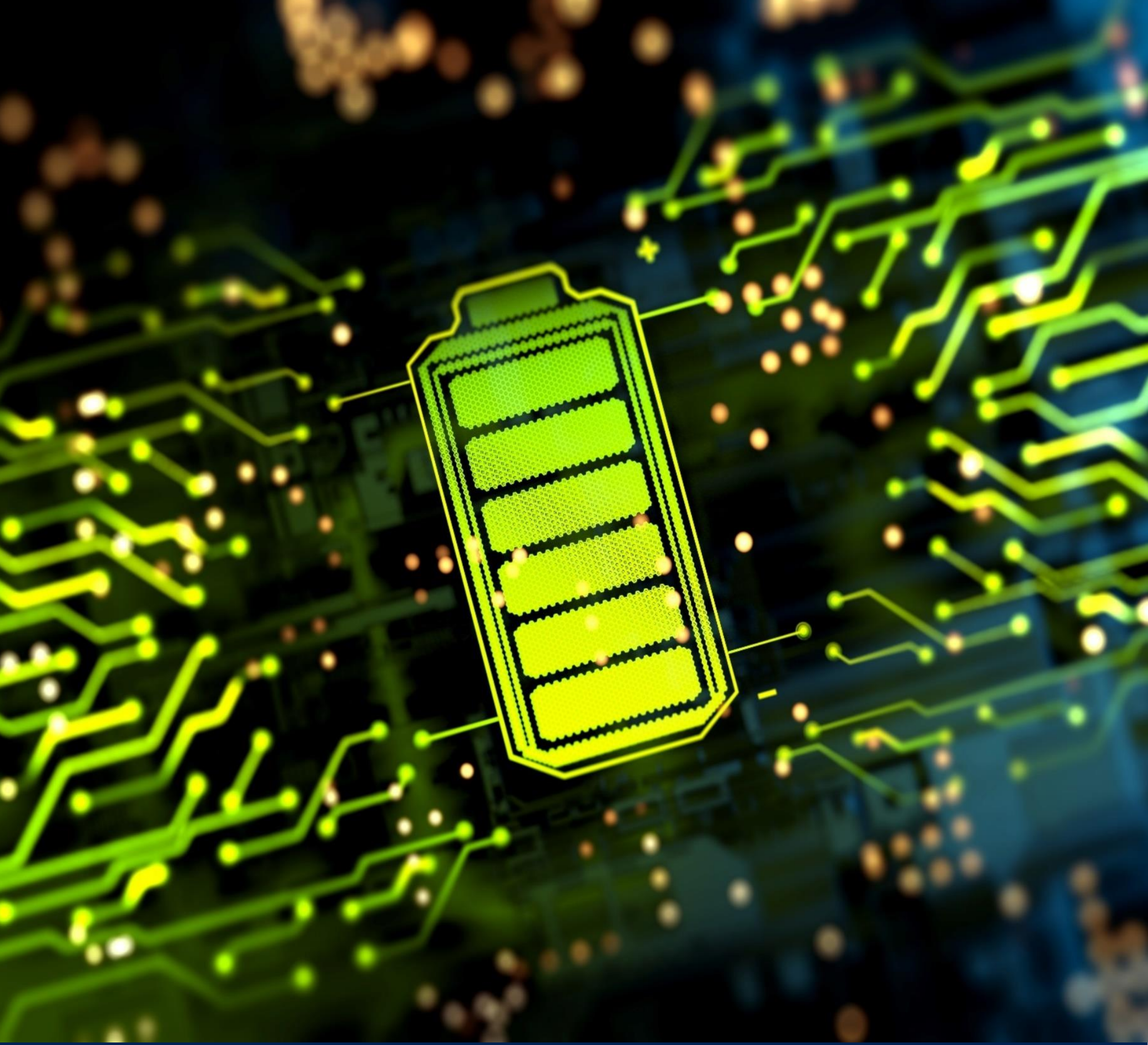

The MOBISUB Project - A Blueprint for International Cleantech Collaboration

Demonstrating Successful Partnership in Developing and Validating Dual-Use Mobile Battery Storage for Emerging Markets

Cambridge Cleantech, September 2025

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Executive Summary

The MOBISUB project represents a groundbreaking international collaboration between the UK and India that demonstrates how Mobile Battery Energy Storage Systems (MBESS) can revolutionise grid infrastructure while advancing global clean energy transition goals. This innovative initiative developed a truck-mounted battery energy storage system that provides dual functionality—substation maintenance support and grid-scale energy storage services—addressing critical challenges in India's rapidly evolving energy landscape while establishing a replicable model for international clean technology collaboration.

The project's technical achievements centre around StorTera's advanced Lithium Ferro Phosphate (LFP) battery technology, successfully integrated into a modular, mobile platform that overcame significant logistical challenges, including Red Sea shipping disruptions that extended transportation from Scotland to India by several weeks. The economic validation provided by PNDC research proves compelling, demonstrating that MBESS generates 43% higher income compared to stationary systems and achieves 62.11% higher resilience. This economic advantage stems from MBESS's strategic flexibility, enabling operators to participate selectively in high-value grid applications while avoiding lower-value commitments.

