ELP305, Design and Systems Lab

Assignment SUNERGY: Tribe D

Week 4: Final Report

Team D (DukhDard)
Submitted to: Prof. Subrat Kar, Instructor, ELP305 Design and Systems Lab

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1. Our Tribe:

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1. This document was submitted on 2 Feb, 2022.
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2. Readability Indices

2.1 Documentation Statistics

Word Count	9522
Total number of complex words	1532
Average number of words per sentence	5.13
Total number of sentences	1852
Average number of syllable per word	1.61

2.2 Document Readability indices

Indice	Value	Meaning
Flesch Kincaid Reading Ease	65	Easy for a 12 to 15 year old to understand
Flesch Kincaid Grade Level	5.5	Easy for a 5th to 6th grade student to understand
Gunning Fog Score	6.7	A 6th to 7th grade student can understand in first reading
SMOG Index	5.5	Easy for a 5th to 6th grade student to read the handwritting
Coleman Liau Index	9.9	A 9th to 10th grade US student can understand
Automated Readability Index	0.9	Easy for a US grade level student to comprehend

3. Preamble

3.1 Abbreviations

Abbreviation	Definition
AC	Alternating Current
ACDB	AC Distributing Board
DCDB	DC Distributing Board
HDPE	High Density Polyethylene
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MC4	Multi Contact, 4 mm
MCB	Miniature Circuit Breakers
MPPT	Maximum Power Point Tracking
PVC	Polyvinyl chloride
PWM	Pulse Width Modulation
RCCB	Residual Current Circuit Breaker
SPD	Search Protective Devices
UV	Ultra-Violet

3.2 Units

Units	Definition
A	Ampere
AWG	American Wire Gauge
ft	feet
Hz	Hertz
k	Kilo
L	Liter
mm	Millimetre
sqft	Square feet
sqmm	Square Millimetre
V	Volt
W	Watt
Wh	Watt hours

3.3 List of Tables

3.4 List of Figures

3.5 Gantt Chart (Attached at the end of this pdf report)

4. Motivation

We are designing a system to meet the entire energy needs of your off-grid house i.e. without drawing commercial electrical power from the utility. This is the final report of the house designed by Tribe D.

5. Abstract

The aim of this project is to design an assembly of power resources to meet the entire energy needs of a home without drawing from commercial electricity. To meet these needs, we've incorporated Solar, Biomass and Wind Energy with an emphasis on Solar energy, and using Wind and Biomass as per the availability of resources in the environment. The location of the house is assumed to be Chennai (Tamil Nadu, India).

The designed house has one floor, with adequate space allocated in the garden area for a Biomass Unit as well as a Windmill unit and the roof which mounts the solar panels all of which connect to a separate battery storage room. The power supplied to the house is enough for daily usage, and incase of a cutoff can provide backup for upto a week.

The setup is designed to harness approximately 7kWh of electricity per day from solar energy which is taken to be available for approximately five hour per day. We have taken an array of six solar panels with connections optimised for continuous and maximum generation. We designed a custom build design of a stand which can hold three panels in one frame. With two of this frame holding 6 panels in total.

The biomass resources have the potential to supply more useful energy at the same time reducing the impacts on the environment compared to fossil fuels. The biomass power plant uses a direct-fired combustion system to produce electricity in which the biomass is burned directly to produce high-pressure steam to drive a turbine generator. The setup is designed to harness 4-5kWh of electricity per day from biomass energy using around 8-10 kg of dry waste everyday. We also propose to use the wet waste using a compost.

The storage unit has wild AC coming from three sources - solar, wind, and biomass. Through charge controllers, this is converted to DC at a constant 24V. The charging voltage for the batteries is set at 24V. Simultaneously, the current is drawn from the battery at 24V and fed to the inverter, converting it into AC at 220V, 50Hz frequency. The AC current is then supplied to the household through MCB to prevent damage.

6. Design

6.1. Energy Sources

The energy requirements of the house are fulfilled by the following sources of energy:

1. Solar : Installed on roof
2. Windmill : Turbine (AC) uses area from the garden
3. Biomass : Chambers containing organic material (carbon content) undergoes reactions to spin the turbine (Store room for production)

6.2 Model of House

The following table contains specifications of the house:

Properties	Specifications
Total Area of the house	2500 sqft
Area around the house for windmill and Biogas Chamber	1000-1200 sqft
	Windmill (Above the ground)
	Biogas Chamber (Underground)
Room height	10 ft

Table 1: Specifications of the house

The following figure shows the top view of the house:

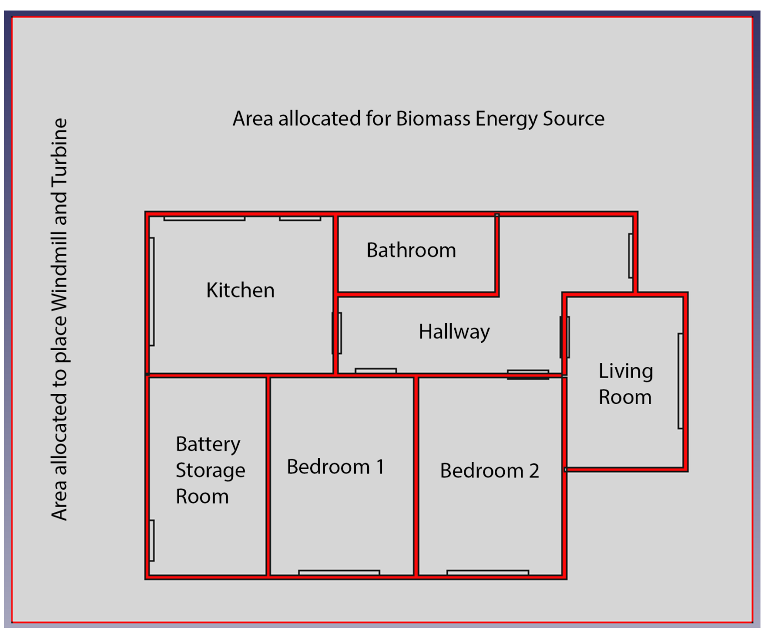


Figure 1: Top View of House

The following figure shows the isometric view of the house:

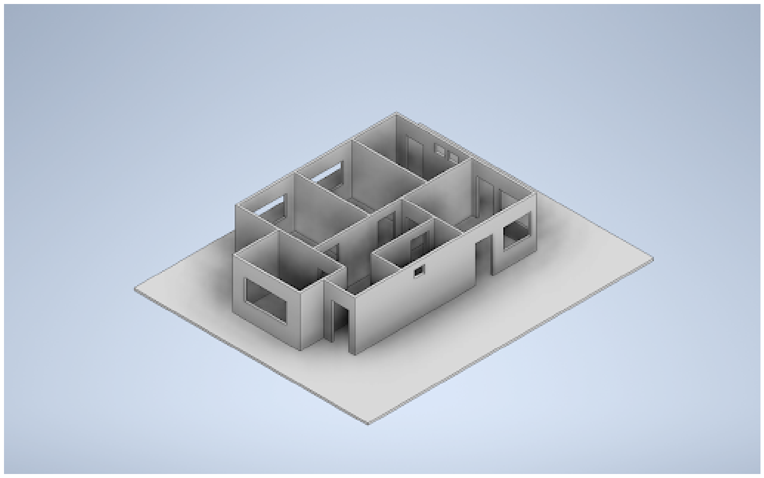


Figure 2: Isometric View of the House

The following table contains information about different rooms in the house along with their specifications:

Room	**Item**	**Quantity**	**Specifications**
1 Kitchen	Exhaust Fan	1	Power: 32 W, Operating Voltage: 230 V
	Light	2	Power: 9 W, Operating Voltage: 230 V
	Power socket for a fridge	1	Operating Voltage: 230 V, Current: 15 A
	Power sockets for normal appliance usage (Toaster, Grinder etc)	1	Operating Voltage: 230 V, Current: 5 A
	Chute system to Biogas chamber	1	
	Doors to the outside	2	
1 Hallway	Light	3	Power: 9 W, Operating Voltage: 230 V
1 Bathroom	Geyser powered by Solar Energy	1	Power: 2000 W, Capacity: 15 L, Operating Voltage: 230 V
	Exhaust Fan	1	Power: 32 W, Operating Voltage: 230 volts
	Light	1	Power: 9 W, Operating Voltage: 230 V
	Chute system to Biogas chamber	1	
2 Bedrooms	Fan	1	Power: 70 W, Operating Voltage: 230 V
	Power sockets for normal appliance usage	1	Operating Voltage: 230 V, Current: 5 A
	Light	1	Power: 9 W, Operating Voltage: 230 V
1 Living room	Tube Lights	2	Power: 20 W, Operating Voltage: 230 V
	Fan	1	Power: 70 W, Operating Voltage: 230 V
	Power sockets for normal appliance usage	2	230 V, 5 A
1 Battery Storage Room	MCB + Fuse Box	1	

Table 2: Specifications of Different Rooms

6.3. House Wiring

The following diagram shows the house wiring:

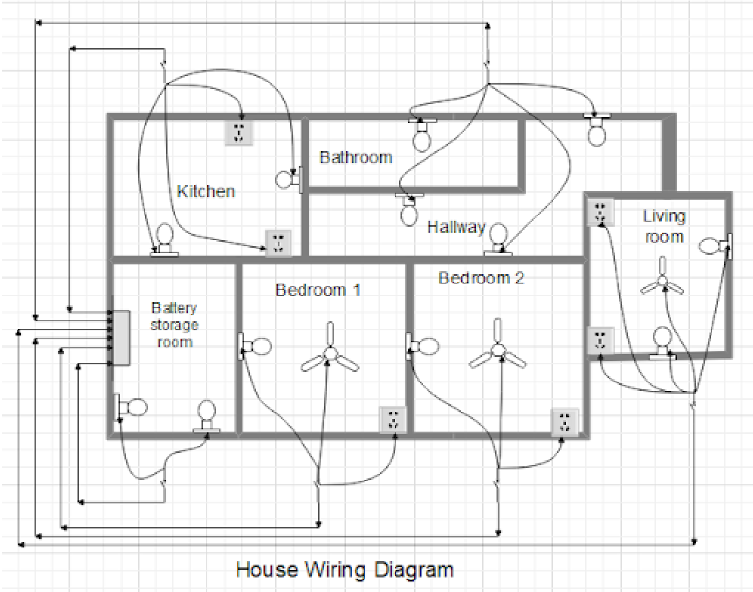


Figure 3: House Wiring

6.4. Battery Storage Room

6.4.1. Electric Wiring Board

The following diagram shows the Electric Wiring Board:

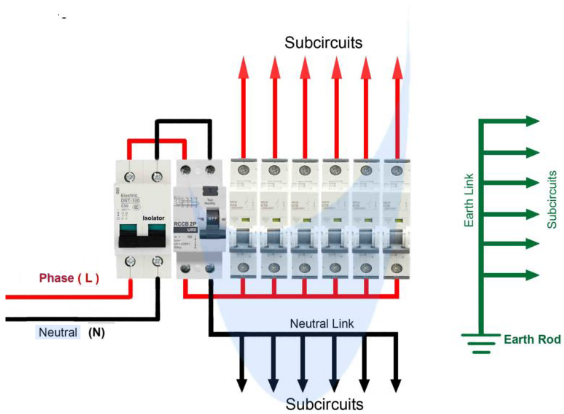


Figure 4: Electric Wiring Board

The following diagrams shows the components of Electric Wiring Board:

Figure 5: Components of Electric Wiring Board

6.4.2. MCB connections

MCB is a Miniature Circuit Breaker built to save the electrical circuit and loads from short circuit and overload faults.
RCCB is Residual Current Circuit Breaker which is also used to break the circuit when leakage current occurs.
The MCB Distribution Box consists of MCB, a neutral link, an earthing link and a distribution board which has a RCCB and a number of MCB for all the rooms.
A phase wire and a neutral wire from the input supply are connected to the MCB which are then connected to the RCCB in series. From the RCCB, the Phase connection goes in parallel to the MCBs and the neutral wire enters the neutral link.
From each MCB the phase wire is connected to the switch board in the room and a neutral wire is connected from the neutral link. Earthing wire is connected from the earthing link for each room.

6.4.3. Battery Room preventive measures against mishappenings

1. Ventilation: During the recharge process hydrogen and oxygen evolve from the lead acid battery. If the hydrogen level exceeds 4% of the available volume in the area then the general atmosphere can become explosive – because of this it is recommended that the concentration of hydrogen never exceeds 1% of available volume.
    - Adequate ventilation needs to be provided to keep the hydrogen level below 1%. The battery room shall be ventilated by means of two exhaust fans (one working + one standby)
    - The standby fan should start automatically in case the other fails
    - The fan should be mounted as high as possible in the wall, but not below the level of the light fittings (Fan used: Havells Ventil Air DX 200mm Exhaust Fan)
2. Personal Protective Equipment and Clothing
    - One ABC fire extinguisher that is properly inspected/maintained
    - One Fire extinguisher
    - Adequate amount of Neutralizer
3. If electrolyte is spilt:
    - Throw sand over the contaminated area and remove the earth or sand once it has soaked up the acid/electrolyte
    - Wash down the area with a solution of common washing soda
    - Dispose of any contaminated material safely
4. Do's & Don'ts in and around battery room:
    - To Ensure that the area is adequately ventilated to dissipated harmful gasses, two exhaust fans have been installed
    - Keep all metallic objects away from battery tops
    - Prevent open flames, sparks or electric arcs in the battery charging areas
    - The battery charging has been well lit with two lights
    - A spill tray should be installed under the battery to contain any spill
    - If installed batteries are at risk of metal tools or other conductive materials touching terminals, then the terminals should be insulated

6.4.4. Cost Analysis

Item	**Price (INR)**	**Quantity**	**Cost (INR)**
Special Exhaust fan	1290	2	2580
Fire extinguisher	210	1	210
Spill Tray	899	1	899
Neutralizer	3271	1	3271
Bucket + Sand	260	1	360
MCB	160	6	960
RCCB	999	1	999
Isolator	747	1	747
		Total	10026

Table 3: Cost Analysis for Battery Room

7. Solar

7.1. Mind Map

7.2. Roof Design

The location of house is assumed to be Chennai (Tamil Nadu, India). We built a flat roof of the house as it provides greater area so there will be proper airflow which helps in the temperature reduction of the panels.

