COST BASED LOAD ANALYSIS OF A HYDRO POWER PLANT WITHOUT AND WITH SOLAR POWER COGENRATION

Aditya Tomar
Faculty of Technology
Uttarakhand Technical University
Dehradun, India
tomaraddi@gmail.com

Mamta Chamoli
Faculty of Technology
Uttarakhand Technical University
Dehradun, India
nitya12345678@gmail.com

ABSTRACT
This paper presents the cost based load analysis of a hydro power plant without the cogeneration of solar power and with cogeneration of solar power. HOMER software is used for the cost analysis. DHAKRANI hydro power plant is chosen for solar resources data and load data inputs. Hourly load data of local colony of DHAKRANI hydro power plant for 24 hours is taken as input. DHAKRANI is a place at DEHRADUN in INDIA. Net present cost and cost of energy are calculated in both operating conditions. Emissions are also calculated in the paper.

Keywords- Cost Analysis, Solar, Hydro, Cogeneration, HOMER.

I. INTRODUCTION

Conventional energy sources are depleting rapidly and they harm the environment when used for power generation. In this era when global warming is a serious issue for whole world renewable energy sources can provide pollution free energy to the world. Uttarakhand has ample amount of renewable energy sources to fulfill its energy demand. Hydro power is the main source of power generation in Uttarakhand which is supposed to be a clean source of energy but some Non-government organizations and National Green Tribunal have filed petitions in Supreme Court against 24 Hydro power schemes of Uttarakhand. These organizations believe that Hydro power plants were responsible for 2013 disaster in Uttarakhand. Solar energy has the potential to provide clean energy to the state to fulfill its energy demand. Hydro power plants get its water from the rivers which originate from hilly areas where weather is rainy for 2-3 months every year and the mud came with the water and power generation has to stop in hydro power plants which are located in areas where weather is not rainy, so solar power can continue to provide supply at that time also and make the continuity of the supply to the consumers.

II. HOMER MODEL OF GRID CONNECTED SYSTEM WITHOUT SOLAR POWER COGENERATION

Figure 1 shows the HOMER model of existing grid which does not have PV system connected. Here grid shows the hydro power plant and Dhakrani local load is the load of the local colony of Dhakrani Hydro power plant. Table 1 shows the of hourly load of colony of Dhakrani hydro power plant.

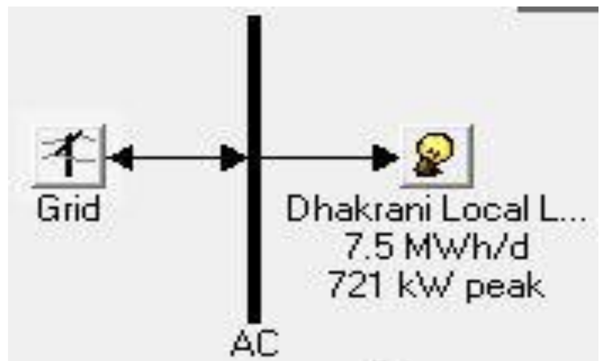

Figure 1: HOMER model of grid connected load

TABLE 1: HOURLY LOAD OF LOCAL CONSUMERS OF DHAKRANI POWER PLANT

Hour	Load (kW)	Hour	Load (kW)
00:00 - 01:00	200	12:00 - 13:00	300
01:00 - 02:00	200	13:00 - 14:00	350
02:00 - 03:00	200	14:00 - 15:00	375
03:00 - 04:00	200	15:00 - 16:00	375
04:00 - 05:00	200	16:00 - 17:00	375
05:00 - 06:00	300	17:00 - 18:00	400
06:00 - 07:00	350	18:00 - 19:00	400
07:00 - 08:00	350	19:00 - 20:00	400
08:00 - 09:00	350	20:00 - 21:00	400
09:00 - 10:00	300	21:00 - 22:00	375
10:00 - 11:00	275	22:00 - 23:00	350
11:00 - 12:00	275	23:00 - 00:00	250

III. HOMER MODEL OF GRID CONNECTED SYSTEM WITH SOLAR POWER COGENERATION

Figure 2 shows the HOMER model of grid connected system with solar power generation. PV system, converter and battery are connected to system. Table 2 shows details of clearness index and daily radiation at Dhakrani.

