A
MSE Presentation
on

Secure Integration of Renewable Energy in DC Microgrid

Presented by

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Under the guidance of

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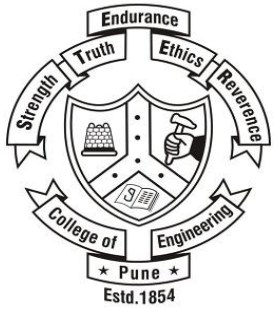


COEP Technological University, Pune

Secure Integration of Renewable Energy in DC Microgrid

Ensuring reliable and safe renewable power delivery

Introduction:-

Emergence of DC Microgrids:-

DC microgridss integrate renewable sources like PV, wind turbines, and BESS for efficient energy management.

Advantages of DC Microgrids:-

They reduce conversion losses, offer modularity, and improve overall energy efficiency in diverse applications.

Applications of DC Microgrids:-

Used in rural electrification, smart buildings, and data centers, providing versatile energy solutions worldwide.

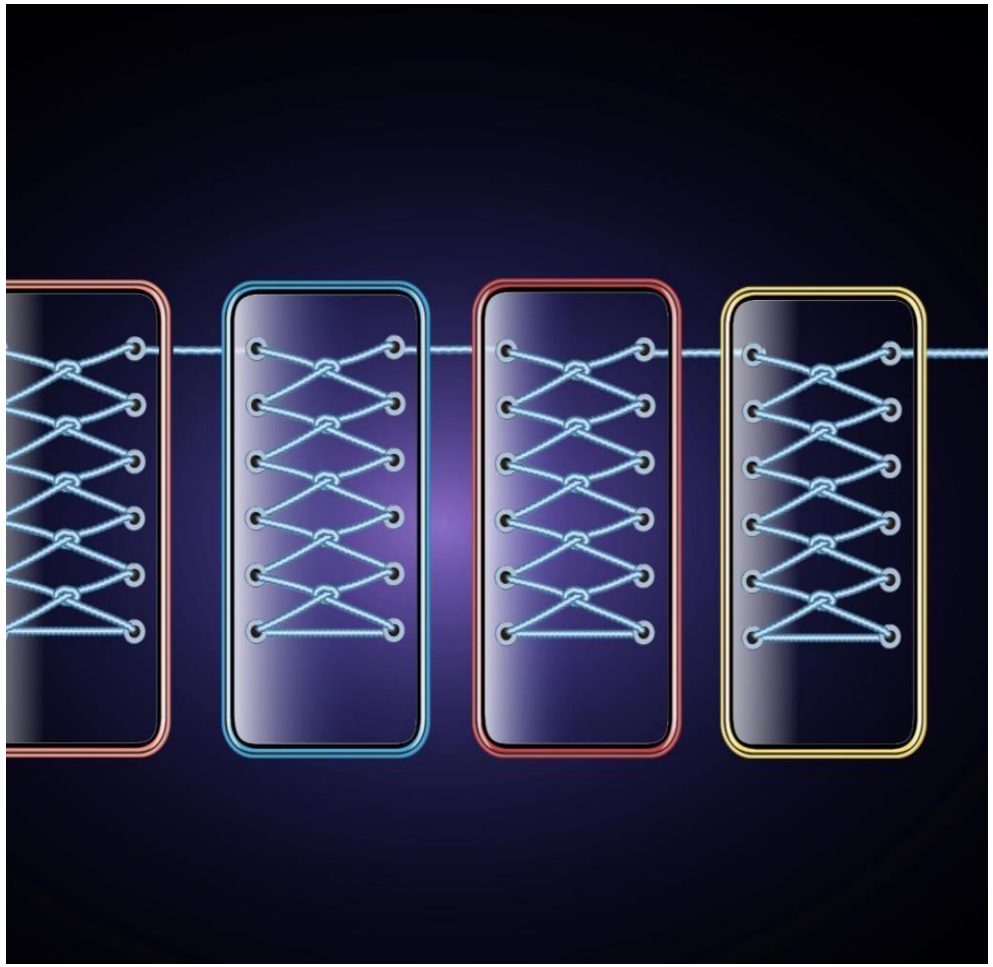
Challenges in Deployment:-

Challenges include lack of standardization, protection issues, harmonic distortions, and cyber security risks.