7.3. Solar panels

Solar Panels should produce approx 6-8 kWh electricity per day. It is the primary component for the solar energy system used to convert sunlight into electricity. Solar panels should fulfill the requirements:

1. They should have anti-reflectin and self cleaning coating for better sunlight incident on solar cells
2. They should be sturdy
3. They should not degrade by constant heating and cooling down
4. They should be UV protected

We are using six 335 W Solar panels (Total 2.01 kW). The following table shows the specifications of the solar panels used:

Properties	**Specifications**
Manufacturer	Luminous (335W/24V)
Material	monocrystalline solar panel
Number of panels	6
Operating Voltage	24 V
Dimensions	height= 6.4 ft, width= 3.2 ft
Short Circuit current	10.57 A
Current at Max Power (i_{max})	10.03A
Open Circuit voltage	46.5 V
One Panel weight	22Kg
One Panel price	14,500 (INR)
Area for solar panels	180 sqft

Table 4: Solar Panels Specifications

Features of Luminous Monocrystalline PERC (Passivated Emitter and Real Cell) Solar Panels are:

1. Excellent performance under low light conditions and comes with highly qualified anti-reflective glass
2. Comes with latest PERC technology with panels made of Potential-Induced Degradation (PID) resistance technology
3. Comes with premium MC4 connectors along with 1000mm DC cable that ensures a secure and safe connection
4. These Solar Panels offer high torsion resistance against wind and snow loads due to its silver anodized aluminium frame

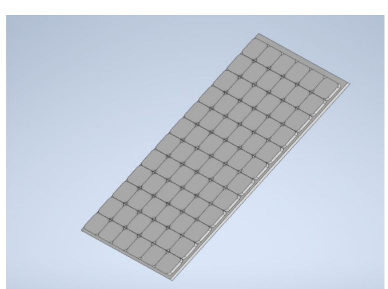


Figure 6: Isometric View of a Single Solar Panel

7.3.1. Solar panel Connection

We have to connect two solar panels in series and three such connections in parallel. We need at least two solar panels in series because the total voltage generated by the solar panels must be significantly higher than battery voltage for efficient performance. We have one solar panel rated at 24 V operating point but this might decrease depending on the production or temperature. Hence, to ensure the panel voltage to be higher than the battery voltage, we are keeping two panels in series but we also need these panels in parallel so that performance of one panel doesn't affect the performance of all other solar panels.

7.4. Off Grid Solar Inverter

It is the central component that converts DC Voltage into AC for AC operated home appliances. Solar inverter should fulfill the following requirements:

1. It should have an overload warning mechanism
2. It should have an overload and short circuit protection
3. It should have at least 2.5 kW power rating
4. It should be able to withstand high temperatures and have a good cooling mechanism
5. It should be resistant to humid climate

7.5. Batteries

Battery should be completely safe, non-burnable, stable and maintenance-free. Battery should fulfill the following requirements:

1. It should have good electrical performance with low resistance
2. It should have a high number of charge cycles and a high current rating

The maximum distance between solar panels and batteries should be 20 to 30 ft and mount the charge controller within a yard or a meter of the batteries. If the distance is more than 30 ft we need high quality cables.
The battery bank and the inverter should also be close — within a yard or so.

7.6. Wires (AC and DC)

The wires that are used in the connection of panels with the Solar inverter are called DC wires. These wires should be in PVC pipe and cable tray for protection from DC current and sunlight. The wires that are used for the connection of the inverter with the grid power and Household loads are called AC wires.
The specifications of DC Wire are as follows:

Use of Wire	**Property**	**Specification**
Solar Array to DCDB	Wire Gauge Diameter One way distance	12 AWG 1.8493 mm 6 m
DCDB to Charge Controllers	Wire Gauge Diameter One way distance	12 AWG 1.8493 mm 6 m
Charge Controller to Batteries	Wire Gauge Diameter One way distance	6 AWG 4.09 mm 2 m
Earthing Wire	Wire Gauge	6 AWG
For Lightning Arrestor	Material Cross Section Area	Aluminum Wire (insulated) 50 sqmm

Table 5: Specifications of DC Wires used to connect solar panels and inverter

7.7. ACDB (1 in 1 out)

It includes AC SPD, AC fuse and MCB to protect the solar inverter from high voltages on the AC current side. ACDB should fulfill the following requirements:

1. It should have capacity upto 3 kW
2. Dust and water protected
3. Polycarbonate Material
4. MCB Based AC disconnection
5. It should have high current rating
6. It should have high voltage and frequency rating as in AC

7.8. DCDB (1 in 1 out)

It protects the solar energy system from DC current from panels and protects panels from reverse current flow. DCDB should fulfill the following requirements:

1. It should include DC Fuse, DC MCB and SPDs
2. With an LED indicator for the Current produced from the panels
3. IP66 Polycarbonate Material
4. With DC SPD,DC Fuse and Indicators
5. It should have fuse with DC rated current rating
6. It should have voltage rating same as the output of solar panels

The following table shows the specifications of the DCDB used:

Property	**Specifications**
Maximum current	39.63 A
Fuse Rating	38-40 A
Brand	Havells
Voltage	220-240 V
Material	PVC IP68
Power rating	1-3 kW

Table 6: Specifications of DCDB used in Solar Energy System

7.9. Solar Water Heater

A Solar water heater with the following requirements:

1. Medium Installation area should be required
2. Solar Collector with copper tubes for better conduction
3. It should have good efficiency
4. Should not get overheated and cause damage
5. Some covering on the sides must be incorporated to prevent burn if someone comes nearby
6. Insulated hot water storage tank approx 200-300 L
7. Cold water tank with required insulated hot water pipelines and accessories

8. It should be able to withstand hot water upto 80 °C

9. The cold water tank used for storing daily water usage can be connected to solar heater tubes for regular heating and reduce the number of storage tank

10. Some valves to control the flow

The following are the specifications of the Solar Water Heater used:

1. Dimensions are : 1.316 m $\times$ 2.105 m

2. 200 L per day Non pressurized ETC (Evacuated Tube Collector-based on thermosyphon principle) because ETC has a very low heat loss coefficient.

3. Average Hot water output is above 40 to 50 °C above ambient temperature.

4. Tank insulation with Polyurethane foam which keeps the water hot for 16 to 18 hours with a small temperature loss of 3 °C

5. Socket provided for the Electrical Back up heating coil in the tank for low sunlight conditions

6. Plumbing Pipes and accessories are required for inlet and outlet connections with domestic water tank and supply

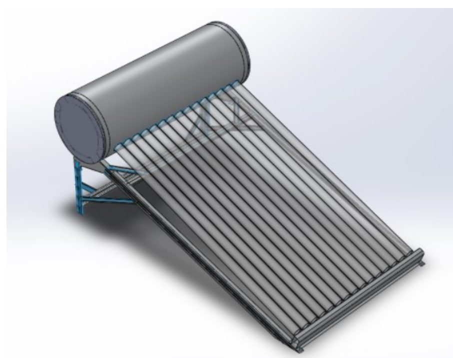


Figure 7: Isometric View of Solar Water Heater

7.10. Charge Controller

We are using charge controllers to regulate voltage and current from solar panels to batteries. In this solar system we used MPPT (Maximum Power Point Tracking). Charge Controller should fulfill the following requirements:

1. It should have high current rating more than the output peak current of solar panels

2. It should charge the batteries correctly and efficiently and protect them from overcharging

3. It should regulate the variation in current voltage characteristics properly

We are using one Victron SmartSolar Charge Controller (85 A,150 V):

Property	**Specifications**
Dimensions	$295 \times 213.9 \times 100.4$ mm
Maximum possible current in the system	83.75 A (Minimum Current Rating)
Upper Voltage limit	93 V (Minimum Voltage Rating)
Maximum power	$6 \times 335 = 2140$ W (Minimum Power Rating)
Efficiency	98%
Wire Size(cross-section)	16 mm^2

Table 7: Specifications of Charge Controller (See Appendix A)

Other specifications of this Charge Controller are:

1. It is a Maximum Power Point Tracking(MPPT) controller and uses advanced MPPT control algorithm to minimize the maximum power point loss rate and loss time
2. It has ultra-fast tracking speed and great tracking efficiency
3. It has fully programmable charge algorithm and eight pre-programmed algorithms, selectable with a rotary switch
4. Comes with auto-voltage detection feature (12, 24, 36, or 48 volts)
5. LCD and indicators to display operating data and status of the system
6. The wireless (Bluetooth) solution to set-up, monitor, update and synchronize Smart Solar Charge Controllers
7. Real-time energy statistics function, Overheating power reduction function

The solar charge controller should always be placed close to the batteries, not close to the panels. It should be within one meter (approximately 3.25 ft) of the battery bank and in the same room or enclosure.

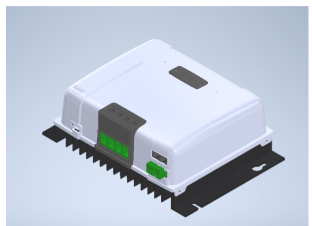


Figure 8: Charge controller outer casing with connection ports

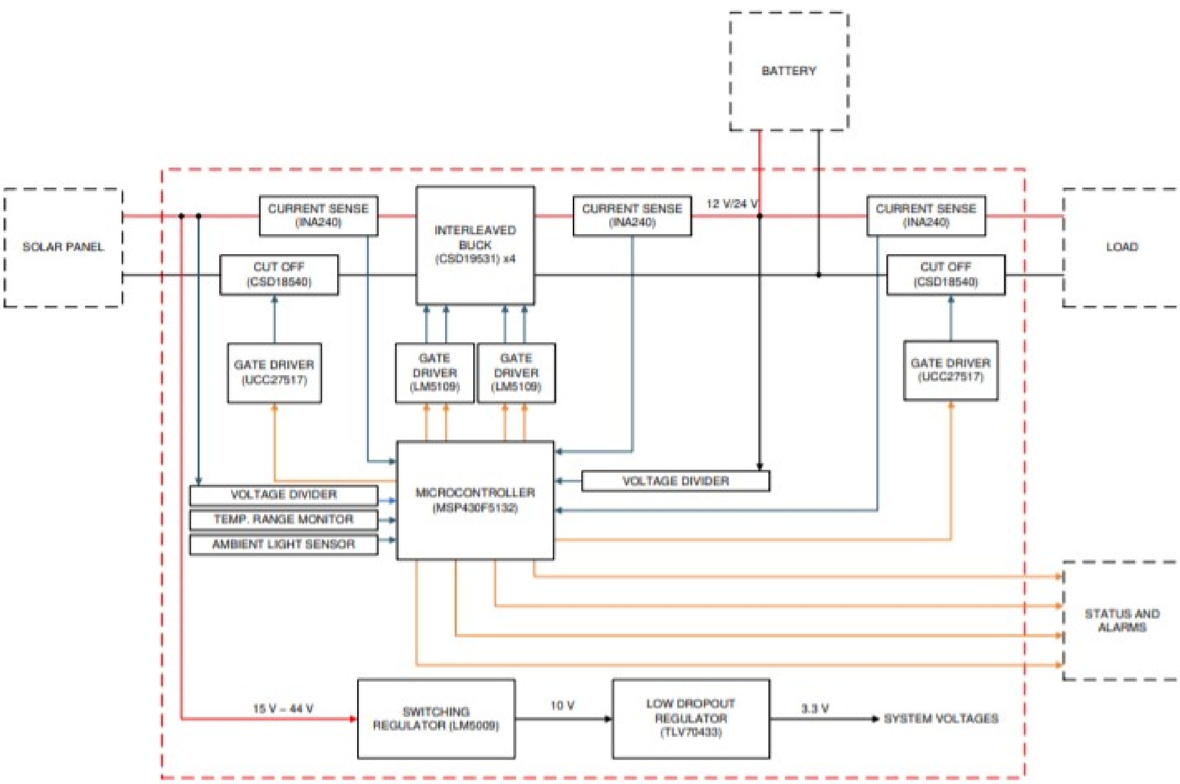


Figure 9: Charge Controller Block Diagram

7.11. Clamp meter

Clamp meter detects the magnetic field emitted by current flowing in wire in order to measure the current value. Charge Controller should fulfill the following requirements:

1. It should be lightweight
2. It should have overload protection system
3. It should be adjusted according to different current ranges for better precision

7.12. MC4 connector

MC4 (Multi Contact and the 4 mm diameter contact pin) connectors are single contact electrical connectors commonly used for connecting solar panels.
We will use the Solar panel system to measure current and voltage whenever required. Two pairs of MC4 connectors are needed.

7.13. Solar Panel Stand

Solar panel stand is an iron structure that fixes the solar panels on the rooftop and protects the solar panels from high blowing wind and animal attacks etc.

Solar Panel Stand should fulfill the following requirements:

1. It should be adjustable according to the position of the sun
2. The stand should be made of a quality material and should be rust proof and universal
3. Additionally, for protection from storms, we require bricks and cement to fix the stand
4. It should be lightweight

7.13.1. Design of solar panel stand

We used Mechanical stands for the panels, which includes change in angle of panels by mechanical movement of the rods. This will increase the energy production by at least 6-7 %. The cost of these stands is almost equal to the fixed stands. The solar panel stand are made such as:

1. Panels will face towards the South direction with an angle of 14.8° from horizontal in Spring/Fall season, 30° in Winter season and 0° (exactly horizontal) in summers
2. Panels will be adjusted four times in a year
3. Height of panels from the roof: The height should be at least 3-5 inches for continuous airflow (The airflow helps in reducing the temperature of the panels for more energy production)

We have designed the Solar panel stands in such a way it have holes from 0-30 which can be adjusted manually according to position of sun, thus giving the desired output.
Area covered by both stands is 170 sqft Total weight of solar panels is approx $22.5 \times 6 = 133$ kg.
We designed our stand such that it support 3 solar panels (upto 66 kg). Weight of each stand is 20-25 kg.

