



Strengthening system security with grid- forming BESS

Dani Alexander
CEO, UNSW Energy Institute

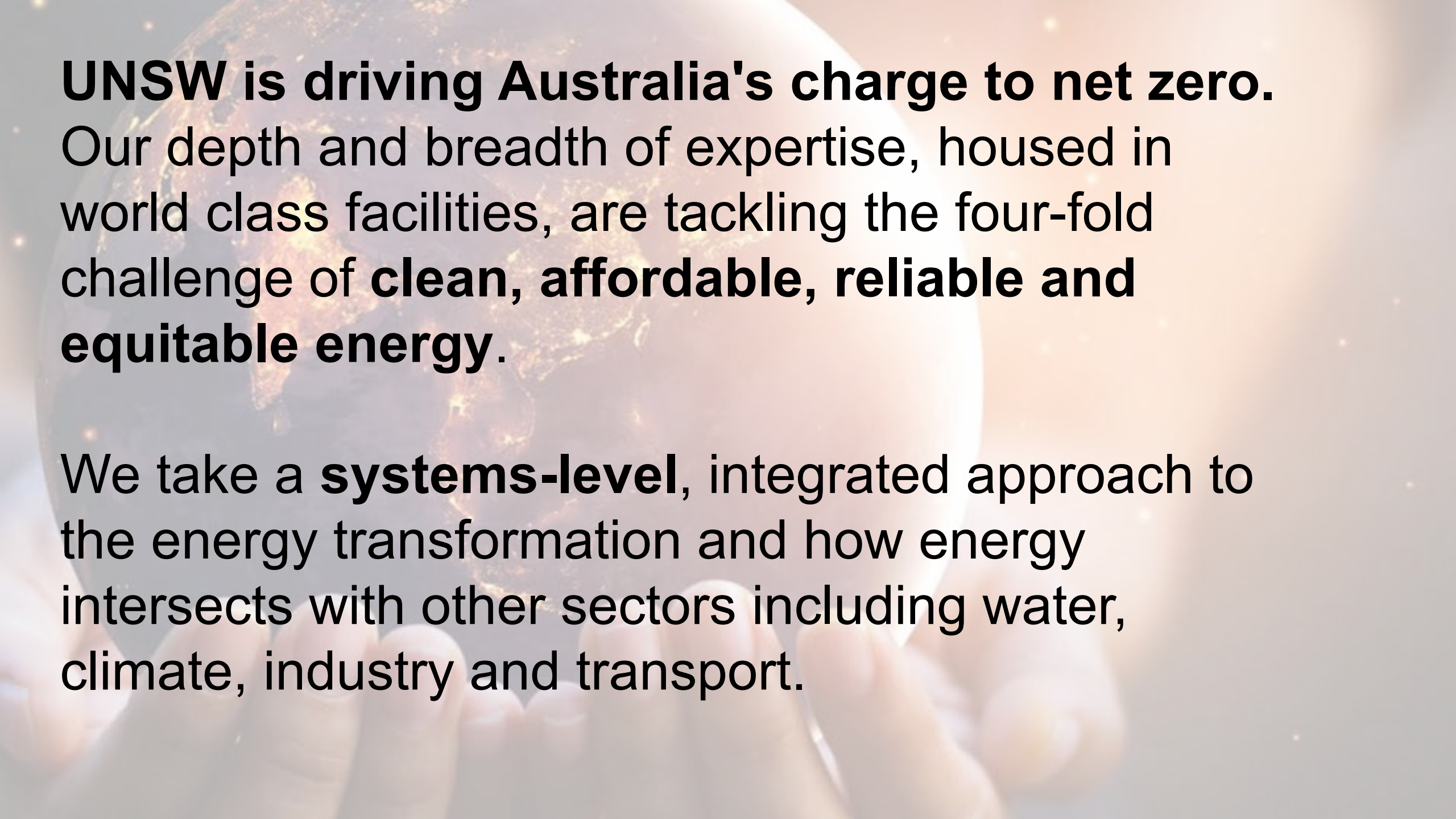
Battery Asset Management Summit
25 August 2026



Acknowledgement of country



"Fish traps"
by Edwards Clarke (2019)



UNSW is driving Australia's charge to net zero.
Our depth and breadth of expertise, housed in world class facilities, are tackling the four-fold challenge of **clean, affordable, reliable and equitable energy.**

We take a **systems-level**, integrated approach to the energy transformation and how energy intersects with other sectors including water, climate, industry and transport.

Vision:

UNSW seeks to maintain its position as a world leader in energy RD&D, accelerating the role energy plays in a growing, zero-carbon economy.

Objectives:

- Delivering low or no carbon power systems
- Securing Australia's position as a future energy powerhouse
- Supporting a consumer-led energy transition

Capabilities



Developing ultra low-cost solar energy

Australian Centre for Advanced Photovoltaics (ACAP)

Solar Industrial Research Facility (SIRF)

UNSW School of Photovoltaic and Renewable Energy Engineering (SPREE)



Catalysing low carbon fuels

ARC Industrial Transformation Training Centre for the Global Hydrogen Economy (GlobH2E)

UNSW Particle and Catalysis Research Laboratory (PartCat)



Preparing networks towards 100% renewables

UNSW Real-Time Digital Simulation Laboratory

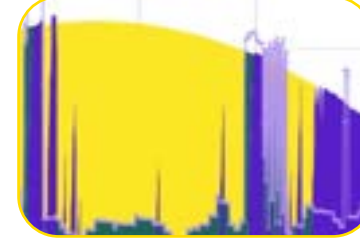
UNSW Digital Grid Futures Institute (DGFI)



Innovating storage for firm renewable energy

ARC Research Hub for Integrated Energy Storage Solutions

CENELEST: German-Australian Alliance for Electrochemical Technologies for Storage of Renewable Energy



Promoting sustainable energy markets

UNSW Collaboration on Energy and Environmental Markets

UNSW Faculties of Law and Arts, Design and Architecture and UNSW Business School



Helping people use clean energy

NSW Decarbonisation Innovation Hub and associated networks

Aligned UNSW Institutes for Industrial Decarbonisation and Climate Risk & Response

