Feasibility Study of a 100MW Photovoltaic Power plant at Bati, Ethiopia Using RETScreen.

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DOI: 10.29322/IJSRP.10.09.2020.p10508
http://dx.doi.org/10.29322/IJSRP.10.09.2020.p10508

Abstract- Today, world is looking for alternate energy sources as the gross effect of GHG is disturbing the nature balance. Ethiopia is a country with an aggressive plan to solely depend on clean Energy. This paper is about feasibility study of a 100MW PV power plant at Bati, Ethiopia. For the study RETScreen software is used, Using the RETScreen the benchmark analysis, emission analysis and financial analysis were made. From the bench mark analysis the energy cost of production is reduced to 1.6 ETB/KWh. The emission analysis shows that 2365.3 tCO_2 will be reduced from the potential emission to the environment and finally from financial analysis the NPV and the cumulative cash flow shows positive results. Hence, this means the project is feasible financially, technically and environmentally and it will help the country to achieve its goal in building clean energy

Key Words: Photovoltaics, Power Plant, RETScreen, Feasibility, NPV
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Index Terms- Feasibility, NPV, Photovoltaics, Powerplant, RETScreen

I. Introduction

P. Chauhan and his friend said that: Because of the daily growing demand for energy we have to find the more and new alternatives of energy to satisfy the demand. And they also outlined solar power as one of the most common sources of energy and its production over other energy sources rising globally[1] I. Elsayed and his friend strengthen the above idea beliving that the utilization of renewable and sustainable energy is nowadays attracting more attention due to the serious energy crisis together with the global appeal for a sustainable future[2] L. Aguilar said that: in the recent decade the world has seen consistent growth in solar power, a renewable and environmentally friendly energy resource, due to its versatility and advances in solar cell development allowing for the technology to become more readily available in different contexts and applications worldwide[3]. E. Al-Ammar and his fried mentioned that PV power plants have been built the world over, and successfully proven as one of the important substitutes of alternative energy[4]

According to E. Gordon, less than a quarter of East Africa's population has access to electricity, the lowest electrification rates in the world. E. Gordon, explained that, this, combined with the region's vast natural resources, represent a major opportunity for renewable energy investors. Solar irradiation levels are high due to proximity to the equator, wind speeds are some of the strongest on the continent, hydropower resources are plentiful, and the Great Rift Valley is a promising source for geothermal power[5]. It has been said that the increase in energy consumption has led to global environmental issues including climate change. The importance of transition to a low carbon society has been widely recognized internationally. The global actions are essential to countries on those issues have been increasing in a drastic manner. The importance of transition to a low carbon society has been widely recognized internationally. The global actions are essential to achieve the goal of low carbon society with sustainable energy supply. low carbon society has been widely recognized internationally [6]. Ethiopia is one of the fast-developing country located in the horn of Africa. According to M. Dorothal, the country boasts an impressive average GDP growth rate between 7 and 10% over the past 3 years, making it the fastest growing economy in the region with one of the highest GDP growth rates in Africa[7]. According to GTP II Major emphasis is given to building a climate resilient green economy in the context of sustainable development and realizing the vision of becoming a lower middle-income country by 2025. GTP II further explains that expanding electricity power generation from renewable sources of energy for domestic and regional markets; leap frogging to modern and energy efficient technologies in transport, industry and constructions are the basic strategies of building climate resilient green economy[8].

Ethiopia is endowed with vast renewable energy potential in hydro, solar, wind, and geothermal power and investing significantly in energy infrastructure over the past decade using public-financed and public-executed approaches. N. E. Benti and his friend said that Ethiopia lies in the sunny belt between northern latitudes of 3^0 and 15^0, and thus the potential benefits of renewable energy resources such as solar energy system can be considerable[9]. According to K. Komota and his friends PV power plants with several hundred MW scale area already in the commercial stage and technically feasible. It may be reasonable to expect that GW-scale PV power plants will come on the market in the near future[10].