The MOBISUB solution directly addresses India's multifaceted energy challenges, including renewable integration gaps where national renewable penetration remains around 8.2% despite impressive capacity additions, grid instability that necessitates frequent load-shedding and power cuts, energy storage bottlenecks caused by prohibitive costs and financially constrained distribution companies, and accelerating electrification demands projected to triple per capita electricity consumption by 2040. The innovative dual-use business model maximises asset utilisation by providing substation backup power during daytime maintenance operations and grid support services during peak demand periods, creating multiple revenue streams while displacing expensive diesel generators.

The international consortium exemplifies effective cross-border collaboration, bringing together Cambridge Cleantech for project coordination, StorTera for technical leadership, PNDC for validation testing, Tata Power DDL as the utility partner and need owner, TERI for policy analysis, TERI SAS for technical evaluation, and IIT Roorkee for power electronics integration. This partnership model created genuine co-innovation rather than simple technology transfer, where Indian insights about grid stability and deployment challenges shaped the technology's development alongside Scottish engineering expertise.

Strategically positioned within India's battery energy storage market (projected to reach $5.3 billion by 2030), MOBISUB contributes meaningfully to the country's ambitious renewable energy goals of 500 GW capacity by 2030. The system's versatility enables comprehensive grid service delivery, including peak shaving, frequency regulation, emergency response, and ancillary services across multiple locations, while its mobile configuration provides unparalleled emergency response capabilities and supports distributed energy resource optimisation. Beyond immediate commercial applications, MOBISUB establishes a blueprint for global clean energy collaboration, demonstrating how strategic partnerships can accelerate technology development, reduce deployment risks, and create mutual benefits for participating nations while advancing the shared global challenge of climate action through coordinated investment and open collaboration.

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1. Introduction: The Critical Role of BESS in Modern Grid Infrastructure

Battery Energy Storage Systems (BESS) have emerged as a foundational technology for addressing the evolving challenges of modern electrical grids. As power systems integrate increasing volumes of renewable energy sources and face growing demand from electrification initiatives, BESS technology provides essential flexibility and stability to maintain grid reliability while optimising economic performance.

The strategic importance of BESS extends beyond simple energy storage, encompassing a comprehensive suite of grid services that enhance system resilience, reduce operational costs, and enable the transition to cleaner energy infrastructure. These systems serve as critical intermediaries, balancing supply and demand fluctuations while providing rapid response capabilities that traditional generation sources cannot match.

The widespread adoption of Low-Carbon Technologies (LCTs) is poised to fundamentally transform distribution network operations. According to research from consortium partner PNDC, the concurrent deployment of electric vehicles and heat pumps is projected to contribute an additional 26 GW and 15 GW to peak demand, respectively. This substantial increase in electrical load poses significant challenges, potentially exacerbating voltage regulation issues and placing excessive strain on transformer infrastructure, ultimately compromising the stability and reliability of networks.

2. Technology Landscape: SBESS vs MBESS

The technology landscape encompasses two primary categories: Stationary Battery Energy Storage Systems (SBESS) and Mobile Battery Energy Storage Systems (MBESS). SBESS installations are characterised by their permanent positioning at fixed locations, making them well-suited for sustained, long-term operations and large-scale energy storage applications, as noted by PNDC research. Nevertheless, these systems exhibit inherent limitations, including reduced operational flexibility and more complex installation and commissioning procedures.

In contrast, MBESS technology represents a paradigm shift toward enhanced operational agility, incorporating advanced energy-dense technologies specifically engineered for mobility, rapid deployment capabilities, and superior operational flexibility (PNDC). These mobile systems facilitate dynamic energy management and enable seamless integration across diverse geographical locations within distribution networks, significantly bolstering grid resilience, operational adaptability, and emergency response capabilities. MBESS units can be strategically repositioned to address localised grid stress, seasonal demand variations, or emergencies, providing utilities with unprecedented operational versatility.

3. Cost-Benefit Analysis of MBESS: PNDC Research Findings

MBESS Revenue Optimisation Model
The PNDC research developed a comprehensive cost-benefit framework for MBESS operations, integrating Levelized Cost of Storage with multi-application revenue streams to maximise service provider profitability. This model demonstrates how MBESS technology can strategically participate across diverse grid applications to optimise financial returns. What sets this study apart is its experimental validation at the Power Networks Demonstration Centre (PNDC) in collaboration with StorTera, making it a unique and practical assessment of MBESS applications.
Key Financial Performance Indicators

The PNDC analysis reveals critical economic advantages for MBESS deployment:

- MBESS generates 43% higher income compared to SBESS systems, representing a substantial revenue advantage for service providers.
- MBESS achieves 62.11% higher resilience compared to SBESS, despite additional operational costs, due to its mobility advantage in bypassing damaged infrastructure and restoring energy supply efficiently.

- Peak shaving and congestion relief applications command premium pricing, as these services are essential during high electricity price periods when grid stress is most acute.
- MBESS flexibility enables selective participation in high-value grid applications, allowing operators to maximise revenue by strategically choosing the most profitable opportunities.

Strategic Revenue Advantage

Unlike stationary systems that must accept all service requests regardless of compensation levels, MBESS technology provides operators with strategic choice capabilities. This flexibility allows service providers to target premium grid applications while avoiding lower-value commitments, resulting in significantly enhanced profitability profiles.

