

Application of Linear Programming for Optimal Allocation of a Diesel- PV Hybrid Power System

Sandip Bordoloi¹, Suman Barman², Kaustav Medhi³, Ankur Kalita⁴, Jyotirmay Das⁵

^{1,2,3,4,5} Department of Electrical Engineering, Girijananda Chowdhury University, Azara, Guwahati, INDIA

¹sandip_ee@gcuniversity.ac.in*, ²sumanbarman789@gmail.com, ³kaustavmedhi52@gmail.com, ⁴meetandrewsmith@outlook.com, ⁵jyotirmaydas26@gmail.com

Abstract: *To address escalating electricity prices and more frequent power cuts in developing countries, hybrid energy systems, including solar and diesel generation, are being installed to ensure reliability and reduce costs. Linear programming can size hybrid systems for operation and cost-effectiveness. Linear programming helps determine the optimal dispatch strategy to improve system reliability, reduce emissions, and lower the associated costs in hybrid generation networks through the formative articulation of objective functions and constraints. The work presented in this paper shows the application of linear programming as an efficient optimization tool for solving an allocation problem involving a hybrid power system problem. Eight load points will be allocated to eight hybrid power sources involving diesel generators and a solar photovoltaic (PV) system. By solving the linear programming, it is shown that the optimal allocation of the power to the load can be done using diesel generators alone or using hybrid power generators, i.e., by using solar power generators along with diesel generators. The allocation algorithm can efficiently allocate the hybrid power generators to the load, thereby helping mitigate power loss and ill effects of pollution from diesel generators.*

Keywords: Optimization; Linear programming; Diesel generators; Solar PV; Hybrid system

Open Access. Copyright ©Authors(s). Distributed under [Creative Commons Attribution 4.0 International License \(CC-BY\)](#).
Article history- Received: 10 January 2025 and Accepted: 15 May 2025.

1. Introduction

A hybrid emergency power system can be designed by optimally allocating the different power sources to supply emergency power. In the absence of the grid supply, often the power supply to the various loads is supplied through diesel generators of different sizes that depend on the size of the generators. Efficient allocation involves strategically placing generators to serve distributed loads, minimizing fuel consumption, operational costs, and emissions while ensuring reliable power delivery. However, diesel generators cause major air and soil pollution in the form of smoke and gases emitted from the generator, in addition to soil degradation from oil spillage from the generators.

The proper allocation of diesel generators aids in the mitigation of air and soil pollution through the efficient utilization of all generators. In addition, if one or two of the generators are replaced by solar power, then the reduction of air and soil pollutants can be further enhanced. Thus, a hybrid system for emergency power supply can be designed. This work focuses on the optimum allocation of a hybrid system of solar photovoltaic (PV)-diesel generator (DG) system for the supply of

emergency power to eight different loads. This work uses the data of the loads from different load points at the campus of Girijananda Chowdhury University, Guwahati, Assam.

In this proposed work, it is expected that the power generation system, hybrid, shall meet the entire load demand while simultaneously reducing the cost of electricity generation and also the environmental impact of diesel generation. The objectives there are twofold:

1. Operate at the lowest cost; both the fuel cost of running the diesel generators as well as the installation and maintenance cost of the solar panel system.
2. Reduce the carbon concentration emitted by diesel generators, since diesel generators are the significant contributors of CO₂ emissions in the hybrid system.

The problem in this study revolves around optimally allocating the combined power output from both sources: diesel and solar sources in pursuit of economic efficiency on one hand and environmental sustainability on the other. This problem centres on determining the amount of solar power to be generated and how much of the power

backup should come from the diesel generators.

