



# From Intermittency to Innovation: A Case Study on Sri Lankan Utility Approaches to Renewable Energy Integration

M Musthaffa Aliyar



**Abstract-** The integration of renewable energy into national electricity grids marks a defining transformation in the global power sector, offering the promise of sustainable, low-carbon futures while simultaneously confronting utilities with complex and multi-dimensional challenges. Renewable sources such as solar, wind, and biomass differ fundamentally from conventional generation in that they are intermittent, geographically dispersed, and less predictable, thereby creating operational challenges in maintaining grid stability and balancing supply with fluctuating demand. These inherent characteristics raise concerns regarding frequency regulation, voltage control, and overall power quality, particularly as renewable penetration increases. Existing grid infrastructure, designed for centralised, dispatchable generation, is often ill-equipped to handle the variability and decentralisation of renewable energy flows, resulting in mounting pressure on utilities to modernise networks and adopt advanced system management techniques. Meeting these challenges necessitates substantial investments in transmission and distribution infrastructure, along with the deployment of smart grid technologies, digital monitoring, and energy storage systems to enhance flexibility and resilience. However, the financial implications are significant. Utilities must manage the substantial capital costs of grid upgrades and transmission expansion while maintaining affordability for consumers. Furthermore, prevailing market structures and regulatory frameworks frequently lag behind technological advances. Current mechanisms often undervalue flexibility, ancillary services, and capacity reserves, leaving utilities with limited financial incentives to adopt the very solutions required for the stable integration of renewables. The resulting misalignment between technological necessity and institutional readiness creates a systemic barrier to progress. This paper presents a qualitative case study that examines these challenges in depth, drawing on expert interviews, document analysis, and stakeholder consultations. The study highlights the interplay among technical, financial, and regulatory issues, showing that generation variability is not merely an operational inconvenience but a catalyst for broader infrastructure strain and economic risk. Equally, the findings demonstrate that effective integration of renewable energy cannot be achieved through isolated technological measures; it requires a holistic, coordinated approach that integrates engineering solutions with policy reform and economic strategy. In response, the research proposes comprehensive strategies to support utilities in navigating the transition. Key recommendations include strengthening forecasting and scheduling tools to manage variability, investing in energy storage and demand-side management to enhance system flexibility, and reinforcing transmission networks to ensure reliable interconnection of dispersed generation sources.

At the policy level, the study underscores the need for adaptive regulatory frameworks and transparent market mechanisms that reward flexibility, incentivise investment, and provide long-term certainty. Taken together, these strategies form a practical framework through which utilities and policymakers can address the challenges of renewable integration while safeguarding system reliability, economic sustainability, and consumer trust. Ultimately, the study argues that the integration of renewable energy is not solely a technical or financial challenge but a systemic transformation of the electricity sector. By approaching this transition as an opportunity for innovation rather than a source of operational strain, utilities and decision-makers can accelerate the path toward a resilient, efficient, and sustainable energy future.

**Keywords:** Renewable Energy Integration, Sri Lanka, CEB, Grid Stability, Energy Storage, Smart Grid, Policy Reform.

## Nomenclature:

IEA: International Energy Agency  
SAARC: South Asian Association for Regional Cooperation  
SASEC: South Asia Subregional Economic Cooperation  
MW: Megawatts  
CEB: Ceylon Electricity Board  
PPA: Power purchase agreement  
TOU: Time-of-Use  
LTGEP: Long-Term Generation Expansion Plan  
AMI: Advanced Metering Infrastructure  
SCADA: Supervisory Control and Data Acquisition  
MOE: Ministry of Energy  
SLSEA: Sri Lanka Sustainable Energy Authority  
PPA: Public-Private Partnerships

## I. INTRODUCTION

Globally, the electricity sector is undergoing a profound transformation, shaped by the rapid expansion of renewable energy sources (RES). According to the International Energy Agency [1], renewables now account for more than 30% of global electricity generation, with solar, wind, and biomass achieving record levels of growth. Within South Asia, regional frameworks such as SAARC and SASEC have highlighted the strategic importance of integrating renewable energy to advance energy security, foster economic development, and address climate change [3].

