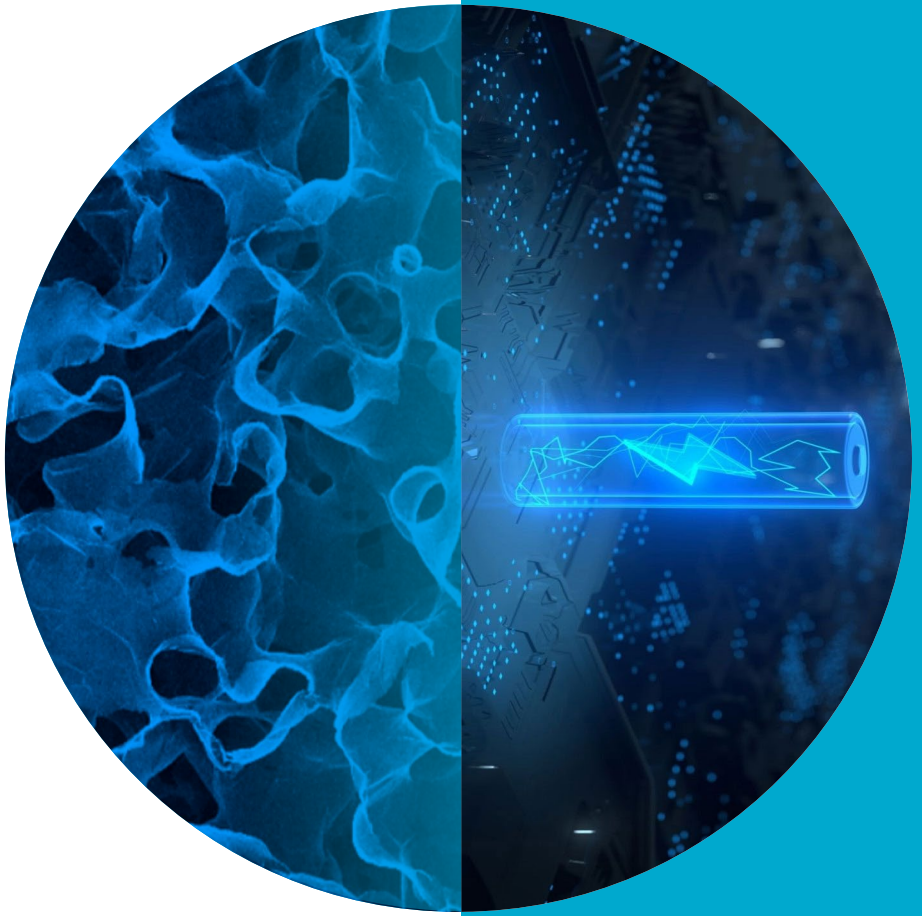
New directions in Long Duration Energy Storage

Research & Development

Revolutionary Energy Storage Systems
Future Science Platform

Flow Battery Symposium

15 Oct 2024



We acknowledge the Whadjuk Noongar people as the Traditional Owners of the land that we live and work on, and pay our respects to their Elders past and present.

REFLECTIONS

- **The Journey so far…**
  - Introduced in 1997
  - Worked on enhancing stability of supersaturated V(II) and V(III) solutions
  - Using Raman spectroscopy to determine sulfate/bisufate ratio
  - Investigated Photocatalytic regeneration of V(IV) solution

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A BIG THANK YOU!

