HYDROSTOR

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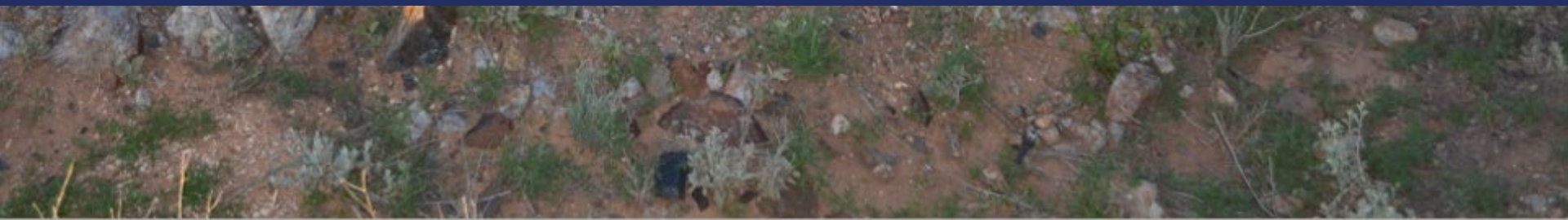
Submission to the AEMO ISP Consultation

February 2021



Our Submission

Our submission primarily pertains to the question on p. 92 of the Draft Report for Consultation, regarding the consultation question

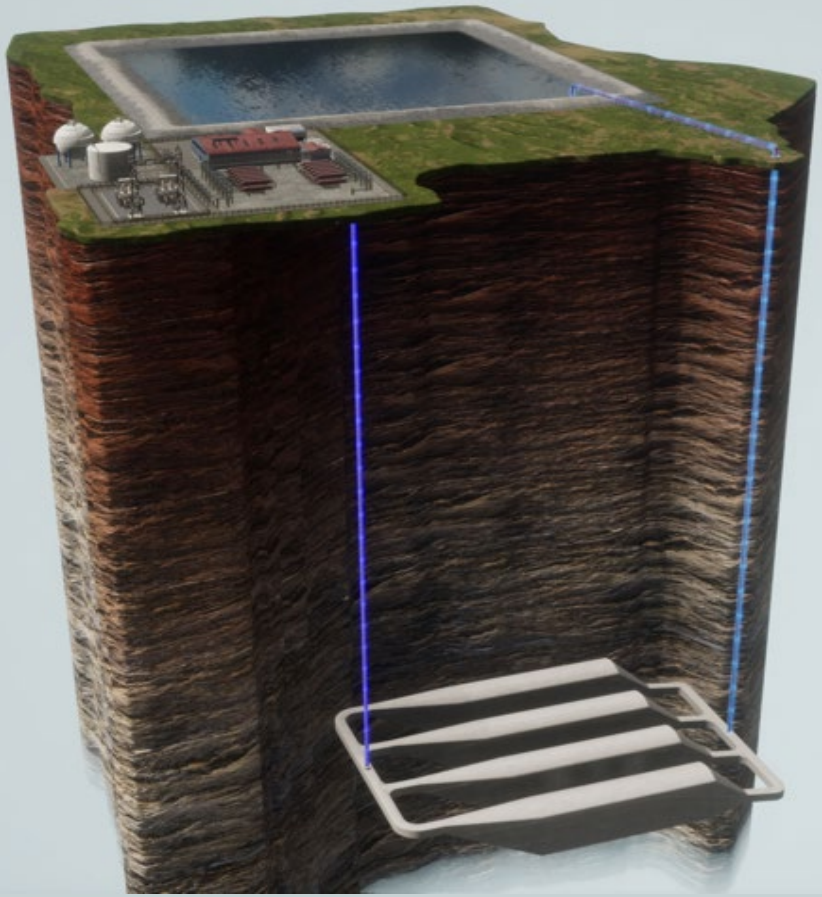
“Is AEMO’s proposed list of candidate technologies reasonable? If not, what should be included/excluded?”