Sri Lanka's power sector reflects these global and regional dynamics. Despite achieving universal household electrification by 2016 and expanding its total installed generation capacity to 5,939 megawatts (MW) by the end of 2024—comprising 37% from fossil fuels, 33% from hydropower (subject to significant seasonal variability), and 30% from other renewable sources, including rooftop solar—Sri Lanka's power sector continues to encounter significant development constraints. Although average

Manuscript received on 21 January 2026 | Revised Manuscript received on 07 February 2026 | Manuscript Accepted on 15 February 2026 | Manuscript published on 28 February 2026.

\*Correspondence Author(s)

M. Musthaffa Aliyar\*, Department of Projects and Heavy Maintenance, Ceylon Electricity Board, Colombo (Western), Sri Lanka. Email ID: [musthaffaaliyar@gmail.com](mailto:musthaffaaliyar@gmail.com)

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annual per capita electricity consumption increased from 480 kilowatt-hours (kWh) in 2011 to 695 kWh in 2024, it remains considerably lower than the Asia-Pacific average of 3,406 kWh recorded in 2022. This disparity indicates that Sri Lanka's electricity demand is poised to grow faster than that of the broader region, even after accounting for potential improvements in energy efficiency.

The CEB serves as the sole vertically integrated utility responsible for generation, transmission, and distribution. Hydropower has historically formed the backbone of the country's generation mix; however, the past decade has witnessed substantial growth in mini-hydro, solar, and wind power projects. Collectively, renewables now contribute over 55% (Hydro -35%, Solar- 15%, Wind and biomass -5%) of the nation's electricity supply, with penetration levels reaching as high as 70% during certain periods in 2025. This rapid transition, while advancing the country's sustainability goals, presents significant operational challenges. In contrast to dispatchable hydro and thermal generation, renewable resources are inherently intermittent, spatially dispersed, and less predictable, thereby complicating real-time grid management and long-term system planning.

This study examines the technical, financial, and regulatory complexities associated with the integration of renewable energy in Sri Lanka. Using a qualitative case study of CEB, the paper highlights key challenges. It proposes practical strategies to strengthen grid reliability, ensure economic sustainability, and align regulatory frameworks with the evolving requirements of a renewable-dominated power system.

## II. LITERATURE REVIEW

### A. Global Experiences with Renewable Integration

High renewable penetration introduces variability, ramping difficulties, and reduced system inertia [1]. Utilities in Europe and Asia employ advanced forecasting, flexible generation, and storage to address these issues [7]. Germany's *Energiewende* underscores the necessity of grid modernisation and market reform to accommodate intermittent supply [5].

### B. Regional Perspectives: SAARC and SASEC

SAARC and SASEC highlight cross-border interconnection, cooperative power trade, and renewable microgrids as strategies for energy security [3,4]. For Sri Lanka, these models suggest benefits in linking domestic generation with regional transmission corridors to enhance reliability and resource sharing.

### C. Sri Lankan Context

The evolution of tariff structures and procurement mechanisms has strongly influenced Sri Lanka's trajectory of renewable energy development. The introduction of an avoided-cost-based feed-in tariff in 1996 stimulated the rapid expansion of small hydropower projects, marking an important phase in the development of decentralised generation. The subsequent transition in 2008 to technology-specific, cost-reflective tariffs broadened investor participation and diversified the renewable energy mix to include wind and biomass power. Between 2015 and 2019, the adoption of competitive bidding for wind and solar

projects further reduced generation costs, with tariffs declining below previous feed-in levels, consistent with global market trends.

Despite strong private sector interest, implementation following the Ministry of Energy's 2021 call for expressions of interest has encountered significant obstacles. These include protracted government approval processes, challenges in land acquisition, investor apprehension regarding sovereign risk, concerns about the financial stability of the CEB as the sole off-taker, and limitations on the bankability of PPAs.

