

KERALA STATE ELECTRICITY REGULATORY COMMISSION



DETAILED PROJECT REPORT

Design and Sizing of a Lithium-Ion Based Battery System for Reliable Power Backup at the Office of the Kerala State Electricity Regulatory Commission

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Executive Summary

This project presents the design of a lithium-ion battery-based power backup system for the office of the Kerala State Electricity Regulatory Commission to ensure reliable and uninterrupted power supply during grid outages. A detailed load assessment has been carried out floor-wise, and the system is designed considering multiple backup durations (2 and 4 hours) to provide flexibility in selecting the most suitable configuration at a later stage. Modern lithium-ion-based batteries feature modular platforms, enabling the backup duration to be increased at a later stage.

Two operating scenarios- with air conditioning (AC) loads and without AC loads- were analyzed. Based on technical and economic considerations, the “without AC loads” configuration is recommended as the final design approach, as it significantly reduces the required inverter capacity and battery size while ensuring backup for critical loads.

The proposed system utilizes lithium-ion battery technology, offering advantages such as higher efficiency, longer lifecycle, reduced maintenance, modular design and compact size compared to conventional batteries. The inverter capacity and battery bank are sized based on the calculated load demand and required backup durations, ensuring reliable operation under varying conditions.

The building of the Kerala Power Finance Corporation, where the Commission is currently functioning, has a 160 kVA diesel generator as backup power supply. Considering the high maintenance requirements and running costs, diesel generators have become obsolete in recent times. Additionally, the office currently operates an existing 5.2 kVA inverter system with Lead Acid batteries, which can be either integrated into the new system for supporting minor loads or retained as a standalone backup unit for redundancy.

The final system configuration will be selected based on the desired backup duration, balancing performance, cost, and operational requirements. The proposed design ensures scalability, improved reliability, and efficient energy management for the office. The DPR also includes suggestions for use of energy efficient equipment to reduce electricity bills.

CHAPTER – 1

INTRODUCTION

Reliable electrical power is essential for the smooth functioning of modern office environments, where critical operations depend on continuous power supply for lighting, computing systems, communication equipment, and other essential services. As KSERC proceedings are primarily held online, a stable power supply is critical to prevent disruptions and maintain the integrity of judicial and administrative sessions. However, grid power interruptions can lead to operational downtime, disruption of these proceedings, potential data loss, and reduced productivity. To address these challenges, the implementation of an efficient and reliable backup power system becomes necessary.

This project focuses on the design of a lithium-ion battery-based power backup system tailored to the office's requirements. A detailed load analysis has been carried out across all floors of the facility, considering present demand. The system is designed for multiple backup durations, 2 or 4 hours, allowing flexibility in selecting the most suitable configuration based on operational needs and budget considerations.

Two load scenarios have been evaluated: with air conditioning loads (AC) and without AC loads. Based on technical feasibility and cost-effectiveness, the design emphasizes the critical load condition (without AC loads) as the preferred mode of operation of the power backup system. The proposed system incorporates lithium-ion battery technology, which offers superior performance, longer service life, and reduced maintenance compared to conventional battery systems.

The building of the Kerala Power Finance Corporation, where the Commission is currently functioning, has a 160 kVA diesel generator as backup power supply. Considering the high maintenance requirements and running costs, diesel generators have become obsolete in recent times. The office currently has an existing 5.2 kVA inverter system, which will be considered in the overall system planning either for integration or as a supplementary backup source. The proposed design aims to deliver a scalable, efficient, and reliable power backup solution that ensures uninterrupted operation of essential services. The report also includes recommendations for energy-efficient equipment to reduce utility costs, along with a break-even analysis for each suggestion.

1.1 Objective

The objective of this project is to design an efficient and reliable lithium-ion battery-based power backup system for the office of the Kerala State Electricity Regulatory Commission to ensure uninterrupted operation during power outages.

The specific objectives are:

- To analyze the existing electrical load of the office on a floor-wise basis
- To identify and prioritize critical loads for optimal system performance
- To design the system for multiple backup durations (2 and 4 hours) for flexible decision-making
- To determine the appropriate inverter capacity and battery bank size based on load requirements
- To adopt lithium-ion battery technology for improved efficiency, longer lifespan, and reduced maintenance
- To incorporate provisions for future load expansion
- To evaluate the possibility of utilizing the existing 5.2 kVA inverter system for supplementary support or redundancy
- Transition to cleaner backup solutions
- The overall aim is to develop a cost-effective, scalable, and technically robust power backup solution tailored to the operational needs of the office.

