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BATTERY ENERGY STORAGE SYSTEM (BESS) PLACEMENT AND SIZING STRATEGIES FOR ENHANCED POWER SYSTEM STABILITY: A SYSTEMATIC REVIEW

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Abstract:

Battery Energy Storage Systems (BESS) have emerged as a critical solution for enhancing power system stability amidst increasing variability from modern power grids. However, determining the optimal placement and sizing of BESS remains a complex challenge due to diverse grid topologies, operational uncertainties, and the need to balance technical and economic performance. This study presents a Systematic Literature Review (SLR) on BESS placement and sizing strategies to improve overall power system stability. Using the PRISMA methodology, a structured search was conducted across Web of Science (WoS) and Scopus, applying advanced keyword combinations to ensure comprehensive coverage. A total of 30 primary studies were identified and screened for relevance and methodological quality. The reviewed literature was synthesized into three thematic areas: (1) Placement, Sizing and Allocation of BESS covering planning approaches and grid-integration strategies; (2) Frequency, Dynamic Stability and Control with BESS focusing on operational stability improvements under low-inertia and contingency conditions; and (3) Optimization Methods, Techno-economic Management, Scheduling and Microgrids addressing algorithmic frameworks and economic considerations in BESS deployment. Numerical findings across the studies show that coordinated placement–sizing decisions can reduce instability indices, while advanced optimization techniques enhance both dynamic performance and cost efficiency. Several studies also highlight the importance of integrating control dynamics and probabilistic assessments to

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avoid over-sizing and improve robustness under uncertainty. Overall, this review consolidates existing knowledge, identifies methodological gaps, and highlights future research opportunities toward developing more integrated, reliable, and cost-effective BESS planning frameworks for enhanced power system stability.

Keywords:

Battery Energy Storage System (BESS), Placement, Sizing, Optimization Strategies, Power System Stability

Introduction

The rapid proliferation of renewable energy sources, particularly wind and solar, has fundamentally transformed the operational landscape of modern power systems. While these resources offer significant environmental and economic benefits, their inherent variability and intermittency introduce new challenges for grid stability, manifesting as voltage fluctuations, frequency deviations, and increased risk of system disturbances. In this context, Battery Energy Storage Systems (BESS) have emerged as a pivotal technology, capable of providing fast-acting support to mitigate these issues and facilitate the reliable integration of renewables into the grid. The strategic placement and optimal sizing of BESS are now recognized as critical factors in maximizing their stabilizing impact, ensuring both technical efficacy and economic viability in diverse grid configurations (Chatzigeorgiou, Theocharides, Makrides, & Georghiou, 2024; Liu, Yue, Yang, Yuan, Wen, & Si , 2025; Mancarella, Hatziargyriou &Kang, 2024).

Over the past five years, the evolution of BESS technologies has been marked by significant advancements in battery chemistry, power electronics, and control strategies. Lithium-ion batteries, in particular, have become the dominant choice for grid-scale applications due to their high energy density, efficiency, and declining costs. Simultaneously, the deployment of BESS has expanded from traditional front-of-meter installations to more complex configurations, including behind-the-meter systems, hybrid plants co-located with renewables, and virtual power plants. These developments have enabled BESS to deliver a broader array of grid services, such as frequency regulation, voltage support, and energy arbitrage, enhancing their value proposition and supporting the transition toward net-zero energy systems (Chatzigeorgiou et al., 2024; Mancarella et al., 2024).

Given the increasing complexity of modern power systems, the optimization of BESS placement and sizing has become a multidisciplinary challenge, requiring the integration of engineering, economic, and operational considerations. Recent research has focused on developing advanced optimization algorithms and modeling frameworks that account for the dynamic behavior of power systems, the stochastic nature of renewable generation, and the degradation characteristics of battery technologies. These efforts aim to ensure that BESS deployments are technically effective and economically sustainable over their operational lifetimes (Aksbi, Elkafazi, Bannari, & El Bhiri, 2025; Damian & Wong, 2022; Erlangga, Danang Wijaya, & Wijoyo, 2024).

This report synthesizes the latest empirical, simulation-based, and theoretical studies from the past five years, with a particular emphasis on methodologies and strategies for BESS placement and sizing that enhance power system stability. The scope encompasses a comparative analysis

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of optimization techniques, technological innovations, and the integration of multi-service value stacking, as well as the incorporation of battery degradation and uncertainty modeling. By bridging theoretical foundations with practical insights, the report aims to provide a comprehensive overview of the state-of-the-art in BESS deployment for grid stability enhancement (Aksbi et al., 2025; Damian & Wong, 2022; Erlangga et al., 2024).

In summary, the strategic deployment of BESS is central to addressing the stability challenges posed by high renewable penetration. The convergence of advanced optimization methods, technological innovation, and holistic modeling approaches is driving the development of resilient, cost-effective, and operationally efficient energy storage solutions. The following literature review delves into the recent advancements, comparative effectiveness, and emerging research gaps in BESS placement and sizing strategies, setting the stage for future innovation in this rapidly evolving field.

Literature Review

Recent literature on BESS placement and sizing strategies reveals a dynamic evolution in both methodological sophistication and technological innovation. Advanced metaheuristic algorithms such as Harris' Hawks Optimization (HHO), Strength Pareto Evolutionary Algorithm 2 (SPEA2), Cayote Optimization Algorithm (COA), Particle Swarm Optimization (PSO), and Salp Swarm Algorithm (SSA) have been widely adopted to address the nonlinear, multi-objective nature of the placement and sizing problem. These algorithms have demonstrated superior performance in minimizing power losses, stabilizing voltage profiles, and supporting frequency regulation, often outperforming traditional approaches in both simulation and real-world test systems (Aksbi et al., 2025; Damian & Wong, 2022; Khunkitti, Boonluk, & Siritaratiwat, 2022; Wichitkrailat, Premrudeepreechacharn, Khunkitti, & Siritaratiwat, 2024; Yuan, Wang, Wang, & Yildizbasi, 2020). Notably, comparative studies indicate that while HHO frequently achieves faster convergence and higher solution quality, the optimal choice of algorithm remains context-dependent, with hybrid and problem-specific adaptations offering further improvements (Çetinbaş, Tamyürek, & Demirtaş, 2021; Damian & Wong, 2022; Wong & Ramachandaramurthy, 2021).

Technological advancements have further expanded the functional scope of BESS. The emergence of grid-forming BESS technologies, which emulate the inertia and damping characteristics of synchronous generators, has been particularly impactful in grids with high renewable penetration and low system inertia. These systems, often deployed in hybrid configurations with renewables, leverage advanced power converter designs and control strategies to provide simultaneous frequency and voltage support, energy arbitrage, and fast frequency response. The concept of multi-service value stacking, where BESS delivers multiple ancillary services, has gained traction, enabling improved economic returns and operational flexibility. Such advancements underscore the importance of coordinated control and optimal configuration to fully realize the stabilizing potential of BESS in modern grids (Chatzigeorgiou et al., 2024; Lin & Huang, 2025; Liu et al., 2025; Ruiz, Rakhshani, Benavides, & Dominguez, 2024).