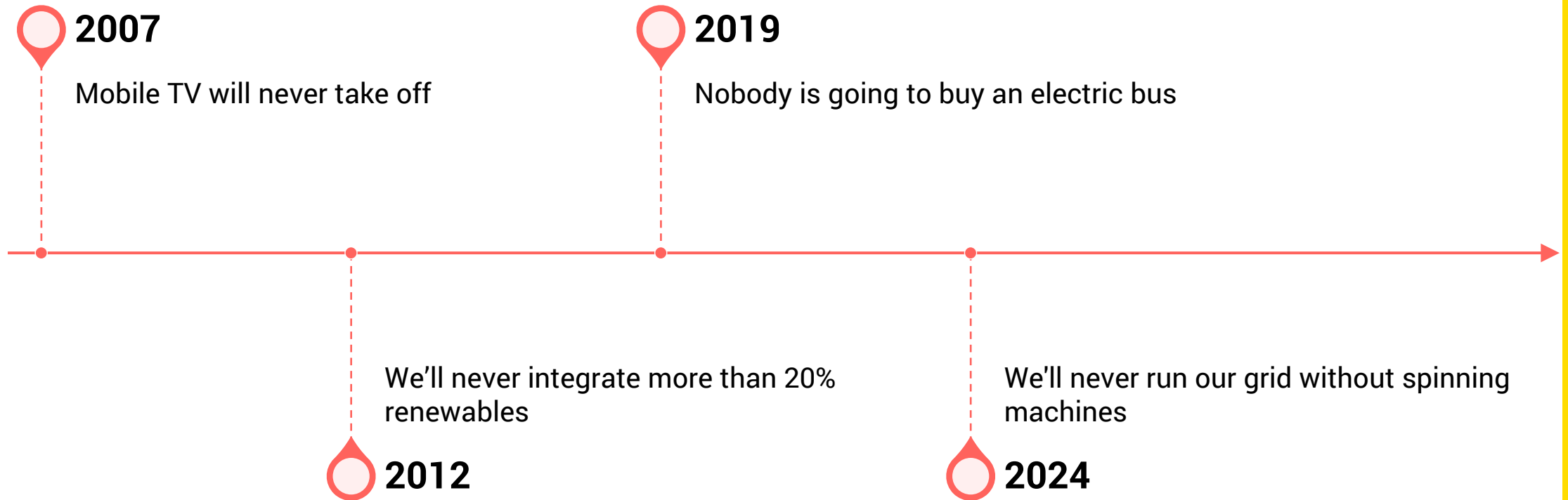
A satellite night photograph of the Iberian Peninsula, showing the outlines of Spain and Portugal. The landmass is dark, while the surrounding oceans are a deep blue. Numerous bright yellow and white lights from cities and towns are visible, particularly concentrated along the coastlines and in the northern and eastern parts of the peninsula. The Balearic Islands are visible in the Mediterranean Sea to the east.

Strengthening system security with utility-scale BESS and grid-forming inverters

**A solution to a Minister's
worst nightmare**

Photo: Jordan D. (29 April 2025)

Background: things that people told me weren't going to happen



"Beware of absolutes. There are many gods." – D. H. Lawrence

System security is one of the major barriers to closing coal power stations



Grid-forming BESS unlocks the *possibility* of 100% renewables

“On that April day in 2023, Kauai had over 150 megawatt-hours’ worth of energy stored in batteries—and also the grid-forming inverters necessary to let those batteries respond rapidly and provide stable power to the grid. They worked exactly as intended and kept the grid going without any blackouts...

The next step for inverter-dominated power grids is to go big.”

(Kroposki & Hoke, 2024)

