A
PROJECT REPORT
ON

SOURCE EXTRACTION AND MANAGEMENT UNDER LOADSHEDDING CONDITION

SUBMITTED IN PARITIAL FULFILLMENT OF THE

REQUIREMENT FOR THE DEGREE OF

BACHELOR OF ELECTRICAL ENGINEERING

SAVITRIBAI PHULE PUNE UNIVERSITY

BY

AAHERWADI MANTESH RAJKUMAR	**B190312501**
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UNDER THE GUIDANCE OF

Name of Guide

Prof. Ms. Snehal Andhale

DEPARTMENT OF ELECTRICAL ENGINEERING

PES's MODERN COLLEGE OF ENGINEERING,

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Shivajinagar, Pune-5
DEPARTMENT OF ELECTRICAL ENGINEERING

CERTIFICATE

This is to certify that the project entitled Title of the project: SOURCE EXTRACTION AND MANAGEMENT UNDER LOADSHEDDING CONDITION

Has been carried out successfully by

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It is bonafied work carried out by them under supervision of Prof.- Ms.S.S. Andhale and is approved for the partial fulfillment of requirement of Savitribai Phule Pune University, for the award of the Degree of Bachelor of Electrical Engineering.

Date:

Approved

Prof. Dr. (Mrs.) N.R. Kulkarni **Prof. Ms. S.S. Andhale**

Head of Electrical Department

Signature of External Examiner

Date:

Abstract

Source Extraction is the process of astronomical image processing that calculates and reports the properties and characteristics of astronomical points of interest or sources. Source extraction and its management is done under load shedding condition. It is basically a demand side management and in that priority of load is also taken in consideration. When load demand exceeds by some amount, it is necessary to go for load shedding. But by load shedding, we have to disrupt someamount of supply because of which there is unavailability of supply at consumer side. To avoid this problem, source extraction is done during load shedding for continuous flow of supply. Due to which our dependency on grid reduces to somewhat of value. Sources using are solar, wind, battery, grid, etc. The renewablesources are active only in day timing and in night timing there is no any use of renewable source, hence the demand and supply balanced is achieved and in night time due to use of grid it helps to achieve the demand and supply balance.

Basically, in this project, load shedding is use to relieve stress on a primary energy source when demand for electricity is greater than the Primary power source can supply. We can see the result of source extraction under load shedding condition using Lab-VIEW.

ACKNOWLEDGMENT

As we are in our final semester of BE Electrical Engineering, we are aware that without the guidance of our beveled professors, it would not have been possible to complete and present this project. It gives us immense pleasure in having an opportunity to express a deep sense of gratitude to our Principal, **Dr. Mrs. K.R. Joshi**, for providing us with necessary facilities. We are also very thankful to our Head of Department, **Dr. Mrs. N.R. Kulkarni** for her time-to-time guidance and support.

We would like to thank our guide **Prof. Ms. S.S. Andhale** under whose guidance we were able to complete the project work. Her constant inspiration right from basic ideas, along with timely criticism made us work with full enthusiasm.

We are also thankful to all teaching and no-teaching staff of the electrical engineering department for their support.

Last but not the least we would like to thank all the unknown hands which made this work directly or indirectly, a success.

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Abbreviations

ANFIS	adaptive neuro-fuzzy inference system
UFLS	Under frequency load shedding
Lab-View	Laboratory virtual instrument engineering workbench
FLC	fuzzy logic control
ANN	artificial neural networks
PSO	particle swarm optimizations

Chapter 1

Introduction

1.1 Overview

Source extraction is the process of collecting different sources from a different variety of sources. Combine all sources and convert them into a usable form. In this project we extract energy from different sources like solar, wind, fuel cell and battery to supply load under load shedding condition.

Lab-view is self-learning software used to design various circuits, grids, etc. LabVIEW consist of front panel and function block diagram. Front panel is nothing but the graphical user interference from which all controlling and monitoring action carried out. The toggle switch is selected to control the sources and Boolean switches are selected to control the loading of dis-patchable and non-dis-patchable load.

Basically, in this project, load shedding is use to relieve stress on a primary energy source when demand for electricity is greater than the Primary power source can supply. We can see the result of source extraction under load shedding condition using Lab-VIEW.

While deciding the dispatchable and non-dis-patchable load operating period of that load is considered. Hence the selection is done based on time period, computers and all tube light are considered to operate whole day. it is selected as the non-dis-patchable load. The motor and load bank are required only for the practical sessions, so it is considered as dis-patchable load.

1.2 Project Motivation

The source extraction and management under load shedding conditions lies in addressing the challenges and implications associated with power outages or load shedding. Load shedding refers to the intentional shutdown of electricity supply to certain areas or customers to balance the demand and supply of power in an electrical grid. This practice is commonly employed when the demand for electricity exceeds the available supply.

Under load shedding conditions, it becomes crucial to identify alternative sources of power to mitigate the impact of the outages. The project's motivation is to develop a system that can effectively extract and manage available power sources during load shedding to ensure a reliable and uninterrupted supply of electricity to critical infrastructure, businesses, and residential areas.

Key motivation:

1. Reliability and Continuity: Load shedding can disrupt essential services, such as hospitals, emergency services, telecommunications, and industrial processes. By identifying and managing alternative power sources, the project aims to ensure the continuity of critical operations during outages, reducing the impact on various sectors.

2. Optimal Resource Utilization: Load shedding often involves shutting down power supply to specific areas or customers in a systematic manner. By extracting power from alternative sources, the project aims to optimize the utilization of available resources, ensuring that power is redirected efficiently to where it is most needed.

3. Resilience and Adaptability: Developing a system for source extraction and management under load shedding conditions contributes to the overall resilience of the electrical grid. By integrating diverse power sources, such as renewable energy systems, backup generators, or energy storage systems, the project aims to create a more flexible and adaptable power infrastructure capable of withstanding disruptions.

4. Environmental Considerations: Load shedding, particularly when relying on conventional power sources, can have negative environmental implications due to increased emissions and pollution when power generation is strained. The project's motivation includes the exploration of cleaner and greener energy sources to minimize the environmental impact of power outages.

5. Economic Impact: Load shedding can have significant economic consequences, including loss of productivity, disrupted supply chains, and financial losses for businesses. By efficiently managing alternative power sources, the project aims to mitigate these economic impacts and ensure the stability of local economies during outages.

Overall, the motivation for source extraction and management under load shedding conditions is to enhance the resilience, reliability, and sustainability of power supply systems in the face of intermittent outages, ultimately benefiting communities, industries, and critical infrastructure.

1.3 Background Theory

1. Power System Operation: Power systems consist of generators, transmission lines, distribution networks, and loads. The goal is to maintain a balance between power generation and demand to ensure a stable and reliable electricity supply. Power system operators monitor and control various parameters, such as frequency, voltage, and power flows, to maintain system stability.

2. Load Shedding: Load shedding is a controlled and planned reduction in electricity supply to manage an imbalance between power generation and demand. It is typically implemented during peak demand periods or when there is insufficient generation capacity. Load shedding strategies involve categorizing customers into different priority levels and selectively disconnecting them to maintain system stability.

3. Source Extraction: Source extraction involves identifying and utilizing alternative power sources during load shedding. This can include a combination of conventional generators (such as diesel generators), renewable energy sources (such as solar or wind), energy storage systems (such as batteries), and demand response programs (such as reducing non-essential loads).

4. Load Management: Load management refers to the process of managing and optimizing the distribution of available power to various loads during load shedding. This involves prioritizing critical loads, shedding non-essential loads, and dynamically balancing the load across different power sources to ensure that the available power is utilized efficiently.

5. Energy Storage Systems: Energy storage systems, such as batteries, play a vital role in source extraction and management. They can store excess power during periods of low demand or high generation and release it during load shedding events to support critical loads. Energy storage systems help maintain system stability, reduce dependence on conventional generators, and enable the integration of renewable energy sources.

6. Renewable Energy Integration: Integrating renewable energy sources, such as solar and wind, into the power system requires specialized control and management strategies. These strategies involve forecasting renewable energy generation, optimizing the utilization of available renewable resources during load shedding, and managing the intermittent nature of renewable generation to ensure a reliable power supply.

Overall, the background theory for source extraction and management under load shedding combines principles from power system operation, load shedding strategies, control systems, and the integration of alternative power sources. By leveraging these concepts, a comprehensive and efficient approach can be developed to ensure a reliable and sustainable power supply during load shedding events.

Benefits:

1. Reliable Power Supply: By extracting power from alternative sources, such as backup generators, renewable energy systems, or energy storage, source extraction and management help maintain a reliable power supply during load shedding.

