Australian Government
Geoscience Australia

Evaluating Australia's energy commodity resources potential for a net-zero emission future

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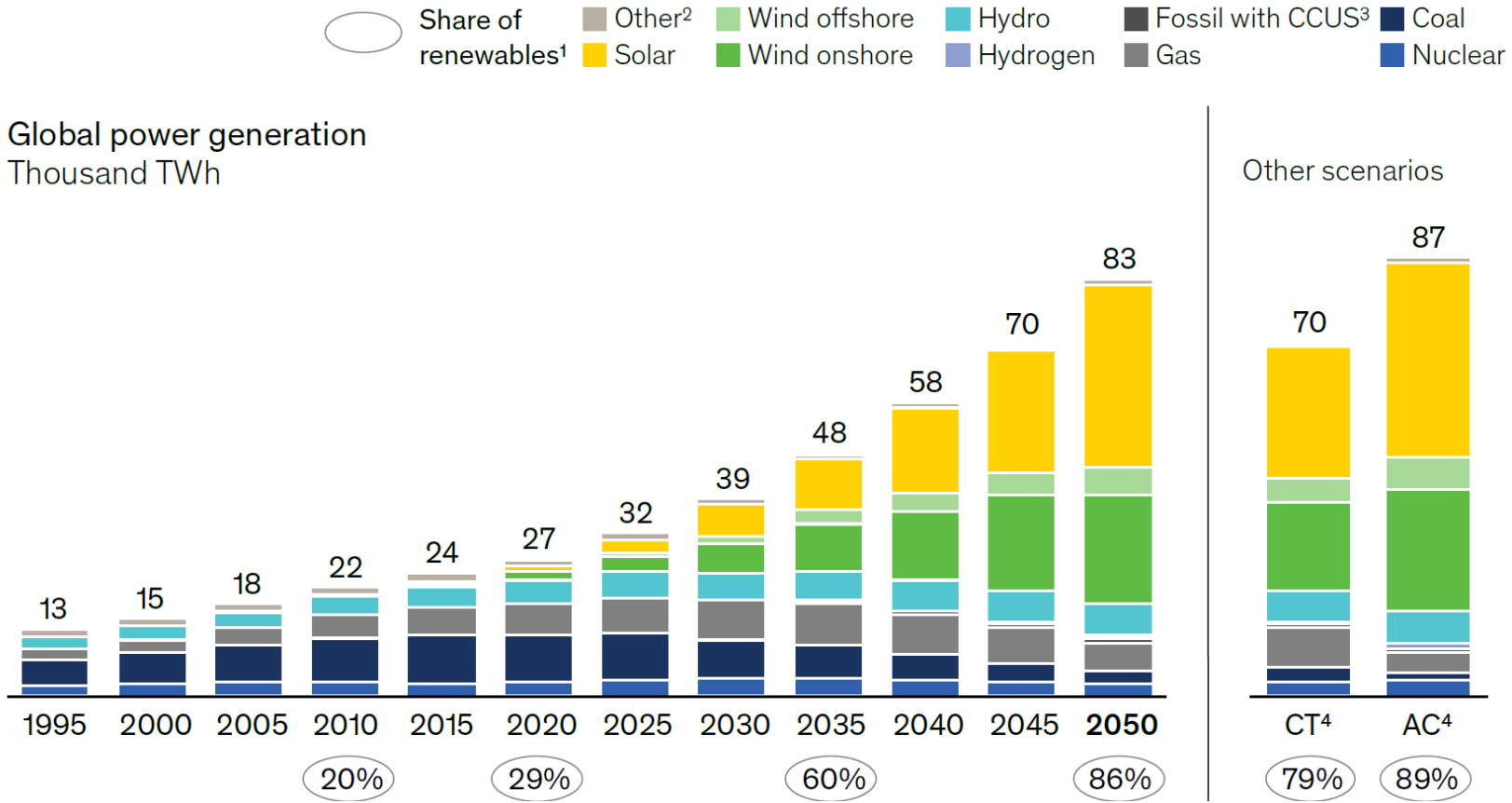
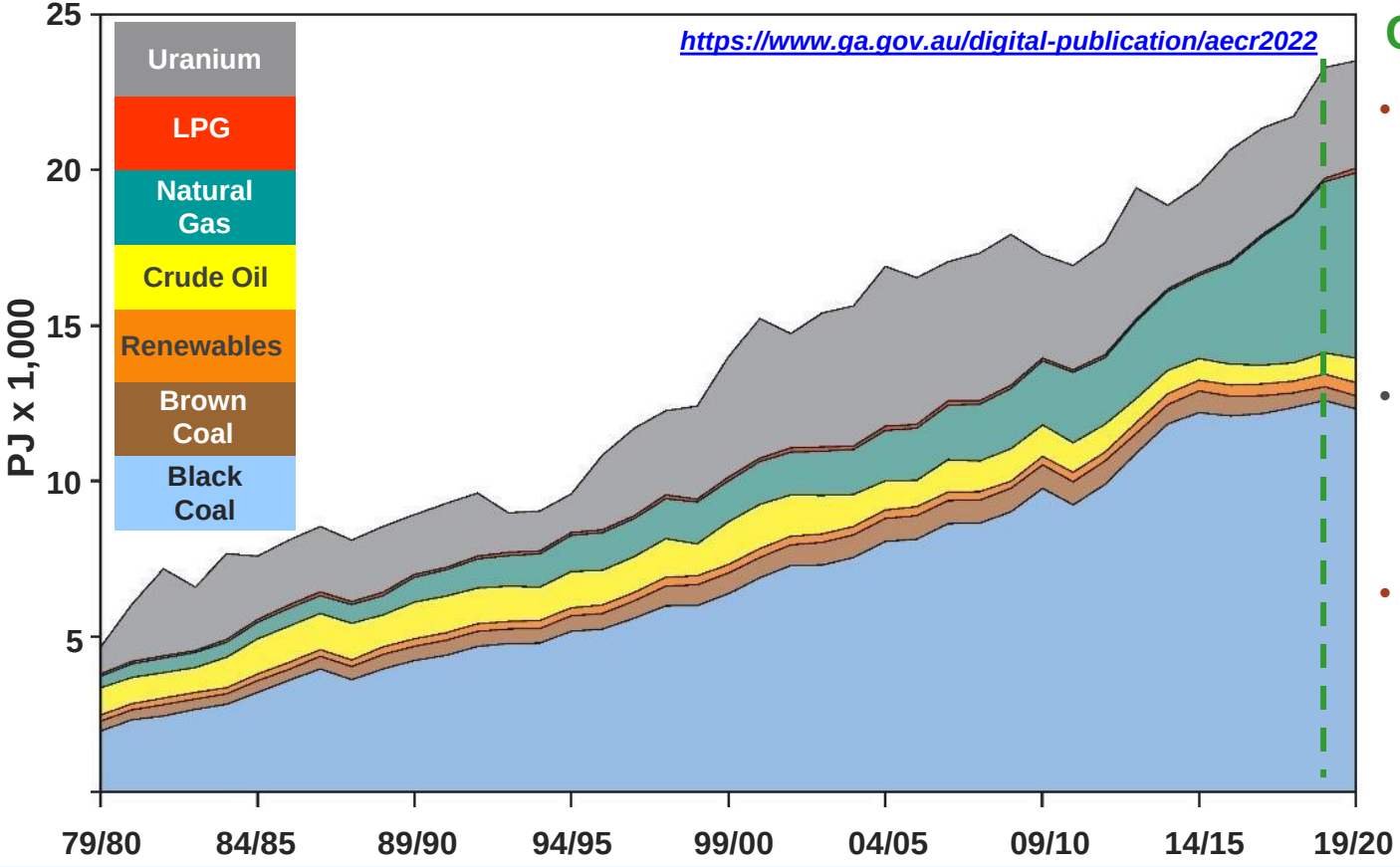
Minerals, Energy and Groundwater Division

