

australian petroleum production & exploration association limited
with technical support from the Commonwealth Scientific and Industrial Research Organisation

A review of Net Zero Energy and Industrial Zones



**Preliminary
Report
May 2023**

Contents

About APPEA

The Australian Petroleum Production & Exploration Association (APPEA) is the peak national body representing Australia's oil and gas exploration and production industry. The oil and gas industry plays a fundamental role in our nation's economy, providing essential energy to power businesses and homes in Australia and across the region. It is also central to meeting Australia's net zero goals as a leading investor in renewable energy, low-carbon hydrogen and carbon capture, use and storage (CCUS) technologies. Our industry invests billions of dollars to generate reliable, secure and cleaner energy, creating jobs and economic growth for the communities in which we operate.

As the effective voice of Australia's oil and gas exploration and production industry, APPEA represents our members through leading research, policy and advocacy to ensure a regulatory and policy framework that is economically stable, environmentally sustainable and socially responsible.

APPEA has around 200 members comprised of oil and gas explorers and producers active in Australia and companies providing goods and services to those explorers and producers. APPEA member companies produce around 95% of Australia's oil and gas.

APPEA is forward-looking and outcomes-focused, aiming to raise awareness of the economic, environmental, and social benefits of the oil and gas industry across the country.

Acknowledgement of traditional owners

APPEA acknowledges the Traditional Custodians of Country throughout Australia and their knowledge in caring for land, sea, and community. We pay our respect to their Elders; past, present, and emerging.

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A review of Net Zero Energy and Industrial Zones

Nine energy and industrial regions around Australia comprise 92% of all safeguard mechanism emissions as well as 98% of all large power generation emissions.

The majority of emissions sources in these regions and across Australia require the same **four net zero technology building blocks:**

 **Renewable energy**

 **Natural gas**

 **Carbon capture, utilisation and storage**

 **Low-carbon hydrogen**

The establishment of Net Zero Energy and Industrial Zones (NZZs) based around the four net zero building blocks and shared infrastructure could provide a range of benefits to support the fair and efficient transformation to a net zero economy:

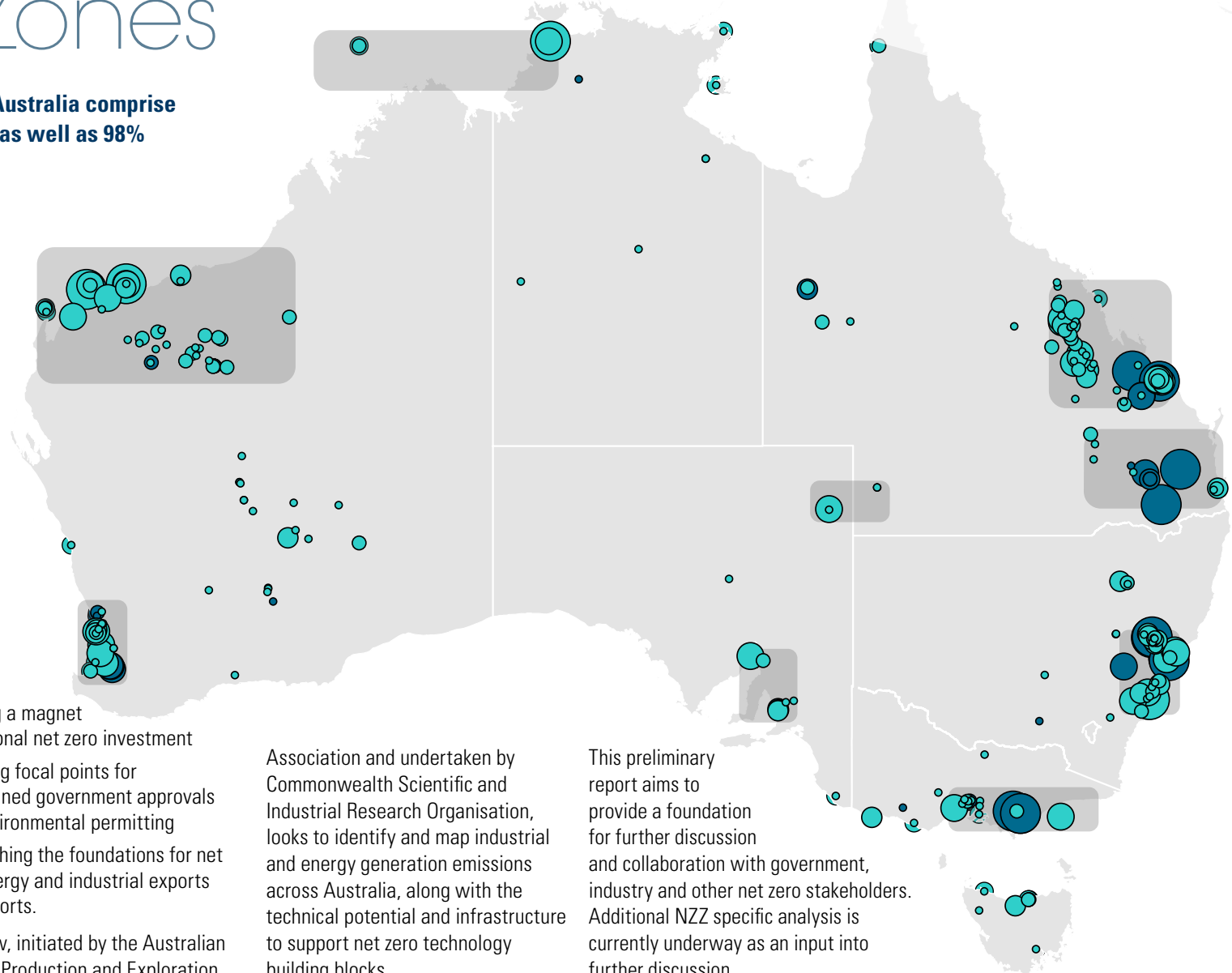
- reducing the costs and timelines for reaching net zero
- powering regional manufacturing and industry, creating and protecting regional jobs
- underpinning net zero critical mineral production and processing
- leveraging existing infrastructure

- creating a magnet for regional net zero investment
- providing focal points for streamlined government approvals and environmental permitting
- establishing the foundations for net zero energy and industrial exports and imports.

This review, initiated by the Australian Petroleum Production and Exploration

Association and undertaken by Commonwealth Scientific and Industrial Research Organisation, looks to identify and map industrial and energy generation emissions across Australia, along with the technical potential and infrastructure to support net zero technology building blocks.

This preliminary report aims to provide a foundation for further discussion and collaboration with government, industry and other net zero stakeholders. Additional NZZ specific analysis is currently underway as an input into further discussion.



