Interim results

Public launch | August 2022

NET ZERO
AUSTRALIA

THE UNIVERSITY OF MELBOURNE

THE UNIVERSITY OF QUEENSLAND AUSTRALIA
CREATE CHANGE

PRINCETON UNIVERSITY

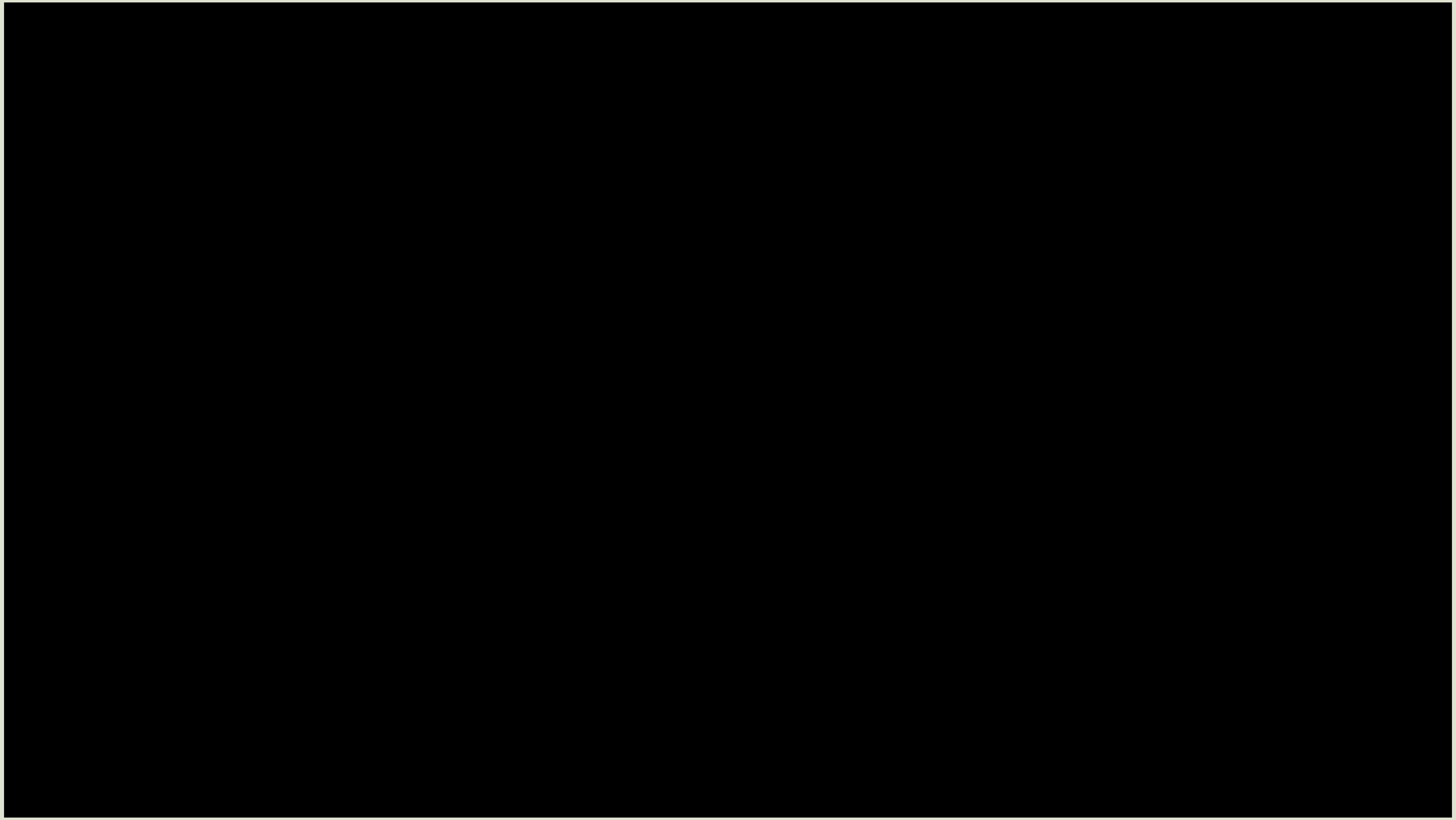
nous

Introductions from the Vice-Chancellors

Introductions from Advisory Board members

A MESSAGE FROM

Kado Muir – Chair, National Native Title Council (NNTC)



A MESSAGE FROM

Kelly O'Shanassy - Chief Executive, Australian Conservation Foundation

A MESSAGE FROM

Michele O'Neil - President, Australian Council of Trade Unions (ACTU)

Agenda

1. About the study  Katherin Domansky
2. Scenarios and key insights  Chris Greig
3. Modelling (1)  Simon Smart
4. Modelling (2) and downscaling  Michael Brear
5. Mobilisation and next steps  Richard Bolt

About the Net Zero Australia study

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

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

CREATE CHANGE

PRINCETON UNIVERSITY

nous

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

NZAu is funded by gifts and grants, and engages broadly

SPONSORS

Generous financial support has enabled this study

apa
Dow
FUTURE ENERGY EXPORTS Cooperative Research Centre
FUTURE FUELS CRC
MINDEROO FOUNDATION
Worley energy | chemicals | resources

Gift and grant agreements protect the project's independence

ADVISORY GROUP

Crucial input is being provided by diverse advisers

AUSTRALIAN CONSERVATION FOUNDATION
ACTU australian council of trade unions
CLIMATE COUNCIL
ENERGY CONSUMERS AUSTRALIA
THE ETHICS CENTRE
National Farmers Federation
National Native Title Council
St Vincent de Paul Society NATIONAL COUNCIL of AUSTRALIA Inc. good works

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 developed

The Net Zero Australia team

STEERING COMMITTEE


Robin Batterham
University of Melbourne and Chair


Katherin Domansky
Independent Member


Michael Brear
University of Melbourne


Simon Smart
University of Queensland


Chris Greig
Princeton University


Richard Bolt
Nous Group

RESEARCHERS and ADVISERS

The University of Melbourne


Rodney Keenan


Richard Eckard


Dominic Davis


Andrea Vecchi


Julian McCoy


Yimin Zhang


Anita La Rosa


Brendan Cullen


Claire Vincent


Pierluigi Mancarella


Maria Lopez Peralta


Erin Mayfield

The University of Queensland Australia
Create Change


Andrew Pascale


Bishal Bharadwaj


Jordan Beiraghi


Mojgan Tabatabaei


Oscar Vosshage


Utkarsh Kiri


Kirsty Fraser


Eloise Larsen


Tapan Saha

Princeton University


Eric Larson


Jesse Jenkins


Molly Seltzer

nous


Tom Strawhorn


Sarah Simon


Nathalie Swainston

Energy System Modelling


Ben Haley


Ryan Jones

We modelled six varied 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
- No limit on renewable rollout
- Lower cap on underground carbon storage

E-

Slower electrification

- Slower electrification of transport and buildings compared to E+
- No limit on renewable rollout rate
- Lower cap on underground carbon storage rate

E+ RE+

Full renewables rollout

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

E+ RE-

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)