MY CRYSTAL BALL

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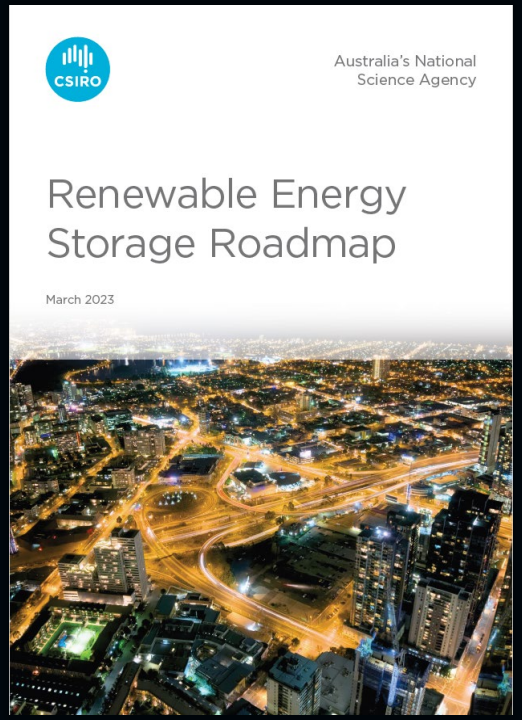
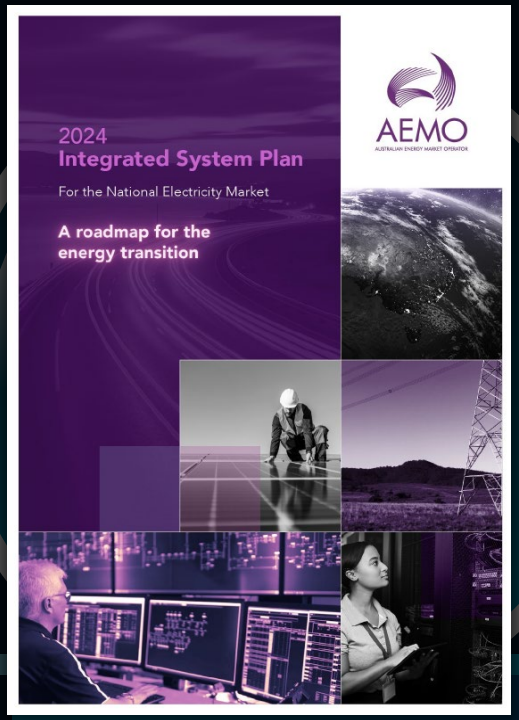
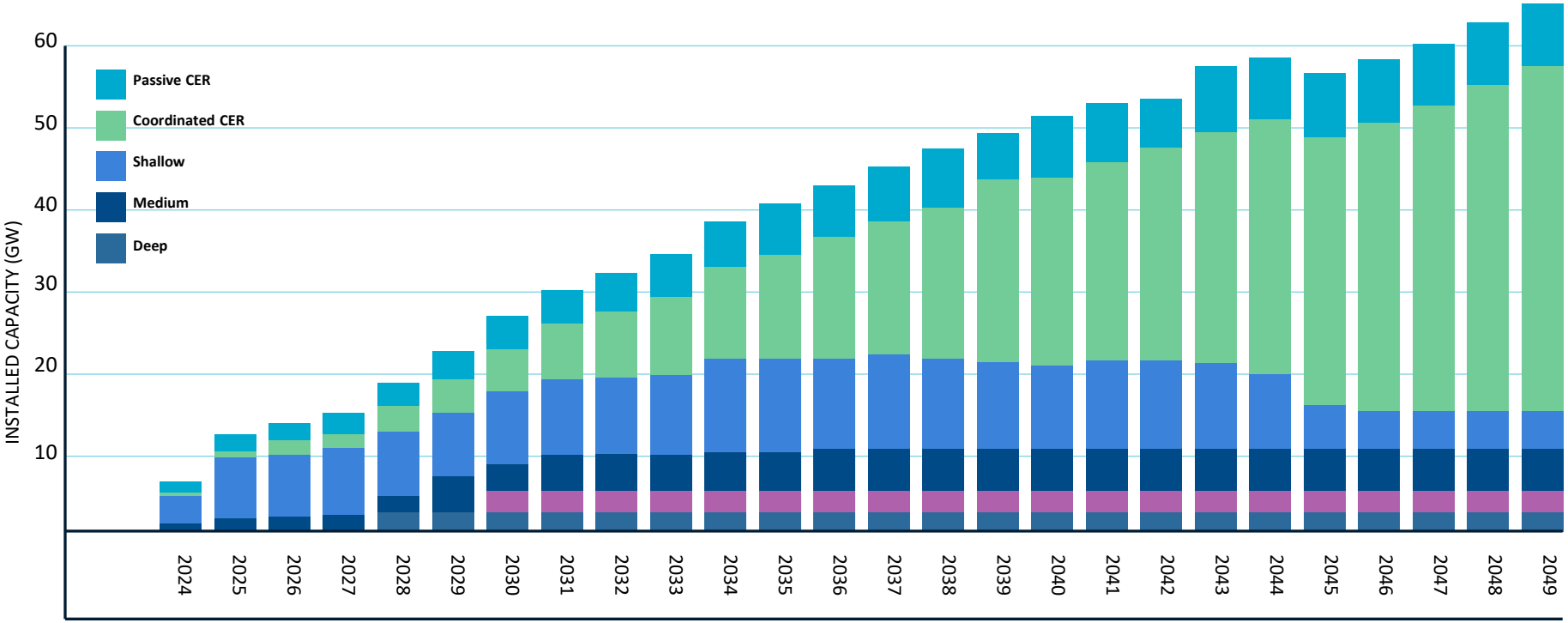




Fast shift to distributed power generation



HIGHLIGHTS

Alternative LDES are needed to fill the gap

Li-ion Batteries | The Missing Middle | **Pumped Hydro**

They typically have energy duration capabilities in the range of 12 hours and above and able to carry stored energy through long periods of time

Most have the capability to repeatedly cycle, with low rates of degradation

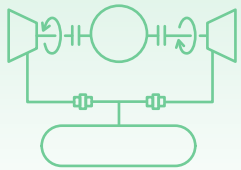
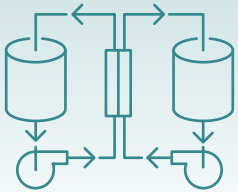
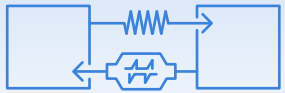
They can provide key system stability services, including synchronous services