Collaborating to achieve net zero

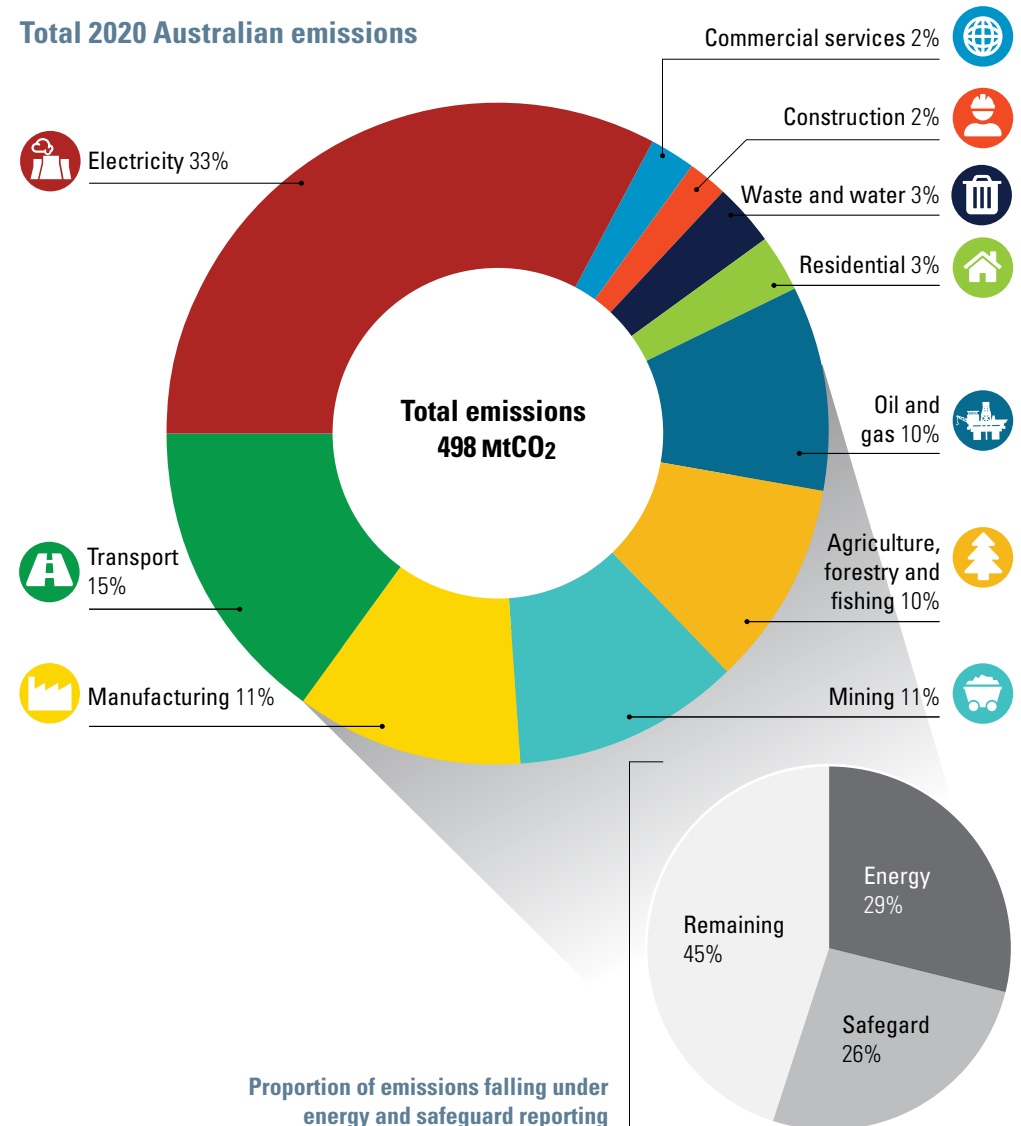
The world is aligned around net zero.

The world is united around a target of keeping global temperature rise to 'well below 2°C' and to pursue efforts to limit the temperature increase to 1.5°C. To reach these goals, the need to move towards a net zero emissions global economy by 2050, is widely accepted. However, the International Energy Agency (IEA) have reported that 2022 represents the highest level of annual emissions ever.¹ The challenge to get to net zero, in little over a quarter of a century is therefore immense. Especially against a backdrop of a growing world economy, population, and the need to ensure sufficient and secure energy for all.

Net zero will require every emissions reduction tool in the toolbox, combined with unprecedented collaboration.

Meeting net zero will require a scale up in technology at a rate never seen before. Renewable energy sources will do much of the heavy lifting, particularly in the power sector. However, to get to net zero, the IEA, the Intergovernmental Panel on Climate Change (IPCC) and the International Renewable Energy Agency (IRENA) are all clear^{2,3,4} that renewable energy will need to be complemented by energy efficiency, low-carbon hydrogen, carbon capture, utilisation and storage (CCUS), natural gas, and a range of other technologies. Carbon dioxide removal (CDR)—negative emissions—technologies will also be required to address residual emissions in the economy. Scaling up and rolling out these technologies will require unprecedented coordination and collaboration—between jurisdictions, across government, between government and industry, and between sectors.

Total 2020 Australian emissions



Reaching net zero in Australia

Australia has a wealth of skills, experience, and natural resources to support the transformation to net zero.

The Australian government passed the *Climate Change Act 2022*⁵ that represents a legally binding commitment to net zero by 2050, with an interim target of 43% emissions reductions below 2005 levels by 2030. Australia has significant natural resources, including wind and solar potential and CO₂ storage capacity to help meet these targets. Australia also has skills and experience for the transformation, in renewable energy, CCUS and low-carbon hydrogen.

A policy landscape is taking shape in Australia to drive emissions reductions.

Australia has a target of 82% renewable energy in the power sector by 2030.⁶ The federal government have also reformed safeguard mechanism⁷ to require all large non-power emitters such as cement, iron and steel, and chemical production, as well as oil and gas operations and mining—215 facilities representing around 28% of Australia's emissions—to reduce their emissions intensity by 4.9% per year to 2030, and onto net zero by 2050.

Net Zero Energy and Industrial Zones

Net Zero Energy and Industrial Zones could provide a framework for rapid, cost-efficient emissions reductions and regional development across Australia.

The overwhelming majority of the 215 safeguard mechanism facilities—79%—as well as much of the power sector, are concentrated in the same industrial regions of Australia. They also require largely the same emissions reductions building blocks to get to net zero—renewable energy, natural gas, low-carbon hydrogen, and CCUS. Instead of industries going it alone, the establishment of Net Zero Energy and Industrial Zones (NZZs) to could help streamline the pathway to net zero.

NZZs could fast-track the transformation to net zero and create a magnet for future investment.

The creation of NZZs based around the four net zero building blocks and shared infrastructure, could provide a range of benefits to support the fair and efficient transformation of the economy to net zero:

- reducing the costs and timelines for reaching net zero
- powering regional manufacturing and industry, creating and protecting regional jobs
- underpinning net zero critical mineral production and processing
- leveraging existing infrastructure
- creating a magnet for regional net zero investment
- providing focal points for streamlined government approvals and environmental permitting
- establishing the foundation for net zero and industrial exports and imports.

