ANALYSIS OF PV SYSTEM AT DAFFODIL INTERNATIONAL UNIVERSITY USING RETSCREEN SOFTWARE

By MD. ABU NAYEEM REJON

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ANALYSIS OF PV SYSTEM AT DAFFODIL INTERNATIONAL UNIVERSITY USING RETSCREEN SOFTWARE

This thesis paper is submitted to **Daffodil International university** of Bangladesh in fractional satisfaction of the necessities of the level of Bachelor of Science in Electrical and Electronics Engineering.

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Dept. of EEE

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The thesis entitled "**ANALYSIS OF PV SYSTEM AT DAFFODIL INTERNATIONAL UNIVERSITY USING RETSCREEN SOFTWARE**" submitted by Abu Nayeem Rejon , ID No: 172-33-485; Session: Spring 2021 has been granted as fractional satisfaction of the necessities of the level of Bachelor of Science in Electrical and Electronics Engineering.

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Dedicated to

Those, who are passed away during cpvid-19

DECLARATION

I announce that this thesis is founded by me . During this analysis those equipment which is not belongs to me are also mentioned. This has been submitted to **Daffodil International University** for partial fulfillment of the requirement of the degree of B.Sc. in Electrical and Electronics Engineering. Any of the part are never submitted to any college or university.

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ABSTRACTS

A system which is connected to the utility grid we can call it grid tie solar inverter system. In this thesis paper we will discuss about grid tie solar inverter & besides we will show a model about this title.

We know that in our home that we use is AC current [subject to Bangladesh]. But it's not like that DC current is not use totally. The current we got from battery is the source of DC current. As a example IPAS. In Bangladesh electronics equipment is perfect for AC current that's why the main line is AC current . but in developed countries they convert the AC current to DC current although it's expensive.

In this solar inverter using full wave inverter topology the DC current converted to AC current. During the power flow , the system control between grid & household. This paper will give you a idea about grid connected solar inverter.

Besides this paper will give you a idea about design and simulation of inverter in RETscreen software.

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List of symbols & abbreviations

PV	Photovoltaic
MPP	Maximum power point
I_L	Photo generated current
STC	Standard test conditions
I_{SC}	Short circuit current
V_{OC}	Open circuit voltage
Q	Electro charge
I_{PV}	Photodiode current
V_{PV}	Photodiode voltage
N	Diode quality factor
K	Boltzmann constant
T	Temperature
C	Capacitor
V	Voltage
I	Current
L	Inductor
R	Resistor
I_D	Diode current
R_S	Series resistance
R_{SH}	Shunt resistance

Chapter 1

INTRODUCTION

1.1: General thought

Natural concerns like a dangerous atmospheric devation and environmental change are driving the requirement for expanded infiltration of appropriated inexhaustible assets into the up and coming age of the power network.The fast growing annual rate & become essential part of our life is solar energy. Most of the countries are now using this energy.

From the beginning we all depend on the petroleum & gas to collect energy. Solar energy will help us to lead away from this type of energy source. Though it can not be compared with them cause solar system is poor. But we all know that one day the renewable energy will be finished that's why we have to find something alternative like this.

For this project we will explore & analysis more & more about solar energy. Particularly our center topic will be PV analysis using RETscreen software.

1.2: Foundation and Motivation

A nation's development depends on natural resources. fossil fuels, oil, natural gas are example of natural resources. In Bangladesh we depends on natural gas. But it will not be continues. so Those who have more resources they can develop more & more.

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Present day power structures have gotten more marvelous with amazing imaginative change and the extension of force interest. Thusly, the power systems become more defenseless against utility power related issues and ordinary disrupting impacts.

Without proper power system an engineer cann't do anything. Just imagine without the light how does it feel . that's why we have to use it properly instead of wasting. Cause one day it will be completely disappear. If this happened the world will be stopped. So that's why we have to analysis more & find alternative like solar panel, wind turbine etc.

Micro grids are restricted scale transformations of brought together force systems where more restricted size flowed generators and maintainable force resourcelike solar panels , wind turbine & energy storage.

Micro grids are restricted scale transformations of brought together force systems where more restricted size flowed generators and maintainable force resources like solar panels , wind turbine & energy storage
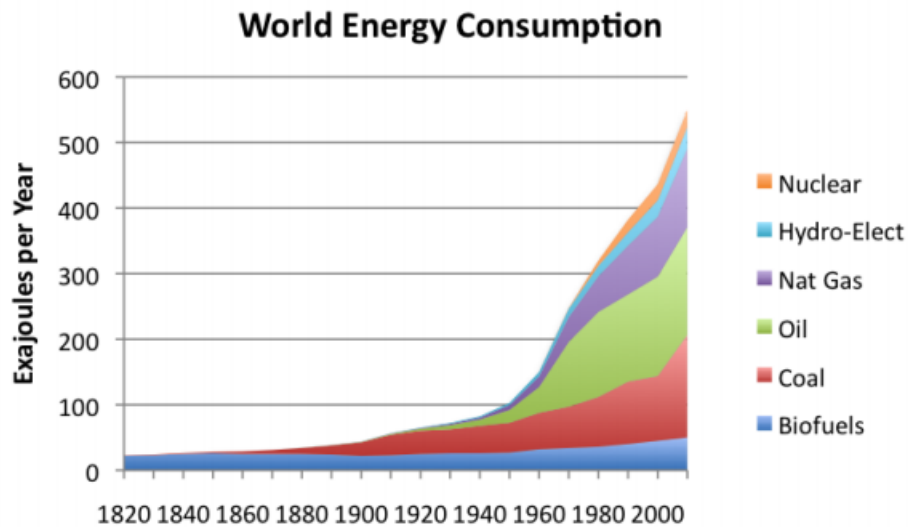
Figure 1.2: World energy consumption from 1800s to 2000s

The human advancement is dependent upon electric power. There is an association between GDP improvement rate and force advancement rate in a country. In Bangladesh there are three associations which is under the Ministry of Energy and Mineral resources (MEMR).

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Chapter 2

Generation of Electric Energy

2.1: Introduction

In Bangladesh the number of people is 160 million. Certainly for this people we need more resources to increase GDP or convert the country into developed countries. And here, natural gas is the prime natural resources. Local oil supply in idea to be irrelevant. A couple of little stores of coal exist on the north eastern area of the country, yet these contain peat, with low caloric worth and especially significant bituminous coal that will be exorbitant to isolate.

Regardless, for low money related headway of 6% where guess shows request on 2020 is 11,794 MW that construes Bangladesh needs to convey 1,794 MW from doable assets for meet the objective set by Government. This goal is ridiculous, positively practical. [**1**] Principally in light of the topographical space of Bangladesh. But now there are many researcher think that the sun light we got everyday so they want to develop more about this solar pane. And that's why the number of solar panel users are increase day by day. Most of them are seen in the village. Also the govt. use this solar panel on the road lamppost.

2.2: Renewable energy

Innocuous to the environment power is in general portrayed as energy that comes from assets which are commonly re-invigorated on a human timescale like light, wind, storm, tide waves and geothermal. About 16% of worldwide last energy utilization as of now comes from inexhaustible assets, with 10% of all energy from conventional biomass, basically utilized for warming, and 3.4% from hydroelectricity.New economical (little hydro, modem biomass, wind, daylight based and geothermal) address another 3% and are developing quickly.