Alternative LDES are needed to fill the gap

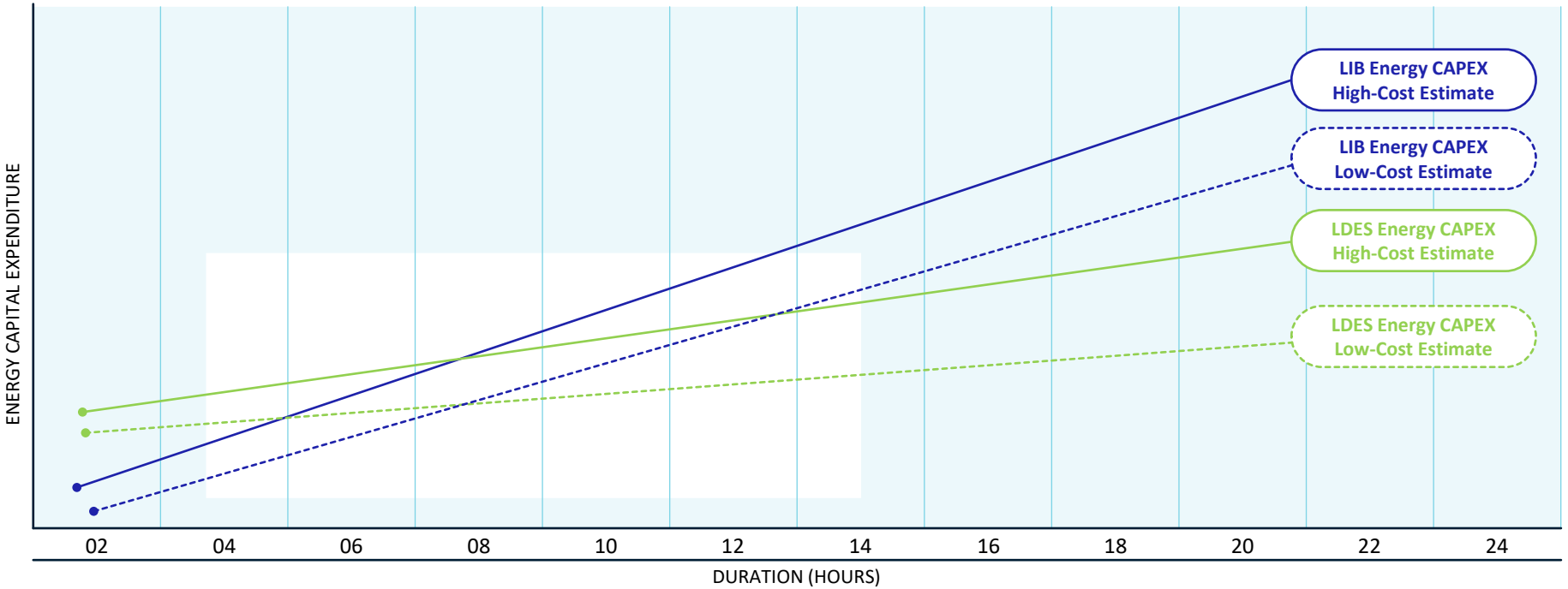
Li-ion Batteries

The Missing Middle

Pumped Hydro

COMPRESSED AIR	REDOX FLOW	THERMAL
		
Diabatic Adiabatic Isothermal Liquid Air	Vanadium Flow Zinc Bromide Flow Iron Flow	Molten Salts Steam Miscibility Gap Alloy

Alternative LDES are needed to fill the gap



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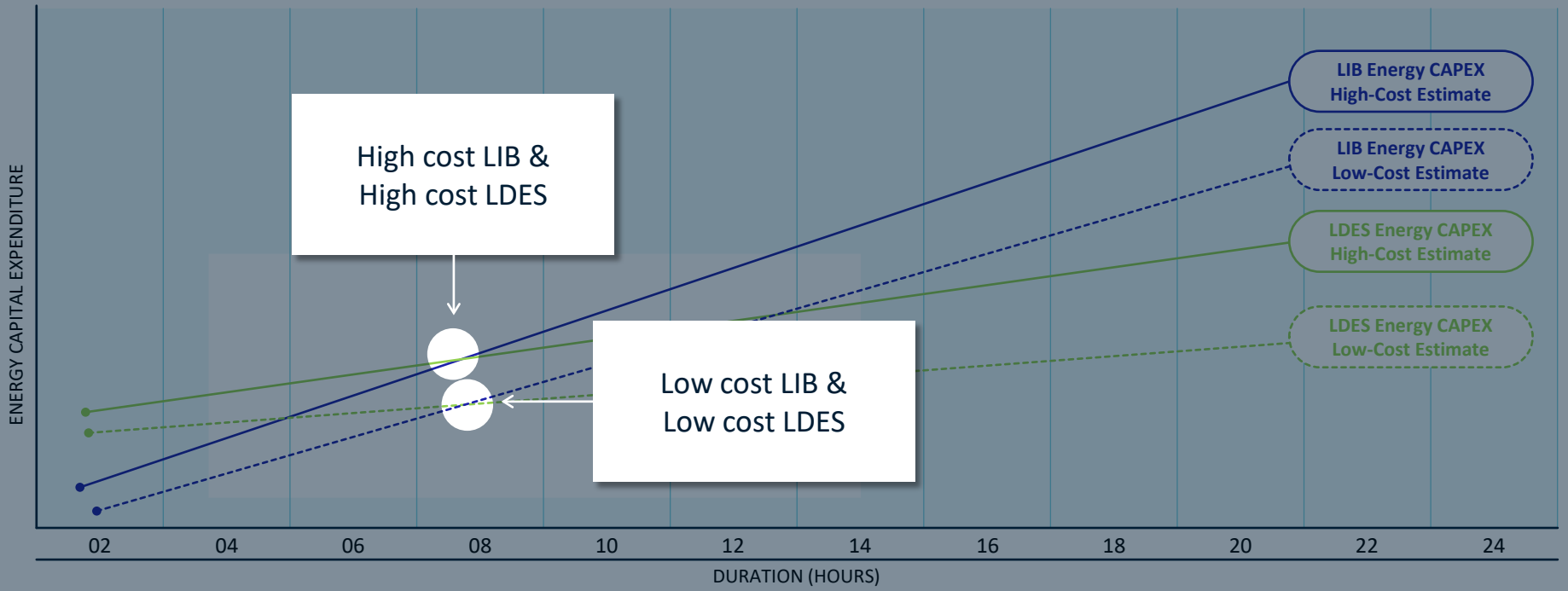