1.2 Scope and Limitations

The scope of the present study is limited to the design of a reliable lithium-ion battery-based power backup system for the office. Although renewable energy-based solutions such as solar photovoltaic systems were considered during the preliminary stage, their implementation has not been included in this project.

This is primarily due to the fact that the building housing the office is not owned by the Commission, thereby limiting the feasibility of installing permanent infrastructure such as rooftop solar panels. Installation of such systems would require structural modifications, long-term ownership considerations, and necessary approvals, which are beyond the scope of the present study.

Accordingly, the project focuses on a standalone battery-based backup system that can be implemented within the existing infrastructure, ensuring flexibility, ease of deployment, and minimal structural intervention.

CHAPTER – 2

EXISTING POWER SUPPLY AND CONSUMPTION DETAILS

The project site is the office of the Kerala State Electricity Regulatory Commission, located at Vellayambalam in Thiruvananthapuram. The office premises consists of multiple floors, with electrical loads comprising lighting, office equipment, computing systems, and other essential services distributed across these levels. The premises also include a dedicated court room where official court proceedings are conducted, further emphasizing the need for a reliable and uninterrupted power supply.

The office is supplied with electricity by Kerala State Electricity Board under a three-phase commercial connection with a connected load of 75 kW, indicating a significant and continuous demand for power. An analysis of electricity consumption data for the years 2024, 2025, and 2026 shows a consistent usage pattern with noticeable seasonal variations. In 2024, monthly consumption ranged from about 2560 to 5000 units, with peak consumption during the summer months. In 2025, consumption remained relatively stable between 1840 and 3632 units, indicating significant dependence on temperature and climatic conditions. For 2026 (up to February), consumption data shows 2520 units for January 2026 and 3360 units for February 2026, with average daily consumption of 81 units/day and 120 units/day respectively.

Overall, the data highlights that the office has a continuous dependence on electrical power for its operations, and any interruption in supply can adversely affect productivity. Hence, the installation of a reliable inverter backup system is essential to ensure uninterrupted power supply to critical loads.

At present, the office is supported by an existing 5.2 kVA inverter system, which is dedicated to supplying backup power to selected critical areas such as the Chairman's office, Members' offices, the court hall, and essential equipment like printers. While this arrangement ensures limited continuity for key operations, it is not sufficient to support broader critical loads across the building.

With increasing operational requirements and the need for a more comprehensive and reliable backup solution, the proposed inverter system is designed to extend support to all identified critical loads (excluding air conditioning) across the facility. The design also considers existing electrical infrastructure, space availability for installation, and provisions for safe and efficient system integration.

Smart Metering

The electricity connection to the Commission office is now supplied through a smart meter commissioned on 21st February 2026, which is installed as part of RDSS project. The system enables accurate and real-time monitoring of electrical energy consumption. Unlike conventional meters, the smart meter records energy usage at regular intervals, providing detailed insights into demand and consumption patterns throughout the day.



Figure 1: The newly installed Schneider make smart energy meter

CHAPTER – 3

EXISTING BACKUP SYSTEMS

Inverter System

The office of the Kerala State Electricity Regulatory Commission currently operates an inverter-based backup system using a Luminous Cruze+ Sine Wave UPS rated at 5.2 kVA (72 V DC system). This system is designed for single-phase operation with a rated output voltage of 220 V AC and supports limited critical loads during power outages.

The inverter is connected to a battery bank consisting of six 12 V, 150 Ah lead-acid batteries connected in series, forming a 72 V DC system. Under normal operating conditions, the system provides approximately 4 hours of backup for the connected critical loads (Excluding Air conditioners), which include the Chairman’s office, Members’ offices, court hall, and essential equipment such as printers.

However, the battery bank is approximately 8 years old, and its performance has degraded due to aging. This results in reduced effective backup duration, decreased efficiency, and increased maintenance requirements. Additionally, the existing system has limited capacity and is not designed to support the broader load requirements across all floors of the office.

Despite these limitations, the inverter unit remains operational and can be retained as a supplementary or standby backup system for critical sections. The proposed upgrade involves the implementation of a higher-capacity inverter system with lithium-ion batteries, ensuring improved efficiency, longer service life, reduced maintenance, and enhanced reliability.