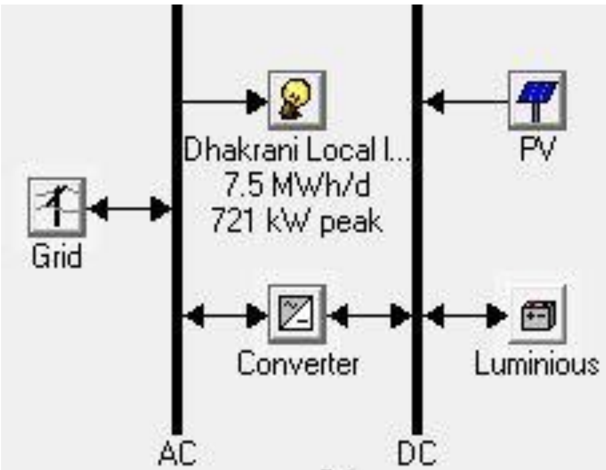

Figure 2: HOMER model of grid connected load with PV panel and battery

TABLE 2: MONTHLY CLEARNESS INDEX AND DAILY RADIATION OF DHAKRANI

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.646	3.72
February	0.681	4.77
March	0.688	5.96
April	0.693	7.05
May	0.683	7.59
June	0.598	6.84
July	0.488	5.49
August	0.46	4.82
September	0.57	5.22
October	0.706	5.28
November	0.742	4.47
December	0.679	3.64

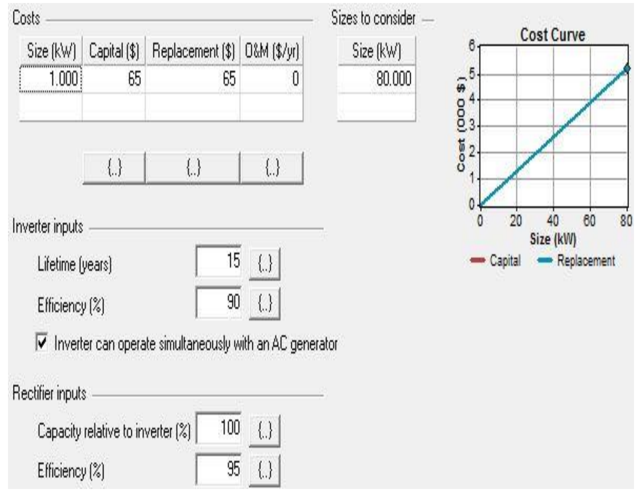

Figure 3: Cost of converter

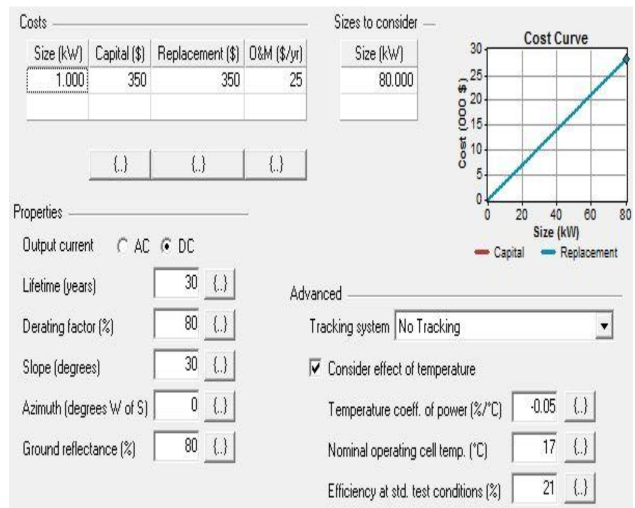

Figure 4: Cost of PV panel

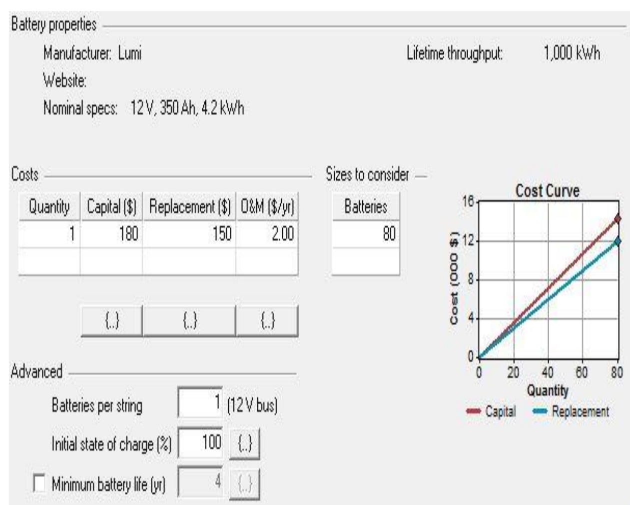

Figure 5: Cost of battery

Figure 3 shows the capital and replacement cost of a converter. Figure 4 shows the details related to PV panel and figure 5 shows the details of battery used in the model.