Safeguard Mechanism and large power emissions⁸

KEY

Net Zero Energy and Industrial Zone (NZZ)

CLEAN ENERGY REGULATOR DATASETS

NGER safeguard facility

NGER large power generation facility

EMISSIONS TPA CO₂

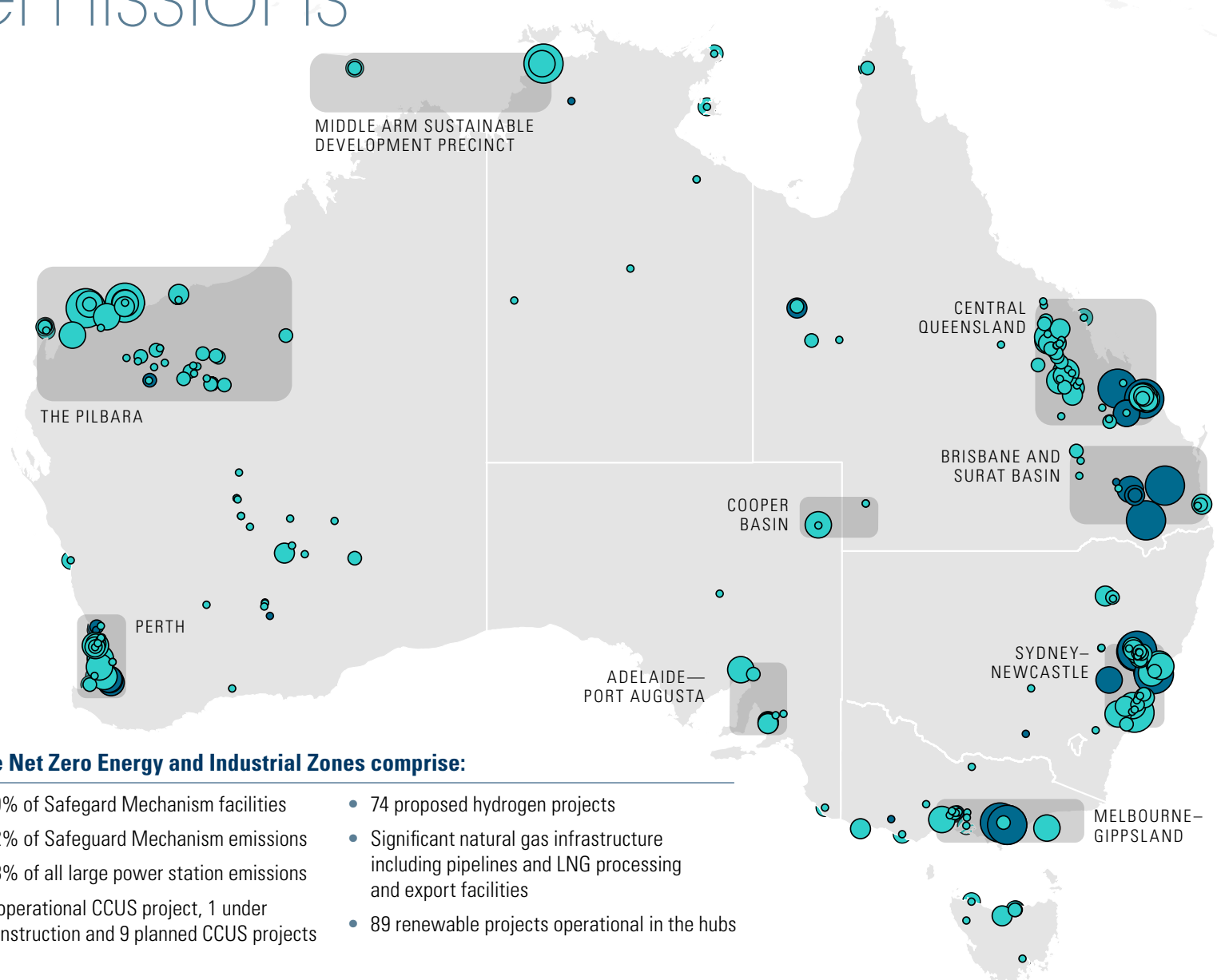
100,000–250,000

250,000–500,000

500,000–1,000,000

1,000,000–5,000,000

5,000,000–17,701,028



The review of Australia's power and industrial emissions sources identified nine potential NZZs across the country.

Nine Net Zero Energy and Industrial Zones comprise:

- 79% of Safeguard Mechanism facilities
- 92% of Safeguard Mechanism emissions
- 98% of all large power station emissions
- 1 operational CCUS project, 1 under construction and 9 planned CCUS projects
- 74 proposed hydrogen projects
- Significant natural gas infrastructure including pipelines and LNG processing and export facilities
- 89 renewable projects operational in the hubs

The building blocks of net zero



Renewable energy

Renewable energy is critical to global and Australian decarbonisation efforts, in particular reaching a net zero electricity sector. The IEA forecast renewable energy will surpass coal to become the largest source of electricity globally by 2027, accounting for 38% of total electricity generation.⁹ Australia has an 82% renewable energy target by 2030.¹⁰ Renewable energy deployment works hand-in-hand with a drive to electrify many parts of the economy. Electrification is a key emissions reductions pathway for many homes and commercial buildings and well as many manufacturing processes. Key to decarbonising the grid will be to firm renewable energy generation with technologies such as batteries, pumped hydropower, and natural gas, to ensure electricity is available when and where it is needed.



Natural gas

Natural gas supports the transition away from coal in Australia and beyond, provides the firm dispatchable energy required to unlock large-scale renewable energy deployment. It also powers Australian industries across the economy including those processing the critical minerals necessary for net zero. The Energy Market Operator sees 10 GW of gas power capacity playing a 'crucial role' in 2050 in the step-change scenario, providing peak loads and firming to support renewable power generation.¹¹ Natural gas with CCUS will be particularly important for hard-to-abate industrial and manufacturing operations that require natural gas as a feedstock or high-temperature heat. The IEA Net Zero scenario sees over 40,000 PJ of gas being required annually in 2050,¹² significantly more than the 6,000 PJ currently produced in Australia today.



Carbon capture, utilisation and storage

CCUS plays a unique role in the portfolio of emissions reductions technologies as it can address emissions from existing facilities, mitigate emissions from hard-to-abate industry and underpin large-scale CDR. Natural gas combined with CCUS is the most affordable pathway to low-carbon hydrogen production today.¹³ The IEA's Net Zero emissions scenario sees 1.6 GtCO₂ captured annually through CCUS in 2030, increasing to 6.2 GtCO₂ in 2050,¹⁴ with the median IPCC scenario requiring 17 GtCO₂ of annual abatement from CCUS in 2050. The Net Zero Australia study¹⁵ finds CCUS to be an integral part of every viable pathway to net zero in Australia. CCUS technology is proven with the equivalent of almost 10% of Australia's emissions stored annually by CCUS around the world.

