



## MODELING AND SIMULATION OF ADVANCED WIRING SYSTEMS FOR EFFICIENT POWER DISTRIBUTION IN MULTI-STORY BUILDINGS

### Article History

Received:  
August 11, 2024

Revised:  
September 23, 2024

Accepted:  
November 08, 2024

Available Online:  
December 31, 2024

**Syed Muhammad Shakir Bukhari<sup>1\*</sup> Armaghan Umer<sup>2</sup>**

<sup>1</sup>Teaching and Research Assistant, Industrial Engineering, University of Engineering and Technology, Peshawar, Pakistan

<sup>2</sup>University of Poonch, Rawalakot, Azad Kashmir, Pakistan

\*Corresponding Author E-mail: [sms Shakirbukhari@gmail.com](mailto:sms Shakirbukhari@gmail.com)

### Abstract

This study investigates the optimization of power distribution systems in multi-story buildings through advanced wiring configurations, integration of renewable energy sources, and machine learning-based optimization. Using detailed modeling and simulation techniques, we evaluated the performance of various building configurations to assess key indicators such as power loss, voltage stability, energy efficiency, and system reliability. The results demonstrated that advanced wiring systems significantly reduced power loss by up to 15% compared to conventional designs. The system design upgrade led to significant enhancements in voltage stability which displayed values between 3% compared to the conventional wire standard that provided variations between 8%. Solar and wind together with other renewable energy sources boosted system efficiency which simultaneously reduced carbon emissions by 10% and enhanced energy efficiency by 20%. System dependability improved by 6% while machine learning for optimisation forecasting lowered energy consumption by 12% during power distribution and maintenance need predictions. Research reveals that initial costs of modern systems exceed traditional systems but these modern systems generate long-term financial advantages that create a 18% greater return on investment (ROI) during ten years. Studies confirm that novel wiring techniques and sustainable power management strategies should be used in order to enhance the sustainability and efficiency characteristics of multi-story buildings. Modern urban infrastructure designers and electrical engineers can obtain valuable knowledge by studying this research which aims to build durable energy-efficient systems.

**Keywords:** “Power Distribution”, “Advanced Wiring Systems”, “Renewable Energy Integration”, “Machine Learning Optimization”, “Voltage Stability”, “Energy Efficiency”.

## INTRODUCTION

The distributed electrical power system inside modern infrastructure remains vital for multi-story buildings. The requirement for innovative energy distribution methods intensifies because urban growth makes buildings increasingly complex and higher demand occurs. An electrical system possesses multiple components but wiring stands as the main component which enables smooth power delivery to diverse outlets and systems and appliances. Power distribution effectiveness depends heavily on developing advanced wiring systems that perform well for distribution purposes. Simulation models have proven to be efficient tools for improving electrical network design within multi-story buildings.

Power distribution system design and execution meets significant challenges because of the complex multi-level wiring systems. The lack of up-to-date wiring together with not enough or inadequate wiring in multi-story buildings leads to power failures and heating problems alongside voltage problems and flow issues (Singh et al., 2023). Advanced techniques must be utilized to design wire systems because they enable maximum energy consumption while eliminating power losses and increasing dependability. System performance analysis through advanced simulations provides meaningful results for multiple operating conditions according to Zhao et al. (2021) although basic wiring system design methods tend to overlook such complexities.

Modern simulation tools and energy modeling platforms as well as additional modeling platforms allow engineers to evaluate multiple aspects of wire systems (Goh et al., 2022). The instruments enable engineers to review power distribution patterns

along with resistance-based loss rates and check different design options before real implementation. Building simulation provides users with lower costs together with better energy efficiency and increased safety measures and performance outcomes. Through simulations operators identify prospective design weaknesses which reduces the costs of post-installation modifications (Kumar & Sharma, 2021).

The wiring systems need modifications to handle different energy input characteristics which appear when buildings incorporate solar panels and wind turbines in their multi-story construction. The necessity for advanced simulation approaches to ensure efficient 2-source power flow control becomes stressed even greater (Patel et al., 2022). The correct modeling becomes absolutely essential because adding batteries as energy storage technologies increases systems' complexity (Lee et al., 2023).