Study Limitations and Applicability

The PNDC findings are specifically calibrated to the battery system tested at their facilities, and results may vary under different operational parameters.

Industry Impact Potential

The research indicates that MBESS flexibility could fundamentally transform energy infrastructure planning, with the potential to:

- Influence strategic grid planning approaches by Distribution Network Operators
- Encourage increased DNO investment in energy storage technologies
- Drive regulatory framework development supporting more stable and cost-effective energy infrastructure

Bottom Line for Service Providers

The PNDC findings provide compelling evidence that MBESS technology offers service providers a clear competitive advantage, delivering 43% higher income potential through strategic flexibility and optimised application selection, making it the economically superior choice for grid service applications.

Battery Energy Storage Solutions for Grid Service Providers

Grid service providers face an increasingly complex challenge in selecting optimal energy storage technologies to support modern distribution networks. The choice between Stationary Battery Energy Storage Systems (SBESS) and Mobile Battery Energy Storage Systems (MBESS) significantly impacts both operational effectiveness and financial viability.

Stationary Battery Energy Storage Systems (SBESS) represent the traditional approach to grid-scale energy storage. These systems excel in applications requiring consistent, high-capacity storage at predetermined locations such as major substations or renewable energy farms. SBESS installations typically offer lower per-kWh costs due to economies of scale and simplified infrastructure requirements. However, their fixed nature limits operational flexibility and requires accurate long-term demand forecasting, potentially leading to underutilization during off-peak periods.

Mobile Battery Energy Storage Systems (MBESS) introduce a transformative approach to grid energy management. These systems provide unparalleled operational versatility, enabling utilities to deploy storage capacity dynamically across multiple locations based on real-time grid conditions. This mobility translates into superior asset utilisation rates, as a single MBESS unit can serve multiple substations throughout its operational cycle.

Cost-Benefit Analysis reveals compelling advantages for MBESS deployment. While initial capital expenditure may appear higher on a per-unit basis, the superior asset utilisation of MBESS systems delivers substantially better return on investment. Industry analysis consistently demonstrates that MBESS solutions achieve utilisation rates exceeding 70-80%, compared to typical SBESS utilisation rates of 40-50%. This enhanced efficiency stems from MBESS's ability to address peak demand across multiple locations, emergency response capabilities, and seasonal load balancing across diverse geographical areas.
The financial case for MBESS becomes even more compelling when considering operational expenditure reductions. MBESS systems eliminate the need for multiple fixed installations, reduce maintenance overhead through centralised servicing, and provide inherent redundancy that minimises grid outage costs. Industry consensus increasingly favours MBESS solutions, with leading utilities reporting 25-35% lower total cost of ownership compared to equivalent SBESS deployments.

The emerging industry perspective strongly supports MBESS adoption, recognising that the technology's inherent flexibility and superior asset utilisation fundamentally redefine the economics of grid-scale energy storage, making it the preferred solution for forward-thinking grid service providers.

4. The MOBISUB Project Initiative

The Mobisub project represents an innovative initiative focused on developing an advanced MBESS solution that meets the stringent technical requirements established by Indian project partners. The primary objective is to deliver a sophisticated mobile energy storage platform capable of providing comprehensive support to multiple substation facilities operating within the operational radius of a centralised depot facility. Following extensive validation testing and performance verification at the renowned Power Networks Demonstration Centre (PNDC), the fully integrated system was successfully transported to India for field deployment. The system is designed for truck-mounted operation, enabling comprehensive field trials that will demonstrate its effectiveness in meeting the demanding operational requirements of mobile substation applications while providing real-world validation of its grid support capabilities in diverse operating environments.

5. Mobisub System Applications

The Mobisub MBESS platform is uniquely positioned to deliver a comprehensive range of grid applications, leveraging its mobility advantage to maximise service delivery across multiple operational contexts:

Revenue-Generating Market Participation - The Mobisub system can engage in sophisticated energy arbitrage operations, strategically positioning itself to capture price differentials across different network locations and time periods. Unlike stationary systems limited to single-point market participation, Mobisub's mobility enables dynamic repositioning to access the most lucrative market opportunities, whether functioning as a price taker in competitive markets or leveraging strategic positioning to influence local pricing dynamics.

Critical Grid Support Services - Mobisub's rapid deployment capabilities make it exceptionally suited for providing essential grid support services. The system can deliver peak shaving services across multiple substations, reducing stress on ageing infrastructure while deferring costly transmission and distribution upgrades. During periods of network congestion, Mobisub can be strategically deployed to provide localised relief, effectively increasing the utilisation of existing grid assets without permanent infrastructure investments. The system's ability to rapidly relocate enables targeted congestion management by storing excess energy during low-demand periods and discharging it precisely where grid bottlenecks occur, thereby alleviating transmission constraints and preventing costly load curtailments.

Advanced Ancillary Services Delivery - The platform's quick response characteristics enable participation in critical ancillary services markets. Mobisub can provide frequency regulation services, rapidly adjusting its charge/discharge cycles to maintain system stability during demand fluctuations or renewable energy intermittency. The system's mobility allows it to serve as both spinning and non-spinning reserve capacity, repositioning to areas of highest need while maintaining grid synchronisation capabilities.

