Net Zero Australia:
Pathways to Decarbonisation

WQAC Assembly | 28 September 2023

NET ZERO AUSTRALIA

The University of Melbourne

The University Of Queensland AUSTRALIA CREATE CHANGE

Princeton University

nous

About Net Zero Australia

The Net Zero Australia project (NZAu) is analysing net zero pathways that reflect the boundaries of the Australian debate, for both our domestic and export emissions

The study is:

- **Rigorous** and **granular**
- **Scenario-based** and **evidence-driven**
- **Technology-neutral** and **non-political**

Net Zero Australia is a partnership between the **University of Melbourne,** the **University of Queensland, Princeton University,** and management consultancy **Nous Group.**

THE UNIVERSITY OF MELBOURNE

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CREATE CHANGE

PRINCETON UNIVERSITY

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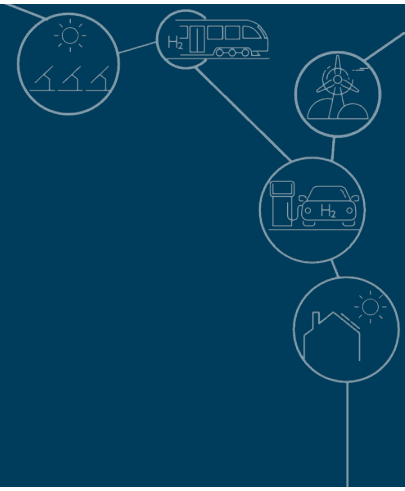
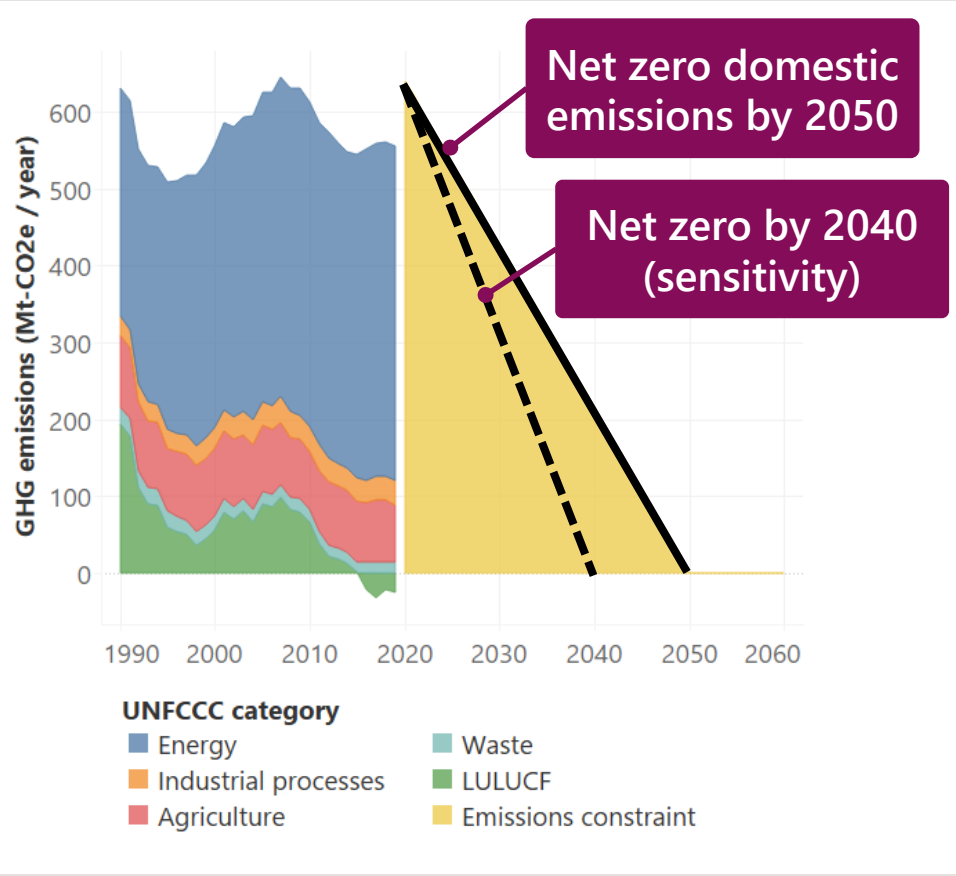
NZAu uses the modelling method developed by Princeton University and Evolved Energy Research for its 2020 ***Net-Zero America study.***

2. What did we model?

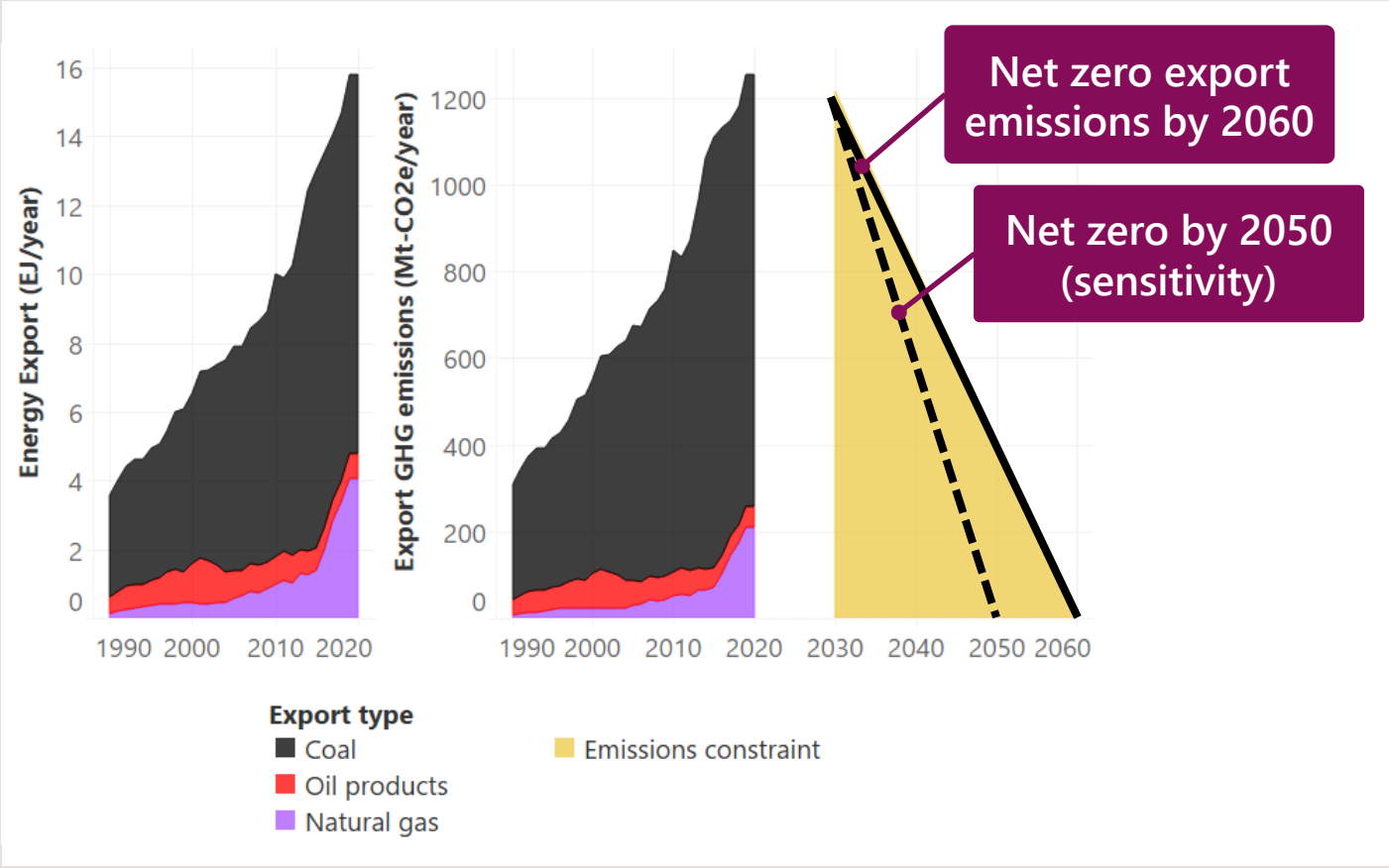


We model linear reductions to net zero

Domestic emissions



Fossil fuel energy export emissions



We have modelled six Core Scenarios

REF

REFERENCE

- Projects historical trends, does not model cost impacts of fossil fuel supply constraints
- No new greenhouse gas emission constraints imposed domestically *or* on exports
- Policy settings frozen from 2020 onwards.

E+

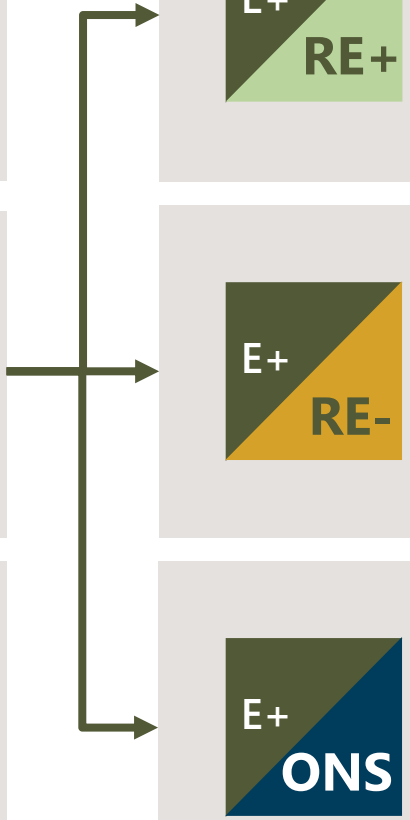
RAPID ELECTRIFICATION

- Nearly full electrification of transport and buildings by 2050
- Renewable rollout rate almost unconstrained
- Lower cap on underground carbon storage rate.

E-

SLOWER ELECTRIFICATION

- Slower electrification of transport and buildings compared to E+
- Renewable rollout rate almost unconstrained
- Lower cap on underground carbon storage rate.



FULL RENEWABLES ROLLOUT

- No fossil fuel use allowed by 2050
- Renewable rollout rate almost unconstrained
- Lower cap on underground carbon storage rate, which is only used for non-fossil fuel sources post 2050 (e.g. cement production).

CONSTRAINED RENEWABLES ROLLOUT

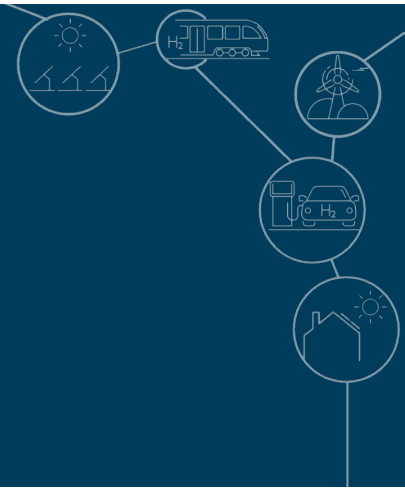
- Renewable rollout rate limited to several times historical levels (to examine supply chain and social licence constraints)
- Much higher cap on underground carbon storage (to make net zero achievable).