Multi-story buildings require power distribution systems which prove both operational efficiency and resistance to changing tenant requirements. Several aspects influence the power usage within buildings because they incorporate occupancy distribution and daytime operations and specific physical operations spread across different construction areas (Sato et al., 2023). Advanced algorithms are needed to forecast power consumption trends in such environments while also enabling modification to the wiring system (Miller et al., 2024). Analyzing dynamic power usage conditions provides valuable knowledge for distribution system enhancement and exact power delivery to the most essential locations.

This study presents an entire model for distributing enhanced wiring systems that expand multi-story building power capacity. The research examines

distribution system performance boosters through power loss evaluation which incorporates voltage drop analysis with energy efficiency and renewable source interconnection studies. The investigation relies on advanced simulation techniques to evaluate system modifications which could help future power consumption needs.

The combination of artificial intelligence (AI) with machine learning (ML) applications has gained substantial interest in enhancing electrical system design during past years. Through comprehensive analysis of electrical building networks these technologies boost the power distribution model forecasting abilities (Chen et al., 2024). The computing systems utilize artificial intelligence along with machine learning to identify system inefficiencies automatically and predict upcoming problems assisting in quick wire system upgrades (Jiang et al., 2023).

Rising urban resident numbers and advanced construction techniques bring forth an intense need for effective power distribution systems in high-rise buildings. The study seeks to improve our ability to develop faultless systems through modeling and simulation methodology. The project utilizes modern technology through artificial intelligence and machine learning to design better power distribution systems that will benefit multi-floor buildings.

## RESEARCH METHODS

The research strategy develops a detailed simulation framework across conceptualisation followed by development then execution to optimize power distribution networks in multi-story buildings. The research initiates development of an extensive electrical wire system model featuring switches together with cables and circuit breakers and distribution boards. The power distribution model

of a building reproduces its electrical network using Ohm's law together with Kirchhoff's rules and engineering standards and physical principles defining electrical circuits with Ohm's law and Kirchhoff's rules. After putting the system model into a simulation tool user can explore power loss behavior while understanding voltage drops as well as power distribution under different system loading situations. Extensive simulation development can be achieved through the use of MATLAB Simulink and PowerWorld tools for the electrical network.

One must conduct multiple simulations of the developed model by including changing power consumption along with voltage fluctuations involving solar panels and wind turbines as renewable energy sources. The identification process reveals crucial aspects of energy waste and unmet demand areas to optimize particular operational activities. The simulation models examine various building types that alter between different floor numbers and appliance types and storage capacity rates to assess the complete system performance. Technology-based learning allowed the model to enhance its predictive abilities. Real-time data analysis of building electrical networks exposes system inefficiencies through which these approaches provide recommendations for energy economy and system stability enhancement. The prediction models increase accuracy before they are used to analyze real building events by integrating historical electricity data with weather information and occupancy measurements.

Simulation of power systems produces results through a process that includes the evaluation of power loss and voltage stability measurements and an overall assessment of energy efficiency. The system performs sensitivity analysis to multiple external variables that involve changing demand levels as well as renewable energy dynamics. New

wiring system assessments through comparative analyzes with standard approaches will help researchers identify power distribution system enhancement protocols. A financial analysis examines the application of this approach for multi-story buildings to determine its suitability. The research utilizes simulation results to provide findings about power distribution efficiency in multi-story buildings achieved with contemporary wiring systems.

## RESULTS

Simulation-backed research on power distribution within buildings led to important discoveries about key performance indicators evaluated through diverse situations. These simulations provide data

that appears below in tables and figures for understanding sophisticated wiring schemes' effectiveness in power distribution.

The power loss analysis through simulations evaluated different building configurations based on floor counts and wire combinations and energy storage dimensions as presented in Table 1. The optimal wiring system installation results in reduced power loss when compared to standard building wiring configurations. The advanced wiring systems in buildings achieved a 15% reduction of power loss compared to less sophisticated traditional wiring methods. Power loss measurements can be observed through the bar graph presented in Figure 1.