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Mainly There are five types of renewable energy like,

1. Hydropower
Main articles: Hydroelectricity and Hydropower

2. Wind power
Main article: Wind power

3. Solar energy
Main articles: Solar energy and Solar power

4. Bioenergy
Main articles: Bioenergy, Biomass, Biogas, and Biofuel

5. Geothermal energy
Main articles: Geothermal energy, Geothermal power, and Renewable thermal energy

 For better understand, some renewable energy figure is given.

Wind power
Main article: Wind power

Global electricity power generation capacity	733 GW (2020)[6]
Global electricity power generation capacity annual growth rate	14% (2011-2020) [7]
Share of global electricity generation	5% (2018) [7]
Levelized cost per megawatt hour	Land-based wind: USD 30.165 (2019) [9]
Primary technology	Wind turbine

Table:2.2.1: Wind power

Wind force or wind energy is the utilization of wind to give mechanical force through wind turbines to turn electric generators for electrical force. Wind power is a standard

achievable, harmless to the ecosystem power source that smallerly influences the environment stood out from burning-through oil based commodities.

Figure: 2.2: Wind turbine

To acquire the electrical energy from a breeze factory consistently, the generator is organized to charge the batteries. During off time of wind turbine the energy supply from the battery.

Hydropower
Main articles: Hydroelectricity and Hydropower

Global electricity power generation capacity	1,211 GW (2020)[**7**]
Global electricity power generation capacity annual growth rate	2.7% (2011-2020) [**4**]
Share of global electricity generation	16% (2018)) [**9**]
Levelized cost per megawatt hour	USD 65.581 (2019) [**8**]

Figure:2.2.2:Hydro power

When blades turn into turbine by the flowing water, the shape is convert to mechanical energy. Turning the generator it can be convert mechanical energy into another energy form- electricity.

Figure:2.2: Hydroelectric power

Bioenergy

Main articles: Bioenergy, Biomass, Biogas, and Biofuel

Biomass, is a limitless regular matter, and can join natural material got from living, or actually living natural elements, similar to wood, waste, and alcohol fills. Wood energy is gotten both from obtained wood as a fuel and from wood coincidental impacts.

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Squander energy can be produced using city squander, making waste, and landfill gas. Biomass liquor fuel, or ethanol, is gotten exceptionally from corn.

Global electricity power generation capacity	127 GW (2020[7]
Global electricity power generation capacity annual growth rate	6.5% (2011-2020) [8]
Share of global electricity generation	2% (2018) [8]
Levelized cost per megawatt hour	USD 118.908 (2019) [9]

Figure:2.2.3: Biomass

Geothermal energy
Main articles: Geothermal energy, Geothermal power, and Renewable thermal energy

High temperature geothermal energy is from atomic force created and taken care of in the Earth. Atomic force is the energy that chooses the temperature of issue. The geothermal tendency, which is the differentiation in temperature between the focal point of the planet and its surface, drives a reliable conduction of atomic force as warmth from the middle to the surface. The modifier geothermal starts from the Greek roots geo, which means earth, and canteen, which means heat.

Global electricity power generation capacity	14 GW (2020) [1]
Global electricity power generation capacity annual growth rate	3.7% (2011-2020) [2]
Share of global electricity generation	<1% (2018) [3]
Levelized cost per megawatt hour	USD 58.257 (2019) [5]

Figure:2.2.4: Geothermal

Solar energy

Main articles: Solar energy and Solar power

Sun situated energy is splendid light and warmth from the Sun that is handled using an extent of continually creating developments like daylight based warming, photovoltaics, sun based atomic force, sun based designing, fluid salt power plants and phony photosynthesis.

In next chapter we will briefly discuss about it. Here just a table that gives the idea of solar energy in global.

Global electricity power generation capacity	714 GW (2020) [11]
Global electricity power generation capacity annual growth rate	29% (2011-2020) [11]
Share of global electricity generation	2% (2018) [12]
Levelized cost per megawatt hour	Utility-scale photovoltaics: USD 38.343 (2019) [13]

Figure:2.2.5: Solar energy

Chapter 3

Solar

3.1: Solar energy

Figure:3.1: Solar power

Daylight based energy is portrayed as the difference in energy that is accessible in the sun and is one of the manageable force sources . this type of power source is called solar energy. Depending on the capture & distribute it can be divided two parts like active & passive solar. The country possess great potential for solar energy, with average solar energy incident about 4-6.5 kWh/m^2/day, and averaging 10.5 hours of sun per day, of which 4-4.5 are peak sunlight hours and 300 clear sunny days per year.[2][3]

Currently, the country is considered a market leader when it comes to SHS, and standalone PV systems [2]
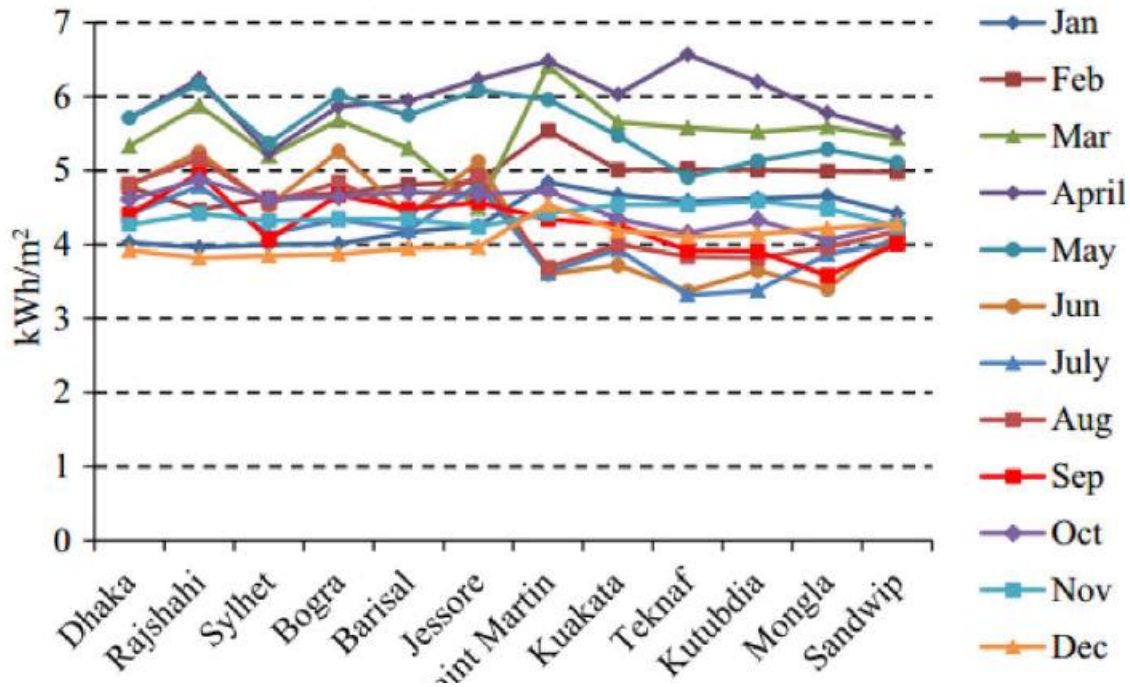
Figure:3.1: Daylight based Irradiation of Different Areas in Bangladesh as the year advanced

3.2: Solar panel

The short form of solar panel is PV.. The meaning of photo is light & voltaic related to electricity. So we can say PV modules can change the light into electricity. Silicon or thin –film cells is used this modules. Two types of layer in module like top layer & black layer. Most modules are inflexible, however semi-adaptable.