Literature Survey:-

Year	Title of the Paper	Methodology	Observations / Remarks
2024	AI-based Adaptive Protection for DC Microgrids — Maveeya Baba et al.	Proposed adaptive protection using AI/ML algorithms for fault detection and coordination.	AI models enhance protection speed and accuracy; address limitations of conventional schemes.
2025	Cybersecurity Vulnerabilities and AI-based Monitoring in DC Microgrids — R. R. Sarangi et al.	Reviewed cyber-physical threats; proposed AI-driven anomaly detection framework.	Emphasized need for resilient, real-time cyber protection in microgrids.
2023	Real-world DC Microgrid Deployments: Academic and Industrial Perspectives — A. W. Adegboyega et al.	Case studies on microgrid deployments analyzing operational and economic aspects.	Reported improved efficiency and reliability; scalability remains challenging.
2024	Power Quality and Standardization in DC Microgrids — Dinesh Kumar et al.	Analytical modeling of harmonics and voltage stability in converter-based systems.	Highlighted necessity for harmonics mitigation and standardization.
2023	Distributed Generation Integration in DC Microgrids — T. G. C. Thippeswamy et al.	Simulated DG configurations using MATLAB to assess performance metrics.	Found DG improves efficiency, reliability, and reduces system losses.
2024	Stochastic Optimization for Secure Operation of Hybrid Microgrids — M. Dabbaghjamanesh et al.	Developed stochastic optimization considering renewable uncertainties and security constraints.	Enhanced resilience and stability under fluctuating renewable conditions.
2025	Review on Distributed Generation Integration and Sustainability — S. Anand et al.	Comprehensive review of DG technologies, control, and integration strategies.	Identified gaps in adaptive control, harmonization, and cybersecurity.

Research Gap:-



Lack of Unified Framework:-

No universal protection and control framework exists for diverse DC microgrid systems.

Limited AI and ML Application:-

AI and ML use for cyber-resilience in DC microgrids remains minimal and underdeveloped.

Underdeveloped Adaptive Coordination:-

Real-time adaptive relay coordination mechanisms need advancement for enhanced system reliability.

Need for Integrated Approaches:-

Integration of optimization and protection strategies is essential to improve microgrid performance.

Motivation /Necessity:-

Renewable Integration Challenges:-

Renewable energy growth demands secure, reliable integration with power systems tailored to DC characteristics.

Adaptive Fault Protection:-

Traditional protection is inadequate for DC systems, requiring adaptive and AI-driven fault protection strategies.