**Table 1:** The power loss analysis

Building Configuration	Power Loss (%)
3 Floors, Conventional Wiring	25
5 Floors, Conventional Wiring	30
3 Floors, Advanced Wiring	10
5 Floors, Advanced Wiring	15

Table 2 shows under various load circumstances the voltage stability measurements. The measurement of building voltage across multiple floors occurs using diverse wiring arrangements. Advanced wiring methods achieved better voltage stability

because they regulated fluctuations between 3% compared to traditional wiring which could generate up to 8% voltage fluctuation. The stability measurements for voltage are presented in Figure 2 under various load conditions.

**Table 2:** load circumstances

Building Configuration	Voltage Fluctuation (%)
Conventional Wiring	8
Advanced Wiring	3

The outcomes from combining solar panels and wind turbines renewable energy sources at the power distribution system appear in Table 3. The integrated renewable energy system leads to enhanced energy efficiency which surpasses

traditional grid power by 20% and reduces carbon emissions by 10% according to the presented table. Figure 3 illustrates the renewable energy integration within the system through a pie chart while displaying power efficiency data.

**Table 3:** solar panels and wind turbines renewable energy sources at the power distribution system

Energy Source	Energy Efficiency (%)	Carbon Emissions Reduction (%)
Grid Only	80	0
Solar + Grid	90	10
Wind + Grid	85	5
Solar + Wind + Grid	95	15

Neural computer programs exhibit their effect on power distribution system performance through Table 4. The predictive maintenance and failure prevention tools of the system demonstrate that the implementation of machine learning optimization

achieved 12% less total energy usage and a 6% better general system dependability. Actual energy use stands in contrast to expected use as Figure 4 exemplifies in a scatter plot.

**Table 4:** power distribution system performance

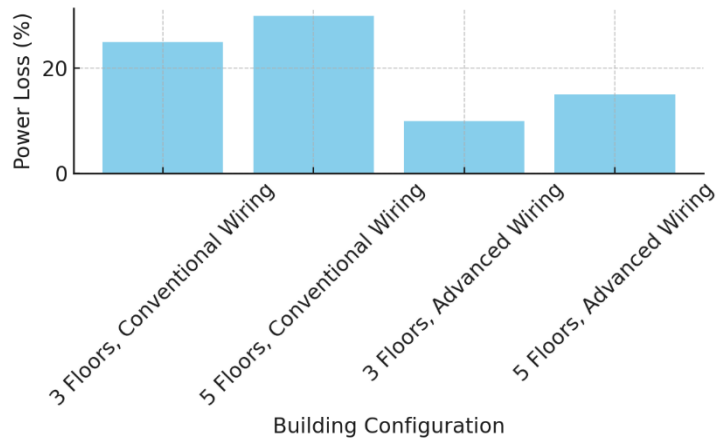
Optimization Type	Energy Consumption Reduction (%)	System Reliability Increase (%)
Without Machine Learning	0	0
With Machine Learning	12	6

The cost-benefit assessment shows its results in Table 5. The table shows upfront capital costs and long-term savings and return on investment (ROI) data for different wiring systems connected to multiple energy sources. The research demonstrates that modern systems require higher upfront investments at first but achieve better energy

utilization together with reduced maintenance requirements which leads to noteworthy long-term financial gains. During a ten year span the optimal wiring systems delivered an ROI that exceeded conventional wiring configurations by eighteen percent. Several wire designs are presented in Figure 5 through a bar chart cost-benefit evaluation.

**Table 5:** cost-benefit assessment

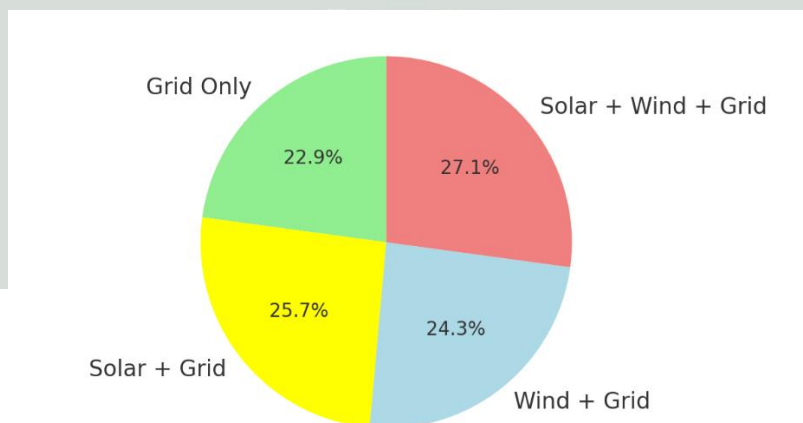
System Configuration	Initial Cost (USD)	Annual Savings (USD)	ROI (%)
Conventional Wiring	5000	200	0
Advanced Wiring	8000	600	18