3.3: Solar cell

We know that solar panel converts the light into electricity . but the question is which part of solar panel doing such a important thing. The part name is solar cell. It convers the light . No matter what happened solar cell can not be damaged. Photovoltaic is the

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field of advancement and investigation related to the sensible utilization of photovoltaic cells in conveying power from light, anyway it is ordinary used unequivocally to insinuate the period of force from sunshine. In such cases the cell is to a great extent used as photo identifier (for example infrared pointers), perceiving light or other electromagnetic radiation near the recognizable reach, or assessing light power. The activity of a photovoltaic (PV) cell required.

1. The maintenance of light, making either electron-opening sets or exactions
2. The parcel of charge carriers of reverse sorts.
3. The different extraction of those transporters to an outer circuit

3.4: Photovoltaic Modules

Solar cells include convergent P-n made in thin wafers or semiconductor layers. In obscurity, the yield trademark IV of the sunlight based cell has a list trademark like that of a diode. When presented to light, photons with energy more prominent than the semiconductor band hole energy are retained and produces a couple of electron openings. These transporters are cleared separated affected by the inward electric fields of the p-n intersection and make a flow relative to the episode radiation. At the point when the cell is shorted, current courses through outside circuit; when the cell is open, the current is inside separated by the inborn p-n intersection diode.

Chapter 4

PV ANALYSIS WITH RETSCREEN SOFTWARE

4.1: Introduction

The RETScreen Clean Energy Management Software is a product bundle created by the Government of Canada. RETScreen is a perfect energy the executives programming framework intended to dissect the possibility of energy effectiveness, sustainable power and cogeneration projects, just as constantly investigate energy execution. RETScreen Expert, a superior variant of the product, is accessible for nothing in Viewer Mode. Let's see the picture then we can clearly know how it look it
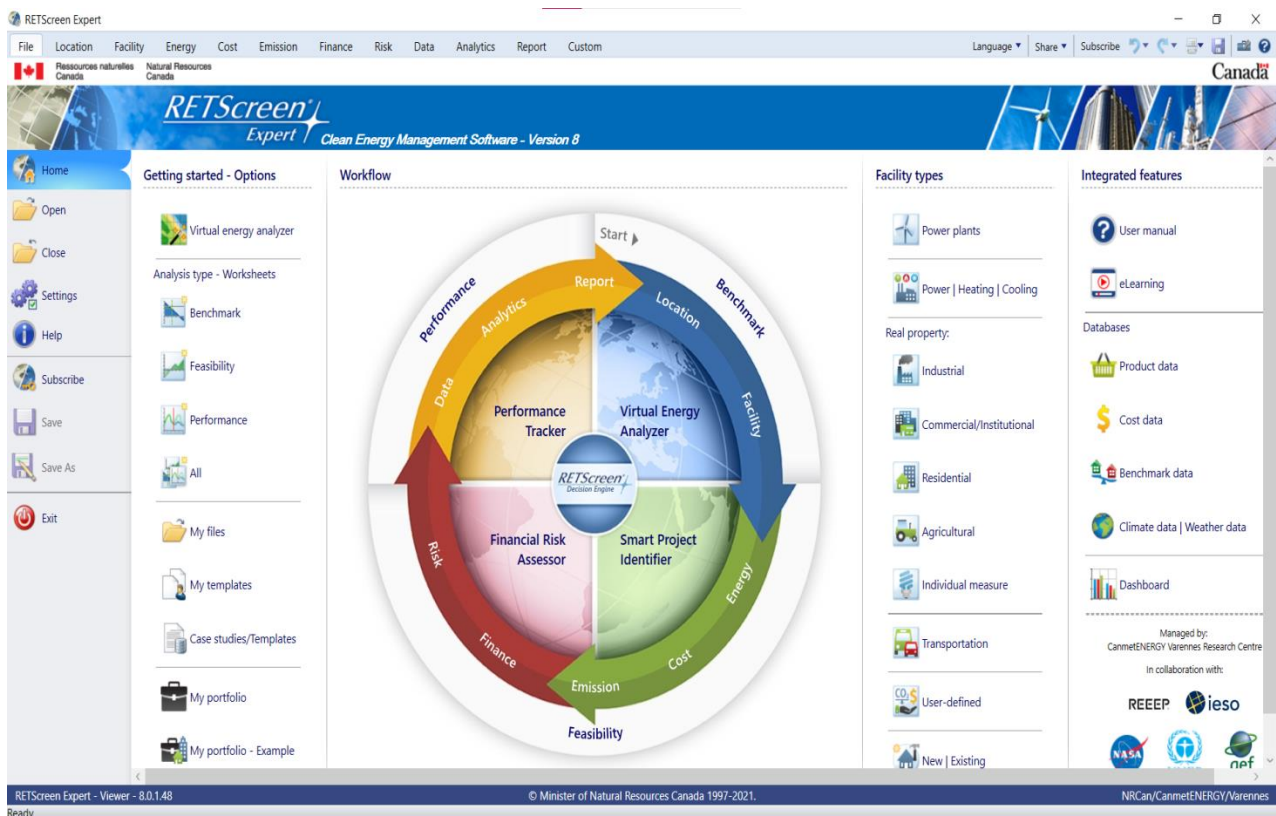
Figure:4.1: Homepage of RETSCREEN software

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4.2: Study area

Daffodil International University

20 MW

Power plant - Photovoltaic

Prepared for:

thesis

Prepared by:

MD. Abu Nayeem Rejon

Figure:4.2: 20 MW project in Daffodil international university

The area of daffodil international university is selected for the analysis. The model registers the area that will be covered by the PV show, in m². A specific area consider for this project. 110,803 meter square area is selected for this project with 20 MW power capacity. For this project number of units will be need 66,667. The unit number is related to the power capacity. For 20 MW we need this amount of units , if we use 10 MW then the number of units might be need 33367.

4.3: Data location

Before starting we can set the currency in dolar or taka or anything. The first we will set the location. We set the location in daffodil international university. Here we see there are two types of location symbol one is facility location other is climate data location. So basically climate data location is the nearest weather office where climate data is available to our project location. Project location is little brown symbol which refers facility location.

	Unit	Climate data location	Facility location
Name		Bangladesh - Dhāka	Bangladesh - Dhaka - ashulia
Latitude	˚N	23.7	23.9
Longitude	˚E	90.4	90.3
Climate zone		1A - Very hot - Humid	1A - Very hot - Humid
Elevation	m	9	16

Figure:4.3: Facility location & climate data location

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4.3.1: Latitude of project location

The client enters the topographical scope of the venture site area in degrees estimated from the equator. Scopes north of the equator are entered as sure qualities and scopes south of the equator are entered as regrettable qualities. The client can counsel the RETScreen Online Weather Database for this data. The scope of the nearest climate area can be glued to the bookkeeping page from the on the web climate data set. In the event that the client knows the scope for the venture area, this worth ought to be entered in the accounting page by overwriting the stuck worth.

4.3.2: Mathematical expression

The declination is the rakish situation of the sun at sun oriented early afternoon, concerning the plane of the equator. Its value in degrees is given by Cooper's equation:

$$\delta = 23.45\sin\left(2\pi\frac{284+n}{364}\right) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

where, n= is the number of the day like n=1 , January 1: n=60 , march 1 (if February is 28 day). Declination varies between -23.45° on December 21 and +23.45° on June 2.1.

