

**Analysis and Optimization of 3MW Grid-tied Solar
Photovoltaic power plant in Bangladesh using
RETScreen Expert**

**A Thesis submitted in partial fulfillment of the requirements for the
Award of Degree of
Bachelor of Science in Electrical and Electronic Engineering**

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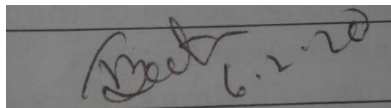


**DEPARTMENT OF ELECTRICAL AND ELECTRONIC
ENGINEERING
FACULTY OF ENGINEERING
DAFFODIL INTERNATIONAL UNIVERSITY
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CERTIFICATION

This is to certify that this thesis entitled “**Analysis and Optimization of 3MW Grid-tied Solar Photovoltaic power plant in Bangladesh using RETScreen Expert**” is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on 30 December 2019

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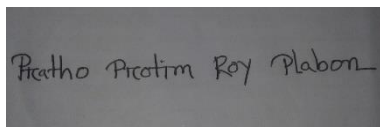
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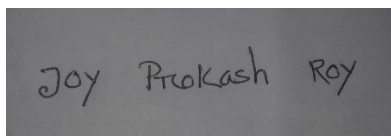
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Dedicated to
Our Parents

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LIST OF ABBREVIATIONS

Short From	Full Form
PV	Photovoltaic
A. Cost	Average Cost
G. Cost	Generation Cost
NASA	National Aeronautics and Space Administration
GHG	Greenhouse gases
DINJ	Dinajpur
SHER	Sherpur
SYL	Sylhet
RAJ	Rajshahi
NARAG	Narayanganj
KHU	Khulna
BRA	Barisal
COX'S	Cox's Bazar

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ABSTRACT

Renewable energy is energy that is collected from renewable resources. In Bangladesh, the geographical situation is better suited for solar renewable energy. The main fact for generating more energy in the PV power plant is sufficient regular radiation and tracking system is one of the major conditions for highly generation. The average daily solar energy obtained in Bangladesh is 4-6.5 kWh / m²/day. which is highly suitable for generation of electricity through solar PV. Slope of panel and generation of electricity are inter related. It can make highly electricity from PV plant using an acceptable slope of using tracking system. The highly generation of electricity is related with (generation cost, Benefit-Cost ratio, Greenhouse Gas etc.). The main objective of this paper is to concentrate on Bangladesh lands that are suitable for PV power plants cost and also to find the relation between slope and azimuth. Finding minimum generation cost and highly yielding for PV power plant in Bangladesh. Also find the minimum generation cost for the best slope range. Analysis between Azimuth and the average generation cost for suitable Azimuth angle for Bangladesh. Study reveals that the region of Northern part Bangladesh is more suited to power plants with PV.

CHAPTER 1

INTRODUCTION

1.0 Introduction

Bangladesh is a booming nation with a total population of 164 million now, with more than 46 percent below the age of 25 years, most of whom are acclimatized to grow up in their homes with electronic devices. And with the increasing urbanization and growth of rural and suburban areas, the availability of electricity plays a crucial role in raising the living standards of people and the country. Over the past decade, energy demand in Bangladesh has risen at an average rate of 10 per cent. [1] However the production of the drug must always be at the same pace. As of September 2019, Bangladesh's utility electricity sector has one national grid with an installed capacity of 21.419 MW. The total capacity installed is 20,000 MW (to combine solar power) and it is estimated that inadequate energy supplies cost the country 2 percent of GDP per year. In FY18 new capacity was 2,817 MW. [2] The Bangladesh electricity sector is highly dependent on fossil fuels, as natural gas and coal are the dominant sources of power generation in the country. Around 62.9% of the electricity generated in Bangladesh comes from natural gas, 10% from diesel, 5% from coal, 3% from heavy oil and 3.3% from renewable sources. Despite the fact that the energy sector in Bangladesh uses and covers a wide range of products; electricity, petroleum products, natural gas, coal, biomass and solar, policymakers and decision-makers are mainly concerned with electricity, since it is the most common form of energy used in the country. [3]

1.1 Renewable Energy in Bangladesh

Renewable energy is extracted from continuously replenishing, natural processes. It arises directly from the sun in its various forms, or from heat generated deep inside the earth. The definition includes solar, wind, ocean, hydropower, biomass, geothermal energy, and renewable biofuels and hydrogen generated electricity and heat. In comparison to other energy sources, which are concentrated in a small number of countries, renewable energy resources and substantial incentives for energy efficiency occur across large geographical areas. Rapid deployment of renewable energy and energy conservation and energy diversification technologies will lead to significant energy security and economic benefits. Climate change and global warming issues, combined with the continued decline in the cost of some renewable energy equipment, such as wind turbines and solar panels, drive

increased renewable energy use. Types of Renewable Energy are solar, wind, hydroelectric, geothermal, ocean, hydrogen and biomass.

Table 1.1: Renewable energy source in Bangladesh

Technology	Off-Grid (MW)	On-Grid (MW)	Total (MW)
Solar	295.63	55.08	350.71
Wind	2	0.90	2.90
Hydro	-	230	230
Biogas	0.68	-	0.68
Biomass	0.40	-	0.40
Total (MW)	298.71	285.98	584.69

Source: SREDA_RE_Present_Status(July 11, 2019)

From previous table we show the geographical condition is more suitable for solar panels in Bangladesh.

1.2 Solar energy

Solar cells are capable of producing electricity from sunlight. It is a device that converts the energy of light into electric power. The term solar cell is sometimes used for systems explicitly intended to capture energy from sunlight, while the term photovoltaic cell is used when the light source is unclear. The long-term average sunshine data shows that the length of bright sunshine hours in Bangladesh's coastal regions ranges from 3 to 11 hours per day. In Bangladesh, insolation ranges from 3.8 kWh / m²/day to 6.4 kWh / m²/day at an average of 5 kWh / m²/day. [4] Such suggest that the country's solar thermal and photovoltaic technologies have good prospects. Some geographical location in Bangladesh are prepared for making this daily radiation.

1.3 Vision for solar energy

Bangladesh has planned to produce 10% of total power generation by 2020 from renewable energy sources like wind, waste, and solar energy. The country plans to increase its renewable energy share to 17% by 2041 under its Intended Nationally Determined Contribution (INDC) commitment to reduce greenhouse gas emissions by 5% until 2030. Researchers have addressed the country's prospect of exploitation of geothermal energy. Geology-led studies have suggested geothermal deposits in the northwest and southeast areas. [4]

1.4 Literature Assessment

1.4.1 Research Background

A solar tracker is an instrument that directs a payload toward the Sun. Typically, payloads are solar panels, parabolic troughs, Fresnel reflectors, lenses or the heliostat mirrors. Trackers are used in flat-panel photovoltaic (PV) systems to minimize the angle of incidence between the incoming sunlight and a PV panel, often referred to as the cosine error. Changing this angle increases the amount of energy produced from the installed capacity to generate a fixed amount of power. The user selects the type of sun tracking device that installs the solar collector on. The choices in the drop-down list are: "Fixed," "One-axis," "Two-axis" and "Azimuth." If the solar collector is installed on a fixed frame, the user can choose "Fixed." If the solar collector is mounted on a tracker, the remaining options can be chosen. A tracker is a tool that assists the solar collector and shifts the collector in a specified manner to decrease the angle of incidence of beam radiation on the surface of the collector.

Slope: The consumer reaches the angle in degrees between the solar collector or tracking point, and the horizontal.

Azimuth: The user enters the angle between the projection, on a horizontal plane, of the normal to the surface and the local meridian, with zero due south (for the purpose of this model, the sign has no importance).

1.4.2 Previous Research

The main purpose of this paper is to concentrate on such Bangladesh lands that are suitable for generation based on PV. In this context, the authors surveyed some areas in Bangladesh's north-western region to research the possibility of generating solar PV based power. [5]

Due to different geographical locations, each of Bangladesh's divisions receives varying amounts of solar irradiation and therefore, for the same system design, different divisions require different number of solar panels, mounting system, inverter power capacity and land quantity, this in turn affects the financial parameters and thus the viability of the device. Review of the grid-connected solar PV system developed separately on the river deltas of each division of Bangladesh in terms of the quantity of land required to develop

the system in each division, together with several financial aspects to assess the viability of the system. [6]

The slope and azimuth of positioning solar panels influence the panel's absorption of solar irradiation, and this has a direct impact on the amount of electricity generated by a solar grid, the technical and financial aspects of the solar grid. Bangladesh is an eight-division Asian country. The amount of solar radiation being incident on the divisions varies significantly due to the different geographical locations. So, positioning solar panels in all divisions at the same slope and azimuth does not cause the panels to absorb the full amount of solar radiation. [7] The consumer enters the angle between the projection of the usual to the surface on a horizontal plane and the local meridian, with zero due south (for the purpose of this model, the sign is irrelevant). The consumer reaches the angle in degrees between the solar collector, or tracking point, and the horizontal. The Slope and Azimuth are related one each other we can discuss our project how they are related one each other. In our paper we work tracking system analysis and the consideration the cost in various location in Bangladesh. We use the RETScreen Expert for collecting the climate data from NASA. In this paper we compare the cost and tariff for various location in Bangladesh.

CHAPTER 2

Equipment of PV Power Plant

2.0 Introduction

A Photovoltaic (PV) power station, also known as a solar farm or solar park, is a large-scale PV system designed to supply the electricity into grid. These vary from most building-mounted and other decentralized solar power systems because these supply power to a local customer or consumer at the utility level. This type of project is sometimes identified with the generic term utility-scale solar.

A PV power station is simpler than other conventional green power station like Hydro-Electric power station. Less components are need in a PV project. In this chapter, we shell focus our attention on the components of a PV project.

2.1. Solar Panel

PV solar panels are the key elements of a solar power system. Sunlight is absorbed by PV solar panels as a source of energy to generate DC electricity. A PV module is a packaged, connected PV solar cell assembly available in various voltages and watts. PV array made of PV module of a PV system that produces and supplies solar power in commercial and residential applications. [8]

PV modules use light energy (photons) from the Sun through the PV effect to generate electricity. Some modules use crystalline silicone cells or thin-film cells based on wafers. The structural (load carrying) member of a module can be either the top layer or the back layer. Cells must be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells are connected electrically in series, one to another to a desired voltage, and then in parallel to increase amperage. The wattage of the module is the mathematical product of the voltage and the amperage of the module A PV junction box is mounted on the back of the solar panel and serves as its interface for output. For most photovoltaic modules, the external connections use MC4 connectors to allow easy weatherproof connections to the rest of the system. We can also use a USB power jack. Electrical connections of modules are made in series to achieve the desired output voltage or in parallel to provide the desired solar panel or PV system current capability (amperes). The conducting wires which remove the current from the modules are sized by ampacity and may contain silver, copper or other non-magnetic transition metals. In the case of partial module shading, bypass diodes may be

incorporated or used externally to maximize the output of still illuminated sections of the module. [9]

2.1.1 Types of Solar Panel

Monocrystalline and Polycrystalline are the two types of solar panels most suitable for PV project installations. Both work equally though the monocrystalline is slightly more efficient and expensive.

2.1.2 Efficiency of Solar Panel

In standard test conditions (STC) each module is rated by its DC output power. Power usually varies between 100 and 365 Watts (W). A module's performance dictates a module's area provided the same rated output—an efficient 230 W module of 8 percent will have twice the area of an effective 230 W module of 16 per cent. Many solar modules that are commercially available reach 24 per cent performance. [10][11]

2.1.3 Application

The use of solar panels or photovoltaics has many practical applications. It may first be used as an irrigation power source in agriculture. Solar panels may be used in health care to refrigerate medical supplies. It can be used for roads, as well. PV modules are used in photovoltaic systems and come with a wide range of electrical devices:

- PV power stations
- Rooftop solar PV systems
- Standalone PV systems
- Solar hybrid power systems
- Concentrated PV Solar planes
- Solar-pumped lasers Solar vehicles
- Solar panels on spacecrafts and space stations

2.2 Inverter

An inverter is a power electronic device that converts direct current (DC) into alternating current (AC).

Input voltage, output voltage and frequency, as well as overall power handling depend on the specific device or circuit design. The inverter makes no power the DC source provides the power. An inverter can be fully electronic, or a combination of mechanical effects (such

as a rotary device) and electronic circuitry. Static inverters do not use movable parts in the process of conversion. [12]

2.2.1 Inverter Input

A typical inverter device requires a relatively stable DC power source that can supply enough current to satisfy the system's intended power requirements. The voltage at the input depends on the inverter design and function. Examples include:

- 12 V DC, for smaller residential and industrial rechargeable 12 V lead acid battery or automobile electrical outlet.
- 24, 36 and 48 V DC, general requirements for home energy systems.
- 200 to 400 V DC, when photovoltaic solar panels provide electricity.
- 300 to 450 V DC, when the electric vehicle battery packs are used in vehicle to grid systems.
- Hundreds of thousands of volts, where the inverter is part of a power transmission system of high voltage direct current. [13]

2.2.2 Inverter Output

2.2.2.1 Output Voltage

An inverter's AC output voltage is often controlled to be the same as the grid line voltage at the distribution point, usually 120 or 240 V AC, even when there are variations in the load the inverter is driving. This enables the inverter to power numerous devices designed to power the standard line. Some inverters also allow voltages for selectable or continuously variable output.

2.2.2.2 Output Frequency

An inverter device's AC output frequency is typically the same as standard power line frequency, 50 or 60 hertz. If the system or circuit output is to be further regulated (e.g., stepped up), then the frequency may be much higher for good transformer performance.

2.2.2.3 Output Power

The overall power output of an inverter is often measured in watts or kilowatts. It defines the power available to the system driving the inverter and, indirectly, the power required from the DC source. Smaller common consumer and commercial appliances typically range from 150 to 3000 watts to mimic line electricity. Not all inverter systems are concerned with power delivery alone or primarily; in some situations, the follow-on circuit or system uses the frequency and or waveform properties.

2.3 Maximum Power Point Tracking (MPPT)

MPPT or sometimes just power point tracking (PPT) is a technique widely used with wind turbines and solar PV systems to optimize power output under all conditions. [14] Although it refers specifically to solar power, the concept generally applies to variable power sources such as optical power transmission, and thermophotovoltaics. In many different configurations, PV solar systems exist about their relationship to inverter systems, external grids, battery banks or other electrical charges. Nonetheless, whatever the ultimate destination of the solar power, the central problem discussed by MPPT is that the efficiency of transferring power from the solar cell depends on both the amount of sunlight falling on the solar panels and the electrical characteristics of the charge. The load characteristic that provides the highest power transfer efficiency changes as the amount of sunlight varies, so that the efficiency of the device is adjusted when the load characteristic changes to maintain the power transfer at maximum efficiency. This characteristic of the load is called the maximum power point (MPP), and the process of finding this point and keeping the characteristic of the load there is MPPT. The electrical circuits can be built to deliver arbitrary loads to the photovoltaic cells and then pass the voltage, current or frequency to other devices or systems, and MPPT solves the problem of choosing the best load to be delivered to the cells in order to obtain the most available material. [15] Solar cells have a complex relationship between temperature and total resistance, creating a non-linear performance efficiency that can be evaluated on the basis of the I-V curve. The purpose of the MPPT device is to measure the output of the PV cells and apply the correct resistance (load) to achieve maximum power for any given environment. Typically, MPPT devices are integrated into an electrical converter system which provides voltage or current conversion, filtering and control for various charges, including power grids, batteries or motors. [16]

2.4 Substation

A substation is a part of a system of electrical generation, transmission and distribution. Substations convert voltage from high to low, or the opposite, or perform other important functions of any kind. Electric power may flow through multiple substations at various voltage levels between the generating station and the consumer. A substation may include transformers that change voltage levels between high transmission voltages and lower distribution voltages, or when two different transmission voltages are interconnected. [17]

2.5 Battery Bank

A battery bank is a collection of any number of similar batteries or individual battery cells. They may be designed to provide the desired voltage, capacity, or power density in a series, parallel or combination of both.

Battery packing components include the individual batteries or cells, and the interconnections between them that provide electrical conductivity. Rechargeable battery packs also include a temperature sensor which is used by the battery charger to detect the charging end. Interconnections can also be found in batteries as they are the component that binds each cell, but batteries are typically organized only in series strings.

When a pack contains parallel groups of cells, different wiring configurations are available which take into account the circuit's electrical balance. Battery regulators are sometimes used to maintain each cell's voltage below its maximum value during charging, so that the weaker batteries are fully charged, bringing the entire pack back into balance. Battery balancing tools which can transfer energy from strong cells to weaker ones in real time for better balance can also perform active balancing. A well-balanced pack lasts longer and performs better. [18]

2.6 Charge Controller

A charge controller, charging regulator or battery regulator regulates the rate at which electric current is applied to or drained from electric batteries. This prevents overcharging and can protect against overvoltage, which can decrease battery performance or lifetime and may pose a safety risk. It may also prevent a battery from being fully drained ("deep discharged") or, depending on the battery technology, it may conduct controlled discharges to protect the battery life. The words "charging controller" or "charge controller" may refer to either a stand-alone device or control circuitry incorporated into a battery pack, battery-powered device or battery charge. [19]

CHAPTER 3

RETSCREEN EXPERT

3.0 Introduction

RETScreen Expert is a clean energy management software system which analyzes the feasibility of energy efficiency, renewable energy and cogeneration projects as well as ongoing energy performance analysis. This software package developed by the Government of Canada. RETScreen Expert is the software's current version, and was released to the public on September 19, 2016. The software enables the comprehensive identification, assessment and optimization of the technical and financial viability of potential renewable energy, energy efficiency and cogeneration projects; as well as the measurement and verification of facilities ' actual performance and the identification of energy savings or production opportunities. [20] RETScreen Suite, which includes RETScreen 4 and RETScreen Plus, is the earlier version of the RETScreen software. RETScreen Suite includes capacities for off-grid analysis. Unlike the RETScreen Suite, RETScreen Expert is an integrated software platform; uses extensive and systematic archetypes for project evaluation; and provides capabilities for portfolio analysis. RETScreen Expert integrates a number of user support databases, including a global climate database from 6,700 ground stations and NASA satellite data; benchmark database; cost database; project database; hydrology database, and product database.[21]

3.1 History

RETScreen's first version was released on 30th April 1998. RETScreen Version 4 was introduced by Canada's Environment Minister on December 11, 2007, in Bali, Indonesia. RETScreen Plus became available in 2011. In 2012, RETScreen Suite (integrating RETScreen 4 and RETScreen Plus with numerous further upgrades) was released. [22] On 19 September 2016 RETScreen Expert was released to the public.[23]

3.2 Requirements of Program

This program requires Microsoft ® Windows 7 SP1, Windows 8.1 or Windows 10 and 4.7 or higher Microsoft ® .NET Framework. Operating on Apple Macintosh computers can be done to the software using Parallels or VirtualBox for Mac.[24]

3.3 Overview

RETScreen Expert helps sustainability practitioners and decision-makers to define, evaluate and maximize potential clean energy projects ' technical and financial viability.