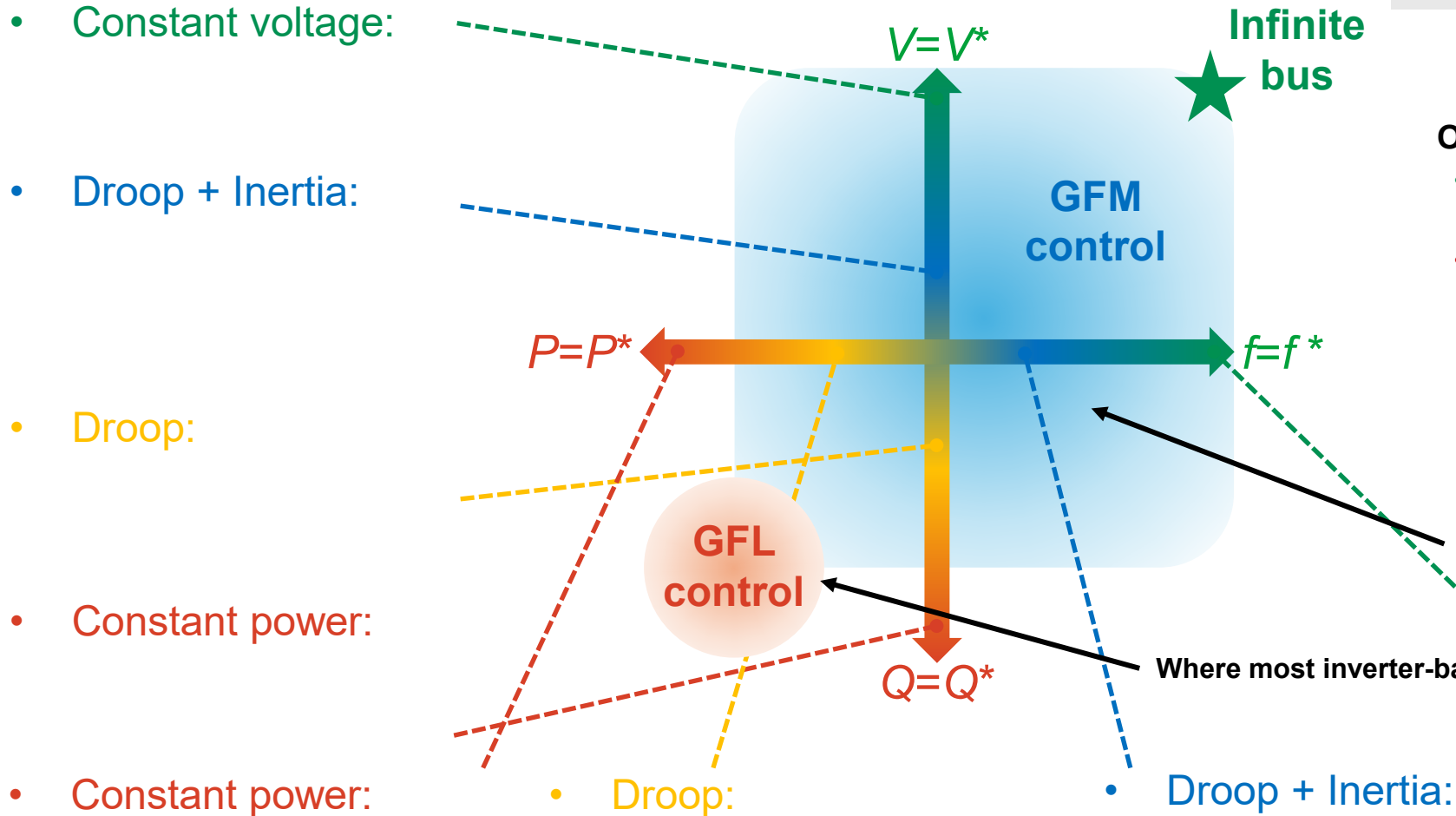


Kauai, the westernmost Hawaiian island

First Principles Considerations

Technical Note:

UNSW's mapping of GFM capabilities demonstrates the very broad area of solutions that are grouped under the GFM term and how different "GFM" implementations can yield very diverse results for an individual system and for the whole network. Understanding these differences and impact on network protection system planning is critical.



Our definition of GFM converters

- **Control aspect:** Strong controllability over voltage & frequency
- **Hardware aspect:** Relative capacity between GFM converter and external grid is large enough

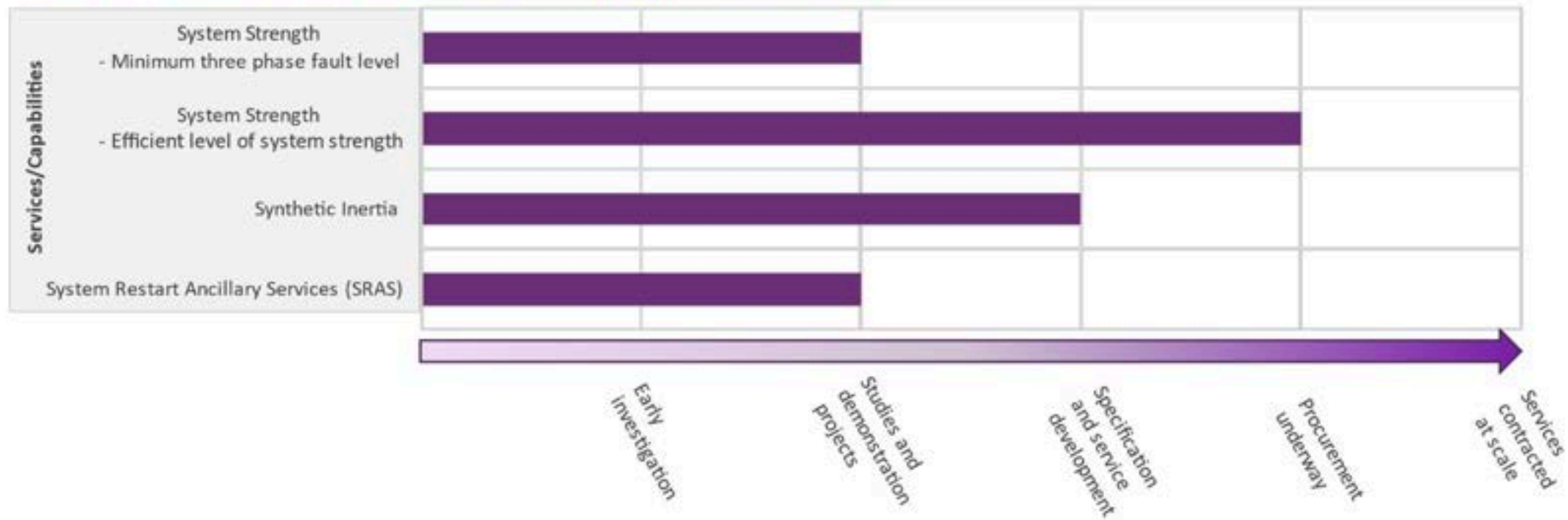
The grid-forming roadmaps in the energy transition landscape



Grid-Forming (GFM) control offers substantial flexibility and adaptability to power systems in transition, but it is not a “one-size-fits all” solution. Understanding how spatial and OEM diverse GFM IBR controls interact is crucial to power system security.

There are some services that AEMO is still not confident GFM can provide

Figure 23 Status of GFM provision of security services in the NEM



Source: 2025 Transition Plan for System Security (AEMO)