ONSHORING

- Domestic production of iron and aluminum using clean energy
- Progressively displaces exports of iron ore, bauxite, alumina and fossil fuels.

The Reference Scenario has *no emissions objective*. All other Scenarios are 'net zero' for both the domestic and exported emissions separately, and start from current emissions, and track in a line to net zero emissions by 2050 (domestic) and 2060 (export). None of the Scenarios are forecasts.

How to make net zero happen?



Key insights from Net Zero Australia modelling

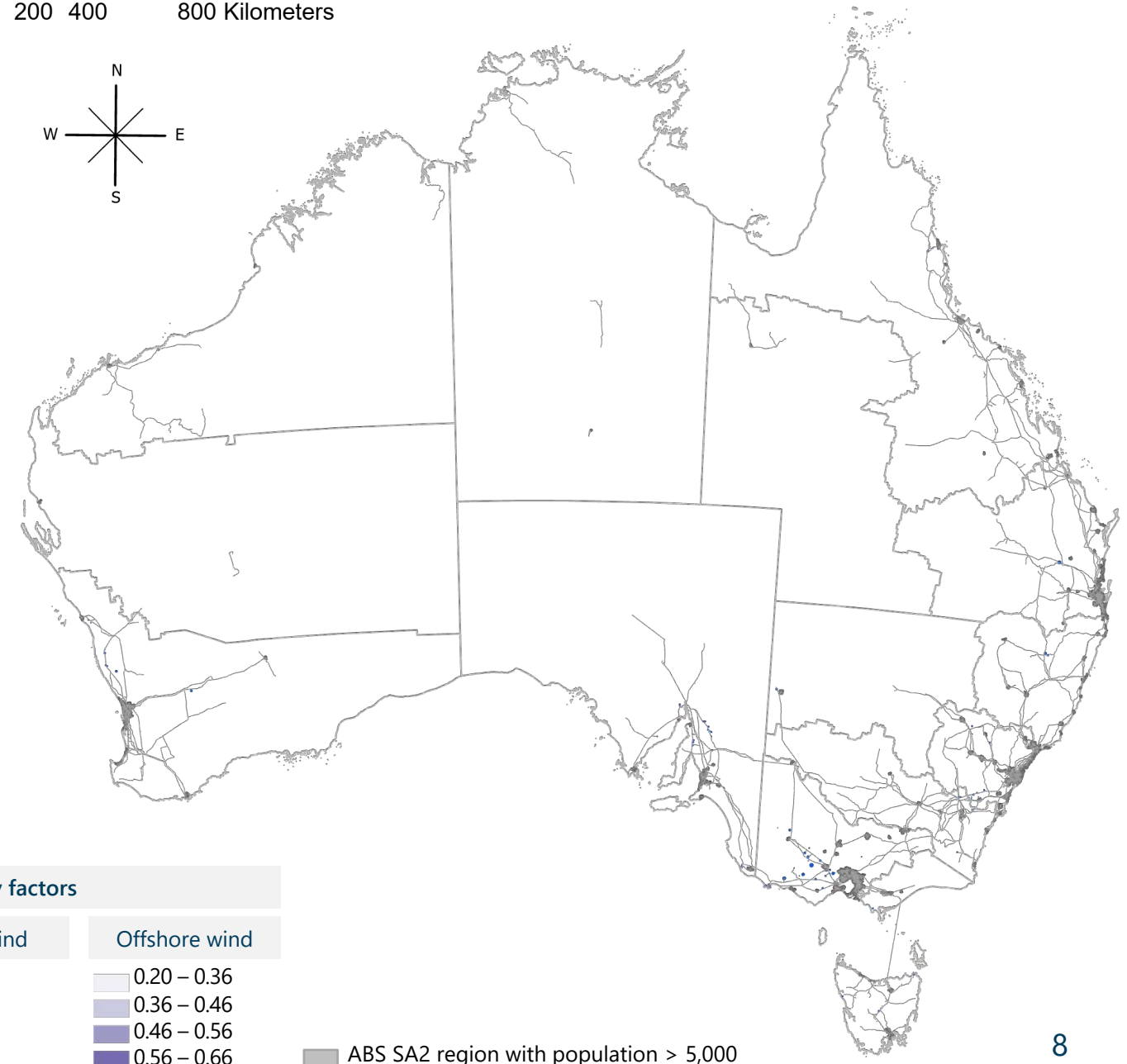
WHAT IT WOULD TAKE TO REACH NET ZERO		WHAT AUSTRALIA MUST DO
1	Grow **renewables** as our main domestic and export energy source	**Deliver an energy transformation** unprecedented in scale and pace
2	Establish a large fleet of **batteries**, **pumped hydro** and **gas-fired firming**	
3	Greatly increase **electrification** and **energy efficiency**	
4	Develop a large **carbon capture, utilisation and storage** industry	
5	Greatly expand our **energy transmission and distribution networks**	
6	Attract and invest $7-9 trillion of **capital** to 2060	
7	No role for **nuclear** unless costs fall sharply and renewables are constrained	
8	Transition to **clean energy** and **clean minerals exports**	**Transform our exports** an essential contribution to global decarbonisation
9	**Locate** these **new export industries** in the north; possibly also in the south	
10	Expand a **skilled workforce** from about 100,000 today to 7-800,000 by 2060	**Invest in our people and land** to reduce impacts and share benefits
11	Move the **land sector** towards net zero and potentially to net negative	
12	Carefully manage major **land use changes**, including the Indigenous Estate, ecosystems and agriculture	

1

Grow renewables as our main domestic and export energy source, to 40 times current National Electricity Market capacity – for direct use and clean fuel production

INDICATIVE ONLY

2020 (for context)



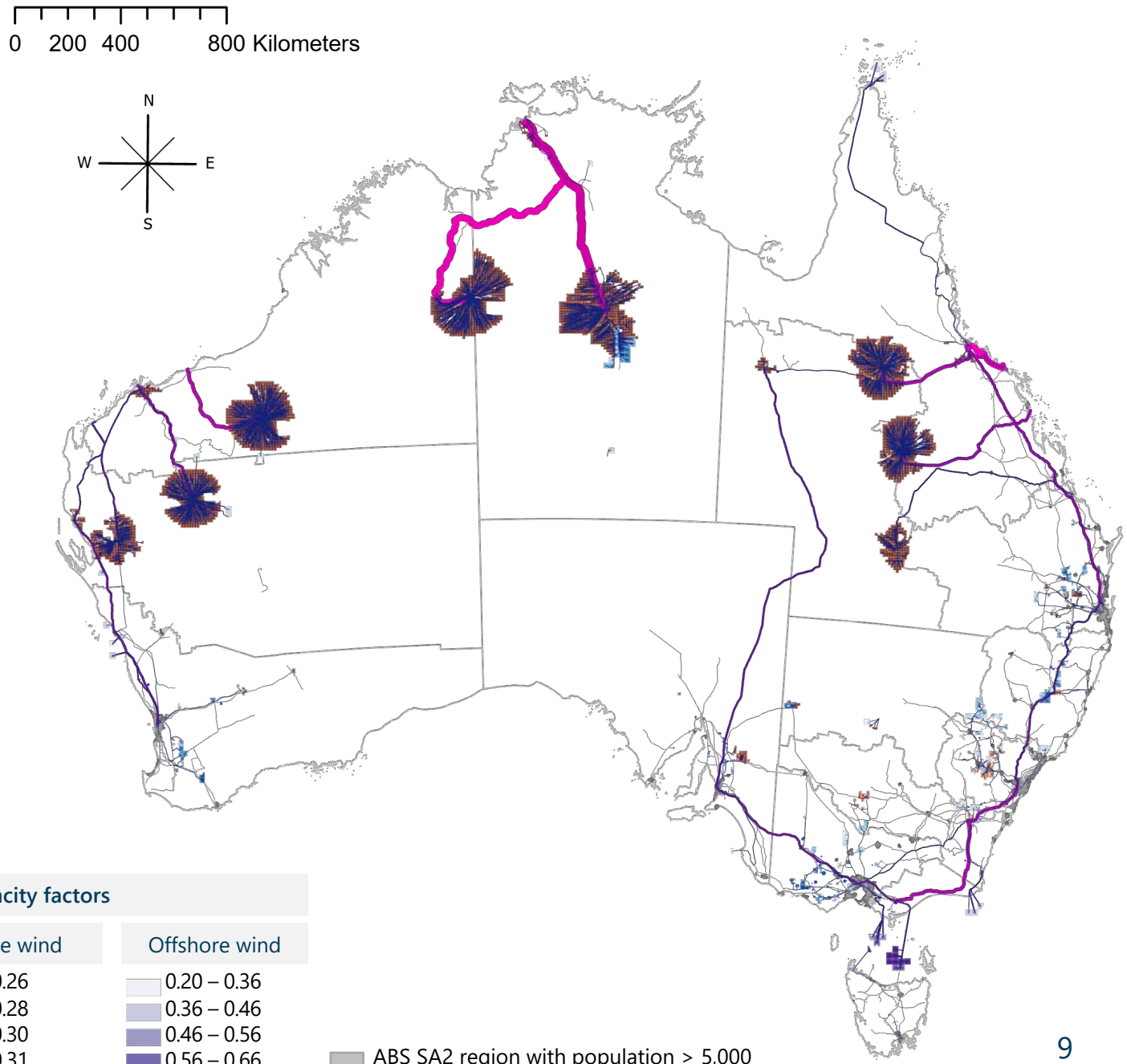
E+ 2020

1

Grow renewables as our main domestic and export energy source, to 40 times current National Electricity Market capacity – for direct use and clean fuel production