The software platform for decision intelligence also allows managers to assess and check facilities actual performance, and helps identify potential energy savings / production opportunities. The software is available in 36 languages and can greatly reduce the time and financial costs of finding and assessing possible renewable energy and energy efficiency projects. RETScreen Expert models a full range of both traditional and non-traditional clean energy sources as well as conventional energy sources and technologies, including energy efficiency (from large industrial installations to individual homes), heating and cooling (e.g., biomass, heat pumps, and solar / water heating), power (including renewables such as solar, wind, wave, hydro, geothermal, etc. Conventional technology such as gas / steam turbines and reciprocating engines as well as heat and power (or cogeneration) combined. Item, mission, benchmark, hydrology, and climate databases as well as links to worldwide maps of energy resources are incorporated into the analytical worksheets. RETScreen Expert is managed under the guidance and ongoing financial support of Natural Resources Canada's Canmet ENERGY Varennes Research Centre, a government department of Canada. The core team partners with a number of other national and multilateral organizations, with technical support from a large network of business, policy and education experts. The major collaborators include NASA's Langley Research Center, the Renewable Energy and Energy Efficiency Partnership (REEEP), the Independent Electricity System Operator (IESO) of Ontario, the Power Unit of the Innovation, Business and Economics Department of UNEP, the Global Environment Facility (GEF), the Carbon Pilot Fund of the World Bank, and the Sustainable Energy Initiative of York University.[25]

3.4 Highlights

A Virtual Energy Analyzer app enables quick and accurate assessment of the potential for energy production and savings for any location in the world using a five-star benchmark ranking system and without requiring a site visit. A Smart Project Identifier accurately identifies the best projects to be implemented at the facility and completes a pre-feasibility analysis or energy audit smartly for further on-site refinement. A Financial Risk Assessor measures the financial risk of the planned investment automatically and systematically calculates the sensitivity of key parameters to the feasibility of a project. A Quality Tracking comprehensively monitors and verifies the actual performance of completed programs and helps to find opportunities for further changes in energy at the plant.[26]

3.5 Project Life-Cycle Analysis

RETScreen Expert has capabilities of analyzing a whole life cycle of a project.

3.5.1 Benchmark Analysis

Benchmark Analysis allows the user to create reference climate conditions at a facility site for any location on Earth and to compare the energy output of different types of reference (benchmark) installations with the approximate (modeled) or measured (actual) annual energy usage of an installation. Energy benchmarking enables designers, facility owners, managers and senior decision-makers to easily gage the energy efficiency of a facility, i.e. projected energy consumption or output versus comparison facilities, as well as room for improvement.[26]

3.5.2 Feasibility Analysis

Feasibility Analysis helps decision-makers to perform a typical analysis in five phases, including energy analysis, cost analysis, pollution analysis, financial analysis, and risk / sensitivity analysis. Benchmarks, commodity, project, hydrology and environment databases, as well as links to worldwide energy resource maps, are fully integrated into this five-step review. A comprehensive collection of models for common clean energy initiatives as well as specific case studies is also built in. [26]

3.5.3 Performance Analysis

Performance Analysis enables a consumer to track, evaluate, and report key energy performance data to facility owners, managers, and senior decision-makers, including the actual energy performance of a facility versus projected output. The Performance Analysis module incorporates NASA's near-real-time satellite-derived weather data across the entire planet's surface and is related to the Green Button Standard.[26]

3.5.4 Portfolio Analysis

Portfolio Assessment allows a customer to control resources across a wide range of facilities, spanning multiple energy efficiency initiatives within a single residential property into a portfolio of thousands of multi-location homes, factories and power plants. The database file "My portfolio" consists of individual facilities which are analyzed using RETScreen Expert. Easily add additional facilities to the portfolio database. Sub-portfolios can be created to allow comparison between different types of facilities and geographic regions, and a mapping tool lets the user view assets around the globe.

The user can enable a portfolio-wide dashboard for the analysis with a populated database. For each individual facility in the portfolio, the dashboard can be configured to include the benchmark, feasibility, and performance analysis results. The dashboard allows the user to aggregate results to track energy consumption and/or output readily, as well as costs and greenhouse gas emissions, all of which can be categorized by type of facility, type of fuel, region, etc. Then those findings can be used to communicate key metrics to specific stakeholders.[26]

3.5.5 Virtual Energy Analyzer

Using the Virtual Energy Analyzer, the user can start a new project by clicking on the map icon in the Open tab in the File worksheet or in the Location worksheet ribbon. Through choosing the details and position of the plant, the algorithm will quickly determine the potential for energy production and savings for any location in the world using a five-star benchmark ranking system without even needing a visit to the site. The robust Facility Archetypes database from the Virtual Energy Analyzer allows a user to start a pre-feasibility analysis or energy audit for a facility quickly and cheaply. Archetypes are required for a full complement of types of facilities including electricity generation, manufacturing, commercial / institutional, residential and agricultural. Human acts can be picked, too. The five-star benchmark rating system of the Virtual Energy Analyzer offers an immediate image of the amount of detail in any given archetype. A five-star standard provides a significant amount of information (including the planned project's projected incremental cost) and can be used as an initial draft of a pre-feasibility analysis or energy audit. An archetype scored below five stars will still contain a large amount of valuable information, but will profit from additional user feedback to help refine the archetype-built analyses.[26]

3.6 Inputs and Outputs

The RETScreen Expert workflow consists of a series of worksheets and associated repositories (tabs located at the top of the program window). Typically, consumer works from left to right, first completing the Location worksheet, then the Facility worksheet, and so on. It is advised to follow the steps illustrated in the ribbon near the top of the program window on each worksheet, completing each worksheet from top to bottom.

The worksheet on the Energy Model is used to model the energy consumption and/or output of various types of installations including individual measures and systems. A fully integrated user manual facility for the user to enter data.[26]

3.7 Buildings and Factories

RETScreen Expert may be used to test different types of projects in buildings and factories for energy efficiency steps. In a wide range of residential, business, institutional and industrial buildings, from single-family homes and apartment complexes to office buildings, schools, massive pump and paper mills, it can examine the feasibility of energy efficiency improvements. The program can be used to assess projects that implement a range of energy efficiency measures related to building insulation, ventilation, lighting, electrical equipment, hot water, pumps, fans, motors, process power, process heat, process steam, heat recovery, compressed air, refrigeration, and more. It's useful both for new and retrofit construction.[25]

3.7.1 Fuels and schedules

In this portion, the user enters details on the fuels and schedules considered for the base case and the case facilities being proposed.[8]

3.7.2 Equipment

The user enters the heating system and cooling system equipment information in this section, for the base case and the proposed case. The user clicks on the equipment they want to describe in the ribbon (e.g. boiler, heat pump, compressor, etc.) to access the forms for data entry. The user enters details about the base case and the proposed case facility in the heating system and cooling system types, including any possible end-use energy efficiency steps. The customer also enters the "incremental initial cost" and "incremental O&M savings" associated with the planned energy efficiency end-use initiatives of the event. Overview and are used to measure annual fuel cost savings, quick payback, etc. along with the details stated in other energy efficiency types.[25]

3.7.3 End Use

In this section, for the base case and the proposed case facilities, the user enters the information about the characteristics of the facility. The user might want to use more than one form to describe each major building zone or each separate measure of energy efficiency for complex projects, etc. In the Description data entry cell the user often enters key information about each form at the top of each page.

The user can pick more than one process or level within some of the forms to perform the calculations. The user selects the type of method or level by clicking on the appropriate button at the top of each form when more than one method or level is available. Typically,

the method or level chosen will depend on the input data availability and the project development stage.[25]

3.7.4 Optimize supply

In this segment, the consumer enters, for the proposed case, details on the heating system and power system equipment used to maximize the energy supply. In the ribbon, the consumer clicks on the equipment they want to identify (e.g. solar water heater, wind turbine, etc.) to access types of data entry.[25]

3.7.5 Summary

This section summarizes key findings based on the information for the base case and proposed case facilities entered in the preceding sections, providing detailed information for each fuel type used, as well as information on fuel consumption and annual energy use for heating, cooling and electricity. [25]

3.8 Power plants

RETScreen Expert may be used to assess different types of power projects. It allows for analyzes of a wide range of renewable and conventional (fossil) fuels (which can be used in parallel), including wind; hydro; solar; landfill gas; biomass; bagasse; biodiesel; biogas; natural gas; oil / diesel; coal; municipal waste etc. [27]

3.8.1 Fuels and schedules

The user enters in this section details about the fuels and schedules that are considered for the base case and the proposed case facilities.[27]

3.8.2 Technology

In this section the customer enters the specifics for the proposed case concerning the power system equipment. The user clicks on the equipment they want to define in the ribbon (e.g. reciprocating engine, gas turbine-combined cycle, wind turbine, etc.) to access data input types. In these forms the consumer enters power system equipment info. The consumer will also join the system-related "initial costs" and "O&M costs (savings)." The results are shown in the "Include System" description and are used to measure the annual electricity export income, easy payback, etc. along with the details listed in the other forms. The user can pick more than one Level within some of the forms to perform the calculations. When more than one level is open, the user chooses the level type by clicking on the corresponding button at the top of each page. Usually, the method or level chosen would depend on the quality of input data and the project development stage (e.g. pre-feasibility vs. feasibility study).[27]

3.8.3 Summary

Each section summarizes key findings (e.g. energy export revenue, easy payback, etc.) based on the information entered in the preceding steps (e.g., Fuels & Schedules and Technology), including detailed information for each fuel type used.[27]

3.9 Integrated Databases

Fully integrated into the RETScreen Expert analytical tools are benchmarks, cost, product, hydrology and climate databases (the latter with 6,700 ground-station locations plus NASA satellite data covering the entire planet's surface), as well as links to worldwide maps of energy resources.

To help a user begin research quickly, RETScreen Expert has developed Archetypes, Case Studies & Templates in a comprehensive project database of standardized clean energy project.[28]

3.9.1 Product Data

Some of the model's product data specifications are made available in the RETScreen Expert Product Database. The user may click on the correct icon in the Energy Model worksheet to access the product database relevant to the type of system to be considered. The inventory database provides information about the project-related equipment. The user may access product specification and performance data from the Inventory Database dialog box, as well as contact information for the supplier.[28]

3.9.2 Cost Data

Some of the cost data specifications for the model are given in the RETScreen Expert Cost Database, including both initial installed costs and continuing operational and maintenance (O&M) costs. To access the cost database related to the type of system or calculation to be considered, the user should click on the correct icon in the worksheet for the Energy Model next to the entry cell for cost details. The cost database offers a collection of common costs related to similar projects.[28]

3.9.3 Climate Data

The climate database RETScreen Expert provides the meteorological data required in the model. The consumer may obtain climate data from ground monitoring stations and/or the global satellite / analysis data from NASA while running the app. If climate data are not available from a specific ground monitoring station, then data are provided from the satellite / analysis data from NASA. The data source (i.e. "Ground" or "NASA") is

indicated alongside the data in the dialog box for the climate database. The user can click on the correct icon in the Location worksheet to access the climate database.[28]

3.9.4 Hydrology Data

For any location in the world the RETScreen Expert Hydro Project Template can be used. The user may utilize Canadian hydrology data included in the RETScreen Expert Hydrology Database for projects in Canada. The hydrology data from other sources can be entered directly in the worksheet for other project locations around the world.[28]

3.10 Benchmark Data

The RETScreen Expert Benchmark Database allows the user to compare the energy efficiency of different kinds of reference (benchmark) facilities around the world with projected (modeled) or tracked (actual) annual energy usage or output for a target facility. Energy benchmarking is useful for helping planners, facility owners, managers and senior decision-makers better gauge the energy efficiency of a facility, i.e., projected energy consumption or output versus reference facilities, and the potential for improvement.[28]

CHAPTER 4

ANALYSIS (of 3MW grid-tied solar power plant)

4.0 Introduction

Bangladesh is located in South Asia with 240N geographical coordinates, 900E with a total surface area of 143,998sq km. In this chapter we will discuss about Sarishabari 3MWp solar power project and also compare the project data with other different location of Bangladesh for the same facilities. We will try to find other suitable location for photovoltaic power plant where generation cost is minimum. We use the primary data in the RETScreen Expert from

3MWp Grid Tide Solar Power Plant at SARISHABARI, JAMALPUR.

Project Executing Agency: Bangladesh Power Development Board (BPDB).

Name of the Sponsor: Engreen Sharishabari Solar Plant Ltd.

Total Area: 8 (Eight) Acre.

Plant capacity: 3 MWp.

Evacuating Voltage: 33 KV

Project Life: 20 Years

Solar panels: 11,600

Inverter: Sunny Tripower 15000TL / 20000TL / 25000TL

Inverter efficiency: 98.4%

Transmission line cost: 14,910,000 BDT

Sub-station: 40,000,000 BDT

Panel Type: poly-silicon.

During summer, the angle of Tilt stays 5 to 7 degrees and in winter angle up to 30 degrees depending on the sun's rotation. There are 96 to 100 panels linked to 1 inverter. Convert 25kw of energy per inverter. And there are 8 lines of inverters connected to 1 box of Junctions.

Need to know and analysis of the software for making a good output.

4.1 Location ANALYSIS

Consider in this step Weather data position, The location of the facility, Latitude Longitude, Climate zone, Heating design temperature, Cooling design temperature, Earth temperature range, Air temperature, Relative humidity, Rainfall Constant solar radiation - Horizontal,

Atmospheric pressure Wind speed, Earth temperature, Heating degree-day, Cooling degree-day & Annual source measured The RETScreen Expert International Photovoltaic Project Model can be used efficiently to assess the amount of energy production, life-cycle costs and the reduction of greenhouse gas emissions. The feasibility of a central-grid connected solar photovoltaic project for the proposed land at SARISHABARI, JAMALPUR was analyzed in this book. NASA Sherpur climatic data (nearest JAMALPUR district)