Further investment and investigation will build confidence across the sector

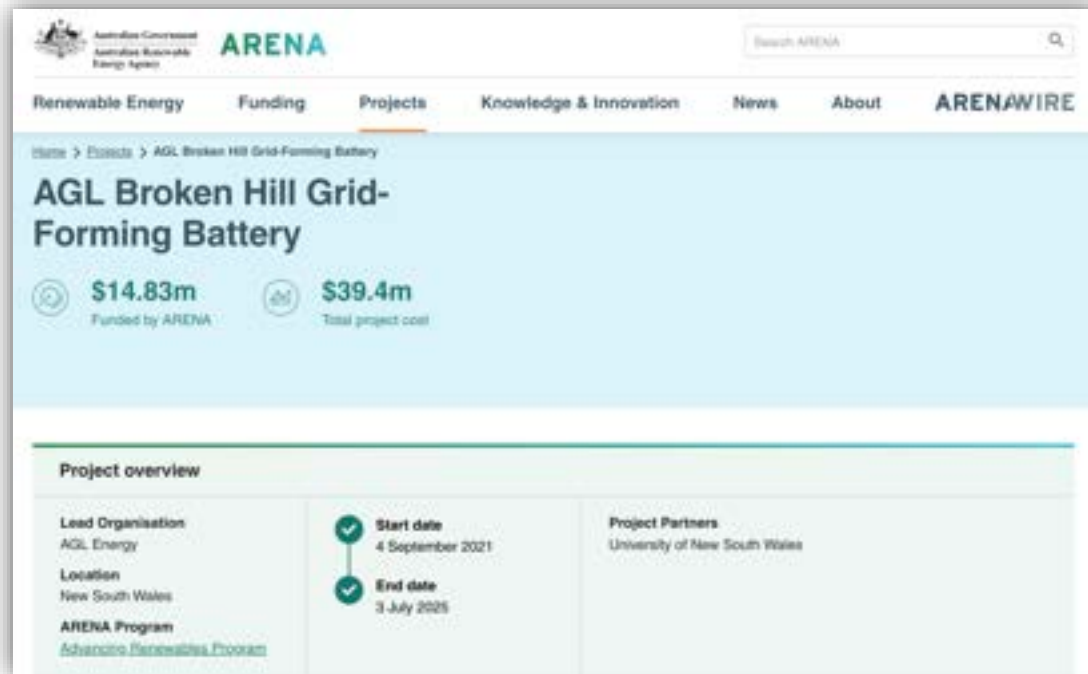
Table 8 Published Statements of Need for Type 2 Transitional Services

Type 2 Transitional Service	Description
Black Start from Inverter-Based Resources (IBR) ^a	Evaluates IBR-based black start solutions to support system restoration in a low-emission environment. The trial are expected to inform future restoration pathways, SRAS procurement and development.
System Restart under High Distributed Photovoltaics (DPV) Conditions ^b	Demonstrates emerging technologies and operational approaches capable of managing reconnection on the system restoration process, particularly where communication is unavailable.
Grid-Forming (GFM) Inverter Protection ^c	Assesses whether GFM inverters can provide fault current of sufficient magnitude.
Grid-forming batteries	
Zero Synchronisation	The system strength RIT-T identified that grid-forming batteries represent half of the portfolio of system strength solutions in NSW by the early 2030s. Transgrid expects that non-network grid-forming batteries will start providing system strength services to the NSW transmission network this year. In early 2026, Transgrid shortlisted nine battery projects following completion of technical modelling, which determined the initial capacity and priority locations in NSW. This initial tranche of procurement is focused on batteries that already exist, or are in the advanced stages of development, in specific locations on our network to address system strength needs as they emerge. Transgrid expects to undertake annual procurement rounds to meet growing system strength requirements and ultimately reach the RIT-T identified portfolio of up to 5 GW of grid-forming batteries by the early 2030s. To be eligible for consideration as part of future tenders, please see the information for non-network proponents below, and return a completed Expression of Interest (EOI) form to Transgrid, so your project can be included in the technical analysis to determine the included parties in subsequent tenders.
Minimum System Strength Services ^d	

Translate. Create. Deliver.

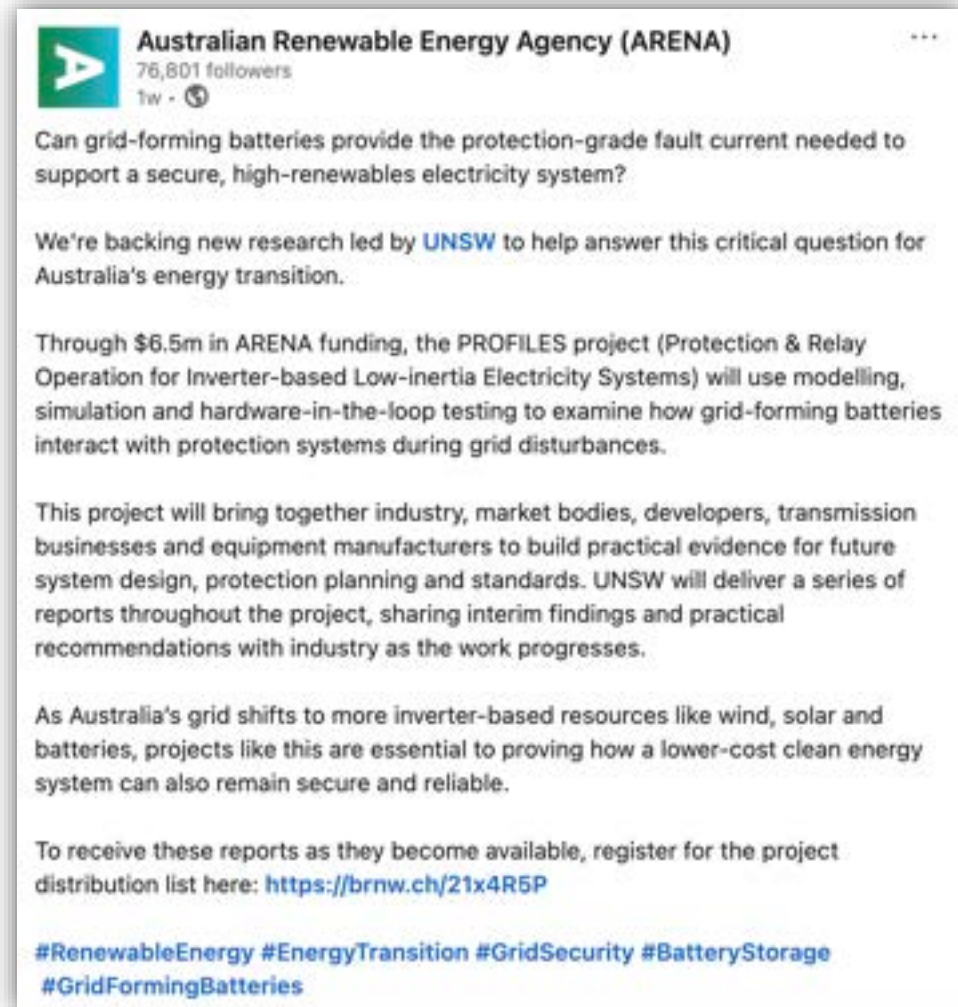
LESSONS LEARNT AND FUTURE DIRECTIONS FROM ARENA'S GRID-FORMING BATTERY PORTFOLIO

