Pumped Hydro Energy Storage
A WA Opportunity?

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Presentation for Sustainable Energy Now WA

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Presentation Agenda

1. Introductions
2. The need for Long Duration Energy Storage
3. PHES – Global Status
4. PHES – Australia
5. Case Studies
6. A WA opportunity?
7. Wrap Up

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Mott MacDonald – global expertise and experience

Advisory

Buildings

Aviation

Ports

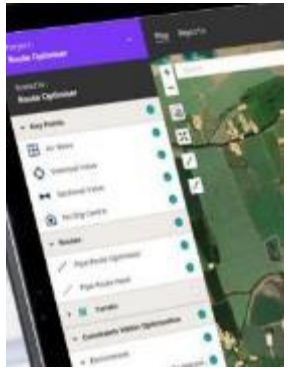
Coastal

Environment

Geotechnical

Bridges and civil structures

Highway



Digital design and delivery

Rail and transit

Tunnels

Power

Pipeline and facilities

Water and wastewater

Transportation planning

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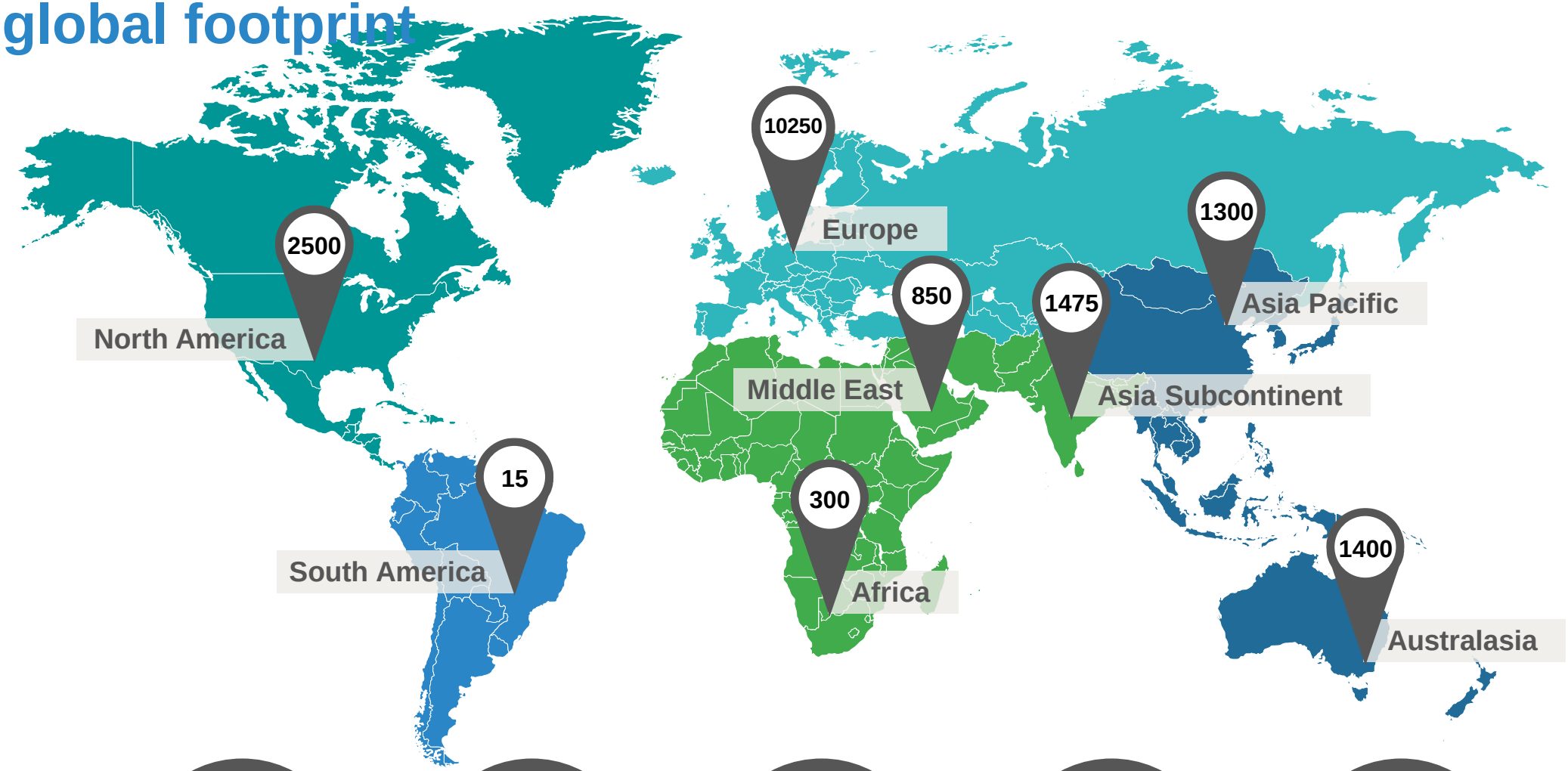
Our global footprint



We work in 135 countries

170 permanent offices in 50 countries

18k staff

$2 billion turnover

Over 150 years' heritage

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The Need for Long Duration Energy Storage

LDES

- LDES offers a solution to reduce reliance on current coal and gas-powered generation and ensure more renewable energy can be supported on the grid.