Figure 2: Existing inverter and battery pack



Figure 3: Existing battery pack (top view) and existing inverter ratings

DG Set

The office is equipped with a 160 kVA (128 kW) Diesel Generator (DG) set intended to provide backup power during grid outages. However, the DG set is currently non-operational due to technical issues, rendering it unavailable for reliable backup support. Even under normal conditions, DG sets involve several limitations such as high fuel consumption, increased operating and maintenance costs, noise pollution, and emissions. Additionally, DG sets require manual intervention for operation and are not suitable for continuous or frequent usage. The present non-functional status of the DG set further highlights the lack of a dependable backup system, thereby affecting the continuity of office operations during power interruptions.

CHAPTER – 4

FLOOR-WISE LOAD ASSESSMENT & ANALYSIS

1. Basement

Total connected loads

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Court Room	0	0	0	0	15	6	2 Nos (5 tonne)	2	6	24
Law SC	0	0	0	0	10	0	1 (843 W)	0	0	8
Law Intern	1	0	0	1	0	8	1 (843 W)	0	2	8
Toilet	0	0	0	0	1	0	0	1	2	0
Common Space	0	0	0	0	0	0	0	0	3	0
Total	1	0	0	1	26	14	4 nos.	3	13	40
Power Rating	20	10	36	60	50	500	7000 + 843	45	20	18
Power in Watts	20	0	0	60	1300	7000	15686	135	260	720
Sub Total (kW)	25.181									

Critical Loads Identified

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Court Room	0	0	0	0	10	6	2 Nos (5 tonne)	2	6	24
Law SC	0	0	0	0	4	0	0	0	0	8
Law Intern	1	0	0	1	0	2	0	0	2	8
Toilet	0	0	0	0	1	0	0	1	2	0
Common Space	0	0	0	0	0	0	0	0	0	0
Total	1	0	0	1	15	1	2 nos.	3	10	40
Power Rating	20	10	36	60	50	500	7000	45	20	18

Power in Watts	20	0	0	60	750	500	14000*	135	200	720
Sub Total (kW)	16.385*									

*Two nos of 5-ton ACs at the court hall is also considered

2. Ground Floor

Total Connected Load

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Compliance Examiner	0	0	0	0	6	0	1500	0	0	8
Security	1	2	0	0	2	0	0	0	0	0
Common	0	0	0	0	0	0	0	0	3	0
Total	1	2	0	0	8	0	1500	0	3	8
Power Rating	20	10	36	60	50	500		45	20	18
Power in Watts	20	20	0	0	400	0	1500	0	60	144
Sub Total (kW)	2.124									

Critical Loads Identified

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Compliance Examiner	0	0	0	0	2	0	0	0	0	8
Security	1	2	0	0	1	0	0	0	0	0
Common	0	0	0	0	0	0	0	0	3	0
Total	1	2	0	0	3	0	0	0	3	8
Power Rating	20	10	36	60	50	500		45	20	18
Power in Watts	20	20	0	0	150	0		0	60	144
Sub Total (KW)	0.394									

3. First Floor

Total Connected Load

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Chairman Chamber	0	0	0	0	8	0	3000	1	12	16
Chairman Office	0	0	2	1	5	0	2050	0	0	0
Visitor Lounge	3	0	0	2	5	0	0	0	0	0
PR	1	0	1	1	4	0	0	0	0	0
Members Chamber	2	0	0	0	8	0	2930	0	8	0
Members Office	0	4	4	0	10	0	2050	0	0	0
Toilet	0	2	0	0	0	0	0	2	0	0
Kitchen	2	2	0	1	3	3	0	0	0	0
Common	0	0	0	0	0	0	0	0	10	0
Total	8	8	7	5	43	3	10030	3	30	16
Power Rating	20	10	36	60	50	500		45	20	18
Power in Watts	160	80	252	300	2150	1500	10030	135	600	288
Sub Total (KW)	15.495									

Critical Loads Identified

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Chairman's Chamber	0	0	0	0	4	0	3000	1	12	16
Chairman's Office	0	0	2	1	2	0	0	0	0	0
Visitor Lounge	3	0	0	2	1	0	0	0	0	0
PR	1	0	1	1	1	0	0	0	0	0
Member's Chamber	2	0	0	0	4	0	2930	0	8	0

Member' s Office	0	4	4	0	2	0	0	0	0	0
Toilet	0	2	0	0	0	0	0	2	0	0
Kitchen	2	2	0	1	1	3	0	0	0	0
Common	0	0	0	0	0	0	0	0	7	0
Total	8	8	7	5	15	3	5930	3	27	16
Power Rating	20	10	36	60	50	500		45	20	18
Power in Watts	160	80	252	300	750	1500	5930 *	135	540	288
Subtotal (KW)	9.935*									

*The ACs provided at the Chambers of the Chairman and Members are also considered as critical load.