II. METHODOLOGY

A. Climate data and Location of the Power Plant

The location of the power plant is at Bati town with Latitude of 11.2°N and Longitude of 40.0°E the other details of the location are given by Table-1. the location is selected based on climate data that can justify its potential through bench mark analysis and the climate data is given by Table-2. The average daily solar radiation-horizontal of Bati is about 5.96kwh/m^2. Therefore, the Bati town have a very good amount of solar radiation which can be utilized for electric generation. Based on the value obtained from the climate data it is easily understandable that the location is suitable for power production.

Table-1: Climate Data Location and Facility Location

	Unit	Climate data location	Facility location
Name		Ethiopia - Bati	Ethiopia - Bati - Bati
Latitude	˚N	11.2	11.2
Longitude	˚E	40.0	40.0
Climate zone		1B - Very hot - Dry	1B - Very hot - Dry
Elevation	m	1100	1624

The facility location is with an elevation of 1624 meters above sea level. The climate data is extrapolated to this elevation to perform the exact calculations of the feasiblity study and the extrapolated results are given by table-2.

Table-2: Climate Data of the Facility Location

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days 18 °C	Cooling degree-days 10 °C
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	21.9	49.5%	11.47	5.35	89.3	2.8	24.0	0	369
February	23.2	46.0%	20.16	5.77	89.3	2.9	25.4	0	370
March	24.8	48.4%	55.18	6.19	89.1	2.8	26.8	0	459
April	26.0	50.7%	61.80	6.44	89.1	2.7	27.9	0	480
May	28.1	39.8%	39.37	6.58	89.0	2.7	30.0	0	561
June	29.5	34.5%	43.50	6.17	88.9	2.6	31.6	0	585
July	27.1	52.2%	168.33	5.75	88.9	2.1	28.2	0	530
August	25.8	60.6%	164.30	5.72	89.0	1.9	26.3	0	490
September	25.9	54.5%	75.60	5.96	89.0	2.0	26.7	0	477
October	24.5	44.5%	29.14	6.09	89.2	2.5	25.8	0	450
November	22.8	43.2%	9.90	6.02	89.3	2.7	24.4	0	384
December	21.7	47.6%	13.33	5.51	89.4	2.7	23.5	0	363
Annual	**25.1**	**47.7%**	**692.08**	**5.96**	**89.1**	**2.5**	**26.7**	**0**	**5,517**

B. Power Plant Capacity

According to L.Marena and his friends Ethiopia is currently about to build a 100MW PV power plant in Metehara and the country is working to reach 5,300 MW of power generated from solar by 2030 [11], to reach this amount it is a must to do potential and feasibility assessments to help the government and interested energy sector investors. Therefore, this study will contribute a potential 100MW of power addition to the national grid and it has its own role to help the country to reach its goal by 2030.

C. Software Used

According to [12] RETScreen is a Clean Energy Management Software system for energy efficiency, renewable energy and cogeneration project feasibility analysis as well as ongoing energy performance analysis. Therefore, RETScreen software is used for all the feasibility anlysis.

III. Results and Discussions

A. Benchmark Analysis

It has been said that Benchmarking analysis is a specific type of market research that allows organizations to compare their existing performance against others and adopt improvements that fit their overall approach to continuous improvement and culture[13]. And according to[14] the energy cost of production of Ethiopia is 0.09 USD for 1kwh which is 2.61 birr per kwh as per the currency during the analysis (1USD is equivalent to 28 ETB). The bench mark analysis result of this study has been given in fig.1 below.