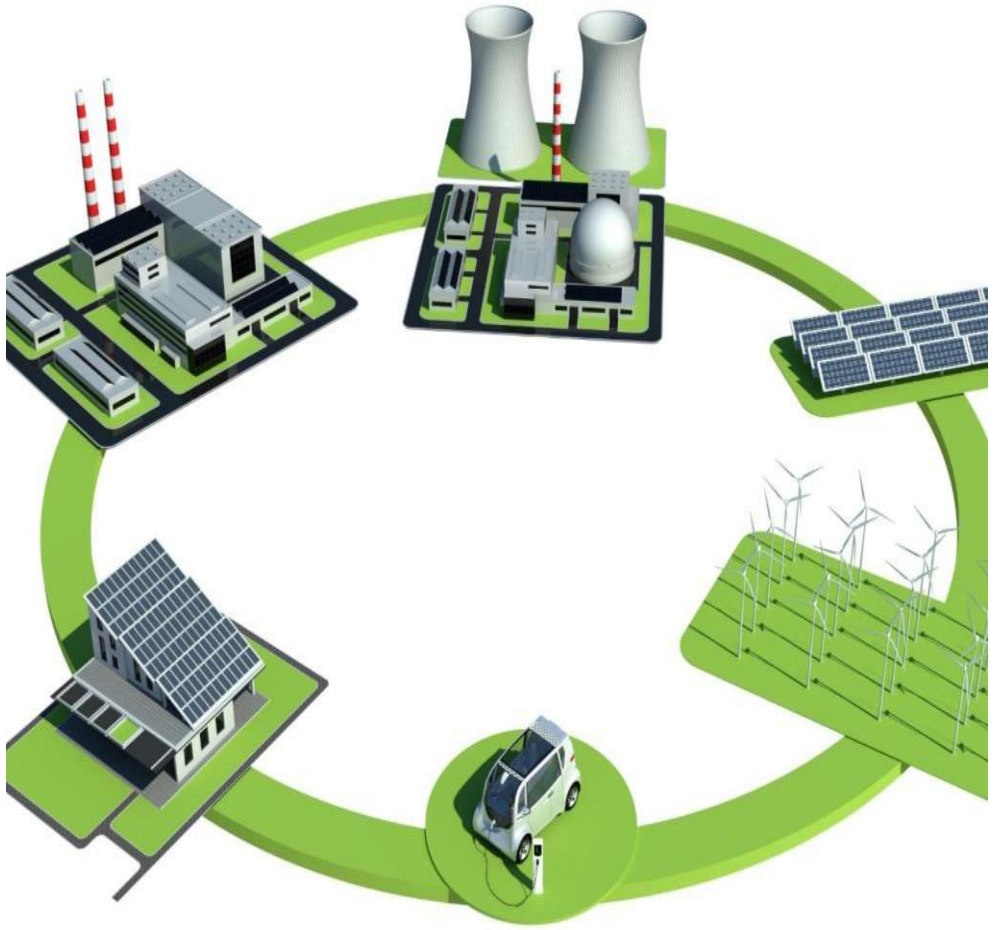
Cybersecurity Concerns:-

Microgrid digitalization introduces cybersecurity risks that must be mitigated for system resilience.

Need for Standardization:-

Lack of uniform inter operability standards complicates integration, necessitating comprehensive frameworks.

Problem Statement:-



Lack of Standardization:-

DC microgrids face challenges due to absence of universal standards, impacting interoperability and safety.

Inadequate Protection and Cybersecurity:-

Current protection mechanisms and cybersecurity measures are insufficient for securing DC microgrids against threats.

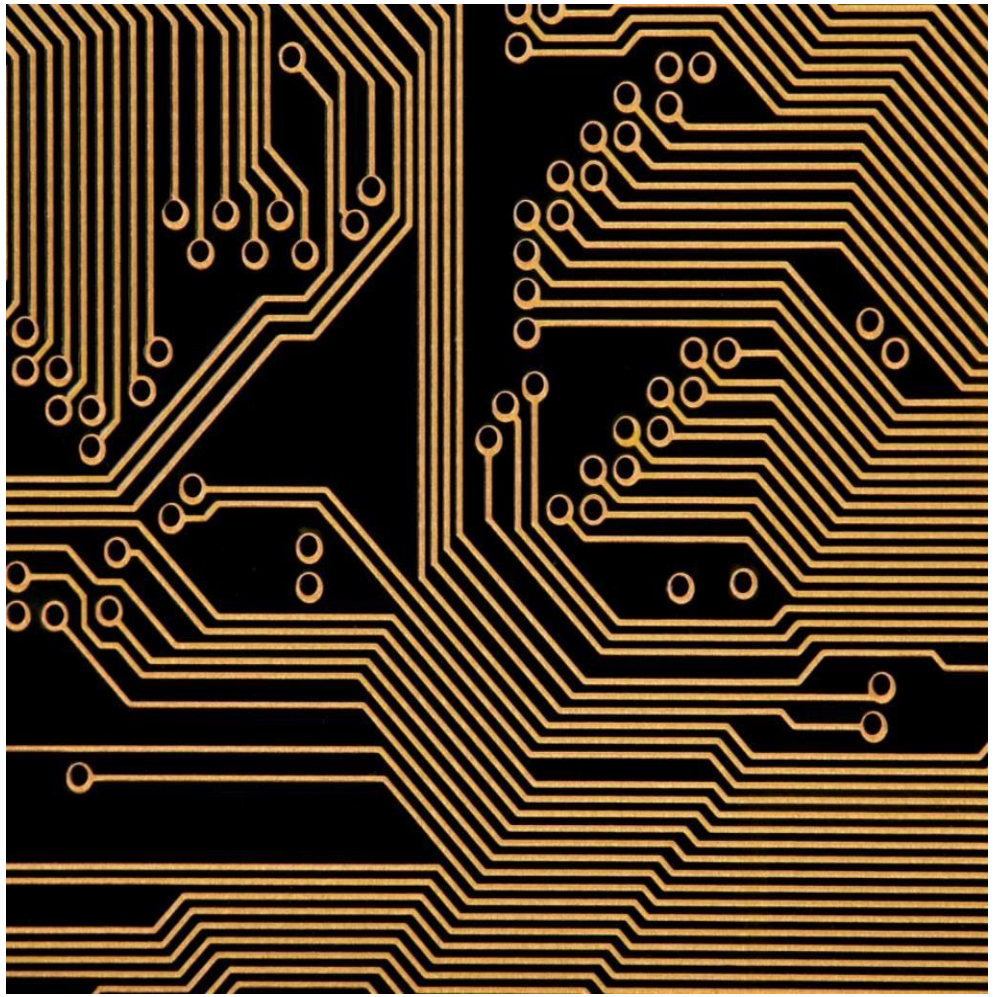
Intermittency and Stability Issues:-

Renewable energy intermittency causes reliability and stability challenges for DC microgrids.

