BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Optimal design of a renewable energy system for off-grid power supply in OIC countries using HOMER PRO

By

UMAR ALMUSTAPHA RABIU (170021183)

MUAADH AHMED SALEH ALSURAIMI (180021346)

UMAR MOHAMMED YUSUF (200032205)

Department of Electrical and Electronic Engineering

Islamic University of Technology (IUT)

Organization of Islamic Cooperation (OIC)

Boardbazar, Gazipur-1704, Bangladesh

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Submitted by

UMAR ALMUSTAPHA RABIU (170021183)
MUAADH AHMED SALEH ALSURAIMI (180021346)
UMAR MOHAMMED YUSUF (200032205)

Approved by
Mr. Muhammad
Assistant Professor
Department of Electrical and Electronic Engineering
IUT, Gazipur, Bangladesh

DECLARATION OF CANDIDATE

We hereby declare that the work reported in the BSc. Thesis entitled — **Optimal Design of a renewable energy system for off grid power supply in OIC countries using HOMER PRO"** submitted at **Islamic University of Technology (IUT)**, Boardbazar, Gazipur, Bangladesh, is an authentic record of our work carried out under the supervision of **Mr. Muhammad** We have not submitted this work elsewhere for any degree or diploma. We are fully responsible for the contents of our BSc thesis.

Umar Almustapha Rabiu Maxahdu
Student Number: 170021183
Academic Year: 2021-2022

Muaadh Ahmed Saleh Alsuraimi
Student Number: 180021346
Academic Year: 2021-2022

Umar Mohammed Yusuf
Student Number: 200032205
Academic Year: 2021-2022

CERTIFICATEOFAPPROVAL

The thesis titled-**Optimal Design of a renewable energy system for off-grid power Supply in OIC Countries using HOMER PRO**", submitted by **Umar Almustapha Rabiu (170021183), Muaadh Ahmed Saleh Alsuraimi (180021346), Umar Mohammed Yusuf (200032205)** of Academic Year: 2021-2022 has been found as satisfactory and accepted as partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on 28 May 2023

7/6/23

Mr. Muhammad
(Supervisor)
Assistant Professor
Department of Electrical and Electronic Engineering
IUT,Gazipur-1704,Bangladesh

Dr. Mohammad Rakibul Islam
Professor & Head
Department of Electrical and Electronic Engineering
IUT,Gazipur-1704,Bangladesh

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Abstract

Any nation can only develop if it has adequate means of supplying energy. The OIC member states are facing a severe electricity crisis despite having ample energy resources. To meet the rising demand, they must enhance their power production capability.

The environment and energy generation are major considerations for member countries. The effective and efficient use of renewable energy sources will be a more environmentally friendly method of solving the electricity problem. In this project, we put forth the idea of constructing green power plants across all of the participating nations. Our design and optimization choice for the proposed power station is Jangebe, Zamfara, Nigeria, where there is also a respectable wind flow. The planned power facility will use batteries to store solar and wind energy.

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Thesis Outline

Our study begins with an overview and global data on solar and wind energy in the first chapter. HRES systems have also been mentioned. The literature section of the second chapter reviews a number of past works on this subject. Our chosen research project's aims, objectives, and motivating factors are described in the third chapter. The fourth chapter focuses mostly on the methodology, process, and operational procedures of our project. In the fifth chapter, the technological components required for our design are discussed, along with their specifications and a number of other significant input variables. The results of the optimization of our models are covered in the sixth chapter. Also included are the cash flow analysis and the sensitivity analysis. The conclusion and a discussion of the likely future of this project are both contained in the last chapter.

Chapter 1

Introduction

1.1 Background

With the start of the industrial revolution, people started using the enormous energy that was concentrated in natural resources like coal, oil, and natural gas are used, Since then, the demand for electrical energy has only been shooting upwards. The world's electricity consumption reached 3084 kWh per capita in 2013, which is a 42.3% increment compared to 1990, a trend more prominent among emerging economies [1]. Most of this electricity is produced from various fossil fuels. In addition to being a finite resource, fossil fuels cause irreparable environmental harm by emitting greenhouse gases such as carbon dioxide, nitrous oxide, methane, etc. As a result, an increasing number of nations are switching to a more sustainable source of electricity. Currently, solar electricity, wind power, geothermal power, and hydropower are some of the most significant sources of sustainable energy. Any nation can only develop if it has adequate means of supplying energy. Despite having abundant energy resources, Nigeria is experiencing a severe electricity deficit and has to increase its power generation capacity to meet the growing demand. OIC countries like Nigeria and Yemen are particularly concerned about power production. Effective and efficient use of sustainable energy sources will be an environment-friendly attempt towards reducing the power crisis, Nigeria is a developing country with more than 200 million people spread across a land of 923,768 sq km.

A thriving economic expansion, rapid urbanization, and increasing industrialization have increased the country’s demand for electricity.

Around 55% of the total population has access to electricity and 137.53 kWh is per capita generation. This power generation is very low compared to other nations. The power supply is lacking in Nigeria and cannot meet the peak demand. A huge amount of sunlight during the day is a great blessing for Nigeria with an average of 1831.42 kWh/m^2. Wind flow is also reasonable and annual average solar radiation is similar throughout the land field areas. Jangebe is one of the Areas with an average annual solar radiation of 5.86 kWh/m^2 /day and monthly average wind speeds at a height of 50 Meter is4.44 m/s. It is possible to set up a hybrid power system in the region based on solar and wind energy, which will help partially alleviate the energy issue. Batteries will be used as storage for storing electricity and a generator will also be used as backup incased there is any problem. In the near future, solar and wind energy will be the very way to power supply. This paper proposes a novel power system at the Jangebe, Nigeria land field based on solar and wind economy. This proposed system has entirely renewable energy with no CO2 emission.

1.2 Renewable Energy

1.2.1 Overview of Renewable Energy

Since it doesn't release any greenhouse gases like carbon dioxide or carbon monoxide, renewable energy refers to obtaining energy from renewed natural resources. Our ozone layer has already been severely damaged by the prolonged usage of fossil fuels as our main source of energy.

Therefore, more and more nations are turning to renewable and "clean" energy sources in order to prevent more irreversible environmental damage.

1.2.2 Global Status of Renewable Energy

With the goal of gradually switching to a cleaner source of energy, 145 nations have established a wide range of renewable energy assistance policies over the past 20 years**.** As of 2015, the annual investment in renewable energy reached $270 billion in 2015 [6]. Significant progress has already been made by numerous nations in the area of renewable energy. Denmark aims to achieve 100% renewable electricity generation by 2035, whereas Germany aims to generate 80% of its electricity from renewable sources by 2050.

1.2.3 Solar Energy

Solar energy has been used by humans since the dawn of time, but it wasn't until roughly a century ago that it was first employed professionally. Among other things, it has been used to produce energy, heat, chill, and provide ventilation. Nevertheless, it has recently experienced tremendous growth in popularity and is anticipated to overtake all other renewable energy sources by the year 2050. The mass availability of solar power makes it a lucrative renewable source of energy. About 3,400,000 EJ of solar energy, or 7000–8000 times more than the world's annual primary energy consumption, are received by the earth each year. While the overall world demand for electricity is somewhere around 6000 GW, 0.1% of this energy could provide 10,000 GW of electricity at a 10% efficiency.

1.2.4 Solar Energy Status in Nigeria

Nigeria's solar energy capacity increased from 15 megawatts in 2012 to approximately 33 megawatts in 2021 [13]. Since 2011, Africa's solar energy capacity has been growing yearly, and it is currently at 11.4 megawatts.