We've come a long way in five years, and are invested over the next five



The screenshot shows the ARENA website with the 'Projects' tab selected. The main heading is 'AGL Broken Hill Grid-Forming Battery'. Below the heading, it states 'Funded by ARENA' with a value of '\$14.83m' and 'Total project cost' of '\$39.4m'. The 'Project overview' section includes a table with the following details:

Project overview		
Lead Organisation AGL Energy	Start date 4 September 2021	Project Partners University of New South Wales
Location New South Wales	End date 3 July 2025	
ARENA Program Advanced Renewables Program		



The tweet is from the Australian Renewable Energy Agency (ARENA), which has 76,801 followers. The text of the tweet reads:

Can grid-forming batteries provide the protection-grade fault current needed to support a secure, high-renewables electricity system?

We're backing new research led by [UNSW](#) to help answer this critical question for Australia's energy transition.

Through \$6.5m in ARENA funding, the PROFILES project (Protection & Relay Operation for Inverter-based Low-inertia Electricity Systems) will use modelling, simulation and hardware-in-the-loop testing to examine how grid-forming batteries interact with protection systems during grid disturbances.

This project will bring together industry, market bodies, developers, transmission businesses and equipment manufacturers to build practical evidence for future system design, protection planning and standards. UNSW will deliver a series of reports throughout the project, sharing interim findings and practical recommendations with industry as the work progresses.

As Australia's grid shifts to more inverter-based resources like wind, solar and batteries, projects like this are essential to proving how a lower-cost clean energy system can also remain secure and reliable.

To receive these reports as they become available, register for the project distribution list here: <https://brnw.ch/21x4R5P>

[#RenewableEnergy](#) [#EnergyTransition](#) [#GridSecurity](#) [#BatteryStorage](#) [#GridFormingBatteries](#)



Real-Time Simulations Laboratory RTS@UNSW

HiL can alleviate future power system security risk and uncertainty



Integration

Modelling tools do not accurately capture the “small signal” interactions between inverter-based generators and associated instability modes.

System Strength



Understand & resolve uncertainties in the capabilities of power electronics and control systems to provide adequate fault current & replace synchronous machines



Inertia

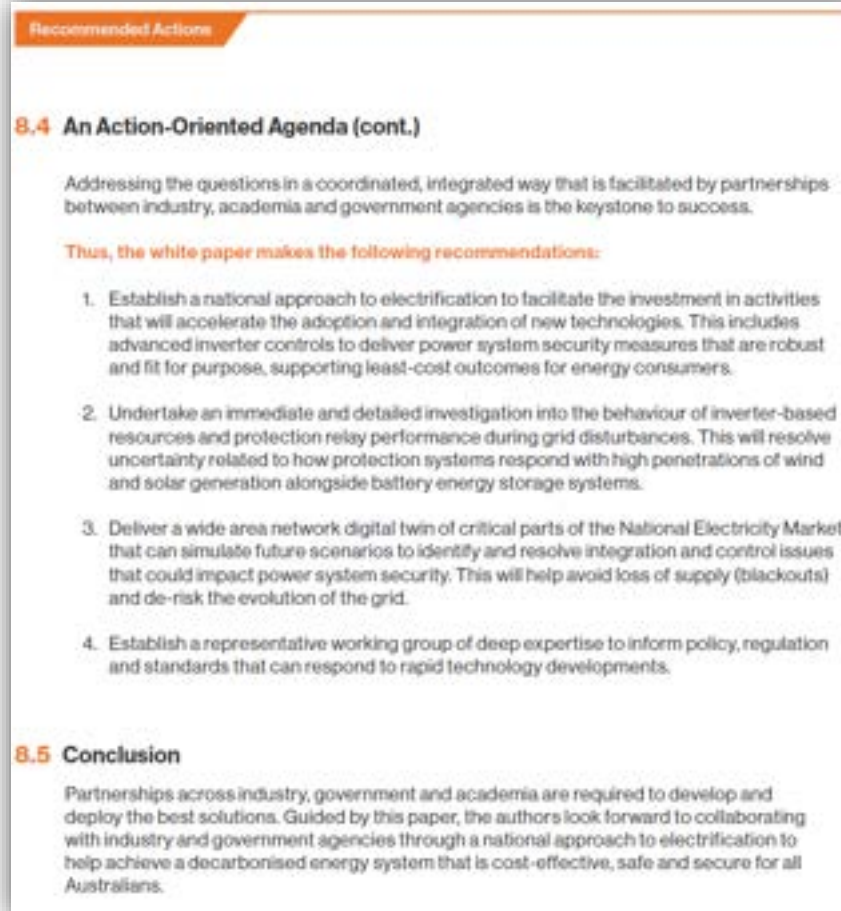
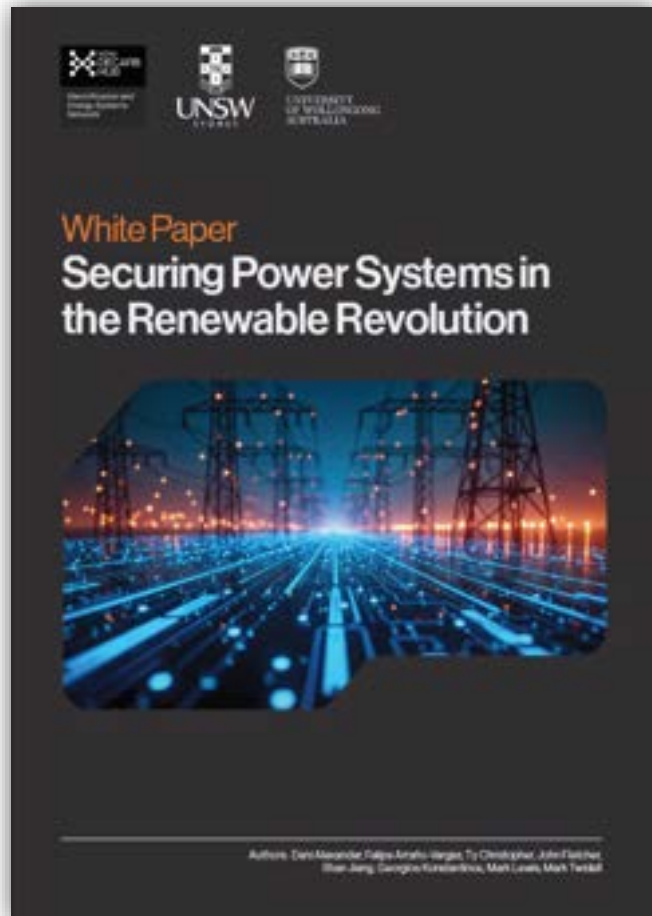
Test the capabilities of a high penetration inverter-based system to provide inertia services in all contingency scenarios