Sri Lanka's rooftop solar program, initiated in 2008 with a net metering framework and strengthened in 2016 through the introduction of a fixed feed-in tariff, continues to attract investment from households and businesses. For the second half of 2025, the average buyback rate for rooftop solar generation is projected at LKR 29.24 (approximately USD 0.10) per kilowatt-hour.

Sri Lanka's hydro-dominant system offers flexibility but is subject to seasonal variability. Expanding solar and wind integration is constrained by poor forecasting, limited storage capacity, and outdated infrastructure [6]. Literature identifies three key clusters of constraints:

#### i. Technical:

Reduced inertia from inverter-based renewables complicates frequency regulation, especially during evening ramp-downs. Voltage fluctuations arise from bidirectional flows in solar-heavy feeders, while inadequate forecasting forces higher reserve margins. Transmission bottlenecks constrain evacuation from wind- and solar-rich northern regions, and the absence of utility-scale storage heightens dependence on hydro reservoirs that are vulnerable to drought.

#### ii. Financial:

Grid modernisation requires substantial capital expenditures, yet CEB's debt burden and dependence on fuel imports constrain investment. Backup capacity and reserve requirements raise operational costs, particularly during dry seasons when oil-fired plants are dispatched. Tariff structures and net metering reduce revenues without compensating for integration costs.

#### iii. Regulatory:

The absence of a well-defined ancillary services market constrains incentives for investments in system flexibility, which is essential for accommodating higher shares of variable renewable energy. Furthermore, policy inconsistencies such as frequent tariff revisions and delays in procurement processes have undermined investor confidence. Grid access and approval procedures remain slow and fragmented across multiple regulatory entities, often resulting in curtailments and delays in the execution of power purchase agreements.

Enhancing private-sector participation, particularly in electricity generation, is therefore pivotal for Sri Lanka to achieve its target of sourcing 70% of electricity from renewable energy by 2030. The Electricity Act of 2024 seeks to operationalize long-pending sector reforms, including the unbundling of the CEB to improve



operational efficiency and promote competition, tariff restructuring to enhance financial sustainability, and policy measures that facilitate competitive renewable energy procurement and open market access. Collectively, these reforms are designed to establish a transparent, predictable, and enabling investment environment that can attract sustained private capital into Sri Lanka's renewable energy sector.

Overall, the literature underscores that successful integration of renewable energy in Sri Lanka requires coordinated advances in technology, financing, and regulation.

### III. METHODOLOGY

This study adopts a qualitative case study approach, with the CEB serving as the focal unit of analysis. The case study design is particularly suited to contexts in which complex, multidimensional challenges require in-depth exploration rather than quantification. Renewable energy integration is influenced not only by technical factors but also by institutional, financial, and regulatory dynamics, all of which demand a nuanced understanding. A qualitative design, therefore, allows the capture of lived experiences, organisational practices, and policy interpretations that cannot be adequately reflected in numerical models or statistical analyses alone.

Data were collected through three complementary methods: expert interviews, document analysis, and stakeholder consultations. First, semi-structured interviews were conducted with 10 senior managers and 15 engineers, planners, and system operators at CEB. These interviews provided valuable practitioner insights into operational realities, technical bottlenecks, and managerial perspectives on renewable energy integration. The semi-structured format balanced consistency across key themes—such as system stability, cost implications, and regulatory barriers—while also allowing flexibility for participants to discuss emergent issues.

Second, document analysis was undertaken to supplement and validate interview findings. The review covered CEB's Annual Reports [2], the Renewable Energy Development Plan, the Long-Term Generation Expansion Plan (LTGEP), the Transmission Development Plan, grid operation manuals, and relevant national policy documents. These sources offered institutionalized perspectives on planning, investment, and operational priorities, enabling triangulation between official strategies and stakeholder accounts.

Third, stakeholder consultations extended the scope beyond the utility, incorporating perspectives from policymakers, renewable energy project developers, and consumer representatives. These discussions highlighted broader policy and market dynamics, particularly tensions among regulatory frameworks, private-sector expectations, and consumer demands for affordable yet reliable electricity.

