Emerging Opportunities for Supercritical CO_2 Technology

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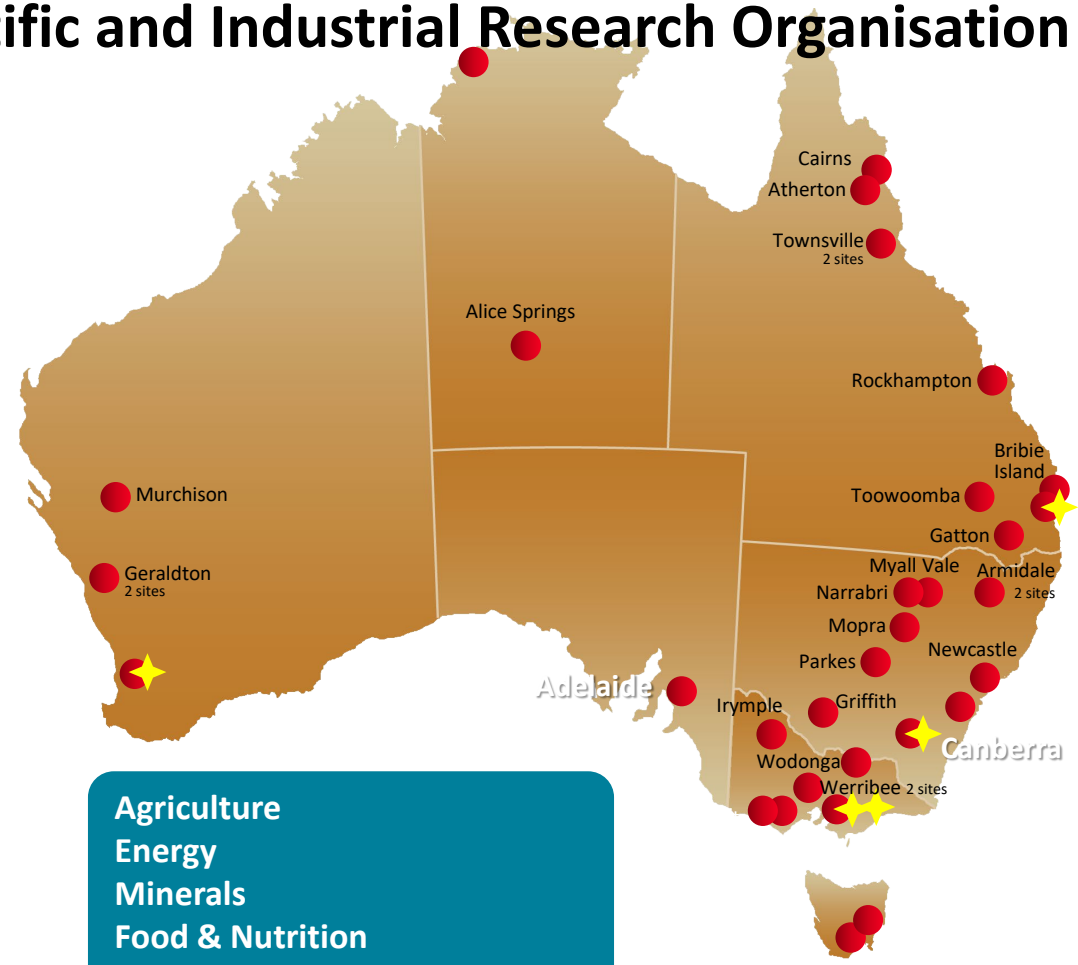
8th International Symposium on sCO_2

