DESIGN AND ANALYSIS OF AN OPTIMAL HYBRID ENERGY SYSTEM FOR BUITEMS

Fouzia MAnwar	53019
Mahima Sanzar	53781

DEPARTMENT OF ELECTRICAL ENGINEERING

BALOCHISTAN UNIVERSITY OF INFORMATION TECHNOLOGY, ENGINEERING, AND MANAGEMENT SCIENCES

Spring 2024

DESIGN AND ANALYSIS OF AN OPTIMAL HYBRID ENERGY SYSTEM FOR BUITEMS

By

Fouzia MAnwar	53019
Mahima Sanzar	53781

Supervisor: Dr. Atiq-Ur-Rehman
Co-Supervisor: Engr. Mugheera Ali Mumtaz
DEPARTMENT OF ELECTRICAL ENGINEERING

BALOCHISTAN UNIVERSITY OF INFORMATION TECHNOLOGY, ENGINEERING, AND MANAGEMENT SCIENCES

Spring 2024

DESIGN AND ANALYSIS OF AN OPTIMAL HYBRID ENERGY SYSTEM FOR BUITEMS

by

Fouzia MAnwar	53019
Mahima Sanzar	53781

Submitted to the

Department of Electrical Engineering

In Partial Fulfillment of Requirements for the Degree of Bachelor of Science in Computer Engineering at Balochistan University of Information Technology, Engineering and Management Sciences

Spring 2024

Signature of Supervisor: ______________________________

Signature of Co-Supervisor (If any): ______________________________

Signature of FYP Coordinator: ______________________________

Undertaking

It is certified that this work titled "design and analysis of an optimal hybrid energy system for Buitems" is our own work. The work has not been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged / referred to.

Fouzia MAnwar
53019

Mahima Sanzar
53781

Table of Contents

UNDERTAKING....4

CHAPTER 1....9

1 INTRODUCTION....9

1.1 BACKGROUND....9

1.1.1 PAKISTAN'S ELECTRICITY GENERATION CAPACITY....9

1.1.2 ENERGY RESOURCES....11

1.1.2.2 NON-CONVENTIONAL OR RENEWABLE ENERGY....11

1.1.3 PAKISTAN'S RENEWABLE ENERGY....13

1.1.4 WORLD TRENDS TOWARDS HAVING RENEWABLE ENERGY....13

1.2 PROBLEM STATEMENT....14

1.3 OBJECTIVES....14

1.4 MOTIVATION....15

1.5 SCOPE....15

1.6 SDG GOAL MAPPING....17

1.7 ORGANIZATION OF THE THESIS....17

CHAPTER 2....18

2. REVIEW OF LITERATURE....18

2.1 ENVIRONMENTAL ANALYSIS OF AN OPTIMAL HYBRID SYSTEM....18

2.2 ECONOMIC FEASIBILITY ANALYSIS....21

2.3 TECHNO-ECONOMIC FEASIBILITY ANALYSIS....23

CHAPTER 3....26

3 RESEARCH METHODOLOGY....26

3.1 SITE DETAILS....27

3.2 MODELING STATISTICS....28

3.2.1. ELECTRIC LOAD....28

3.4. PEAK LOAD PROFILE FOR BUITEMS....35

3.5 EXISTING SYSTEM OF BUITEMS....37

3.5.1 DETAILS OF GENERATORS OF BUITEMS....37

3.6 ELECTRICAL LOAD PROFILE....39

3.6.1. PEAK LOAD PROFILE FOR BUITEMS....39

3.6.2. OFF-PEAK LOAD PROFILE FOR BUITEMS ON HOMER....40

3.7. OPTIMIZATION RESULTS....41

3.7.1 COMPONENTS OF EXISTING SYSTEM....41

3.7.2 HOMER OPERATION 41
3.7.3 RESULTS FOR EXISTING SYSTEM 41
REFERENCE: 43

List of Figures

Figure 1.1. Percentage of installed power capacity in Pakistan 10
Figure 1.2. Renewable energy sources [7] 12
Figure 1.3. Pakistan's renewable energy sources [14] 13
Figure 3.1. Schematic layout of present work 27
Figure 3.2. Geographical location of BUITEMS on HOMER 28
Figure 3.3. Map of the BUITEMS Campus 28
Figure 3.4. Energy consumed BUITEMS per day (in KWh) 36
Figure 3.5. Energy consumed by BUITEMS per month (in KWh) 36
Figure 3.6. Schematic Diagram of existing system 38
Figure 3.7. Schematic diagram of existing system. 41
Figure 3.6. Results for existing system when generators are offline. 41
Figure 3.7. Results for existing system when generators are operating 41

List of Tables

Table 1.1: Total installed capacity of power generation in Pakistan 10
Table 3.1: Units consumed on working days from Friday to Monday (peak and off-peak) load profile for BUITEMS per day. 30
Table 3.1: Units consumed on working days from Friday to Monday (peak and off-peak) load profile for BUITEMS per day. 31
Table 3.1: Units consumed on working days from Friday to Monday (peak and off-peak) load profile for BUITEMS per day. 32
Table 3.2: units consuming on weekend’s (peak and off peak) load profile for BUITEMS per day 33
Table 3.3. Electrical load Estimation on the basis of peak and off-peak hours and per day, per month, per year for BUITEM. 34
Table 3.4. Details of Generators of BUITEMS 37
Table 3.5: Yearly electrical peak load profile of BUITEMS on HOMER... 39
Table 3.6: Yearly electrical off peak load profile of BUITEMS on HOMER.. 40
Table 3.7. Cost comparison with and without generators... 42
Table 3.7. Comparison of emissions of gases without and with generators 42

CHAPTER 1

1 INTRODUCTION

1.1 BACKGROUND

The need for electricity is growing globally, but even in areas that are connected to the grid, mostly in rural areas, a sizable portion of the demands still need to be connected to the power network. Lack of electricity is a problem. Major obstacle for those who are disconnected from the grid. [1] For small towns where power is generated and used locally, federalized generation is a more reliable option. Most of the generators are employed both as a secondary supply for power shortages in grid-connected areas and as the primary source of electricity in remote grid regions to meet energy demand. In addition to being an unstable supply, the diesel engine also contributes to global warming. Certainly, the availability of fossil fuels is decreasing significantly, increasing the speed of global warming. Therefore, there is a global concentration among researchers studying abundant, pollution-free, energy-efficient solutions. [2]

Both in grid-connected and off-grid places, solar and wind technologies are clean substitutes for traditional energy that can end the world's energy disaster. In remote places where grid expansion is too expensive and fuel prices rise sharply due to transportation to distant areas, solar and wind power supplies are easily accessible and a profitable replacement for diesel generators. In rural areas where grid expansion is too expensive and fuel prices have risen suddenly because of transportation to far-off places, [3]

1.1.1 PAKISTAN’S ELECTRICITY GENERATION CAPACITY

Pakistan’s capacity to produce electricity from July to April 2022 increased by 11.5 percent to 41,557 MW from 37261 MW during the same period in the previous fiscal year. In January 2023, the nation’s electricity production increased marginally by 1.2 percent monthly to 8,515 GWh (11,445 MW), up from 8417 GMh in December. Electricity production decreased by 3.2 percent annually from the 8,797 GWh (11,824 MW) measured in January 2022. Pakistan has a total installed power generation capacity of 43,687 MW, according to the National Electric Power Regulatory Authority's (NEPRA) 2022 annual report (see table 1.1). [4]

Table 1.1: Total installed capacity of power generation in Pakistan

Sr.no	**Sources**	**Installed capacity in MW**	**Percentage %**
1	Thermal	26,683	61%
2	Hydroelectric	10,635	24.34%
3	Wind	1,838	4.20
5	Solar	530	1.21%
6	Gas	369	0.84
7	Nuclear	3,632	8.31%
	Total	43,687	100%

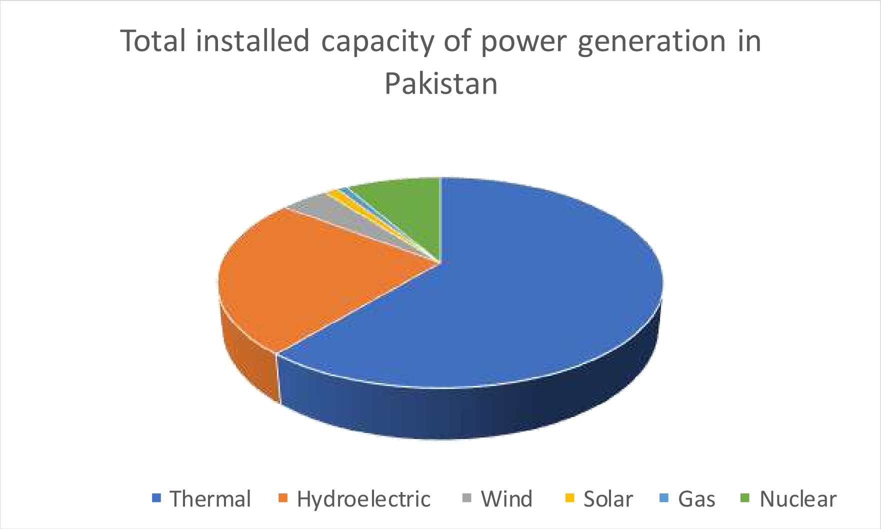


Figure 1.1. Percentage of installed power capacity in Pakistan

From Table 1.1, it has found that Pakistan has generated 61% of energy from Conventional resource (thermal energy) which is not environment friendly. Every energy source has drawbacks, but they are very different in size. Like nuclear and modern renewable energy sources are much safer and cleaner than fossil fuels (thermal energy etc.) which are polluted, global warming, and rain acid and most toxic. So, to reduce the emissions of these energies, used the renewable energy sources. They are used in large amounts everywhere which are a good replacement for fossil fuels.