2. Improved Service Continuity: Source extraction and management allow for prioritization of critical loads during load shedding. Essential services like hospitals, emergency response centres, and telecommunications networks can be allocated power from alternative sources, minimizing the impact of outages and ensuring uninterrupted service.

3. Optimal Resource Utilization: By intelligently managing available power sources, source extraction and management help optimize resource utilization. This includes efficiently utilizing backup generators, maximizing the utilization of renewable energy systems, and utilizing energy storage to balance supply and demand. It ensures that power is allocated to where it is most needed, reducing wastage and improving overall system efficiency.

4. Environmental Benefits: Integrating renewable energy sources as alternative power sources during load shedding can help reduce the environmental impact associated with conventional power generation. By utilizing cleaner and greener energy sources, source extraction and management contribute to reducing greenhouse gas emissions, air pollution, and reliance on fossil fuels.

5. Economic Stability: Load shedding can have significant economic consequences, affecting productivity, interrupting business operations, and disrupting supply chains. Source extraction and management mitigate these impacts by providing uninterrupted power supply to businesses, minimizing financial losses, and maintaining economic stability during load shedding events.

6. Demand Response and Energy Conservation: Load shedding events often involve encouraging consumers to reduce their electricity consumption. Source extraction and management can integrate demand response programs, where customers voluntarily reduce their non-essential loads during peak demand periods. This helps in managing the power demand, minimizing the need for load shedding, and promoting energy conservation.

7. Grid Flexibility and Future-readiness: Developing source extraction and management capabilities enhances the flexibility of the electrical grid. It allows for the integration of new technologies, such as energy storage systems and renewable energy sources, paving the way for a more sustainable and resilient power system in the future.

1.4 Objectives

1. Identify Alternative Power Sources: The primary objective is to identify and assess alternative power sources that can be utilized during load shedding events. This involves evaluating backup generators, renewable energy systems (such as solar or wind), energy storage systems, and other potential sources of power.

2. Optimize Power Source Utilization: The objective is to efficiently utilize available power sources to meet the demand during load shedding.

3. Prioritize Critical Loads: One of the key objectives is to prioritize critical loads during load shedding. This involves identifying essential services, critical infrastructure, and sensitive equipment that require uninterrupted power supply.

The objective is to allocate power from alternative sources to these critical loads to minimize the impact of outages on public safety, healthcare, communication, and other vital services

4. Support Demand Response: An objective is to support demand response initiatives during load shedding.

5. Promote Sustainability: Another objective is to promote sustainability by incorporating renewable energy sources into the power system. The aim is to reduce dependence on fossil fuels, minimize greenhouse gas emissions, and contribute to a cleaner and more sustainable energy infrastructure. This objective aligns with global efforts to mitigate climate change and transition to a low-carbon economy

1.5 Project contributions

- Integration of renewable energy sources
- Simulation design using LabVIEW software.
- Demand and supply balance with optimization of load.

1.6 Organization of report

Chapter 1 – This chapter includes the introduction of source extraction and management under load shedding condition.

Chapter 2 - This chapter includes the literature review of source extraction and management under load shedding condition.

Chapter 3 – This chapter includes the methodology of source extraction and management under load shedding condition.

Chapter 4 – This chapter includes the results and discussion of source extraction and management under load shedding condition cases.

Chapter 5 – This chapter includes the conclusion and future scope of source extraction and management under load shedding condition

Chapter 2

Literature Survey

Table 2.1 Literature survey

Paper No.	Title of Paper	Name of Publisher
1.	Smart solar power plant	Sam Jose and Dr. Raieshwari L ItagiIEEE ICCSP 2015 Conference
2.	Study on Energy storage system smoothing wind power fluctuations	Li Jianlin, Liang Liang, yangshuili, Hui Dong
3.	A review of fuel cell and energy cogeneration technologies	Renewable Energy conference (IREC 2018)
4.	Battery Storage Systems	IEEE Smart grid
5.	Optimal Load Shedding Scheme for a Model Renewable Energy Micro-Grid	2020 IEEE PES/IAS Power Africa Conference University of Nairobi

6.	Load-shedding probabilities with hybrid renewable power generation andenergy storage	Huan Xu, Ufuk Topcu,Steven H. Low, Christopher R. Clarke.
7.	Solar-Wind Hybrid Energy Generation System	IEEE Conference Paper -November 2020
8.	Recent Advances of Wind-Solar Hybrid Renewable Energy Systems for Power Generation	IEEE Open journal of the Industrial Electronics Society- 2 February 2022

1. Smart solar power plant

Sam Jose and Dr. Raieshwari L Itagi
IEEE ICCSP 2015 conference

• The electrical energy generated by the solar PV (Photo Voltaic) is getting stored in a storage medium i.e., battery bank.
• The autonomy (battery backup) of the system can be designed according to the environmental conditions of the installation side and the application requirement.
• The electricity generated by the solar PV is consumed by the connected loads. There is a provision for feeding the utility grid when the surplus amount of energy is generated, which is referred to as 'net metering system.

2. Study on Energy storage system smoothing wind power fluctuations

Li Jianlin, Liang Liang, yangshuili, Hui Dong

• In order to promote wider spread of wind farm, the technology of reducing fluctuations in wind power output is indispensable. By introducing the storage batteries in the wind power system, the generated power is smoothed, thereby reducing undue influence on the power system.
• This paper presents a different solution to short-term wind-power variability, using advanced power electronic devices combined with energy storage systems

3. A review of fuel cell and energy cogeneration technologies

Renewable Energy conference (IREC 2018)

• The voltage generated by the fuel cells has a low value (0.5 to 0.9V), making it necessary to combine several cells in series to provide a high value voltage. Due to the different types of fuel cell technologies, cells that generate watts up to megawatts of power per module can be found on the market.

• Typically, cells have an efficiency of between 40% and 60%, but when combined in cycles of heat and power (CHP), they can achieve efficiencies of up to 85%.

4. Battery Storage Systems

IEEE Smart grid

• This chapter presents a review of available and emerging battery 11 technologies and their design and performance characteristics.

• The benefits of battery storage in micro-grids.

5. Optimal Load Shedding Scheme for a Model Renewable Energy Micro- Grid

2020 IEEE PES/IAS Power Africa Conference University of Nairobi

• Optimization of demand control in renewable energy micro-grids involves developing load shedding schemes and searching for the most optimum.

• The main objective in this study was to model a purely renewable energy sources micro-grid, investigate its transient frequency stability and optimize the under-frequency load shedding scheme to achieve required levels of frequency and voltage fluctuations with minimum load disconnection and least cost for power storage, as formulated in the multi-objective function.

6. Load-shedding probabilities with hybrid renewable power generation and energy storage

• We incorporate simple storage dynamics into a load-shedding model to understand the effects of intermittency in generation and/or demand on the characteristics of the electricity network.

• Use a simple storage model alongside a combination of renewable and varying load-shedding characterizations to determine the appropriate area of PV cells, number of wind turbines, and energy storage capacity.

7. Solar-Wind Hybrid Energy Generation System

IEEE Conference Paper -November 2020

• Renewable energy integration has attracted widespread attention due to its zero-fuel cost, cleanliness, availability, and ease of installation. Among various renewable energy sources, photovoltaic (PV) and wind turbines (WT) have become very attractive due to the abundant local availability in nature, technological progress, and economic benefits.

• The hybrid combination of both distributed energy resources eliminates mutual intermittences due to their adverse nature; therefore, the reliability of the system will be improved.

• The basic key objective of this project is to generate electrical energy by using renewable and clean energy with minimum pollution.

8. Recent Advances of Wind-Solar Hybrid Renewable Energy Systems for Power Generation

IEEE Open journal of the Industrial Electronics Society- 2 February 2022

• A hybrid renewable energy source (HRES) consists of two or more renewable energy sources, such as wind turbines and photovoltaic systems, utilized together to provide increased system efficiency and improved stability in energy supply to a certain degree.
• The uncertainty of HRES can be reduced further by including an energy storage system, this paper presents several hybrid energy storage systems coupling technologies, highlighting their major advantages and disadvantages.

