Design and Cost Optimization of a Renewable Energy System to Meet the AC Load Requirement of a Tourist Spot in West Bengal Using Matlab Simulation

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M.Tech Energy Science & Technology
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CERTIFICATE OF RECOMMENDATION

This is to certify that the thesis entitled "**Design and Cost Optimization of a Renewable Energy System to Meet The AC Load Requirement of a Tourist Spot in West Bengal Using Matlab Simulation**" is a bonafide work carried out by **Mr. SOURAV SARKAR** under our supervision and guidance for partial fulfillment of the requirements for the Post Graduate Degree of Master of Technology in Energy Science and Technology, during the academic session 2021-2023.

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CERTIFICATE OF APPROVAL

This foregoing thesis is hereby approved as a credible study of an engineering subject carried out and presented in a manner satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned does not endorse or approve any statement made or opinion expressed or conclusion drawn therein but approves the thesis only for the purpose for which it has been submitted.

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The final examination for ----------------------------------

Evaluation of Thesis ----------------------------------

DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains a literature survey and original research work by the undersigned candidate, as part of his Master of Technology in Energy Science and Technology studies during the academic session 2021-2023.

All information in this document has been obtained and presented following academic rules and ethical conduct.

I also declare that, as required by these rules and conduct, I have fully cited and referred all materials and results that are not original to this work.

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Nomenclature

HRES	Hybrid Renewable Energy Systems
HOMER	Hybrid Optimization of Multiple Energy Resources
NFHS	The National Family Health Survey
HDI	Human Development Index
SPV	Solar Photovoltaic
WT	Wind Turbine
DG	Diesel Generator
COE	cost of energy
NPC	Net Present Cost
RF	Renewable Fraction
LCE	Life Cycle Emission
GHI	Global Horizontal Irradiance
Wp	Watt Peak
d	De-rating Factor Of SPV Module
C_p	Performance coefficient
η_w	Wind Turbine efficiency
$ð_i$	Lifetime equivalent CO_2 emissions of components
E_L	Surplus Energy (kWh/Yr)
N_h	Number of human consumer for HRES.

CHAPTER -1

1. INTRODUCTION:

1.1 Introduction of Renewable Energy:

Daylight and wind are such sources that are continually being renewed. Environmentally friendly power sources are abundant and all around us. Fossil energies like coal, oil, and gas - then again, are non-inexhaustible assets that require countless years to reproduce. Sustainable power is gotten from regular sources that are renewed at a higher rate than they are consumed. Petroleum derivatives, when consumed to deliver energy, cause hurtful ozone-harming substance outflows, like carbon dioxide and carbon monoxide. Environmentally friendly power makes far lower outflows than consuming petroleum derivatives. Progressing from petroleum derivatives, which at the present record for the overwhelming majority of discharges, to environmentally friendly power is vital to tending to the environmental crisis. Renewable is currently less expensive in many nations. It develops huge job opportunities in various fields of energy sources.[1]

1.2 Common Sources of Renewable Energy:

There are various types of renewable sources of energy available which are described below.

1.2.1 Solar Energy:

Sun-powered energy is the most plentiful of all energy assets and might be saddled in an overcast climate. Humanity consumes lesser energy radiated by the sun moreover earth's atmosphere absorbs much higher radiation energy. Solar innovations can convey heat, cooling, normal lighting, power, and energy for a large group of uses. Sun-based advancements convert daylight into electrical energy either through photovoltaic boards or through mirrors that concentrate sun-powered radiation. Although not all nations are similarly supplied with sunlight-based energy, a critical commitment to the energy blend from direct sunlight-based energy is workable for each country. A solar energy system outlook has been shown in Fig: 1.1.The cost of assembling sunlight-based chargers has plunged decisively somewhat recently, making them reasonable as well as frequently the least expensive type of power.[1]

Fig1.1 SolarEnergy

1.2.2 Wind Energy:

Wind energy outfits the motor energy of moving air by utilizing enormous breeze turbines situated ashore (coastal) or in the ocean or freshwater (seaward). Wind energy has been utilized for centuries, however coastal and seaward wind energy innovations have developed throughout recent years to augment the power created - with taller turbines and bigger rotor measurements. However normal breeze speeds shift extensively by area, and the world's specialized potential for wind energy surpasses worldwide power creation and more than adequately expected exists in many locales of the world to empower critical breeze energy sending.

A wind energy system outlook has been shown in Fig:1.2 Many regions of the planet have solid breeze speeds, however, the best areas for producing wind power are now and again far-off ones. Seaward wind power offers enormous potential.[1]

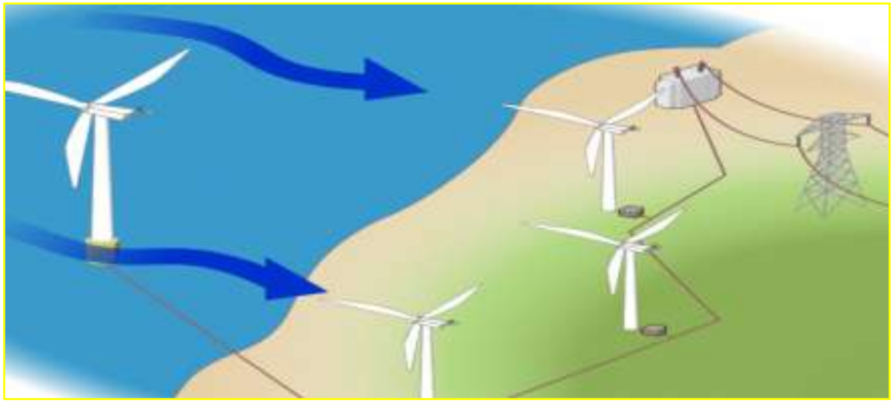

Fig1.2 WindEnergy

1.2.3 Bio Energy:

Bioenergy is delivered from different natural materials, called biomass, like wood, charcoal, waste, and different fertilizers for intensity and power creation, and agrarian yields for fluid bio-fuels. A Bioenergy system outlook has been shown in Fig: 1.3.

Most biomass is utilized in provincial regions for cooking, lighting, and space warming, by and large by less fortunate populaces in creating countries. Modern biomass frameworks incorporate devoted harvests or trees, deposits from farming and ranger service, and different natural waste streams. Energy made by consuming biomass makes ozone-harming substances outflow yet at lower levels than consuming petroleum products like coal, oil, or gas. Be that as it may, bioenergy ought to just be utilized in restricted applications, given the potential negative ecological effects connected with enormous scope expansions in woods and bioenergy ranches, and coming about deforestation and land-use change.[1]

Fig: 1.3 Bio Energy

1.2.4 Geothermal Energy:

Geothermal energy use heat that naturally came out from the earth's interior surface. Heat came out automatically by huge inner gaseous pressure forming a well or a reservoir. A Geothermal power plant outlook has been shown in Fig: 1.4

Hydrothermal reservoirs are those which are naturally sufficiently hot. Whereas enhanced geothermal systems are those which have improved hydraulic stimulation and are sufficiently hot.

Once it starts generating electricity from the hot steam coming out from the hot crack or well then its aim will be completed. The technology for electricity generation from hydrothermal reservoirs is mature enough and reliable and has been operating for more than 100 years.[1]

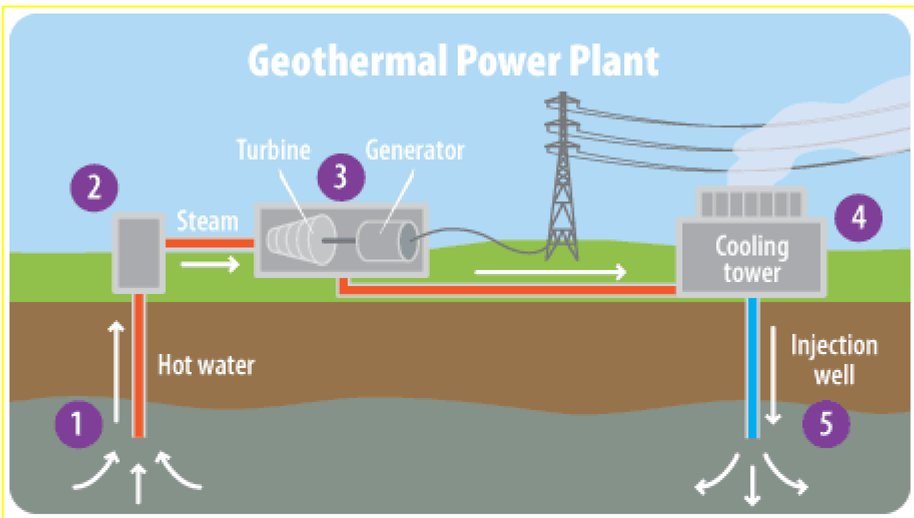

Fig: 1.4 Geothermal Power Plant

1.2.5 Hydropower:

Hydropower outfits the energy of water moving from higher to bring down rises. It very well may be created from repositories and waterways. Repository hydropower plants depend on putting away water in a repository, while run-of-stream hydropower plants saddle energy from the accessible progression of the river. Hydropower repositories frequently have numerous purposes - giving drinking water, water for the water system, flood and dry spell control, route administrations, as well as energy supply. Hydropower right now is the biggest wellspring of environmentally friendly power in the power area. A Hydropower system outlook has been shown in Fig: 1.5

It depends on commonly stable precipitation designs and can be harmed by environment-prompted dry spells or changes to biological systems which influence precipitation patterns. The framework expected to make hydropower can likewise affect biological systems in antagonistic ways. Thus, many consider limited-scope hydro all the more harmless to the ecosystem choice, and particularly reasonable for networks in remote locations.[1]

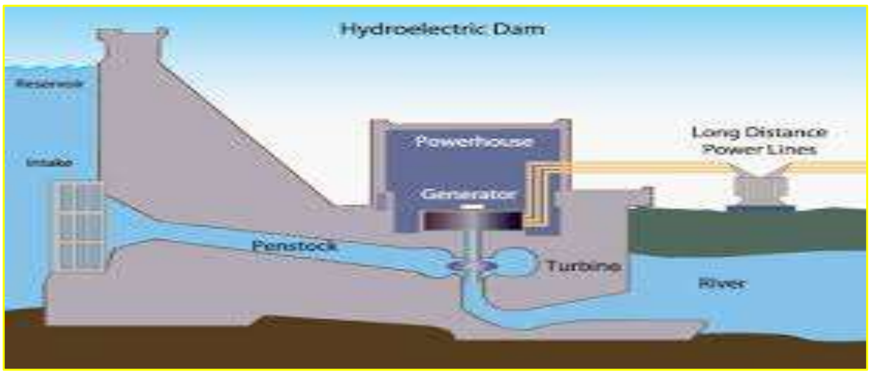

Fig: 1.5 Hydro-Power

1.2.6 Ocean Energy:

Hydropower reins the energy of water moving from higher to bring down rises. It very well may be created from repositories and streams. An Ocean energy system outlook has been shown in Fig: 1.6

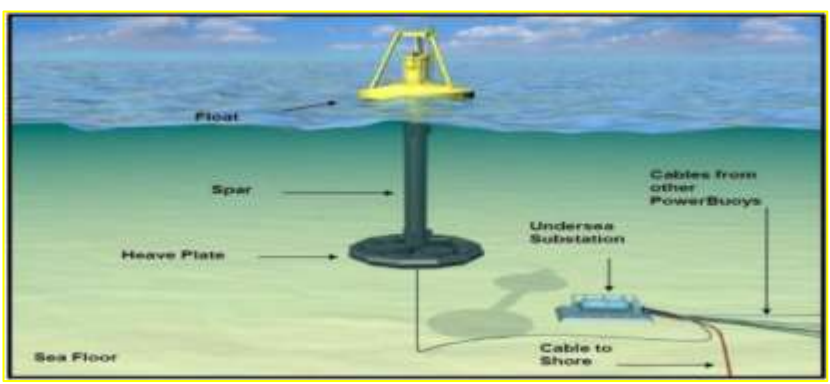

Fig: 1.6 Ocean Energy

Sea energy gets from innovations that utilize the dynamic and nuclear power of seawater - waves or flows for example - to create power or heat. Ocean energy frameworks are currently at the beginning. There is a lot more to innovate and research to say about its potential in the upcoming future. The potential of sea energy is not that huge that could meet the present human energy requirement. [1]

1.3 Why Do We Need Renewable Energy?

1.3.1 Fossil Fuels Are Limited:

The first and primary justification for why states and organizations are quick to move to sustainable power sources at the earliest opportunity is that petroleum derivatives are a limited asset. We might have arrived at top oil - the place where request exceeds supply - and by current figures, numerous specialists appear to concur we did as such around 2008 with just outer elements spurring changes in interest making it challenging to foresee exactly when it will run out. That is another discussion altogether that our lawmakers and financial specialists have contended for quite a long time, and will keep on contending for a long time to come. However we take a gander at it, non-renewable energy sources will run out in the end and it will require nearly 10,000,000 years to recharge what we have utilized in something like 150 years.

As the human population expands our pace of utilization of these petroleum derivatives likewise increments. Geologists and others whose work it is to find and access these pockets of unrefined petroleum are finding it progressively hard to find and concentrate new sources. Whether we have 1 year or 100 years left of oil, from now onward we need to shift our energy outsourcing to the renewable energy sector, so that we could easily manage our needs effectively in a much more efficient and sustainable way. [2]

1.3.2 Carbon Emissions & Climate Change:

The quickest issue, especially considering the COP21 understanding of 2016, and the progressions we have seen in the environment over the most recent 150 years, is environmental change and the fossil fuel byproducts that are constraining it. In the most recent couple of years particularly, no region of the planet has been immaculate by freak atmospheric conditions. Most main land’s have kept record high temperatures in summer, record lows in winter, and expanded recurrence of tropical storms and typhoons, record droughts, dry spells, and flooding. There is no question that these odd weather patterns are influencing each country.

Most environmentally friendly power sources, and the innovation used to saddle them, are low fossil fuel byproducts. By and large, when introduced they have insignificant or no carbon yield and can in any case give our energy needs. We can never go completely carbon impartial as it takes assets to make a sun-powered charger, construct a dam, etc, however, it is a basic and huge decrease of our carbon yield. What we have to do, is to make the strides we can to diminish our carbon impression for global guidelines, to help those in the creating scene, and to safeguard ourselves against the odd climate. We likewise realize that the ice covers are softening and the ocean levels are rising which makes food deficiencies and public shakiness as well similar to a costly circumstance for our protection.[2]

1.3.3 Environmental Damage:

As the non-renewable energy source supply gets more earnest to obtain, miners look for new pockets of oil and need to penetrate longer and more profoundly to procure it, there has been a struggle between ecological gatherings and industry and among state-run administrations and the two gatherings when nearby untamed life and earth delicate regions are undermined. Here in the public cognizance and the need to safeguard our untamed life and normal scenes implies that numerous new advancements are fought with worries of natural harm. Continuous fights against deep earth drilling and new penetrating. However some renewable will have an ecological effect, many don't and when assembled, have no further effect - dissimilar to progressing drilling. [2]

1.3.4 Public Health:

Oil, gas, and coal boring and mining have elevated degrees of contamination that are siphoned into nearby conditions and the more extensive air, so while protesters endeavor to forestall the structure of pipelines or new prospecting in virgin regions and wild, it is as much about general well-being for what it's worth about protection. We have known for a long time about the thump on the impact of modern cycles on general well-being. Few renewable are totally outflow free, yet their result is a lot lower than regular petroleum product obtaining and processing. [2]

1.4 Renewable Hybrid Energy System Recent Trends in India:

The energy prerequisite has been rising dramatically because of the great populace development and industrialization across the world. Right now, energy use is one of the essential boundaries utilized for characterizing monetary turn of events and the country's advancement.[3] Around the world, the greater part of the energy request is satisfied by petroleum product-based customary resources[4-5]. The expansion in ecological corruption and restricted accessibility of petroleum derivatives has progressed the requirement for substitute energy resources [6-8]

In non-industrial nations like India, the rising interest and country zap require extra energy sources. India has loosened up the power organization to the greater part of the occupants, yet, a huge number of families can't get to the matrix supply [9-12]. The power transmission and conveyance area in India is as yet confronting a few limitations like monetary emergencies, transmission misfortunes, temperamental sporadic stockpile, charging issues, and influence robbery. The current power age (370 GW) in India shares 62.8% non-renewable energy source-based limit and 23.6% from sustainable resources [13-14]. Normally, India's power request would triple by 2040.

The significant issue looked at by agricultural nations is giving clean power to the large numbers of country individuals who have no admittance to power. Lattice expansion is a massively costly methodology because of the land obtaining, the establishment of a broad framework, and socio-specialized requirements. Aside from these, the aggravation of the town Eco-framework and immense fossil fuel by-product is likewise unsettling matrix expansion factors. Hence, an elective game plan of force age is required for a country jolt. In a non-industrial nation, improvement and. McKinsey's restrictive demonstrating proposes that assuming the above upgrades are considered; wind-sun-based capacity crossover frameworks could produce nonstop power with cost as well as unwavering quality levels similar to existing coal-terminated power plants in the following 4-5 years. For instance, a mixture framework which is expected to convey a level heap of 250 megawatts (MW) could be planned by joining sunlight-based, wind, and battery stockpiling, at a levelized cost of energy at 3-4 Indian Rupees for every kWh by 2025. This is subject to the particular area and some occasional variations. India's service of new and environmentally friendly power delivered a sun-based breeze crossover strategy in 2018. This gives a structure to advance matrix-associated cross-breed energy through set-ups that would utilize land and transmission foundations ideally and deal with the fluctuation of sustainable assets somewhat.

Improvement of millions of rustic people groups' financial condition becomes an extensive challenge [15]. Sustainable power turns into a reassuring choice for rustic locals. The use of inexhaustible assets makes the townspeople's energy-autonomous, works on horticultural efficiency, and, makes better agro-industrial structures.

September 10, 2019, India as of late led two sell-offs for wind/sun-oriented crossover projects. Both the closeouts were under-bought, with offers adding up to 1.56 Gigawatts (GW) granted to SB Energy, Adani Efficient Power Energy, and Reestablish Power, against a sum of 2.4 GW on offer. The found costs were possibly under the roof duty of 2.70 Indian Rupees. Albeit the underlying reaction from industry seems monitored, we accept that sustainable mixtures can assume a key part in assisting India with speeding up the DE-carbonization of force age and bringing down the expense of power in the medium term.

India has added 65-70 GW of wind and sun-powered limit up until this point, with wind and sun based contributing.