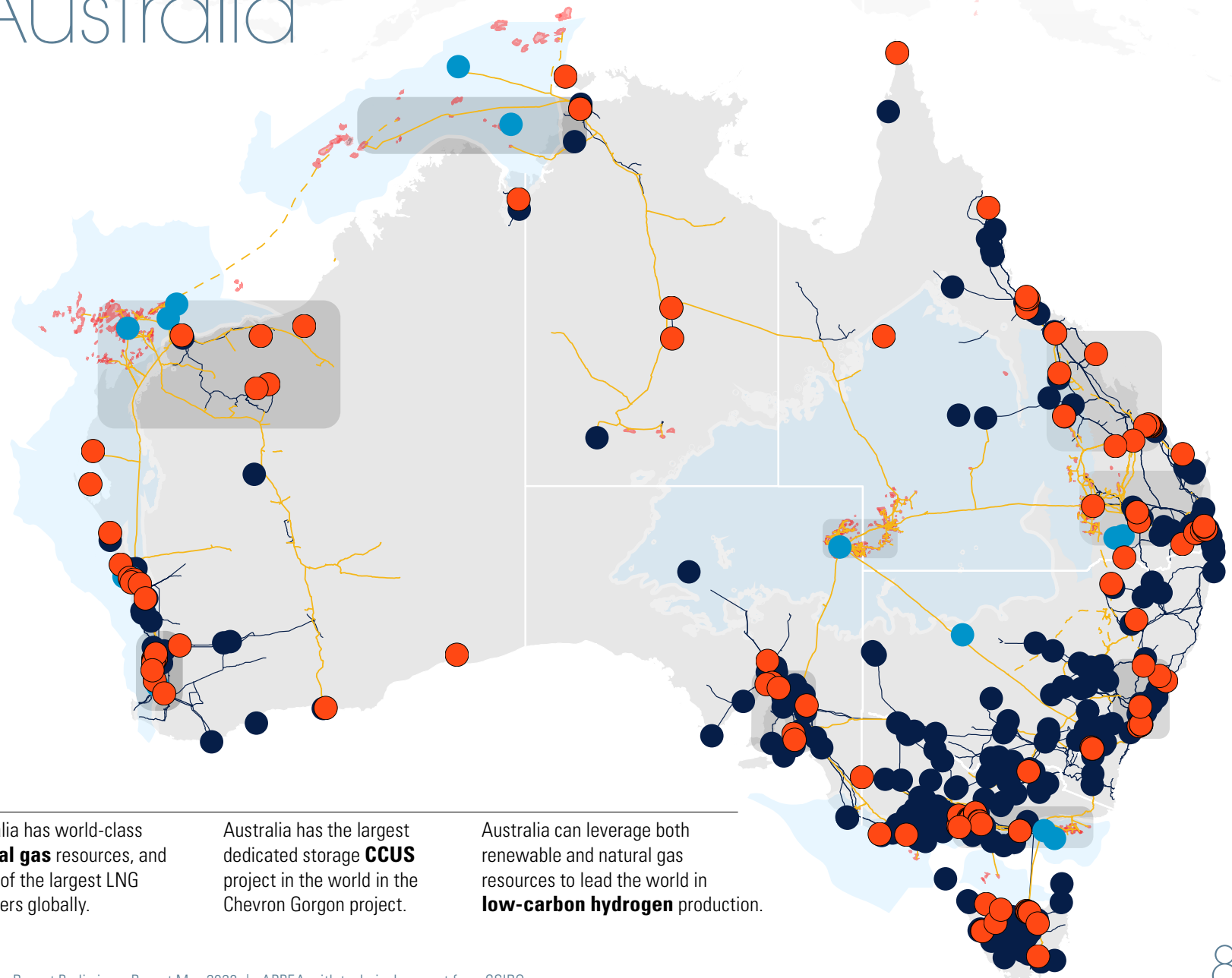
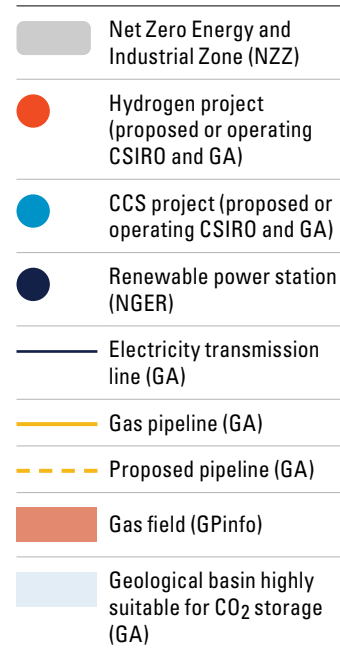


Low-carbon hydrogen

Hydrogen has a versatile role in decarbonisation, able to be used as a feedstock, to generate electricity both in fuel cells and gas turbines as well as being used to generate heat in high temperature manufacturing processes such as steel making. Hydrogen has the potential to become a major net zero energy export to the region. Low-carbon hydrogen can be produced through electrolysis of water using renewable energy or the from natural gas with CCUS. If produced using low or zero emissions sources, hydrogen can enable deep decarbonisation across the energy and industrial sectors.¹⁶ Less than 1 Mt of low-carbon hydrogen is produced today however it is expected to scale up quickly—the IEA identify that if all low-carbon hydrogen projects currently in the pipeline are realised, “by 2030 the production could reach 16–24 Mt per year, with 9–14 Mt based on electrolysis and 7–10 Mt on fossil fuels with CCUS.”¹⁷

Net zero building blocks across Australia

KEY



Australia aims to become a **renewable energy** superpower by 2050.

Australia has world-class **natural gas** resources, and is one of the largest LNG exporters globally.

Australia has the largest dedicated storage **CCUS** project in the world in the Chevron Gorgon project.

Australia can leverage both renewable and natural gas resources to lead the world in **low-carbon hydrogen** production.