The collected data were analysed using thematic coding, which identified recurring patterns and clustered challenges into technical, financial, and regulatory dimensions. Coding was conducted iteratively, ensuring that themes emerged organically from the data while remaining grounded in the study's objectives. This method also allowed for the

identification of practical mitigation strategies proposed by both utility staff and external stakeholders.

By integrating multiple sources of evidence and perspectives, this methodological design strengthens the validity of findings. Moreover, the qualitative case study framework is justified by the exploratory nature of the research. Rather than seeking generalizable statistical relationships, the study aims to generate a rich, contextualized understanding of Sri Lanka's renewable energy integration challenges and potential solutions.

### IV. DISCUSSION

The fundamental challenges arise from the limited pace of sectoral reforms, persistent delays in implementing fully cost-reflective tariffs across all consumer categories, and continued reliance on high-cost imported fossil fuels. Additionally, the slow advancement of competitive procurement processes for renewable energy generation, coupled with inadequate system modernisation and insufficient energy storage capacity, constrains the power system's ability to manage daily and seasonal fluctuations in renewable energy output.

#### A. Technical Challenges

The integration of intermittent renewable energy sources such as solar and wind into national grids presents several complex technical challenges. One of the foremost issues is intermittency and forecasting limitations. Renewable generation is highly weather-dependent, and sudden output reductions from solar or wind farms necessitate rapid ramping by dispatchable thermal or hydro units to maintain system balance. Moreover, the lack of real-time monitoring of distributed rooftop solar generation exacerbates this problem. System operators regard these units as negative loads, which complicates accurate demand estimation and hinders optimal generation resource scheduling.

Another critical concern is voltage and frequency control. Solar and wind are primarily connected via distributed generation schemes, often at the medium-voltage level, which can cause reverse power flows and voltage regulation issues. The increasing penetration of distributed renewable generation contributes to localised voltage fluctuations that can adversely affect power quality. At the system level, the reduced inertia from conventional synchronous generators challenges frequency stability, especially under high renewable penetration scenarios.

Finally, infrastructure constraints pose significant challenges. Existing distribution networks were not designed to accommodate high penetration of renewables, widespread EV charging, or bidirectional power flows. As a result, millions of rupees' worth of approved PV projects remains pending grid connection. Historically, most transmission and distribution systems were designed for unidirectional power flows—from centralised power plants to end users. However, the bidirectional flows resulting from decentralised generation now increase the risk of network congestion, power losses, and equipment stress. Overcoming these challenges will require substantial modernization and reinforcement of the grid infrastructure. Furthermore,

the development of new substations or the reinforcement of existing transmission lines often takes significantly longer than the construction of renewable energy assets.

## B. Financial Challenges

The integration of renewable energy into the national grid necessitates extensive investment in grid expansion, modernization, and deployment of advanced technologies. For example, utilities often discuss the issue of intermittency, yet the deployment of commercial-scale energy storage remains fragmented. Without adequate storage, excess renewable generation is curtailed rather than being used to provide clean, reliable, and dispatchable power. Transitioning toward a smart grid requires the installation of smart meters, energy storage systems, sophisticated protection and control mechanisms, and robust communication networks. These investments involve substantial capital expenditure. If the associated costs are directly passed on to end users through tariffs, electricity prices may escalate to unsustainable levels. In the case of the CEB, financial constraints are particularly acute. The utility currently lacks adequate internal funds to support such large-scale investments and increasingly relies on commercial borrowing at high interest rates. This approach raises long-term financial risks while limiting affordability for consumers. Furthermore, existing market frameworks provide limited incentives for flexibility services, thereby discouraging investment in solutions such as battery storage and demand response programs, which are critical for integrating variable renewable generation.