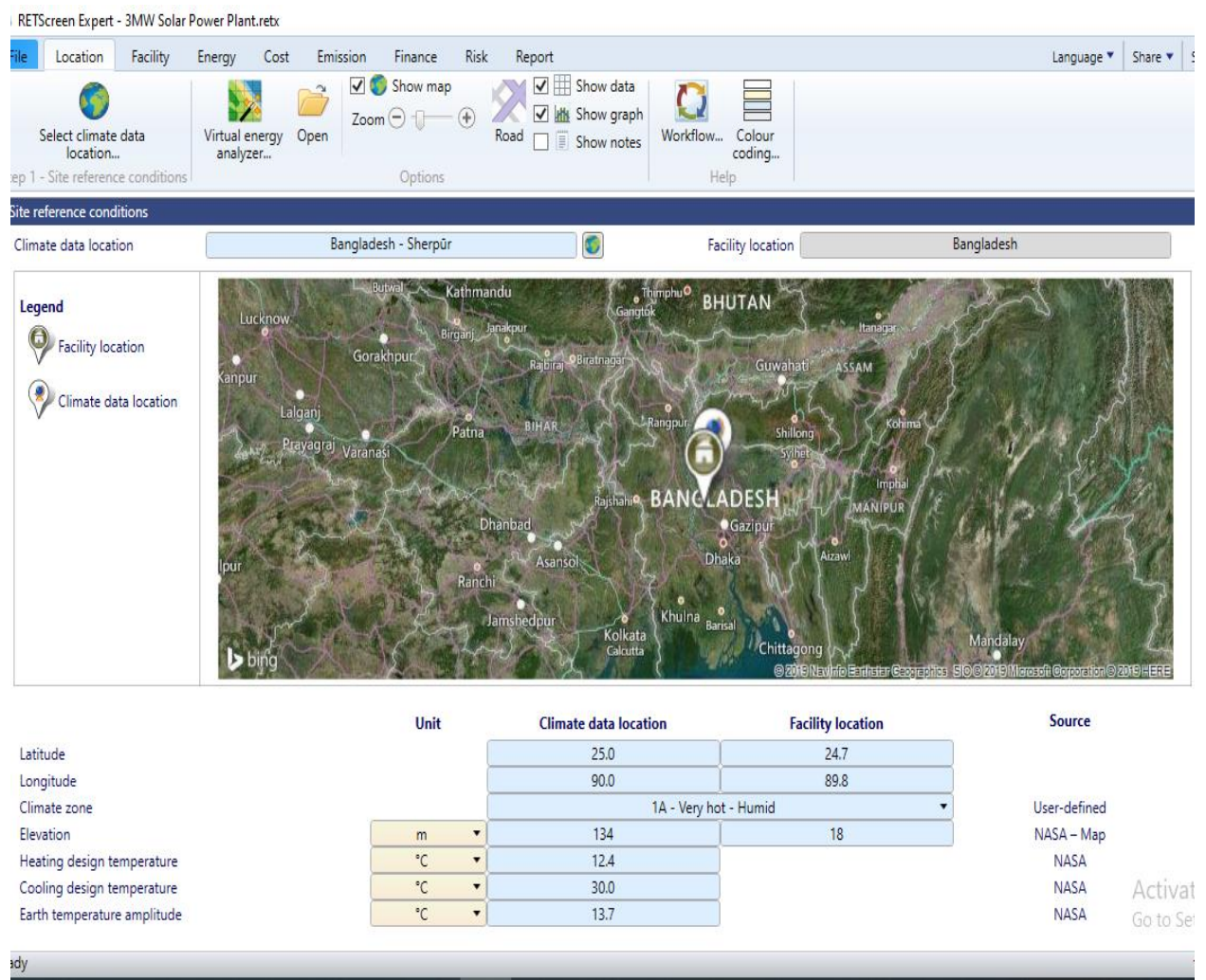


Fig4.1: Selected location

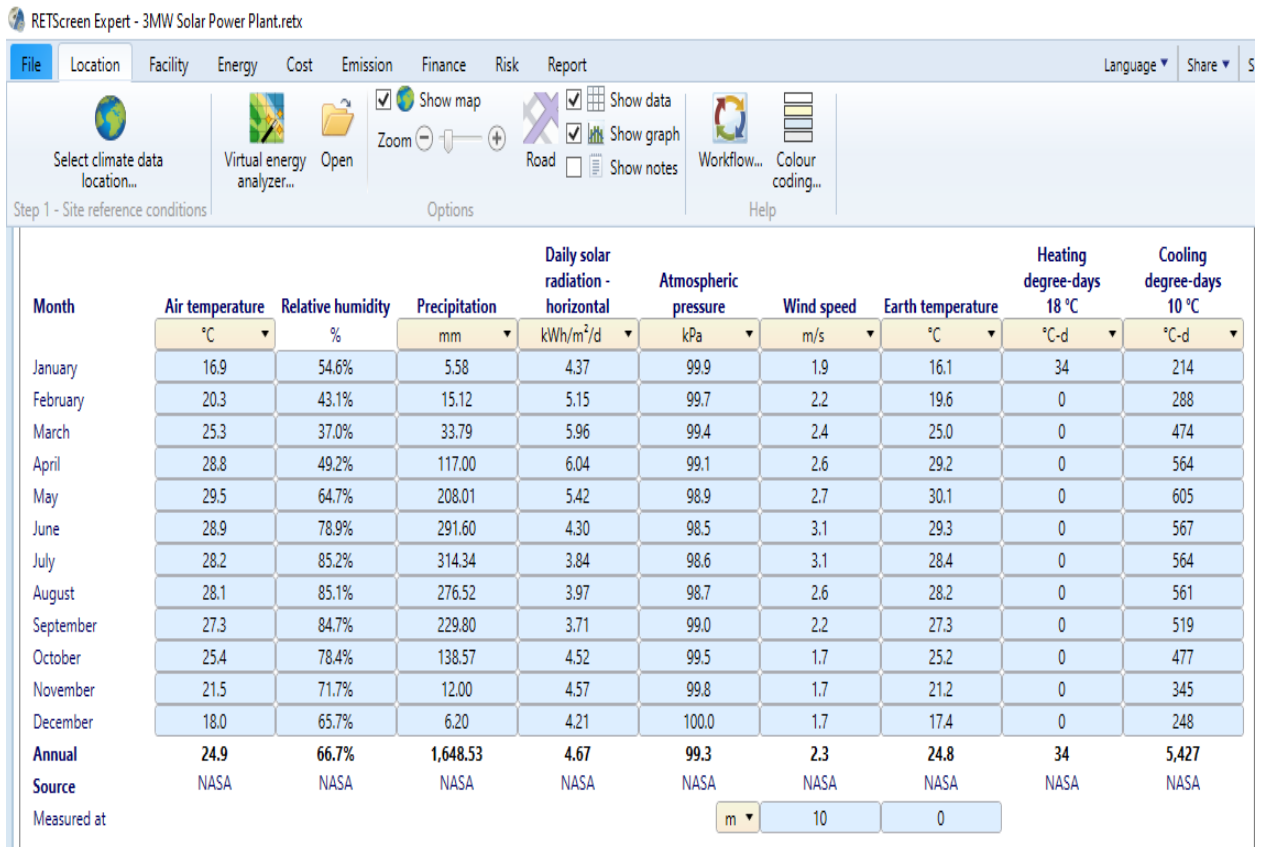


Fig4.2(a): Climate Data graph for one year

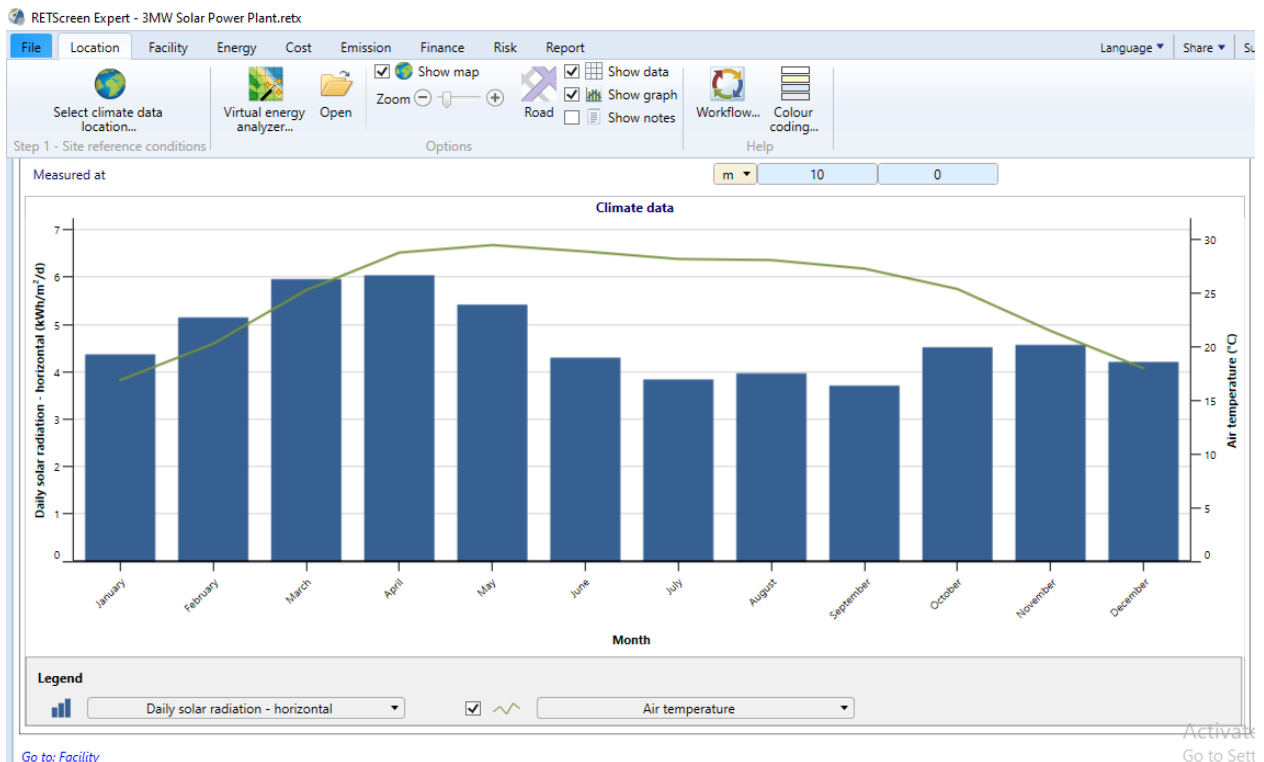


Fig4.2(b): Climate Data graph for one year

The model shows a bar and a line graph of the monthly long-term average climate data chosen in the legend below the map.

In the month of May is the air temperature is maximum. In the month of March & April is the maximum radiation. In this time the daily solar radiation -horizontal is 6.03 kwh / m² /d.

4.2 Facility Analysis

The worksheet on the facility is used as part of the RETScreen Expert Clean Energy Management Software to enter general information about the facility. The consumer also has the option of creating a facilities benchmark study.

SARISHABARI is the nearest place to the proposed location and therefore the table above indicates the latitude and longitude of the prospective site, respectively 24.7N and 89.8S. Using poly-Si and power capacity 3000kw.Using number of units 11600 and efficiency 15.75%. An Inverter efficiency is 98.4% and capacity is 9000 kw.



Fig4.3: location of the PV power plant

4.3 Energy Analysis

Using RETScreen Expert we get the yearly generation for 3MWp PV power plant is 5114MWh and the Unit cost is 11.69BDT/kWh. At the same time carbon emission is 3638

BDT/tCO₂.

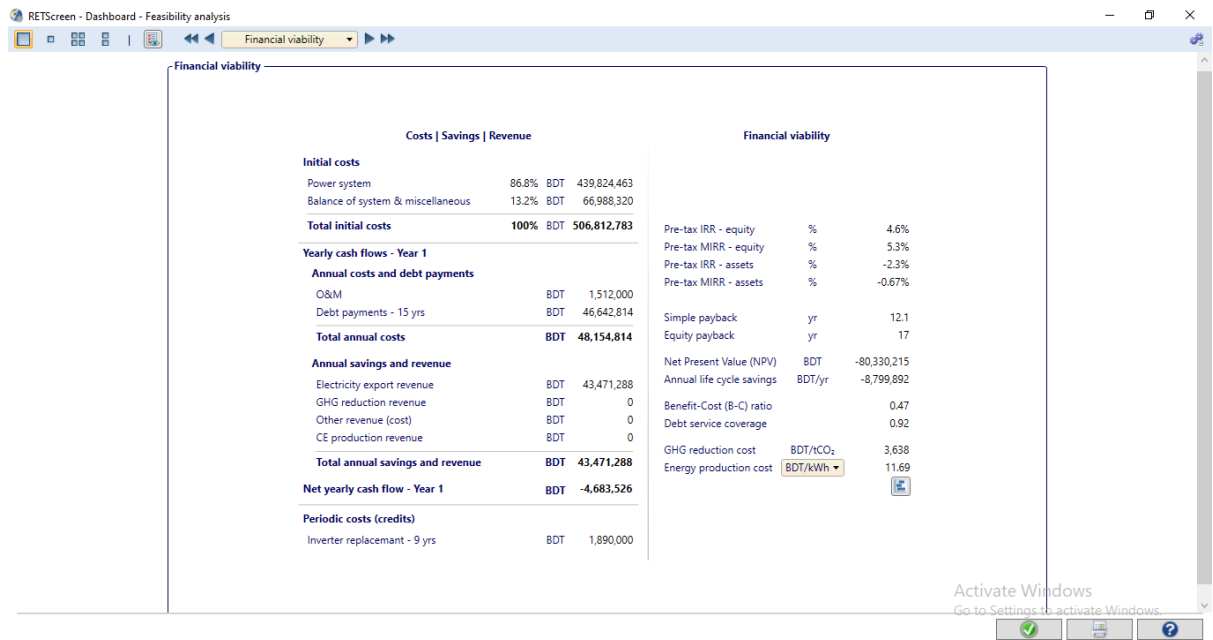


Fig4.4(a): Overall scenario of Sarishabari project

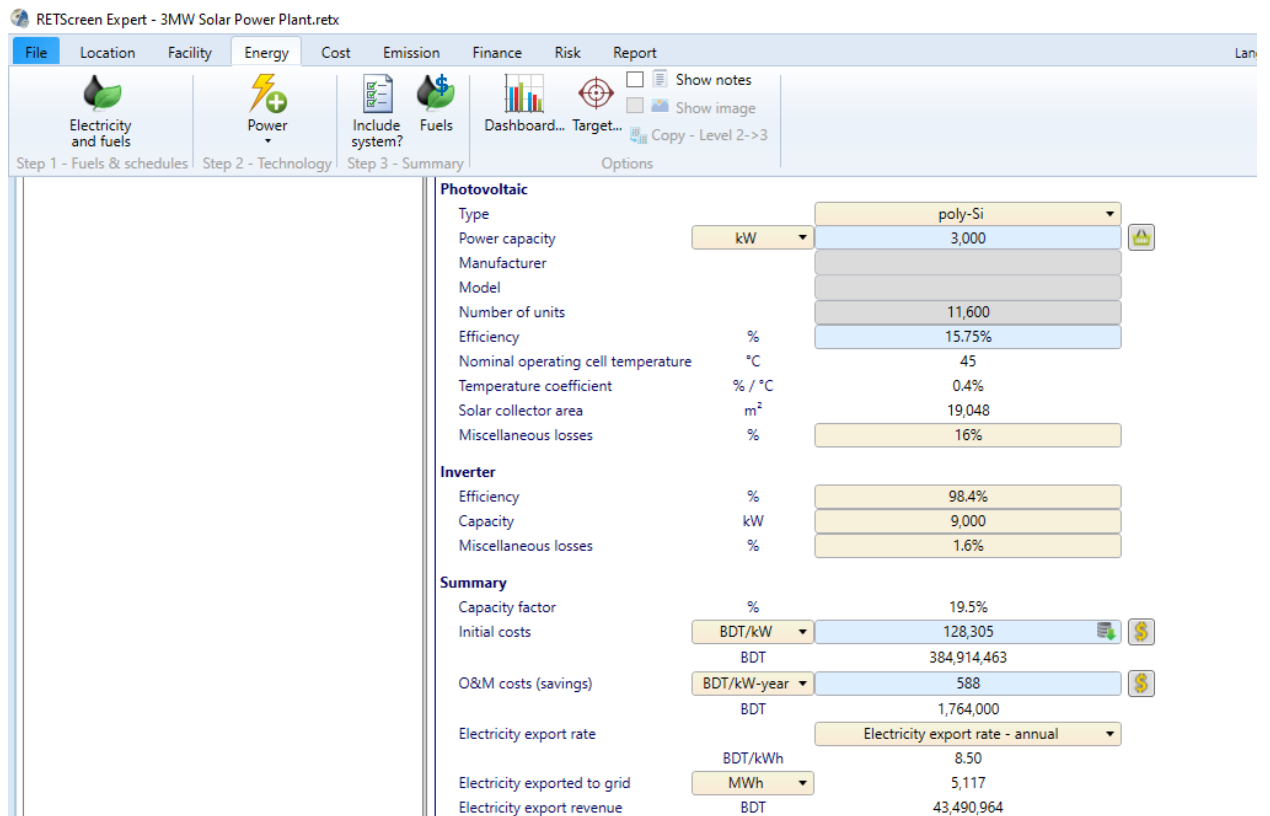


Fig4.4(b): Specifications of PV module & inverter

4.4 Cost Analysis

The Cost Analysis worksheet is used as part of RETScreen Expert Clean Energy Management Software to help the user estimate costs (and credits) associated with the case being proposed. Such costs are dealt with from the initial, or investment, cost point of view and from the annual, or recurrent, cost point of view. To obtain prices or other information required, the user may refer to the RETScreen Expert Product Database for contact information about the supplier.

By clicking on the correct button, the user selects the stage of the study. Level 1 is likely to be used for an initial pre-feasibility analysis where typically less detailed and less accurate information is required. Level 2 is likely to be used for a feasibility analysis where usually more detailed and accurate information is required. Level 3 is likely to be used to initiate phases of development and engineering where more detailed and accurate information is usually required.

RETScreen - Cost Analysis Subscriber: Daffodil International University - Educational Use Only

Initial costs (credits)	Unit	Quantity	Unit cost	Amount
Initial cost			BDT	384,914,463
Show data				
- User-defined	cost		BDT	-
Total initial costs				BDT 384,914,463

Annual costs (credits)	Unit	Quantity	Unit cost	Amount
O&M costs (savings)	project		BDT	1,764,000
Show data				
- User-defined	cost		BDT	-
Total annual costs				BDT 1,764,000

Annual savings	Unit	Quantity	Unit cost	Amount
- User-defined	cost		BDT	-
Total annual savings				BDT -

Go to: Emission

Fig4.5(a): Cost Level 1

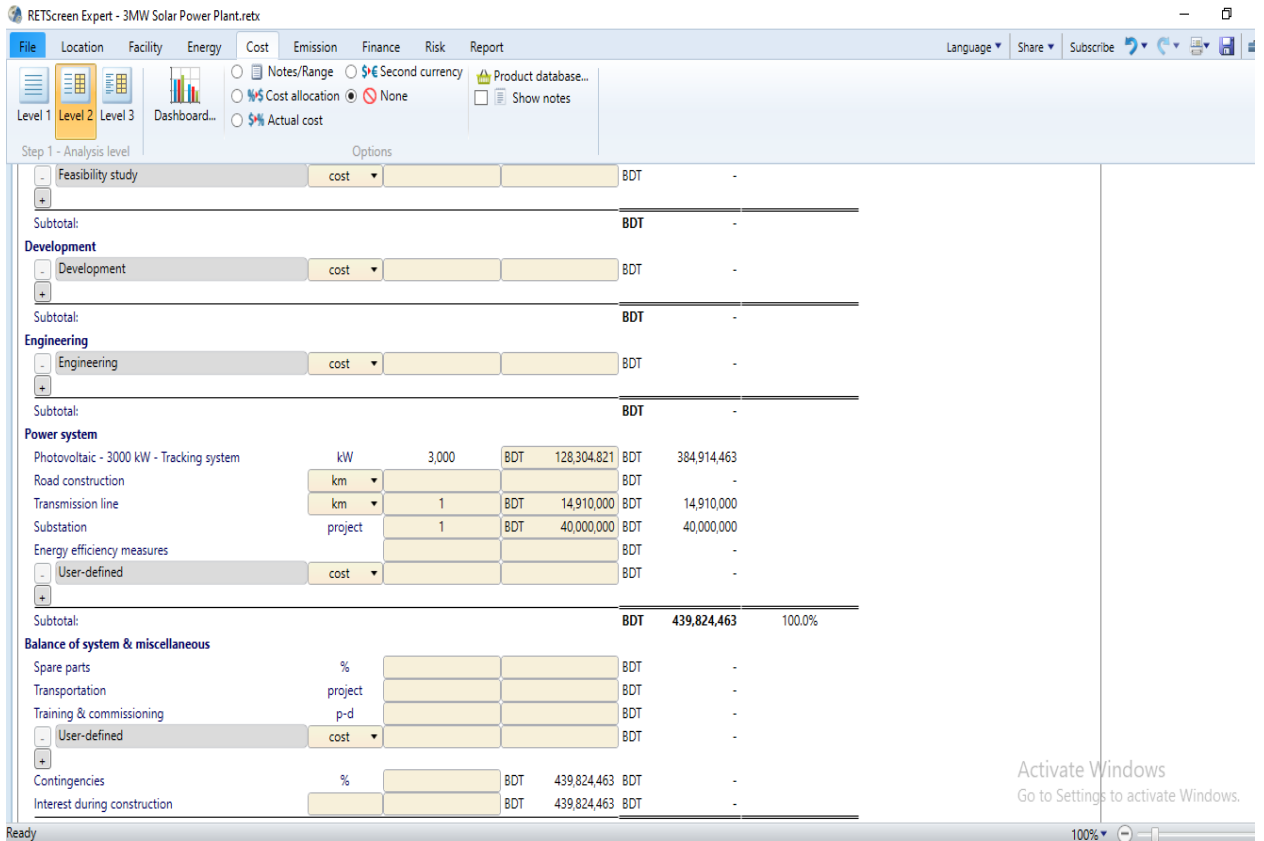


Fig4.5(b): Cost level 2

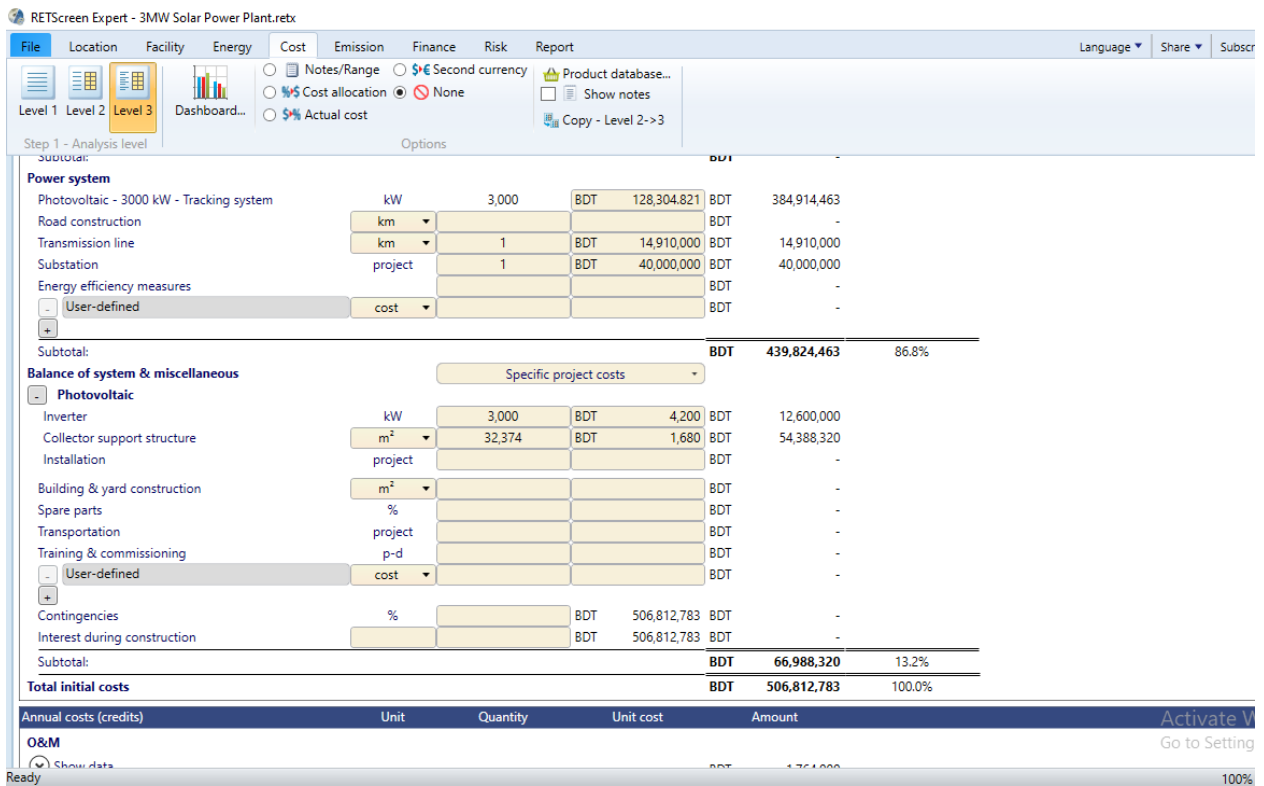


Fig4.5(c): Cost level 3

4.5 Emission Analysis

A worksheet on Emission Analysis is provided as part of the RETScreen Expert Clean Energy Management Software to help the user estimate the greenhouse gas emission reduction (mitigation) potential of the proposed facility.

The first step is to pick the ribbon's preferred type of analysis. The ribbon also provides potential factors for global warming at GHG. For level 1, this worksheet evaluating emission reduction includes three main sections: base case energy system (Baseline), GHG emissions and GHG reduction revenues. This includes five main sections for rates 2 and 3: Base case electricity system (Baseline), Base case system GHG overview (Baseline), Proposed case system GHG summary (Plan), summary of GHG emissions reduction and GHG income reduction. The Base case electrical system and Base case system GHG overview parts provide a definition of the baseline system emission profile. The GHG overview portion of the Proposed case system includes a definition of the proposed facility's emission profile. The overview section on GHG emission reduction provides a description of the expected reduction in GHG emissions based on the data entered by the user in the preceding chapter. Returns are measured as tons of CO₂ equivalent avoided per annum.

Level 1: Usually, the consumer should choose level 1 if the emission factors for electricity generation are already known.

