentage of total power consumption (UAC + SAC) with respect to total generation is known as % auxiliary power consumption (APC). The typical auxiliary power consumption for thermal power plant varies from 8.5% to 10% depending upon fuel, technology and aging of the plant (Table 1).

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TABLE 1

	MW	Percentage
Generation (G)	1370	100%
Unit auxiliary consumption (UAC)	112	8.18%
Station auxiliary consumption (SAC)	17	1.24%
Total auxiliary consumption (UAC +SAC)	129	9.42%
Export to grid {G – (UAC + SAC)}	1241	90.58%

Installation of solar panel to cater station auxiliary loads

Required station load is 17 MW. Now if 10MW solar panel is installed to cater the station load, power drawal from grid for station consumption will reduce from 17 MW to 15.20 MW (Table 2).

TABLE 2

Parameters	Station	Solar
Load MW	17	10
Capacity utilization factor (CUF)	100%	18%
Average load (MW)	17.00	1.80
Reduced load with solar generation (MW)	15.20	***

Reduction in % APC due to solar generation

Due to reduction of power drawal from grid for station auxiliary power consumption, % APC of the plant will also come down from 9.42 % to 9.28% (Table 3).

Annual fuel cost saving due to solar generation

With reduction of % APC, plants net heat rate (NHR) will also reduce from 3140.73 kcal/kWhr to 3136.18 kcal/kWhr resulting in annual fuel cost saving of Rs.4.42 crores (Table 4).

Impact on tariff due to solar generation

With reduction of % APC, tariff will also reduce from Rs 3.351 to 3.347 (Table 5).

Incentive under PAT scheme due to solar generation

Under PAT scheme, energy saving certificate is issued in proportion to the reduction of net heat rate (NHR). It is estimated that approximate 4980 energy saving certificates can be earned due to reduction of NHR (Table 6).

TABLE 3

Parameters	Formula	Existing		With solar generation	
		MW	Percentage	MW	Percentage
Generation	G	1370	100%	1370	100%
Unit auxiliary consumption	UAC	112	8.18%	112	8.18%
Station auxiliary consumption	SAC	17	1.24%	15.2	1.11%
Total auxiliary consumption	APC = (UAC+SAC)	129	9.42%	127.2	9.28%

TABLE 4

Parameters	Formula	Existing	With solar generation
Gross heat rate (kcal/kWhr)	GHR	2845	2845
Net heat rate (kcal/kWhr)	NHR=GHR/(1-% APC)	3140.73	3136.18
Annual generation (MU)	MU=1470×24×365×0.85	10945.62	10945.62
GCV – fuel kcal/kg)	GCV	2650	2650
Annual fuel consumption (tonne)	FC=NHR×MU×1000/GCV	12972555.85	12953767.15
Fuel purchase cost (Rs/tonne)	CP	2350	2350
Annual fuel cost (Rs. Cr)	AFC=FC×CP/10000000	3,048.55	3,044.14
Annual fuel cost saving (Rs. Cr)	AFC (before - after)	***	4.42

TABLE 5

Parameters	Measuring units	Formula	Norms	Present	With solar generation
Gross station heat rate	kcal/kWhr	GHR	2900	2845	2845
Specific fuel oil consumption	ml/kWhr	SFC	2	2	2
Calorific value - secondary fuel	kcal/ml	CVSF	10	10	10
Landed price - primary fuel	Rs/kg	LPPF	2.35	2.35	2.35
Calorific value - primary fuel	kcal/kg	CVPF	2950	2950	2950
Auxiliary power consumption	%	AUX	10	9.42	9.28
Energy charge rate (EC)	Rs/kWhr	EC=[(GHR – SFC×CVSF) × LPPF/CVPF] ×100/(100-AUX)	2.563	2.499	2.495
Capacity charges	Rs/kWhr	CC	0.852	0.852	0.852
Tariff	Rs/kWhr	CC + EC	3.415	3.351	3.347

TABLE 6

Annual generation (MU)	MU = 1470×24×365×0.85	10945.62
Net heat rate before (kcal/kWhr)	NHR 1	3140.73
Net heat rate after (kcal/KWhr)	NHR 2	3136.18
Energy saving certificate (Nos)	ESC = (NHR 1-NHR2) × MU/10	4980.26
Cost per certificate (Rs.)	C	1000
Total cost (lakhs)	TC	49.8
Annual incentive (lakhs)	TC/3	16.6

Land availability for erection of solar panels

The specific land requirement for setting up a thermal plant and solar plant is approximately 0.3 acres/MW and 7 acre/MW respectively. Under this estimation, about 70 acres of space is required for erecting solar panel of 10 MW capacities (Table 7).

In thermal power, water reservoir, various buildings (TG Hall, CWPH, ADPH, AO building etc), fuel storage area occupies about 10%, 2% and 8% of space respectively. It is about 88 acres of space are available in thermal power plant

TABLE 7

	Thermal	Solar	Unit
Specific land requirement	0.3	7	Acre/MW
Plant capacity	1470	10	MW
Total land requirement	441	70	Acre

TABLE 8

Availability of land in thermal power plant	Percentage	Acre
Water reservoir	10%	44.1
Building area	2%	8.82
Coal handling area	8%	35.28
Total area available for erection of solar panel		88.2

for the erection of solar panels (Table 8).