1.1.2 ENERGY RESOURCES

Human society depends on both nonrenewable and renewable energy sources to run daily. Renewable resources can naturally regenerate themselves, whereas nonrenewable resources cannot, which is how these two types of resources differ from one another. [5]

1.1.2.1 NONRENEWABLE OR CONVENTIONAL ENERGY

The energy that comes from sources that will run out, can be exhausted one day, and cannot be used repeatedly is called non-renewable energy resources (fossil fuel, natural gas, petroleum, oil, nuclear energy, etc.). It has high carbon emissions and is not environmentally friendly, causing pollution.

1.1.2.2 NON-CONVENTIONAL OR RENEWABLE ENERGY

The energy that comes from sources that will not run out or be replenished in our lifetimes is called renewable energy (Solar, Waterpower, Wind power, Biomass, and hydropower). It is the kind of energy that is constantly usable. These are the energy resources that cannot be exhausted in human time. These have low carbon emissions and are environmentally friendly and pollution-free. Since clean, renewable energy can be used everywhere, it is a good replacement for fossil fuel. Three characteristics define renewable energy. [6]

- Clean energy resources are limitless; hence, they will never run out.
- Green energy does not directly harm the land or water.
- Unconventional energy sources do not release any carbon.

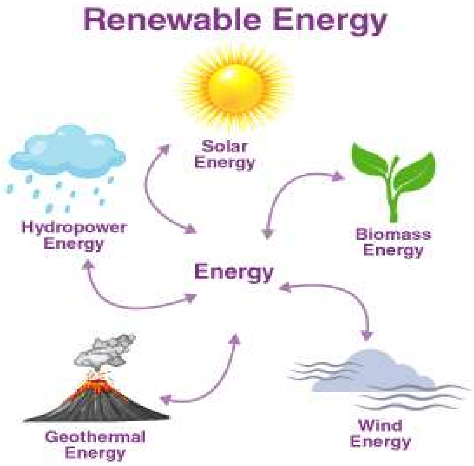


Figure 2.2. Renewable energy sources [7]

These are all the most prevalent renewable energy resources (Wind, Solar, Biomass, Hydropower, and geothermal energy).

Solar energy is a continuous source of renewable energy that can be used for thermal and power-generating applications. Solar power is a clean technology because it does not produce toxic pollutants such as solids, liquids, or gases and does not cause pollution. And can also reduce operating costs. [8]

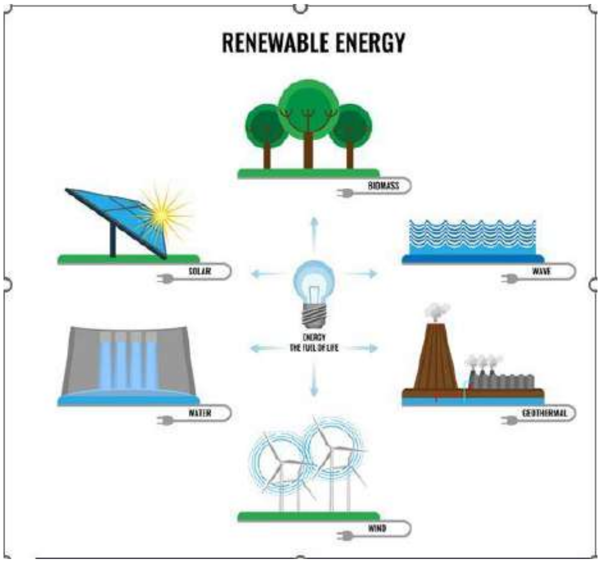
Using wind energy to create useful work is known as wind power. One of the electrical sources with the lowest costs per unit of energy produced is wind power. In comparison to burning fossil fuels, wind power is seen as an environmentally friendly renewable energy source because it has less of an adverse effect on the environment. [9]

Hydropower is a cheap, clean, and renewable source of electricity that uses kinetic water energy to generate electricity. A dam or other construction that alters the natural flow of a river or other body of water is used to generate hydropower. Hydropower can be utilized for power generation on a large or small scale, depending on the head and water flow rate. Therefore, hydropower is the most significant RER in the world. [10]

Geothermal energy is heating energy that is created by the earth. Geothermal resources are hot water tanks that are naturally occurring or artificially created at various temperatures and depths below the surface of the Earth. [11]

1.1.3 PAKISTAN’S RENEWABLE ENERGY

Pakistan is one of the countries that produces the most renewable energy. It has a total installed capacity of 43,687 MW, of which 61% is thermal (derived from fossil fuels). 24.34% is hydroelectric. 6.25% is renewable (derived from wind, solar, and biomass), and 8.31% is nuclear, according to the National Electric Power Regulatory Authority's (NEPRA) 2022 annual report. Renewable energy (RE) has the potential to play a significant role in bridging the existing gap. Considering the current administration's support for renewable energy, the Organization of Energy improved the 2019 Renewable Energy (RE) Policy. By 2030, the Pakistani government hopes to end the country's reliance on imported petroleum by sourcing 60% of its energy from renewable sources, including hydropower. [12] [13]



1.3. Pakistan’s renewable energy sources [14]

Figure 1.3 shows the cycle of Pakistan's renewable energy (solar, wind, thermal, biomass, and hydropower) resources.

1.1.4 WORLD TRENDS TOWARDS HAVING RENEWABLE ENERGY

A greater transition of the world from fossil fuels to renewable energy is occurring because more nations are capitalizing on the advantages and energy potential that renewables have, and both developing and developed nations are increasing their savings in renewable energy. Due to the lack of power, generators are working as the primary and backup energy source in companies, schools, retail centers, offices, homes, and remote areas. Reduced use of diesel is necessary as it increases reliance on imports. A key component of our schemes to reduce the worst effects of climate change is clean, renewable energy. Our greenhouse gas emissions will be significantly reduced if wind and solar energy are used to power our homes and businesses instead of fossil fuels. The additional benefit is that it will simultaneously reduce air pollution as well as greenhouse gas emissions throughout the nation. Therefore, for renewable energy to be technologically and economically feasible and effective, it must be properly sized based on resource accessibility. [15]

Therefore, there is a global trend among researchers and scientists to significantly increase the number of pollution-free and energy-efficient solutions. The purpose of this project is to design and analyze an optimal hybrid energy system (HES) for BUITEMS University. BUITEMS's existing energy relies on grid-supplied energy, which is expensive, and a large amount of the BUITEMS budget is wasted on paying these monthly electricity bills. To overcome this problem, we will propose a hybrid energy system for BUITEMS. This will fulfil the energy requirements of BUITEMS and will also be cost-effective. For the simulation and optimization of an optimal hybrid energy system, we will use software such as HOMER Pro, PVSyst, MATLAB/SIMULING, and OpenDSS.

1.2 PROBLEM STATEMENT

Pakistan’s power sector is heavily dependent on conventional energy (majorly fossil fuels) resources, which is the source of pollution in the environment and has a negative effect on Pakistan’s economy and leads to power shortage within the country. BUITEMS rely on the national power grid, which utilizes fossil fuel, which is a costly alternative and increasingly declining. The economic situation at BUITEMS is not of a high standard, and most of the funds are used for paying university bills. BUITEMS faces electricity issues in case faults occur at the power station (grid). The generators are used for stable power supply, but they are expensive as diesel prices are continuously raising.

1.3 OBJECTIVES

The main objectives of the study are:

1. To evaluate the energy requirements and consumption of BUITEMS.
2. To propose an optimal hybrid energy system that can ensure continuous power supply and minimize the energy cost for BUITEMS.
3. To assess the environmental impact of deploying the proposed hybrid energy system in BUITEMS.

4. To analyze the harmonic effect of integrating a proposed hybrid energy system into a grid station

1.4 MOTIVATION

A dependable and sustainable energy solution is provided by a hybrid energy system, which includes solar PV panels, battery storage, and a conventional generator. By ensuring a steady supply of electricity, this system lessens the need for fossil fuels and their negative effects on the environment. Clean, renewable energy is produced by solar PV panels, and power is supplied during grid disruptions via battery storage, which also stores excess energy during peak hours. This technology promotes a greener campus and lessens the carbon footprint of BUITEMS, in line with the institution's sustainability goals. Additionally, it lessens reliance on a single energy source, improving resistance to variations. Reduced operating expenses and better energy efficiency are among the long-term benefits, even if the initial expenditure may be larger. By optimizing energy distribution and consumption, smart grid integration might potentially result in savings and improved energy management.

1.5 SCOPE

- **System Design:** Create a thorough design for the hybrid energy system that is adapted to the energy requirements of BUITEMS. This entails defining the power output of the backup generator, battery storage, and solar PV panels in addition to the required control systems.
- **Energy Resource Assessment:** To maximize the system's performance, do a thorough evaluation of the solar and wind resources at the BUITEMS location. To ensure efficient energy generation, this entails examining historical data, weather trends, and local variables.
- **Control and Integration:** Put into practice efficient control and integration methods to regulate the interplay of solar, battery storage, and the backup generator. Creating smart grid technology is one way to achieve smooth energy distribution and use.
- **Performance Analysis:** Assess the hybrid system's performance in various scenarios, such as high demand, low generation of renewable energy, and grid failures. To guarantee efficiency, stability, and dependability, run simulations and analysis.
- **Economic Viability:** Evaluate the project's economic viability by taking into account the project's initial outlay, ongoing expenses, and possible long-term savings. To ascertain the financial viability and return on investment, present a cost-benefit analysis.