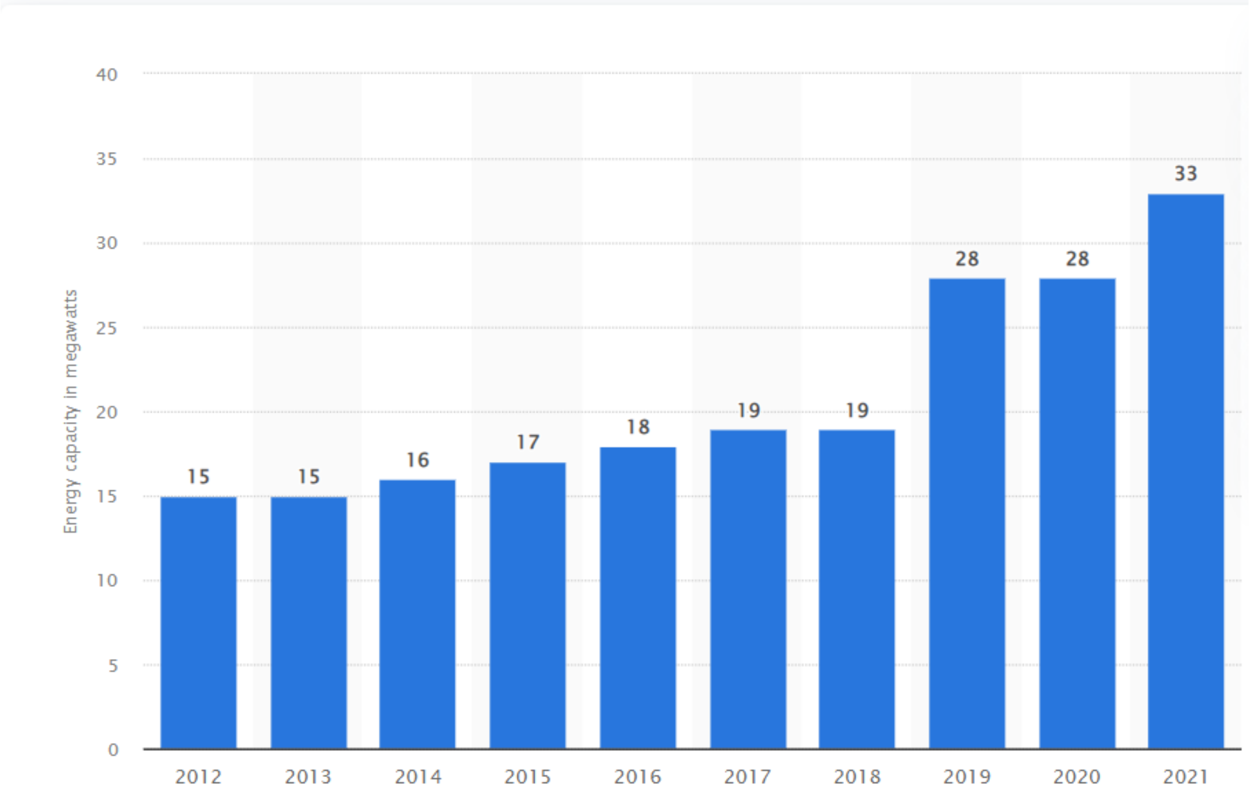


Fig.1. Solar energy capacity in Nigeria from 2012 to 2021

1.3 Hybrid Renewable Energy Systems (HRES)

Stand-alone power plants that generate electricity in rural areas primarily using renewable energy sources are known as hybrid renewable energy systems. A hybrid renewable energy system consists of two or more renewable energy sources to generate increased system efficiency for a greater balance in energy supply [12]. Solar inverters or microinverters are used to create on-grid systems, and the generated electricity is supplied to the public electrical grid. As a result, on-grid systems are more reliable because electricity is still available if the system is unable to generate it. Once more, when too much electricity is generated surplus power is provided to the grid so that it can be made up for.

An off-grid system, on the other hand, consists of solar inverters and batteries. The extra electricity in this instance is kept in a battery for future use.

Chapter 2

Literature Review

Numerous significant studies on renewable energy have been carried out in Homerpro. K.J. Hancock, “The expanding horizon of renewable energy in sub-Saharan Africa: leading research in the social sciences [5], A total of 91,715 households in rural and peri-urban areas, 21 percent of which were female-headed households, acquired high-quality pico systems: autonomous, mobile solar energy systems that can be used for rural electrification at subsidized prices [6] has worked on the design and economic analysis of an off-grid PV system using HOMER Pro software.

Chapter 3

Aim and Objectives

3.1 Our Proposal

We suggest building a renewable energy power plant that will supply electricity based on green energy production in order to expand the usage of renewable energy in OIC member states and establish a more dependable power source for the benefit of the community. Nigeria and Yemen were both chosen because they both require electricity. The simulation was done using HOMER Pro software.

3.2 Motivation Behind Our Proposal

One of the main reasons for our recommendation is the fact that practically all OIC member states employ conventional fossil fuel power plants, making it extremely difficult to restrict their use without also harming the environment. As a result, we decided to build a renewable power plant that would benefit the states. Nearly all of these states have an adequate amount of wind and sunshine, which is the perfect environment for establishing a wind and solar project. We decided to do our research on wind and solar energy as a result.

3.3 Objectives of our research

The primary goals of our research are:

- To examine and analyze the sustainable power potential mainly for those two resources i.e. solar and wind
- Design more sustainable power production for the rural community.
- Provide a more environmentally friendly power plant.

Chapter 4

SYSTEM METHODOLOGY

We have chosen two renewable energy sources, solar and wind because we wish to build a green energy facility. The power generated from both sources will pass through the converter and be converted to an ac load when solar radiation strikes the PV panel and wind rotates the turbine.

- Choose a location within the OIC member states, where it is most practical to build the power plant.

- Gather the PV and wind energy data from NASA surface meteorology & solar energy that is required for the proposed system at a particular site.

- Create the system and run a simulation using the resource inputs for the chosen location.

6.2 Basic Workflow of Our Project

On the basis of our needs and simulation, the technical components and input parameters are first specified. The best systems, as determined by the chosen optimization variable, are then identified by HOMER utilizing the information supplied, which is then used to investigate all potential combinations of the system design in a single run. Following this, a sensitivity analysis is performed in which different variable input parameters, such as the fuel price and discount rate, are altered, and the impact on the output is then assessed.

6.3 HOMER Software

For designing our model, we have used Homer Pro 3.10.3; a microgrid analysis tool developed initially by the United States (US) National Renewable Energy Laboratory (NREL), which can simulate cost-effective microgrid system projects for both off-grid and grid-connected systems [7]. It is widely used for planning, simulating, and analyzing the viability of hybrid systems and renewable energy models. It's necessary for Homer Pro to simulate, optimize, and sensitivity investigation. It is used to model the most practical system while comparing all feasible arrangements of the materials and parts selected for our design. At the simulation stage, all the input parameters and the necessary hardware are fixed before running the simulation. In the optimization process, HOMER looks at all conceivable system configurations to identify the design that is most economically viable based on net present cost (NPC). The final step is to perform a sensitivity analysis, which involves altering input parameters like the diesel price and discount rate and then evaluating how the output changes in response. Prior to taking these actions, a pre-Homer study [8] is carried out, which entails the gathering of data on solar and wind resources, load profiles, and other necessary input parameters like the diesel price, random variability parameters, and other comparable data. Again, HOMER offers a large variety of converters, generators, PV modules, batteries, wind turbines, and other equipment options, allowing for a great deal of design freedom. Additionally, this software analyzes the systems' economies and environments.

6.4 Operation Schemes

6.4.1 Off-grid Scheme:

Off-grid schemes are entirely independent and not connected to the main grid or power system's utility [9]. Microinverters, batteries, and solar inverters make up this system. Due to its complete independence from the main grid, this system produces a higher proportion of clean energy. The extra energy supplied is stored in a battery for use on overcast days or during the winter months when solar power is scarce. Since off-grid devices cannot access the main grid in the event of a power outage or shortage, they are a less dependable source of electricity. On the other hand, in case of a severe storm or other similar mishaps, failure of the main grid does not affect this system. Hence our power access remains unchanged, while the rest of the area faces a blackout [10]. Fig.2 shows the rough schematic of the off-grid model.

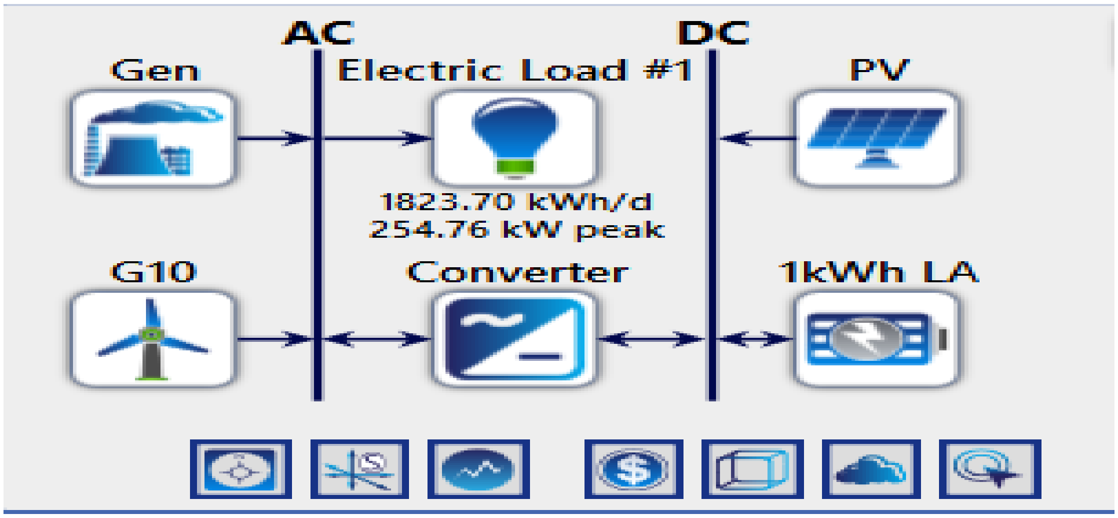


Fig 2. shows the off-grid model schematic

Chapter 5

Input Parameters and System Components

5.1 Site Details

Part 1 (Jangebe, Nigeria)

Nigeria's Zamfara state is where our work is first being done. The chosen location's coordinates are 12.1998° N and 6.0573° E. The chosen location was chosen because of its flourishing economy and rapidly increasing population. A satellite view of Jangebe from Google map given in Fig 3.

