Dissertation

On

GREEN MICRO HYBRID POWER GENERATION

Submitted in partial fulfillment of the requirement for the award of the degree of

MASTER OF TECHNOLOGY in **ELECTRICAL ENGINEERING**

(With specialization in **Power System Engineering**)

Under

ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY

SESSION:2022-2024

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ABSTRACT

In a world facing rising electricity demands and environmental concerns, traditional energy sources are becoming unsustainable. Hybrid power generation emerges as a promising solution. This technology combines multiple energy sources, often renewables like solar and hydro, to create a more reliable and eco-friendly electricity supply. Hybrid systems surpass the limitations of single-source generation. They address the intermittency of renewables like solar (unavailable at night) by incorporating sources like hydro, which can operate 24/7. This flexibility ensures a more consistent and dependable power output. Hybrid power generation offers a cost-effective approach to meeting ever-increasing electricity demands. By combining renewable sources with potentially lower operating costs, hybrid systems can reduce dependency on expensive fossil fuels, leading to long-term economic benefits. This report delves into currently available hybrid power generation techniques, with a focus on the combination of micro-hydro and solar photovoltaic (PV) cells. It also contains the potential of hybrid power generation capacity in some selected sites inside Assam Engineering College campus at Jalukbari, Guwahati, Assam, India. By combining the available resources of micro-hydro and solar energy the total generation capacity is estimated. Both the systems work as stand alone systems.

ACKNOWLEDGMENT

The successful competition of this project would not have been possible without the valuable guidance provided by some experienced personalities. The overwhelming joy experienced throughout the project work was the sincere help I received from many personals and I acknowledge them with deep and heartfelt gratitude.

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We take this opportunity to thank all the faculty members of Assam Engineering College, who have directly or indirectly helped my project. I pay my respects and love to my parents and all other family members and friends for their love and encouragement throughout my career.

I thank all those persons who directly or indirectly helped me in making my project a success.

Manchuam Gohain [PG/E/22/09]

CERTIFICATE OF APPROVAL FROM THE SUPERVISOR

This is to certify that the work presented in this report entitled "**GREEN MICRO HYBRID POWER GENERATION**" is carried out by

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Further, the report has not been submitted/ reproduced in any form for the award of any other degree/diploma.

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TABLE OF CONTENTS

CHAPTER-1

INTRODUCTION

LITERATURE REVIEW:

Jamiu Omotayo Oladigbolu, Makbul A.M. Ramli and Yusuf A. Al-Turki [1] examined the possibility of providing off-grid electricity to a typical Nigerian rural village using hybrid solar photovoltaic (PV)/hydro/diesel/battery system. The optimized solution was selected by using the HOMER analysis tool. The simulation results showed that the hybrid PV solar/micro-hydro/diesel/battery storage was the most optimized solution and economic one. This system also showed better performances in terms of technical aspects making it ideal for rural electrification and for clean energy development.

Prateek Manjunath Naik, Sujithraj Y, Pradeep K Borannavar, Sudarshan M S [2] focused on the generation of electricity from Solar and Hydro power sources. They emphasized the need of hydro power which is a clean and renewable source of energy. Generation of hydro power can also control the running water during heavy rainfall which will also be a way of flood control, irrigation and water supply.

RamadoniSyahputra and Indah Soesanti [3] proposes the planning of micro hydro and solar photovoltaic system for the rural areas of Central Java, Indonesia. The research was conducted to determine the capacity of the hybrid system, load analysis and the optimal design of the hybrid micro-hydro and solar photovoltaic system. The results showed that the hybrid power generation were able to meet the local electricity demands and the excess power generated can be sold to the national grid.

RamadoniSyahputra and Indah Soesanti [4] discussed about the development of renewable energy in the rural area of Yogyakarta, Indonesia. They used the extended particle swarm optimization (PSO) technique. The final results of optimization were based on capital cost, grid sales, cost of energy, and net present value.

Nathan Lee, Ursula Grunwald, Evan Rosenlieb, Heather Mirletz, Alexandra Aznar, Robert Spencer and Sadie Cox [5] provided a review of the benefits associated with hybrid FPV-hydropower system. Their study showed significant global potential for FPV hybridized with hydropower in the range of 3.0 TW to 7.6 TW based on the assumptions made.

R. Rajesh Kanna and R. Raja Singh’s [6] analyzed the techno-economic feasibility and designed a framework for a rural hybrid energy system of a village in Assam, India. The optimizations were carried out using HOMER Pro software.

A.Selvanayakam, M.Suganya, B.Niranjana, N.Subhashini [7] tried to find suitable conditions in India for the development of solar-hydro hybrid power plant. Their hybrid system was developed to produce cost effective power and to increase renewable energy generation in India.

Susmita Bandyopadhyay, Vipina Valsan, Kanakasabapathy P [8] proposed a solar micro-hydro hybrid system. Th results showed that it can be implemented in the Amrita Micro-Hydro system alongwith the solar DC microgrid at a village called Komalikuddi in Idukki district.

Adikanda Parida, Bikuk Lomdak [9] conducted a case study of an educational institution. The findings of the case study has been utilized for the preparation of an energy chart from renewable energy. They used Micro-hydro and solar energy as the sources of renewable energy.

Alpesh Desai, Indrajit Mukhopadhyay and Abhijit Ray [10] analyzed a solar PV-hydro based picogrid. The total generation of energy was in the range of 1200-1500 kWh/kW/Year and with Capacity Utilization Factor 40%.

Emile Niringiyimana, Sun WanQuan and Giovanni Dushimimana [11] conducted feasibility study of a hybrid PV/hydroelectric system to connect more homes to electrical power in the district of Musanze, Rwanda. To design the hybrid system a100 kW PV array is tied to the already operational 200 Kw Mutobo micro hydro system. The results showed it to be viable solution in mitigating power shortage problem in the region.

Getnet ZewdeSomano, Getachew Shunki [12] suggested a 10 KW PV, 14 KW hydro, 14 KW converter and a 32 battery string as an optimized solution for meeting the electricity needs of MenkoToli, Euthiopia.

Solar Energy: Definition and History

In simple words the energy received from the Sun is known as Solar energy. The potential of solar energy is immense but its tapping has been a hurdle for many years. But recent technologies have made it possible. Still its use is limited. If the total amount of solar energy received by the earth is tapped and converted to electrical energy it would be more than enough for the current demand. Solar energy is the radiation received from the sun that is capable of producing heat and generating electricity. The solar PV cells receive the sunlight and convert it into electrical energy. The energy produced by the solar cells is stored in a battery. From the battery it is converted into ac by an inverter and from that the power is fed to household loads or fed into the grid. Solar energy can be of great help in the far-flung areas where grid connectivity is absent.

Human beings began using solar energy since the 7th Century B.C [17,18]. In the 1860s Augustin Mouchot [13,14] started developing technologies to trap the solar energy. Charles Fritts was the first person to install a rooftop photovoltaic solar array [15,16]. He installed it on a roof in New York City in 1884. But because of the rise of use of petroleum in the 20th century the development in the field of solar technology slowed down. It continued upto to the mid 1990s. After the mid 1990s the use of solar PV cells began to rise. Residential buildings, commercial buildings and even the power utility companies started installing solar PV cells. Till 2010 the growth of solar PV cells was mainly driven by the European countries but then it slowly started to grow in Asian countries like China and Japan and then to other parts of the world also. In 2022 the worldwide generation of solar power crossed 1TW for the first time [41]. According to estimates soon solar energy will surpass power generation from coal as the largest source of installed electrical energy [42].

In India the first PV cell was made in the year 1977. But the first solar power plant was inaugurated only in March 2012 in Naukh village in the state of Rajasthan. It was developed by Godawari Green Energy Limited [19]. Thereafter India has been rapidly increasing its installed capacity from solar power generation. As of 2023 the total installed capacity of solar is 73.31 GW. According 2022 report India stands 4th in terms of solar energy generation [20]. During the last five years India has increased its solar installed capacity from 21651 MW to 70096 MW. The largest solar power plant in the world is also located in India at a village called Bhadla [35] in Rajasthan's Jodhpur district.

Assam too has been rapidly increasing its solar capacity with some projects already commissioned and some upcoming projects. The first solar power plant was inaugurated on 19th July 2022 in Udalguri with an installed capacity of 25 MW [36]. A 70 MW solar plant has also been inaugurated at Amguri in Sivsagar district [37]. Some floating solar projects are also in the pipeline like the Sonbeel Floating Power Project [38]. There is also a plan for 1000 MW solar plant in the district of Karbi Anglong [39,40].

Micro-Hydro: Definition and History

Micro hydro power plants are small hydro power plants that have less capacity. Their capacity is less than 100 kilowatts. These micro hydro power plants are environment friendly. They don't require any large dams or reservoir to operate. They are mostly run-off-the-river power plants. Micro hydro power plants normally consist of a pressurized pipeline or penstock that runs into a turbine. The force of the water rotates the turbine and this in turn rotates the rotor of the generator thus producing electrical energy. The generated electricity can be fed into the grid or local households.

The earliest known use of water power was done by the Greeks some 2000 years ago to grind wheat into flour. The modern hydro power turbine was revolutionized by a French Hydraulic and Military engineer named Bernard Forest de Belidor in the mid1700s [29]. William Armstrong developed the world's first hydroelectric power scheme in 1878 at Cragside, England [21].

In India the first small hydroelectric power project of 130KW was commissioned in Darjeeling in 1897 [22]. The total installed capacity of India from small hydro power projects is 4.98 GW [23]. India's potential from small and mini hydro projects is estimated to be about 21.1 GW [23,28].

In Assam studies revealed that the state has a potential of about 202 MW from small hydro power projects [24]. Most of these sites have been found in Karbi Anglong and Dima Hasao Districts. The difficulty in reaching these places has been a hinderance to the execution of these projects. With these small and micro hydro projects remote villages which are otherwise not covered by grid connectivity can be electrified.

Hybrid Solar and Micro-Hydro

These unconventional and renewable sources of energy are not so reliable if working alone as their generation are constrained by time of the day and season of the year. For e.g during the night time the solar cells will not be able to generate electricity so their working is limited Similarly the micro hydro power plants will not be able to operate at its full capacity during the dry season since they do not have any reservoir. So the combined system of power generation is more reliable and efficient. Hybrid power generation of solar and micro hydro is a good combination since the combined generation can fill the gap if one of the generation systems is not generating up to its capacity. For instances during rainy season when the sun does not shine or are covered by clouds the solar cells will not be able to work to its full capacity. This deficiency can be met by the extra generation with the micro hydro power plants. Similarly during the dry season when there is less water in the streams and rivers the deficit generation of the micro hydro can be met by the solar cells.

Implementation of Hybrid Power Generation in India

India's first hybrid power plant is located in Jaisalmer, Rajasthan. It was commissioned on 28 May 2022 by Adani Hybrid Energy Jaisalmer One Limited, a subsidiary of Adani Green Energy Limited. It is a 390

MW [25,27] wind solar hybrid power plant. Adani Green Energy Limited has been constantly increasing its installed capacity through hybrid power plants. The world's largest Hybrid solar and wind power project is also located in Jaisalmer, Rajasthan. It is a 600 MW solar and 510 MW wind plant [25,27].

Overview of India's first Hybrid Power Plant: The project area consists of flat lands to uneven lands. It covers 12 villages mostly consisting of private and agricultural lands. The project required a total area of 2160 acre lands (1500 acre for solar plant and 276 acre for Wind Turbine Generators). 286.6acre land is required for external transmission line and remaining 97.4 acre of land is used for roads and other transmission lines.[26]

As the state of Assam is power deficit such type of hybrid projects could also be taken up in Assam. Since lot of barren lands are available in the state which are not fit for agricultural purpose.

Also till now no projects of hybrid power has been taken in Assam.

India's Power Scenario

India is the 5th largest economy in the world and the country with the largest population. So the electricity demand has been growing day by day. India's electricity demand rose by 7% in 2023, driven by rapid economic growth and increased space cooling needs. The annual average growth rate of 6.5% is expected between 2024-2026. India's electricity demand is projected to outpace China's by 2026 with the worlds fastest growth rate. Currently the peak hour demand of the country is 221.70 GW as of March 2024. The same was 208.92 GW in 2023 March 199.43 GW in 2022 March. The peak hour demand of the year 2023 was 243 GW. The peak hour demand is expected to be 260 GW for the year 2024.

This high demand of power is mainly met from the non renewable sources of energy. Bulk of the power is generated from coal. Power generation from coal was about 77% and natural gas 6.83% during the FY 2022-2023. So we can say that more than 80% of the total power demand is met from the fossil fuels. To meet the goal of Net Zero carbon emissions by 2070 India must decrease its dependence on fossil fuels. The total installed capacity of India is 428 GW as on 31/12/2023. The renewables contribute only 190.57 GW of power out of the total installed capacity as of March 2024. The breakup of the renewable energy contribution is as follows:

- Wind power: 45.88 GW
- Solar Power: 81.81 GW
- Biomass/Cogeneration: 10.35 GW
- Small Hydro Power: 5 GW
- Waste to Energy: 0.58 GW
- Large Hydro: 46.92 GW

The estimated potential of renewable energy in India is about 2109.7 GW. We can see that the actual utilization of renewable energy has been very less compared to its potential. To make a sustainable and ecofriendly earth the focus of energy production should be shifted towards renewables.