E+ ONS

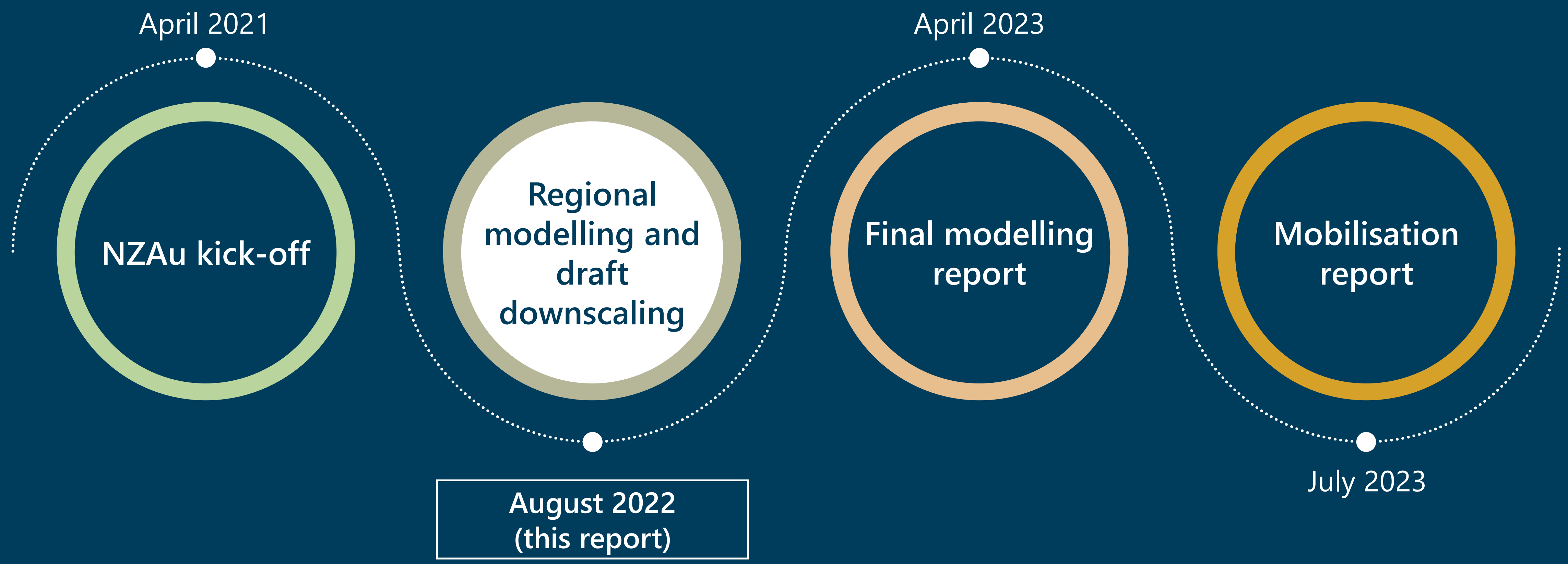
Onshoring

- Local 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.

This document is the first of our public results

NET ZERO AUSTRALIA STUDY TIMELINE



About the modelling: approach and scenarios

Modelling approach

- Linear emissions reduction for domestic and export
- Best available inputs and assumptions
- Least cost optimisation
- 'Downscale' to model changes at a fine resolution.

Design of Scenarios

Reflect the boundaries of the Australian debate

- Rate of electrification
- Renewable build rates
- Limits on fossil fuels
- Carbon storage.

About the study

What *does* this study do?

Illustrates pathways to net zero to help everyone appreciate:

- scale, complexity and cost
- different pathways
- how we all might contribute
- how change could be managed.

What *doesn't* this study do?

- predictions or recommendations
- consider fossil fuel supply constraints
- costs of inaction on climate change
- model demand for clean energy exports.

Key insights

Key insights from interim modelling results

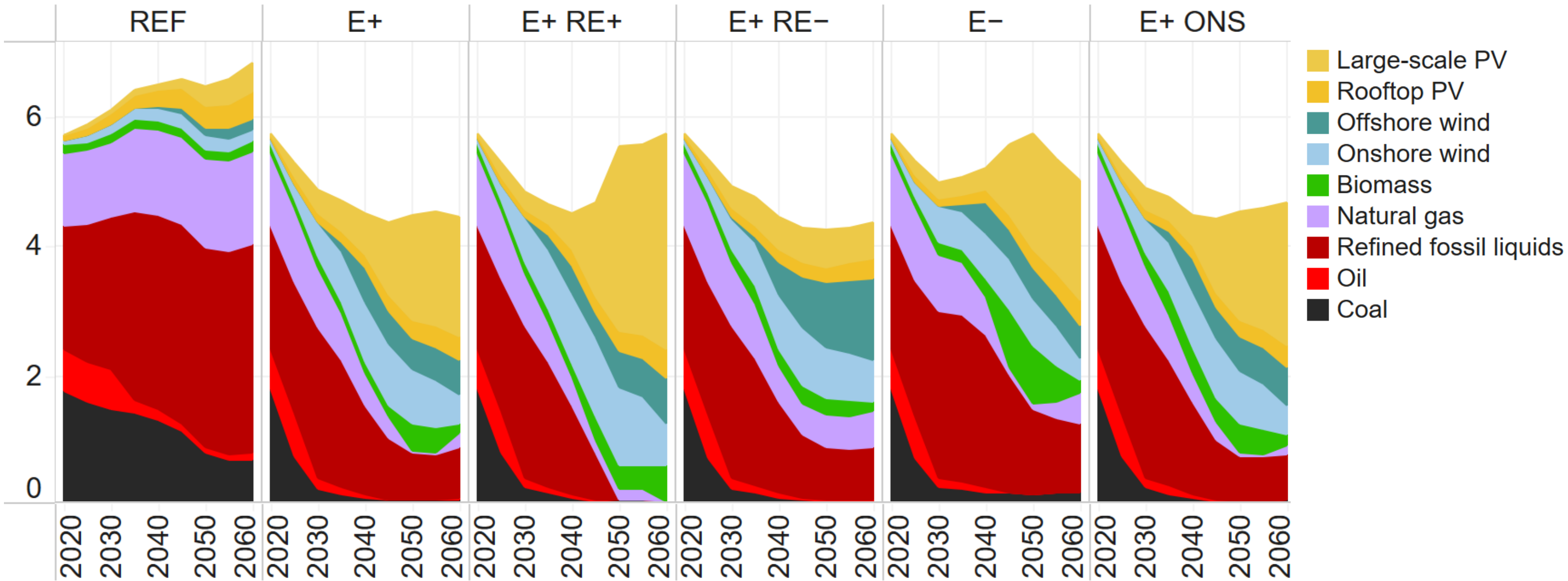
Net zero is both an immense challenge and a once-in-a-generation, globally significant and nation-building opportunity

1. Renewables will produce most or all domestic energy by 2050
2. More productive use of energy can keep domestic demand about the same, despite population growth
3. Carbon capture, utilisation and storage (CCUS) can play an important role, complementing renewables
4. Unprecedented capital investment is needed, which will produce significant benefits
5. Domestic energy's share of GDP need not rise above today's level, while being less prone to price shocks
6. Clean energy can replace our fossil fuel exports
7. The cost to export clean energy may rise, but should be competitive in a decarbonising global economy
8. A large workforce with new skills will grow across the nation, particularly in northern Australia
9. Emissions from farms, forestry and waste should fall, but are unlikely to reach net zero
10. Large changes in land and sea use will occur, and will need careful planning and community engagement

Renewables will produce most or all domestic energy by 2050 (Graph 1 of 2)

