الجامعة الإسلامية للتكنولوجيا
UNIVERSITE ISLAMIQUE DE TECHNOLOGIE
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DHAKA, BANGLADESH
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“Techno-economic assessment of stand-alone solar PV system at community Hospital”

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING Submitted as a thesis in partial fulfillment of the degree requirement by the electrical and electronic engineering department at the Islamic University of Technology (IUT).

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We hereby declare that the work reported in the B.Sc. thesis entitled **“Techno-economic assessment of stand-alone solar PV system at community Hospital”** submitted at **Islamic University of Technology (IUT),** Board Bazar, Gazipur, Bangladesh, is an authentic record of our work carried out under the supervision of **Mr. Muhammad**. We have not submitted this work elsewhere for any degree or diploma. We are fully responsible for the contents of our B.Sc. thesis.

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ACKNOWLEDGMENT

We would like to take advantage of this chance to offer our most heartfelt gratitude to everyone who has assisted us in successfully completing this thesis.

We would like to begin by extending our thanks to Mr. Muhammad sir, who oversaw the completion of our thesis and was a source of essential direction, patience, and experience throughout the whole of this project. Without his intelligent insights and unwavering support, it would not have been possible to pursue this particular path of investigation.

We would also like to take this opportunity to thank the staff at the community hospital, Somaliland for their willingness to cooperate and aid in providing me with the pertinent information and data for this investigation. We are grateful to them for their support in this matter. Their guidance and knowledge was really helpful in directing me towards a comprehension of the demands that are placed on the hospital's energy resources as well as the restrictions that are imposed by those resources. In addition, we would want to use this opportunity to extend our thanks to our families and friends, who have been a consistent source of support and encouragement for us throughout our pursuits in the academic world. Their never-ending love and steadfast encouragement have been our primary source of strength and motivation during this journey.

In closing, we would like to take advantage of this occasion to express our gratitude to each and every individual who has made a significant contribution to the expansion of the field of renewable energy, namely the technology of photovoltaic solar system expansion. Their studies and discoveries have paved the way for a future that is not just more sustainable but also more resilient. Despite the fact that we put in all of the work that was humanly possible, we would like to offer our sincere apologies in advance for any errors that may have been contained in this report.

Abstract

Solar photovoltaic (PV) systems are gaining in popularity as a direct response to the increased need for dependable and ecologically beneficial forms of electricity. In order to be able to provide the necessary services, essential facilities, and community hospitals in particular, we need to have a constant and reliable supply of electricity. The purpose of this thesis is to offer both a technical and economic study of a solar photovoltaic (PV) system that is built in a community hospital. The objective of this research is to ascertain not only the practicability of such a system from a monetary and a technological point of view but also the impact that it would have on the natural environment in the immediate vicinity. Conducting a literature review on solar photovoltaic (PV) technology and its application in hospitals and other types of medical institutions is the first thing that has to be done for this inquiry. The following thing that needs to be done is an exhaustive study of the energy needs of the local community hospital. This study should take into account the load profiles of the various appliances and pieces of equipment. After the appropriate size of the solar photovoltaic (PV) system has been estimated with the help of a system sizing tool, the system itself is modeled with simulation software.

The cost of the system during its whole life will be analyzed as part of the economic research. This will take into account the costs of purchasing the system, operating the system, and maintaining the system over the course of its lifetime. A cost-benefit analysis is performed so that it may be determined whether or not the project has the potential to be financially successful. This analysis takes into account the potential earnings that may be made by selling any excess energy back to the grid if it is available.

It was calculated that the cost of producing one kilowatt-hour of electricity using solar radiation was $0.456 per kilowatt-hour, with a total net current cost of $267729.42. When the prices of the various components were broken down and compared, it was found that batteries had the highest individual cost.

CHAPTER 1: INTRODUCTION

1.1 Introduction

An assessment of the technological and economic viability of a stand-alone solar photovoltaic system for a community hospital would involve determining whether or not it is possible, how much it would cost, and what the potential advantages would be. The following is a list of important factors to take into account when doing such an analysis:

1.1.1 Determining the Energy Demand of the Hospital

The first thing that would need to be done in the evaluation is to figure out the energy demand that the hospital has. This would necessitate conducting an analysis of the patterns of electricity use at the hospital, as well as peak loads and the power requirements for various pieces of equipment, lighting systems, and climate control systems.

1.1.2 Solar Resource Assessment

The following stage would be to evaluate the hospital's location in terms of its potential to make use of solar resources. In order to accomplish this, historical data on solar irradiance, weather patterns, and shading concerns that may have an impact on the operation of the solar PV system would need to be analyzed.

1.1.3 Design of the Solar PV System

In order to satisfy the healthcare facility's energy requirements, the solar PV system would be constructed after an analysis of the available solar resources and the energy demand. Solar panels, inverters, batteries, charge controllers, and any other components necessary to convert solar energy into electricity and store it for later use would all be included in the system.

1.1.4 Economic Analysis In the context of a techno-economic assessment

A cost-benefit analysis of the proposed solar PV system would include calculating the capital cost of the system, as well as its running and maintenance costs, as well as the savings that the hospital would realize by using solar energy rather than the grid's electricity would be included in this step. The analysis would also take into account other criteria such as the price of fuel for backup generators, the price of power from the grid, and any incentives or subsidies for which the hospital might be qualified.

1.1.5 Positive Effects on the Environment

A techno-economic analysis would take into account, in addition to the positive effects on the economy, the positive effects that using solar energy would have on the environment. This would entail a decrease in emissions of greenhouse gasses, an improvement in air quality, and less reliance on fuels that are derived from fossils.

1.2 Why we need energy

Energy is necessary for our bodies since it is used to power all of the different biological activities that occur in our bodies, such as breathing, digestion, and movement.

For the purpose of providing power to our homes and businesses: We rely on energy to provide power to our homes, buildings, and businesses so that we can run our appliances, lights, and machinery.

Energy is required to power all modes of transportation, including automobiles, buses, trains, and airplanes. This includes the energy needed to fuel transportation.

To produce electricity: Electricity is a crucial form of energy that is utilized in our day-to-day life to power electronic devices, appliances, and lighting.

Energy is a crucial economic growth driver since it is necessary for a wide variety of industrial processes, including manufacturing, transportation, and others. This means that economic growth can be driven by energy.

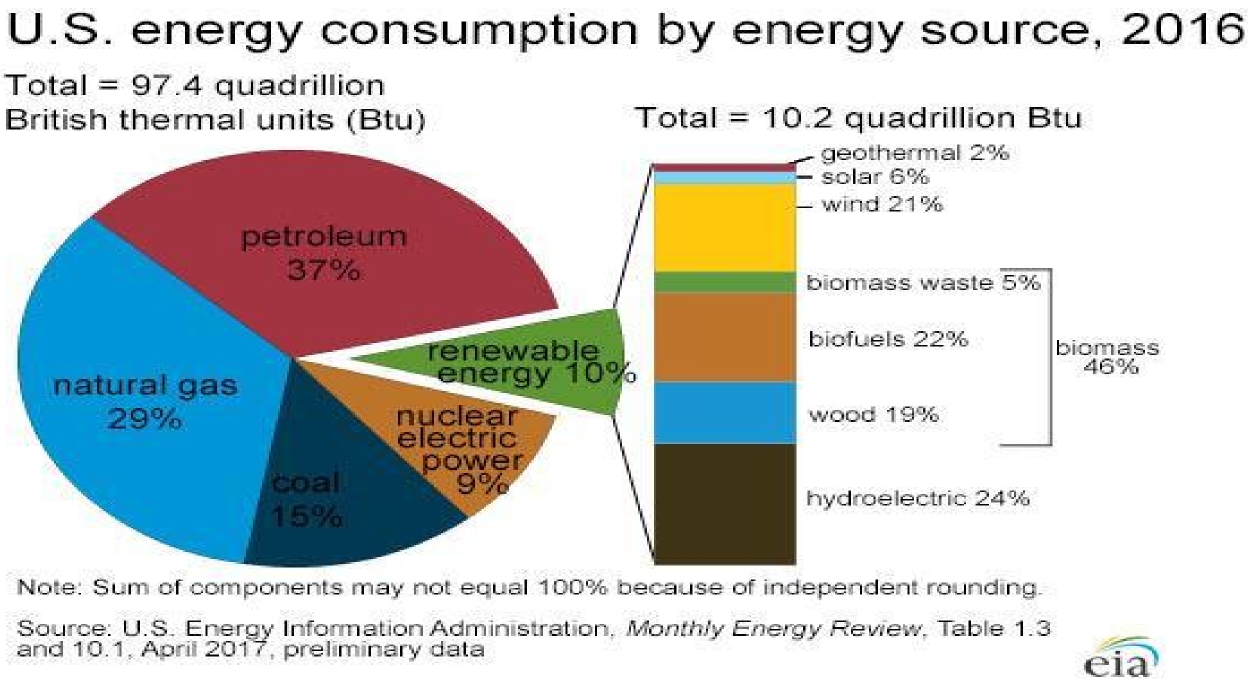


Fig:1 energy consumption

The above graph illustrates the various types of energy sources that are utilized throughout the United States. Approximately ninety percent of all the energy that was used came from nonrenewable sources. The most significant source of renewable energy, biomass, which includes wood, biofuels, and waste biomass, accounted for close to half of all forms of renewable energy and five percent of the overall energy consumption in the United States.