Forecasting the global energy mix: 2022 model

Source: McKinsey Energy Insights Global Energy Perspective, April 2022



Australia's energy production (PJ), by fuel type, 1979/80 to 2019/20

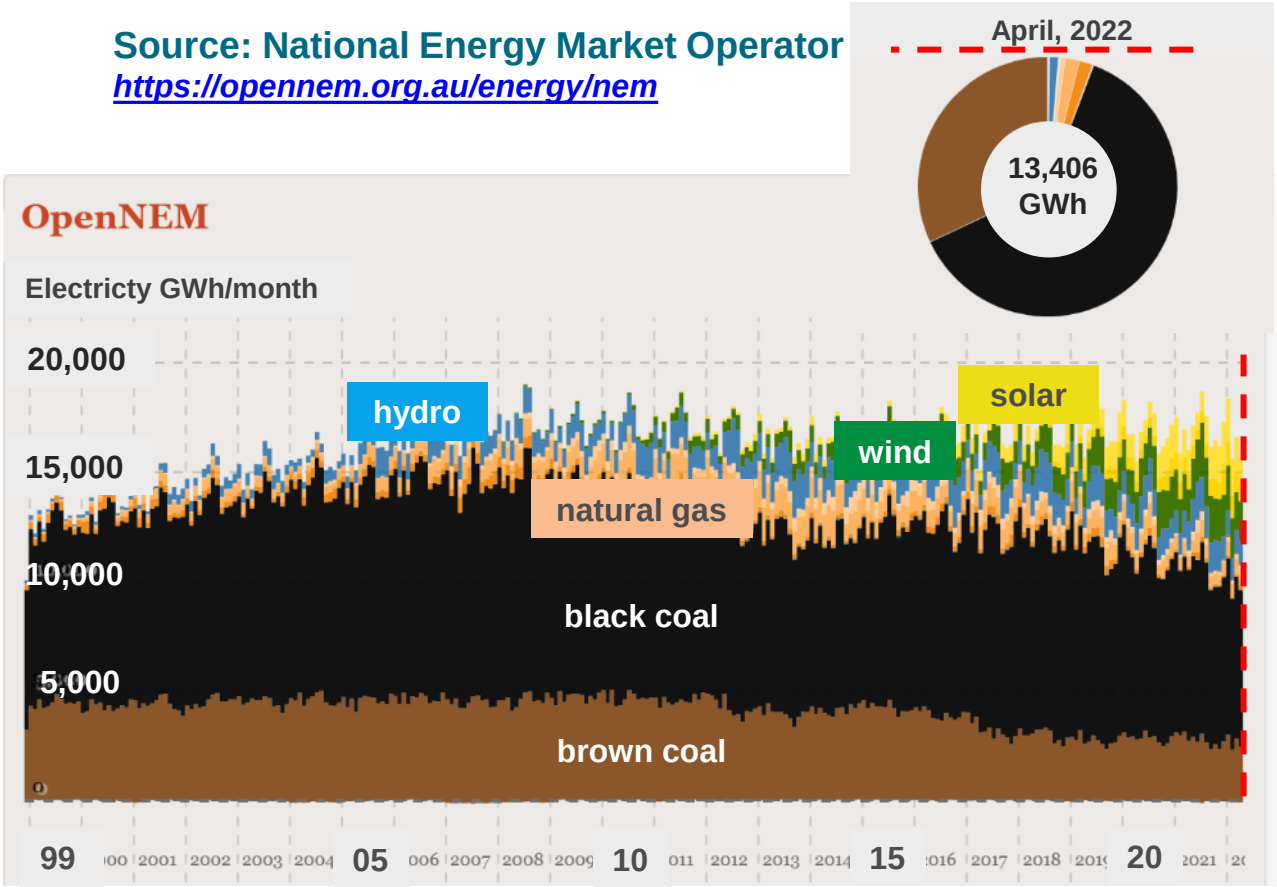


Compared to 2018/19:

- Black coal continues to be dominant fuel type, despite production decreased by 2% to 12,317 PJ
- Production of natural gas has increased by 7.9% to 5,945 PJ
- Renewables (solar, wind) account for 1.4% of total energy production, but have increased by 4.6% to 419 PJ *(32% of electricity generated)*

Australia's monthly electricity consumption (GWh), by fuel type, 1999-2022

Source: National Energy Market Operator
https://opennem.org.au/energy/nem

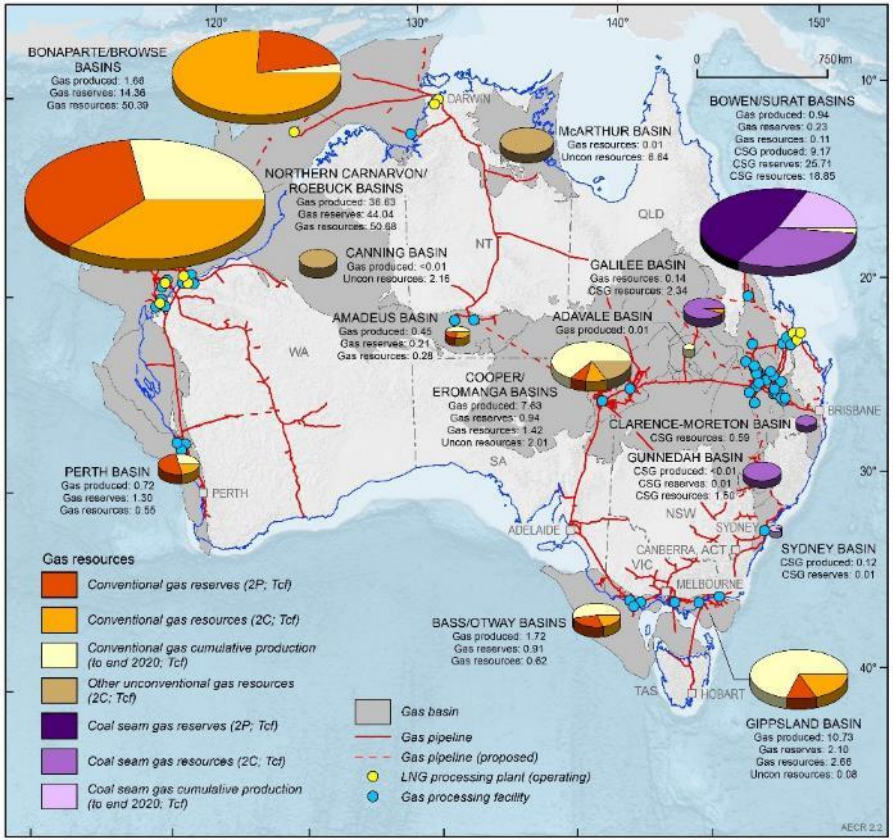


In April 2022:

- Black and brown coal contributed 80.2% (55.2% ; 25%) to energy consumption
- Renewables (hydro, wind, solar) contributed 11.6%
- Natural gas contributed 8.1% (reflecting that most gas is being exported)

Opportunity to decarbonise Australia's economy by utilising more natural gas for domestic energy generation

Australia's remaining gas reserves (2P) and contingent resources (2C) during 2020, and cumulative production to end 2020 (petajoules)

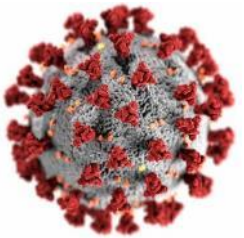


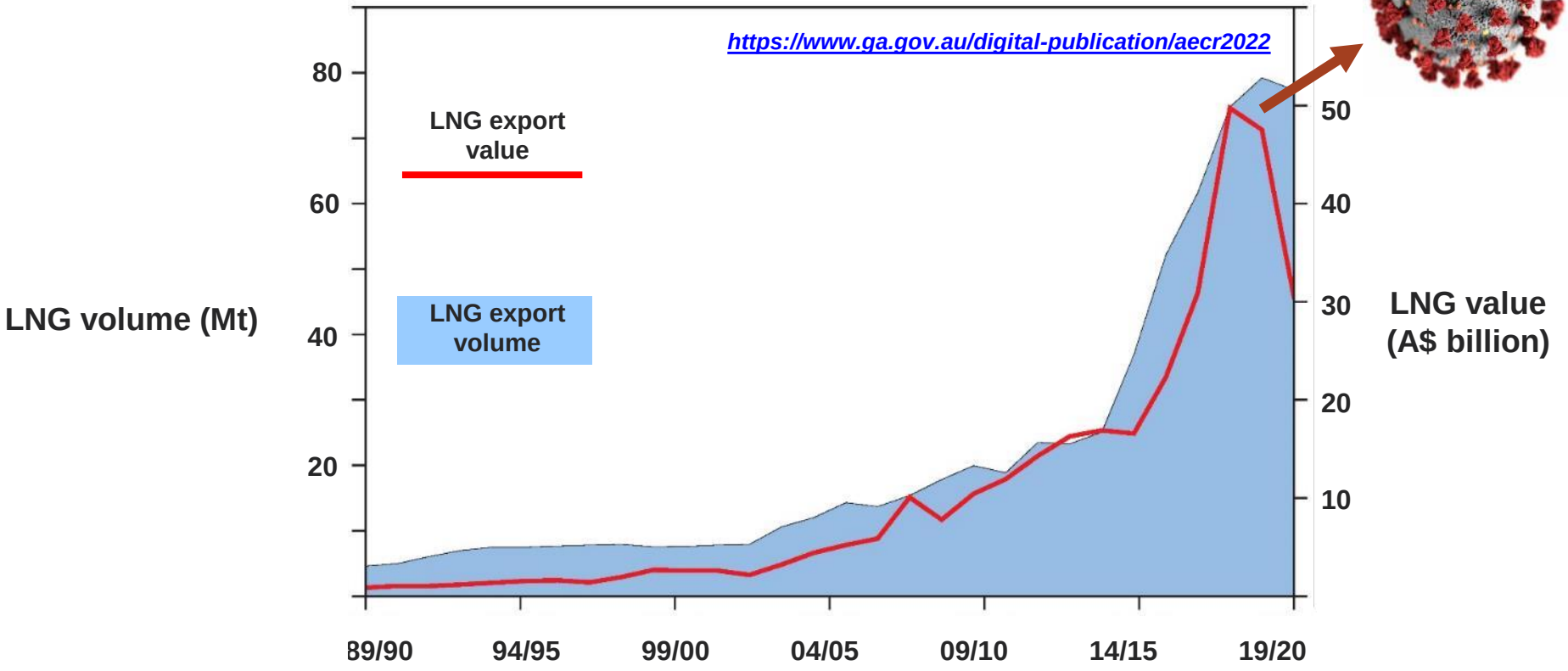
Sources: Geoscience Australia; GPInfo.
Pipeline routes from the GPInfo petroleum database.
Note: LNG = liquefied natural gas, Tcf = Trillion cubic feet.