Energy Estate and Hydrostor would like to draw AEMO’s attention to Compressed Air Energy Storage (CAES) technology and suggest that it should be included in the “List of technologies to be available in the 2021-22 ISP”

We provide detailed justification as to why we believe CAES should be included in this submission, but to summarise

1. CAES is included in Lazard’s recent LCOS review as the North American market now has sufficient project examples to provide cost estimates.
2. A CAES project was the preferred option in the recent Broken Hill Reliability RiT-T PADR and this non-network option should materially enhance the transmission limits for this REZ
3. The US DOE’s recent Energy Storage Cost and Performance Report lists CAES as the lowest energy storage technology
4. Multiple CAES technology companies are actively targeting the Australian market, including HydroStor, CTG and Highview Power and the NSW Government has supported A-CAES through its emerging energy program

CAES is a viable and cost effective long-duration energy storage solution that has very different (and usually less) siting constraints in comparison to PHES, so should be given consideration in AEMO’s modelling



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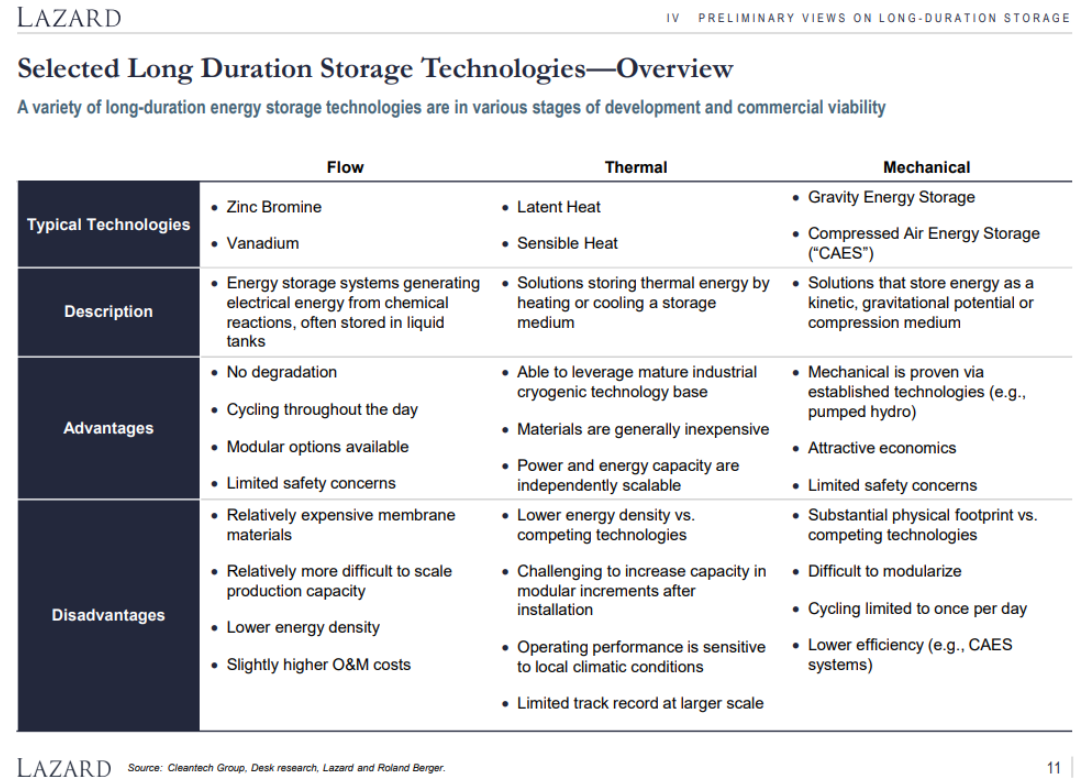
1. Lazard's Levelized Cost Of Storage 2020 (V 6.0)

- The Lazard's LCOE and LCOS reports are comprehensive are widely used by industry in Australia. Lazard's recently released Version 6.0 of its LCOS analysis for 2020
- The LCOS considers CAES for the first time, as there are now real projects from which to benchmark
- A copy of the analysis can be found here



LAZARD

IV PRELIMINARY VIEWS ON LONG-DURATION STORAGE

Selected Long Duration Storage Technologies—Overview

A variety of long-duration energy storage technologies are in various stages of development and commercial viability