1.3 Definition: Renewable Energy

Energy that is generated from naturally renewing resources that may continue to be replaced or renewed is referred to as renewable energy. Some examples of renewable energy include solar power, wind power, hydro power, geothermal energy, and biomass. In contrast to non-renewable sources of energy such as fossil fuels, these types of energy are always accessible and do not run out over the course of time; as a result, they are said to be renewable. The use of traditional fossil fuels, which contribute to climate change and air pollution, is considered as an unsustainable and ecologically unfriendly alternative to the use of renewable energy, which is seen as both sustainable and environmentally benign.

1.4 Why it is important to use renewable energy

Renewable energy sources such as solar, wind, hydro, and geothermal power produce very little to no greenhouse gas emissions, which are a key contributor to climate change. Climate change can be mitigated by using these types of energy sources. We will be able to drastically lower our carbon footprint and help minimize the consequences of climate change if we make the switch to renewable energy sources.

Energy security is achieved by the use of renewable energy sources, which are readily available on a domestic scale and are less susceptible to price variations than nonrenewable energy sources, such as oil and natural gas, which are frequently the target of geopolitical disputes and price shifts.

Traditional fossil fuels such as coal and oil are major contributors to environmental pollution and the development of respiratory diseases, both of which have the potential to have a negative effect on public health. Renewable forms of energy release a negligible amount of contaminants into the atmosphere, which contributes to an overall improvement in the state of public health.

Economic Benefits The construction of infrastructure for renewable energy sources can result in the creation of new employment openings and the acceleration of economic growth. Households and companies both stand to benefit monetarily from the usage of renewable energy sources because of their potential to help bring down overall energy prices over the long run.

1.5 Solar energy

The rays of the sun are the source of the power that is referred to as solar energy. Solar energy is a form of energy that may be harnessed using solar panels or other technologies that convert sunlight into useful electricity or heat. It is a source of energy that is renewable and sustainable. Solar power is quickly becoming a mainstream alternative to conventional fossil fuels such as coal, oil, and gas due to its low environmental impact and competitive price point.

Solar power has a broad variety of potential uses, one of which is the generation of electricity for buildings as large as entire cities, as well as for individual houses and businesses. Additionally, it can be utilized for the heating of air and water, the propulsion of vehicles, and the provision of illumination in inaccessible regions.

Solar energy is a clean source of energy, meaning that it does not cause any emissions of greenhouse gasses or other hazardous pollutants. This is one of the most significant advantages of solar energy. Because of this, selecting this strategy to lessen our impact on the environment and fight climate change is an appealing alternative.

In spite of the numerous advantages it offers, broad adoption of solar energy is still hindered by a number of obstacles, including the high cost of installation and the inconsistent availability of sunlight. However, continual improvements in solar technology are helping to overcome these problems and make solar energy a more accessible and feasible choice for addressing our energy demands.

1.6 Solar photovoltaic

Solar photovoltaic technology, also known as solar PV technology, is a process that uses solar cells to convert sunlight directly into electricity. Semiconductor elements, such as silicon, are used in the construction of solar cells. These materials, when exposed to sunlight, take in photons and then release electrons, which results in the creation of an electric current.

Solar photovoltaic, or PV, systems can be as simple as home installations on a household scale or as complex as utility-scale solar power plants that feed electricity into the grid. The energy that is generated by solar photovoltaic systems can be put to use to power homes, companies, and other buildings, as well as applications that require power in remote locations, such as water pumps and telecommunications equipment.

The usage of solar photovoltaic (PV) technology has increased at a rapid rate over the past several years due to the environmental benefits it provides, such as lowering emissions of greenhouse gasses and lessening reliance on fossil fuels, as well as the fact that its prices have been steadily falling. Solar photovoltaic power is becoming increasingly competitive with traditional sources of electricity, which makes it an attractive option for many households and organizations who are wanting to minimize their carbon footprint as well as their energy bills.

Fig 2: A view of Solar panels

1.7 Solar thermal

The term "solar thermal" refers to a form of technology that makes use of the sun's rays to generate heat. This heat can then be put to use for a variety of reasons, including the generation of electricity and the heating of water for use in homes and businesses.

Solar thermal systems often fall into one of two categories:

Systems that utilize concentrated solar electricity (CSP): These devices concentrate the light of the sun onto a small area using mirrors or lenses. The concentrated light then heats up a fluid or gas. The heated fluid or gas is subsequently put to use in the process of turning a turbine, which results in the generation of electricity. In most cases, concentrated solar power (CSP) systems are implemented in large-scale power generation endeavors.

Solar water heating systems: These systems utilize flat-plate collectors or evacuated tube collectors to absorb sunlight and heat water, which can subsequently be utilized for a variety of purposes, including the heating of space, the delivery of hot water, and the heating of pools.

1.8 Characteristics of solar energy

Solar energy, also known as photovoltaic energy, is a type of renewable energy that comes from the sun's rays. The following is a list of some of the most important features of solar energy:

- ☐ An Abundance: The sun is the source of an incredible quantity of energy, and the amount of energy that travels from the sun to the earth in just one hour is sufficient to run every single device on the planet for an entire year.
- ☐ Free of hazardous Emissions and Pollutants: In contrast to fossil fuels, solar energy does not release any hazardous emissions of pollutants into the atmosphere during its generation.
- ☐ Solar energy has been more accessible and cost-effective in recent years due to the dramatic drop in the price of solar panels that has occurred over the course of the past several decades.
- ☐ Dependable: Solar panels are a dependable source of energy because they do not contain any moving components and require just a minimal amount of upkeep.

The quantity of solar energy that can be generated depends on the location, climate, and time of day, in addition to the angle and position of the solar panels. This determines how much solar energy can be harvested from the sun.

Solar power is intermittent since it is dependent on the presence of sunshine and so cannot be generated whenever it is needed. Because of this, it is possible that energy storage or backup systems will be necessary in order to guarantee a continuous supply of electricity.

Adaptable to a Wide Range of Energy Demands: Solar power may be adjusted to satisfy a wide range of energy demands, from the energy requirements of a single house to those of an entire city.

1.9 Why we need sustainable solar energy

The struggle over climate change is the fundamental impetus behind the shift toward the use of renewable energy sources such as solar power. The generation of electricity from fossil fuels is a significant contributor to the release of greenhouse gasses, which are the primary driver of global warming because they keep heat trapped in the earth's atmosphere. Solar energy is a clean, renewable form of energy that does not create any greenhouse gasses; as a result, it is an excellent alternative to fossil fuels in terms of both its environmental impact and its economic viability.

Energy Security Solar energy is a source of energy that is sourced domestically, which reduces dependence on sources of energy that come from other countries and increases energy security. This can help countries lessen their reliance on politically volatile or unstable regions for their energy supply, which can be beneficial.

Solar energy is becoming a more cost-competitive alternative to traditional energy sources as a result of major price reductions in solar panels and other equipment involved with their use over the past few years. Cost reductions can be attributed to several factors. Businesses and homeowners can reduce their overall energy expenses and save money on their monthly energy bills by putting solar panels in their properties.

The solar business is a fast expanding sector, and the adoption of sustainable solar energy has the potential to offer job opportunities in the manufacturing, installation, and maintenance of solar systems.

System Design and Simulation The first thing that has to be done is to design and simulate the solar PV system by making use of the required software tools that are offered by HOMER pro. The design needs to take into account the amount of energy that the hospital consumes, the amount of space that is available for PV installation, and the solar radiation profile in the area. During the simulation, you should assess the performance of the system and make estimates for the amount of energy produced, the capacity factor, and the levelized cost of electricity (LCOE). The economic analysis needs to consider the whole cost of the PV system, which includes the cost of the equipment, installation, and maintenance, as well as the financial incentives that are available for solar energy projects. These incentives include tax credits, grants, and rebates. During the course of the analysis, you should calculate the payback period, net present value, and internal rate of return in order to evaluate the financial viability of the system. Impact on the Environment The environmental impact assessment should analyze the system's environmental benefits, such as the reduction of greenhouse gas emissions and the conservation of energy. The evaluation should also take into account the photovoltaic system's possible effects on the surrounding environment, which may include land use, waste disposal, and end-of-life management. Evaluation of the System's Social advantages The evaluation of the system's social advantages should include increased healthcare services and a reduction in energy poverty. The evaluation needs to take into account the potential societal effects of the PV system as well, such as how well it is received in the community, how well it protects the public, and how many jobs it creates. Study of Sensitivity The sensitivity study should analyze the influence that various characteristics have on the system's performance and economic viability. These parameters include things like the size of the system, the amount of solar radiation, and the cost of the equipment. The analysis should help identify the important aspects that have an effect on the practicability of the system and provide insights into the risks and uncertainties associated with the project.

Recommendations Should the results of the above analysis be analyzed, the study should make recommendations on the ideal system design, financial structure, and implementation strategy for the stand-alone solar PV system at the community hospital. These recommendations should be based on the results of the analysis. The recommendations should provide project developers, policymakers, and other stakeholders with insights that can be put into action, and they should consider the many technical, economic, environmental, and social concerns.