A critical trend in recent research is the integration of battery degradation and uncertainty modeling into the optimization of BESS placement and sizing. Recognizing that battery performance degrades over time due to cyclic and calendar aging, researchers have developed models that incorporate these effects into both planning and operational frameworks.

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Stochastic programming, scenario-based optimization, and machine learning techniques are increasingly used to account for uncertainties in renewable generation, load demand, and market prices. These approaches enable more robust and realistic assessments of BESS deployment, ensuring that solutions remain technically and economically viable under a wide range of operating conditions (Adeyemo, Marra, & Tedeschi, 2025; Amini, Sanjareh, Nazari, Gharehpetian, & Hosseinian, 2024; Siface, 2020; Wu & Ma, 2021).

Other than that, comparative analyses of placement and sizing strategies highlight the effectiveness of multi-objective and artificial intelligence–driven optimization approaches in balancing cost, reliability, and grid stability. Studies demonstrate that optimally placed and sized BESS can significantly reduce power losses, improve voltage profiles, and enhance system resilience, particularly in distribution networks with high renewable and electric vehicle penetration. The use of second-life batteries has also been explored as a cost-effective alternative, with mixed-integer linear programming and metaheuristic algorithms facilitating optimal integration. However, the performance of these strategies is influenced by factors such as network topology, ownership models, and regulatory frameworks, necessitating context-specific optimization (Aksbi et al., 2025; Apribowo, Hadi, & Danang Wijaya, 2022; Apribowo, Hadi, & Wijaya, 2024; Su et al., 2021; Yuvaraj, Devabalaji, & Tangirala, 2024).

Despite these advancements, several research gaps and challenges persist. Notably, there is a need for more comprehensive transient stability analyses that incorporate detailed battery degradation, load uncertainty, and unbalanced network conditions. Many existing studies rely on simplified models or standard test systems, limiting their applicability to real-world grid topologies. Furthermore, aligning regulatory frameworks and grid codes with emerging BESS technologies remains an ongoing challenge, particularly in the context of multi-service value stacking and cybersecurity. Addressing these gaps will require the development of holistic optimization frameworks, advanced modeling techniques, and coordinated policy initiatives to support the large-scale, reliable integration of BESS into future power systems (Alsharif, Jalili, & Hasan, 2022a; Jannesar, Sadr, & Savaghebi, 2024; Mohd Razif, Ab Aziz, Ab Kadir, & Kamil, 2024; Shamarova, Suslov, Ilyushin, & Shushpanov, 2022; Shams et al., 2024).

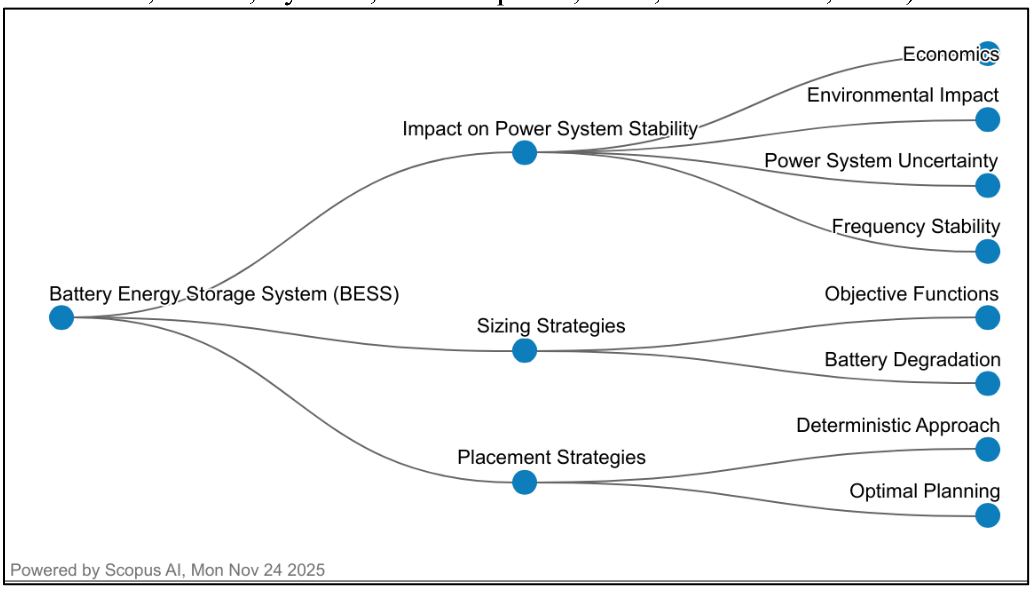

Figure 1: Concept Map of Key Themes in BESS Placement and Sizing Strategies for Power System Stability

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Figure 1 illustrates a structured concept map outlining the key themes dominating the literature on BESS placement and sizing strategies for enhanced power system stability. The map highlights three central research pillars: Impact on Power System Stability, Sizing Strategies, and Placement Strategies. Under system stability, topics such as power system uncertainty, frequency stability, environmental impact, and economics indicate that researchers view BESS as a technical stabilizing mechanism and as a tool that influences operational costs, sustainability, and long-term system resilience. Meanwhile, the sizing strategies branch emphasizes objective functions, battery degradation, and analytical approaches, reflecting the importance of accurate modelling to balance performance, cost, and battery lifetime. The placement strategies cluster focuses on deterministic and optimal planning methods, demonstrating that strategic positioning of BESS units is crucial for maximizing grid reliability and minimizing congestion or instability in low-inertia environments.

Overall, the concept map shows that the literature has matured into a multidisciplinary field that integrates technical, economic, and environmental considerations. The interconnected themes highlight that optimal BESS deployment requires integrated planning approaches that simultaneously address uncertainty, system security, and long-term operational efficiency. The strong presence of optimization-based topics and stability-focused themes indicates growing recognition of BESS as a transformative component in renewable-rich and low-inertia power systems. This synthesis underscores the need for holistic frameworks that combine advanced modelling, strategic placement, and robust sizing methods to fully leverage BESS capabilities in enhancing modern grid stability.

Research Question

Research Questions (RQs) play a vital role in a Systematic Literature Review (SLR) as they establish the foundation and direction for the entire review process. They define the scope and focus of the study, guiding the inclusion and exclusion of literature to ensure that the review remains specific and relevant to the topic under investigation. Clearly formulated RQs enable a comprehensive and systematic search strategy, ensuring that all pertinent studies addressing key aspects of the topic are captured. This approach minimizes potential bias and provides a complete overview of existing evidence.

Moreover, RQs facilitate the categorization and organization of data extracted from the selected studies, providing a structured framework for analysis, synthesis, and interpretation of findings. They enhance the clarity and focus of the review by preventing ambiguity and maintaining concentration on specific issues, which in turn makes the findings more relevant and actionable. In addition, well-defined RQs contribute to the transparency and reproducibility of the review process, allowing other researchers to replicate the methodology, verify findings, or extend the investigation to related domains. Ultimately, RQs ensure alignment between the review and its overarching objectives—whether to identify research gaps, assess intervention effectiveness, or explore emerging trends, making them the backbone of a rigorous, focused, and meaningful SLR.