1

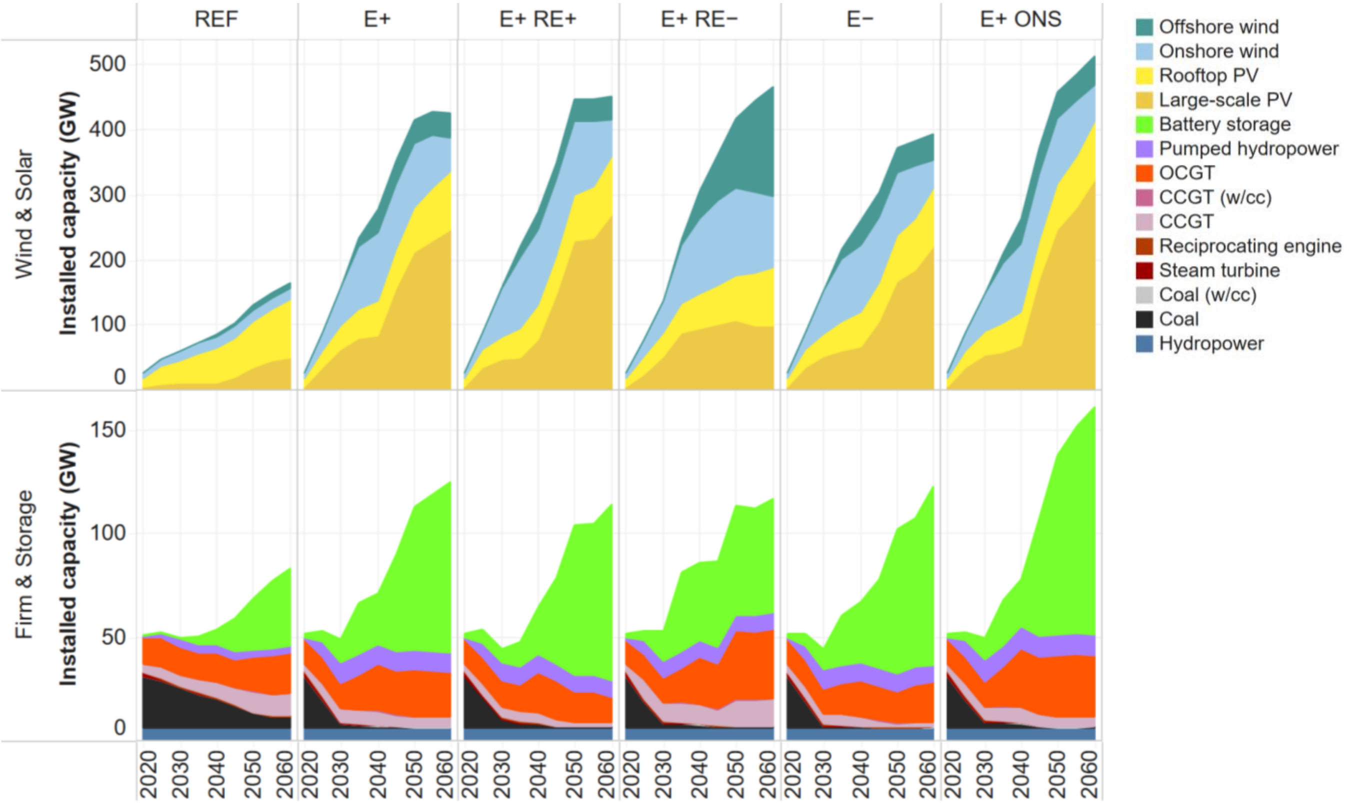
Projected domestic primary energy
(Exajoules/year)



- **Solar and wind** will be the main sources of renewable energy for domestic use
- The required **rate at which renewable energy capacity is added** will be much higher than historical levels
- **Natural gas and oil products** will play a significant role in all Scenarios (with CCUS), except if they are not permitted (which is modelled in E+RE+).

Renewables will produce most or all domestic energy by 2050 (Graph 2 of 2)

Projected domestic electricity generation capacity (Gigawatts)

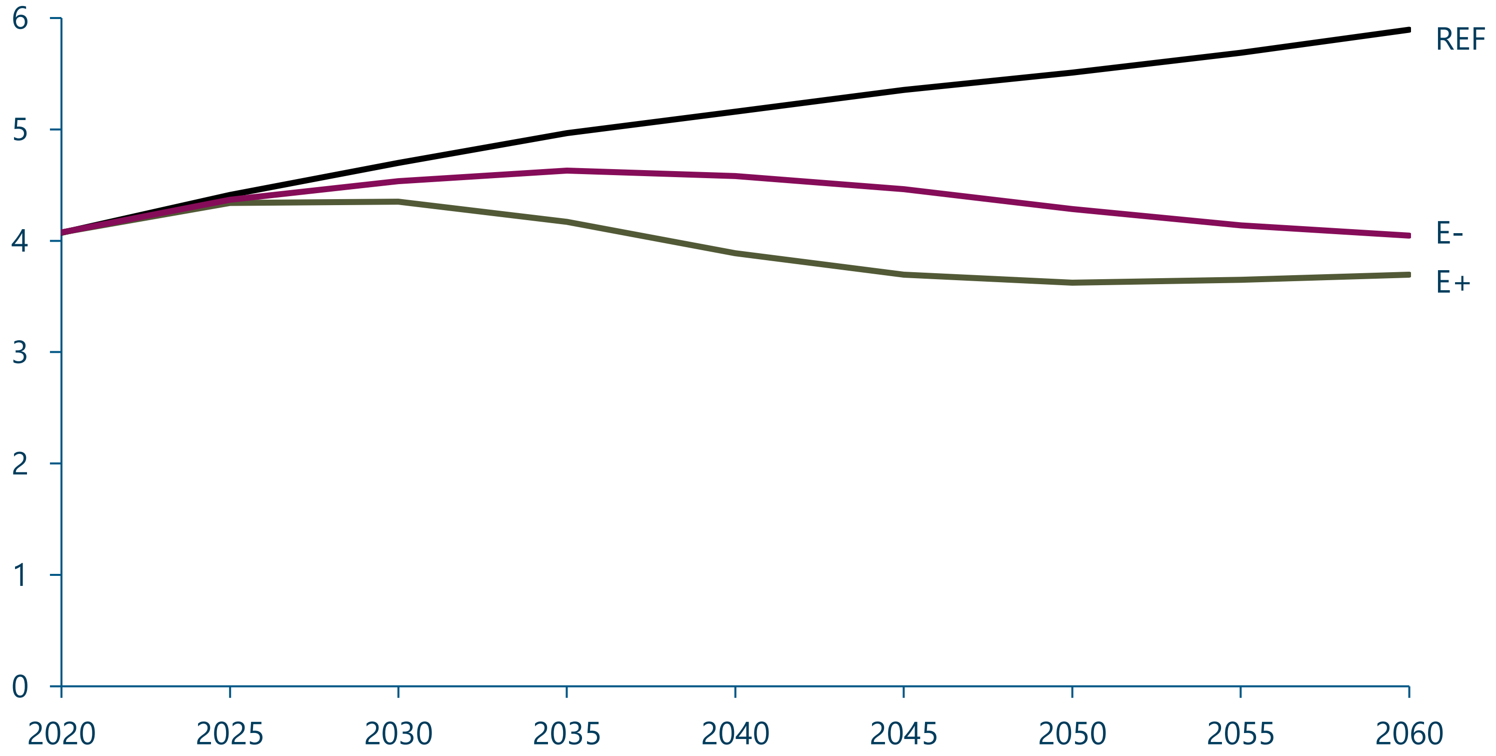


- **Solar and wind** will be the main sources of renewable energy for domestic use
- The required **rate at which renewable energy capacity is added** will be much higher than historical levels
- **Natural gas and oil products** will play a significant role in all Scenarios (with CCUS), except if they are not permitted (which is modelled in E+RE+).