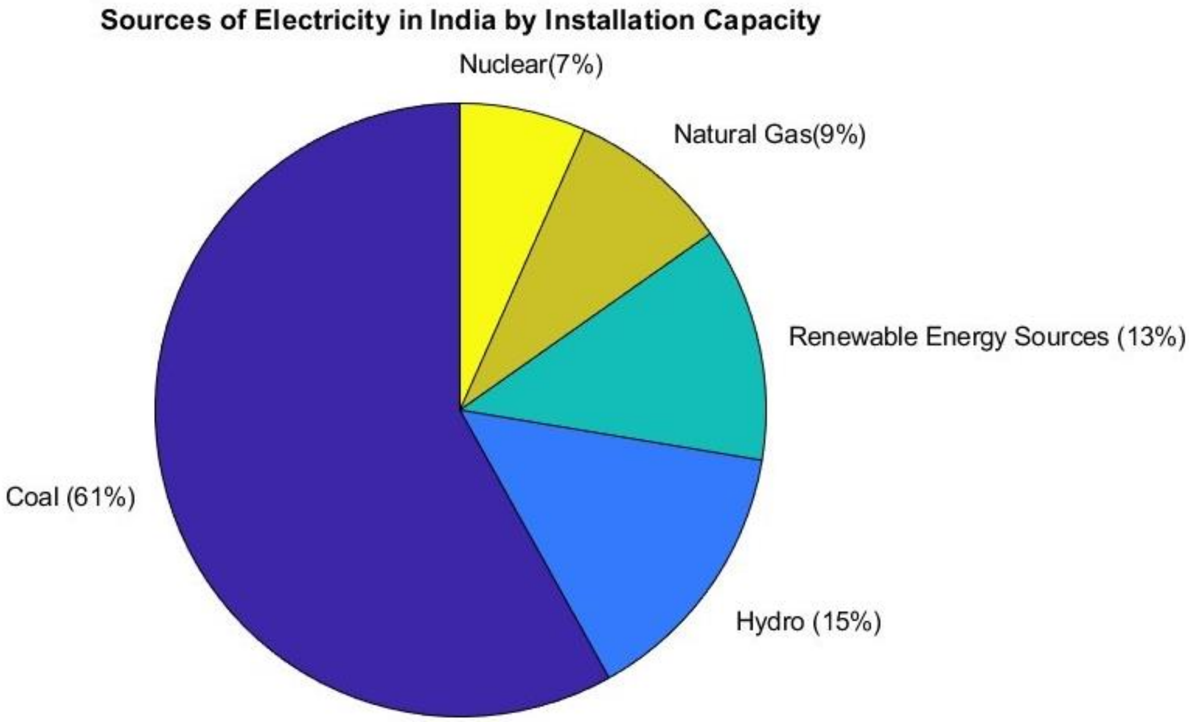

Fig 1: Pie Chart showing different sources electricity generation in India

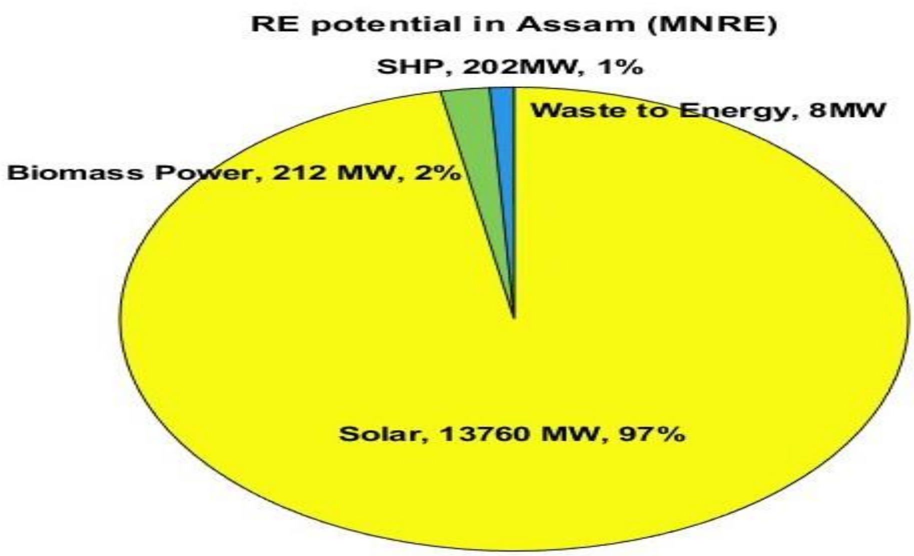

Fig 2: Pie Chart showing RE potential of Assam

Classification of Hydro Power Plants:

Hydroelectric power plants can be classified according to the generation capacity.

- **Large hydro power project**

Generation ranges above 100MW and usually feeding into a large electricity grid.

- **Medium hydro power project**

Generation ranges from 15MW-100MW and feeding an electricity grid.

- **Small hydro power project**

Generation ranges from 1MW-15MW and feeding an electricity grid.

- **Mini hydro power project**

Generation ranges above 100KW but below 1MW. They are either stand alone schemes or feeding a grid.

- **Micro hydro power project**

Generation ranges from 5KW to 100KW. They provide power to rural areas or small communities.

- **Pico hydro power project**

Generation ranges below 5KW. They provide power to individual home.

Suitable conditions for Micro-Hydro Power Plants:

The ideal geographical areas for exploiting small scale hydro schemes is where there are steep rivers flowing all year round. Islands with moist marine climates are also suitable. Low-head turbines have been developed for small-scale exploitation of rivers or irrigation canals where there is a small head but sufficient flow to provide adequate power.

To understand more about a suitable potential site, the hydrology of the site needs to be known and a site survey carried out so as to determine the actual flow and head data. Hydrological information is easily accessible from the metrological or irrigation department of the particular national government. Site surveys usually give a more detailed information of the site conditions to allow power calculation to be done and design work to begin.

General Principles of MHP:

Power generation from water depends upon a combination of head and flow. Both must be available to produce electricity. Water is diverted from a stream into a pipeline, where it is directed downhill and through the turbine (flow). The vertical drop (head) creates pressure at the bottom end of the pipeline. The pressurized water emerging from the end of the pipe creates the force that drives the turbine. The turbine in turn drives the generator where electrical power is produced. More flow or more head produces more electricity. Electrical power output will always be slightly less than water power input due to turbine and system inefficiencies.

Water pressure or Head is created by the difference in elevation between the water intake and the turbine. Head can be expressed as vertical distance (feet or meters), or as pressure, such as pounds per square inch (psi). Net head is the pressure available at the turbine when water is flowing, which will always be less than the pressure when the water flow is turned of (static head), due to the friction between the water and the pipe. Pipeline diameter also has an effect on net head.

Flow is quantity of water available, and is expressed as volume per unit of time, such as gallons per minute (gpm), cubic metres per second (m3/s), or litres per minute (lpm). Design flow is the maximum flow for which the hydro system is designed. It will likely be less than the maximum flow of the stream (especially during the rainy season), more than the minimum flow, and a compromise between potential electrical output and system cost.

Power Derived from MHP:

To calculate the power derived from a Micro Hydel Power Plant it is necessary to know the flow rate of the water and the available head.

The flow rate of water gives the amount of water which can be diverted through an intake into the pipeline in a certain amount of time. This is normally expressed in cubic meters per second (m3/s) or in litres per second (l/s).

Head is the vertical difference in level (in meters) through which the water falls down. The theoretical power (P) available from a given head of water is in exact proportion to the head and the quantity of water available. The calculation of power can be done with the help of following equation.

Hydroelectric power is a function of the Height and Volume

$$P=\eta\rho Qgh$$

- *P is power*
- *η is the dimensionless efficiency of the turbine*
- *ρ is the density of water (1000 kg/m^3)*
- *Q is the volumetric flow rate (m^3/s)*
- *g is the acceleration due to gravity (9.8 m/s^2)*
- *h is the height difference between inlet and outlet (m)*

The available mechanical power will be converted into electrical power by the generator.

Losses in MHP:

Losses can be broken down in terms of:

(i) **Incomplete extraction of available water energy**- sometimes all the water available may not be utilized for generation purpose because of constructional deficiency or flow disturbances. Problems may arise in the intake and in the pipeline.

ii) **Water energy loss from wall friction**- the walls of the pipeline provide friction to the flow of water which ultimately decreases the flow rate.

iii) **Turbine losses**- there may be losses in the turbine, generally turbine efficiencies are in between 80-95 percent.

iv) **Mechanical losses between the turbine and generator systems**- losses may occur in the shaft due to friction as it is a rotating equipment.

v) **Losses from generator inefficiencies**- generator efficiencies are normally considered to be around 90 percent.

Losses in Solar PV Scheme:

The different forms of losses in a Solar PV scheme are:

i) **Nameplate losses**: These are the losses associated with the solar module. This is the loss due the difference in stated power of the module compared to how it actually works at the standard conditions.

ii) **Inverter losses:** Though the inverter losses had reduced many fold but still some losses are associated with it.

iii) **Battery Losses:** There are some losses in the battery also.

iv) **Solar panel mismatch losses:** When two or more solar panels are connected in an array they may produce differing amounts of energy there is a mismatch between the solar modules.

v) **Thermal losses:** A solar cell loses 0.5% of its output for every 1 degree C above the STC-rated temperature of 25 degrees C, making this one of the largest losses in energy. This loss is due to an intrinsic feature of the solar cell construction.

vi) **Low radiation loss:** This shows the reduction in efficiency when the irradiance is decreased from the STC rating (Standard test Conditions) of 1000W/m2 to a low irradiance of 200W/m2. It is averaged out for practical reasons at 1.5 percent.

vii) **Dust loss:** This loss occurs when dust gathers above the solar panels. It accounts for about 2 percent loss in power generation.

viii) **Shading loss:** Blocking of the sunlight from reaching the panel is known as shading. It decreases the maximum output of the panel.

CHAPTER-2

COMPONENTS REQUIRED

Components of a Micro Hydro Power Scheme:

The micro hydropower plant is a renewable energy plant which has many advantages over the same size of wind and solar renewable energy plants. It has a high efficiency (up to 90%), high capacity factor (up to 60%) and slow rate of change (as the water flow varies gradually from time to time). This section covers suitable selection of the micro hydropower plant components such as turbine type, which is the main part in the plant and the generator size and capacity, which is the second main component in the plant.

1) CIVIL WORKS

A micro hydropower station essentially needs water to be diverted from the stream and brought to the turbines without losing the elevation/head. Given below are some of the important factors that must be kept in mind while designing a micro hydropower system:

Available head: The design of the system has effects on the net head delivered to the turbine. Components such as the channel and penstock cannot be perfectly efficient. Inefficiencies appear as losses of useful head of pressure.

Flow variations: The river flow varies during the year but the hydro installation is designed for almost a constant flow. If the channel overflows there will be serious damage to the surroundings. The weir and intake must therefore be designed for such eventualities and divert only the required amount of flow irrespective of whether the river is in low or in high flow. The main function of the weir is to ensure that a constant flow in the channel is maintained when there is less flow in the river. The intake structure is designed to regulate the flow to within reasonable limits when the river is in high flow. Further regulation of the channel of is provided by the spillways.

Sediment: Flowing water in the river sometimes carry small particles of hard abrasive matter (sediment) which can cause wear to the turbine if they are not removed before the water enters the penstock. Sediment may also block the intake or cause the channel to clog up if adequate precautions are not taken.

Floods: Flood water will carry large suspended particles and will even cause large stones to roll along the stream bed. Unless careful design principles are applied, the diversion weir, the intake structure and the embankment walls of the river may be damaged.

Turbulence: In all parts of water supply line, including the weir, the intake and the channel, sudden alterations to the flow direction will create turbulence which erodes structures and causes energy losses.

Most common civil structures used in an MHP scheme are:

Weir and Intake: A micro hydropower system necessitates that water from the river to be diverted and extracted in a reliable and controllable manner. The water flowing in the channel must be regulated during high river flow and low flow conditions. A weir can be used to raise the water level and ensure a constant supply to the intake. Sometimes it is possible to avoid building a weir by using natural features of the river. A permanent pool in river. Another condition in site selection of the weir is to protect it from damage. Sometimes, in remote hilly regions, where annual flooding is common it may be prudent to build temporary weir using local resources and manpower. The temporary weir is a simple structure at low cost using local labour, skills and materials. It is expected to be destroyed by annual or bi-annual flooding. However, advanced planning has to be done for rebuilding of the weir. The intake of a MHP is designed to divert only a portion of the stream flow or the complete flow, depending upon the flow condition and the requirement.