Fig 4. Location of Jangebe from Google map

Part 2 (Sanaa, Yemen)

Our second site of choice is Sanaa, with coordinates of 15.3694°N, and 44.1910°E. This area is likewise experiencing tremendous development. A satellite view of Sanaa from Google map given in Fig 4.

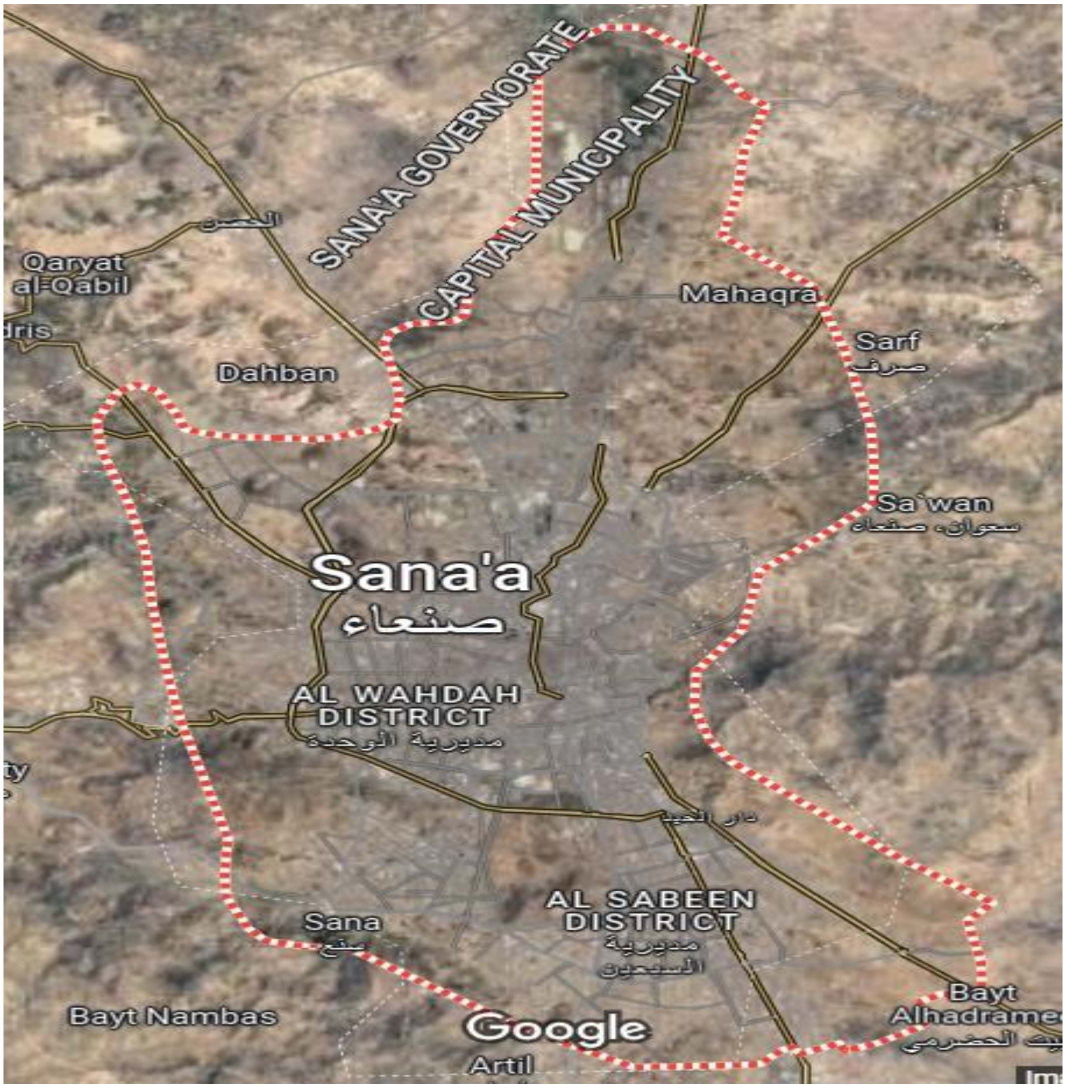
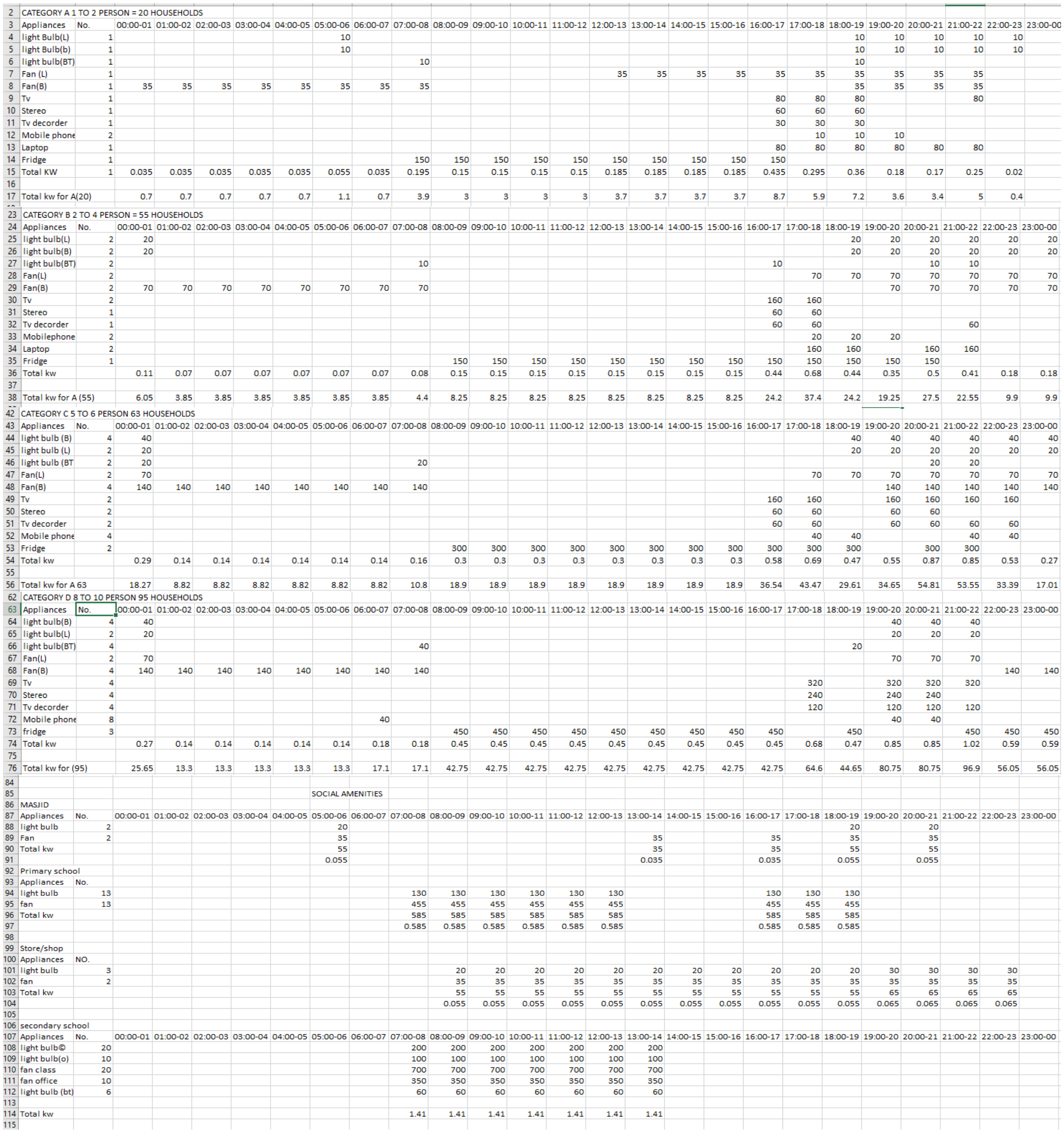


Fig 4. Location of Sanaa from Google map

5.2 Community data collection

The population, housing, and appliances used at home, work, and in all public buildings are displayed in the tables below.