	Flow	Thermal	Mechanical
Typical Technologies	• Zinc Bromine • Vanadium	• Latent Heat • Sensible Heat	• Gravity Energy Storage • Compressed Air Energy Storage ("CAES")
Description	• Energy storage systems generating electrical energy from chemical reactions, often stored in liquid tanks	• Solutions storing thermal energy by heating or cooling a storage medium	• Solutions that store energy as a kinetic, gravitational potential or compression medium
Advantages	• No degradation • Cycling throughout the day • Modular options available • Limited safety concerns	• Able to leverage mature industrial cryogenic technology base • Materials are generally inexpensive • Power and energy capacity are independently scalable	• Mechanical is proven via established technologies (e.g., pumped hydro) • Attractive economics • Limited safety concerns
Disadvantages	• Relatively expensive membrane materials • Relatively more difficult to scale production capacity • Lower energy density • Slightly higher O&M costs	• Lower energy density vs. competing technologies • Challenging to increase capacity in modular increments after installation • Operating performance is sensitive to local climatic conditions • Limited track record at larger scale	• Substantial physical footprint vs. competing technologies • Difficult to modularize • Cycling limited to once per day • Lower efficiency (e.g., CAES systems)

LAZARD *Source: Cleantech Group, Desk research, Lazard and Roland Berger.* 11

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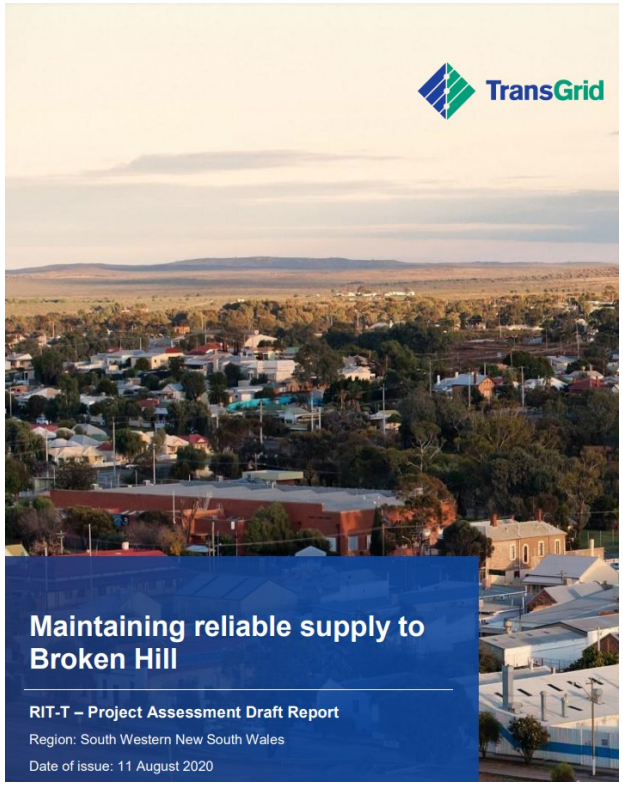
2. CAES the Preferred Option in RiT-T

- A Regulatory Investment Test for Transmission (RIT-T) is currently being conducted for maintaining reliable supply to Broken Hill. The Project Assessment Draft Report (PADR) showed that the CAES project proposed was the preferred option by some margin.
- Modelling conducted by Ernst and Young showed that the CAES project provided $110m more network benefits than the next best project in the RiT-T.
- These benefits were primarily from deferred costs, and essentially relate to more efficient use of the existing transmission system. Broken Hill has excellent renewable energy resources, but the REZ is constrained by the high cost of transmission augmentation.
- The modelling showed that the CAES was able to defer the need to build new transmission, whilst still enabling new solar PV to be developed in Broken Hill. **This should be considered in assessing the REZ Resource Limits and REZ Transmission Limits (4.9.2 and 4.9.3 of the IASR) in the context of the Broken Hill REZ. We believe that incorrect assumptions have been made as the utility of a long duration A-CAES solution as a non-network option is not assessed despite the results of the recent RIT-T. This has wider implications across the NEM in terms of analysis and decision making.**
- The modelling report and subsequent work by TransGrid have also confirmed the CAES project has the ability to supply Broken Hill in an islanded situation, as well as to have positive network stability impacts in Broken Hill, thanks to the synchronous nature of the technology.