## C. Regulatory Challenges

In Sri Lanka, the regulatory environment for electricity sector operations remains insufficiently aligned with the requirements of large-scale renewable energy integration. Existing regulations do not adequately recognize or compensate ancillary services such as reactive power support, spinning and frequency reserves, or fast-response storage solutions. These services are critical for maintaining grid stability under conditions of high variability in solar and wind generation. However, the absence of explicit market mechanisms or remuneration frameworks discourages investment in such capabilities. Furthermore, prevailing policies are largely prescriptive, emphasising compliance with rigid technical and operational standards rather than fostering innovation or enabling performance-based approaches. This limits opportunities for utilities and private investors to adopt modern grid management tools, including advanced forecasting, automation, and digital technologies. Addressing these regulatory gaps is essential to enhance flexibility, attract investment, and ensure the reliable integration of renewable energy into Sri Lanka's national grid.

The technical, financial, and regulatory challenges associated with integrating renewable energy into Sri Lanka's national grid are not isolated; rather, they are deeply interdependent and mutually reinforcing. For instance, limitations in forecasting and real-time monitoring of intermittent renewable generation increase reliance on spinning reserves and fast-ramping thermal or hydro units. This, in turn, raises operating costs and intensifies financial pressures on the CEB, which is already constrained by limited capital availability and dependence on high-interest

commercial borrowing. At the same time, the absence of well-defined regulatory frameworks for ancillary services prevents the establishment of efficient market mechanisms to value flexibility, further compounding both technical and financial difficulties.

The implications of these interlinked challenges are profound. If left unaddressed, they increase the risk of grid instability, localised blackouts, rising consumer tariffs, and long-term financial stress for the sector. Conversely, a systemic and coordinated response—encompassing advanced forecasting, grid modernization, innovative financing models, and regulatory reforms—can enhance operational reliability, enable higher renewable energy penetration, and ensure the long-term sustainability of Sri Lanka's power sector.

## V. RECOMMENDATION

A central outcome of this study is the identification of strategies to address the technical, financial, and regulatory barriers hindering renewable energy integration in Sri Lanka. These strategies span improvements in forecasting, storage, grid modernization, policy reform, and regional cooperation.

### A. Enhancing Forecasting and Scheduling

Accurate forecasting of renewable generation is essential for minimizing uncertainty in power system operations. The adoption of advanced weather prediction models and satellite-based monitoring can significantly improve short- and medium-term forecasts of solar and wind output. Coupled with machine-learning-driven generation forecasting, these tools would enable the CEB to anticipate fluctuations in renewable supply better. In parallel, improvements to unit commitment and dispatch algorithms can optimise the scheduling of thermal, hydro, and renewable plants, ensure efficient use of reserves while reducing the cost of balancing operations. By integrating forecasting into real-time system operations, the risk of curtailment and frequency instability can be mitigated.

### B. Energy Storage and Demand-Side Management

The deployment of grid-scale energy storage systems, including batteries and pumped-hydro systems, is essential for mitigating the variability of renewable energy and providing ancillary services such as frequency regulation and reserve capacity. These systems store surplus energy during periods of high solar or wind output and discharge it during peak demand, reducing reliance on costly oil-fired generation, particularly in dry seasons. Complementing storage, demand-side management (DSM) measures can encourage flexible electricity use among consumers. Power systems should adopt demand response strategies that utilise flexible loads, such as electric vehicles, desalination plants, and hydrogen production, alongside cost-reflective Time-of-Use (TOU) tariffs to incentivise off-peak consumption. Together, these approaches enhance renewable energy utilization, minimize daytime curtailments, and reduce dependence on high-cost night-time generation. Moreover, industrial load-shifting incentives and TOU programs can align consumption with renewable availability—for



example, promoting daytime industrial activity during peak solar hours can ease evening ramping challenges.

### C. Grid Modernization

Strengthening the transmission and distribution (T&D) network is vital for integrating geographically dispersed renewable projects. This requires upgrading transmission lines to accommodate higher loads, modernising transformers, and automating substations to enhance system responsiveness. Investments in smart grid technologies—including advanced metering infrastructure (AMI), real-time sensors, and SCADA systems—would enable more granular monitoring of grid conditions and more rapid responses to fluctuations. Smart grids also support bidirectional power flow, enabling efficient integration of rooftop solar and distributed energy resources. Such modernization enhances both the resilience and flexibility of the power system.