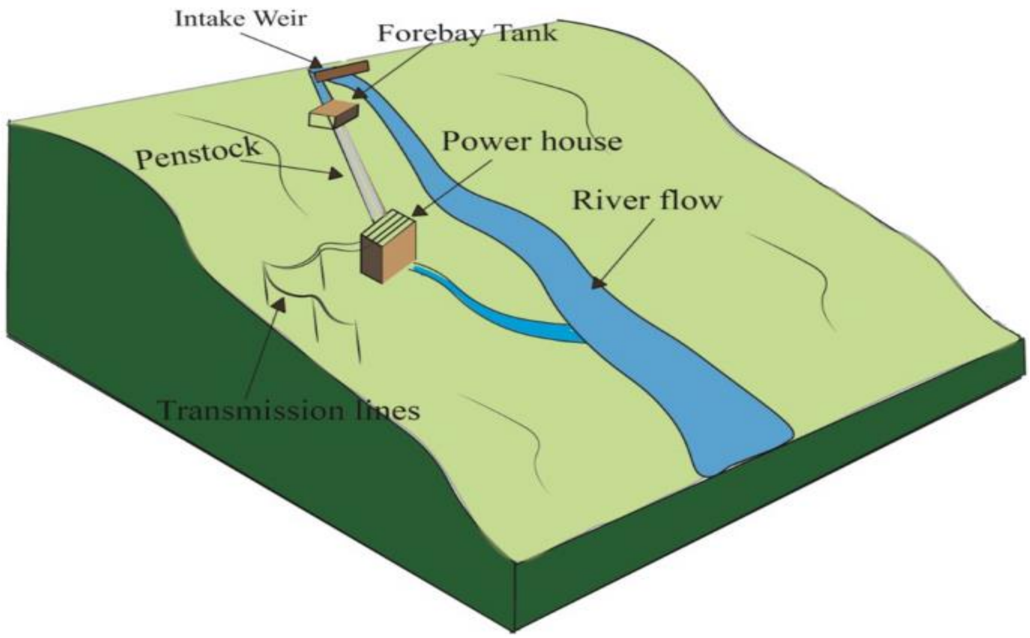

Fig 3: Typical MHP Scheme

Power Channels: The power channel or simply a channel conducts the water from the intake to the forebay tank. The length of a channel depends upon the topography of the region and the distance of powerhouse from the intake. The designing of the MHP systems states the length of the channel sometimes a long channel combined with a short penstock can be cheaper or required, while in other cases a combination of short channel with long penstock would be more suitable. In the Himalayan region, the MHP channels are sometimes as long as a few kilometres to create a head of 10 to 60 metres or more. Generally power channels are excavated and to reduce friction and prevent leakages these are often lined with cement, clay or polythene sheet. Size and shape of a channel and material used for lining are often a dictated by cost and head considerations. During the process of owing past the walls and bed material, the water loses energy. The rougher the material, the greater the friction loss and higher is the elevation difference needed between channel entry and exit. In hilly regions it is common that the power channel would have to cross small streams. In such situations it is often prudent to build a complete crossing over the channel, as during rainy season, ash woods, rocks, mud may block the channel or worse still, wash away sections of the channel. Sometimes just the provision of a drain running under the channel (in case of very small streams along stable slopes) is usually adequate.

Settling Basin: The water diverted from the stream and carried by the channel usually carries a suspension of small particles such as sand that are hard and abrasive and can cause expensive damage and rapid wear to turbine runners. To get rid of such particles and sediments, the water ow is allowed to slow down in settling basins so that the sand and silt particles settle on the basin floor. The deposits are then periodically flushed. The design of settling basin depends upon the flow quantity, speed of flow and the tolerance level of the turbine (smallest particle that can be allowed). The maximum speed of the water in the settling basin can thus be calculated as slower the flow, lower is the carrying capacity of the water. The flow speed in the settling basin can be lowered by increasing the cross-sectional area.

Spillways: Spillways along the power channel are designed to permit overflow at certain points along the channel. The spillway acts as a flow regulator for the channel. During floods the water flow through the intake can be twice the normal channel large enough to divert this excess flow. The spillway can also be designed with control gates to empty the channel. The spillway should be designed in such a manner that the excess flow is fed back to the without damaging the foundations of the channel. The forebay tank serves the purpose of providing steady and continuous flow into the turbine through the penstocks. Forebay also acts as the last settling basin and allows the last particles to settle down before the water enters the penstock. Forebay can also be a reservoir to store water depending on its size (large dams or reservoirs In large hydropower schemes are technically forebay). A sluice will make it possible to close the entrance to the penstock. In front of the penstock a trash rack is required to be installed to prevent large particles to enter the penstock. A spillway completes the forebay tank.

Penstock: The penstock is the pipe which conveys water under pressure from the forebay tank to the turbine. Penstock is a significant component of the MHP scheme and needs to be designed and selected carefully as it represents a major expense in the total budget (for some high head installations this alone could cost as much as 30% of the total costs). Here the main aspects to consider are head loss and capital cost. Head loss due to friction in the pipe decreases dramatically with increasing pipe diameter. Conversely, pipe costs increase steeply with diameter. Therefore, a compromise between cost and performance is considered for design and selection of pipe diameter and material. While designing penstocks, the first principle is to identify available pipe options and then to decide upon acceptable head loss (5% of the gross head is generally considered). The details of the pipes of various materials and diameters with losses close to this target are then tabulated and compared for cost effectiveness. A smaller penstock may be lighter on pocket, but the extra head loss may account for lost revenue from generated electricity each year**.**

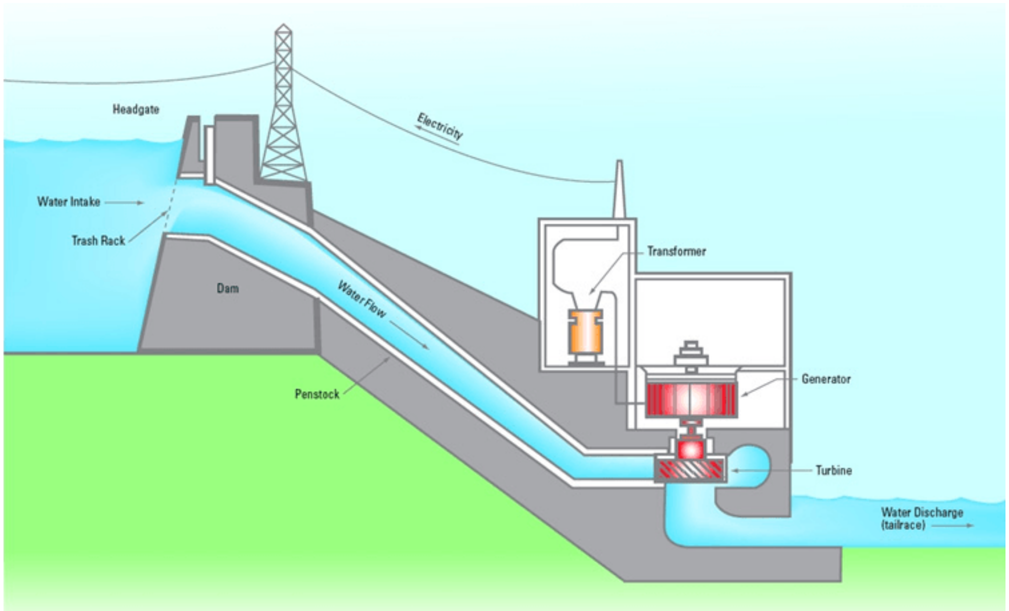

Fig 4: Figure containing different parts of a MHP Scheme

Penstock Joining: Pipes are generally available in standard lengths (it is easier for transportation also) and have to be joined together on site. There are several methods of joining penstock pipes. The following materials can be considered for use as penstock pipes in micro hydro schemes.

Burying or Supporting the Penstock: Penstock pipelines can either be laid upon the surface generally depends upon the material of the pipe, the nature of the terrain and environmental and cost considerations. While burying a penstock, it is very important to ensure proper installation because any subsequent problems such as leaks are much harder to detect and resolve.

2) ELECTRICAL COMPONENTS

TURBINES: Turbine is the main piece of equipment in the MHP scheme that converts energy of the falling water into the rotating shaft power. The selection of the most suitable turbine for any particular hydro site depends mainly on two of the site characteristics head and flow available. All turbines have a power-speed characteristic. This means they will operate most efficiently at a particular speed, head and ow combination. Thus, the desired running speed of the generator or the devices being connected on to the turbine also in sequence selection.

The design speed of a turbine is largely determined by the head under which it operates. Turbines can be classified as high head, medium head or low head machines.

There are basically two types of turbines- Reaction Turbines and Impulse Turbines

i)Reaction Turbines: Reaction turbines generate electrical energy by using the mutual action of pressure and moving water. When the rotor is completely filled in the water and is enclosed in a pressure casing, the operation of reaction turbines is attained. A draft tube is a diffuser that exists in all reaction turbines below the runner. The water discharges through the draft tube. Accordingly, the static pressure below the runner is reduced and the effective head increases. Application of reaction turbines is in sites with lower heads and higher flow rates. Two main kinds of reaction turbines are the Propeller and the Francis turbine.

The reaction turbines require more sophisticated fabrication than impulse turbines because they involve the use of larger and more intricately pro led blades together with carefully pro led casings. The higher costs are often set by high efficiency and the advantages of high running speeds at low heads from relatively compact machines. Expertise and precision required during fabrication make these turbines less attractive for use in micro-hydro in developing countries. Most reaction turbines tend to have poor part-flow efficiency characteristics.

a)Kaplan Turbine: A Kaplan Turbine is a type of turbine used in hydroelectric plants. They are a type of “propeller” turbine that has an axial flow, taking in water parallel to its rotational axis. Specifically, Kaplan turbines are a specific type of propeller turbine that allows for the angle of the blades to change with demand to maintain maximum efficiency at any time.

The area that water can enter these turbines is large, equal to the entire area that the blades occupy. Because of this, Kaplan turbines are most useful where large volumes of water flow, and can be used even in dams with relatively low head. This is especially important as previous to the development of the Kaplan turbine, most turbines were only suitable for large heads of water. Viktor Kaplan designed this turbine off of the design of ship propellers, and because of that they work essentially in the opposite way as propellers.

The way that water Is moved through” a Kaplan turbine is slightly different from other turbines. First, the water is directed towards the turbine radially, approaching from the side. This is done because the generator is usually located somewhere along the axis of the turbine’s rotation, so if the generator was located here it could get wet.

The water then moves down over the blades of the propeller, turning it with the swirl of the water. This type of turbine is therefore known as Reaction Turbine as the reaction force from the push of the water on the propeller forces the propeller to move. Thus, the water leaves the turbine axially.

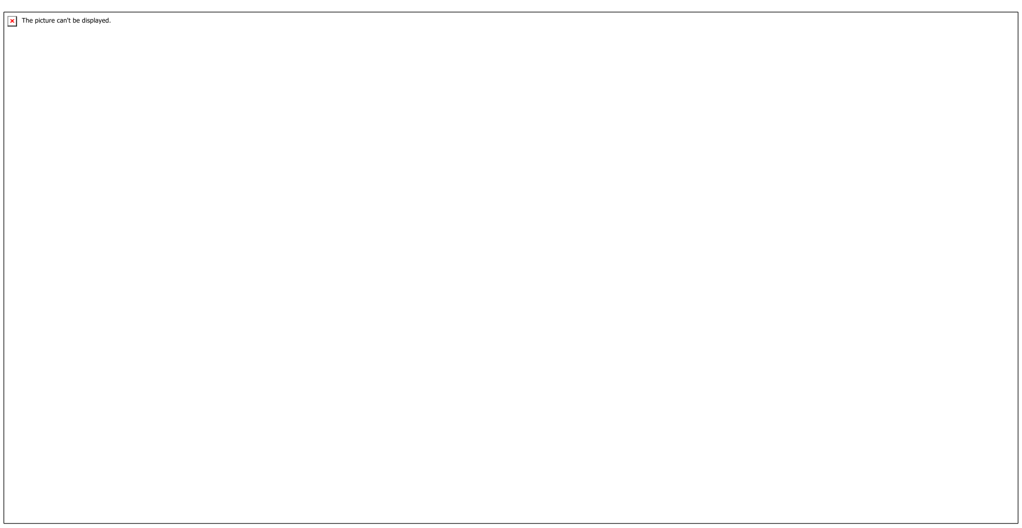

Fig 5: Kaplan Turbine

b)Francis Turbine: Francis turbines are the most well-known type of reaction turbines. This turbine has a radial flow runner or a mixed radial/axial flow runner. Radial water flow to the runner and axial emerge as a result of the runner spinning. Wicket gates and a draft tube are two other main elements of the Francis turbine. Systems with medium head size are appropriate for Francis turbine application. Francis turbines can be designed for a wide range of heads and flows and along with their high efficiency makes them one of the most widely used turbines in the world. Large Francis turbines are usually designed specifically for each site so as to gain highest levels of efficiencies (these are typically in the range of over 90 percent). Francis turbines cover a wide range of head from 20 meters to 700 meters, and can be designed for outputs power ranging from just a few kilowatts to one Gigawatt.