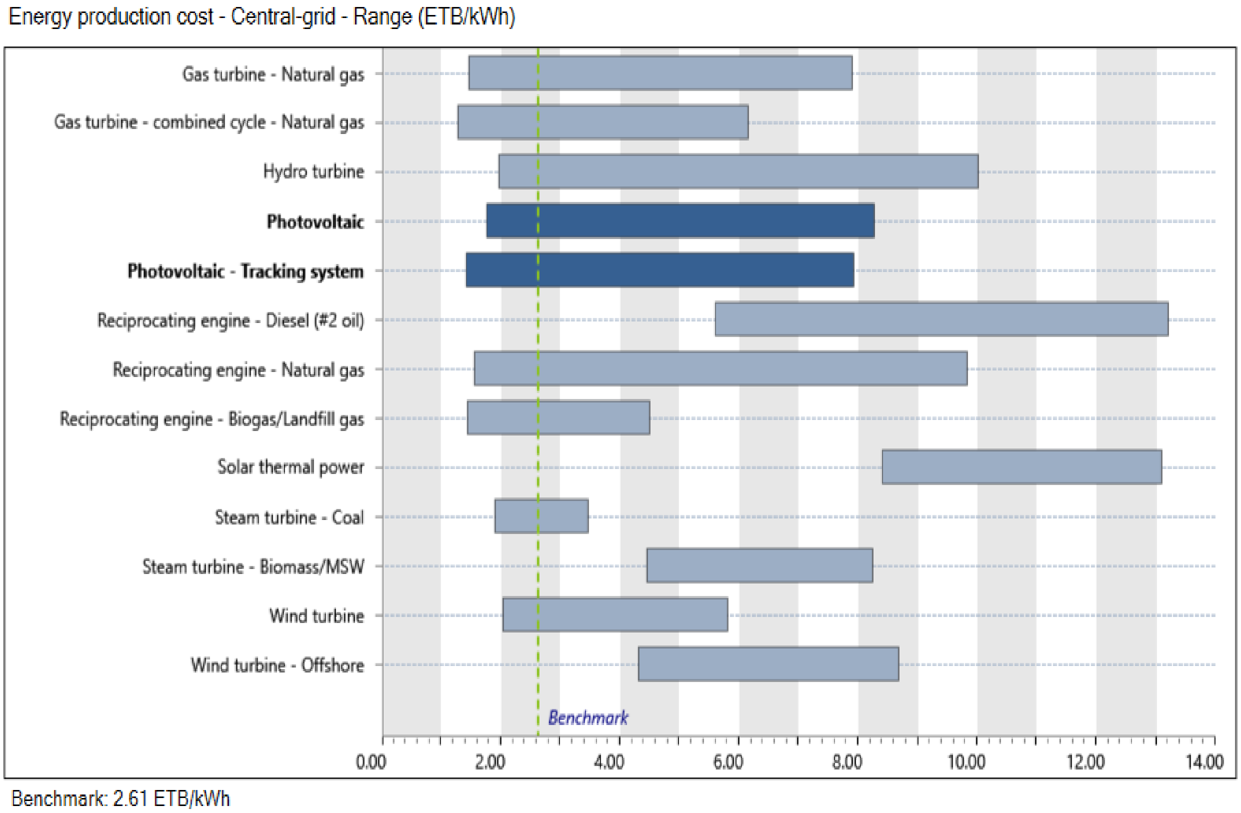


Figure-1: Benchmark Analysis

From the bench mark analysis in Fig. 1 the cost of production for 1kwh photovoltaic power plant is about 1.6 ETB which is much less than the existing power generation options in the country. Therefore, it is clear that photovoltaic powerplant at Bati Ethiopia is feasible regarding the cost of power production and this positive result pushes for further economic analyses.

B. Energy Analysis

The Energy analysis is made based on The bench mark analysis in section 3.1 and the climate data in section 2.1. The target plant capacity is about 100MW, this means the plant should deliver constantly 100MW of power to the national grid. But, from the nature solar radiation intensity it is difficult to get constant power production as the solar radiation intensity is different from hour to hour and day to day. After performing the energy analysis, the maximum capacity of the plant is 135,000Kw and the electricity supplied to the national grid is calculated to be 275,701MWh and this is given by table-3 below.