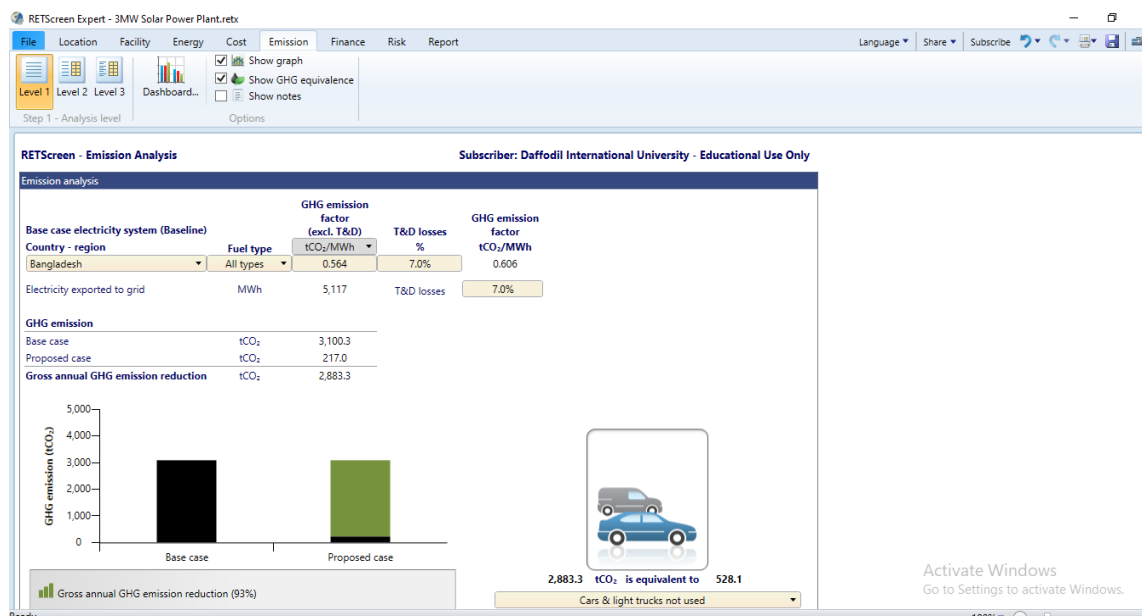


Fig4.6(a): Emission Analysis (level 1)

Level 2: An option is to plan a more detailed standard review by choosing level 2. The grid and the mix of the different power plants can also be defined with their respective fuels, fuel mix and various T&D losses.

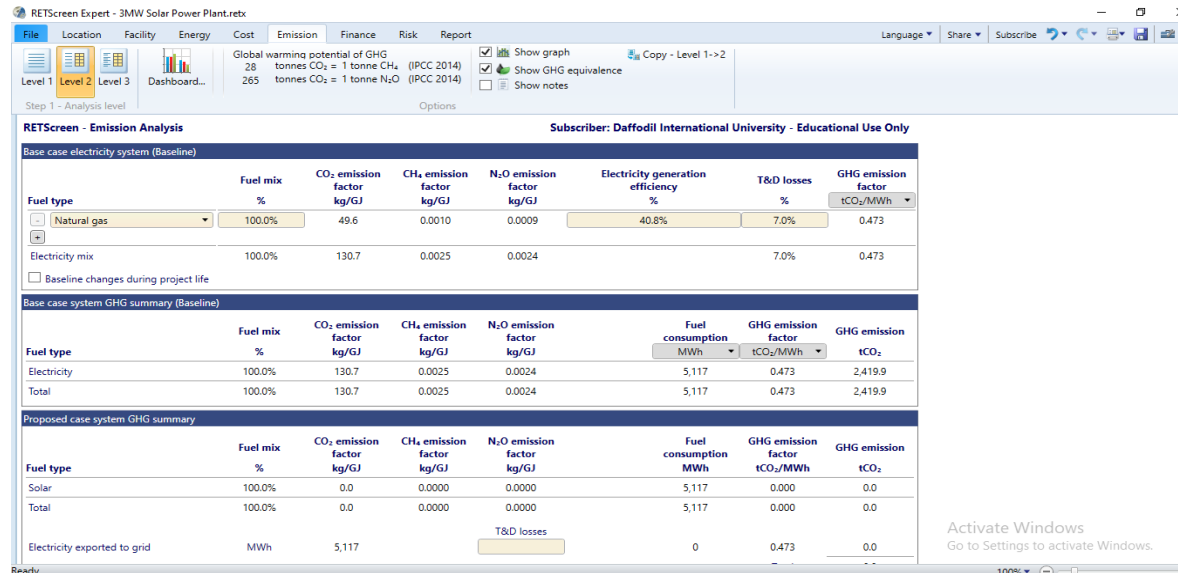


Fig4.6(b): Emission Analysis (level 2)

Level 3: Some users might prefer a much more detailed analysis of the facility's GHG reduction potential (e.g. an economist working for a public utilities commission). The model enables a more detailed analysis of the efficiency of electricity generation and T&D losses, and using Level 3, the user can prepare an even more detailed analysis of emission factors etc.

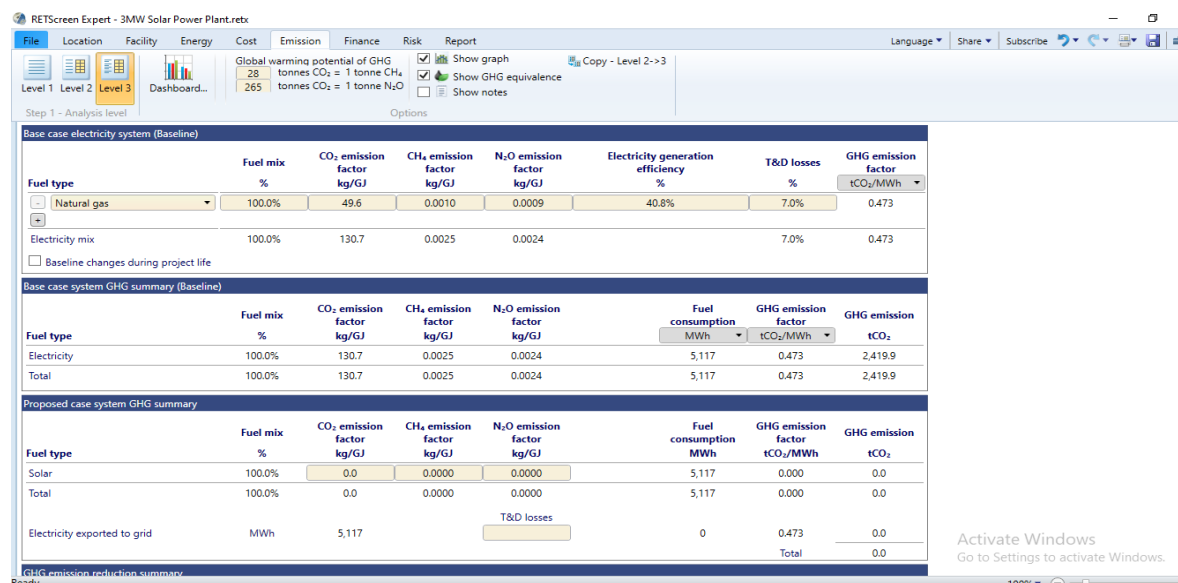


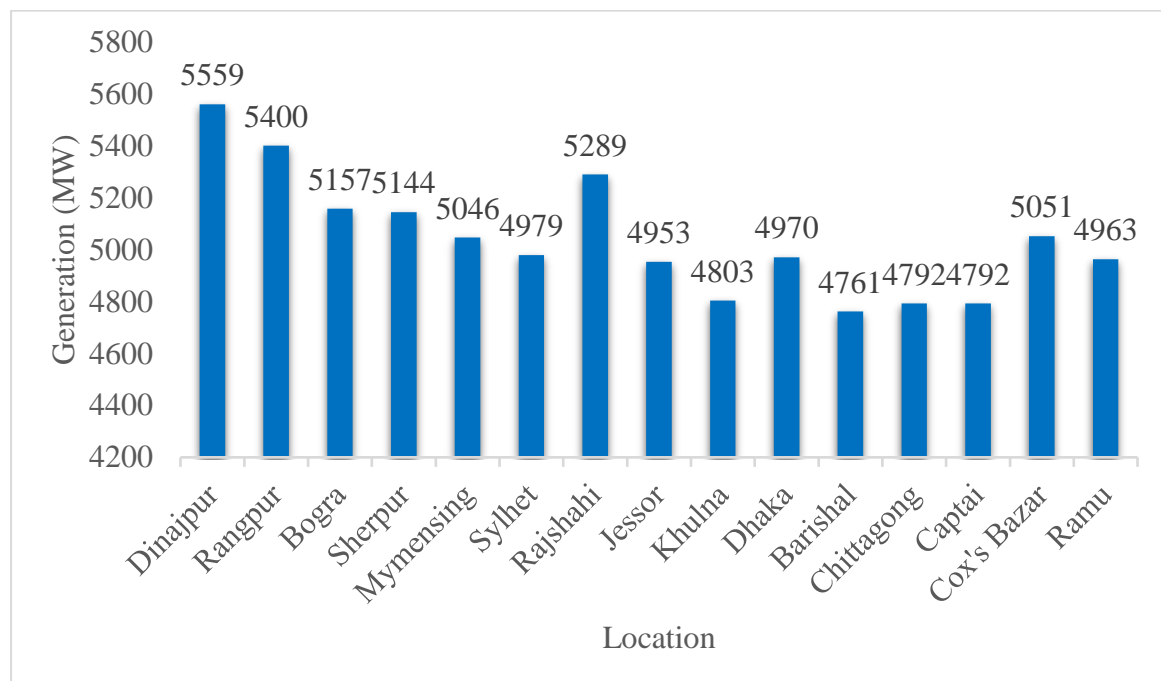
Fig 4.6(c): Emission Analysis (level 3)

If we use the PV power plant, we can GHG 2419 tco2 in every year. We consider the power plant for 20 years so total GHG reduction is 48376 tco2 in 20 years.

We know 28tonnes CO₂=1tonneCH₄ &265tonnes CO₂=1tonne N₂O.

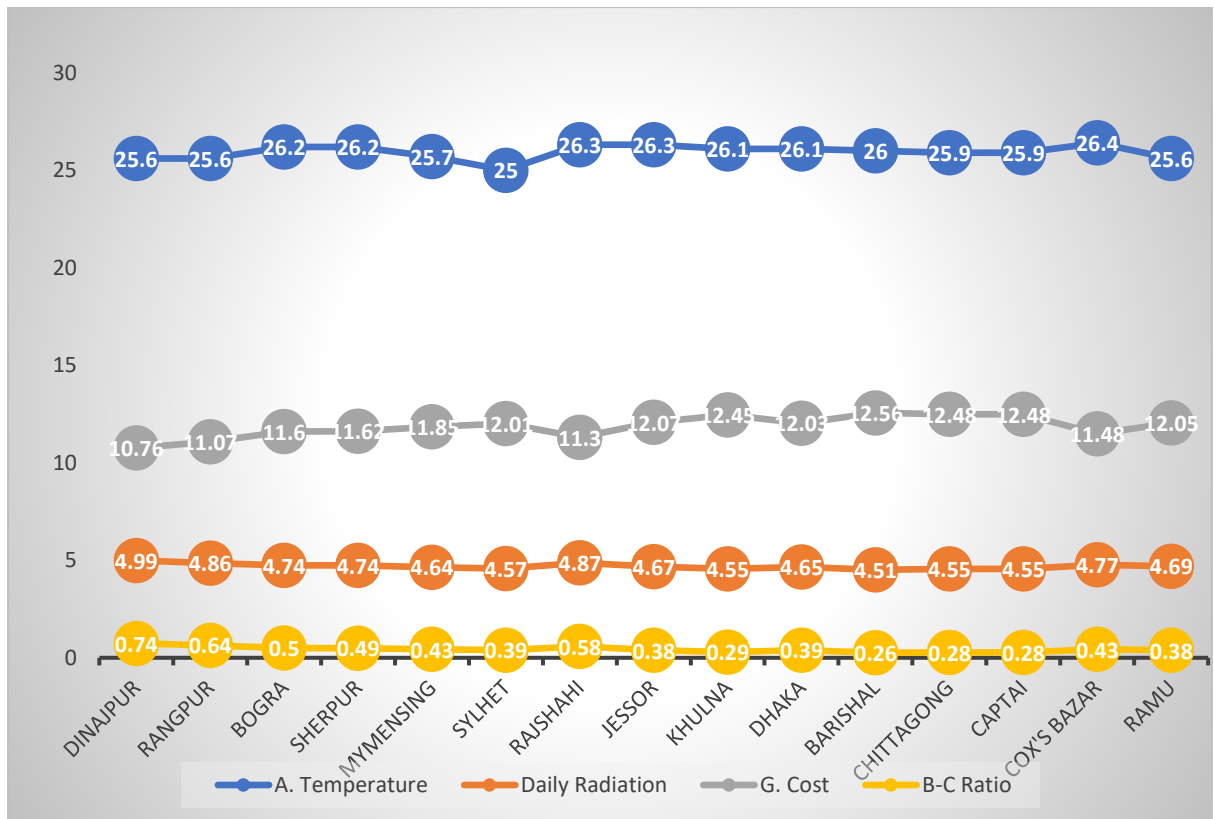
4.6 Comparing Sarishabari Solar Power Plant with Other Location

By learning about Sarishabari project from above topic. Now compare the same facilities with other different location of Bangladesh are Dinajpur, Rangpur, Bogra, Sherpur, Mymensingh, Sylhet, Rajshahi, Jessor, Khulna, Dhaka, Barisal, Chittagong, Captai, Cox's Bazar and Ramu.



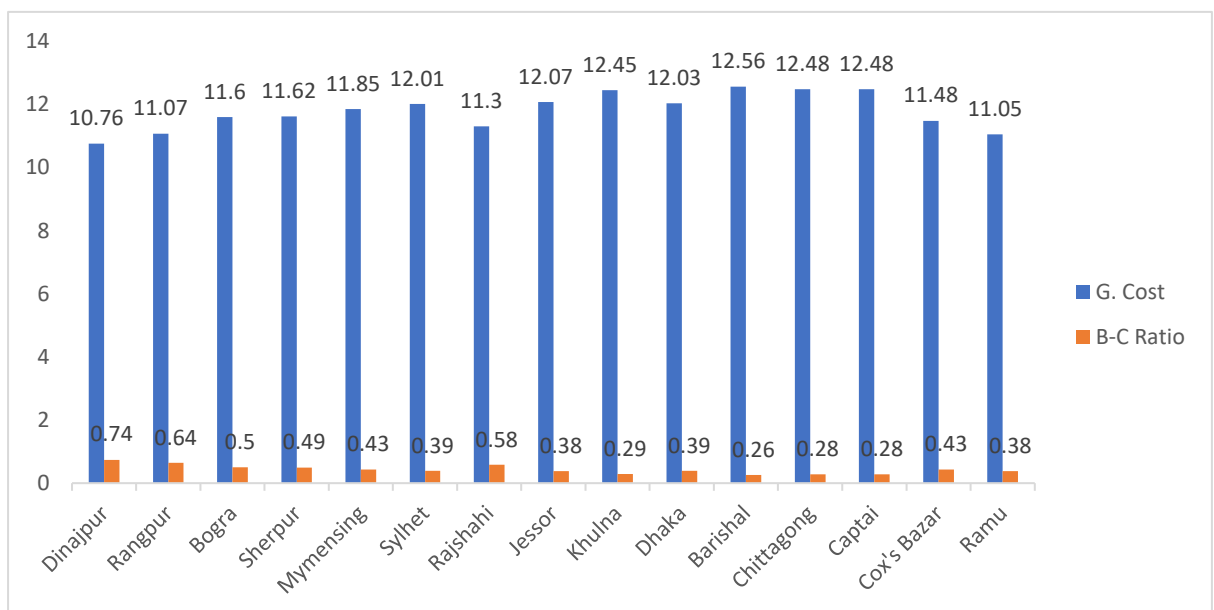
Graph 4.1: Generation of 3MWp solar power plant

This graph clearly indicate that change the generation of electricity with change the location. The maximum generation in Dinajpur is 5559 MW and the minimum generation in Barisal is 4761 MW. Average generation is 5044 MW. Generation is high in Dinajpur because of the daily radiation is high on the other hand in Barisal the daily radiation is low.



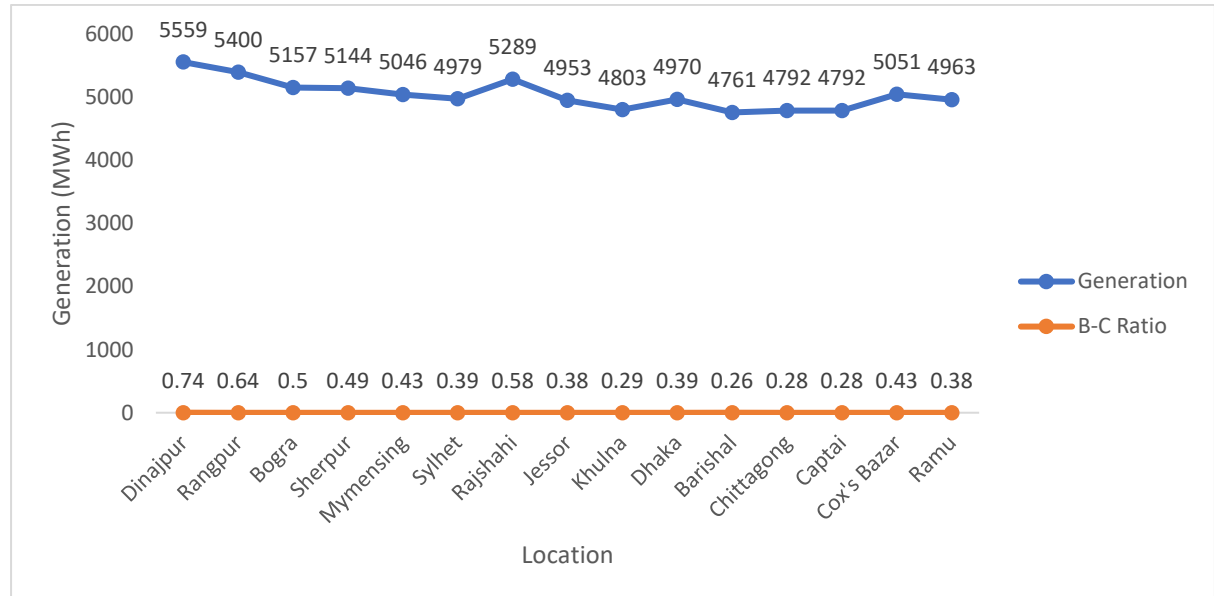
Graph4.2: Location Vs Different Data

From the graph the generation is not depends on temperature. The daily radiation is the main factor for which the generation varies with different location and generation cost varies with variation of generation. Also, B-C ratio change with respect to generation cost.



Graph4.3: Generation cost Vs B-C ratio

Generation cost is the main factor which effect the B-C ratio and generation cost depends on generation. Since the generation is high at Dinajpur so the generation cost is low from other location and the B-C ratio is high. So the generation of electricity and B-C ratio are related.



Graph4.4:Generation vs B-C ratio

From the above discussion, it is clear that North Bengal is more suitable for PV projects than other areas of Bangladesh. If a PV project is installed in North Bengal the generated more low-cost electricity than any other location for the same cost of installation.

4.7 Solar Tracking mode

The user selects the type of sun tracking device that mounts the solar collector to. The drop-down list choices are: "Fixed," "One-axis," "Two-axis," and "Azimuth." When the solar collector is mounted on a fixed structure the user should choose "Fixed." If the solar collector is mounted on a tracker the remaining choices can be picked.

A tracker is a tool that assists the solar collector and shifts the collector in a specified manner to decrease the angle of incidence of beam radiation on the surface of the collector. There for incident radiation from the beam (i.e. absorbed solar energy) is maximized. The following can be listed as Solar trackers.

One-axis trackers track the sun by rotating around an axis in the collector plane. The axis can have any direction but is generally east-west horizontal, north-south horizontal, or parallel to the axis of the earth:

Trackers Azimuth have a fixed slope and rotate around a vertical axis:

Two-axis trackers often align their normal surface by moving along two axes to the sun's beams.