The allocation of diesel generators to loads can be done using different methods, such as linear programming, genetic algorithm, particle swarm optimization, etc. Many works have been reported on this subject. The application of linear programming in optimizing the allocation of a diesel-PV hybrid power system is crucial for enhancing operational efficiency and reducing costs. Various studies have employed mixed integer linear programming frameworks to minimize operational costs, battery degradation, and emissions in hybrid renewable-diesel power plants [1]. Additionally, the integration of photovoltaic (PV) systems with diesel generators significantly lowers operational and maintenance costs while mitigating greenhouse gas emissions [2]. The optimization process also considers uncertainties in power generation and load demand, utilizing Monte Carlo simulations and advanced algorithms like cloud leopard optimization to ensure reliability and performance [3]. Furthermore, tools based on genetic algorithms and artificial neural networks have been developed to optimize the operation of these hybrid systems, demonstrating effective energy dispatch strategies and configurations [4]. Overall, linear programming serves as a foundational approach for achieving optimal resource allocation in hybrid power systems [5]. In a study [5], a multi-objective optimization has been proposed which is used for sizing an off-grid hybrid energy microgrid with optimal dispatching of a diesel generator. This proposed method [5] increases the lifetime of diesel generators by 42.9%. The optimal design of a Hybrid PV-Diesel-Battery System for a Small Cement Brick Factory has been discussed in another work [6]. The work does not discuss the application of linear programming for the optimal allocation of a diesel-PV hybrid power system. It focuses on the optimization and financial testing of a hybrid PV-Diesel-Battery system using HOMER software for a cement brick factory [6]. Another reported work [7] focuses on using differential evolution (DE) for optimizing the planning of diesel generators and solar panels in a hybrid system to minimize costs and improve voltage profiles. A capacity allocation model for a diesel-storage micro-grid vehicle that incorporates photovoltaic uncertainty and typical load scenarios, utilizing linear programming to optimize the configuration and planning of the hybrid power system effectively has been proposed [8]. Two optimization strategies—load dispatch optimization and unit commitment optimization—are explored to unequally distribute loads among different grid-connected DGs and sequence their start/stop based on predictive demand profiles respectively [9]. Apart from linear programming, new types of algorithms have been developed for optimization for improved power efficiencies. A Hybrid improved

Sparrow Search Algorithm and sequential quadratic programming have been used for solving the cost minimization of a hybrid photovoltaic, diesel generator, and battery energy storage system [10]. Also, an optimal Solar-Biomass-Diesel-Generator Hybrid Energy for Water Pumping System Considering Demand Response has been reported [11]. A new type of optimizer known as artificial protozoa optimizer has been used for PV/diesel hybrid systems to reduce diesel consumption [13].

This study investigates the optimal way to allocate generating sources in a hybrid power system that combines diesel generators and solar photovoltaics. This work aims to provide an effective, economical, and reliable energy supply using the Linear Programming Problem (LPP) as the primary optimization technique. Geographic coordinates, generator efficiency, load demand, and generator capacity – all are taken into consideration in the formulation. The R programming environment was used to implement the experimental setup, which is based on actual load and generation data from the campus of the Girijananda Chowdhury University, Guwahati Assam.

This study aims to accomplish two main goals:

- i) To reduce running costs, such as fuel and maintenance for solar PV systems and diesel generators.
- ii) To contribute to a cleaner, more sustainable energy system by lowering carbon emissions, particularly from diesel generators.

By employing Linear Programming Problem (LPP) to optimize the distribution of power sources to load points, these goals are accomplished in this work.

2. Theoretical Overview of the Work and Methodology

This experimental work aims to investigate the optimal allocation of generating sources in hybrid generation networks that integrate renewable energy sources, such as solar PV, with conventional power generation systems like diesel generators. The generalized task in this work is to develop a comprehensive methodology for achieving an efficient, reliable, and cost-effective energy generation system.

The primary objective of this work is to determine the most efficient way to distribute hybrid power sources, particularly solar PV and diesel generators, among several load points so that:

- i) Every load gets adequate power,

- ii) The overall cost of the system is reduced, and
- iii) Effective use of the available resources is achieved to reduce the impact on the environment.

The Linear Programming Problem (LPP) optimization method has been used to optimize the load-generator demand-supply. The role of LPP becomes essential for:

- i. creating the objective function: reducing the cost of transportation (distance-based) while considering efficiency into account,
- ii. putting limitations in place, like source efficiency, load demands, and generator capacities,
- iii. finding the most effective load-source combinations while reducing environmental expenses and system losses,
- iv. assisting with the practical layout design and offering a visual representation of the connections between the generator and the load.