Control System Limitations:-

Existing control systems lack adaptability to disturbances and dynamic changes in the grid environment.

Research Objectives:-



Analyze Security and Stability:-

Research focuses on identifying security and stability challenges in DC microgrids to enhance reliability.

AI-Enabled Protection Framework:-

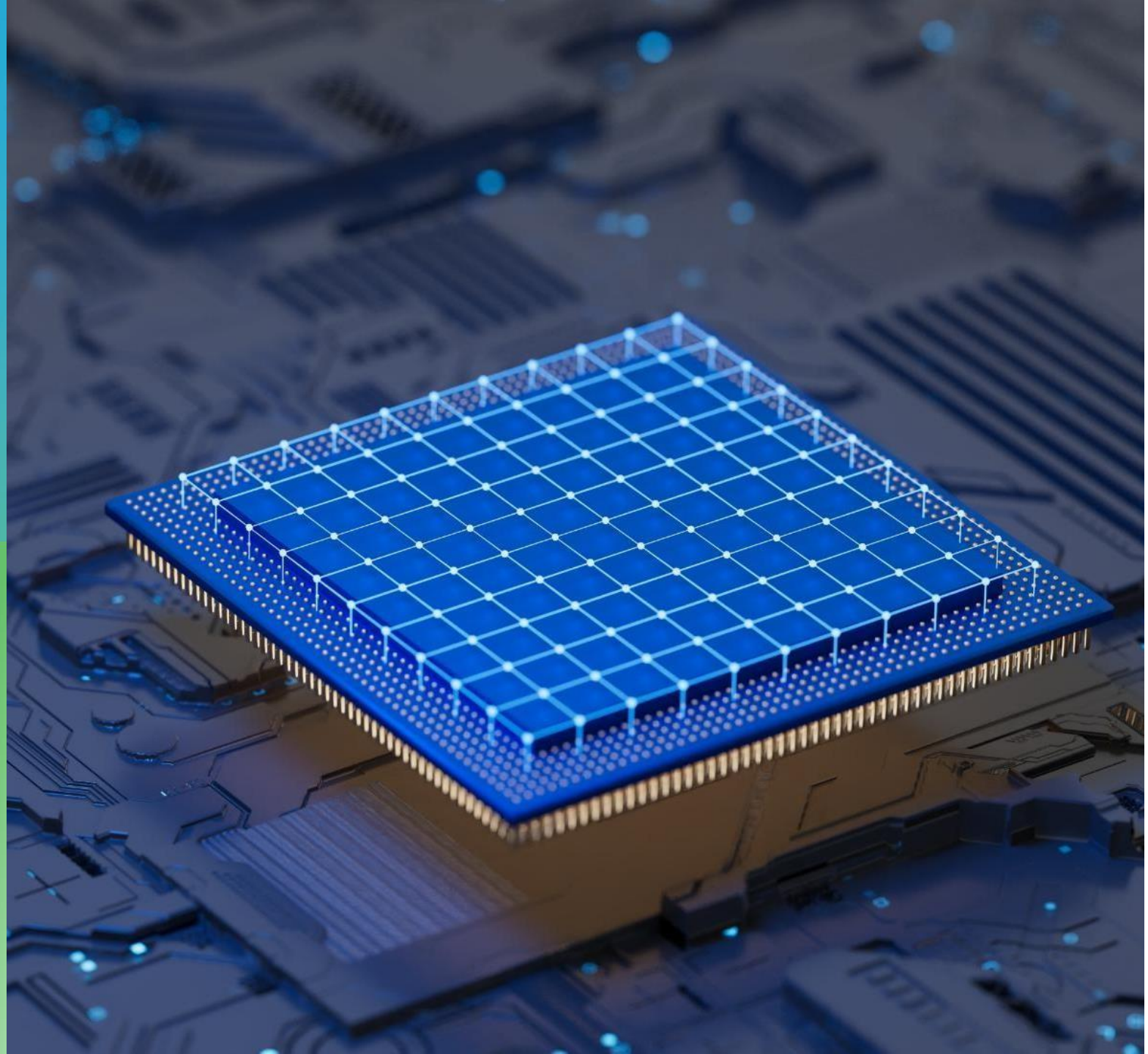
Development of a secure AI-based framework to protect DC microgrid operations effectively.