Net zero technology needs by sector



Power generation

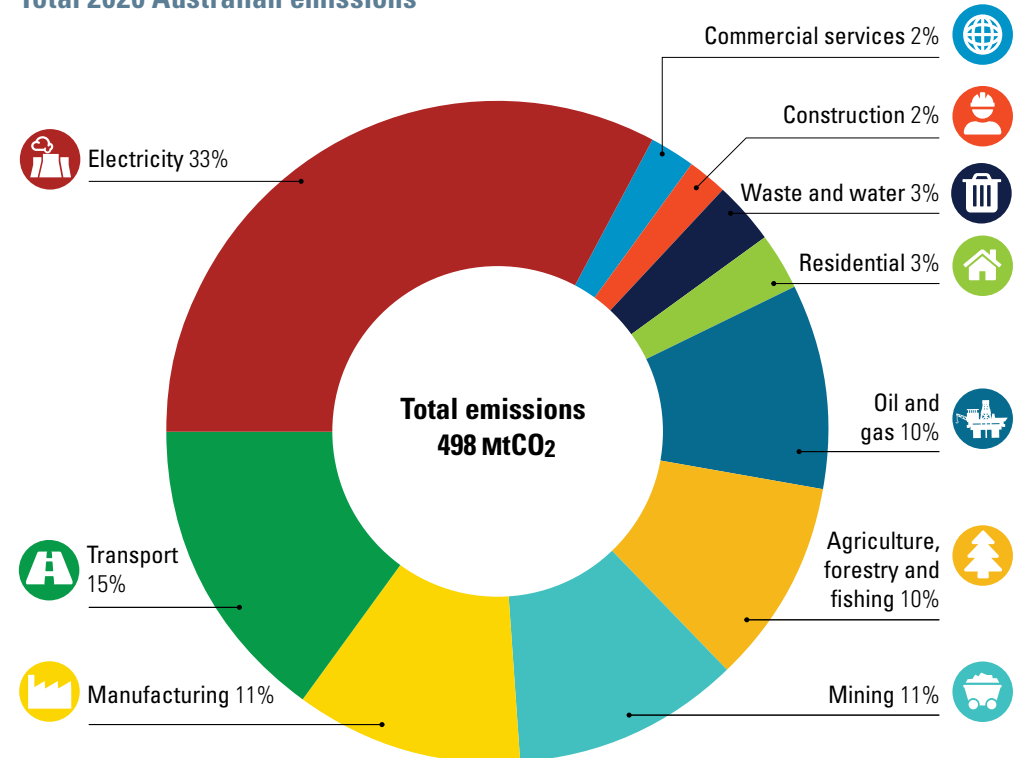
Power generation is the largest source of emissions in Australia, representing 33% of total 2020 emissions. It will require large scale renewable energy deployment growth along with some natural gas to decarbonise and meet the government's 82% renewable energy in the power sector by 2030. Today 51% of Australia's electricity needs are met by coal with 18% from gas.¹⁸ Renewable energy provides 29% of Australia's total electricity generation—solar (12%), wind (10%), and hydro (6%). As we transform the power sector, the role of variable renewable energy will increase significantly, along with a strengthened transmission grid to get the power to where it is needed. To ensure the grid remains reliable and stable variable renewables will need to be firmed batteries, hydro or natural gas for when the sun isn't shining and the wind isn't blowing. The Net Zero Australia study finding that gas power capacity, will need to double between now and 2050 to provide firming power as we transform to net zero.



Manufacturing and industry

Manufacturing and industry represents 11% of Australia's emissions. The manufacturing and industrial sector is diverse and will need a wide range of technologies to decarbonise including renewables, natural gas, CCUS and low-carbon hydrogen. There will be opportunities for manufacturing and industry to electrify with firmed renewable power. However, some sectors, such as cement, iron and steel, aluminium, chemical production and some critical mineral processing produce CO₂ as part of the process chemistry; require natural gas as a feedstock or need natural gas for high temperature heat. In these instances, a combination of natural gas with CCUS and or low-carbon hydrogen will be required. Regarding CCUS, IRENA states that "certain industrial processes [...] no other major mitigation option is currently on the table".¹⁹

Total 2020 Australian emissions



Net zero technology needs by sector (continued)



Mining

Mining represents 11% of Australia's emissions. Mining emissions come from a combination of fugitive emissions along with onsite power generation and transport. Decarbonisation of mining will require firm renewables to provide electricity as well as potentially powering vehicles and heavy machinery. Low-carbon hydrogen may also have a role in powering mining equipment. Where mineral processing occurs on site, there may be a need for a combination of natural gas, CCUS as well as low-carbon hydrogen. Fugitive emissions require process-specific actions or offsetting.



Oil and gas

Oil and gas production represents 10% of Australia's total current emissions. Oil and gas emissions include reservoir CO₂, power requirements including to drive compression, as well as some fugitive emissions. For reservoir CO₂, CCUS is the most viable option—the majority of CCUS projects globally capture and store CO₂ from natural gas production and processing.²⁰ The oil and gas sector will also deploy significant renewable energy capacity to provide electricity to facilities. The compression for liquefied natural gas (LNG) production is done by large turbines conventionally powered by natural gas. To align with net zero these turbines could be driven by low-carbon hydrogen, by natural gas with CCUS, or electrified with renewable power. The oil and gas sector has a significant program in place to address fugitive emissions in line with global targets.^{21,22}



Transport and other sources

15% of Australia's total emissions come from transport with the remaining 17% coming from agriculture, residential, construction, commercial services. A combination of net zero building blocks will be required across these sectors, for example electrification with renewable energy as well as low-carbon hydrogen may have a role to play in decarbonising transport. In some instances, residual emissions will be technically challenging or expensive to decarbonise directly. In these instances they will need to be offset, including with CDR technologies such as direct-air capture and storage (DACCS) or bioenergy with CCUS (BECCS).

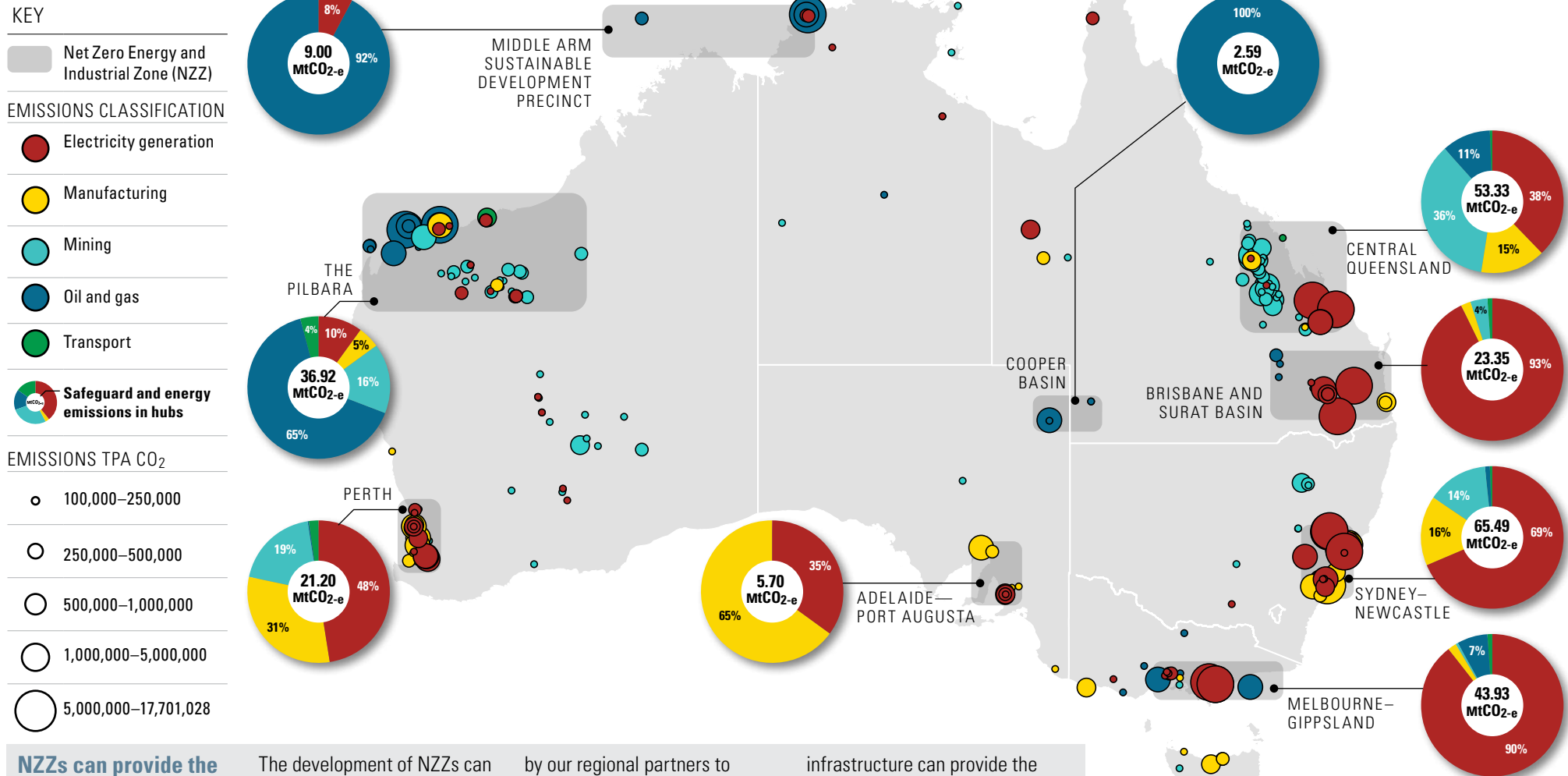
NZZ can provide the infrastructure needed for negative emissions