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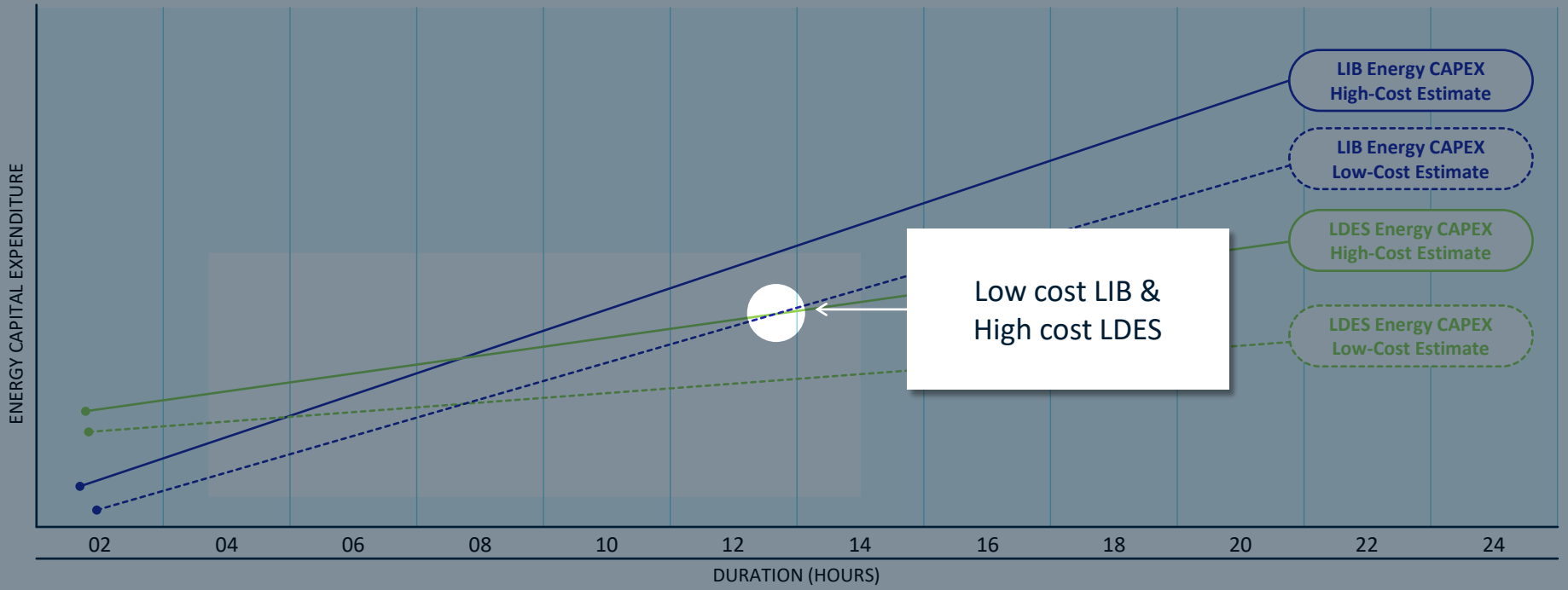