INDICATIVE ONLY

2060



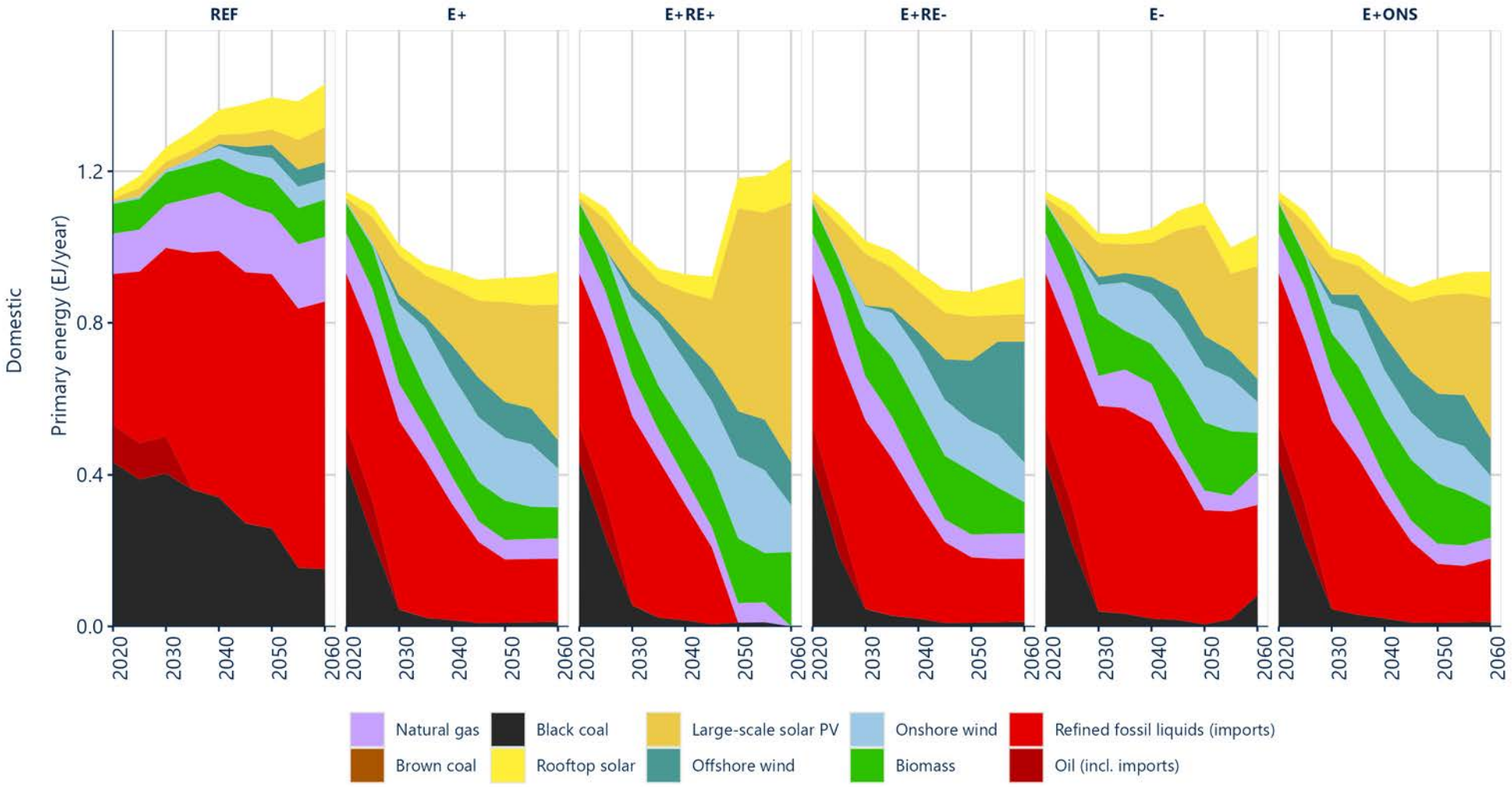
E+ 2060

Insights for Queensland

WHAT AUSTRALIA MUST DO	QLD-SPECIFIC MODELLING RESULTS
Deliver an energy transformation unprecedented in scale and pace	1. Most domestic energy is sourced from **solar and wind in the central-west**, but development faces **challenges** of location, labour, and community acceptance. 2. QLD is a domestic **energy exporter** to other states due to superior renewables. 3. Electricity storage is provided predominantly by **batteries** with **some pumped hydro**. **4. Carbon capture, utilisation and storage** expands rapidly within QLD, with good sequestration sites for CO_2 storage. **5. Total gas use decreases**, but **new gas *capacity* is needed** as a strategic reserve.
Transform our exports an essential contribution to global decarbonisation	6. QLD's **export transition** is ~6 times the size of its domestic challenge, with **coal replaced by solar** to produce hydrogen in most Scenarios. 7. QLD's **hydrogen export** potential is nation-leading, but will require community acceptance and willing trading partners. 8. Small **increases to capital costs** in remote northern regions more than **double QLD's energy exports** as production is shifted east from WA and NT.
Invest in our people and land to reduce impacts and share benefits	9. QLD **land sector** approaches but does not reach net zero due to enteric fermentation. 10. Gross energy sector **employment** could be ~100-200,000 by 2060.

Wind and solar dominate domestic energy supply

Projected domestic primary energy (EJ/ year).

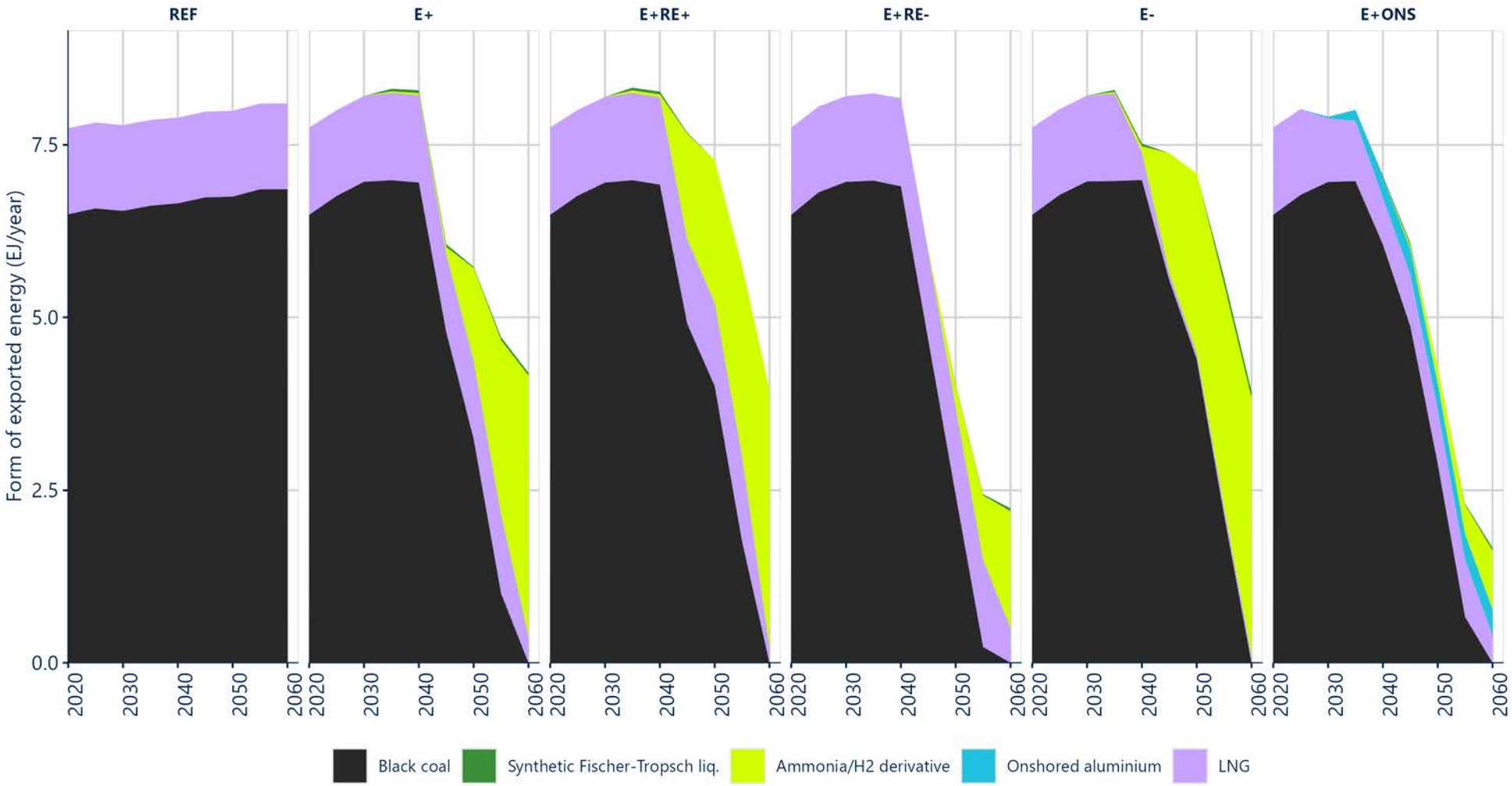


KEY TAKEAWAYS

- Renewable electricity leads energy supply in all Scenarios.
- Total primary energy supply is lower than REF in all Scenarios, due to productivity gains from end-use electrification and efficiency improvements.
- Offshore wind competes domestically on cost and is significant in E+RE- due to limitations on rollout of other renewables.

Exported energy is mainly hydrogen, with some potential to onshore aluminium

Projected form of exported energy (EJ/ year).



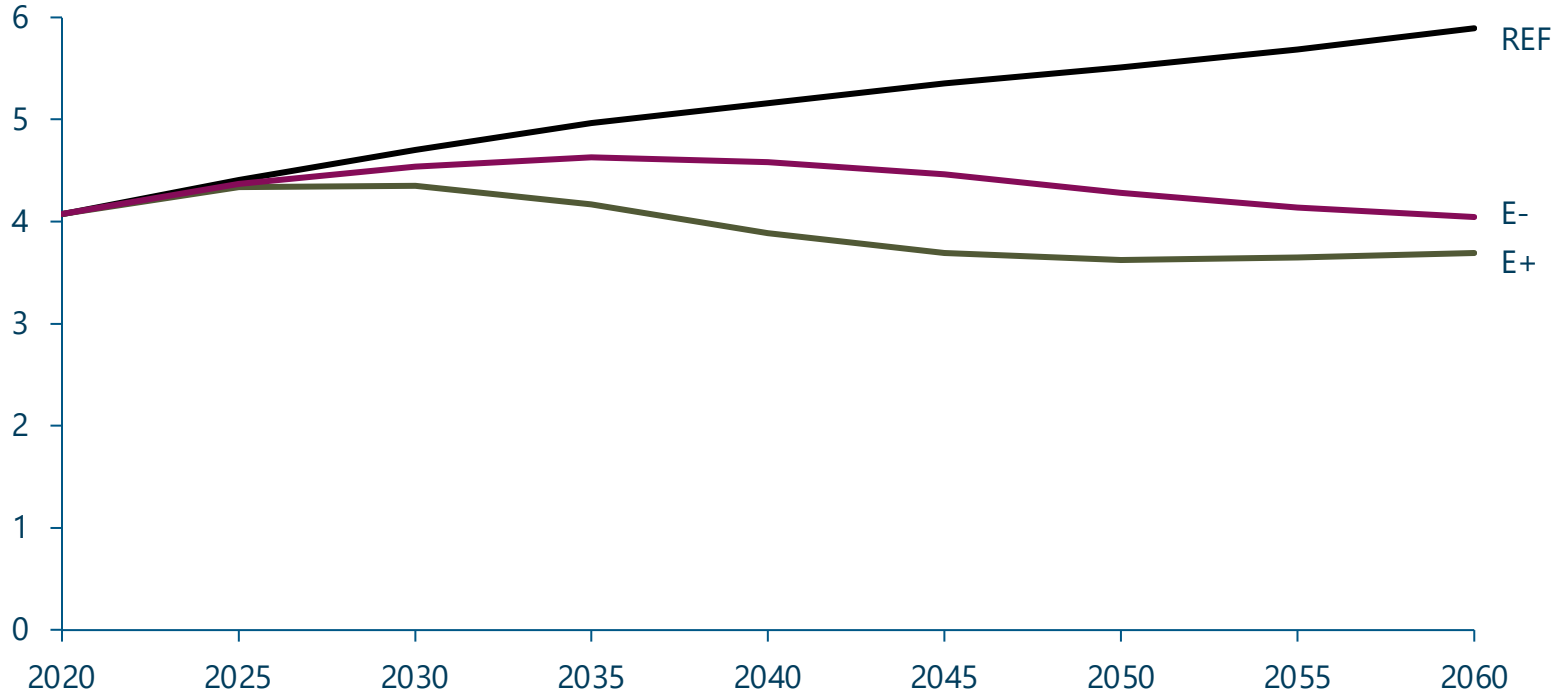
KEY TAKEAWAYS

- Ammonia/Hydrogen derivative dominates energy exports in E+ E+RE+ and E- as fossil fuel exports decline.
- Onshore processing of Australian alumina ores plays a more significant role in the E+ONS Scenario.
- Coal and LNG exports decrease rapidly from 2040.