The development of NZZs provides the CO₂ transport and storage infrastructure necessary to scale-up and roll-out two important CDR technologies—DACCS and BECCS. CSIRO these technologies as the most permanent pathways to negative emissions for offsetting emissions elsewhere in the economy.²³

DACCS is the process of capturing CO₂ direct from the atmosphere for permanent geological storage. This approach is currently high cost (both capital and operating). However large investments are being made into the technology that are expected to reduce costs and further develop the technology. Significant incentives have been put in place in the United States and elsewhere to advance the technology.²⁴

BECCS involves the capture and storage of CO₂ from biomass power generation and processing and allows the energy generated to be negative emission. Bioenergy is a form of renewable energy generated from the conversion of biomass—derives from forestry, agriculture or municipal waste streams—into heat, electricity, biogas and liquid fuels.

Emissions sources by NZZ



NZZs can provide the foundation for net zero energy and industrial exports and imports

The development of NZZs can leverage existing port and energy export infrastructure to ramp up net zero energy and industrial exports and imports. LNG will continue to be needed

by our regional partners to assist with their transition to net zero, supporting the shift away from coal and partnering with renewables to decarbonise power generation. Looking forward this

infrastructure can provide the foundation for future low-carbon hydrogen exports as well as potentially the import of CO₂ for permanent storage utilising shared CO₂ storage infrastructure.

Current national and international decarbonisation hub case studies

The development of energy and industrial decarbonisation hubs, based around the key net zero building blocks and shared infrastructure are being explored international in a number of industrial regions.

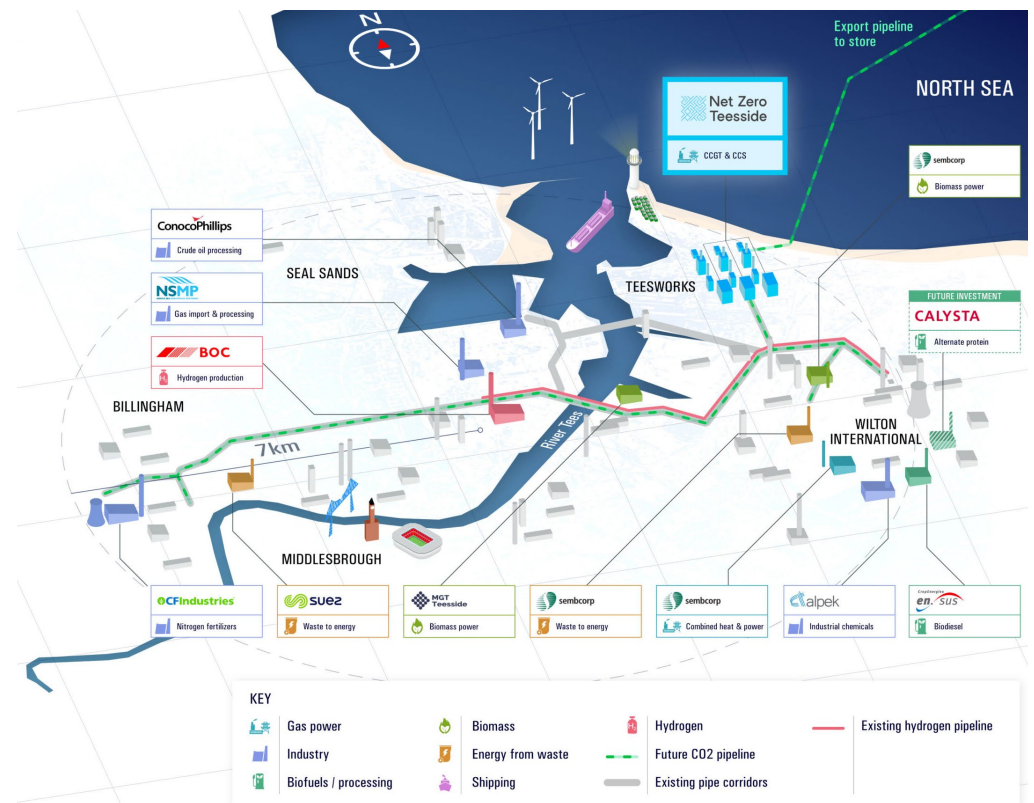
Two examples include the Middle Arm Sustainable Development Precinct in the Northern Territory—one of the proposed NZZs—and the Net Zero Teesside hub in the United Kingdom.

The Middle Arm Sustainable Development Precinct, Northern Territory

The Northern Territory Government, with the support of the Australian Government and industry is looking to transform Middle Arm into a globally competitive, sustainable precinct with a focus on low emission, renewable hydrogen, CCUS and minerals processing. Middle Arm is already home to a globally significant LNG export hub. Further development of Middle Arm into a globally competitive, sustainable precinct provides critical growth opportunities for the Territory. The estate will provide a variety of lot sizes for sale or lease, to accommodate a diverse range of new and emerging industries including minerals processing, carbon capture utilisation and storage, utilities, logistics and commercial industries. The government are also working with industry to streamline environmental permitting and approvals in the precinct.