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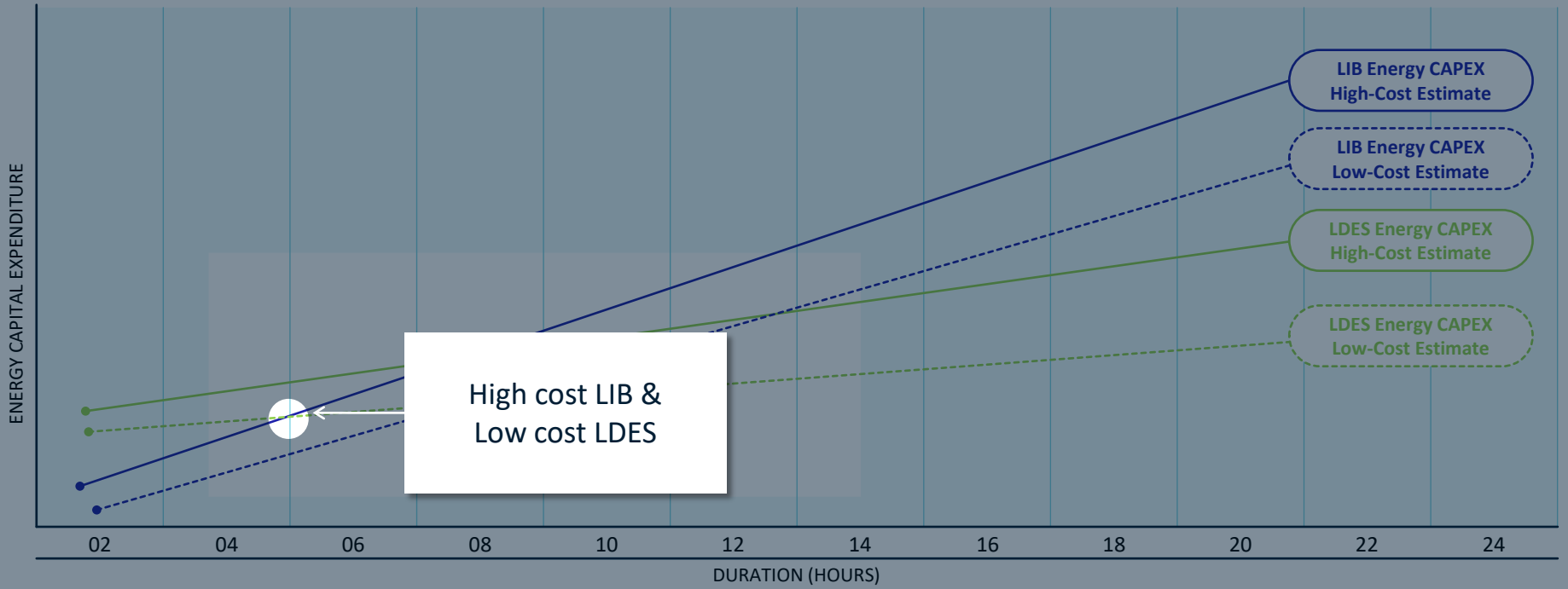


Alternative LDES are needed to fill the gap

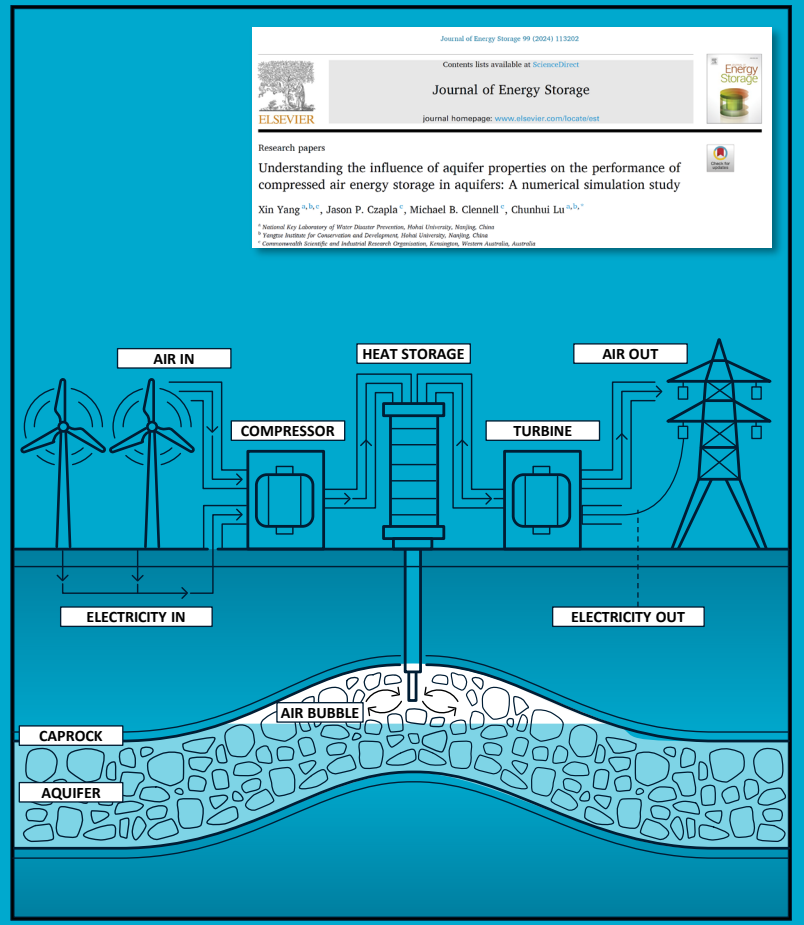
	A-CES	VRB	Zr-Br RB	CST TES	MGA
Rated power output (MW)	200 - 500	10 - 100	10	300	100
Energy Duration (h)	8 - 12	8 - 12	8 - 12	12 - 24	12 - 24
Round trip efficiency (%)	40 - 80	60 - 85	60 - 70	60 - 80	20 - 50
Cycling capability (Cycle)	NA	15,000 – 20,000	11,000	NA	10,000
Lifespan (year)	up to 60	25 +	10 - 20	40+	20+
Locational dependency	Moderate	Low	NA	High	Low
Capital cost (US$/kWh)	120 - 280	640 -1,100	370 - 1,470	47 - 84	30 - 60
Construction year	2 -3	1	1	1-2	1-2