Network Protection



Understand limitations of current network protection settings and systems and test alternative scenarios.

More work is required to secure power systems in our renewables future



Project PROFILES
addresses a key
recommendation of this
White Paper

Sometimes, you leave with more questions than answers...



What additional technical work do we need to do to prove GFM inverter's

And what happens if the synchronous condensers are late?



What costs are we willing to bear in order to do this technical work?

And how do these costs compare to any capex that could be avoided?



What training would help our engineering community become more comfortable

And would they want to do it?



UNSW
SYDNEY

UNSW
Energy Institute

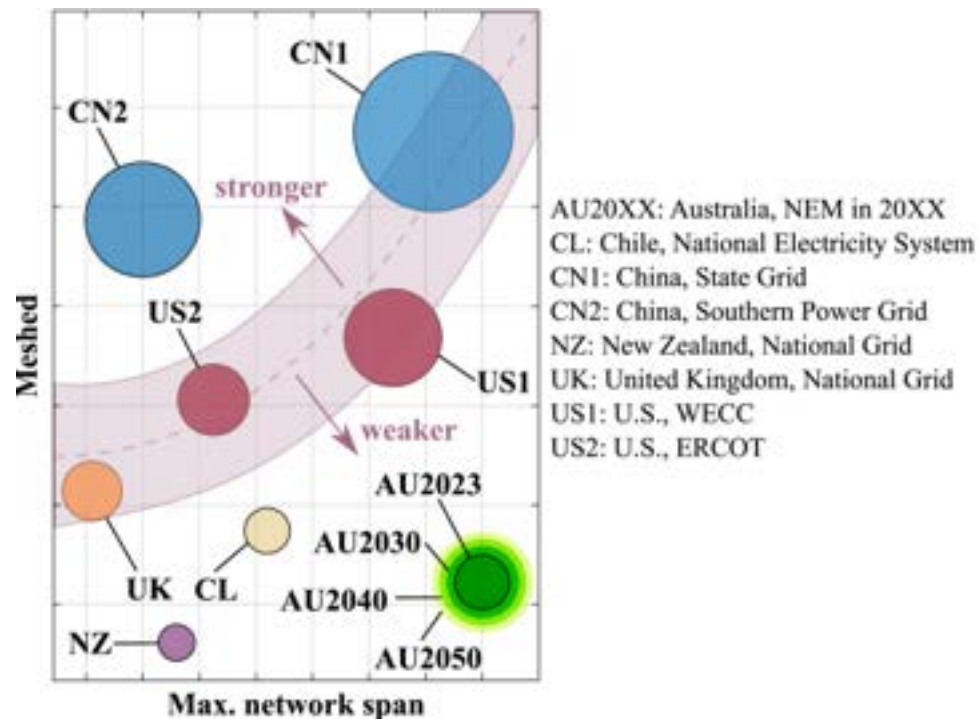
LEARN MORE



Background slides

Australia will be a world leader in IBR

Our long skinny grid creates unique challenges and opportunities



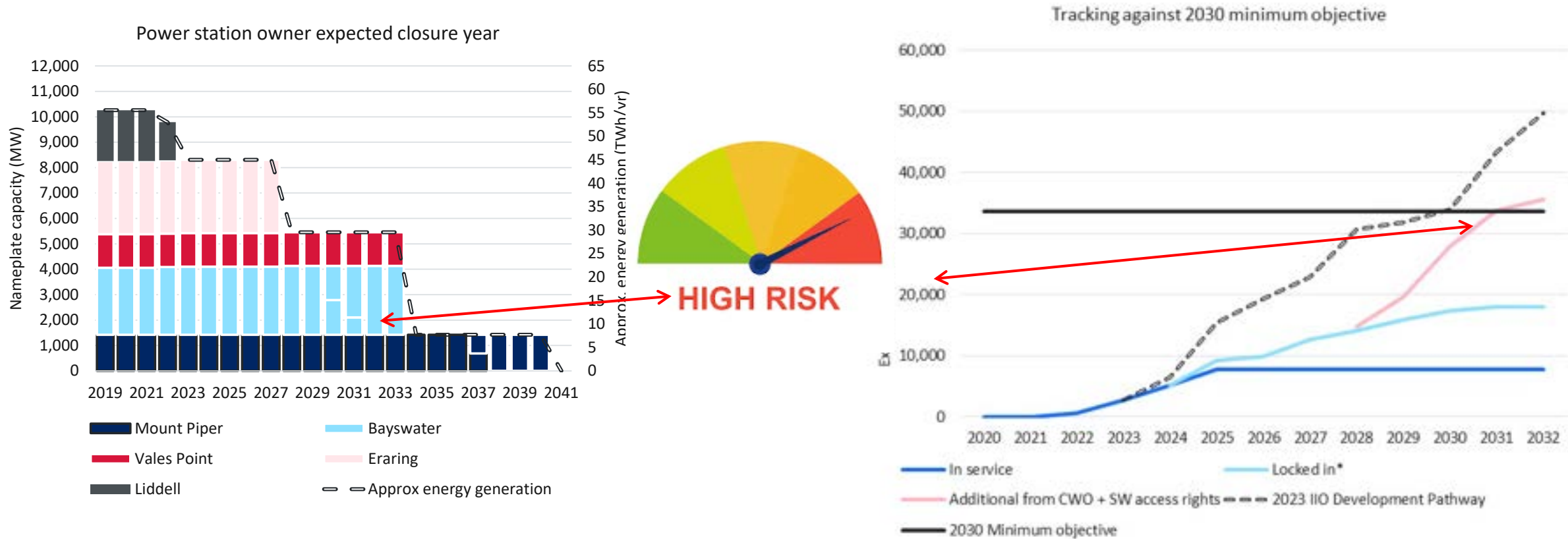
Source: Arraño-Vargas et al. (2024)