Chapter 3

Project Title

3.1 Block Diagram

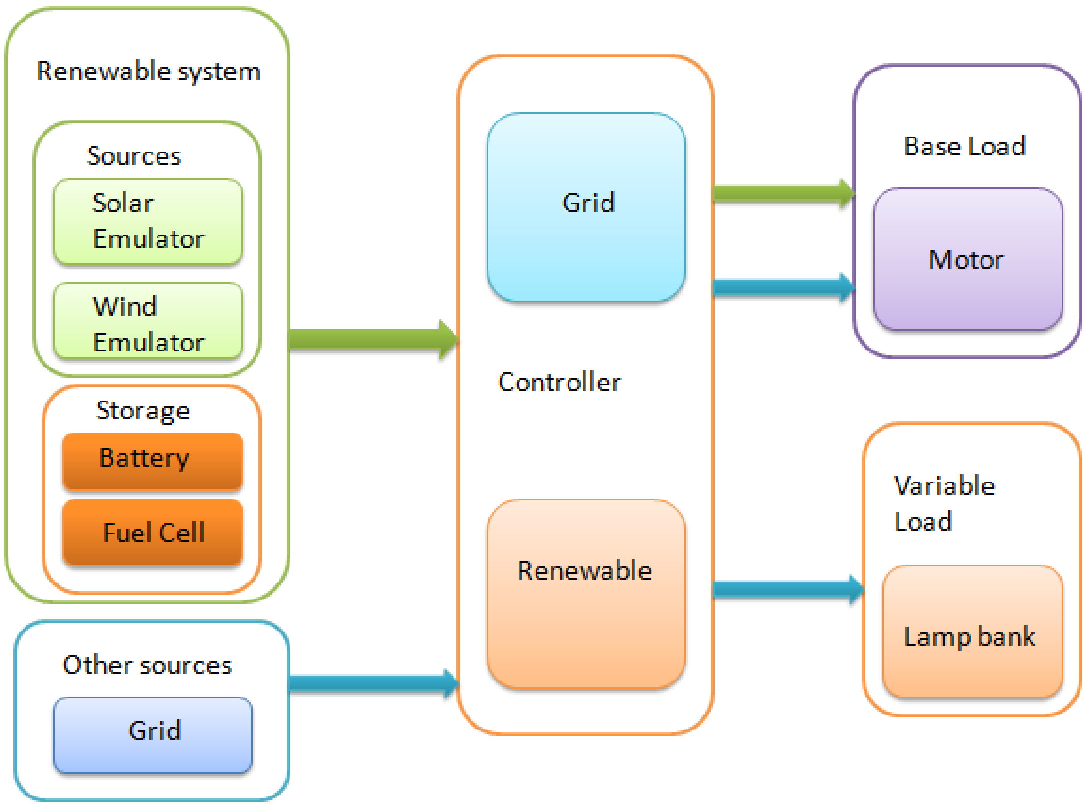

Fig. 3.1 Block diagram of system

3.2 Methodology

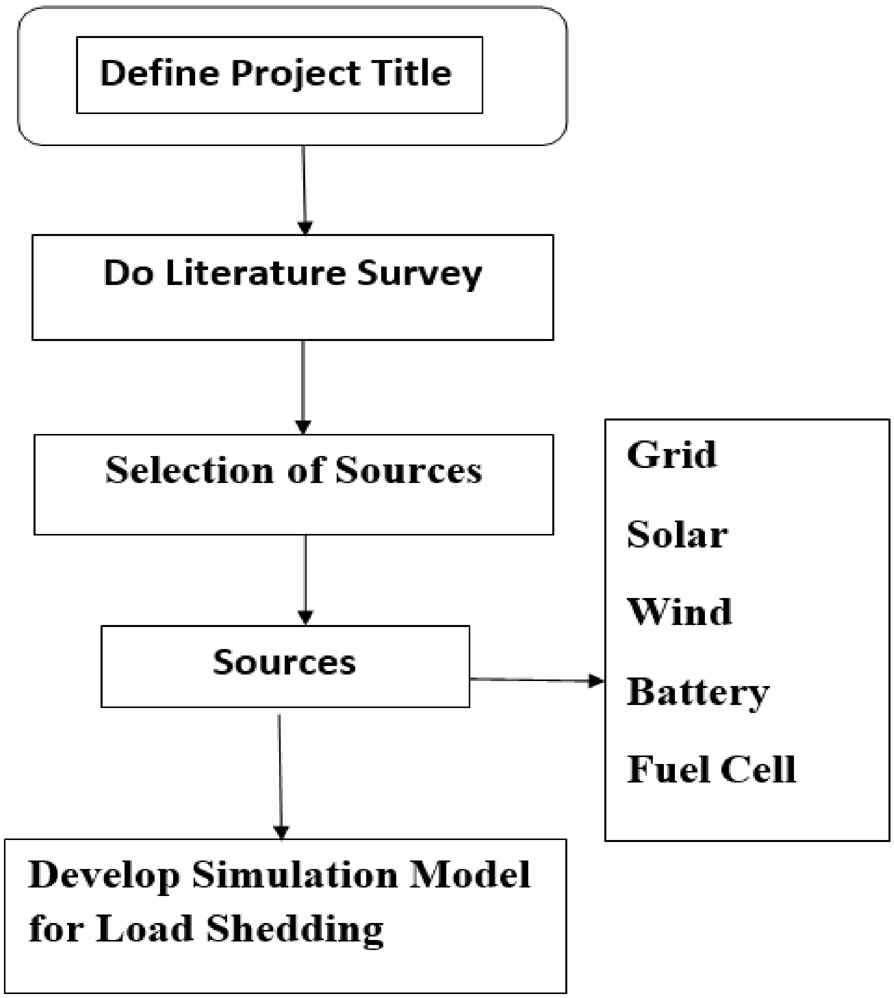

Fig. 3.2 Methodology of system

Chapter 4

SOFTWARE SUBSYSTEM

Lab-VIEW (**Lab**oratory **V**irtual **I**nstrument **E**ngineering **W**orkbench) is a graphical programming environment which has become prevalent throughout research labs, academia, and industry. It is a powerful and versatile analysis and instrumentation software system for measurement and automation. It's graphical programming language called G programming is performed using a graphical block diagram that compiles into machine code and eliminates a lot of the syntactical details.

Lab-VIEW offers more flexibility than standard laboratory instruments because it is software-based. Using Lab-VIEW, the user can originate exactly the type of virtual instrument needed and programmers can easily view and modify data or control inputs. The popularity of the National Instruments Lab-VIEW graphical dataflow software for beginners and experienced programmers in so many different engineering applications and industries can be attributed to the software's intuitive graphical programming language used for automating measurement and control systems.

Lab-VIEW programs are called virtual instruments (VIs), because their appearance and operation imitate physical instruments like oscilloscopes. Lab-VIEW is designed to facilitate data collection and analysis, as well as offers numerous display options. With data collection, analysis and display combined in a flexible programming environment, the desktop computer functions as a dedicated measurement device. Lab-VIEW contains a comprehensive set of VIs and functions for acquiring, analysing, displaying, and storing data, as well as tools to help you troubleshoot your code.

4.1 FRONT PANEL

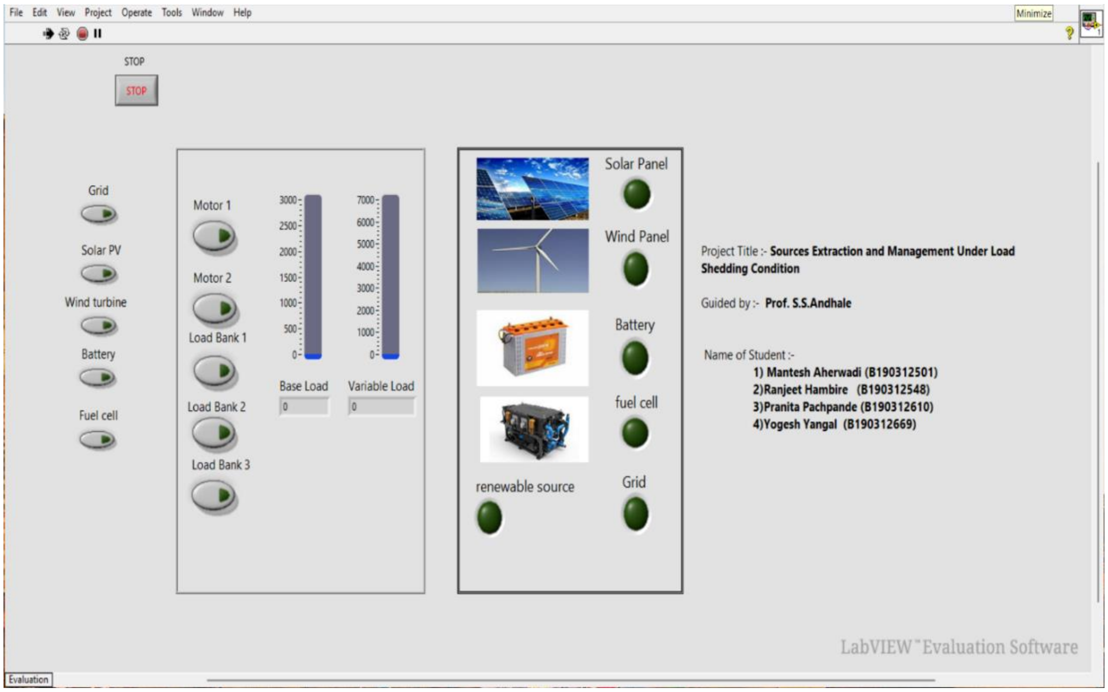

Fig.4.1 Front Panel

In front panel all controls and indicators are placed in well manner. Dis-patchable and un-dis-patchable load are segregated separately. All source controls are placed in LHS top corner and all load controls are placed beneath of it.