ENERGY STORAGE R&D ACROSS CSIRO

ENERGY STORAGE R&D ACROSS CSIRO

Compressed Air storage

- A-CAES is demonstrated, cost-effective technology suitable in areas of hard rocks (caverns-demonstrated), or sedimentary rocks that are sufficiently permeable (not demonstrated)
- Further development to enhance efficiency through better waste heat harvesting, storage and recovery

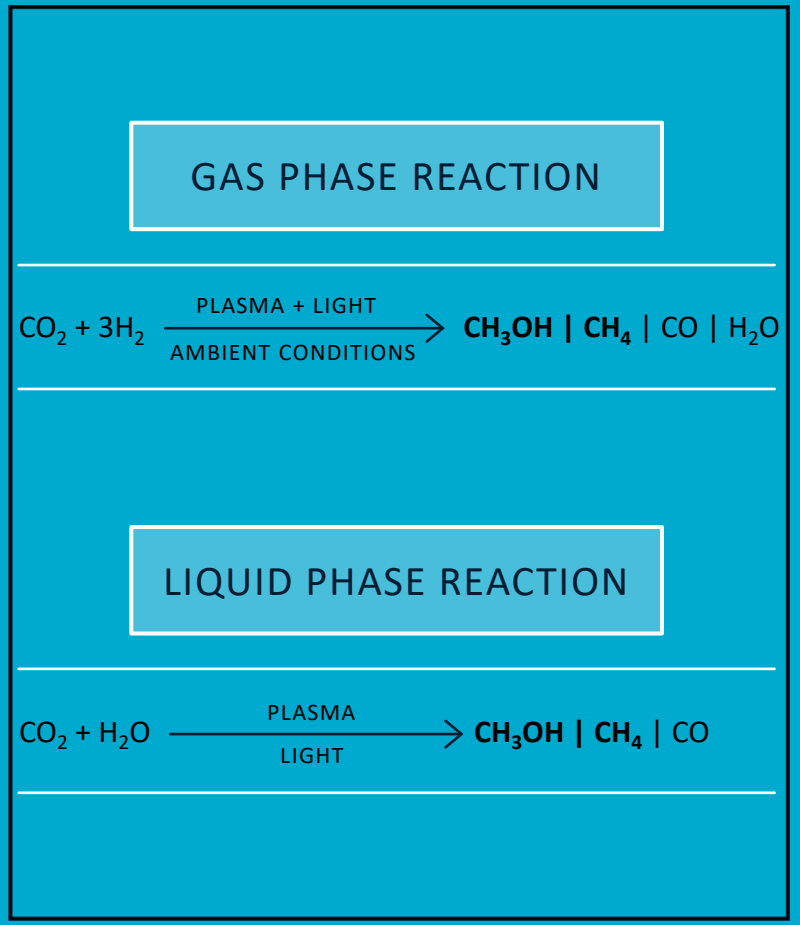


Xin Yang, **Ben Clennell, Jason Czapla**, Chunhui Lu

ENERGY STORAGE R&D ACROSS CSIRO

Plasma enhanced CO_2 hydrogenation

- Ambient conditions
- ~150˚C
- ~80% conversion
- 99% CH_4 selectivity
- Well suited for RE
- Reactor design



Yunxia Yang
A/Prof Jason Scott (UNSW), Dr Emma Lovell (UNSW)
Karen Wilson (Griffith University), Adam Lee (Griffith University)

ENERGY STORAGE R&D ACROSS CSIRO

New Electrolyte Strategy

- Cheap
- Environmentally friendly
- Stable
- High voltage
- Fast kinetics and transport
- High solubility (capacity)

Tim Jones, Gavin Collis

High theoretical capacity over **50 Ah L^{-1}**

Precursors scaled to 50 g scale

Stable to strong acid and base for over 100 days

Tim Jones, Gavin Collis

RESS FSP PORTFOLIO

High power thermoelectric devices

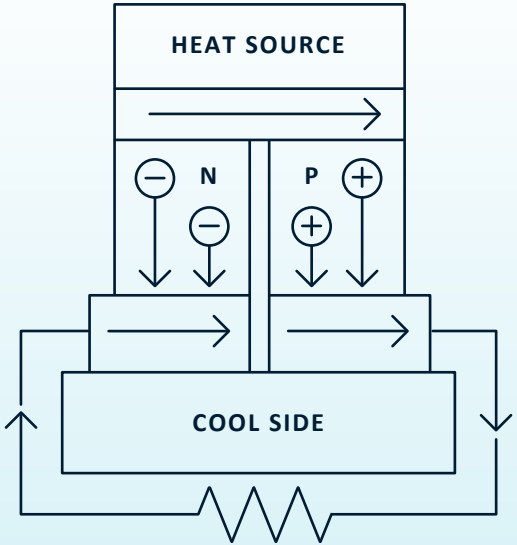


Figure of merit:

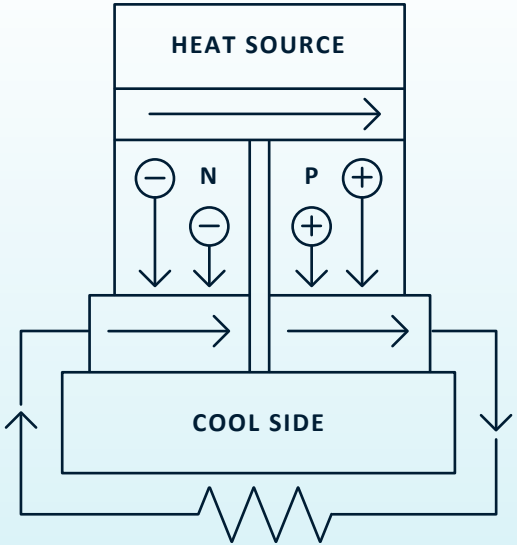
$zT = S^2\sigma T/(\kappa_e + \kappa_L)$,

Power Factor:

$PF = S^2\sigma$

A thermoelectric power generator.(Source: Wikimedia Commons).

High power thermoelectric devices



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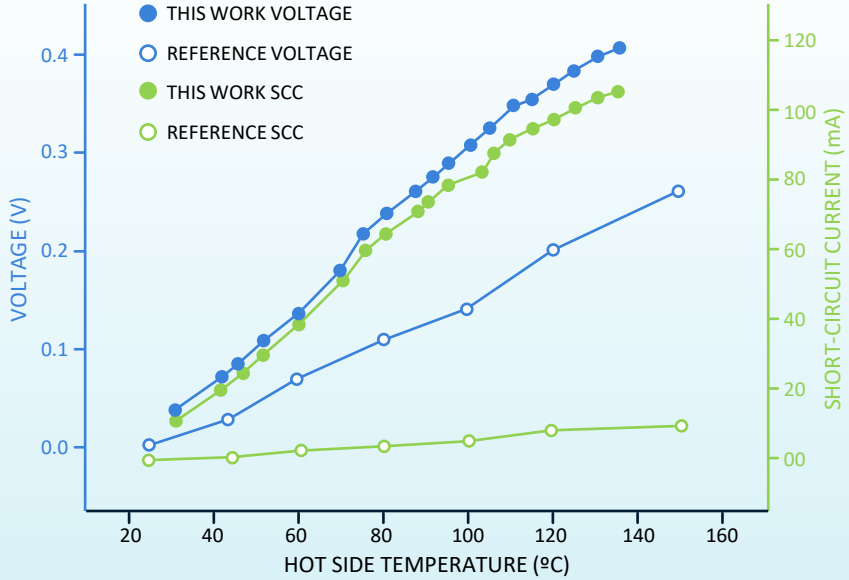


A thermoelectric power generator.(Source: Wikimedia Commons).

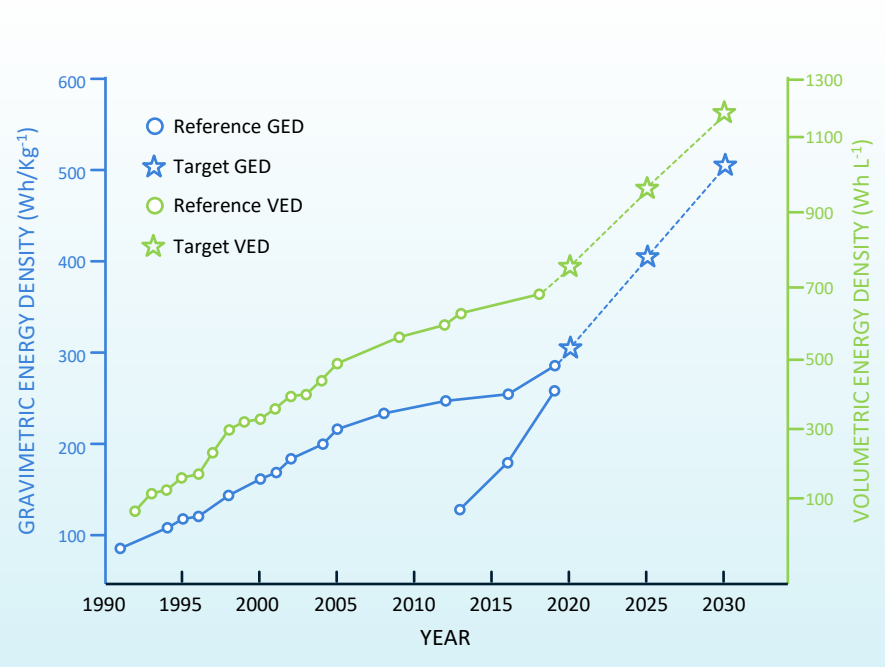
RESS FSP PORTFOLIO

High power thermoelectric devices

CSIRO CST-Steam power plant.
Heat loss: 52-67%.