Formulating the RQs is therefore the most critical task during the planning stage and remains the central component of any SLR, as it dictates the overall review methodology (Kitchenham, 2007). Given that the objective of this SLR is to identify and analyze the current state-of-the-art in the selected domain, the PICo framework was adopted to guide the formulation of RQs. The PICo framework, proposed by (Lockwood, Munn, & Porritt, 2015), is a mnemonic used

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particularly in qualitative and exploratory research. It consists of three components: Population (P), which defines the subject or system of interest; Interest (I), which specifies the phenomenon or issue being investigated; and Context (Co), which refers to the environment or conditions in which the phenomenon occurs.

1. Population (P): This refers to the group or participants of interest in the study. It specifies whom the research is focused on, such as a specific demographic, patient group, or community.

2. Interest (I): This represents the main focus or phenomenon of interest in the study. It could be a particular experience, behavior, intervention, or issue that the research aims to explore or understand.

3. Context (Co): This defines the setting, environment, or specific context in which the population and interest are situated. It might refer to geographical location, cultural or social settings, or any other relevant backdrop for the research.

Using the PICo framework helps in structuring RQs clearly and systematically by breaking down the key elements of the study into these three components. This approach ensures that the research is focused and the questions are well-defined, making it easier to search for relevant literature or design a study. This study achieved two RQs as follows:

RQ1. How do optimized strategies for placement and capacity sizing of battery energy storage systems affect voltage stability, power losses, and reliability in distribution and transmission networks with high renewable generation and increasing EV penetration?
RQ2. In low-inertia power systems with high inverter-based generation, how does joint optimization of BESS size, location, and dynamic control improve frequency stability and operational resilience when subject to realistic uncertainty and contingency events?
RQ3. What are the comparative benefits of surrogate-assisted and robust multi-objective optimization algorithms versus traditional metaheuristics when planning fixed and mobile BESS placement and schedule in interconnected microgrids under deep uncertainty and market-driven constraints?

Material and methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, as established by Page et al. (2021), is widely recognized as the gold standard for conducting SLRs due to its emphasis on transparency, methodological completeness, and procedural consistency. By adhering to PRISMA guidelines, researchers ensure a rigorous, reproducible process for systematically identifying, screening, and including relevant studies, thereby enhancing the validity and reliability of the resulting evidence synthesis. The framework also underscores the critical role of high-quality empirical research, particularly randomized studies, in minimizing bias and strengthening the evidentiary foundation of the review. In this study, two major scholarly databases, Web of Science (WoS) and Scopus, were employed owing to their extensive coverage, indexing robustness, and recognized credibility in capturing high-impact research outputs.

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Structured into four sequential stages: identification, screening, eligibility, and data abstraction, the PRISMA methodology provides a comprehensive pathway for executing a methodologically sound review. The identification stage involves a systematic search to retrieve all potentially relevant publications, followed by the screening stage, in which studies are evaluated against predefined criteria to exclude irrelevant or low-quality studies. The eligibility stage then subjects the shortlisted studies to more thorough scrutiny to ensure full compliance with the inclusion criteria. Finally, the data abstraction stage entails extracting and synthesizing key information from the included studies, forming the empirical basis for generating reliable and meaningful insights. This structured and rigorous approach ensures that the review process remains methodologically defensible and yields trustworthy conclusions that inform future research and practice.

Identification

In the Identification phase of the PRISMA framework, the initial search was conducted using two reputable and high-impact scholarly databases, Scopus and the WoS, to ensure comprehensive coverage of peer-reviewed literature related to BESS, specifically focusing on placement, sizing, and power system stability (see Table 1). Using these targeted keywords, the Scopus database returned 139 records, while WoS contributed an additional 47 records, yielding a combined total of 186 unique publications. The use of multiple globally recognized indexing platforms is critical, as each database covers different journal scopes, indexing policies, and disciplinary emphases. Scopus is known for its broad engineering and energy-related coverage, whereas WoS provides deeper archival indexing and higher selectivity. Therefore, merging results from both sources increases the likelihood of capturing influential studies, high-impact articles, and methodological advancements that may not appear in one database alone.

The resulting dataset of 186 records reflects the growing academic attention towards BESS optimization, driven by the global shift toward renewable energy integration and grid stability enhancement. The relatively higher number of records from Scopus may indicate broader indexing of contemporary engineering research, while the lower count in WoS suggests stricter curation aligned with high-impact journals. This numerical pattern also signals the multidisciplinary nature of BESS research, spanning power engineering, optimization, energy economics, and smart grid technologies. Collecting a large, diverse set of studies at the identification stage lays a strong foundation for subsequent screening and eligibility assessments, ensuring that the final SLR is grounded in a robust, inclusive, and methodologically defensible dataset.

Table 1: The Search String.

Scopus	((“Battery Energy Storage Systems” OR “BESS”) AND (“Positioning” OR “Placement” OR “Allocation”) AND (“Sizing” OR “Capacity”) AND “Power System”) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024) OR LIMIT-TO (PUBYEAR , 2025)) AND (LIMIT-TO (DOCTYPE , “ar”)) AND (LIMIT-TO (LANGUAGE , “English”)) AND (LIMIT-TO (SRCTYPE , “j”)) AND (LIMIT-TO (PUBSTAGE , “final”)) **Date of Access: November 2025**
WoS	(“Battery Energy Storage Systems” OR “BESS”) AND (“Positioning” OR “Placement” OR “Allocation”) AND (“Sizing” OR “Capacity”) AND “Power

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System" (Topic) and 2025 or 2024 or 2023 or 2022 or 2021 (Publication Years) and Article (Document Types) and English (Languages)
Date of Access: November 2025

Screening
During the screening phase of the PRISMA process, the first 186 records obtained from Scopus and WoS were systematically considered through pre-established inclusion and exclusion rules. Relevance filters were used to refine the Scopus and WoS datasets to 51 and 34 records, respectively, yielding 85 studies for further research. This decrease is an indication of a developed emphasis on research specifically offering BESS placement and sizing in power system applications. The drop between the identification stage and the next stage highlights the need for a strict screening process to remove studies that are not directly related to the research scope or that are not adequately relevant in terms of their methodology. This degree of selectivity will make sure that only high-quality, technically sound, and contextually suitable studies go to the next stage of the eligibility phase, thus enhancing the validity of the resulting SLR results.

The total number of records left out was 101, which failed to meet the set criteria, including non-English, published prior to 2021, or conference proceedings, book chapters, reviews, and in-press papers (see Table 2). The reasoning behind this exclusion strategy is that peer-reviewed journal articles, especially those published in recent years, are generally more methodologically consistent, have more precise reporting criteria, and greater citation impact, and therefore would be more appropriate to a high-impact systematic review. Moreover, the elimination of 19 duplicate records will guarantee that the dataset is free of bias and redundancy, which is critical to analytical integrity. The selected set of 85 unique and relevant studies represents a selective body of research as it is in the present day, which meets the goal of creating a rigorous and evidence-based synthesis on BESS placement and sizing strategies to promote power system stability.