Table 1



2	CATEGORY A 1 TO 2 PERSON = 20 HOUSEHOLDS																									
3	Appliances	No.	00:00-01	01:00-02	02:00-03	03:00-04	04:00-05	05:00-06	06:00-07	07:00-08	08:00-09	09:00-10	10:00-11	11:00-12	12:00-13	13:00-14	14:00-15	15:00-16	16:00-17	17:00-18	18:00-19	19:00-20	20:00-21	21:00-22	22:00-23	23:00-00
4	light Bulb(L)	1						10													10	10	10	10	10	
5	light Bulb(b)	1						10													10	10	10	10	10	
6	light bulb(BT)	1								10											10					
7	Fan (L)	1													35	35	35	35	35	35	35	35	35	35		
8	Fan(B)	1	35	35	35	35	35	35	35	35											35	35	35	35		
9	Tv	1																	80	80	80			80		
10	Stereo	1																	60	60	60					
11	Tv decorder	1																	30	30	30					
12	Mobile phone	2																		10	10	10				
13	Laptop	1																	80	80	80	80	80	80		
14	Fridge	1								150	150	150	150	150	150	150	150	150	150							
15	Total KW	1	0.035	0.035	0.035	0.035	0.035	0.055	0.035	0.195	0.15	0.15	0.15	0.15	0.185	0.185	0.185	0.185	0.435	0.295	0.36	0.18	0.17	0.25	0.02	
16																										
17	Total kw for A(20)		0.7	0.7	0.7	0.7	0.7	1.1	0.7	3.9	3	3	3	3	3.7	3.7	3.7	3.7	8.7	5.9	7.2	3.6	3.4	5	0.4	
23	CATEGORY B 2 TO 4 PERSON = 55 HOUSEHOLDS																									
24	Appliances	No.	00:00-01	01:00-02	02:00-03	03:00-04	04:00-05	05:00-06	06:00-07	07:00-08	08:00-09	09:00-10	10:00-11	11:00-12	12:00-13	13:00-14	14:00-15	15:00-16	16:00-17	17:00-18	18:00-19	19:00-20	20:00-21	21:00-22	22:00-23	23:00-00
25	light bulb(L)	2	20																		20	20	20	20	20	20
26	light bulb(B)	2	20																		20	20	20	20	20	20
27	light bulb(BT)	2								10									10				10	10		
28	Fan(L)	2																		70	70	70	70	70	70	70
29	Fan(B)	2	70	70	70	70	70	70	70	70												70	70	70	70	70
30	Tv	2																	160	160						
31	Stereo	1																	60	60						
32	Tv decorder	1																	60	60				60		
33	Mobilephone	2																		20	20	20				
34	Laptop	2																		160	160		160	160		
35	Fridge	1									150	150	150	150	150	150	150	150	150	150	150	150	150			
36	Total kw		0.11	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.44	0.68	0.44	0.35	0.5	0.41	0.18	0.18
37																										
38	Total kw for A (55)		6.05	3.85	3.85	3.85	3.85	3.85	3.85	4.4	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	24.2	37.4	24.2	19.25	27.5	22.55	9.9	9.9
42	CATEGORY C 5 TO 6 PERSON 63 HOUSEHOLDS																									
43	Appliances	No.	00:00-01	01:00-02	02:00-03	03:00-04	04:00-05	05:00-06	06:00-07	07:00-08	08:00-09	09:00-10	10:00-11	11:00-12	12:00-13	13:00-14	14:00-15	15:00-16	16:00-17	17:00-18	18:00-19	19:00-20	20:00-21	21:00-22	22:00-23	23:00-00
44	light bulb (B)	4	40																		40	40	40	40	40	40
45	light bulb (L)	2	20																		20	20	20	20	20	20
46	light bulb (BT	2	20							20													20	20		
47	Fan(L)	2	70																	70	70	70	70	70	70	70
48	Fan(B)	4	140	140	140	140	140	140	140	140												140	140	140	140	140
49	Tv	2																	160	160		160	160	160	160	
50	Stereo	2																	60	60		60	60			
51	Tv decorder	2																	60	60		60	60	60	60	
52	Mobile phone	4																		40	40			40	40	
53	Fridge	2									300	300	300	300	300	300	300	300	300	300	300		300	300		
54	Total kw		0.29	0.14	0.14	0.14	0.14	0.14	0.14	0.16	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.58	0.69	0.47	0.55	0.87	0.85	0.53	0.27
55																										
56	Total kw for A 63		18.27	8.82	8.82	8.82	8.82	8.82	8.82	10.8	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	36.54	43.47	29.61	34.65	54.81	53.55	33.39	17.01
62	CATEGORY D 8 TO 10 PERSON 95 HOUSEHOLDS																									
63	Appliances	No.	00:00-01	01:00-02	02:00-03	03:00-04	04:00-05	05:00-06	06:00-07	07:00-08	08:00-09	09:00-10	10:00-11	11:00-12	12:00-13	13:00-14	14:00-15	15:00-16	16:00-17	17:00-18	18:00-19	19:00-20	20:00-21	21:00-22	22:00-23	23:00-00
64	light bulb(B)	4	40																			40	40	40		
65	light bulb(L)	2	20																			20	20	20		
66	light bulb(BT)	4								40											20					
67	Fan(L)	2	70																			70	70	70		
68	Fan(B)	4	140	140	140	140	140	140	140	140															140	140
69	Tv	4																		320		320	320	320		
70	Stereo	4																		240		240	240			
71	Tv decorder	4																		120		120	120	120		
72	Mobile phone	8							40													40	40			
73	fridge	3									450	450	450	450	450	450	450	450	450		450			450	450	450
74	Total kw		0.27	0.14	0.14	0.14	0.14	0.14	0.18	0.18	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.68	0.47	0.85	0.85	1.02	0.59	0.59
75																										
76	Total kw for (95)		25.65	13.3	13.3	13.3	13.3	13.3	17.1	17.1	42.75	42.75	42.75	42.75	42.75	42.75	42.75	42.75	42.75	64.6	44.65	80.75	80.75	96.9	56.05	56.05
84																										
85								SOCIAL AMENITIES																		
86	MASJID																									
87	Appliances	No.	00:00-01	01:00-02	02:00-03	03:00-04	04:00-05	05:00-06	06:00-07	07:00-08	08:00-09	09:00-10	10:00-11	11:00-12	12:00-13	13:00-14	14:00-15	15:00-16	16:00-17	17:00-18	18:00-19	19:00-20	20:00-21	21:00-22	22:00-23	23:00-00
88	light bulb	2						20													20		20			
89	Fan	2						35								35			35		35		35			
90	Total kw							55								35			35		55		55			
91								0.055								0.035			0.035		0.055		0.055			
92	Primary school																									
93	Appliances	No.																								
94	light bulb	13								130	130	130	130	130	130				130	130	130					
95	fan	13								455	455	455	455	455	455				455	455	455					
96	Total kw									585	585	585	585	585	585				585	585	585					
97										0.585	0.585	0.585	0.585	0.585	0.585				0.585	0.585	0.585					
98																										
99	Store/shop																									
100	Appliances	NO.																								
101	light bulb	3									20	20	20	20	20	20	20	20	20	20	20	30	30	30	30	
102	fan	2									35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	
103	Total kw										55	55	55	55	55	55	55	55	55	55	55	65	65	65	65	
104											0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.065	0.065	0.065	0.065	
105																										
106	secondary school																									
107	Appliances	No.	00:00-01	01:00-02	02:00-03	03:00-04	04:00-05	05:00-06	06:00-07	07:00-08	08:00-09	09:00-10	10:00-11	11:00-12	12:00-13	13:00-14	14:00-15	15:00-16	16:00-17	17:00-18	18:00-19	19:00-20	20:00-21	21:00-22	22:00-23	23:00-00
108	light bulb©	20								200	200	200	200	200	200	200										
109	light bulb(o)	10								100	100	100	100	100	100	100										
110	fan class	20								700	700	700	700	700	700	700										
111	fan office	10								350	350	350	350	350	350	350										
112	light bulb (bt)	6								60	60	60	60	60	60	60										
113																										
114	Total kw									1.41	1.41	1.41	1.41	1.41	1.41	1.41										
115																										

5.3 Load Profile

A load profile is a graph that shows the variation of the load on electrical equipment over time. Because the load varies depending on the time of day and temperature, it is useful to look for a daily load profile that illustrates the electrical load variance over 24 hours. Once more, the load will change according to the season, the weather, and the rising need for electricity. In order to plan and eventually execute a solar power generation system and determine how it will function over time, monthly and yearly load profiles are useful. An impartial look at the demand for electricity at a particular time of the day, month, or season can be provided via a load profile. Buildings and their electrical appliances were taken into account for our data gathering, and the software took into account random variability on an hourly and daily basis. The software has drawn a load profile with varied times (daily, monthly, and yearly) using the load data and variation data provided.

5.3.1 Daily Load Profile

The program depicted in Fig. 5 has been used to plot the daily load profile. Given that the majority of electrical appliances are still in use in the morning, we may infer from the graph that electricity usage is typically high from 12 a.m. to 11 p.m. It has been discovered that the typical energy consumption is 1823.7 kWh/day.

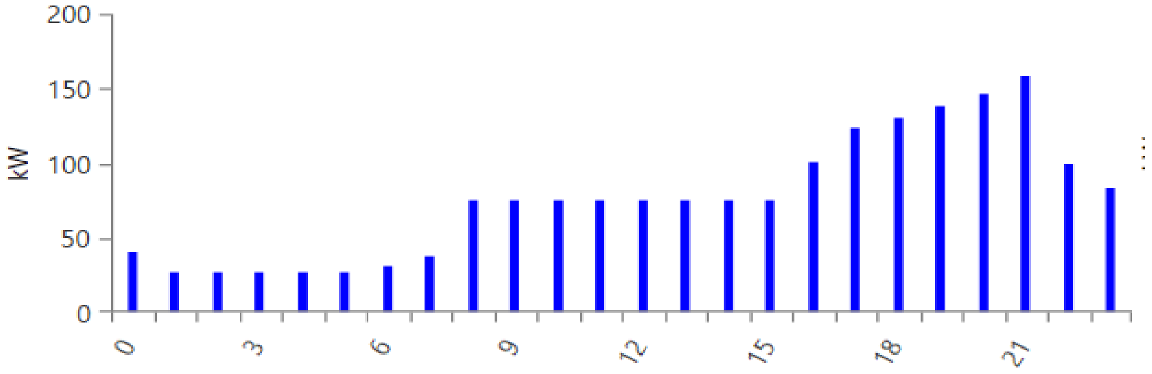


Fig 5. Daily Load Profile

5.3.2 Monthly Load Profile

Fig. 6. depicts the monthly load profile. We can see from the load profile graph that power usage is typically high, occurring between June and August. Average daily electricity use can rich up to 75.99 kW, with a peak of 254.77 kW. From November through January, consumption often declines.