ENERGY
www.csiro.au

Commonwealth Scientific and Industrial Research Organisation

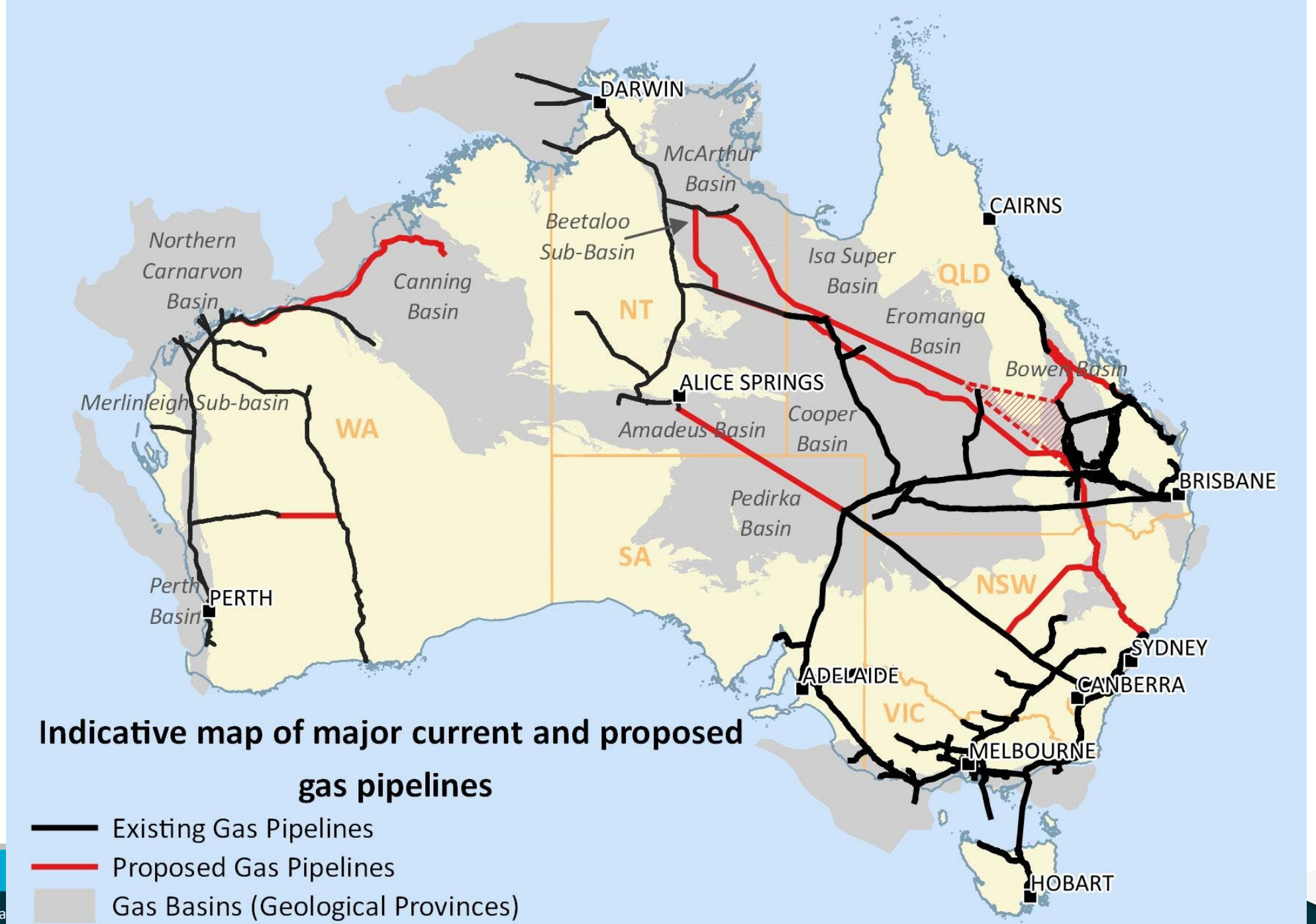
People	>6000
Locations	55
Business units	9
Budget	$1B+
Industry	2800+

Top 1% global research org.



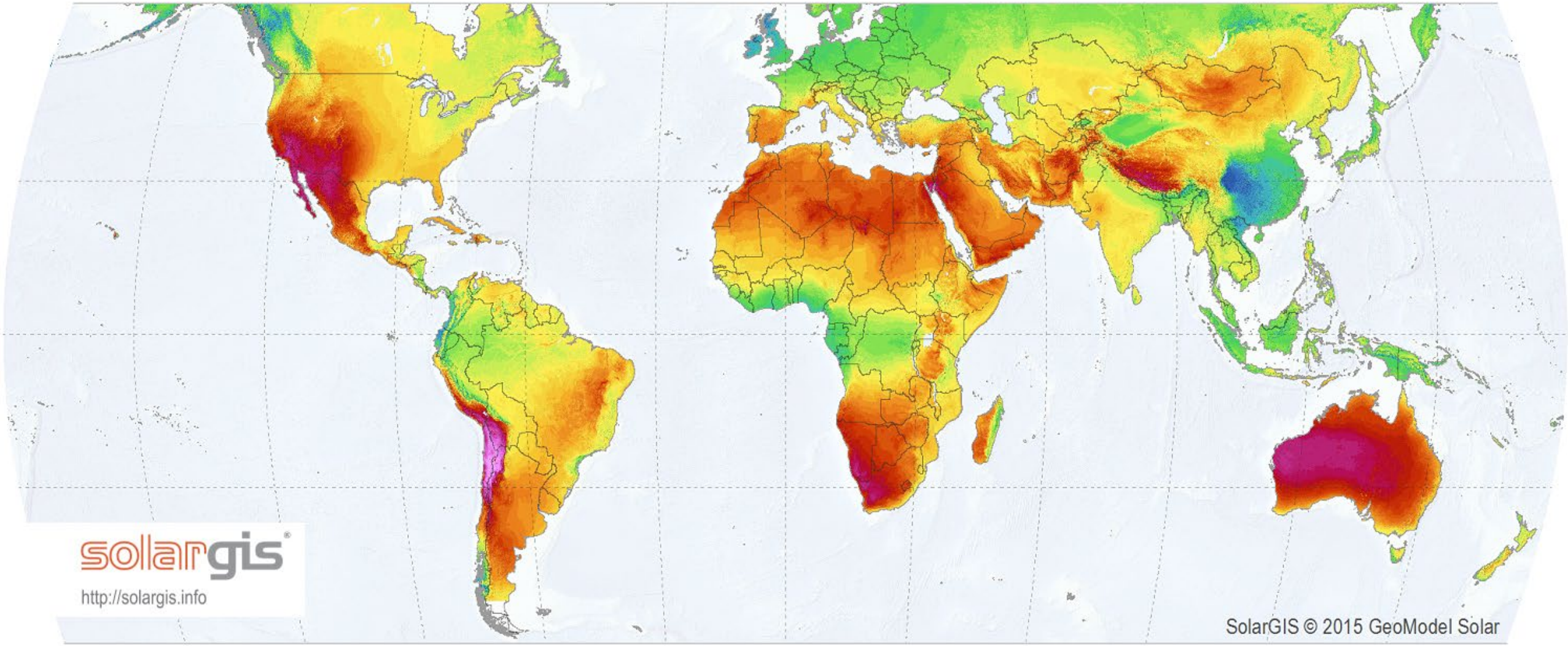
- Agriculture
- Energy
- Minerals
- Food & Nutrition
- Oceans & Atmosphere
- Land & Water
- Health & Biosecurity
- Manufacturing
- Data61