The Net Zero Teesside, UK

Teesside is a region in the north of England with an industrial heritage and home to a diverse cluster of industrial, power and manufacturing companies. These businesses aim to decarbonise their operations and help the UK reach net zero by 2050 through the collaborative deployment of CCUS and low-carbon hydrogen. The geography of the Teesside industrial region along with its proximity to offshore CO₂ storage sites in the North Sea, combined with strong support from the local community and political support make Teesside a prime candidate for a decarbonisation hub, supporting industry and helping kick-start the low-carbon hydrogen economy in the UK using CCUS.²⁵



Emissions and building blocks summary of NZZs

NZZ	State/territory	Safeguard emissions (mtpa)	Energy emissions (mtpa)	Total emissions (mtpa)	Emissions sources	Building blocks
Sydney–Newcastle	New South Wales	22.12	43.38	65.49	  	  
Middle Arm	Northern Territory	8.24	0.76	9.00	  	   
Brisbane and Surat Basin	Queensland	2.29	21.77	24.06	  	   
Central Queensland	Queensland	33.23	20.10	53.33	   	   
Adelaide–Port Augusta	South Australia	3.73	1.98	5.71	 	  
Cooper Basin	South Australia	2.59	0	2.59		   
Melbourne–Gippsland	Victoria	4.68	39.25	43.93	  	   
The Pilbara	Western Australia	34.27	1.74	36.02	   	   
Perth	Western Australia	10.97	10.23	21.20	  	   

The Middle Arm Sustainable Development Precinct, NT

KEY

- Net Zero Energy and Industrial Zone (NZZ)
- Hydrogen project (proposed or operating CSIRO and GA)
- CCS project (proposed or operating CSIRO and GA)
- Renewable power station (NGER)

EMISSIONS CLASSIFICATION

- Electricity generation
- Manufacturing
- Mining
- Oil and gas
- Transport

EMISSIONS TPA CO₂

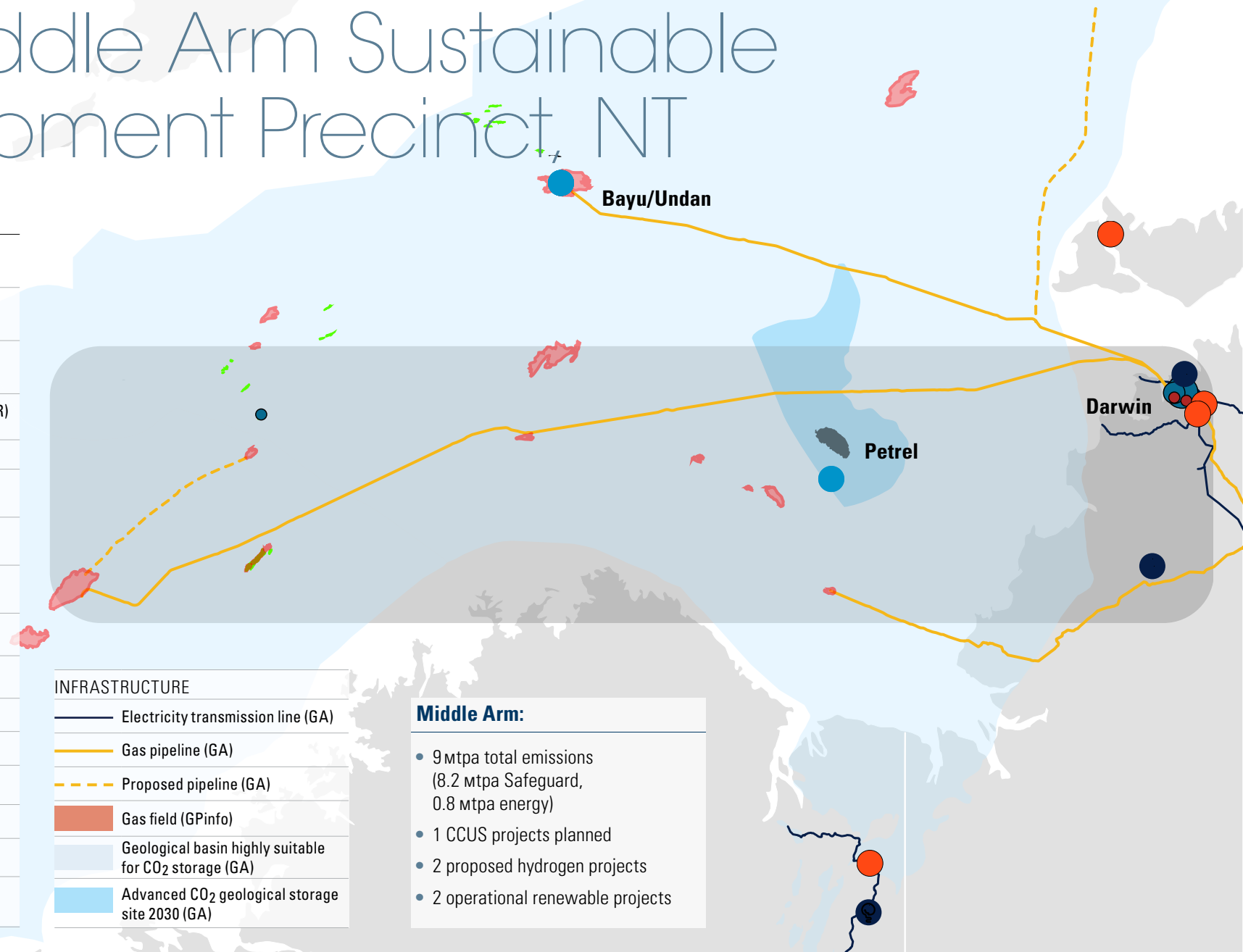
- 100,000–250,000
- 250,000–500,000
- 500,000–1,000,000
- 1,000,000–5,000,000
- 5,000,000–17,701,028