Greatly increase electrification from 20% to 50% of all energy use, switch to clean fuels for some industrial and transport uses, and rapidly grow energy efficiency

3

Projected domestic final energy demand (Exajoules / year)



Progressive adoption of more **energy-efficient technology** keeps 2060 energy demand to around 2020 levels – despite growth in population (1.2%) and GDP (2.1%).

Some efficiency will come from **electrification**: switching to new uses such as electric vehicles and heat pumps.

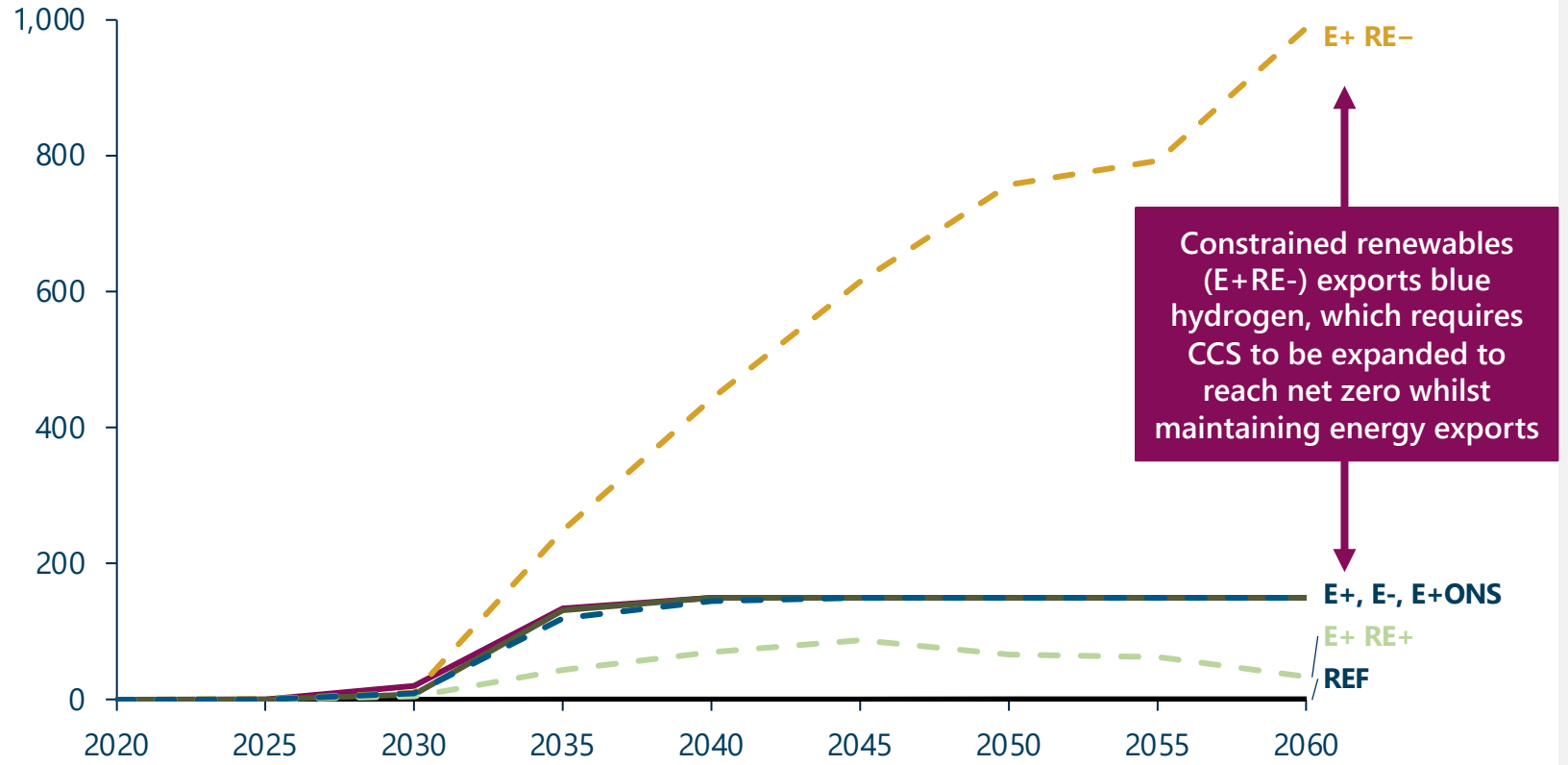
Some efficiency will also come from **upgrading technologies** now in use.

CHART 1 OF 2

Develop a large carbon capture, utilisation and storage industry – to permanently store 80-1000 Mt/yr of CO2 to make clean fuels and negative emissions

4

Geological carbon dioxide (CO_2) sequestration (Mt-CO_2 / year)



CCUS is needed for:

- **non-energy uses**
- **producing 'negative emissions'**, i.e. storing carbon emissions taken out of the atmosphere.

Also, when renewable and transmission builds are constrained, **CCUS with fossil fuels** helps to reach net zero.

CCUS is needed in all scenarios and sensitivities, except for 100% renewable power (E+RE+) and a net negative land sector (Land+).

Attract and invest $7-9 trillion of capital to 2060 from international and domestic sources

6

Cumulative supply-side capital committed by year (2020 AUD trillions)