Front panel is nothing but the graphical user interference from which all controllingand monitoring action carried out. The toggle switch is selected to control the sources and Boolean switches are selected to control the loading of dis-patchable and non-dis-patchable load. when the Boolean switch of un dis-patchable load is pressed then the that much amount of load shows the requirement of energy hence the available led glows and that load get connected to the grid, so the LED of grid is alsoglows. This un-dispatchable load is always connected to grid whenever requirementis occurred.

Dis-patchable load is work with DSM techniques hence this load plays important role while managing the demand and end supply balance.

In day time, whenever the dis-patchable load required energy, its first priority is renewable source and second priority is grid. Again, in renewable resources priorities are decided on the basis of unit cost, first priority is given to the solar energy, second priority is given to the wind energy, third priority is given to the battery and last priority is given to the fuel cell.

4.2 PROGRAM

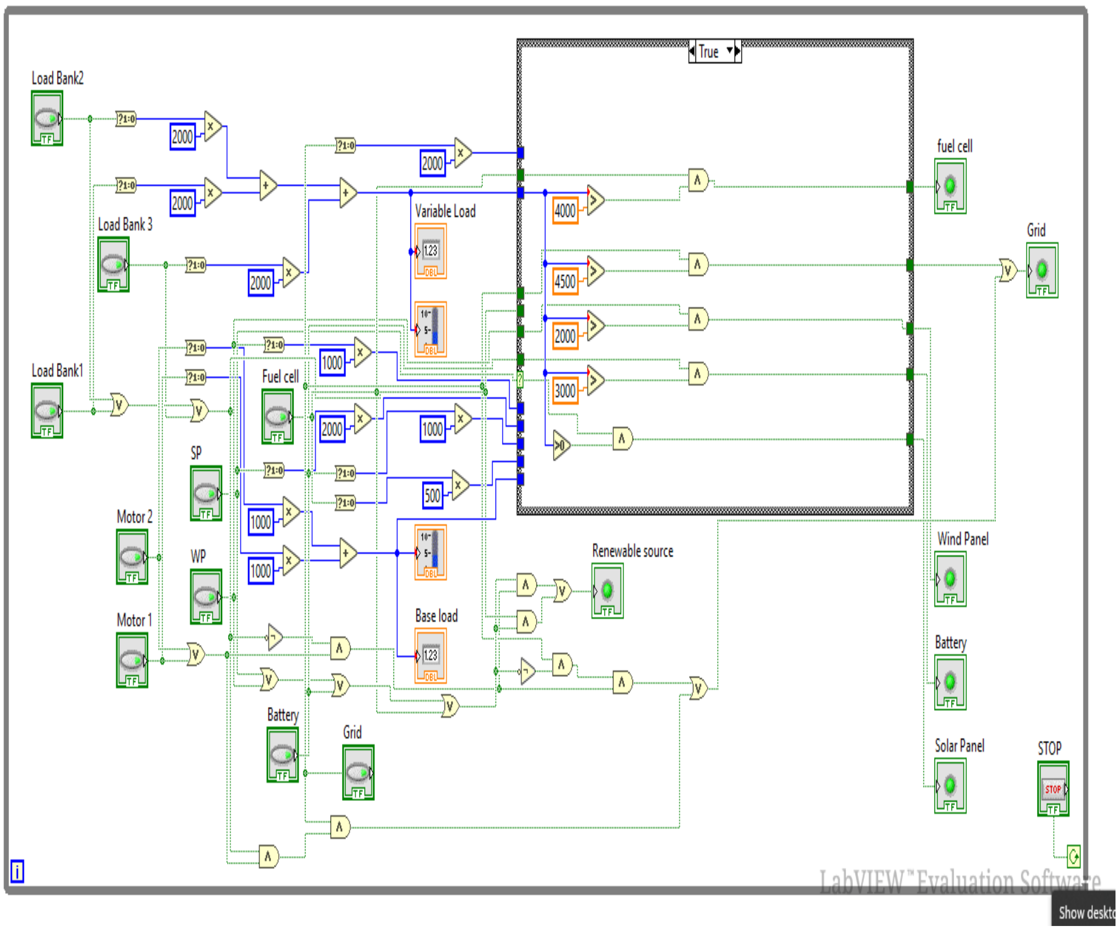

Fig.4.2 Program

4.3 Advantages of Lab-VIEW

The following are the advantages of Lab-VIEW:

- **Graphical user interface:** Design professionals use the drag-and-drop user interface library by interactively customizing the hundreds of built-in user objects on the control's palette.
- **Drag-and-drop built-in functions:** Thousands of built-in functions and IP including analysis and I/O, from the functions palette to create applications easily.
- **Modular design and hierarchical design:** Run modular Lab-VIEW VIs by themselves or as sub-VIs and easily scale and modularize programs depending on the application.
- **Multiple high level development tools:** Develop faster with application-specific development tools, including the Lab-VIEW State chart Module, Lab-VIEW Control Design and Simulation Module and Lab-VIEW FPGA Module.
- **Professional Development Tools:** Manage large, professional applications and tightly integrated project management tools; integrated graphical debugging tools; and standardized source code control integration.
- **Multi platforms:** The majority of computer systems use the Microsoft Windows operating system. Lab-VIEW works on other platforms like Mac OS, Sun Solaris and Linux. Lab-VIEW applications are portable across platforms.
- **Reduces cost and preserves investment:** A single computer equipped with Lab-VIEW is used for countless applications and purposes—it is a versatile product. Complete instrumentation libraries can be created for less than the cost of a single traditional, commercial instrument.
- **Flexibility and scalability:** Engineers and scientists have needs and requirements that can change rapidly. They also need to have maintainable, extensible solutions that can be used for a long time. By creating virtual instruments based on powerful development software such as Lab-VIEW, you

inherently design an open framework that seamlessly integrates software and hardware. This ensures that your applications not only work well today but that you can easily integrate new technologies in the future.

- **Connectivity and instrument control:** Lab-VIEW has ready-to-use libraries for integrating stand-alone instruments, data acquisition devices, motion control and vision products, GPIB/IEEE 488 and serial/RS-232 devices, and PLCs to build a complete measurement and automation solution. Plug-and Play instrument drivers access the industry's largest source of instrument drivers with several instruments from various vendors.
- **Open environment:** Lab-VIEW provides the tools required for most applications and is also an open development environment. This open language takes advantage of existing code; can easily integrate with legacy systems and incorporate third party software with .NET, ActiveX, DLLs, objects, TCP, Web services and XML data formats.
- **Distributed development:** Can easily develop distributed applications with Lab-VIEW, even across different platforms. With powerful server technology you can offload processor-intensive routines to other machines for faster execution, or create remote monitoring and control applications.
- **Visualization capabilities:** Lab-VIEW includes a wide array of built-in visualization tools to present data on the user interface of the virtual instrument as chart, graphs, 2D and 3D visualization. Reconfiguring attributes of the data presentation, such as colors, font size, graph types, and more can be easily performed.
- **Rapid development with express technology:** Use configuration-based Express VIs and I/O assistants to rapidly create common measurement applications without programming by using Lab-VIEW signal Express.
- **Compiled language for fast execution:** Lab-VIEW is a compiled language that generates optimized code with execution speeds comparable to compiled C and develops high-performance code.

- **Simple application distribution:** Use the Lab-VIEW application builder to create executables (exes) and shared libraries (DLLs) for deployment.
- **Target management:** Easily manage multiple targets, from real-time to embedded devices including FPGAs, microprocessors, microcontrollers, PDAs and touch panels.
- **Object–oriented design:** Use object-oriented programming structures to take advantage of encapsulation and inheritance to create modular and extensible code.
- **Algorithm design:** Develop algorithms using math-oriented textual programming and interactively debug .m file script syntax with Lab-VIEW Math Script.