Emergency Response and Resilience Enhancement - Mobisub's truck-mounted configuration provides unparalleled emergency response capabilities. During grid disturbances or infrastructure failures, the system can rapidly deploy to affected areas, providing voltage support to maintain power quality and enable black start operations for critical infrastructure restoration. This mobility advantage is particularly valuable in disaster response scenarios where traditional fixed infrastructure may be compromised.

Customer-Centric Applications - Beyond utility-scale applications, Mobisub can support distributed energy resource optimisation by enhancing renewable energy integration at customer sites. The system can increase solar PV self-consumption rates by providing temporary storage capacity during peak generation periods, then redistributing this energy during evening demand peaks or grid outages.

Strategic Grid Planning Benefits - The Mobisub platform offers Distribution Network Operators (DNOs) unprecedented flexibility in grid planning and asset utilisation. Rather than investing in multiple fixed storage installations, utilities can deploy mobile units strategically to address seasonal demand patterns, support planned maintenance activities, or provide temporary capacity during infrastructure upgrades.

This comprehensive application portfolio demonstrates how the Mobisub MBESS transcends traditional energy storage limitations, delivering a dynamic, multi-service platform that adapts to evolving grid needs while maximising economic returns for operators and system benefits for grid users.

6. India's Energy Landscape and Strategic Context

The MOBISUB project operates within India's complex and rapidly evolving energy ecosystem. As the world's most populous nation, one of the fastest-growing major economies, and the third-largest global energy consumer, India confronts a defining challenge: ensuring reliable energy access for its vast, diverse population while executing an ambitious transition to a low-carbon, sustainable energy future.

India's climate commitments reflect this dual imperative. At COP21 in Paris (2015), the country pledged to increase non-fossil fuel power generation capacity to 40% by 2030 and install 175 gigawatts (GW) of renewable capacity by 2022. These ambitions expanded at COP26, with India committing to meet 50% of its energy requirements from renewables by 2030.[1] While these goals position India as a potential global clean energy leader, achieving them requires overcoming significant systemic challenges.

Challenge 1: Renewable Energy Integration Gap

Despite impressive capacity additions—over 100 GW of installed solar and wind capacity by 2021, ranking 5th globally in solar and 4th in wind—renewable energy penetration remains uneven and suboptimal. While some states exceed 20% renewable penetration, the national average hovers around 8.2%.[2] This disparity stems from the inherent intermittency of renewables combined with insufficient grid flexibility. Outdated infrastructure, limited energy storage deployment, and inadequate demand response mechanisms prevent full utilisation of clean energy resources, creating systematic inefficiencies and underperformance across the renewable energy ecosystem.

Challenge 2: Grid Instability & Operational Constraints

Grid reliability remains a critical vulnerability, particularly in rural and peri-urban regions where frequent voltage fluctuations, brownouts, and blackouts persist during peak demand periods or extreme weather events. The increasing integration of variable renewable energy sources exacerbates these stability challenges. To prevent grid overload, electricity distribution companies (DISCOMs) frequently implement load-shedding, planned power cuts, and curtailment—the intentional reduction of renewable output when the grid cannot absorb excess power. This reactive approach wastes clean energy, reduces revenue for producers, and undermines confidence in renewable investments. Transmission bottlenecks, insufficient storage capacity, and inflexible grid operations create compounding technical and economic barriers that impede essential battery storage adoption required for grid stability and renewable integration.

Challenge 3: Energy Storage & Market Reform Bottlenecks

Energy storage technologies, particularly batteries, are fundamental to balancing supply and demand, enabling time-shifting of renewable energy, and enhancing overall grid resilience. However, prohibitive costs have severely limited widespread adoption. While the Indian government has initiated large-scale storage tenders[3] to address this gap, financially constrained DISCOMs often lack the capital reserves to invest in these solutions or commit to the long-term renewable power purchase agreements necessary for market transformation. This financial constraint significantly slows the pace of essential market reforms and technological innovation.

Challenge 4: Accelerating Demand & Electrification Pressures

India's electricity consumption trajectory presents both opportunities and challenges. Per capita electricity consumption is projected to triple by 2040,[1] driven by rising living standards, rapid urbanisation, and the systematic electrification of transport and industrial sectors. Without substantial upgrades to grid infrastructure and the deployment of intelligent energy management systems, this dramatic demand growth will place unprecedented pressure on an already strained power network, potentially undermining both reliability and India's clean energy transition goals.

7. The MOBISUB Solution Framework

The MOBISUB project directly confronts India's multifaceted energy challenges through an innovative dual-function mobile system that seamlessly integrates substation maintenance support with grid-scale energy storage capabilities. Its modular architecture enables rapid transportation and interconnection across diverse deployment sites, delivering a flexible, scalable solution for both planned maintenance operations and emergency energy requirements.

Built on StorTera's advanced battery technology and proven expertise in intelligent energy networks, MOBISUB provides a cost-effective pathway to enhance grid resilience while establishing the foundation for smart, decentralised energy infrastructure. This pioneering approach directly aligns with India's strategic vision for a flexible, intelligent, and inclusive energy future.