- Stockpile large amounts of energy when it is cheap and plentiful, for use to meet electricity needs at times of peak demand.

- Supports power system security by helping balance load, improving reliability and reduce risk of blackouts.

- Various LDES's technologies are rapidly evolving and include a range of emerging mechanical, electrochemical, thermal and hydrogen derived options.

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Australia’s growing need for storage

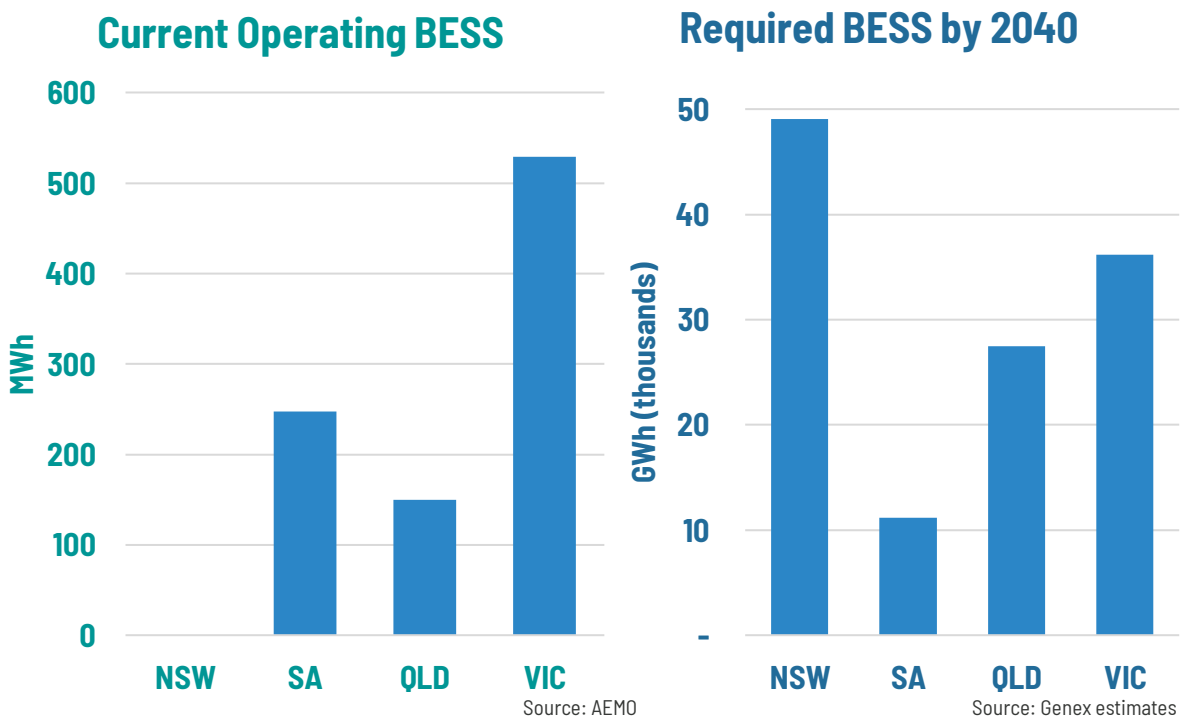
There is a requirement for significant large-scale storage roll out along the east coast of Australia

Approximately 123GWh of capacity needed by 2040

There are many standalone storage systems in Australia are located in SA, VIC & QLD and now WA with KBESS

Large-scale storage inserted into renewable energy zones fill the gaps in dispatchable supply allowing renewable generation to be used more effectively