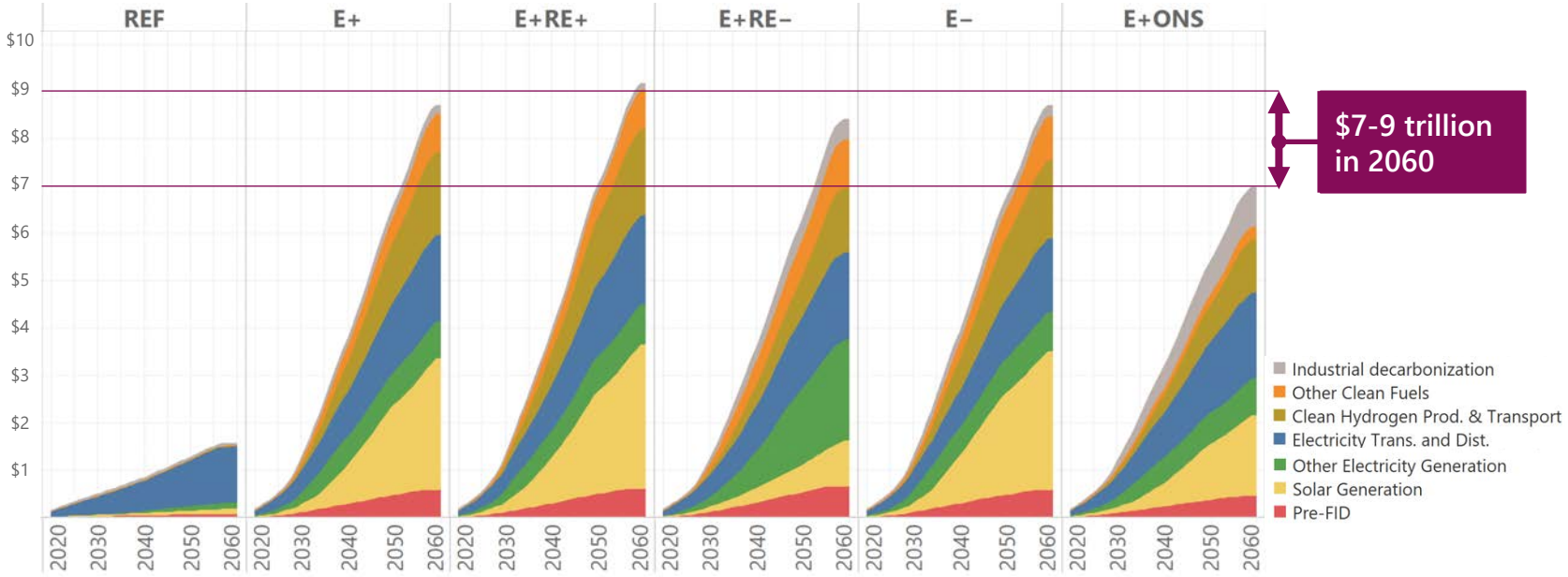


CHART 1 OF 3

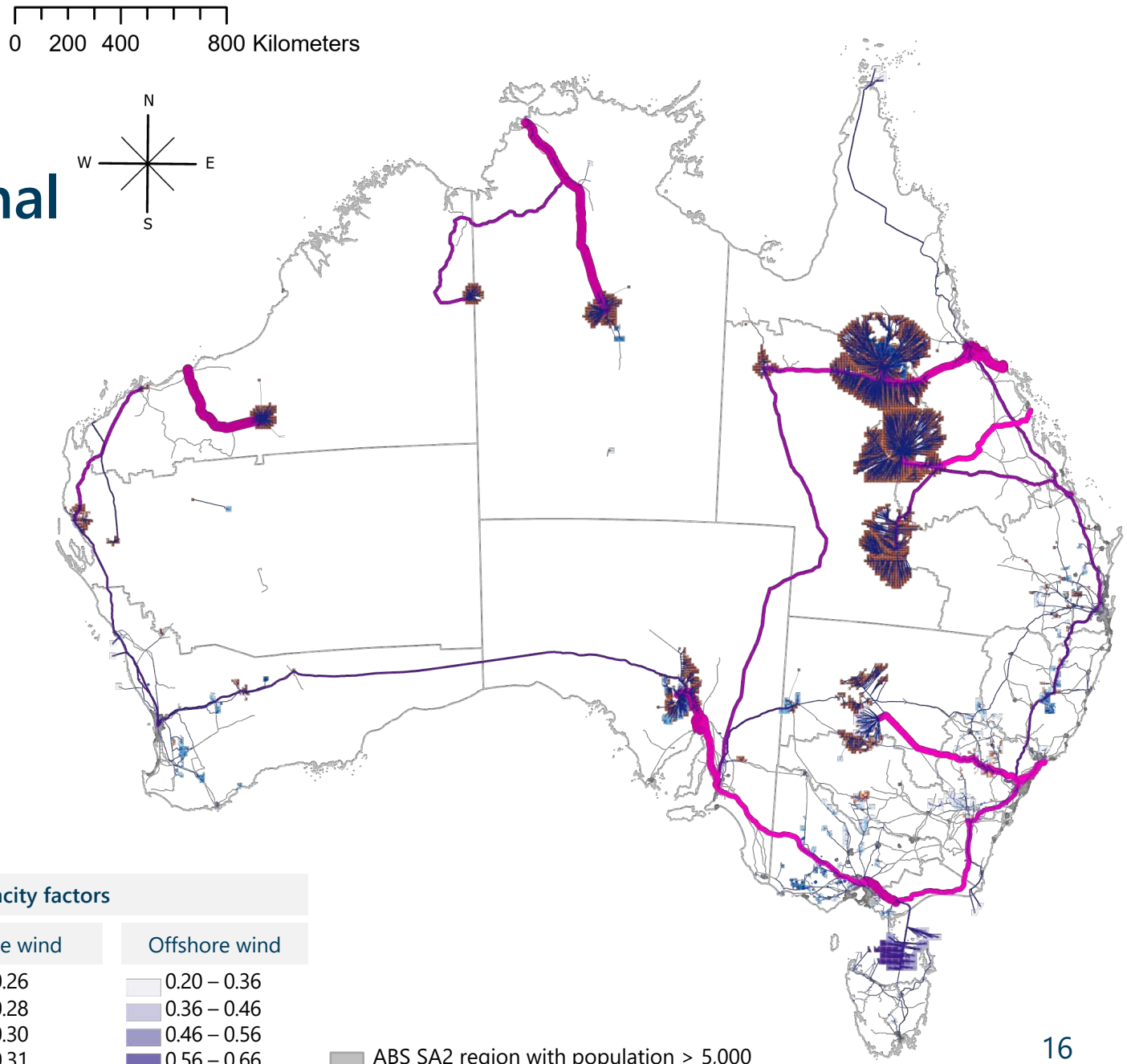
Investment is much higher in the net zero transition than continuing to use fossil fuels. However:

- Decarbonisation will **reduce our reliance on gas and oil imports**.
- The Reference case **assumes that fossil fuel costs remain consistently low**, which is deeply uncertain and has not been modelled.
- **Conventional technologies that use fossil fuels** will become less available.
- The **costs of inaction** would be substantial

9

Locate these new export industries in the north, and possibly also in the south

INDICATIVE ONLY



2060 Higher regional construction costs

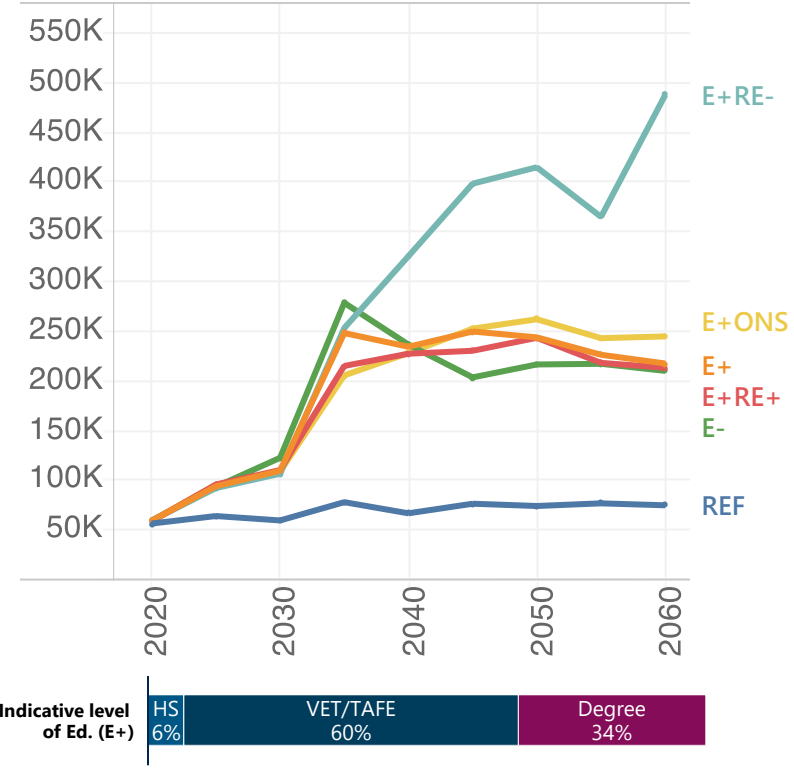
E+ 2060 Sens: RemoteCost+

Expand a skilled workforce from about 100,000 today to 700,000 - 850,000 by 2060

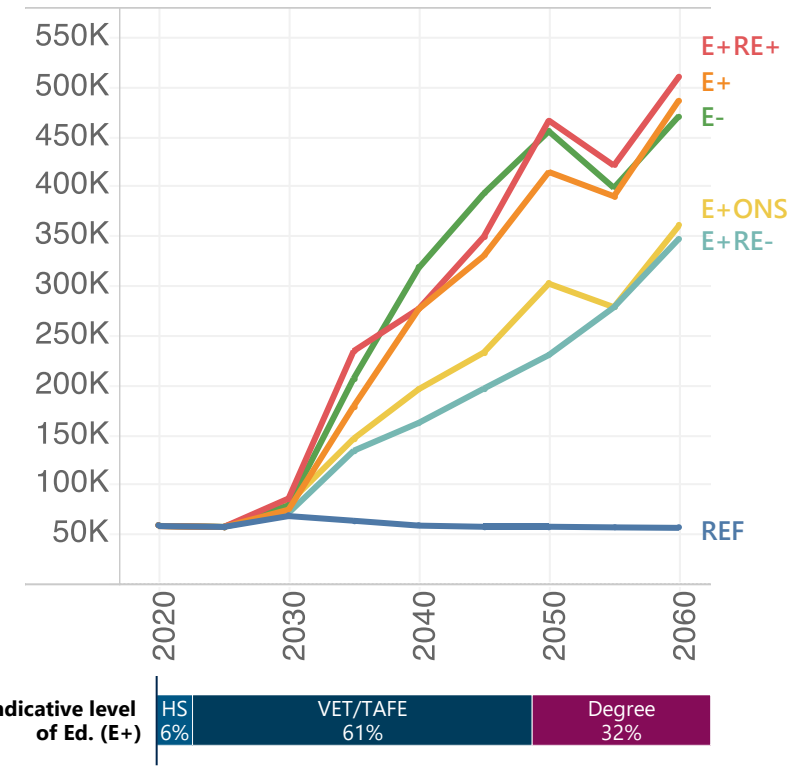
10

Gross energy sector employment (full time equivalent jobs)

DOMESTIC SYSTEM



EXPORT SYSTEM



By 2060, the current energy sector workforce of 100,000 would expand to **700,000 - 850,000 workers** – most with **technical skills**.

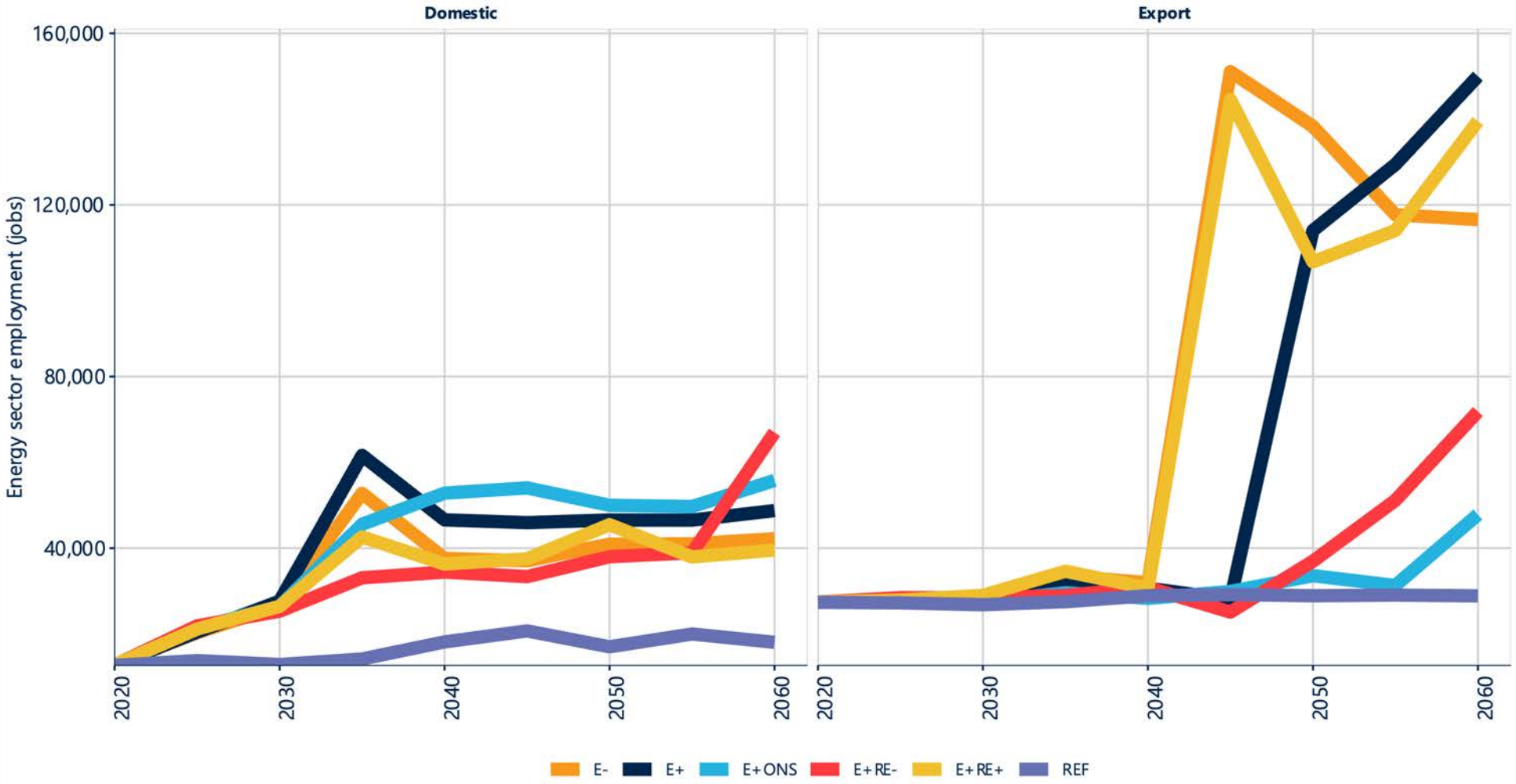
Most new workers will be in **regional and remote Australia**, which would experience **significant population growth**.