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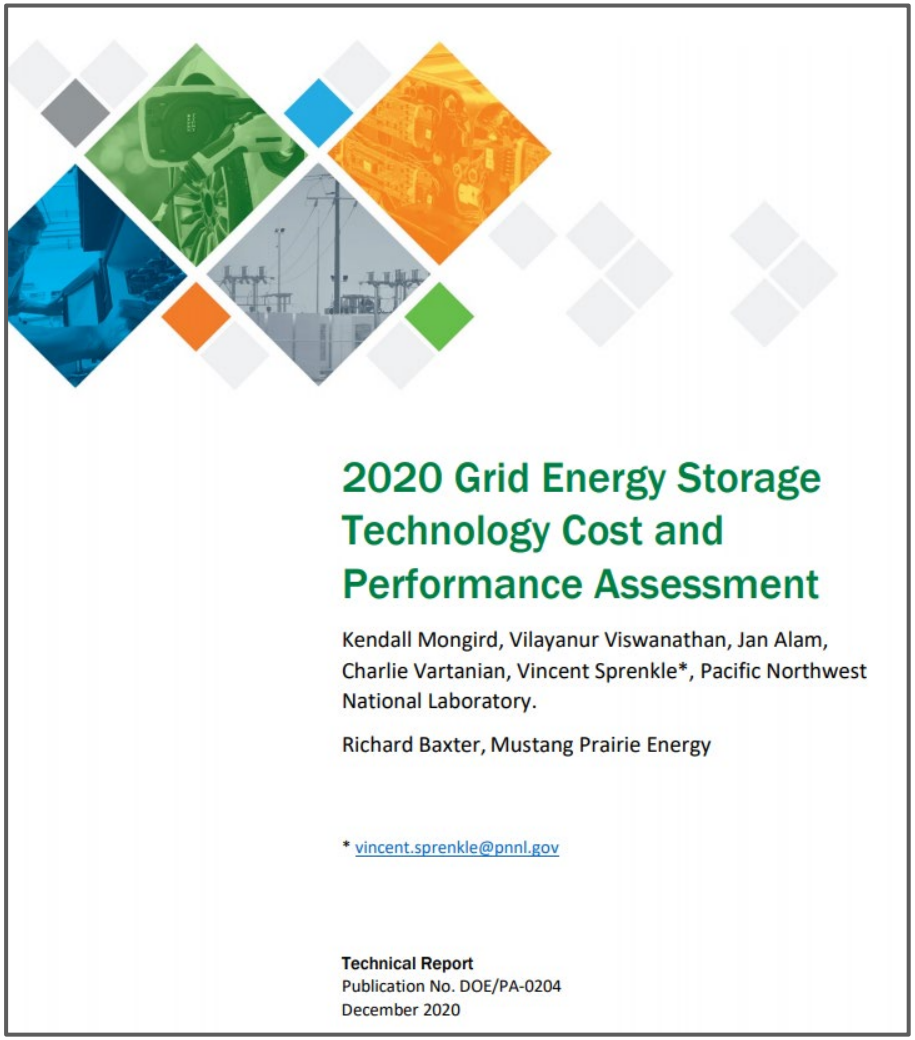
3. US DOE Grid Energy Storage Report

- The US Department of Energy (DOE) recently released their comprehensive Grid Energy Storage Technology Cost and Performance Assessment Report.
- The report shows CAES as having the lowest installed cost of all storage technologies overall (119 USD/kWh), as well as extremely low long duration (10 hr) LCOS of 29 USD/kWh
- The report provides detailed capital, operational and annualized (LCOS) cost estimates with breakdowns, as well as forecasted learning rates through to 2030 that could underpin the data requirements of the ISP modelling
- The report provides a comprehensive review of CAES and previous CAES analyses, plus reviews of grid scale CAES currently in operation, providing increased certainty for data inputs into the ISP



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4. Multiple CAES Technologies Targeting Australian Market

There are multiple CAES technologies targeting the Australian market at present. We include here a summary and present more detailed slides in the technology section.

HydroStor is a Canadian technology company with an Advanced CAES design that uses underground caverns to store compressed air. They have operational plants in Canada, a project under development in Australia at Strathalbyn, SA and a another, much larger plant in central NSW.

Highview Power is a British technology company that develops cryogenic CAES systems globally. They have operational plants in the UK up to 50 MW and multiple larger projects in development in the UK and USA. Highview now has a representative in Australia and is actively pursuing opportunities in Australia.