https://www.ga.gov.au/digital-publication/aecr2022

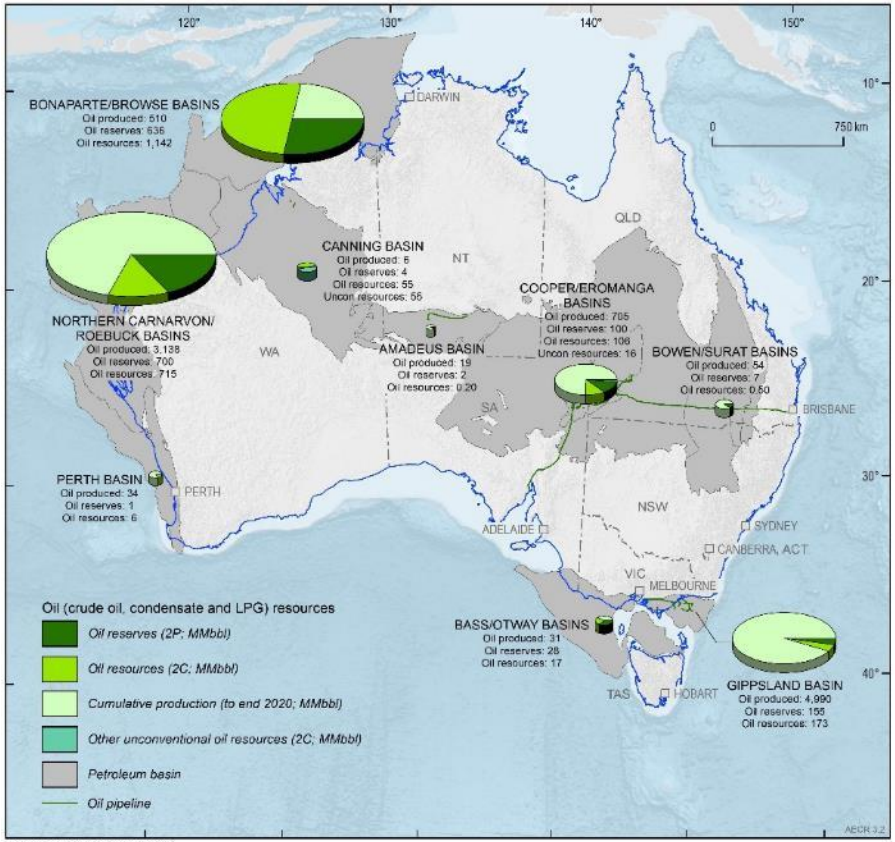
- Total conventional gas resources: 192,252 PJ (172 Tcf), lasting 42 years at current production levels
- Total coal seam gas resources (CSG): 55,131 PJ (49 Tcf), lasting 35 years at current production levels
- Total other unconventional gas resources (incl. shale gas, tight gas): 12,252 PJ (11 Tcf)

Australia's LNG export





Australia's remaining oil reserves (2P) and contingent resources (2C) during 2020 and cumulative production to end 2020 (MMbbl)



Sources: Geoscience Australia; GPInfo.
Pipeline routes from the GPInfo petroleum database.
Note: LPG = liquefied petroleum gas. MMbbl = Million barrels

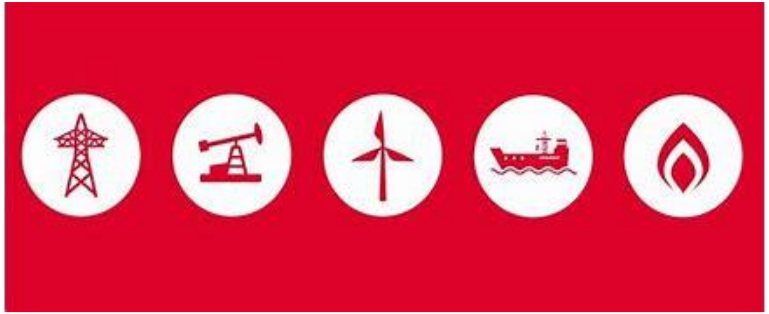
https://www.ga.gov.au/digital-publication/aecr2022

- Australia currently imports >80% of its oil requirements
- Existing producing fields in rapid decline
- New liquids province emerging in Roebuck Basin (Bedout Sub-basin)
- Total demonstrated resources (end December 2020): 5,205 PJ (878 MMbbl), 75 % of these are being exported
- Reliance on imports negatively impacts on energy security

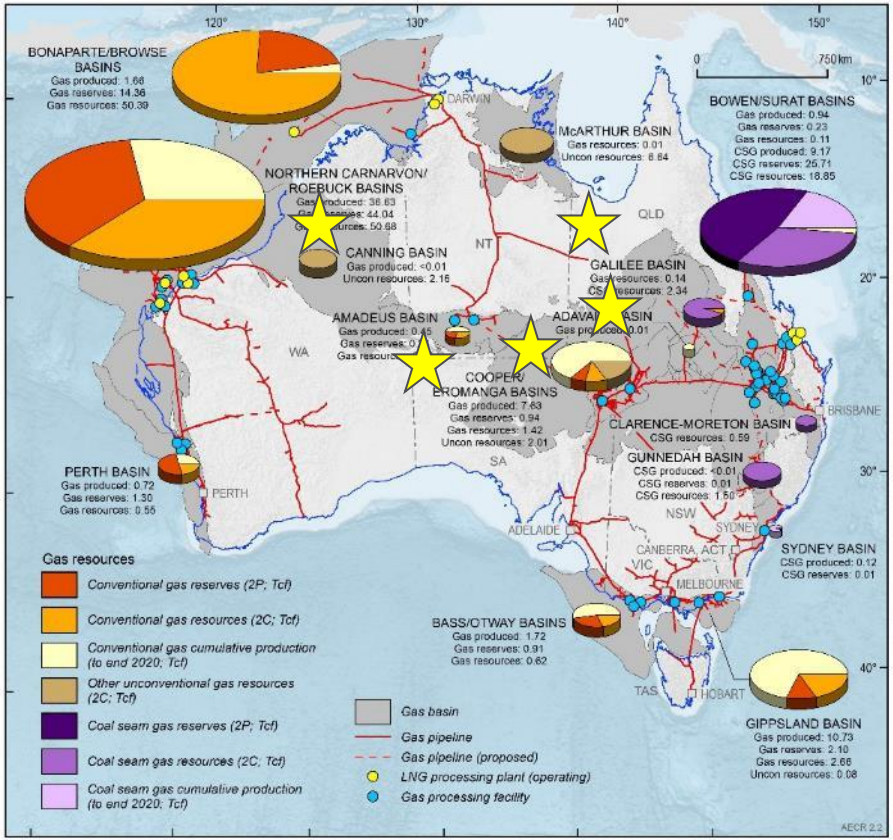
The future of Australia's energy resources

- Post-Covid 19 response to stimulate economy
- Secure and stable energy supply to enable expansion of domestic manufacturing
- Accelerate the transition to a low carbon economy
- Establish a world class hydrogen export industry

Geoscience Australia assesses the resource potential of those commodities that support the changing energy mix