4. Second Floor

Total Connected Load

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Secretary's chamber	0	0	0	0	4	0	850	0	0	8
Accounts	6	0	2	4	13	1	1465	0	0	0
Interns	1	0	1	1	4	0	0	0	0	0
SC Administration	0	0	2	1	4	0	1465	0	0	0
SC Engg	0	0	2	1	4	0	805	0	0	0
SC Finance	0	0	2	1	4	0	0	0	0	0
SC Finance	0	0	2	1	4	0	1284	0	0	0
SC Tech 1	0	0	2	1	4	0	805	0	0	0
JC	1	0	1	1	4	0	0	0	1	0
System Admin	1	0	1	1	4	0	1370	0	0	0
SC Tech 2	2	0	0	1	4	0	0	0	0	0
Printer	0	0	2	1	6	15	1500	0	0	0
Kitchen	1	0	2	1	2	2	0	0	0	0
Toilet	0	5	0	0	1	0	0	2	0	0
JC	1	0	1	1	6	0	0	0	0	0
Common Space	0	0	0	0	0	0	0	0	15	0
Total	13	5	20	16	68	18	9544	2	16	8
Power Rating	20	10	36	60	50	500		45	20	18
Power in Watts	260	50	720	960	3400	9000	9544	90	320	144

Sub Total (KW)	24.488									
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Critical Loads Identified

	LED Tube 1200 mm	LED Tube 660 mm	F. Tube	Fan	6 A Plug	16 A Plug	AC	Exhaust Fan	Led Bulb	F.Tube 660mm
Secretary	0	0	0	0	2	0	0	0	0	8
Accounts	6	0	2	4	5	1	0	0	0	0
Interns	1	0	1	1	2	0	0	0	0	0
SC Administration	0	0	2	1	1	0	0	0	0	0
SC Engg	0	0	2	1	1	0	0	0	0	0
SC Finance	0	0	2	1	1	0	0	0	0	0
SC Finance	0	0	2	1	1	0	0	0	0	0
SC Tech 1	0	0	2	1	1	0	0	0	0	0
JC	1	0	1	1	1	0	0	0	1	0
System Admin	1	0	1	1	1	0	0	0	0	0
SC Tech 2	2	0	0	1	1	0	0	0	0	0
Printer	0	0	2	1	4	15	0	0	0	0
Kitchen	1	0	2	1	2	2	0	0	0	0
Toilet	0	5	0	0	1	0	0	2	0	0
JC	1	0	1	1	2	0	0	0	0	0
Common Space	0	0	0	0	0	0	0	0	12	0
Total	13	5	20	16	26	1	0	2	13	8
Power Rating	20	10	36	60	50	500		45	20	18
Total Power	260	50	720	960	1300	500	0	90	260	144
Sub Total (KW)	4.284									

Summary

The present total connected load of the building is 67.288 kW, distributed across different floors. Among all floors, the basement floor has the highest load (25.181 kW), followed closely by second floor (24.488 kW). The ground floor has the lowest load at 2.124 kW, while first floor carries a moderate load of 15.495 kW.

This variation indicates that major electrical demand is concentrated in the upper and lower basement floors, while the ground floor contributes minimally to the overall load.

The critical load assessment indicates the distribution of essential power demand across different floors of the building.

- The Basement Floor has the highest critical load, amounting to 16.385 kW (including two AC's), making it the primary contributor to the backup requirement.
- The First Floor follows with a significant load of 9.935 kW, indicating considerable essential usage.
- The Second Floor has a moderate critical load of 4.284 kW, contributing to the overall demand.
- The Ground Floor has a minimal critical load of 0.394 kW, having negligible impact on system sizing.
- Total Critical Load is 31 kW

The critical load is predominantly concentrated in the Basement and First Floor as air conditioners are involved, which together account for the majority of the backup requirement. This distribution plays a key role in determining the inverter capacity and battery sizing for reliable operation during power interruptions.