4.3.2: Solar hour angle & sunset angle

The sun powered hour point is the rakish removal of the sun east or west of the neighborhood meridian; morning negative, evening positive. The sun powered hour point is equivalent to zero at sun oriented early afternoon and fluctuates by 15 degrees each hour from sunlight based early afternoon. For instance at 7 a.m. (sun powered time2) the hour point is equivalent to – 75° (7 a.m. is five hours from early afternoon; multiple times 15 is equivalent to 75, with a negative sign since it is morning).The dusk hour point ωs is the sun based hour point relating to when the sun sets. It is given by the accompanying condition:

$$\cos\omega s = -\tan\psi\,\tan\delta \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

where δ is the declination, calculated through equation (1), and ψ is the latitude of the site, specified by the user.

4.4: Solar radiation & tTemperature

Climate data

Month	Air temperature	Relative humidity	Precipitation	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	mm	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	18.4	51.6%	5.58	4.36	101.4	2.5	18.1	0	260
February	22.2	42.6%	13.16	4.92	101.2	2.5	22.2	0	342
March	27.4	40.0%	31.93	5.59	100.8	2.8	28.0	0	539
April	30.6	51.9%	84.90	5.76	100.6	3.6	31.8	0	618
May	30.6	65.3%	182.28	5.30	100.3	3.8	31.6	0	639
June	29.5	79.4%	233.70	4.53	99.9	4.3	30.0	0	585
July	28.7	85.1%	256.06	4.23	100.0	4.3	29.0	0	580
August	28.5	85.6%	218.86	4.29	100.1	3.7	28.8	0	574
September	27.9	85.3%	197.40	4.02	100.4	3.0	28.1	0	537
October	26.5	77.9%	118.73	4.32	100.8	2.2	26.6	0	512
November	23.1	68.4%	21.30	4.28	101.2	2.1	22.9	0	393
December	19.4	61.8%	8.06	4.21	101.4	2.2	19.0	0	291
Annual	**26.1**	**66.4%**	**1,371.96**	**4.65**	**100.7**	**3.1**	**26.4**	**0**	**5,869**

Heating design temperature: 14.6
Cooling design temperature: 31.6
Earth temperature amplitude: 14.2

Table

Table:4.4: Climate data

If we click on data collection & set the date we can see the ehole weather data like my weather date is set 2021-01-01 to 2021-08-18. The data derived by NASA. Here we have

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to add heating data that means our as asual normal data. Our average temperature is 30 degree Celsius.

4.4.1: Mathematical expression

The model figures the PV temperature coefficient. For the situation where the client chooses "Client characterized" under "PV module type," the client enters the temperature coefficient of the PV module. The effectiveness of photovoltaic cells fluctuates with their working temperature. Most cell types display a reduction in proficiency as their temperature increments. The PV temperature coefficient, µ (communicated in %/ºC), is characterized in the RETScreen PV model as:

$$\eta(T) = \eta(T_{ref})(1-\mu(T-T_{ref}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where $\eta(T)$ = the efficiency of the solar cell at temperature T,

   $\eta(T_{ref})$ = the efficiency of the cell at temperature Tref,

   T = the operating temperature of the module, and

   T_{ref} = the reference temperature (usually 25ºC).

4.5: Nominal pv module efficiency

The client enters the nominal efficiency (%) of the PV module viable. The client can counsel the RETScreen Online Product Database for more data.Module proficiency relies basically upon the kind of cell utilized (mono-Si, poly-Si, a-Si, CdTe, CIS, round Si).

Anyway inside every one of these classifications there are wide varieties in module proficiency from one producer to another, contingent upon the assembling measures utilizedAmong various sun oriented board types, monocrystalline cells have the most elevated proficiency regularly in the 15-20% territory and it's relied upon to settle the score higher.

Most polycrystalline PV cells have efficiencies between 13% to 16%, which is as yet a generally excellent proportion and it's relied upon to get just higher later on. Most monocrystalline sun powered cells have a temperature coefficient of around - 0.3%/C to - 0.5%/C.

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Cell type	efficiency
Mono-si	13
Poly-si	11
a-si	5
CdTe	7
CIS	7.5

So when the temperature rises 1 degree Celsius or 32 degrees Fahrenheit, the monocrystalline sun based cell will momentarily lose 0.3% to 0.5% of its viability. Polycrystalline PV cells have a higher temperature coefficient than the monocrystalline oneses.This implies that polycrystalline boards will lose a greater amount of their effectiveness when the temperature rises making them not ideal to be utilized in hot region. Most monocrystalline PV boards have a yearly productivity deficiency of 0.3% to 0.8%.**That's why we will use mono-si cell type**. Again I can also pick a module by click the option near the power capacity folder. Clicking the icon at the right a folder will show up like the first figure. Here we see technology type is mono-si. As manufacturers option there are many company which supply suitable model. Jinko solar , Apni solar, Canadian solar, China solar, BP solar   etc.

we will use Canadian solar & model will be mono-si-CS3k-300MS-KUpower. Number of units will be related to the power. For 20 Mw the numbers of unit will be 66,667. By clicking the data all thing will show up in the figure like last one. Miscellaneous loss will be depend upon those who can assume that he can hold the loss as low as he can. So I will assume it 10%. The software will show you it's calculated number but it can be changed

4.6: PV array tracking mode

Retscreen expert assumes that electricity will be sold at 10 dolars per kilowatt. Don't be concerned that natural gas appears here. A fuel is always included by default if isn't being used like in solar project. Second there is 10 mw (click the technology option) project defined under the technology section. I can look up the details by click the option. Now the screen showing me a level two analysis that is the capacitor factor is being calculated based on inputs describing the type & orientation of the solar panel as well as various loss factors. Capacitor factor is the average output of a power system

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that expressed in percentage. The client chooses the sort of sun tracking device upon the PV framework is mounted. The alternatives starting from the drop list are: "Fixed," "One-hub," "Two-pivot" and "Azimuth.". On the off chance that the PV exhibit is mounted on a proper design the client might choose "Fixed." The leftover decisions might be chosen if the PV exhibit is mounted on a tracker.In level 2 the top part of energy page where the orientation of the PV arrays specified as fixed. We can also set this as one axis or two axis. But will set it fixed option rather than tracker the sun. **Here we use fixed mode**.

4.6.1: Azimuth of PV array

The azimuth refers to the geographic direction at the front of the array faces by clicking on the word azimuth , the we can see the details of it. **So we will set it 0**

4.6.2: Slope of PV array

For fixed clusters, equivalent to the incline of the rooftop on which the photovoltaic exhibit is to be introduced: This doesn't really address an ideal as far as energy creation, however can decrease fundamentally establishment costs by disposing of the requirement for a help structure, or might be more attractive from a style viewpoint. The slope we set it 25 degrees. This was chosen as based on latitude of a site. A slope equal to latitude generally maximizes the annual solar collection in reality. However, the slope should not be high. To keep land utilization down we should choose lower number of slope. **The number of slope is 25**.

4.6.3: project life

Project life time means for how many years it will continue besides how many years it will give us revenue. So we assume that maximum 25 years.

4.7: Benchmark

The graphic below shows typical ranges of energy production cost for different types of power plant. The green dash line is position to indicate the energy production cost based o the archetype defaults applied to this project location. This benchmark can moved as our experience or expectation.