Australia’s growing need for storage



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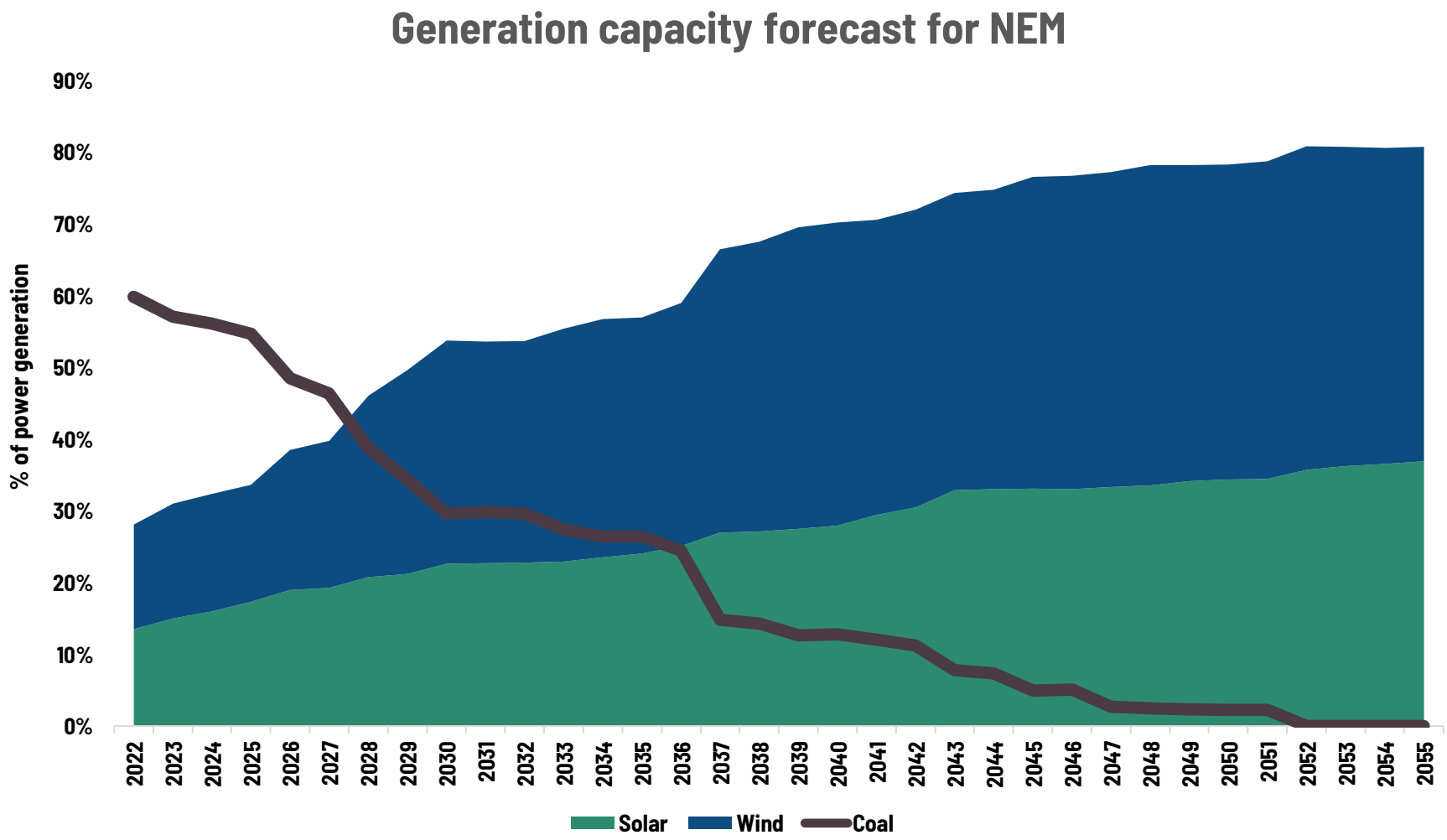
Renewable energy growth



Renewable energy is expected to increase to 83% of NEM total power supply in 2055

Growing penetration of renewable generation underpins the business case for storage

Large-scale storage will maximise renewable energy availability (particularly solar)

Source: Genex

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Pumped Hydro for LDES

- Effective at storing large amounts of energy in comparison to other technologies.
- Effective at storing energy over long periods - weeks and months - when we might have limited renewable energy generation.
- Operating life of 40 years +
- Not effective at very fast discharge over short periods (LiOn BESS dominates here).
- Provides excellent inertial energy storage (heavy rotating generator) supporting power system security against disturbances, fast response times and black start capability.

Ffestiniog Pumped Storage Power station, commissioned 1963
Source : Mott Macdonald