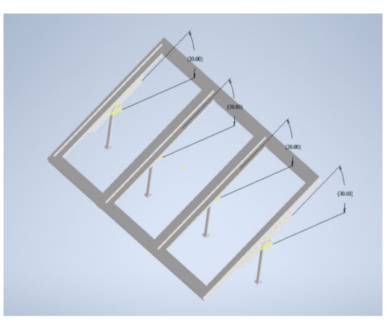


Figure 10: Isometric View of Solar Panel Stand

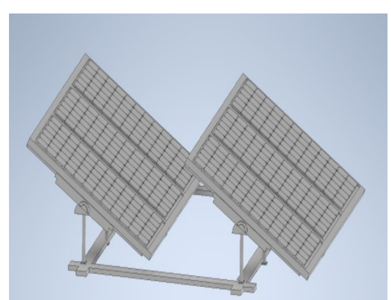


Figure 11: Assembly of Solar Panels and Solar Stand

7.14. Earthing Kit

The following flow chart shows the components of Earthing kit:

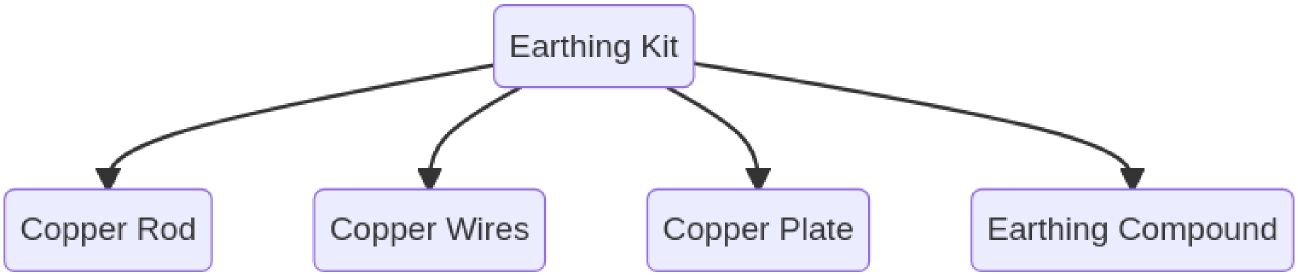


Figure 12: Components of Earthing Kit

Two separate earthings are required, one for Inverter and other one for Lightning Arrester.

Copper rod should conduct lightning to earth and not degrade or GI(Galvanised Iron) can also be taken buried upright in the earth manually or with the help of a pneumatic hammer.

The following table shows the specifications of Copper rod:

Property	**Specifications**
Length	6-8 ft
Material	Mild Steel
Finish	Copper Bonded/Coated
Dimension	24×24 inches

Table 8: Specifications of Copper Rod

Earthing is required for protection of human life as well as for protection of equipment of the system from excessive touch voltages, earthing provides the path to neutralise the surge voltage. The benefits of using Earthing compound are as follows:

1. Improves soil resistance and the Electrical Conductivity of the Soil
2. Non Toxic and Long Lasting
3. Excellent Moisture Absorption and Retaining Capacity
4. Enriches the Charge Carrying Ions in the soil

7.15. Lighting Arrester

Lighting Arrester (LA) protects solar panels from thunder. In dangerous lightning strikes, LA activates and diverts lightning to ground.
We are using copper bonded Lightning Arrester of length 1 meter with earthing rod for home and building protection. This 1.35 kg weight offers a coverage of 45 from the top point of the Arrester, that is the surrounding area with a 2 m radius.
In order to let the surge current flow to the ground via the earthing system, the copper strip or 4 mm copper AC wire is connected between this Lightning Arrester and ground earthing system.
The following table shows the specfications of Lighting Arrester used:

Property	**Specifications**
Phase	Single Phase
No. of Poles	5
Building Protection Coverage	45° from the top point
Application	Residential
Material	Copper
Surface Treatment	Galvanized
Total length	1 m
Diameter	9.2 mm
Dimension of base plate	9 × 9 cm

Table 9: Specifications of Lighting Arrester

7.16. Basic tools required

The following flow chart shows the basic tools required for installing the set up:

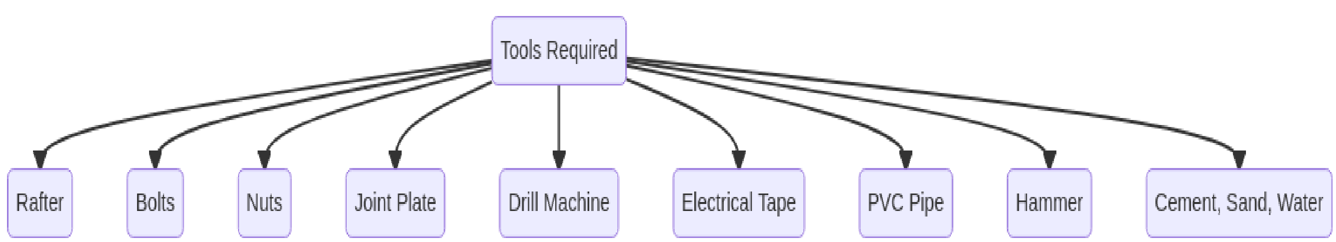


Figure 13: Basic Tools required for installing Solar Unit

7.17. Block Diagram and Wirings

The following figure shows the block diagram for electricity production and transmission from solar energy:

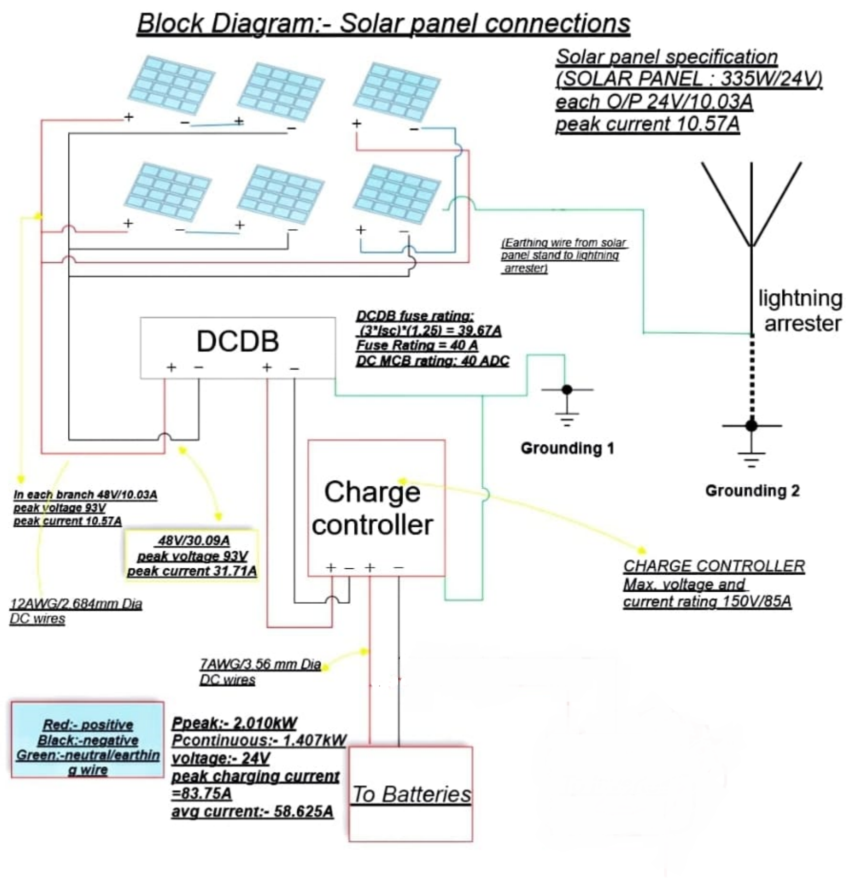


Figure 14: Block Diagram for Solar Panel Connections

7.18. Cost Analysis

Item	Price (INR)	Quantity	Total Price(INR)
Luminous Solar Panel	14,500	6	87,000
Charge Controller	55,000	1	55,000
DCDB and MC4 connectors	4,765	1	4,765
Wires (12 AWG 12 feet)	1,235	4	4,940
Wires(6 AWG 1m)	839	2	1,678
Lighting arrester Full set	5,531	1	5,531
Water heater	26,828	1	26,828
Stands	6,500	1	6,500
		Total	1,92,242

Table 10: Cost Analysis for Solar Unit

8. Wind

8.1. Componenets of Wind Mill

The following flow chart shows the components of a wind mill:

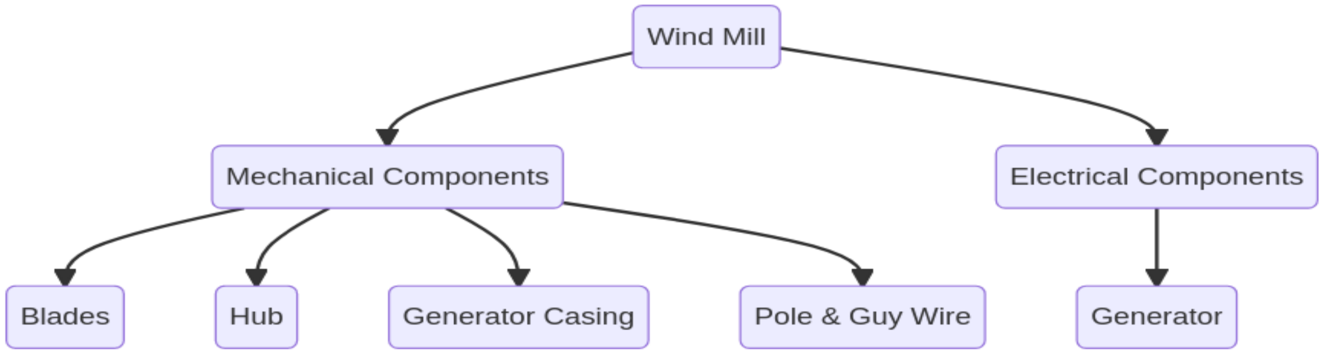


Figure 15: Components of a Wind Mill

8.2. Component Description

8.2.1. Blade of a Wind Mill

The following table shows the specifications of the blade used:

Property	Specifications
Length	0.9 m
Material	Carbon Fibre
Quantity	3 pieces

Table 11: Specifications of Blade

We chose this blade because the higher stiffness and lower density of carbon fibre allows a thinner blade profile while producing stiffer, lighter blades. These blades have a longer lifetime because carbon fiber materials have a high fatigue and corrosion resistance.

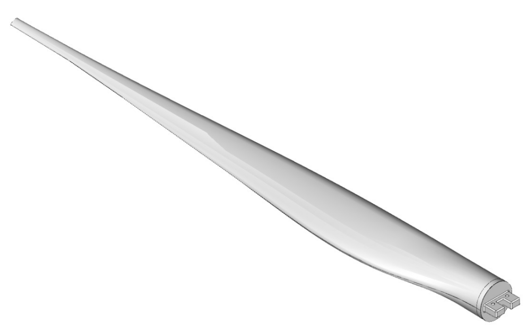


Figure 16: Blade of a Wind Mill

8.2.2. Pole and Guy Wires

The following table shows the specifications of the pole used:

Property	Specifications
Height	27 ft / 8.23 m
Material	Aluminium
Maximum Load Capacity	150 Kg

Table 12: Specifications of Pole and Guy Wires

We chose aluminium for the pole because it has low density and high tensile strength. Aluminium forms a protective oxide layer which makes the poles highly corrosion resistant and prolongs their life. The lower weight is not just beneficial during installation, it also offers advantages during shipping and storage that all help to keep the cost down.
Guy wires provide extra stability during extreme weather conditions.

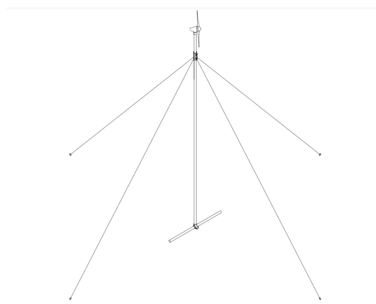


Figure 17: Pole and Guy Wires of a Wind Mill

8.2.3. Specification of Hub

The following table shows the specifications of the hub used:

Property	Specifications
Radius	135 mm
Material	Carbon Fibre

Table 13: Hub Specification

The hub is a key component not only because it holds the blades in their proper position for maximum aerodynamic efficiency, it also rotates the shaft of the generator.

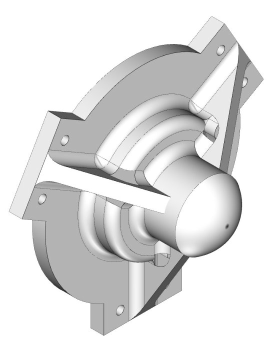


Figure 18: Hub of a Wind Mill

8.2.4. Turbine and Generator

The following table shows the specifications of the turbine used:

Property	Specifications
Product Name	CECPL - PMGL 270
Material	NdFeB (Neodymium Iron Boron)
Frequency	50 Hz
Efficiency	93% (Highly efficient)

Table 14: Specifications of Turbine and Generator Wires

This generator uses direct-drive mechanism, which eliminates the need for a gearbox and can operate at variable RPM. A gearbox free mechanism such as ours reduces the weight and cost.

Figure 19: Generator of a Wind Mill

8.2.5. Casing

The following table shows the specifications of the casing used:

Property	Specifications
Inner dimensions	485 mm × 275 mm × 275 mm
Thickness	10 gauge (2.59 mm)
Material	5052 Aluminium H32
Weight	4.78 kg

Table 15: Specifications of Casing for Wind Mill

5052 Aluminum is optimal for sheet metal work and is very easy to form at room temperature. This material is very bendable, and can therefore handle tight radii.