This has significant implications for **First Nations** peoples, **national security** and **immigration.**

Workforce growth would be needed for both **domestic and export** decarbonisation.

Gross energy sector employment could be ~100-200,000 by 2060, across both domestic and export energy systems

Net energy sector employment (jobs), domestic and export system.



EMPLOYMENT

KEY TAKEAWAYS

- Thousands of jobs are needed to serve energy systems in all Scenarios.
- Gross domestic jobs do not significantly vary between most Scenarios, with between ~40-60,000 jobs required in 2060 for all Scenarios.
- However, gross export jobs do significantly vary, with between ~50-150,000 jobs modelled for all net zero Scenarios in 2060.
- Gross export jobs are highest in the E+ Scenario, as faster electrification means that QLD will be able to export more energy.

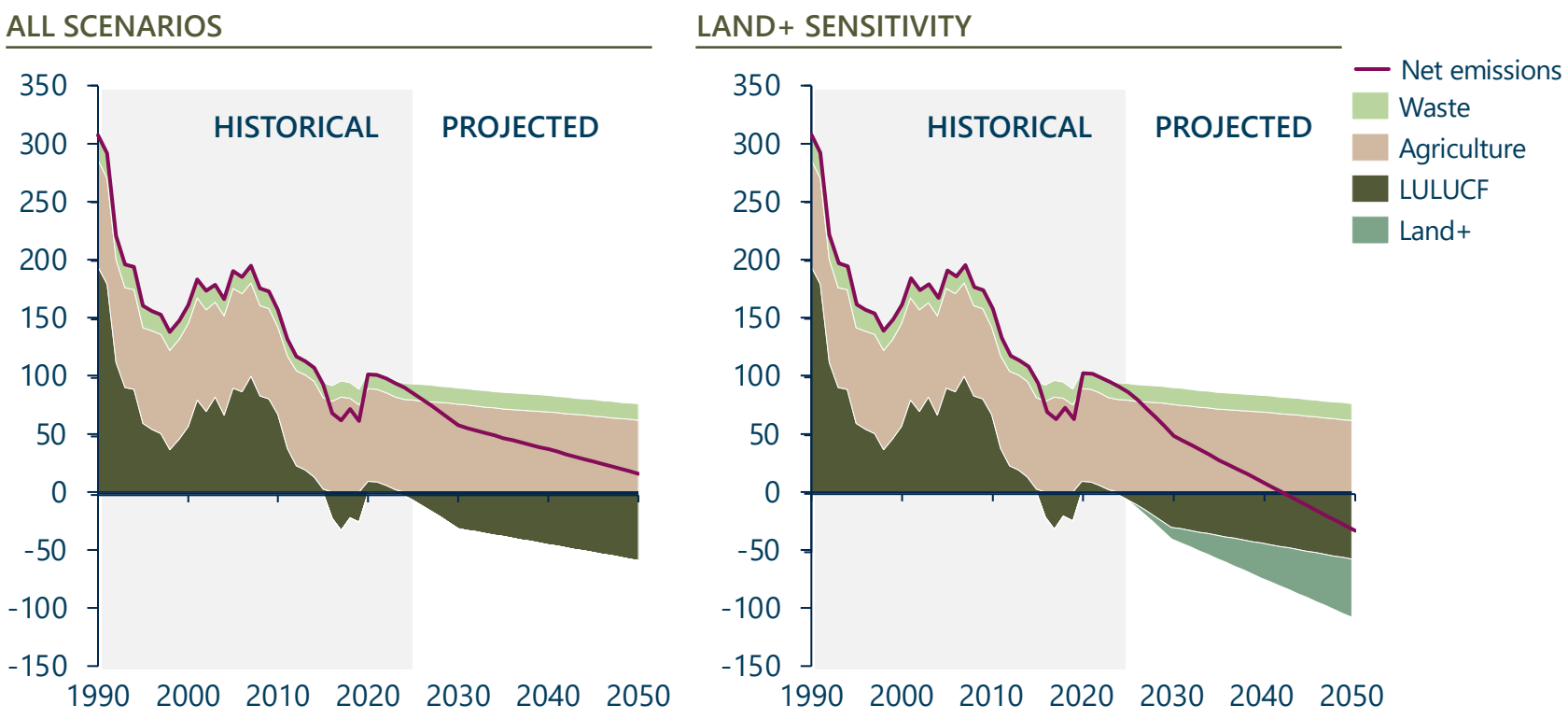
Modelling note

- Gross jobs represent the total number of jobs in each year employed in the energy sector.

Move the land sector towards net zero and potentially net negative – by reducing livestock emissions by 20 Mt/yr and expanding revegetation by 50 Mt/yr

11

Historical and projected GHG emissions (Mt-CO_2e / year).



Land sector emissions are reduced by:

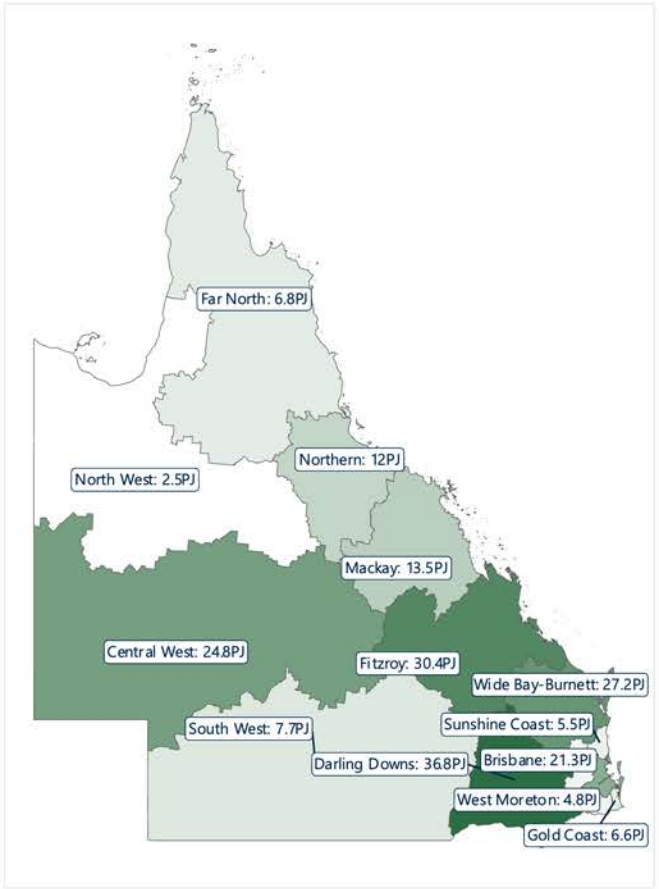
- feeding supplements
- Revegetation
- adding fertiliser inhibitors
- using waste methane.

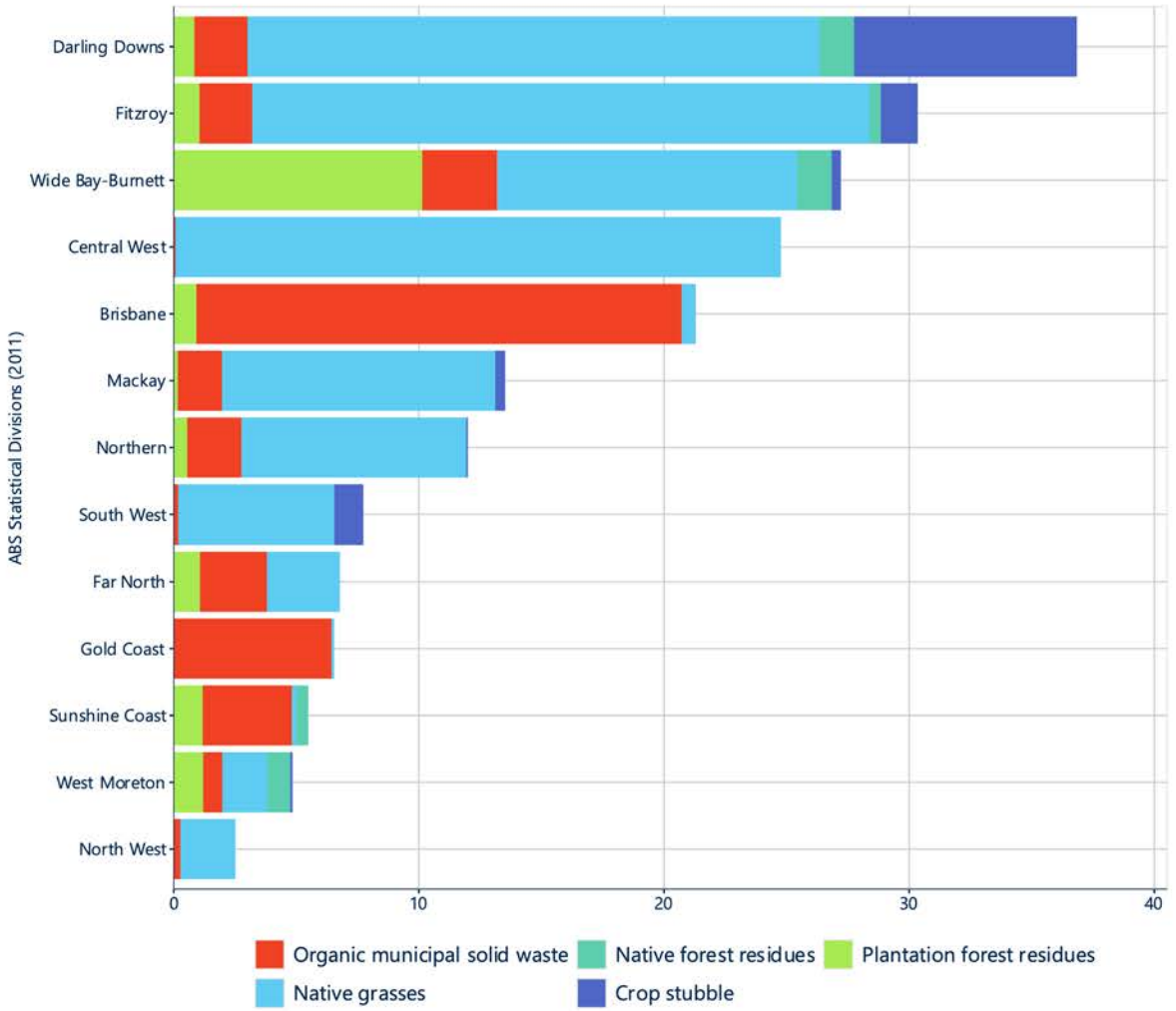
Land sector **does not quite reach net zero** in our Core Scenarios, and reaches modest net negative in our Land+ sensitivity (from better management of rangeland).