Table-3: Energy Capacity

Photovoltaic - 100000 kW			
Capacity	135,000	●	kW
Electricity	275,701		MWh

C. Financial Viability

According to[15] financial viability is the ability to generate sufficient income to meet operating payments, debt commitments and, where applicable, to allow for growth, while maintaining service levels. Therefore, in this section the financial viability of the power plant is discussed. for a project to be financially viable the financial parameters are the determining factors. Those financial parameters are given in table:4. Before the financial analysis, it is important to take the proper assumptions of the inflation rate, discount rate, reinvestment rate and project life as this all helps in the financial viability process and the assumptions taken are given in table:4.

Table-4: Financial parameters

General		
Inflation rate	%	2%
Discount rate	%	9%
Reinvestment rate	%	9%
Project life	yr	20
Finance		
Debt ratio	%	70%
Debt	ETB	113,400,000
Equity	ETB	48,600,000
Debt interest rate	%	7%
Debt term	yr	15
Debt payments	ETB/yr	12,450,710

All the expenses and yearly dept payment are discussed in table:4 and the project have to pay 12,450.710 ETB annually. The viability is then examined based on annual revenue analysis and it is given in table:5.

Table-5: Annual revenue

Electricity export revenue		
Electricity exported to grid	MWh	275,701
Electricity export rate	ETB/kWh	0.35
Electricity export revenue	ETB	96,495,490
Electricity export escalation rate	%	2%

For the annual revenue analysis, the electricity export rate to the grid is taken 0.35ETB/KWh which is the less than the current rate of 0.5ETB/KWh, and all calculations are based on this assumption.

D. *Emission Analysis*

The main target of installing renewable energy sources as power means is reducing the Greenhouse Gas emission and this study also investigates how much GHG will be reduced, if the location is solely depending on natural gases instead of renewable energy for the same amount of 100MW annually. The gross annual greenhouse gas reduction is about 93% and this is a meaningful value this is shown in fig.2 and, installing a 100MW PV power plant will reduce the GHG emission from 2188.4 tCO_2 to 152.2 tCO_2 annually and this is shown in Fig.3.