Fig 6: Francis Turbine

ii)Impulse Turbine: The impulse turbine is the descendant of the stream wheel. Like the latter, it uses the impulse or kinetic energy in a stream of water to drive the turbine and provide power. However, while the stream wheel relies on the natural flow of water in a river or stream, an impulse turbine uses a powerful jet of water that is generated from a high head of water. The impulse turbine is the simplest type of turbine. It consists of a row of nozzles followed by a row of blades. The gas is expanded in the nozzle, converting the high thermal energy into kinetic energy. The high-velocity gas impinges on the blade where a large portion of the kinetic energy of the moving gas stream is converted into turbine shaft work. The static pressure decreases in the nozzle with a corresponding increase in the absolute velocity. The absolute velocity is then reduced in the rotor, but the static pressure and the relative velocity remain constant. To get the maximum energy transfer, the blades must rotate at about half the velocity of the gas jet velocity.

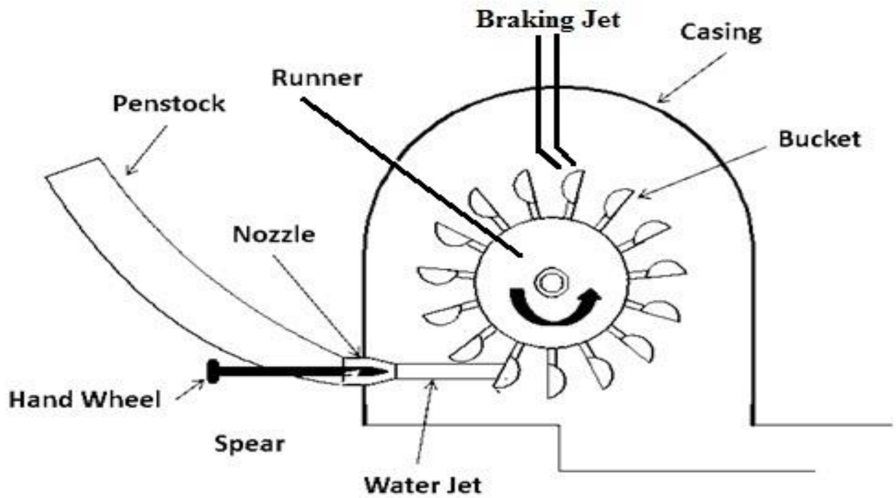

Fig 7: Impulse Turbine

There are different types of impulse turbines- Pelton turbine, Turgo Impulse turbine, Cross Flow turbine.

a)Pelton Turbine: The Pelton turbine consists of a wheel with a series of split buckets set around its rim; a high velocity jet of water is directed tangentially at the wheel. The jet hits each bucket and is split in half, so that each half is turned and deflected back almost through 180º. Nearly all the energy of the water goes into propelling the bucket and the deflected water falls into a discharge channel below.

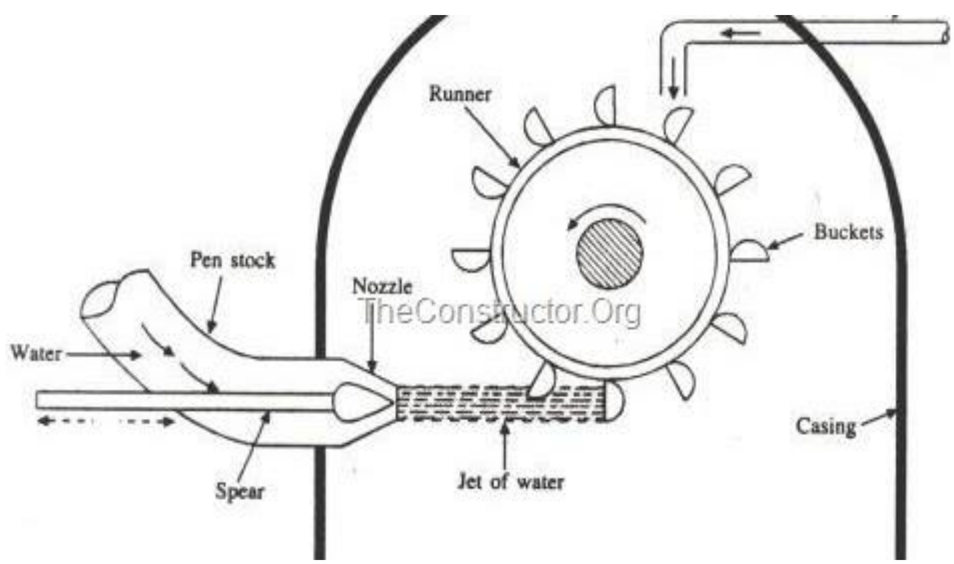

Fig 8: Pelton Turbine

b)Turgo Turbine: The Turgo turbine is similar to the Pelton but the jet strikes the plane of the runner at an angle (typically 20° to 25°) so that the water enters the runner on one side and exits on the other. Therefore, the flow rate is not limited by the discharged fluid interfering with the incoming jet (as is the case with Pelton turbines). As a consequence, Turgo turbine can have a smaller diameter runner and rotate faster than a Pelton for an equivalent flow rate.

The specific speed of Turgo runners is between the Francis and Pelton. Single or multiple nozzles can be used. Increasing the number of jets increases the specific speed of the runner by the square root of the number of jets i.e., four jets yield twice the specific speed of one jet on the same turbine.

c)Archimedian Screw Turbine: The Archimedean screw hydro turbine is a relative newcomer to the small-scale hydro world having only arrived on the scene over the last ten years. However, they have been around for many decades as pumps where tens-of-thousands have been installed worldwide, particularly in sewage treatment works. The same manufacturers that dominate the pump market are now the main suppliers into the hydropower market as well.

Archimedean screws for hydropower are used on low head/high flow sites. They can work efficiently on heads as low as 1 metre, though are not generally used on heads less than 1.5 m (more for economic reasons than technical ones). Single screws can work on heads up to 8 metres, but above these multiple screws are generally used, though in many cases for heads above 8 metres there may be more appropriate turbines available with much smaller footprints.

The maximum flow rate through an Archimedean screw is determined by the screw diameter. The smallest screws are just 1 metre diameter and can pass 250 litres/second, then they increase in 250 mm steps all of the way up to 5 metres in diameter with a maximum flow rate of around 14.5 m3/s. The 5 metre maximum is really based on practical delivery restrictions, and in many cases 3 metres is the maximum diameter that can be delivered to a site. If there is more flow available, multiple screws can be installed in parallel. In terms of power output, the very smallest Archimedean screws can produce as little as 5 kW, and the largest 500 kW. Archimedean screws typically rotate at around 26 rpm, so the top of the screw connects to a gearbox to increase the rotational speed to between 750 and 1500 rpm to make it compatible with standard generators. Even though they rotate relatively slowly Archimedean screws can splash water around, though this is reduced significantly by the use of a splash guard.

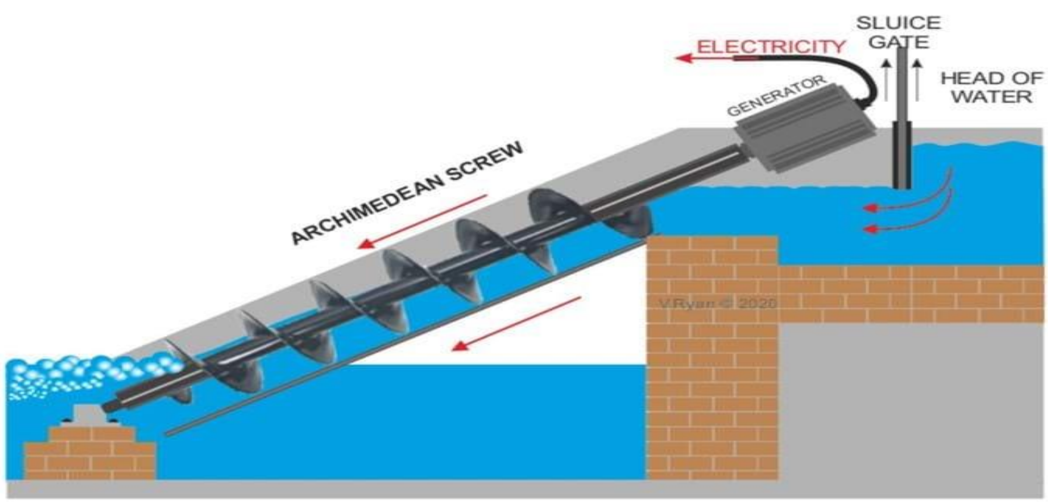

Fig 9: Archimedian Screw Turbine

d)Cross Flow Turbine: The Crossflow turbine has a drum-like rotor with a solid disk at each end and guttershaped “slats” joining the two disks. A jet of water enters the top of the rotor through the curved blades, emerging on the far side of the rotor by passing through the blades a 2nd time. The shape of the blades is such that on each passage through the periphery of the rotor the water transfers some of its momentum, before falling away with little residual energy.

Turbine Selection Criteria: Selection of an appropriate turbine to a large extent is dependent upon the available water head and to a lesser extent on the available ow rate. In general, impulse turbines are used for high head sites, and reaction turbines are used for low head sites. Kaplan turbines with adjustable blade pitch are suitable for wide ranges of flow or head conditions, since their peak efficiency can be achieved over a wide range of ow conditions. Small turbines (less than 10 MW) may have horizontal shafts, and even fairly large bulb-type turbines up to 100 MW or so may be horizontal. Very large Francis and Kaplan machines usually have vertical shafts because this makes best use of the available head, and makes installation of a generator more economical. Pelton turbines may be installed either vertically or horizontally. Some impulse turbines use multiple water jets per runner to increase specific speed and balance shaft thrust. Turbine type, dimensions and design are basically governed by the following criteria:

- Net head
- Flow discharge through the turbine
- Rotational speed
- Cavitation problems (quality of water available from penstock)
- Cost

The main criterion considered in turbine selection is the net head.

Switch Gear Equipment: The term switchgear, used in association with the electric power system, or grid, refers to the combination of electrical disconnects, fuses and circuit breakers used to isolate electrical equipment. Switchgear is used both to de-energize equipment to allow work to be done and to clear faults downstream. One of the basic functions of switchgear is protection, which is interruption of short-circuit and overload fault currents while maintaining service to unaffected circuits.

Switchgear also provides isolation of circuits from power supplies. Switchgear also is used to enhance system availability by allowing more than one source to feed a load. Switchgear must be installed to control the generators and to interface them with the grid or with an isolated load. It must provide protection for the generators, main transformer and station service transformer.

Automatic Control: Controlling the power plant is very essential to ensure greater efficiency and regulation with less loss of energy. If a proper control system characterised with PID Controllers and closed loop components.

Micro hydropower schemes are normally unattended and operated through an automatic control system. Since all MHP schemes are unique, it is impossible to determine and standardize the extent of automation that should be included in a given system. However, some requirements of general automation application are:

i. The system must include the necessary relays and devices to detect malfunctioning of a serious nature and then act to bring the unit or the entire plant to a safe condition.
ii. Relevant operational data of the plant should be collected and made readily available for making operational decisions, and stored in a database for later evaluation of plant performance.

iii. An intelligent control system should be included to allow for full plant operation in an unattended environment.
iv. It must be possible to access the control system from a remote location and over-ride any automatic decisions.
v. The system should be able to communicate with similar units, up and downstream, for the purpose of optimizing operating procedures.

Automatic control systems can significantly reduce the cost of energy production by reducing maintenance and increasing reliability, while running the turbines more efficiently and producing more energy from the available water.

GENERATOR: A generator is a device which converts the mechanical energy (potential or kinetic) or chemical energy into electrical energy through a closed circuit. Sources of mechanical energy include steam turbines, gas turbines, water turbines, internal combustion engines, wind turbines and even hand cranks. In addition to electricity- and motion-based designs, photovoltaic and fuel cell powered generators use solar power and hydrogen-based fuels, respectively, to generate electrical output.

Mainly there are two categories of generators: a) Dynamos b) Alternators

a) Dynamos: They generate direct current. They are commonly known as the D.C Generators.

b) Alternators: Alternators generates alternating currents. There are known by the name synchronous generators. It is an A.C Generator.

Another type of generators are the Induction Generators or Asynchronous Generators. It is also an A.C Generator. Normally Induction Generators are not used to generate electrical power except in wind turbines.