Optimized Distributed Generation;-

Enhancing system resilience by optimizing integration of distributed generation sources within the grid.

Simulation-Based Validation:-

Using simulation testing methodologies to validate performance of proposed DC microgrid solutions.



Methodology /Theme:-

Microgrid Modeling:-

The microgrid model integrates PV, wind, energy storage systems, and loads using MATLAB/Simulink for accurate simulations.

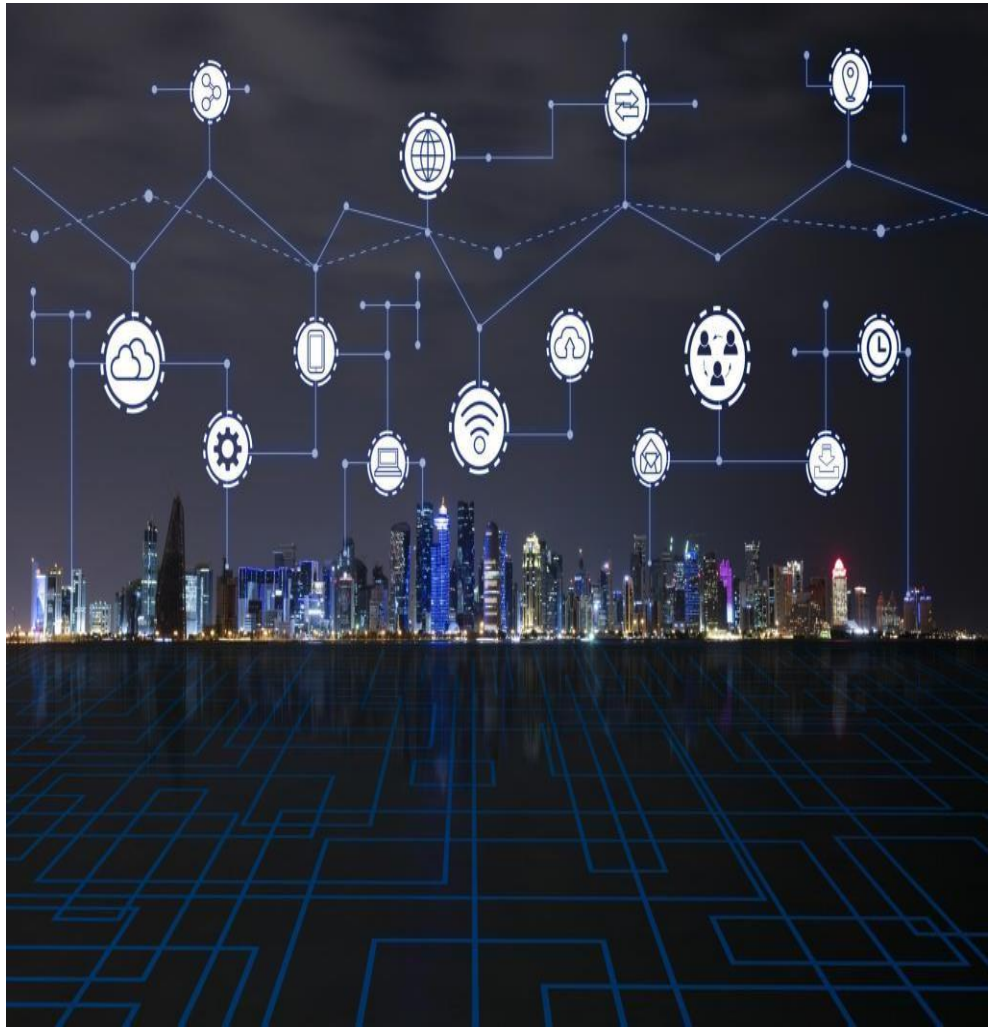
AI and ML Applications:-

AI and ML techniques are utilized for fault detection, anomaly prediction, and adaptive relay coordination in the microgrid.

Performance Validation:-

System performance is validated using metrics like **THD, SAIFI, and SAIDI** through detailed simulation studies.