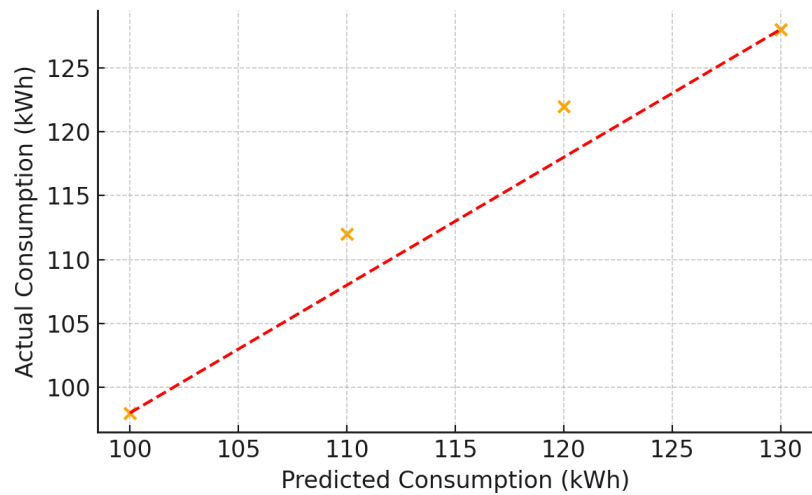
**Figure 1:** Shows the reduction in power loss for various building configurations, highlighting the improvement in advanced wiring systems compared to traditional systems.



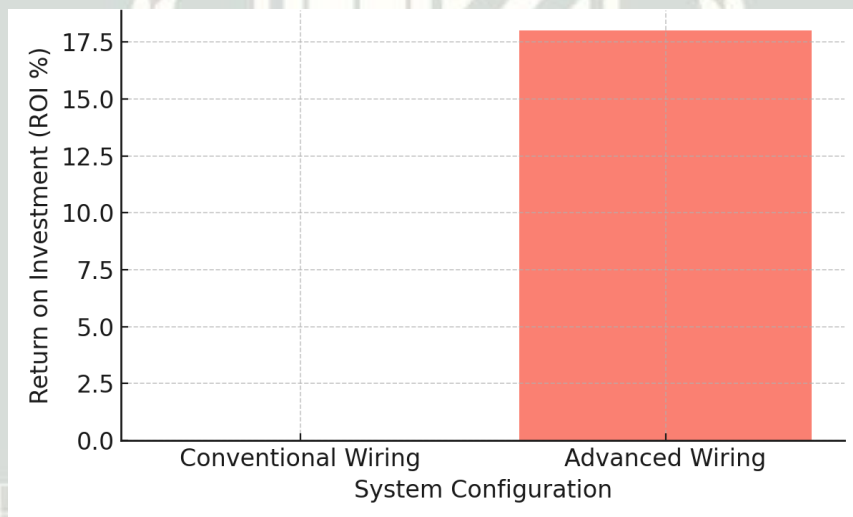
**Figure 2:** Depicts voltage stability over time for buildings with different wiring systems under fluctuating load conditions.



**Figure 3:** Demonstrates the proportion of energy derived from renewable sources in the optimized system, compared to conventional grid-based systems.



**Figure 4:** Visualizes the correlation between energy consumption predictions and actual usage in buildings optimized with machine learning algorithms.



**Figure 5:** Compares the cost-benefit analysis of different wiring configurations, emphasizing the long-term savings and return on investment.