Now let's see by changing the azimuth and slope how the generation is varies in same location. Considering the 0 and 1 azimuth for Bangladeshi perspective are more suitable. So change the slope with azimuth for electricity generation, generation cost, B-C ratio and GHG are in the table:

Table 4.1 (a): Change in generation with the change of azimuth and slope (DINJ)

Slope °	Azimuth 0°				Azimuth 1°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	5512	10.85	0.71	2607	5512	10.85	0.71	2607
17	5519	10.83	0.71	2610	5518	10.84	0.71	2610
18	5527	10.82	0.72	2614	5527	10.82	0.72	2614
19	5533	10.81	0.72	2617	5533	10.81	0.72	2617
20	5540	10.79	0.73	2620	5540	10.79	0.73	2620
21	5544	10.78	0.73	2622	5544	10.79	0.73	2622
22	5550	10.77	0.73	2625	5550	10.77	0.73	2625
23	5553	10.77	0.73	2626	5553	10.77	0.73	2626
24	5558	10.76	0.74	2629	5558	10.76	0.74	2628
25	5559	10.76	0.74	2629	5559	10.76	0.74	2629
26	5562	10.75	0.74	2631	5562	10.75	0.74	2631
27	5562	10.75	0.74	2631	5562	10.75	0.74	2631
28	5564	10.75	0.74	2632	5564	10.75	0.74	2632
29	5563	10.75	0.74	2631	5563	10.75	0.74	2631
30	5563	10.75	0.74	2631	5563	10.75	0.74	2631
31	5560	10.75	0.74	2630	5560	10.75	0.74	2630
32	5560	10.76	0.74	2630	5560	10.76	0.74	2630
33	5556	10.76	0.74	2627	5555	10.76	0.74	2627
34	5554	10.77	0.73	2627	5554	10.77	0.73	2627
35	5548	10.78	0.73	2624	5548	10.78	0.73	2624

Table 4.1 (b): Change in generation with the change of azimuth and slope (DINJ)

Azimuth 2°					Azimuth 3°			
Slope °	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	5511	10.85	0.71	2606	5510	10.85	0.71	2606
17	5518	10.84	0.71	2610	5517	10.84	0.71	2609
18	5527	10.82	0.72	2614	5526	10.82	0.72	2613
19	5532	10.81	0.72	2616	5531	10.81	0.72	2616
20	5539	10.79	0.73	2620	5538	10.80	0.73	2629
21	5543	10.79	0.73	2622	5542	10.79	0.73	2621
22	5550	10.77	0.73	2625	5549	10.78	0.73	2624
23	5552	10.77	0.73	2626	5551	10.77	0.73	2625
24	5557	10.76	0.74	2628	5556	10.76	0.74	2628
25	5558	10.76	0.74	2630	5557	10.76	0.74	2628
26	5562	10.75	0.74	2630	5561	10.75	0.74	2630
27	5563	10.75	0.74	2630	5561	10.75	0.74	2630
28	5564	10.75	0.74	2631	5563	10.75	0.74	2631
29	5564	10.75	0.74	2631	5561	10.75	0.74	2631
30	5563	10.75	0.74	2631	5562	10.75	0.74	2630
31	5560	10.75	0.74	2629	5559	10.76	0.74	2629
32	5559	10.76	0.74	2629	5558	10.76	0.74	2629
33	5555	10.76	0.74	2627	5554	10.77	0.74	2627
34	5553	10.77	0.73	2626	5552	10.77	0.73	2626
35	5547	10.78	0.73	2624	5546	10.78	0.73	2623
36	5544	10.78	0.73	2622	5543	10.79	0.73	2622

Justify: From Table 4.1(a) and 4.1(b) indicate that slope 25 to 29 is more suitable for highly generation at the same time the generation cost is low in this range and the B-C ratio, GHG are high.

For Sherpur change the slope with azimuth for electricity generation, generation cost, B-C ratio and GHG are in the table:

Table 4.2 (a): Change in generation with the change of azimuth and slope (SHER)

Slope °	Azimuth 0°				Azimuth 1°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	5091	11.75	0.46	2408	5091	11.75	0.46	2408
17	5098	11.73	0.46	2411	5098	11.73	0.46	2411
18	5105	11.71	0.47	2414	5105	11.71	0.47	2414
19	5111	11.70	0.47	2417	5111	11.70	0.47	2417
20	5117	11.69	0.47	2420	5117	11.69	0.47	2420
21	5122	11.67	0.48	2422	5122	11.67	0.48	2422
22	5126	11.66	0.48	2424	5126	11.66	0.48	2424
23	5130	11.66	0.48	2426	5130	11.66	0.48	2426
24	5133	11.65	0.48	2428	5133	11.65	0.48	2428
25	5135	11.64	0.48	2429	5135	11.64	0.48	2429
26	5137	11.64	0.49	2430	5137	11.64	0.49	2430
27	5138	11.64	0.49	2430	5138	11.64	0.49	2430
28	5139	11.64	0.49	2430	5139	11.64	0.49	2430
29	5139	11.64	0.49	2430	5139	11.64	0.49	2430
30	5138	11.64	0.49	2430	5138	11.64	0.49	2430
31	5136	11.64	0.48	2429	5136	11.64	0.48	2429
32	5134	11.65	0.48	2428	5134	11.65	0.48	2428
33	5132	11.65	0.48	2427	5131	11.65	0.48	2427
34	5128	11.66	0.48	2425	5128	11.66	0.48	2425
35	5124	11.67	0.48	2424	5124	11.67	0.48	2423
36	5120	11.68	0.47	2421	5119	11.68	0.47	2421

Table 4.2 (b): Change in generation with the change of azimuth and slope (SHER)

Azimuth 2°					Azimuth 3°			
Slope °	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce
16	5090	11.75	0.46	2407	5089	11.75	0.46	2407
17	5098	11.73	0.46	2411	5097	11.73	0.46	2411
18	5105	11.71	0.47	2414	5104	11.72	0.47	2414
19	5111	11.70	0.47	2417	5110	11.70	0.47	2417
20	5116	11.69	0.47	2420	5116	11.69	0.47	2419
21	5121	11.68	0.48	2422	5121	11.68	0.48	2422
22	5126	11.67	0.48	2424	5125	11.67	0.48	2424
23	5129	11.66	0.48	2426	5129	11.66	0.48	2426
24	5132	11.65	0.48	2427	5132	11.65	0.48	2427
25	5135	11.64	0.48	2429	5134	11.65	0.48	2428
26	5137	11.64	0.49	2429	5136	11.64	0.48	2429
27	5138	11.64	0.49	2430	5137	11.64	0.49	2430
28	5138	11.64	0.49	2430	5138	11.64	0.49	2430
29	5138	11.64	0.49	2430	5137	11.64	0.49	2430
30	5137	11.64	0.49	2430	5137	11.64	0.49	2429
31	5136	11.64	0.48	2429	5135	11.64	0.48	2429
32	5134	11.65	0.48	2428	5133	11.65	0.48	2428
33	5131	11.65	0.48	2427	5130	11.65	0.48	2426
34	5128	11.66	0.48	2425	5127	11.66	0.48	2425
35	5124	11.67	0.48	2423	5123	11.67	0.48	2423
36	5119	11.68	0.47	2421	5118	11.68	0.47	2421

Justify: The slope range is 25 to 29 degree in this time the generation is high and the generation cost, B-C ratio and GHG are related to generation of electricity. so 25 to 29 degree are the best case of consideration of electricity generation.

For Sylhet

Table 4.3 (a): Change in generation with the change of azimuth and slope (SYL)

Slope °	Azimuth 0°				Azimuth 1°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	4940	12.10	0.37	2336	4940	12.10	0.37	2336
17	4947	12.09	0.37	2340	4947	12.09	0.37	2339
18	4953	12.07	0.38	2343	4953	12.07	0.38	2342
19	4959	12.06	0.38	2345	4959	12.06	0.38	2345
20	4564	12.05	0.38	2348	4564	12.05	0.38	2348
21	4968	12.04	0.38	2350	4968	12.04	0.38	2350
22	4972	12.03	0.39	2352	4972	12.03	0.39	2351
23	4975	12.02	0.39	2353	4975	12.02	0.39	2353
24	4978	12.01	0.39	2354	4978	12.01	0.39	2354
25	4980	12.01	0.39	2355	4980	12.01	0.39	2355
26	4981	12.00	0.39	2356	4981	12.00	0.39	2356
27	4982	12.00	0.39	2356	4982	12.00	0.39	2356
28	4982	12.00	0.39	2356	4982	12.00	0.39	2356
29	4981	12.00	0.39	2356	4981	12.00	0.39	2356
30	4980	12.01	0.39	2355	4980	12.01	0.39	2355
31	4978	12.01	0.39	2354	4978	12.01	0.39	2354
32	4976	12.02	0.39	2353	4976	12.02	0.39	2353
33	4973	12.02	0.39	2352	4973	12.02	0.39	2352
34	4969	12.03	0.38	2350	4969	12.03	0.38	2350
35	4965	12.04	0.38	2348	4965	12.04	0.38	2348
36	4960	12.06	0.38	2346	4960	12.06	0.38	2346

Table 4.3 (b): Change in generation with the change of azimuth and slope (SYL)

Slope °	Azimuth 2°				Azimuth 3°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	4939	12.11	0.37	2336	4938	12.11	0.37	2336
17	4946	12.09	0.37	2339	4945	12.09	0.37	2339
18	4952	12.07	0.37	2342	4952	12.08	0.37	2342
19	4958	12.06	0.38	2345	4957	12.06	0.38	2345
20	4563	12.05	0.38	2347	4562	12.05	0.38	2347
21	4968	12.04	0.38	2349	4967	12.04	0.38	2349
22	4971	12.03	0.39	2351	4971	12.03	0.39	2351
23	4975	12.02	0.39	2353	4974	12.01	0.39	2352
24	4977	12.01	0.39	2354	4976	12.01	0.39	2354
25	4979	12.01	0.39	2355	4978	12.01	0.39	2355
26	4980	12.01	0.39	2356	4980	12.01	0.39	2355
27	4981	12.00	0.39	2356	4980	12.01	0.39	2356
28	4981	12.00	0.39	2356	4981	12.01	0.39	2356
29	4981	12.00	0.39	2356	4980	12.01	0.39	2355
30	4980	12.01	0.39	2355	4979	12.01	0.39	2355
31	4978	12.01	0.39	2354	4977	12.01	0.39	2354
32	4975	12.02	0.39	2353	4975	12.02	0.39	2353
33	4972	12.03	0.39	2352	4972	12.03	0.39	2351
34	4969	12.03	0.38	2350	4968	12.04	0.38	2350
35	4964	12.04	0.38	2348	4964	12.05	0.38	2348
36	4959	12.06	0.38	2346	4959	12.05	0.38	2348

Justify: Slope range is 25 to 29 degree is most suitable for generation and all other (g. cost, B-C ratio, GHG). At the same time, the azimuth of the geographical location is more acceptable than any other Bangladeshi location. 0 and 1 azimuth are acceptable for Sylhet.

For Rajshahi

Table 4.4(a): Change in generation with the change of azimuth and slope (RAJ)

Azimuth 0°					Azimuth 1°			
Slope °	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	5255	11.38	0.56	2485	5255	11.38	0.56	2485
17	5261	11.36	0.56	2488	5261	11.36	0.56	2488
18	5267	11.35	0.56	2491	5267	11.35	0.56	2491
19	5272	11.34	0.57	2494	5272	11.34	0.57	2493
20	5277	11.33	0.57	2496	5277	11.33	0.57	2496
21	5281	11.32	0.57	2497	5280	11.32	0.57	2497
22	5284	11.32	0.57	2499	5284	11.32	0.57	2499
23	5286	11.31	0.57	2500	5286	11.31	0.57	2500
24	5288	11.31	0.58	2501	5288	11.31	0.58	2501
25	5289	11.30	0.58	2502	5289	11.30	0.58	2502
26	5290	11.30	0.58	2502	5290	11.30	0.58	2502
27	5290	11.30	0.58	2502	5290	11.30	0.58	2502
28	5289	11.30	0.58	2501	5289	11.31	0.58	2501
29	5288	11.31	0.58	2501	5288	11.31	0.58	2501
30	5286	11.31	0.57	2500	5285	11.31	0.57	2500
31	5283	11.32	0.57	2499	5283	11.32	0.57	2498
32	5280	11.33	0.57	2497	5279	11.33	0.57	2497
33	5276	11.33	0.57	2495	5275	11.33	0.57	2495
34	5271	11.34	0.57	2493	5271	11.34	0.57	2493
35	5266	11.36	0.56	2490	5266	11.36	0.56	2490
36	5260	11.37	0.56	2488	5260	11.37	0.56	2488

Table 4.4 (b): Change in generation with the change of azimuth and slope (RAJ)

Slope °	Azimuth 2°				Azimuth 3°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	5254	11.38	0.56	2485	5253	11.38	0.56	2485
17	5261	11.37	0.56	2488	5260	11.37	0.56	2488
18	5266	11.35	0.56	2491	5266	11.36	0.56	2490
19	5272	11.34	0.57	2493	5271	11.34	0.57	2493
20	5276	11.33	0.57	2495	5275	11.33	0.57	2495
21	5280	11.32	0.57	2497	5279	11.33	0.57	2497
22	5283	11.32	0.57	2499	5282	11.32	0.57	2498
23	5286	11.31	0.57	2500	5285	11.31	0.57	2499
24	5287	11.31	0.58	2501	5287	11.31	0.57	2500
25	5289	11.31	0.58	2501	5288	11.31	0.58	2501
26	5289	11.30	0.58	2501	5288	11.31	0.58	2501
27	5289	11.30	0.58	2502	5288	11.31	0.58	2501
28	5288	11.31	0.58	2501	5288	11.31	0.58	2500
29	5287	11.31	0.58	2501	5286	11.31	0.57	2500
30	5285	11.31	0.57	2500	5284	11.32	0.57	2499
31	5282	11.32	0.57	2498	5282	11.32	0.57	2498
32	5279	11.33	0.57	2497	5278	11.33	0.57	2496
33	5275	11.34	0.57	2495	5274	11.34	0.57	2494
34	5270	11.35	0.57	2493	5270	11.35	0.56	2492
35	5265	11.36	0.56	2490	5264	11.36	0.56	2490
36	5265	11.36	0.56	2490	5258	11.37	0.56	2489

In this time the generation is high, the slope range 25 to 28 is more acceptable. Regular radiation during Raj is high so the production of electricity is high. The B-C ratio and GHG are also high at the same time, but the cost of generation is very small.

For Narayangang

Table 4.5 (a): Change in generation with the change of azimuth and slope (NARAG)

Azimuth 0°					Azimuth 1°			
Slope °	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	4939	12.11	0.37	2336	4939	12.11	0.37	2336
17	4944	12.09	0.37	2338	4944	12.09	0.37	2338
18	4949	12.08	0.37	2341	4949	12.08	0.37	2341
19	4954	12.07	0.38	2343	4954	12.07	0.38	2343
20	4957	12.06	0.38	2345	4957	12.06	0.38	2345
21	4961	12.05	0.38	2346	4960	12.05	0.38	2346
22	4963	12.05	0.38	2347	4963	12.05	0.38	2347
23	4965	12.04	0.38	2348	4965	12.04	0.38	2348
24	4966	12.04	0.38	2349	4966	12.04	0.38	2349
25	4967	12.04	0.38	2349	4967	12.04	0.38	2349
26	4967	12.04	0.38	2349	4967	12.04	0.38	2349
27	4966	12.04	0.38	2349	4966	12.04	0.38	2349
28	4965	12.04	0.38	2348	4965	12.05	0.38	2348
29	4963	12.05	0.38	2347	4963	12.05	0.38	2347
30	4961	12.05	0.38	2346	4961	12.05	0.38	2346
31	4958	12.06	0.38	2345	4957	12.06	0.38	2345
32	4954	12.07	0.38	2343	4954	12.07	0.38	2343
33	4950	12.08	0.37	2341	4949	12.08	0.37	2341
34	4945	12.09	0.37	2339	4945	12.09	0.37	2338
35	4939	12.11	0.37	2336	4939	12.11	0.37	2336
36	4933	12.12	0.36	2333	4933	12.12	0.36	2333

Table 4.5 (b): Change in generation with the change of azimuth and slope (NARAG)

Azimuth 2°					Azimuth 3°			
Slope °	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	4938	12.11	0.37	2336	4937	12.11	0.37	2335
17	4944	12.09	0.37	2338	4943	12.10	0.37	2338
18	4949	12.08	0.37	2341	4948	12.08	0.37	2340
19	4953	12.07	0.38	2343	4952	12.07	0.37	2342
20	4957	12.06	0.38	2344	4956	12.06	0.38	2344
21	4960	12.06	0.38	2346	4959	12.06	0.38	2345
22	4962	12.05	0.38	2347	4962	12.05	0.38	2347
23	4964	12.04	0.38	2348	4964	12.05	0.38	2348
24	4966	12.04	0.38	2348	4965	12.04	0.38	2348
25	4966	12.04	0.38	2349	4965	12.04	0.38	2348
26	4966	12.04	0.38	2349	4965	12.04	0.38	2348
27	4966	12.04	0.38	2348	4965	12.04	0.38	2348
28	4964	12.04	0.38	2348	4964	12.05	0.38	2348
29	4963	12.05	0.38	2347	4962	12.05	0.38	2347
30	4960	12.05	0.38	2346	4959	12.06	0.38	2346
31	4957	12.06	0.38	2344	4956	12.06	0.38	2344
32	4953	12.07	0.38	2343	4953	12.07	0.37	2342
33	4949	12.08	0.37	2341	4948	12.08	0.37	2340
34	4944	12.09	0.37	2338	4943	12.10	0.37	2338
35	4939	12.11	0.37	2336	4938	12.11	0.37	2335
36	4932	12.12	0.36	2333	4932	12.12	0.36	2332

At this location, low generation and low B-C ratio and also the slope range is 25 to 29 but 0 azimuth is more appropriate for this area.

For Khulna

Table 4.6 (a): Change in generation with the change of azimuth and slope (KHL)

Slope °	Azimuth 0°				Azimuth 1°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	4780	12.51	0.27	2261	4780	12.51	0.27	2261
17	4785	12.50	0.27	2263	4785	12.50	0.27	2263
18	4789	12.49	0.28	2265	4789	12.49	0.28	2265
19	4793	12.48	0.28	2267	4792	12.48	0.28	2267
20	4795	12.47	0.28	2268	4795	12.47	0.28	2268
21	4798	12.46	0.28	2269	4798	12.46	0.28	2269
22	4800	12.46	0.28	2270	4800	12.46	0.28	2270
23	4801	12.45	0.28	2271	4801	12.46	0.28	2270
24	4801	12.45	0.28	2271	4801	12.45	0.28	2271
25	4801	12.45	0.28	2271	4801	12.45	0.28	2271
26	4801	12.45	0.28	2271	4801	12.46	0.28	2270
27	4800	12.46	0.28	2270	4799	12.46	0.28	2270
28	4798	12.46	0.28	2269	4798	12.46	0.28	2269
29	4795	12.47	0.28	2268	4795	12.47	0.28	2268
30	4792	12.48	0.28	2266	4792	12.48	0.28	2266
31	4789	12.49	0.28	2265	4788	12.49	0.28	2265
32	4784	12.50	0.27	2263	4784	12.50	0.27	2263
33	4780	12.51	0.27	2261	4779	12.51	0.27	2260
34	4774	12.52	0.27	2258	4774	12.52	0.27	2258
35	4768	12.54	0.26	2255	4768	12.54	0.26	2255
36	4762	12.56	0.26	2252	4761	12.56	0.26	2252

Table 4.6 (b): Change in generation with the change of azimuth and slope (KHL)

Azimuth 2°					Azimuth 3°			
Slope °	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce
16	4779	12.51	0.27	2260	4779	12.51	0.27	2260
17	4784	12.50	0.27	2263	4783	12.50	0.27	2262
18	4788	12.49	0.28	2265	4788	12.49	0.28	2265
19	4792	12.48	0.28	2266	4791	12.48	0.28	2266
20	4795	12.47	0.28	2268	4794	12.47	0.28	2267
21	4797	12.46	0.28	2269	4797	12.47	0.28	2269
22	4799	12.46	0.28	2270	4798	12.46	0.28	2269
23	4800	12.46	0.28	2270	4800	12.46	0.28	2270
24	4801	12.45	0.28	2271	4800	12.46	0.28	2270
25	4801	12.45	0.28	2271	4800	12.46	0.28	2270
26	4800	12.46	0.28	2270	4800	12.46	0.28	2270
27	4799	12.46	0.28	2270	4798	12.46	0.28	2269
28	4797	12.46	0.28	2269	4796	12.47	0.28	2268
29	4795	12.47	0.28	2268	4794	12.47	0.28	2267
30	4792	12.48	0.28	2266	4791	12.48	0.28	2266
31	4788	12.49	0.28	2265	4787	12.49	0.28	2264
32	4784	12.50	0.27	2263	4783	12.50	0.27	2262
33	4779	12.51	0.27	2260	4778	12.51	0.27	2260
34	4774	12.53	0.27	2258	4773	12.53	0.27	2257
35	4768	12.54	0.26	2255	4767	12.54	0.26	2255
36	4761	12.56	0.26	2252	4760	12.56	0.26	2251

Regular radiation is low so the B-C ratio is very poor. The generation is very low and GHG is also low on the other hand the cost of generation is very high.