CHAPTER – 5

INVERTER AND BATTERY SIZING FOR DIFFERENT OPERATING SCENARIOS

Three operating scenarios have been considered for the design and sizing of the inverter system, based on the inclusion of air conditioning loads and utilization of existing infrastructure:

- **Case 1: With AC Load in Court Hall:** In this case, the air conditioning load of the Court Hall is included along with other critical loads. This represents the maximum load condition, ensuring full functionality during power outages.
- **Case 2: Without AC Load in Court Hall:** In this scenario, the Court Hall AC load is excluded while maintaining other essential loads. This represents a moderate load condition, reducing overall power demand and backup requirements.
- **Case 3: Integration with Existing Inverter System:** This case considers the utilization of the existing inverter system along with the proposed system. The objective is to optimize cost and improve system efficiency by sharing the load between old and new configurations.

Detailed Calculations

Case 1: With AC Load in Court Hall

Critical Load details

Floor	Load(kW)
Basement	16.385
Ground Floor	0.394
First Floor	9.935
Second Floor	4.284

Total Critical Load = 30.998 \approx 31 kW

Inverter Capacity (KW) = 31 kW

Inverter Capacity (KVA) = 34.4 kVA

Battery Capacity

Case 1 : 2 Hour Backup

Battery Capacity \approx 1520 Ah

Case 2 : 4 Hour Backup

Battery Capacity \approx 3039 Ah

Calculations are based on 48 V system voltage and 85% efficiency.

Case 2: Without AC Load in Court Hall

Critical Load details

Floor	Load(kW)
Basement	2.385
Ground Floor	0.394
First Floor	9.935
Second Floor	4.284

Total Critical Load = 16.998 \approx 17 kW

Inverter Capacity (KW) = 17 kW

Inverter Capacity (KVA) = 18.8 kVA

Battery Capacity

Case 1 : 2 Hour Backup

Battery Capacity \approx 833 Ah

Case 2 : 4 Hour Backup

Battery Capacity \approx 1667 Ah

Calculations are based on 48 V system voltage and 85% efficiency.

Case 3: Integration with Existing Inverter System

In this case, the proposed backup system is designed by utilizing the existing inverter system with the new inverter configuration to optimize overall capacity and cost. The existing inverter, rated at 5.2 kVA / 4.8 kW, is utilized to supply a portion of the building load, specifically the Second Floor. By effectively distributing the load between the existing and proposed systems, the overall demand on the new inverter and battery bank is reduced. This approach not only ensures efficient utilization of available infrastructure but also minimizes

additional investment while maintaining reliable backup supply for critical loads.

Case 3A : With AC Load in Court Hall

Critical Load details

Floor	Load(kW)
Basement	16.385
Ground Floor	0.394
First Floor	9.935
Second Floor	4.284

Existing inverter capacity = 5.2 kVA / 4.8 kW

Proposed: Use this inverter to supply Second Floor load

Second Floor Load = 4.284 kW

Since 4.284 kW < 4.8 kW, the existing inverter can safely handle the Second-Floor load

New Load=30.998-4.284=26.714 kW

Inverter Capacity (KW) = 26.714 kW

Inverter Capacity (KVA) = 33.4 kVA

Battery Capacity

Case 1 : 2 Hour Backup

Battery Capacity ≈ 1310 Ah

Case 2 : 4 Hour Backup

Battery Capacity ≈ 2619 Ah

Calculations are based on 48 V system voltage and 85% efficiency.

Case 3B : Without AC Load in Court Hall

Critical Load details

Floor	Load(kW)
Basement	2.385
Ground Floor	0.394
First Floor	9.935
Second Floor	4.284

Existing inverter capacity = 5.2 kVA / 4.8 kW

Proposed: Use this inverter to supply Second Floor load

Second Floor Load = 4.284 kW

Since 4.284 kW < 4.8 kW, the existing inverter can safely handle the Second-Floor load