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Benchmark

Energy production cost - Central-grid - Range ($/kWh)
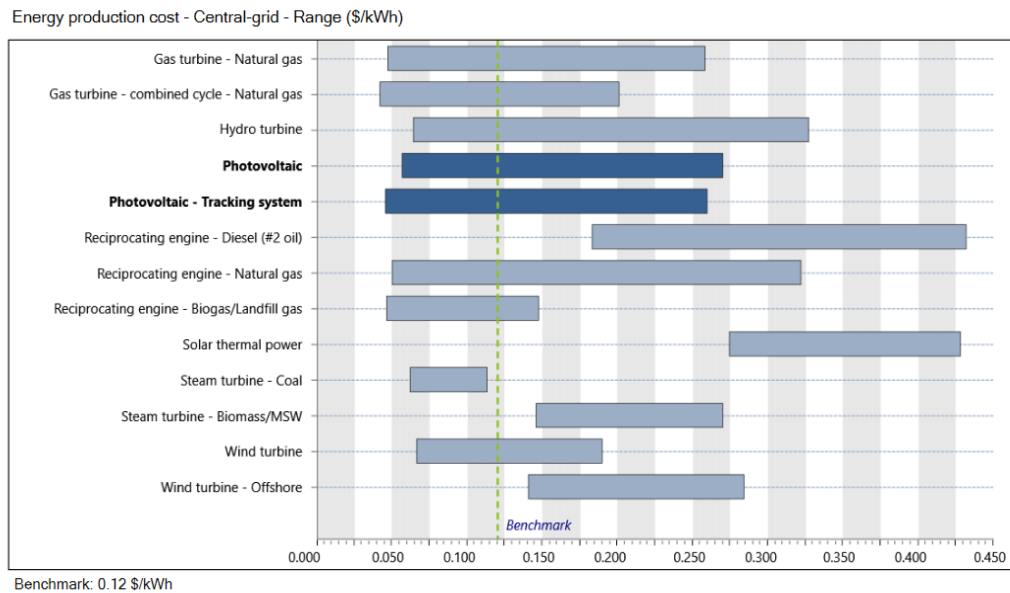

Benchmark: 0.12 $/kWh

Figure:4.7: Energy production cost

4.8: Greenhouse gas emissions

Sun based photovoltaic framework devours limited quantity of energy and produces limited quantity of green house gases, yet these gases are produced during the assembling system of photovoltaic framework . Hence energy age measure by photovoltaic framework is climate well disposed.On the emission page the virtual energy analyzer has provided level 3 analysis. That analysis is based on average emission factors. Red screen data base indicates 473 kilograms of co2 equivalent are emitted on average to generate a megawatt hour of electricity in our location. For different reasons T&D losses can increase or decrease. For these losses an average of 13138.3 kilograms of co2 equivalent are emitted for each megawatt hour grid electricity consumed in Bangladesh.

For emission analysis T&D losses consider 7.0%. The investigation of discharges is done contrasting a base instance of power age with natural gas. This case generates an emission factor of 0.473 tCO2/MWh and its total contribution is13,138.3 tCO2 for the 27779 MWh generated with that fuel. For base cased GHG emission is 13,138.3 tCO2. Thus the proposed case is 0 tCO2

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GHG emission

GHG equivalence

13,138.3 tCO₂ is equivalent to 2,406.3

Cars & light trucks not used
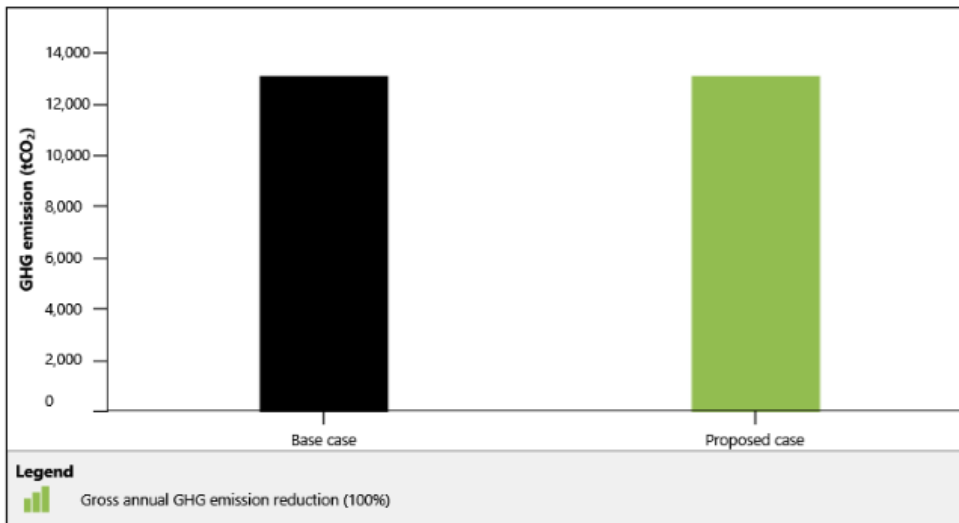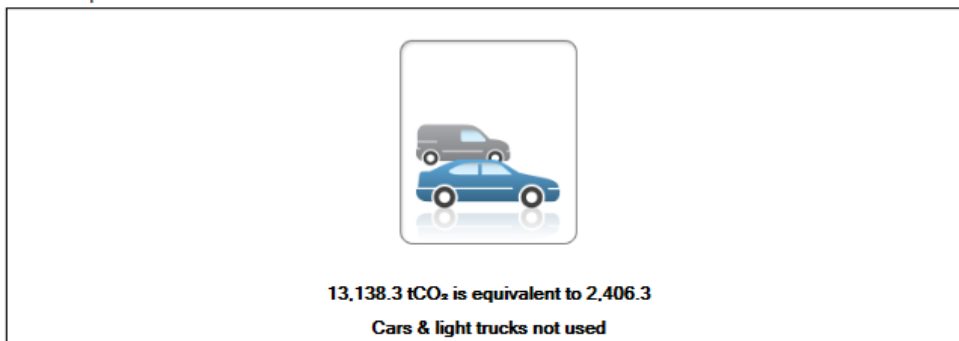
GHG emission		
Base case	13,138.3	tCO₂
Proposed case	0	tCO₂
Gross annual GHG emission reduction	**13,138.3**	**tCO₂**

Figure:4.8: GHG emission chart.

4.8.1:Theoratical expression oh GHG

The discharges' examination assesses the ozone harming substance emanation decrease (moderation) potential of proposed case. RETScreen gauges the yearly GHG discharge decrease, ΔGHG of power byutilising the accompanying Equation

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$$\Delta_{GHG} = (e_{base} - e_{proposed}) E_{proposed} (1 - \lambda_{proposed}) (1 - e_{credit}) \quad \text{.....................................(4)}$$

where e_{base}: base case GHG emission factor; $e_{proposed}$: proposed case GHG emission factor; $E_{proposed}$: proposed case annual electricity produced; $\lambda_{proposed}$: the fraction of electricity lost in transmission and distribution (T&D) for the proposed case; e_{credit}: the GHG emission reduction credit transaction fee.

For a single fuel type or source, the following formula is used to calculate the base case electricity system GHG emission factor, e_{base}:

$$e_{base} = (e_{CO2} GWP_{CO2} + e_{CH4} GWP_{CH4} + e_{N2O} GWP_{N2O}) \frac{1}{n} \frac{1}{11 - \lambda} \quad \text{...................(5)}$$

where , e_{CO2} e_{CH4} and e_{N2O} are respectively the CO_2, CH_4 and N_2O emission factors for the fuel/source considered. GWP_{CO2}, GWP_{CH4}, and GWP_{N2O} are the global warming potentials for CO2, CH4 and N2O, η is the fuel conversion efficiency, and; λ is the fraction of electricity lost in transmission and distribution

for $e_{proposed}$ case,

$$e_{proposed} = \sum_{i=1}^{n} f_i e_{proposed,i}$$

$$\text{...............................(6)}$$

Then the main equation will be ,

$$e_{proposed,i} = (e_{CO2,i} GWP_{CO2} + e_{CH4,i} GWP_{CH4} + e_{N2O,i} GWP_{N2O}) \frac{1}{\eta i} \frac{1}{11 - \lambda i} \quad \text{............(7)}$$

where, $e_{CO2,i}$, $e_{CH4,i}$, and $e_{N2O,I}$ are respectively the CO2, CH4 and N2O emission factors for fuel/source **i**,

η**i** is the fuel conversion efficiency for fuel **i**,

Chapter 5

Result & conclusion

5.1: Financial viability

The RETScreen Software empowers a client to include different types of monetary information like markdown rates, and so forth, which it naturally ascertains to create key monetary achievability markers, for example, basic compensation, value restitution, and net present worth. In view of the information entered by the client, monetary pointers for the undertaking being examined are given, along these lines determining fundamental data which works with the task assessment measure for organizers and chiefs.