9.5 percent of created energy in May 2019. Assuming the public authority focus of 175 GW is accomplished by 2022, this offer could surpass 15-16 percent. Sustainable power has three innate difficulties. To begin with, it depends on irregular sources, delivering energy just when the sun is sparkling, or the wind is blowing; second, its result is compelled to explicit hours of the day; third, its utilization prompts lower use of transmission lines. This can make issues in coordinating pinnacle power interest with the sustainable result (for example in night hours when sun-oriented energy isn't free), and raise expenses of transmission. Experience in nations that have accomplished sustainable power entrance of north of 15% shows that some adaptable energy assets which can quickly increase or down are required. These could incorporate hydro or gas-based power, or energy stockpiling arrangements.

Inexhaustible half-breeds can be one answer for the above issues. A crossover framework can join wind, and sun powered with an extra asset of age or capacity. Allow us to take a model: in India, we see that sun-powered yield is most extreme somewhere in the range of 11 am and 3 pm, while wind yield is most noteworthy in late night and early morning. The top interest for power arrives at night long stretches of 6-9 pm, which can't be taken care of by one or the other breeze or sunlight based. On the off chance that we can store a little energy during overabundance sustainable age hours and deliver it into the matrix during top interest hours, the joined "mixture" framework can create nonstop clean energy in light of changing degrees of interest as the day progressed. The capacity can take many structures, like batteries, siphoned hydro, or mechanical capacity through flywheels. The discontinuity of wind and sun based could likewise be adjusted by adding a quick-sloping wellspring of force; for instance, an open cycle gas turbine. The general result of the mixture framework can subsequently be matched against a necessary burden on an hourly premise. Along these lines, it can give both base load and adaptable power.

Mixture frameworks are supposed to turn out to be progressively cost-cutthroat, driven by diminishing expenses of battery stockpiling and sun-oriented energy. An ideal blend of sun-oriented, wind, and capacity can convey stable nonstop power even at the present expenses of around 6-7 Indian Rupees each kilowatt hour (kWh). Contrasted with base load coal plants, this is altogether higher. Notwithstanding, lithium-particle battery costs are supposed to tumble from the current $220-240/kWh to underneath $100 in the next 3-4 years. Also, Levelized expenses of sun-powered energy have plunged from 4.63 Indian Rupees per kWh in 2016 to 2.50 Indian Rupees per kWh in the most recent sell-offs and may fall as low as 2 Indian Rupees for each kWh in the following three to five years.

India isn't the main nation arranging half-breed projects; 50 or more crossover tasks of MW-scale have proactively been declared or are under development internationally, with Australia and US being the pioneers. For bigger limits or longer span adjusting, siphoned hydro is a practical stockpiling arrangement, however, is confined by the absence of reasonable actual locations. If the financial matters of crossover frameworks truly do move toward the above levels, our examination shows that they might be cutthroat with 30-40 percent of existing coal-terminated stations in India. They can in this way turned into a feasible answer for meeting future baseload power necessities, all at zero fossil fuel byproducts and future expense expansion evidence. A few driving Indian corporates are likewise showing dynamic interest in expanding their use of clean power if nonstop arrangements are available [16].

1.5 Aim and Objective of the Thesis:

If we analyze according to our energy needs, we need clean sustainable energy that supports our requirements as well as an Eco-friendly solution. To resolve these aspects only thing we have in the current scenario is Renewable sources of energy. Hybrid energy plays a key role in the current solution. Hybridization means combining of various types green energy into one common platform to serve our common energy needs. In our research, we have introduced two types of renewable energy that are Solar photovoltaic energy, Wind energy.

In this work, we can see an On-grid model, that is connected with a Wind energy system, Solar photovoltaic system. This work utilizes Solar energy as a leading energy contributor and Grid, Wind as a secondary source of energy source.

In our project we are intended to bypass the energy requirement of Air-conditioning load using renewable energy in a large three-star hotel '**Le ROI DIGHA**' in West Bengal India. In this work, we have analyzed our load by "HOMER PRO SOFTWARE. Then Whole On-grid model we simulate in "MATLAB SIMULINK SOFTWARE. This work sequentially addresses the techno-economic and socio-environmental indicators for optimization analysis. It is found that maximum recent techno-economic research works lack in addressing the social aspects as presented in this work.

1.6 Overview of Thesis:

This whole research it is describes how we can replace the Air conditioning Load of a large Hotel consisting of 45 deluxe rooms by simply introducing the Grid connected HRES. The location for this research is chosen Hotel Le ROI Digha, West Bengal, India. This is one of the Hot places to visit in terms of the beautiful sea beach in West Bengal. There are lots of 3-star or big hotel room stay available. Due to hot climatic conditions for almost 9 months in a year, this spot's rooms are in demand of Air-conditioner (AC). So that may lead to daily huge electricity consumption.

To solve this burden of huge load demand our thesis would be really helpful. This whole thesis is divided into 7 chapters. In this every chapter it can be seen a stepwise analysis of each topic.

In the first chapter, we have discussed the introduction of the thesis. We have mentioned the various sources of renewable energy systems available.

In the second chapter, it is discussed the review of earlier work that essentially support completing our research efficiently. In this chapter, we can see a review of various papers and a clear projection of the work plan and aim of the thesis.

In the third chapter, we have discussed the recent development in renewable energy systems both Off Grid and grid-connected HRES models. In this chapter one can see the diversification of the various renewable sources. Also, we can be seen the newest technology available in the current context of the research field.

In the fourth chapter, we can be seen Overview of the software technique used in the present work. This segment it is analyzed software overview of Matlab and Homer pro. This part clarifies the basic view of software, effectively.

In the fifth chapter, we have discussed the methodology of the thesis. Here one can see the structure-wise analysis of the various methods. This method we have used to design our research. It ensures the clarification of our work process.

In the sixth chapter, we analyzed the result and discussion of our thesis. In this part, we can be seen all results, plots, graphs, and critical outcomes of our result body.

In the final seventh chapter, we have discussed the conclusion, future scope, and limitations of the thesis. Here we have put all the results, outcomes, data, etc sequentially. It signifies future enhancement and motivation.

1.7 Conclusion:

This work presents an optimum Techno-Economic analysis that addresses the environmental and economic solution in terms of energy consumption. The main objective of this work is to analyze the best cost-effective solution for larger load-handling solutions comparing Grid and Renewable sources of energy. Here we can see how to bypass the Air conditioning load by using Solar photo-voltaic and Wind Energy systems and, how the whole system meets the desired load daily. Also in this work, we will be seeing, what is the ROI (Return on Investment). This Eco- friendly solution would be helpful. Especially Tourist spots like Digha where 60% of hotel rooms are AC. This room draws huge power collectively the whole day is a concern. Among all the major loads the Air conditioning load is the heaviest load except the pumping load. The pumping load is active only one or two times a day but in the case of AC loads are activated 8-9 hr collectively in summer(considering auto cut system) and in winter nearly zero.

That is the reason our work comes into the game and drives us to analyze what is the best approach to bypass this huge burden of electricity bills.

CHAPTER-2

2. REVIEW OF EARLIER WORK

2.1 Introduction:

In the previous chapter, we have seen the different types of Renewable sources that are remarkable in terms of their performance. It is seen that clean energy becomes now a revolution in an energy security context. Carbon emission is a big problem all over the globe. To prevail the harsh effect on the environment by carbon emissions, the United Nations has given an ultimatum to all counties. Replacement with renewable sources is the best option in this current context. It is very difficult for large developing countries like India because it involves a huge budget to modernize.

But we need to focus initially modernize whoever wants to replace our budget after getting brief knowledge about ROI (return on Investment), Capital cost, all backups, and power savings. That's our work is to motivate people like large Hotels, Restaurants, and Industries. The outcome of this work quite

- It surveys the literature on Hybrid Renewable energy systems.
- It synthesizes the formation of the literature summary.
- It critically analyses the information gathered by identifying gaps in the summary.
- It presents the literature in an organized way.

2.2 Literature Survey:

Sandip Kumar, Dr. Mani Kant Paswan, Sudhakar Behera[17] have investigated on development of a productive approach of a design, simulation, and analysis of a stand-alone hybrid renewable energy source for a typical rural village remote area situated in Digha, West-Bengal, India whose location (21° 37.6'N, 87° 30.4'E). The purpose of this study is to get optimized operating cost and levelized cost of energy. Based on NASA meteorological data and the National Renewable Energy Lab(NREL), they confined the whole work.

A remote village Digha having an energy consumption of 1650 kWh/day with 385.51 kW peak power and a Deferrable load of 24.86 kWh/day with 4.62 kW peak load demand was evaluated. The optimal solution is analyzed for a remote village with 1000 households with an average of five family members per household with school, hospital, and other commercial uses like tube well. The proposed hybrid systems are capable to generate 96% of the total electricity requirement for this village. For additional load requirements there is a battery backup and Diesel Generator to mitigate the load.

In West-Bengal, where maximum radiation occurs in may and the minimum radiation available in August. Out of total electricity consumption, 86.5% is consumed by Solar photo voltaic arrays and 11.5% of energy is delivered from wind turbines, Diesel generators used 1.96%. Four types of systems are compared in Homer software that are PV, WIND, DG, and BATTERY storage. After calculating all combinations he found the first system was the best. Out of four, the best systems are optimized in terms of low NPC (net present cost), and low COE (cost of energy). The result shows $1.56M NPC and $0.197/kWh which is the least among all other combinations in the simulation result.

The combination of PV array, diesel generator, wind turbine, battery storage, and converter bring to the optimal configuration of a hybrid renewable energy system applicable to be used as an off-grid system for the selected village of 1000 household in the eastern region of India with the cost of energy $0.197/kWh. Since the solar resource potential of the site is high 86.5 % of the energy is produced from the solar array and 11.5 % from the wind turbine and 1.96% from the diesel generator.

Samir M. Dawoud[18] have investigated a combination of four different hybrid renewable sources of solar photovoltaic (SPV), wind turbines, diesel engines, and storage batteries are considered for residential systems. The simulation results, optimization, and modeling procedures are accomplished with the use of HOMER software. From the technical and economic assessment, the SPV-wind-diesel battery source has a minimum value of the cost of energy annually 0.275$/kWh and the SPV-diesel source has a higher value of the cost of the energy with 0.36 $/kWh. The creators clarified the functional and genuine answers for ecological and monetary plans that could be referenced by issues like unnecessary populace development, decimation of normal sources, obliteration of contamination, and natural frameworks, and avoidance of environmental change. The maintainable advancement of natural security and diminishing of the ozone depleting substances, which contaminate the demeanor of the climate, were examined. Hurghada city is sited in Egypt and it has a high chance of sun oriented radiation which could be utilized to create power. An examination study for the four sources shows that crossover SPV-wind has a higher electrical creation worth of 9,79,3034 kWh/y, while SPV-diesel has a lower electrical production value of 2,899,285 kWh/y. Hence out of four hybrid sources, the SPV-wind system has no pollution, zero value, and the SPV-Diesel system has a maximum value of 808,742 kg/y.

S. Gudzius, S. Gecys, L. A. Markevicius, R. Miliune, A. Morkvenas[19] have introduced the development of a sustainable and efficient economy that ensures the balanced use of the natural resources, delicate climate change and protection of our environment. These efforts are at the center of the public attention. An ambitious policy framework is provided in the EU "Climate and Energy Package" for the evaluation of the infrastructure of service for public needs. Smart electric power distribution grids are easier to manage; they are more reliable and transparent than today's grids. The smart grid allows the integration of different electric power generation sources and guaranty reliable electric power supply for customers under liberal market conditions. The modernization of electric power distribution systems and implementation of modern fault location, insulation resource monitoring, and post-fault regime optimization equipment allows the significant reduction of the fault location time and costs of maintenance.

Sushmita Banerjee1, Abhishek Meshram2, N. Kumar Swamy[20] have introduced grid technology as the key to the efficient use of distributed energy resources. The concept of a smart grid plays a crucial role and can be successfully applied to power systems. This paper introduces the study of integrating renewable energy in a smart grid system. The basic objective of a smart grid is to promote active customer participation and decision-making as well as to create an operating environment in which both utilities and consumers can interact with each other. In smart grids, users can motivate utilities by providing DG sources such as photovoltaic modules or energy storage devices at the point of use and reacting pricing signals. In this paper, the key technologies of the smart grid have been studied and reviewed. Further nanotechnology-based solutions and applications in the devices/components could help us shortly for improving the efficiency using smart grids.

Sanjoy Kumar Nandi, Mohammad Nasirul Hoque, Himangshu Ranjan Ghosh, Riku Chowdhury[21] have investigated the wind data for the five stations obtained from Local Government Engineering Department have been assessed, but simply two of them appear to be qualified for energy production. Measured climatologist data such as cloud cover and sunshine duration data of Bangladesh Meteorological Department from 1992 to 2001 were used for the estimation of global solar radiation as they are correlated. Techno-monetary practicality examination is finished for 100 kW Grid connected wind and solar based photovoltaic frameworks. The review uncovers that Kutubdia and Kuakata have the potential for wind power age and are reliable with different examinations, for example, BCAS estimation locales. In Bangladesh generally, several foggy days can be seen in January. For this reason, we have connected meteorological parameters for 11 months (except January). For the estimation of sunshine duration, we have calculated the ratios of measured and estimated values for satisfactory stations and considered that as the fog factor (value 0.85–1.00) for this month. The monthly averaged daily global radiation varies from 3.2 W/m2/day to 6.1 kW/m2/day.

Iftikhar, Mughees Sarwar Awan[22] have introduced in this paper about power synchronization of four different power sources (solar-PV, wind turbine, Diesel-generator, and local grid). A hybrid Power system is a combination of output power of two or more different power sources mostly renewable power sources such as wind-turbine and solar photovoltaic (PV), to drive a common load. Synchronization of two powers is a difficult task. Technically a lot of effort is involved to make capable two different power sources to drive a common load.

The modeling of this system is done in Matlab-Simulink software. The wind-solar based crossover framework can create power when we want it, yet consider the possibility that on overcast days or when there is no adequate wind current to pivot the turbine's cutting edges? To get rid of this situation we have to add one more source (nonrenewable) and synchronize it (such as a diesel generator) to a wind-solar hybrid system. The system observed transients when initially the diesel power source was synchronized into the system. The overall system showed stability over the loads.

M. Nagaiah*, N. M. Girish Kumar, Shaik Rafi Kiran [23] have investigated the performance of Bidirectional Converters and Energy Administration system (EAS) of a Grid-connected crossover series of Solar and Wind Generation. Inventive typologies for Renewable Energy (RE) change systems that incorporate electric grids and energy storage systems are to be considered for different needs in smart grid applications. DC-DC bidirectional converter is to be connected between the batteries bank and DC-connect bus voltage, which is utilized to control the power through DC-link voltage. It is additionally to be utilized to make the batteries bank stores the overflow of solar energy and supply this energy to the load during solar power lack. Soft Computing Techniques need to be considered for the control of Bidirectional Converters. The proposed research is to build up a setup that uses solar and wind energy systems in a most ideal way so that the power can be created whenever it fulfills the load necessity. The proposed investigative work is to be checked by utilizing Simulink in MATLAB condition. The proposed project describes the hybrid dc system consisting of solar and wind power generation with a dc-dc Bidirectional converter between the DC Bus and Battery Storage system to ensure efficient utilization of energy. And also Bidirectional Converter between the DC grid to the main AC grid with the motto of achieving bidirectional power flow from the DC grid to the AC grid and vice versa is applied and tested hybrid System in Matlab Simulink.

Joakim Widén[24] has investigated the large order of solar and wind power in a prospect for Sweden, using climatic data containing eight years with an hourly goal. As a variable output has to be adjusted by the power system's reserves, it is important to study the time variability, coincidence, and correlations between energy sources. For wind power it has been assessed, taking the smoothing effect into account, that a 10% increase in the wind power entrance of gross demand increases the reserve prerequisites by 2%–8% of rated wind power Capacity. This study aims at describing and analyzing the variability in, and correlations between, large-scale solar and wind power in a future scenario for Sweden, as part of a project that is to determine the potential for distributed PV in the country. A fundamental assumption for the project is that wind power will already be integrated with the power system. a smoothing effect on the aggregate output resulting from the dispersion of generation units for solar power, but lower than that for wind power because of systematic variability in the availability of solar irradiance. combination of solar and wind power generation predicts a minimum standard deviation of 30% solar and 70% wind power (annual production) because of the complementary indicated by the negative correlations.

Majid Vafaeipour, Mohammad H. Valizadeh, Omid Rahbari, Mahsa Keshavarz Eshkalag[25] have investigated solar and wind energy parameters of a studied area located in Tehran, Iran, using input meteorological data optimized for one year period provided by the Iran Renewable Energy Organization from a ground station, Letman Jungle. However, the present paper adopts the random fluctuations of wind speed data for classification purposes. Furthermore, it utilizes a temperature-based method to estimate the solar energy potential of the region. The daily and monthly global solar irradiation on horizontal surfaces and various wind energy properties were assessed using a temperature-based method and Weibull distribution function, respectively. To investigate the most probable direction of the wind, wind direction, and velocity data were employed to plot the 2D and 3D wind roses of the region. The sum of received annual global solar radiation on
horizontal surface yielded 1.85 MWh/m2 /year for 2011. The highest and the lowest ambient temperatures happened in July and January but the highest and the lowest average of global solar irradiation were assessed in June (7.46 kWh/m2 /day) and December (2.46 kWh/m2 /day), respectively.

Rolex Muceka, Tonny Kukeera, Yunus Alokore, Kebir Noara, and Sebastian Groh[26] have introduced a swarm grid hybrid node consisting of a solar PV system integrated with the existing individual backup generators for households and retail shop end users. The hybrid system framework resulted to be a suitable system with excess energy of 27%, fuel savings of 39%, and a reduced cost of backup electricity by 34% for the household end user. For the retail shop end user, the hybrid system was found to be a suitable system with a fuel cost saving of 53%, excess energy generation of 28%, and reduced cost of backup electricity by 45%. The outcome in high reliance on fossil-fuel backup generators for small enterprises and households. In any case, these generators are uproarious and their fuel is expensive. The study aimed at the hybrid node of the swarm grid. From the result, potential fuel savings and overall system cost reduction are found. Integrating solar hence increases the share of renewable energy mix for the end users, and generates excess energy that can be shared in a swarm grid by the grid participants. The overall result is that a swarm grid would enable the energy consumers to become prospers capable of sharing or trading energy produced among themselves.