Energy and industry can not plan to rely on significant **offsets** from the land sector.

Queensland biomass resource is mostly made up of native grasses

2050 biomass resource availability (PJ/ year). Aggregated by resource type and ABS statistical division



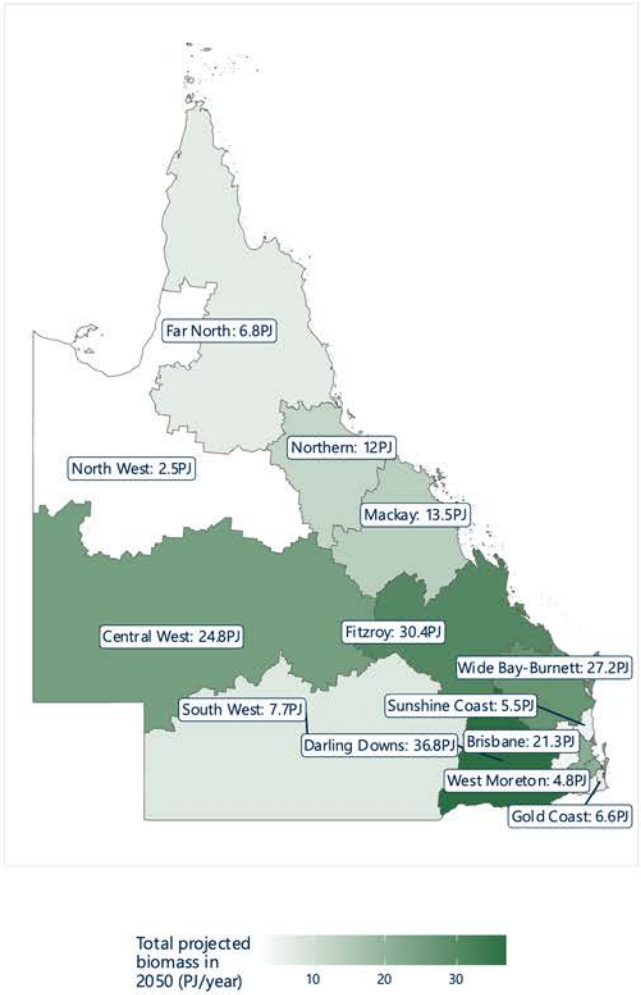


KEY TAKEAWAYS

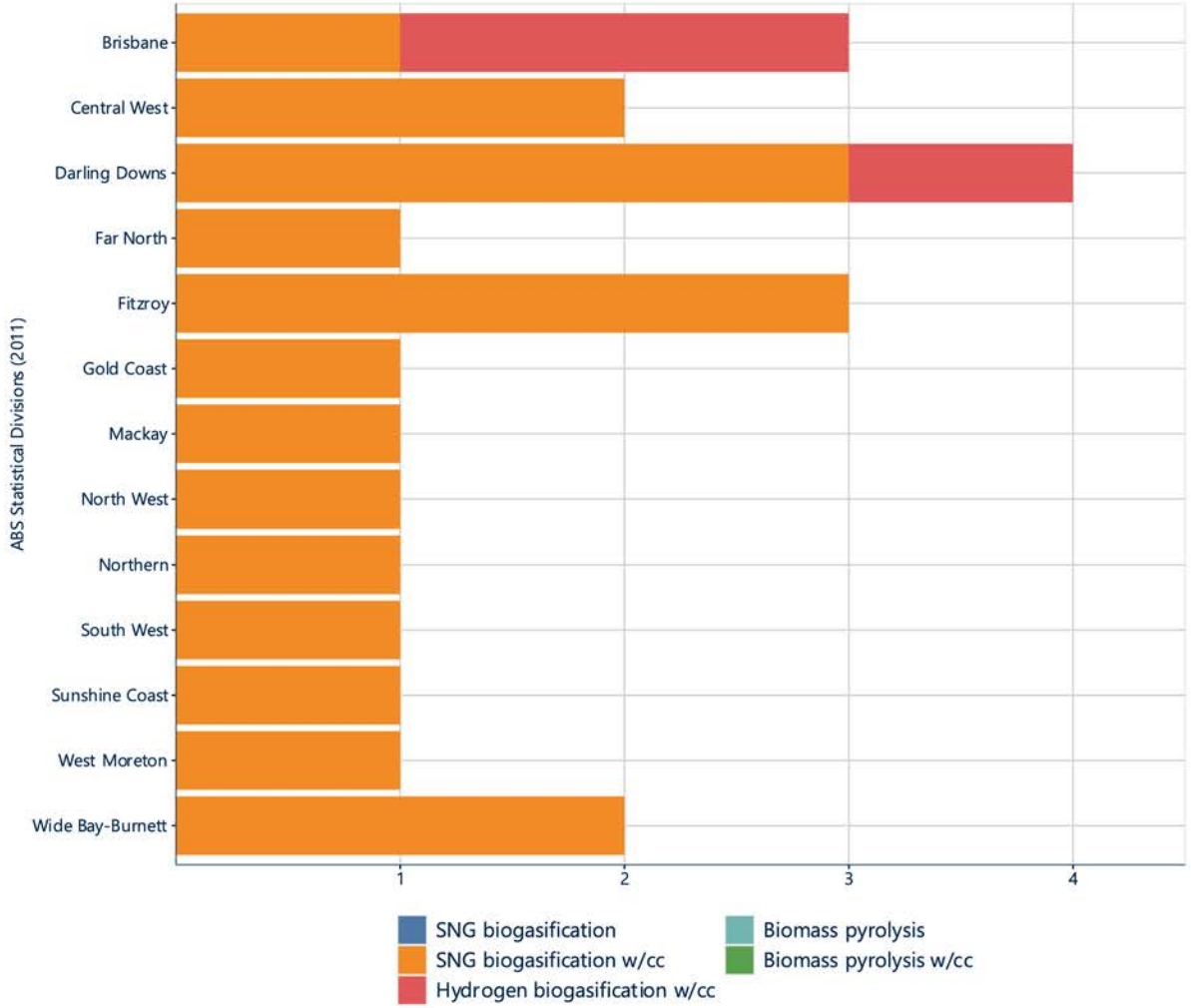
- Approx. 192.2/year is available dry biomass resource.
- The biomass resource in Queensland is comprised of native grasses, organic municipal waste from cities, and waste residues from cropping and forestry.

Biomass is used to produce low emissions gaseous fuels

2050 biomass resource availability (PJ/year).
Aggregated by resource type and ABS statistical division



Number of bioenergy conversion facilities, E+ 2050.
Aggregated by plant type and ABS statistical division

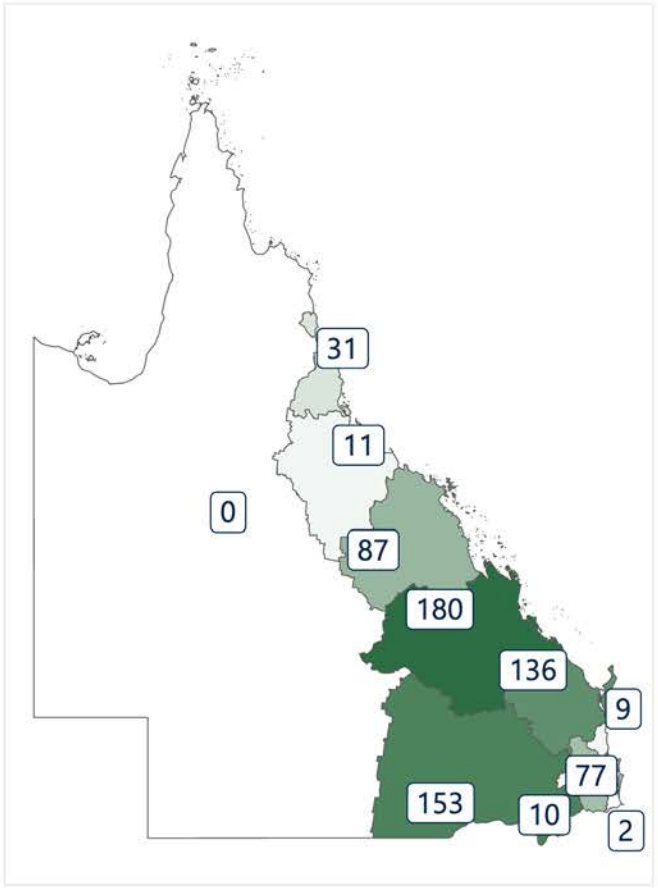


KEY TAKEAWAYS

- Biomass is used primarily to produce low-emissions gaseous fuels (methane/SNG via biogasification) for pipeline injection.
- Treatment occurs across the state, largely in the southeastern regions, through SNG bio gasification and hydrogen bio gasification, with carbon capture.

Afforestation of 696 kilo hectares of farmland is possible in Queensland

Downscaled farmland afforestation in Queensland by ABS Statistical Area 4 2021 (kHa).



SENSITIVITY

Land+

Combined land sector goes to modest net negative emissions

KEY TAKEAWAYS

- Any program establishing trees on farmland should consider: the impact of natural disturbances and climate change, the need for carbon monitoring improvement, and the impacts on stakeholders.
- Farmland afforestation is available across the state. The Fitzroy Region makes up the highest proportion (25.9%) of available land for afforestation.

Summary of strategic directions

OPTIONS	**Accelerate all options** that could make a material contribution to decarbonisation.
EXPORTS	A **clean energy export framework** will be needed to ensure that we phase out fossil fuel exports and grow clean energy exports in an orderly, fair, and net zero-compatible transition. Both **clean energy** and **clean processed minerals** should be pursued as export opportunities. **Industry** strategies and import replacement pathways should be re-oriented towards **comparative advantages.** We should be **early adopters** of export technologies, and **fast followers** of domestic technologies.
IMPACTS	The speed of **land use change** will be essential and requires proactive management, particularly for First Nations communities and farming communities. **Benefit sharing** must be prioritised, proactive, and based on principles of partnership, inclusion, and net gain. Net gain for **environments and biodiversity** should be pursued in parallel with net zero. Minimising public impacts requires **orderly asset closures**, supported by multiple policy mechanisms. **Low-income households** and **fossil fuel regions** will need support to mitigate impacts.
ROLES	**Trust** in government institutions and businesses involved in the transition is essential to its success. **Governments** must stimulate and coordinate **private action**, and decide who pays, and how. Private sector **investment risk** will be too high in many cases, unless mitigated by government. Building net zero workforces and supply chains requires a certain, large, and long **investment pipeline.** Net zero must be a **high national priority** for decades, requiring sustained leadership and collaboration.