Australia's low carbon energy resources potential: areas of interest



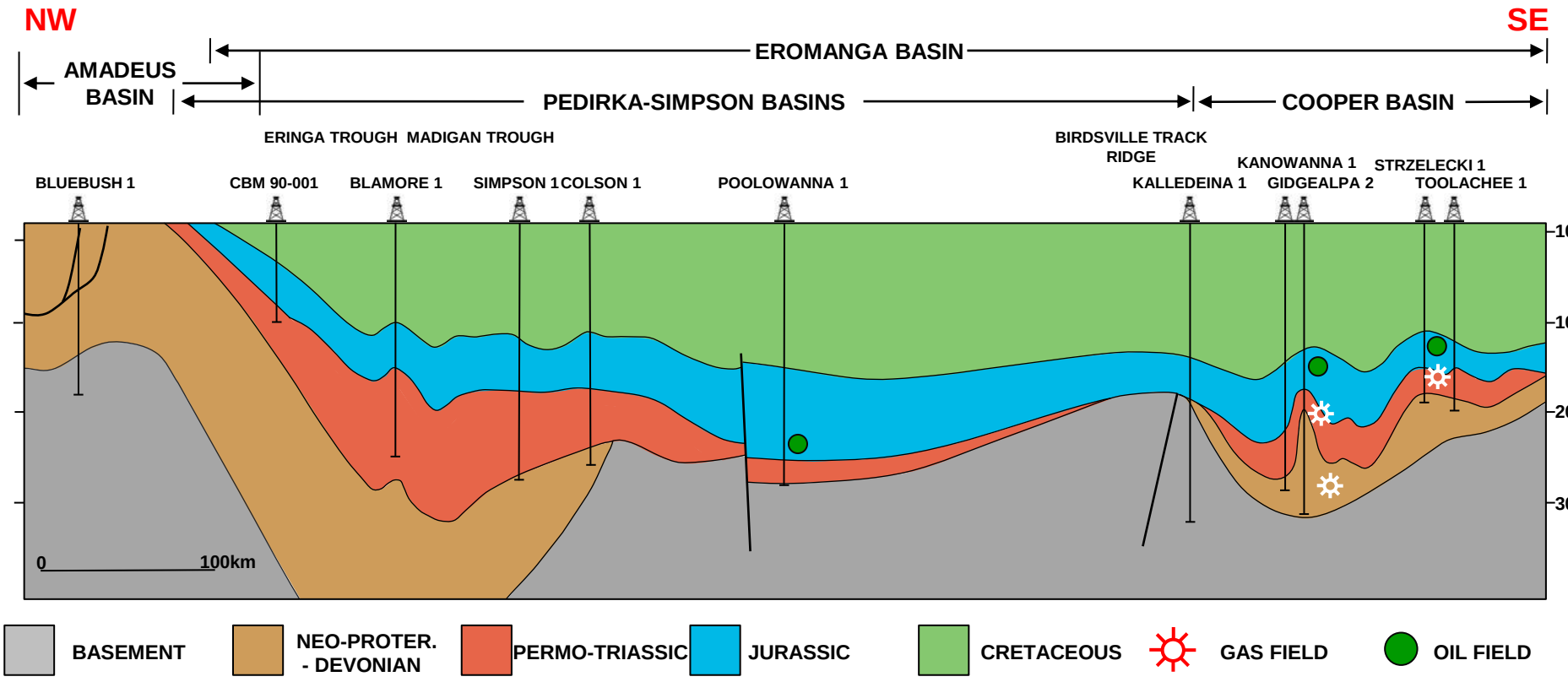
Sources: Geoscience Australia; GPInfo.
Pipeline routes from the GPInfo petroleum database.
Note: LNG = liquefied natural gas, Tcf = Trillion cubic feet.

https://www.ga.gov.au/digital-publication/aecr2022

- Pedirka/Simpson province
  - conventional oil, gas, coal seam gas;
  - deep-seated hot aquifers (for the production of hydrogen)
- Amadeus and Officer basins
  - conventional oil and gas, shale gas; hydrogen, helium, salt (for hydrogen storage)
- Adavale and Galilee basins
  - conventional gas, coal seam gas; salt
- South Nicholson Basin
  - shale gas
- Canning Basin (Kidson Sub-basin)
  - shale gas; salt

Legacy data, as well as new data indicate that these areas have resource potential, but to be developed require linkage to existing infrastructure

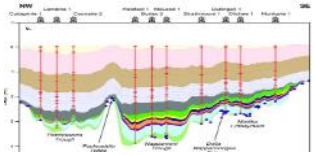
Regional cross section



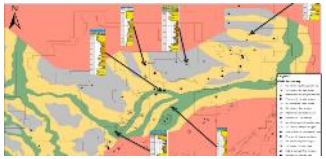
after: Meaney, 2009

Energy resource assessments: basin scale, multidisciplinary, multipurpose

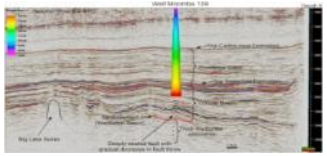
PETROLEUM SYSTEM STUDIES



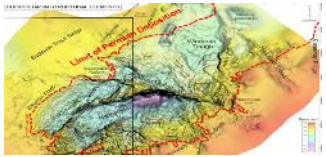
Play Correlations & Tops



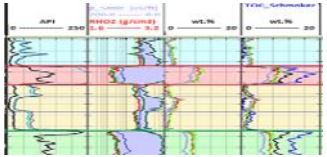
GDE Maps



Seismic Interpretation

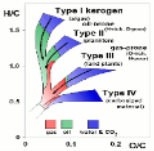


Depth & Isopach Maps

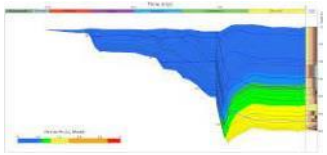


Petrophysical Analyses

Cores & Cuttings Analyses

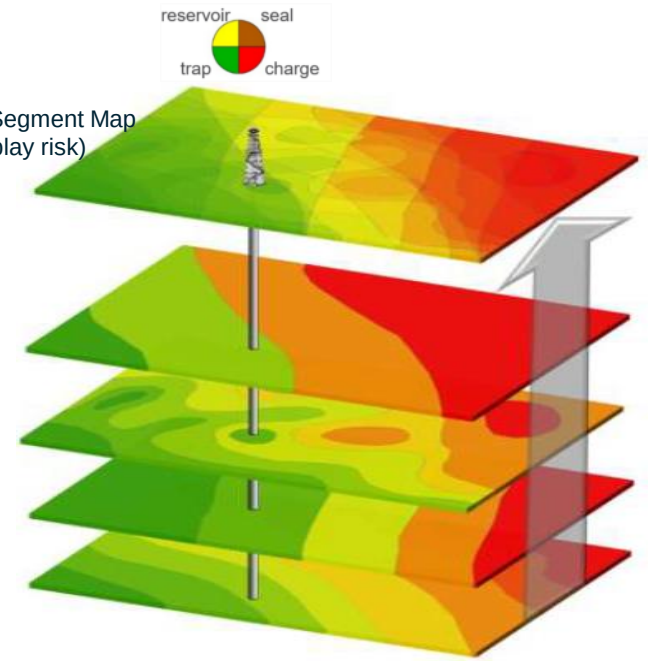


Source Rock & Fluid Analyses



Burial History & Charge

Result
Common Risk Segment Map
(shows overall play risk)



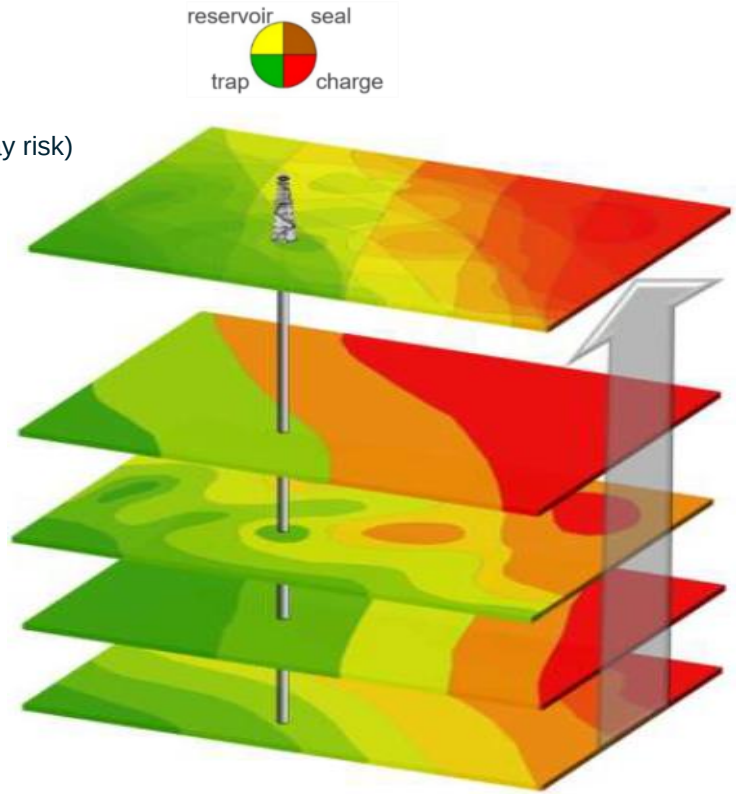
Charge (hydrocarbons)

