Policy Brief

How net-zero microgrids could support Queensland's future electricity system

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About the Hub

The Queensland Decarbonisation Hub brings together knowledge, people and innovation to co-create solutions to accelerate Queensland's clean growth future. We connect Queensland universities, industry, communities, First Nations people and government to build and share the knowledge needed to reduce emissions. The Hub's vision is for Queensland to become a leading decarbonised economy in which communities, industry and the environment thrive.

About this policy brief

In 2024, the Queensland Decarbonisation Hub initiated a funded research stream, inviting proposals for research that could contribute to understanding and supporting Queensland's decarbonisation transition. The Hub's Advisory Committee, which brings together representatives from industry and other sectors, helped inform the selection process by identifying areas where research could add value to emerging policy and practice. Eight projects were selected across a diverse range of topics, including the research featured in this brief.

Each project has produced a detailed technical report, which is undergoing review prior to publication. Alongside these reports, the Hub has worked with the research teams to consider a different question: what does the research mean for policy and practice?

This question was explored through a series of workshops and the Hub's Research Showcase, where researchers presented their findings to an audience drawn from government, industry, research and the wider community. These policy briefs build on that process. They are intended as short, accessible companions to the technical reports, highlighting the findings that matter most beyond the research itself and the questions and opportunities they raise for Queensland and Australia more broadly.

About this research

Much of the global energy transition is framed around large-scale renewable generation, transmission infrastructure and system-wide planning. This research examines a different part of the electricity system by considering how coordinated local energy systems could contribute to the transition. Rather than relying solely on centralised infrastructure, it explores how rooftop solar, battery storage and local energy management could work together to improve renewable integration, system resilience and the efficient use of existing electricity networks.

One of the most significant findings of the study is that the principal challenge is no longer the availability of technology. Solar photovoltaics, battery storage and communication systems are already mature and widely deployed. The research suggests that future progress will depend increasingly on how these technologies are coordinated through forecasting, operational control and energy management. This approach represents a shift from developing new technologies to improving the way existing technologies operate together.

While further demonstration under real-world conditions will be required, the study broadens the discussion about how Australia's electricity system may evolve. It suggests that local energy systems could complement investments in generation, transmission and storage by providing greater flexibility within communities and distribution networks. These approaches have the potential to support a more resilient, distributed and coordinated electricity system.

Dr Liz Young

Research Director, Queensland Decarbonisation Hub

From the Showcase Session Facilitator

Australia's energy system is predominantly based on centralised infrastructure. However, incentives to encourage solar panel installation have changed the nature of our energy system. More recently, government policies aimed to support consumer battery installations have created a new category of consumer in the energy market. Whether they are referred to as prosumers (the individuals) or microgrids (the infrastructure), these changes will potentially support the net-zero transition and ensure long term energy security in Australia.

The findings from this research indicate that the benefits of these microgrids extend beyond servicing the individual households. Indeed, where there is proper integration across the network, there can be system-wide benefits. However, in order to achieve these benefits, there needs to be thought given to 'renewable integration, grid congestion, resilience, and the need for more flexible local energy management'. As this study demonstrates, in a country with the size and diversity of Australia, this challenge can be even greater. This research paves the way for future work integrating electric vehicles and vehicle to grid technology.

Professor Felicity Dean

School of Law, Queensland University of Technology

1. Why this research matters

Australia's electricity system is undergoing rapid change as rooftop solar, battery storage, and electrification increase across homes and communities. While renewable energy deployment continues to grow, managing the variability of solar generation and maintaining a reliable electricity supply are becoming increasingly important challenges for distribution networks and local communities. The shift from centralised fossil-fuel electricity systems requires local coordination of renewable energy generation, storage and demand rather than reliance solely on centralised infrastructure.

This research examines whether net-zero microgrids (NZMGs) could provide a practical pathway to support the transition toward a low-carbon electricity system in Australia. NZMGs coordinate local solar generation, battery storage, flexible demand, and grid interaction to balance energy production and consumption over time moving away from a centralised generation approach.

The study is particularly relevant for Queensland as the state has high rooftop solar penetration, outstanding solar resources, and a growing interest in distributed energy systems. It also addresses broader challenges facing regional and suburban electricity networks, including renewable energy integration, grid congestion, resilience, and the need for more flexible local energy management.

2. Key findings

The research found that forecast-informed energy management can enable residential microgrids to maintain a net-zero energy balance over time while operating within practical storage and grid constraints. Rather than requiring real-time optimisation, the proposed approach uses daily forecasting and adaptive updating to coordinate battery charging, discharging and grid exchange.

The study showed that battery storage plays a central role in balancing fluctuations in solar energy generation and electricity demand. During high solar generation periods, excess energy can be stored or exported, while stored energy can support loads during cloudy periods or evening demand peaks.

A second key finding from the study is that interconnected or networked microgrids can improve overall system flexibility by sharing surplus and deficit energy between neighbouring microgrids. This interconnection reduces reliance on centralised infrastructure and helps maintain stable net-zero performance across wider areas.