IV. RESULTS AND DISCUSSION

The results of both the models are calculated in HOMER environment and are presented here in the below section.

A. Results of Grid Connected System Without Solar Power Cogeneration

Figure 6 shows the net present cost of the grid connected system. NPC of the grid connected system is $29,23,020. Figure 7 shows the NPC of the grid connected system by cost type. Operation and maintenance cost is the main element of NPC of grid connected system. Figure 8 shows the nominal cash flow of grid connected system for thirty years.

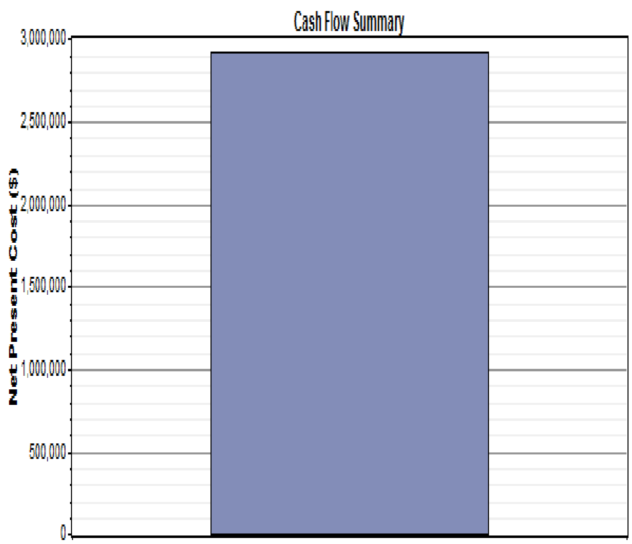

Figure 6: Net Present Cost of Grid Connected System without Solar Power Cogeneration by Component type

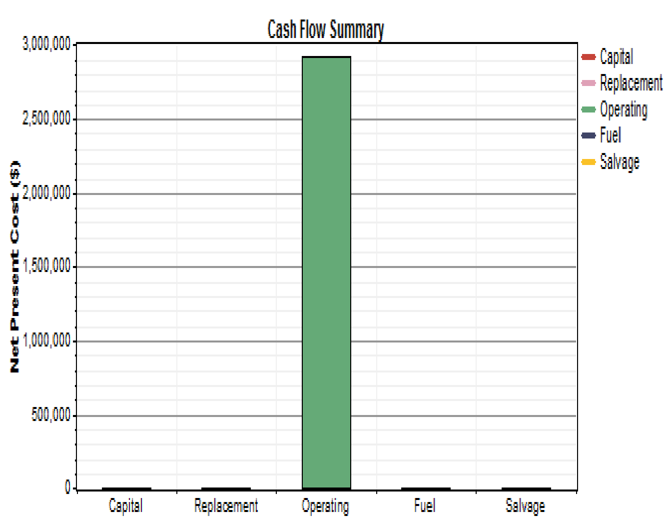

Figure 7: Net Present Cost of Grid Connected System without Solar Power Cogeneration by Cost type

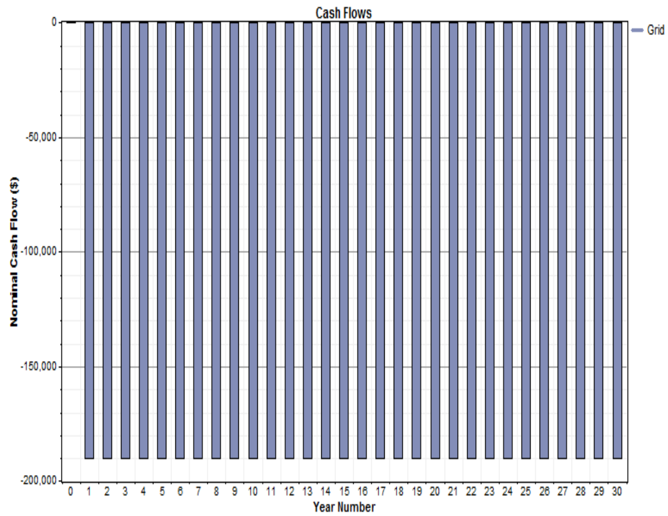

Figure 8: Nominal Cash Flow of Grid Connected System without Solar Power Cogeneration for 30 Years

Table 3 shows the annual production of the grid and table 4 shows the annual consumption of the grid.