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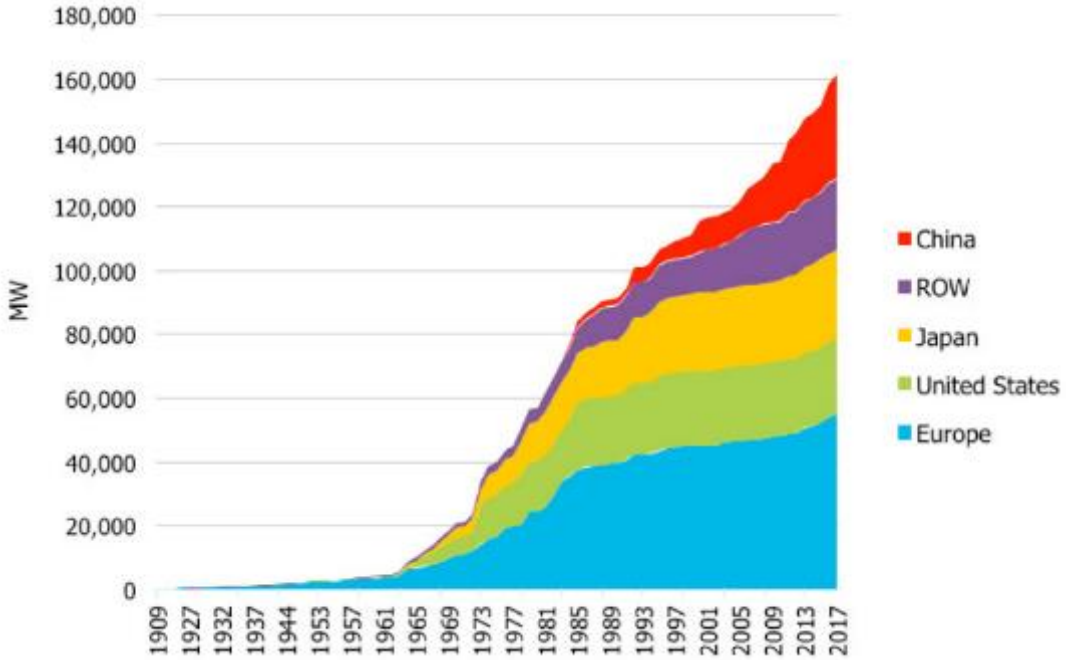
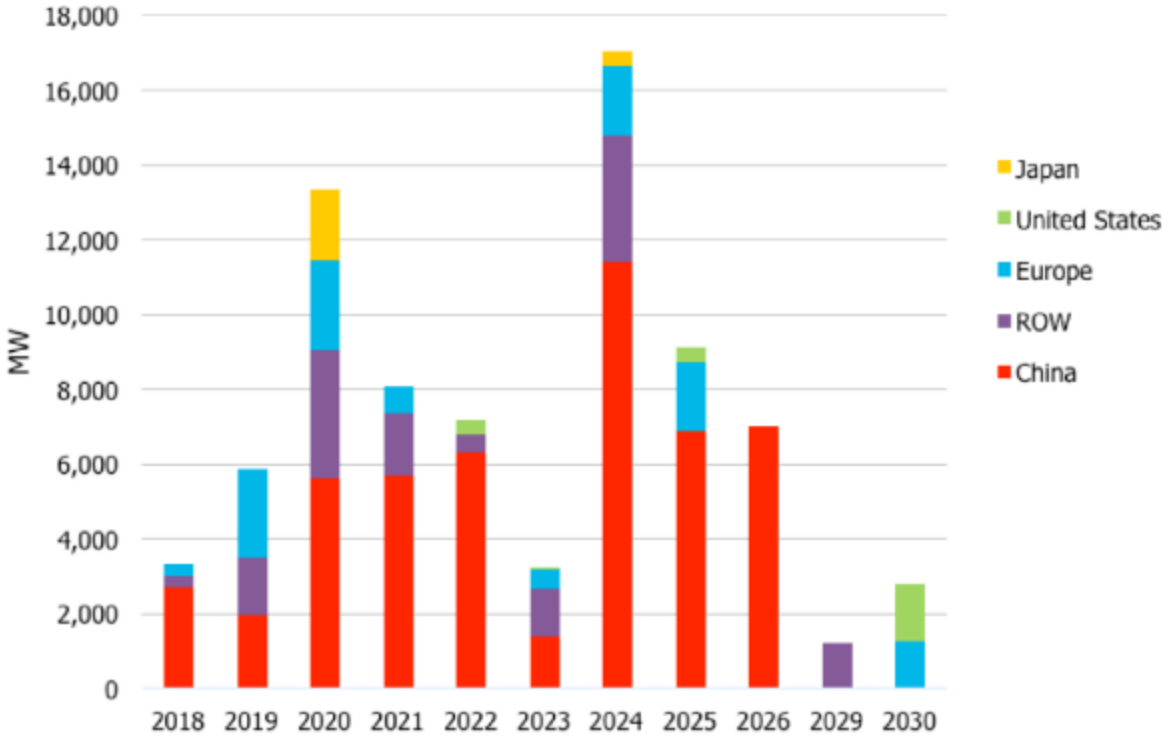
PHES – Global Status and Benchmarks