CHAPTER 2: BACKGROUND STUDY

2.1 Introduction

The beginning of the Industrial Revolution marked the beginning of man's efforts to harness the enormous amounts of energy contained in natural resources such as coal, oil, and natural gas in order to generate electrical energy. Since that time, there has been nothing but a continuous and meteoric rise in the need for electrical energy. The amount of power used throughout the world reached 3084 kw/h per capita in 2013, which is an increase of 42.3% in comparison to 1990, a trend that is more prevalent among emerging economies [1]. The vast majority of this power comes from the combustion of a variety of fossil fuels. The use of fossil fuels depletes finite resources and causes irreparable harm to the natural world by contributing to the emission of a number of gasses that contribute to global warming. These gasses include carbon dioxide, nitrous oxide, methane, and others. As a result, an increasing number of nations are moving towards a power supply that is more environmentally friendly.

At the moment, solar electricity, wind power, geothermal power, and hydropower are some of the most significant sources of environmentally friendly energy. Figure 1 presents data relating to the usage of energy in countries all around the world.

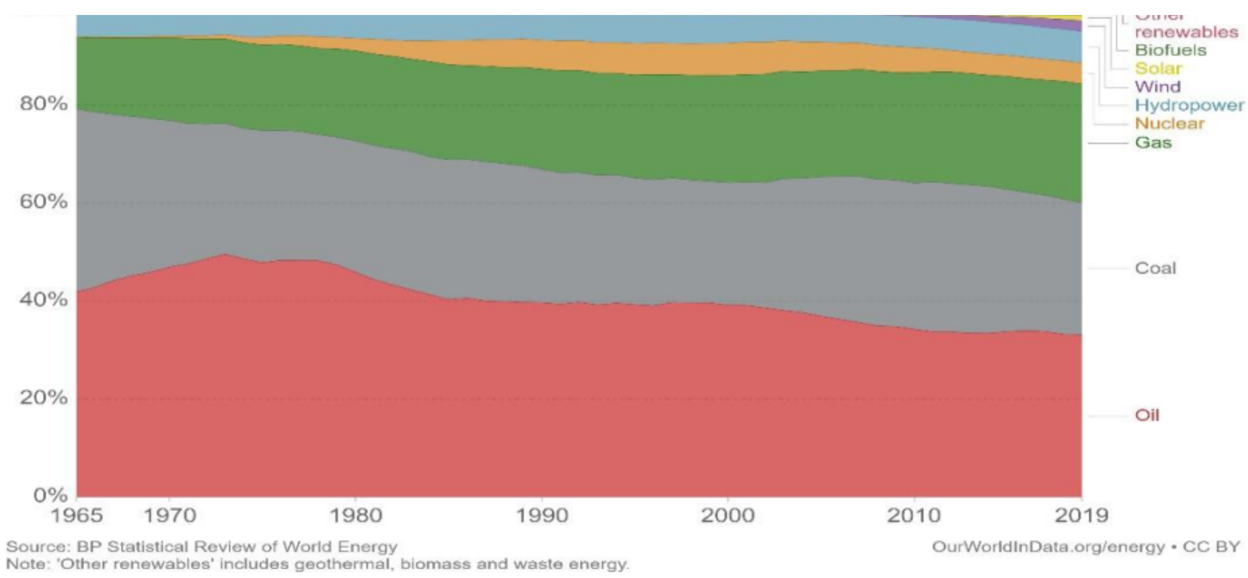


Fig 3. Global Statistics of Energy Consumption

Among all these, solar power is increasing in popularity due to ease of access, leading to lower costs for installation and operation, with tiny and medium-sized panels becoming more practicable for remote locations as well as for huge projects. So, there is a growing trend of putting remote solar panels to provide electricity in a certain area or structures.

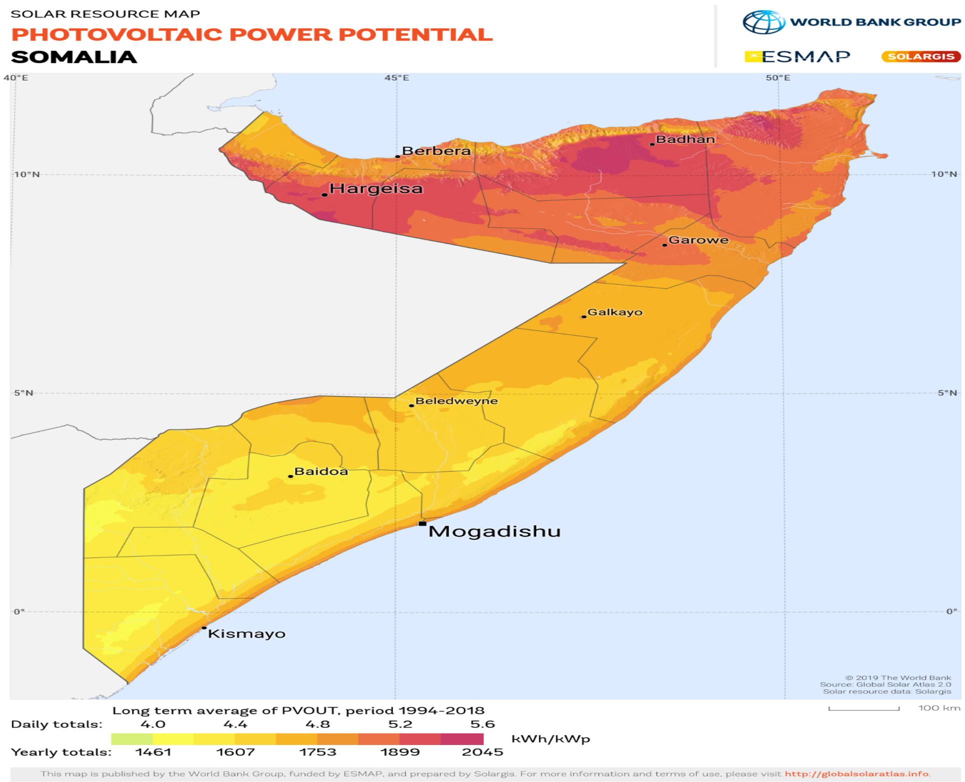
Among commercial buildings, hospitals are the greatest consumer of power per floor area [2]. From conducting numerous intricate surgeries to refrigerating critical vaccines and medicines and having effective life support systems, hospitals require constant access to energy for diverse heavy loads. Hence, hospitals changing to solar energy will be a big step for Bangladesh in its journey of moving towards sustainable energy.

2.2 Current energy statistics of Somaliland

In the years after the year 1991 when Somaliland gained its independence, just 20% of the population had access to a source of reliable electrical power.

There has been an incredible amount of development in the field of energy research and development ever since that time. Concurrently, the expansion of a wide variety of industries (including, for example, those involving textiles, cotton, and leather) has resulted in greater urbanization, which has led to an increase in the demand for energy. This demand has led to an increase in the price of energy. According to the report titled "Somalia: Increasing Access to Energy," as of the year 2015, the rate of electrification had reached 70 percent. This was done in an attempt to keep up with the growing demand for energy in the economy. As of the month of September 2019, the national grid of Bangladesh has the capacity to supply 21,419 MW of power correspondingly. Despite this, forecasts suggest that by the year 2030, the demand for energy will have increased to 34,000 MW in order to keep up with the GDP growth rate of over 7% [3].

At the time, fossil fuels, which were in short supply in Somaliland, are the primary contributor to the generation of power in the country. More than 80 percent of the electrical current that flows through the national grid is generated by natural gas [4]. As a direct consequence of this, Somaliland is forced to rely nearly exclusively on the meager domestic resources at its disposal in addition to external imports [5].



2.3 Global Status of Renewable Energy

With the goal of gradually switching to a cleaner source of energy, 145 nations have established a wide range of renewable energy assistance policies over the past 20 years. The amount invested in renewable energy annually as of 2015 was $270 billion [6]. Many nations have already achieved significant advancements in the area of renewable energy. Denmark wants to produce all of its electricity from renewable sources by 2035, whereas Germany wants to generate 80% of its electricity from them by 2050 [7]. 2019 saw the installation of the largest hospital solar PV project in the world at the Abdali Medical Centre in Jordan. The system produces 8.2 MW of electricity using 25,090 Philadelphia Solar Polycrystalline 325-W panels and Philadelphia Solar Mounting Structure options [8]. The $5.5 million NSW Health Solar Programme in New Wales, Australia, has installed solar panels at 37 healthcare facilities across the state. Through a $14.5 million enlarged solar conversion programme, nine ambulance stations and eight more hospitals were expected to save money and operate more efficiently. This project is anticipated to cut emissions by approximately 9,445 tonnes of CO_2 annually and save $2.6 million in energy costs.