For Barisal

Table 4.7 (a): Change in generation with the change of azimuth and slope (BAR)

Slope °	Azimuth 0°				Azimuth 1°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	4739	12.62	0.25	2241	4739	12.62	0.25	2241
17	4744	12.60	0.25	2244	4744	12.60	0.25	2244
18	4748	12.59	0.25	2246	4748	12.59	0.25	2246
19	4752	12.58	0.25	2247	4752	12.58	0.25	2247
20	4755	12.57	0.26	2249	4755	12.58	0.26	2249
21	4757	12.57	0.26	2250	4757	12.57	0.26	2250
22	4459	12.56	0.26	2251	4459	12.56	0.26	2251
23	4761	12.56	0.26	2252	4760	12.56	0.26	2251
24	4761	12.56	0.26	2252	4761	12.56	0.26	2252
25	4761	12.56	0.26	2252	4761	12.56	0.26	2252
26	4761	12.56	0.26	2252	4761	12.56	0.26	2252
27	4760	12.56	0.26	2251	4760	12.56	0.26	2251
28	4758	12.57	0.26	2250	4758	12.57	0.26	2250
29	4756	12.57	0.26	2249	4756	12.57	0.26	2249
30	4753	12.58	0.26	2248	4753	12.58	0.26	2248
31	4749	12.59	0.25	2246	4749	12.59	0.25	2246
32	4745	12.60	0.25	2244	4745	12.60	0.25	2244
33	4741	12.61	0.25	2242	4741	12.61	0.25	2242
34	4735	12.63	0.24	2240	4735	12.63	0.24	2240
35	4730	12.64	0.24	2237	4729	12.64	0.24	2237
36	4723	12.66	0.24	2234	4723	12.66	0.24	2234

Table 4.7 (b): Change in generation with the change of azimuth and slope (BAR)

Azimuth 2°					Azimuth 3°			
Slope °	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce
16	4738	12.62	0.24	2241	4738	12.62	0.25	2241
17	4743	12.61	0.25	2243	4743	12.61	0.25	2243
18	4748	12.59	0.25	2245	4747	12.60	0.25	2245
19	4751	12.58	0.25	2247	4751	12.59	0.25	2247
20	4754	12.58	0.26	2249	4754	12.58	0.26	2248
21	4757	12.57	0.26	2250	4756	12.57	0.26	2249
22	4459	12.56	0.26	2251	4458	12.57	0.26	2250
23	4760	12.56	0.26	2251	4759	12.56	0.26	2251
24	4761	12.56	0.26	2252	4760	12.56	0.26	2251
25	4761	12.56	0.26	2252	4760	12.56	0.26	2251
26	4760	12.56	0.26	2251	4760	12.56	0.26	2251
27	4759	12.56	0.26	2251	4759	12.57	0.26	2251
28	4758	12.57	0.26	2250	4757	12.57	0.26	2250
29	4755	12.57	0.26	2249	4755	12.58	0.26	2249
30	4752	12.58	0.26	2248	4752	12.58	0.25	2247
31	4749	12.59	0.25	2246	4748	12.59	0.25	2246
32	4745	12.60	0.25	2244	4744	12.60	0.25	2244
33	4740	12.61	0.25	2242	4739	12.62	0.25	2242
34	4735	12.63	0.24	2239	4734	12.63	0.24	2239
35	4729	12.64	0.24	2237	4728	12.65	0.24	2236
36	4723	12.66	0.24	2234	4722	12.66	0.24	2233

The power costs for the low generation are very high. B-C is very low.

For Cox's Bazar

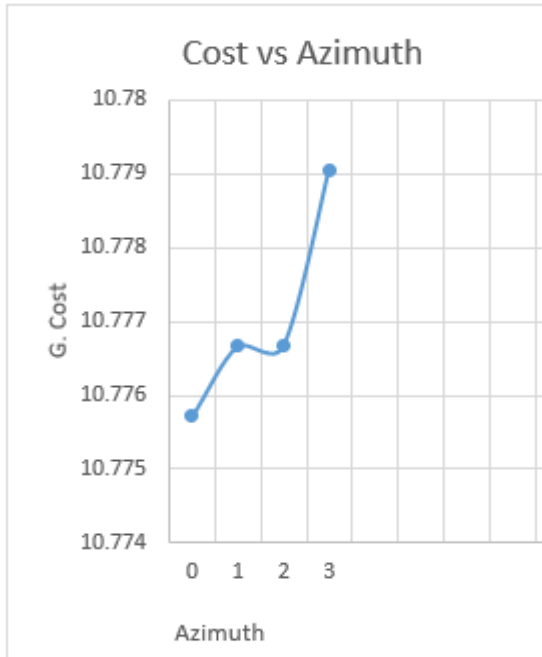
Table 4.8 (a): Change in generation with the change of azimuth and slope (COX'S)

Slope °	Azimuth 0°				Azimuth 1°			
	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e	Generatio n MWh	Cost BDT/KW h	B-C Rati o	GHG Reduc e
16	5032	11.88	0.42	2380	5031	11.88	0.42	2380
17	5036	11.87	0.43	2382	5036	11.87	0.42	2382
18	5040	11.86	0.43	2384	5040	11.86	0.43	2384
19	5044	11.85	0.43	2385	5044	11.85	0.43	2385
20	5047	11.85	0.43	2387	5047	11.85	0.43	2387
21	5049	11.84	0.43	2388	5049	11.84	0.43	2388
22	5051	11.84	0.43	2389	5050	11.84	0.43	2389
23	5052	11.84	0.43	2389	5051	11.84	0.43	2389
24	5052	11.84	0.43	2389	5052	11.84	0.43	2389
25	5052	11.84	0.43	2389	5051	11.84	0.43	2389
26	5051	11.84	0.43	2389	5051	11.84	0.43	2389
27	5049	11.84	0.43	2388	5049	11.84	0.43	2388
28	5047	11.85	0.43	2387	5047	11.85	0.43	2387
29	5044	11.85	0.43	2386	5044	11.85	0.43	2386
30	5041	11.86	0.43	2384	5041	11.86	0.43	2384
31	5037	11.87	0.43	2382	5036	11.87	0.43	2382
32	5032	11.88	0.42	2380	5032	11.88	0.42	2380
33	5037	11.90	0.42	2377	5026	11.90	0.42	2377
34	5021	11.91	0.42	2375	5021	11.91	0.42	2374
35	5014	11.92	0.41	2371	5014	11.93	0.41	2371
36	5009	11.94	0.41	2365	5007	11.94	0.41	2365

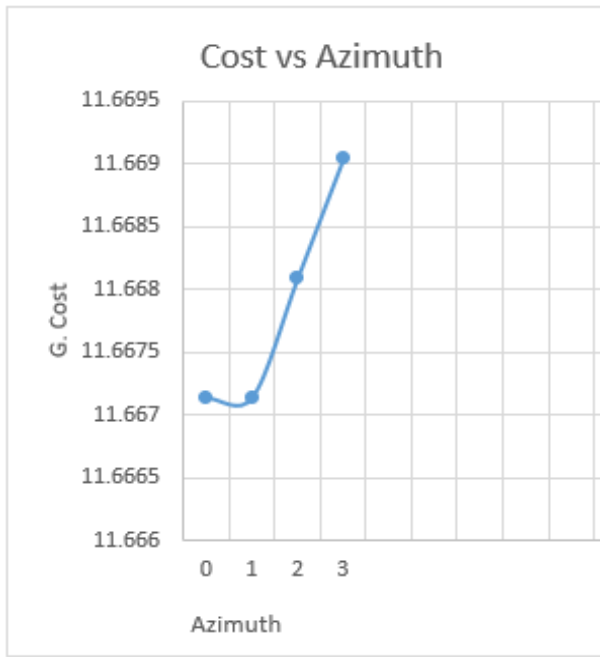
Table 4.8 (b): Change in generation with the change of azimuth and slope (COX'S)

Slope°	Azimuth 2°				Azimuth 3°			
	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce	Generation MWh	Cost BDT/KWh	B-C Ratio	GHG Reduce
16	5031	11.89	0.42	2379	5030	11.89	0.42	2379
17	5036	11.87	0.42	2382	5035	11.88	0.42	2381
18	5040	11.86	0.43	2384	5039	11.87	0.43	2383
19	5043	11.86	0.43	2385	5042	11.86	0.43	2385
20	5046	11.85	0.43	2387	5045	11.85	0.43	2386
21	5048	11.84	0.43	2388	5048	11.85	0.43	2387
22	5050	11.84	0.43	2388	5049	11.84	0.43	2387
23	5051	11.84	0.43	2389	5050	11.84	0.43	2388
24	5051	11.84	0.43	2389	5050	11.84	0.43	2389
25	5051	11.84	0.43	2389	5050	11.84	0.43	2388
26	5050	11.84	0.43	2388	5049	11.84	0.43	2388
27	5049	11.84	0.43	2388	5048	11.84	0.43	2387
28	5046	11.85	0.43	2387	5046	11.85	0.43	2386
29	5044	11.86	0.43	2385	5043	11.86	0.43	2385
30	5040	11.86	0.43	2384	5039	11.87	0.43	2383
31	5036	11.86	0.42	2382	5035	11.87	0.42	2381
32	5031	11.88	0.42	2380	5031	11.89	0.42	2379
33	5026	11.90	0.42	2377	5025	11.90	0.42	2377
34	5020	11.91	0.42	2374	5019	11.91	0.41	2374
35	5014	11.93	0.41	2371	5013	11.93	0.41	2371
36	5006	11.94	0.41	2368	5006	11.94	0.41	2369

The average cost is different for eight different locations and the average cost of generation is related to azimuth. so below is the relation and suitable for different locations:



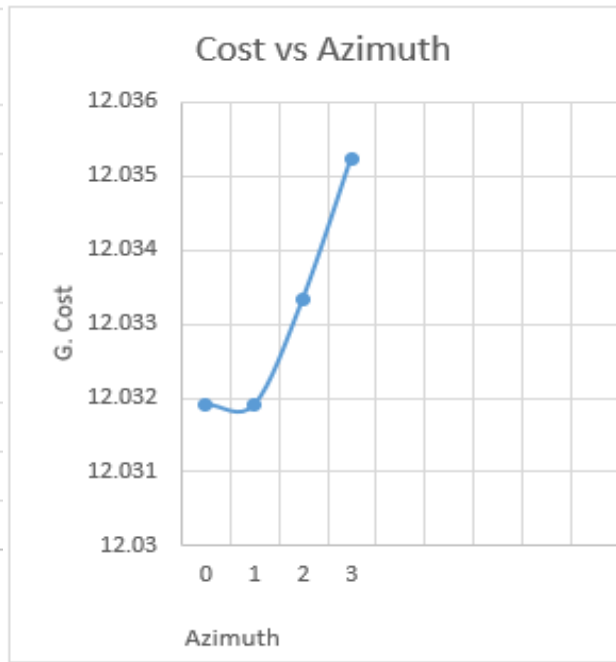
Graph4.5(a): Aveg. Cost Vs Azimuth (DINJ)



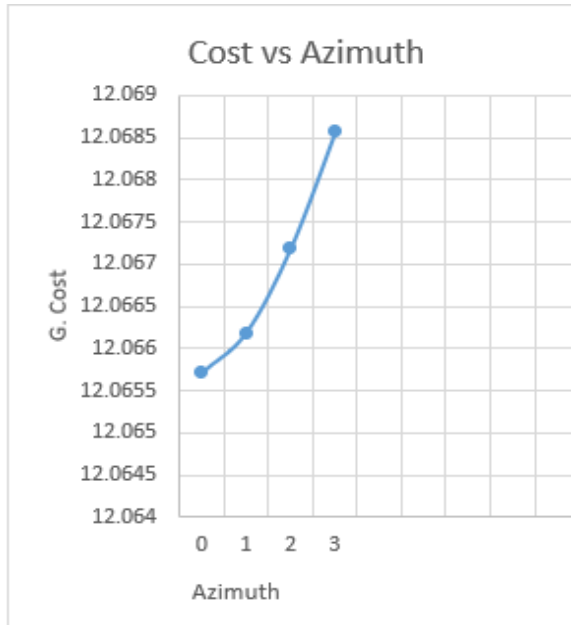
Graph4.5(b): Aveg. Cost Vs Azimuth (SHER)



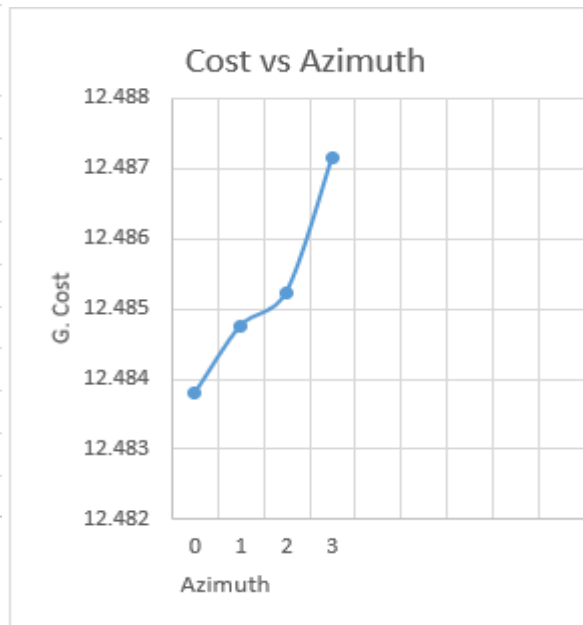
Graph4.5(c): A.Cost Vs Azimuth (SYL)



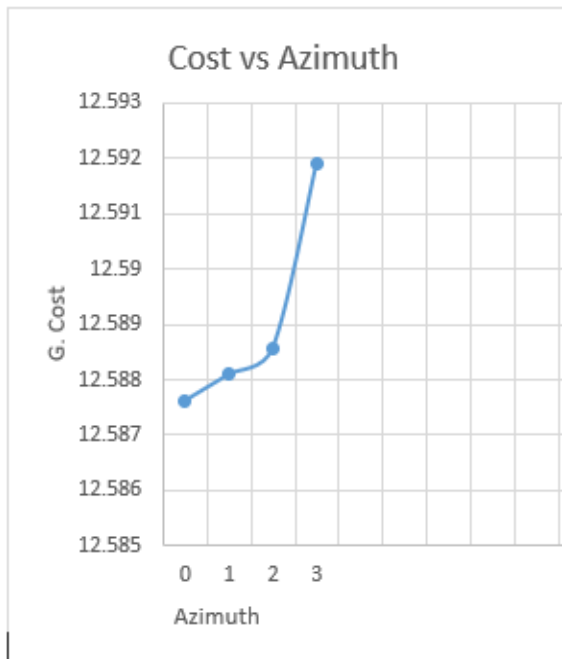
Graph4.5(d): A.Cost Vs Azimuth (RAJ)



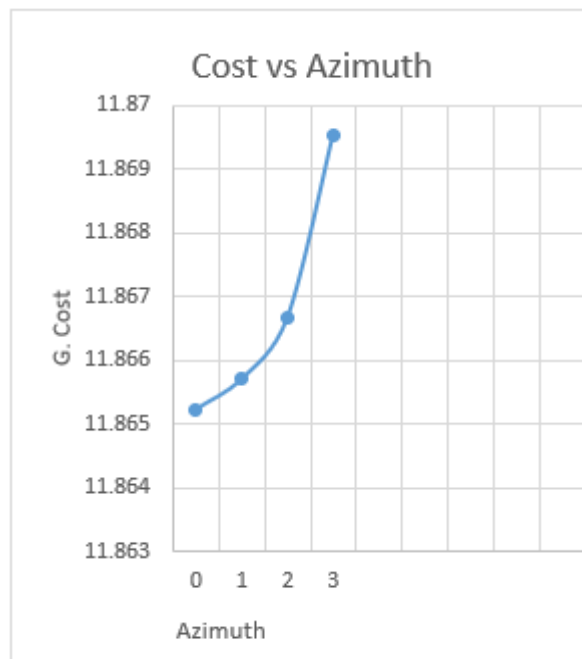
Graph4.6(e): A.Cost Vs Azimuth (NARAG)



Graph4.6(f): A.Cost Vs Azimuth (KHL)

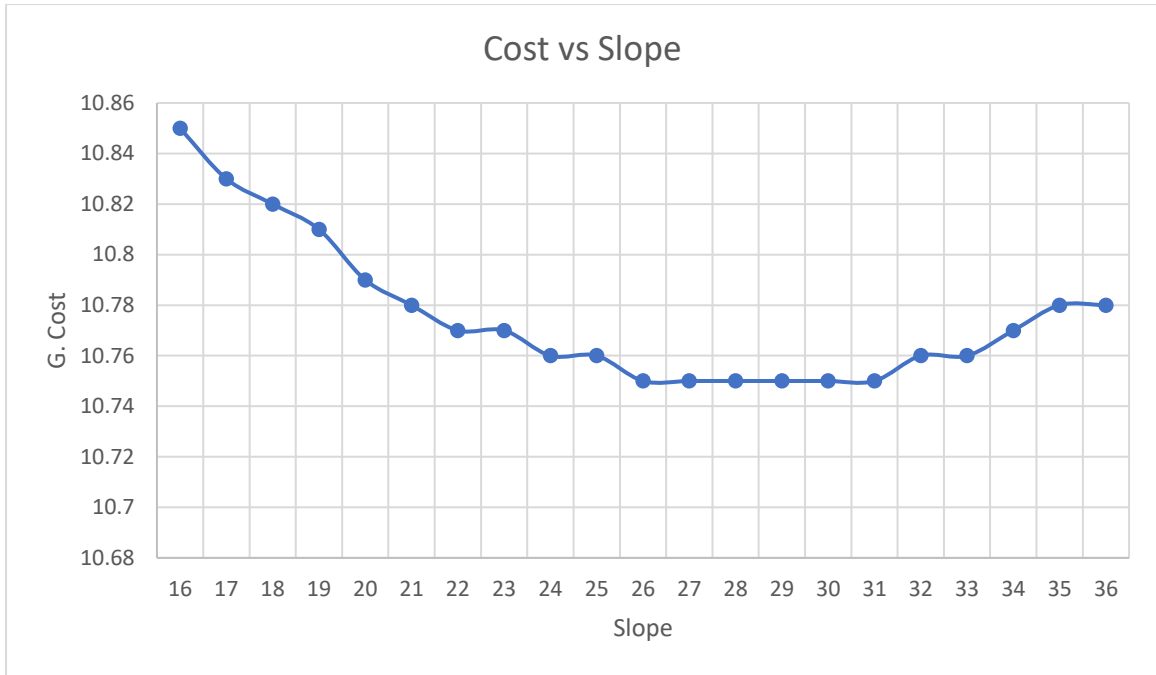


Graph4.6(g): A.Cost Vs Azimuth (BAR)
(COX'S)