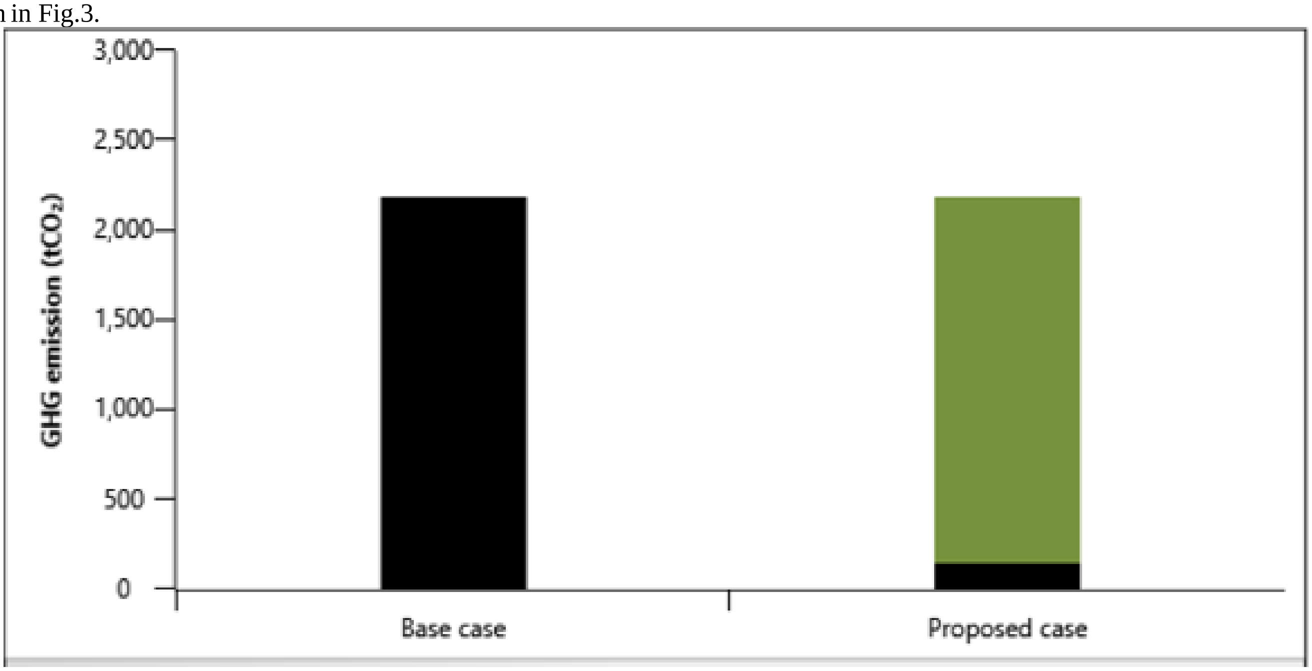
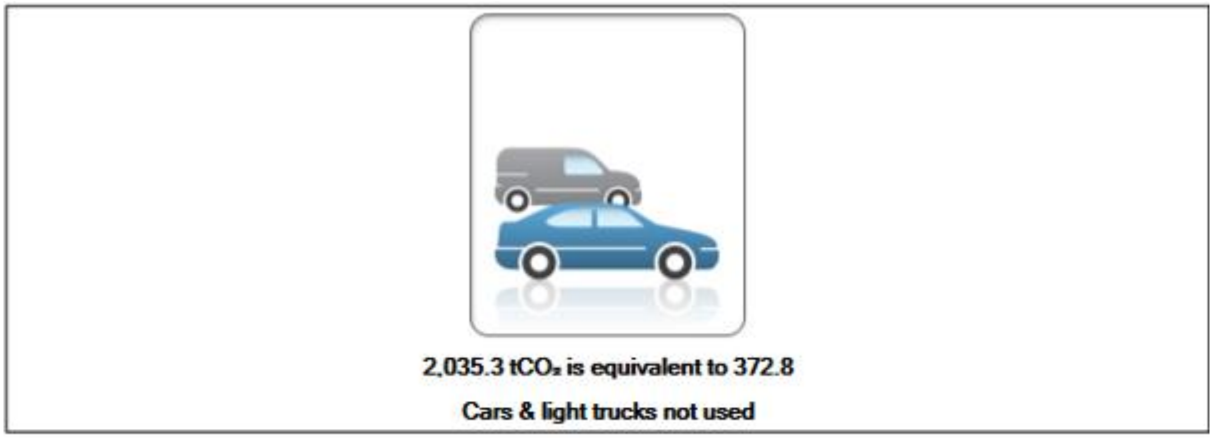


Figure-2: GHG Emission Reduction



GHG emission		
Base case	2,188.4	tCO_2
Proposed case	153.2	tCO_2
Gross annual GHG emission reduction	**2,035.3**	**tCO_2**

Figure-3: GHG Equivalence

According to GTP II the Country is heading to green Solely green energy by 2025 and already started some positive works to exploit solar and wind energy, this value with the solar power potential is very vital as it forces the government and investors to look for another options for power production from solar Radiation.

E. Annual Cash flow and Cumulative Cash Flow

From section 3.3 and 3.4 the electricity exported to grid is 275,701MWh, electricity export revenue is 96,495,490 ETB and the GHG emission reduction is 2,035.3 tCO_2. Based on this and other consideration the Annual and cumulative cashflow analysis has been made and the results are given in figure 4&5. According to[16] A positive result indicates that the company generated more cash than it has spent and for this case in figure 5, the company has generated more cash than the spent. The project profitability is not under question and the results genuinely explains that the cash flow since the beginning is positive except at the first year of the project execution.