CHAPTER 3: METHODOLOGY

Designing Systems and Running Simulations: The first thing that has to be done is to design and simulate the solar PV system by making use of the necessary software tools that are provided by HOMER pro. In order to do this, the first thing that needs to be done is to design the solar PV system. The design should take into account the quantity of energy that the hospital uses, the amount of space that is available for PV installation, and the solar radiation profile in the area. During the course of the simulation, you should evaluate the performance of the system and formulate estimations for the amount of energy produced, the capacity factor and the levelized cost of electricity (LCOE). Statistical Examination of the Economy The economic analysis needs to take into consideration the total cost of the PV system, which includes the cost of the equipment, installation, and maintenance. Additionally, the analysis needs to take into account the financial incentives that are available for solar energy projects. Tax credits, grants, and rebates are some examples of these types of incentives. In order to determine whether or not the system is financially feasible, you should perform calculations to determine its payback time, net present value, and internal rate of return all during the duration of the investigation. Influence on the surrounding natural environment The environmental impact assessment needs to include an analysis of the system's positive effects on the environment, such as the decrease in emissions of greenhouse gasses and the increased energy efficiency. In addition, the study needs to take into account the photovoltaic system's potential effects on the environment in its immediate vicinity. These consequences may include land use, waste disposal, and management of end-of-life issues. Consideration of the Contributions to Society Made by the System. The evaluation of the system's social advantages should take into account an increase in the availability of healthcare services as well as a reduction in the number of people living in energy poverty. The evaluation needs to take into account the potential societal implications of the PV system as well, such as how well it is received in the community, how well it protects the general public, and how much employment it provides . Investigation of or research into sensitivity. The sensitivity study's primary objective should be to investigate the impact that the system's myriad of attributes have on the system's capacity to function well and maintain a profitable business. In this context, "parameters" refers to factors like the size of the system, the amount of solar radiation, and the cost of the equipment and. The analysis should help identify the significant factors that have an effect on the practicability of the system and provide insights into the risks and uncertainties involved with the project. The study should also assist identify the essential components that have an influence on the practicability of the system.

Recommendations: In light of the findings of the analysis that were presented earlier, the research should provide some proposals for the most effective system design, financial structure, and implementation strategy for the stand-alone solar PV system that will be placed at the community hospital. The recommendations should provide project developers, legislators, and other stakeholders with insights that can be put into action, and they should consider the numerous technical, economic, environmental, and social considerations.

3.1 Basic workflow of our project

Collect data on the energy usage of the community hospital as well as the energy requirements of the facility. This includes the total amount of energy that is utilized in a single day, the peak demand for energy, and any other relevant data such as load profiles, energy pricing, and requirements for power quality. Determine the exact location of the medical facility and gather information about the climate, including the prevailing weather conditions, sun irradiance levels, and any other climate-related data that may be relevant in the situation. You will be able to generate a model of the solar photovoltaic system that is independent of any other system if you make use of HOMER Pro and enter the data that was acquired. At this point in the process, you will choose the components that will make up the system, such as solar modules, charge controllers, batteries, and inverters. Simulations should be done on the model in order to evaluate the performance of the system and decide whether or not it is technically and economically feasible. In order to accomplish this, an investigation into the system's energy generation, load matching, battery sizing, and any other performance indicators that may be pertinent must be carried out. Investigate the financial aspects of the system, such as the original investment, the continuous costs of running and maintaining it, and the prospect of any new revenue sources, such as selling any excess energy back to the grid. HOMER Pro is able to build comprehensive financial models, which can be of assistance when deciding whether or not the project will be lucrative. Make use of the results of the simulation and analysis to perfect the design of the system and determine its optimal configuration. This will ensure that the community hospital's energy requirements are satisfied while also optimizing the system's benefits in terms of both the economy and the environment.

3.2 HOMER software

The design and optimisation of microgrids and distributed energy systems can be achieved with the use of a software tool called HOMER (Hybrid Optimisation of Multiple Energy Resources). It was produced by the National Renewable Energy Laboratory (NREL), and you may obtain a free copy of it by downloading it from their website. If you are interested in learning more about it, visit their website.

Through the use of HOMER, users are able to model and simulate the operation of a wide variety of conventional and renewable energy resources. Solar, wind, hydroelectric, biomass, and diesel generators are all types of resources that fall under this category. The programme comes with a variety of features, including options for energy storage, load control strategies, and connections to the grid.

Users are given the freedom to define their own energy system configurations and objectives, such as minimizing costs to the greatest extent possible, maximizing reliability to the greatest extent possible, or minimizing greenhouse gas emissions to the greatest extent possible. Following this, an advanced optimisation algorithm is applied to the problem of determining the most effective approach to the design and operation of an energy system, taking into consideration the goals that have been given. This is done in order to solve the problem of determining the most effective approach.

In order to construct and evaluate microgrids and distributed energy systems, researchers, engineers, and policymakers make use of HOMER in a wide variety of different applications. Off-grid villages, military installations, island grids, commercial and industrial facilities, and other types of establishments are some examples of these applications.

3.3 Microgrid hybrid scheme

A microgrid hybrid system is a combination of many types of energy sources and storage systems that work together to supply a small local community with power in a dependable and efficient manner. This type of system is often used in developing countries. Components that are commonly involved in the operation scheme of a microgrid hybrid system include the following:

Renewable energy sources, also known as solar photovoltaic (PV) panels, wind turbines, and hydropower generators, as well as conventional energy sources, such as diesel generators and natural gas turbines, can be considered to be examples of energy sources. The system is able to switch between different sources based on the availability, demand, and cost of the respective option.

Energy storage: The microgrid hybrid system may contain several forms of energy storage technologies such as batteries, flywheels, or supercapacitors to store surplus energy created during periods of low demand and to supply backup power during periods of high demand or grid outage circumstances. These technologies are referred to together as "energy storage."

Power electronics: Devices that use power electronics, like inverters, converters, and controllers, are used to govern the flow of energy between the various components of the microgrid hybrid system. This helps to ensure that the system functions in an efficient and dependable manner.

Energy management system (EMS): A software-based system known as an EMS monitors and regulates a microgrid hybrid system in order to guarantee that it functions in the most efficient manner possible. The Energy Management System (EMS) makes decisions regarding which energy sources to use, when to charge or discharge storage systems, and how to balance energy demand and supply based on data that is collected in real time by sensors and other equipment.

Connection to the main power grid: A microgrid hybrid system can be connected to the main power grid, which enables the system to either import or export energy depending on the requirements. The microgrid has the capability of functioning in island mode, which allows it to continue supplying the neighborhood with electricity even when the main grid is down.

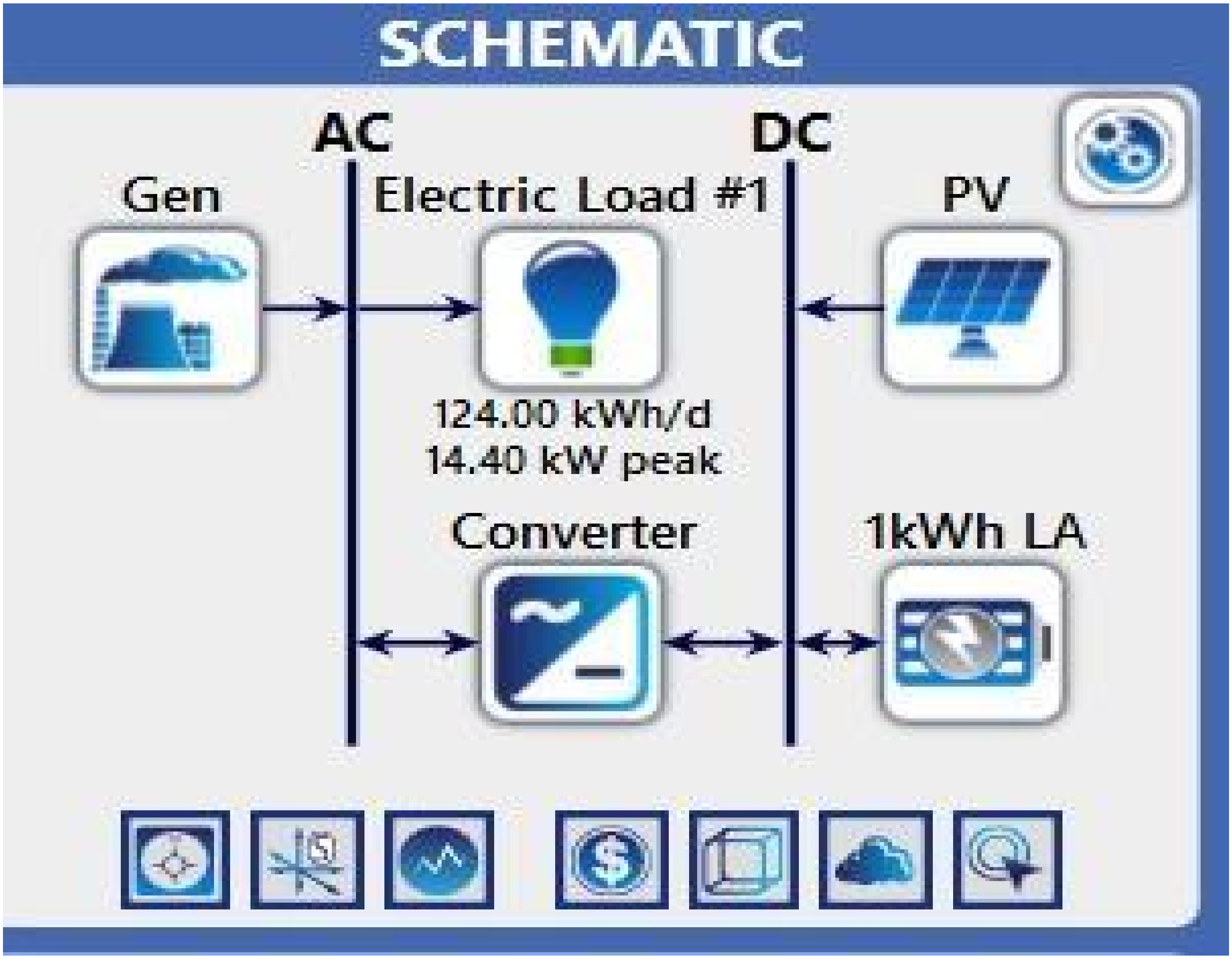


Fig 4: Schematic diagram of microgrid hybrid system

3.4 Input Parameters and System Components

3.4.1 Site Details

The location that has been chosen for our work may be found in waaheen, which is within Hargeisa, which is the capital and largest city of Somaliland.