Masoud Farhoodnea, Azah Mohamed, Hussain Shareef, Hadi Zayandehroodi[27] have investigated a large PV system connected to the distribution network under variable weather conditions, it may cause severe problems for power system components. This paper assesses power quality analysis on a grid-connected PV system in a distribution system under different climatic conditions. A 1.8 MW grid-connected PV system in a radial 16-bus test configuration is demonstrated and simulated under varying solar irradiation using the Matlab Simulink software. To investigate the effects of different weather conditions on the produced power of the PV modules, required meteorological data related to Kuala Lumpur for one year are collected from the Malaysian Meteorological Division (MMD), and simulation is done on a changed outspread 16-bus test framework with an inserted 1.8 MW grid associated PV system with Sun-power SPR 305 and Sanio HIP 225 modules utilizing Matlab-Simulink programming under radiant and overcast weather patterns. A 1.8 MW grid-connected PV system in a radial 16 bus test system is simulated using the Matlab-Simulink software under different solar irradiance and the results show that the produced active power by the PV system causes voltage rise, voltage flicker, and power factor reduction, which may create severe problems for system components.

Shiying Zhou, Xudong Zou, Donghai Zhu, Li Tong, Yingying Zhao, Yong Kang, and Xiaoming Yuan[28] have investigated, an improved design of the current controller, i.e., PI controller and capacitor current feedback active damping, proposed to reduce the negative effect of PLL on current control. Initially, a small signal impedance model is created to

dissect the effect of PLL on current control. Then, the effect of current controller parameters on the converter output impedance is analyzed, The small-signal model of current control considering the effect of PLL is established for three-phase LCL-type grid-connected converters. Then the converter output impedance is analyzed, and the main conclusions can be summarized as follows. PLL will deteriorate the grid current control under a weak grid, due to the negative incremental of q-axis converter output impedance and the decrease. The current PI controller parameters can also affect the converter output
impedance and PMcross which includes the PLL dynamics. Moreover, with the increases of Kp and decreases of Ki , the PMcross will increase, namely the system stability will be improved.

Mustafa Abu-Zaher, Yousry Atia, Farag K . Abo-Elyousr, Emad H. El-Zohri [29] have introduced a maximum power point tracking algorithm for single-stage three-phase grid-connected PV system by using incremental conductance method. maximum efficiency is realized when PV works at its maximum power point, which is contingent on irradiation and temperature. The control strategy is supported using MATLAB/Simulink and experimentally validated with the dSPACE MicroLabBox controller. Many MPPT techniques have been developed such as perturb and observe method and the incremental conductance method. MPPT algorithm is done and controlled by many controllers such as fuzzy logic controllers and neural network controllers. This paper depicts experimental and implementation results to have it from PV as well as to increase the efficiency and performance of a single-stage three-phase system connected to a grid, where an incremental conductance algorithm is used in this research. To check the theoretical results, an experimental prototype was built. The developed MPPT algorithm was validated through the experimental results, Based on the simulated and the experimental results, the developed algorithm can track the PV MPP with a high degree of accuracy and stability, it can reach the MPPT in 3 seconds.

Naki Güler, Erdal Irmak[30] have investigated Model Predictive Control (MPC) approach to obtain high accuracy and fast dynamic response. The tracking capability of the base algorithm is improved by the combination of the two methods. The proposed control approach was tested on a three-phase grid-connected inverter that was fed by a PV panel group. Switching signals of the inverter are created by the MPC algorithm. Reference current of the MPC algorithm optimized by Perturb and Observe MPPT method. Power flow, MPPT efficiency, and THD analyzes are examined in a simulation performed by using MATLAB/Simulink environment.

Besides the MPPT analysis, the current tracking capability of the MPC algorithm is examined under dynamic transition conditions. Results show that the MPPT efficiency of the proposed control approach is 98%. The paper proposes a combined control algorithm for PV systems. The proposed control approach consists of MPPT and MPC algorithms. Thanks to the fast and sensitive control capability of MPC, the combined algorithm offered effective tracking under both varying irradiation and cloudy conditions.

M. Azri and N.A. Rahim[31] has investigated the design analysis of a single-phase grid-connected photovoltaic with inverter control low pass filter. It minimizes current harmonics, improving output signal parameters. The inverter is an H-bridge zero vector rectifier (HB-ZVR) transformer less topology. Switching frequencies such as 8kHz,14kHz, and 20kHz were analyzed for validation of the experiment and simulation. Outputs of an LC low-pass passive filter for a single-phase grid-connected transformer less inverter have been presented. Computations made on equations were simulated on PSIM, a program that not only helped the study and analysis of the basic filter but also minimized the filter's design time. Experiment results verified the proposed design for the LC low-pass passive filter as satisfying the below-5% output THD requirement at8kHz switching frequency

Michael Bierhoff, Ramy Soliman, and José R. Espinoza C[32] have investigated in this paper a simple PI controller can cause instabilities when applied to control the current of this filter. A general analytically closed approach is implemented to determine the safe operating areas for both grid current control mode and inverter current control mode, both with and without additional active damping feedback of the capacitor current. Combined with the proposed PI controller design for fast dynamic response it also helps to overcome corresponding single loop stability restrictions by associated dual loop AD design procedure. Hence, the simple overall design guideline provided supports the current controller design as it maintains a constant phase margin at consistent dynamical performance versus the entire carrier frequency range for both GCM and ICM.

SUJIL, Saurabh Kumar AGARWAL, Rajesh KUMAR [33] have investigated multi-agent-based critical load securing in a PV-based micro grid. This work also clearly discusses the modeling and simulation of a specialized micro-grid called an Intelligent Distributed Autonomous Power System (IDAPS). The IDAPS micro grid assumes a basic part in laying out a power grid that works with the utilization of sustainable power advances. Intelligent Distributed Autonomous Power System (IDAPS) comprising solar photovoltaic as DER and loads, as well as their control algorithms, has been developed. Many case studies have been monitored to optimize the operation of the IDAPS micro grid.

Neethi R Nair, Mabel Ebenezer [34] have introduced the operation and control of a hybrid power system powered by wind and photovoltaic sources. A utility grid connection is provided to replenish energy levels in case of power shortage from renewable energy sources. A Permanent Magnet Synchronous Generator (PMSG) is used to drive the wind turbine. Wind power and solar irradiance are considered in different variable conditions. The input current control method for MPPT wind turbine and incremental conductance method for PV are analyzed. The simulation is done in MATLAB/Simulink based on a 30kWwind–solar hybrid power system and the performance of this system is analyzed based on the availability of sources. LC filter along with inverter control maintains the ac load voltage harmonics within limits. The simulation results show that the dc link voltage is maintained constant by the proper control of the PWM inverter. This system transfers all the power generated to the local ac loads and the grid when either one or both of the sources are available. The MI Ćuk converter was able to track the maximum power for each of the sources individually. The input current control method for MPPT of wind turbine and incremental conductance method for PV has been discussed.

C.S. SUPRIYA, M. SIDDARTHAN [35] have introduced to evaluate the optimal design of a hybrid wind-solar power system for either autonomous or grid-linked applications. The proposed analysis employs quadratic programming techniques to minimize the cost while meeting the load requirements reliably. Using this procedure, an optimum number of PV modules and wind turbines subject to minimum cost can be obtained with good accuracy. Notwithstanding, before the development of a renewable station, it is important to decide the ideal number of PV panels and wind turbines for insignificant expense during the coherence of created energy to meet the ideal utilization. For both solar and wind energy, the major aspects in the design of the HPWS are the reliable power supply of the consumer under varying atmospheric conditions and the cost of the kWh of energy. To conclude, the grid-connected wind systems happen to be the best configuration in both cases considering the cost. But if we can spend a little more, considering PV panels also is not a bad option, in a way that it further decreases the amount of power drawn from the grid and hence the carbon emission and global warming. This project proves that using renewable sources is far better than the conventional grid systems, especially in remote areas where the per unit cost of utility is itself very high. The proposed system reduces both the cost and the amount of CO2 emitted from the entire setup.

Kenneth E. Okedu, Roland Uhunmwangho[36] has researched the energy efficiency of renewable power systems with a segregated AC diesel generator. A model framework comprising a PV, three batteries, and a converter system was thought of. Further analysis was carried out considering two cases with two different load profiles to show that the load profiles affect the responses of the renewable energy system and the cash flow summary of some of the system equipment. In this part, a wind turbine is coordinated into the PV, battery, converter, and AC diesel generator system. Also, to get an accurate comparison, the model system was considered and its parameters were kept constant. The results display that the higher the load profile, the higher the cash flow summary, with increased capital, fuel consumption, operating, and replacement cost and a higher salvage value of the project. However, the load profiles do not affect the converter system. A model system consisting of a wind turbine, PV system, diesel ac generator, battery, and converter system was investigated using different load profiles. The cash flow summary results demonstrate that an increased load profile leads to more capital, operating, replacement, increase fuel, and salvage value of the project for the wind turbine, PV, diesel, and battery systems. Along with the converter, the system was found to be independent of the load profiles.

Mirzohid R. Koriyev, Abdujamil A. Abdujabborov[37] have investigated the need to use alternative energy sources, which are environmentally friendly natural energy resources. The consequences of the concentrate on the potential of alternative energy assets of Uzbekistan, the conceivable outcomes of their viable use, and the large-scale changes completed in such a manner are also presented.

There are The target indicators of the program of measures for the further development of renewable energy presented in this decision. According to it, in the structure of energy production facilities in our country, it is planned to increase the share of energy production facilities generated by renewable energy sources by 19.7% by 2025. Of this, it is laid out that 15.8 percent compares to hydropower, 2.3 percent to sun-based energy, and 1.6 percent to wind power. To achieve this goal, the implementation of large investment projects for the development of renewable energy is planned.

The above proofs are a prime example of this. A very large part of these resources has not yet been used, and in recent years the first serious steps have been taken to effectively use existing capacities.

Alternative energy sources play an important role in saving primary hydrocarbon resources (oil, gas, coal, etc.), and ensure the energy security of the country.

Thus, the possibilities of reducing the anthropogenic impact on the environment will be expanded due to the broad involvement of environmentally friendly, renewable energy sources in the energy balance. This makes it possible to save hydrocarbon resources not for the production of electricity, but for use as raw materials in the petrochemical industry.

Pavel Atănăsoae, Radu Dumitru Pentiuc, Dan Laurențiu Milici, Elena Daniela Olariu, Mihaela Poienar[38] have investigated the electricity production from renewable energy sources in power stations with over 1 MW capacity supported by the mechanism of mandatory quotas combined with the transaction of green certificates in Romania. Romania has adopted the mechanism of mandatory quotas combined with the transaction of green certificates since 2008 for electricity production from renewable energy sources in power stations with over 1 MW capacity. A support scheme for small-scale renewable energy sources will allow the guaranteed connection of residential prosumers to the grid (priority/guaranteed grid access) and the obligation for network operators to feed energy produced by renewable generation units into the grid (priority dispatch). In this paper, He has estimated that under the current conditions of Romania, the renewable energy sources of low on-grid power can be profitable at a specific investment of less than 2300 Euro/kWh. The profitability also depends on the share of electricity from renewable sources used for self-consumption. A higher share of electricity delivered to the public network creates problems for the network operator in terms of balancing, especially when there are more local producers of renewable sources.

Tushar Shetty, Chirag Shetty, Ishaan Shah[39] have investigated the most of India's energy demands are fulfilled by fossil fuels like coal, petroleum, natural gas, etc. Because of such popularity of petroleum derivatives, these non-renewable energy sources will before long get exhausted. In the following couple of many years, petroleum products will become more difficult to find bringing about an energy lack because of an increase in energy costs and energy security. Increased use of fossil fuels also degrades the environment by releasing greenhouse gases. he government has announced that between the period 2017-2022 no new coal-based capacity addition is required beyond the 50 GWs under different stages of construction likely to come online between 2017 and
2022. There is an urgent need for the transition from fossil fuel energy systems to renewable resource energy systems to decrease reliance on depleting reserves of fossil fuels and mitigate global climate change. Lastly, valuable lessons have been learned by grid managers in coping with increasing variability in power demand-supply.

Siti Indati Mustapa1, Leong Yow Peng, and Amir Hisham Hashim [40] have examined Malaysia the potential of RE as a choice to guarantee the maintainability of energy assets. In this way, the green innovation strategy was sent off to advance the use of low-carbon energy and innovation of which RE has been distinguished as the promising environmentally friendly power energy choice. This paper will thoroughly search in detail the hindrances to

RE proliferation, wide strategies, and activity plans which will be a catalyst for RE production in Malaysia. This paper aims to identify the key barriers to RE development in Malaysia and explore the broad strategies and action plans implemented by the government which will be the catalyst for RE penetration in power generation. In addition, the paper will also highlight the impact of strategic improvements that have been made by the government so far. Over the past 10 years, Malaysia has instituted various efforts and initiatives to promote renewable energy. The progress on RE generation has been slow but over time the growth rate of RE in Malaysia has shown an upward trend as more energy users took advantage of the incentives provided by the government.

Vipin Kumar, Sandip Ghosh, N.K. Swami Naidu, Shyam Kamal, R.K. Saket, S.K. Nagar [41] have explored a load voltage-based (LVB) maximum power point following (MPPT) procedure utilizing adaptive step-size (ASS) for independent photovoltaic frameworks. The method further develops the intermingling rate of the MPPT utilizing a unique voltage sensor to quantify the load voltage (VL) no matter what the idea of burden type. This ASS-based control technique develops the intermingling execution over a fixed step-size plot under differing insolation conditions. A converter is utilized for connecting the PV system with the resistive load, which builds the working scope of the PV framework. A result voltage-based MPPT procedure is proposed for an independent PV framework with a SEPIC converter. The proposed MPPT method is enabled with versatile step-size for quicker following reaction as contrasted and fixed step-size strategies. The proposed procedure is displayed to perform better in following reactions and in this way yield better general effectiveness of the framework.

John Vourdoubas [42] have investigated that Crete has rich indigenous renewable energy resources which are currently utilized for covering part of its energy requirements. The total installed electric power of renewable energies in Crete, located mostly in rural areas, is approximately 30% of the total electric power installed. They currently generate more than 20% of the island’s annual electricity needs.

This will result in Crete’s transformation to a low or zero carbon economy following EU targets for zero carbon emissions in the next decades complying with the global goal for climate change mitigation.

The fact that the electric grid in Crete is autonomous restricts the installation of more solar and wind electricity generation systems. Future uses of different RE technologies in rural areas in Crete are predicted including the use of solar thermal energy for electricity generation and space cooling, the use of biomass for the generation of electricity and bio-fuels, the use of water dams for electricity generation as well as the production of hydrogen with water electrolysis using solar and wind electricity. Further research should be focused on the investigation of the possibility of zeroing carbon emissions due to energy use on the island of Crete complying with the EU target for zero carbon emissions by 2050 and the global efforts for mitigation of climate change.

Garba Danjumma Sani, Suleiman Sahabi, Abubakar Ibrahim, Bashar Badamasi Lailaba[43] have investigated renewable energy sources, their economic benefits for sustainable development, environmental impact including global warming, advantages and disadvantages, and strategies for optimum exploitation for sustainable development are highlighted. he risks that result from using fossil fuels increasingly (petroleum, coal, and gas) must be decreased. To decrease such risks and maximize energy production, energy resources that emit less harmful gas in the atmosphere (like Carbon-dioxide (CO2) must be preferred in addition to renewable energy. The negative effects of renewable energy resources on the environment are lesser than those of conventional energy resources. Most renewable energy sources are harmless to living things with the ability to produce a lot of energy. Although, some renewable energy plants are expensive but harnessing them can be a very big step in protecting the resources in the world and reducing greenhouse gases that affect the environment greatly. Sustainable energy systems are necessary to save natural resources avoiding environmental impacts which would compromise the development of future generations.

Dr. B. Madhusudhan and G. Damodhar[44] have investigated a collection of energy technologies i.e. solar, wind, and geothermal derived from sources that are never-ending and can be replenished time after time. Renewable energy is one of the environmentally friendly sources of energy and effectiveness in the growth and economic development of the country. Developing economies have set ambitious Renewable Energy capacity addition targets to reduce energy exportation on an estimate of their growing and developing economy. It was estimated that the emissions of greenhouse gas can be reduced from 4% to 45% in the upcoming years of 2020. These include up to 14% replacing coal with renewable energy.

Dominika Čeryová, Tatiana Bullová, Izabela Adamičková , Natália Turčeková , Peter Bielik[45] have investigated to determine whether the selected countries of the world produced renewable energy efficiently or not. The monitored countries were divided into 10 groups according to the different ranges of estimated output-oriented technical efficiency from 0.00 to 1.00. Most nations ought to build the sustainable power age roughly by 40-49%, given the level of inputs (16 countries of the 6th group with estimated output-oriented technical efficiency 0.51-0.60) for the year 2017. To achieve the main objective, the Stochastic Frontier Analysis (SFA) model is used to monitor not only the direct dependence between inputs and outputs but also the efficiency of input-to-output transformation → output-oriented technical efficiency, which also helps in assessing the competitiveness of the countries. The biggest group was the 6th group with an estimated output-oriented technical efficiency of 0.51-0.60. In this group, 16 out of 89 countries in the world were identified. Therefore, given the level of inputs, most countries should increase the production of renewable energy by approximately 40-49%. However, it is important to note that the results might be improved if one could employ the data on private investments as well.

Saurav Datta, Pragyashree Dubey[46] have investigated the, best practices in sustainable energy has been defined. Keeping in view the Indian context, the comparison scale has been analyzed with a few developing countries. These analyses are based on secondary data research. A comparison of policies has also been covered under this subject.

Many forms of sustainable energy sources can be incorporated by countries to stop the use of fossil fuels. Sustainable energy incorporates no sources that are gotten from petroleum derivatives or byproducts. This energy is replenishable and assists us with diminishing ozone depleting substance outflows and makes no harm the climate. In the event that we will utilize petroleum products at a consistent rate, they will lapse soon and make adverse impacts our planet.. The best practices in sustainable energy will come across a fruitful stage when government along with all private stakeholders will put up the initiative to promote green and renewable energy for better sustainability, and economic generation and provide better livelihood to the community.

2.3 Gap of Knowledge:

It is observed in most of the paper discussed economic aspects, environmental aspects, and technical aspects but we don't see any clear-cut plan to outsource the major load handling problem by introducing proper methodology. In this modern world, all we need is a clean reliable source of energy. In this research work, we have addressed major problems in the tourism industry to manage the Air condition load by renewable sources of energy introducing solar and wind energy. Here in this research, we have addressed how such heavy loads (Air conditioning) impacting on overall building energy. In this research, it can be seen load diversion introducing renewable sources in a 3star hotel in Digha, west-Bengal India.