Global Pumped Storage Development

Previous Development



Future Development



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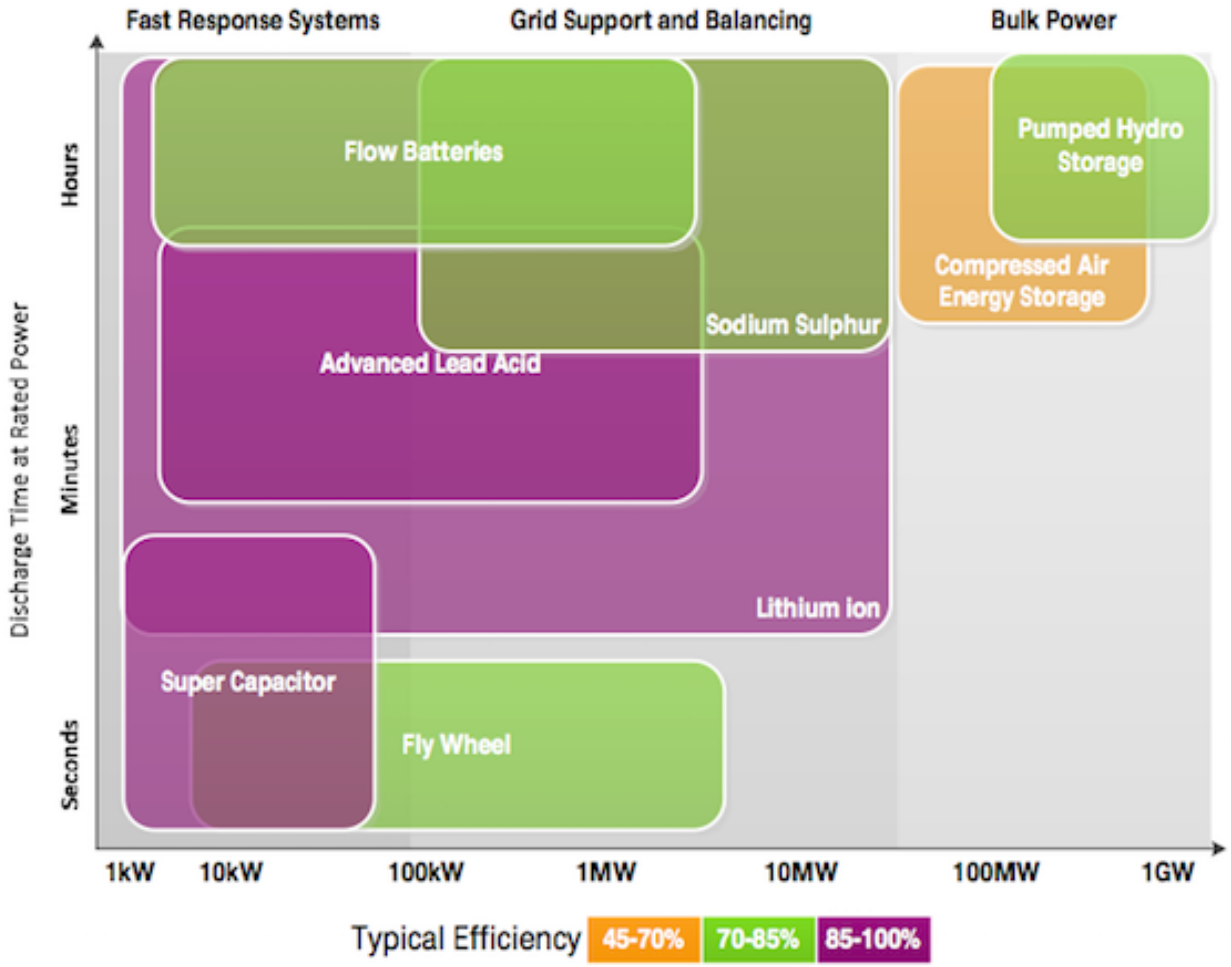
Source: IHA

PHES comparable to other LDES technologies

Figure 8 Electricity storage technologies comparison – discharge time vs. power capacity (MW), [5]



Source: reneweconomy.com

$/MW Costs

- Various studies undertaken last 5 years
- Inferences to trending lower $/MW costs are outdated given rising costs of economy / living / supply chains etc
- Unit costs highly variable – highly influenced by infrastructure contractor capabilities in Australia.

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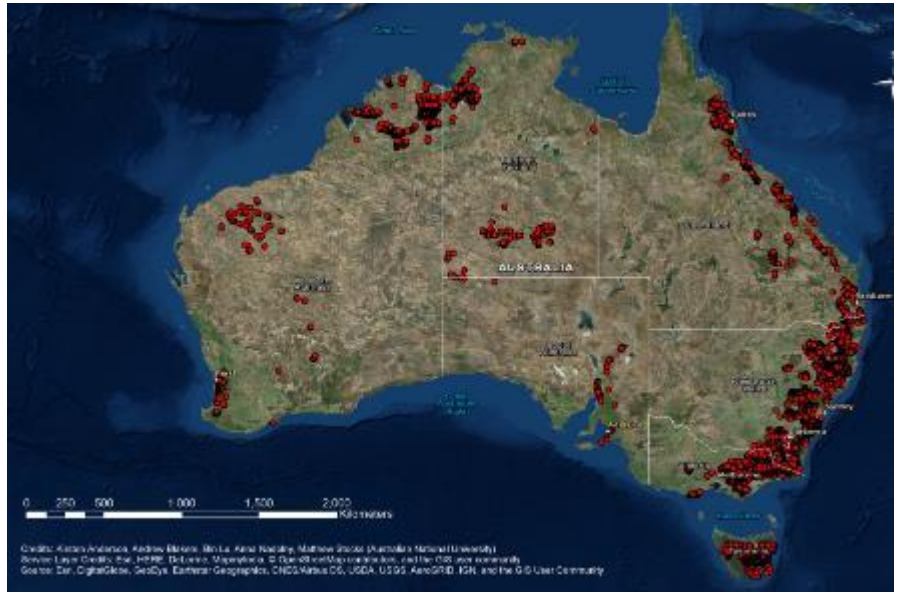
PHES – Australia

Pumped Storage Supporting Energy Transition

- 2017 ANU Study - A clarion call but was it relevant?
- Industry evolution in understanding of PHES scheme viability since.
- Further industry study reduced the ANU's theoretical desktop sites to more realistic sites based on detailed engineering examinations of:
  - Geology
  - Hydrology
  - Environment
  - Supporting infrastructure i.e. transmission networks
- ANU Study identified sites in the East Kimberly (Lake Argyle), Pilbara and the South-West.
- No surprise in WA that mining sites draw attention based on head difference