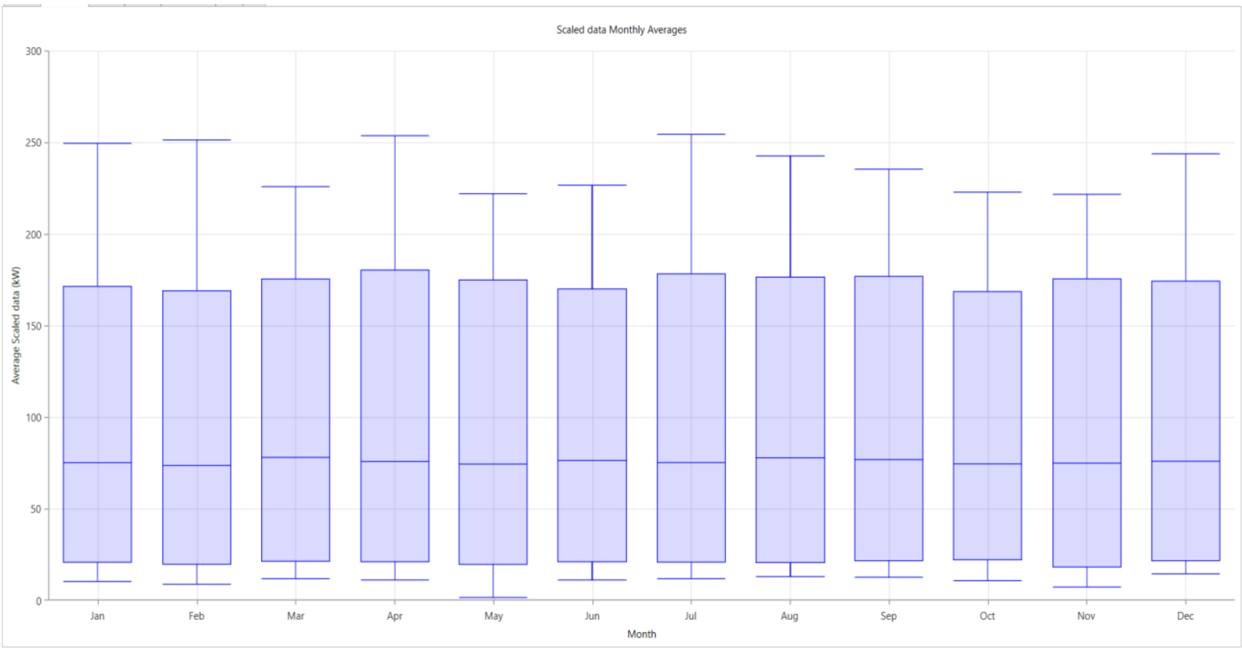


Fig 6. Monthly Load Profile

5.3.3 Yearly Load Profile

The yearly load profile aids in the load increase assumption even though it does not immediately supply substantial data. Fig. 7 provides the profile.

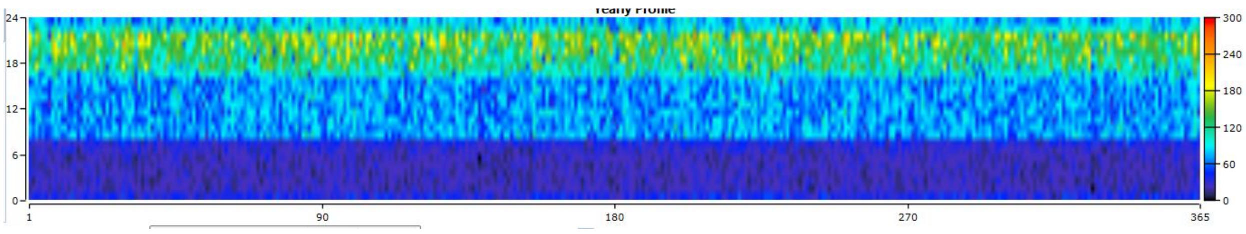


Fig.7. yearly Load Profile

5.4 Solar and Wind Resources

The monthly average global horizontal irradiance (GHI) data and the clearness index data are the main solar resource data that Homer Pro deals with. NASA's database of solar energy and surface meteorology was used to get the necessary information. The average daily solar radiation is 5.86 kWh/m^2/day. where the summer season's peak values were located between March and May. Table 3 contains the monthly irradiation and clearness index data.

Table 2. Monthly Average Solar Global Horizontal Irradiance and Clearness Index Data

MONTH	CLEANNESS INDEX	Daily Radiation kWh/m^2 /day
January	0.636	5.478
February	0.641	6.000
March	0.607	6.144
April	0.615	6.488
May	0.606	6.394
June	0.570	5.950
July	0.498	5.211
August	0.497	5.208
September	0.560	5.720
October	0.652	6.219
November	0.679	5.939
December	0.663	5.522

The atmosphere's clarity is indicated by the clearness index. It is the ratio of extraterrestrial irradiation to horizontal global irradiance. The total radiation is measured across that particular area at that time in order to determine the average solar radiation. The average solar radiation is calculated over a certain area during a specific time. Figure 8 shows a graph of the daily irradiance and clearness data.

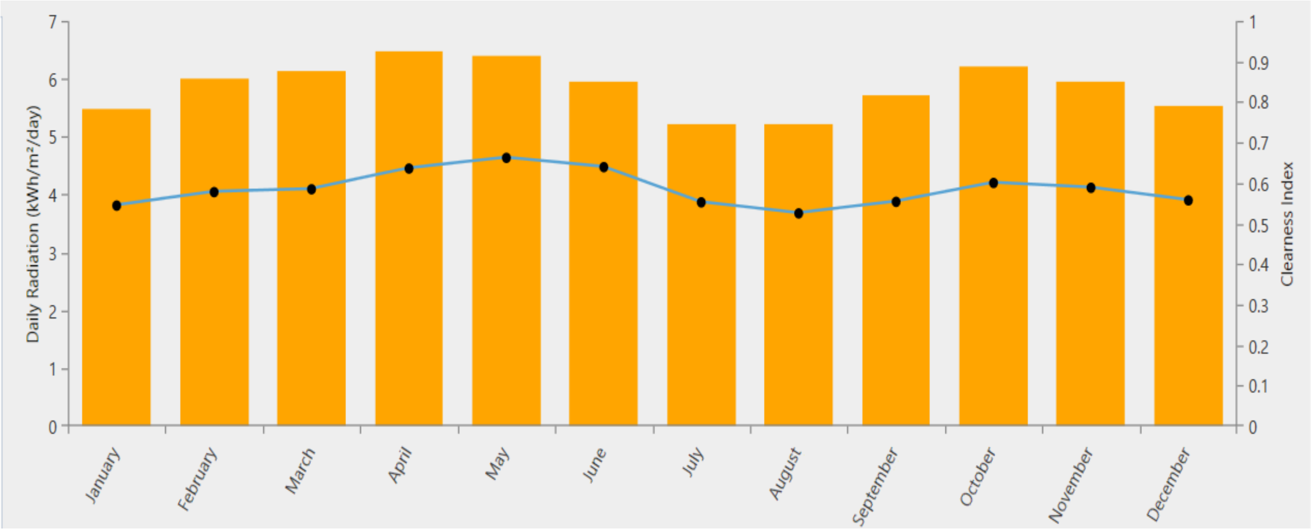


Fig.8. Solar Radiation Data and Clearness Index Data

5.5 Wind Resources

The monthly average wind speed (m/s) data is the main wind resource data that Homer Pro deals with. The necessary information was gathered from the NASA surface meteorological and wind energy databases. The average wind speed is 4.44 m/s. Here, the greatest values of the summer season occurred between March and April. In Table 3, the monthly wind speed is provided.

TABLE 3. Wind speed data for Jangebe, Zamfara

Month	Wind speed
January	4.810
February	4.700
March	5.180
April	5.340
May	4.940
June	4.130
July	3.850
August	3.680
September	3.410
October	3.790
November	4.410
December	4.980

The average wind speed is computed over a certain amount of area over a specific period; throughout this time, the wind speed is measured inside that region to get the average wind speed data. The wind speed represents the speed range of the area. Figure 9. shows the daily speed graph.