Transmission Infrastructure


DARWIN
McArthur Basin
Beetaloo Sub-Basin
Northern Carnarvon Basin
Canning Basin
NT
Isa Super Basin
QLD
CAIRNS
Eromanga Basin
Bowen Basin
ALICE SPRINGS
Merlinleigh Sub-basin
WA
Amadeus Basin
Cooper Basin
BRISBANE
Pedirka Basin
SA
NSW
Perth Basin
PERTH
SYDNEY
ADELAIDE
CANBERRA
VIC
MELBOURNE
HOBART
Indicative map of major current and proposed gas pipelines
Existing Gas Pipelines
Proposed Gas Pipelines
Gas Basins (Geological Provinces)

DIRECT NORMAL IRRADIATION

GeoModel SOLAR



Long-term average of

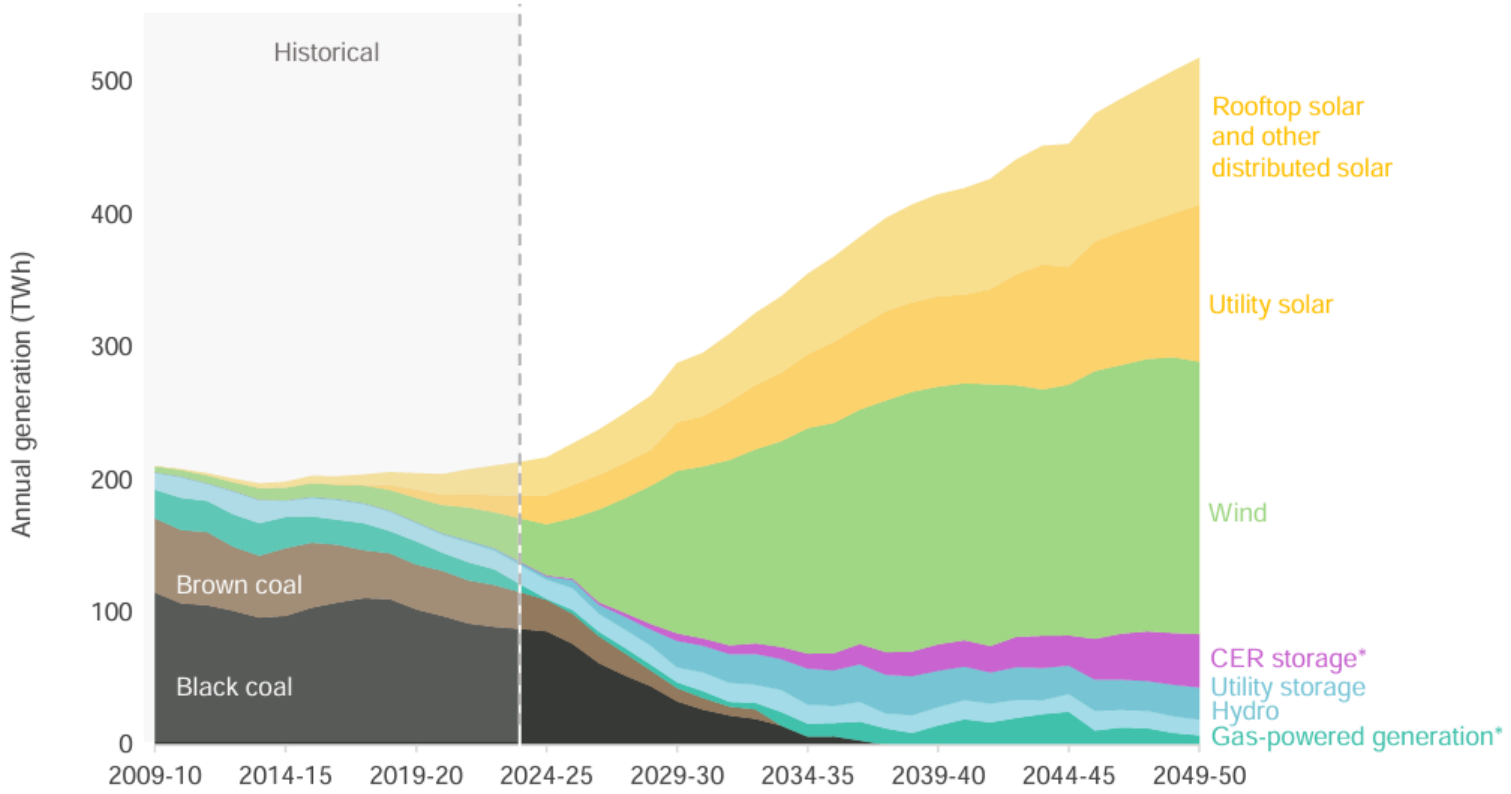
annual sum < 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 >