TABLE 3: ELECTRICAL PRODUCTION OF GRID CONNECTED SYSTEM WITHOUT SOLAR POWER COGENERATION

Production	kWh/yr	%
Grid purchases	27,55,749	100
Total	27,55,749	100

TABLE 4: ELECTRICAL CONSUMPTION OF GRID CONNECTED SYSTEM WITHOUT SOLAR POWER COGENERATION

Consumption	kWh/yr	%
AC primary load	27,55,749	100
Total	27,55,749	100

TABLE 5: EMISSIONS (KG/YR) OF GRID CONNECTED SYSTEM WITHOUT SOLAR POWER COGENERATION

Pollutant	Emissions (kg/yr)
Carbon dioxide	12,40,087
Carbon monoxide	1,92,902
Unburned hydrocarbons	2,20,460
Particulate matter	27,557
Sulfur dioxide	7,551
Nitrogen oxides	3,720

B. Results of Grid Connected System With Solar Power Cogeneration

In this section all the results of the grid connected system with solar power cogeneration obtained using HOMER software are presented. NPC of this system $26,73,162.

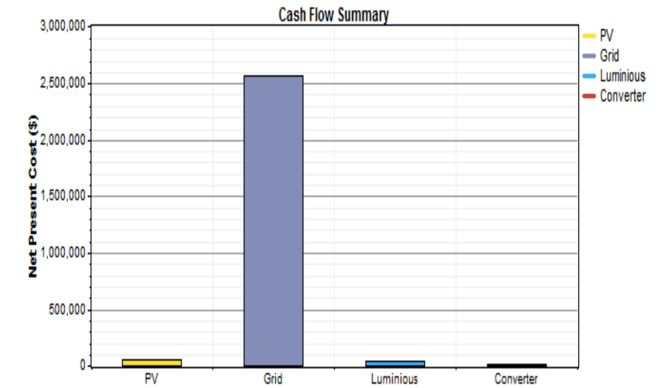

Figure 9: Net Present Cost of Grid Connected System with Solar Power Cogeneration by Component type

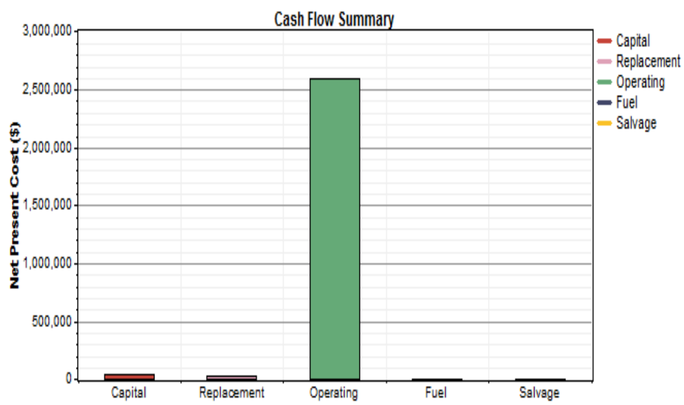

Figure 10: Net Present Cost of Grid Connected System with Solar Power Cogeneration by Cost type

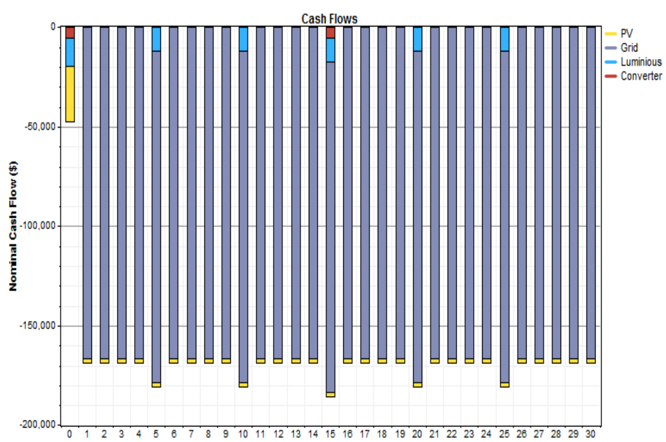

Figure 11: Nominal Cash Flow of Grid Connected System with Solar Power Cogeneration for 30 Years

TABLE 6: ELECTRICAL PRODUCTION OF GRID CONNECTED SYSTEM WITH SOLAR POWER COGENERATION

Production	kWh/yr	%
PV array	1,39,705	5
Grid purchases	26,30,018	95
Total	27,69,723	100