The LPP model requires operational and geographic constraints into account while assisting in achieving a demand-supply balance.

The Azara campus of the Girijananda Chowdhury University is the particular location for this case study. On the university campus, real-time data from eight major load points and eight hybrid generating sources, including one solar PV unit, are used. The study illustrates the potential of optimized hybrid energy systems in academic and institutional settings by modelling an emergency hybrid power supply system for the university in scenarios when grid supply is unavailable. Eight load points were chosen for this study in order to represent a diverse but manageable subset of the university's emergency power needs. These sites were selected for testing the optimization framework in a realistic hybrid energy installation scenario because of their importance, spatial distribution, and power demand variation.

Eight load points were selected for the model in order to balance representational accuracy and computational simplicity; the model is complex enough to be validated while remaining understandable for result analysis and visualization. However, the developed LPP-based allocation algorithm is not limited to eight loads. The model can readily scale up or down to accommodate any number of load points or generating units because it makes use of dynamic data structures.

The LPP technique is used for optimization for optimal allocation of the available power source which acts as an emergency power source to the

loads in case the load cannot be supplied from the main electricity source or the grid. Based on the LPP optimization result, the layout of a diesel generator (DG) plant has been designed, so that the DG plant is designed to give the most feasible allocation based on the demand-supply, the distance of the load-supply, and the generator efficiency.

The data analysis and the allocation have been carried out in the RStudio tool using an R environment. A brief description of the LPP method and R is described here.

2.1 Linear Programming Problem (LPP)

Linear Programming Problem (LPP) is a technique used for optimizing a particular scenario. Using linear programming provides us with the best possible outcome in a given situation. It uses all the available resources in a manner such that they produce the optimum result. LPP involves optimizing a linear function to find the optimal value solution for the function. The optimal value can be either the maximum value or the minimum value. In LPP, the linear functions are called objective functions. An objective function can have multiple variables, which are subjected to conditions and have to satisfy the linear constraints [14].

2.2 R Programming

The R Language stands out as a powerful tool in the modern era of statistical computing and data analysis. R programming is a leading tool for machine learning, statistics, and data analysis, allowing for the easy creation of objects, functions, and packages. The R programming language is used for statistical analysis, data visualization, and data science. It is popular among researchers, data scientists, and statisticians for its powerful tools and packages [15].

3. Experimental Analysis

3.1 Data used for the LPP optimization

To carry out the study for the LPP optimization, the load data for all eight load points are collected through a load survey. The diesel generator (DG) capacity data was recorded and the solar PV maximum power was obtained through historical data analysis. Table 1, shows the input data used for the analysis.

Table 1: Load and Generator Specification

Load Pt.	Load Demand in kW	Generator ID	Power Source Type	Generator Capacity	Source Efficiency
1	57.206	G1	Diesel	304	25
2	41.89	G2	Diesel	304	25
3	82.06	G3	Diesel	224	20
4	98.49	G4	Solar	76	16
5	423.04	G5	Diesel	60	20
6	57.53	G6	Diesel	44	20
7	110	G7	Diesel	40	20
8	2.71	G8	Diesel	44	20

As the system is hybrid- having both solar and diesel generators, the optimization technique has been used for both systems. R-programming was used to optimize the LPP. For applying the LPP algorithm in a generator allocation problem, the following conditions have been considered:

- All the generators are located at the same location,
- All the loads are located at different locations,
- The study considers that the generators will be connected to the load points, however, the power to the load points can be given only by switching the selected generator to the load,
- The LPP program does not consider transmission loss or loss due to external or environmental sources.

The approach is to optimize load allocation to generators, minimizing transportation by using the LPP algorithm. The LPP algorithm takes the following inputs:

- Load demand,
- Generator capacity,
- Locations of load and generator in terms of geographical coordinates,
- Efficiency of the sources.