- **Environmental Impact Assessment:** Compare the hybrid system's environmental effects to those of conventional energy sources. Evaluate how the use of renewable energy will lower carbon emissions, air pollution, and other environmental benefits
- **Operational Optimization:** Create plans to maximize the institution's energy use. To lessen reliance on the backup generator, this involves demand-side management, load balancing, and optimizing the use of renewable energy sources.
- **Educational and Training Components:** Include staff and students in the project's implementation and monitoring procedures by incorporating educational components. Provide training courses to guarantee the hybrid energy system is maintained and operated efficiently.
- **Reporting and Documentation:** Offer thorough records of the processes involved in the design, execution, and analysis. Provide thorough reports that include the project's methodology, results, and suggestions for enhancements in the future.
- **Scalability and Replicability:** Consider scalability while designing the hybrid energy system to accommodate future growth. Give advice and information to other organizations wishing to implement a similar on-grid hybrid energy solution

1.6 Significance of study

- **Continuous Power Supply and Reliability:** The hybrid energy system combines several power sources, such as solar, battery storage, and a conventional generator, to ensure a dependable and continuous power supply. This is essential for BUITEMS to run well, particularly when important duties like research, lectures, and administrative work are involved.
- **Environmental Impact and Sustainability:** Integrating solar panels and other renewable energy sources is in line with sustainability objectives. The project makes the campus greener by decreasing the reliance on traditional fossil fuel-based generators, minimizing the institution's carbon footprint, and encouraging ecologically friendly energy practices.
- **Cost Efficiency and Operational Savings:** Assessing the project's economic viability and possible cost savings is probably part of the analysis component. The hybrid system has the ability to optimize energy consumption, minimize fuel consumption, and perhaps lower BUITEMS power costs, resulting in long-term operational savings if it is deployed properly.
- **Innovation in Technology and Campus Exhibition:** Implementing on-grid hybrid energy system, BUITEMS demonstrates its commitment to technical innovation. The initiative can act as

a template for other educational establishments, showcasing the benefits and viability of combining various energy sources to satisfy sustainability and dependability goals.

- **Research Impact and Educational Opportunities:** Students that participate in the project's creation and analysis have educational possibilities. By examining the effectiveness, efficiency, and effects of on-grid hybrid systems, it also advances research. The results might provide insightful information to the larger fields of sustainable campus development and renewable energy.
- **Energy independence and grid resilience:** Energy storage is incorporated into the hybrid system to increase the robustness of BUITEMS's energy infrastructure. This function lessens the main power grid's susceptibility to outside influences by decreasing grid fluctuations and offering a certain level of energy independence.

1.6 SDG GOAL MAPPING

- Quality Education (SDG 4)
- Affordable and Clean Energy (SDG 7)
- Decent Work and Economic Growth (SDG 8)

1.7 ORGANIZATION OF THE THESIS

We will discuss the methods of achieving the goals in the methodology chapter along with the results. In next chapter we will review the literature related to our project in which we will discuss the limitations of previous work and the gaps in their work which we will fill in our project. In chapter 3 we will discuss about the method and techniques through which we will design our project. In chapter 4 we will discuss about the experiments and its results, in chapter 5 we will discuss about the results and finally in the last chapter i.e. chapter 6 we will conclude with the future area of research in our project.

CHAPTER 2

2. REVIEW OF LITERATURE

2.1 ENVIRONMENTAL ANALYSIS OF AN OPTIMAL HYBRID SYSTEM

Li Xu, Ying Wang, Yasir Ahmed Solangi, Hashim Zameer, and Syed Ahsan Ali Shah (May 22, 2019) explore the feasibility and commercial viability of off-grid solar PV systems in Pakistan's isolated rural areas. The capacity for solar energy generation is increased by the results, which demonstrate acceptable solar irradiance and an appropriate tilt angle. The system offers electricity for PKR 6.87/kWh, making it more affordable than other energy sources. The off-grid PV system can also reduce CO_2 emissions on an annual basis, aiding the government's use of this technology in isolated rural areas. In five rural areas of Sindh province, this study assesses the techno-economic viability of installing solar PV systems off the grid. The outcomes indicate that installing these technologies can improve solar energy output and reduce CO_2 emissions. These technologies are less expensive than traditional electricity sources, according to the study. For the purpose of installing off-grid solar PV systems in these areas, the government must plan and provide a solid policy framework. [16]

Ramhari Poudyall, Pavel Loskotss, and Ranjan Parajuli (2021) examine the techno-economic feasibility of installing a 3-kWp photovoltaic (PV) system in Kathmandu, Nepal, and its potential to contribute to the country's energy generation mix. The study uses PVsyst and Meteonorm simulation software to assess the system's technical viability. The results show that the system can generate 100% of the electricity consumed by a typical residential household in Kathmandu, with a levelised cost of energy of 0.06 $/kWh and a payback period of 8.6 years. The installation of the solar PV system could save 10.33 tons of CO_2 emissions over its lifetime. The study suggests that government policies and implementations can play crucial roles in developing a decentralized energy system and that rooftop PV solar potential should be evaluated on a broader scale. [17]

A. Karthick, V. Kumar Chinnaiyan, J. Karpagam, V.S. Chandrika, and P. Ravi Kumar (September 2021) described a healthcare facility in Chennai, India, where hybrid energy resources combine solar photovoltaic and wind energy to produce 4,437 kWh/year and 577 kWh/year, respectively. To optimize the system, the HOMER software is used. In the summer and on windy days, the system produces 584 kWh/year of electricity. The system has a 0.86 renewable energy component and reduces carbon dioxide emissions by about 495 kg annually. The capacity of a hybrid energy system for Chennai's intelligent city area is estimated by the HOMER optimization tool. The system generates 3771 kWh/year of capacity through the combination of wind turbines and photovoltaic modular power generation. Integrating the system enables independent buildings and zero-energy structures, assisting stakeholders in remote electrification using renewable energy. [18]

Ravi Chaurasia, Sanjay Gairola, and Yash Pal (August 31, 2021) this research offers an optimized off-grid integrated renewable energy system (REES) that combines solar photovoltaic (SPV) and battery energy storage (BES) for low-load profiles in remote, hilly places such as village Dewal in Uttarkashi district, Uttarakhand, India. The system lowers greenhouse gas emissions by 28.61%, LCOE, NPC, and unmet load by 14.73%, 28.61%, and 28.70%, respectively. Additionally, the technology lowers annual greenhouse gas emissions by at least 21545 kg and diesel usage by at least 8113 L. Furthermore, only 0.02% of the unmet demand percentage is used to produce 13.9% of the extra energy produced annually. For the research region, the best energy option is suggested by the study to be a resource configuration with SPV (21 kW), BES (5707.8 kW), and a converter (12 kW). The suggested SPV/BES-based IRES can meet future energy demands and is independent, cost-effective, and environmentally benign. [19]

Muhammad Aqil Afhan Rahmat, Ag Sufiyan Abd Hamid, and Yuanshen Lu (October 21, 2022) identified the best renewable energy technology combination for Malaysian scenarios. Two scenarios exist in Pekan, Pahang, and Mersing, Johor. To optimize the system, HOMER software is used. The result shows that the most economical choice for the selected location is the PV-wind hybrid system, with a net present cost (NPC) of $317,505 in scenario 1 and $659,990 in scenario 2, and payback periods with faster payback periods, higher savings, and reduced pollutants. The study found that a PV-wind hybrid system is preferable to a single renewable energy (RE) technology on rural residential properties, offering faster returns, cost savings, and fewer pollutants. [20]

Faizan A. Khan, Nitai Pal, Syed H. Saeed, and Ashiwani Yadav (10 February 2022) described the ideal size and design concept for a standalone hybrid renewable energy system (HRES) to electrify a rural Indian community. The HOMER software performed the complete simulation and optimization of the hybrid power system. The system includes 20 kW of photovoltaic modules, 4 kW of wind turbines, and 13 kW of DG, with energy costs and net present costs of $34,344 and $0.152 per kWh, respectively. With an annual cumulative CO_2 emission of 48,440 kg and a renewable portion of 97.7%, the system delivers respectable environmental results. The system delivers environmental benefits, enhances the human development index (HDI), local employment, and social lives. The study evaluates standalone hybrid solutions and identifies low-cost, high-reliability alternatives using solar and wind energy sources. [21]

Yasir Basheer, Asad Waqar, Saeed Mian Qaisar, Toqeer Ahmed, Nasim Ullah, and Sattam Alotaibi (September 29, 2022) explore the use of hybrid energy in Pakistani cement plants, focusing on the potential of off-grid hybrid energy models (HEMs). The study analyzed five cement plants, and four models were taken into consideration: HEM-1 was comprised of PV, a converter, and a fuel cell. HEM-2 had only acted as a base case in this study. HEM-3 had solar panels and a battery-converter system. In HEM-4, diesel generators, PV, and converters were considered, and HEM-4, which had a 0.249 USD/KWh LCOE, was the optimal model. The proposed HEMs could provide 24 hours of electricity with minimal environmental impact, reducing CO_2 emissions by 29.80% compared to the base case. The study also found that HEM-1 and HEM-3 were the best models with 0% GHG emissions. [22]

Md. Rasel Ahmed, Md. Rokib Hasan, Suharto Al Hasan, Muhammad Aziz, and Md. Emdadul Hoque (4 February 2023) this research is intended to reduce the net present cost (NPC), cost of energy (COE), and CO_2 emissions of a hybrid renewable energy system (HRES). The study chooses the best grid-connected system for hospital, diagnostic, educational, and operating room loads using HOMER Pro software. The best choice is the metric real-time rate (year), since total NPC and COE are favorite economic criteria. This research examined the use of hybridized structures. It compares the proportional benefits and drawbacks of seven distinct hybrid system scenarios to determine what arrangement is best based on lower energy costs, fewer pollution emissions, and other factors. The hybrid PV/Battery/DG system, which consists of a 224 kWh battery bank, a 340 kW DG set, and 47 kW PV modules, is an effective design for supplying the 3750 kWh daily load demand. The COE and NPC of the improved hybrid structure design are 0.0445 USD/kWh and USD 3,464,268, respectively. Compared to kerosene-based lighting and grid-connected power, it is less expensive than a diesel-based energy system and lowers operational CO_2 emissions. [23]