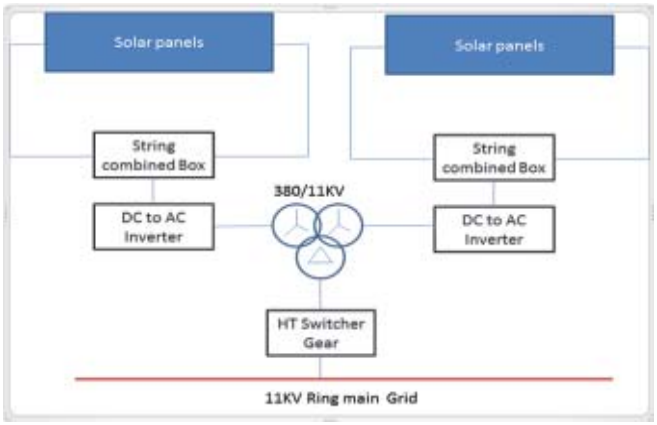
Mounting of solar panels

Roof top solar panels are to be mounted over all the building available inside the plant premises and the floating type solar panels are to be arranged for water reservoir. The advantages of using floating type solar panels for water reservoir are –

1. Reduce evaporation loss of circulating water from lake that leads to reduction in water consumption.
2. Reduce CW temperature during summer and therefore load reduction due to high CW temperature can be avoided.

Arrangement of panels and evacuation of power

Ring main grid of 11 kV is to be laid throughout the boundary of the plant which in turn is to be connected with station bus. Solar panels will be feeding the 11kV ring main bus and the peripherals loads such as office lighting and AC, water supply pumps and other station loads are to be connected with 11 kV grid.



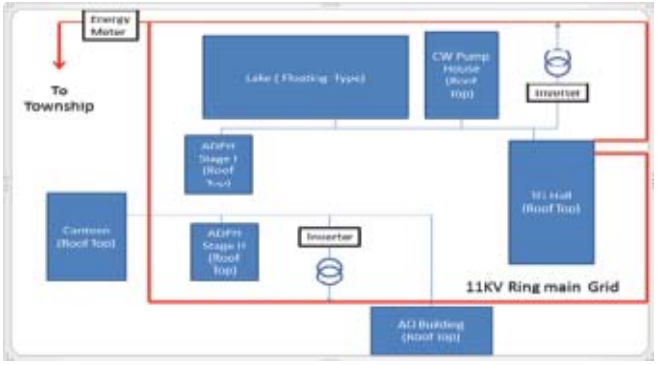


TABLE 9

	Particulars	Capital Cost norm proposed for FY 2016-17 (Rs. lakhs/MW), for Solar PV projects	% of Total Cost
1	PV Modules	310.19	61.9%
2	Land Cost	25	5%
3	Civil and General Works	35	7%
4	Mounting Structures	35	7%
5	Power Conditioning Unit	30	6%
6	Evacuation Cost up to Inter-connection Point (Cables and Transformers)	40	8%
7	Preliminary and Pre-Operative Expenses including IDC and Contingency	26.13	5.2%
	Total Capital Cost	501.32	100%

TABLE 10

Capital cost parameters	Cr/MW	10 MW
PV modules	3.10	31.019
Land cost	0.25	0
Civil and general works	0.35	0
Mounting structures	0.35	1
Power conditioning unit	0.30	3
Evacuation cost up to interconnection point (cables and transformers)	0.40	4
Preliminary and pre-operative expenses including contingency	0.26	1
Total capital cost	5.01	40.02
Annual interest @10%	***	4.00
Annual depreciation @5.58%	***	2.23
Total project cost	***	46.25
Annual cost @25 years life	***	1.85

Capital cost for solar generation as per CERC guideline (Table 9)

Annual cost for setting up of 10MW solar generation in thermal power plant is given in Table 10.

Advantages

1. Reduction in approximate fuel cost of Rs.4.42 crores annually against the annual project cost of Rs.1.85 crores.
2. Earning energy saving certificate due to reduction in Net Heat rate under PAT scheme
3. Earning renewable energy certificate under government scheme
4. Increase possibility for evacuating excess generation of the plant through power treading due to lower tariff.
5. Erection of separate switchyard is not required
6. Excess solar generation can be pumped to township grid
7. No additional establishment cost
8. Floating panels over lake will reduce the CW temp during summer and therefore load reduction due to poor condenser vacuum can be avoided.

9. Roof top panels will reduce the room temperature that lead to reduce AC and ventilation consumption.

Disadvantages

1. Water sprinkler system is to be installed to keep the panels free from dry ash deposition as well as cooling purpose in order to increase efficiency of the PV cell.
2. About 200kW is required to operate water sprinkler system.
3. The investment cannot be capitalized.

Conclusions

The investment for this solar generation shall not be capitalized with the main plant as asset since it is not going to feed the grid with definite tariff. Rather it shall be accounted as investment for energy conservation measures with definite payback period. As the annual fuel saving and other incentives for energy conservation is comfortably higher than the annual project cost, this project is found to be feasible in technical and financial point of view.