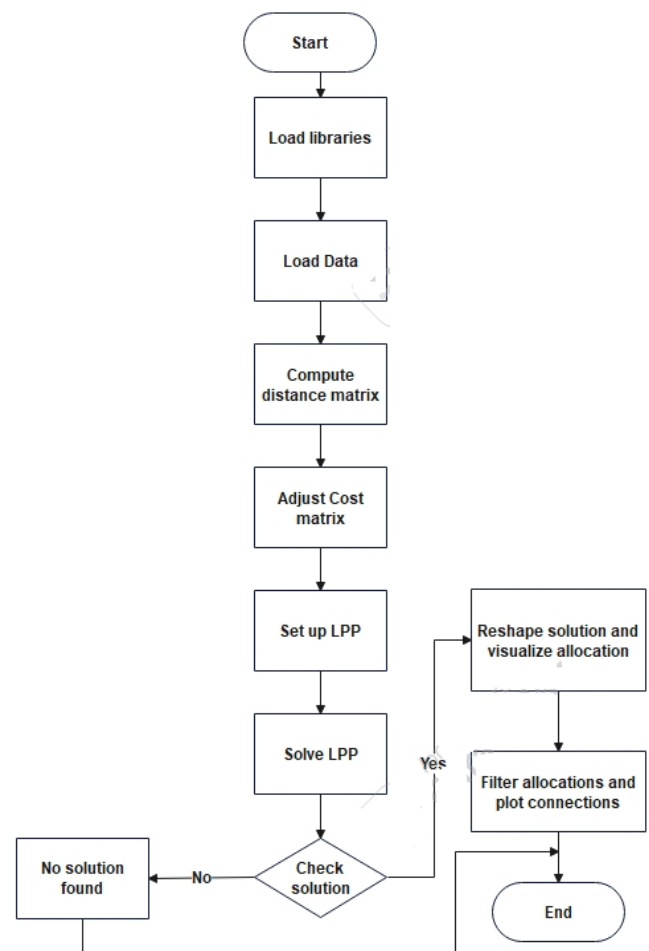
The LPP algorithm is used to determine an optimized allocation of loads to generators based on the minimum distance between them. The LPP finds a solution that balances load demand and generator capacity, minimizing transport costs. Each load is allocated to one or more generators in a way that reduces the distance, thus lowering transportation costs.

As the geographical are given as inputs, by calculating the distances based on geographic coordinates, the LPP algorithm accounts for the spatial relationship between loads and generators, which is a critical consideration for real-world applications.

The LPP algorithm is also used to provide a visual representation of the optimized allocation. The lines represent the allocation from each load to its assigned generator(s), with thickness corresponding to the allocation proportion. This visualization helps to verify the efficiency and balance of the allocations.

The LPP optimization was carried out to allocate the different power sources, including the solar panels of the hybrid system. The LPP code is written in the R environment, according to the program flowchart shown in Figure 1. After running the program according to the stated flowchart, the following allocation matrix has been obtained as shown in Table 2. The loads are designated from 1 to 8, while the sources are marked as G1 to G8. From the allocation matrix, obtained from the LPP program, it has been found that-

- The generators G1 to G3 are mainly used in this optimum allocation problem,
- Generator G4, i.e., the solar PV system is not used in the allocation problem,
- Generator G5 is used for meeting the demand of only one load.

**Figure 1:** Flowchart of the LPP program

3.2 Allocation map

The allocation map as in Figure 2 shows the allocation of the loads to the generators. This

allocation map shows the allocation based on the geographic coordinates, the load demand and generator capacity.