Expected Outcomes:-



AI-Based Adaptive Control:-

Development of AI-driven adaptive protection and control systems enhances the efficiency of DC microgrids.

Improved Power Quality:-

The system improves power quality and resilience, ensuring stable and reliable DC microgrid operation.

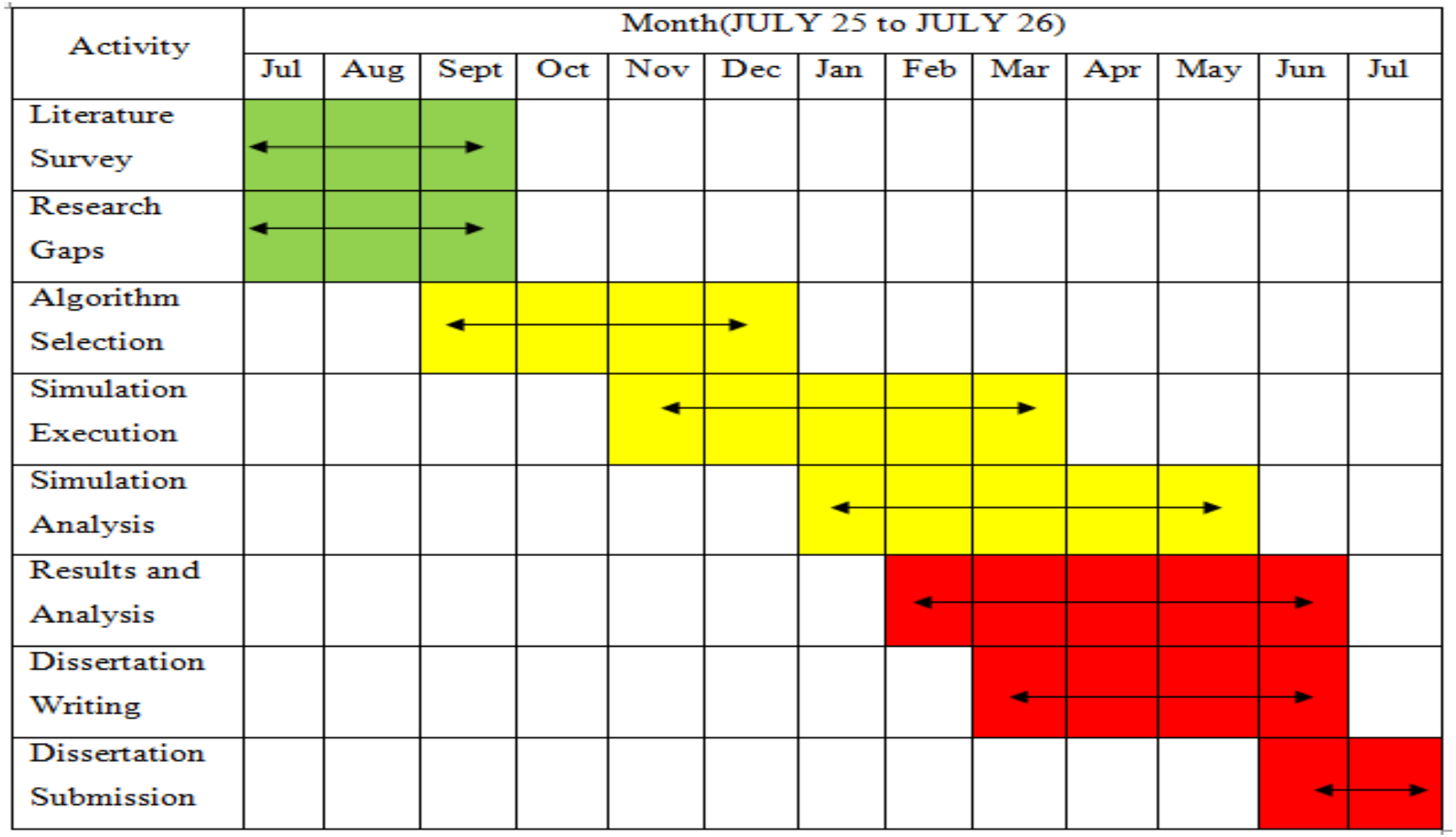
Enhanced Cybersecurity:-

Enhanced cybersecurity measures protect microgrid infrastructure from digital threats and vulnerabilities.

Global Standardization Support:-

Research contributes to global standardization, promoting widespread adoption of DC microgrid technologies.

Action plan Timeline:-



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Thank you