Components of a Solar PV System:

1) Solar Panel: A solar cell or photovoltaic cell (PV cell) is an electronic device that converts the energy of light directly into electricity by means of the photovoltaic effect. It is a form of photoelectric cell, a device whose electrical characteristics (such as current, voltage, or resistance) vary when it is exposed to light. Individual solar cell devices are often the electrical building blocks of photovoltaic modules, known colloquially as "solar panels". Almost all commercial PV cells consist of crystalline silicon, with a market share of 95%. Cadmium telluride thin-film solar cells account for the remainder. The common single-junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts.

Photovoltaic cells may operate under sunlight or artificial light. In addition to producing energy, they can be used as a photodetector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

The operation of a PV cell requires three basic attributes:

- The absorption of light, generating excitons (bound electron-hole pairs), unbound electron-hole pairs (via excitons), or plasmons.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

PV cells are made of materials that produce excited electrons when exposed to light. The electrons flow through a circuit and produce direct current (DC) electricity, which can be used to power various devices or be stored in batteries. Solar panels are also known as solar cell panels, solar electric panels, or PV modules.

Types of Solar Cells: Presently, around 90% of the world's photovoltaics are based on some variation of silicon. The different types of Solar Cells are:

i. Crystalline Silicon Cells
ii. Monocrystalline Silicon Cells
iii. Polycrystalline Silicon Cells
iv. Thin Film Solar Cells

i. Crystalline Silicon Cells: Crystalline silicon or (c-Si) is the crystalline forms of silicon, either polycrystalline silicon (poly-Si, consisting of small crystals), or monocrystalline silicon (mono-Si, a continuous crystal). Crystalline silicon is the dominant semiconducting material used in photovoltaic technology for the production of solar cells.

ii. Monocrystalline Silicon Cells: Monocrystalline solar cells are made from single crystalline silicon. They are very distinctive in their appearance as they are often coloured, and the cells hold a cylindrical shape. In order to keep the costs low and performance at optimal levels, manufacturers cut out the four sides of the monocrystalline cells. This gives them their recognisable appearance.

Advantages

- Here are some of the advantages of monocrystalline solar cells:
- They have the highest level of efficiency at 15-20%
- They require less space compared to other types due to their high efficiency
- Manufacturers state that this form of solar cell lasts the longest, with most giving them a 25-year warranty
- They perform better in low levels of sunlight, making them ideal for cloudy areas

Disadvantages

- Here are some of the disadvantages to monocrystalline solar cells:
- They are the most expensive solar cells on the market, and so not in everyone's price range
- The performance levels tend to suffer from an increase in temperature. However, it is a small loss when compared to other forms of solar cell
- There is a lot of waste material when the silicon is cut during manufacture

iii. Polycrystalline Silicon Cells: The polycrystalline solar panels were first introduced to the public in 1981. Unlike the monocrystalline cells, polycrystalline ones do not require each of the four sides to be cut. Instead, the silicon is melted and poured into square moulds. These then form perfectly shaped square cells.

Advantages

- The manufacturing process is cheaper and easier than the monocrystalline cells
- It avoids silicon waste
- High temperatures have less negative effects on efficiency compared with monocrystalline cells. This makes the polycrystalline cells more attractive to people in warmer areas as the price is lower

Disadvantages

- Efficiency is only around 13-16% due to low levels of silicon purity. So they are not the most efficient on the market
- They have lower output rates which make them less space efficient. So more roof space is needed for installation

iv. Thin Film Solar Cells: Thin film solar cells are manufactured by placing several thin layers of photovoltaic on top of each other to creates the module. There are actually a few different types of thin film solar cell, and the way in which they differ from each other comes down to the material used for the PV layers. The types are as follows:

- Amorphous silicon
- Cadmium telluride
- Copper indium gallium selenide
- Organic PV Cells

Depending on the technology that has been used, the efficiency rates for thin film solar cells tends to vary from 7% to 13%. Since 2002, the knowledge levels and popularity for thin film solar cells has risen dramatically, which also means that research and development have been increased. Due to this, we can expect future models to hold efficiency rates of 10-16%.

Advantages

- They can be manufactured to be flexible, making them widely applicable to a range of situations and building types
- Mass production is easy to achieve, making them potentially cheaper to produce than crystalline solar cells
- Shading has a similar effect on their efficiency

Disadvantages

- They are not ideal for domestic use as thy take up a lot of space
- Low space efficiency means that they will cause further expenses in the form of enhancers, like cables of support structures
- They have a shorter lifespan and so shorter warranty periods

2) Battery: In electricity and electrochemistry, any class of devices that convert chemical energy directly into electrical energy is a battery. An electric battery is a source of electric power consisting of one or more electrochemical cells with external connections for powering electrical devices. When a battery is supplying power, its positive terminal is the cathode and its negative terminal is the anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy. Historically the term "battery" specifically referred to a device composed of multiple cells; however, the usage has evolved to include devices composed of a single cell.

A battery is basically used as a storage device. It is used to store energy to use it at a later stage. There are different types of battery available. The first classification is done on the basis of wheather it is rechargeable or not. Accordingly they are classified as Primary cells or non-rechargeable batteries and Secondary cells or rechargeable batteries.

Examples of some Primary cells or non-rechargeable batteries are:

- Alkaline battery
- Aluminium–air battery
- Bunsen cell
- Chromic acid cell (Poggendorff cell)
- Clark cell
- Daniell cell
- Dry cell
- Earth battery
- Frog battery
- Galvanic cell

Examples of some Secondary cells or rechargeable batteries are:

- Aluminium-ion battery
- Calcium battery
- Flow battery
- Lead–acid battery
- Glass battery
- Lithium-ion battery
- Rechargeable lithium–metal battery
- Magnesium-ion battery
- Metal–air electrochemical cells
- Molten-salt battery

Batteries are also classified on the basis of their application. Some examples on the basis of their application are:

- Inverter battery
- Electric-vehicle battery
- CMOS battery
- Automotive battery
- Backup battery
- Battery (vacuum tube)
- Battery room
- Battery-storage power station
- Nanobatteries

- Water-activated battery

3) Inverter: An inverter is a device that changes direct current (DC) into alternating current (AC). Inverters do the opposite of rectifiers which were originally large electromechanical devices converting AC to DC. The inverter does not produce any power; the power is provided by the DC source. The resulting AC frequency obtained depends on the particular device employed. The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry.

The inverter may be built as standalone equipment for applications such as solar power, or to work as a backup power supply from batteries which are charged separately. The other configuration is when it is a part of a bigger circuit such as a power supply unit, or a UPS. In this case, the inverter input DC is from the rectified mains AC in the PSU, while from either the rectified AC in the in the UPS when there is power, and from the batteries whenever there is a power failure.

Considering the classification based on the mode of operation, inverters can be classified into three broad categories:

1. Stand-alone inverters (supplies stable voltage and frequency to load)
2. Grid-connected inverters (the most commonly used option)
3. Bimodal inverters (usually more expensive and are used less often)

Aside from the modes of operation, grid-connected inverters are also classified according to configuration topology. There are four different categories under this classification.

1. Central inverters, which are usually around several kW to 100 MW range.
2. String inverters, typically rated around a few hundred Watts to a few kW.
3. Multi-string inverters, typically rated around 1 kW to 10 kW range.
4. And finally, Module Inverters or Micro Inverters, typically rated around 50 to 500 W.

4) Charge Controller: A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries to protect against electrical overload, overcharging, and may protect against overvoltage. This prevents conditions that reduce battery performance or lifespan and may pose a safety risk. It may also prevent completely draining ("deep discharging") a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full. Charge controllers may also monitor battery temperature to prevent overheating. Some charge controller systems also display data, transmit data to remote displays, and data logging to track electric flow over time.

A solar charge controller is used to keep the battery from overcharging by regulating the voltage and current coming from the solar panel to the battery. It is programmed at 15-A/200-W unit and uses MPPT (maximum power point tracking) to accelerate solar charging of the battery up to 30% per day.

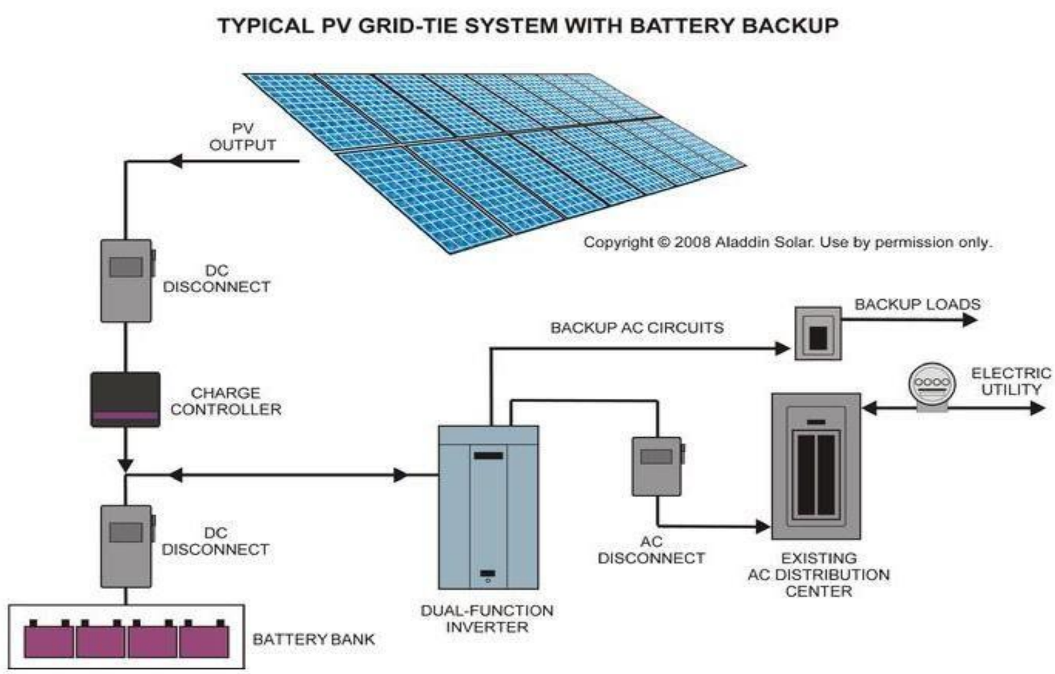

Fig 10: Typical PV System

CHAPTER 3

METHODOLOGY

1) MEASUREMENT OF FLOW:

The flow measuring techniques are:

a) Bucket method
b) Float method
c) Current meter
d) Weir method
e) Salt Gulp Analysis

a) Bucket Method:

- Take a bucket or any container with known volume.
- If the volume of the container is not known then it can be found out by filling the container with water from a 1liter bottle. Count the number of liter that has been added. This is giving the volume of the container.
- Finding a location along the stream where all of the water can be caught in the bucket. This is done by placing the bucket at the bottom of a natural narrow fall in the stream path.
- Using a stopwatch and record the time it takes to fill the bucket. Repeating the experiment more than three times and take the average value of time.
- The volume of the bucket divided by the average time it takes to fill the bucket gives the flow rate of water.

b) Float Method:

- Measuring the average depth of the stream.
- The speed of the water flowing is found out by using a float and timing its travel between two points in the stream.
- But in the case of the river or stream it is much more difficult to calculate the cross sectional area.
- To estimate the area at a particular section, measure the width of the stream at that point. Then with the help of a long pole, take the depth measurements at regular intervals across the stream where the width has been measured.
- Plot this depth measurement in a grid sheet and estimate the area of the cross section by calculating the number of squares of the grid sheet enclose.
- To measure the surface flow, place two markers at a distance. Using a weighted float that can be clearly seen and it place well upstream of the measurement area.
- Start the stop watch when the float pass the first marker and stop it when the float passes the second marker. Repeat the experiment at least three times to obtain consistent results.

c) Current Meters:

- This is more accurate than the float method.
- A current meter consists of a shaft with a propeller or revolving cups connected to the end.
- The propeller is free to rotate and the speed of rotation is related to the stream velocity.

- A simple mechanical counter records the number of revolutions of a propeller placed at a desired depth. By averaging readings taken evenly throughout the cross section, an average speed of the stream can be obtained.

d) Weir Method:

- A flow measurement weir is a weir with a notch in it through which all the water in the stream is made to flow.
- The flow rate can be determined from the difference in height between the upstream water level and bottom of the notch.
- For reliable results, the crest of the weir must be sharp and sediment must be prevented from accumulating behind the weir.
- Weir can be made of concrete, metal or even timber and must always be oriented at right angles to the stream flow.
- Location of the weir should be at a point where the stream is straight and free from eddies.
- Upstream, the distance between the point of measurement and the crest of the weir should be at least twice the maximum head to be measured.
- There should be no obstructions to flow near the notch and the weir must be perfectly sealed against leakage.

e) Salt Gulp Method:

- This method requires more calculations than the other methods but is easier to conduct the experiment.
- It needs a conductivity meter and an instrument to accurately weight salt.
- The flow rate is determined by measuring the speed and concentration of a cloud of salty water as it passes downstream.
- A known mass of salt is mixed with some water in a bucket until it is fully dissolved.
- Record the mass of the salt added to the nearest gram. All the salt water solution is then tipped into the stream.
- The mass of the salt used depends on the size of the flow. As a thumb rule, use about 25g of salt for every 5 lisper second flow.
- The conductivity meter probe is placed in a fast moving area of flow 25m to 30m downstream from where the salt solution was added.
- The normal conductivity level of the water is recorded. This is called background conductivity.
- As soon as the conductivity readings begin to climb, record then every 5 seconds. Readings should be recorded until the conductivity has returned to its background level.
- Plot a graph of changing salt concentration versus time.