### D. Policy and Market Reforms

Institutional and regulatory reforms are essential to establish an enabling environment for the integration of renewable energy. In Sri Lanka, challenges in advancing renewable energy projects primarily stem from unclear procedural frameworks and insufficient coordination among relevant agencies. The Ministry of Energy (MOE), CEB, and Sri Lanka Sustainable Energy Authority (SLSEA) play key roles in promoting renewable energy through resource assessments, mapping, and prefeasibility studies. However, due to the land-intensive nature of wind and solar parks, many projects—particularly those above 10 MW—have experienced delays as developers struggle to obtain necessary land clearances. To address these constraints, Sri Lanka needs a comprehensive and systematic renewable energy development plan that proactively identifies potential project sites, defines clear implementation timelines, and assigns specific institutional responsibilities.

A second critical measure is the introduction of dynamic tariffs that reflect real-time system conditions, thereby incentivizing both consumers and producers to align their behavior with grid requirements. Establishing dedicated markets for ancillary services and capacity reserves would further enable financial compensation for fast-response resources such as battery storage, flexible hydropower, and demand-side management. In addition, public-private partnerships (PPPs) can mobilise investment for large-scale infrastructure development by sharing financial risks between the government and the private sector. Finally, maintaining clear, consistent, and transparent policy frameworks is vital to attract sustained domestic and international investment in renewable energy projects.

### E. Regional Cooperation

Regional integration offers significant opportunities to enhance energy security and manage the intermittency of renewable energy across national boundaries. By leveraging interconnection initiatives under the SASEC and the SAARC, Sri Lanka could actively participate in cross-border electricity trade. Such cooperation would enable the country to export surplus renewable energy during peak-generation periods and import power during shortages, thereby strengthening overall system reliability. Moreover, regional collaboration facilitates the pooling of generation and balancing resources,

reducing the need for each country to maintain excessive backup capacity.

#### i. Green Finance Facility

A dedicated SASEC Renewable Energy Finance Facility, modelled on the ASEAN Catalytic Green Finance Facility and adapted to South Asian conditions, could play a transformative role. By providing concessional finance, blended financial instruments, and credit guarantees, this mechanism would help reduce investment barriers, attract private-sector participation, and accelerate the deployment of renewable energy. It would also complement ongoing regional efforts in grid integration and policy harmonization

#### ii. Digital Utility Initiative

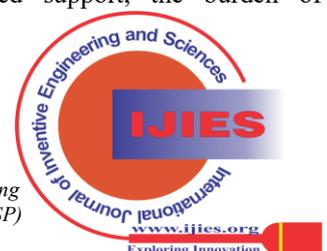
Digitalisation can be a critical enabler of regional power trade by enhancing the efficiency, transparency, and reliability of cross-border energy transactions. Real-time monitoring of power supply and demand through digital platforms can help mitigate blackout risks, enhance grid stability, and facilitate seamless coordination among utilities. Developing a digitalization roadmap and establishing a regional digital platform for data sharing on power demand, supply, transmission availability, and trade transactions would significantly strengthen regional integration, promote market transparency, and support access to affordable and sustainable energy across the SASEC subregion.

Collectively, these strategies emphasize a multi-pronged approach—combining technological innovation, institutional reform, and regional collaboration—to ensure that Sri Lanka can achieve its renewable energy targets while maintaining grid stability, financial sustainability, and consumer affordability.

## VI. CONCLUSION

The integration of renewable energy into Sri Lanka's national grid represents both a necessity and a formidable challenge in the country's ongoing energy transition. As this study highlights through the case of the CEB, the pathway toward a renewable-based electricity system is neither straightforward nor achievable through technical measures alone. While advancements in forecasting, grid automation, and energy storage technologies are critical, they remain insufficient without complementary financial and regulatory frameworks that enable their effective deployment.