CleanTech Geomechanics (CTG) is a Canadian technology company with a novel CAES technology that utilises underground wells as the compressed air storage vessel, reducing land footprint significantly. They have demonstration scale plant under construction in Singapore and planned developments across Australia's mainland states.

CAES Technologies

HydroStor

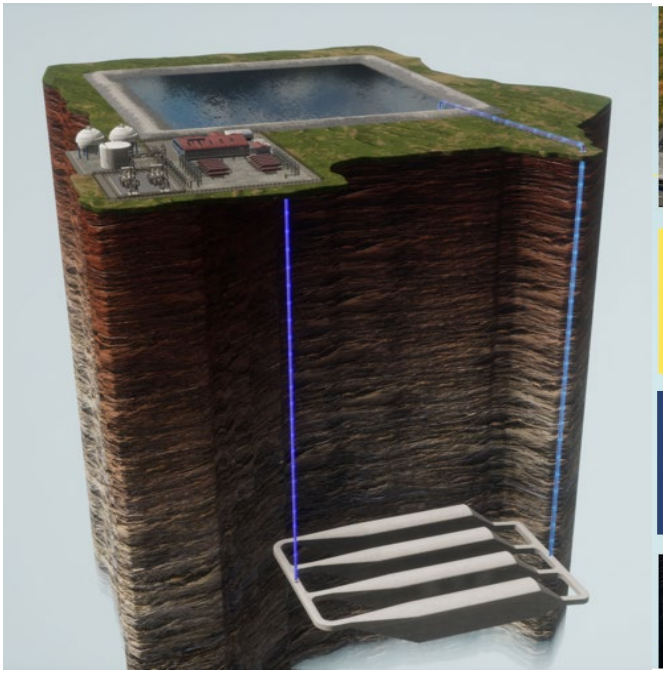
Hydrostor is a Canadian technology company with an Advanced CAES design that uses underground caverns to store compressed air.

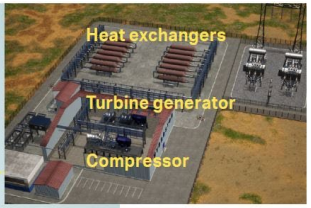
Hydrostor has operational plants in Canada, a project under development in California and in central NSW at Broken Hill.

HydroStor Technology

Hydrostor integrates proven technologies and construction approaches in innovative ways to produce a superior long-duration grid-scale energy storage solution

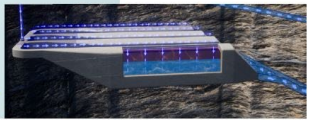
- ***CAES is Mature Technology Class:*** Multiple conventional-CAES plants reliably operated for over 30 years.
- ***Electrical Conversion:*** Relies on off-the-shelf synchronous generating equipment, including compressors, expanders, heat exchangers, available in a variety of sizes and configurations and that have decades run-time experience across multiple industry applications (e.g. oil & gas).
- ***Underground:*** Simple and cost-effective, purpose-built underground cavern construction using industry standard and well-proven mining techniques with large precedent for hydrocarbon storage (i.e. 100's rock caverns, dozens with hydrostatic compensation).





Charge
As compressed air is sent into the air storage cavern, water is displaced via a flooded decline or shaft.

Discharge
As water enters the air storage cavern, hydrostatic pressure forces air to the surface.



Step 1
Compress air using electricity

Electricity runs a compressor to produce heated compressed air

Hydrostor Innovations

Step 2
Capture heat in thermal store

Heat is extracted from the air stream and stored in a proprietary thermal store

Hydrostor Innovations

Step 3
Store compressed air

Air is stored in a purpose built underground cavity where water is used to maintain constant pressure

Step 4
Convert the air to electricity

Water forces air to the surface where recombined with heat and expanded through a turbine

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HydroStor Project Overview

Hydrostor has completed two projects in Canada, as well as a third project in Australia (Angas) that is shovel-ready with A$9 million ARENA and S.A. government grant funding approved.

The Company is continually developing its project pipeline which currently includes 15+ projects in various development stages across North America, Australia and Chile that range in size up to 500 MW, 4 gigawatt hours (GWh) per project.

