Addressing the energy transition challenge: Electricity grid

CSIRO actively researches the challenges associated with the transition of energy, industrial, manufacturing, agricultural and transport sectors to meet Australia's net zero emissions ambitions.

As Australia's national science agency, CSIRO is well positioned to support governments, industries and communities through the energy transition.

Science and innovation will be critical in supporting Australia's transition, which is being driven by new technologies, changing consumer preferences, and efforts to reduce greenhouse gas emissions.

As we move towards a net-zero emissions future the four key components of the energy sector – electricity, industry, transport and exports – are evolving rapidly. In this dynamic landscape, CSIRO provides reliable, actionable, evidence-based research.

Here we look at the role of the electricity grid.

The future of Australia's electricity grid What's the challenge?

Electricity grids in Australia were mainly built to transfer electricity from large, centralised coal-fired power stations with assistance from gas and hydro.

This transfer was essentially in one direction to end-users and, with a diversity of energy consumption, large scale generators and electricity networks were well placed to meet demand.

Over time, electricity consumption patterns have changed considerably – including uptake of air-conditioning, distributed photovoltaics (PV), energy storage systems and electric vehicle charging – and expectations of reliability have increased.

As we move towards a net-zero emissions future, the energy sector is undergoing a rapid transition. It's an exciting time, but also presents a number of major technical challenges that, if left unaddressed, would undermine the stability of the electricity system.

One key issue is the changing energy mix used to generate electricity. Our key renewable resources – wind and solar – are inherently intermittent. As the percentage of Variable Renewable Energy (VRE) sources increases, there is a need for greater interconnection and affordable energy storage solutions that tackle the problem of intermittency.

These VRE sources typically use power electronics (inverters) to connect to the electricity system, with significantly different characteristics than conventional synchronous generators. This requires new modelling, simulation and control room tools to ensure ongoing system security and reliability.

A second key issue is increased decentralisation and electricity consumption. According to the Australian Energy Market Operator (AEMO), Australia will soon have one of the highest decentralisation ratios of non-grid generation in the world. CSIRO and Energy Networks Australia estimate that by 2050, between 30 to 45 per cent of our annual electricity consumption could be supplied from consumer-owned generators. The expected increased electrification of the transport sector and industrial processes, along with production of future green energy exports such as hydrogen, will require a significant increase in energy throughput through the electricity system.

Together these present not only a challenge to ensure the continued reliable operation of the electricity system, but also a need to improve network infrastructure utilisation.

What is the goal?

Decarbonising the energy sector is essential for Australia to achieve its emissions reductions targets, and there is already a range of mature low-emission technology options available.

The focus now is how to integrate these efficiently into our electricity systems and ensure that Australia has an energy supply that is sustainable, affordable, and reliable.

Grid reliability and capacity are potential barriers to realising the benefits of the anticipated growth in renewables but could be overcome through the integration of smaller but more numerous renewable generators, along with dispatchable sources to move power around the system locally and interstate.

Solutions will need to draw on a range of technologies such as load flexibility and energy storage meeting dispatchable energy needs and synchronous condensers for inertia. Together a combination of technologies will provide load and generation coordination while managing capacity, stability, voltages and frequency.

Digital innovation such as Artificial Intelligence and Machine Learning will also have a role to play in optimising power generation and transmission. Digital tools can help optimise what energy sources to use, when, and for how long – thereby provide a levelling effect of generation and load.

What is CSIRO doing to help?

CSIRO has a long history of energy research, and is currently undertaking a major program of work focused on reliable, secure and sustainable electricity networks.

Alongside AEMO and other Australian partners, CSIRO is contributing to the Global Power System Transformation (G-PST) consortium – an international research collaboration seeking to accelerate the transition to low emissions, low cost, secure and reliable power systems.

Leading the Australian research delegation to G-PST provides an opportunity for CSIRO to conduct relevant research, but also to coordinate with other research institutions and industry stakeholders and ensure that we are directly addressing the energy challenges most relevant to Australia.

Priorities in the first round of research include quantifying the technical requirements of future power systems to operate reliably; exploring the opportunities associated with rooftop solar; inverter design; and power system stability tools and methods.

Additional work taking place at CSIRO to improve utilisation of existing infrastructure through the adoption of our energy system modelling, simulations, and data tools includes:

- ongoing collaboration with the system operator (AEMO) and distribution network operators
- developing an Australian energy system modelling platform
- demonstrating technological solutions that reduce cost and improve reliability of low emissions power transmission, distribution, storage and utilisation.

With decades of experience in research-industry collaborations, and a trusted reputation for providing evidence-based, actionable energy research, CSIRO is well placed to help Australia's energy sector navigate the challenges ahead and develop reliable, secure power systems for the future.

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