From that one big such hotel data, it can be accessed any no of big area's load that we want to divert by a renewable source. Here in this research, you can see two sources of how it is managing such a big no of AC load throughout the whole day on an hourly basis over the one year contributing to Grid.

After reading all the previous papers we have analyzed no such papers are not addressing such big issues. In one such previous paper, it was seen to analyze the overall load optimization in a village containing 1000 household loads introducing off-grid renewable sources (solar and wind) but they discussed some remote areas where Grid connection had not been introduced. This was the location of a village in Digha, west Bengal India. But in that work, it was seen OFF Grid to remote areas. There was no such further future planning while connecting to Grid. Even many papers have not even discussed this issue in this hot climatic condition. Due to Global warming average temperature of the month has increased. It is very obvious to use AC (air conditioner) due to heavy hot weather nowadays. The usage will be enhanced in the upcoming decades. This may along with dragging a huge portion of energy in the whole consumption.

In this research, one can easily see future load assessment techniques, Green technology assessment, a new scope of industrial growth in this sector, and Eco-friendly solutions.

2.4 Problem and Solution:

This techno-economic and social investigation is being done based on real-time data analysis of a Big 3-star Hotel containing 45 rooms. The design parameter and load assessment are being analyzed by Homer Pro software. Then the further design of the Whole Grid Interactive system with the MPPT technique is optimized by MATLAB SIMULINK SOFTWARE. To obtain the best solution here is analyzed several combination sources in simulation to get the best cost-effective solution overall. Here Grid, Solar, and Wind have been taken out of which best combination found Grid with Solar combination over sets of solutions.

It is being found Solar is a major contributor to energy sources among all combinations. After reviewing this paper here we have come to know to optimize load in Homer is the best. It depicts the robustness of the software and a clear tool set and more accurate optimization to create effective software.

2.5 Conclusion:

It is evident from the above chapter introduction of HRES to different energy needs is the key intention. To assess this process efficiently we need some reliable software to test the data accurately. Here comes some reliable option like HOMER SOFTWARE and MATLAB. Depending upon the test result it can be concluded the success of this research. In the next chapter “The recent development in renewable energy system” has been discussed.

CHAPTER-3

3. RECENT DEVELOPMENT IN THE RENEWABLE ENERGY SYSTEM

3.1 Introduction:

In this modern era, it is very essential to have as many as many renewable sources that are possible to induct into our energy system. It is needed to mitigate the huge demand for electricity requirement. As in our country, the growth of population is increasing, it is very much required to fulfill all energy requirements of every individual. That is why, we need additional energy sources that support the clean environment agenda. To improve such power quality and efficiency of the system, it is required proper research and development in this sector. We have discussed some modern technology that is currently in use and some future technology in this chapter.

3.2 Modern Solar Cell and Technology:

The photovoltaic impact, the cycle by which the sun's beams are changed over into electrical flow, was found as far as possible back in 1839 by French physicist Edmond Becquerel, yet it was only after the 1950s that the main current silicon-based sun-powered cells were shown at Bell Labs. From that point forward, the competition to make sun-based energy more productive and more affordable has been in progress and progress has been emotional. In the decade alone, the expense per kilowatt of sun-based energy has tumbled from almost $2 to around 34 pennies.

New developments vow to make sunlight-based chargers that are less expensive, all the more impressive, and less inefficient toward the finish of their valuable life. Arising innovations incorporate pyramidal focal points, created by specialists at Stanford College, which vow to focus on how much light hits a sun-powered cell — getting a similar measure of light to hit a region 33% of the size — a cutting edge that could make sun powered chargers more effective in backhanded light circumstances.

A few researchers are in any event, scrutinizing the basic material of sun-powered chargers silicon and trying different things with natural photovoltaic and perovskite sun-oriented cells, which supplant silicon with additional generally accessible mixtures for less expensive assembling, as well as quantum sun-based cells, which are made of minuscule semiconductor particles and can all the more productively collect the sun's energy.

A lighter, more adaptable method for gathering the sun's energy could be applied to additional structures in additional spots. Planners are as of now adjusting rooftops, siding, and even windows for energy generation. San Jose, California's GAF Energy has fostered a solar roofing system framework that is installed like ordinary black-top shingles, while Omnipresent Energy, situated in neighboring Redwood City, has fostered a straightforward board that harvests light from the imperceptible range and can be utilized on windows and different surfaces

However, the speed of developments in solar may be too fast, meaning the present sun-powered cells might be old tomorrow. Where some see a brewing e-waste problem, others see an opportunity. It has developed technology to recover valuable ingredients like silver and silicon from panels' complex lamination, intending to use materials from the last generation to build the next.[47]

India's sun-oriented power limit has reached 64,380.68 MW as of February 2023, as indicated by information from the Service of New and Sustainable Power (MNRE). The nation's wind power limit has likewise crossed the 42,015.38 MW mark, showing critical advancement in the reception of sustainable power sources.

The MNRE report also highlights that the total installed renewable energy capacity in India has now surpassed the 122 GW mark. Of this, sun-oriented power represents the biggest offer, trailed by wind power and bio-power. As far as states, the report shows that Rajasthan drives the nation altogether sustainable power limit, trailed by Gujarat, Tamil Nadu, and Karnataka.

India has set an aggressive objective of accomplishing 175 GW of sustainable power limit by 2022, of which 100 GW is to be contributed by solar power. While there have been difficulties in gathering these objectives, the MNRE report recommends that huge headway has been made, and the nation is on target to accomplish its sustainable power objectives. It is described The monthly regional solar power generation is below in Table 3.1.[48]

Table:3.1 Monthly solar power generation, April 2022 – March 2023[49]

Month	Regional solar power generation (GWh)					Total (GWh)
	North	West	South	East	North East	
April 2022	3,208.06	1,632.07	3,376.37	92.37	15.04	8,323.92
May 2022	3,558.22	1,744.64	3,402.17	99.98	22.55	8,827.56
June 2022	3,447.78	1,538.53	3,177.10	78.58	17.92	8,259.91
July 2022	3,000.77	1,178.11	2,699.70	74.34	12.98	6,965.89
August 2022	3,136.11	1,216.88	2,972.50	75.70	27.07	7,428.25
September 2022	3,662.69	1,390.23	3,052.64	76.37	25.79	8,207.73
October 2022	3,835.41	1,657.49	3,123.65	88.36	21.92	8,726.83
November 2022	3,389.91	1,577.53	2,898.03	89.57	21.85	7,976.88
December 2022	3,436.29	1,564.96	3,098.10	85.72	22.44	8,207.51
January 2023	3,539.94	1,831.84	3,806.66	87.91	23.66	9,290.01
February 2023	3,733.67	1,977.84	3,726.01	98.09	19.80	9,555.41
March 2023	4,172.76	1,930.04	4,018.53	97.45	25.5	10,244.34
Total (GWh)	**42,121.59**	**19,240.16**	**39,351.45**	**1,044.45**	**256.58**	**102,014.24**

Table:3.2 Solar power various category[49]

Application	31 January 2023
Ground mounted including floating and hybrid.	53,387.30
Rooftop	8,218.00
Off-grid	2,288.00
TOTAL	63,893.30

It installed a total rooftop system, Off Grid system, and a grounded mounted floating and hybrid system in India till 31 January 2023 in Table 3.2. That shows the enormous progress in this particular field.

3.3 Modern Wind Technology:

There are now a couple of exhibit projects all over the planet for drifting seaward wind turbines, however, the innovation is entering another stage, with additional legislatures defining objectives for establishments and bigger ventures entering the preparation and allowing stages. California could be a significant proving ground for innovation.

Drifting breeze turbines face designing, regulatory, and strategic difficulties; however, if they're sent at scale, the innovation could be a significant, reliable power source to seaside networks. “The ocean has more energy than we’ve ever needed, as long as we can capture it and use it,” Weinstein said at the event.

One of the major benefits of offshore wind is that it can provide more consistent power than other renewable energy sources, Weinstein said. Fluctuations in wind speed still happen, but overall the effect is less dramatic than it tends to be onshore. In general, the wind doesn’t fully drop off at night as solar power does. That consistency is key to building an electricity grid powered by renewable energy sources. Below table 3.3 describes the installed state-wise wind capacity in India on 23 April 2023. [50]

Table:3.3 Installed wind capacity by the state as of 30 April 2023 India[49]

State	Total Capacity (MW)
Total	**42,868.08**
Telangana	128.10
Tamil Nadu	10,073.52
Rajasthan	5,193.42
Others	4.30
Maharashtra	5,026.33
Madhya Pradesh	2,844.29
Kerala	62.50
Karnataka	5,294.95
Gujarat	10,144.02

3.4 Modern renewable systems:

There are two types of modern renewable systems available in India 1) OFF Grid systems and 2) Grid connected systems.

3.4.1 OFF Grid System:

The system which is capable to generate electricity in an isolated manner is called Off-Grid. In some areas, Grid connection is not reached even today by our National grid connection. Particularly those areas that are used to connect with their local generation such as Solar PV Wind turbines, Biogas generation plants, etc.

In far-off areas, stand-alone frameworks can be more financially savvy than stretching out an electrical cable to the grid. To understand the basic layout of the Off Grid System we have given in below fig: 3.1.

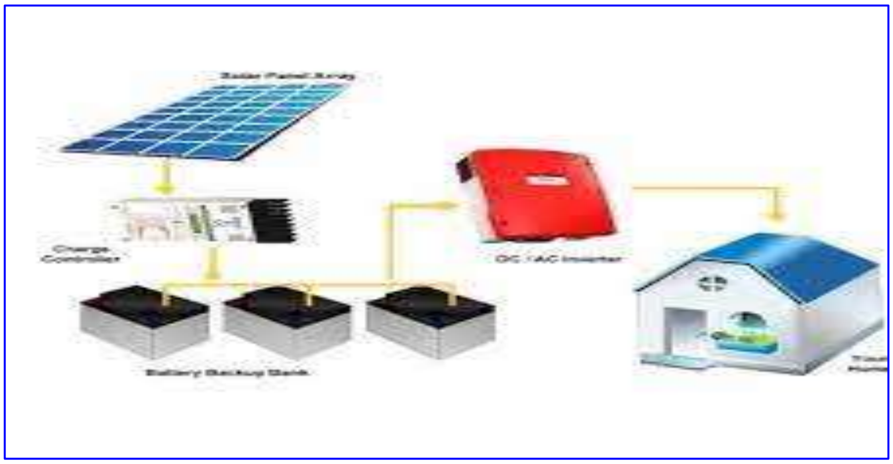

Fig3.1 Off-Grid system

The installations under the Off-grid Solar PV Applications program is as given below in Table: 3.4 on various application: [51]

Systems	No units/ capacity installed
Solar Lamps/Lanterns	65,17,180
Solar Pumps	2,37,120
Solar Street Lights	6,71,832
Solar Home Lighting Systems	17,15,639
Solar Power Plants/Packs	212 MWp

Table: 3.4 Off- Grid data on various applications in India

3.4.2 Grid Connected System:

A grid-connected framework permits you to control your home with environmentally friendly power during those periods when the sun is shining, the water is running, or the breeze is blowing. Any overabundance of power you produce is taken care of once more into the grid. At the point when sustainable assets are inaccessible, power from the grid supplies your necessities, eliminating the cost of power stockpiling gadgets like batteries. To understand the basic layout of a Grid-connected System we have given in below fig: 3.2.

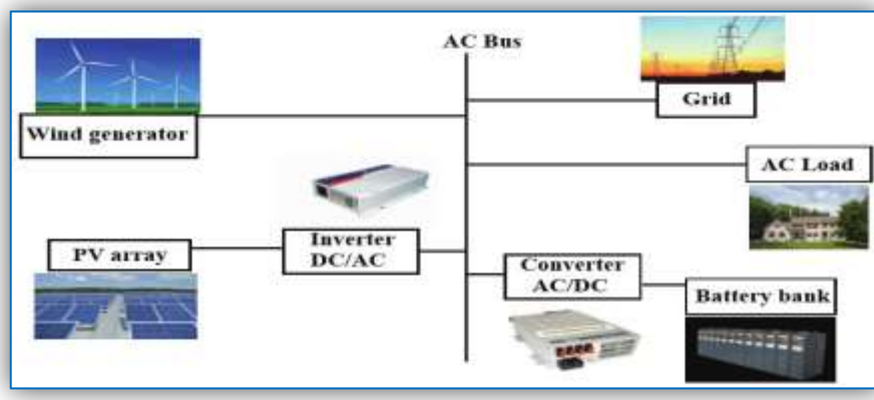

Fig: 3.2 Grid-connected system

There are various types of renewable sources are available, which are given by the flow chart in Fig: 3.3. Here is given a short view of various sources.

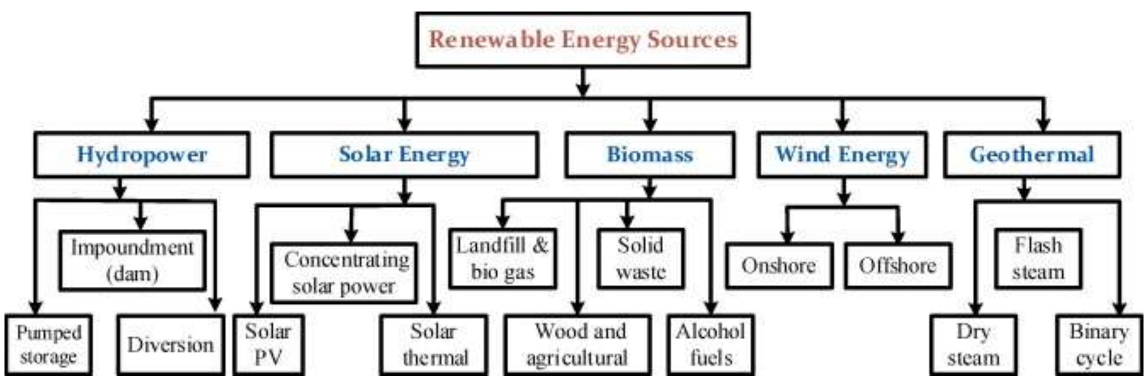

Fig: 3.3Various renewable energy sources

3.5 Conclusion:

Our main intention is to create a clean sustainable energy chain that meets our mutual interests such as zero carbon emission, high efficiency, less transportation loss, and an Eco-friendly solution. Clean energy secures our life and it is very important for the upcoming generation. This energy shift is very essential in every aspect of our society. It must be our prime goal to ensure energy security for our future growth. In the twenty-first century, it is very essential to monitor the environmental pollution level, the level of natural gas and coal that how many years does it able to give energy. Along with we need to replace the Renewable source of energy and the Hybrid energy model to minimize the need of requirement of fossil fuel. Then it will be needed a farm good cost-effective technology to recycle the solar panel and wind energy system equipment. Unfortunately, to date, we don't have any such reliable recycling model.

It is very much essential to improve good Battery technology to store the charge on a bigger scale with a minimum loss of charge. Although some private sector has already got success particularly in this sector.

But again it is very much essential to train our workers, technicians, and field man continuously because this would help maintenance, testing, installation, and repair work run smoothly at a very fast track way. This market is massive and enhancing in its speed that we need always large no of workers and skilled technicians in every sector.

Hence it is a huge chance for creating new employment, a new supply chain ecosystem, and a green clean society. To address its massiveness various MSMEs are coming in this sector. Also, the Govt Of India launches a PLI scheme to motivate small and medium enterprises in this sector. In the next chapter, Software has discussed briefly.

CHAPTER-4

4 OVERVIEW OF THE SOFTWARE TECHNIQUE USED IN THE PRESENT WORK:

In this thesis, we have used two software that is, Homer Software and Matlab Software. Let us see one by one to get an overview of the two software.

4.1 Introduction:

Hybrid Optimization Model for Electrical Renewable is a micro-power optimization model, that simplifies the task of evaluating designs of both off-grid and grid-connected power systems for a variety of applications. The HOMER Hybrid Optimization Modeling Software is used for designing and analyzing hybrid power systems, which contain a mix of conventional generators, co-generation, wind turbines, solar photovoltaic, hydropower, batteries, fuel cells, biomass, and other inputs. In this thesis, all analyses are done using this Homer Software. Matlab software is very useful software in the field of Electrical, Mechanical, Aeronautics, robotics field and many more. It is very useful because its large library and user-friendly coding option make it lethal software. That is why it is very popular software in the research work field. It depicts robustness, reliability, faster computation, accurate results, simulation, and coding option-making multi-combination software. [51]

4.2 Homer Overview:

National Renewable Energy Laboratory is created the HOMER software application in the United States. This product application is utilized to plan and assess actually and monetarily the choices for off-grid and on-grid power systems for remote, stand-alone and distributed generation applications. It permits you to consider countless innovation choices to represent energy asset accessibility and different factors. HOMER software was first introduced in 1993 for limited operational use to figure out the split the differences between various energy plans. A few years after the original design NREL made a version publicly available for free to serve the growing community of system designers interested in Renewable Energy. In this chapter Homer software has been discussed in detail. From that point forward HOMER has stayed a free programming application that has developed into an extremely hearty software for demonstrating both ordinary and sustainable power innovations. A basic Homer software model has been shown in Fig: 4.1. [52]

Fig: 4.1HomerSoftware

4.2.1 Steps for Using Homer Software:

- Downloading the Software
- Defining the Power System
- Defining the Site Load
- Specify Wind and Solar Resources
- Specify the market price of each piece of equipment
- Specify Economics
- Specify Equipment
- Calculate Results

4.3Matlab Software Overview:

MATLAB is a multi-mode user-friendly and numeric computing platform created by Math-Works. MATLAB permits matrix controls, plotting of capabilities and information, execution of calculations, implementation of algorithms, and communication with programs written in different languages. This is one of the renowned software in the field of engineering. This software allows simulation as well as coding freedom to the user which makes it perfectly user friendly. Fig: 4.2 is shown a basic Matlab 2021a software.