Trap Presence

Seal Presence & Effectiveness

Reservoir Presence & Effectiveness

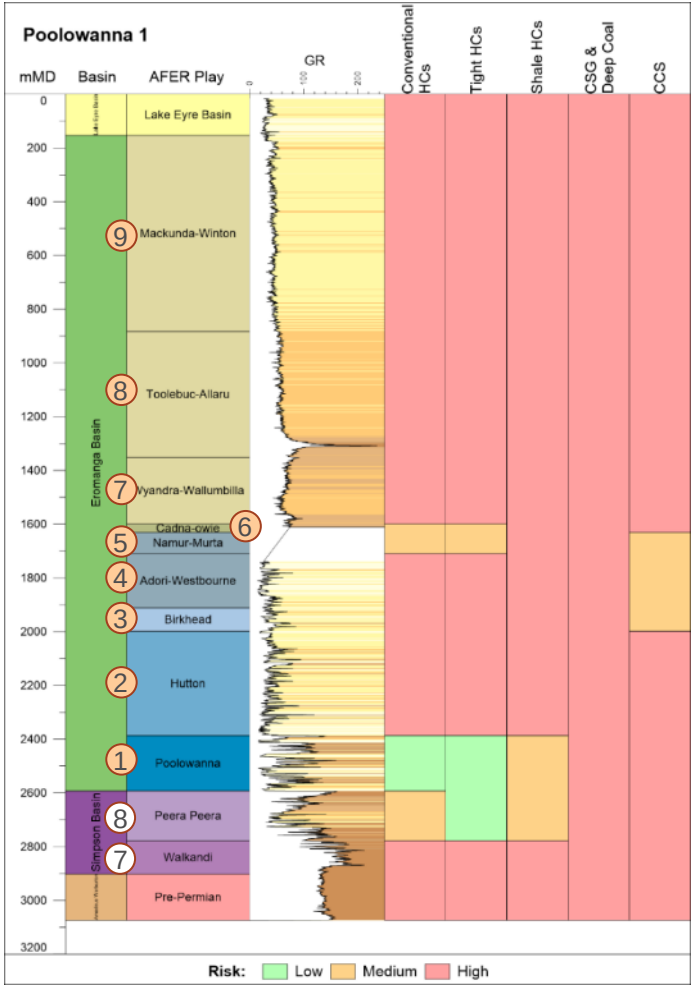
Energy resource assessments – approach, outcomes



- Quantitative, spatially-enabled play-based prospective resource assessments of conventional and unconventional hydrocarbons, following industry standards (utilising GIS-Pax Player™)
- Use play-based geological frameworks to identify exploration targets for other sub-surface resources (H_2 storage, CC(U)S, deep groundwater, sediment-hosted minerals)
- Develop improved understanding of regional geological framework for onshore Permian, Triassic, Jurassic and Cretaceous basins

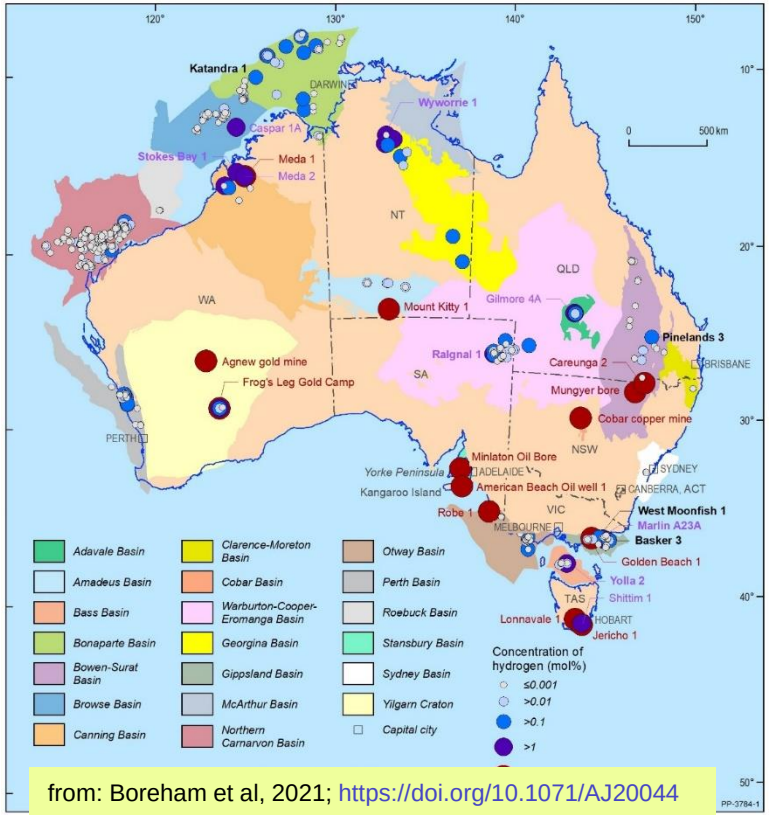
Post Drill Analysis

- Post Drill Analysis (PDA) being conducted on 36 conventional petroleum wells and 7 coal bed methane wells.
- PDA provides systematic approach is to evaluate discrete play intervals and trapping mechanisms
- Player software by GIS-Pax™ being used to evaluate the presence and effectiveness for the main conventional petroleum systems' play elements of reservoir, seal, trap and charge
- Methodology to assess conventional hydrocarbons has been modified to assess the elements and criteria essential for unconventional petroleum resources and CCS potential



Hydrogen

Location map showing exploration well, mine and groundwater samples with measurable concentrations of H_2 (mol%)



from: Boreham et al, 2021; https://doi.org/10.1071/AJ20044

≤0.001

>0.01

>0.1

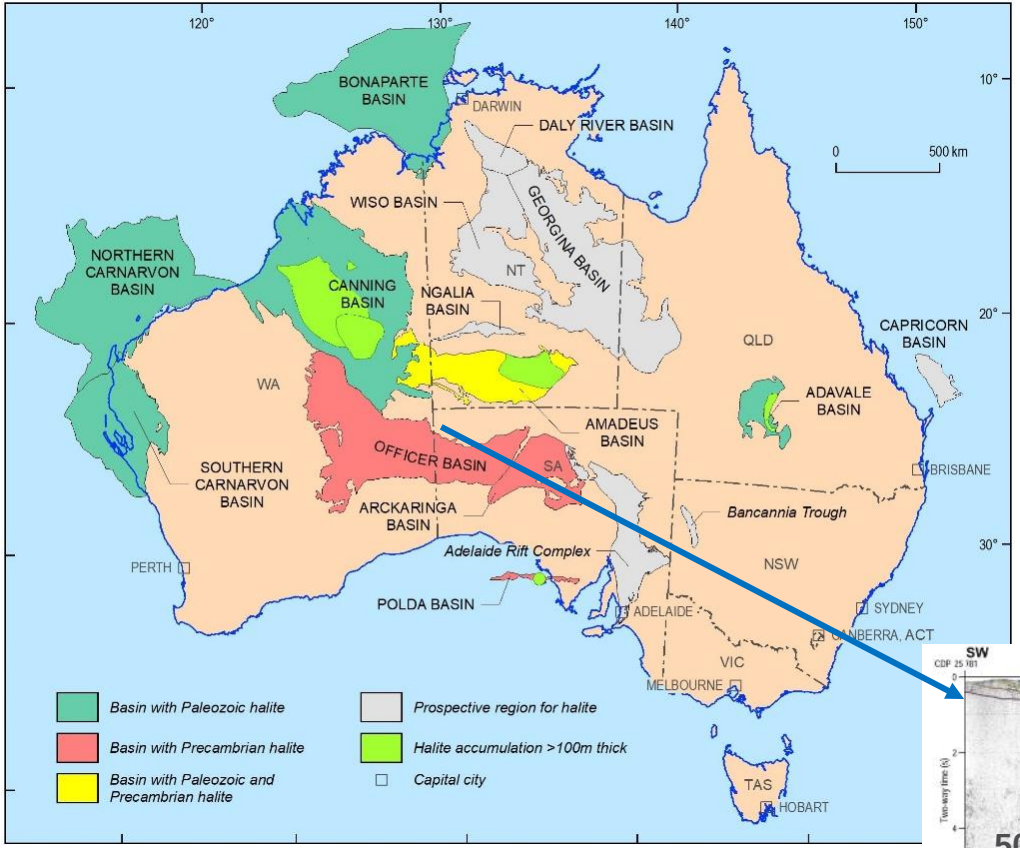
>1

>10

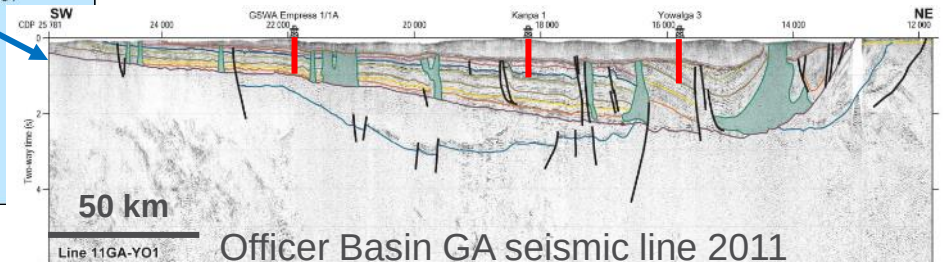
H_2 concentration (mol%)

- H_2-rich natural gases identified as early as 1917 (Yorke Peninsula; Kangaroo Island, SA)
- GA lab identified ~1000 natural gases from 470 wells that penetrated Neoarchean to Cenozoic reservoir rocks with detectable H2 levels of up to 91.9 mol%
- Gases with elevated H_2 contents a mixture of deep inorganic sources and decomposed organic matter at high maturities.
- Opportunity to discover natural H_2 in areas previously not targeted by petroleum exploration