More productive use of energy can keep domestic demand about the same, despite population growth

2

Projected domestic final energy demand
(Exajoules/year).

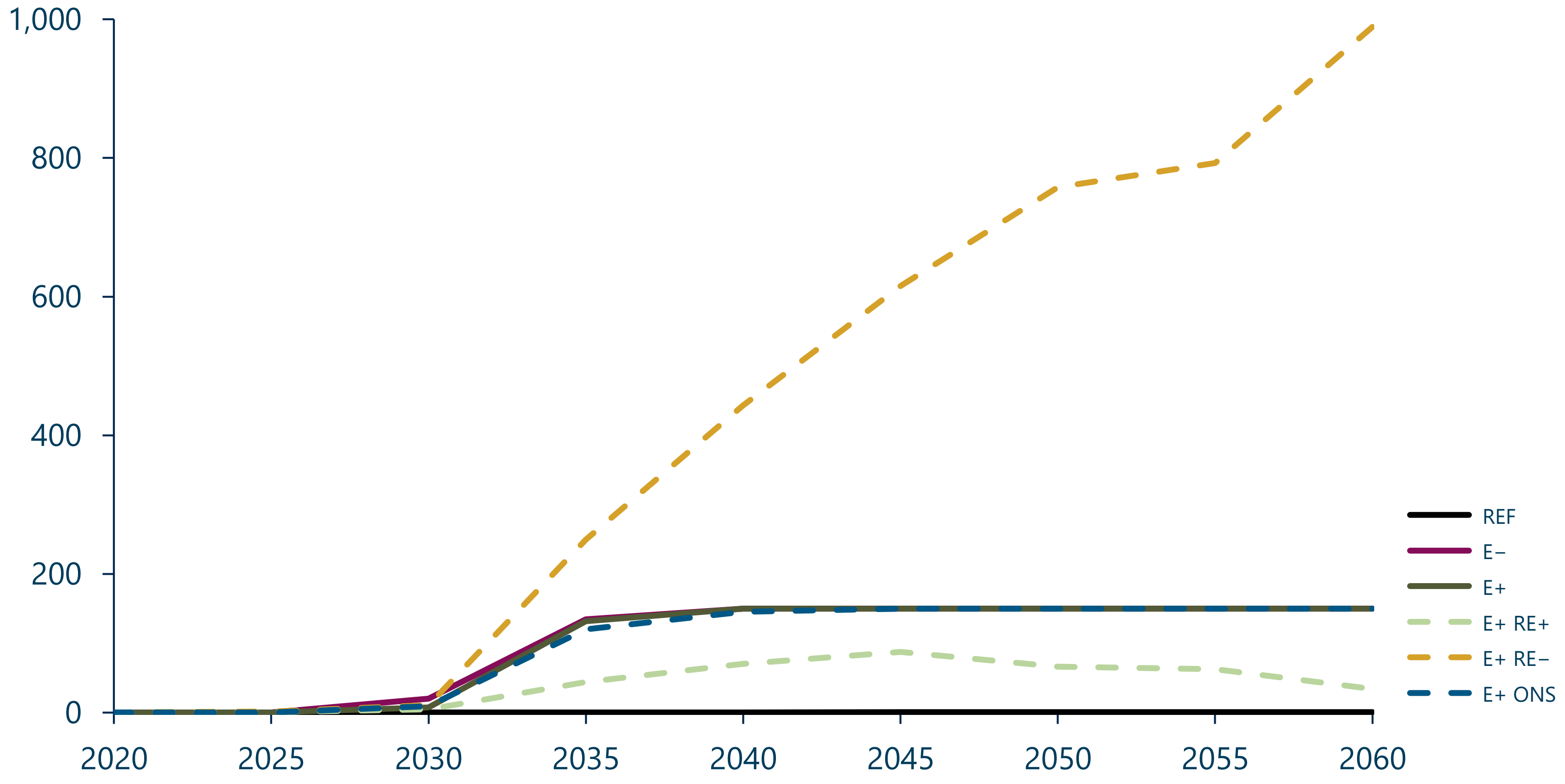


- Progressive adoption of more **energy-efficient technology** will keep 2060 energy demand to around 2020 levels, despite substantial population and GDP growth
- Some efficiency will come from **electrification**: switching to new energy sources such as electric vehicles and heat pumps
- Some efficiency will also come from **upgrading technologies** now in use.

Carbon capture, utilisation and storage (CCUS) plays an important role, complementing renewables

3

Geological CO2 sequestration (Mt-CO2/year)

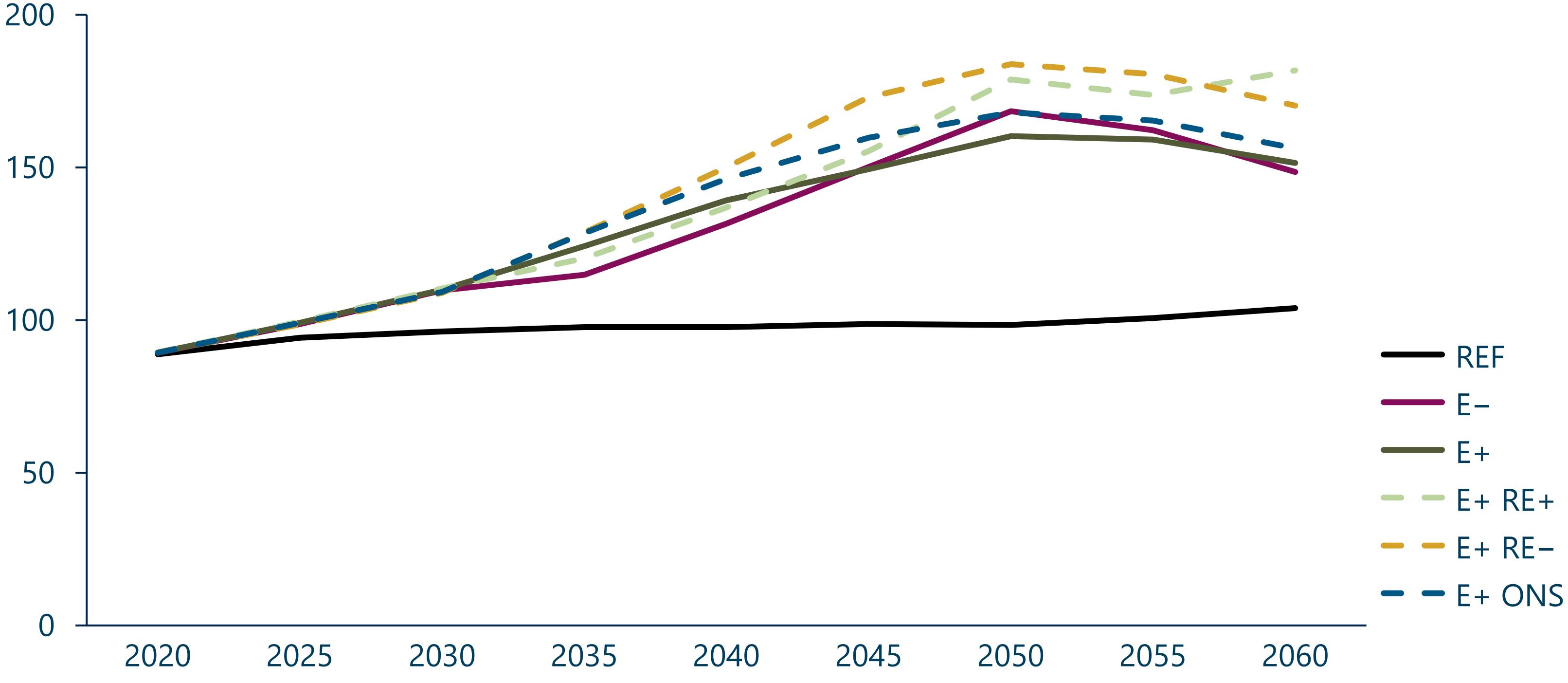


- **CCUS** is needed for:
  - **non-energy uses**
  - **producing 'negative emissions'**, i.e. storing carbon emissions taken out of the atmosphere
- If we hit renewables and transmission build limits, **CCUS with fossil fuels** will help reach net zero
- Most carbon emissions will be permanently stored in **deep underground formations**, and some used in industry.