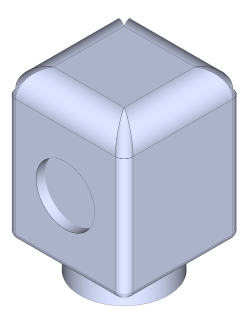


Figure 20: Casing of a Wind Mill

8.3. Assembly

Flow Chart of Mechanical Assembly of the Wind Mill is shown below:

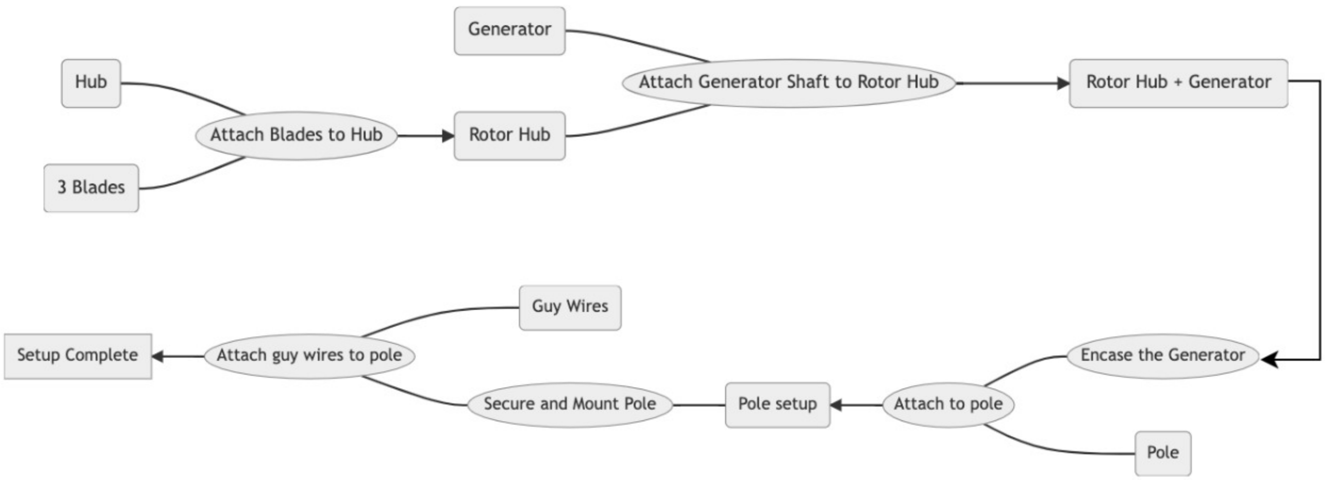


Figure 21: Flowchart of Mechanical Assembly of Wind Mill

Working schematics of the Wind Mill is shown below:

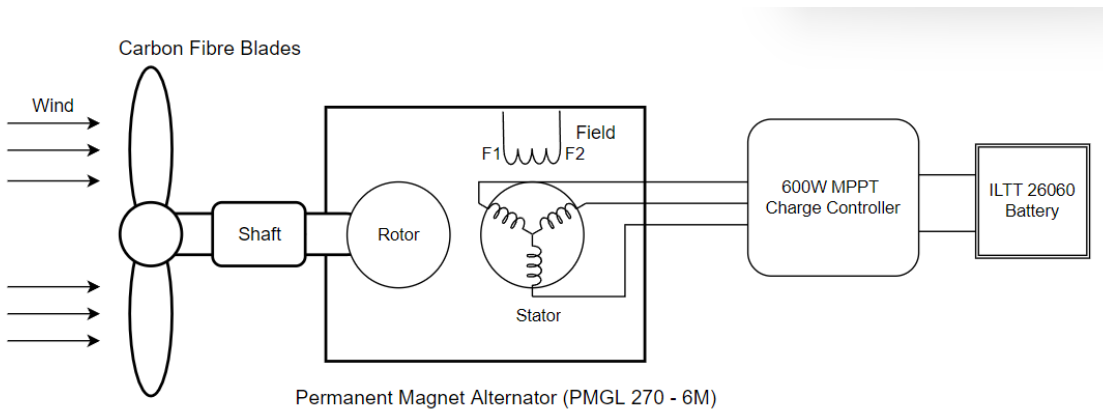


Figure 22: Working schematics of the Wind Mill

8.4. Cost Analysis

The following table shows the cost of the components:

Component	Quantity	Cost per unit(INR)
Aluminum Casing	1	2,500
Permanent Magnet Alternator (PMGL 270)	1	22,000
Guyed Tower (27 ft.)	1	27,442
Carbon Fibre Blades(3) & Hub	1	6,348
Total	-	58,290

Table 16: Cost Analysis for Wind Energy

8.5. Power Analysis

Assuming Average Wind Speed = 4.51 m/s (see Appendix B and C), we get the following results:

Property	Specifications
AC 3-Phase Line-to-Line Voltage Output	18.8 V
Total 3-Phase Power	440 W
Total units generated per month	278 kWh
Cut-off Wind Speed	1.2 m/s

Table 17: Power Analysis for Wind Energy

The above calculations were done using a tool that we built called Wind-Box. The source code is available here.

```
(base) sajal@Sajals-MacBook-Pro WindEnergy_Toolbox_Tribe-D-main % python windbox.py
 _    _ _           _______
| |  | (_)         | | ___ \
| |  | |_ _ __   __| | |_/ / _____  __
| |/\| | | '_ \ / _` | ___ \/ _ \ \/ /
\  /\  / | | | | (_| | |_/ / (_) >  <
 \/  \/|_|_| |_|\__,_\____/ \___/_/\_\
 For all the tasks from 1 to 5 except 4, windspeed is expected from an anemometer present near the wind-turbine or
 for approximation purposes at height 10 meter from the ground (if you're using wind-speed reports please note the
 height they've been reported at and use tool 4 i.e. windspeed convertor)
 1. WindEnergy Potential
 2. Rotational Speed of Windmill/turbine or Frequency of AC
 3. Voltage Output of Windmill/Turbine
 4. Power Output of Windmill/Turbine
 5. Windspeed Convertor
 6. Monthly Output
Please input the index corresponding to task that you want to perform i.e. if you want to calculate Voltage output
```

Figure 23: Command Line Interface of Wind Box

9. Biomass

9.1. Mindmap

The following diagram shows the mind map used while designing the Biomass energy production unit:

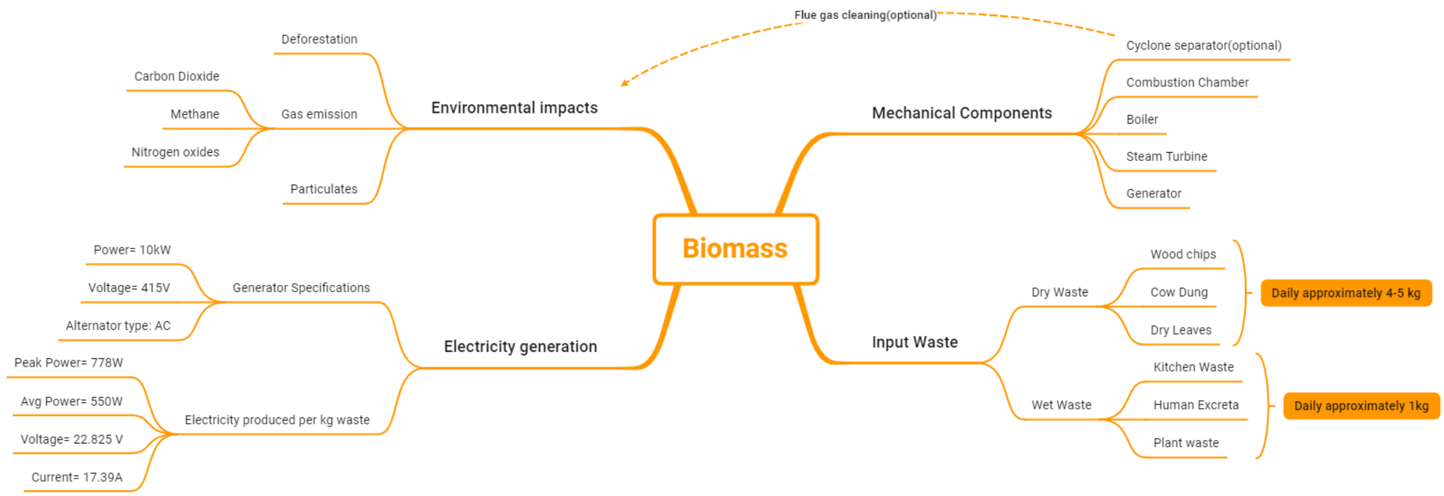


Figure 24: Mindmap used while designing the Biomass energy production unit

9.2. Components of a biomass plant

9.2.1. Combustion Chamber

Design and Specifications of the combustion chamber are as follows:

1. The 3 mm thick aluminum (1050a recommended) is used to withstand high combustion temperatures with dimensions of 0.5 m (L) $\times$ 0.5 m (W) $\times$ 2 m (H) and a volume of $\sim$ 0.5 m^3.
2. An inlets for fuel can be used like shown in Figure 26 as design would be almost resembling for at least combustion part. The combustion chamber working temperature would be 473 K in controlled oxygen.
3. A hole will be made on the top of the chamber of diameter 100 mm with funnel on top.
4. The combustion chamber will be installed with a steam boiler (refer to boiler design specification), as shown in Figure 27.
5. For starting, the combustion burner is attached through the inlet of fuel in the combustion chamber and closed once temperature (473 K) is attained.

Taking cost/m^2 of 3 mm sheet = INR 7,000
Total cost of making a combustion chamber = INR 30,000(sheet) + INR 5,000(manufacturing cost) = INR 35,000

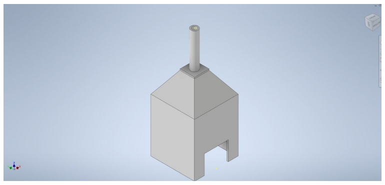


Figure 25: Isometric view of the burner

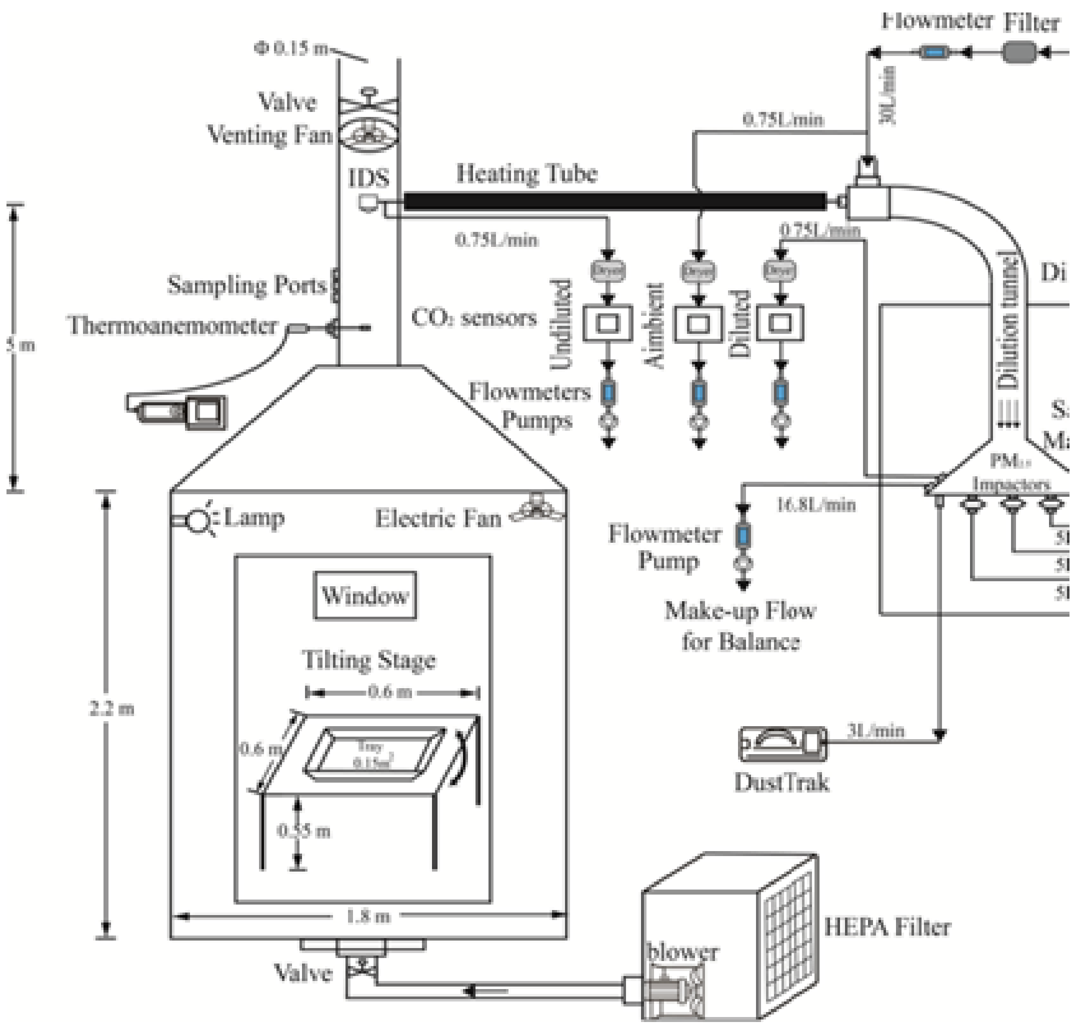


Figure 26: Design of combustion chamber

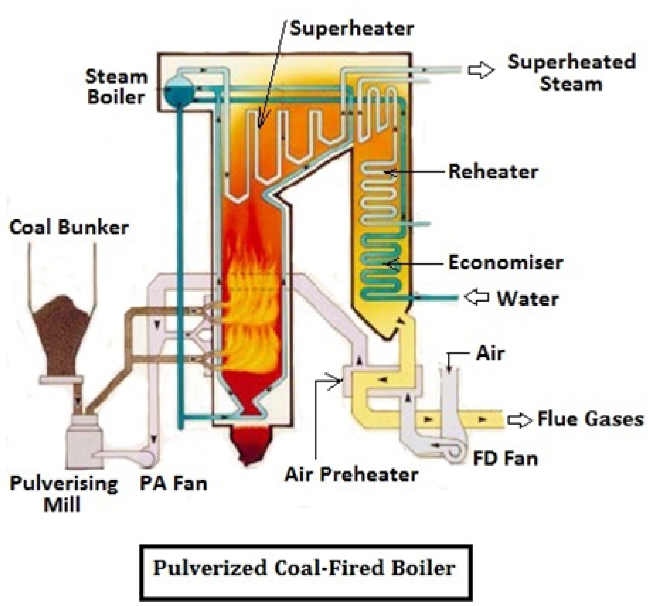


Figure 27: Chamber's burner attachment

9.2.2. High Pressure Boiler

Heated gasses, from the burning fuel, are circulated by natural convection or forced by a pump in a High Pressure Boiler. Boiler processes this water to steam at high pressure. Input is water produced by combustion of 8 kg wood. For 8 kg of wood, the steam produced is 22.58 kg at 70% efficiency.
The required specifications for the boiler are as follows:

Property	**Specifications**
Length	1.9 m
Diameter of cylindrical base	1.2 m
Area of cylindrical base	1.13 m^2
Maximum temperature of water return/supply	65-80 °C
Boiler capacity	80 L of water
Cost	INR 45,000

Table 18: Specifications of High Pressure boiler

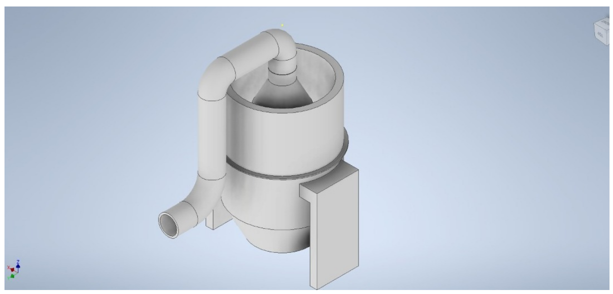


Figure 28: Isometric view of the boiler

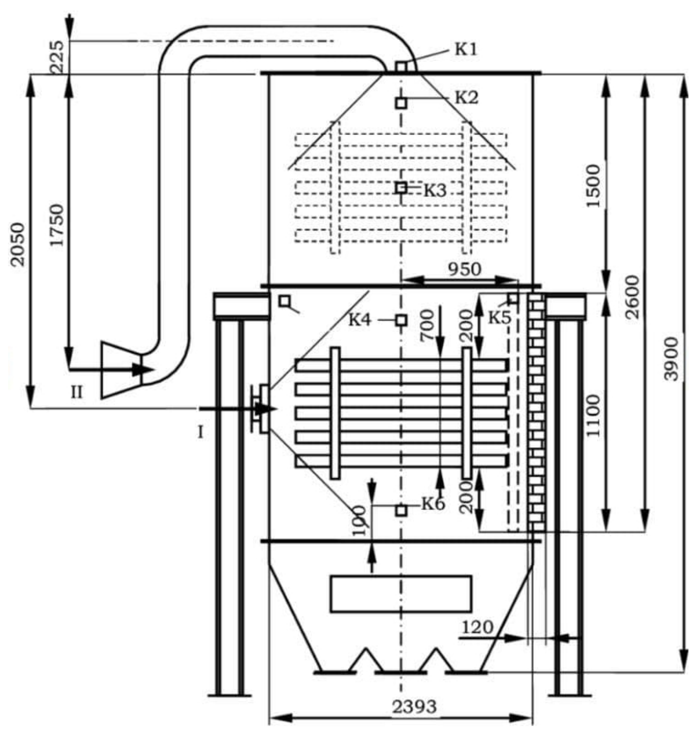


Figure 29: Dimensions of high pressure boiler (scaled to half the dimensions in mm)

9.2.3. Steam Turbine

Steam turbine extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. The turbines are connected to a generator with an axle, which in turn produces energy via a magnetic field that produces an electric current.
The required specifications for the steam turbine are as follows:

Property	Specifications
Pressure range	10 bar- 87 bar
Power	1 kW - 5 MW
Power capacity	1 kW - 40 MW
Cost	INR 50,000

Table 19: Specifications of Steam Turbine

9.2.4. Generator

Figure 30: Top view of the generator

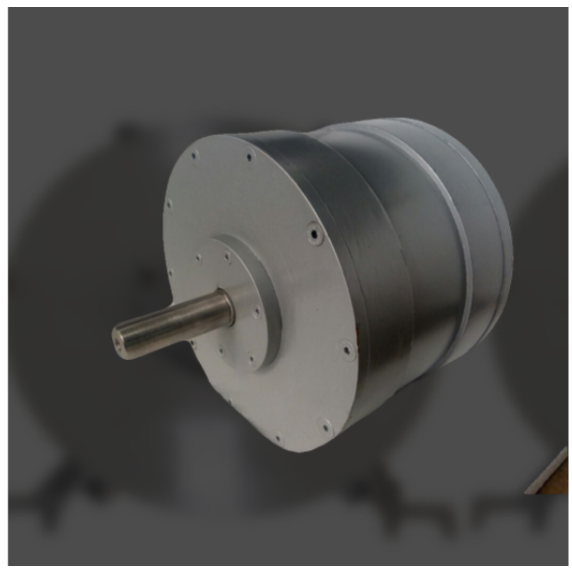


Figure 31: Isometric view of the generator

The required specifications for the generator are as follows:

Property	Specifications
Power	10 kW
Voltage	415 V
Alternator type	AC
Frequency	50 Hz, 60 Hz
Cost	INR 22000

Table 20: Specifications of Generator

9.2.5. Compost Tumbler

The basic requirements for a good compost tumbler are as follows:

1. Having a proper food-web: a mixture of creatures, which include many insects, bugs, slugs, bacteria, and mushrooms, adding a small quantity of soil to this mixture can be used to start the process.
2. Nitrogen/Carbon Ratio : The ideal mix is 3/4 "brown" and 1/4 "green" ingredients by volume which will ensure that the mass maintains the appropriate quantity of humidity and air, and hastens the decomposing process.
3. The compost should remain humid throughout the process. About 50 % humidity is acceptable. Allow the excess water to drain out through the ventilation bores. The mixture should remain humid, but not wet.
4. All creatures and mushrooms in the compost mixture need oxygen during the process. The tumbler must be rotated every second day or so to prevent cutting off air supply and hastening the process.
5. Location- The fastest decomposition occurs between 140°F (60°C) and 160°F (71°C). We should position the Compost Tumbler out of the excessive wind and in full sunlight.

Material	**Carbon/Nitrogen**	**Info**
Fruit and vegetable scraps	Nitrogen	Add with dry carbon items
Chicken/rabbit manure	Nitrogen	Excellent compost 'activator', use in moderation
Coffee grounds	Nitrogen	Filters may also be included
Tea leaves	Nitrogen	Loose or in bags
Grass clippings	Nitrogen	Add in thin layers so they don't mat into clumps and putrefy
Garden plants	Nitrogen	Use disease-free plants only
Lawn & garden weeds	Nitrogen	Only use weeds which have not gone to seed
Flowers, cuttings	Nitrogen	Chop up any long woody stems
Seaweed and kelp	Nitrogen	Rinse first; good source for trace minerals
Eggshells	Neutral	Best when crushed
Leaves	Carbon	Leaves break down faster when shredded
Straw or hay	Carbon	Straw is best; hay (with seeds) is less ideal
Pine needles	Carbon	Acidic; use in moderate amounts
Wood ash	Carbon	Only use ash from clean materials; sprinkle lightly
Cardboard	Carbon	Shred material to avoid matting
Corn cobs, stalks	Carbon	Slow to decompose; best if chopped up
Dryer lint	Carbon	Best if from natural fibers
Wood chips	Carbon	High carbon content can overwhelm, and shut down, an otherwise good compost batch; use sparingly
Sawdust	Carbon	High carbon content can overwhelm, and shut down, an otherwise good compost batch; use sparingly. Be sure sawdust is clean, with no machine oil or chain oil residues from cutting equipment. Do not use sawdust from painted or treated lumber

Table 21: Information about various material used in compost

The following items should be avoided in compost:

1. Meat, fish, fats, bones and other foods like dairy products, sauces, salad dressing, and cooking oil as these could ferment or putrefy, causing odors, and attracting flies, rodents, or other animals that can be pests
2. Ashes but could be used in small quantities
3. Dog and cat feces may cause a risk of adding diseases
4. Perpetual weeds that have turned to seed or diseased plants are not to be used as they can spread with the compost
5. Any cooked or canned foods that contain salt as salt kills the little creatures that do the composting in your mixture

Materials required for making a Compost Tumbler are as follows:

1. 55-gallon plastic drum of length 39 inches, diameter 25 inches and thickness- 3/16 inches
2. Two pressure-treated wooden boards of dimensions 4 ft x 8 ft and one of dimensions 6 ft x 8 ft
3. Six HDPE plastic sheets of dimension 0.5 inches × 0.5 inches each
4. Stainless steel butt hinges
5. Stainless steel latch
6. A galvanized metal Axle of diameter 0.5 inches and length 42 inches

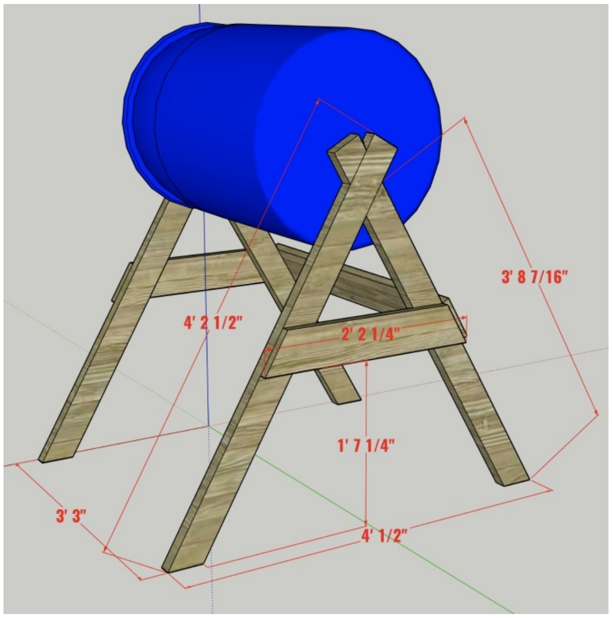


Figure 32: Image of the Compost Tumbler

Design specifications for the Compost Tumbler are as follows:

1. Tumbler's Hatch Door- 12 inches x 12 inches, attached with a hinge and locked with a latch.
2. Drill holes in the drum to allow airflow in and out. Sufficient airflow is important to allow rain and air to enter and drain out of the drum. Space them 2-3 inches apart. Holes can be of 3/8 inches diameter.
3. We add 1/2 inches square HDPE plastic inside the drum, to prevent the compost from stelling at the base.

Our compost tumbler can process around 200 L of waster at one time. A properly combined mixture will reach a working temperature of about 140° F (60° C) in about five days. At this time, the mixture will be settling. The compost is ready when the original ingredients have turned into a uniform, dark brown, crumbly product with a pleasant, earthy aroma.

Cost Estimations for the Compost Tumbler:

The major parts required are a pressure-treated wooden board, a 55-gallon plastic drum, and a 0.5 inches × 0.5 inches HDPE plastic sheet. Other than those we would need screws, hinges, and a latch.

1. Drum- INR 600 to INR 800
2. Pressure treated wooden boards- INR 300
3. HDPE Plastic sheet- INR 100

So the total cost would be INR 1200 to INR 1500.

9.2.6. Flue Gas Cleaning

Flue gas is the gas that emanates from combustion plants and which contains the reaction products of fuel and combustion air and residual substances such as particulate matter (dust), sulfur oxides, nitrogen oxides, etc, that are hazardous to the environment and health. The purpose of a flue gas cleaning system is to reduce atmospheric emissions of these substances. Many gas cleaning systems can be summarized as removal of particulates, removal of water soluble gas and pollutants, removal of NO_x and removal of toxic and hazardous pollutants like mercury (Hg).

