International Journal of Research and Applied Innovations (IJRAI)

| ISSN: 2455-1864 | www.ijrai.com | editor@ijrai.com | A Bimonthly, Scholarly and Peer-Reviewed Journal |

||Volume 3, Issue 1, January – February 2020||

DOI:10.15662/IJRAI.2020.0301002

Optimal Scheduling of Microgrids with PV, Wind, and Storage

Preeti Charulata Bhavsar

Channabasaveshwara institute of Technology, Gubbi, Karnataka, India

ABSTRACT: This paper presents an overview of optimal scheduling strategies for microgrids integrating photovoltaic (PV), wind generation, and energy storage systems, reflecting approaches and insights from 2019. Addressing the inherent uncertainty of renewable generation and load variability, several methodologies emphasized robust, stochastic, and multi-objective optimization. Lin (2019) proposed a stochastic optimal dispatch using state-space approximate dynamic programming to handle variable PV and wind output, emphasizing reliable, cost-aware scheduling IET Research Journals. Similarly, research in *IET Renewable Power Generation* (2019) applied a modified Particle Swarm Optimization (PSO), adjusting inertia weight to enhance global search capability and mitigate forecast error impacts, improving day-ahead microgrid scheduling performance The IET Digital Library. Another significant contribution introduced the Stochastic Quasi-Gradient Method (SQGM) for optimal charging/discharging control of battery energy storage within hybrid microgrids; integrating AC load flow constraints, SQGM showed faster convergence and robustness compared to traditional stochastic dynamic programming (SDP/SDDP) approaches The IET Digital Library. Additionally, robust scheduling frameworks from 2019, such as model predictive control with soft SoC constraints and two-stage robust dispatch models, optimized microgrid operations under uncertainty, ensuring feasible and resilient performance arXiv+1. Collectively, these 2019 studies highlight significant strides in algorithmic innovation—balancing economic objectives, forecast uncertainty, computational efficiency, and system reliability. This paper synthesizes these methods, comparing their effectiveness, constraints handling, and simulation insights, ultimately offering a cohesive reference for microgrid operation under variable renewable energy supply.

KEYWORDS: Microgrid Scheduling, Photovoltaic (PV), Wind Energy, Energy Storage Systems, Stochastic Optimization, Particle Swarm Optimization (PSO), Stochastic Quasi-Gradient Method (SQGM), Model Predictive Control (MPC), Forecast Uncertainty, Robust Dispatch

I. INTRODUCTION

In 2019, optimizing the scheduling of microgrids combining PV, wind, and storage became essential for enhancing operational efficiency, cost-effectiveness, and resilience. Microgrids, as localized energy systems integrating variable renewable generation and storage, must adapt to unpredictable environmental inputs and load demands. Addressing these challenges, Lin (2019) developed a stochastic dispatch framework based on approximate dynamic programming, enabling adaptive scheduling considering real-time renewable variability IET Research Journals. Concurrently, modified PSO approaches refined search capabilities to improve convergence and robustness in day-ahead scheduling under forecast uncertainty The IET Digital Library. The SQGM method integrated AC load flows into optimization, enabling faster convergence and superior reliability compared to SDP/SDDP techniques The IET Digital Library. At the same time, robust optimization models employing model predictive control with soft state-of-charge (SoC) constraints improved operational flexibility while maintaining feasibility under uncertainty arXiv+1. This research landscape signifies a pivot toward efficiency and reliability—prioritizing economically optimal energy use, adapting to forecast errors, and ensuring system stability. This paper offers a synthesized review of these 2019 methodologies, investigating their comparative strengths, implementation considerations, and collective contributions to optimal microgrid management.

II. LITERATURE REVIEW

Prominent 2019 works on microgrid scheduling reveal diverse optimization strategies:

- **Lin (2019)** investigated stochastic dispatch using approximate dynamic programming to manage PV/wind uncertainty and load variability, aiming for cost-effective and secure microgrid operation IET Research Journals.
- A modified PSO algorithm, introduced in *IET Renewable Power Generation* (2019), enhanced day-ahead scheduling via adaptive inertia weight, improving search robustness amidst forecast errors The IET Digital Library.

| ISSN: 2455-1864 | www.ijrai.com | editor@ijrai.com | A Bimonthly, Scholarly and Peer-Reviewed Journal |

||Volume 3, Issue 1, January – February 2020||

DOI:10.15662/IJRAI.2020.0301002

- The **Stochastic Quasi-Gradient Method (SQGM)**, proposed the same year, integrated AC load flow constraints into optimization. Compared to SDP and SDDP, SQGM provided faster convergence and reduced solution variance The IET Digital Library.
- **Robust scheduling techniques** featured in two 2019 preprint studies: (1) a model predictive control scheme with soft SoC constraints allowed controlled state-of-charge deviations for tractability, using quadratic programming in a receding-horizon framework arXiv; (2) a two-stage robust dispatch model combined day-ahead and real-time scheduling across multiple timescales, enhancing flexibility under worst-case renewable and load uncertainties arXiv.

These contributions collectively targeted critical challenges—forecast uncertainty, real-time adaptability, convergence speed, and system reliability. They advanced theoretical and computational tools for integrating PV, wind, and battery storage within microgrid control frameworks.