Unprecedented capital investment is needed, which will produce significant benefits

4

Levelised domestic energy system cost
(2020 A$ billion / year)



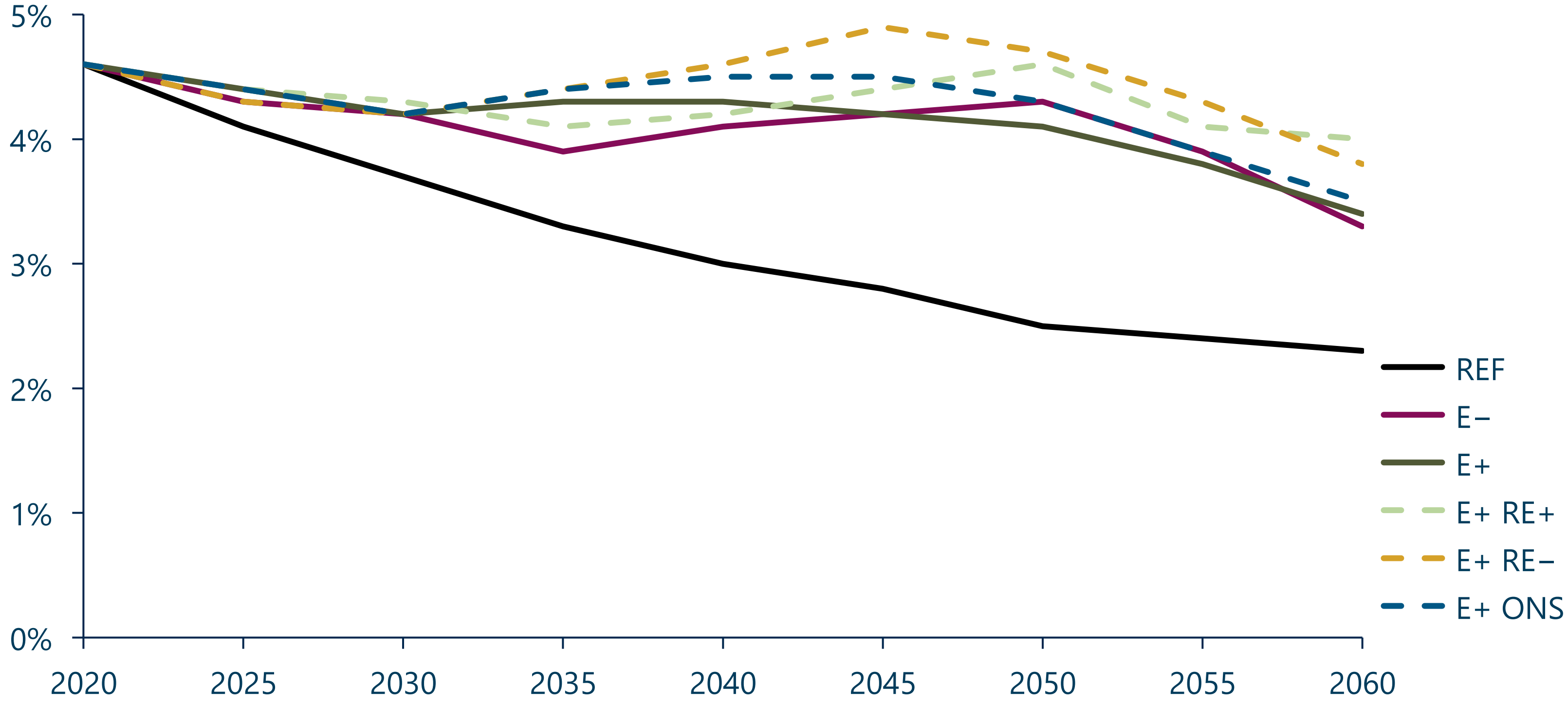
Much higher investment than continuing to use fossil fuels. However:

- The **costs of inaction** would be substantial
- Decarbonisation will **reduce our reliance on gas and oil imports**
- **Conventional technologies that use fossil fuels** will become less available.

Domestic energy's share of GDP need not rise above today's level, while being less prone to price shocks

5

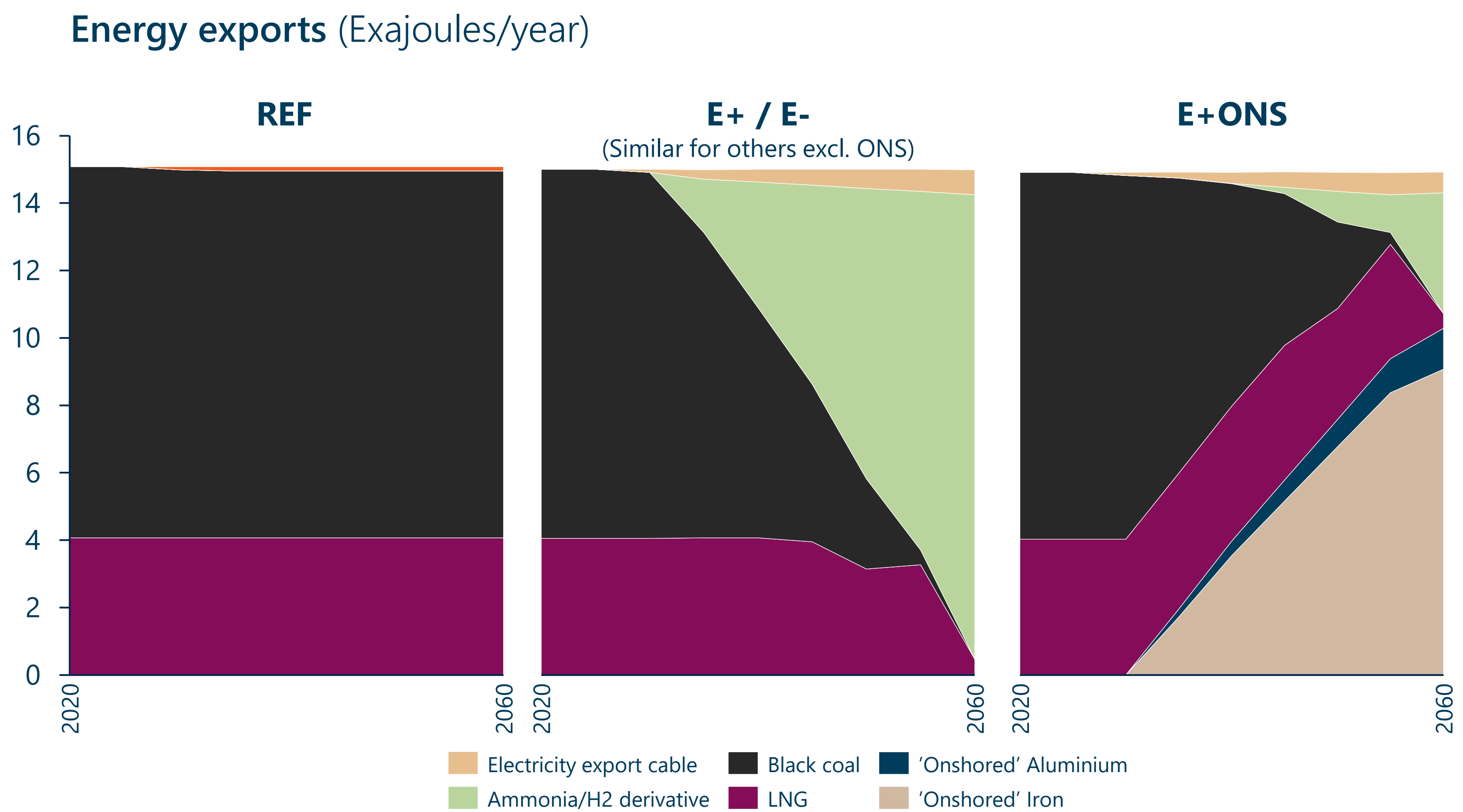
Levelised domestic energy system cost as share of GDP
(% Australian Gross Domestic Product)