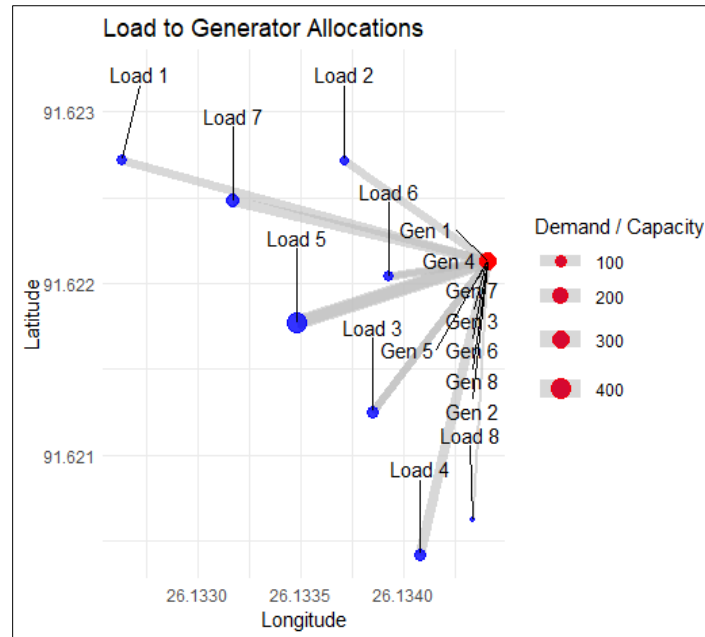


Figure 2: Load-Source Allocation Map

Table 2: Generator-load Allocation by LPP

Load Pt.	Load Demand in kW	Generator Capacity in kW								Total
		G1	G2	G3	G4 (Solar)	G5	G6	G7	G8	
1	57.206	57.206	0	0	0	0	0	0	0	57.206
2	41.89	0	0	41.89	0	0	0	0	0	41.89
3	82.06	35.594	46.466	0	0	0	0	0	0	82.06
4	98.49	98.49	0	0	0	0	0	0	0	98.49
5	423.04	0	257.534	165.506	0	0	0	0	0	423.04
6	57.53	0	0	16.604	0	40.926	0	0	0	57.53
7	110	110	0	0	0	0	0	0	0	110
8	2.71	2.71	0	0	0	0	0	0	0	2.71
Generator utility in kW	304	304	224	0	40.926	0	0	0	0	

The allocation map shows the load allocation in terms of the thickness of the lines. From the allocation matrix shown in Table 2 and the allocation map shown in Figure 2, it has been found that the LPP algorithm has allocated those generators which have the largest capacity to serve the load, taking the efficiency of the sources into consideration. The efficiency of the sources has been considered low due to the ageing of the generators used in this study. While some of the

generators are not being utilized, this allows those generators to be kept as standby. Also, not all the loads connected to G1, G2 and G3 and G5, need to be used at the same time. Thus, the allocation matrix allows the generators to be used optimally reducing overuse of the generators and mitigating the air pollution and soil pollution due to overspilling of oil from the generators. As, it has also been found from the allocation matrix, that the solar PV system is not allocated to any of the load, the solar PV system can

be used directly to supply to the grid, thus saving on the electricity charges and also helping in sustainable power generation. The analysis also gives an observation that since the solar PV system is not being used for any allocation, the PV system can be used for direct supply to the grid, thereby minimizing the battery and the power system cost to a great extent.

From the allocation solution, the generator and load interconnection layout can be visualized as shown in Figure 3.

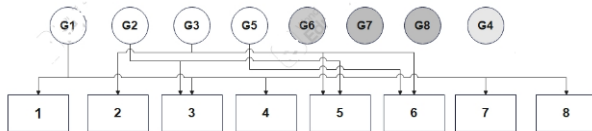


Figure 3: Load-source allocation based on the allocation matrix

From Figure 3, it can be observed that all the loads are connected to the generators G1, G2, G3 and G5, either once or twice. Thus, for loads designated by 3, 5 and 6, either of two generators can be used for meeting the demands of these loads. This can be achieved by switching the loads to the generators based on the needs of the loads.

Both the solar PV system and diesel generators are included as power sources in the optimization model. The capacity, efficiency, and geographic coordinates of each source have been defined. According to their capacity to satisfy load demands with the least amount of transportation expense and operational inefficiencies, all sources are evaluated equally by the LPP algorithm.

- However, the solar PV system (G4) was not allocated to any load in the final allocation results. This is possibly because, under the specified constraints, it was less efficient than high-capacity diesel generators due to its relatively lower capacity (76 kW) and efficiency (16%).
- The LPP algorithm automatically eliminated the solar PV system from the final solution considering that it was a part of the optimization process, illustrating that source selection is an outcome of algorithmic decision-making.