Renewable energy zones are a novel approach to energy infrastructure



Source: 2026 Integrated System Plan (AEMO)

There are high risk periods as NSW coal-fired power stations close over the next decade



Data Source : Liam Ryan NSW Govt DCCEEW UNSW Presentation 15th May 2025

HiL testing is commonly used where complex systems and high-stakes validation are essential

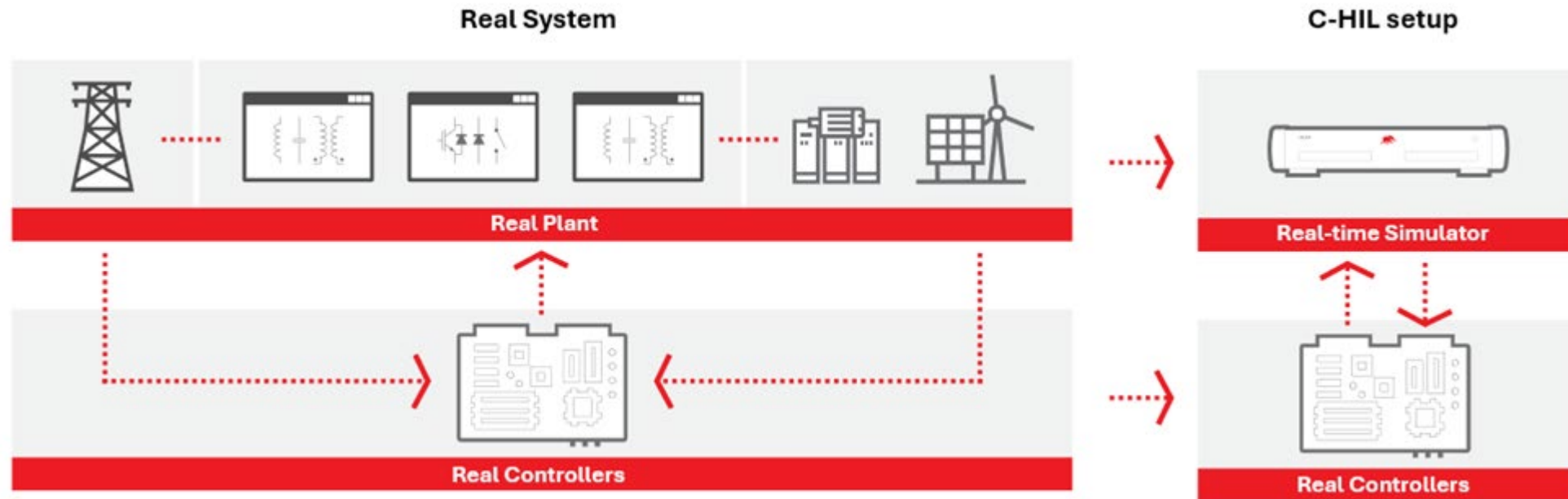
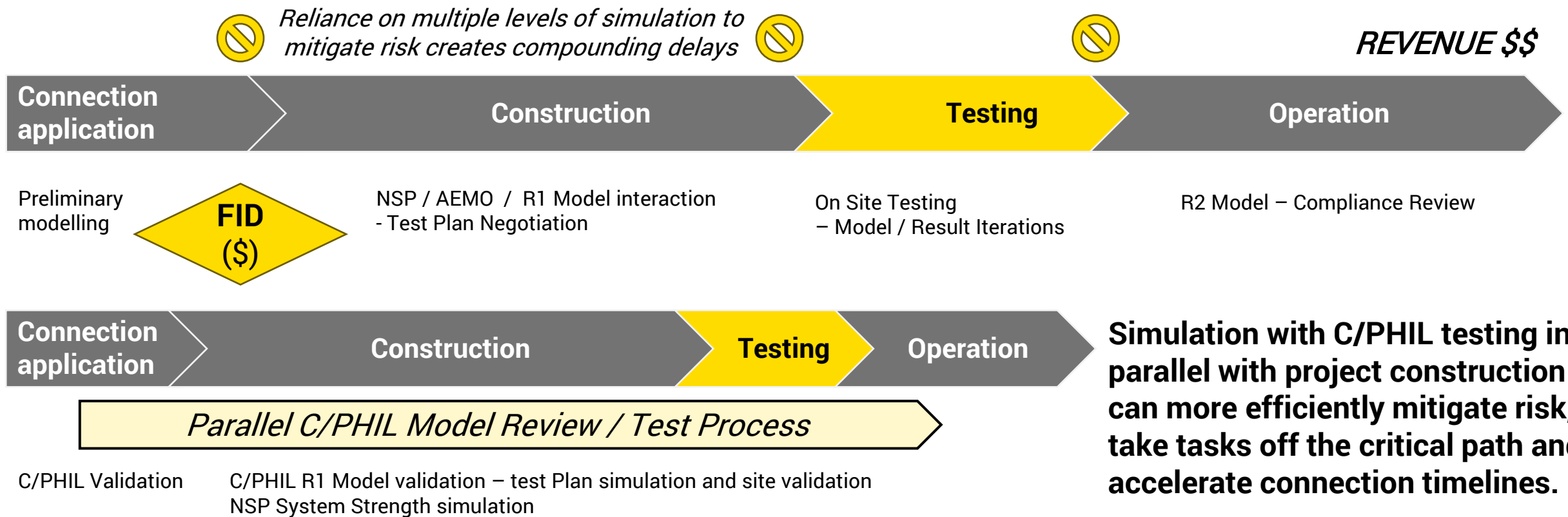