2) SELECTION OF TURBINE AND GENERATOR FOR THE PROPOSED SITE

Selection of Turbine: As our proposed site has a medium head value and a normal flow rate as well as considering the geography of the site we had to deal with the decision of selecting the proper type of turbine for harnessing the power.

After much analysis from different papers on turbine selection we came with a curve which explains about the appropriate turbine required for the generation of energy for a particular ranges of flow rate.

From our collected data we have flow rate which ranges from 1.2 m^3/sec to 1.4m^3/sec and the calculated head has as height of 134 m and our energy requirement is of the Micro hydro power range i.e. from 5kw to 100kw. The appropriate turbine that we are proposing is the Turgo Turbine.

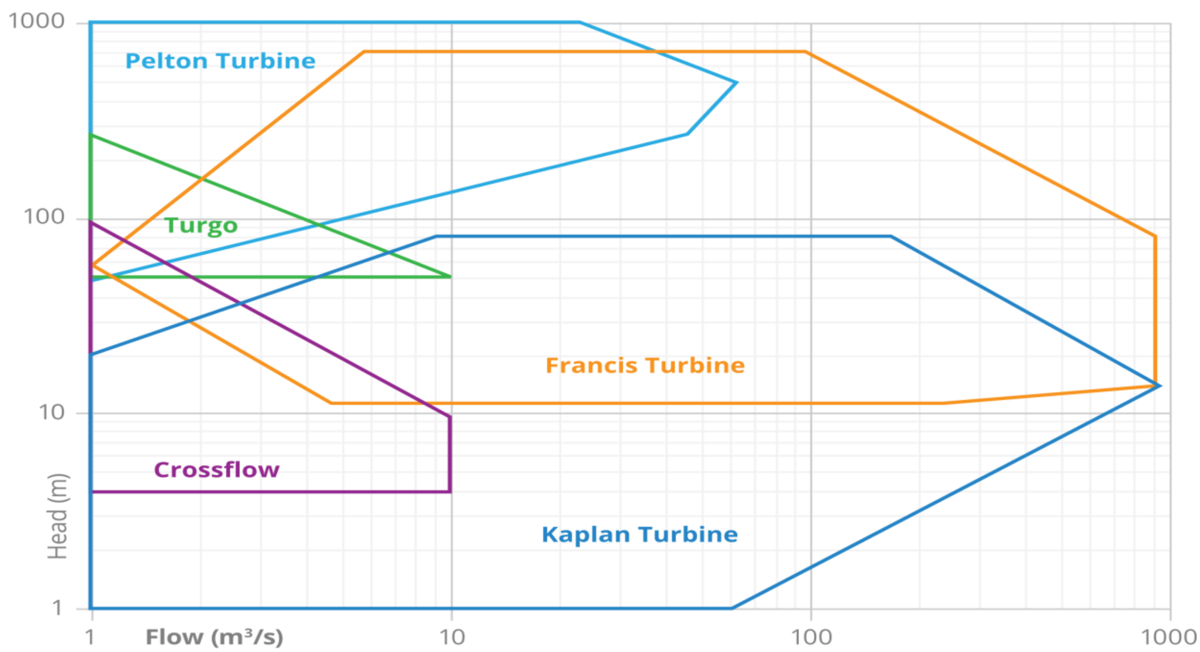

Fig 11: Selection of turbine chart

Selection of Generator: For generation of electrical power, a synchronous generator is preferred. It is easier to extract power from a synchronous generator. It does not require any commutator like the DC Generators. The power can be directly extracted from the stator. Synchronous generators also have high efficiency and better power factor. The power factor can also be controlled in a synchronous generator.

In case of synchronous generator, it consists of an armature winding and a field winding. The stator consist the armature winding and the rotor consist of the field winding. The armature winding carries the load current. The armature winding is stationary because it is easier to extract power from a stationary armature than the rotating rotor.

3) SELECTION OF SOLAR PANELS, INVERTERS and BATTERIES

Since it is a micro power generation project therefore the generation capacity of the system lies between 5KW to 100KW. So we have taken the load demand as 100KW and have done the necessary calculations.

CHAPTER 4

CALCULATIONS AND RESULTS

CALCULATIONS FOR MICRO-HYDRO SCHEME

Formulas to be used in calculation are:

FOR MEASURING FLOW RATE, $Q = V/t$

FOR MEASURING MECHANICAL POWER, $P = \rho \times g \times H \times Q$

Where V= volume of water (m^3)

t = time taken (sec)

ρ= Density of water (997 kg per m^3)

g = Acceleration due to gravity (9.8 m/s^2)

Q = Flow rate (m^3 per sec)

P= Power (in watt)

Mechanical Power, $P = \rho \times g \times H \times Q$

$= 1000 \times 9.8 \times 134 \times 1.2$

= 1575840 W

= 1575.84KW

= 1.57 MW

Considering the turbine efficiency of 0.85 the power developed is

$P = 0.85 \times 1.57$

= 1.33 MW

CALCULATIONS FOR SOLAR PV SCHEME

No. of Solar PV Panels:

For 100KW load and 10 hours of back up service the total energy required is 1000KWh.

Inverter efficiency is 95 percent so 1000/0.95=1052.631 KWh/day should be the capacity to meet the required demands.

Battery efficiency is taken as 85 percent, so to get the required energy the total capacity should be more.

Therefore 1176.4705/0.85=1238.39 KWh/day should be generated.

Require battery rating:

24V battery is chosen for providing the service.

Therefore required battery rating = 1238.39/24

=51.59 Kah

Therefore no of 200 Ah batteries required =$51.599*10^3/200$

= 258 approx

No. of Solar PV panels required = (1238.39*1000)/4.78 (4.78 is the peak sun hours)

=259077.4059/370 (370 is the maximum power of the solar panel)

=700 approx

SIMULATION MODEL OF MHP

Using the formulas for power generated from the micro hydro power scheme. The following simulation model has been designed to represent the process. Here the all the inputs are taken as constant as collected from the field data. The values of head, flowrate, density of water and acceleration due to gravity are multiplied and the output is obtained as the water power. Next the turbine efficiency is multiplied with the water power to get the final output i.e the electrical power.

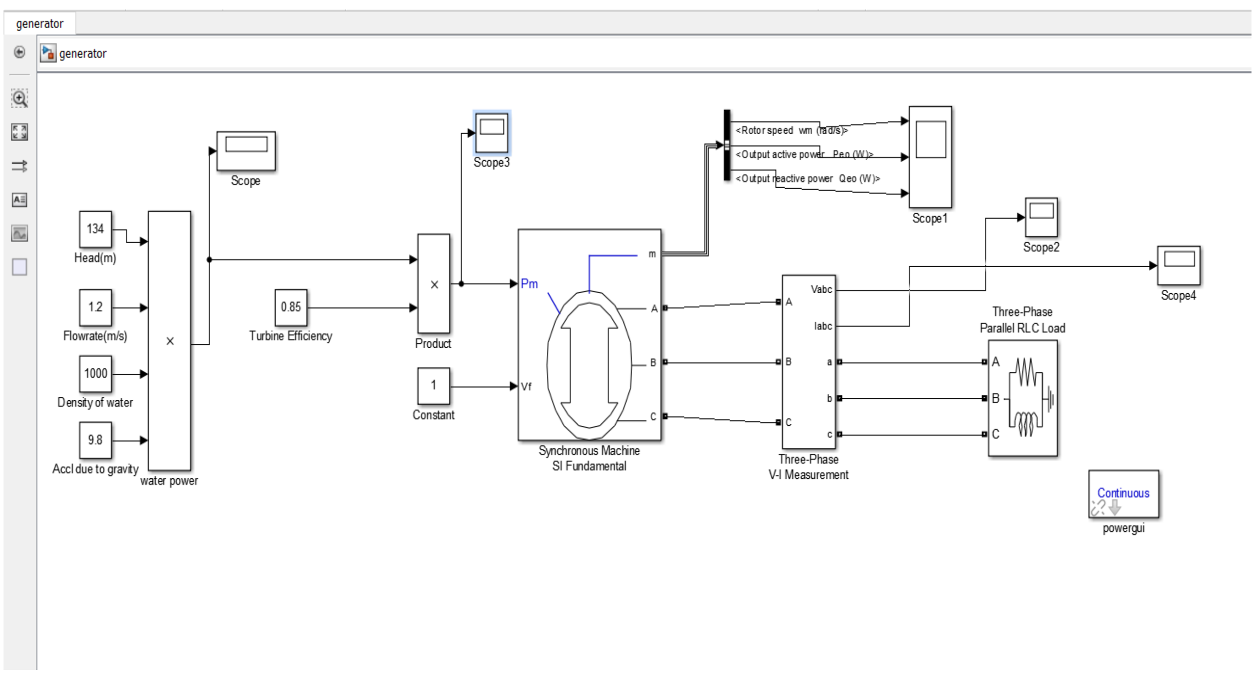

Fig 12: Simulation Model of MHP

GRAPHS:

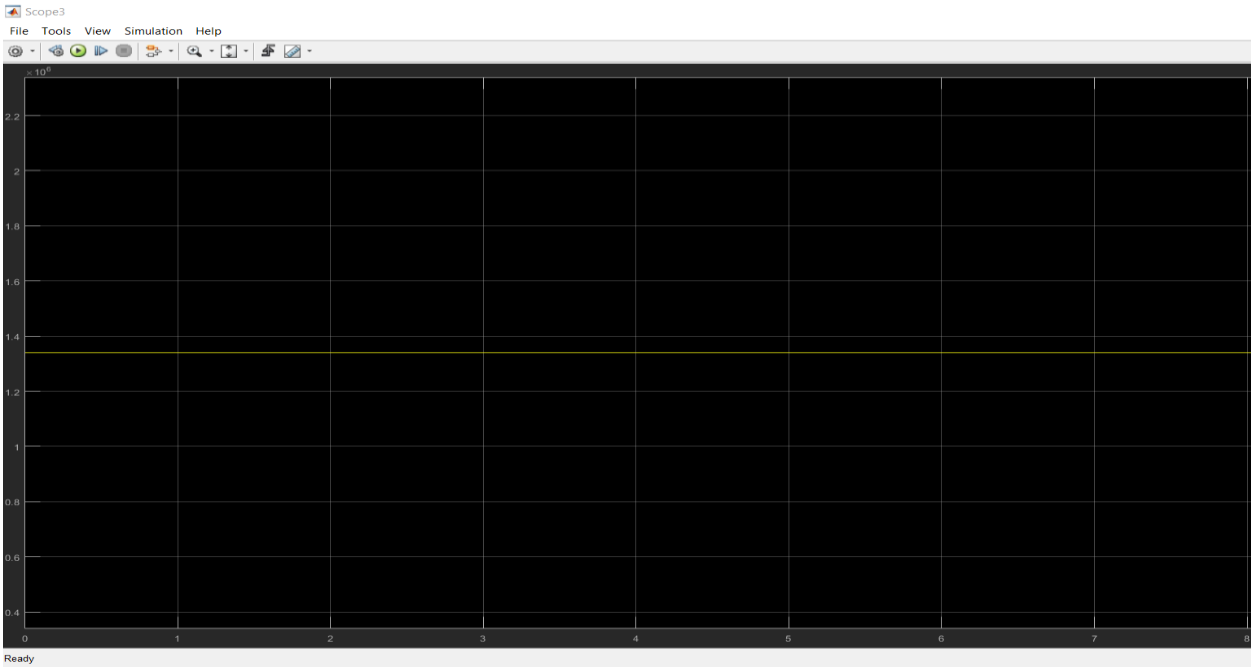

Fig 13: Power output

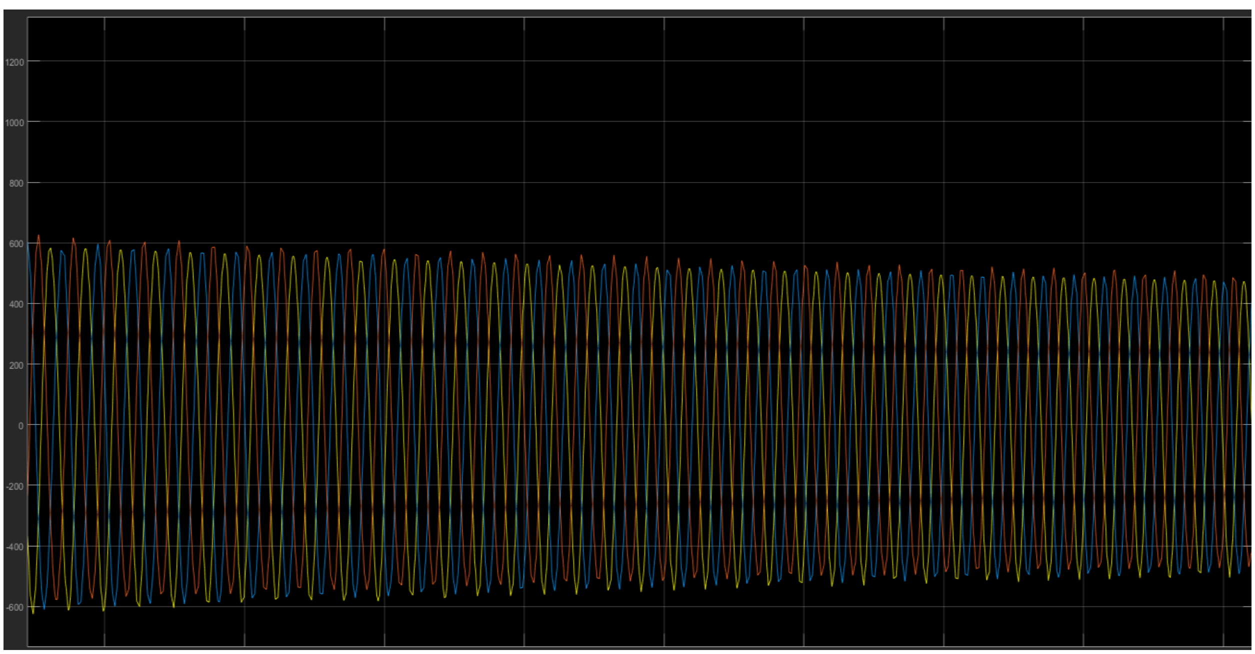

Fig 14: Voltage output at 1.2 m/s

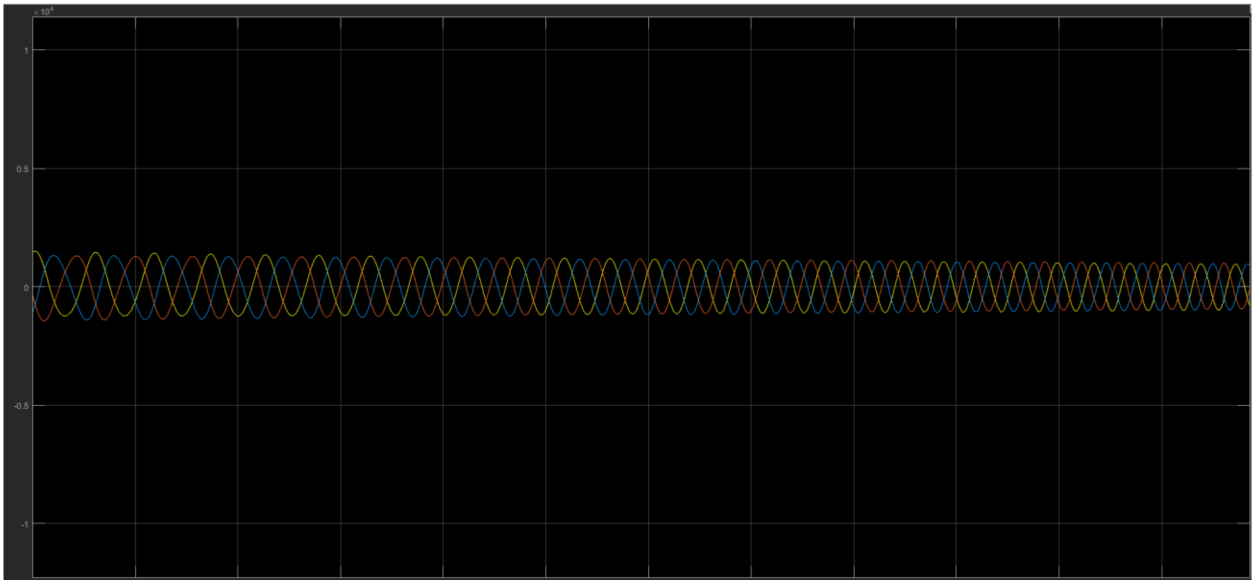

Fig 15: Voltage output at 1.4 m/s

SIMULATION MODEL OF SOLAR POWER SCHEME

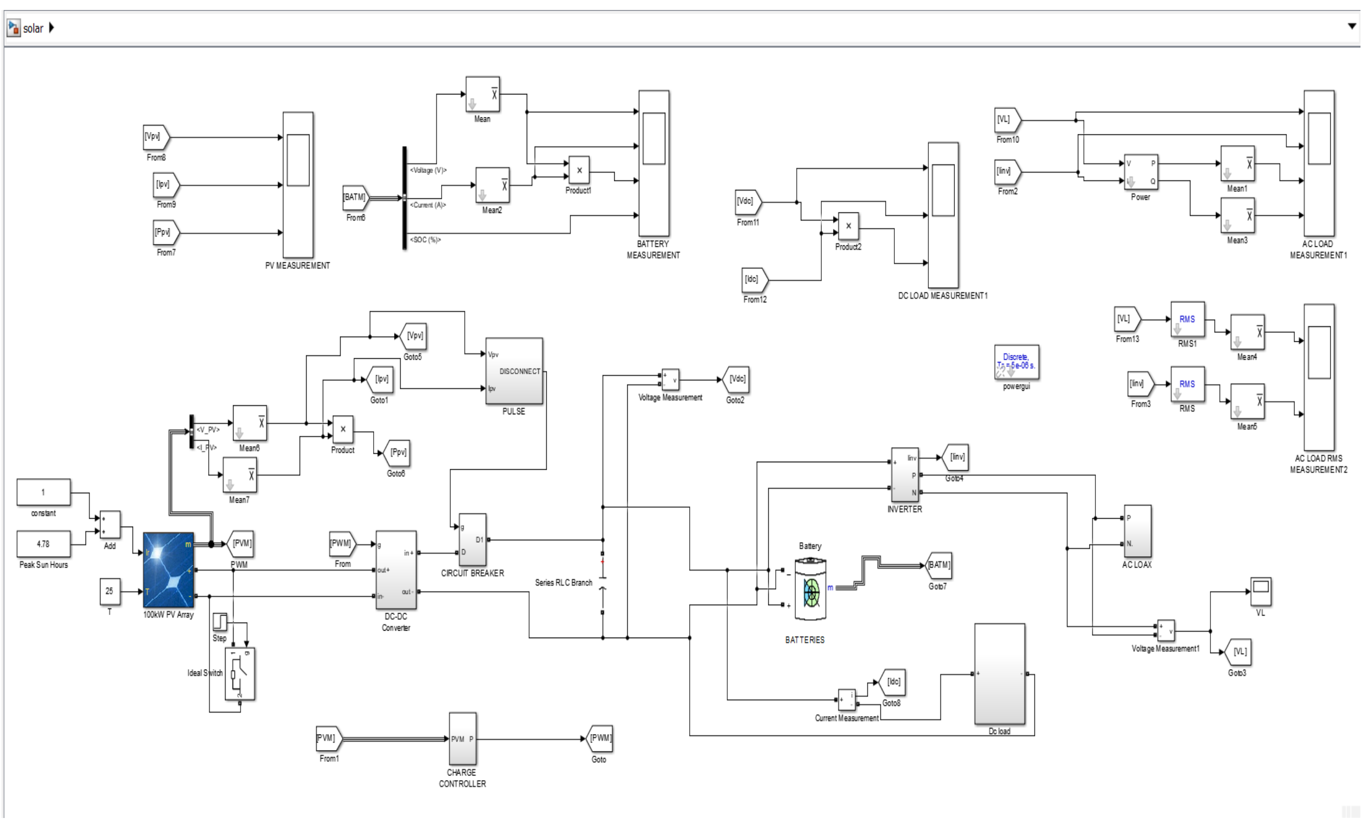

Fig 16: Simulation Model of Solar PV Scheme

The Simulation Model represents a typical Solar PV Scheme of 100KW. The model consists of Solar PV panels which convert the sun's energy into electrical energy. The model also contains a dc-dc converter, a circuit breaker, a series RLC filter, batteries and inverters. Some loads such as DC loads and AC loads are also connected. The converter is used for voltage regulation. The power generated from the panels are directed into the battery for storage purposes. The inverter converts the DC power into AC power to feed the AC loads and DC loads are directly fed from the battery. Here 258 no.s of lead acid battery of 24V are connected to match the load requirement. An ideal switch is also connected for regulating the power supply.