daily sum < 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 >

kWh/m²

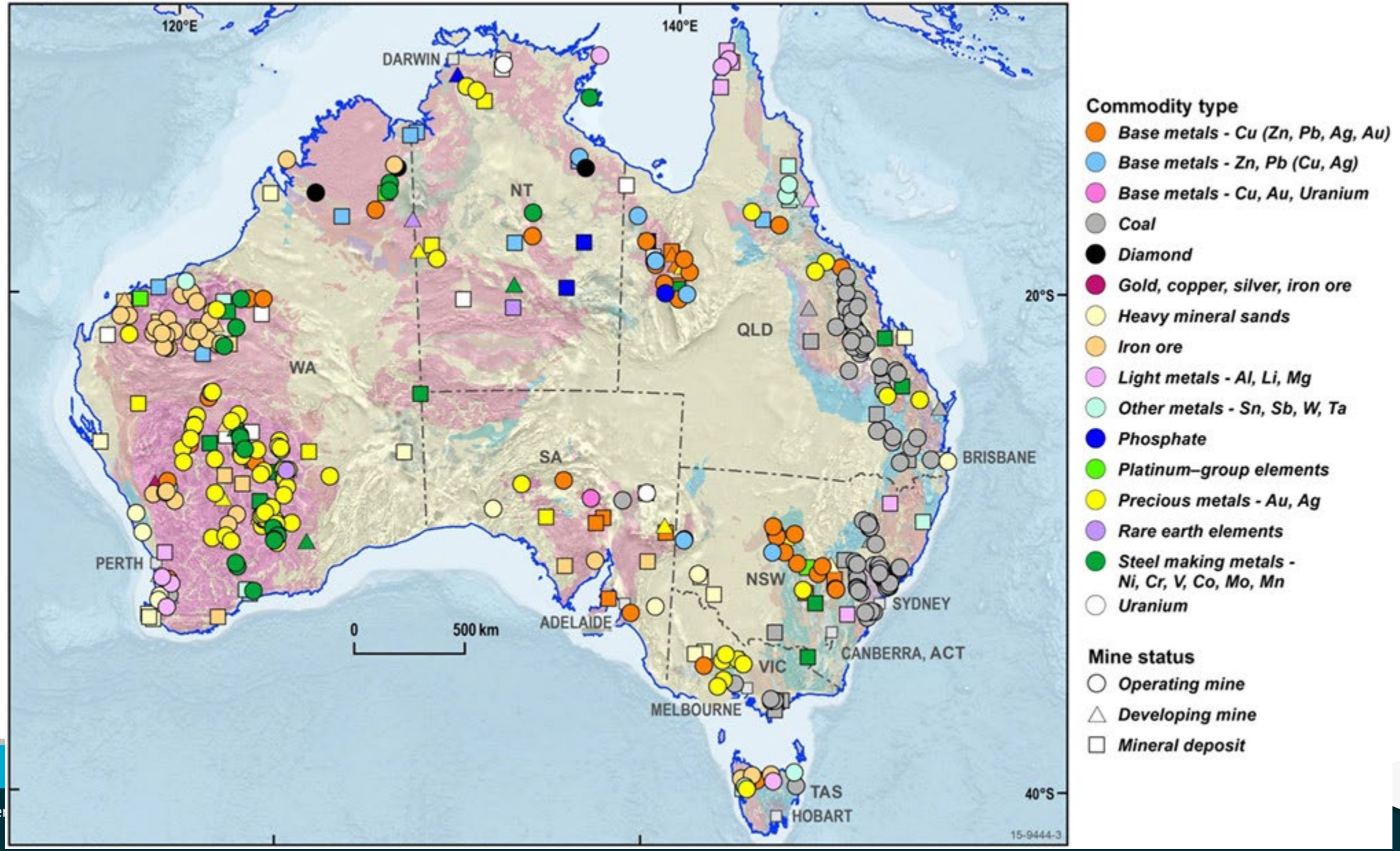
Integrated System Plan for Australian Electricity Generation

Figure 9 **Generation mix, NEM** (TWh, 2009-10 to 2049-50, *Step Change*)