Business Case: Dual-Use Economic Model
At MOBISUB's core lies a sophisticated dual-use business model that combines substation maintenance support with energy storage services, fundamentally enhancing economic viability in markets where standalone grid storage often proves financially unfeasible. The system capitalises on complementary usage patterns, enabling continuous asset utilisation and dramatically improved cost-effectiveness.

Operational Cycle:

- **Daytime Operations**: MOBISUB units provide uninterrupted backup power during substation maintenance, ensuring a continuous electricity supply to residential and commercial consumers when substations require temporary offline service.
- **Evening/Peak Operations**: During India's high-demand periods, particularly throughout summer months, the same systems are dynamically repurposed for grid support, releasing stored energy to reduce peak-hour pressure (peak shaving) while providing critical ancillary services including voltage regulation, frequency control, and rapid-response backup power for grid stability.

This dual functionality enables utilities like Tata Power DDL to maximise year-round asset utilisation from a single MOBISUB fleet, creating multiple revenue streams and accelerating return on investment timelines. By displacing expensive and polluting alternatives such as diesel generators, the model simultaneously advances cleaner, more reliable energy delivery across the network.

Advancing Inclusive Energy Access
Grid instability—characterised by frequent brownouts and blackouts—disproportionately impacts economically disadvantaged households and communities throughout India. Essential services are routinely interrupted during substation maintenance periods, compounding daily disruptions for populations least equipped to adapt to these challenges.

MOBISUB addresses intermittency and demand management obstacles by functioning as a sophisticated Virtual Power Station. This capability to prevent power outages and reduce dependence on polluting diesel generators directly benefits residents in deployment areas through enhanced grid reliability, reduced carbon emissions, and improved air quality outcomes.

Scaling for Equity: Beyond urban deployment scenarios, MOBISUB's modular design enables strategic expansion into remote and off-grid communities, creating transformative opportunities for community ownership models, participatory governance structures, and equitable energy access. This scalability directly supports global initiatives to eliminate energy poverty and advance climate justice principles, positioning MOBISUB as a catalyst for more equitable, low-carbon energy access across India's diverse geographic and socioeconomic landscape.

University of Strathclyde – Power Networks Demonstration Centre

8. International Consortium Overview

The MOBISUB project assembled a dynamic international consortium comprising leading academic institutions, industry innovators, and utility operators from Scotland, England, and India. Each partner contributed specialised expertise to deliver the project. The project benefited from strong governmental support in both countries, exemplifying successful bilateral cooperation in clean energy innovation.

StorTera

Location: United Kingdom
Partner Role: Technical Lead & System Integration

As the project's technical lead, StorTera oversaw all aspects of system design, development, and integration. The company successfully adapted its advanced Lithium Ferro Phosphate (LFP) battery modules and proprietary Tri-layer Artificial Intelligence Controller (TRAICON) to meet specific Indian grid conditions and operational requirements. StorTera led comprehensive system assembly and testing phases, leveraging extensive experience from smart energy network deployments in Canada. The project directly supported StorTera's strategic ambition to position Scotland as a global leader in next-generation energy storage solutions.

Tata Power Delhi Distribution Limited

Location: India
Partner Role: Utility Partner & Need Owner

Tata Power DDL served as the project's primary 'need owner,' defining both commercial and technical requirements for the innovative dual-function system. The utility will provide comprehensive field trial hosting in India, including dedicated test sites and extensive operational support throughout the deployment phase. It coordinated complex deployment logistics, including the critical transportation of the system to the Rohini 66kV substation. Their active involvement ensured the solution remained grounded in real-world utility operational needs while maintaining scalability across India's broader distribution network infrastructure.

Power Networks Demonstration Centre (PNDC), University of Strathclyde

Location: United Kingdom
Partner Role: Testing & Validation Facility

PNDC provided the sophisticated testing and validation environment for the MOBISUB system throughout the Scottish development phase. As a globally recognized smart grid research facility, PNDC designed and executed comprehensive test protocols specifically calibrated to simulate Indian grid conditions accurately, evaluating system performance under scenarios such as substation maintenance, blackouts, and ancillary service provision. PNDC also assessed key technical metrics including roundtrip efficiency, electrical protection, and total harmonic distortion (THD).

The Energy and Resources Institute (TERI)

Location: India
Partner Role: Policy & Regulatory Analysis

TERI SAS conducted rigorous comparative technical evaluation of battery technologies, with particular focus on flow battery versus solid-state system performance characteristics. The institution collaborated closely with PNDC to design comprehensive testing and simulation frameworks, ensuring the MOBISUB system underwent thorough assessment against specific Indian operational parameters and performance requirements.

TERI School of Advanced Studies (TERI SAS)

Location: India
Partner Role: Technical Evaluation & Research Collaboration

TERI SAS conducted rigorous comparative technical evaluation of battery technologies, with particular focus on flow battery versus solid-state system performance characteristics. The institution collaborated closely with PNDC to design comprehensive testing and simulation frameworks, ensuring the MOBISUB system underwent thorough assessment against specific Indian operational parameters and performance requirements.

Indian Institute of Technology Roorkee (IIT Roorkee)

Location: India
Partner Role: Power Electronics & Integration Systems

IIT Roorkee led the sophisticated development of dual-function power electronics and advanced control systems that enabled seamless battery-grid integration. The institute managed critical logistical operations including customs clearance and inland transportation of the system upon arrival in India. IIT Roorkee will oversea the complex integration of the power conversion system (PCS) with the battery infrastructure, ensuring optimal performance during comprehensive field trials.