N. Chinna Alluralah and P. Vijayapriya (30 June 2023) The aim of this study is to create the best hybrid micro grid system possible for Doddipalli village in Chittoor, Andhra Pradesh, India. In order to produce hydrogen, the system combines a grid-integrated hybrid micro grid system

(GIHMGS) with a hydrogen tank. The system features a high renewable energy proportion, a low levelised cost of energy, CO_2 emission and a minimum net present cost. PV/WT/Grid is the best design since it offers dependable power at a cheap cost of generation. According to the research, this hybrid system works well in isolated locations. [24]

Refat Al Afif, Yasmie Ayed, Omer Nawaf Maaitah (2023) this research evaluates the techno-economic viability of off-grid and on-grid hybrid renewable energy systems in Jordan's Al-Karak governorate. Using HOMER Pro software, it evaluates the feasibility of integrating renewable energy into hybrid systems. The study finds that a PV/Wind system connected to the grid with batteries is the optimal configuration for sustainable electrification, offering low net present and levelised costs, high renewable energy share, and improved environmental quality. [25]

2.2 ECONOMIC FEASIBILITY ANALYSIS

H. Umar, M. Amudy, and T.A. Rizal (2019) the aim of this research paper is that Universitas Samudra (UNSAM) in Aceh Province, Indonesia, plans to expand secondary school graduates' access to higher education by constructing green buildings. The campus has nine buildings with a total roof area of 11,232 m2, making it suitable for solar photovoltaic installation. A study analyzing the economic feasibility of solar photovoltaic systems on the UNSAM campus found that the installation is economically beneficial, with an economic payback of Rp. 1,990/kWh. The economic potential of the PV system depends on the building's geography and direction of installation. [26]

Amjad Iqbal and M. Tariq Iqbal (23 April 2019) In this paper, the thermal modeling of a rural Pakistani home using building energy optimization (BEopt) to calculate the hourly load profile is shown. Using HOMER Pro, a standalone PV system with a 5.8 kW PV, eight 12 V, 255 Ah batteries, and a 1.4 kW inverter was designed. The system accommodates appliance and lighting loads in rural homes. For household loads, simulation results indicate consistent voltage and frequency. Different parts of the world can use the methodology and analysis. [27]

Sureshkumar, Dr. P.S. Manoharan, and A.P.S. Ramalakshm (8 December 2020) analyzed the optimal cost of a hybrid renewable energy system (HRES) using the Hybrid Optimization Model for Electric Renewable (HOMER). The software is used to design and analyze hybrid power systems combining conventional generators, cogeneration, wind turbines, solar photovoltaics, hydropower, batteries, fuel cells, hydropower, and biomass. The study finds that a combination of PV, WG, and battery is the optimal off-grid system for Mandapam, Tamil Nadu, India. The cost of generating energy from this system is 0.235 KWh. The paper also provides a cash flow summary for the optimal cost allocation of each component in the system. [28]

Mubarick Issahaku, Emmanual Dovia, Saani Adam Sandow, and Khadija Sarqual (4 August 2021). The aim of this research paper is that grid-connected solar PV systems can lower startup costs and offer an affordable solution for a restaurant in Ghana. A grid-connected solar PV system, which was determined to be the optimum alternative for the 25-year project, had its viability tested in this study. The system, which included a 25.7 kW inverter and a 35.8 kW monocrystalline solar PV collector, met 73.3% of the load demand for a net present cost (NPC) of $72,521 with low operating costs. This analysis validates the economic viability of Ghana's solar development. By installing solar PV systems and feeding the national grid with excess energy, private network-connected producers may reduce the demand for electricity from the grid. [29]

Khaled Mohammad Shifuallah Bhuiyal, Md. Mostafizer Rahman Rony, Sabbir Ahed Udoy Shownitro Bhowmilk, Nahid Imtiaz Masuk, and A K M Saif Shairar (December 2022) this paper presents a case study analyzing six different power system configurations using the Hybrid Optimization Model for Electric Renewables (HOMER) software for a university campus in Bangladesh. The study found that the PV-Wind Turbine-Grid configuration is the most economic, with a minimum energy cost of $0.0895 and a minimum net present cost of $4,972.47. This configuration consists of PV arrays with a capacity of 1.25 KW, a capital cost of $809, and an annual production of 1748 KWh. The simulation results show that this system has a good percentage of renewable penetration and is 72.1% less environmentally friendly than a power system using only a diesel generator. [30]

Isaac Amoussou, Emmanuel Tanyi, Ahmed Ali, Takele Ferede Agajie, Baseem Khan, Julien Brito Ballester and Wirnkar Basil Nsanyuy (9 January 2023) This study looks at the installation of renewable energy facilities in northern Cameroon to replace light fuel oil (LFO) thermal power plants. There are three different scenarios: PV-Wind-PHSS, wind with a pumped hydro storage system, and solar photovoltaic (PV) and a PHSS. Based on total cost and loss of load probability (LOLP), the total cost of various scenarios is assessed. MATLAB software was used to apply the non-dominated sorting whale optimization algorithm (NSWOA) and non-dominated sorting genetic algorithm-II (NSGA-II). Hourly weather data and the hourly electricity produced by the thermal power plants connected to the electrical grid were used to calculate the ideal component sizing. Both algorithms yielded acceptable outcomes. Compared to Wind-PHS and PV-PHSS, the PV-Wind-PHSS scenario at LOLP 0% has a total cost that is 4.6% and 17% lower, respectively. [31]

2.3 TECHNO-ECONOMIC FEASIBILITY ANALYSIS

Sunaina and Baboria Harpreet Kaur's (March 11, 2020) described the techno-economic feasibility analysis of the load patterns and renewable energy sources of a solar hybrid energy system in Patyari Kaltan, Jammu, India. The system described in this paper includes solar panels, batteries, and wind turbines. Using HOMER software, the study assesses the potential of hybrid energy systems in Jammu province. The Patyari Kaltan Jammu solar PV hybrid arrangement is optimized, its sensitivity is observed, and its applicability in urban and rural locations is established. With a net present cost of Rs. 9914019.93 and a cost of energy (COE) of Rs. 2.33/kWh, the ideal system for the chosen location consists of a 282 kW solar PV array, 98.6 kW converters, and 19 parallel strings of batteries. The solar-battery hybrid model satisfies the load requirements in the chosen location, according to sensitivity analysis. [32]

Seyma Emec and Gokay Akkaya (March 11, 2020): This study explores how the increasing population in Turkey necessitates a shift towards renewable energy sources (RESs) to meet the country's growing energy demand. This paper investigates the feasibility of providing a university's electrical energy needs with hybrid systems (HSs) using the HOMER program. The study identifies scenario 4 as the optimal solution, with the lowest initial cost of $67,000. The optimum system consists of a 25 kW PV module and a grid, with a net present cost of $28,273,000. This is the first time this issue has been investigated using the HOMER program for universities in Turkey. The study contributes to the literature on renewable energy sources for universities in Turkey. [33]

Muhammad Sharjeel Ali, Syed Umaid Ali, Saeed Mian Qaisar, Asad Waqar, Faheem Haroon, and Ahmad Alzahrani (6 December 2022) the thrust of this research paper is that Pakistan's third deep-water port, Gwadar, has load shedding because there is no electric grid. In order to solve this, three models were taken into consideration in a study that used the Hybrid Optimization Model for Multiple Energy Resources (HOMER) software: solar cells, wind turbines, converters, and batteries. With a payback period of 4.98 years and the lowest LCOE and renewable fraction of 73.3%, Model 2 was determined to be the best option based on the results. Pakistan buys power from Iran because Gwadar city lacks a national grid. A study looked into micro grids that used PV modules and wind turbines to solve this problem. Three models were taken into consideration: Model 1 consisted of photovoltaic (PV) cells, wind turbines, converters, and batteries. Model 2 consisted of PV cells, wind turbines, converters, and a grid. Model 3 consisted of PV cells, wind turbines, converters, and diesel generators. The USD 0.401/kWh, USD 0.0347/kWh, and USD 0.185/kWh COEs were the respective amounts. The short payback duration [34]

T.M.I. Riayatsyah, T.A. Genumpana, I. M. Rizwanaul Fattah, Samsul Rizal, and T.M. Indra Mahlia (June 24, 2022) examined the techno-economic performance and optimization of grid-connected PV, wind turbines, and battery packs for Syiah Kuala University in Sumatra, Indonesia. Renewable energy is optimized using the HOMER (Hybrid Optimization Model for Electric Renewables) model. Wind turbines and solar PV each made a 62% and 20% contribution, respectively. Energy prices decreased from $0.060 per kWh to $0.0446 per kWh. The system is capable of supplying up to 82% of the required electricity. According to research using HOMER software, the system would use a 100 kW wind turbine, a 431 kW converter, and 682 kW of solar PV to power the institution. Low electricity costs in Indonesia, which are mostly caused by inexpensive coal generation, are the biggest barrier to the use of renewable energy. [35]

Sheeraz Iqbal, Mishkat Ullah Jan, Anis-Ur-Rehman, Atiq-Ur-Rehman, Aqib Shafiq, Haseeb-Ur-Rehman, and Muhammad Aurangzeb (6 January 2022) The thrust of this research paper is that for the King Abdullah Campus, the University of Azad Jammu and Kashmir Muzaffarabad installed a hybrid power network (PV/Battery/Grid). To optimize the system, the HOMER software is used. This technology reduces energy expenses by up to Rs. 0.251 per kWh and is more reliable, stable, economical, and ecologically friendly than previous systems. The system allows for continuous power supply for instructional, administrative, and experimental operations while also optimizing real-world performance. The current on-grid hybrid system's COE is Rs. 27.32/kWh, which shows that solar energy can cut energy prices by up to Rs. 251/kWh when used effectively. [36]