Financial viability

Pre-tax IRR - equity	%	50.8%
Pre-tax MIRR - equity	%	18.8%
Pre-tax IRR - assets	%	16.2%
Pre-tax MIRR - assets	%	11.8%
Simple payback	yr	4.6
Equity payback	yr	2.1
Net Present Value (NPV)	$	16,114,926
Annual life cycle savings	$/yr	1,765,333
Benefit-Cost (B-C) ratio		5.6
Debt service coverage		2.9
GHG reduction cost	$/tCO$_2$	-134
Energy production cost	$/kWh	0.054

Table:5.1: Financial viability

5.1.1: IRR & IOR

  IRR means Internal rate of return & IOR means return on investment. The inner pace of return IRR is the markdown rate that causes the Net Present Value (NPV) of the task to be zero. It is calculated by solving the following formula for IRR:

$$\sum_{n=0}^{N} \frac{Cn}{(1+IRR)^n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 8$$

Where N is the project life , and Cn is the cash flow for year .The pre-tax cash flows is using to calculate the pre-tax IRR, while the after tax cash flows is used to calculate the after-tax IRR.

5.1.2:Simple Payback

The straightforward restitution SP is the quantity of years it takes for the income (barring obligation installments) to rise to the all out venture (which is equivalent to the amount of the obligation and value)

SP= (G-IG)/((C $_{ener}$ + C $_{capa}$+ C$_{RE}$ + C$_{GHG}$)-(C$_{O\&M}$ + C$_{fuel}$))....................... ....(9)

5.1.3: Net present value

The net present worth NPV of a task is the worth of all future incomes, dis-tallied at the rebate rate, in the present money. It is calculated by discounting all cash flows as given in the following formula:

NPC= $\sum_{n=0}^{N} \frac{Cn\prime}{(1+r)^n}$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (10)

Where r is the discount rate. The net present value is 16,114,926$

5.1.4: Benefit-Cost (B-C) ratio

The advantage cost proportion, B-C , is a statement of the general productivity of the venture. It is determined as a proportion of the current worth of yearly incomes (pay and additionally reserve funds) less yearly expenses for the task value.

B-C= (NPV+(1+fd)C)/ (1-fd)C...(11)

5.1.5: Energy production cost

The energy creation cost is the stayed away from cost of energy that carries the net present worth to nothing. This boundary is excluded from the Combined Heat and Power Model, since there are conceivably many kinds of energy created, each possibly having a particular creation cost . The energy creation cost, The energy production cost, C_{prod} , is thus obtained by solving for:

$$0= \sum_{n=0}^{N} \frac{C_{n'}}{(1+r)^n} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(12)$$

Here energy production cost is 0.054$/kwh

5.1.6: Annual life cycle savings

The model ascertains the annual life cycle investment funds (ALCS) which is the levelized ostensible yearly investment funds having the very same life and net present worth as the task. The yearly life cycle reserve funds are determined utilizing the net present worth, the markdown rate and the undertaking life.here the annual life cycle saving cost is   1,765,333 $/yr

5.2: Financial parameters

Financial parameters are critical for anticipated income. Since benefit misfortune, hazard everything relies upon the Financial parameters. Financial parameters can be divided into two parts. One part is general & other part is finance. In general part inflation rate, discount rate, reinvestment rate & project life is included. The other part is finance where debt ratio , debt, equity, debt interest rate, debt term & debt payments included.

5.2.1: Inflation rate

The client enters the expansion rate (%), which is the extended yearly normal pace of swelling over the existence of the task. For example , inflation rate for the next 25 years in our project is 2%.

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Financial viability

Financial parameters

General		
Inflation rate	%	2%
Discount rate	%	9%
Reinvestment rate	%	9%
Project life	yr	20
Finance		
Debt ratio	%	70%
Debt	$	8,230,312
Equity	$	3,527,276
Debt interest rate	%	7%
Debt term	yr	15
Debt payments	$/yr	903,644

Table:5.2: Financial viability

5.2.2: Discount rate

The client enters the markdown rate (%), which is the rate used to limit future incomes all together to get their current worth. The rate commonly saw as being most suitable is an association's weighted normal expense of capital. The rebate rate used to survey the monetary attainability of a given venture is once in a while called the "obstacle rate," the "remove rate," or the "required pace of return. Here, the discount rate is 9%.

5.2.3: Debt ratio

The client enters the debt ratio (%), which is the ratio of debt over the amount of the debt and the value of a task. The debt ratio mirrors the monetary influence made for a task; the higher debt ratio, the bigger the monetary influence. Most likely debt ratio range is between 50% to 90%. Here in this project debt ratio is 70%

5.2.4: Debt interest rate

The client enters the debt interest cost (%), which is the yearly pace of revenue paid to the debt holder toward the finish of every extended period of the term of the debt. The model uses the debt interest rate to calculate the debt payments. Here debt interest is 7%.

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5.2.5: Debt term

The client enters the debt term (year), which is the quantity of years over which the debt is reimbursed. The debt term is either equivalent to, or more limited than the undertaking life. Generally, the longer the term, the more the financial viability of a project improves. The term of the debt normally falls within a 1 to 25 year range. It should not exceed the estimated project life.

5.3: Annual revenue

Yearly income is ascertain base of all out creation cost and power trade rate to the network. Electricity production cost is .10 $/kwh. Annually 27,779 MWH electricity will export to the grid. And predicted electricity export revenue is 2,777,947$. Finally the export escalation rate is 2%.

Annual revenue

Electricity export revenue		
Electricity exported to grid	MWh	27,779
Electricity export rate	$/kWh	0.10
Electricity export revenue	$	2,777,947
Electricity export escalation rate	%	2%

Table:5.3: Annual revenue

5.4: Cash flow

5.4.1: Pre-tax

In RATESCREEN software there are two types of analysis , one is Pre-tax cash flow another one is cumulative cash flow. In Pre-tax analysis in per year the cash is calculated . in first year cash flow is negative , the amount is more than 3,000,00. In next year the amount is positive and it is almost 2,000,000. From the second year to 13 year the amount continuously increasing & positive. In 14th year the amount is less then previous year. Cause in that years a periodic cost happened, though its positive.. And for the next years it continuously increased. From fourteen-year cash flow is as usual. Benefit after thirteen years is large in amount.