Cambridge Cleantech

Location: United Kingdom
Partner Role: Project Coordination & Strategic Communication

Cambridge Cleantech provided comprehensive international project management, leading communication and dissemination activities across the consortium. As a key facilitator of global cleantech collaboration, the organization ensured effective stakeholder engagement throughout the project lifecycle, managed critical project reporting requirements, and contributed expertise in deployment logistics and strategic planning. Their leadership role was instrumental in building visibility and momentum for MOBISUB across both UK and Indian innovation ecosystems.

10. Technical and Scientific Developments

System Design and Components

The Mobisub Battery Energy Storage System (BESS) is designed as an integrated energy storage solution comprising several key components working together to provide reliable power storage and delivery.

Core Components:

Battery System: The system uses multiple battery modules, each providing 51.2V and 100Ah capacity. These modules are arranged in cabinets and connected systematically to form the main energy storage unit.

The battery module & correctly installed battery modules in the battery case are shown below:

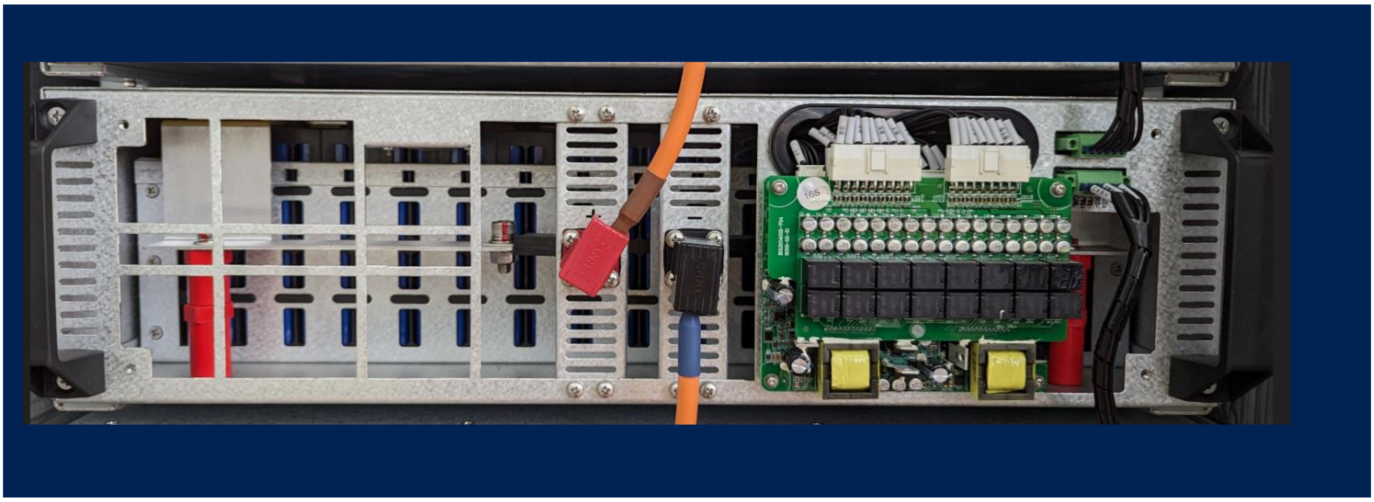

Figure 1 : A single battery module

Power Management: Energy conversion is handled by two 50kW power conversion modules along with a static transfer switch. The system currently uses StorTera equipment, with plans to upgrade to IIT Roorkee units for future testing in India.

Climate Control: Four HVAC units maintain optimal operating temperatures throughout the system, ensuring battery performance and longevity.

Safety Systems Each battery module includes built-in fire suppression to prevent overheating and contain any potential fire hazards.

Electrical Infrastructure: A 100kW three-phase isolation transformer provides electrical protection, while pre-installed switchgear manages power distribution and system communication.

Housing and Protection: The entire system is enclosed in a weatherproof, vibration-resistant housing rated to IP 54 standards for outdoor operation.

System Integration

All components are factory-integrated and tested to work together seamlessly. The modular design allows for efficient installation and maintenance, while the comprehensive safety features ensure reliable operation under various conditions.

This integrated approach provides a complete energy storage solution that meets project requirements for safety, efficiency, and operational reliability.

Figure 2: HVAC System

Figure 3: BESS Enclosure Front View

11. Cross-Border Transportation & Logistics

The Journey from Scotland to India

The transportation of the Mobisub BESS from Scotland to India became a two-phase operation that demonstrated the complexities of international shipping in 2024.

Phase 1: Crossing the Seas

In April 2024, the disassembled battery system began its journey from StorTera's Edinburgh facility. The components were carefully packed and transported by road to Grangemouth Port in Scotland, where they were loaded into a dedicated 20-foot shipping container.

Figure 4 : BESS System Ready for Shipping

The planned shipping route faced an unexpected challenge. Global shipping disruptions in the Red Sea, caused by regional conflicts, forced carriers to abandon the traditional Suez Canal route. Instead, vessels had to take the much longer journey around the Cape of Good Hope in South Africa. This detour added approximately 8,000 kilometers to the voyage and extended the shipping time from the usual 3-4 weeks to around 40 days.