Table 2: The Selection Criterion is Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2021 – 2025	< 2021
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press
Subject	Engineering, Energy	Besides Engineering, Energy

Eligibility
In the third step, designated as the eligibility phase, 66 articles were shortlisted for detailed assessment. During this stage, each study's title, abstract, and core content were critically examined to ensure full adherence to the predefined inclusion criteria and alignment with the research objectives. Following this evaluation, 36 articles were excluded due to factors such as misalignment with the research domain, insufficient relevance indicated by the title, abstracts that did not correspond to the study's aims, or the absence of accessible full-text versions supported by empirical evidence. Consequently, 30 articles were confirmed as eligible and were carried forward to the final review stage.

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Data Abstraction and Analysis

An integrative analysis approach was used to synthesize the various quantitative research designs found in the literature, chosen in a systematic manner, with the goal of condensing the main themes and subthemes that the study was based on. Figure 2 illustrates that the data extraction process started with a meticulously filtered data extraction stage, where 30 strictly filtered publications were analyzed in detail. The studies were appraised on the basis of methodological soundness, empirical validation, and their substantive content to the dynamic discourse of BESS placement and strategies to improve power system stability. Based on this evidence base, the authors jointly developed a thematic organization, which was backed by an extensive analysis log that documented interpretive reflections, methodological choices, and emerging conceptual findings to provide transparency and auditability. The systematic cross-comparisons of the thematic framework were then conducted to evaluate the presence of possible divergences or conceptual tensions. The inconsistencies were sorted out with the help of repetitive scholarly discussions between the authors, thus guaranteeing the approval and enhancing analytical integrity of the review. It was a rigorous, reflective, and methodologically sound process that generated a thematically coherent structure that meets the requirements of high-impact scholarly research and offers a sound basis on which further analysis should be based.

Table 3: Number and Details of Primary Studies Database

Ps	Authors	Title	Source title	Scopus	Science Direct
1	Minzhuo et al. (2025)	Optimal capacity allocation strategy of battery energy storage system considering the frequency regulation of wind-battery energy storage combined system	Electric Power Systems Research	/	
2	Yang et al. (2025)	Adaptive multi-objective Bayesian optimization approach for capacity planning of the interconnected offshore wind farms	Energy	/	
3	Moghadasi et al. (2025)	Techno-economic management of mobile battery energy storage systems in microgrids considering self-driving electric trucks and uncertainty of generation and consumption	International Journal of Electrical Power and Energy Systems	/	
4	Jiao et al. (2025)	Coalition-Stabilized Distributionally Robust Optimization of Inter-Provincial Power Networks Under Stochastic Loads, Renewable Variability, and Emergency Mobilization Constraints	Energies	/	

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Ps	Authors	Title	Source title	Scopus	Science Direct
5	Karve, Thakare & Vaidya (2025)	Optimal Sizing of Photovoltaic and Battery Energy Storage Systems Incorporating Constant Current and Constant Power Load Models	SSRG International Journal of Electrical and Electronics Engineering	/	
6	Zhao, Shang, Qi, Wang & Zhang (2025)	Optimal sizing and siting of energy storage systems based on power grid vulnerability analysis: a trilevel optimization model	Energy Strategy Reviews	/	
7	ALAhmad, Verayiah, Ba-swaimi, Hussain & Abu-Rayash (2025)	Optimal allocation and configuration of renewable energy sources, electric vehicle parking lots, and fixed and mobile batteries under uncertainty and demand response program	Energy Conversion and Management: X	/	
8	Jeon & Bae (2025)	Integrated optimization for sizing, placement, and energy management of hybrid energy storage systems in renewable power systems	Journal of Energy Storage	/	/
9	Zhang, Shafiullah, Das & Wong (2025)	Optimal allocation of battery energy storage systems to improve system reliability and voltage and frequency stability in weak grids	Applied Energy	/	/
10	Gunadin et al. (2025)	Optimal Placement and Sizing of BESS Considering Voltage Stability Index Using Hybrid Galactic Swarm Optimization and Particle Swarm Optimization Algorithm	International Review of Electrical Engineering	/	
11	Deeum et al. (2025)	Monte Carlo-Based Optimal Placement of Multiple PV/BESS Units in Power Distribution System with Varying Electric Vehicle Load Penetration	International Review of Electrical Engineering	/	
12	Ghatuari & Kumar (2024)	Controller design and optimal sizing of battery energy storage system for frequency regulation in a multi-machine power system	Energy Reports	/	

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Ps	Authors	Title	Source title	Scopus	Science Direct
13	Jannesar et al. (2024)	Optimal sitting, sizing and control of battery energy storage to enhance the dynamic stability of low-inertia grids	IET Renewable Power Generation	/	
14	Parajuli, Gurung & Chapagain (2024)	Optimal Placement and Sizing of Battery Energy Storage Systems for Improvement of System Frequency Stability	Electricity	/	
15	Ali et al. (2024)	Dynamic Multi-Objective Optimization of Grid-Connected Distributed Resources Along With Battery Energy Storage Management via Improved Bidirectional Coevolutionary Algorithm	IEEE Access	/	
16	Sattar et al. (2024)	A predictive tool for power system operators to ensure frequency stability for power grids with renewable energy integration	Applied Energy	/	/
17	Zhang et al. (2024)	Optimal Sizing and Siting of BESS in High Wind Penetrated Power Systems: A Strategy Considering Frequency and Voltage Control	IEEE Transactions on Sustainable Energy	/	
18	Ahlawat & Das (2023)	Optimal sizing and scheduling of battery energy storage system with solar and wind DG under seasonal load variations considering uncertainties	Journal of Energy Storage	/	
19	Mukhopadhyay & Das (2023)	Comprehensive multi-benefit planning of sustainable interconnected microgrids	Sustainable Energy, Grids and Networks	/	
20	Hassanzadeh et al. (2023)	Hierarchical optimal allocation of BESS using APT-FPSO based on a stochastic programming model considering voltage sensitivity and eigenvalues analyses	International Journal of Electrical Power and Energy Systems	/	/
21	Yang et al. (2023)	Optimal Allocation of Primary Frequency Modulation Capacity of Battery Energy Storage Based on Antlion Algorithm	Energies	/	
22	Maddina, Thirunavukkara	Investigation of Power Saving and Optimal Placement of	International Journal of	/	