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5.4.2: Cumulative Cash Flows

According to the figure, the project will be profitable after 5 years and the power plant will continue to generate revenue. After 10 years, the graph of cumulative cash group is more upbeat because the debt burden will not be after 10 years. After 14 years the graph goes down because at this time the lifetime of inverter expires. In next years there is no new cost, so the cumulative cash flow continues to grow at the same rate .
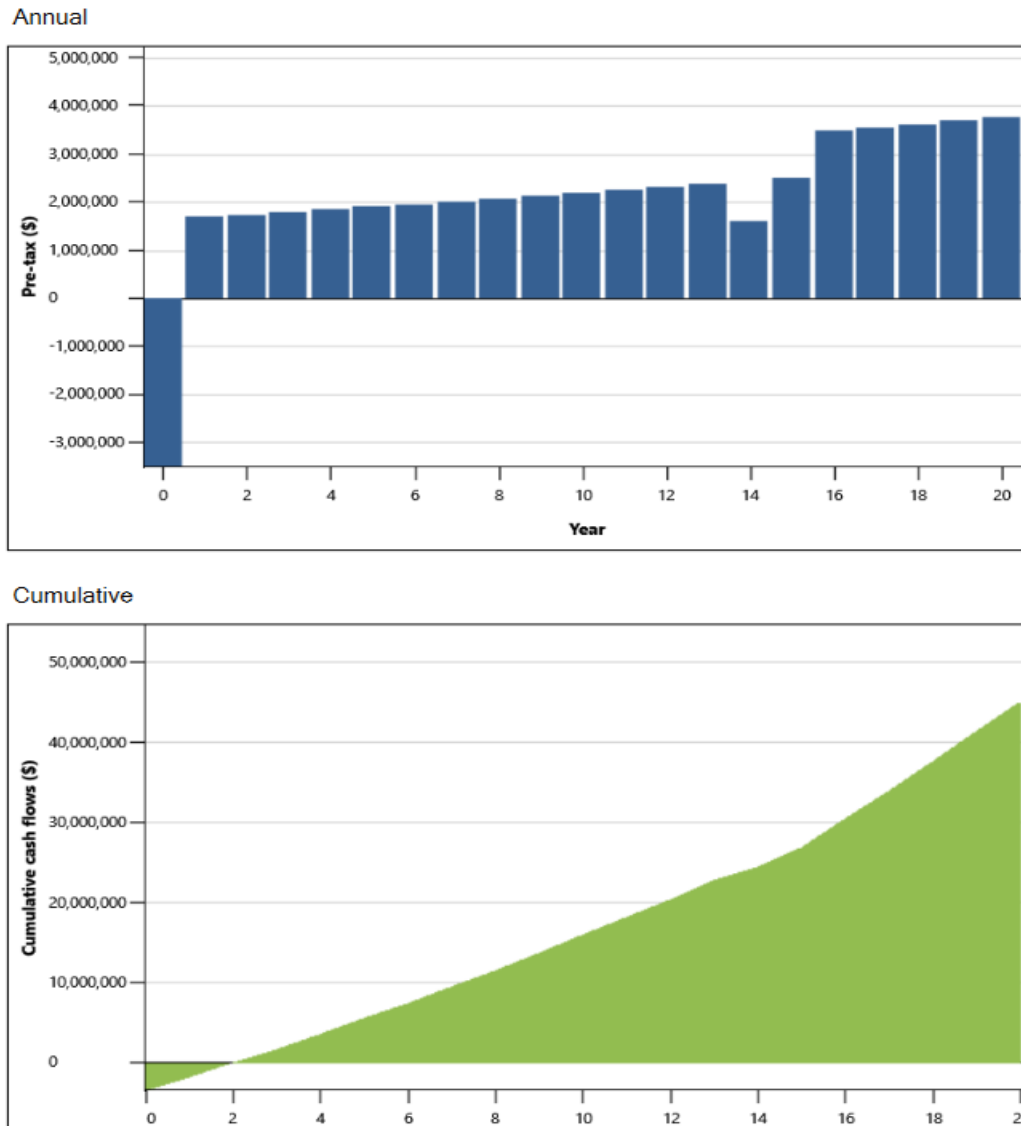

Figure:5.4: Cash flow

The Cumulative Cash Flows are plotted versus time in the total incomes diagram. These incomes determined in the model and revealed in the Yearly Cash Flows table.

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5.5: Yearly cash flow

Yearly cash flows

Year #	Pre-tax $	Cumulative $
0	-3,527,276	-3,527,276
1	1,685,062	-1,842,214
2	1,736,836	-105,378
3	1,789,646	1,684,268
4	1,843,512	3,527,779
5	1,898,455	5,426,234
6	1,954,497	7,380,731
7	2,011,660	9,392,390
8	2,069,966	11,462,356
9	2,129,438	13,591,794
10	2,190,099	15,781,893
11	2,251,974	18,033,867
12	2,315,087	20,348,954
13	2,379,461	22,728,415
14	1,609,418	24,337,834
15	2,512,099	26,849,932
16	3,484,058	30,333,990
17	3,553,739	33,887,729
18	3,624,813	37,512,542
19	3,697,310	41,209,852
20	3,771,256	44,981,108

Table:5.5: Yearly cash flow.

5.6: Executive summary

The executive summary of PV project is given below the table. The summary proposed that the electricity exported to the grid will be 27,779 MWh. From this project the revenue of electricity export is 2,777,947$. The GHG emission reduction is tCO2.

Target

Summary

	Electricity exported to grid MWh	Electricity export revenue $	GHG emission reduction tCO$_2$
Proposed case	27,779	2,777,947	13,138

Table:5.6: Executive summary

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5.7: Project cost & savings

The project cost & savings part can be described in four section. Totak initial cost, total annual cost, total annual savings & revenue and last one is periodic cost.

5.7.1: Initial cost

The total initial cost address the complete speculation that should be made to welcome an undertaking on line, before it starts to produce reserve funds (or pay). The total initial costs are the sum of the power ssystem and miscellaneous costs. Power system cost is 7,600,00$ & miscellaneous cost 4,157,588 $. Miscellaneous expenses are costs that qualify as **tax deductions that do not fall into other tax deduction categories**. So the initial cost is 11,757,588 $.

5.7.2: Total annul cost

The total annual expenses are determined by the model and address the yearly expenses caused to work, keep up with and finance the undertaking. The table shows that total annual cost is 1.143,644$. O&M and a debt payment is included in annual cost. The operation 7 maintenance (O&M) costs are the amount of the yearly costs that should be brought about to work and keep up with the energy framework, in abundance of the O&M cost needed by the base case power framework. The O&M cost is 240,00 $.

The model ascertains the obligation installments, which is the amount of the head and interest paid yearly to support the obligation. Whereas debt payments are constant over the debt term, the principal portion increases and the interest portion decreases with time. The debt payments is 903,6444 $.

5.7.3: Annual savings or income

The total annual savings address the yearly reserve funds acknowledged because of the execution of the venture. According to the viewpoint of an autonomous force maker or specialist co-op, these "investment funds" will be seen as "pay, in this project the annual savings cost is 2,777,947. So for the next 25 years this is our annual savings or income.