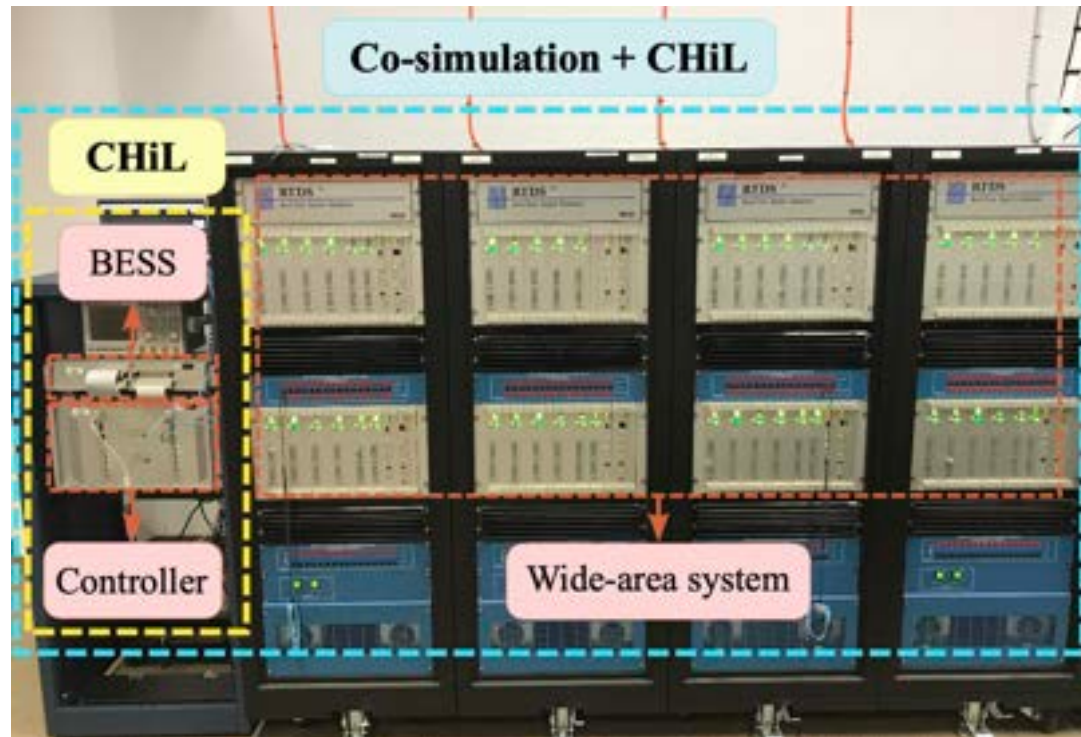
Image : Illustration of a typical Controller-HIL (C-HIL) testing system. [Typhoon HiL](#)

A scaled approach to HiL testing can mitigate delay risk in renewables rollout

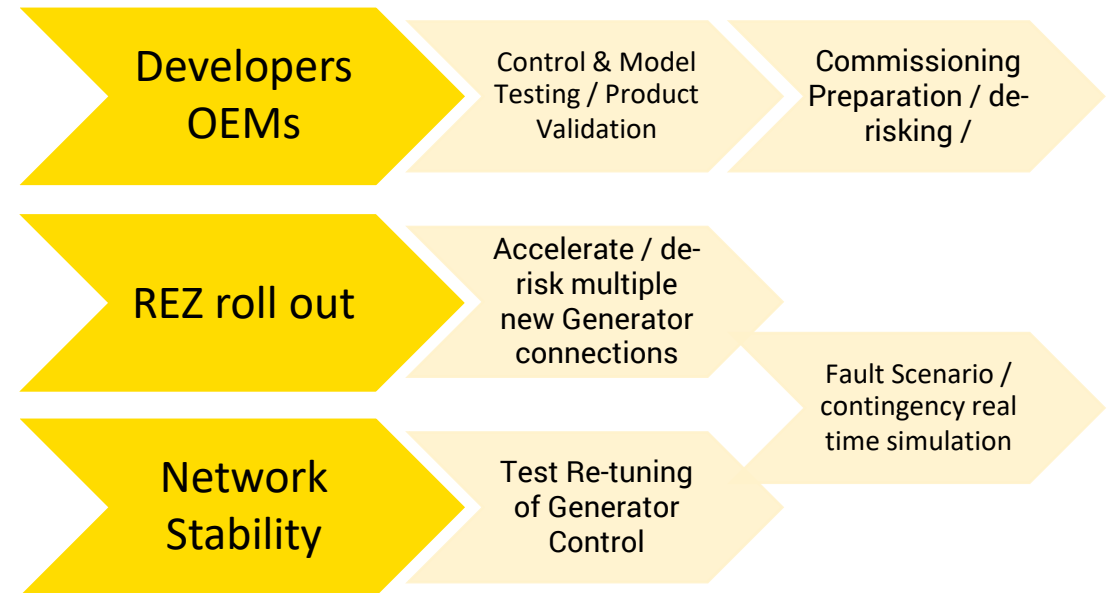


RTS with HiL can provide many services to support REZ development

Hardware-in-the-Loop (HiL) facility



Supporting services



HiL and RTS allow problems to be resolved in parallel with construction



Model
validation

Modern power system models frequently fall short of fully capturing the complexities of their real-world equivalents.

Parameter
configuration



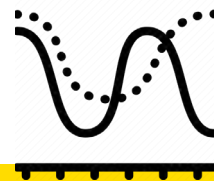
Parameters, configurations, and logics can be misconfigured



Communications

Communication protocols, delays, packet loss, data security, etc. are often not modelled.

Discretisation



Cycle times of equipment, measuring times, and discrete updates may not be well-coordinated, causing instabilities.