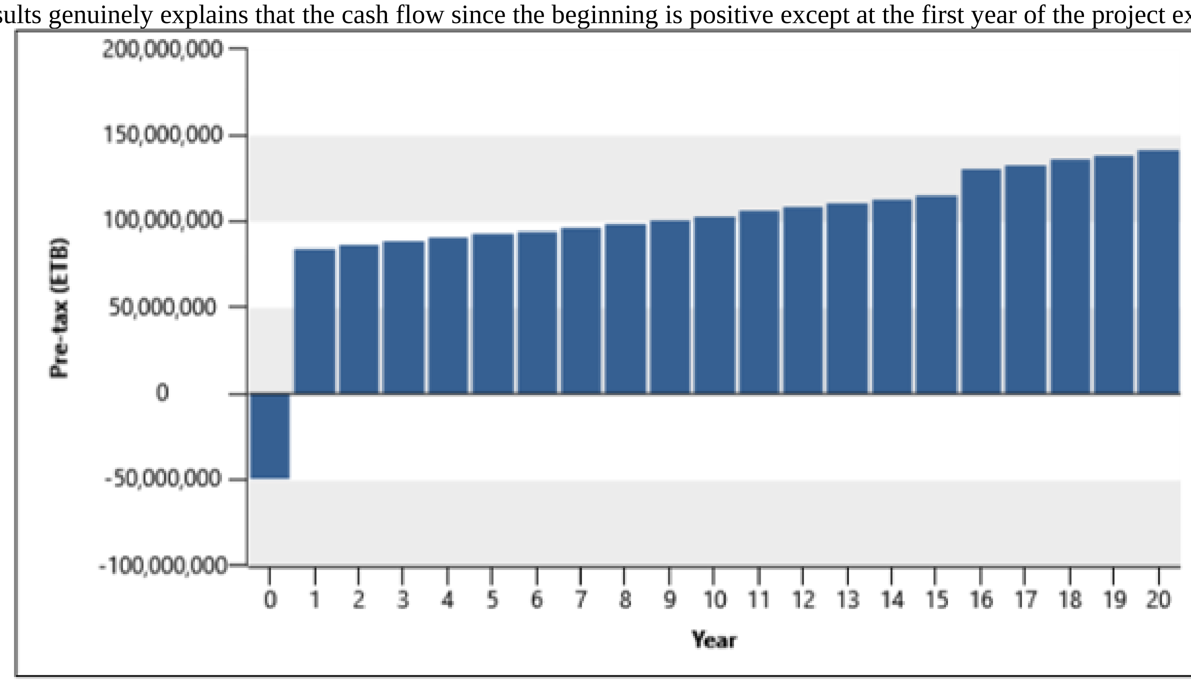


Figure-4. Annual Cash Flow

http://dx.doi.org/10.29322/IJSRP.10.09.2020.p10508

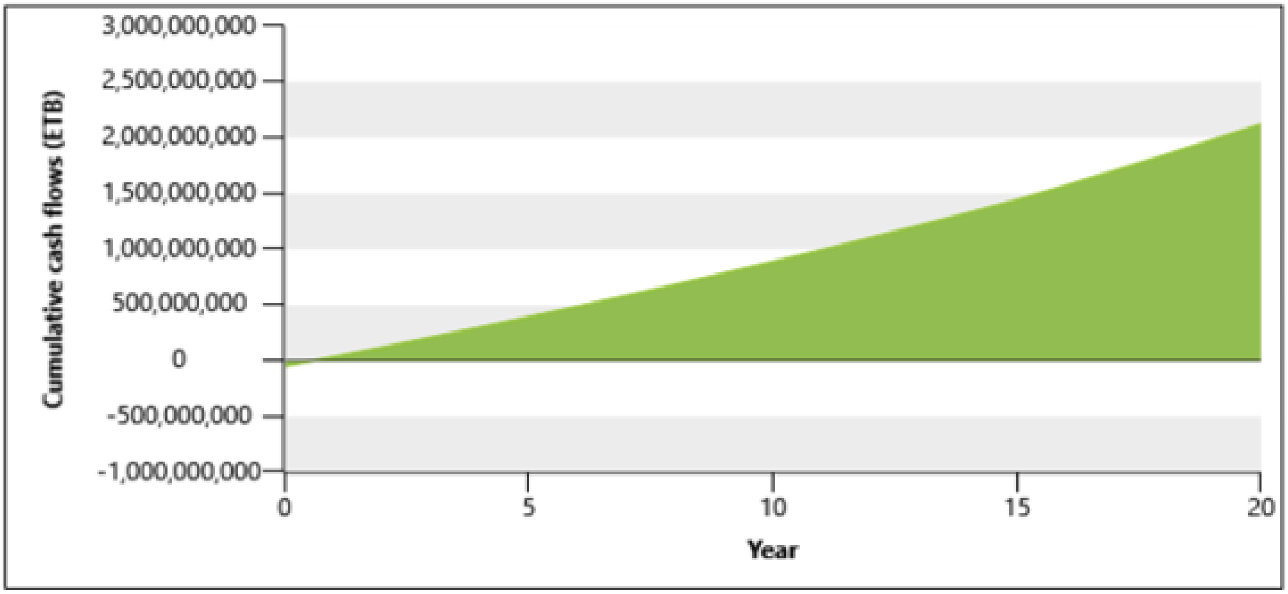


Figure-5. Cumulative Cash Flow

F. Net present Value (NPV)

Net present Value will tell us whether we are getting a positive or negative return on investment and the analysis for this study was made based on the relative impacts of the parameters on the NPV. The relative impact of parameters on NPV is given by Figure 6.