Heat given off from Data centres that typically uses 120 MW per Facebook data centre at 50% efficiency can warm up homes of 10s thousands of people

Metal Air Systems



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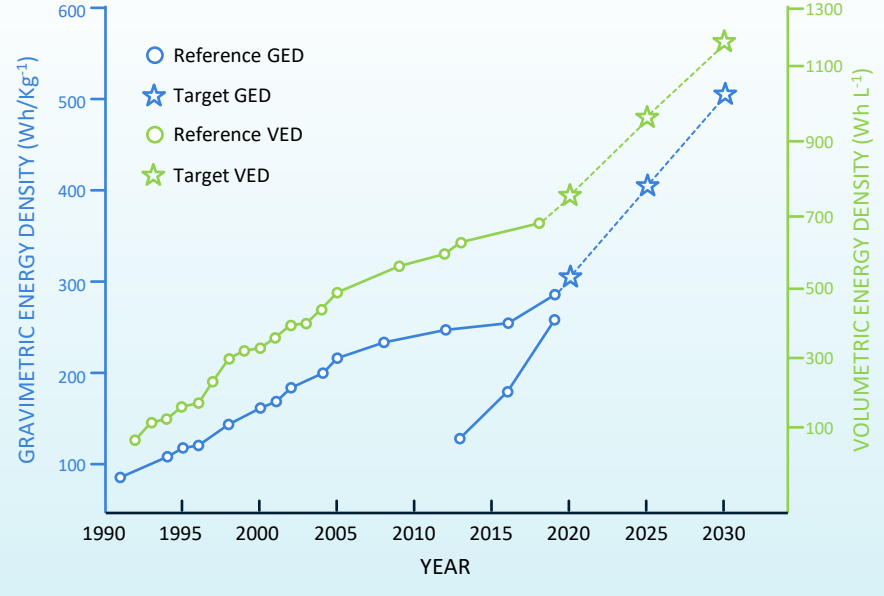
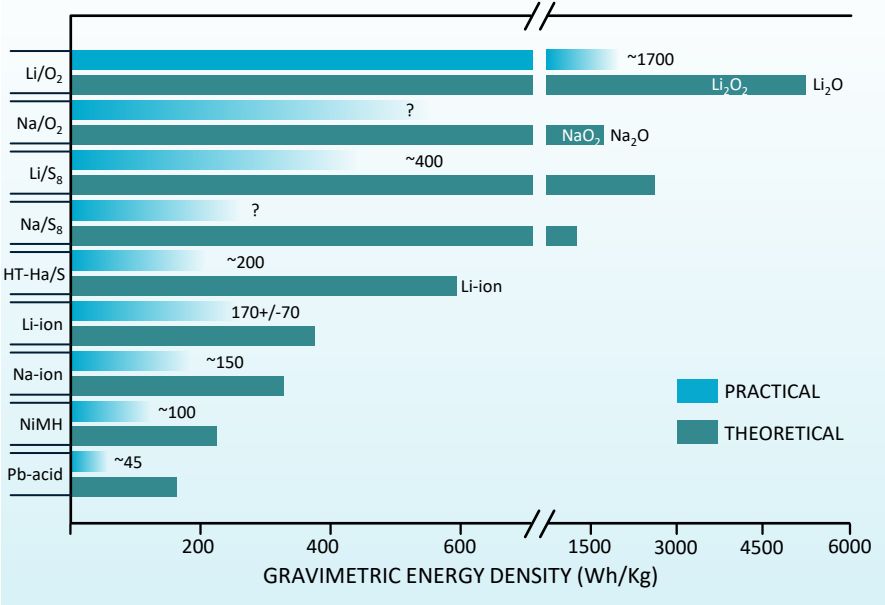
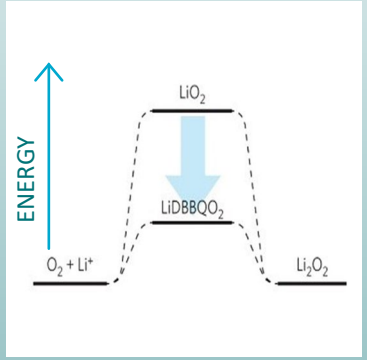


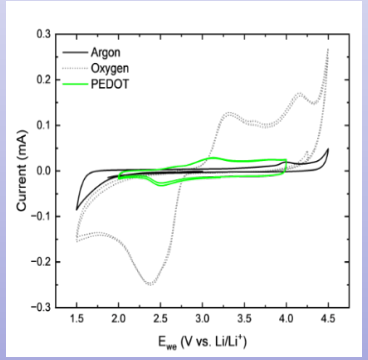


Metal Air Systems

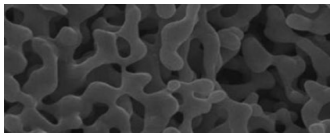
New electrolyte systems to reduce the charging over-potential



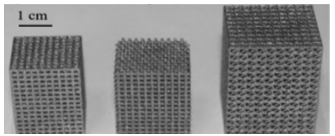
Nanomaterial catalysts to enhance kinetics of redox reactions



Stochastic (foam/mesh) and architected (micro-lattices/truss) metal and metal alloy cathodes to enhance oxygen permeability

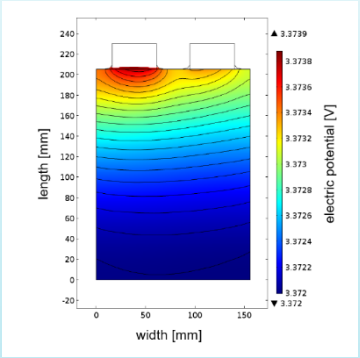


RANDOM POROUS STRUCTURE



LATTICE STRUCTURE

Modelling and simulation of electrochemical processes



Thank you
Questions?