By considering the Solar PV system (G4) to have more capacity than the diesel generators (G1-G3, G5-G8), or having more efficiency than the diesel generators, the optimization can be modified to allocate G4 to other loads. By increasing the efficiency of G4 from 16% to 25%, the following generators and loads are allocated by the LPP as follows-

Load 1 → 57.206 kW to G1
 Load 2 → 41.890 kW to G3
 Load 3 → (35.594 kW to G1) + (46.466 kW to G2)
 Load 4 → 98.49 kW to G1
 Load 5 → (76 kW to G4) + (257.534 kW to G2) + (89.506 kW to G3)
 Load 6 → 57.530 Kw to G3
 Load 7 → 110 kW to G1
 Load 8 → 2.710 kW to G1

On the contrary, if the efficiencies of all the generators except G4 are kept at 20%, while G4 efficiency is increased to 25% keeping the capacity constant, the LPP gives the allocation as follows-

Load 1 → **57.206 kW to G4**
 Load 2 → 41.890 kW to G3
 Load 3 → 82.06 kW to G1
 Load 4 → (79.096 kW to G2) + (**18.794 kW to G4**)
 Load 5 → (219.23 kW to G1) + (114.3 kW to G2) + (89.506 kW to G3)
 Load 6 → 57.530 kW to G3
 Load 7 → 110 kW to G2
 Load 8 → 2.710 kW to G1

The allocation shows that if the efficiency of the solar PV system is increased more than the efficiencies of the diesel generators, then the LPP allocates the PV to the loads.

Similarly, by increasing the capacity of the Solar PV system to 100 kW, while keeping the efficiency at 16%, the LPP does not allocate any load to the PV generators, indicating that efficiency is an important factor in the allocation of load to the generators.

The developed LPP-based allocation algorithm, however, is not limited to eight loads. The model can readily scale up or down to accommodate any number of load points or generating units. For example, the number of loads has been increased to 10. The loads in kW are as follows- 57.206, 41.89, 82.06, 98.49, 423.04, 57.53, 110, 2.71, 33.5, 75.2. The allocation done by LPP is as follows-

Load 1 → 57.206 kW to G1
 Load 2 → (9.794 kW to G5) + (32.096 kW to G6)
 Load 3 → 82.060 kW to G2
 Load 4 → 98.49 kW to G1
 Load 5 → (148.434 kW to G2) + (224 kW to G3) + (50.206 kW to G5)
 Load 6 → (7.904 kW to G6) + (40 kW to G7) + (9.627 to G7)
 Load 7 → 110 kW to G1
 Load 8 → 2.710 kW to G1
 Load 9 → 33.5 kW to G1
 Load 10 → (2.094 kW to G1) + (73.106 kW to G2)

It has been observed that G4 (Solar PV generator) has not been allocated to any load since its efficiency is less than that of other generators. Thus, the efficiency of the generators is a pivotal factor in the allocation of load to the generators by the LPP model.

A comparative analysis comparing the reviewed literature mentioned and this proposed method has been included in Table 3.

Table 3: Comparison of current work with reference works

Study	Optimization Type	Scope of Optimization
This Work	Linear Programming (LP)	Optimal allocation of 8 loads to 8 hybrid sources (1 solar, 7 diesel)
A. Amer <i>et al.</i> (2024) [1]	Mixed-Integer Linear Programming (MILP)	Minimizing operational cost, battery degradation, emissions
C. S. Esobinenwu <i>et al.</i> (2023) [2]	LP-based sizing	System sizing for reliable electricity
Z. A. Memon and M. A. Akbari (2023) [3]	Robust Optimization	Uncertainty in PV, load, and reliability
M. P. Almeida <i>et al.</i> (2023) [4]	Heuristic Forecast Optimization	Day-ahead power forecast optimization
P. N. D. Premadasa <i>et al.</i> (2023) [5]	Multi-objective Optimization	Sizing and dispatching
Z. Tao <i>et al.</i> [8] (2022)	Linear Programming	Diesel-storage microgrid with PV uncertainty
I. Matragi <i>et al.</i> (2024) [9]	Custom Algorithm (non-LP)	Genset operations for fuel efficiency
H. Tian <i>et al.</i> (2025) [10]	Hybrid Metaheuristic + SQP	Cost minimization
R. G. Mohamed <i>et al.</i> (2025) [12]	Artificial Protozoa Optimizer	Diesel reduction in PV-DG system
H. M. Farghally <i>et al.</i> (2021) [6]	HOMER simulation tool	Cement brick factory energy plan
K. Pavithra <i>et al.</i> (2021) [7]	Differential Evolution (DE)	PV-Diesel planning