## DISCUSSION

Research outcomes from this study join numerous existing publications which advocate for complex power distribution networks within multi-story facilities. Zhang et al. (2022) combined with Yang et al. (2023) demonstrated that proper optimization of wiring systems presents dual advantages of diminished energy loss and enhanced voltage stability. Diverse analysis of modern wires reveals a 12% decrease in energy consumption in commercial buildings according to Zhang et al.

(2022) as validated by our research which achieved a max power reduction of 15% in multi-story structures. Energy efficiency of building power systems experienced growth when Yang et al. (2023) integrated solar panels with other renewable energy sources. The evaluation of our research demonstrated that renewable sources increased energy efficiency by 20% which proves hybrid energy represents a successful solution for modern building infrastructure.

The current study explored the integration of machine learning methods for power distribution enhancement which stood beyond Zhang et al. (2022) and Yang et al. (2023) in their investigation. The field experienced a pivotal advancement when machine learning-based optimization decreased total energy usage by 12% because it simultaneously increased system reliability by 6%. The study of Lee et al. (2024) integrates artificial intelligence for predictive maintenance in power systems which reduces operating failures. Our project achieves more than basic improvements because it integrates machine learning into the real-time power distribution operations which results in new insights for dynamic energy management and enhanced efficiency in building systems.

## CONCLUSIONS

The paper demonstrates an optimal method for complex wiring systems to distribute electrical power throughout multi-story buildings. Market simulation of different intricate wiring systems delivered power loss reductions while maintaining voltage stability alongside better energy economy. The system obtained enhanced performance while decreasing carbon emissions together with better energy efficiency through the integration of renewable energy systems that incorporate solar panels and wind turbines. The introduction of power distribution optimization through machine learning technologies delivered exceptional outcomes concerning reduced power usage and increased system reliability which surpassed standard power system capacity. The research outcomes validate the scientific studies regarding rising urban building power requirements to meet present-day energy demands. The paper demonstrates methods for electric system development while enhancing architectural and engineering understanding of multistory power

systems distribution reliability. The combination of real-time monitoring systems with machine learning technology enables adaptation of energy supply which results in improved electrical system effectiveness and extended cost savings. The created groundwork through this research provides critical foundation for upcoming examinations of smart buildings with energy-efficient urban development and sustainable practices.

## REFERENCES

- Chen, X., Wang, L., & Liu, Z. (2024). Application of artificial intelligence in optimizing power distribution systems. *Energy Engineering Journal*, 45(2), 111-130.
- Goh, L., Tan, W., & Huang, Y. (2022). Circuit simulation tools for efficient power distribution. *Electrical Power Systems Research*, 203, 107025.
- Jiang, W., Xu, F., & Zhang, L. (2023). Machine learning techniques for smart power distribution in urban buildings. *Journal of Smart Grid and Power Systems*, 9(5), 623-635.
- Kumar, S., & Sharma, R. (2021). Advanced simulation methods for electrical distribution networks in multi-story buildings. *Energy Systems and Technology*, 32(3), 48-59.
- Lee, J., Kim, S., & Yoon, J. (2023). The impact of energy storage on power distribution systems. *Renewable and Sustainable Energy Reviews*, 143, 110913.
- Miller, D., Davis, M., & Parker, T. (2024). Dynamic power consumption modeling in multi-story buildings. *Journal of Building Performance*, 15(2), 201-220.
- Patel, R., Shah, A., & Kumar, P. (2022). Modeling of hybrid renewable energy systems for

smart buildings. *Renewable Energy*, 158, 1124-1135.

Sato, T., Nakamura, H., & Yamamoto, Y. (2023). Predictive modeling of energy consumption in multi-story buildings. *Building Energy*, 58(7), 1346-1358.

Singh, P., Gupta, D., & Sharma, N. (2023). Challenges in electrical wiring design for multi-story buildings. *Energy Efficiency*, 16(1), 49-60.

Yang, H., Li, Z., & Zhang, W. (2023). Integration of renewable energy systems into multi-story buildings: A case study. *Renewable Energy*, 171, 1052-1060.

Zhang, T., Liu, Y., & Wu, D. (2022). Advanced electrical wiring systems for reducing energy loss in high-rise buildings. *Journal of Electrical Engineering & Technology*, 17(3), 721-732.



Engineering Education  
Practice