New Load = 16.998 - 4.284 = 12.714 kW

Inverter Capacity (KW) = 12.714 kW

Inverter Capacity (KVA) = 15.9 kVA

Battery Capacity

Case 1 : 2 Hour Backup

Battery Capacity ≈ 623 Ah

Case 2 : 4 Hour Backup

Battery Capacity ≈ 1247 Ah

Calculations are based on 48 V system voltage and 85% efficiency

Summary

The inverter and battery sizing has been carried out under three different operating scenarios to evaluate the most feasible and cost-effective solution. In Case 1 (with AC in Court Hall), the total load is 30.998 kW, resulting in a higher inverter requirement along with substantial battery capacity. In Case 2 (without AC in Court Hall), the load reduces significantly to 16.998 kW, leading to a corresponding reduction in inverter and battery sizing. Further optimization is achieved in Case 3, where the existing inverter (5.2 kVA / 4.8 kW) is used to supply the Second-floor load. This reduces the effective load on the proposed system to 26.714 kW (with AC) and 12.714 kW (without AC), thereby lowering both inverter capacity and battery requirements.

Overall, the analysis clearly indicates that exclusion of air conditioning loads and integration of the existing inverter system significantly reduce the overall system size and cost. Hence, the scenario incorporating existing inverter utilization along with selective load management is found to be the most efficient and economical solution for the proposed backup system. The following table describes the various combinations with inverter capacity and battery capacities in Ampere-hour and kWh.

Case	Description	Critical Load (kW)	Load on new Inverter (kW)	New Inverter Capacity (kVA)	Battery (Ah) 2 Hr	Battery (Ah) 4 Hr	Energy Capacity in (kWh)	
							2 Hr	4Hr
Case 1	With AC in Court Hall	30.998	30.998	38.75	1520	3039	62	124
Case 2	Without AC in Court Hall	16.998	16.998	21.25	833	1667	34	68
Case 3A	With AC + Existing Inverter	30.998	26.714	33.40	1310	2619	53	107
Case 3B	Without AC + Existing Inverter	16.998	12.714	15.90	623	1247	25	51

#Calculated for 48 V system with 85% overall efficiency

Battery Technology Selection

The selection of battery technology is a critical aspect in the design of the proposed backup system, as it directly influences system efficiency, lifecycle, maintenance requirements, and overall cost. The commonly available battery options for such applications include Lead-Acid batteries and Lithium-ion (Li-ion) batteries.

Lead-acid batteries are widely used due to their lower initial cost and established technology. However, they have certain limitations such as shorter cycle life, lower energy density, higher maintenance requirements, and longer charging time. These factors may lead to higher replacement frequency and increased operational effort over the system lifetime.

On the other hand, Lithium-ion batteries offer significant advantages including higher energy density, longer cycle life, faster charging capability, and minimal maintenance. They also provide better efficiency and deeper depth of discharge, making them more suitable for applications requiring reliable and frequent backup support. Although the initial investment is higher, Lithium-ion batteries tend to be more economical in the long run due to their extended lifespan and improved performance.

Considering the operational requirements of the facility, including reliability, space constraints, and reduced maintenance, Lithium-ion battery technology is preferred for the proposed system. However, the final selection will be based on a detailed financial evaluation and vendor quotations to ensure optimal balance between performance and cost.

CHAPTER – 6

COST IMPLICATIONS

The financial analysis of the proposed inverter and battery backup system has been carried out to evaluate the economic feasibility of the project and to identify the most cost-effective configuration. A range of power backup solutions are currently available in the market, including integrated units, all-in-one systems, and conventional setups comprising separate inverters and battery banks. Each option varies in terms of capital cost, installation complexity, operational flexibility, and scalability.

The assessment considers multiple operating scenarios, including cases with and without air conditioning loads, as well as the integration of the proposed system with the existing inverter infrastructure. Critical parameters such as inverter capacity, battery storage capacity, backup duration, and system sizing have been analysed to determine their impact on the overall project cost and performance.

Based on the evaluation, the following indicative configurations have been considered:

- A 15kW system 30 kWh Lithium-Ion battery, providing around 2 hours of backup, at an estimated total cost of ₹7,00,000/-*+ GST.
- A 30kW system 60 kWh Lithium-Ion battery, providing around 2 hours of backup, at an estimated total cost of ₹16,00,000/-*+GST.

(* The rates are obtained on market enquiry)

Both configurations are technically capable of meeting the backup requirements. However, the higher capacity system entails a substantially greater capital investment without a proportionate increase in functional benefits under the current load profile. Furthermore, the presence of an existing inverter system reduces the need for additional high-capacity installation, as part of the load demand is already supported.