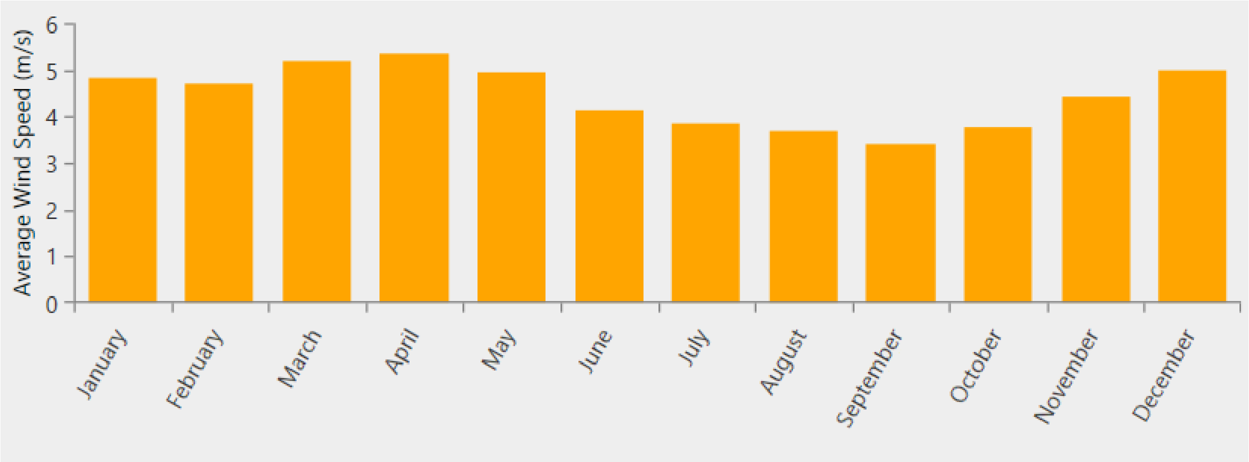


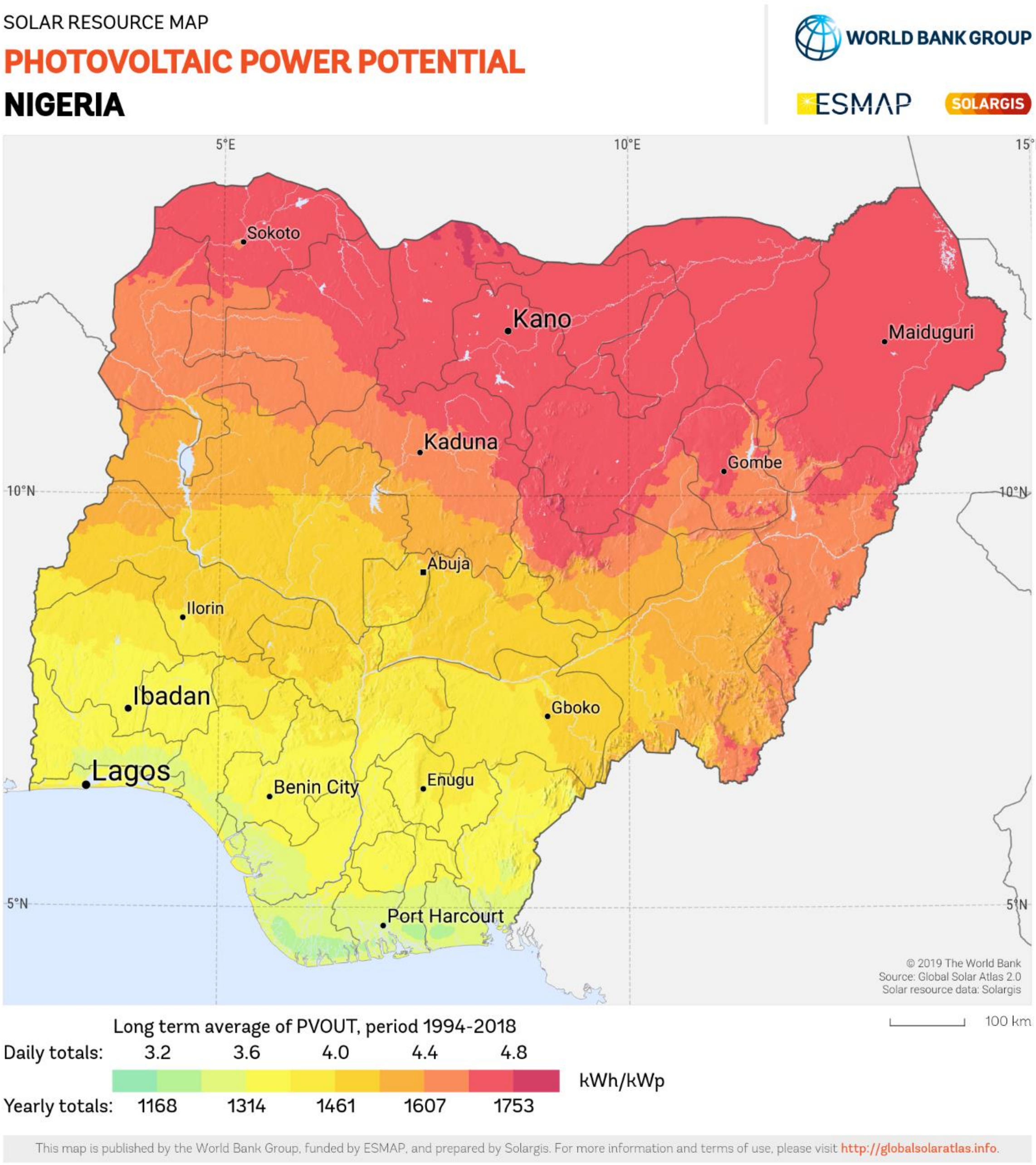
Fig 9. Average wind speed data

5.6 Technical Components

The primary elements are solar panels, batteries, converters, and a diesel generator.

5.6.1 PV Power Potential

High solar irradiation (2,200 kWh/m^2) is available across most of the OIC countries and even with daily or seasonal variations, excellent opportunities exist for the deployment of solar PV power generation[11]. Figure 10 & 11 shows the PV power potential in our respective project.



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Source: Global Solar Atlas 2.0
Solar resource data: Solargis

This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit http://globalsolaratlas.info.

Fig 10. Photovoltaic power potential Nigeria

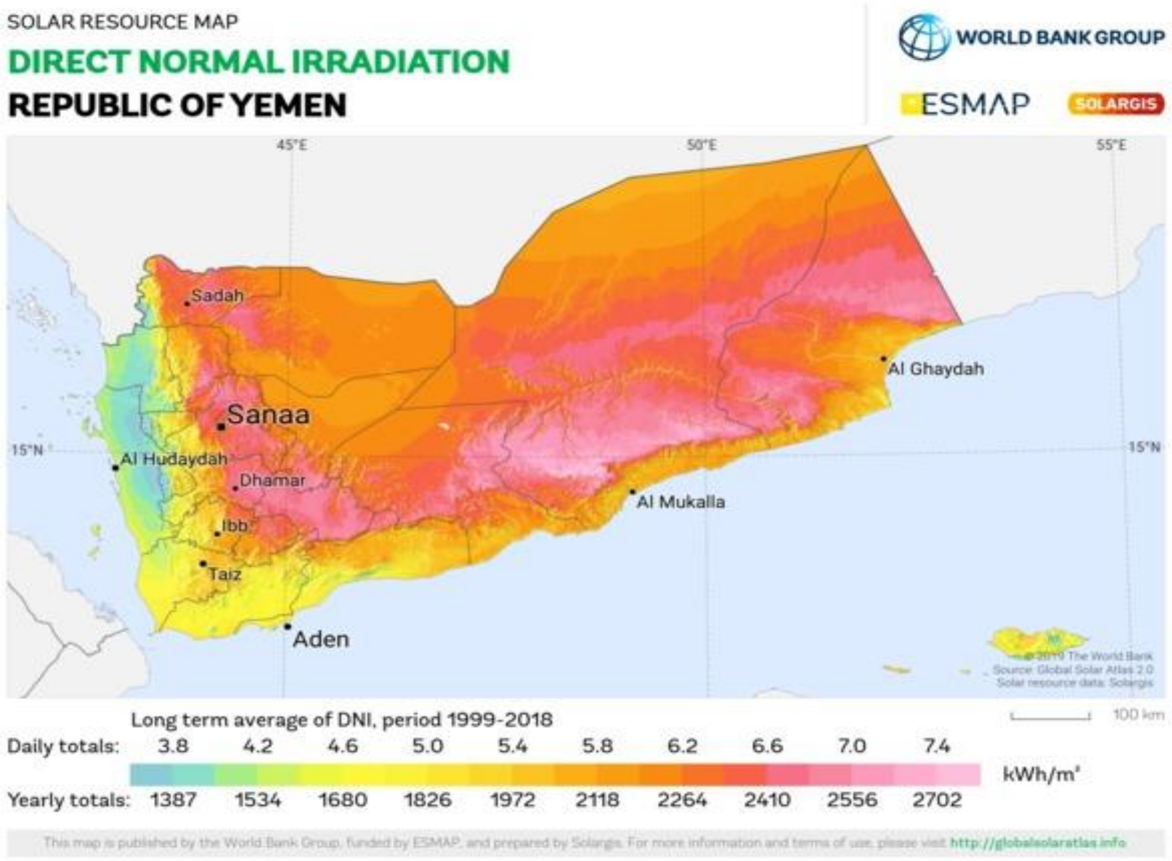


Fig 11. Photovoltaic power potential Yemen

5.6.1 PV Modules

The arrays of photovoltaic cells in a PV module also referred to as a photovoltaic module, absorb solar radiation and transform it directly into electricity. The photovoltaic effect is used by PV cells to produce electricity. Given this, The selected PV model was selected automatically by Homer Software. The details for this specific model are already provided by the HOMER software and can be found in Table 4.