From a technical perspective, intermittency, limited forecasting accuracy, voltage fluctuations, and infrastructure bottlenecks underscore the urgent need to modernise the existing grid. Investment in smart grid technologies, real-time monitoring of distributed generation, and advanced system operator tools will be indispensable for maintaining stability as renewable penetration rises. At the same time, financial constraints remain a major barrier. CEB, as a state-owned commercial utility, lacks the capital to undertake large-scale infrastructure upgrades and instead faces growing reliance on high-cost commercial borrowing. Without government-backed concessional financing, innovative funding models, or international climate-linked support, the burden of renewable integration risks translating into unsustainably high consumer tariffs.



## From Intermittency to Innovation: A Case Study on Sri Lankan Utility Approaches to Renewable Energy Integration

Equally critical are regulatory gaps. Current policies and provisions of the Sri Lanka Electricity Act do not adequately recognise the value of ancillary services, such as frequency reserves, reactive power support, and demand response. The absence of market-based mechanisms to incentivise flexibility discourages investment in battery storage and other emerging solutions vital for managing variability. Prescriptive rather than performance-oriented regulation further restricts innovation and private sector participation.

The implications of leaving these challenges unaddressed are significant. Technical shortcomings increase the likelihood of grid instability and localized blackouts; financial constraints amplify sectoral debt and consumer burden; and regulatory inertia limits the development of a resilient and adaptive power system. Yet, the challenges are not insurmountable. By adopting a holistic, systemic approach that aligns technological upgrades with financial innovation and regulatory reform, Sri Lanka can turn renewable integration into a pathway to long-term sustainability.

This requires recognising that CEB cannot bear the national responsibility for the transition alone. Government leadership is essential to create enabling policies, provide financial instruments, and establish transparent regulatory frameworks that reward flexibility and resilience. Moreover, aligning Sri Lanka's renewable energy roadmap with international best practices and climate finance mechanisms can unlock external support and reduce domestic fiscal strain.

Ultimately, renewable energy integration should not be viewed merely as a technical obligation but as a transformative opportunity. It offers an opportunity to strengthen innovation, enhance system resilience, and achieve long-term energy security, while contributing to global decarbonization efforts. By carefully coordinating technology, finance, and policy, Sri Lanka can build a reliable, economically viable, and low-carbon electricity system capable of meeting its ambitious renewable energy targets and securing its future energy needs.

The next phase of the energy transition will be characterized not by the speed at which renewable energy capacity is expanded, but by the effectiveness with which these resources are integrated into the broader energy system.

Future research in the energy sector should increasingly focus on enhancing infrastructure resilience, fostering cross-border energy cooperation, and advancing innovation in storage and grid technologies. Strengthening infrastructure resilience is essential to ensure system reliability amid increasing renewable penetration, climate-induced disruptions, and evolving demand patterns. At the same time, regional and international collaboration can optimise resource utilisation, facilitate power trade, and enhance collective energy security. Moreover, breakthroughs in energy storage and smart grid technologies will be critical for managing variability, enhancing grid flexibility, and accelerating the global transition toward a sustainable, decarbonised energy future.

### DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

- **Conflicts of Interest/ Competing Interests:** Based on my understanding, this article has no conflicts of interest.
- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted objectively and free from external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

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### AUTHOR'S PROFILE



**M. Musthaffa Aliyar**, MBA (PIM-USJ), BSc Eng. (Hons), CEng, FIE (SL), IntPE (Sri Lanka), MIET (UK), ACG. With over 30 years of experience since graduation, he brings a unique blend of technical, managerial, and academic expertise in the power and energy sector. For 33 years, he served in various capacities at the Ceylon Electricity Board (CEB) in Sri Lanka, gaining extensive,

hands-on experience across electricity generation, transmission, and distribution. His work has spanned key areas including project and asset management, maintenance and materials management, procurement, electricity pricing, corporate strategy, utility regulation, human resource development, and policy and process development. He has also actively contributed to power sector reform initiatives in Sri Lanka. In parallel, He has over a decade of academic experience—both full-time and part-time—in Sri Lanka and Malaysia, mentoring and teaching the next generation of engineers and energy professionals.

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