Toronto Island (Canada)

- **Owner**: Hydrostor
- **Utility Host**: Toronto Hydro
- **Rating**: 660 kW / +1 MWh
- **In-Service**: 2015 - 2019
- **Application**: Demonstration, R&D

Goderich (Canada)

- **Owner**: Hydrostor contracted by IESO
- **Rating**: 2 MW / +10 MWh
- **In-Service**: Q2-2020
- **Application**: Commercial, load-leveling

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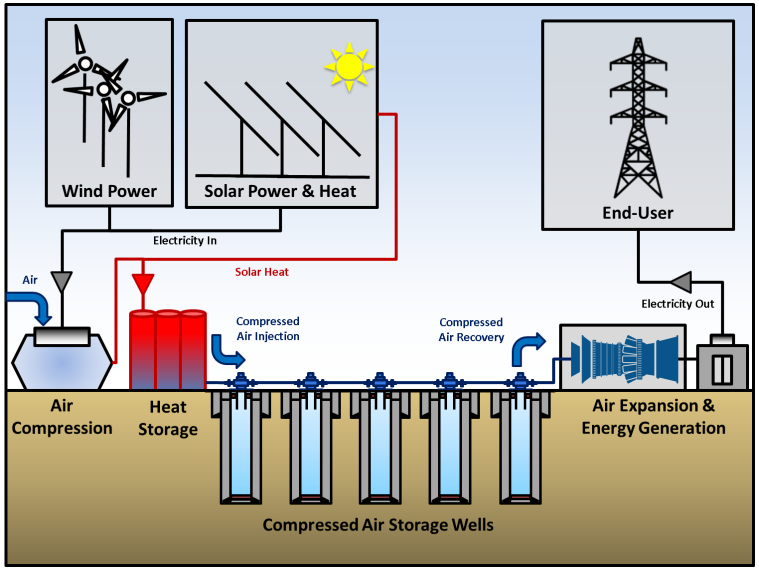
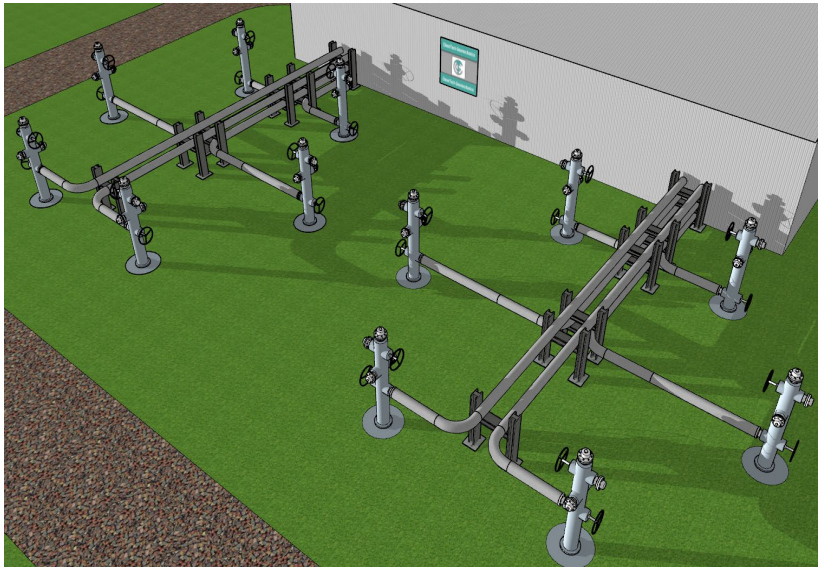
CleanTech Geomechanics

CleanTech Geomechanics (CTG) is a Canadian technology company with a novel CAES technology that utilises underground wells as the compressed air storage vessel, reducing land footprint significantly.

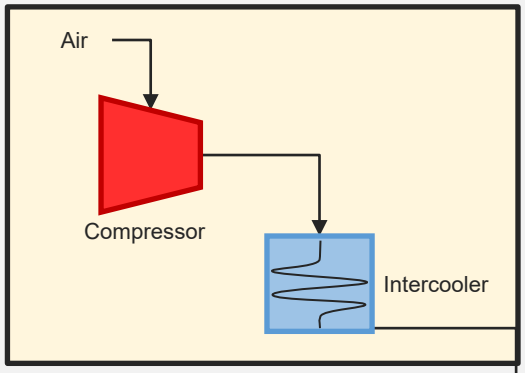
They have demonstration scale plant under construction in Singapore and planned developments across Australia's mainland states.