TABLE 7: ELECTRICAL CONSUMPTION OF GRID CONNECTED SYSTEM WITH SOLAR POWER COGENERATION

Consumption	kWh/yr	%
AC primary load	27,55,749	100
Grid sales	3	0
Total	27,55,753	100

TABLE 8: DETAILS OF PV SYSTEM

Quantity	Value	Units
Rated capacity	80	kW
Mean output	15.9	kW
Mean output	383	kWh/d
Capacity factor	19.9	%
Total production	1,39,705	kWh/yr

TABLE 9: OUTPUT DETAILS OF PV ARRAY

Quantity	Value	Units
Minimum output	0	kW
Maximum output	76.5	kW
PV penetration	5.07	%
Hours of operation	4,380	hr/yr
Levelized cost	0.0274	$/kWh

TABLE 10: DETAILS OF BATTERY BANK

Quantity	Value
String size	1
Strings in parallel	80
Batteries	80
Bus voltage (V)	12

TABLE 11: OUTPUT DETAILS OF BATTERY BANK

Quantity	Value	Units
Nominal capacity	336	kWh
Usable nominal capacity	67.2	kWh
Autonomy	0.214	hr
Lifetime throughput	80,000	kWh

Battery wear cost	0.168	$/kWh
Average energy cost	0	$/kWh

TABLE 12: DETAILS OF CONVERTER

Quantity	Inverter	Rectifier	Units
Capacity	80	80	kW
Mean output	14.4	0	kW
Minimum output	0	0	kW
Maximum output	68.9	0	kW
Capacity factor	17.9	0	%

TABLE 13: OPERATIONAL DETAILS OF CONVERTER

Quantity	Inverter	Rectifier	Units
Hours of operation	4,380	0	hrs/yr
Energy in	1,39,705	0	kWh/yr
Energy out	1,25,734	0	kWh/yr
Losses	13,970	0	kWh/yr

TABLE 14: EMISSIONS (KG/YR) OF GRID CONNECTED SYSTEM WITH SOLAR POWER COGENERATION

Pollutant	Emissions (kg/yr)
Carbon dioxide	11,83,506
Carbon monoxide	1,84,101
Unburned hydrocarbons	2,10,401
Particulate matter	26,300
Sulfur dioxide	7,206
Nitrogen oxides	3,524

TABLE 15: COMPARISON OF BOTH THE SYSTEMS

Parameters	Existing System	Proposed System
Net Present Cost ($)	29,23,020	26,73,167
Levelized Cost of Energy ($)	0.069	0.063
Cost of Operation ($)	1,90,147	1,70,797
Emissions (kg/yr)	16,92,277	16,15,038

V. CONCLUSION

Models of grid connected system without and with solar power cogeneration are presented in the paper using HOMER. Results of both the models have been presented and compared in the paper. Table 15 shows the comparison between results of both the models. It is clear from table 15 that grid connected system with solar power cogeneration is better than the existing system. This model can be used to upgrade the existing hydro power plants.

REFERENCES

[1]. Sureshkumar, U., P. S. Manoharan, and A. P. S. Ramalakshmi. "Economic cost analysis of hybrid renewable energy system using HOMER." Advances in Engineering, Science and Management (ICAESM), 2012 International Conference on. IEEE, 2012.
[2]. Sen, Rohit, and Subhes C. Bhattacharyya. "Off-grid electricity generation with renewable energy technologies in India: an application of HOMER."Renewable Energy 62 (2014): 388-398.
[3]. HOMER, V–2.14, National Renewable Energy Laboratory (NREL), USA, http://www.nrel.gov/homer.
[4]. 24*7 Power for all Uttarakhand, "A joint initiative of Government of India and Government of Uttarakhand".
[5]. Energypedia, "Energy situation Uttarakhand, India.
[6]. Vineesh V, A. Immanuel Selvakumar, "Design of Micro Hydel Power Plant", International Journal of Engineering and Advanced Technology, ISSN: 2249-8958, Vol. 2, Issue 2, Dec. 2012.
[7]. "Global Trends in Sustainable Energy Investment 2007", United Nations Environment Pogramme/New Energy Finance Ltd. 2007.
[8]. M. H. Nehrir, A course on alternative energy wind/PV/fuel cell power generation, IEEE Power Engineering Society Meeting, June 18-22, 2006, Montreal, Canada.
[9]. Lambert T, Gilman P, Lilienthal P. Micropower system modeling with HOMER. In: Farret FA, Simões MG, editors. Integration of alternative sources of energy. Hoboken (NJ): IEEE Press; Wiley-Inter-Science; 2006. p. 379– 418.