- Domestic energy costs will account for a **similar share of the economy**
- The shift to capital-intensive renewable electricity should reduce the economic impact of commodity **price shocks**
- Placing fewer constraints on the transition results in **lower costs**.

Clean energy can replace our fossil fuel exports

6

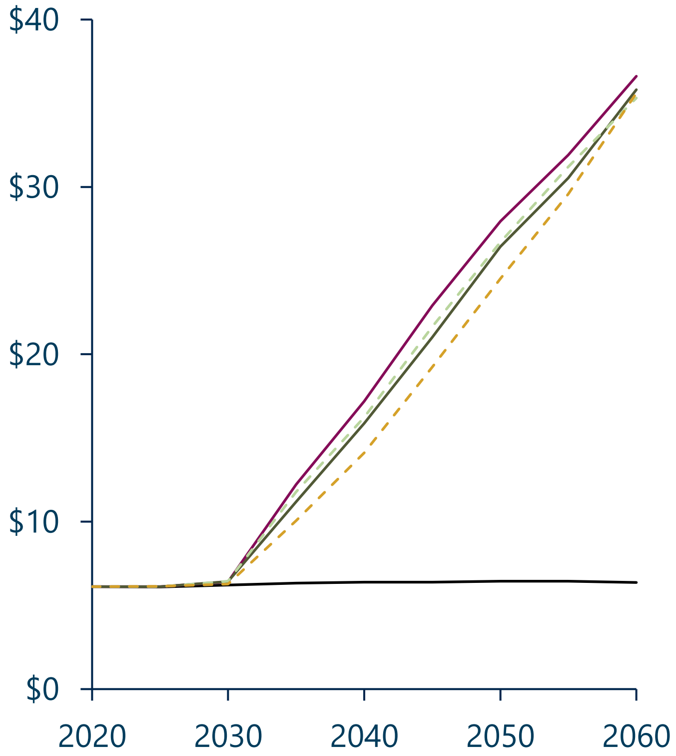


- Australia has the resources to build a new **clean export industry** by:
  - producing **clean energy carriers**
  - **'onshoring'** the processing of minerals using clean energy.
- **'Green' hydrogen** from solar is projected to be the **largest clean energy export**; 'Blue' hydrogen could contribute a major share if there are renewable build rate limits and high rates of carbon storage.

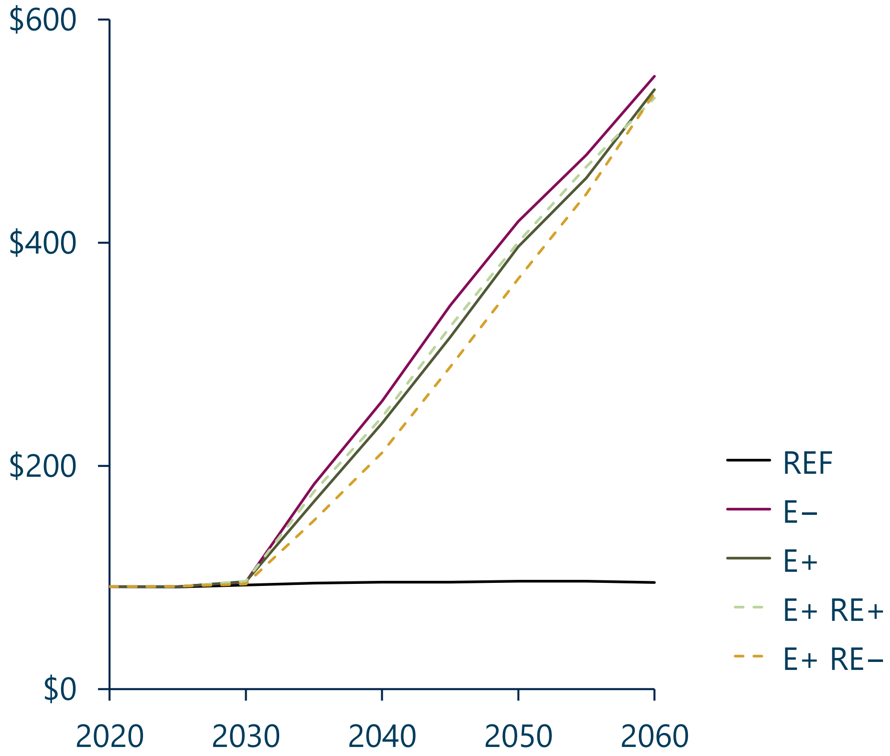
The cost to export clean energy may rise, but should be competitive in a decarbonising global economy

7

Average annual energy export cost ($/GJ)



Levelised export system cost ($ billion/year)