Table 4. PV Module Specification

Model	Generic flat plate PV
Power	1KW
Module efficiency	13%
Temperature coefficient	-0.5%/°C
Operating Temperature	47°C
Derating Factor	80%
Lifetime	25 years
Ground Reflectance	20%
Capital Cost	900 US dollars
Replacement Cost	850 US dollars

5.6.2 Wind Turbine

Wind turbines work on a simple principle: instead of using electricity to make wind—like a fan—wind turbines use wind to make electricity. The wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity. The Homer software already provides the specification for the desired model given in Table 5.

Table 5. wind turbine specification

Model	Generic 10 kw
Lifetime	25 years
Hub Height	40m
Rated capacity	10 kw
Capital cost	9,500 US dollars
Replacement cost	9000

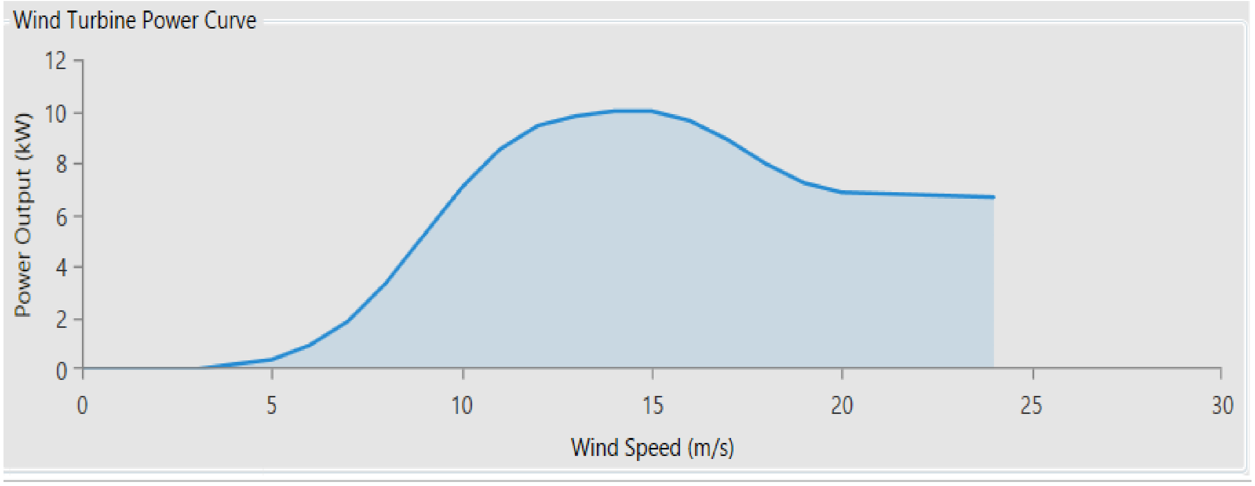


Fig 12. Wind turbine power curve

5.6.3 Diesel Generator

Typically, a diesel generator works by burning fuel; in this example, diesel creates electricity from mechanical energy. In this situation, the diesel generator is regarded as a backup power supply. During the day, the PV panels will provide electricity. when demand is high and there is sufficient solar radiation available. When the sun's radiation declines at night or on overcast days or when the wind is not sufficient to rotate the wind turbine, the generator will supply the power. For this purpose, an Auto-size Genset diesel generator is used as a backup. Its specifications are given in Table 6. The fuel efficiency curve is given in Fig 13.

Table 6. Diesel Generator Specification

Model	Auto-size Genset
Minimum Load Ratio	25%
Lifetime	15000 hours
Capital Cost	500 US dollars
Replacement Cost	400 US dollars
O&M Cost	20 USD

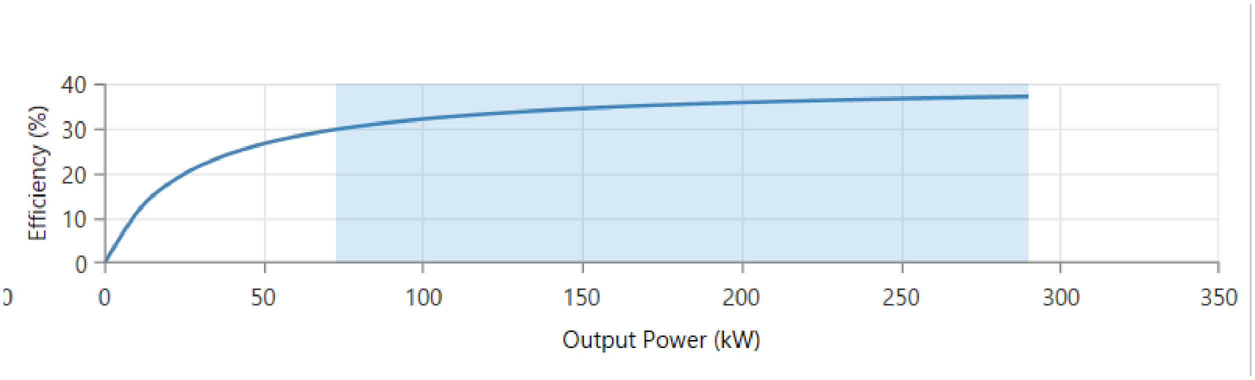


Fig 13. Fuel efficiency Curve for diesel generator

5.6.4 Converter

PV cells convert solar energy to direct current, The solar-generated DC needs to be converted into AC using a converter. For this reason, a Converter is needed, the table below shows its specification.

Table 7. Converter specification

Model	System Converter
Efficiency	95%
Lifetime	20 years
Capital Cost	300$
Replacement Cost	300$

5.6.5 Batteries

Batteries are essential for storage and emergencies. The selected battery was selected automatically by the software in use, The table below shows the specifications for the battery.

Table 8. Battery Specification

Model	Kinetic battery
Nominal Capacity	1 kWh
Nominal Voltage	12 volts
Maximum Capacity	83.4 Ah
Roundtrip Efficiency	80%
Max Charge current	16.7 A
Minimum state of charge	40%
String size	1
Thoroughput	800.00 kWh
Lifetime	15 years
Capital Cost	300$
Replacement Cost	300$
O&M Cost	10$

Chapter 6

Results

6.1 Optimization Result

We may get a list of all the suitable simulations for the chosen model in the section on optimization results. The optimized results are listed according to the type of system. The radio buttons above the Optimization Results table allow us to choose the list of suitable models according to system type [7]. In this section, the technical and financial viability of our suggested energy models will be examined. Following the completion of the simulations, HOMER will make recommendations for the best systems based on NPC.

6.1.2 Electricity Production

Electricity production is the average amount of power produced over a period of time. Table 9 shows the optimization result and Fig 14. Shows the monthly average electricity production.

Table 9. Optimization Result

PV	Generator (kW)	Converter (kW)	Battery (string)	Dispatch	Capital Cost($)	Operating Cost ($)	NPC ($)	COE ($/kWh)	Ren Fractio (%)
1,216	0	239	3,038	Load Following (LF)	1,094,400	88,320	3,790,000	0.520	100

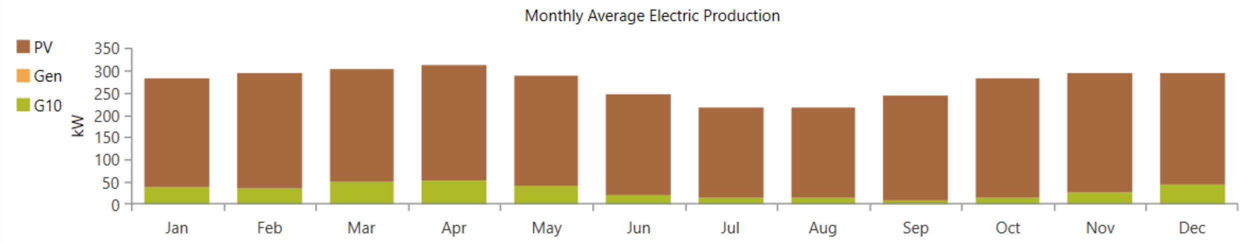


fig 14. monthly average electricity production

6.2 Cash Flow Analysis

The difference between the cash available at the start of a project's life and the cash available at the end represents the cash flow at any given period. The cash goes to pay for operating costs, direct costs, initial debt servicing, and the acquisition of assets such as equipment. It also covers loan payments and capital costs, salvage costs, replacement costs, and asset sales. Fig 15. Shows the cash flow diagram.