4.4 Flow Chart

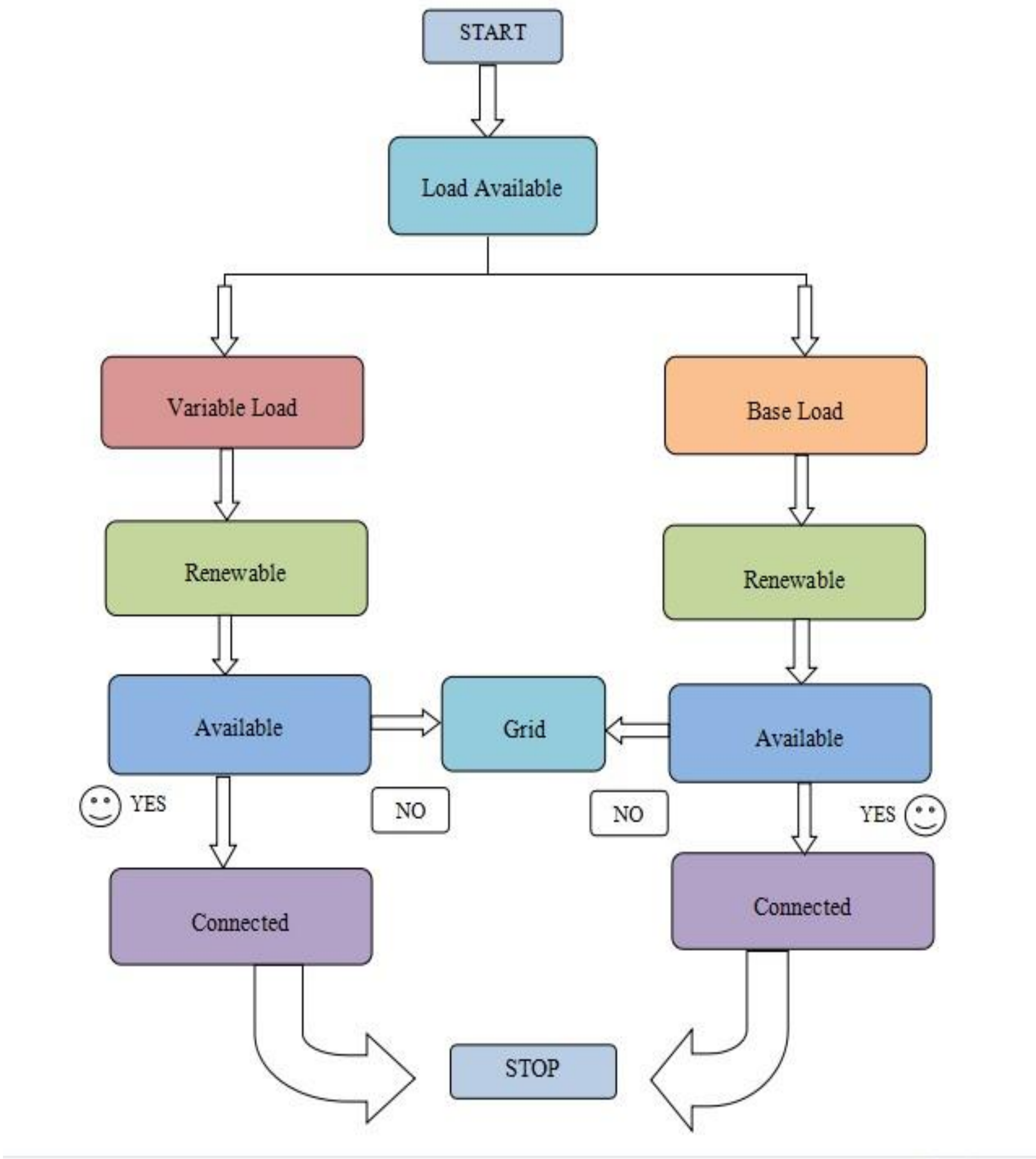

Fig.4.3 Flow Chart

Chapter 5

Technical Specifications of Components

5.1 Wind Turbine Emulator

Working

The Wind Turbine Emulator is a complete stand-alone Wind Energy System that provides real time emulation of static and dynamic behaviour of a Wind Turbine.
Wind turbine emulator mimics the behaviour of wind turbine for hardware level as well as software level simulations. This system has a DC motor coupled with the Induction generator/Permanent Magnet Synchronous Generator, speed of which is controlled as per the speed reference calculated by solving the mathematical model of wind turbine. An induction generator is coupled to the DC motor and bidirectional inverter is connected to the terminals of the generator.

Component and specification of Wind Turbine Emulator

Table 5.1 Wind turbine emulator component with ratings

S. No.	Component	Specification
1.	DC Motor Output Power Nominal Field Voltage Speed at rated voltages	 2 hp 220V DC 1500
2.	DC Drive Input voltage Output Voltage Output Current	 230 V 200 V 15 A
3.	Buck Converter after generator Input voltage Output Voltage Output Current Switching Frequency	 450 V 150 V 10 A 10 kHz
4.	Bidirectional Converter Input voltage Output Voltage Output Current Switching Frequency	 105 V (Battery Side) 150 V (Inverter Side) 10 A 10 kHz

5.	Three Phase Inverter 3 Leg inverter Maximum DC Input Voltage Output Voltage Output Current Switching Frequency	 150V DC 112 V AC 25 A 10*k*Hz

5.2 Solar PV Emulator (source)

Working

The Solar PV Emulator gives you the benefit of Simulating the IV Curve under varying environmental conditions without the requirement of an actual PV Panel or an external setup for data monitoring and data acquisition.
The software of PV Emulator is based on LabVIEW. User can see the response of Solar PV Panel as per his/her own set of user's defined parameters.

Component and specification of solar PV emulator

Table 5.2 solar PV emulator specification & ratings

S. No.	Components	Sub- Components	Specifications
1.		Supply Voltage	230V AC/ 50Hz
		No. of Channels	1
		Short Circuit Current (Isc)/Channel	0-20 A
		Open Circuit Voltage (Voc)/Channel	0-50 VDC
		Max Output Power /Channel	1000 W
		Operating Environment	Indoor Use
2.	Boost Converter	Input voltage Output Voltage Output Current Switching Frequency	10-50 V 150 V 10 A Hz

5.3 Fuel Cell

Working

Fuel Cell unit receives dry hydrogen from the Hydrogen gas cylinder at preset LPM. The generated power can be used directly by a DC load but as per the V-I curve of Fuel cell system, the voltage reduces as we increase the load, therefore, the power generated by fuel cell system cannot be used directly hence the output is connected to a charge controller which charges the battery and maintain output as per the battery voltage.

Component and specification of Fuel Cell

Table 5.3 Fuel cell with specifications & Ratings

Type of fuel cell	**PEM**
Number of cells	24
Rated Power	500W
H2 Supply valve voltage	12V
Reactants	Hydrogen and Air
External temperature	5 to 30ºC
Max. stack temperature	65ºC
Cooling	Air (integrated cooling fan)
Dimension	268mm x 130mm x 122.5mm
Start-up time	≦30S at ambient temperature
Efficiency of stack	40% @ 14.4V
Low voltage shut down	12V
Over current shut down	42A

5.4 Lithium Ion Battery

Working

The lithium-ion batteries are used for storage for load management. Lithium-ion battery performance can give a better result with good efficiency.
It can work as storage device. It is made up of lithium cobalt oxide (cathode) and graphite (anode). It gives capacity of two to three years with outstanding result.

Component and specification of Lithium-Ion battery

Table 5.4 Lithium-ion battery with Specification & ratings

Specification Of Lithium-ion battery	**Ratings**
Input Voltage	12 V
Output Voltage	0.5 To 12 V
Number of Cells	48 cells
Temperature Shutdown	65°C

5.5 Grid

Working of Grid

The generator produces energy. Convert energy into a high voltage for distribution.

Power lines deliver power to populated areas while transformers intersect the high voltage power and convert it back to a voltage that houses can use. Then power is delivered to consumers.

It will work as source of load management and its will available in all over India with full capacity.

Component and specification of Grid

Table 5.5 Grid Specifications

Specification	Ratings
Input Voltage	230 V
Maximum output efficiency	99.05%
Availability	Infinite energy source

5.6 Load

A) BASE LOAD : ***1 phase induction motor***

Fig.5.6.1 1-ph Induction Motor

Motor is an inductive type of load, which uses electrical energy and convertsit into mechanical energy. It is a variable type of load because the currentdraws from the motor depends on the loading of motor but in this case, weare considering it is as constant load.

Table.5.6. 1 -phase induction motor

Operating voltage	230v, Ac
Output power	1 hp
Input power	1 kW
Current rating	8 Amps
frequency	50hz
speed	1440 Rpm

B) VARIABLE LOAD : Load bank

A load bank is a resistive type of load having number of lamps connected in series and parallel combination. It is a variable type of load, by switching the lamp on and off the load can be varied.