Arpan Dwivedi, Yogesh Pahariya (14 June 2023) In this research article, two energy models PV alone and PV-Hydro—are used to investigate the viability of power generation for rural electrification in India. The study creates a simulation model to assess the region's solar potential using HOMER PRO software. Findings indicate that renewable energy sources work well; the PV/Hydro system lowers overall costs by 1.22 and 13.25 per kWh. Additionally, the study offers a useful site investigation for supplying electricity need. The HOMER PRO software is used to assess the techno-economic feasibility analysis and determine the ideal cost of the total NPC and COE. [37]

Takele Ferede Agajie, Ahmed Ali, Armand Fopah Lele, Isaac Amoussou, BaseemKhan, Carmen Lili Rodriguez Velasco and Emmanuel Tanyi (5 January 2023) The focus of this study is on hybrid renewable energy power production systems with an emphasis on environmental friendliness, energy sustainability, techno-economic feasibility, and reliability. The optimal sizing strategy for hybrid renewable energy sources (HRES) is described by the authors, taking into account important elements, characteristics, procedures, and data. Goal functions, design restrictions, system elements, optimization software tools, and meta-heuristic algorithm techniques are also covered. Along with discussing current problems brought on by scaling HRES, the report makes recommendations for additional research. The primary findings indicate that by introducing FITs for loads in grid-connected HRES, the percentage of HRES that uses renewable energy resources can be increased, resulting in decreased power prices and money generation for the community. Efficient component sizing requires new software tools and meta-heuristic optimization techniques. [38]

CHAPTER 3

3 RESEARCH METHODOLOGY

This chapter provides a full explanation of our study technique, which includes the careful study of solar, wind, etc. locations as well as the design, simulation, and optimization of the components of the hybrid energy system. Our main instrument for this assessment is the software called Hybrid Optimization Model for Electric Renewables, or HOMER.

In our study The HOMER software is widely used in our research since it is a useful tool for assessing the production potential of hybrid systems. This software can create a wide range of hybrid system configurations with various components such solar PV modules, wind turbines, generators, batteries, and converters.

The process of creating an optimal hybrid energy system at BUITEMS University involves selecting the university, estimating power requirements, researching available renewable resources, activating the HOMER program, using MATLAB/Simulink to simulate the system, and then analyzing the harmonics of the system. This step-by-step procedure involves determining the best location, estimating power requirements, researching available resources, and analyzing the details. as shown in Figure 3.1.

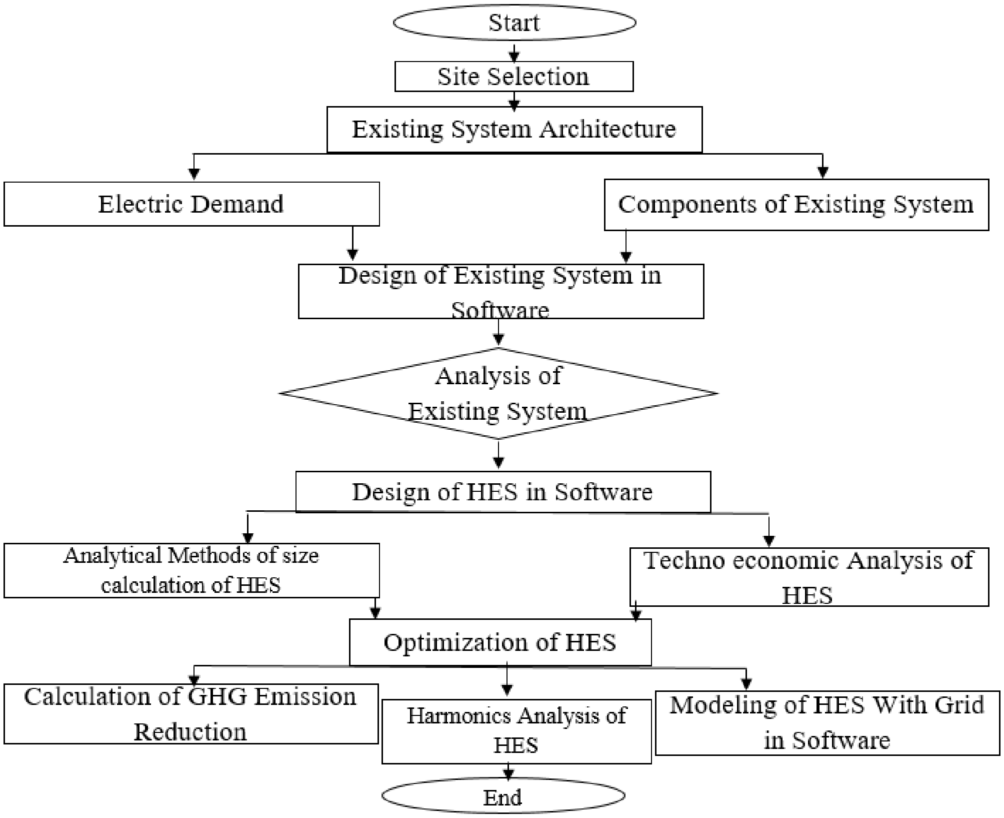
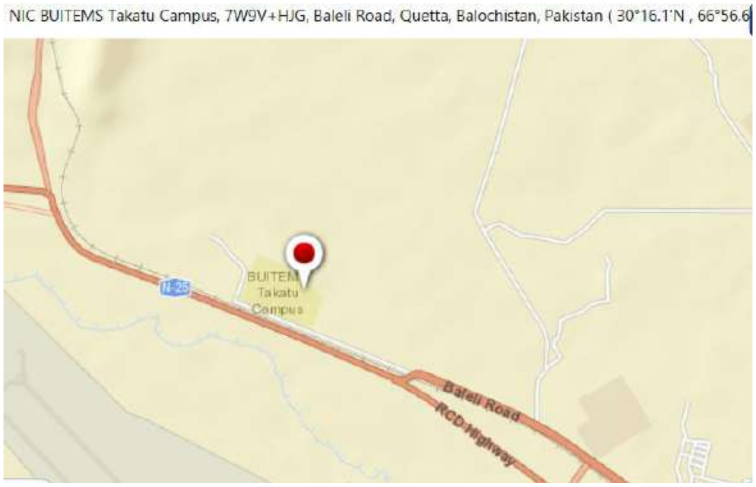


Figure 3.1. Schematic layout of present work

3.1 SITE DETAILS

The consider site in the study is BUITEMS campus, located on Baleli Road in Quetta, Pakistan, which includes both flat and hilly land. The latitude and longitude of BUITEMS are 30°17.9'N and 66°56.0'E, respectively, with an associated time zone of UTC+C05.00 (Islamabad). The geographical location of BUITEMS is depicted in Figure 3.2.



NIC BUITEMS Takatu Campus, 7W9V+HJG, Baleli Road, Quetta, Balochistan, Pakistan (30°16.1'N , 66°56.6

Figure 3.2. Geographical location of BUITEMS on HOMER

This map illustrates the layout of the Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS) campus, highlighting key academic buildings, facilities, and surrounding areas.

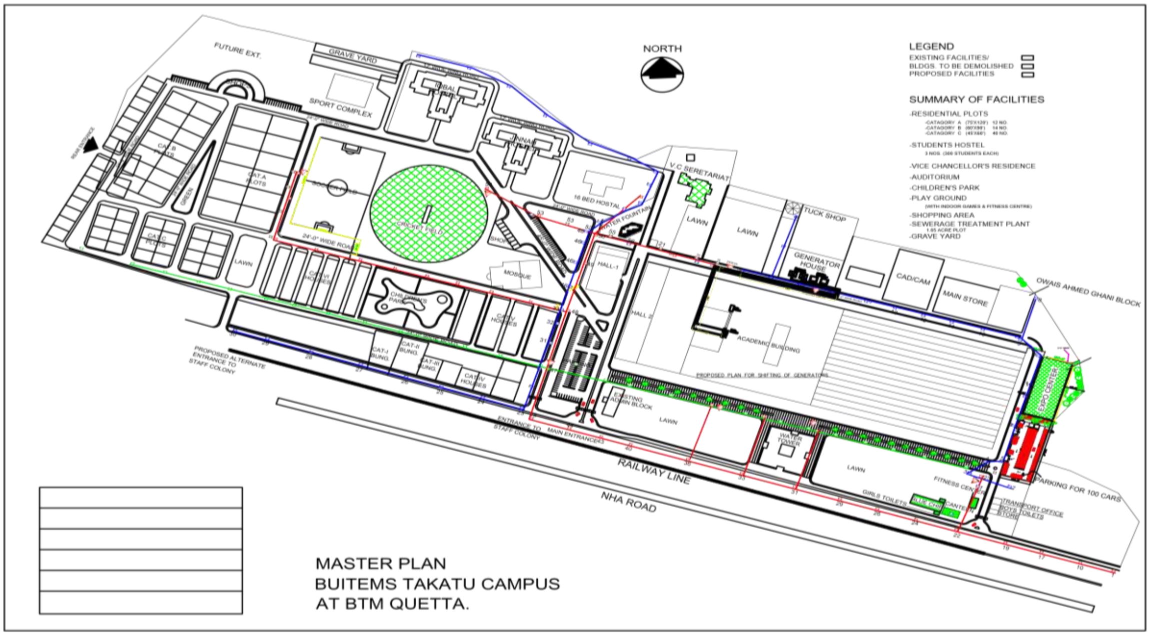


Figure 3.3. Map of the BUITEMS Campus

3.2 MODELING STATISTICS

3.2.1. ELECTRIC LOAD

BUITEMS University's electrical load consumption varies according to discrete peak and off-peak times. There is a clear correlation between these times and what goes on campus. Peak times, which are 9 a.m. to 5 p.m., are when academic and administrative activities are at their highest, which results in a significant rise in electricity usage. Based on the data presented in Table 3.1, the total daily electricity usage at BUITEMS University is 3258.824 kilowatt-hours (KWh). Table 3.2 illustrates that of these total units, 2316.744 KWh are consumed daily during peak hours, and 942.08 KWh are consumed during off-peak hours. Following that, Table 3.3 presents and summarizes these data to give a thorough picture of the electrical load based on working and non-working days, taking into account both peak and non-peak times. This table, which details the precise electricity usage trends at various times, is an essential point of reference for strategic planning related to resource allocation and energy optimization at BUITEMS University.