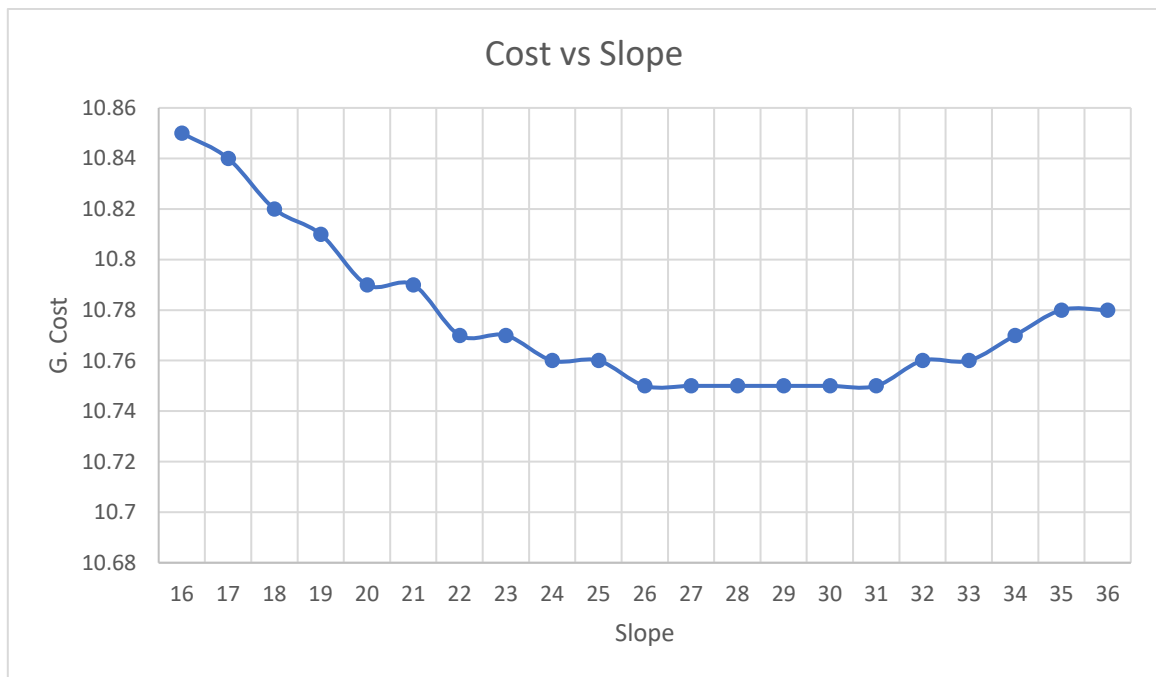


Graph4.6(h): A.Cost Vs Azimuth

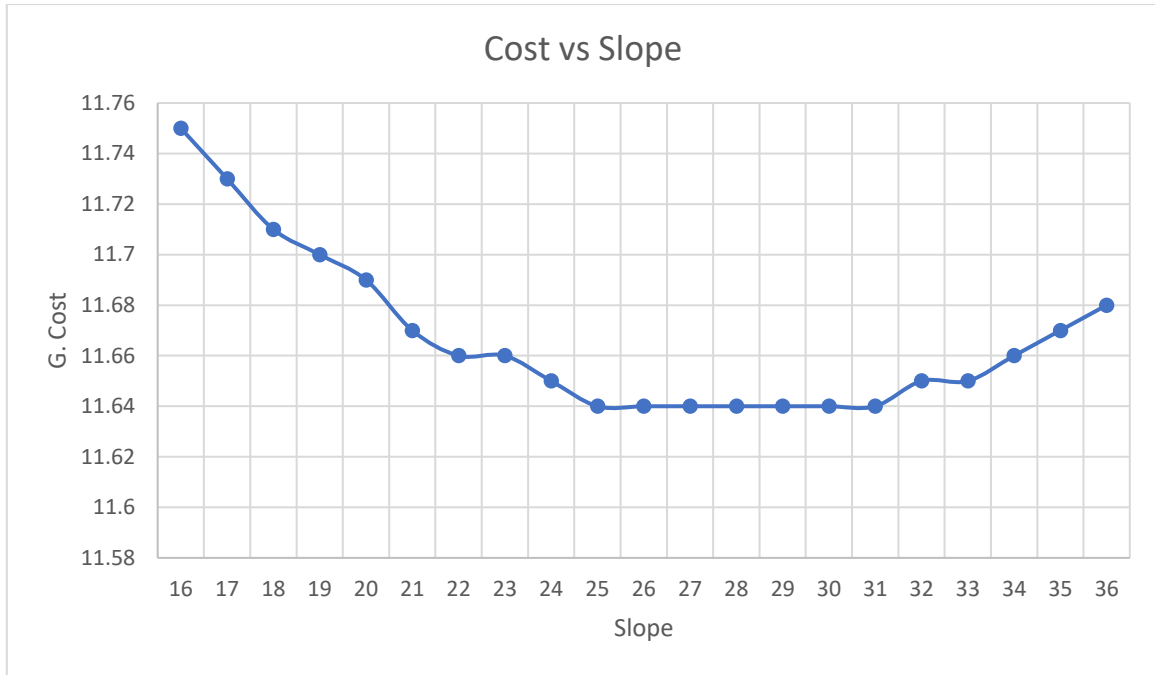
Such graphs clearly show an increase in the cost of generation with an increase in azimuth. That means the azimuth rise decreases the generation. In Bangladesh 0 and 1 degree azimuth are more fitting. Slope is associated with age. On the other hand slope is also related to cost of production.



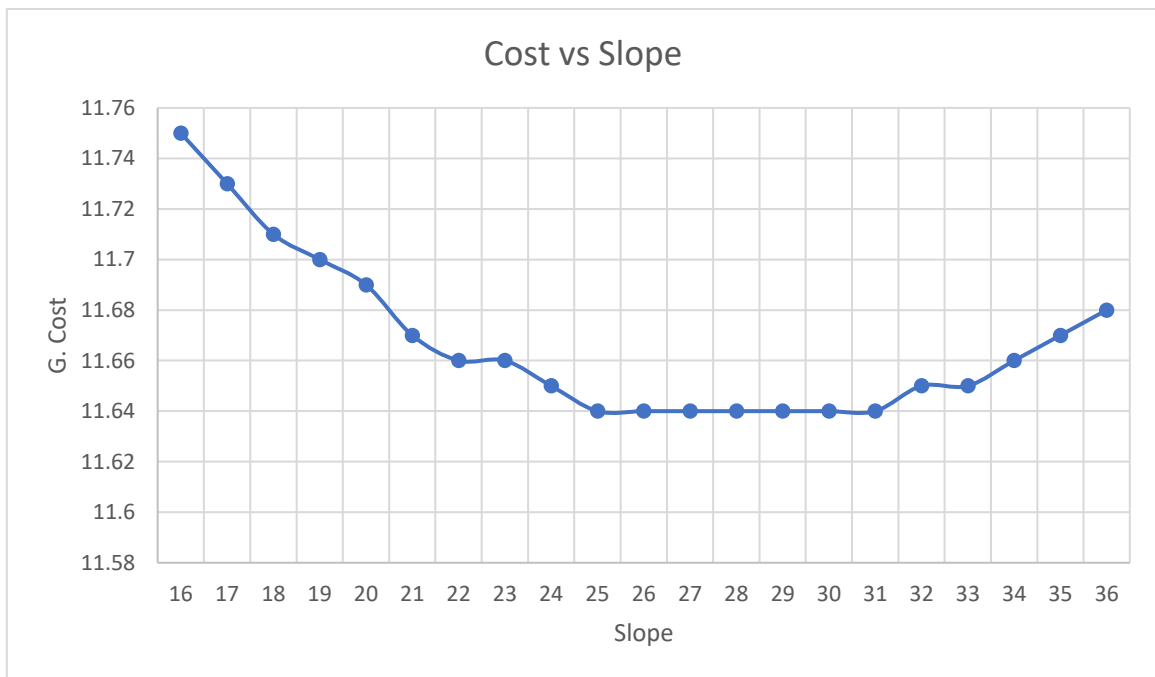
Graph 4.7(a): Slope Vs G. Cost (0degree azimuth for DINJ)



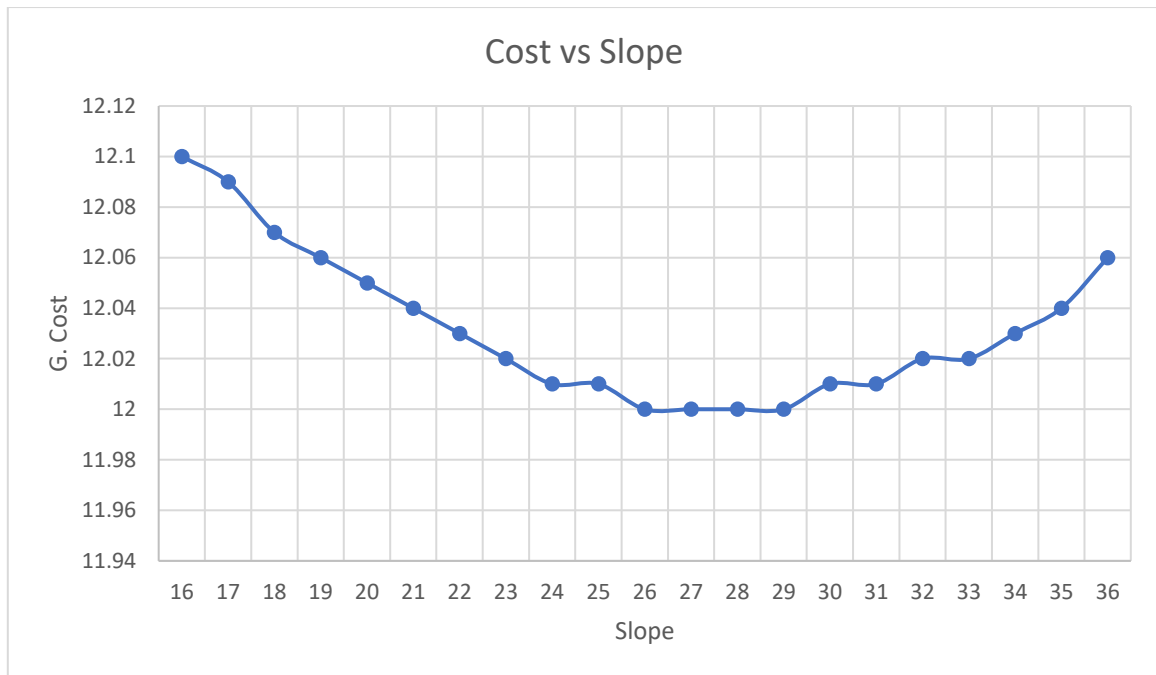
Graph 4.7(b): Slope Vs G. Cost (1degree azimuth for DINJ)



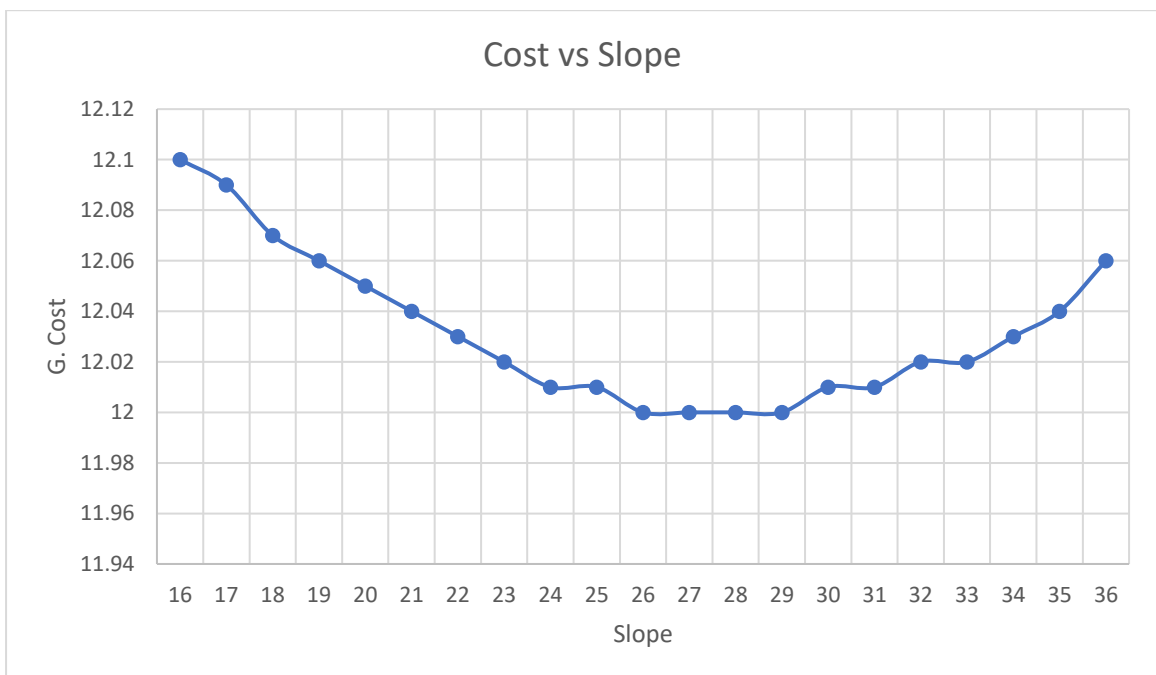
Graph 4.8(a): Slope Vs G. Cost (0degree azimuth for SHER)



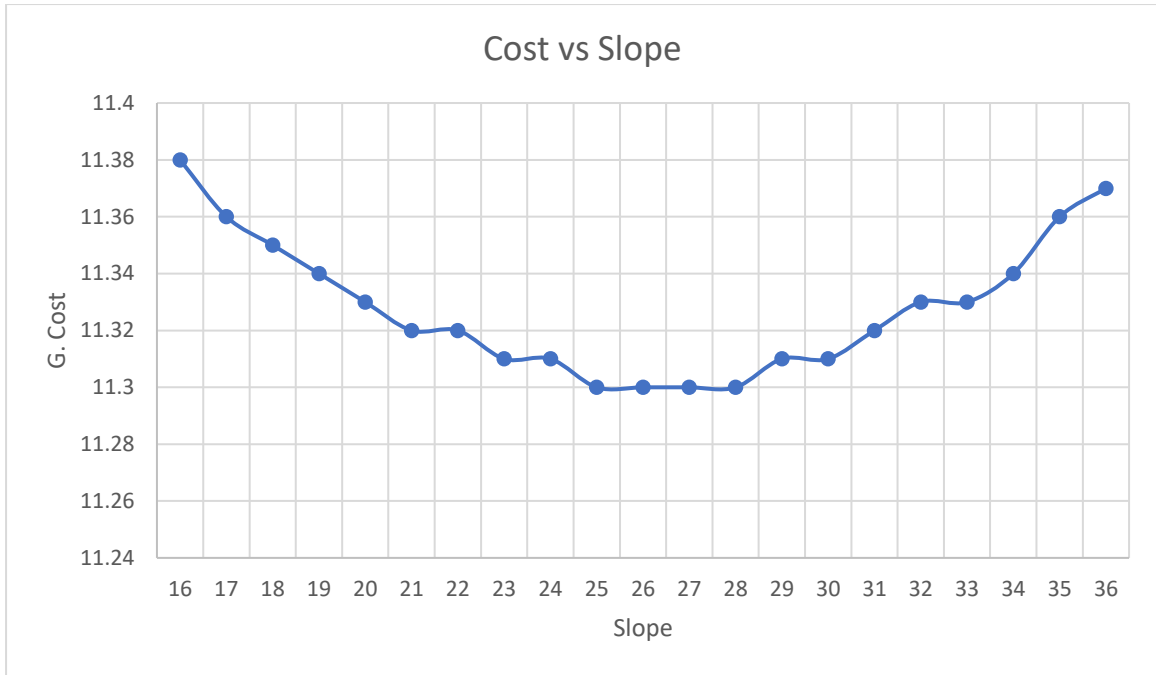
Graph 4.8(b): Slope Vs G. Cost (1degree azimuth for SHER)



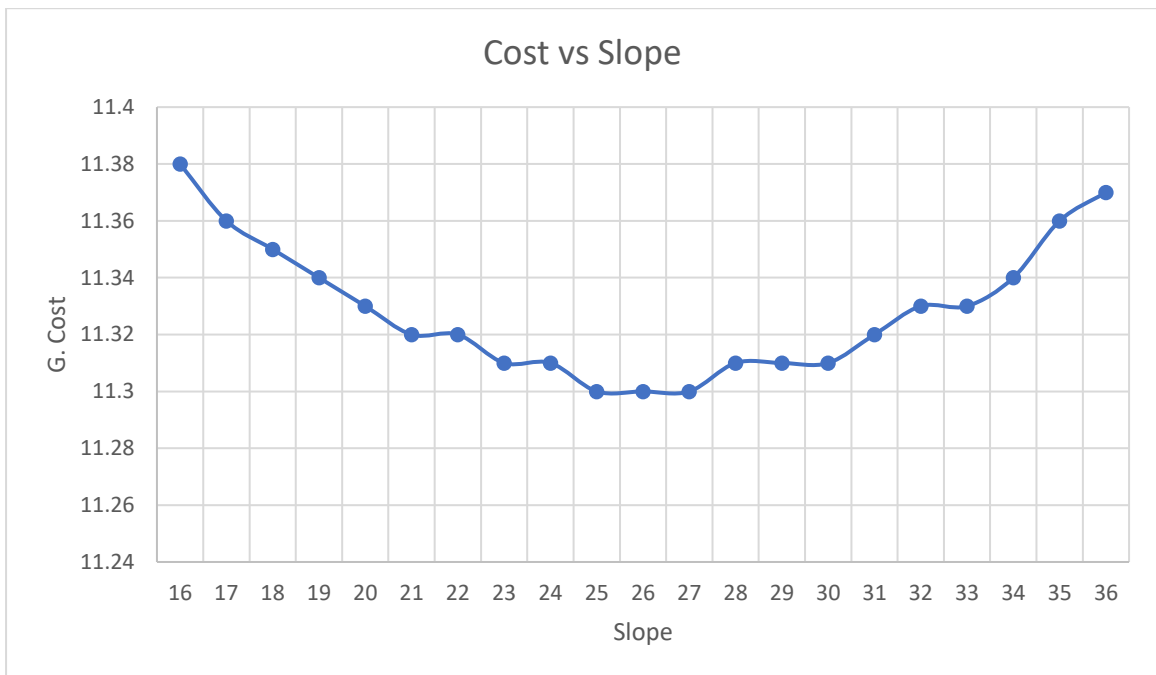
Graph 4.9(a): Slope Vs G. Cost (0degree azimuth for SYL)



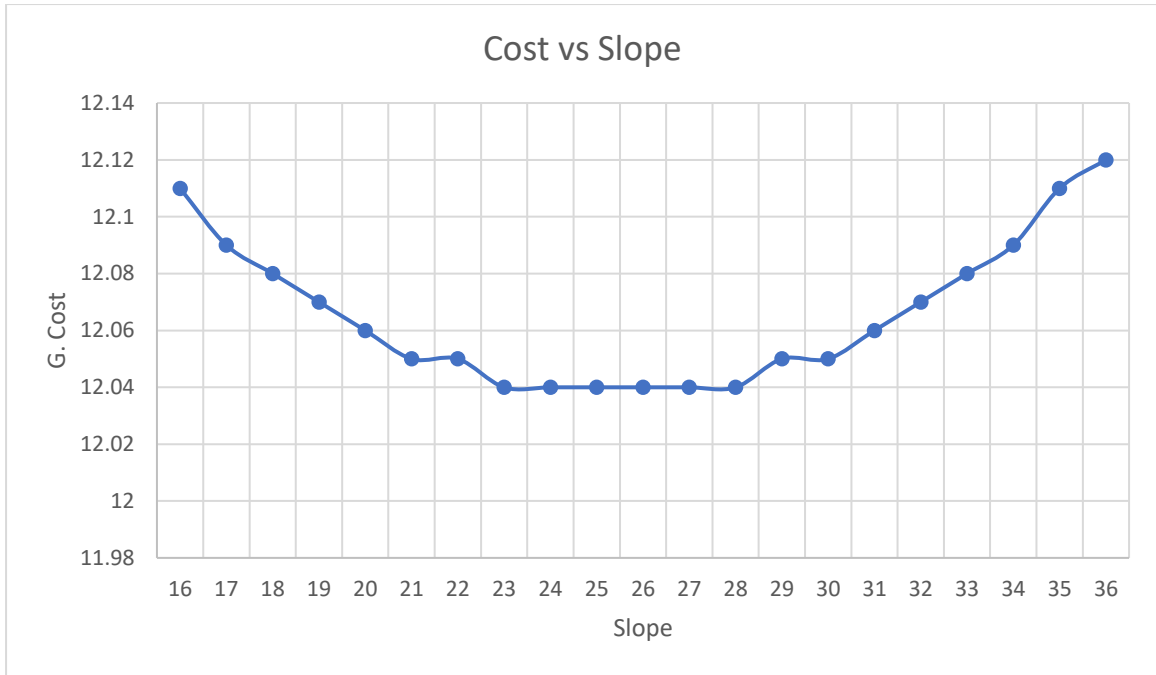
Graph 4.9(b): Slope Vs G. Cost (1degree azimuth for SYL)