Fig.5.6.2. Load Bank

Table 5.7 load bank specifications and ratings

Operating voltage	230-volt Ac
Operating current	10 amps
Input power	2 kW
frequency	50 Hz

Energy sources-

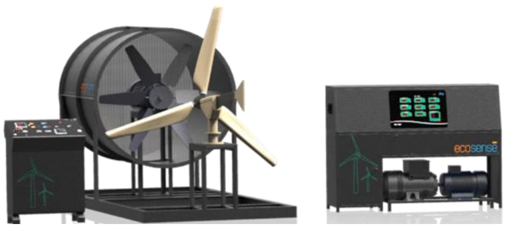 Wind Turbine Emulator	 Solar PV Emulator
Fuel Cell 	 Lithium Ion Battery

Fig.5.6.3. RES sources

Chapter 6

Results

Table 6.1 Load Shifting

Base load (KW)	Variable load (KW)	On which source load depends?
1 kw	0	Grid / Renewable
2 kw	0	Grid / Renewable
2 kw	2 kw	Grid + solar
2kw	4 kw	Grid + solar + Wind+ Battery
2 kw	**6 kw**	**Grid + solar + wind + battery+ Fuel cell**

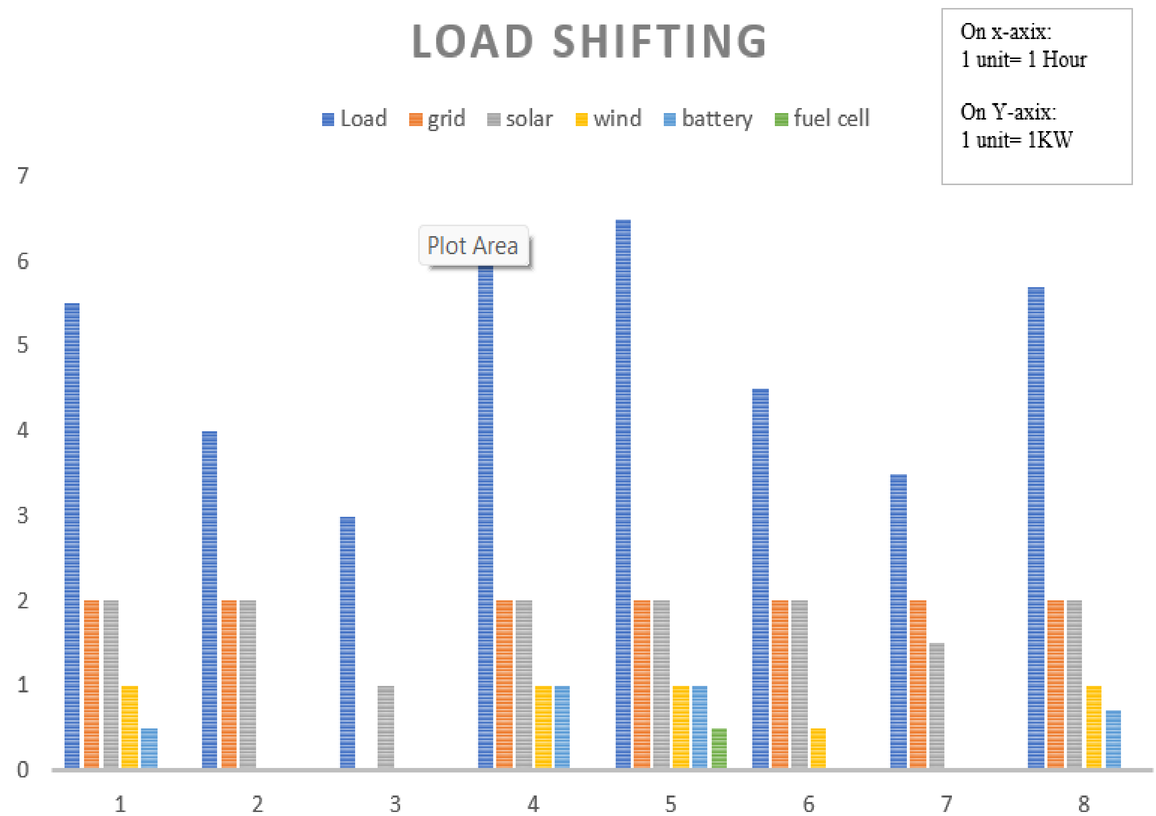

Fig 6.1 Graph of load shifting

➢ Case I:

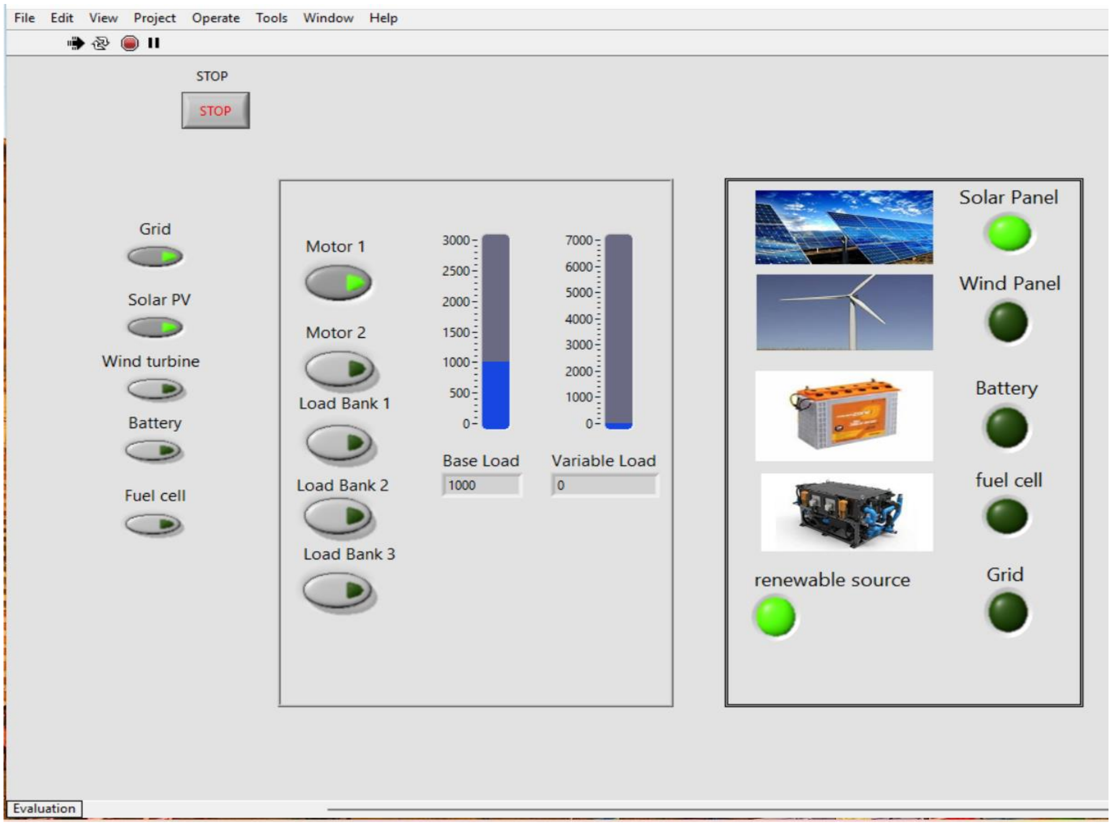

Fig 6.2 Case I

When renewable source (solar) is available, base load of 2KW is shifted on solar panel rather than on grid. Benefit of this is that we use renewable sources when available rather using grid which saves in cost of billing.