Hydrogen storage



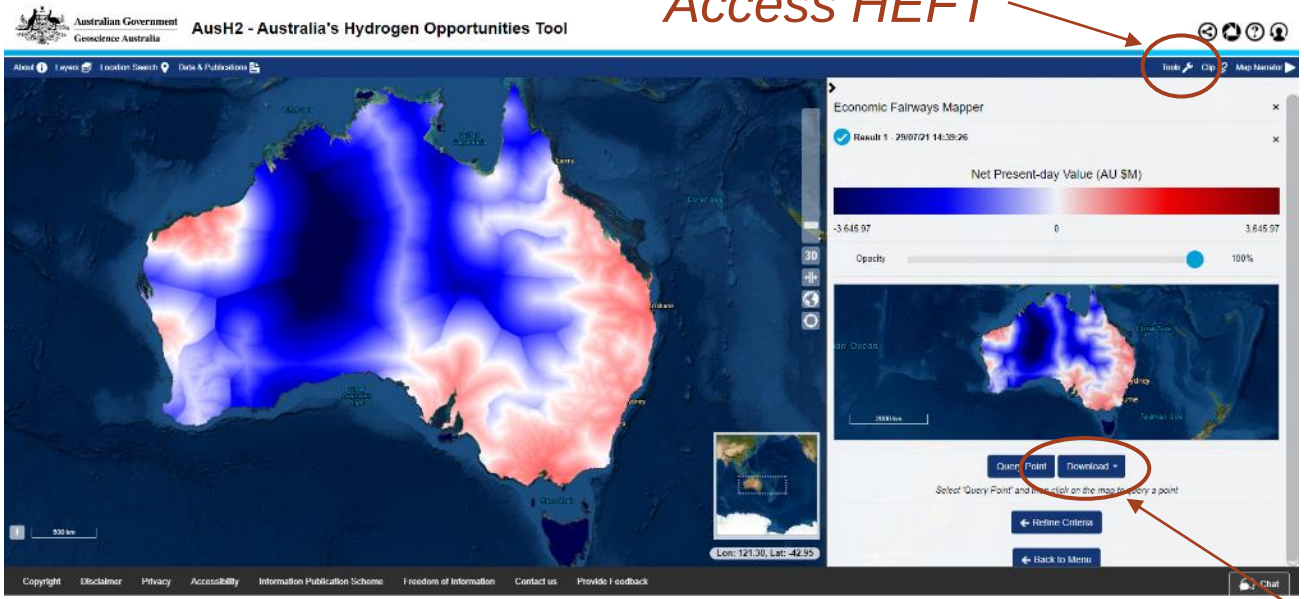
- Naturally occurring hydrogen can be trapped within or below evaporite accumulations (perfect seal)
- Salt can act as buffer preventing reservoir breaching during prolonged tectonic activity
- Evaporites widely distributed across many sedimentary basins in Australia
- Salt accumulations provide excellent hydrogen storage potential (caverns)
- Important consideration for establishing hydrogen production centres



Officer Basin GA seismic line 2011

Hydrogen Economic Fairway Tool (HEFT)

Access HEFT



https://portal.ga.gov.au/persona/hydrogen

Customisable inputs:

- AU$5.5/GJ natural gas price
- Desalinated water
- 500 t H_2/day
- 25 year operating life
- Hydrogen sent to port
- 5% company discount rate
- **AU$3.1/kg hydrogen price (2030)**

Download GeoTIFF or PNG

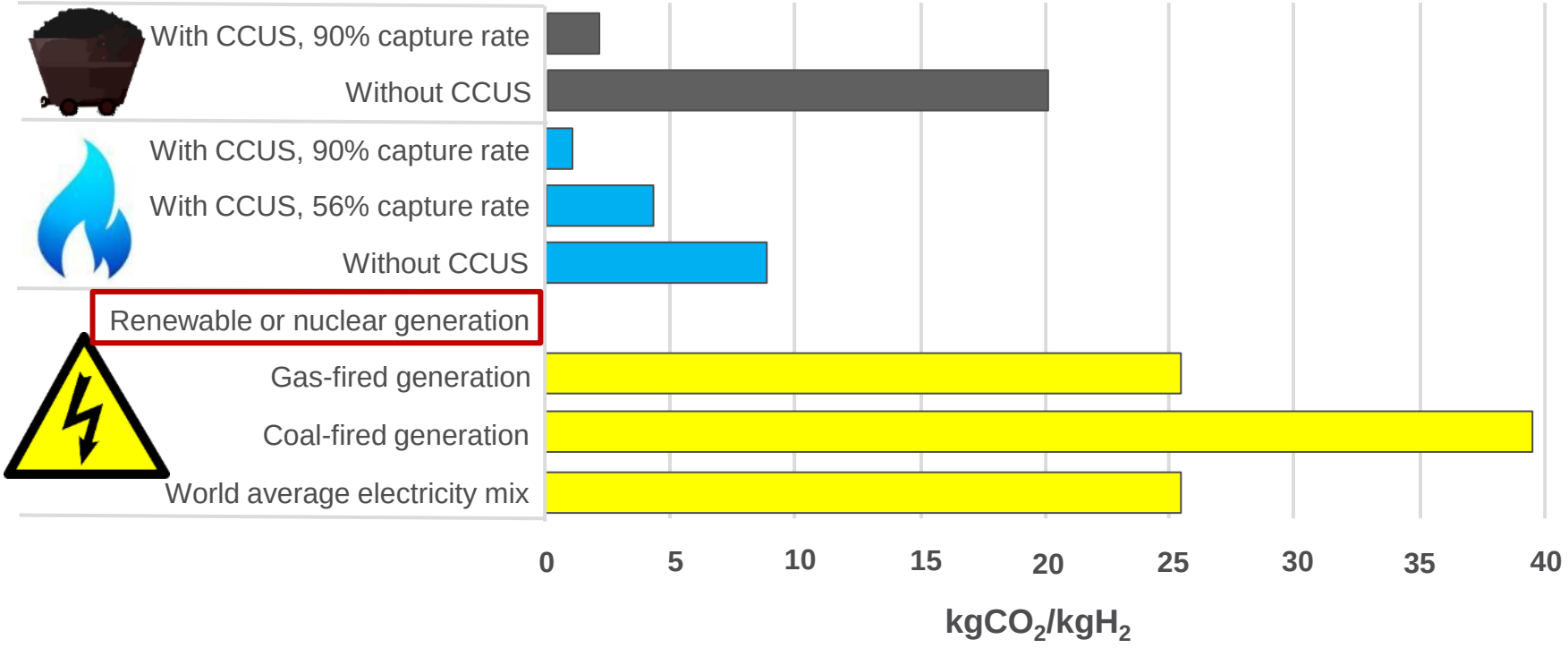
Cost of hydrogen production is coming down …

	Cost 2018 est. US$/kg (CSIRO)	Cost 2020 est. US$/kg (BNEF)	Cost 2030 est. US$/kg (BNEF)	Cost 2050 est. US$/kg (BNEF)
Natural gas + CCS	1.61 – 1.96	1.34 - 2.91		1.25 - 2.82
Coal + CCS	1.82 – 2.17	2.51 - 3.30		2.22 - 3.05
Renewable H_2	3.36 – 5.18	2.53 – 4.57	1.14 - 2.71	0.73 - 1.64

Sources: BloombergNEF Hydrogen: the Economics of Production from Fossil Fuels with CCS, 2020
BloombergNEF Hydrogen Economy Outlook, 2020
CSIRO Hydrogen Strategy, 2018

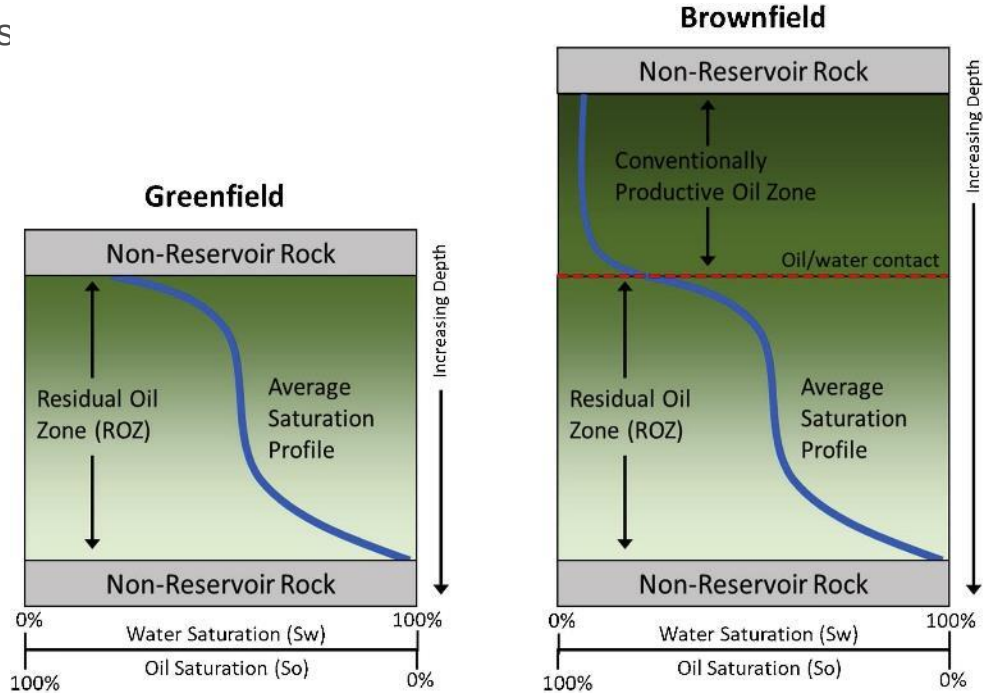
CO_2 intensity of hydrogen production (source: IEA, 2019)