	Approximate number of sites	Approximate energy storage capacity (GWh)	Minimum head (m)
NSW/ACT	8600	29,000	300
Victoria	4400	11,000	300
Tasmania	2050	6,000	300
Queensland	1770	7,000	300
South Australia	195	500	300
Western Australia	3800	9,000	200
Northern Territory	1550	5,000	200
TOTAL	**22,000**	**67,000**	

Source: ANU Study 2017

Pumped Storage in Australia

Announced Early Stage / Suspended
Baroota | Bendigo Gold Mine System | Kanmantoo Mine | Middlebank Ranges | Cultana | Goat Hill | Bunkers Hill

Development Stage - Study Phase
Dungowan Dam | New England Oven Mountain | Urannah Dam | Cethana | Muswellbrook | Big T | Borumba | Cardstone | Ingham | Pioneer-Burdekin

ECI - Tender Stage - now progressing to Financial Investment Decision
Lake Lyell | Shoalhaven | **Central West**

Final Investment Decision
Snowy 2.0 | **Kidston**

Australia has 2 pump storage projects totaling 2,610MW

Planned pump storage growth of between 6 to 9GW by 2030

Progressing to or have started construction Kidston / Snowy 2.0

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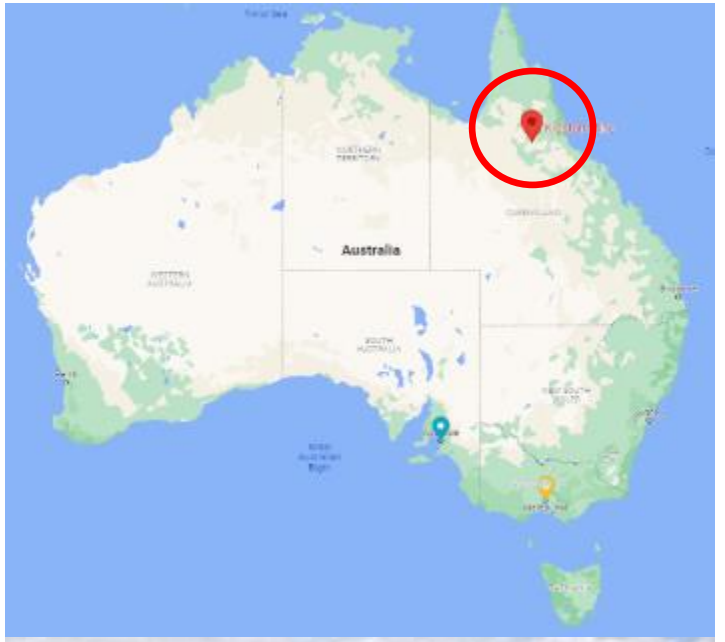
Case Studies

250MW Kidston Pumped Storage

Kidston
Pumped Storage Hydro Project

Re-purposing an abandoned gold mine site to create a closed loop pumped storage hydro scheme as part of a renewable energy hub



Kidston history of development

- In 2014 the former mine site was identified by Genex Power as a suitable location to develop a multi asset clean renewable power generating facility comprising solar, wind and energy storage assets.
- In 2017 development commenced with a 50 MW photovoltaic solar farm.
- Surplus energy arising from the solar and wind generating assets will be stored in the Kidston Pumped Storage Hydro Project
- At times of high energy demand, water will flow back down through the turbines to generate electricity to be fed back to the interconnected grid.
- Driven by need for grid stability, and need for storage in that geography.

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Technical Facts

- 250MW, 2,000MWh pumped storage project in North Queensland, using disused gold mine
- Underground powerhouse with two reversible pump-turbine units and associated vertical shafts and tunnels. 18 mths detailed design, 39 mths for construction
- MM lead designer in DJV with GHD for McConnell Dowell and John Holland
- Digital delivery: BIM for detailed design
- Construction: remote site requiring heavy off-site work and assembly at site
- Some improvements we introduced:
  - Utilised existing mining pit (Wises) as upper reservoir.
  - Helped mitigate excess water management issues for lower pit during construction.
  - Redesigned the access tunnel to avoid faults
  - Numerous cost saving measures for powerhouse
  - An alternative waterway design was proposed using available ground investigation data.