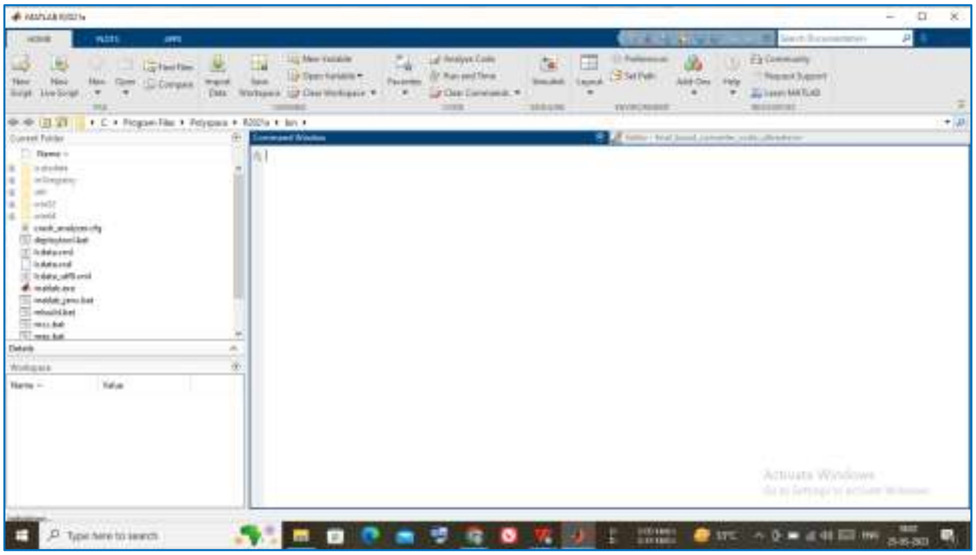

Fig: 4.2 MATLAB 2021a SOFTWARE

4.3.1 Steps for Using Matlab Software:

The below steps are essentially needed to start the software in the Matlab software.

Step 1: Download the software.

Step 2: Installation of the software.

Step 3: For circuit design open the Simulink option.

Step 4: Design your layout selecting the necessary blocks.

Step 5: For coding write on the Editor page.

Step 6: Select the necessary computing method to optimize the calculation.

Step 7: Study the Graphs and values.

4.3.2 Advantage and Dis-Advantage of Matlab:

Advantage:

- Easy to use.
- Platform Independence.
- Predetermined Function.
- Plotting.

Dis -advantage:

- Can be slow.
- Commercial software.

4.4 Conclusion:

Crossover Enhancement Model for Electrical Inexhaustible is a miniature power improvement model, that works on the errand of assessing plans of both off-network and matrix-associated power frameworks for various applications. The HOMER Cross breed Streamlining Demonstrating Programming is utilized for planning and breaking down half and half power frameworks, which contain a blend of regular generators, co-age, wind turbines, sun-oriented photovoltaic, hydropower, batteries, energy units, biomass, and different information sources.

It simulated two renewable sources Solar PV and wind power systems with Grid. The whole design parameter and data optimization are observed in this thesis. Here in this simulation, a 10 kW power-rated solar PV array with a 10 kW power-rated wind power system has been assembled.

In the simulation of our design out of various combinations of results, it is found that 10kW solar PV with Grid is the best. A total of 87.2% renewable penetration have been seen and the remaining 12.8% is taken from Grid.

In this modern era, it is very obvious to introduce a modern testing facility after satisfying the result we can go with the initial prototype model of any system. So Matlab is one of the premium software that gives you the freedom to simulate the model and test the software-related data very effectively. This work freedom motivates engineers and technical people in their respective domains.

Matlab library has a vast database and tools that create lots of options very simple in function. It is accurate data interpretation and result analysis and plotting display feature makes it premium software.

Initially, Matlab was used for Matrix calculation only, later on, it expanded its domain to feature lots of simulation options and tools.

Also In this research work, we have used its various features and were quite surprised about its block-to-block data interpretation skill. It is found to simulate and design HRES best on its own. After analyzing the load assessment by Homer software the whole design is done in the Matlab Simulink Software. All the results and plotting came rightly. The next chapter will be discussed Methodology.

CHAPTER-5

5 METHODOLOGY

5.1 Introduction:

The first phase it is started with the collection of data for a real-time feasibility study for the research and then SOLAR GHI data collection from the National Renewable Energy Laboratory. Initially, the site inspection is done for which type of load they are using. The energy chart is being created for each load in an hourly order division, it is calculated for 45 deluxe rooms. The hotel chosen for prime calculation is the 3-star Hotel "Le Roi Digha". All the rooms have single 1.5-ton Ac is there. According to the most possible way of the usage of the room, the operational hour is being calculated. The final load profile for the Ac load and the remaining load for each room is prepared.

Next, it is proposed to have source selection based on market availability for Solar Photovoltaic panels and Horizontal axis wind turbines. Here it is selected 10 KW Canadian Solar Max Power CS6U-330P panels and 12 KW Generic wind turbines. It is calculated as the result in Homer software. Now we have the Ac load (load 1) and the remaining load (load 2).

It is being created and designed in Matlab Simulink Software to optimize the necessary plot and data. This whole project is being performed inhomogeneously.

5.2 Techno-Economic and Social Analysis:

In the second phase, it is optimized and Simulated the design model in Matlab Software. To get the essential data and graphs related to the research have been evaluated. After all this real-time data assessment we can come to a particular conclusion.

5.3 Flow Chart To Determine The Optimal Design FOR Homer Software:

In the below fig: 5.1 show the basic flow chart of homer optimization in the following work.

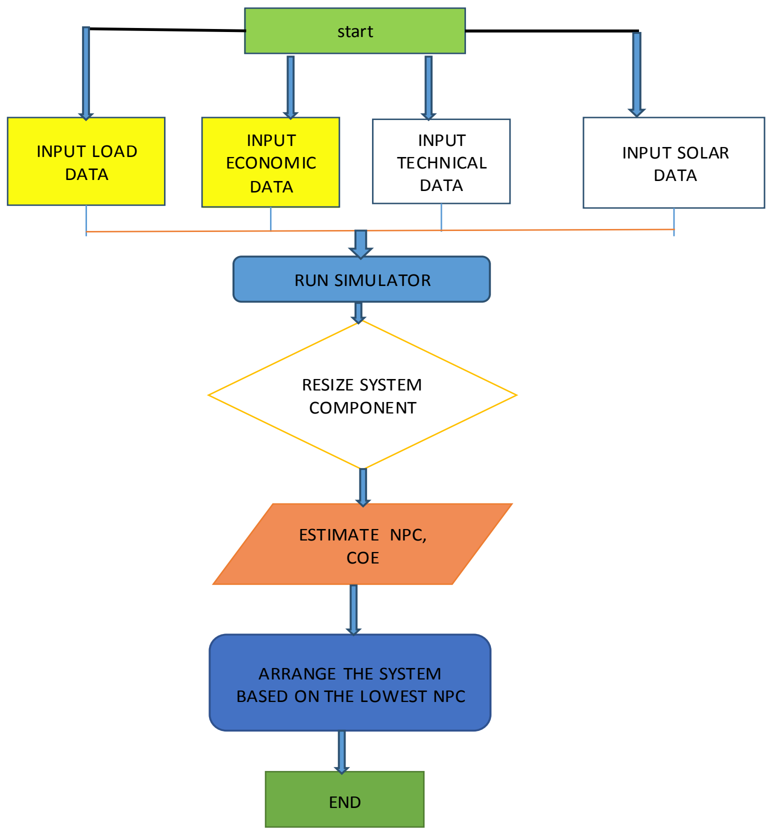

Fig5.1 Flow chart to determine the optimal system

5.4 Execution of the Proposed HRES System

5.4.1Meteoro Logical & Social Profile of the Selected Site:

The site is chosen for HRES in the Hotel “Le ROI Digha” near Digha Railway station, West Bengal India. The site's exact position is at 21.62^{o}N, 87.509^{o}E.

5.4.2 Load Estimation In The Selected Site:

●In this Hotel, there are 45 deluxe rooms. Other rooms are two non-Ac staff rooms and one kitchen.

●The total area of the building is 4178.36m^2 (44975.46ft^2**).**

●In each room there is a single 1.5-ton Ac load and One Ceiling Fan, One Led Tube light, Three Led lamps including the washroom, and one Television.

●Here in this research, we are only calculating 45 deluxe Ac rooms that are the main objective area to replace its AC load source by proposed Renewable energy source.

●In this calculation, we have also taken an extra 100-watt load for other personal equipment to power such as a laptop, speaker, charger (power bank), phone charger, etc for each room.

●Here it is considered two types of load (Load 1 AC load for 45 rooms, Load 2 others load for 45 rooms).

●According to my research, a 1.5-ton 5-star split inverter air conditioner typically consumes between 1.5 to 1.75 kilowatts per hour when operating at a temperature setting of 20 degrees Celsius. However, the exact energy consumption can vary depending on factors such as the model of the AC, the efficiency of the unit, and the ambient temperature and humidity. Additionally, the energy consumption may lower when the unit is operating in an energy-saving mode.

5.4.2.1 Summertime Ac Load Calculation For 45 Rooms Through The Day: LOAD 1

The below table: 5.1 describe the energy consumption of the 45 rooms/day in the Summertime, when the load is Air conditioner. Table: 5.1 Load Estimation in Summer load1

Types of load	Quantity	Operational time	The period in a whole day (hr)	Power consumed (kW)	Energy consumed by single room/day (kWh)	Energy consumed by **45** rooms /day (kWh)	Average load/day (kW)
AC load(1.5ton)	1	10-10:30 11-11:30 12-12:30 1-1:30 2-2:30 3-3:30 4-4:30 5-5:30 6-6:30 8-8:30 9-9:30 10-10:30 11-11:30 12-12:30 1-1:30 2-2:30 3-3:30	8.5	1.75	14.875	669.3	27.33

Table: 5.2 shows the hourly basis load variation in Load 1 throughout the year.

Table: 5.2 load1variation on an hourly basis.

Hour	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	50	50	50	50	50	50	50	50	50	0
1	0	0	45	45	45	45	45	45	45	45	45	0
2	0	0	38	38	38	38	38	38	38	38	38	0
3	0	0	5	5	5	5	5	5	5	5	5	0
4	0	0	2	2	2	2	2	2	2	2	2	0
5	0	0	2	2	2	2	2	2	2	2	2	0
6	0	0	6	6	6	6	6	6	6	6	6	0
7	0	0	30	30	30	30	30	30	30	30	30	0
8	0	0	32	32	32	32	32	32	32	32	32	0
9	0	0	37	37	37	37	37	37	37	37	37	0
10	0	0	28	28	28	28	28	28	28	28	28	0
11	0	0	25	25	25	25	25	25	25	25	25	0
12	0	0	22	25	24	24	23	23	24	25	22	0
13	0	0	38	38	38	38	38	38	38	38	38	0
14	0	0	33	33	33	33	33	33	33	33	33	0
15	0	0	32	34	32	32	32	32	32	32	32	0
16	0	0	45	45	45	45	45	45	45	45	45	0
17	0	0	33	33	33	33	33	33	33	33	33	0
18	0	0	32	32	32	32	32	32	32	32	32	0
19	0	0	28	28	28	28	28	28	28	28	28	0
20	0	0	25	25	25	25	25	25	25	25	25	0
21	0	0	24	24	24	24	24	24	24	24	24	0
22	0	0	22	22	22	22	22	22	22	22	22	0
23	0	0	20	20	20	20	20	20	20	20	20	0
	0	0	654	659	656	656	655	655	656	657	654	0
Average load		0	27.25	27.4	27.3	27.33	27.29	27.2	27.3	27.	27.2	0

Table: 5.3 shows the hourly basis load variation in Load 2 throughout the year

Table: 5.3 load2 variations on an hourly basis

Hour	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	3.5	3.5	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	3.5
1	3.6	3.6	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	5.3	3.6
2	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
3	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
4	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
5	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
6	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
7	2.6	2.6	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.9	2.6
8	2.8	2.8	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	5	2.8
9	2.9	2.9	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.5	2.9
10	3	3	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.8	3
11	3.1	3.1	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.4	6.2	3.1
12	5.1	5.1	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.5	5.1
13	5.9	5.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	5.9
14	6.1	6.1	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.6	6.1
15	6.4	6.4	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.9	6.4
16	4.1	4.1	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	6.7	4.1
17	3.7	3.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	3.7
18	3.6	3.6	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.6	3.6
19	3.3	3.3	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	3.9	3.3
20	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
21	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
22	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05
23	2	2	2	2	2	2	2	2	2	2	2	2
	71.36	71.36	98.16	98.16	98.16	98.16	98.16	98.16	98.16	98.16	98.36	71.36
average load	2.97	2.97	4.09	4.09	4.09	4.09	4.09	4.09	4.09	4.09	4.09	2.97

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- In wintertime, there is no need for an Ac load considering three months (December, January, February) that time generally active fan load.

5.4.2.2Other Load During Summer Energy Consumption: LOAD2

The below table: 5.4describes the energy consumption by the 45 rooms/day in the summertime when the load is other.

Table: 5.4 Load Estimation in the Summer of load2.

Types of load	Quantity	The time in a whole day (hr)	Power consumed (watt)	Energy consumed by single room/day (KWh)	Energy consumed by **45** rooms /day (KWh)	Average Load/day (kW)
LIGHT(LED Tube light)	1	10	20	0.2	9.0	
LIGHT(LED)	3	12	12	0.432	19.44	
CEILING FAN	1	15	56	0.84	37.8	
TELEVISION(smart TV 32”)	1	10	41	0.41	18.45	
others(speaker, charger etc)		2	150	0.30	13.5	
Total				2.182	98.19	4.09

5.4.2.3 Other Loads during Winter Energy Consumption: LOAD2

The below table: 5.5 describe the energy consumption by the 45 rooms/day in the summertime when the load is other.

Table: 5.5 Load estimation in the winter season of load2.

Types of load	Quantity	The period in a whole day (hr)	Power consumed (watt)	Energy consumed by single room/day (KWh)	Energy consumed by **45** rooms /day (KWh)	Average Load/day (kW)
LIGHT(LED Tube light)	1	10	20	0.2	9.0	
LIGHT(LED)	3	12	12	0.432	19.44	
CEILING FAN	1	4	56	0.224	10.08	
TELEVISION(smart TV 32")	1	10	41	0.41	18.45	
others(speaker,charger etc)		2	150	0.30	13.5	
Total				1.566	70.47	2.97

- This work analyses the performance of a Solar Photovoltaic-wind renewable energy system for the Hotel of 494.07kWh/day with 50.0kWpeak in Grid connected system for an AC load of a total of 45 rooms is shown in Fig: 5.2

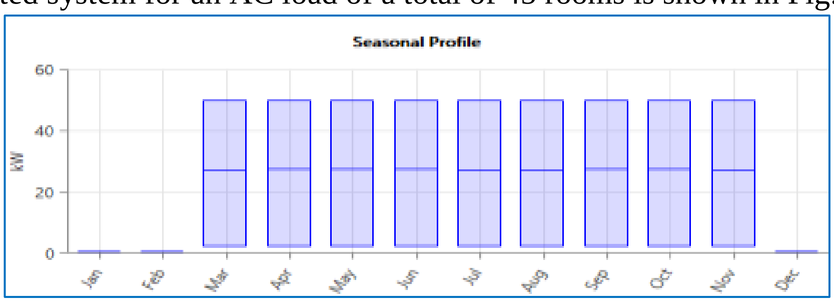


Fig: 5.2 Total Electrical Load served monthly Average for AC Load

- It is estimated of the solar photovoltaic and wind renewable energy system for the hotel of 91.57kWh/day with a 7.9kW peak in the Grid connected system for Load2 of a total of 45 rooms as shown in Fig: 5.3.

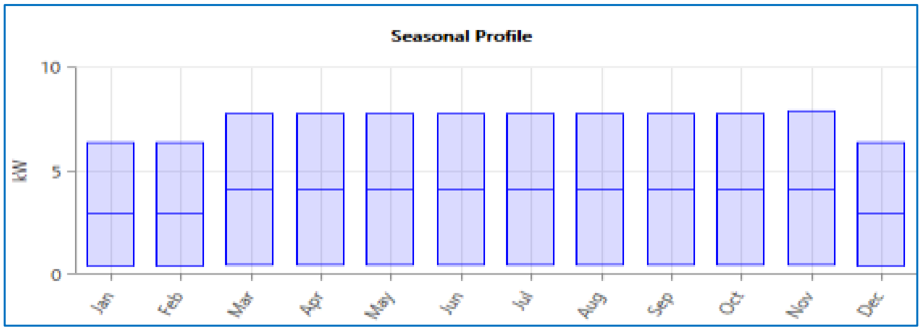


Fig: 5.3Total Electrical Load served monthly Average for load2

5.5 Renewable Resources At The Selected Site

5.5.1 Solar Energy Resources:

The monthly average Solar Global Horizontal irradiance data of the selected site is given in below Fig: 5.4.

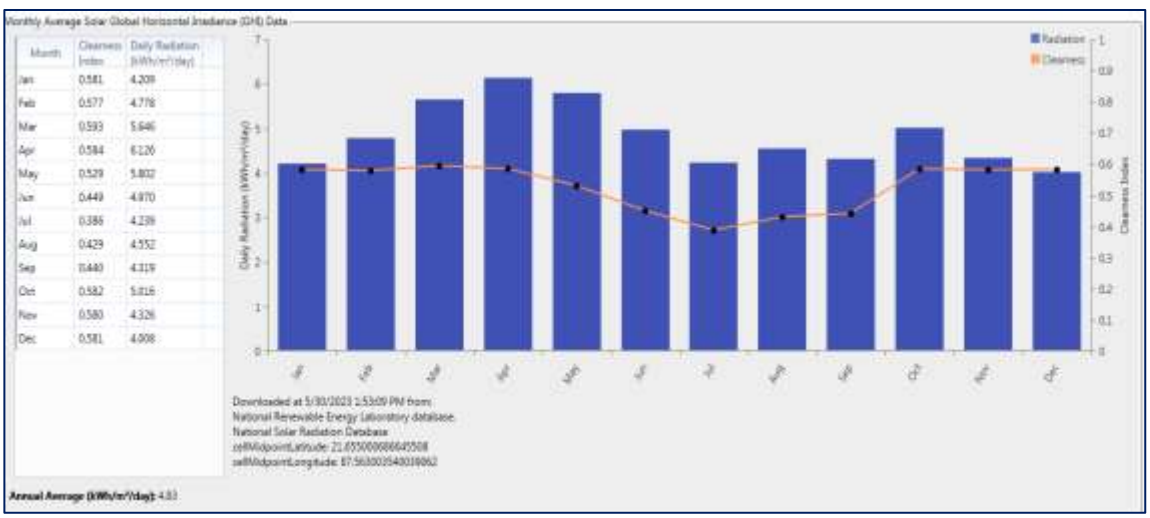


Fig: 5.4 GHI data for the selected site

5.6 Specification and Modeling of HRES Components:

5.6.1 Solar array

In this research, the solar modules have been used in combination with wind turbines, and the whole arrangement is configured with Grid, to meet the load requirement throughout the year. The PV modules (Canadian Solar Max-Power CS6U-330P) are of polycrystalline silicon types with a maximum rated power of 10kW with a lifetime of 25 years. The capital cost of the 10kW capacity of the solar PV module is considered 7251.32 $ and the de-rating factor is 88 %. Eq.(1)calculates the power generated by photovoltaic arrays[42-43].

$$P_{PV} = \frac{P_{STC} f_d G}{G_{STC}[1+KT(T_C - T_{STC})]} \quad (1)$$

Where P_{PV} is the actual PV output power at site conditions, P_{STC}, G_{STC}, and T_{STC} are the power output, solar irradiance, and temperature of the PV module under Standard Test Conditions (STC), T_C is the temperature of the PV module under climatic conditions of the site, KT is the temperature coefficient of the material of the PV module, and fd is the de-rating factor of the PV module. The specification of the Solar PV array's costing is given in Fig: 5.5

Fig: 5.5 Specification Of the solar array

5.6.2 Wind Energy:

The wind turbine (Generic 10 kW)is connected nearby location with a maximum rated power of 10kW with a lifetime of 20 years. The capital cost of 10kW capacity of the wind turbine is considered 8568.65 $ with operational and maintenance costs 2570.79$ per year. The specification of the Wind turbine costing is given in Fig: 5.6.