Table 3.1: Units consumed on working days from Friday to Monday (peak and off-peak) load profile for BUITEMS per day.

Time(hr)	FICT	Admin	NIC	Central Store	EXPO	OAG	JICA Hall	Central ENG	Textile Lab	New/ FMS Block
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
11	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
12	33.12	7.36	40.48	3.68	10.12	6.44	6.44	7.36	6.44	43.608
13	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
14	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
15	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
16	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
17	33.12	7.36	40.48	3.68	0	6.44	6.44	7.36	6.44	43.608
18	0	0	0	0	0	0	0	0	0	0
19	0		0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0
Addition	**264.96**	**58.88**	**323.84**	**29.44**	**10.12**	**51.52**	**51.52**	**58.88**	**51.52**	**348.864**

Table 3.1: Units consumed on working days from Friday to Monday (peak and off-peak) load profile for BUITEMS per day.

Power House	**CEPEC**	**New Library**	**New Block FOE**	**SSA Block**	**VC Office**	**Bachelor Hostel**	**Architure/Hall1**	**Tube Well(8)**	**Female Hostel**	**Faculty Hostel**
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3.68	0	0	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
2.76	9.2	8.28	11.96	27.6	7.36	3.68	12.88	11.04	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
0	0	0	0	0	0	3.68	0	0	5.52	5.52
22.08	**73.6**	**66.24**	**95.68**	**220.8**	**58.88**	**58.88**	**103.04**	**88.32**	**88.32**	**88.32**

Table 3.1: Units consumed on working days from Friday to Monday (peak and off-peak) load profile for BUITEMS per day.

Jinnah Hall	Iqbal Hall	WTR(Lab)	Sport Complex	Colony	Masjid	Takatu Lodges	Flats	Tube Well(12)	Markhor Auditorium	Tube Well(8)	Addition
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	2.76	0	9.2	0	0	0	24.84
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	0	0	9.2	0	0	0	22.08
0	0	0	0	12.88	0	0	9.2	0	0	0	36.8
0	0	0	0	12.88	0	5.52	9.2	0	0	0	42.32
7.36	7.36	2.76	7.36	12.88	0	5.52	9.2	7.36	0	12.88	333.408
7.36	7.36	2.76	7.36	12.88	0	5.52	9.2	7.36	0	12.88	333.408
7.36	7.36	2.76	7.36	12.88	0	5.52	9.2	7.36	7.36	12.88	350.888
7.36	7.36	2.76	7.36	12.88	2.76	5.52	9.2	7.36	0	12.88	336.168
7.36	7.36	2.76	7.36	12.88	2.76	5.52	9.2	7.36	0	12.88	336.168
7.36	7.36	2.76	7.36	12.88	0	5.52	9.2	7.36	0	12.88	333.408
7.36	7.36	2.76	7.36	12.88	2.76	5.52	9.2	7.36	0	12.88	336.168
7.36	7.36	2.76	7.36	12.88	2.76	5.52	9.2	7.36	0	12.88	336.168
0	0	0	7.36	12.88	2.76	5.52	9.2	7.36	0	0	59.8
0	0	0	7.36	12.88	2.76	5.52	9.2	7.36	0	0	59.8
0	0	0	7.36	12.88	0	5.52	9.2	7.36	0	0	57.04
0	0	0	7.36	12.88	2.76	0	9.2	7.36	0	0	54.28
0	0	0	0	12.88	0	0	9.2	0	0	0	36.8
0	0	0	0	12.88	0	0	9.2	0	0	0	36.8
58.88	**58.88**	**22.08**	**88.32**	**309.12**	**22.08**	**66.24**	**220.8**	**88.32**	**7.36**	**103.04**	**3258.824**

Three Tables 3.1 provides an overview of BUITEMS University's electricity usage during off-peak hours, particularly in residential areas like apartments, hostels, and colonies. These hours are typically late nights or early mornings, with fewer academic activities and administrative responsibilities. This decrease in electricity demand is primarily due to reduced energy usage in residential settings. Understanding these patterns helps optimize energy management tactics, allowing for adjustments to scheduling and energy-saving techniques.

Table 3.2: units consuming on weekend’s (peak and off peak) load profile for BUITEMS per day

Bachelor Hostel	Female Hostel	Faculty Hostel	Colony	Masjid	Takatu Lodges	Flats	Tube Well(8)	Addition
0	0	0	12.88	0	0	9.2	0	22.08
0	0	0	12.88	0	0	9.2	0	22.08
0	0	0	12.88	0	0	9.2	0	22.08
0	0	0	12.88	0	0	9.2	0	22.08
0	0	0	12.88	0	0	9.2	0	22.08
0	0	0	12.88	2.76	0	9.2	0	24.84
0	0	0	12.88	0	0	9.2	0	22.08
0	0	0	12.88	0	0	9.2	0	22.08
3.68	5.52	5.52	12.88	0	0	9.2	0	36.8
3.68	5.52	5.52	12.88	0	5.52	9.2	0	42.32
3.68	5.52	5.52	12.88	0	5.52	9.2	11.04	53.36
3.68	5.52	5.52	12.88	0	5.52	9.2	11.04	53.36
3.68	5.52	5.52	12.88	0	5.52	9.2	11.04	53.36
3.68	5.52	5.52	12.88	2.76	5.52	9.2	11.04	56.12
3.68	5.52	5.52	12.88	2.76	5.52	9.2	11.04	56.12
3.68	5.52	5.52	12.88	0	5.52	9.2	11.04	53.36
3.68	5.52	5.52	12.88	2.76	5.52	9.2	11.04	56.12
3.68	5.52	5.52	12.88	2.76	5.52	9.2	11.04	56.12
3.68	5.52	5.52	12.88	2.76	5.52	9.2	0	45.08
3.68	5.52	5.52	12.88	2.76	5.52	9.2	0	45.08
3.68	5.52	5.52	12.88	0	5.52	9.2	0	42.32
3.68	5.52	5.52	12.88	2.76	0	9.2	0	39.56
3.68	5.52	5.52	12.88	0	0	9.2	0	36.8
3.68	5.52	5.52	12.88	0	0	9.2	0	36.8
58.88	**88.32**	**88.32**	**309.12**	**22.08**	**66.24**	**220.8**	**88.32**	**942.08**

Table 3.3. Electrical load Estimation on the basis of peak and off-peak hours and per day, per month, per year for BUITEM.

Sr No	**Building name**	**Units consumption in Operating hours**	**Units consumption in Non-Operating hours**
1	FICT, Admin Block	323.84	0
2	NIC, Central store, Expo, OAG Hall, JICA Hall, Central Eng., Textile Lab	576.84	0
3	New/ FMS Block	348.864	0
4	Power House, CEPEC, New Library, New Block FOE, SSA Block, VC Office, Hall1	640.32	0
5	Bachelor Hostel A.Tube Well, Female Hostel, Faculty Hostel	0	323.84
6	Jinnah Hall, Iqbal Hall, WRT(Lab), , Sport Complex	228.16	0
7	Colony, Masjid	0	331.2
8	Takatu Lodges, Flats	0	287.04
9	Blue Chip. Tube Well, F.H.Tube Well, Markhor Auditorium	198.72	0
		2316.744	**942.08**
	Addition	**2316.744+942.08**	
	Total units	**3258.824 kwh/d**	

Table 3.3. Electrical Load Estimation for BUITEMS (per day, per month, and per year). These are the total units of all places in Buitems working days of a week (from Monday to Friday) per day, and if we calculate the units of the same value (3258.824) per month, then in one month there are 22 working days out of 30 and the rest of 8 days are weekends, so the total units consumed of BUITEMS during working days (Monday to Friday per month) amount to 2,316.744 KWh/d, calculated by multiplying the daily consumption of 3,258.824 kilowatt-hours by 22 days in a month. Now those places in Buitems that operate all 7 days of the week, like the bachelor hostel, female hostel, faculty hostel, colony, masjid, Takatu lodges, flats, and tube well, as we have calculated their units from Monday to Friday, now calculate the units for these places on the

weekend. On weekends, there are 942.08 KWh/d units per day, and if we find the units of the same value (9,42.08) per month, then in one month, there are 4 weekends, or 8 days**,** so the total units consumed during weekends per month amount to 7,536.64 KWh/d, calculated by multiplying the daily consumption of 9,42.08 kilowatt-hours by 8 days in a month.

The combined total units consumed during working days (Monday to Friday per month) and weekends amount to 79230.768 KWh/d, derived from the sum of 71694.128 units for working days and 7536.64 units for weekends per month. The monthly unit consumption for 11 months in a year totals 871,536 kilowatt-hours (kWh), calculated from the average monthly consumption of 79230.768 kWh.

In February, the consumption amounts to 2637.24 kWh, calculated based on the daily usage of 942.08 kWh over 28 days.

When combining the yearly load consumption from these figures, the total consumption stands at 897916.6 kWh.

On average, the daily consumption over the course of a year equals approximately 2460.92 kWh/d, derived from dividing the yearly consumption (897916.6 kWh) by 365 days.

3.4. PEAK LOAD PROFILE FOR BUITEMS

The electrical peak load profile for BUITEMS University during the weekdays (Monday to Friday) outlines the university's highest energy consumption periods. Peak load periods align with the university's busiest hours, such as class schedules, laboratory usage, and administrative activities, providing insights into maximum energy usage patterns. The daily load profile for BUITEMS in KWh (per day) graphical representation shows the university’s consumption patterns on a day-to-day basis, revealing peak usage periods and trends over a 24-hour cycle, as presented in Figure 3.4.