It is also evident that restricting backup supply to essential loads by excluding high-power equipment such as air conditioning enables optimal system sizing and prevents unnecessary cost escalation.

It is important to note that the overall project cost is not significantly influenced by the specific type or configuration of inverter selected. Whether the system is implemented using integrated units, modular inverter-battery combinations, or other commercially available technologies, the total cost is expected to remain within a similar range for the chosen capacity. Minor variations may occur

depending on vendor specifications and procurement conditions; however, these do not materially affect the financial viability of the project.

In order to further evaluate the financial implications, a comparison has been made with conventional DG sets of comparable capacities, namely 15 kVA and 30 kVA.

The capital cost of a 15 kVA DG set typically ranges from ₹4–6 lakhs, while a 30 kVA DG set ranges from ₹8–12 lakhs. Although these values appear lower than inverter-based systems, DG installations require additional infrastructure such as foundation work, acoustic enclosures, exhaust systems, and fuel storage arrangements, which increase the effective installation cost.

From an operational perspective, DG sets incur significant recurring expenses due to fuel consumption. A 15 kVA DG set consumes approximately 3-4 litres of diesel per hour, while a 30 kVA DG set consumes about 5–6 litres per hour. At an average diesel price of ₹96 per litre, the hourly operating cost is approximately ₹336 per hour for 15 kVA and ₹480–576 per hour for 30 kVA. In addition, maintenance costs such as periodic servicing, lubrication, and component replacement further increase lifecycle expenditure.

In contrast, the inverter-based system has minimal operating costs, with expenses primarily limited to electricity required for battery charging and negligible maintenance requirements. Over time, this results in substantial cost savings compared to DG-based systems.

Considering both capital and operational aspects, it is evident that although DG sets may have a lower initial cost in some cases, their high running cost and maintenance requirements make them less economical over the long term. The inverter-based system offers a more cost-effective solution, particularly for applications involving short duration backup and selective critical load supply.

Based on the overall financial assessment, the 15kW inverter system with approximately 30 kWh battery capacity emerges as the most suitable and economically viable option. It adequately meets the backup requirements for essential loads, integrates effectively with the existing system, and avoids unnecessary capital expenditure associated with over-sizing.

CHAPTER – 7

ENERGY CONSERVATION MEASURES

To improve energy efficiency and reduce overall power consumption in the office, the following measures are recommended:

1. **Replacement of existing old air conditioning units:** – The existing air conditioning units (non-inverter type) installed near the photostat machine/printer area on the second floor and in the Compliance Examiner’s office are observed to be old and operating with reduced efficiency. These units consume higher power and may not provide optimal cooling performance. It is recommended to replace these with modern energy-efficient inverter-type air conditioners with higher star ratings, which can significantly reduce energy consumption and improve operational reliability.
2. **Replacement of existing ceiling fans with BLDC fans:** – The current ceiling fans used in the office consume relatively higher power compared to modern alternatives. Replacing all existing fans with BLDC (Brushless Direct Current) fans is strongly recommended. BLDC fans consume up to 50–60% less energy than conventional fans, while providing similar or better air delivery. This replacement can lead to substantial energy savings, especially considering the continuous usage of fans in office environments.
3. **Replacement of existing fluorescent lighting system with LED tubelights:** – The existing fluorescent lighting system in the office can be replaced with energy-efficient LED tube lights to significantly reduce power consumption. LEDs consume substantially lower wattage while providing equal or better illumination levels, leading to considerable energy savings. Additionally, LED lighting has a longer lifespan, reduced maintenance requirements, and improved reliability compared to conventional fluorescent lamps. This transition not only lowers monthly electricity costs but also contributes to sustainable energy practices and reduction in carbon footprint. Payback periods for the above three energy conservation measures are given below.