The place that was chosen has the coordinates 9 degrees 33.6 north and 44 degrees 3.7 east. The old hospital is the structure that will serve as the inspiration for our new architectural concept.

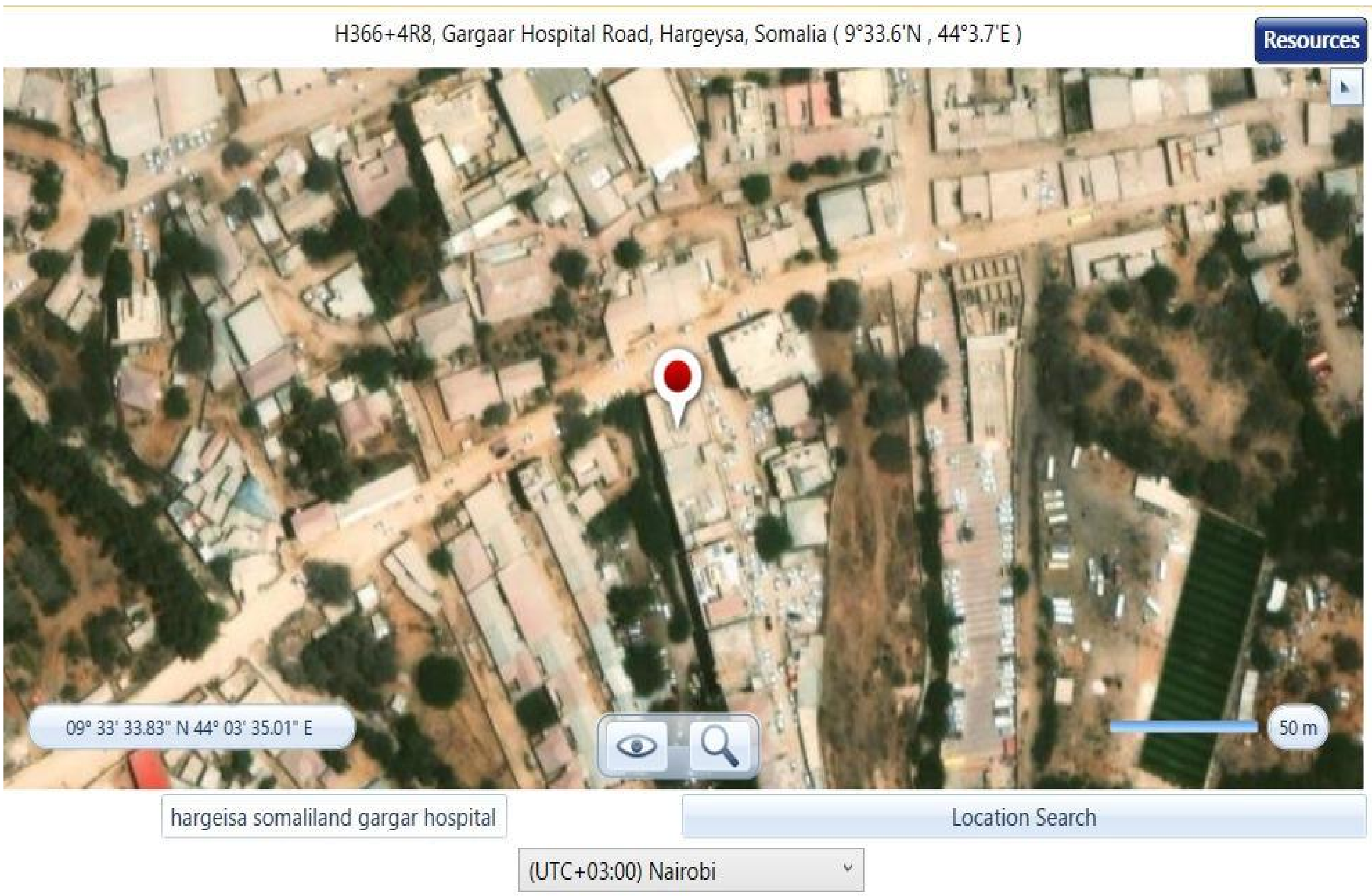


Fig 5: . Location of Gargaar Hospital

3.5 Medical Equipment

Table 1:Total Hourly Wattage

equipment	No of equipment	Power (w)	total power (W)
Wall fan	40	50	2000
Domestic refrigerator	3	100	300
microscope	1	20	20
Centrifuge	3	200	600
Centrifuge(mini)	2	25	50
Hematology analyzer	3	60	180
lighting	100	17	1700
Incubator	1	200	200
Suction machine	1	80	80
Surgery spot lights	4	50	200
X-ray machine	1	1000	1000
Laptop	1	60	60
Laptop	1	60	60
Computer	12	100	1200
Printer	12	10	120
AC	7	1000	7000
Water pump (mini)	4	750	3000
Water pump	1	2250	2250
GeneXpert Machine	1	190	190
Water heater	1	1000	1000
Pulse oximeter	4	30	120
Diathermy	1	100	100
Autoclave	2	2000	4000
Anesthetic machine	3	100	300
Vaccine refrigerator	5	50	250

3.6 Load Profile

A diagram called a load profile illustrates how the load that is placed on electrical equipment varies over a period of a specific amount of time. It would be good to find a daily load profile that plots the electrical consumption. This is because the load can alter depending on the time of day as well as the weather variance throughout the course of a single day. Again, the load will alter based on the time of year, the weather, and the growing need for electricity. Monthly and yearly load profiles are helpful tools that can be used in the planning and ultimate implementation of a solar power generation system, as well as in determining how the system will function over time. A load profile is able to provide an accurate estimation of the demand for power at a specific time of the day, month, or year. When we were collecting this information, we made sure to take into account the location of the old hospital building as well as its electrical system.

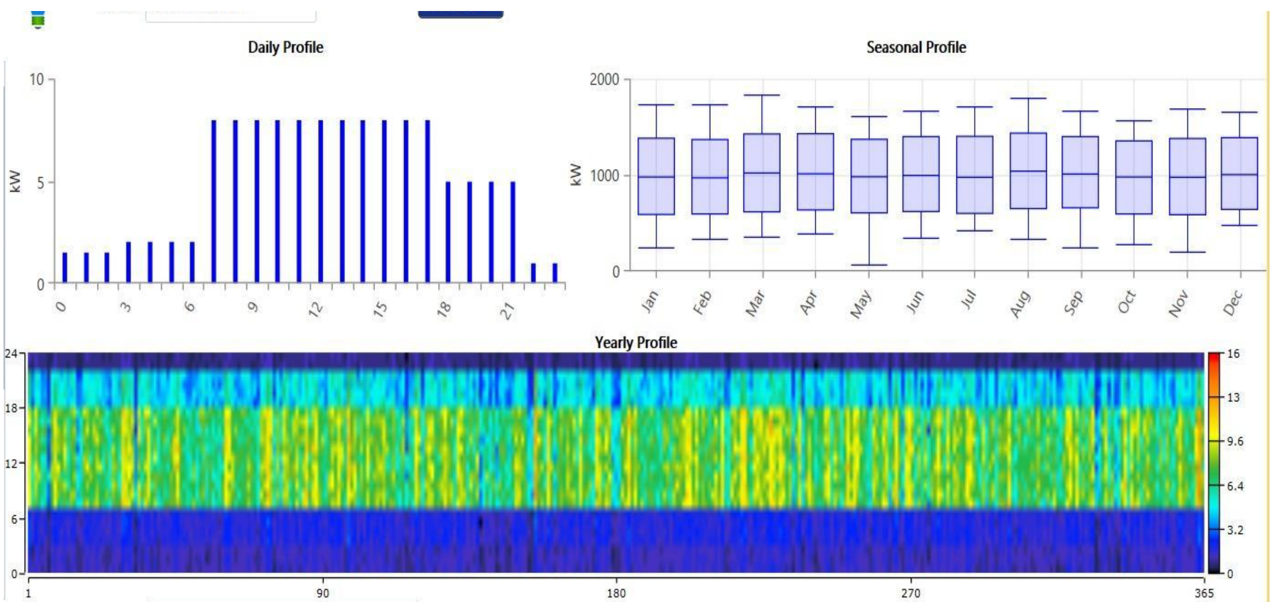


Fig:6 load profile

3.7 Yearly Load Data

The yearly load profile data helps hospitals to plan for the production and distribution of electricity. By understanding the patterns of electricity demand, they can adjust their production and distribution systems to ensure that they are able to meet the needs of their hospital while maintaining a reliable and stable of electricity.