INFRASTRUCTURE

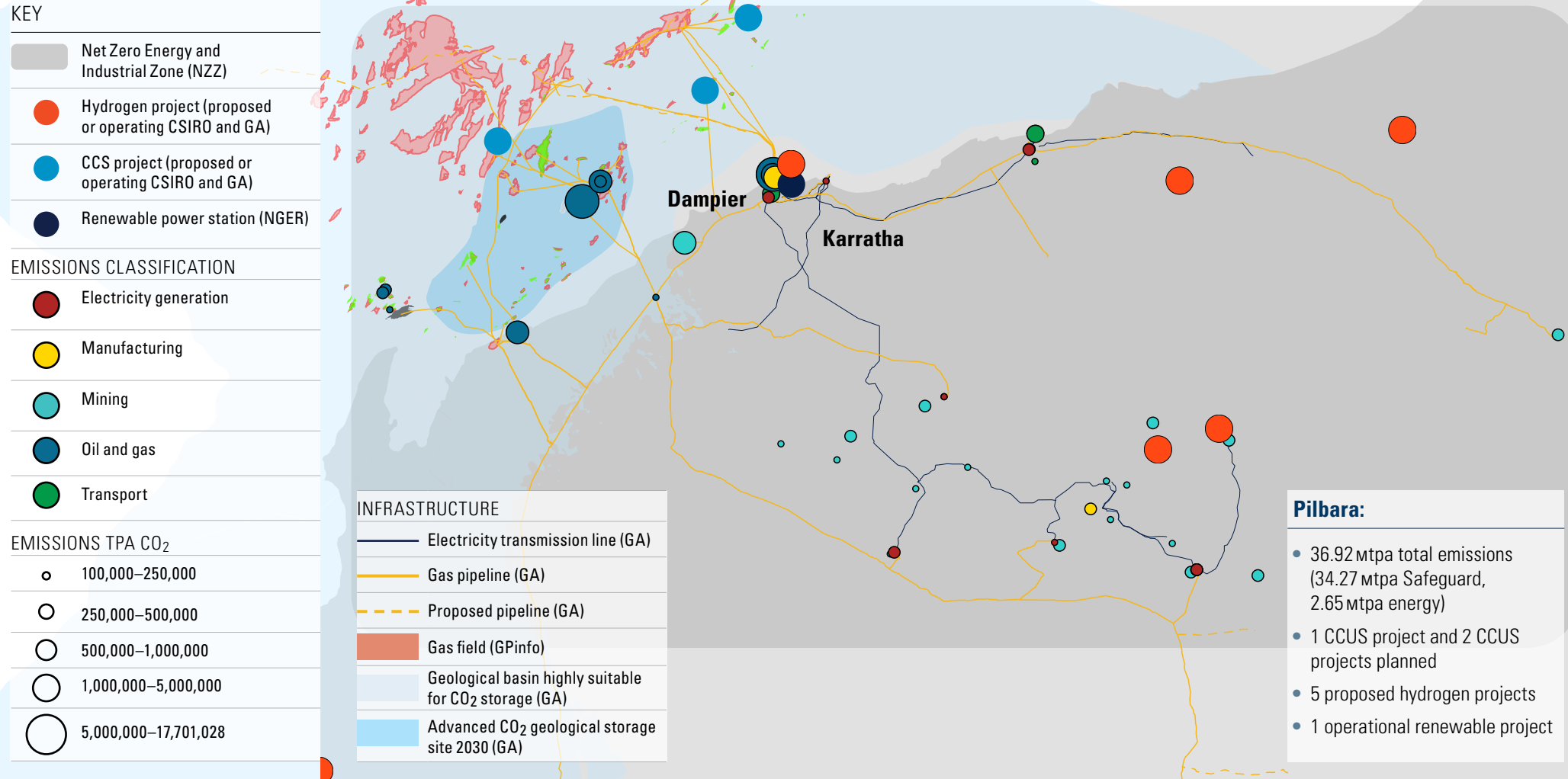
- Electricity transmission line (GA)
- Gas pipeline (GA)
- Proposed pipeline (GA)
- Gas field (GPinfo)
- Geological basin highly suitable for CO₂ storage (GA)
- Advanced CO₂ geological storage site 2030 (GA)

Middle Arm:

- 9 mtpa total emissions (8.2 mtpa Safeguard, 0.8 mtpa energy)
- 1 CCUS projects planned
- 2 proposed hydrogen projects
- 2 operational renewable projects



The Pilbara NZZ, WA



Data

All data used in the generation of this report has been from publicly available sources.

Emissions data has been sourced from the national data inventory reported under the *National Energy and Greenhouse Reporting Act 2007* (NGER Act) which is then summarised and published by the Department of Climate Change, Energy the Environment and Water (DCCEEW) as a part of 'Australia's National Greenhouse Accounts'. The study has used the 'National Inventory by Economic Sector 2020: figures and data'.

Energy and safeguard reporting is available from NGER with the most recent published dataset being utilised 'Safeguard facility reported emissions 2021–22'.

Standardised economic sectors have been applied in accordance with the standards and classifications maintained by the Australian Bureau of Statistics.

Details of map layers are included in the following table.

Mapping layer	Source
Coastline	Natural Earth (https://www.naturalearthdata.com/downloads/10m-cultural-vectors/)
State boundaries	GPInfo (https://www.gpinfo.com.au/software)
Electricity networks	Geoscience Australia—layer from—Foundation Physical Infrastructure, sub category Electricity Transmission Line (https://services.ga.gov.au/)
Pipelines	Geoscience Australia—National Oil and Gas Infrastructure (https://services.ga.gov.au/)
Oil and gas fields	GPInfo (https://www.gpinfo.com.au/software)
Geological basin	Geoscience Australia
Emissions and safeguard data	www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020/national-inventory-by-economic-sector-data-tables-and-methodology www.cleanenergyregulator.gov.au/NGER
CCS	Advanced CO ₂ geological storage sites 2030 layer, Geoscience Australia www.csiro.au/en/research/environmental-impacts/emissions/carbon-sequestration-potential page 182 and 184 and references therein
Renewable energy projects	NGERS producing assets
Hydrogen projects	www.csiro.au/en/maps/hydrogen-projects#markerName=Central%20Queensland%20Hydrogen%20Project

Endnotes

- 1 IEA 2023 CO₂ Emissions in 2022 <www.iea.org/reports/co2-emissions-in-2022>
- 2 IEA 2022 World Energy Outlook 2022 <www.iea.org/reports/world-energy-outlook-2022>
- 3 IPCC 2023 Sixth Assessment Report <www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_SPM.pdf>
- 4 IRENA 2020 Reaching Zero Report <www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Sep/IRENA_Reaching_zero_2020.pdf>
- 5 Australian Government 2022 *Climate Change Act 2022*
- 6 AEMO 2022 Integrated Systems Plan for the National Electricity Market
- 7 Department of Climate Change, Energy, the Environment and Water 2023 <<https://www.dcccew.gov.au/climate-change/emissions-reporting/national-greenhouse-energy-reporting-scheme/safeguard->>>
- 8 Power emissions over 100,000 tCO₂ per year
- 9 IEA 2022 Renewables 2022 <www.iea.org/reports/renewables-2022>
- 10 DCCCEW 2022 Australia's emissions projections 2022
- 11 AEMO 2022 Integrated Systems Plan for the National Electricity Market
- 12 IEA 2022 World Energy Outlook 2022 <www.iea.org/reports/world-energy-outlook-2022>
- 13 <www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/energy-and-resources/national-hydrogen-roadmap>
- 14 IEA World Energy Outlook 2022 <www.iea.org/reports/world-energy-outlook-2022>
- 15 NetZero Australia Report <www.netzeroaustralia.net.au/wp-content/uploads/2023/04/Net-Zero-Australia-final-results-full-results-pack-19-April-23.pdf>
- 16 <www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/csiro-futures/energy-and-resources/national-hydrogen-roadmap>
- 17 IEA Global Hydrogen Review 2022 <<https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf>>
- 18 DCCCEW 2023 <energy.gov.au>
- 19 IRENA 2020 Global Renewables Outlook <www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020>
- 20 <<https://status22.globalccsinstitute.com/>>
- 21 <<https://ogmpartnership.com/>>
- 22 <www.appea.com.au/wp-content/uploads/2020/08/Industry-Action-on-Emissions-Reduction-1.pdf>
- 23 CCA 2022 Australia's Potential Sequestration
- 24 <<https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/>>
- 25 Net Zero Teesside <<https://neecco.org.uk/net-zero-teesside-and-northern-endurance-partnership/>> NEECCO Copyright © 2023

A map of Australia is shown in a light blue color. Overlaid on the map are numerous circles of varying sizes and shades of blue, representing different locations or data points. A large, dark blue, stylized graphic element, resembling a large 'A' or a series of overlapping shapes, is positioned on the left side of the map, partially obscuring it.

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