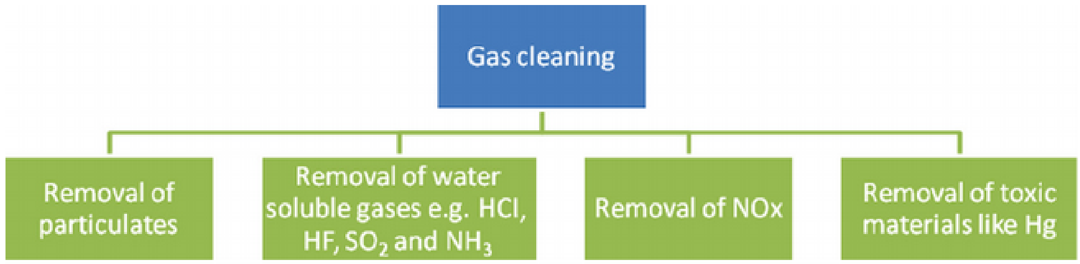


Figure 33: Flow chart depicting Flue Gas Cleaning

9.2.7. Cyclones (Cyclone separator)

1. In cyclones, particles are separated by centrifugal forces. Flue gas containing particulates is fed into a cylinder tangentially in order to achieve rotational movement. The inside of the chamber creates a spiral vortex, similar to a tornado.
2. The lighter components of this gas have less inertia, so it is easier for them to be influenced by the vortex and travel up it.
3. Contrarily, larger components of particulate matter have more inertia and are not as easily influenced by the vortex and drop down into a collection hopper.
4. The cleaned flue gas escapes out the top of the chamber.
5. Estimated Cost : 1.2-1.5 m (4-5 ft) tall cyclone separator can cost about INR 75000.
6. Efficiency : 70-80% for particulate matter

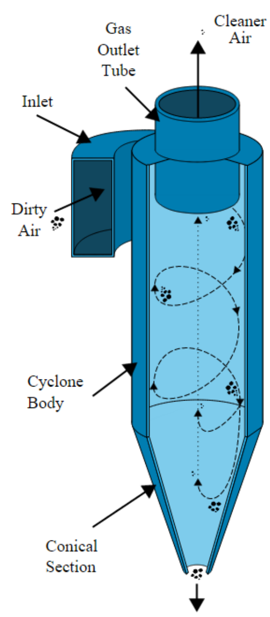


Figure 34: Section View of a Cyclone

9.3 Cost Analysis

Components	**Price (INR)**
Combustion chamber	35000
High Pressure boiler	45000
Steam turbine	50000
Generator	22000
Cyclone separator (optional for environment purposes)	75000
Fuel for combustion chamber and boiler	10000
Compost tumbler	1500

Table 22: Cost of individual components of Biomass Unit

9.4 Results for Biomass Production

The total cost would be INR 1,68,500.
Total electricity produced is 550 W per kg waste

10. Storage

10.1. Mind Map

The mindmap used while developing the Storage unit is as follows:

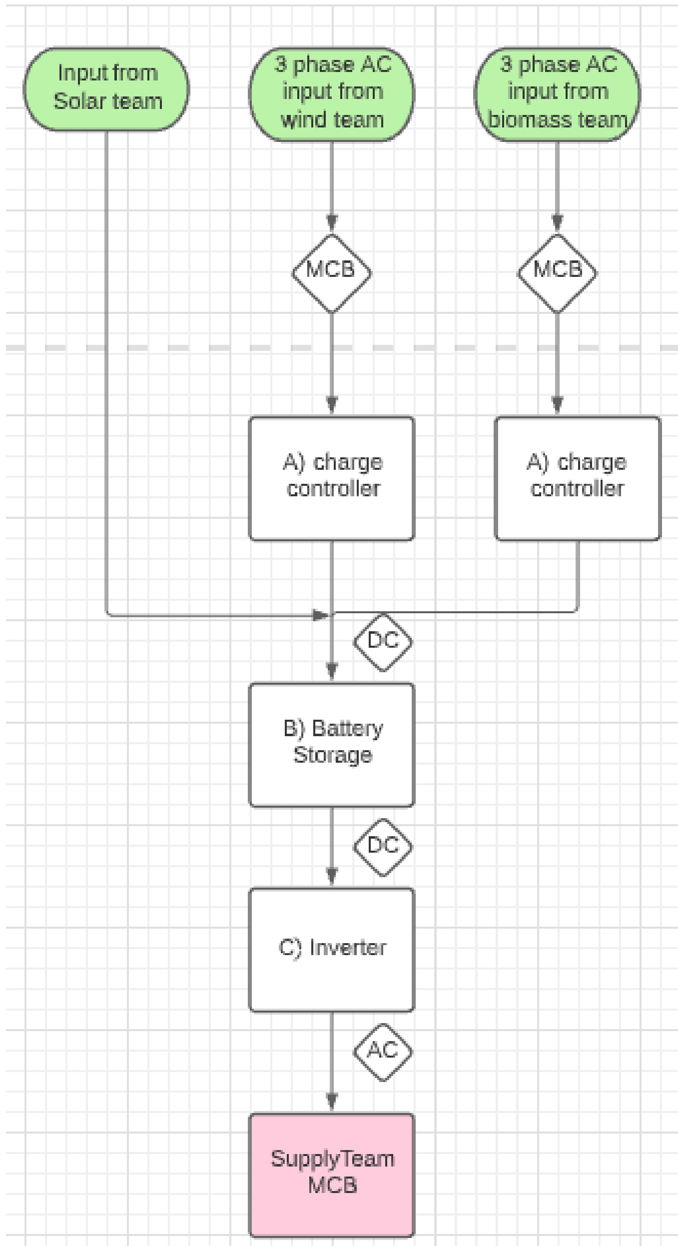


Figure 35: Mindmap used while developing the Storage unit

10.2. Requirements

1. The battery must be durable and resistant to temperature, pressure, and interference changes. Along with being durable, it should be space-efficient and flexible to changing loads.
2. Capacity should be enough to generate electricity to power up the entire house.
3. Connecting wires should be robust and long-lasting.
4. Depth of discharge, an indicator of the percentage of the battery capacity that can be used before potentially shortening its life span, should be high to increase the usage.
5. There must be an Input and Output device that shows the amount of energy stored in the electrical storage devices.
6. Set-up and Maintenance costs should be kept in mind.
7. Provisions for DC/AC conversion using inverter and DC/DC conversion
8. The working system must require minimal supervision, including protective coverings, automated systems, and a single point of contact for all the user interfaces.
9. Circuit breakers must be added to handle the excessive load.
10. There must be a system to efficiently store distinct types of energy (AC/DC) from various sources without interference.
11. Provisions to cut-off storage and sell off surplus energy.
12. Peer to peer energy sharing mechanism (off-grid communities).
13. Round-trip efficiency, which signifies the fraction of energy put into the storage that can be retrieved, should be high.
14. Coolants must be added.

10.3. Specifications

10.3.1. 85A Charge Controller

- 85A - as per the given maximum current allowed
- A Power combiner box to monitor high-voltage fuses, over-voltage and provide protection against over-current using charging management algorithm.
- Charging management algorithm

10.3.2. 3500W 24V/240V Inverter

Property	Specification
Input Voltage	24 V DC
Output Voltage	240 V AC
Frequency	50 Hz / 60 Hz $\pm 5\%(auto)$
Waveform	Pure sine wave
Power Load factor	≤ 0.8
Transfer efficiency	$\geq 85\%(FullLoad)$

Table 23: Specifications of Inverter

The inverter should have the following properties for protection:

1. Overload capacity: 105-120%at 30 s; 120-150% at 10 s; > 150% at 5 s
2. Low voltage: DC 10.5 (12 V) / DC 21 (24 V)
3. High temperature: 85 ℃, Auto shut down after alarm.
4. Short-circuit: Automatic shut-down.
5. Over Voltage: DC 17 V (12 V)/ DC 33 V (24 V)
6. Auto restart while AC is recovering.
7. Inverter PC connection to display power left, any faults.
8. Intelligent air cooling of inverter.

10.3.3. Characteristics of Supplied Power

Property	Specification
Base consumption	1.3 kW
Peak Output Power to Supply	7.5 kW
Maximum Peak load Duration	1 hour

Table 24: Characteristics of Supplied Power

10.3.4. Battery Design

Property	Specification
Nominal (average) battery output voltage	24 V DC
Max continuous charge current	85 A
Total capacity	9.6*safety factor (1.5)
Cell Cathode Material	$LiFePO_4$ (Lithium Iron Phosphate)
Cycle Life	2000-3000
Operating Temperature	5 °C - 45 °C

Table 25: Characteristics of Battery

10.4. Design

10.4.1. Charge Controller

For an optimal charging operation, the current and voltage supplied to the battery must follow specific characteristics depending on the battery to ensure its longevity. Circuits called charge controllers can be used to prevent overcharging and protect the battery from over-voltage.
PWM based control: Switch between the controller and the battery.
MPPT based control: Adjusts the load on the supply dynamically with an incentive to maximize the power drawn from the supply.
A charge controller either uses PWM or MPPT to control the battery supply.

1. A PWM based control is more suitable for smaller systems where the efficiency is not critical.
2. A charge controller equipped with MPPT dramatically improves the efficiency at which energy at which the energy is stored. This form of control is more suitable for our use case as the energy stored is of high importance.

Remark: The output voltage of the supply needs to be close to the charging voltage of the battery, but using a battery of such a charging voltage was not feasible from a cost perspective.

1. Solar Charge Controller

Property	**Specification**
Charging Voltage	24 V
Charging Current Allowed	80 A
Allowed Charging Power	6000 W
Uses	MPPT
Dimension	394 mm × 240 mm × 134 mm
Cost	INR 55,000
Chosen controller	

2. Wind Turbine Charge Controller

Property	**Specification**
Charging Voltage	24 V
Charging Power	600 W
Uses	MPPT
Dimension	100 mm × 80 mm × 15 mm
Weight	0.4 kg
Cost	INR 7,820
Chosen controller	

Table 26: Characteristics of Wind Turbine Charge Controller

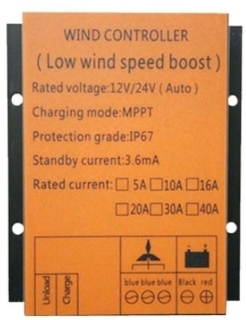


Figure 36: Wind Controller

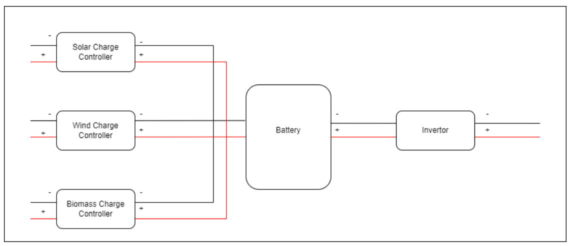


Figure 37: Connection Diagram Battery

3. Biomass Turbine Charge Controller

Property	**Specification**
Charging Voltage	24 V
Charging Power	800 W
Uses	MPPT
Dimension	100 mm × 80 mm × 15 mm
Weight	0.4 kg
Cost	INR 7,462
Chosen controller	

Table 27: Characteristics of Biomass Turbine Charge Controller

10.4.2. Battery

The battery bank stores energy produced by the three power sources.
It receives a DC input of 24 V from the charge controllers and gives a DC output at 24 V to the inverter.
There are two types of batteries available in the market: Lithium-Ion batteries and Lead Acid batteries.
For our domestic storage requirements, a lead-acid battery is a more suitable and cost-effective option than Lithium-ion-polymer batteries.
The battery bank comprises six lead-acid batteries, such as sets of 2 batteries connected in series, and three such sets are connected in parallel.
Two batteries connected in series ensure a 24 V (2*12 V) bank capacity.
Three parallel sets can handle 132 A (3*44 A) charging current and ensure a 660 Ah (3*220 Ah) and hence 15.84 kW bank capacity.

Selected battery: ILTT26060, Lead Acid Storage Battery (Factory Charged)

Property	**Specification**
Capacity	220 Ah
Output Voltage	12 V
Weight	Filled weight $(\pm 5\% Kg) -> 64kg$
Dimension	50.2 × 19.1 × 44 cm
Number of batteries in the bank	6
No. of parallel sets	3
No. of series connected batteries	2
Total power	(12) V * (6*220) Ah = 15.84 kW
Total Cost	6*20,856 = INR 1,25,136

Table 28: Characteristics of Battery

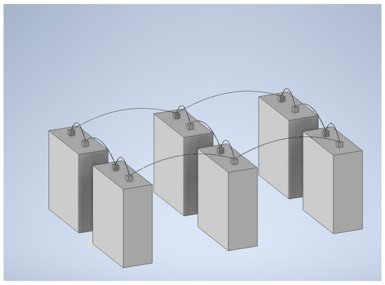


Figure 38: Battery

- 1 Battery, 6 Float Indicator, 1 Warranty Card, 2 MS fasteners
- Warranty 60 Months
- Tall tubular battery with good charge acceptance and long backup
- 30% more acid volume per ampere hour than ordinary tubular batteries.
- It has high purity, corrosion-resistant proprietary spine alloy composition for extended battery life
- Extra-strong, flexible oxidation-resistant gauntlet for better performance and durability
- Puncture-resistant polyethylene separator which minimize the possibility of internal short circuits
- High durability with sealed plastic housing
- Suitable for areas with long and frequent power cuts
- Easy maintenance with level indicators

10.4.3. Inverter (For converting DC to AC)

The battery provides a DC, but the household appliances and the electrical grid of a household require an AC. Therefore, the DC current first needs to be converted into AC current using an inverter device.
Design of a simple inverter:-

Many inverters are available in the market, depending on the output frequency requirement (50 Hz for us) and input voltage requirement:-

1. 12 V DC - for smaller consumer and commercial inverters that typically run from a rechargeable 12 V lead-acid battery or automotive electrical outlet.
2. 24, 36 and 48 V DC - common standards for home energy systems.
3. 200 to 400 V DC - when power is from photovoltaic solar panels.
4. 300 to 450 V DC - when power is from electric vehicle battery packs in vehicle-to-grid systems.
5. 1000 V - when the inverter is part of a high-voltage direct current power transmission system.