Yearly Load Data

Weekdays Weekends

Hour	January	February	March	April	May	June	July	August	September	October	November	December
0	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
1	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
2	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
3	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
4	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
5	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
6	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
7	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
8	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
9	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
10	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
11	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
12	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
13	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
14	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
15	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
16	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
17	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
18	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
19	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
20	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
21	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
22	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Fig:7 Yearly load data

3.8 Solar Resources

The monthly average sun global horizontal irradiance (GHI) data and the clearness index data are the main solar resource data that Homer Pro deals with. NASA's solar energy and surface weather systems were used to get the necessary information.

Fig. 8 Solar Radiation Data and Clearness Index Data

Table2: Monthly Average Solar Global Horizontal Irradiance and Clearness Index Data

Month	Clearness index	Daily radiation (kw/h/m2 /day)
January	0.678	6.067
February	0.675	6.481
March	0.680	6.970
April	0.609	6.397
May	0.654	6.801
June	0.639	6.543
July	0.620	6.367
August	0.636	6.608
September	0.670	6.888
October	0.690	6.730
November	0.693	6.275
December	0.684	5.947

The clearness index indicates the clarity in the atmosphere. It is the ratio of the global horizontal irradiance and the extraterrestrial irradiance. Average solar radiation is calculated over a specific amount of area during a specific time; during this time, the total radiation is measured over that specific area to find the average solar radiation data.

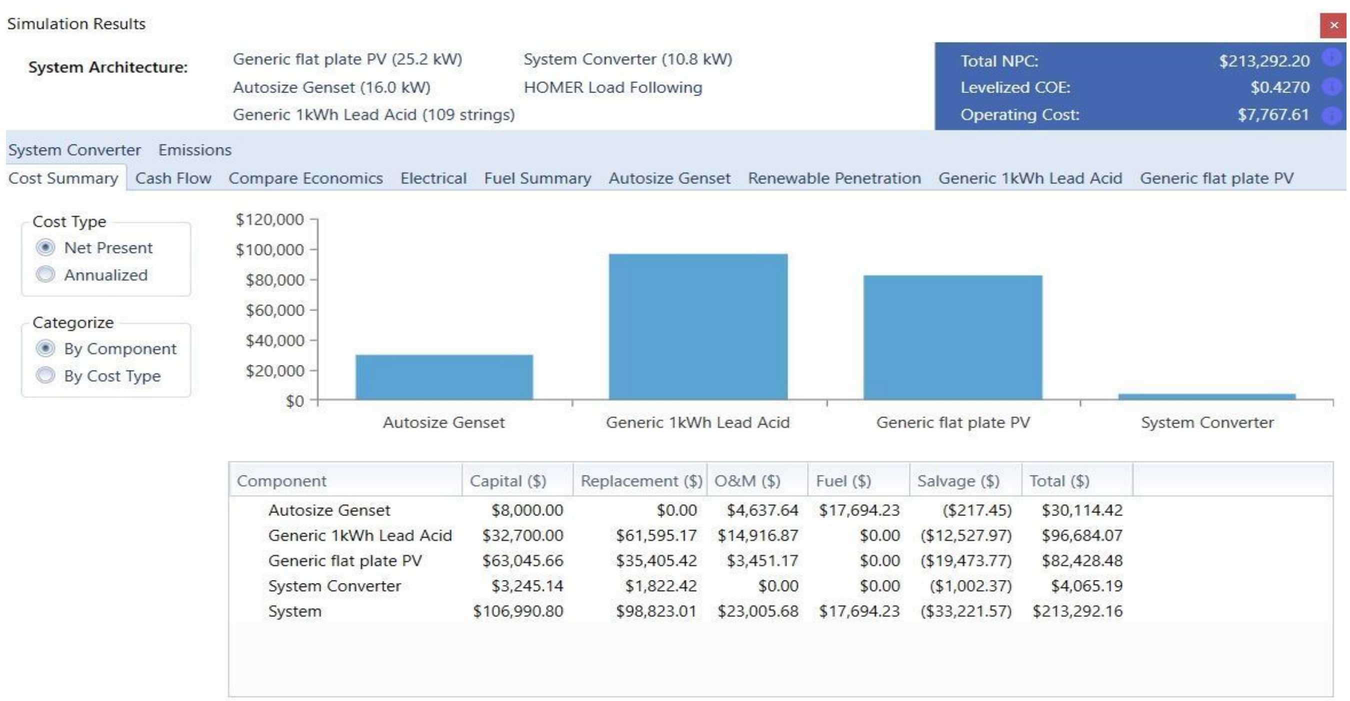
CHAPTER 4: RESULTS

4.1 Optimization results

The Optimization Results section gives us a list of all the suitable simulations for the selected model. The less feasible or profitable results are not shown. The optimized results are listed according to the type of system.

4.1.1 Cost summary

Our research indicates that the grid system has the highest operational and maintenance costs.Whenever we run a simulation in HOMER Pro and generate a cost summary report, the report will include a breakdown of the capital costs, operational costs, and revenue earned by the system over the course of its lifetime. In addition to this, the report will consist of metrics on the project such as its internal rate of return (IRR), levelized cost of energy (LCOE), and net present value (NPV).



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Autosize Genset	$8,000.00	$0.00	$4,637.64	$17,694.23	($217.45)	$30,114.42
Generic 1kWh Lead Acid	$32,700.00	$61,595.17	$14,916.87	$0.00	($12,527.97)	$96,684.07
Generic flat plate PV	$63,045.66	$35,405.42	$3,451.17	$0.00	($19,473.77)	$82,428.48
System Converter	$3,245.14	$1,822.42	$0.00	$0.00	($1,002.37)	$4,065.19
System	$106,990.80	$98,823.01	$23,005.68	$17,694.23	($33,221.57)	$213,292.16

Fig.9: Cost summary of hybrid grid system

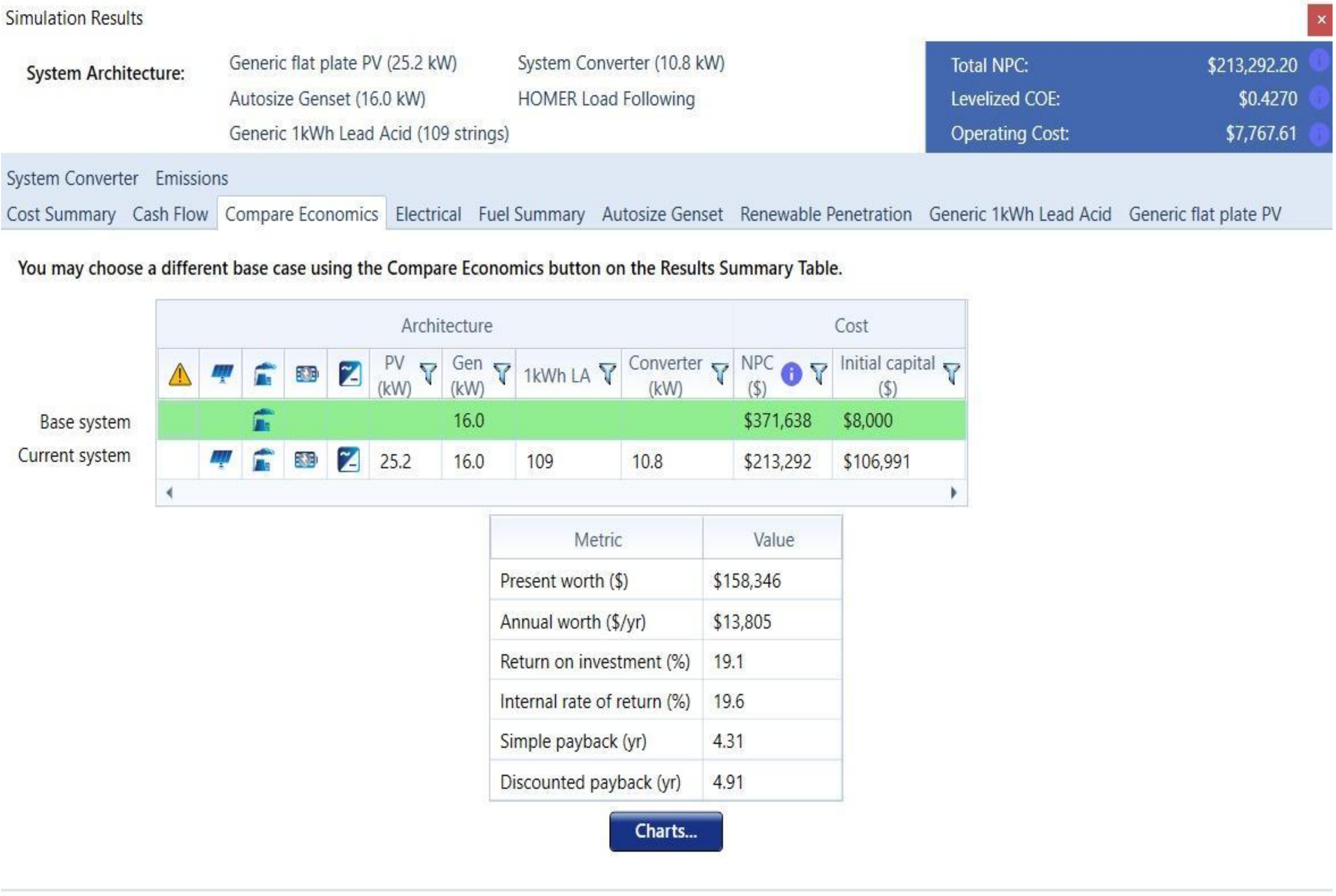


Fig: 10 The simulated financial parameters for the cost analysis of the hybrid system