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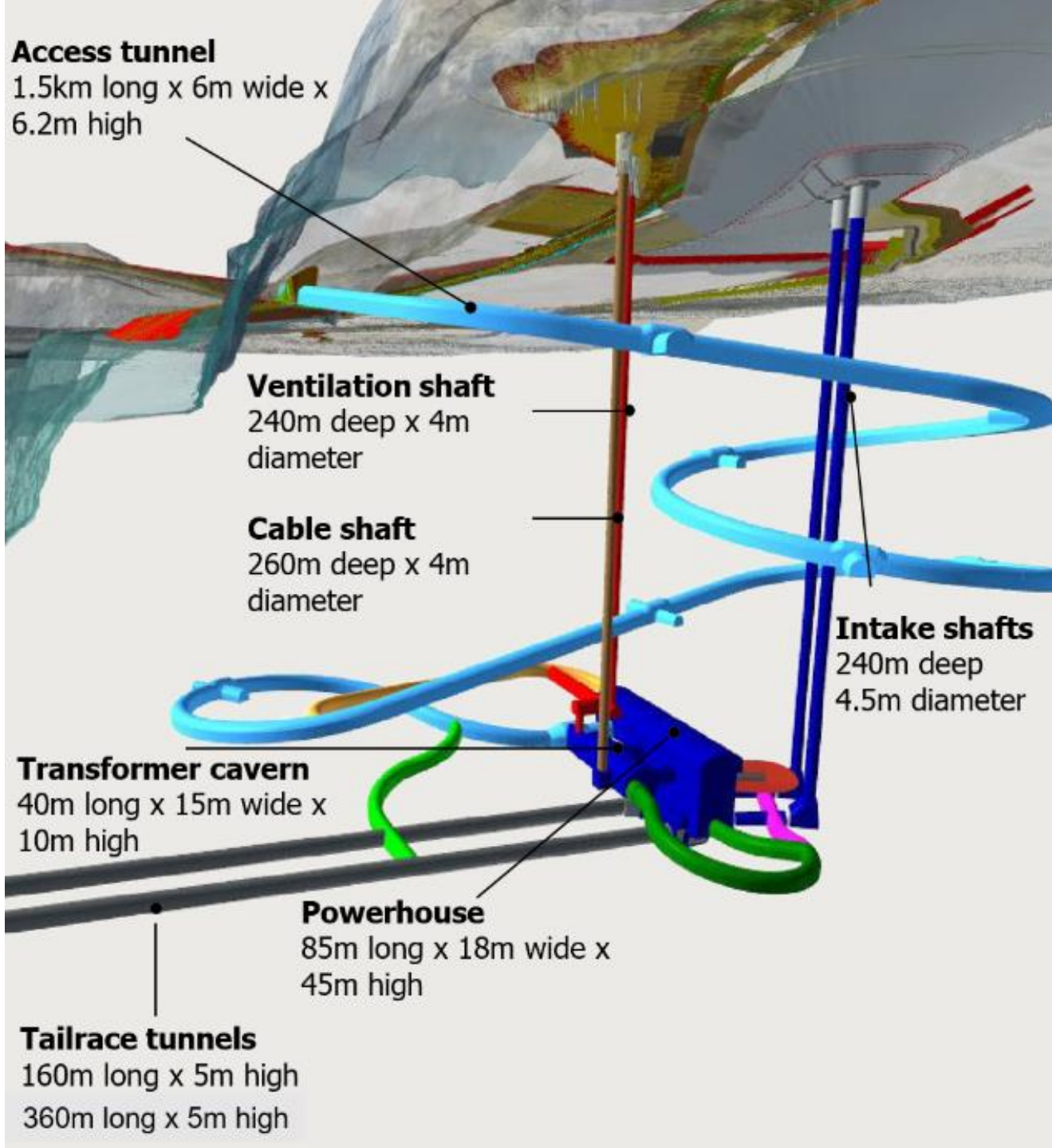


Other Pumped Storage Projects

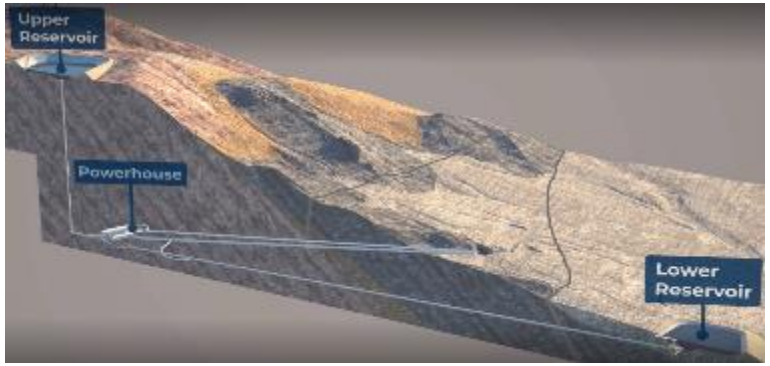
Lake Onslow Pumped Storage Scheme, NZ

- Project includes a large upper reservoir (nominally 5TWh of energy storage), headrace and tailrace tunnels, and underground powerhouse with a set of 250 MW reversible variable speed Francis units (1000 MW in total).
- Delivered a detailed, comprehensive and credible design, with schedule and cost assessment to enable robust evaluation of the Lake Onslow solution to the NZ battery program.
- Significant optioneering analysis performed. Several opportunities identified (e.g., surge chamber) for further development / enhancement.

Central West Pumped Storage Scheme, NSW

- 325MW privately developed scheme capable of 8-hour continuous generation
- Developed and optimized the reference design and produced a tender design for construction of the project.
- Value Engineering included:
  - Adjusted powerhouse configuration to de-risk constructability and accommodate equipment
  - Introduced draft-tube gate for flood management
  - Options under review for main components: powerhouse type, penstock configuration, dam type - to reduce risk, improve performance/ energy production, reduce cost, improve constructability, reduce schedule.