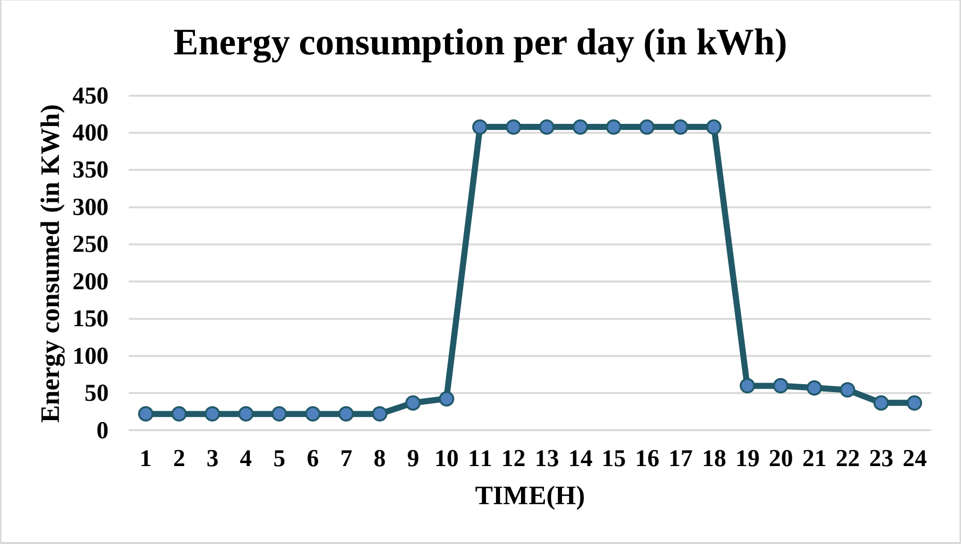


Figure 3.4. Energy consumed BUITEMS per day (in KWh)

Throughout the year, especially in February, when the institution is closed, the off-peak load profile for the BUITEMS institution shows that residential areas, including apartments, colonies, and hostels, are at lower levels compared to operational months. The load profile clearly reflects the energy usage patterns of these residential regions during this period of time, when academic and administrative operations have concluded. The monthly load profile of BUITEMS in KWh, a graphical representation that shows the university's consumption patterns per month, is presented in Figure 3.5.

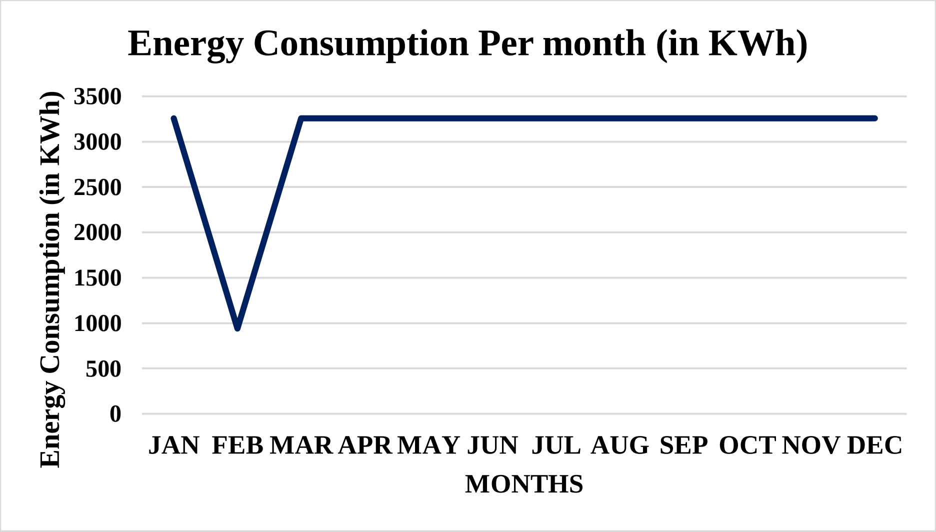


Figure 3.5. Energy consumed by BUITEMS per month (in KWh)

3.5 EXISTING SYSTEM OF BUITEMS

3.5.1 DETAILS OF GENERATORS OF BUITEMS

A variety of generators are available from BUITEMS, such as a 1200 KVA unit located in the power house, a 312 KVA unit, and mobile 100 KVA generators, among others. To provide dependable electricity distribution in the event of load shedding, nine generators are strategically located. Table 3.4. shows the details of the generators of BUITEMS.

Table 3.4. Details of Generators of BUITEMS

Sr No	Capacity of Generators and Location	Capital Cost (Rs)	Optinance and Maintenance cost (Rs/op. hr)
1	1200 KVA, Power House	Rs. 6,800,000	47438
2	312 KVA, Power House	Rs. 39,000,000	46477
3	210 KVA, City Campus	Rs. 5,000,000	48277
4	100 KVA, Data Center	Rs. 1,650,000	900001
5	100 KVA, Mobile Generator	Rs. 1,650,000	900001
6	34 KVA, Executive Block	Rs. 445,000	27945
7	35 KVA, for Takatu Lodges	Rs. 445,000	194152
8	20 KVA, Lying at Power House	Rs. 1,000,000	47736
9	10 KVA, Lying at Power House	Rs. 172,000	86743

The primary power source for BUITEMS University is the main grid supply, providing electricity during regular hours. There are eight transformers in different locations. During load-shedding hours or power disruptions, the university relies on generators to fulfill its requirements. There are nine diesel generators with different capacities to supply power directly to the electrical load. These diesel generators are integrated into the university's electrical system and connected to the AC bus to provide direct power to the loads when needed. During load-shedding hours, these generators are responsible for meeting the entire electrical demand of the university. Conversely, during regular hours when the grid supply is stable, the system relies on the main grid to power all loads. This setup ensures continuity of power supply during grid disruptions but comes at a cost due to the reliance on diesel, which can be expensive, especially with transportation expenses factored in. The details of generators in BUITEMS are presented in Table 3.6.

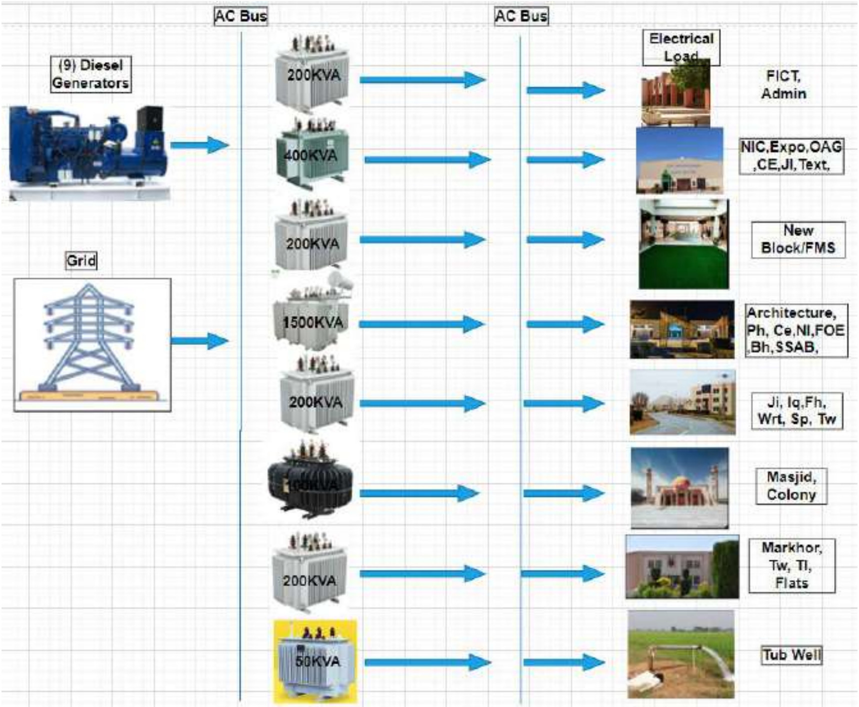


Figure 3.6. Schematic Diagram of existing system

The complex arrangement of the electrical system of BUITEMS is shown in Figure 3.6, which also illustrates the interactions between different parts such as distribution networks, generators, and consumer endpoints. It provides a graphic representation of the flow of power inside the university's electrical setup, including connections and routes.

3.6 ELECTRICAL LOAD PROFILE

3.6.1. PEAK LOAD PROFILE FOR BUITEMS

The load profile of the BUITEMS university has a total peak load of 350.89 kw, with added consideration for variation of 0% from day to day and hour to hour in Homer software. Table 3.5 shows the yearly electrical peak load profile of the interest area. The load demand starts to peak after 9 a.m.

Table 3.5: Yearly electrical peak load profile of BUITEMS on HOMER

Yearly Electrical Peak Load Profile(in KW)												
Hours	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
0	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
1	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
2	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
3	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
4	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
5	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840
6	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
7	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
8	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800
9	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320
10	333.408	53.360	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408
11	333.408	53.360	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408
12	350.888	53.360	350.888	350.888	350.888	350.888	350.888	350.888	350.888	350.888	350.888	350.888
13	336.168	56.120	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168
14	336.168	56.120	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168
15	333.408	53.360	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408	333.408
16	336.168	56.120	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168
17	336.168	56.120	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168	336.168
18	59.800	45.080	59.800	59.800	59.800	59.800	59.800	59.800	59.800	59.800	59.800	59.800
19	59.800	45.080	59.800	59.800	59.800	59.800	59.800	59.800	59.800	59.800	59.800	59.800
20	57.040	42.320	57.040	57.040	57.040	57.040	57.040	57.040	57.040	57.040	57.040	57.040
21	54.280	39.560	54.280	54.280	54.280	54.280	54.280	54.280	54.280	54.280	54.280	54.280
22	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800
23	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800

3.6.2. OFF-PEAK LOAD PROFILE FOR BUITEMS ON HOMER

The BUITEMS University's off-peak load profile shows its electricity consumption during periods of minimal activity and lower energy demand, like unit consumption by flats, colonies, hostels, etc. These periods occur during late evenings, early mornings, or other times when academic activities are minimal, administrative operations are limited, and facility usage is reduced. Table 3.6. shows the yearly electrical off peak load profile of the interest area.