This hospital is going through significant power rationing since there is not enough electricity generation, and this is most noticeable during the daylight hours of the working day. Because of this, there is a huge need for electricity, particularly during the day. This demand is particularly high. As a result, putting up a hybrid rooftop photovoltaic system would be a speedy solution to the problem of finding a reliable source of energy for the long run. The hybrid PV system that is currently being considered is able to supply clean energy on a daily basis, particularly during the day. Although photovoltaic technology is a reliable method for the production of renewable energy, the initial cost of the system is still significantly higher than the cost of the majority of other methods for the creation of electrical power. Because of the high cost of capital, power consumers, as well as public and private investors, are forced to contend with budgetary limits. This is especially true in developing and rising nations. Even though Somaliland has a very high population density, the nation's land is always in high demand, and the cost of land is a primary concern for the country. As a result, the cost of the land contributes further to the increase in the PV installation. Microgrid photovoltaic systems offer the possibility of avoiding the financial burden of battery banks, charge controllers, and other similar components. In addition, you can avoid the expense of purchasing land by constructing the system on a rooftop that already has accessible space. This results in a significant reduction in the total capital cost. The techno-economic studies that have been looked into could be of use to the administration of the hospitals in order to facilitate the installation of a rooftop microgrid system for medical facilities that makes use of competitive economic investment. Despite the fact that it is a relatively new phenomenon, the literature research phase of the case study for PV integration in Somaliland that was mentioned previously brought to light the large amount of capital expenditure associated with such medical applications.

4.2 The electricity generation rate

The yearly capacity is about 47,888 kW, which is also the system's entire load requirement.

Fig: 11 Monthly Average Electricity Production

4.3 DIESEL GENERATOR SIMULATION RESULT

The way a diesel generator works is by burning fuel in this instance, diesel to create electricity from mechanical energy. The diesel generator is regarded as the backup power source in this case. The PV panels will provide the electricity during the day, when the hospital has a high demand, as well as when there is enough solar radiation. The generator will provide the power at night or on cloudy days, when solar radiation is reduced.

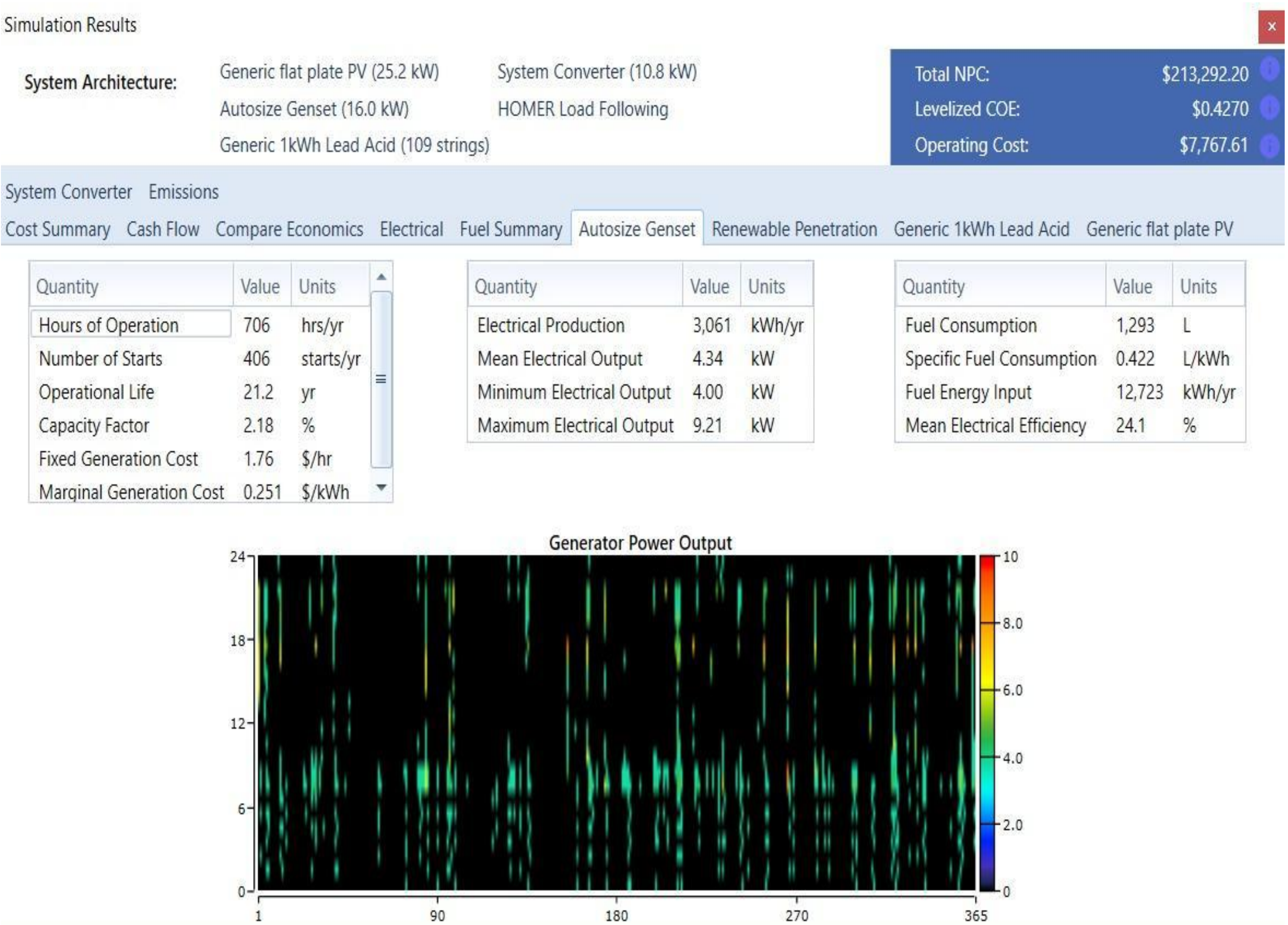


Fig: 12 Results for the Generator output Power

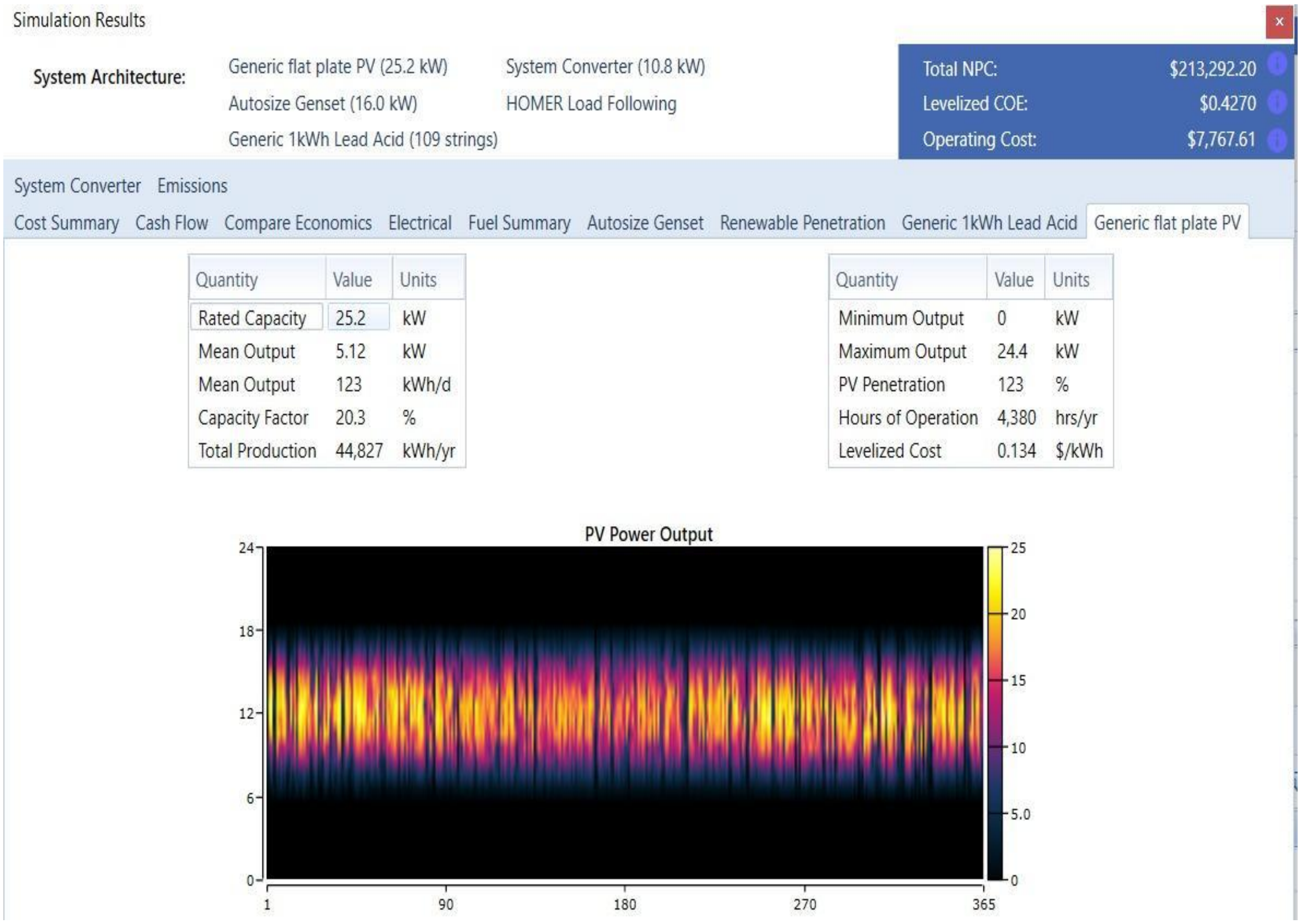
4.4 Simulation result for Batteries

Batteries are necessary for energy storage because the solar system cannot produce electricity at night because of a lack of solar radiation. For our work, we have chosen generic 1 kw/h lead acid batteries, which have enough energy storage to handle our design.