- **Case II:**

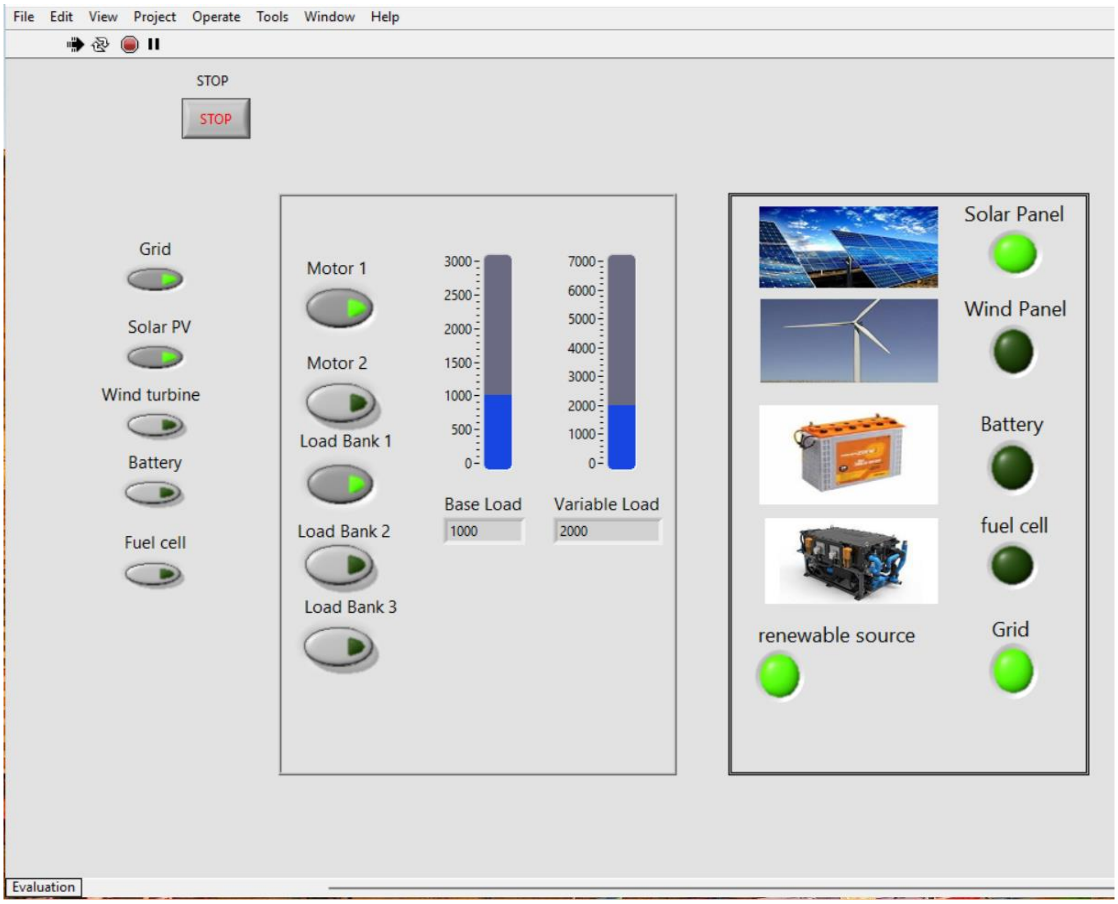

Fig 6.3 Case II

When one motor (1KW) and one load bank (2KW) are turned ON, motor load which is dispatchable is directly connected to grid as shown in above figure. The dispatchable load has to be fulfilled irrespective of availability of renewable sources. As shown in panel, as all renewable sources are available the undispatchable (load bank) load is shifted to Solar panel. This shifting is done on priorities which are on the basis of unit cost. (First priority is given to the solar energy, second priority is given to the wind energy, third priority is given to the battery and last priority is given to the fuel cell).

➢ Case III:

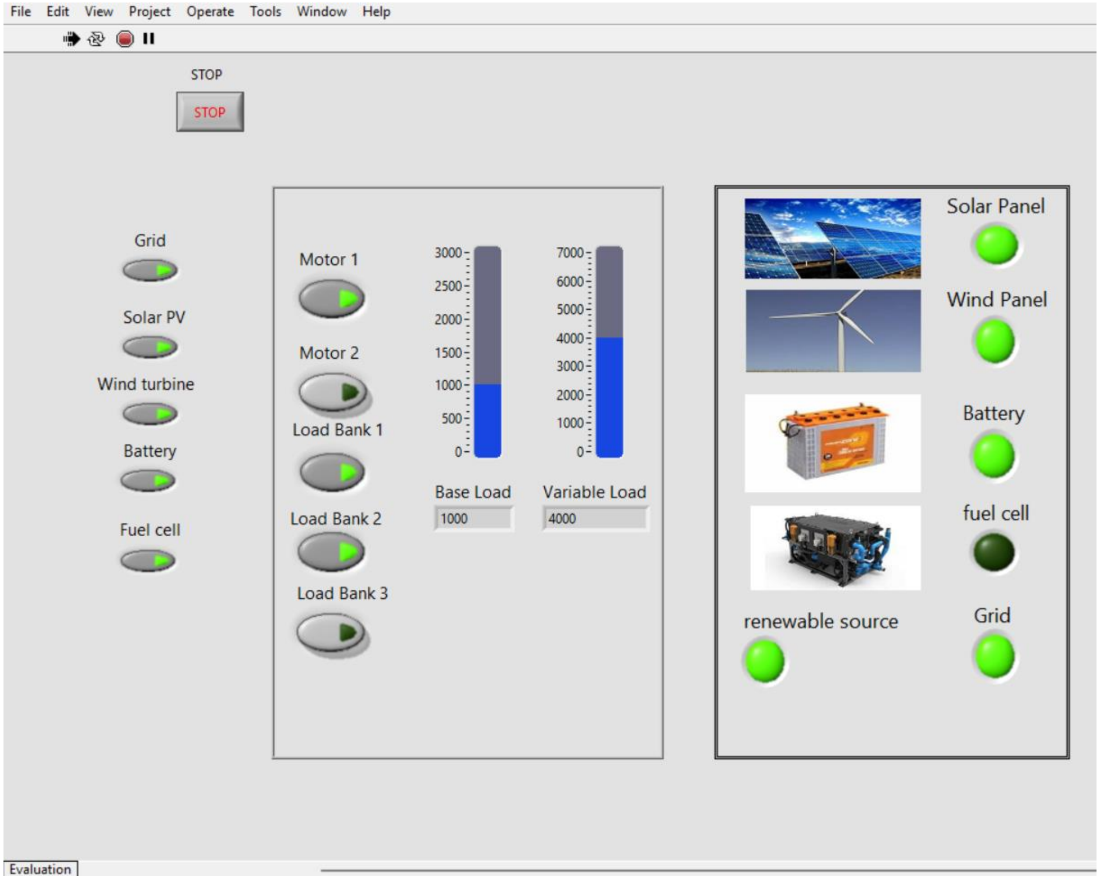

Fig 6.4 Case III

When one motor (1KW) and two load banks (each - 2KW) are turned ON, motor load which is dispatchable is directly connected to grid as shown in above figure. As shown in panel solar (2KW), wind (1KW) and battery (1KW) contribute together to fulfill the undispatchable load demand of 4KW.

➢ **Case IV:**

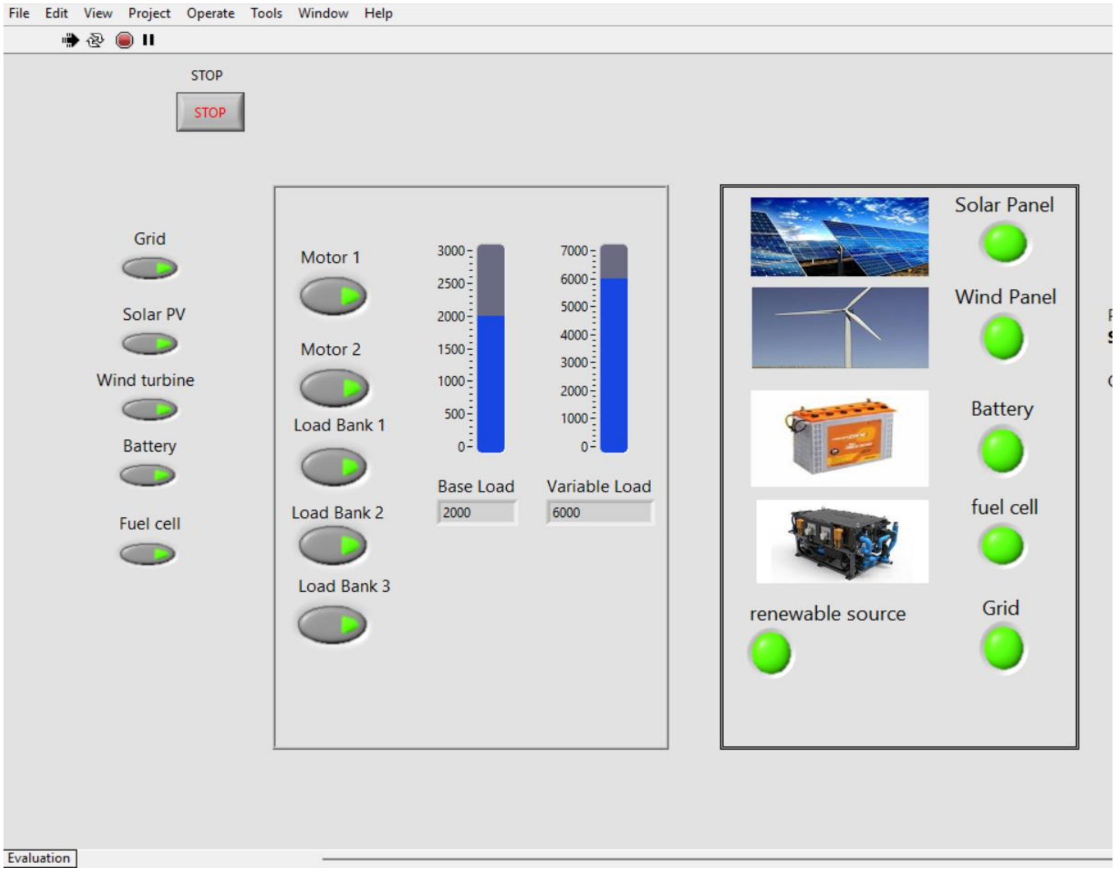

Fig 6.5 Case IV

When two motor (1KW) and three load banks (each - 2KW) are turned ON, motor load which is dispatchable is directly connected to grid as shown in above figure. As shown in panel solar (2KW), wind (1KW) and battery (1KW) contribute together to fulfill the dispatchable load demand of 4KW. Addition to above fuel cell (0.5 KW) will also contribute to fulfill the demand of load bank (6KW).