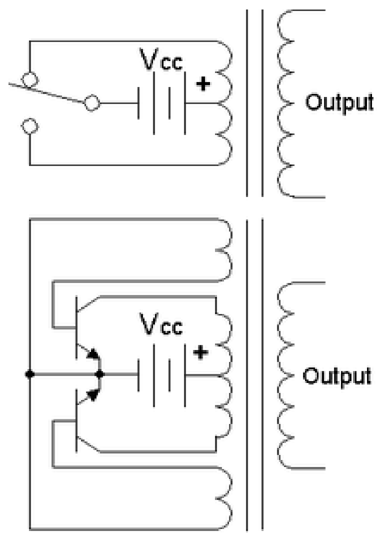


Figure 39: Inverter

10.4.4. Cost Analysis

Item	Quantity	Price/Item (in Rs)	Total
MCB 100 A	1	1700	1700
MCB 20 A	2	100	200
Inverter	1	1200	1200
Battery	6	20856	125136
Wire 100 A	20 ft	1000	20000
Wind Turbine Charge Controller	1	7500	7500
Biomass Charge Controller	1	8000	8000

Table 29: Cost Analysis for Storage

11. Closure

12. Appendix

Appendix A: Rating Calculations for Solar Charge Controller

Rating of Solar Charge Controller: 85 A,150 V Maximum charging current for batteries = (Solar panel Wattage / System voltage) = (6*335/24) = 83.75 A (<85 A).
Maximum rated voltage of the charge controller is 100V. Short circuit Voltage rating of each solar panel is 46.5 V and total maximum voltage from combination of panels is 46.5x2=93 V (<150 V)

Appendix B: Wind Energy Density Distribution over India

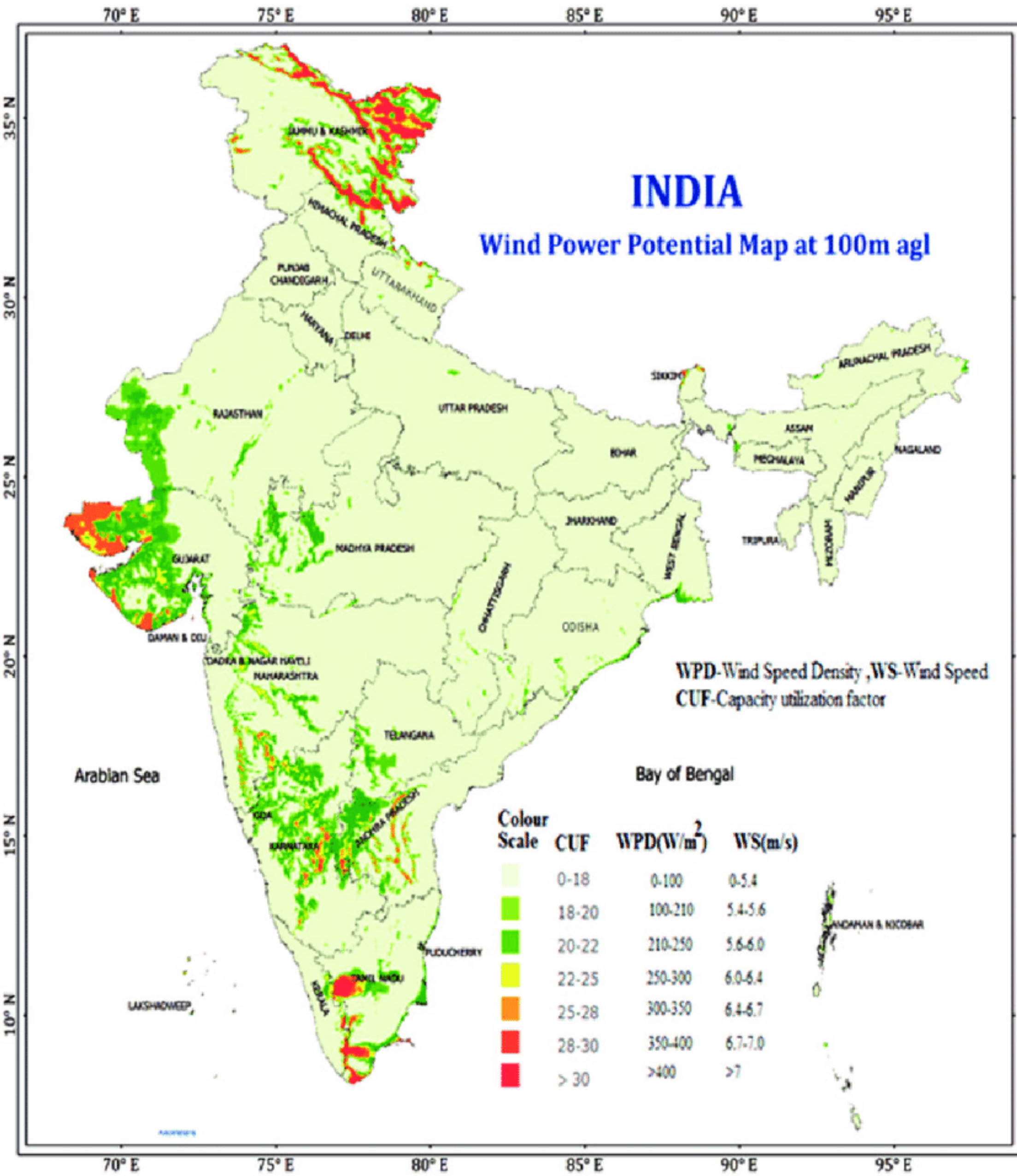


Figure 40: Map showing wind power potential at 100m

Appendix C: Power Calculation for Electricity generated by Wind Energy

Formulas used :

Quantity	Formula
ω	$\leq \frac{V \times TSR}{\pi \times D}$
P_{wind}	$(1/2) \times density \times (r^2) \times v^3 \times C_p$
P_{load}	$\tau\omega$
P_{load}	$\leq P_{wind}$
P_{load}	$10.5 \times 60 \times \omega = 630\omega$
τ	$\geq 0.136 \times P_{load}$ or $86.1 \times \omega$ $\forall$ $P_{load} \leq 1170\omega$ or $\omega \leq 1.85hz$
$\tau \leq P_{wind}$ / ω	

Now for τ to exist, P_{wind} / $\omega \geq 86.1 \times \omega$
Hence, $0 \leq \omega \leq (P_{wind}/86.1)^{1/2}$

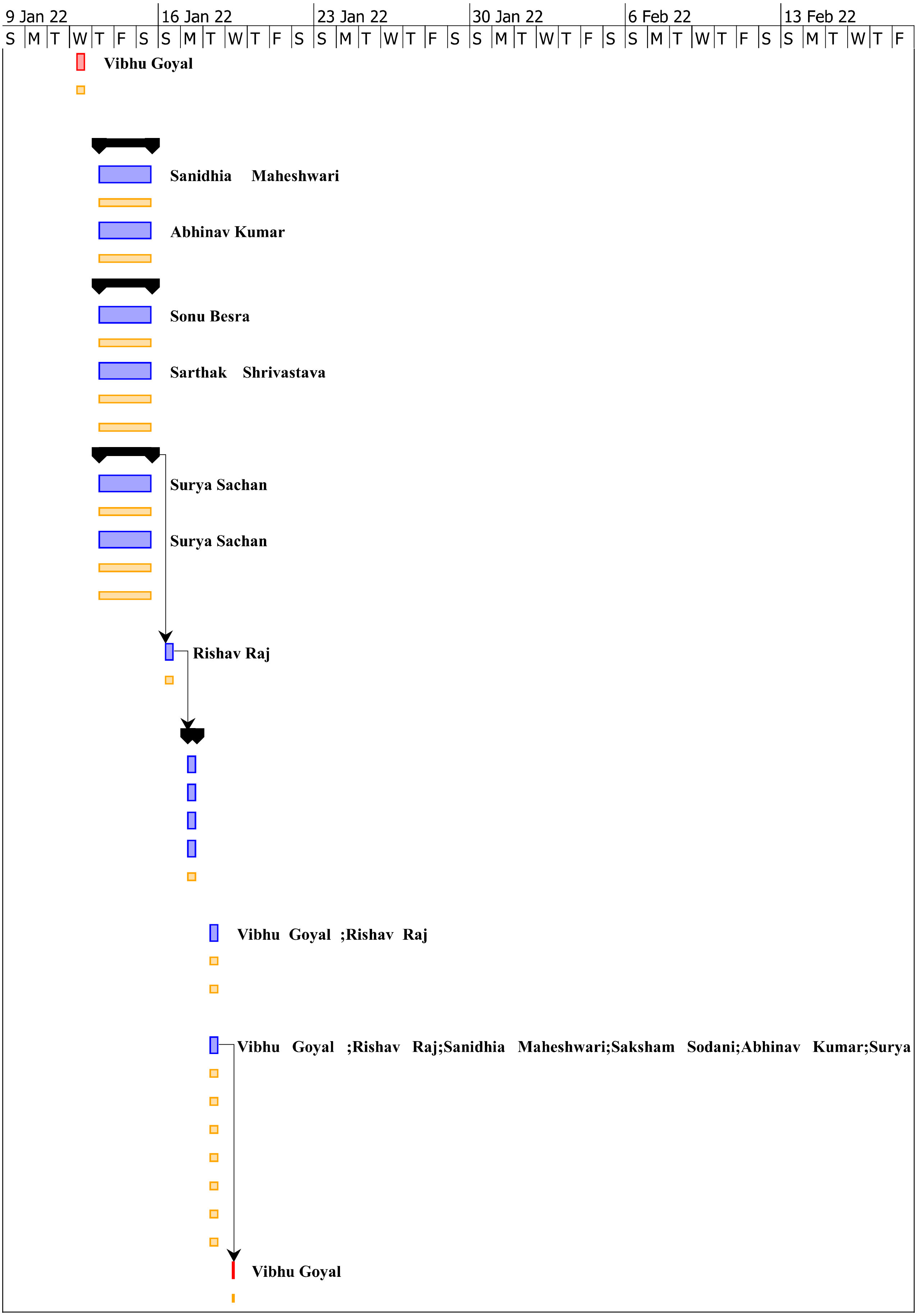
Here:

Symbol	Stands for
τ	Torque generated by the wind
P_{wind}	Power of flowing air(wind)
P_{load}	Power input to generator
TSR	Tip speed Ratio(Inherent property)
ω	angular velocity of turbine
v	Velocity of wind
C_p	Power Coefficient

Now, we have 3 upper limits of omega and our system will run on the largest of these three and accordingly we'll get P_{load} as given.
Reliable Data for wind speeds was available at 50 meters above ground level. As our wind mill is 10 meters above ground, we can use the formula below to approximate wind speed at that height.
$v_{10} = v_w(h) \cdot \left(\frac{h_{10}}{h}\right)^a$
From this, we get 4.51 m/s as stated above. Output power at Wind Speed(4.5 m/s) $\sim$ 470 Watts

SPECIFICATIONS

WEEK 2

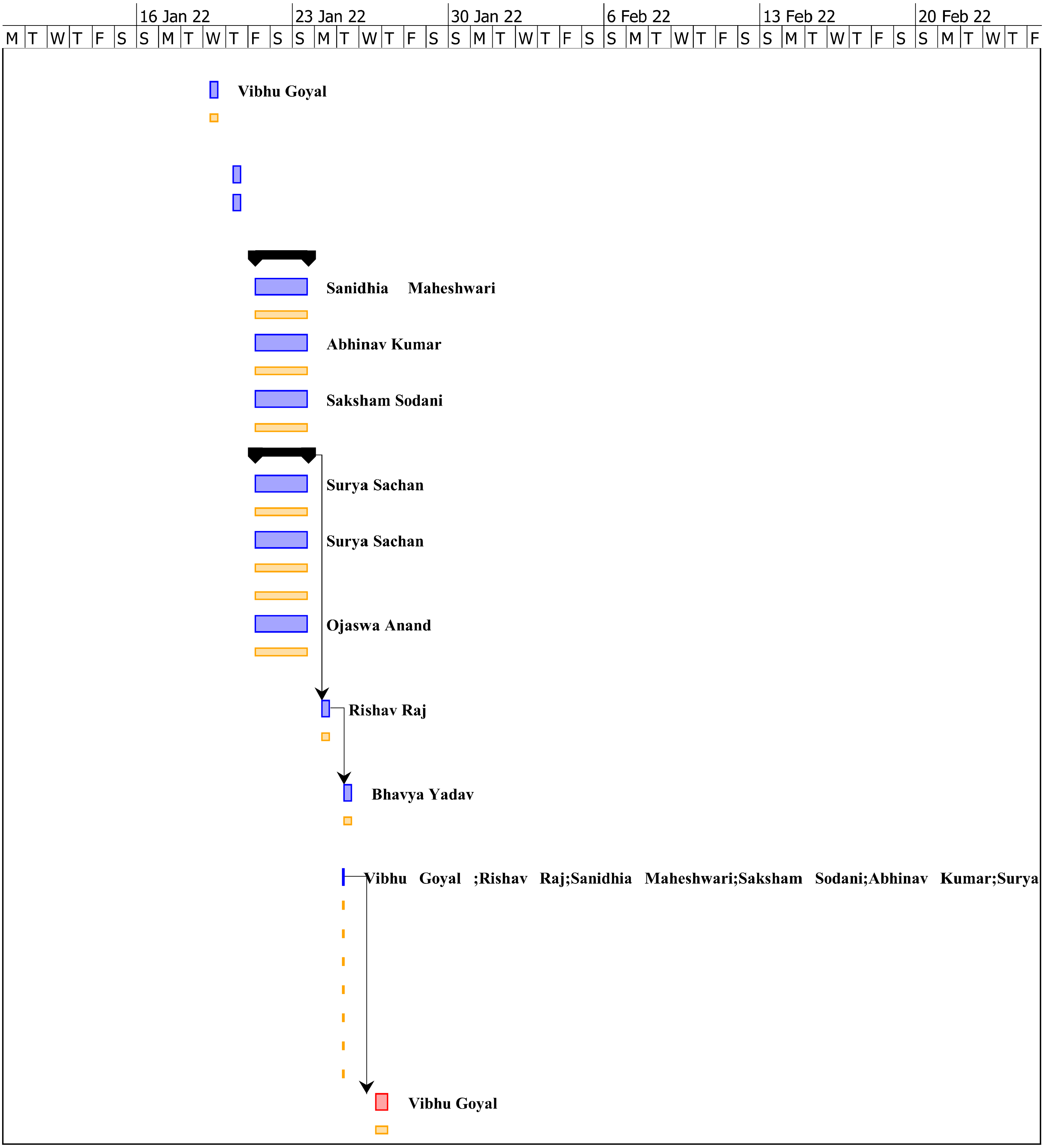

9 Jan 22
16 Jan 22
23 Jan 22
30 Jan 22
6 Feb 22
13 Feb 22
S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F
Vibhu Goyal
Sanidhia Maheshwari
Abhinav Kumar
Sonu Besra
Sarthak Shrivastava
Surya Sachan
Surya Sachan
Rishav Raj
Vibhu Goyal ;Rishav Raj
Vibhu Goyal ;Rishav Raj;Sanidhia Maheshwari;Saksham Sodani;Abhinav Kumar;Surya
Vibhu Goyal