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Ps	Authors	Title	Source title	Scopus	Science Direct
	su & Karthik (2023)	Energy Storage Units in Active Distribution Network with reference to Conservation Voltage Reduction and Contingent Load Configuration	Intelligent Systems and Applications in Engineering		
23	Asija et al. (2023)	Transmission network congestion control by DESS through interval computation and capacity optimization via a hybrid DE-PSO technique	IET Generation, Transmission and Distribution	/	/
24	Tee et al. (2022)	Battery Energy Storage System Sizing Using PSO Algorithm in DIgSILENT PowerFactory	International Journal of Renewable Energy Research	/	
25	Alsharif, Jalili & Hasan (2022b)	Power system frequency stability using optimal sizing and placement of Battery Energy Storage System under uncertainty	Journal of Energy Storage	/	/
26	Hameed, Hashemi, Ipsen & Traeholt (2021)	A business-oriented approach for battery energy storage placement in power systems	Applied Energy	/	/
27	Peng, Gong, Liu, Lu & Ai (2021)	Optimal Locating and Sizing of BESSs in Distribution Network Based on Multi-Objective Memetic Salp Swarm Algorithm	Frontiers in Energy Research	/	
28	Al-Humaid, Khan, al-Ismail & Khalid (2021)	Multi-input nonlinear programming-based deterministic optimization framework for evaluating microgrids with optimal renewable-storage energy mix	Sustainability (Switzerland)	/	
29	Anuradha, Jayatunga & Perera (2021)	Loss-Voltage Sensitivity Analysis-Based Battery Energy Storage Systems Allocation and Distributed Generation Capacity Upgrade	Journal of Energy Storage	/	/
30	Khaki (2021)	Joint sizing and placement of battery energy storage systems and wind turbines, considering reactive power support of the system	Journal of Energy Storage	/	/

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Quality of Appraisal

Based on the recommendations suggested by Kitchenham and Charters (Kitchenham, 2007), the next step after identifying the primary studies requires evaluation of the quality of the study and a quantitative comparison. The Quality Assessment (QA) method suggested by Anas Abouzahra, Sabraoui, and Afdel (2020) was adopted in this study, and it proposes six QA criteria for our SLR. Each of the criteria was graded with a scoring scale of three possible grades: Yes (Y) with a score of 1 in case the criterion was completely satisfied, Partly (P) with a score of 0.5 in case the criterion was partially fulfilled although had some limitations, and No (N) with a score of 0 in case the criterion was not satisfied.

QA1. Is the purpose of the study clearly stated?
QA2. Is the interest and the usefulness of the work clearly presented?
QA3. Is the study methodology clearly established?
QA4. Are the concepts of the approach clearly defined?
QA5. Is the work compared and measured with other similar work?
QA6. Are the limitations of the work clearly mentioned?

The QA process is a table that is used to determine the quality of every study using specific criteria. The studies are rated by three experts who rate them with the scores of Yes (Y), partially (P), or No (N) per criterion. The following is an elaborate explanation:

1. **Is the purpose of the study clearly stated?**
   This criterion analyzes the study as to whether it is clear enough in the research objectives it is attempting to achieve, and the overall direction and scope of the work are clear.
2. **Is the interest and usefulness of the work clearly presented?**
   This determines the effectiveness of the study in terms of communicating the relevance and implications of the study in the field in which the research is conducted.
3. **Is the study methodology clearly established?**
   This measures how well the research methodology has been presented and is suitably designed to address the objectives of the research in the establishment of validity and reproducibility of the findings.
4. **Are the concepts of the approach clearly defined?**
   This criterion helps to understand whether the theoretical framework and main ideas are well-elaborated, and it is possible to understand the analytical approach of the study in a coherent way.
5. **Is the work compared and measured with other similar work?**
   This evaluates the extent to which the research has been methodically contrasted with other related studies, which aids in placing the research in the wider academic perspective and shows its contribution.
6. **Are the limitations of the work clearly mentioned?**
   This measures the transparency of the study as it critically recognizes the limitations of the study and the awareness of the limitations that may be present in the study.

The scores of the individuals are then added up to create a total score among all the experts. A study should have a cumulative score exceeding 3.0 to pass to the next analysis stage. Therefore, only studies with a certain level of quality will be taken into consideration.

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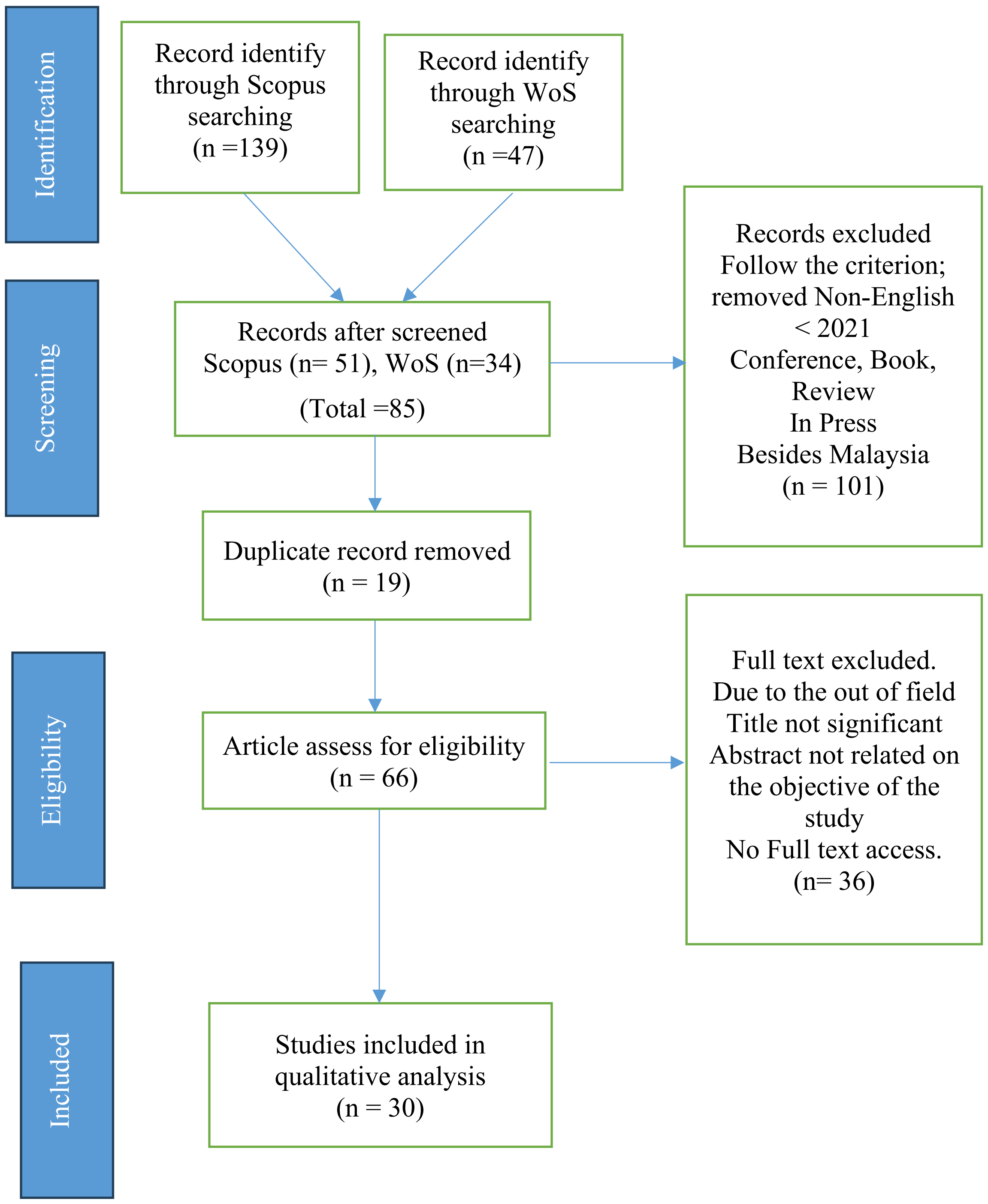