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5.7.4: Periodic cost

period costs allude to costs that are not attached to or identified with the creation of stock. Models incorporate selling, general and managerial (SG&A) costs, promoting costs, CEO compensation, and lease cost identifying with a corporate office. Periodic cost is 633,360$

Costs | Savings | Revenue

Initial costs			
Power system	64.6%	$	7,600,000
Balance of system & miscellaneous	35.4%	$	4,157,588
Total initial costs	**100%**	**$**	**11,757,588**
Yearly cash flows – Year 1			
Annual costs and debt payments			
O&M		$	240,000
Debt payments - 15 yrs		$	903,644
Total annual costs		**$**	**1,143,644**
Annual savings and revenue			
Electricity export revenue		$	2,777,947
GHG reduction revenue		$	0
Other revenue (cost)		$	0
CE production revenue		$	0
Total annual savings and revenue		**$**	**2,777,947**
Net yearly cash flow – Year 1		**$**	**1,634,303**
Periodic costs (credits)			
Periodic costs - 14 yrs		$	633,360

Table:5.7: Project cost & savings

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Chapter 6

Risk analysis

6.1 : Risk analysis

Perform analysis on	Net Present Value (NPV)				
Number of combinations	500				
Random seed	No				
Parameter	**Unit**	**Value**	**Range (+/-)**	**Minimum**	**Maximum**
Initial costs	$	11,757,588	25%	8,818,191	14,696,985
O&M	$	240,000	25%	180,000	300,000
Electricity exported to grid	MWh	27,779.47	25%	20,834.60	34,724.34
Electricity export rate	$/MWh	100.00	25%	75.00	125.00
Debt ratio	%	70.0%	25%	52.5%	87.5%
Debt interest rate	%	7.00%	25%	5.25%	8.75%
Debt term	yr	15	25%	11	19
Median				$	16,141,336
Level of risk				%	10%
Minimum within level of confidence				$	10,617,468
Maximum within level of confidence				$	21,932,501

Table:6.1: Risk analysis

Risk analysis   is pretty much as same as sensibility examination however the fundamental contrast is at the hour of risk analysis there is an end yet for sensibility there is no end. The energy creation cost is chosen as the monetary marker and the reach considered is ± 25% for every one of the boundaries.

In the risk analysis section, the impact of each input parameter on a financial indicator is obtained by applying a standardised multiple linear regression on the financial indicator.

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In the risk analysis part initial cost, O&M, electricity export rate, debt ratio, debt interest rate, debt term, median, level of risk ,minimum & maximum within level of confidence is included.

6.1.1: Median

The model ascertains the median of the monetary pointer. The median of the financial indicator is the 50th percentile of the 500 qualities produced by the Monte Carlo reproduction. The median will regularly be near the monetary pointer esteem determined in the Financial Summary worksheet. The median cost 16,141,336 $.

6.1.2: Level of risk

The level of risk addresses the likelihood that the financial pointer will fall outside this certainty span. The user can select 5% or 10% which is standard for the risk analysis. Here we will use 10%.

6.1.3: Minimum within level of confidence

The model calculates the "Minimum within level of confidence, which is the lower furthest reaches of the certainty span inside which the monetary pointer probably falls. For example, for a "Minimum within level of confidence" value of 15% IRR, a level of risk of 10% means that 5% (half the level of risk) of the possible IRR values are lower than 15%.

6.1.4: Maximum within level of confidence

The model calculates the "Minimum within level of confidence which is the maximum furthest reaches of the certainty span inside which the monetary pointer probably falls. For example, for a "Maximum within level of confidence" value of 25% IRR, a level of risk of 10% means that 95% of the possible IRR values are lower than 25%.

6.2: Impact graph

The impact chart shows the overall commitment of the vulnerability in each critical boundary to the changeability of the monetary pointer. r. The X pivot at the lower part of the chart doesn't have any units, but instead presents a general sign of the strength of the commitment of every boundary.

The info boundaries are naturally arranged by their effect on the monetary marker. The info boundary at the top (Y hub) contributes the most to the fluctuation of the monetary marker while the information boundary at the base contributes the least
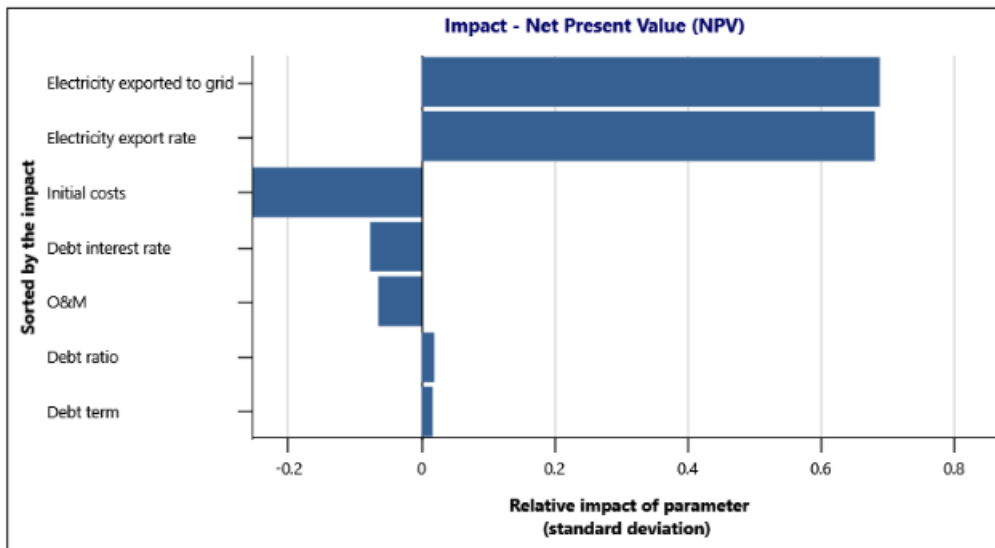

figure:6.2: Impact graph

6.3: Distribution graph

This histogram gives an appropriation of the potential qualities for the monetary pointer coming about from the Monte Carlo reproduction. The stature of each bar addresses

the recurrence (%) of qualities that fall in the reach characterized by the width of each bar. The worth relating to the center of each reach is plotted on the X pivot.

At times, there is inadequate information to appropriately plot the chart. For instance, when the yearto-positive income is quick, the outcome is certainly not a mathematical worth, and in this way these qualities can't be plotted.
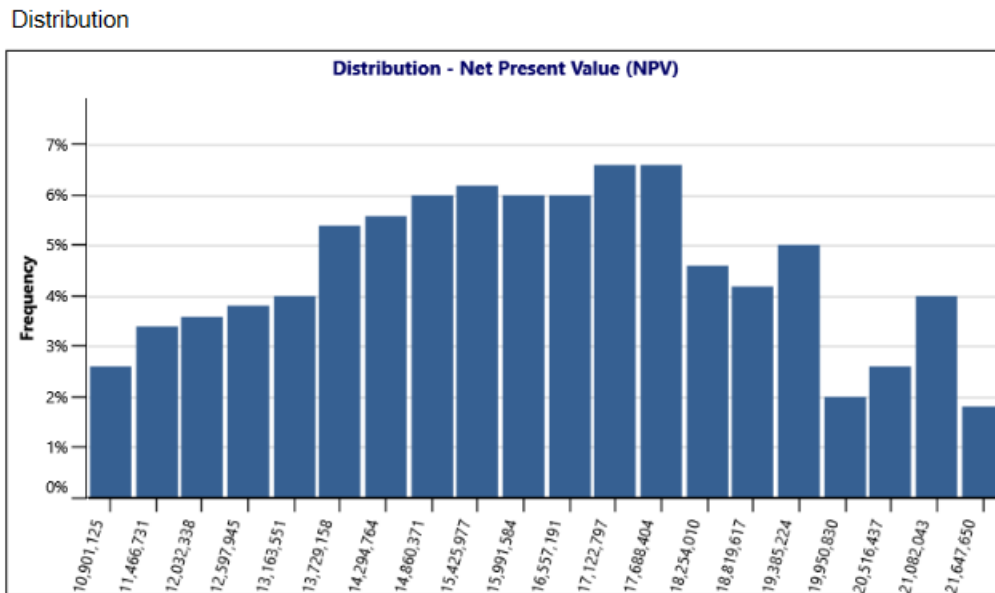
Distribution

Figure:6.3: istribution graph

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