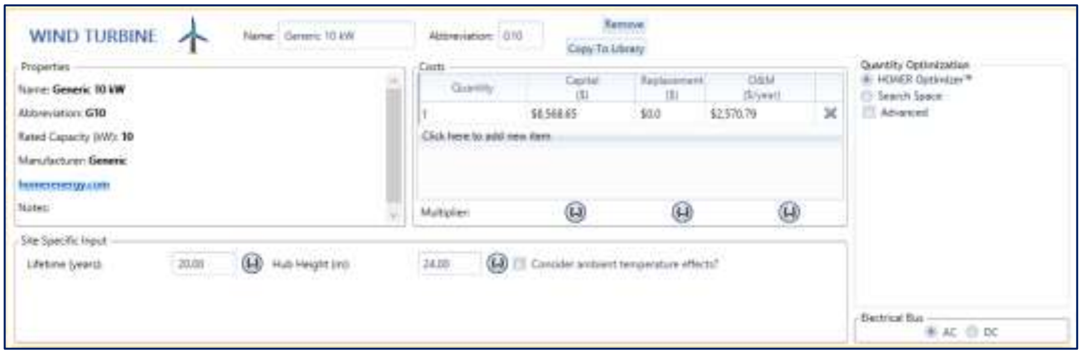


Fig: 5.6 Specification Of wind turbine

5.6.3 Grid-Connected System:

A grid-connected system allows you to power your home or small business with renewable energy during those periods (daily as well as seasonally) when the sun is shining, the water is running, or the wind is blowing. Any excess electricity you produce is fed back into the grid. When renewable resources are unavailable, electricity from the grid supplies your needs, eliminating the expense of electricity storage devices like batteries. Figure: 5.7 is given a Grid specification that is used in Homer software.

Fig: 5.7 Specification Of Grid

5.6.4 Converter System:

Considering the converter efficiency of 97%, its initial capital cost is estimated at 846.07$. Specification of the converter is shown below in fig5.8.

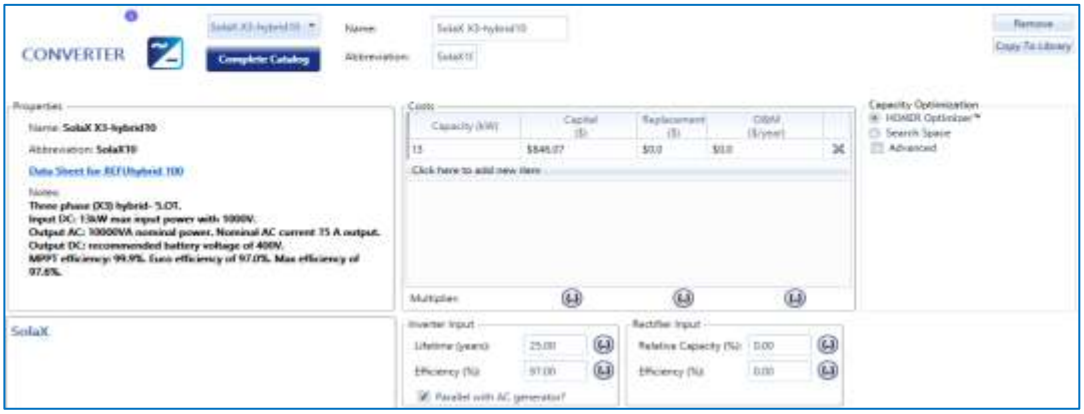


Fig: 5.8 Specification of Converter

5.7 Techno-Economic Analysis of The Proposed HRES System:

The optimal sizing of the HRES system is performed according to the design or sizing parameters used in HOMER. The primary design parameters are Capital Cost, Replacement Cost, Operation and Maintenance Cost, and the Life span of each component used in HRES.

5.7.1 Criteria of Evaluation

The optimization process of various HRES arrangements is performed by the different parameters from different domains, as discussed below.

- Net Present Cost
- Cost of Energy.

5.7.1.1 Net Present Cost:

The net present cost (NPC) is an essential parameter for the economic analysis of a system. It is the summation of the initial cost (IC) of the system, replacement cost (RC) of each component, and OMC of the entire lifetime as shown by equation (1).

$$\textbf{Net Present Cost} = \frac{\text{TOTAL Annual Cost(\$/year)}}{\textbf{Capital}\text{ Recovery Factor}} \quad \textbf{(1)}$$

Here, t is the lifetime of the project, I_y is the annual real interest rate (%) that is calculated in terms of an annual inflation rate (f) and nominal interest rate (I_n) by the equation(2)

$$I_y = \frac{I_n - f}{1+f} \quad \textbf{(2)}$$

The capital recovery factor is defined as the element used for calculating the present value of annual cash flows in the number of years(k) and real interest rate (I_y) as shown by equation(3)

$$Capital\ Recovery\ Factor(Iy,t) = \frac{I_y(1+I_y)^k}{(1+I_y)^k-1} \quad \textbf{(3)}$$

5.7.1.2 Cost of Energy:

The cost of energy (COE) is defined as the average per-unit cost of electrical energy produced by a renewable hybrid system for the system's entire lifetime as shown by below equation (4)

$$COE = \frac{Total\ annualized\ cost\ of\ system(C_{an})}{Total\ Electricity\ consumption\ per\ year E_t\left(\frac{kWh}{year}\right)}$$

5.8 Matlab Design For Essential Parts:

5.8.1 Selection Of Component Parameter For The Boost Converter:

```
    Vinmin=50; %minimum out voltage available at the rectifier output
    Vout=800; %Dc-Dc converter output
    Po=12000;% The power rating of the DC-DC converter
    fs=20000;%switching frequency
    n=0.95;%efficiency of the DC-Dc converter
D=(1-(Vinmin*n)/Vout);%D is the duty of the dc-dc boost converter
Io=Po/Vout;
%input current ripple(dI)
Ioripple=0.2;%20% to 40% of the output current
dI=Ioripple*Io*(Vout/Vinmin);
%output voltage ripple(dV)
%I am considering a 0.5% voltage variation in output voltage
%standard is 0.5% to 1%.

dV=Vout*0.5/100;
%inductance value (L)
L=((Vinmin)*(Vout-Vinmin))/(dI*fs*Vout);
%the capacitance value
C=(Io*D)/(fs*dV);
%minimum load to be applied more than this value
RL=(Vout/Io);
```

5.8.2 Purturb And Observer Algorithm For MPPT Design:[56]

Purturb and Observer algorithm flow chart is shown in below Fig: 5.9.

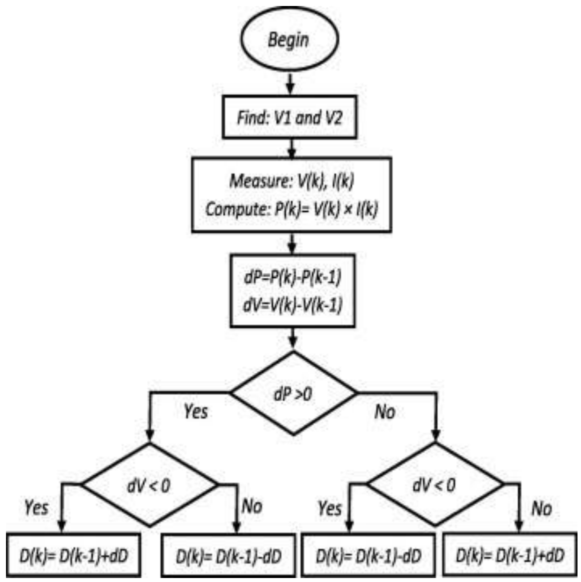


Fig: 5.9 P&O algorithm

5.8.2.1 Purturb And Observer Algorithm For MPPT Code:

```
function D= Pand0(VPV,IPV)
persistent Dprev Pprev Vprev
if isempty(Dprev)
   Dprev =0.6;
   Pprev =190;
   Vprev =2000;
end

deltaD = 125e-6;

%calculate the measured array power
PPV=VPV*IPV;
%increase or decrease duty cycle based on conditions
if (PPV-Pprev) ~=0
if (PPV-Pprev)>0
if (VPV-Vprev)>0
            D = Dprev- deltaD;
else
            D = Dprev+ deltaD;
end
else
```

```
if (VPV-Vprev)>0
            D = Dprev+ deltaD;
else
            D = Dprev- deltaD;
end
end
else
    D = Dprev;
end

%Update internal values
Dprev=D;
Vprev=VPV;
Pprev=PPV;
```

5.8.3 PLL(Phase Lock Loop):

A Phase Locked Loop (PLL) is an electronic circuit with a voltage or current-driven oscillator that is constantly adjusted to match in phase with the (and thus lock on) the frequency of an input signal. The PLL is used in various applications of electrical technology as a fundamental concept. The PLL logic block is shown below in Fig: 5.10.[57]

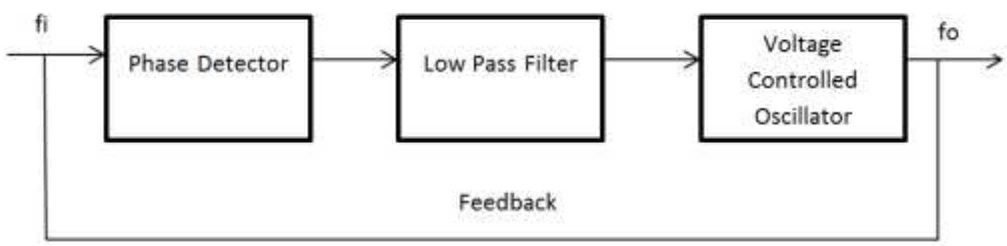
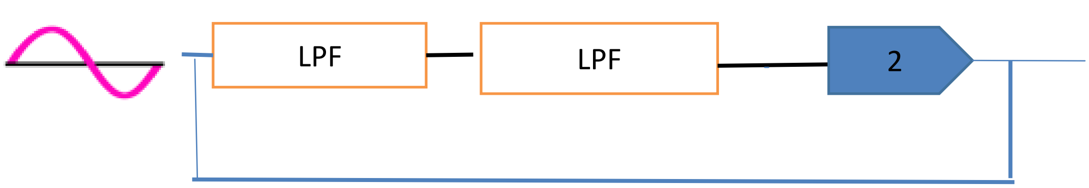


Fig: 5.10 PLL LOGIC BLOCK DIAGRAM

There are required two LPFs with gain blocks that would convert the exact 90° phase shift of the input signal.



The transfer function (T.F)=$\frac{w_c}{S+w_c}$ of an LPF whereas w_c is a correction factor filter.

[S=jw].

Put the value s=jw.

S. F= $\frac{w_c}{jw+w_c}$;

$|M|$= $\frac{w_c}{\sqrt{w^2+w_c^2}}$;

If w_c=w then

$|M|$= $\frac{w_c}{\sqrt{w^2+w_c^2}} = \frac{1}{\sqrt{2}}$;

$\theta=\sqrt{} - \tan^{-1} 1$; θ=-45°.

Then if it is two LPF cascaded the resultant magnitude is $|M|=\frac{1}{2}$; θ=-90°.That is why it is multiplied by 2 in the gain block to make it magnitude 1. That's how it is possible to make it a reactive component from this block. The PLL block is shown in the below Fig: 5.11.

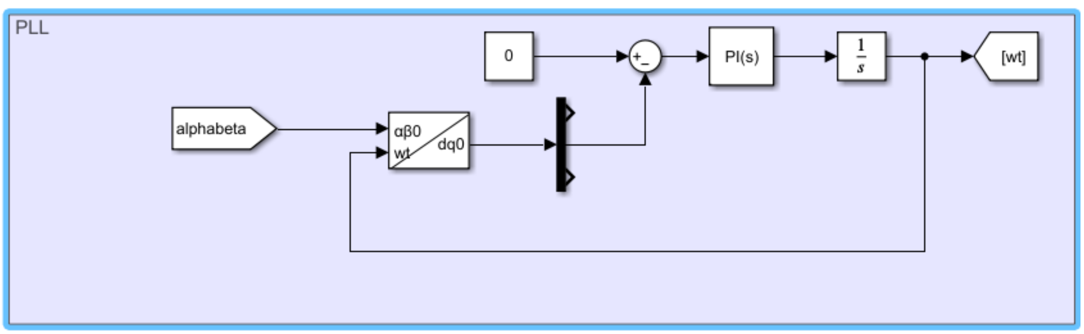


Fig: 5.11 Phase Lock Loop

5.8.4 Park Transformation:

The Park Transform block converts the time-domain components of a three-phase system in an ABC reference frame to direct, quadrature, and zero components in a rotating reference frame. The block can preserve the active and reactive powers with the powers of the system in the *ABC* reference frame by implementing an invariant version of the Park transform. For a balanced system, the zero components are equal to zero. The park transformation is shown in the below Fig: 5.12. [58]

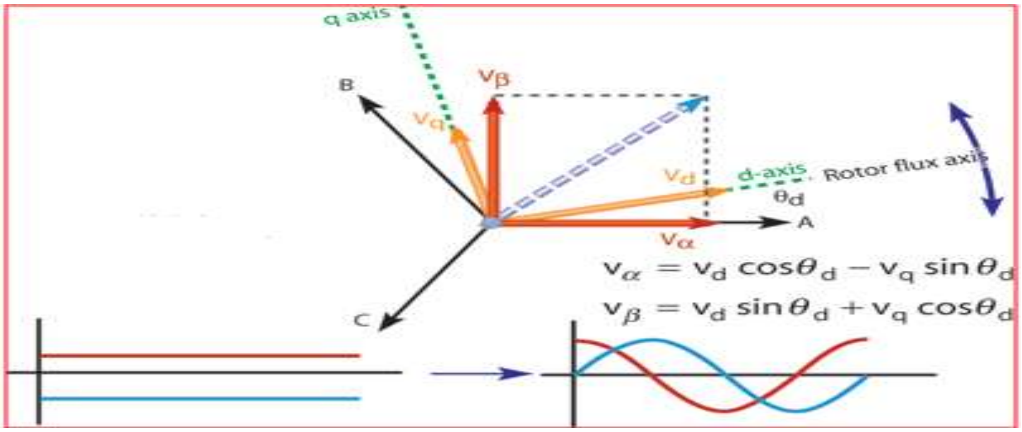


Fig: 5.12 Park transformation

5.8.5 Clarke Transformation:

This transformation converts balanced three-phase quantities into balanced two-phase quadrature quantities. The three-phase quantities are translated from the three-phase reference frame to the two-axis orthogonal stationary reference frame using Clarke transformation.[59]

5.9 Conclusion:

The optimal configuration is confined in a way that is possible to run the whole system homogeneously. In this context HRES system first assesses the feasibility study then it is estimated the load demand of the 45 deluxe rooms in the Hotel LE ROI Digha. After assessing all this it is being designed in homer software for optimal low NPC and low COE. There it is estimated various combinations of Solar, wind, and grid combination to serve the load.

After all this completion it is performed various subsystems in the Matlab software are separated to check individual setup performance and characteristics. This sub-system combination then it is placed to perform under actual load conditions to figure out whether any differences are occurring or not. After systematic analysis, the optimum design is prepared. In the next chapter, it is to be analyzed of Result and discussion in brief of this research.

CHAPTER-6

6 RESULT AND DISCUSSION

6.1 Introduction:

A Grid connected HRES is confined in a way so that our main interest can be fulfilled. The combination of two sources of Solar Photovoltaic and wind incorporated with the Grid. After completion of the Homer software simulation, it is found peak load was 50.0kW and 494.07KWh/Day for Load 1. In the case of Load2 peak load is 7.9KW and 91.57KWh/Day for Load2.

Both Load 1 and Load 2 are being assessed by various combination checking. In Homer, it is seen that Solar photo-voltaic with Grid is the best cost-affected solution in terms of Lowest NPC and Lowest COE over other combinations of the sources.

The whole Design is being optimized in the MATLAB SIMULINK Software to check the viability of the system in actual working condition. It is being checked for optimal results after analysis in MATLAB and shown here are all the necessary results in this chapter.

6.2 Optimal Model:

This system is designed with Solar Photovoltaic and wind with Grid confined as its source in Fig: 6.1. It is found best Solar with Grid among all the combinations.

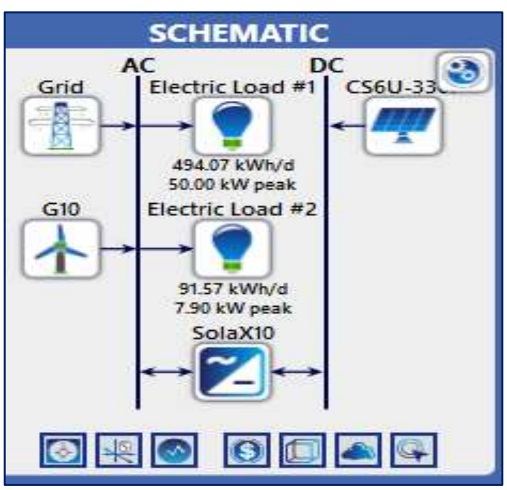


Fig: 6.1Schematic Diagram of PV wind Grid Converter based HRES Model

6.3 System Architecture:

After Optimizing by Using Homer Software optimal system arrangement is being achieved. The optimal architecture of Solar PV, Wind, and Converter are being achieved. The whole result is being analyzed in Homer software which is shown below in Table: 6.1.