Figure 2. Flow Diagram of the Proposed Searching Study

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Result and Finding

As shown in Table 4, the QA level is rather high in the 30 chosen studies concerning the BESS placement and sizing strategies to improve the stability of power systems. All the studies were rated within six criteria (QA1-QA6) with a possible score of Yes (Y = 1), Partial (P = 0.5), or No (N = 0), and the summation of marks and percentages was calculated to obtain a quantitative assessment of the methodological rigor. The compliance (Y) for QA1, QA2, and QA3 was full, which means that there were no issues with the clarity of the research objectives, the frameworks of methods, and the use of analytical procedures. The differences were identified in QA4 and QA5, which represent the differences in the level of data analysis completeness, support of the methodological decisions, or the level of discussion of practical implications. It is noteworthy that QA6 was rated with N in all studies, indicating the tendency to leave the description of possible limitations, bias, or reproducibility metrics empty, which can be considered as one of the aspects of BESS research that will be improved in terms of its methods in the future.

The distribution of scores of QA further highlights the strengths as well as the slight weaknesses of the literature that was reviewed. The research with the best score of 83.3% (e.g., PS4, PS7) contained a transparency of all methodology, rigorous methods of modelling, and well-supported conclusions, and all but one of the criteria are satisfied (QA6 was not met). The studies with a score of 75% were those that showed some compliance in either QA4 or QA5, that is, some gap (e.g., lack of justification of methodological choices or some reporting of practical relevance). However, they were not analytically weak or technically irrelevant. The lowest-scoring studies, 66.7% (e.g., PS1, PS3, PS6), were mostly partial compliance in QA4 and QA5, indicating slight reporting problems, but not conceptual ones. On the whole, the QA findings indicate that the chosen body of literature comprises a strong and valid base to extrapolate the findings on the best BESS placement and sizing options. The methodological consistency is high, and this garnered the credibility of the conclusions, which can be used to make evidence-based recommendations to increase power system stability and which are contextually relevant. All these results emphasize the methodological rigor of the studies reviewed and point to future research being a potentially more thorough report on the limitations and reproducibility.

Table 4. Quality Assessment Results of Selected Studies on Battery Energy Storage System (BESS) Placement and Sizing Strategies for Enhanced Power System Stability

Paper ID	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	Percentage (%)
PS1	Y	Y	Y	P	P	N	4	66.7
PS2	Y	Y	Y	P	Y	N	4.5	75
PS3	Y	Y	Y	P	P	N	4	66.7
PS4	Y	Y	Y	Y	Y	N	**5**	**83.3**
PS5	Y	Y	Y	Y	P	N	4.5	75
PS6	Y	Y	Y	P	P	N	4	66.7
PS7	Y	Y	Y	Y	Y	N	**5**	**83.3**
PS8	Y	Y	Y	P	Y	N	4.5	75
PS9	Y	Y	Y	P	Y	N	4.5	75
PS10	Y	Y	Y	P	P	N	4	66.7
PS11	Y	Y	Y	P	P	N	4	66.7

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Paper ID	QA1	QA2	QA3	QA4	QA5	QA6	Total Mark	Percentage (%)
PS12	Y	Y	Y	P	P	N	4	66.7
PS13	Y	Y	Y	P	P	N	4	66.7
PS14	Y	Y	Y	P	P	N	4	66.7
PS15	Y	Y	Y	P	Y	N	4.5	75
PS16	Y	Y	Y	P	P	N	4	66.7
PS17	Y	Y	Y	P	P	N	4	66.7
PS18	Y	Y	Y	P	P	N	4	66.7
PS19	Y	Y	Y	P	P	N	4	66.7
PS20	Y	Y	Y	P	P	N	4	66.7
PS21	Y	Y	Y	P	P	N	4	66.7
PS22	Y	Y	Y	P	P	N	4	66.7
PS23	Y	Y	Y	P	P	N	4	66.7
PS24	Y	Y	Y	P	P	N	4	66.7
PS25	Y	Y	Y	P	P	N	4	66.7
PS26	Y	Y	Y	P	P	N	4	66.7
PS27	Y	Y	Y	P	P	N	4	66.7
PS28	Y	Y	Y	P	P	N	4	66.7
PS29	Y	Y	Y	P	P	N	4	66.7
PS30	Y	Y	Y	P	P	N	4	66.7

Placement, Sizing, and Allocation of BESS (Planning & Grid Integration)

A coherent image of capacity and location optimization is formed as a result of a number of studies that measure both the technical and economic impacts of the deployment of storage facilities. According to Zhao et al. (2025), trilevel methodology with vulnerable siting options being filtered prior to capacity optimization enhances a global vulnerability index and revenue increase in a year, and declining payback periods. Jeon and Bae (2025) indicated that a hierarchical MILP-NSGA-II model achieves significant cuts in the voltage-profile deviation, line losses, and overall expenditure on IEEE test feeders. Meanwhile, Minzhuo et al (2025) demonstrated that wind-turbine parameter optimization with battery assignment can be used to reduce life-cycle cost and BESS capacity required by wind-turbine frequency control without affecting frequency performance. Collectively, these results point to the conclusion that multi-stage optimization, linking siting filters, capacity sizing, and operational scheduling, offers better combined technical-economic solutions than single-stage solutions (Zhao et al., 2025; Jeon & Bae, 2025; Minzhuo et al., 2025).

Voltage-stability-driven allocation and sensitivity-aware placement have been validated across multiple regional and test-system studies. Gunadin et al. (2025) reported measurable Voltage Stability Index improvement after deploying BESS at carefully chosen substations using a hybrid GSO-PSO optimizer, while Hassanzadeh et al. (2023) combined stochastic bi-level sizing with eigenvalue and voltage-sensitivity objectives to reduce losses and mitigate low-frequency variations. On the other hand, Anuradha et al (2021) formulate a Loss–Voltage Sensitivity Index that enables numerical estimation of BESS capacities to simultaneously minimize losses and voltage deviations. Convergence of results from these works supports the merit of incorporating voltage-sensitivity metrics or eigenvalue-based dynamic constraints into

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placement decisions to strengthen voltage envelopes and lower distribution losses (Gunadin et al., 2025; Hassanzadeh et al., 2023; Anuradha et al., 2021).

Frequency-centered allocation and contingency-aware sizing form another coherent cluster of findings. Zhang et al. (2025) applied adaptive grey-wolf optimization in weak, high-renewable grids to demonstrate joint gains in voltage and frequency stability and improved reliability indices. Alternatively, Alsharif et al. (2022b) discovered that probabilistic frequency-stability analysis that accounts for generation and load uncertainty produces more accurate BESS sizing and placement recommendations than deterministic methods, with optimal placement typically nearer significant load centers. Minzhuo et al. (2025) further indicated that including wind-turbine participation in frequency regulation reduces storage requirements and operational cost. Collectively, these results argued for frequency-focused placement models that explicitly incorporate uncertainty and contingency location as design constraints (Zhang et al., 2025; Alsharif et al., 2022b; Minzhuo et al., 2025).