Chapter 7

Conclusion and future scope

7.1 Conclusion

In this system source extraction is done during peak load period to avoid shut down of system. The approach of Hybrid Energy system can be applied to micro grid, due to this the reliability and stability of the system increases. The available renewable energy sources and loads are used in LabVIEW software to implement this system.

7.2 Future Scope

1. Advanced Control and Monitoring Systems: Future advancements in control and monitoring systems will enable more accurate and real-time management of power sources during load shedding. This includes advanced algorithms, machine learning, and artificial intelligence techniques that can optimize resource utilization, predict demand patterns, and dynamically allocate power from alternative sources.

2. Integration of Smart Grid Technologies: The integration of smart grid technologies will play a crucial role in the future of source extraction and management. Smart meters, advanced sensors, and real-time communication systems will enable more efficient load shedding strategies, enhanced coordination between power sources and loads, and better demand response capabilities.

3. Energy Storage Technologies: The development of advanced energy storage technologies will greatly impact source extraction and management under load shedding. Continued advancements in battery technologies, including higher energy densities and longer lifespans, will enable more effective utilization of stored energy during outages, reducing reliance on conventional generators

4. Integration of Distributed Energy Resources (DERs): The integration of distributed energy resources, such as rooftop solar panels, wind turbines, and small-scale generators, will continue to evolve. DERs can contribute to the power supply during load shedding events, and advancements in grid integration techniques will enable seamless management and utilization of these distributed resources.

5. Demand Side Management: Future developments will focus on expanding demand side management capabilities. More sophisticated demand response programs, incentivization mechanisms, and consumer engagement strategies will encourage consumers to actively participate in load shedding management by reducing their electricity consumption during peak periods

6. Policy and Regulatory Support: Future advancements in source extraction and management under load shedding will require supportive policies and regulations.

Chapter 8

References

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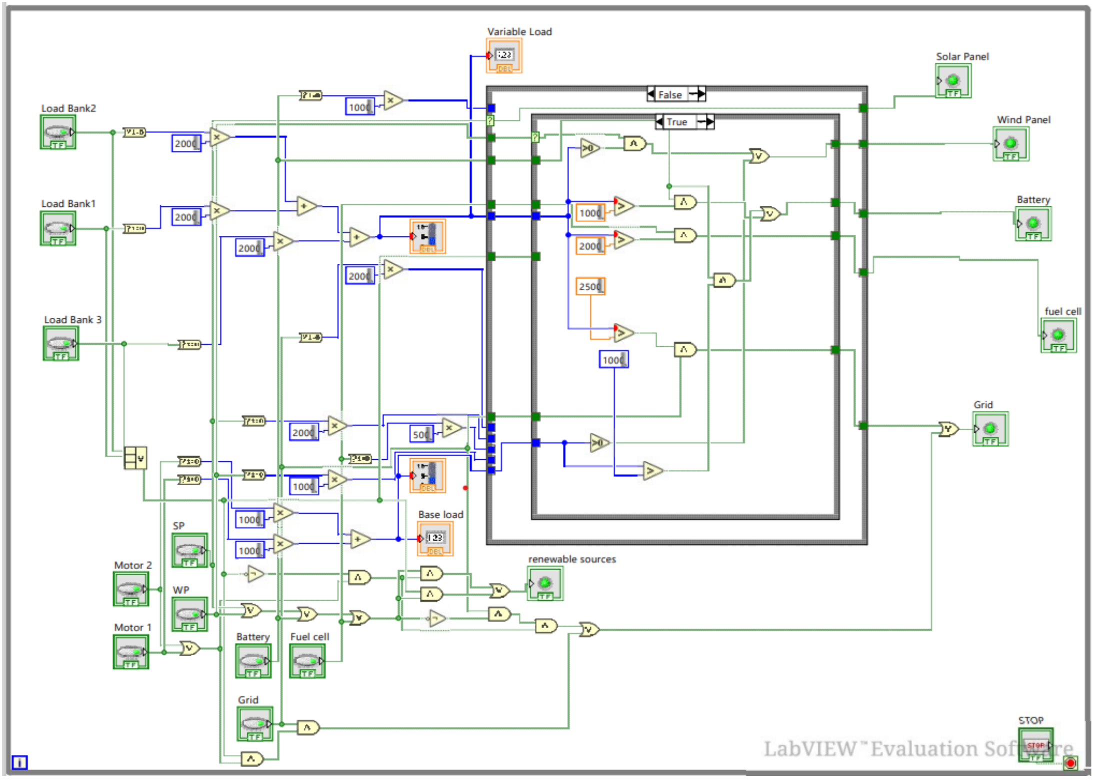
4) Wei-Jen Lee, “***Battery Storage Systems***”, 2018 IEEE Smart Grid Battery Storage Working Group.

5) Paul Muia Musyoka, Peter Musau, Abraham Nyete, “***Optimal Load Shedding Scheme for a Model Renewable Energy Micro-Grid***”, 2020 IEEE PES/IAS Power Africa Conference.

6) Huan Xu, Ufuk Topcu, Steven H. Low, Christopher R. Clarke, and K. Mani Chandy, “***Load-shedding probabilities with hybrid renewable power generation and energy storage***”, 2010 Annual review of energy and environment.

Annexure I

Program-



While loop:

The while loop will repeat the instructions inside it until the condition evaluates to false. Once the condition becomes false, the while loop will exit, and the program will continue executing the code after the while loop.

Conditional structure:

Conditional structures used to control the flow of your program based on specific conditions. There are two types of conditional structures in LabVIEW: the "Case Structure" and the "Conditional Terminal."

1. Case Structure: The case structure allows you to execute different sets of instructions based on the value of a selector or condition

2. Conditional Terminal: The conditional terminal is a simpler conditional structure that allows you to choose between two sets of instructions based on a condition

If else structure:

"If" and "Else" structures to create conditional branching in your program. The "If" structure allows you to execute a set of instructions if a condition is true, while the "Else" structure allows you to specify what to do if the condition is false.

LED indicators:

LED indicators are used to show the activeness of loads and sources. Numeric indicator. These indicators are used to show the numeric value of load demand.

By controlling the value of the Boolean control, you can change the state of the LED indicator. When the Boolean control is true, the LED will be illuminated or display a specific colour (depending on your configuration). When the Boolean control is false, the LED will be turned off.

Boolean switch:

These switches are used to control the loads as well as sources availability. When the switch is in true condition then it indicates the available condition and when the switch is in false condition then it represent unavailable condition. Binary to integer converter. This converter is used to convert the binary value into integer number.

Arithmetic comparator:

Arithmetic comparators used to compare numerical values and determine relationships between them. LabVIEW provides several arithmetic comparators, such as Equal To (=), Not Equal To (≠), Less Than (<), Less Than or Equal To (≤), Greater Than (>), and Greater Than or Equal To (≥).The output of the arithmetic comparator will be a Boolean value (true or false) indicating the result of the comparison. If the comparison is true, the output will be true; otherwise, it will be false.

Logic gates:

There are two logic gates are used in this system, which are AND gate and OR gate. These logic gates are used while designing the conditions of availability of loads and sources.

Loads:

The contribution of load is controlled through the Boolean switch operation, when the Boolean switch is in true condition then by using binary to integer converter the value 1 is obtained. To indicate the amount of load the multiple comparators is used. The value obtained from the converter is multiply with the constant term, this indicates the amount of load contribution. When the Boolean switch is in false conditions then the load contribution is zero and when the Boolean switch is in true condition then the load contribution is constant value.