Phase 2: The Final Stretch

By late May 2024, the system arrived at India's busiest port. Here, IIT Roorkee's Material Management team took over, handling customs clearance and organising the final leg of transportation to their campus. The successful delivery marked the end of a complex international logistics operation that had navigated both geographical challenges and global shipping.

Testing, Integration and Field Deployment

Once at IIT Roorkee, the real work began. The StorTera team, connecting remotely from Scotland, guided their Indian colleagues through reassembling the battery system. This virtual collaboration allowed for initial testing and commissioning, ensuring the system was ready for the next phase of trials.

From Laboratory to Real-World Application
Following its successful arrival in India, the MOBISUB system embarked on a carefully orchestrated testing and deployment journey designed to validate its performance under real-world conditions and prepare it for commercial scalability.

Phase 1: Academic Testing and Integration at IIT Roorkee
The battery system's journey in India began at IIT Roorkee, where it serves a dual purpose as both a testing facility and an educational platform. The initial phase focuses on comprehensive integration testing, where the complex interaction between the battery infrastructure and power conversion system (PCS) is thoroughly evaluated. IIT Roorkee's role extends beyond simple testing. The academic institution brings rigorous scientific methodology to the validation process, ensuring that every aspect of the system's performance is documented and analysed. This academic rigour is particularly valuable for establishing credibility with potential investors and regulatory bodies.The testing protocol at IIT Roorkee follows established international standards, replicating the methodology previously used at Scotland's Power Networks Demonstration Centre (PNDC). This consistency ensures that performance data from both countries can be directly compared, strengthening the evidence base for the technology's reliability. A key milestone in this phase involves the integration of a locally sourced power conversion system. IIT Roorkee's selected third-party power electronics manufacturer will replace the original StorTera PCS, demonstrating the system's adaptability to local supply chains and potentially reducing long-term operational costs.

Phase 2: Urban Field Trials in New Delhi
Once laboratory testing is complete, the system transitions to its most challenging phase: real-world deployment in one of India's busiest urban environments. The field trials in New Delhi represent a significant step up in complexity, moving from controlled academic conditions to the unpredictable demands of actual grid operations. Tata Power DDL, as the local distribution company, brings invaluable operational expertise to this phase. Their involvement ensures that trials are conducted under realistic conditions, with real grid constraints, actual customer loads, and genuine operational challenges.

Strategic Deployment Framework

The New Delhi trials are built around a sophisticated operational framework:

Mobile Operations Base: A designated facility serves as the system's home base, providing charging infrastructure, maintenance capabilities, and operational coordination. This base concept is crucial for demonstrating the practical aspects of mobile energy storage deployment. Then seven strategically selected substations within a 5-kilometer radius will be used for further trials.

Transportation and Logistics: The system's trailer-mounted configuration enables rapid deployment via commercial vehicles, proving its practical mobility. This transportation capability is essential for the system's value proposition in markets where permanent installations may not be feasible.

Operational Scenarios: The trials are designed to test both planned and emergency deployment scenarios. Planned shutdowns allow for controlled testing of system performance, while unplanned outages provide opportunities to validate emergency response capabilities.

Data Collection and Analysis

Throughout all testing phases, comprehensive data collection ensures that every aspect of system performance is captured and analysed. This data serves multiple purposes: validating technical performance, identifying optimisation opportunities, and building the evidence base for commercial deployment. The data sharing protocol involves all project stakeholders, ensuring that insights benefit both UK and Indian partners. This collaborative approach to data analysis strengthens partnerships while building collective expertise in mobile energy storage applications.

Preparing for Commercial Scale

The ultimate goal of this testing and deployment program extends far beyond technical validation. The insights and operational experience gained through these trials directly inform proposals for commercial scalability to both UK and Indian funding bodies. Each phase of testing builds towards a comprehensive understanding of the system's commercial viability, operational requirements, and market potential. This systematic approach ensures that when MOBISUB transitions from demonstration to commercial deployment, it does so with a robust foundation of real-world performance data and operational expertise. The testing program also serves as a training ground for the next generation of energy storage professionals in both countries, building human capital that will support the broader clean energy transition.

12. MOBISUB: A Blueprint for Global Collaboration

The MOBISUB project stands as a powerful testament to what becomes possible when innovation meets opportunity across borders. What began as a Scottish energy storage solution has evolved into something far greater: a blueprint for how international partnerships can accelerate the global transition to clean energy.

Two Nations, One Vision

India and the UK share ambitious climate commitments and the recognition that the energy transition requires bold, collaborative action. MOBISUB proved that this shared vision can translate into tangible results.

Scotland brought technical innovation—a mobile, modular battery energy storage system designed for flexibility and resilience. India offered something equally valuable: scale, ambition, and real-world deployment opportunities that could transform a promising prototype into a market-ready solution. Together, they created something neither could achieve alone.

The strength of this partnership lay in its complementary nature. While Scotland possessed the research excellence and innovation ecosystem to develop advanced energy storage solutions, India provided the critical mass and urgent deployment needs that could prove the technology's real-world value. This wasn't merely a case of technology export—it was genuine collaborative innovation.