Table 3.6: Yearly electrical off peak load profile of BUITEMS on HOMER

Yearly Electrical off Peak Load Profile												
Hours	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
0	22.080	22.080	22.080	2s2.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
1	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
2	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
3	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
4	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
5	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840	24.840
6	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
7	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080	22.080
8	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800
9	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320
10	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360
11	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360
12	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360
13	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120
14	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120
15	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360	53.360
16	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120
17	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120	56.120
18	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080
19	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080	45.080
20	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320	42.320
21	39.560	39.560	39.560	39.560	39.560	39.560	39.560	39.560	39.560	39.560	39.560	39.560
22	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800
23	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800	36.800

3.7. OPTIMIZATION RESULTS

3.7.1 COMPONENTS OF EXISTING SYSTEM

Three primary parts make up the current system: the grid, the generators, and the load. The annualized cost of the current system is shown in Figure 3.7.

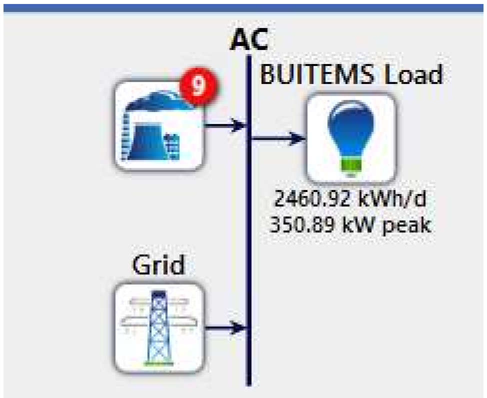


Figure 3.7. Schematic diagram of existing system.

3.7.2 HOMER OPERATION

When BUITEMS' generators are inactive, the facility only relies on the grid, incurring a net present cost of Rs. 2.50 million with an associated energy cost of Rs. 34.7 per unit, as indicated in Figure 3.6. In contrast, the current system shows a greater net present cost of Rs. 2.43 billion along with an elevated energy cost of Rs. 198.06 per unit when BUITEMS' generators are operational and coexisting with the grid (Figure 3.7). This comparative study highlights the significant influence of generator engagement on unit energy expenditure and overall cost at BUITEMS, hence requiring a more thorough investigation of efficiency and possible optimization strategies.

3.7.3 RESULTS FOR EXISTING SYSTEM

		Grid (kW)	Dispatch	COE (Rs)	NPC (Rs)	Operating cost (Rs/yr)	Total Fuel (L/yr)
		999,999	CC	Rs0.215	Rs2.50M	Rs81,672	0

Figure 3.6. Results for existing system when generators are offline.

		Dispatch	COE (Rs)	NPC (Rs)	Operating cost (Rs/yr)	Fuel cost (Rs/yr)
		LF	Rs198.06	Rs2.43B	Rs156M	Rs23,200

Figure 3.7. Results for existing system when generators are operating

*Table*3.7. Cost comparison with and without generators

Comparison							
Results for Existing System When Generators are offline.				**Results for Existing System When Generators are Operating.**			
COE (Rs)	**NPC (Rs)**	**Operating Cost (Rs/yr.)**	**Fuel Cost**	**COE (Rs)**	**NPC (Rs)**	**Operating Cost (Rs/yr.)**	**Fuel Cost**
34.7	2.50M	81,672	0	198.06	2.433B	156M	23,200

Table 3.7. Comparison of emissions of gases without and with generators

Comparison					
Emission of Gases when Generator are offline			**Emission of Gases when Generator are Operating**		
Quantity	**Value**	**Units**	**Quantity**	**Value**	**Units**
Carbon Dioxide	567,637	Kg/yr.	Carbon Dioxide	618,748	Kg/yr.
Carbon Monoxide	0	Kg/yr.	Carbon Monoxide	369	Kg/yr.
Sulfur Dioxide	2,461	Kg/yr.	Sulfur Dioxide	2,568	Kg/yr.
Nitrogen Oxides	1,204	Kg/yr.	Nitrogen Oxides	1,266	Kg/yr.

Table 3.9. shows generators' offline operation reduces emissions and carbon monoxide release, while running them increases chemicals like nitrogen oxides, sulfur dioxide, and carbon dioxide, emphasizing the need for optimized consumption for environmental sustainability.

REFERENCE

[1] https://en.wikipedia.org/wiki/Electricity_sector_in_Pakistan

[2] https://onlinelibrary.wiley.com/authored-by/Salman/Muhammad+Umar

[3] https://en.wikipedia.org/wiki/Wind_power_in_Pakistan

[4] https://www.energy.gov/eere/water/how-hydropower

[5]https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.javatpoint.com%2Frenewable-energy&psig=AOvVaw2Lf0tdeUy3amr5tOENCG-

[6]Z&ust=1691392837888000&source=images&cd=vfe&opi=89978449&ved=0CBEQjRxqFwoTCNCb5In9xoADFQAAAAAdAAAAABAJ

[7] https://en.wikipedia.org/wiki/Electricity_sector_in_Pakistan

[8] https://www.energy.gov/eere/water/how-hydropower

[9]works#:~:text=Hydropower%2C%20or%20hydroelectric%20power%2C%20is,or%20other%20body%20of%20water.

[10] https://www.energy.gov/eere/geothermal/geothermal-

[11]basics#:~:text=Geothermal%20energy%20is%20heat%20energy,depths%20below%20the%20Earth's%20surface.

[12]https://www.greenpeace.org.uk/challenges/renewable-

[13]energy/#:~:text=Clean%2C%20renewable%20energy%20is%20a,pollution%20at%20the%20same%20time.

[14]https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.javatpoint.com%2Frenewable-energy&psig=AOvVaw2Lf0tdeUy3amr5tOENCG-

[15] "Sunina Baboria Harpreet Kaurtechno", "Economic Feasibility Analysis of Solar Pv Hybrid System in Jammu", (2020).

[16] "Sunina Baboria Harpreet Kaurtechno", "Economic Feasibility Analysis of Solar Pv Hybrid System in Jammu", (2020).

[17] "Sunina Baboria Harpreet Kaurtechno", "Economic Feasibility Analysis of Solar Pv Hybrid System in Jammu", (2020).

[18] "Sunina Baboria Harpreet Kaurtechno", "Economic Feasibility Analysis of Solar Pv Hybrid System in Jammu", (2020).

[19] Li Xu, Ying Wang, Yasir Ahmed Solangi, Hashim Zameer and syed Ahsan Ali Shah (22 May 2019)

[17] H Umar, M Amudy and T.A Rizal (2019)

[18] Amjad Iqbal and M. Tariq Iqbal (23 April 2019)

[19] Sunaina and Baboria Harpreet Kaur's (11 March 2020)

[20] U. Sureshkumar, Dr. P.S. Manoharan, and A.P.S. Ramalakshm (8 December 2020)

[21] Seyma Emec and Gokay Akkaya (11 March 2020)

[22] Ravi Chaurasia, Sanjay Gairola, Yash Pal (31 August 2021)

[23] Karthick, V. Kumar Chinnaiyan, J. Karpagam, V.S. Chandrika and P. Ravi Kumar (September 2021)

[23] Khaled Mohammad Shifuallah Bhuiyal, Md. Mostafizer Rahman Rony, Sabbir Ahed Udoy Shownitro Bhowmilk, Nahid Imtiaz Masuk, and A K M Saif Shairar (December 2022)

[24] Musarshammad Sharjeel Ali, Syed Umaid Ali, Saeed Mian Qaisar, Asad Waqar, Faheem Haroon, and Ahmad Alzahrani (6 December 2022)

[25] Ramhari Poudyall, Pavel Loskot, and Ranjan Parajuli (2021)

[26] Muhammad Aqil Afhan Rahmat, Ag Sufiyan Abd Hamid, and Yuanshen Lu (21 October 2022)

[27] Faizan A. Khan, Nitai Pal, Syed H. Saeed, Ashiwani Yadav (10 February 2022)

[28] Khaled Mohammad Shifuallah Bhuiyal, Md. Mostafizer Rahman Rony, Sabbir Ahed Udoy Shownitro Bhowmilk, Nahid Imtiaz Masuk, and A K M Saif Shairar (December 2022)

[29**]** Musarshammad Sharjeel Ali, Syed Umaid Ali, Saeed Mian Qaisar, Asad Waqar, Faheem Haroon, and Ahmad Alzahrani (6 December 2022)

[30] Yasir Basheer, Asad Waqar, saeed Mian Qaisar, toqeer Ahmed, Nasim Ullah and Sattam Alotaibi (29 September 2022)

[31] Sheeraz Iqbal, Mishkat Ullah Jan, Anis-Ur- Rehman, Atiq-Ur-Rehman, Aqib Shafiq, Haseeb-Ur- Rehman and Muhammad Aurangzeb (6 January 2022)

[32] T.M.I. Riayatsyah, T.A. Genumpana, I. M. Rizwanaul Fattah, Samsul Rizal and T.M. Indra Mahlia (24 June 2022)

[33] Md. Rasel Ahmed, Md. Rokib Hasan, Suharto Al Hasan, Muhammad Aziz and Md. Emdadul Hoque (4 February 2023)

[34] Fionnuala Murphy, and Kevin MeDonnell 18 February 2017

[35] Ramhari Poudyall, Pavel Loskot, and Ranjan Parajuli (2021)

[37] Muhammad Aqil Afhan Rahmat, Ag Sufiyan Abd Hamid, and Yuanshen Lu (21 October 2022)

[38] Faizan A. Khan, Nitai Pal, Syed H. Saeed, Ashiwani Yadav (10 February 2022)