Fig:13 simulation result for the generic 1 kw/h lead acid

4.5 HOMER Pro simulation results for the generic flat-plate PV modules

Flat-plate PV modules are one of the most common types of solar panels used for generating electricity from sunlight. They consist of a flat surface made up of photovoltaic cells that convert sunlight into direct current (DC) electricity. The simulation results for flat-plate PV modules will depend on a variety of factors, including the specific brand and model of the module, the location and orientation of the solar array, and the weather conditions at the site. It's important to carefully analyze and interpret the results of any simulation to ensure that the system is designed and configured to maximize performance and minimize costs.



Simulation Results

System Architecture: Generic flat plate PV (25.2 kW) | System Converter (10.8 kW) | Autosize Genset (16.0 kW) | HOMER Load Following | Generic 1kWh Lead Acid (109 strings)

Total NPC: $213,292.20
Levelized COE: $0.4270
Operating Cost: $7,767.61

System Converter | Emissions

Cost Summary | Cash Flow | Compare Economics | Electrical | Fuel Summary | Autosize Genset | Renewable Penetration | Generic 1kWh Lead Acid | Generic flat plate PV

Quantity	Value	Units
Rated Capacity	25.2	kW
Mean Output	5.12	kW
Mean Output	123	kWh/d
Capacity Factor	20.3	%
Total Production	44,827	kWh/yr

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	24.4	kW
PV Penetration	123	%
Hours of Operation	4,380	hrs/yr
Levelized Cost	0.134	$/kWh

Fig: 14 Simulation Result for Generic flat plate PV

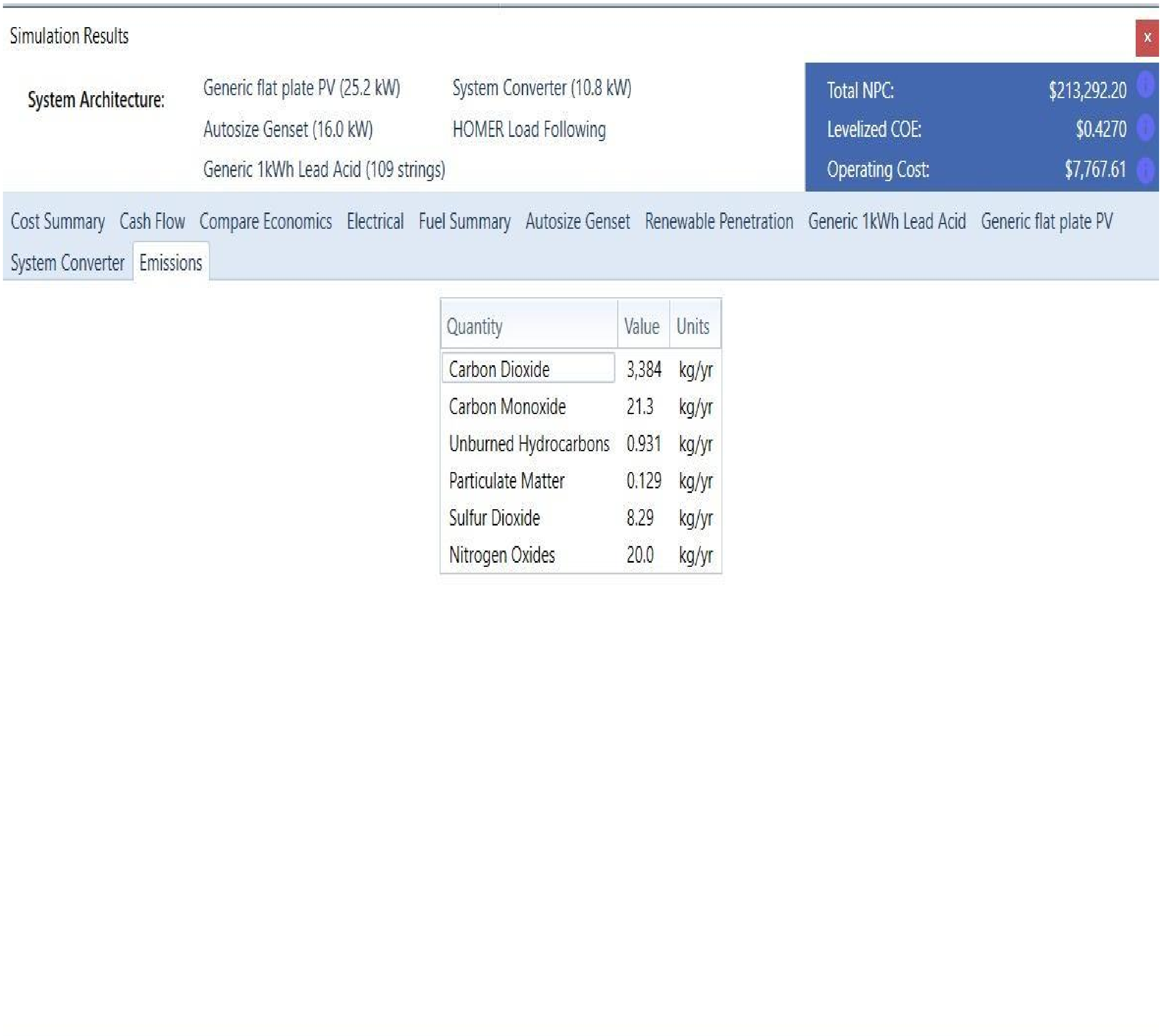
4.6 System converter

While the old hospital and the medical equipment run on alternating current, PV cells convert solar energy into direct current. Therefore, a converter is needed to convert the DC that the solar panels produce into AC.

Fig: 15 simulation result for the output for the system converter

4.7 Emissions

The emission of various gasses and other substances will be discussed in this figure.



Quantity	Value	Units
Carbon Dioxide	3,384	kg/yr
Carbon Monoxide	21.3	kg/yr
Unburned Hydrocarbons	0.931	kg/yr
Particulate Matter	0.129	kg/yr
Sulfur Dioxide	8.29	kg/yr
Nitrogen Oxides	20.0	kg/yr

Fig: 16 simulation results for emissions

4.8 Sensitivity cases

Under the direction of an established set of assumptions, sensitivity analysis establishes how the values of a variety of independent variables influence the behavior of a certain dependent variable. It does this by analyzing how different sources of uncertainty in a mathematical model contribute to the model's overall level of uncertainty.

The primary focus of sensitivity analysis is on the modification of a few input variables and the subsequent observation of the effect that this has on a few output parameters. We observed the corresponding response on COE and NPC and the electricity price, which means the cheapest price will be one dollar and the most expensive will be one and a half dollars.

Table 3. Sensitivity analysis

PROJECT LIFETIME (YEARS)	DIESEL FUEL PRICE	COE	NPC
20 yrs	1 $	$0.427	$213,292
25 yrs	1.18 $	$0.430	$218,903
20 yrs	1.2 $	$0.434	$248,681
25 yrs	1.3 $	$0.435	$250,347

2

CHAPTER 5: CONCLUSION

An independent solar photovoltaic system has the potential to supply a community hospital with a dependable and long-term source of energy, particularly in locations where there is either inconsistent or no access to the electrical grid. The energy demand of the hospital, which is decided by the equipment that is utilized, the number of patients, and the hours that the hospital is open, will determine the size of the solar PV system that will be installed. It is possible that the initial investment cost of a solar PV system that is stand-alone will be higher than the first investment cost of a system that is linked to the grid; however, the long-term benefits, such as cheaper operating expenses and energy independence, outweigh the initial expenditure. A stand-alone solar photovoltaic system requires meticulous preparation prior to its design and installation, including the selection of a site, the scale of the system, and the selection of its components. The economic sustainability of a solar photovoltaic system that is completely independent from the grid is contingent on a number of factors, including the price of energy purchased from the grid, the price of solar PV components, and the cost of both maintenance and operation. Stand-alone solar photovoltaic (PV) systems can become more financially viable for community hospitals, particularly in developing countries, with the help of incentives and subsidies offered by the government.

In conclusion, a solar photovoltaic system that operates independently has the potential to offer community hospitals a dependable and long-term source of electricity. Community hospitals, particularly those located in regions where there is unstable or no access to grid electricity, may find it to be a viable choice even though the initial investment cost may be higher because of the long-term benefits as well as the potential for government incentives and subsidies. The success of the system is entirely dependent on the careful preparation and implementation of the plan.

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