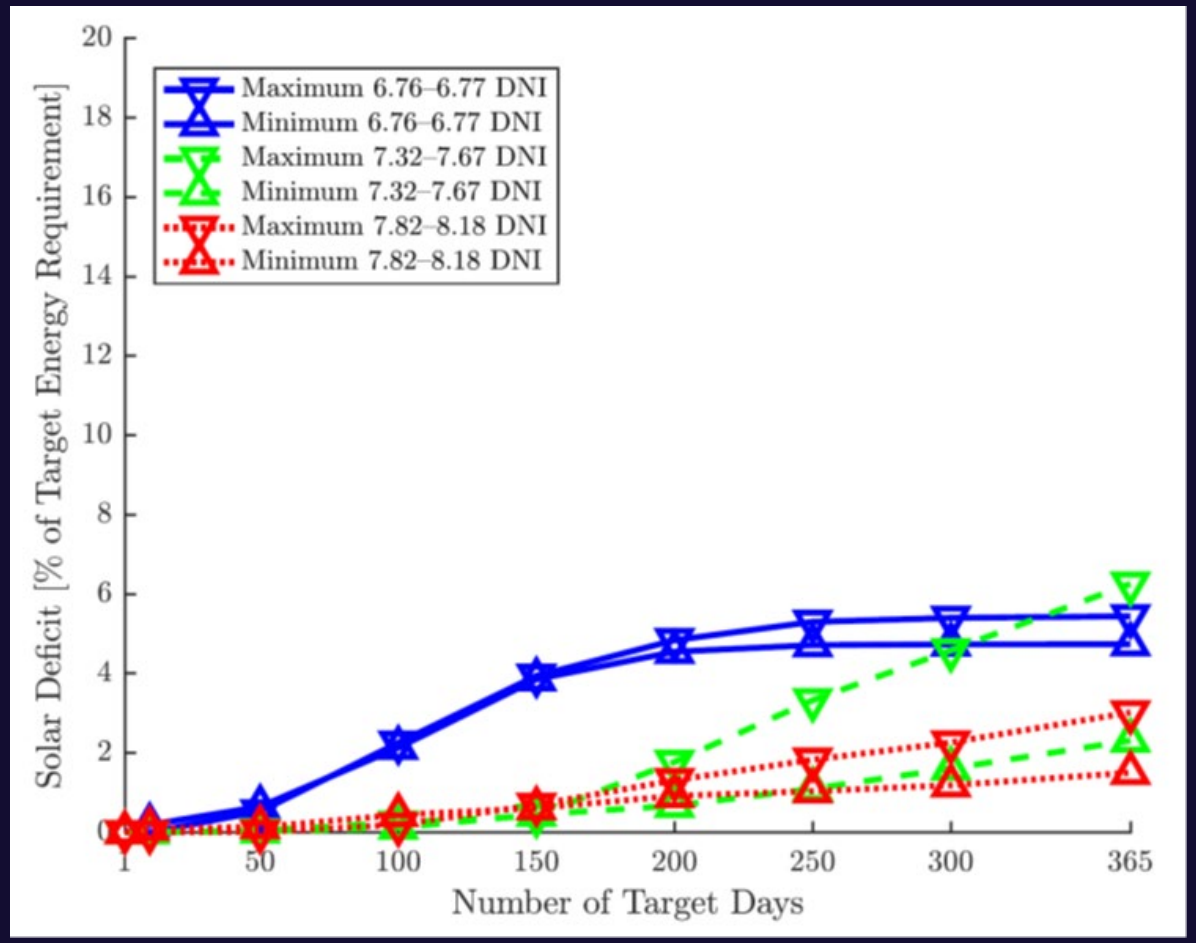


Notes: Annual generation for 2023-24 has been estimated for the full financial year.
The forecasted gas-powered generation includes some potential hydrogen and biomass capacity.
"CER storage" are consumer energy resources such as batteries and electric vehicles.