CTG's Geo-ESS Technology

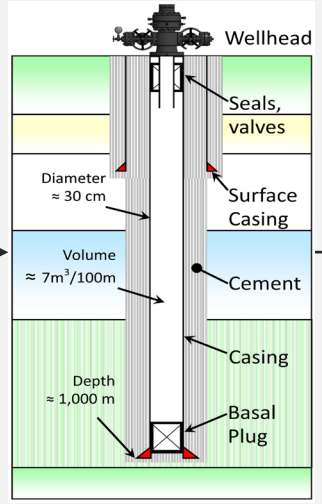
COMPRESSION



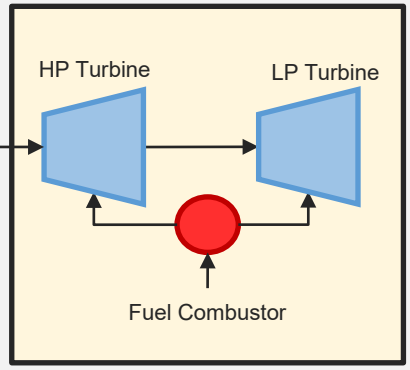
- Ambient air is compressed with electrical power from a grid-connected or off-grid system
- The heat released during compression is transferred to the ground as a thermal energy store, or to a thermal storage tank above ground

STORAGE

- Compressed air stored in a high temperature/pressure cased-wellbore
- 50 MPa maximum pressure
- Up to 10 MWh energy storage / well
- Wells up to 1.5km deep using existing technology and workforce



EXPANSION



- Compressed air is released through turboexpanders and turns a generator, producing dispatchable electricity
- Round Trip Efficiency: 55-70%
- Scalable output power and storage duration to suit application

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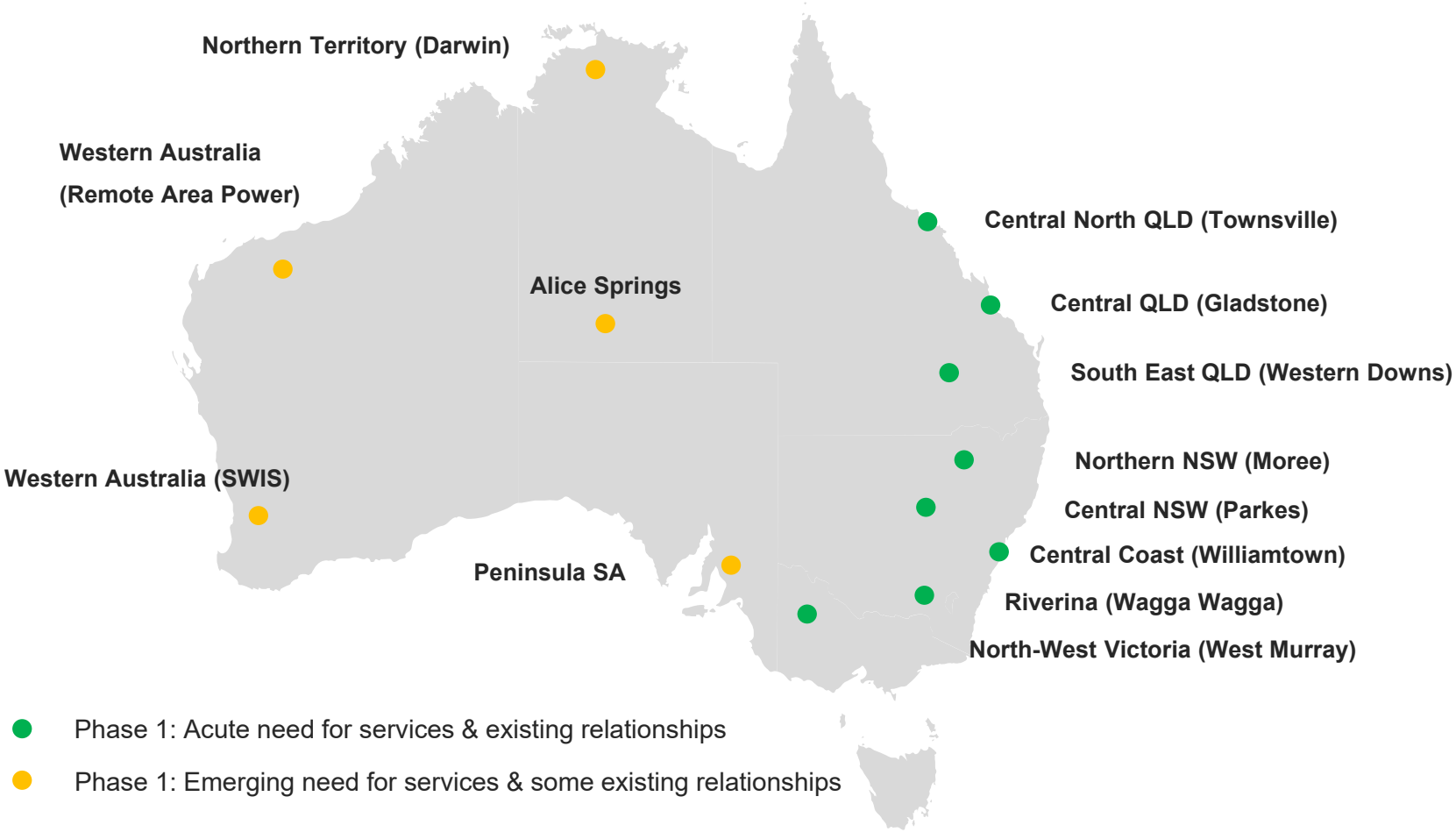
CTG's Australian Project Pipeline