Deployment strategies that take into consideration the evolving demand-side factors have shown that flexibility and the ability to relocate influence the optimal configurations of electric-vehicle loads, mobile storage, and multi-resource portfolios. Deeum et al. (2025) utilized Multi-Objective Monte Carlo simulations to demonstrate that optimal PV/BESS site selection varies with EV penetration levels and that significant loss and emission reductions are achievable when designs adapt to penetration scenarios. ALAhmad et al. (2025) constructed a stochastic MINLP that jointly sizes fixed/mobile storage, EV parking infrastructure, and DG under demand-response programs, revealing that balanced configurations with moderate EV fleets and strategic mobile-BESS relocation yield the best trade-offs in emissions, loss reduction, and cost. On the other hand, Peng et al. (2021) and Jeon and Bae (2025) highlighted that Pareto-front approaches help manage trade-offs among investment, loss cost, and power fluctuation when multiple asset types coexist. These studies recommend inclusion of relocation policies, zoning limits, and demand-response coordination into placement models for future electrified grids (Deeum et al., 2025; ALAhmad et al., 2025; Peng et al., 2021; Jeon & Bae, 2025).

Methodological trends and remaining gaps appear across the corpus. Metaheuristic hybrids (PSO variants, GSO-PSO, MMSSA, APT-FPSO) exhibit strong performance in handling nonlinear, multi-objective placement problems, with frequent validation on IEEE test systems or regional grids (Gunadin et al., 2025; Peng et al., 2021; Hassanzadeh et al., 2023). Economic metrics equivalent annual revenue, payback, and life-cycle cost gain prominence when operational scheduling is co-optimized with siting and sizing (Zhao et al., 2025; Minzhuo et al., 2025; Tee et al., 2022). Persisting gaps include limited standardized benchmarks for algorithm comparison, incomplete integration of dynamic eigenvalue constraints in many placement models, and scarce field-scale validation. Meanwhile, policy implications emphasize the adoption of sensitivity-aware, multi-stage optimization that couples technical indices with scheduling value and relocation flexibility to prioritize BESS siting under increasing renewable and EV penetration (Zhao et al., 2025; Minzhuo et al., 2025; Tee et al., 2022; ALAhmad et al., 2025).

Frequency, Dynamic Stability, and Control with BESS (Operational Stability)
Controller design, sizing, and placement are treated as interdependent tasks across the abstracts, with most studies emphasizing the need to stabilize frequency behavior following disturbances.

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Ghatuari and Kumar (2024) demonstrated that BESS controllers such as Proportional Integral (PI), Proportional Integral Derivative (PID), and Tilt Integral Derivative (TID) controllers, when tuned through metaheuristic techniques like PSO and BAT, can significantly reduce frequency deviations in multimachine systems, although larger MVA networks require proportionally higher storage capacity. Jannesar et al. (2024) discovered that simultaneous optimization of BESS siting, sizing, and control through genetic algorithms restores voltage and frequency stability in low-inertia settings, with relatively moderate storage capacity achieving stability recovery when parameter tuning is optimized. Parajuli et al. (2024) supported this by demonstrating that metaheuristic-based allocation improves both the frequency nadir and RoCoF indices across outage, loading, and RES-penetration scenarios. Overall, these studies indicated that coordinated optimization of BESS control settings and allocation produces more efficient dynamic support than sequential or isolated planning approaches (Ghatuari & Kumar, 2024; Jannesar et al., 2024; Parajuli et al., 2024).

Note that differences in control strategies and allocation formulations play a major role in defining storage capacity and dynamic effectiveness. Ghatuari and Kumar (2024) highlighted through time-domain and hardware-in-the-loop tests that PSO-tuned controllers outperform classical settings in reducing transients. Meanwhile, Zhang et al. (2024) embedded model-predictive control into an allocation formulation and showed that control-aware optimization reduces unnecessary oversizing. Yang et al. (2023) introduced an antlion-based optimization of primary frequency modulation capacity. They indicated that explicitly modelling dead-band and capacity margin improves operational adequacy and reserve deployment. Parajuli et al. (2024) noted that algorithm selection, whether PSO, firefly, or bat, affects the robustness of BESS allocation across varying contingency scenarios, suggesting that control-integrated allocation can prevent excessive investment. Collectively, these studies show that allocation models incorporating dynamic controllers (Model Predictive Control (MPC) or enhanced Primary Frequency Control (PFC) models) are more capable of delivering stable frequency support under variable operating conditions (Ghatuari & Kumar, 2024; Zhang et al., 2024; Yang et al., 2023).

Several abstracts emphasize the need for probabilistic assessment and predictive tools to account for uncertainty and time-varying inertia. Alsharif et al. (2022b) demonstrated that probabilistic frequency-stability analysis yields different, more realistic BESS sizing and placement recommendations than deterministic methods, with optimal capacity often located near critical load centres sensitive to contingency events. Consequently, Sattar et al. (2024) presented an online predictive tool that continuously estimates system inertia and frequency-response capability, then computes additional reserve requirements from PV and BESS units to handle disturbances, with validation on large-scale test systems. Zhang et al (2024) also established that integrating control into the allocation problem helps manage stochastic wind variations without requiring oversized BESS installations. These works collectively indicated that uncertainty-aware and predictive frameworks strengthen BESS planning, especially for systems approaching low inertia (Alsharif et al., 2022b; Sattar et al., 2024; Zhang et al., 2024).

In combination, the reviewed abstracts point toward several converging directions and remaining gaps. Control-integrated allocation methods such as GA-based joint optimization and MPC-embedded formulations reduce sizing requirements compared with static heuristics (Jannesar et al., 2024; Zhang et al., 2024). Probabilistic planning and contingency-location analysis provide more resilient placement decisions, better aligning BESS locations with system vulnerabilities (Alsharif et al., 2022b; Sattar et al., 2024). The variety of optimization techniques, PSO, BAT, antlion, GA, and MPC, suggests no universal solver is dominant, highlighting the need for benchmark comparison across diverse system conditions. Furthermore, limited hardware-validated studies indicate that more real-time and hardware-in-the-loop (HIL) validations would enhance reliability assessment under realistic communication and control delays (Ghatuari & Kumar, 2024; Yang et al., 2023; Alsharif et al., 2022b). Overall, approaches linking control dynamics, uncertainty modelling, and predictive allocation appear most suitable for ensuring stable frequency behavior in modern low-inertia power systems (Jannesar et al., 2024; Ghatuari & Kumar, 2024; Alsharif et al., 2022b).