www.iea.org/hydrogen2019



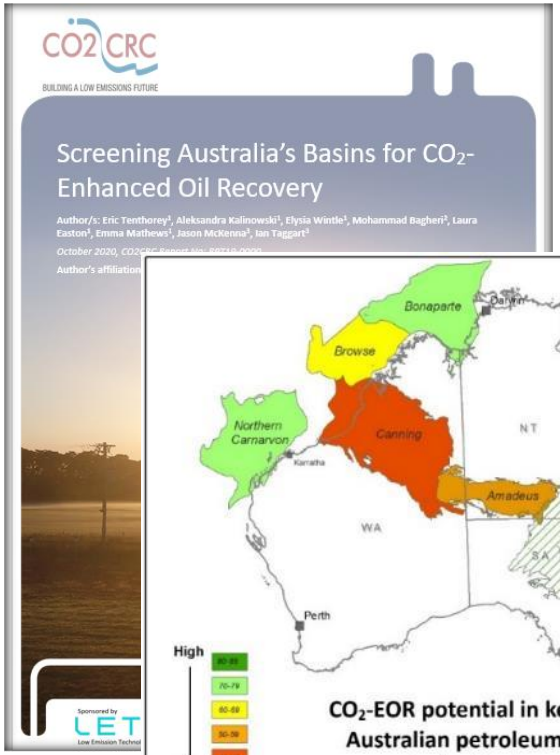
CO_2-enhanced oil recovery (CO2-EOR) in Residual Oil Zones (ROZ)

- CO2-EOR can unlock remaining oil resources while permanently storing CO_2
- GA's analysis of Australian oil-producing basins shows that CO2-EOR is feasible in many depleted fields
- ROZ: similar to depleted fields - oil-bearing reservoirs which have undergone a *natural* waterflood
  - Brownfield – associated with producing field
  - Greenfield – not associated main pay zone
- Potentially significant oil and CO_2 storage resources
  - Actively producing significant oil from ROZ in the Permian Basin, USA
- **Can we find producible ROZ in Australia?**
  - Initial focus on Cooper-Eromanga region



Sanguinito et al., 2020

CO2-enhanced oil recovery and geological storage



The APPEA Journal 2021, **61**, 118–131
https://doi.org/10.1071/AJ20076
Peer reviewed paper

CO2-EOR+ in Australia: achieving low-emissions oil and unlocking residual oil resources

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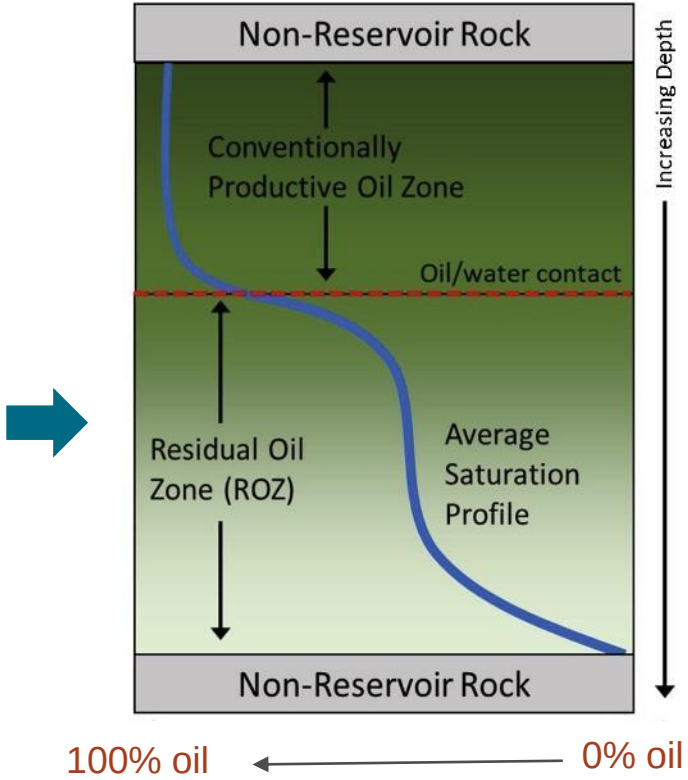
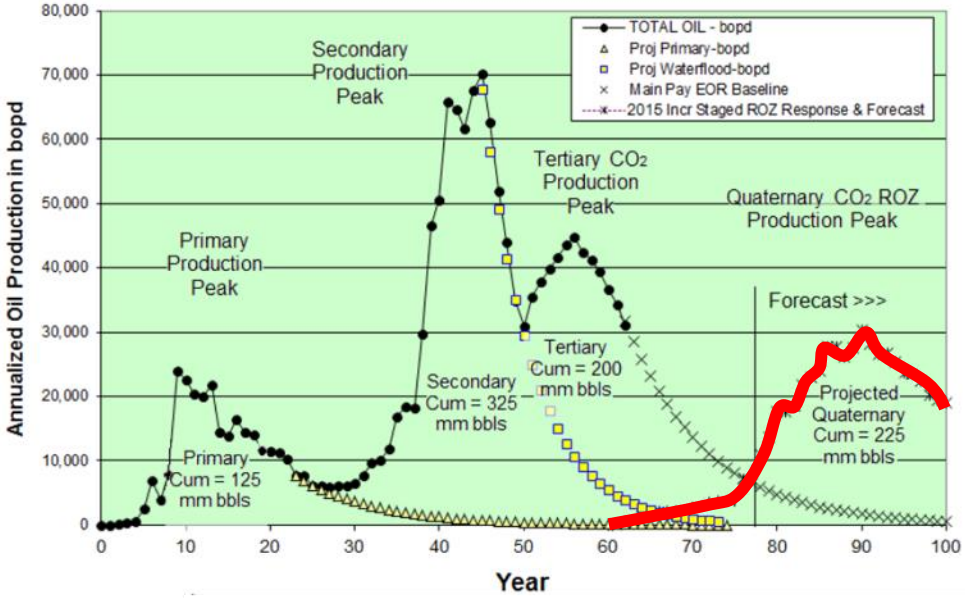
Description	Net utilisation tCO_2/bbl oil	Net negative?
"Average" CO_2 EOR	0.3 - 0.5	No
"Good" CO_2 EOR (minimum CO_2)	0.15 - 0.2	No
Conventional EOR+	0.3	No
Advanced EOR+	0.6	Possible
Maximum storage EOR+	0.9	Yes

CO_2-EOR and residual oil zones (ROZ)



(after Sanguinito et al., 2020)

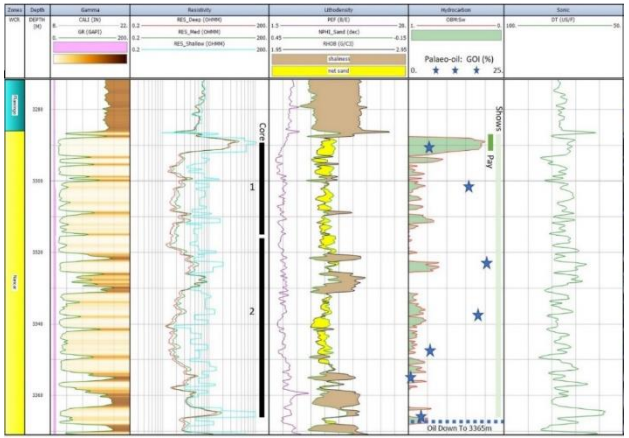
Permian Basin - Seminole field example



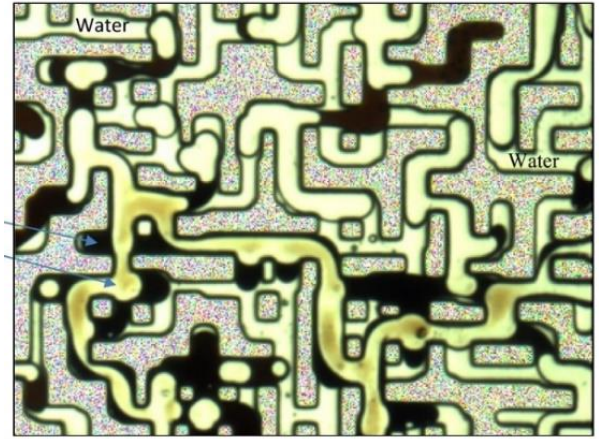
(after Trentham et al. 2015)