		Name	Duration	Start	Finish
1		SubCoordinators Meeting	1 day	12/1/22 8:00 AM	12/1/22 5:00 PM
		Vibhu Goyal	*1 day*	*12/1/22 8:00 AM*	*12/1/22 5:00 PM*
2		**⊟Specifications Gathering**	**3 days**	**13/1/22 8:00 AM**	**15/1/22 5:00 PM**
3		Wind	3 days	13/1/22 8:00 AM	15/1/22 5:00 PM
		SanidhiaMaheshwari	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
4		Solar	3 days	13/1/22 8:00 AM	15/1/22 5:00 PM
		Abhinav Kumar	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
5		**⊟Biomass**	**3 days**	**13/1/22 8:00 AM**	**15/1/22 5:00 PM**
6		Subteam-A	3 days	13/1/22 8:00 AM	15/1/22 5:00 PM
		Sonu Besra	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
7		Subteam-B	3 days	13/1/22 8:00 AM	15/1/22 5:00 PM
		Sarthak Shrivastava	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
		Saksham Sodani	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
8		**⊟Battery and Storage**	**3 days**	**13/1/22 8:00 AM**	**15/1/22 5:00 PM**
9		Subteam-A (DC to AC)	3 days	13/1/22 8:00 AM	15/1/22 5:00 PM
		Surya Sachan	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
10		SubTeam-B	3 days	13/1/22 8:00 AM	15/1/22 5:00 PM
		Surya Sachan	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
		Surya Sachan	*3 days*	*13/1/22 8:00 AM*	*15/1/22 5:00 PM*
11		Subcoordinators Meeting	1 day	16/1/22 8:00 AM	16/1/22 5:00 PM
		Rishav Raj	*1 day*	*16/1/22 8:00 AM*	*16/1/22 5:00 PM*
12		**⊟Documentation**	**1 day?**	**17/1/22 8:00 AM**	**17/1/22 5:00 PM**
13		Wind	1 day?	17/1/22 8:00 AM	17/1/22 5:00 PM
14		Biomass	1 day?	17/1/22 8:00 AM	17/1/22 5:00 PM
15		Solar	1 day?	17/1/22 8:00 AM	17/1/22 5:00 PM
16		Battery and Storage	1 day?	17/1/22 8:00 AM	17/1/22 5:00 PM
		Bhavya Yadav	*1 day*	*17/1/22 8:00 AM*	*17/1/22 5:00 PM*
17		SubCoordinators Meeting	1 day	18/1/22 8:00 AM	18/1/22 5:00 PM
		Rishav Raj	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		Vibhu Goyal	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
18		Final touch and Error Corr...	1 day	18/1/22 8:00 AM	18/1/22 5:00 PM
		Vibhu Goyal	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		Saksham Sodani	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		Bhavya Yadav	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		Rishav Raj	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		SanidhiaMaheshwari	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		Surya Sachan	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
		Abhinav Kumar	*1 day*	*18/1/22 8:00 AM*	*18/1/22 5:00 PM*
19		Submission	0.01 days	19/1/22 9:08 AM	19/1/22 9:12 AM
		Vibhu Goyal	*0.01 days*	*19/1/22 9:08 AM*	*19/1/22 9:12 AM*

Predecessors	Resource Names
	Vibhu Goyal
	SanidhiaMaheshwari
	Abhinav Kumar
	Saksham Sodani
	Sonu Besra
	Sarthak Shrivastava
	Surya Sachan
	Surya Sachan
	Surya Sachan
8	Rishav Raj
11	**Bhavya Yadav**
	Vibhu Goyal ;Rishav Raj
	Vibhu Goyal ;Rishav Raj;San...
18	Vibhu Goyal

DESIGN PHASE 1

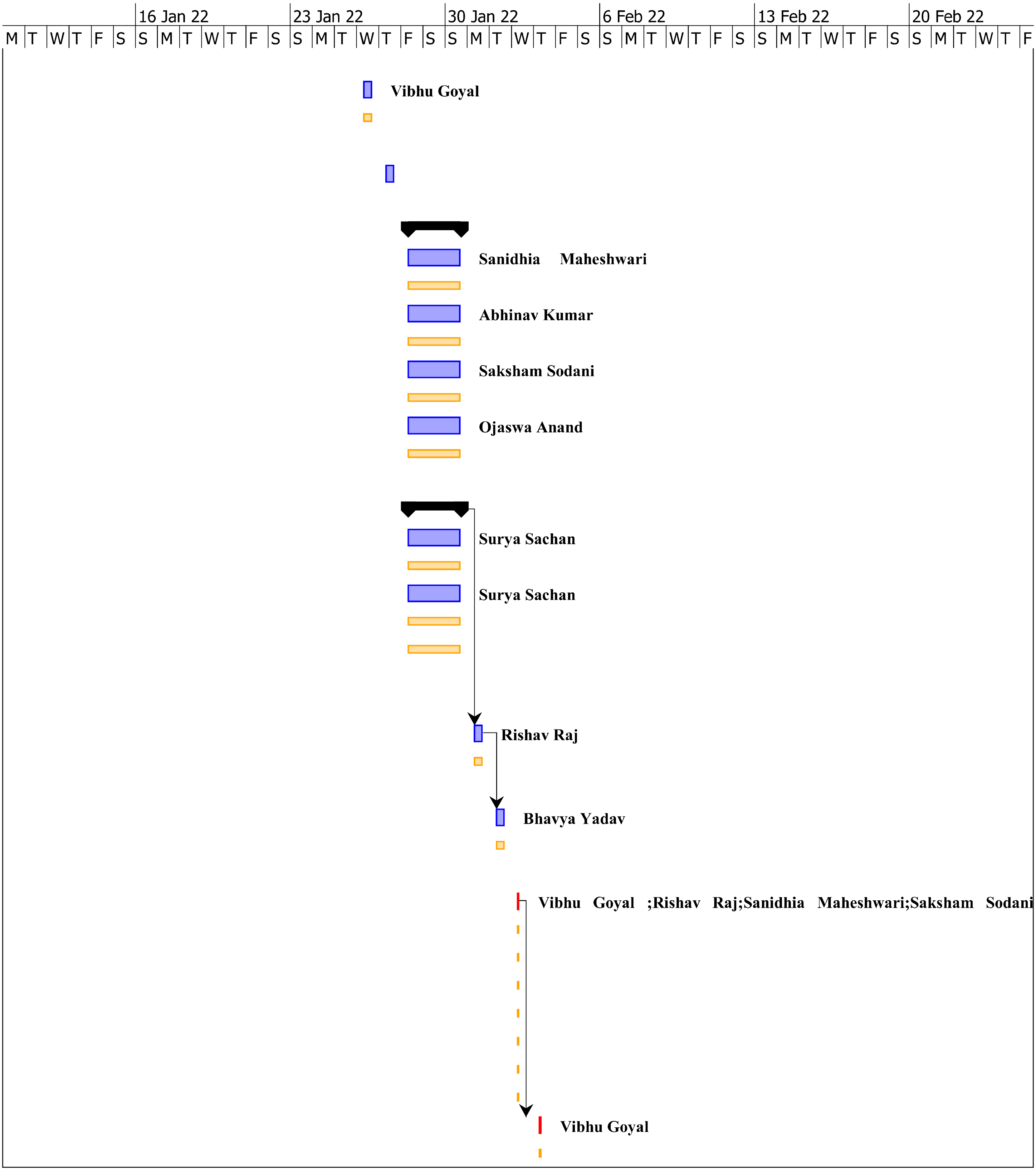
WEEK 3


16 Jan 22
23 Jan 22
30 Jan 22
6 Feb 22
13 Feb 22
20 Feb 22
Vibhu Goyal
Sanidhia Maheshwari
Abhinav Kumar
Saksham Sodani
Surya Sachan
Surya Sachan
Ojaswa Anand
Rishav Raj
Bhavya Yadav
Vibhu Goyal ;Rishav Raj;Sanidhia Maheshwari;Saksham Sodani;Abhinav Kumar;Surya
Vibhu Goyal

		Name	Duration	Start	Finish
2		SubCoordinators Meeting	1 day	19/1/22 8:00 AM	19/1/22 5:00 PM
		Vibhu Goyal	*1 day*	*19/1/22 8:00 AM*	*19/1/22 5:00 PM*
4		Reorganization of teams	1 day?	20/1/22 8:00 AM	20/1/22 5:00 PM
5		Creation of Supply team	1 day?	20/1/22 8:00 AM	20/1/22 5:00 PM
7		**Design Creation**	**3 days**	**21/1/22 8:00 AM**	**23/1/22 5:00 PM**
8		Wind	3 days	21/1/22 8:00 AM	23/1/22 5:00 PM
		SanidhiaMaheshwari	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
9		Solar	3 days	21/1/22 8:00 AM	23/1/22 5:00 PM
		Abhinav Kumar	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
10		Biomass	3 days	21/1/22 8:00 AM	23/1/22 5:00 PM
		Saksham Sodani	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
11		**Battery and Storage**	**3 days**	**21/1/22 8:00 AM**	**23/1/22 5:00 PM**
12		Subteam-A (DC to AC)	3 days	21/1/22 8:00 AM	23/1/22 5:00 PM
		Surya Sachan	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
13		SubTeam-B	3 days	21/1/22 8:00 AM	23/1/22 5:00 PM
		Surya Sachan	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
		Surya Sachan	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
14		Supply team	3 days	21/1/22 8:00 AM	23/1/22 5:00 PM
		Ojaswa Anand	*3 days*	*21/1/22 8:00 AM*	*23/1/22 5:00 PM*
16		Subcoordinators Meeting	1 day	24/1/22 8:00 AM	24/1/22 5:00 PM
		Rishav Raj	*1 day*	*24/1/22 8:00 AM*	*24/1/22 5:00 PM*
18		Documentation Combining	1 day?	25/1/22 8:00 AM	25/1/22 5:00 PM
		Bhavya Yadav	*1 day*	*25/1/22 8:00 AM*	*25/1/22 5:00 PM*
20		Final touch and Error Corr...	0.01 days	25/1/22 8:00 AM	25/1/22 8:04 AM
		Bhavya Yadav	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
		Rishav Raj	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
		Vibhu Goyal	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
		Saksham Sodani	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
		SanidhiaMaheshwari	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
		Abhinav Kumar	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
		Surya Sachan	*0.01 days*	*25/1/22 8:00 AM*	*25/1/22 8:04 AM*
21		Submission	0.01 days	26/1/22 8:00 AM	27/1/22 8:03 AM
		Vibhu Goyal	*0.01 days*	*26/1/22 4:59 PM*	*27/1/22 8:03 AM*

DESIGN PHASE 2

WEEK 4


16 Jan 22
23 Jan 22
30 Jan 22
6 Feb 22
13 Feb 22
20 Feb 22
M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F
Vibhu Goyal
Sanidhia Maheshwari
Abhinav Kumar
Saksham Sodani
Ojaswa Anand
Surya Sachan
Surya Sachan
Rishav Raj
Bhavya Yadav
Vibhu Goyal ;Rishav Raj;Sanidhia Maheshwari;Saksham Sodani
Vibhu Goyal

		Name	Duration	Start	Finish
1		SubCoordinators Meeting	1 day	26/1/22 8:00 AM	26/1/22 5:00 PM
		Vibhu Goyal	*1 day*	*26/1/22 8:00 AM*	*26/1/22 5:00 PM*
2		Feedback to Documentatio...	1 day?	27/1/22 8:00 AM	27/1/22 5:00 PM
3		**⊟Final Design Creation**	**3 days**	**28/1/22 8:00 AM**	**30/1/22 5:00 PM**
4		Wind	3 days	28/1/22 8:00 AM	30/1/22 5:00 PM
		SanidhiaMaheshwari	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
5		Solar	3 days	28/1/22 8:00 AM	30/1/22 5:00 PM
		Abhinav Kumar	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
6		Biomass	3 days	28/1/22 8:00 AM	30/1/22 5:00 PM
		Saksham Sodani	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
7		Supply team	3 days	28/1/22 8:00 AM	30/1/22 5:00 PM
		Ojaswa Anand	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
8		**⊟Battery and Storage**	**3 days**	**28/1/22 8:00 AM**	**30/1/22 5:00 PM**
9		Subteam-A (DC to AC)	3 days	28/1/22 8:00 AM	30/1/22 5:00 PM
		Surya Sachan	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
10		SubTeam-B	3 days	28/1/22 8:00 AM	30/1/22 5:00 PM
		Surya Sachan	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
		Surya Sachan	*3 days*	*28/1/22 8:00 AM*	*30/1/22 5:00 PM*
11		Subcoordinators Meeting	1 day	31/1/22 8:00 AM	31/1/22 5:00 PM
		Rishav Raj	*1 day*	*31/1/22 8:00 AM*	*31/1/22 5:00 PM*
12		Documentation Combining	1 day?	1/2/22 8:00 AM	1/2/22 5:00 PM
		Bhavya Yadav	*1 day*	*1/2/22 8:00 AM*	*1/2/22 5:00 PM*
13		Final touch and Error Corr...	0.01 days	2/2/22 8:00 AM	2/2/22 8:04 AM
		SanidhiaMaheshwari	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
		Saksham Sodani	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
		Vibhu Goyal	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
		Abhinav Kumar	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
		Surya Sachan	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
		Bhavya Yadav	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
		Rishav Raj	*0.01 days*	*2/2/22 8:00 AM*	*2/2/22 8:04 AM*
14		Submission	0.01 days	2/2/22 8:04 AM	3/2/22 8:08 AM
		Vibhu Goyal	*0.01 days*	*3/2/22 8:03 AM*	*3/2/22 8:08 AM*

Predecessors	Resource Names
	Vibhu Goyal
	SanidhiaMaheshwari
	Abhinav Kumar
	Saksham Sodani
	Ojaswa Anand
	Surya Sachan
	Surya Sachan
	Surya Sachan
8	Rishav Raj
11	Bhavya Yadav
	Vibhu Goyal ;Rishav Raj;San...
13	Vibhu Goyal