4. Conclusion

A comprehensive study has been made in this research work to design the layout of a diesel generator plant operating as a hybrid unit along with

a solar PV system. The LPP optimization technique is used to optimize the system using the following parameters – load demand, source capacity (peak), distance of source and load, and source efficiency. After running the LPP program in the R environment using Rstudio, the optimized allocation of the load and the power sources were obtained. It has been found that the LPP technique didn't make use of the solar PV system as an alternative to the DG sets. Also, it was found that three generators were not used for the load-generator allocation, meaning that these generators can be kept on standby in case of failures of the main generators. Thus, the solar PV system can directly be used for on-grid electricity supply, while three generators be used as standby generators for meeting small demands. The three major generators represented by G1, G2 and G3 can be used as emergency power sources to meet the demand of the loads. The allocation of the generators has been done by the LPP model based on the efficiency and the distance of the loads from the generators. It was also observed that the solar PV generator (G4) was allocated to the loads only when the efficiency was greater than the efficiencies of the diesel generators. The LPP model didn't allocate any load to the generator G4 even when the capacity of G4 was increased to 100 kW, keeping the efficiency at 16%. This study utilizes an assumption that all load-generator pairs have uniform or negligible transmission losses. By focusing on minimizing transport distance as a stand-in for losses and cost, this assumption simplifies the optimization process. Although this technique is commonly employed in theoretical models, it is well known that in practical applications, transmission losses can have an impact on the economic feasibility and net efficiency of power delivery, especially in long-distance or low-efficiency networks. Future research can incorporate a sensitivity analysis or case scenario where solar capacity or efficiency is artificially increased to see how that would affect allocation in order to more clearly demonstrate solar PV's involvement in the optimization process. If solar capacity is increased, this would show the dynamic role of renewable sources and direct future system planning.

References

- [1] A. Amer, A. Massoud, and K. Shaban, "Optimization of hybrid renewable-diesel power plants considering operational cost, battery degradation, and emissions," *Heliyon*, vol. 10, no. 6, p. e27021, Mar. 2024, doi: 10.1016/j.heliyon.2024.e27021.
- [2] C. S. Esobinenwu, "Optimization of Hybrid Solar PV and Diesel Generator System for an Efficient Electricity Supply," *International*