Optimization Methods, Techno-economic Management, Scheduling and Microgrids (Algorithms & Economics)

Adaptive and surrogate-assisted optimization techniques have been advanced to handle high-dimensional, noisy capacity-planning problems. Yang et al. (2025) developed an adaptive multi-objective Bayesian optimization that builds a probabilistic surrogate to reduce simulation burden while producing informative Pareto fronts for offshore wind, cable, BESS, and hydrogen capacity choices. Jiao et al. (2025) combined Bayesian learning with distributionally robust optimization and hierarchical decomposition to manage epistemic uncertainty and to preserve coalition stability in large inter-provincial systems, demonstrating welfare gains and reliability improvements when cooperative dispatch and mobile storage are included. Ali et al. (2024) proposed an Improved Bi-directional Coevolutionary (I-BiCo) algorithm for joint allocation of distributed resources and BESS, reporting superior hypervolume and convergence metrics over conventional multi-objective evolutionary algorithms (MOEAs). The three studies indicated that probabilistic surrogates, Bayesian distributionally robust optimization (Bayesian-DRO) formulations, and tailored multi-objective evolutionary frameworks can each tighten the trade-off between computational cost and solution quality for complex capacity-planning problems (Yang et al., 2025; Jiao et al., 2025; Ali et al., 2024).

On the other hand, techno-economic scheduling and mobile storage operations present important practical opportunities and challenges. Moghadasi et al. (2025) formulated a techno-economic optimization for mobile BESS transported by self-driving trucks, integrating transport cost dynamics and stochastic generation/load to minimize generation cost, losses, and voltage deviation while allowing relocation of storage. Meanwhile, Mukhopadhyay and Das (2023) designed a multi-microgrid stochastic planning model that jointly sizes renewables and BESS to reduce annual cost, emissions, and losses and to defer grid upgrades, demonstrating substantial economic and environmental gains under probabilistic modelling. Hameed et al.'s (2021) approach is employed from a business perspective, assessing project-stage factors and grid-level connection economics to identify commercially viable BESS sites. Together, these works reveal that inclusion of transport economics, market-oriented placement criteria, and multi-entity planning yields materially different capacity and siting recommendations compared with purely technical optimization (Moghadasi et al., 2025; Mukhopadhyay & Das, 2023; Hameed et al., 2021).

Hybrid metaheuristics, sensitivity-based rules, and interval/stochastic methods are recurrent algorithmic choices for practical implementation. Asija et al. (2023) applied a hybrid DE-PSO approach with interval computation to address daily congestion and solar intermittency while sizing DESS, reporting improved congestion mitigation relative to single algorithms. Alternatively, Ahlawat and Das (2023) combined loss-sensitivity factors with scheduling under

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seasonal loads and uncertainty to derive BESS charging schedules that reduce grid energy dependence by around a third. Ali et al. (2024) demonstrated that I-BiCo with optimal network reconfiguration attains near-unity voltage profiles and reduced losses across dynamic constraints. These results suggested that hybridized solvers and sensitivity metrics help handle multi-timescale requirements and uncertainty in realistic distribution networks (Asija et al., 2023; Ahlawat & Das, 2023; Ali et al., 2024).

Findings point to several convergent implications and research needs for optimization, economics, and operations. Coalition and DRO-style formulations offer policy-relevant mechanisms to align incentives across regions and to integrate mobile storage into emergency mobilization plans while improving expected welfare (Jiao et al., 2025; Moghadasi et al., 2025). Moreover, techno-economic analysis and business-level placement rules can increase investor uptake when co-optimized with operational scheduling (Hameed et al., 2021; Mukhopadhyay & Das, 2023; Ahlawat & Das, 2023). Remaining gaps include standardized benchmark problems for algorithm comparison, scalable stochastic solvers for very large systems, and empirical validation of mobile-BESS logistics in field trials. Research that couples surrogate-assisted optimization, robust game-theoretic allocation, and cost-sensitive placement is likely to deliver practically adoptable solutions for future grids with distributed and mobile storage (Yang et al., 2025; Jiao et al., 2025; Moghadasi et al., 2025).

Conclusion

This systematic review was conducted to consolidate recent advancements in BESS placement and sizing strategies to improve power system stability in modern grids with high renewable penetration and declining inertia. The review targeted journal publications from 2021 to 2025 indexed in Scopus and WoS, applying strict inclusion criteria to ensure methodological soundness and empirical relevance. The purpose of this study was to examine how optimized BESS deployment strategies influence voltage stability, frequency performance, power loss reduction, and system reliability across different grid conditions. By applying the PRISMA framework, the review sought to answer three primary RQs: the stability effects of optimized BESS allocation; the role of joint sizing–placement–control in low-inertia systems; and the comparative effectiveness of advanced optimization methods relative to traditional metaheuristics. Through this structured assessment, the review aimed to address fragmentation in the literature, identify common methodological patterns, and synthesize emerging insights to advance understanding of BESS planning and operational strategies.
The analysis of 30 eligible studies highlighted several consistent findings across diverse modelling environments, optimization techniques, and operational assumptions. First, multi-objective and hybrid metaheuristic algorithms remain the dominant methodological approach due to their flexibility in handling nonlinear placement and sizing challenges. These methods were frequently applied to improve voltage profiles, enhance transient frequency response, and reduce system losses. Second, coordinated optimization where BESS capacity, spatial location, and dynamic control parameters are jointly considered emerged as a crucial strategy for avoiding oversizing and for increasing the functional contribution of storage to frequency stability. Third, the literature demonstrated clear trends toward uncertainty-aware planning frameworks, including probabilistic modelling, scenario-based optimization, and robustness analysis, which collectively support more resilient BESS decisions under renewable variability and load uncertainty. Additionally, the review found significant advancement in techno-economic management, including multi-stakeholder planning, mobile storage operations, and market-driven scheduling approaches, all of which extend traditional system-centric studies.

These thematic patterns show that optimized BESS deployment contributes to operational stability and to long-term system flexibility and economic efficiency. The review also identified unique contributions in the form of novel optimization structures, integrated control-siting formulations, and frameworks incorporating degradation modelling and multi-service value stacking.

Beyond synthesizing methodological and technical findings, the review contributes to the field by integrating dispersed evidence into a clearer conceptual structure that links planning, operational behavior, and system-level stability outcomes. The analysis demonstrates how strategic BESS placement and sizing can provide measurable improvements in voltage stability across various loading scenarios, stabilize the frequency nadir and the rate-of-change-of-frequency following contingencies, and support system resilience in grids with high levels of inverter-based resources. The findings also carry important implications for practice. Grid planners may apply sensitivity-based placement approaches and multi-stage optimization structures to reduce technical uncertainty during investment planning. System operators may adopt predictive and probabilistic control strategies to reinforce stability margins in low-inertia environments. Policy and regulatory bodies may use techno-economic insights to shape market incentives, grid codes, and investment frameworks that support wider integration of storage technologies in distribution and transmission networks. Nevertheless, limitations exist due to the reliance on only two databases, the restriction to English-language journal publications, and the exclusion of conference papers where cutting-edge techniques often first appear. Future research should incorporate more diverse datasets, develop standardized benchmark systems for comparing optimization algorithms, and expand hardware-in-the-loop and field-based validation to improve real-world applicability. Additionally, deeper investigation into mobile storage logistics, cybersecurity constraints, and multi-energy system coupling may further strengthen the understanding of complex storage deployment environments. Overall, the study highlights the essential role of systematic reviews in consolidating emerging findings, reducing duplication of effort, and supporting the development of evidence-based strategies that improve both theoretical understanding and practical deployment of BESS for power system stability.

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