Table: 6.1 System Architecture

COMPONENT	**NAME**	**SIZE**
PV	**Canadian Solar Max-Power CS6U-330P**	**10 kW**
WIND	**Generic 10KW**	**10 kW**
CONVERTER	**Solax X3 Hybrid10**	**13 kW**
GRID		

6.4 Result Of The Homer Optimization:

- The final result is being optimized and found solar with Grid formation is best out of all these combinations. The optimized data are found that NPC $154,774 and COE $0.0204/kWh which is shown in the below Fig: 6.2.

Architecture							Cost					System	
CS6U-330P (kW)	G10	Grid (kW)	SolaX10 (kW)	Dispatch			COE ($)	NPC ($)	Operating cost ($/yr)	Initial capital ($)		Ren Frac (%)	Total Fuel (L/yr)
333		999,999	225	CC			$0.0204	$154,774	-$7,853	$256,292		82.1	0
334	1	999,999	225	CC			$0.0258	$195,883	-$5,357	$265,140		82.2	0
		999,999		CC			$0.100	$276,338	$21,376	$0.00		0	0
	1	999,999		CC			$0.115	$317,151	$23,870	$8,569		0.358	0

Fig: 6.2 Economic Optimization Result

- ❖ Table: 6.2 show the cost analysis of the various systems. Compiling all the results it is estimated that the Solar PV ~ Grid combination is the best out of all these four types of combination. It is shown $154,774 NPC and $0.0204/kWh COE which is the lowest among all other combinations. In the optimization of the result, it is found the first combination is the best cost-effective solution. Here the operational cost is the lowest US$7,853.

Table: 6.2 Cost analysis of the systems

SL NO	Various Combination of Sources	NPC (US$)	COE (US$/kWh)	Operational Cost (US$/Yr)
1	Solar PV~ Grid	US$154,774	US$0.0204	US$7,853
2	Solar ~wind~ Grid	US$195,883	US$0.0258	US$5,357
3	Grid	US$276,338	US$0.100	US$21,376
4	Wind~ Grid	US$317,151	US$0.115	US$23,870

- It is found the total cost for Canadian solar CS6U-330P is $245,956.83 including O&M cost. The Solax X3-hybrid10 converter's total cost is the same as the capital cost due to its no cost of O&M cost. The economic cost optimization result is shown in fig:6.3

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
CanadianSolar MaxPower CS6U-330P	$241,648.76	$0.00	$4,308.07	$0.00	$0.00	$245,956.83
Grid	$0.00	$0.00	($105,826.12)	$0.00	$0.00	($105,826.12)
SolaX X3-hybrid10	$14,643.52	$0.00	$0.00	$0.00	$0.00	$14,643.52
System	$256,292.28	$0.00	($101,518.05)	$0.00	$0.00	$154,774.23

Fig: 6.3 Economic cost optimization result.

- In this configuration, it is found penetration of renewable energy is 82.1%. The Excess electricity over the year was found 13,946kWh/year which is 2.26%.

- The total net production of electricity by Canadian solar is 511,281 kWh/year which is 83% and total Grid purchases happened 104,934 kWh/year which is 17%.

,

- There is no consideration of matching the unmet load because it is used with Grid connected system. In the below Fig: 6.4 it is mentioned the detailed result of the model.

Fig: 6.4 Overall optimizations of load profile.

❖ As it is found from the result total renewable production divided by load is 87% and total renewable production divided by generation is 83%. Overall renewable production is shown in Fig: 6.5.

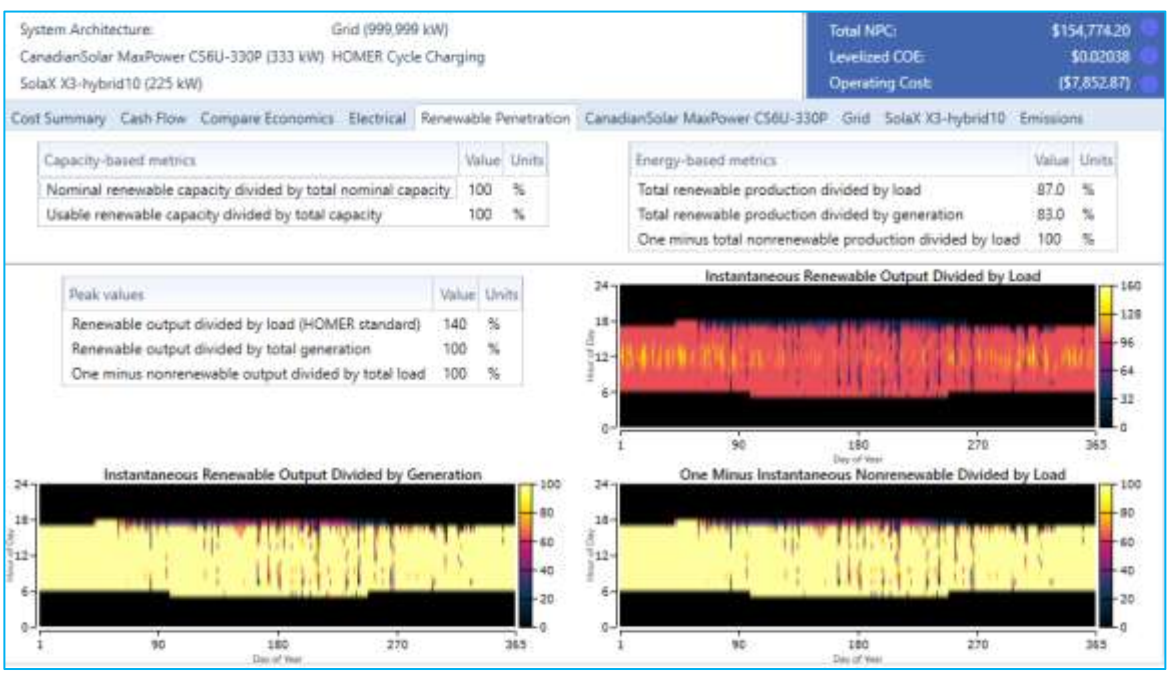


Fig: 6.5Overall renewable production

❖ PV power output is shown in Fig: 6.6.Which depicts the power output, PV penetration, and levelized cost of the design.

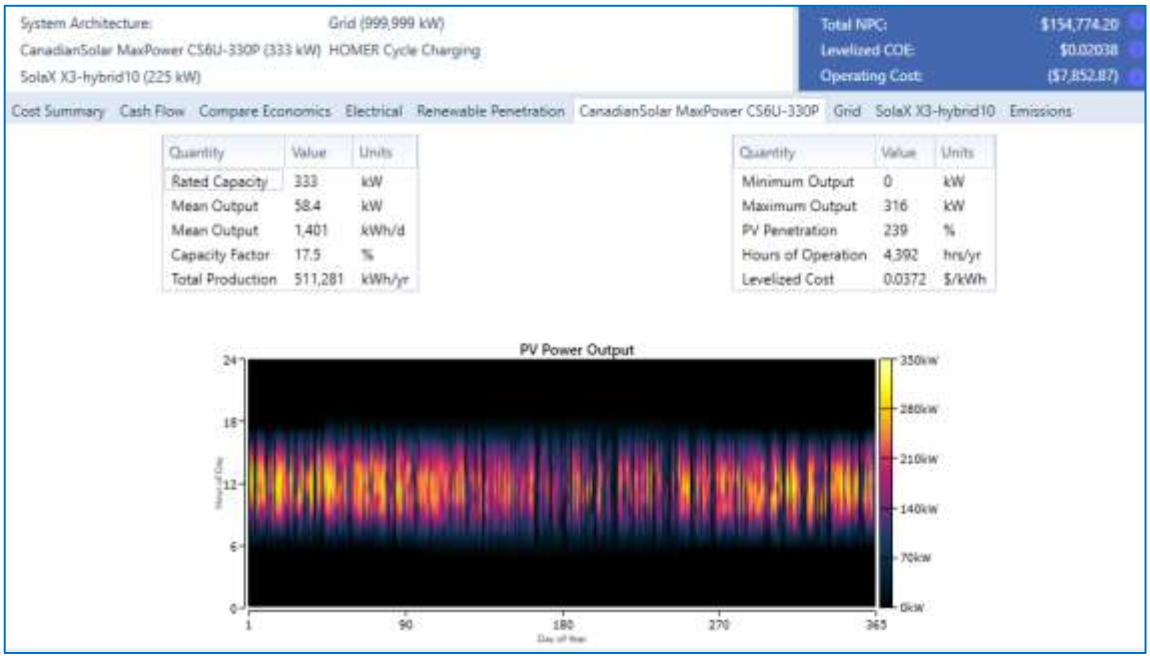


Fig: 6.6 PV power output

❖ In this research, it is found the emission of the total pollution index appeared as Carbon Dioxide 66,318 kg/year, sulfur Dioxide 288 Kg/year, and Nitrogen Oxides 141 kg/year.

Quantity	Value	Units
Carbon Dioxide	66,318	kg/yr
Carbon Monoxide	0	kg/yr
Unburned Hydrocarbons	0	kg/yr
Particulate Matter	0	kg/yr
Sulfur Dioxide	288	kg/yr
Nitrogen Oxides	141	kg/yr

Fig: 6.7 Emission of total pollution index

6.5 Result of Matlab Optimization:

The below diagram is a complete design that has been performed in MATLAB SIMULINK software. The loads have been fed to the design layout to see system performance. Here it is being designed 10kW solar array and 10KW wind has been fed to the system. Here we have designed two subsystems one is Solar PV and Wind turbines respectively.

Here solar subsystem is being controlled by MPPT with a boost controller then this near about 800-volt dc is fed to the Grid inverter input. For the MPPT logic, we have used perturb and observer.

In the case of the wind turbine subsystem, it is used MPPT controller. Here it is fed 415volt RMS to the three-phase bus system to supply the 10 kW power to the grid system. In the grid, we have used a 415V RMS bus.

The grid bus is controlled by the current controller. It can control suitable current as we want in the grid. Because it is very necessary to control to set an optimal current level in the grid bus, which is associated with a current transformer (CT).Because the circuit breaker (CB) can sense only the current of CT. If any fault occurs in the bus or system then CT senses, and trips the relay circuit to safeguard the healthy section of the power system.

Fig: 6.8 describe the overall system design of Matlab 2021a software. This is the combined model of Grid interacted HRES.

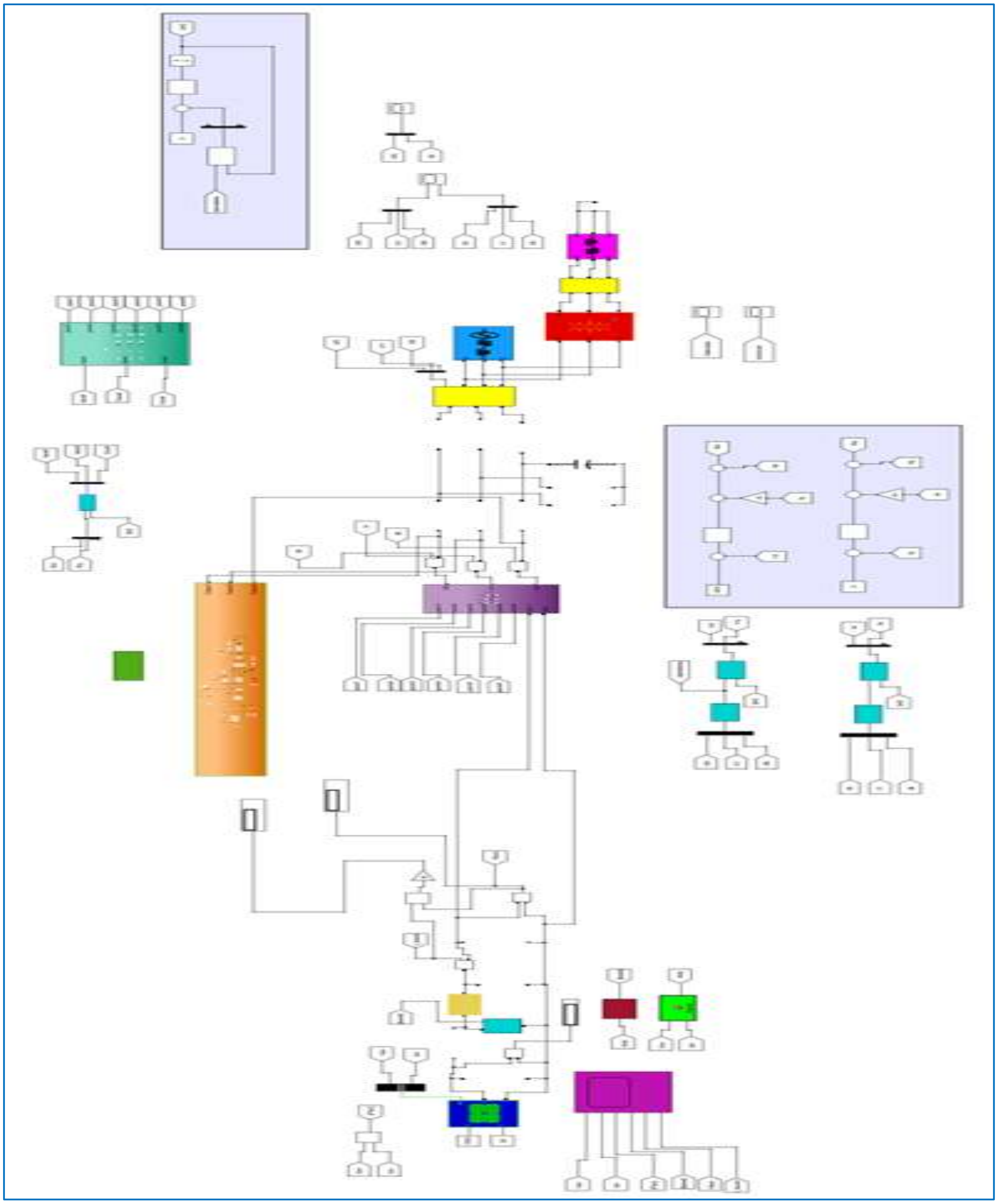


Fig: 6.8 Overall system design in Matlab 2021a

To analyze design parameters we need to observe the design layout one by one then it is possible to understand the design layout very effectively.

6.5.1 PV Array:

Now let's have a quick analyze the first 10 kW solar PV array. Fig: 6.9 describe the design layout of the solar PV array.

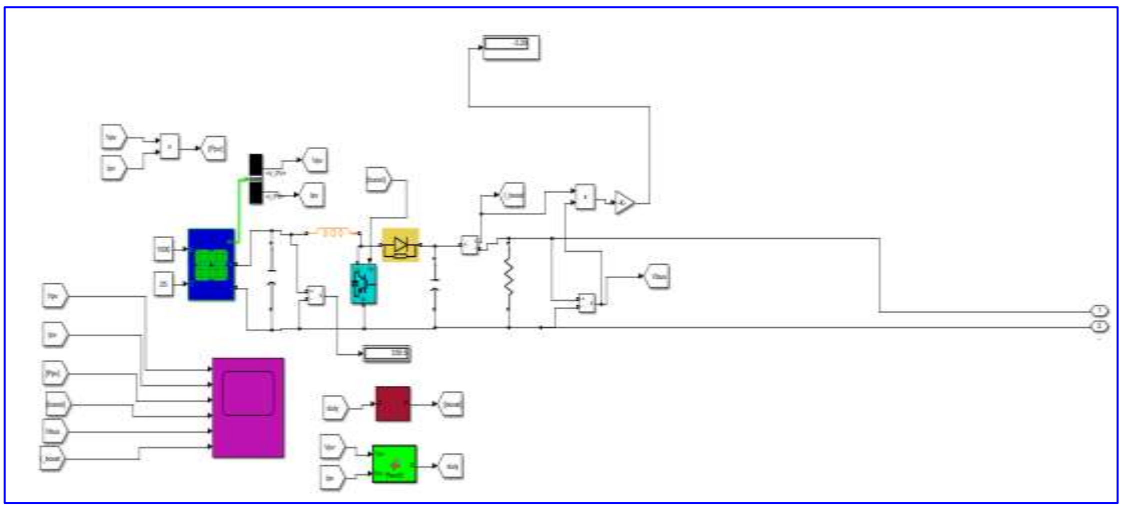


Fig: 6.9 10kW solar PV array:

- ❖ In the above design, 10kW solar PV has been shown. The MPPT control Grid connected system is configured. Here it is some fixed input given to the input of the solar array which is irradiance and temperature.
- ❖ After the solar PV array, it is fed to the boost converter and filter to increase the voltage and rectify the noise to an optimal level respectively. It boosts up the voltage to around 800 V dc then it is fed to the Grid inverter to convert it into dc to 3-phase RYB 120°phase displaced bus. Here the bus voltage is set to 415 V RMS line to line.
- ❖ Here it is very much possible to use a transformer for voltage step-up and then rectify to DC instead of a Boost converter. But actually, again it needs two types

of converter one dc to ac inverter then fed to the transformer then it needs another filter circuit to rectify it to dc then fed to the Grid Inverter.

- ❖ The PV array design is done in Matlab software. It is found 12 series modules with the combination of 3 parallel string total of 36 modules is used which has been shown in the below fig: 6.10.