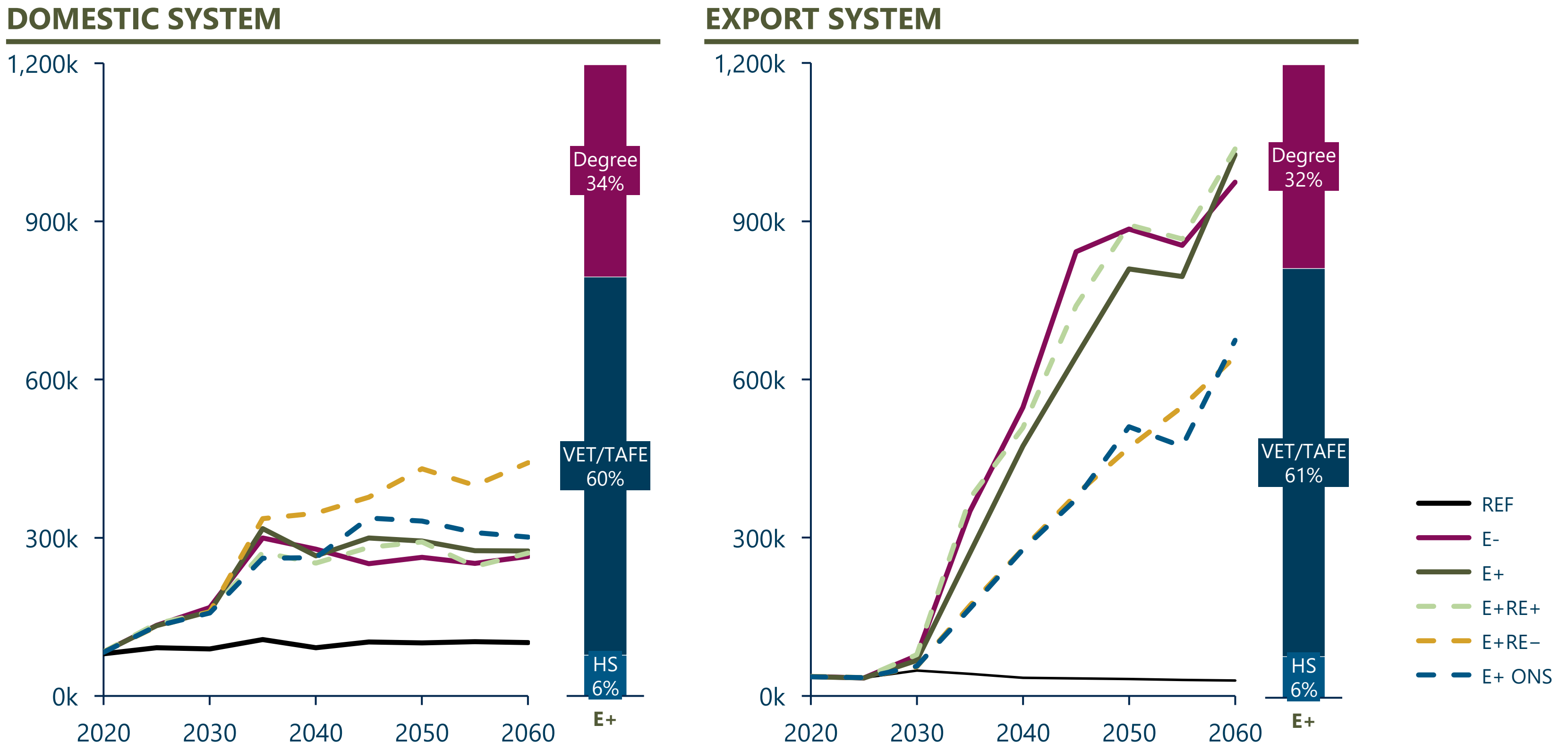
The **cost of decarbonised exports** will be higher than average pre-COVID prices of our coal and LNG exports. However:

- Costs are **comparable to current** crude oil and LNG spot prices
- Australian energy exports should be **cost-competitive** with other int'l exporters
- There is significant potential for **innovation** to lower export costs.
- **Onshoring** can improve cost efficacy.

A large workforce with new skills will grow across the nation, particularly in northern Australia

8

Gross energy sector employment (full time equivalent jobs)

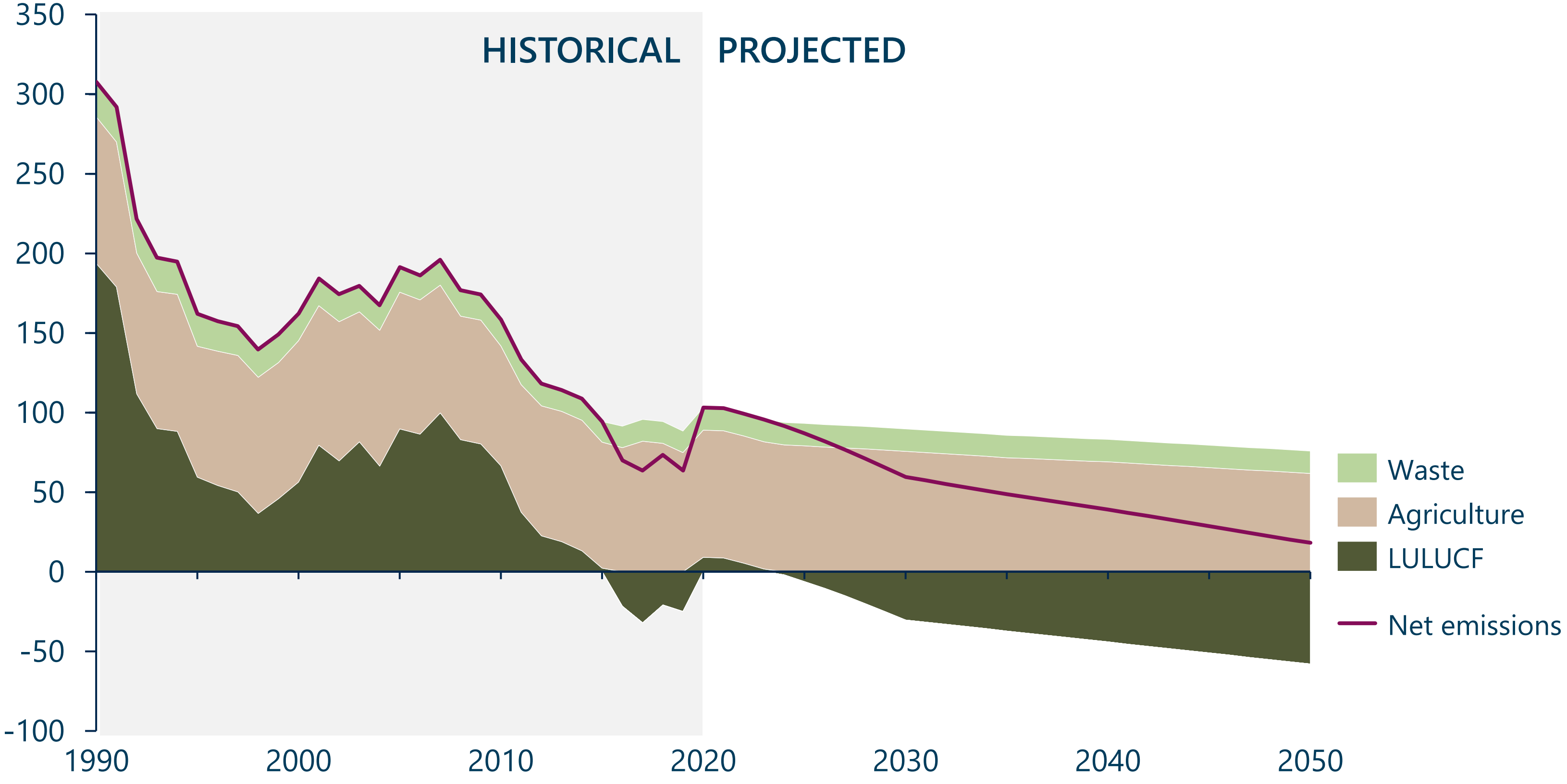


- **1 to 1.3 million new workers** will be needed
- Mostly to grow exports **across northern Australia**, which would experience **significant population growth**. This growth has significant implications for **First Nations** peoples, **national security** and **immigration**
- Most of the workforce will need **technical skills**
- **Domestic decarbonisation** will require significant workforce growth too.