GRAPHS

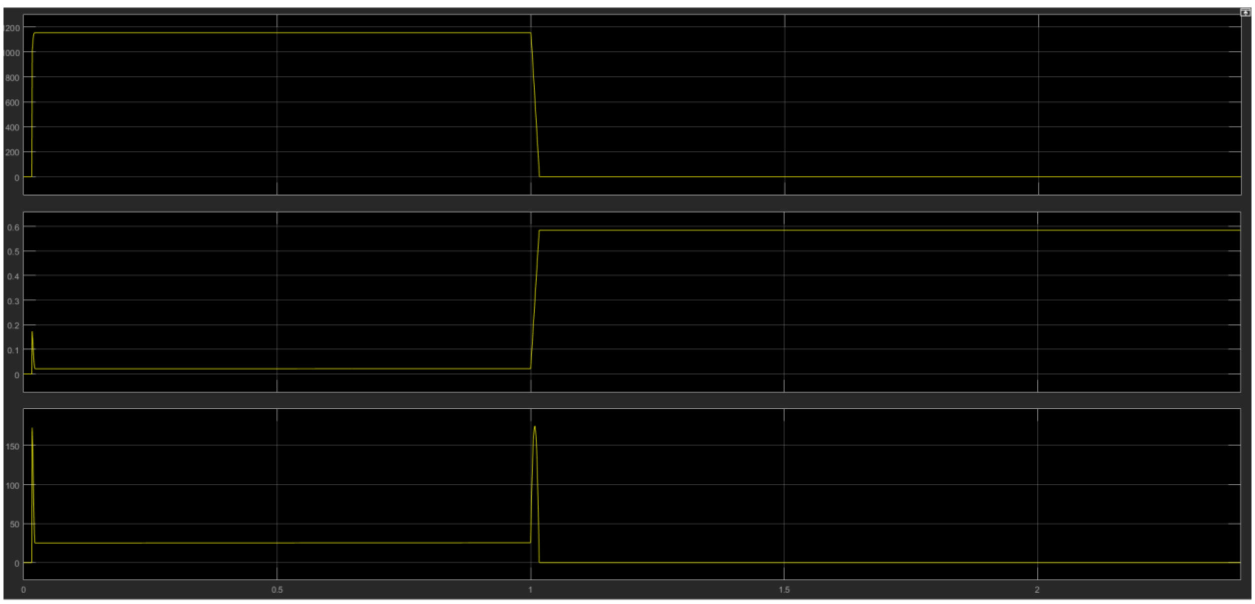

Fig 17: PVI Graph

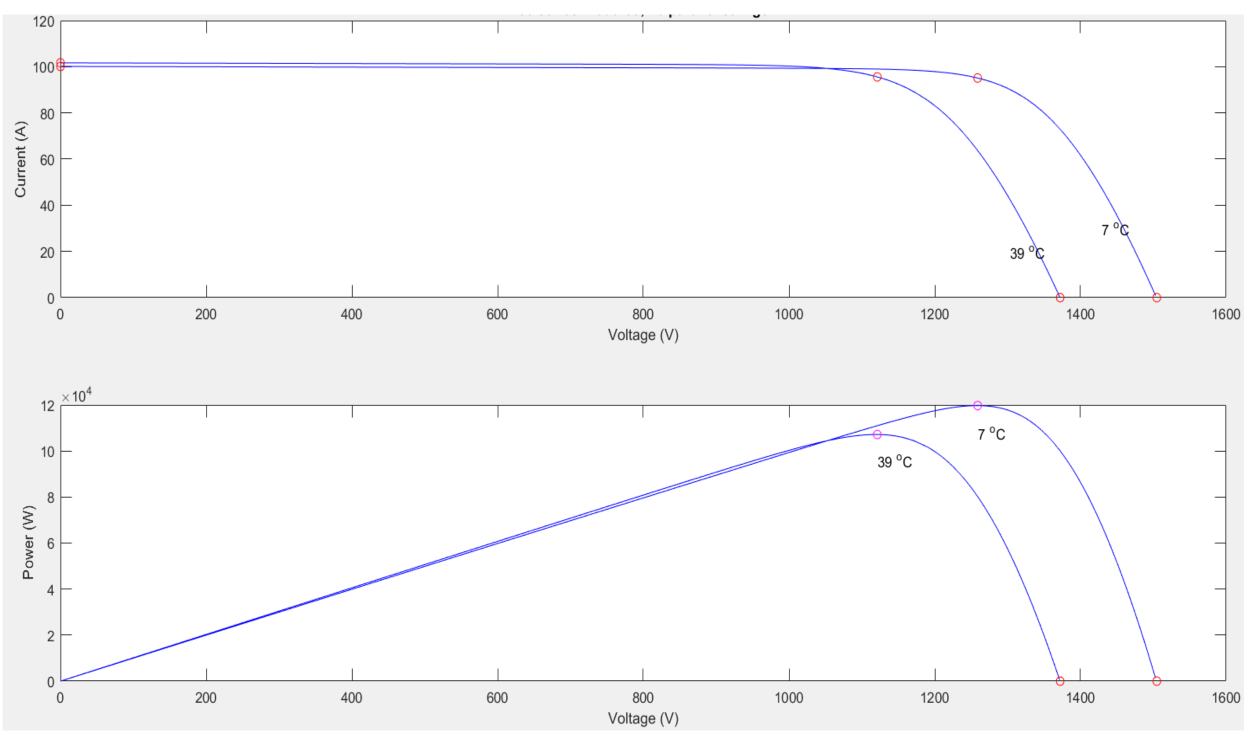

Fig 18: Power, Current and Voltage Graph of whole array

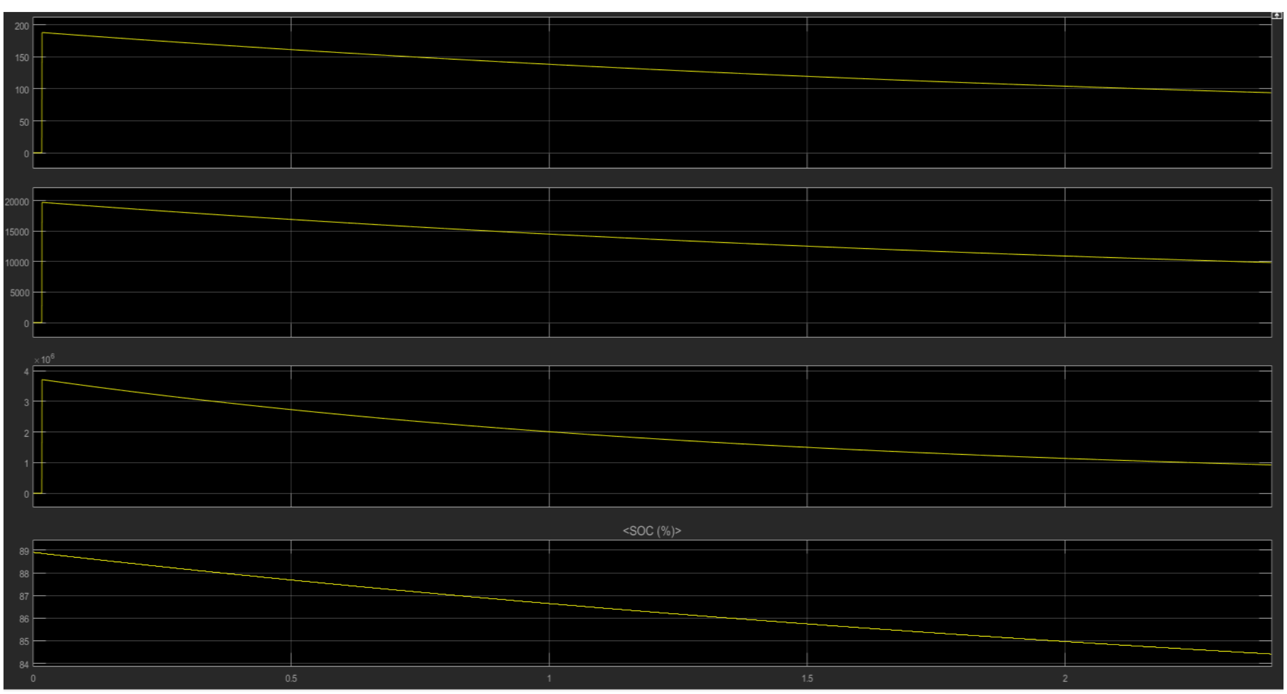

Fig 19: Battery Measurement

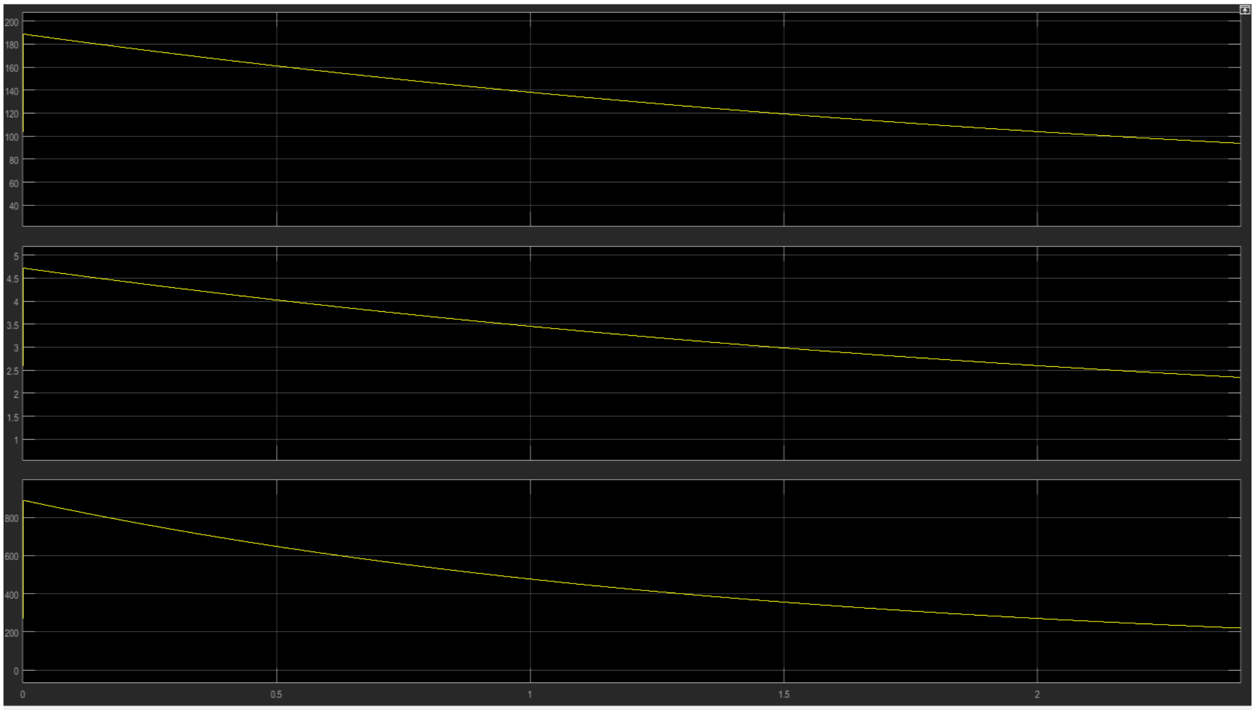

Fig 20: DC Load Measurement

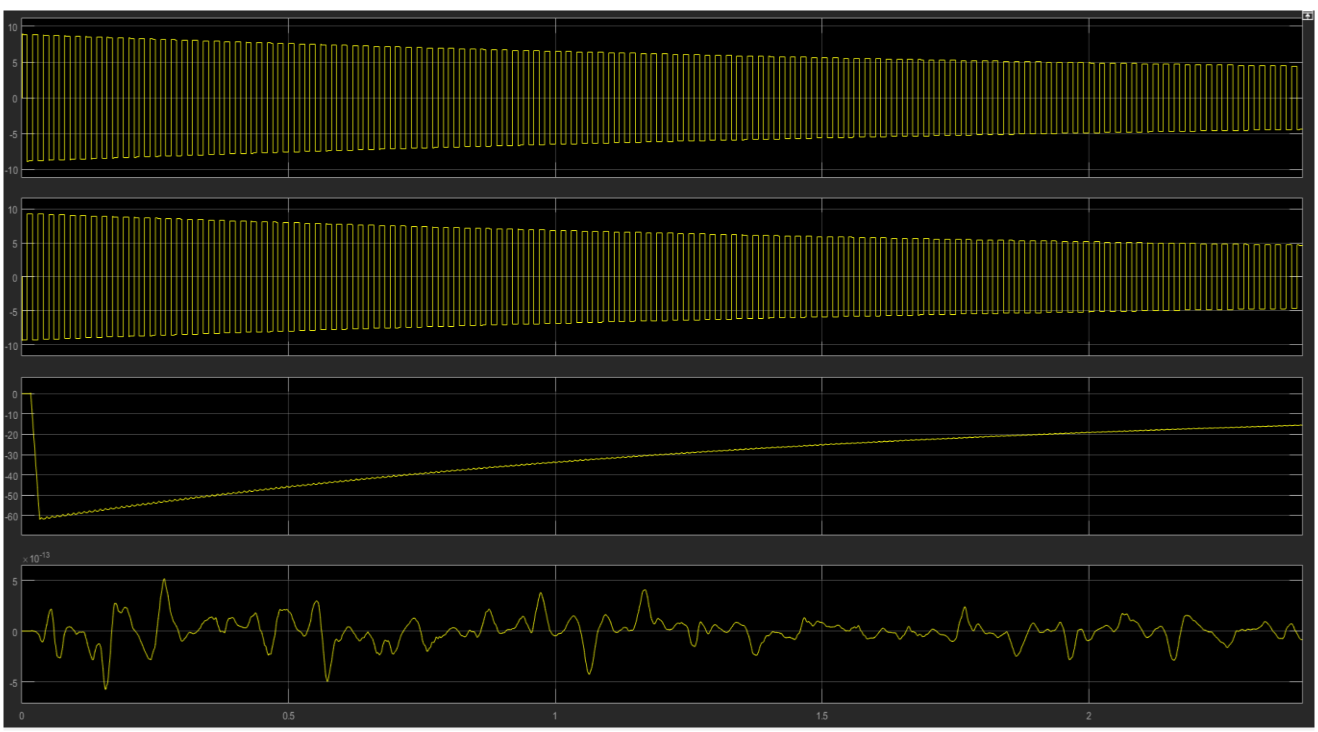

Fig 21: AC Load Measurement

CHAPTER 5

PROPOSED SITE

Site for Micro-Hydro Project Scheme:

Fig 22: Map of proposed site for MHP

The photograph of this map was taken from the Guwahati Jal Board office. It shows different reservoirs of Guwahati Jal Board. The reservoir marked with red is the proposed site of this project which is the Jalukbari reservoir inside Assam Engineering College Campus.

Site for Solar PV Scheme:

Fig 23: Site of Solar PV Scheme

The AEC pond is selected as the site for the solar pv scheme. It was selected as the water will help to maintain the temperature close to STC of the solar panels. This will help in optimizing the working efficiency of the solar pv panels.

CHAPTER 6

CONCLUSION

India's burgeoning economy faces a critical challenge of meeting the ever-increasing demand for electricity while ensuring sustainable development. Fossil fuels, the traditional energy source, are not only finite but also contribute significantly to environmental pollution. Nuclear power, while offering high energy density, raises concerns regarding waste disposal. Additionally, the national grid struggles to reach far-flung rural areas, leaving them without access to reliable power.

Green micro-hybrid power emerges as a compelling solution to these challenges. By harnessing a combination of renewable energy sources, such as solar and micro-hydro, this technology provides a clean, reliable, and efficient power generation option. Renewable energy sources like solar and micro-hydro are inexhaustible, minimizing dependence on finite fossil fuels and promoting long-term environmental sustainability. Micro-hydro can effectively address peak power demands, reducing the strain on conventional power plants and minimizing reliance on fossil fuels during peak hours. Micro-hybrid systems operate efficiently as off-grid power sources, illuminating remote villages currently deprived of grid connectivity. This fosters rural development and improves the quality of life for communities. Reduced dependence on fossil fuels translates to lower greenhouse gas emissions, mitigating the impacts of climate change and promoting cleaner air. India's vast geographical diversity offers immense potential for exploiting various renewable energy resources. The abundance of rivers and streams in Northeast India makes it particularly suitable for micro-hydro power generation. This, combined with the country's ample solar irradiation, presents a unique opportunity to leverage green micro-hybrid power for sustainable electrification. By embracing green micro-hybrid power solutions, India can ensure energy security, environmental sustainability, and equitable access to electricity for all its citizens. This technology paves the way for a more prosperous and developed future, driven by clean and reliable energy.

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