NZAu is funded by gifts and grants, and engages broadly

SPONSORS

Generous financial support has enabled this study

Gift and grant agreements protect the project's independence

ADVISORY GROUP

Crucial input is being provided by diverse advisers

INDEPENDENT MEMBERS

SPONSOR NOMINEES

ENGAGEMENT

Numerous briefings have been provided to:

COMMONWEALTH MINISTERS AND DEPARTMENTS

STATE MINISTERS AND DEPARTMENTS

NON-GOVERNMENT ORGANISATIONS

RESEARCH BODIES

A website has also been established
netzeroaustralia.net.au

NZAu has consulted widely with the project's sponsors, Advisory Group members and many stakeholders, but is independent of all of them.
NZAu does not purport to represent their positions or imply that they have agreed to our methodologies or results.

netzeroaustralia.net.au

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THE UNIVERSITY OF QUEENSLAND AUSTRALIA CREATE CHANGE

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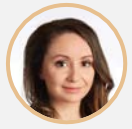

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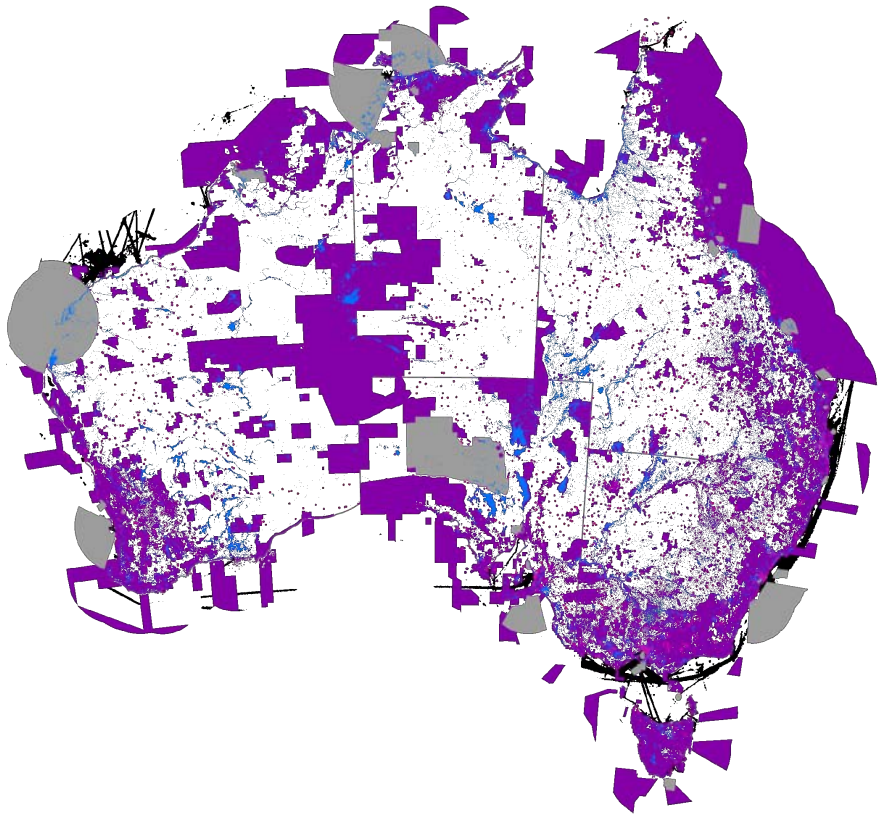
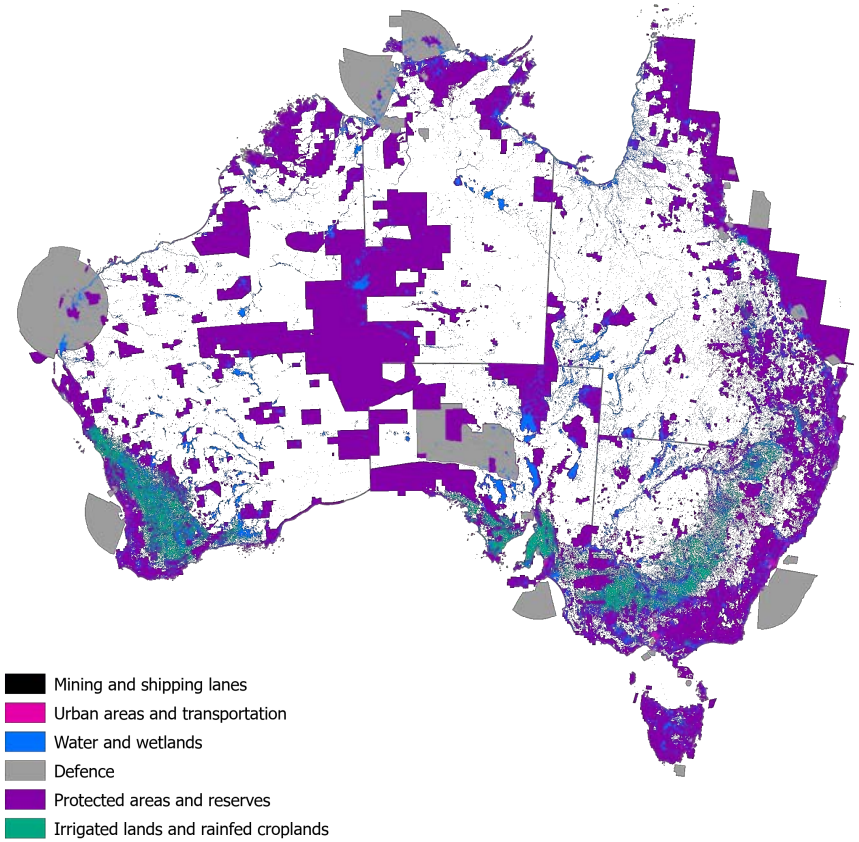
12

Carefully manage major land use changes, including to the Indigenous Estate, ecosystems and agriculture

Wind generation exclusion areas



Solar PV generation exclusion areas



Our exclusion process for land and sea areas

1. Removes areas protected by law
2. Removes areas supported by empirical evidence, research, or stakeholder interaction
3. Updates as risks and threats evolve, collaborations deepen, and data allow

12

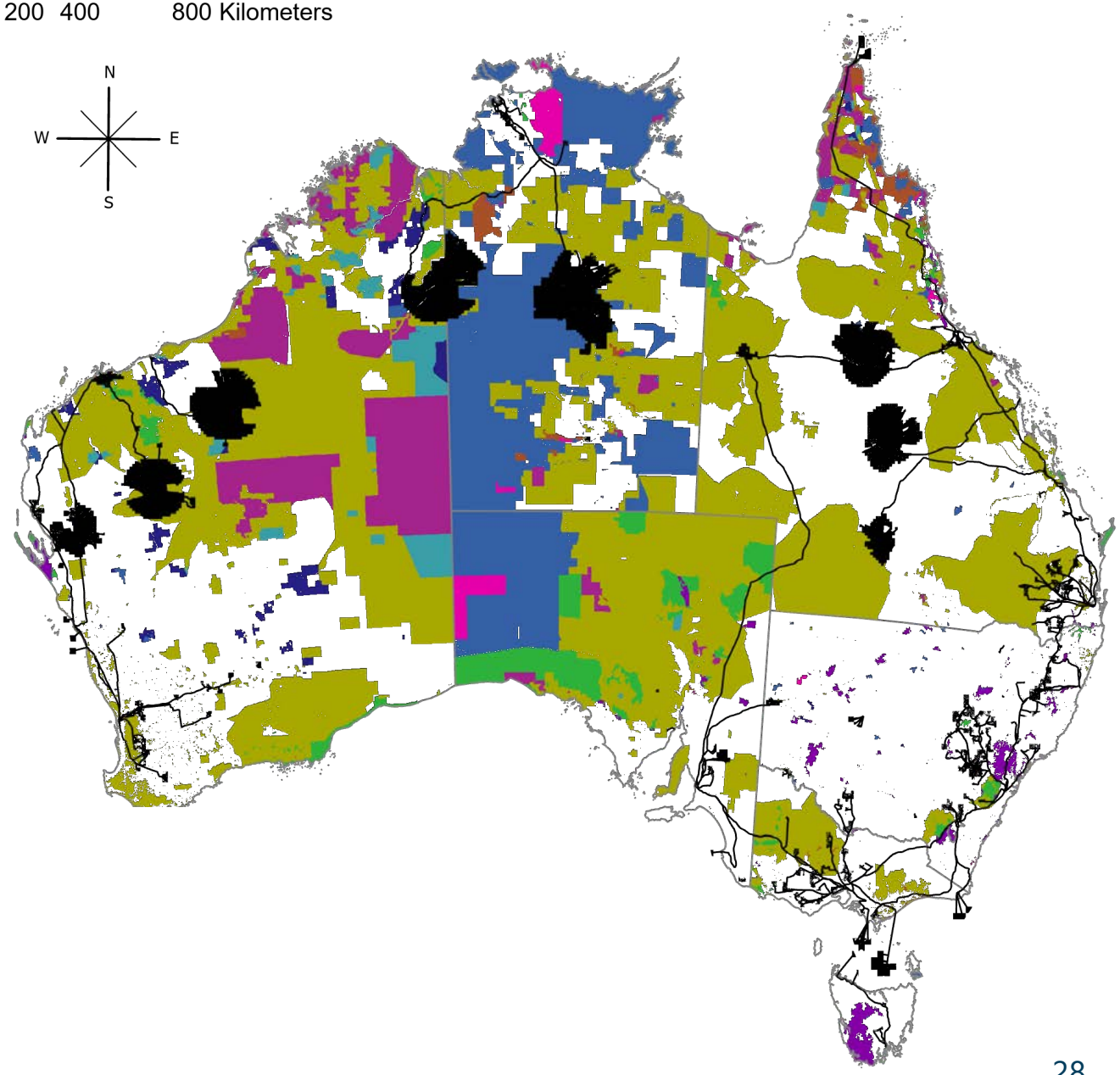
Carefully manage major land use changes, including to the Indigenous Estate, ecosystems and agriculture

INDICATIVE ONLY

0 200 400 800 Kilometers

N W E S

Estate category	Total build area (km²)	Share of NZAu build (%)	Share of category area (%)
Indigenous co-managed	33	< 0.1%	<1%
Indigenous managed	1,958	1.6%	2.2%
Indigenous owned	17,465	14.5%	2.2%
Subject to other special rights	32,186	27%	1.2%
Combined total	**51,642**	**43%**	**1.2%**



E+ 2060

Note: the specific location of export zones are assumed not optimised

L. Lymburner, P. Tan, A. McIntyre, M. Thankappan, and J. Sixsmith, "Dynamic Land Cover Dataset Version 2.1," Geoscience Australia, Canberra, 2017. Accessed: June 21, 2021. [Online]. Available: http://pid.geoscience.gov.au/dataset/ga/83868a