Major mining and mineral deposits in Australia



CSP with natural gas backup

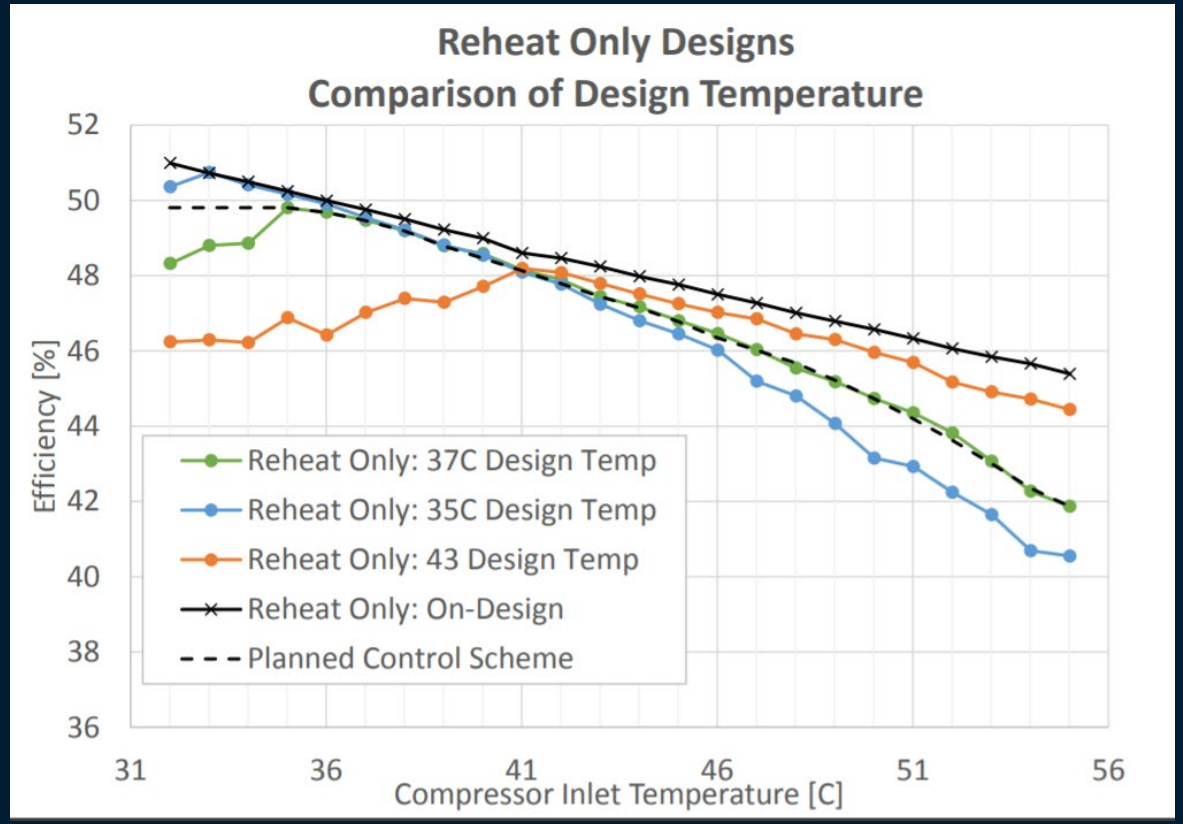


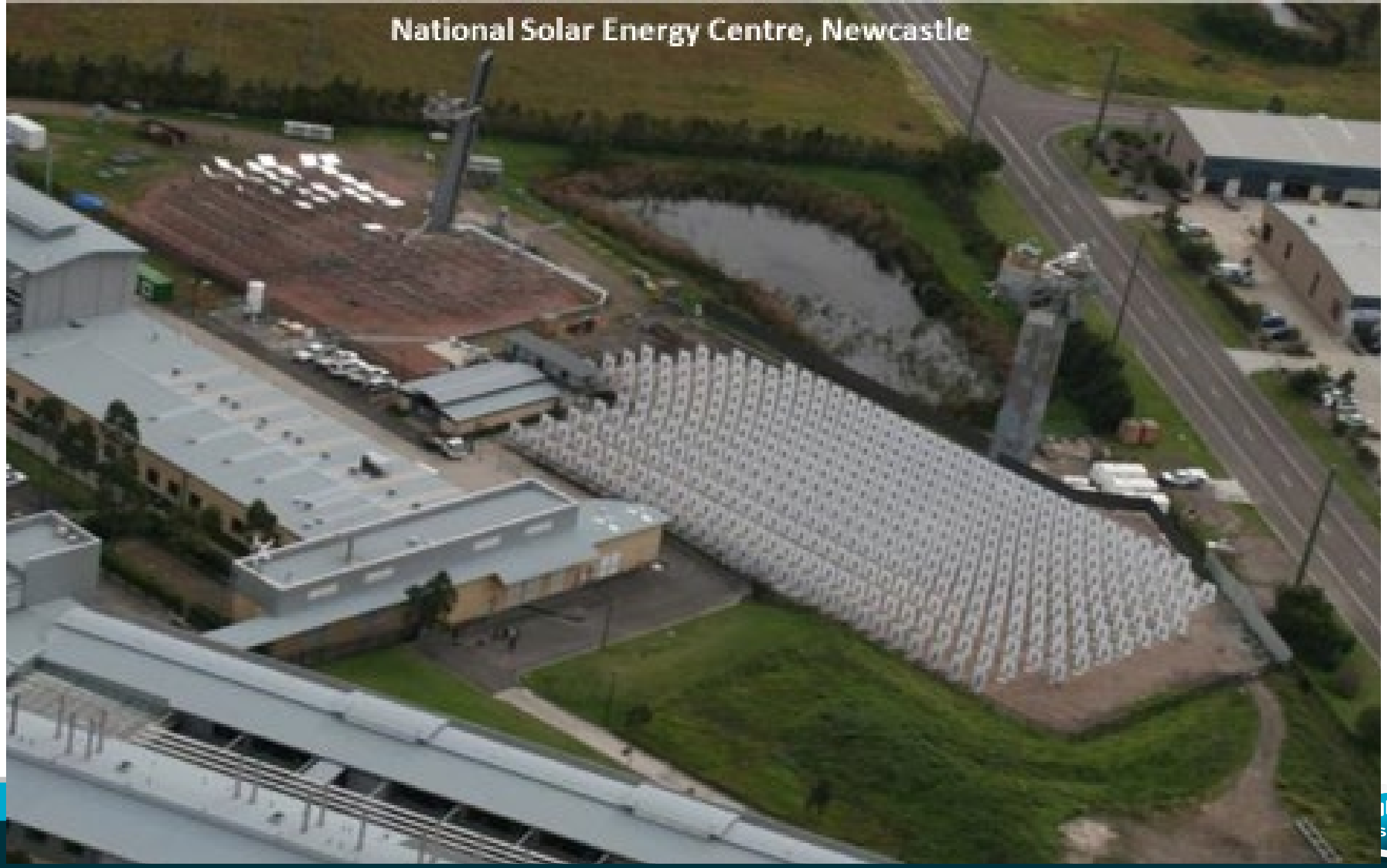
Yagi, Sioshansi, Denholm. *Solar Energy, 191*, **2019**, 686

- A CSP plant with 12 hours of storage can provide 365 day capacity with 2-5% of the fuel consumption of a natural gas plant

Performance at high $T_{ambient}$

- sCO_2 cycles will ideally operate at or near the critical point in order to reduce compressor work
- With dry cooling, high ambient temperatures + the air cooler initial temperature difference can see CIT>50°C, well away from $T_{critical}$
- Solution?
  - Have a design point configuration based on a higher CIT
  - CIP (inventory management) can be used to optimise efficiency when $T_{ambient}$ + ITD is above the design point CIT




National Solar Energy Centre, Newcastle

Next gen CSP in Australia

CSP hybrids

- variety of configurations with PV or gas

Receivers

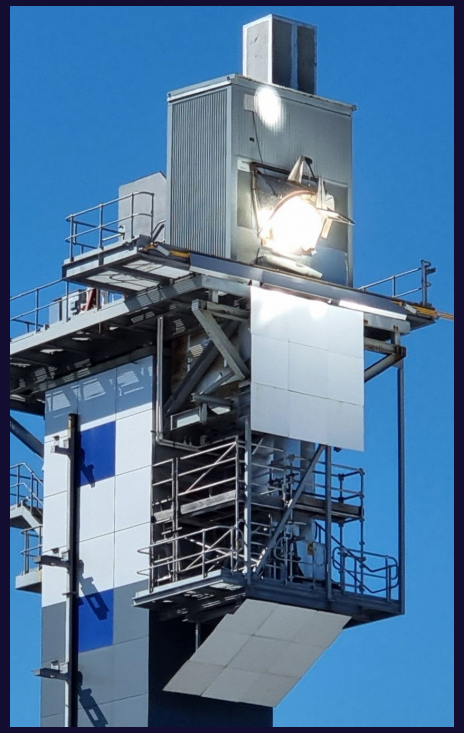
- Higher temperatures
- Receivers using single phase HTF (particles, Na)
- Volumetric receivers (air)