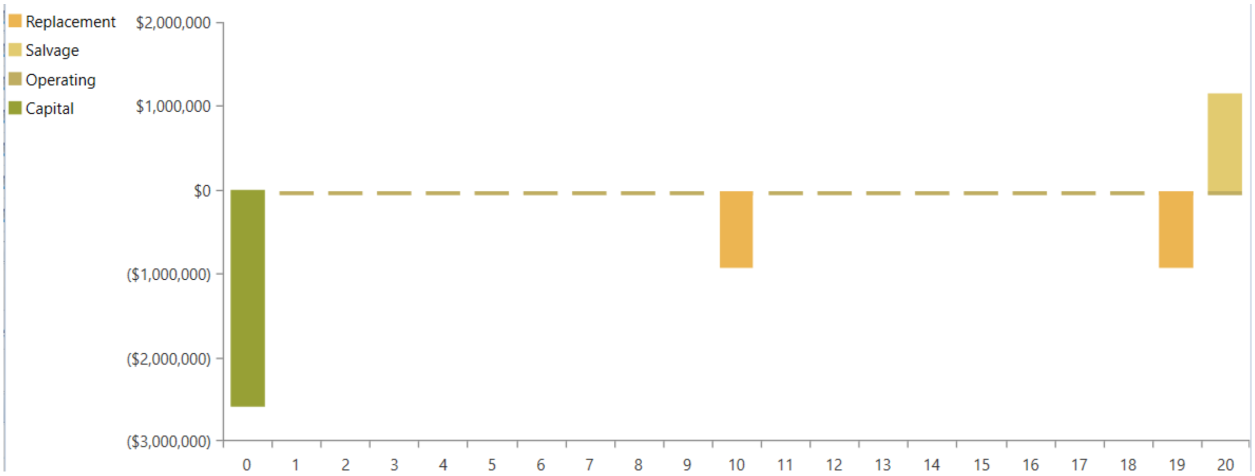


Fig 15. Shows the cash flow diagram

As observed from the diagram, a considerable amount of cash outflow occurs initially due to the installation and capital costs. The converter involves a replacement cost after 20 years. The batteries require replacement at an interval of 15 years. Also, there is a replacement cost for the PV modules after 25 years. At the end of the equipment's lifetime, a salvage cost is also observed since the equipment is depreciable.

6.3 Wind Turbine Power Output

The wind turbine has a total capacity of 380kW with a maximum output of 380kW and a total power production of 266,146kWh/yr. Fig 16. shows wind turbine power output.

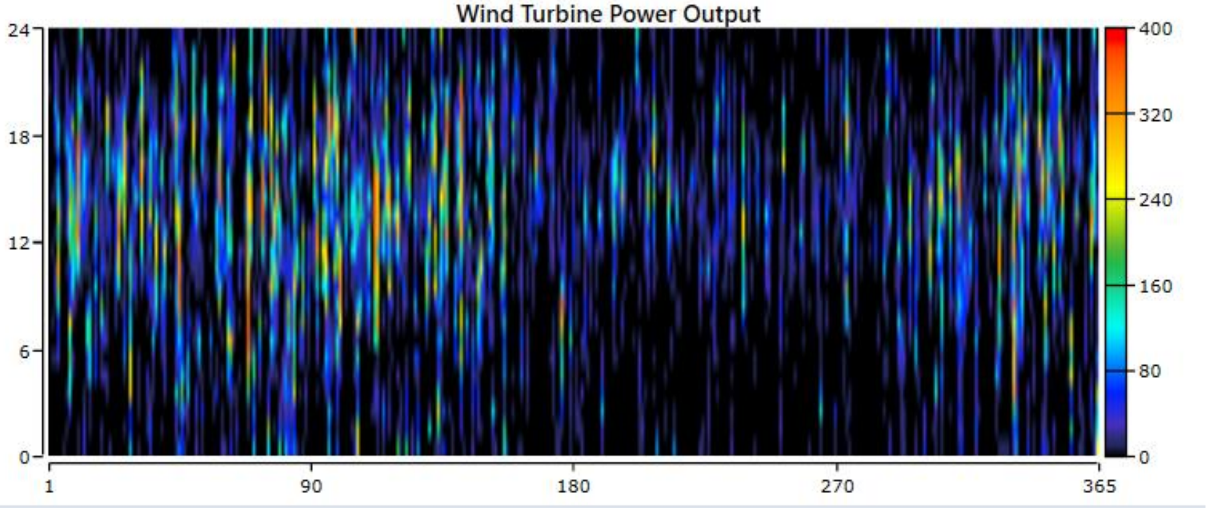


Fig 16. wind turbine power output

6.4 PV power output

The PV has a total capacity of 1,216kW and a maximum output of 1,174kW it has a total power production of 2,119,432kWh/yr. Fig 17. Shows the power output diagram.

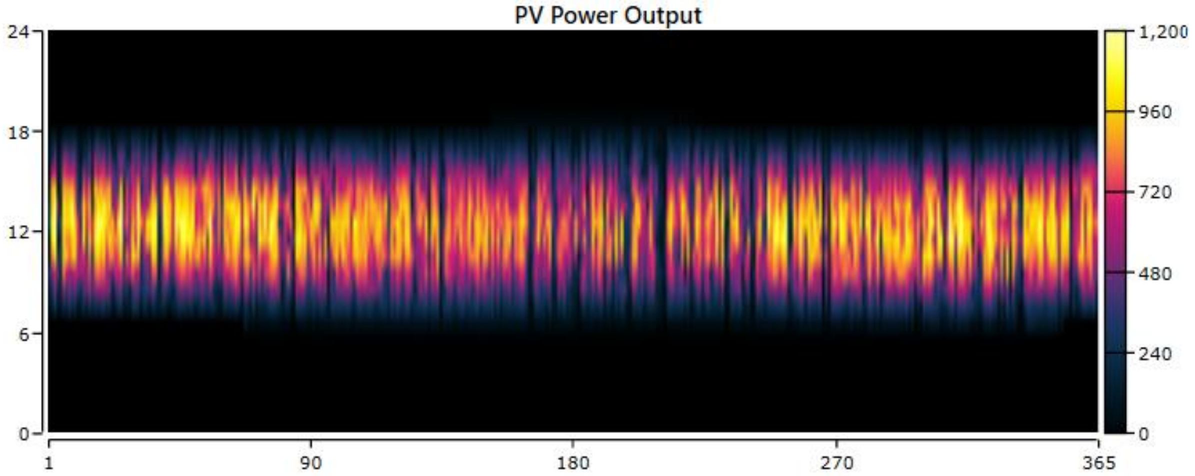


Fig 17. PV power output diagram

6.5 Electrical Summary

This section explains the generation parameters and electricity consumption, in Table 9. Shows these parameters.

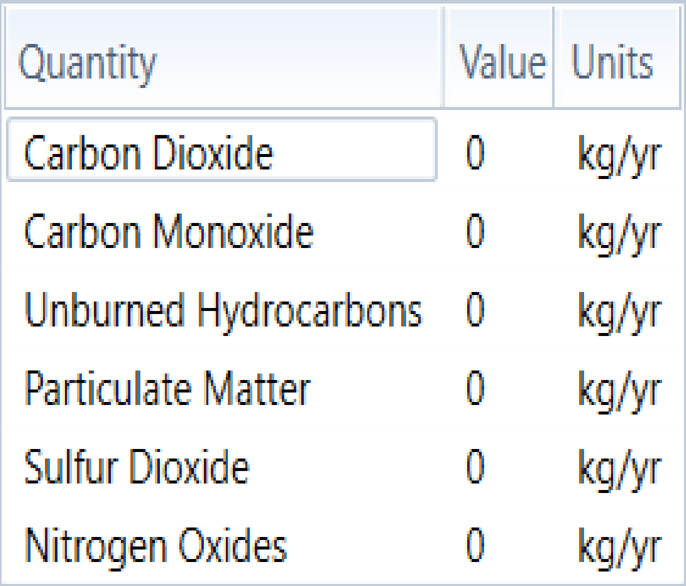
Table 9. Electrical Data

Quantity	Value (kWh/yr)
AC Primary Load	533,14
DC Primary Load	0
Excess Electricity	1,773,416
Unmet Electric Load	0
Capacity	0

6.6 Emission Summary

Emission parameters and other substances are discussed in this section. These parameters are given in Table 10.

Table 10. Emission Data



Quantity	Value	Units
Carbon Dioxide	0	kg/yr
Carbon Monoxide	0	kg/yr
Unburned Hydrocarbons	0	kg/yr
Particulate Matter	0	kg/yr
Sulfur Dioxide	0	kg/yr
Nitrogen Oxides	0	kg/yr

Chapter 7

Conclusion

The proposed scheme provides a different way for the member nations of the OIC to obtain energy and is suitable for all OIC members.

In order to grow economically and socially, emerging nations must increasingly deal with the issue of access to electricity. In both developing and wealthy countries, remote village electrification has become a potent tool for ensuring the long-term development of such regions. This study has drawn attention to the potential for supplying renewable energy to the numerous remote areas in the OIC nations. The proposed method can be used in any land-based environment with wind and sunlight.

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