The Power of Strategic Partnership

This collaboration worked because it was truly strategic. Each partner contributed their unique strengths:

- **Scotland's Innovation Ecosystem** delivered cutting-edge technology through StorTera, backed by world-class research institutions and supportive government policies that encourage clean tech development. The Scottish government's commitment to clean energy innovation created fertile ground for technologies like MOBISUB to flourish.

- **India's Deployment Platform** provided the scale and urgency needed to test, refine, and validate the technology through partners like Tata Power, who understood both the market needs and the path to commercial viability. India's rapid economic growth and expanding energy infrastructure created the perfect testing environment for innovative solutions.

- **Government Alignment** in both countries created the policy frameworks, financial support, and regulatory facilitation that made cross-border collaboration not just possible, but efficient and effective. This institutional backing proved crucial in navigating the complexities of international technology deployment.

Beyond Technology Transfer

MOBISUB represents something more sophisticated than traditional technology transfer. This was true co-innovation—where Indian insights about grid stability, energy access, and deployment challenges shaped the technology's development just as much as Scottish engineering expertise.

The project created a learning loop that benefited both nations. Scotland gained invaluable insights into deploying energy storage solutions in challenging, high-growth markets, understanding firsthand the operational realities of emerging economies. India is accelerating its clean energy transition while building local expertise in advanced battery technologies, creating capabilities that will serve the country's long-term energy transformation.

This mutual learning extended beyond technical aspects to include regulatory approaches, market dynamics, and deployment strategies. The UK partners learned about navigating complex regulatory environments and diverse stakeholder needs, while Indian partners gained exposure to advanced manufacturing techniques and quality assurance processes.

The Industry Connection

Perhaps most importantly, MOBISUB demonstrated the critical role of industry partners in bridging the gap between laboratory and market. Tata Power's involvement wasn't just about providing a testing ground—it was about ensuring the technology met real market needs from day one. This private sector engagement transformed MOBISUB from an interesting technical exercise into a commercially viable solution with clear paths to scale. It showed how corporate partners can de-risk innovation for future investors while accelerating the journey from prototype to deployment. Tata Power brought more than just deployment opportunities—they provided market intelligence, operational expertise, and credibility that proved invaluable. Their participation validated the technology's commercial potential and helped position it for broader adoption across India's diverse energy landscape.

A Market Ready for Impact

India's battery energy storage market is projected to reach $5.3 billion by 2030, growing at over 11% annually. This represents not just a commercial opportunity but a chance for MOBISUB to contribute meaningfully to India's renewable energy integration and grid modernisation goals. The Indian market presents unique characteristics that make MOBISUB particularly relevant: the need for flexible, mobile solutions to serve remote areas; requirements for robust systems that can operate in challenging environmental conditions; and demand for cost-effective solutions that can scale rapidly. MOBISUB's modular design and proven performance address all these needs.

Furthermore, India's commitment to achieving 500 GW of renewable energy capacity by 2030 creates unprecedented demand for energy storage solutions. MOBISUB is positioned to play a significant role in this transformation, particularly in areas where traditional grid infrastructure is limited or where rapid deployment is essential.

The Ecosystem Effect

MOBISUB has demonstrated how academic institutions, industry partners, and government agencies can work together across borders to accelerate clean technology development and deployment. This ecosystem approach—where innovation, manufacturing, and deployment are connected through strategic partnerships—offers a replicable model for future clean technology initiatives worldwide. The project has created a network of relationships and expertise that extends far beyond the immediate participants, building capacity and knowledge that will benefit future collaborations.

Lessons for the Future

The MOBISUB experience offers valuable insights for future international clean energy collaborations. Key success factors include:

1. Early engagement with end-users to ensure market relevance
2. Strong government support to navigate regulatory complexities
3. Industry partnership to provide commercial validation and
4. Genuine two-way knowledge exchange that benefits all participants.

The project has shown that the energy transition is not a zero-sum competition between nations, but a shared global challenge that benefits from open collaboration, mutual learning, and coordinated investment. In a world where climate goals require unprecedented technological deployment at unprecedented speed, MOBISUB offers a roadmap for how we can work together to get there.

The relationships built through MOBISUB extend beyond the immediate project participants. This network effect multiplies the project's impact, creating value that will compound over time. The future of clean energy is collaborative, and MOBISUB has shown us how to make that collaboration work. It has demonstrated that when nations combine their strengths in pursuit of shared goals, they can achieve outcomes that benefit not just themselves but the global community working toward a sustainable energy future.

Appendix A: Project Participants

- Dr. Brenda Park | StorTera Ltd
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- Dr. Federico Coffele, PNDC, University of Strathclyde
- Kapil Kumar | TATA DDL
- Kathleen Goldie |PNDC, University of Strathclyde
- Naqui Anwer | TERI SAS
- Pasidu Pallawela| StorTera Ltd
- Ryan Sims, PNDC | University of Strathclyde
- Sam Goodall | Cambridge Cleantech
- Satyajit Mohanan | Cambridge Cleantech
- Shirish Garud | TERI
- Soumia Ayyadi, PNDC | University of Strathclyde
- Swarnim Jain | TATA DDL
- Tarun Katiyar | TATA DDL

Appendix B: Sources and Bibliography

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