Thermal storage

- Higher storage temperatures (energy density)
- Thermochemical systems (displacing gas use, or making green fuels)

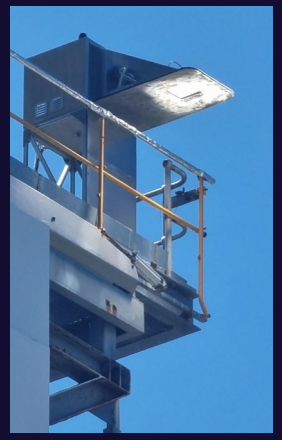
End use

- Advanced power cycles - s-CO_2
- Industrial process heat

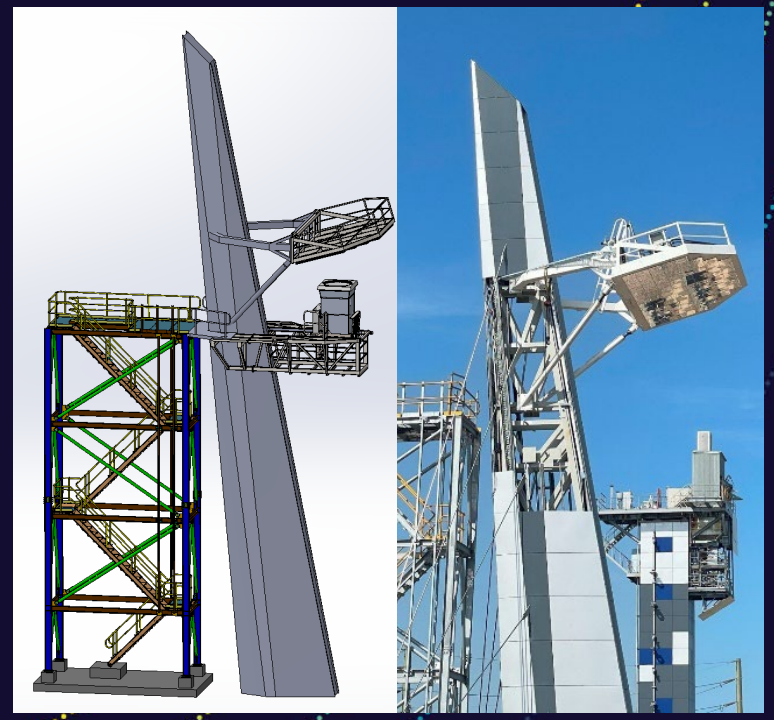


Particle receiver 800°C

Sodium Receiver 740°C



Sparc Hydrogen



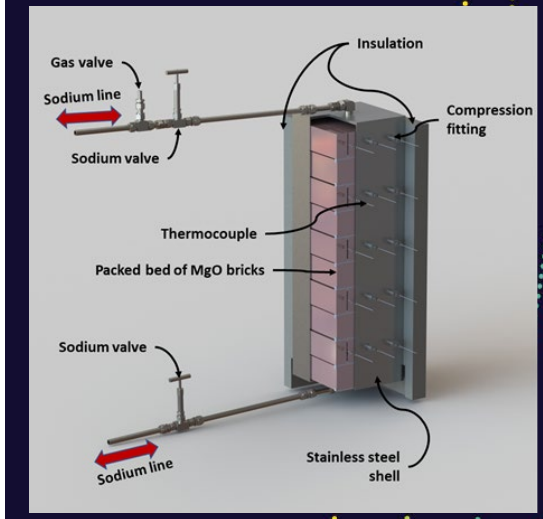
Beam-down thermochemical H_2

TES options for Na

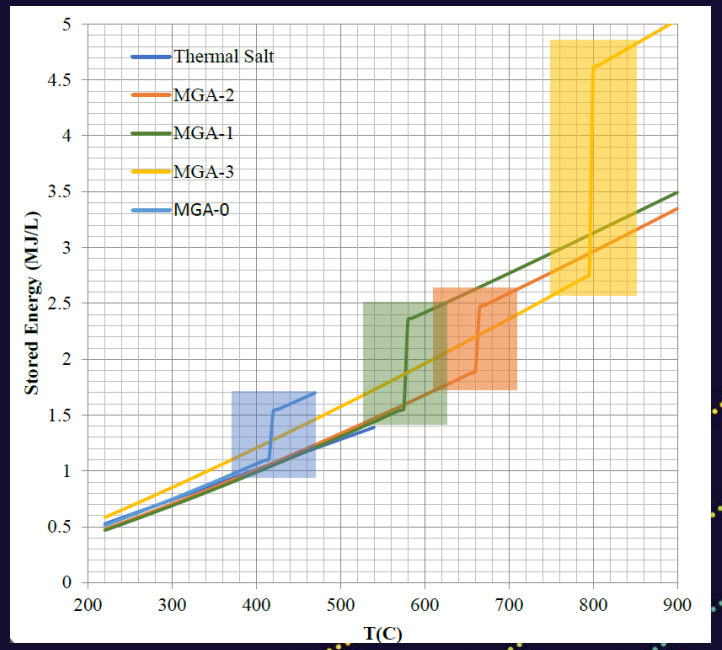
- ASTRI is developing sodium-cooled receivers for ≈650-700°C operation, thus conventional nitrate molten salts are not suitable for TES
- sCO_2 turbine cycles prefer a limited ΔT across PHX thus some level of phase change can be advantageous
- Aim to demonstrate sodium receiver on CSIRO solar tower in 2024.
- Followed by a demonstration of TES + sCO2 turbine