Residual oil zones in Australia

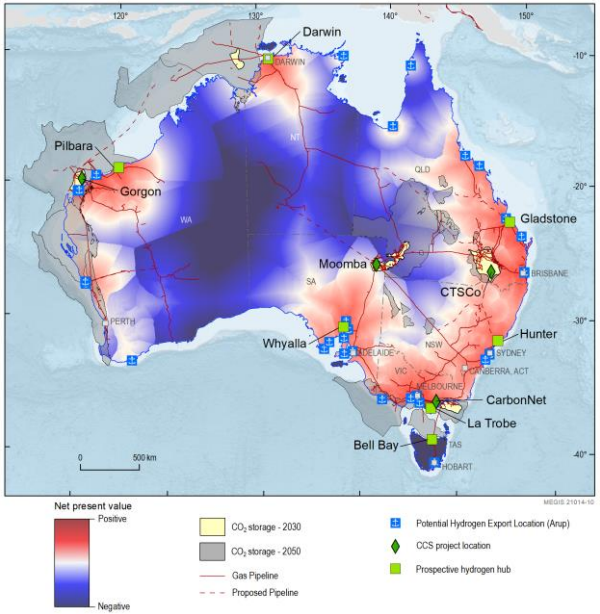
Identify ROZ → Calibrate and predict → Technical and economic feasibility



Kalinowski et al., 2022 (in press)



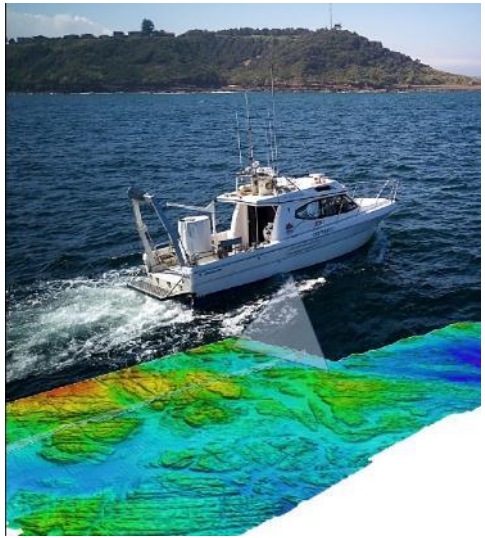
Seyyedi and Sohrabi, 2020



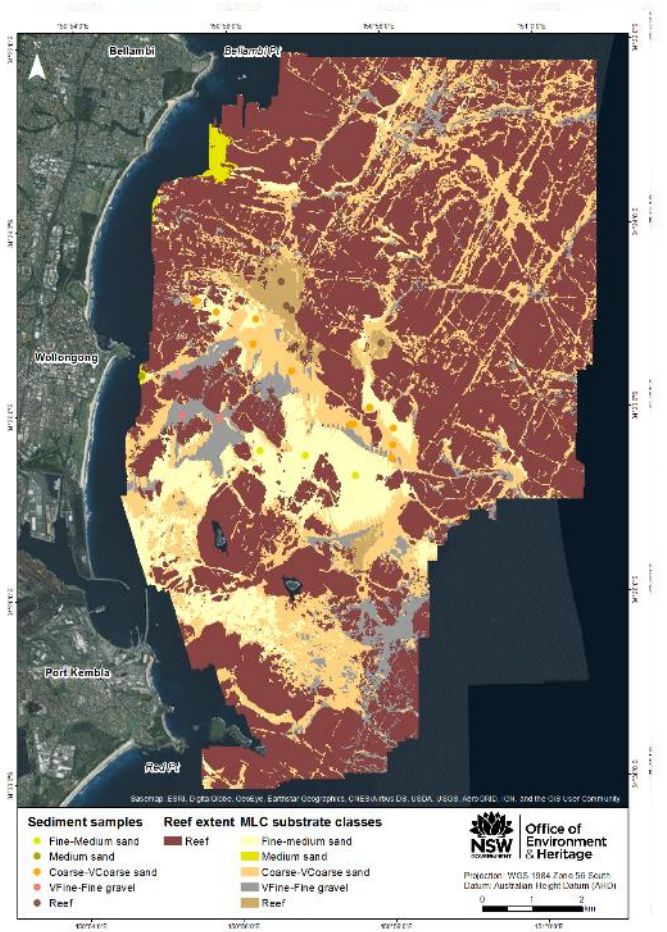
Hydrogen production (HEFT)

Sea-bed mapping

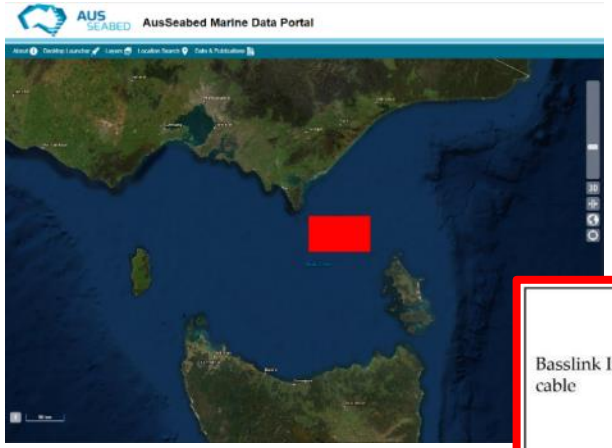
AUS SEABED

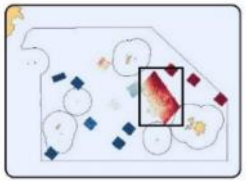


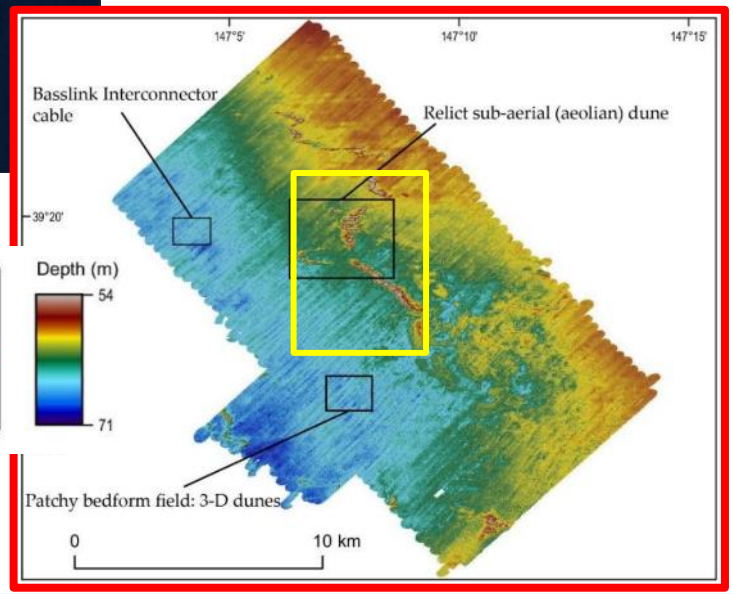
- National seabed mapping coordination program
- Collaborative initiative led by Geoscience Australia, but operated by Commonwealth, State and Territory entities, universities and industry
- Coordinating collection efforts in Australian waters and improving data access
- Collected data is GIS-based, providing insights into marine habitats and geomorphology
- Highly relevant for offshore infrastructure planning

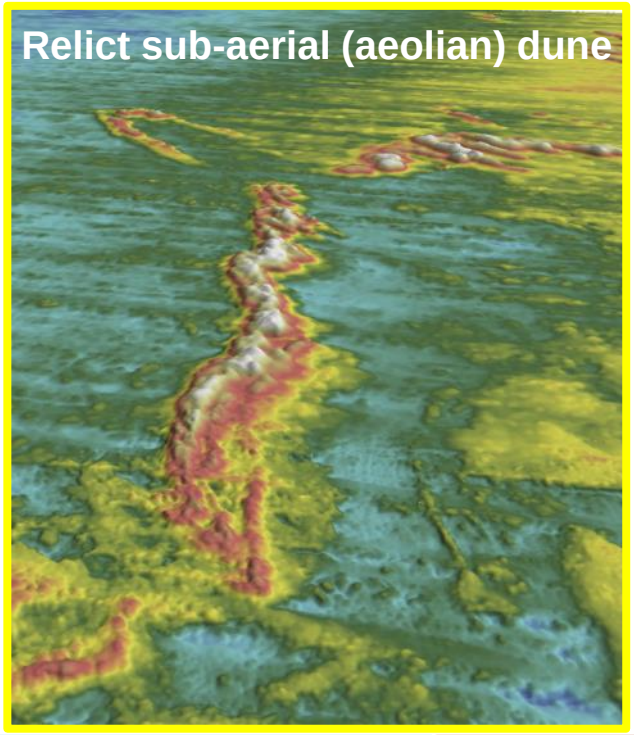


Sea-bed mapping – example Bass Strait









Summary and outlook

- GA undertakes multidisciplinary studies assessing the energy resources potential of those commodities that contribute to a decarbonisation of the economy.

- Close cooperation with State/Territory Geological Surveys and where possible with industry, essential for achieving results

- Innovative approach to utilisation of existing data

- Data available on GA's portal (under various "personas") https://portal.ga.gov.au

- Outcome of studies will demonstrate untapped resource potential and inform government and industry decision makers about economically feasible and environmentally sustainable development opportunities