- Journal of Electrical and Electronics Engineering Studies*, vol. 9, no. 1, pp. 37–46, Jan. 2023, doi: 10.37745/ijeees.13/vol9n13746.
- [3] Z. A. Memon and M. A. Akbari, “Optimizing Hybrid Photovoltaic/Battery/Diesel Microgrids in Distribution Networks Considering Uncertainty and Reliability,” *Sustainability*, vol. 15, no. 18, p. 13499, Sep. 2023, doi: 10.3390/su151813499.
- [4] M. P. Almeida, A. R. A. Manito, G. F. P. Filho, and R. Zilles, “Optimization tool for operating isolated diesel-photovoltaic-battery hybrid power systems using day-ahead power forecasts,” *Journal of Renewable and Sustainable Energy*, vol. 15, no. 4, Jul. 2023, doi: 10.1063/5.0156371.
- [5] P. N. D. Premadasa, C. M. M. R. S. Silva, D. P. Chandima, and J. P. Karunadasa, “A multi-objective optimization model for sizing an off-grid hybrid energy microgrid with optimal dispatching of a diesel generator,” *Journal of Energy Storage*, vol. 68, p. 107621, May 2023, doi: 10.1016/j.est.2023.107621.
- [6] H. M. Farghally, N. M. Ahmed, F. H. Fahmy, E. A. Sweelem, and A. A. Hassan, “Optimal Design of Hybrid PV-Diesel - Battery System for a Small Cement Brick Factory: A Case Study for Bahteem, Egypt,” *International Journal of Energy*, vol. 15, pp. 1–7, Mar. 2021, doi: 10.46300/91010.2021.15.1.
- [7] K. Pavithra, D. Kavitha, and R. Krishnavenishri, “Optimal Planning of PV-Diesel Hybrid Systems,” in *Lecture notes in electrical engineering*, 2021, pp. 1499–1507. doi: 10.1007/978-981-15-8221-9_140.
- [8] Z. Tao, P. Yu, N. Sun, S. Gao, Y. Li, and H. Shao, “Optimal configuration of diesel-storage micro-grid vehicle considering PV uncertainty,” *2022 IEEE International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA)*, pp. 1410–1415, Feb. 2022, doi: 10.1109/eebda53927.2022.9744749.
- [9] I. Matragi, A. Maiboom, X. Tauzia, B. Moricet, and Y. Thevenoux, “A novel algorithm for optimizing genset operations to minimize fuel consumption in remote diesel-RES microgrids,” *Energy Conversion and Management X*, p. 100728, Oct. 2024, doi: 10.1016/j.ecmx.2024.100728.
- [10] H. Tian, K. Wang, B. Yu, C. Song, and K. Jermittiparsert, “Hybrid improved Sparrow Search Algorithm and sequential quadratic programming for solving the cost minimization of a hybrid photovoltaic, diesel generator, and battery energy storage system,” *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, vol. 47, no. 1, pp. 6237–6253, Dec. 2025, doi: 10.1080/15567036.2021.1905111.
- [11] O. T. Amusan, N. I. Nwulu, and S. L. Gbadamosi, “Optimal Solar-Biomass-Diesel-Generator Hybrid Energy for Water Pumping System Considering Demand Response,” *Engineering Reports*, vol. 7, no. 1, p. e13055, Jan. 2025, doi: 10.1002/eng2.13055.
- [12] R. G. Mohamed, A. A. Hassan, and S. H. E. Abdel Aleem, “A modified energy management strategy for PV/diesel hybrid system to reduce diesel consumption based on artificial protozoa optimizer,” *Scientific Reports*, vol. 15, no. 1, p. 4440, Feb. 2025, doi: 10.1038/s41598-025-87716-y.
- [13] “Linear Programming,” *GeeksforGeeks*, May 30, 2025. Available: <https://www.geeksforgeeks.org/linear-programming/#what-is-linear-programming> [Accessed: May 30, 2025]
- [14] “R Programming Language Introduction,” *GeeksforGeeks*, May 26, 2025. Available: <https://www.geeksforgeeks.org/r-programming-language-introduction/>

Authors' Profiles

electric motors, like using smart algorithms, to ensure they work accurately and efficiently.

Sandip Bordoloi, PhD, is working as an Associate Professor in Girijananda Chowdhury University, Assam India. He received his PhD degree in Electrical and Electronics Engineering from Assam Don Bosco University (India) in 2015. His research interest is in sensor and instrumentation, energy analytics, data analytics and machine learning.



Suman Barman, is currently pursuing his B.Tech degree in Electrical Engineering at Girijananda Chowdhury Institute of Management and Technology, India. His area of interest is in areas of interest include power system optimization techniques, power system protection, renewable energy integration, sustainable renewable energy solutions, and power system analysis.



Kaustav Medhi, is currently pursuing his B.Tech degree in Electrical Engineering at Girijananda Chowdhury Institute of Management and Technology, India. His area of interest are Power Electronics and Power Systems to improve the efficiency and sustainability of electrical power conversion.



Ankur Kalita, is currently pursuing his B.Tech degree in Electrical Engineering at Girijananda Chowdhury Institute of Management and Technology, India. His area of interest is in exploring, developing and implementing Artificial intelligence systems for efficient working and accurate monitoring of the electrical systems. This will certainly create many opportunities for future development for control of automated electrical systems.



Jyotirmay Das, is currently pursuing his B.Tech degree in Electrical Engineering at Girijananda Chowdhury Institute of Management and Technology, India. His area of interest includes exploring advanced ways to control