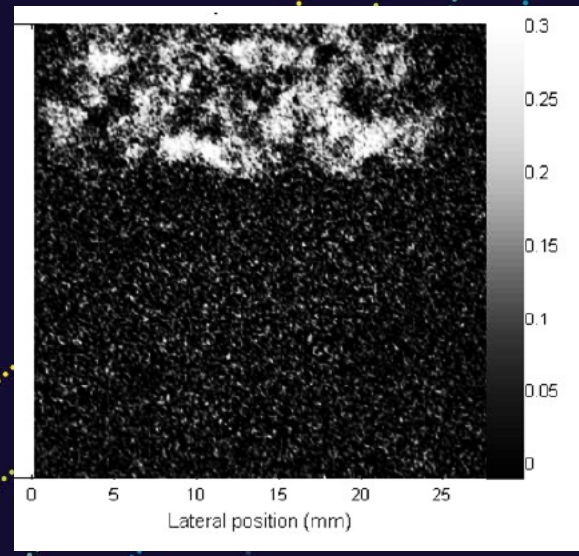
Sodium Test TES (ANU) Validation Rig 2.0

Courtesy Graphite Energy



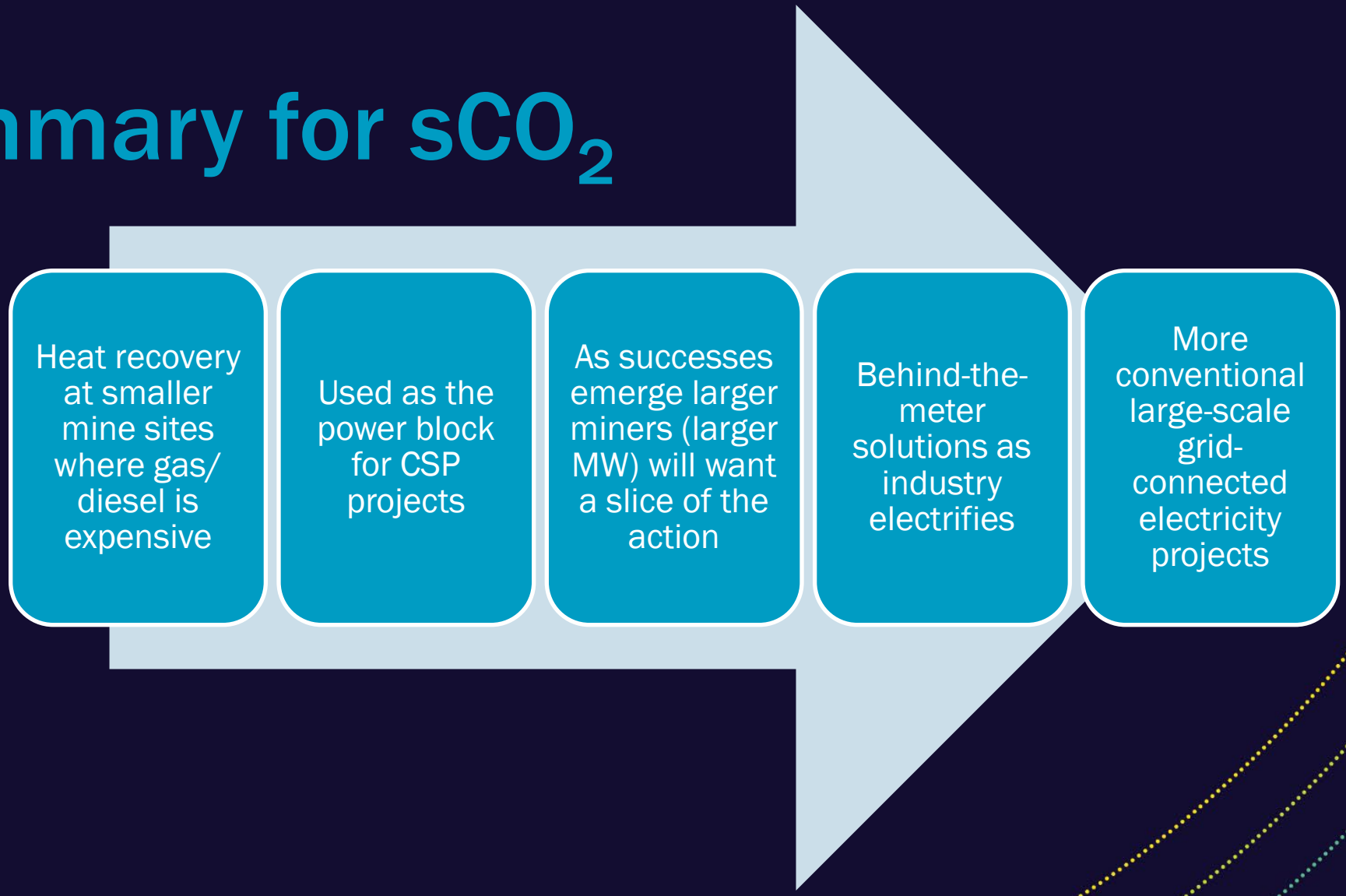
Courtesy ANU





Courtesy MGA Thermal

In summary for sCO_2



Thank you

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