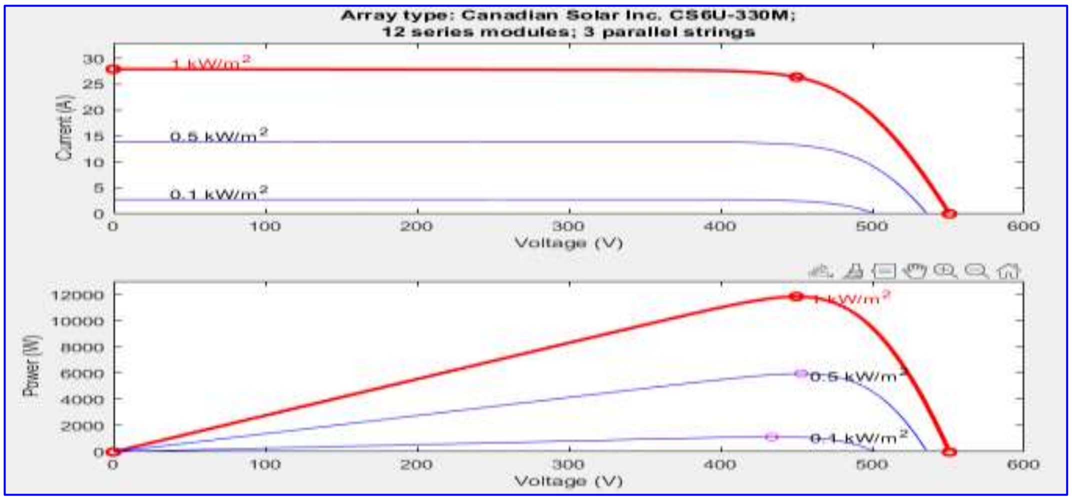


Fig: 6.10 10kW solar 36 module design

6.5.2 Wind Power System:

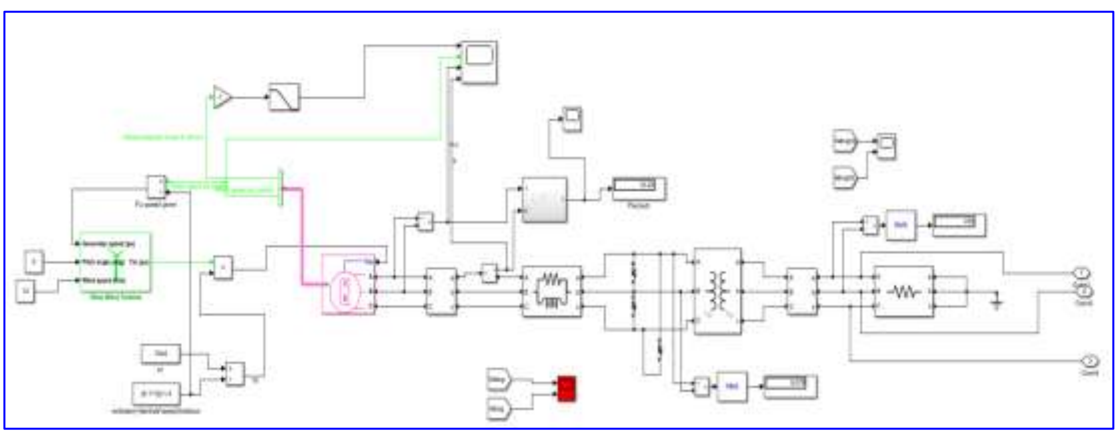


Fig: 6.11 10kW wind plant design

- ❖ In this wind power system as it can be seen it's nearly 10kW of power is sent to the Grid. Fig: 6.11 describe a 10kW wind power plant design sub-system block. In the design, we have taken a constant pitch angle of 0° and a wind speed of 12m/sec.

  In this design, it is used permanent magnet synchronous machine gives the system component a constant speed output so that it is possible to generate steady-state power output.

- ❖ Grid synchronized power is represented here, three phase configuration RYB peak is 586.9 Volt, and RMS voltage as can be seen 418.6 Volt we want to be 415V. Hence it is a good value. Here Grid injected power means combining a parallel combination of two 10 kW renewable sources Solar PV and Wind. Below fig 6.12 describes the RYB injected voltage to the grid

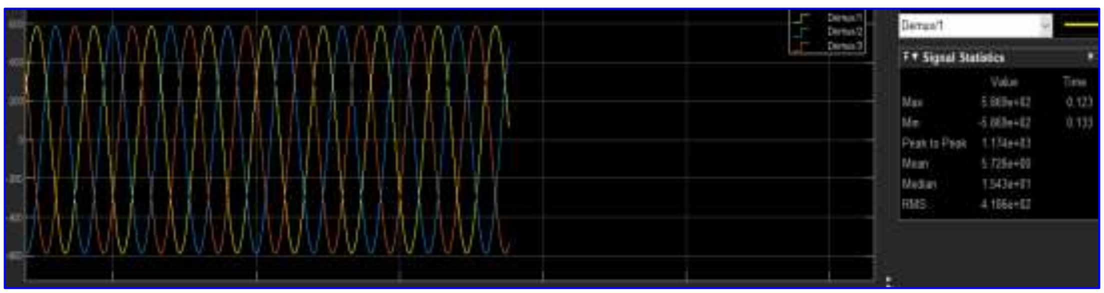


Fig: 6.12 RYB synchronized voltage to the grid

Below figure 6.13 it is shown the plot of the voltage of the R phase with the current of the R phase as it is set grid current control -205A. Its star from the -205A mark signifies the success of the voltage and current alignment.

Yellow line is V_R and the Blue line I_R of the same phase.

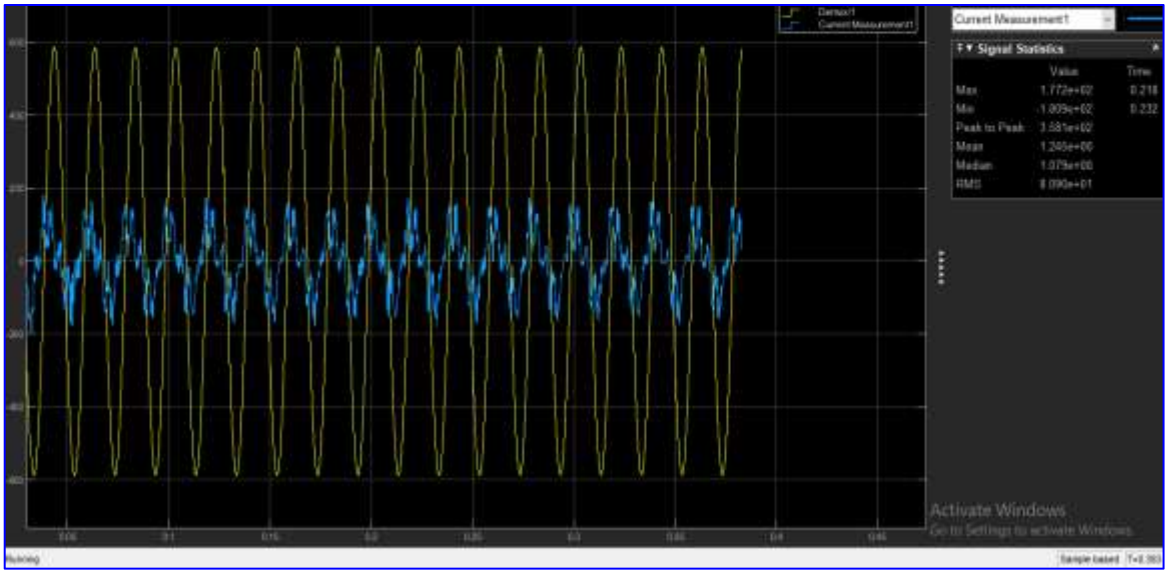


Fig: 6.13 V_R and I_R alignment in the R phase.

The system is running well as expected. Now time to test the load and prepare the simple data sheet. So here first it is to be done Load 1 only summer time loads to be taken. The loads are to be analyzed with the average load demand per day which is 27.32kW.

Assuming load is resistive type.

Formula to find load R = $\frac{V^2}{P}$, here p is the power P=27.32KW.

And V is the phase voltage that is 230v RMS.

Now R= $\frac{230^2}{27.32*1000}$=1.93 ohm. This is the per-phase quantity.

Then see the characteristics below Fig: 6.14

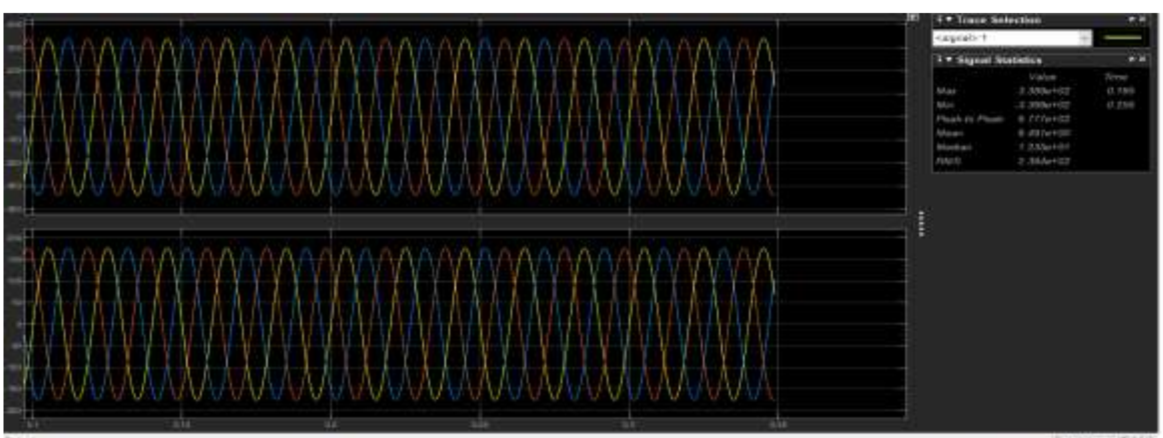


Fig: 6.14 Characteristics of average load 27.32kW per phase.

For load-2 to be analyzed average load demand per day in the summertime is 4.09kW. Assuming load is resistive type.

Formula to find load R = $\frac{V^2}{P}$, here p is the power P=4.09kW.

And V is the phase voltage that is 230v RMS.

Now R= $\frac{230^2}{4.09*1000}$=12.93 ohm. This is the per-phase quantity.

The below Fig: 6.15 shows the characteristics of load 2 at average load demand per day in the summer at a value of 4.09 kW.

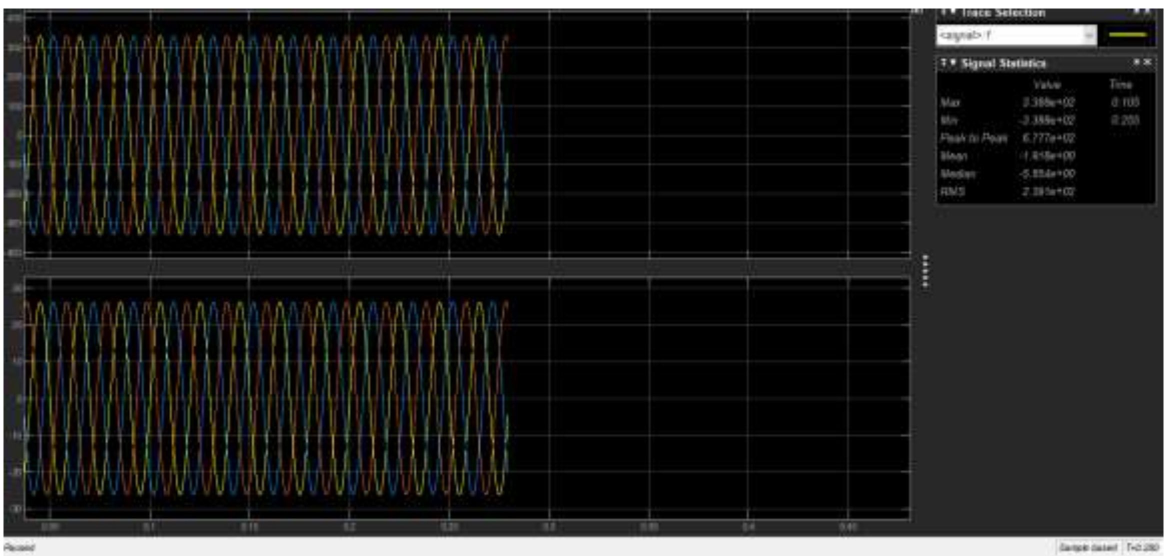


Fig: 6.15 Characteristics of average load 4.09 kW per phase.

For the load-2 are to be analyzed average load demand per day in the winter time is 2.97kW. Assuming load is resistive type.

Formula to find load R = $\frac{V^2}{P}$, here p is the power P=2.97kW.

And V is the phase voltage that is 230v RMS.

Now R= $\frac{230^2}{2.97*1000}$=17.81 ohm. This is the per-phase quantity.

The below Fig: 6.16 shows the characteristics of load 2 at average load demand per day in the winter at a value of 2.97 kW.

Fig: 6.16 Characteristics of average load 2.97 kW per phase.

6.6 simulated result by variation inputs:

In this segment, we will be looking at some input variations in both solar PV and WIND and see the impact on the power output and voltage.

6.6.1 Solar PV sub-block:

If it is fixed temperature at 25□ and varies the solar irradiation then the power and voltage are shown in the below table: 6.3.

Table: 6.3 Irradiance Vs output parameter variation (with fixed 25□ temperature)

Sl no	Irradiation(W/m^2)	DC Voltage(V)	DC power(kW)
1	1000	786.7	10.88
2	800	720	9.11
3	600	638	7.16

If it is fixed irradiation at 1000 W/m^2 and vary the temperature then the power and voltage are shown in the below table: 6.4.

Table: 6.4 Temperature Vs output parameter variation (with fixed 1000 W/m^2 irradiation)

Sl no	Temperature(□)	DC Voltage(V)	DC power(kW)
1	25	786.7	10.88
2	30	745	9.22
3	35	724	9.15

6.6.2 Wind sub-block:

If the pitch angle is fixed to 0° and we vary the wind speed then voltage and Power output are shown in the below table: 6.5.

Table: 6.5 Wind speed Vs output parameter variation (with fixed pitch angle at 0°)

Sl no	Wind speed (m/sec)	RMS Voltage(V)	AC power(kW)
1	12	421	10.54
2	10	418	7.2
3	8	415	4.5
4	6	413	2.4

6.7 Conclusion:

This section it is described the result and discussion of this research. The desired system model runs efficiently as per our projections. Here in the first case, it is calculated for Load-1, 27.33 kW (average value in a day of summer) per phase the value of the load is found 1.93 ohms in 230v RMS voltage configuration. It is found the result came perfectly extracting the power from Grid. Hence it is successful.

It is calculated, for Load- 2, 4.09kW (average value in a day of summer) per phase. The value of the load is found 12.93 ohm in 230v RMS voltage configuration. It is calculated, for Load- 2, 2.97kW (average value in a day of winter) per phase. The value of the load is found 17.81 ohm in 230v RMS voltage configuration.

It is found the result came perfectly, extracting the power from Grid. Hence it is successful. Thus our load profile check is successful. Now it is time to move to the next chapter that elaborately describes the Conclusion of this research.

CHAPTER-7

7 CONCLUSION, FUTURESCOPE & LIMITATIONS

7.1 Conclusion:

This thesis introduces an optimal design of Grid-connected HRES in a large hotel consisting of 45 rooms in Digha, West-Bengal India. I think this is also the future of “NET ZERO CARBON EMISSION MISSION”. An initial study has been done in the Homer Pro software to optimization of costing, economic outcome, NPC, COE, etc to evaluate. After all these evaluation results Grid with a Solar PV array arrangement is the best combination of all these.

Then the design is done in Matlab Simulink Software to see its load characteristics in actual condition. This technical and economical assessment would be helpful for future enhancement projects. Here various parameters of the Grid and Current Controller have been monitored.

The major outcome of this thesis is pointed out below sequentially.

1. Grid-connected HRES has been designed in a combination of a 10kW Solar photovoltaic system with a 10kW Wind turbine to supply the load demand of 27.33 kW (average value in a day of summer) AC load, 4.09 kW (average value in a day of summer) of Load2 and 2.97 kW (average value in a day of winter) of Load2. The result comes to NPC $154,774 and COE is $0.0204/kWh. The return on Investment is 6.1% and the simple payback year is 9.9 years.

2. The renewable energy contribution of this much load is 82.1% remaining power is being outsourced by Grid. But the solar PV with Grid combination renewable 83.0% and the 17.0% power from Grid are being outsourced.

3. In this whole process, total emissions are being projected as CO_2 66,3181 kg/year, SO_2 288 kg/year, 141 kg/year of nitrogen oxides no particulate matter was found.

4. In the Matlab Simulink AC Load1 (average load in summer) 27.33kW, Load2 4.09kW (average load in summer), and Load2 2.97kW (average load in winter) are being analyzed in the per phase 230V RMS voltage reference. The current controller

of Grid is functioning well. That gives us essential freedom of any load variation with the Involvement of PLL intervention.

5. In the Matlab Simulation, it is checked all the plots that are given as expected results. Overall the motive of this thesis is fulfilled.

Hence the HRES with interconnection Grid makes it an efficient and best optimal option to move in the future. Here it is analyzed a large 3-star-rating Hotel consisting of 45 deluxe rooms but in the future, it is possible to extend the load with the enhancement of an equivalent combination source.

7.2 Future Scope:

The NFHS-5 report released in March last year showed 97% of India's households have electricity - 95% of rural and 99% of urban. So it needs to connect them to electricity in rural locations, where till time Grid connection not being touched. So our prime focus should be to facilitate them to the mainstream basic electrification needs. To do it we need to introduce standalone HRES so that necessary load demand can be fulfilled. In some cases, it is very much possible to electrify street light poles, small club by pole mounted PV system. Now it can be seen using this type of arrangement in our National Highway Street light.

1. Following our current thesis if we do start to replace all the Air-condition load (AC) by the source of HRES with Grid interconnection then a huge burden of load demand can be diverted in Large hotels, restaurants, and malls. Then in the future, all the load demand can be diverted through a similar enhanced model.
2. Here we have assumed load to be as resistive load, but in real case there must be inductive as well as resistive load. To calculate effectively we need know exact model wise inductive load. In future we will surely considering these issues.
3. To accommodate more no sources in HRES we need to see various possible options such as Biodiesel, Hydrogen fuel, and ethanol blending with petrol.
4. Also in the future, we need high-grade battery cell that is associated with cars, transportation medium electricity storage. In India, we have found lithium storage in J&K that also boosts the Indian economy.

5. I think Govt. of India should consider big renewable projects to generate a mass amount of electricity and initiate a sea-based wind turbine model, a new small Hydel project in hilly areas.

7.3 Limitations:

- The major limitation we have found in this whole analysis is the capital cost of the system is too large. The silicon extraction cost for making the panel needs to be modified.
- Matlab Simulink is the software for the visualization of our design with some limited input parameter variation can be done. If it is a need for extra variation in the input parameter to see its output performance. It will be required to test in actual working conditions to prepare its data chart.
- Less Govt. encouragement or subsidy is given to the macro buyer.
- Another is the technology gap, in terms of Battery technology, and recycling of solar panels after the operational period is over. This is gonna be a major problem to date, there is no such ready-to-go technology not in our hands for proper recycling.
- Now in various places, it is seen EV charging station which is powered by Grid. That is not negotiable at all. It should be powered by standalone renewable sources or some grid-connected renewable sources.

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