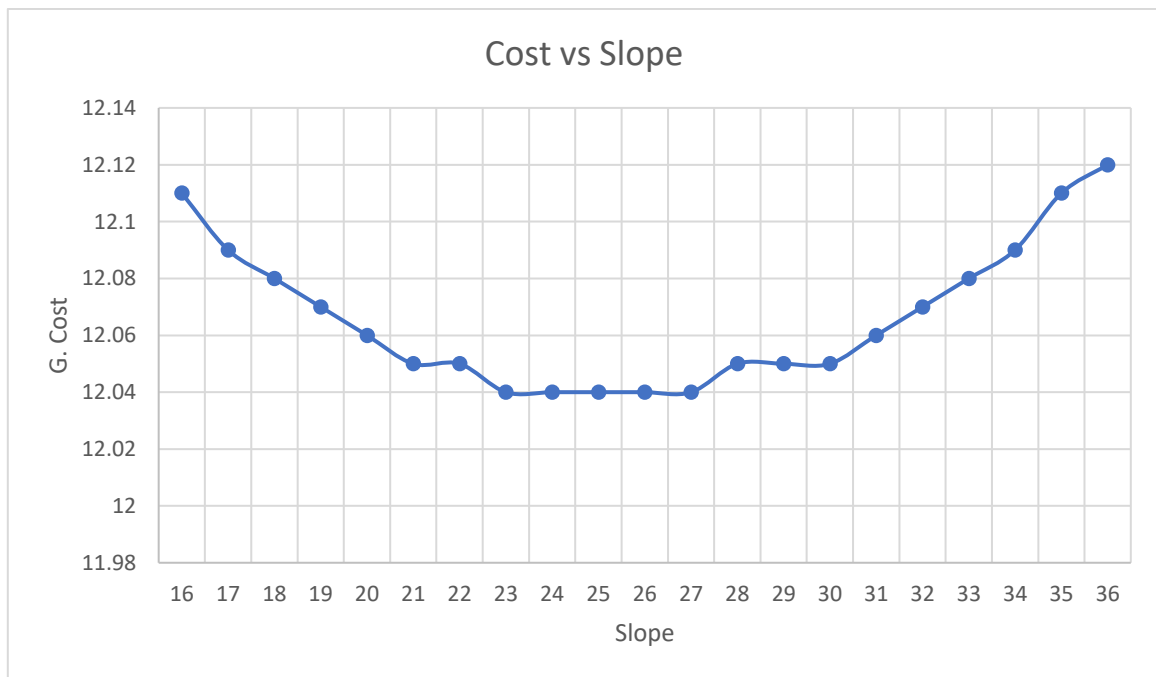
Graph 4.10(a): Slope Vs G. Cost (0degree azimuth for RAJ)



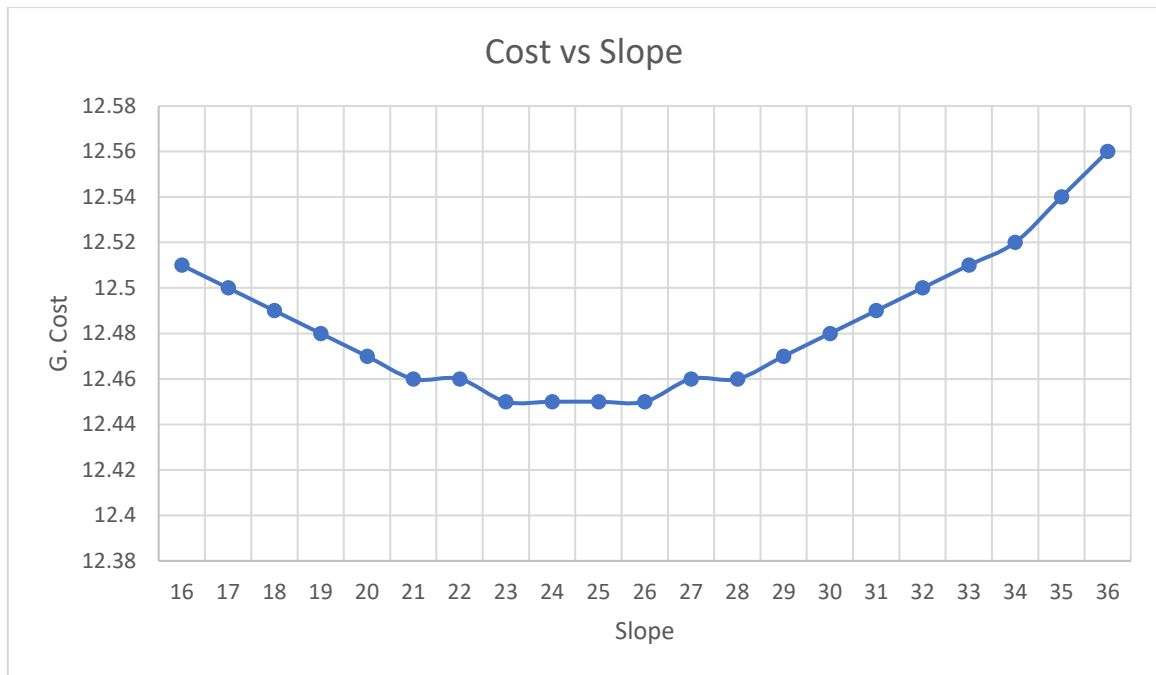
Graph 4.10(b): Slope Vs G. Cost (1degree azimuth for RAJ)



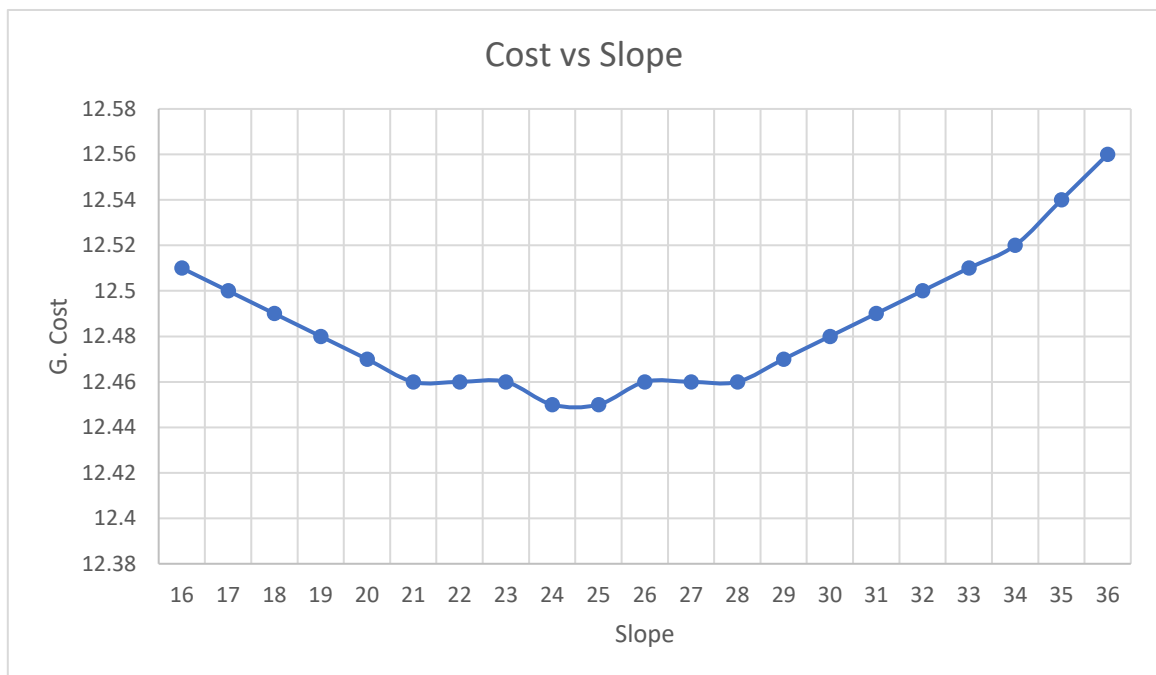
Graph 4.11(a): Slope Vs G. Cost (0degree azimuth for NARAG)



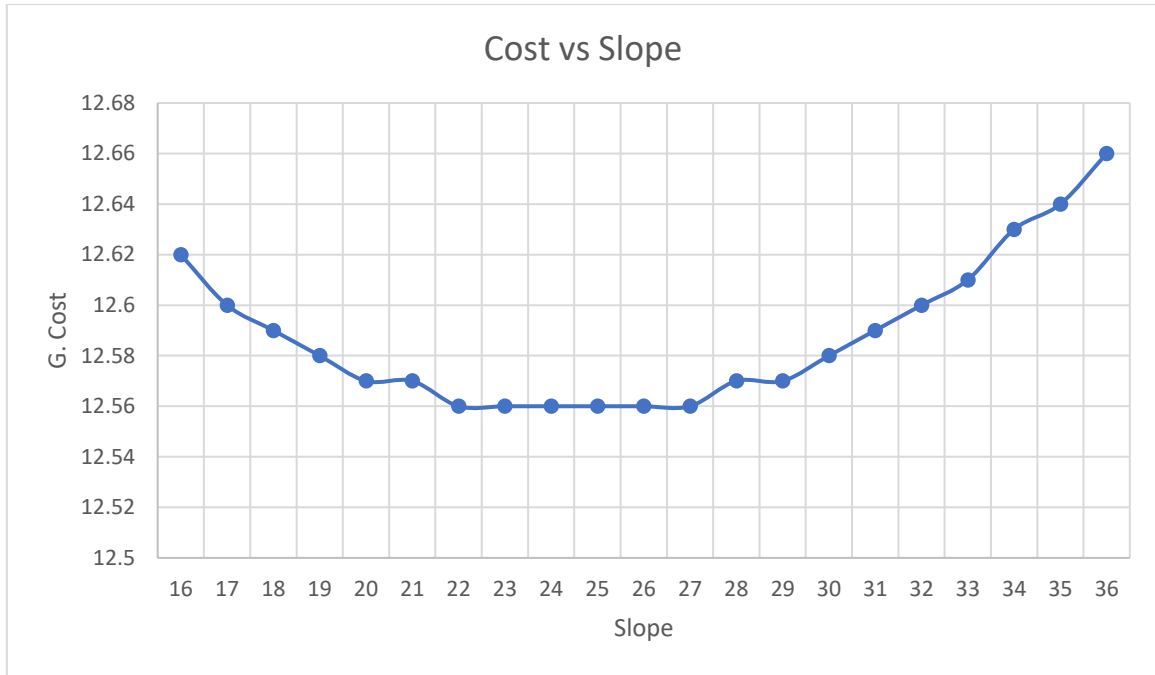
Graph 4.11(b): Slope Vs G. Cost (1degree azimuth for NARAG)



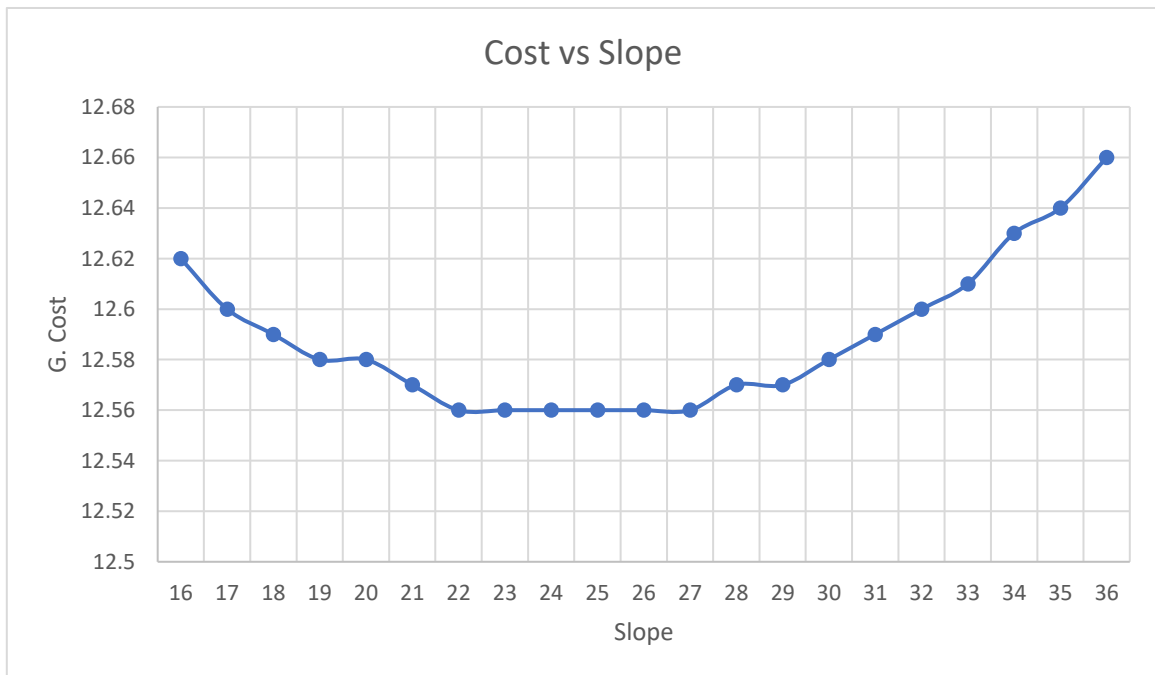
Graph 4.12(a): Slope Vs G. Cost (0degree azimuth for KHL)



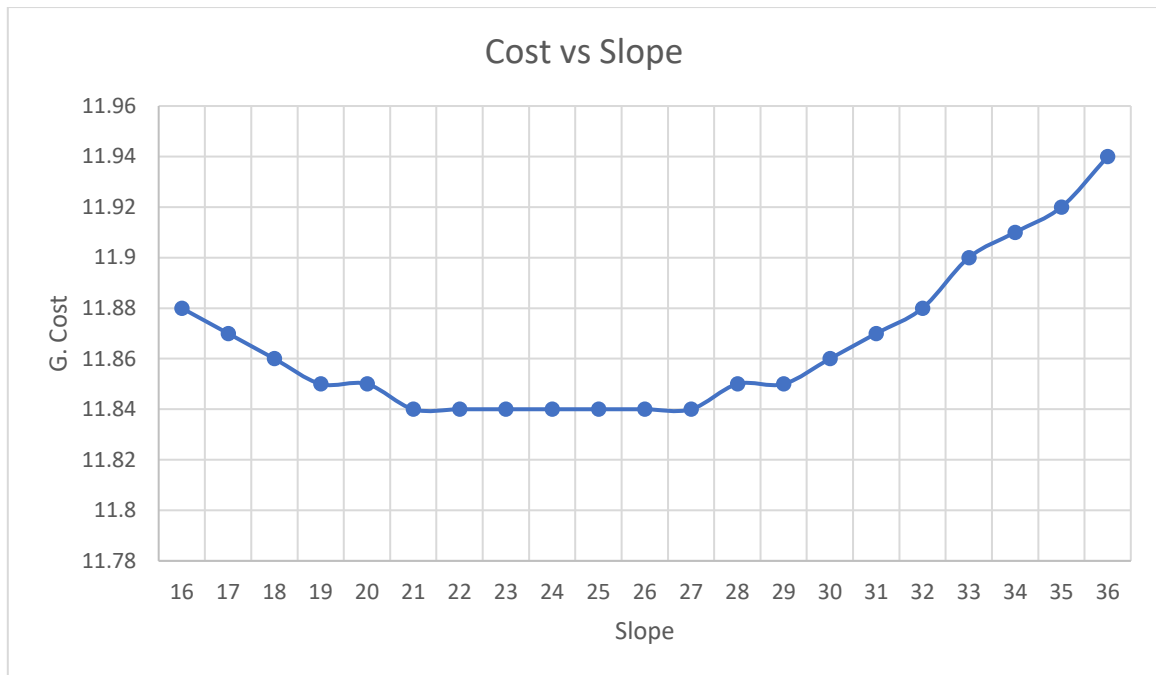
Graph 4.12(b): Slope Vs G. Cost (1degree azimuth for KHL)



Graph 4.13(a): Slope Vs G. Cost (0degree azimuth for BAR)



Graph 4.13(b): Slope Vs G. Cost (1degree azimuth for BAR)



Graph 4.14(a): Slope Vs G. Cost (0 degree azimuth for COX'S)



Graph 4.14(b): Slope Vs G. Cost (1 degree azimuth for COX'S)

From above discussion Azimuth and solar power plant Slope are 0 and 23 to 29 degree suitable for Bangladesh.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.0 Queries

Bangladesh is a booming nation with a total population of 164 million now with 7.2% GDP growth rate. Major impact of the electricity in the total GDP in Bangladesh. In all economies, households and companies have extensive demand for electricity. Electricity is a major source of energy in the industrial and agricultural sectors in Bangladesh. These two sectors collectively contribute to 50.3 percent of Bangladesh's GDP. To maintain the country's economic growth, electricity supply has to be reliable, uninterrupted as well affordable. Studies show that 17% renewable energy in total generation will bring great impact in total GDP of Bangladesh []. Under the Intended Nationally Determined Contribution (INDC) pledge to reduce greenhouse gas emissions by 5 per cent by 2030, the country plans to increase its share of renewable energy to 17 percent by 2041. There is huge scope for Renewable energy in Bangladesh but current solar generation is only 3% of total generation with 350 MW off-grid and on-grid capacity.

In this study, Sarishabari, generation cost of Jamalpur 3MWp solar power project has been analyzed as a benchmark and project data have been used for the same size facilities with other different locations in Bangladesh. Result reveals suitable location for photovoltaic power plant in Bangladesh in terms of highest yield and lowest generation cost per unit consider tracking the Azimuth and panel Slope angle. Minimum angle of the tracking system (slope) are contributing increase the electricity generation. The Benchmark value is 11.62 BDT/kWh (from Sarishabari, Jamalpur) and consider locations are Dinajpur, Rangpur, Bogra, Mymensingh, Sylhet, Rajshahi, Jessor, Khulna, Dhaka, Barisal, Chittagong, Captai, Cox's Bazar and Ramu. The generation cost for the considered location is

- **Dinajpur 10.76 BDT/kWh;**
- Rangpur 11.07 BDT/kWh;
- Bogra 11.60 BDT/kWh;
- Mymensingh 11.85 BDT/kWh;
- Sylhet 12.01 BDT/kWh;
- Rajshahi 11.30 BDT/kWh;
- Jessor 12.07 BDT/kWh;

- Khulna 12.45 BDT/kWh;
- Dhaka 12.03 BDT/kWh;
- Barisal 12.56 BDT/kWh;
- Chittagong 12.48 BDT/kWh;
- Captai 12.48 BDT/kWh;
- Cox's Bazar 11.84 BDT/kWh and
- Ramu 12.05 BDT/kWh.

It is seen that the Northern region of Bangladesh is more suitable for Photovoltaic power plant. Overall the study clearly indicates that location, Slope, Azimuth, etc. are paramount factors for successful operation of PV power plant as well generation.

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