III. RESEARCH METHODOLOGY

Based on 2019 methodologies, a synthesized methodological framework might include:

Problem Formulation & Scenario Modelling

Define objective (e.g., minimize cost, maximize renewable utilization) under uncertainty (PV, wind, load).
Generate forecast scenarios or define stochastic models.

Uncertainty Handling Approaches

Approximate Dynamic Programming (Lin, 2019) for stochastic dispatch optimization IET Research Journals.
Adaptive PSO with modified inertia weight for robust day-ahead scheduling The IET Digital Library.
SQGM with integrated AC load flow analysis for dispatch optimization The IET Digital Library.
Model Predictive Control with soft SoC constraints—quadratic programming in a receding horizon arXiv.
Two-stage robust dispatch integrating day-ahead and real-time schedules under worst-case scenarios arXiv.

Optimization Solvers & Algorithms

Use dynamic programming, PSO variants, SQGM solvers, quadratic programming, or robust optimization solvers depending on method.

Simulation & Case Studies

Employ realistic microgrid models (PV, wind, storage, grid interaction).
Test under varied conditions—forecast errors, renewable variability, load patterns.

Performance Evaluation Metrics

Convergence speed, computational burden, economic cost savings, renewable utilization rates, system reliability, resilience to uncertainty.

Comparative Analysis

Evaluate methods under same datasets to identify trade-offs among accuracy, speed, robustness, and implementability.

Advantages

- **Effective uncertainty management** via dynamic programming, robust/Predictive Control frameworks.
- **Improved convergence and global search** using adaptive PSO techniques The IET Digital Library.
- **Fast convergence and fewer local minima** via SQGM, yielding consistent results The IET Digital Library.
- **Resilience and flexibility** from MPC with soft SoC handling and two-stage robust dispatch arXiv+1.
- **Integrated AC load flow** ensures operational feasibility (SQGM) The IET Digital Library.

Disadvantages

- **High computational complexity**, especially for dynamic programming and robust schemes.
- **Scenario generation and tuning overhead** for PSO and MPC methods.
- **Forecast dependency**—performance sensitive to quality of renewable/load forecasts.
- **Parameter sensitivity**, such as inertia weight in PSO or soft constraint thresholds.
- **Implementation complexity**, requiring advanced mathematical and optimization tools.

International Journal of Research and Applied Innovations (IJRAI)

| ISSN: 2455-1864 | www.ijrai.com | editor@ijrai.com | A Bimonthly, Scholarly and Peer-Reviewed Journal |

||Volume 3, Issue 1, January – February 2020||

DOI:10.15662/IJRAI.2020.0301002

IV. RESULTS AND DISCUSSION

Key observations from 2019 research:

- **Stochastic dynamic programming (Lin, 2019)** enabled reliable dispatch under variability, improving operational cost performance IET Research Journals.
- **Modified PSO** enhanced scheduling performance with strong convergence and handling of forecast uncertainties The IET Digital Library.
- **SQGM** achieved faster convergence and lower variance than SDP/SDDP, with physical feasibility via AC load flow integration The IET Digital Library.
- **MPC with soft SoC constraints** balanced feasibility and conservatism effectively through quadratic programming in real time arXiv.
- **Two-stage robust scheduling** provided flexible yet resilient operation across day-ahead and real-time timescales in simulated microgrid systems arXiv.

These results underline progress in synthesizing algorithmic efficiency with robustness and practicality.

V. CONCLUSION

In 2019, significant methodological advances emerged for microgrid scheduling with PV, wind, and storage. Research emphasized stochastic dynamic programming, PSO adaptations, SQGM, MPC with soft constraints, and multi-timescale robust optimization to manage uncertainty, enhance convergence, and maintain operational feasibility. Each approach addressed specific challenges—forecast error tolerance and computational tractability—with varying trade-offs in performance. Together, they form a robust foundation for modern microgrid scheduling strategies.

VI. FUTURE WORK

- **Hybrid algorithms** combining robust optimization with machine learning-based forecasting.
- **Real-time adaptive control** integrating short-term predictions into scheduling.
- **Scalability testing** on larger microgrid clusters or networked systems.
- **User-friendly decision-support tools** for operators.
- **Incorporation of demand response and electric vehicles** for enhanced flexibility.

REFERENCES

1. Lin. "Stochastic optimal dispatch of PV/wind/diesel/battery microgrids using state-space approximate dynamic programming." *IET Generation, Transmission & Distribution*, 2019 IET Research Journals.
2. *IET Renewable Power Generation* (2019). "Optimal optimisation-based microgrid scheduling considering impacts of unexpected forecast errors", modified PSO method The IET Digital Library.
3. *IET Smart Grid* (2019). "Optimal scheduling of the energy storage system in a hybrid micro-grid considering uncertainties, using the stochastic quasi-gradient method (SQGM)" The IET Digital Library.
4. Valibeygi et al. (2019). "Robust Power Scheduling for Microgrids with Uncertainty in Renewable Energy Generation", MPC with soft SoC constraints (arXiv) arXiv.
5. Han et al. (2019). "A Multi-timescale Two-stage Robust Grid-friendly Dispatch Model for Microgrid Operation", robust two-stage model (arXiv) arXiv.