BLDC Fan Replacement – Calculation of Payback period

Number of fans = 22

Existing fan power = 70 W

BLDC fan power = 28 W

Working hours = 8 hours/day

Working days = 20 days/month

Energy rate = 7.3 per unit

Power Savings:

Power saved per fan = $70 - 28 = 42$ W

Total saving = 22×42 W = 924 W = 0.924 kW

Energy Savings:

Monthly energy saving = $0.924 \times 8 \times 20 = 147.84$ units

Cost Savings:

Energy saving = $147.84 \times 7.3 = ₹ 1079$ /month

Total Savings:

Total monthly saving = ₹ 1079/Month

Investment:

Cost per BLDC fan = 3000

Total investment = $22 \times 3000 = ₹ 66,000$

Payback Period:

Payback = $₹ 66000 / ₹ 1079 \approx 61$ months ≈ 5 years

The replacement of 22 conventional ceiling fans (70 W) with BLDC fans (28 W) results in a total load reduction of approximately 0.924 kW. The monthly energy savings is estimated to be 147.84 units, resulting in a cost saving of ₹1,079 at an energy rate of ₹7.3 per unit. Considering an investment of ₹66,000 for BLDC fans replacement, the s payback period is 5 years. This measure not only improves energy efficiency but also contributes to lowering electricity costs, while reducing the load on the proposed inverter system.

Fluorescent Tube Replacement – Calculation of Payback period

Existing Load

Fluorescent Tubes (1200 mm) = 27×36 W = 972 W

Small Fluorescent Tubes (660 mm) = 72×18 W = 1296 W

Total E Load = $972 + 1296 = 2268$ W = 2.268 kW

Proposed LED tube lights

LED Tubes (1200mm) = 27×20 W = 540 W

LED Tubes (660 mm) = 72×10 W = 720 W

Total Proposed Load = $540 + 720 = 1260$ W = 1.26 kW

Power Saving

Power Saving = Existing Load – Proposed Load = 2.268 – 1.26 = 1.008 kW

Operating Hours Working Hours per Day = 8 hours

Working Days per Month = 20 days

Total Monthly Operating Hours = 8 × 20 = 160 hours

Energy Saving Energy Saving = Power Saving × Time = 1.008 kW × 160h =161.28 kWh/month

Cost Saving

Electricity Tariff = Rs 7.3 per unit

Monthly Cost Saving = 161.28 × 7.3 = ₹ 1177 (approx.)

Investment:

Cost of 20 W LED tube ≈ ₹250

Cost of 10 W LED tube ≈ ₹150

Total Investment = (27×250) + (72×150) ≈ ₹17,550

Payback Period:

Annual saving = 1177 × 12 = ₹14,124

Payback = 17550/14124 ≈ 1.24 years

The analysis shows that replacing the existing fluorescent lighting system with energy-efficient LED tubes significantly reduces power consumption. The total connected load decreases from 2.268 kW to 1.26 kW, resulting in a net saving of 1.008 kW.

With an average operation of 160 hours per month, the proposed system achieves a monthly energy saving of 161.28 kWh. At an electricity tariff of ₹7.3 per unit, this corresponds to an estimated monthly cost saving of ₹1,177. Considering an investment of ₹17,550 for replacement, the simple payback period is reduced to approximately 1.24 years.

Implementation of these measures will not only reduce the overall energy consumption and electricity bills but also contribute to improved efficiency and sustainability of the office power system.

CHAPTER – 8

CONCLUSION

The present study has been done to design a reliable and efficient inverter-based power backup system for the office of the Kerala State Electricity Regulatory Commission. Based on detailed floor-wise load assessment and analysis of multiple operating scenarios, the critical load requirements of the facility have been identified and suitable system configurations have been proposed.

The analysis indicates that excluding air conditioning loads from the backup system significantly reduces the overall system capacity while ensuring uninterrupted supply to essential services. Further optimization is achieved through the effective utilization of the existing 5.2 kVA inverter system. The existing system can be used to supply selected portions of the load, thereby reducing the load on the proposed system. This results in a reduction in the required inverter capacity and battery size, ultimately minimizing the overall system cost.

In view of the technical feasibility and operational efficiency, it is recommended to adopt a configuration that integrates the existing inverter system along with the proposed new inverter system. This approach ensures optimal utilization of available infrastructure.

It is also observed that the implementation of the proposed system will require modifications to the existing electrical wiring and distribution network within the premises to ensure proper load segregation, safety, and efficient operation. Therefore, it is recommended that all necessary wiring works and associated modifications be included as part of the project scope during the tendering process while inviting quotations.

The detailed financial analysis and final system configuration will be determined based on vendor quotations and cost estimates, enabling selection of the most suitable option considering both performance and investment.

Overall, the proposed lithium-ion battery-based backup system provides a scalable, efficient, and reliable solution to ensure uninterrupted operation of critical services, thereby enhancing operational continuity and effectiveness of the office.