The study also found that operational strategies that account for uncertainty can maintain reliable performance, even when solar conditions differ from forecasts.

Figure 1 illustrates how a microgrid-level energy management system can coordinate distributed energy assets, forecasting, storage, flexible demand, and local controllers to support practical net-zero microgrid operation. The results suggest that effective NZMG operation depends primarily on coordination and operational intelligence rather than the invention of new energy technologies.

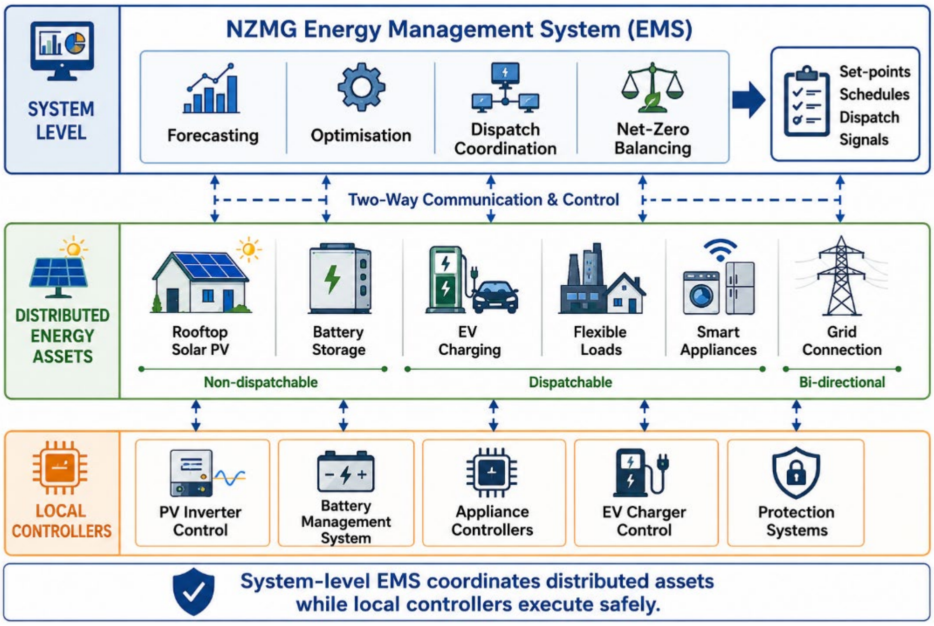

Figure 1: Conceptual architecture of a coordinated net-zero microgrid energy management system.

Finally, the study found that the main barrier to NZMG implementation is no longer the availability of enabling technologies. Solar PV, batteries, and communication systems are already mature and widely deployed. Instead, the key challenge is coordinating these distributed assets through forecasting, control systems, and operational integration.

3. Why the findings matter in practice

The findings suggest that the transition toward net-zero electricity systems increasingly depend on local energy coordination rather than solely expanding centralised generation and transmission infrastructure.

The research provides evidence that coordinated microgrid operation could support renewable integration, reduce pressure on distribution networks, improve resilience during local disturbances, and help communities manage energy locally. The work also demonstrates that many of the required technologies already exist and can be integrated using practical supervisory control approaches.

For policymakers and infrastructure planners, the study highlights the importance of operational testing and regulatory support for distributed energy coordination rather than focusing only on hardware deployment. The feasibility assessment indicates that most of the required NZMG capabilities are already available or emerging, but still need stronger real-world validation.

4. Who should pay attention

Government and energy policymakers can use the research for planning future net-zero strategies, distributed energy integration, and regional energy resilience initiatives.

Distribution network service providers (DNSPs) can leverage the findings to managing increasing rooftop solar penetration, local network congestion, and distributed energy coordination challenges.

Energy industry and technology providers of batteries, microgrids, and energy-management infrastructure may use the findings to guide development of operational platforms and integrated control systems.

Regional councils and community energy organisations can use the work to provide insights into how local renewable energy systems could support regional resilience and local energy independence.

Researchers and universities may also benefit as the framework offers a foundation for future work on uncertainty-aware microgrid coordination and scalable net-zero operation.

5. What could happen next

The research supports the development of pilot-scale NZMG demonstrations in Australia to validate operational performance under real-world conditions. Controlled trials involving communities, utilities and technology providers could help assess integration challenges, customer participation and operational reliability at larger scales.

Further work could also examine electric vehicle integration, flexible household demand, market participation, and more detailed network constraints, such as inverter and transformer capacity limits.

The findings suggest that regulatory sandboxes and collaborative industry-government demonstration projects may be valuable next steps toward practical implementation.

6. Points to note

The study uses computer simulations to assess the operational feasibility of NZMGs, rather than their commercial deployment. It assumes that equipment such as inverters, transformers, and grid connections are sufficiently sized, allowing the analysis to focus on how distributed energy resources are coordinated rather than on network design components.

The analysis uses Queensland residential load and solar conditions, and therefore, may require adaptation for other regions or industrial applications. While the operational strategies performed well under simulated uncertainty, further real-world validation and pilot testing would be required before large-scale deployment.

7. Contact

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