White Pine Pumped Storage Scheme, USA



- 1000 MW closed loop facility in northeast Nevada
- Advanced the feasibility study for preferred alternative with further optimisation including selection of OEM technology (variable speed units), transmission routing, risk assessment, construction schedules cost estimation.
- Value Engineering included:
  - Developed reservoirs to make best use of locally sourced material while balancing cut and fill.
  - Increased scheme head utilising turkey nest reservoir.
  - Reduced length of high-pressure waterways by shifting powerhouse cavern as close as possible to vertical pressure shaft.

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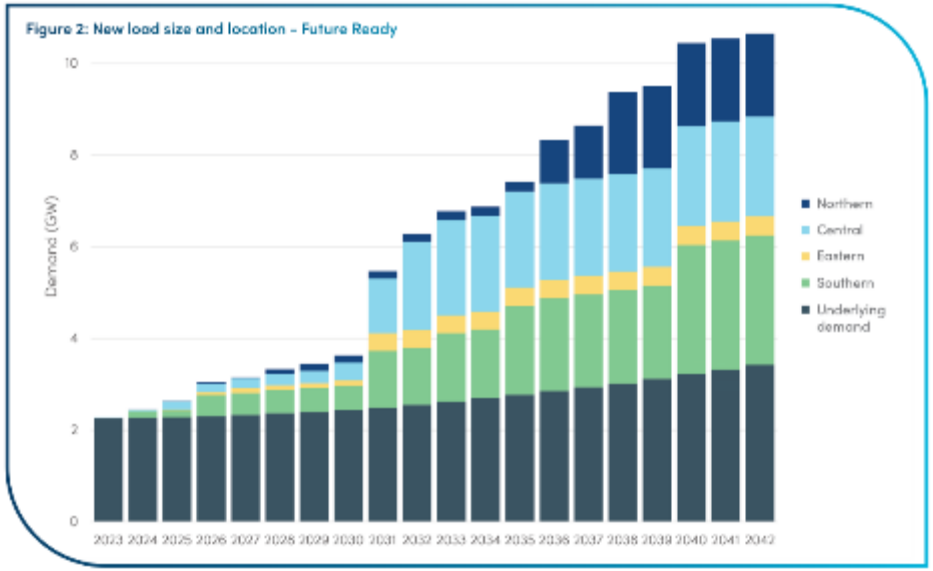
PHES
A WA opportunity?

PHES in WA

- SWISDA [2023] modelled up to 10hr storage needed from 2030 onwards and based on PHES technology and CAES
- *…PHES is challenging in the SWIS given the topography and drying climate…*
- PHES has characteristics that constrain its widespread use across WA in comparison to other locations across in Australia - appropriate locations with elevational difference, land and water availability.
- Various studies undertaken by government utilities over the last 10 years.
- Synergy “not actively” developing PHES in Collie (Oct 2023)
- Private organisations have expressed interest in developing PHES in SWIS and Off-Grid



Source: SWIS Demand Assessment

Walpole Mini-Pumped Hydro (westernpower.com.au)

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Alternative to mine rehabilitation ?

- WA resources sector is also decarbonising - increasing penetration of renewables supported by LDES
- Abandoned mine rehabilitation costs vary
- Lower environmental and social impact through repurposing of pits
- Water supply from mine dewatering operations
- Pilbara - expected losses from evaporation and process losses to be considered
- CAPEX compared to NEM PHES – the Pilbara premium
- MM currently looking at Muswellbrook PHES in NSW utilising coal mine void.

Figure 15: Potential PHES upper reservoir sites at Collie, WA, with 200 m head into the pit and a good volume of stored water.

Source: ANU Study 2017

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Where and how could PHES stack up in WA

- WEM market mechanisms are being implemented to encourage investment in new storage facilities
- NWIS / Pilbara – addressing dewatering and grid decarbonisation.
- The role of technology advancements and role of R&D to reduce costs
- Micro PHES – agricultural water reservoirs and innovative storage solution
- *…no energy solution can exist outside of the real and competitive pressures of the market. Technical viability and environmental benefits won't be enough to get projects over the line if they can't demonstrate their financial soundness…*

A good site generally has:

Large head difference

Good access to water

Appropriate geological characteristics

Attractive water / rock ratio

Short and steep connecting pressure pipes/tunnels

Minimum conflicts with indigenous, environment, social, heritage, urban, agricultural and land management

Good access to roads and transmission network

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Wrap up
Bringing it all together

Is PHES a technology for WA LDES needs?

Challenges

- Financial (esp for private developers)
- Alignment of Costs and Benefits
- Environmental Impacts
- Approvals processes (esp in WA)
- Community and Social License

Opportunities

- Emissions Reduction
- LDES supporting greater RE penetration
- Repurposing old mines
- System inertia in SWIS
- Water security off-grid areas

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Thank you