CTG and Energy Estate have identified a strong project pipeline in Australia, utilizing existing relationships and developing new opportunities for rapid deployment.



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Highview Power

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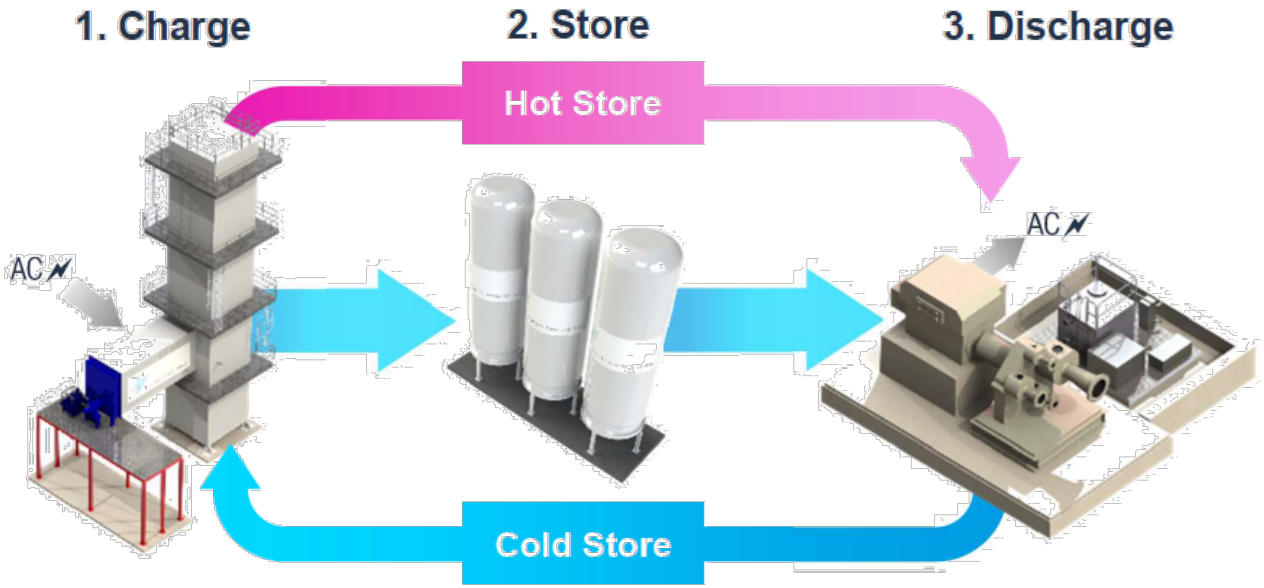
Highview Power's Technology



Additional hot and cold thermal recycling increases efficiency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