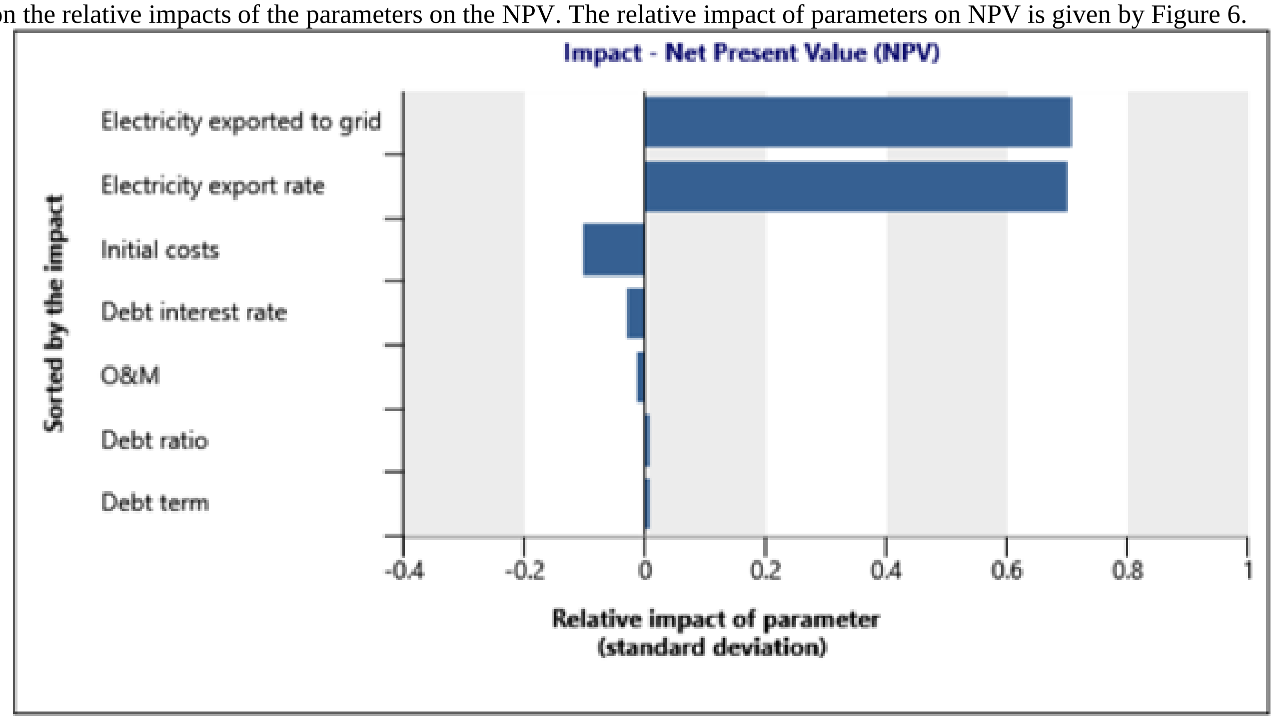


Figure-6: Parametrs Impact on NPV

From the impact of the parametrs and the NPV value remains positive, therefore, the project gives positive return. And, the distribution of the NPV is given below in Figure 7.

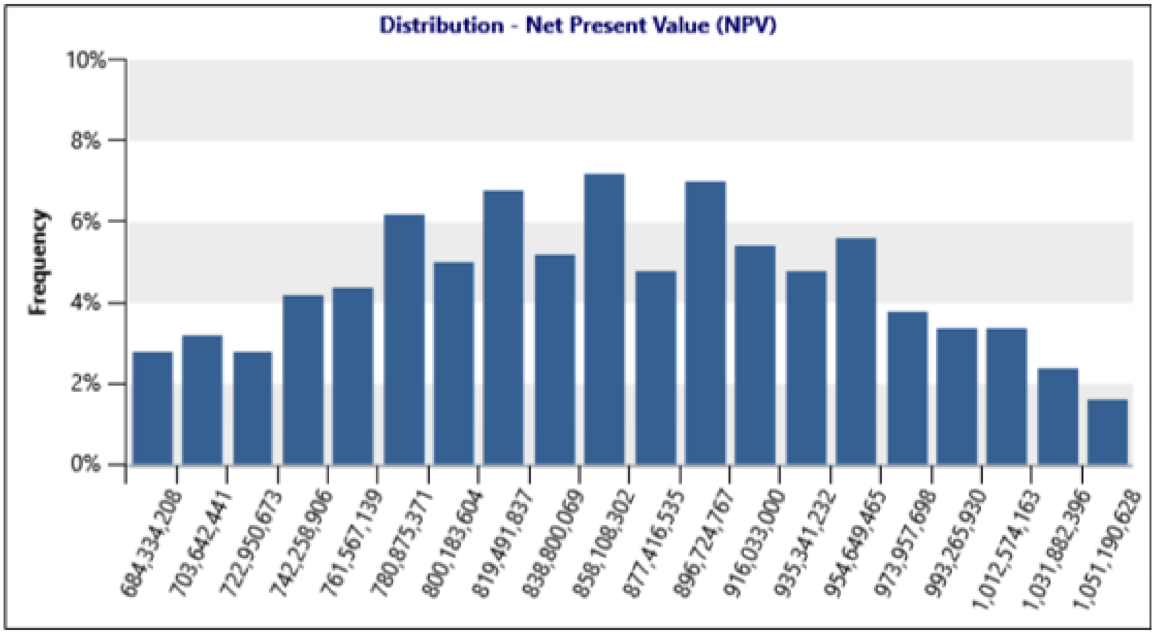


Figure-7: Distribution of NPV

IV Conclusion

The feasiblity study of a 100MW PV powerplant in Bati, Ethiopia has been completed and the following conclusions are made based on the results.

1. From bench mark analysis employing a PV power plant at Bati will reduce the energy cost of production from 2.61ETB/KWh to 1.6KWh. and this alone can tell us the feasiblity.
2. Installing this plant in Bati, Ethiopia will reduce the GHG emission from 2188.4 tCO_2 to 153.2 tCO_2. And, this result shows that the plant has a great role in reducing the GHG in a meaning manner.
3. The Cash flow and the NPV shows positive results

From the above points it is cocluded that the project is feasible technicaly, financilly and environmentally. And, it will play a great role for the country to achive its goal by 2030.

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