Emissions from farms, forestry and waste should fall, but are unlikely to reach net zero

9

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

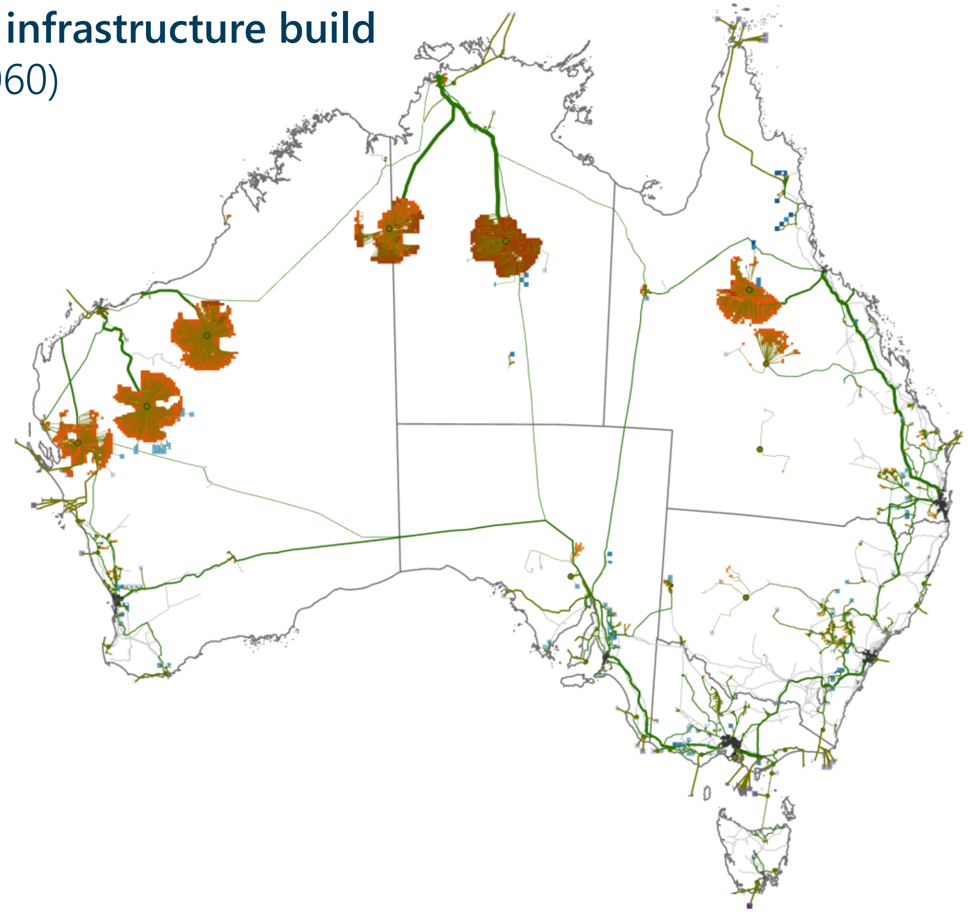


- Significant land clearing, ruminant animals and waste emissions can be reduced by **revegetating** land, **feeding supplements** to cattle, **adding inhibitors** to fertiliser, and **using methane** from waste as an energy source
- However we find that these **emissions are unlikely to reach net zero**
- We will **analyse the opportunities and trade-offs** in using vegetation to store carbon or for bioenergy
- These results mean that energy and industry **may not be able to rely on offsets** from the land and waste sectors to reach net zero.

Large changes in land and sea use will occur, and will need careful planning and community engagement

10

INDICATIVE new infrastructure build
(E+ scenario in 2060)



- ‘Downscaling’ our modelled results illustrates the **detailed land and sea use changes**
- Many new energy sources will require **much more surface area** than the energy sources they are replacing
- The modelling indicates an immense level of new **transmission powerlines and pipelines** (carrying hydrogen and carbon dioxide)
- This **work is preliminary**, and the results will vary significantly as we analyse different assumptions.

Early downscaling results

We are presenting early downscaling results, with important caveats

'Downscaling' our modelled results illustrates the detailed land and sea use changes which may arise from the net zero transition.

Our modelling excludes many areas from development due to conflicting land uses

However, **our downscaling work is continuing and additional constraints are yet to be finalised** particularly concerning native title, conservation and agriculture.

In reality, the location of new industries and infrastructure will be affected by such factors as:

- Traditional Owners, rural landowners and communities
- decisions by governments.

We will engage stakeholders and model sensitivities to explore further.

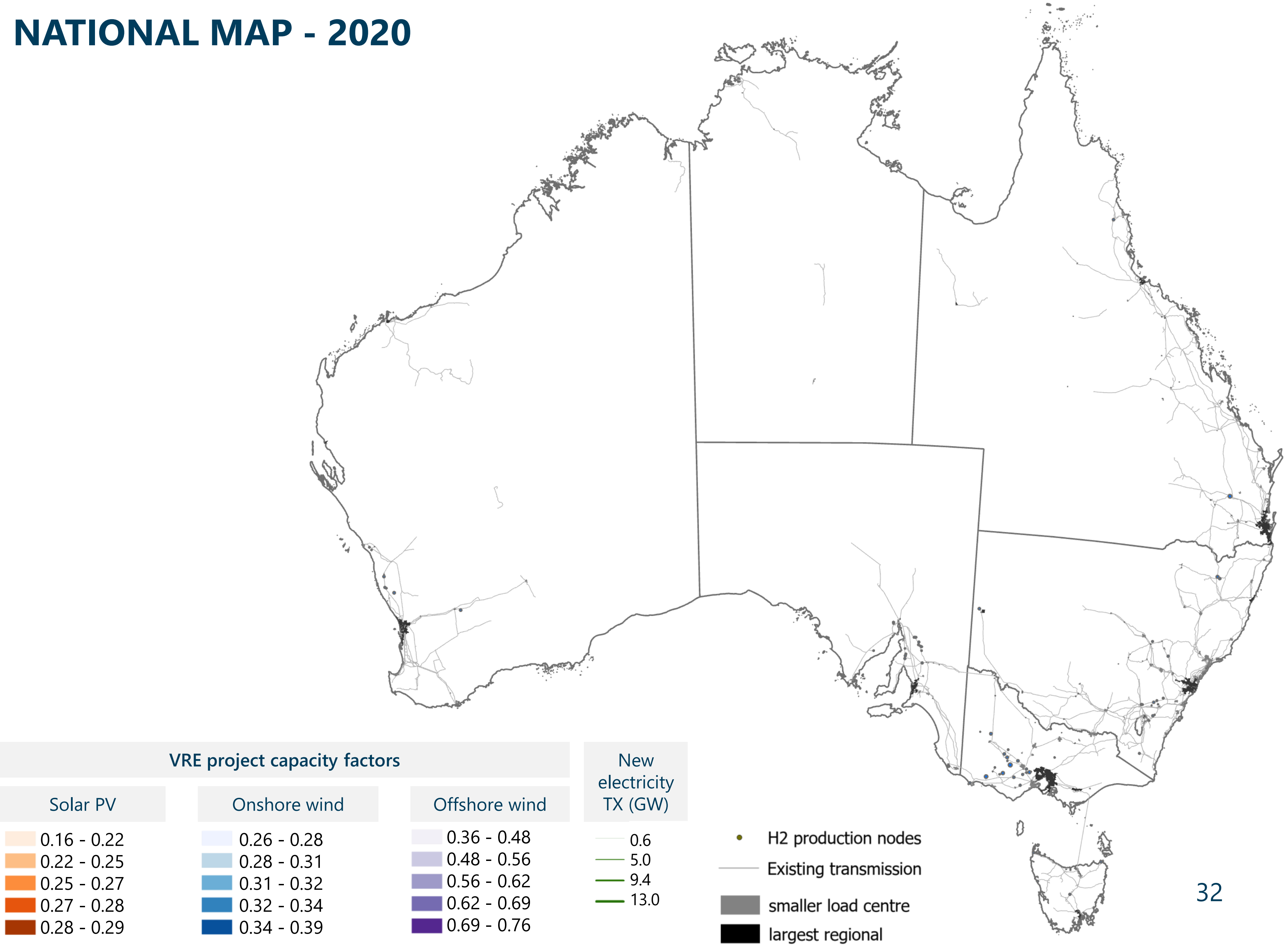
National maps

Early downscaling

E+ in 2020, solar and wind with transmission

159 pre-existing operating VRE projects

NATIONAL MAP - 2020



Early downscaling

E+ in 2030, solar and wind with transmission

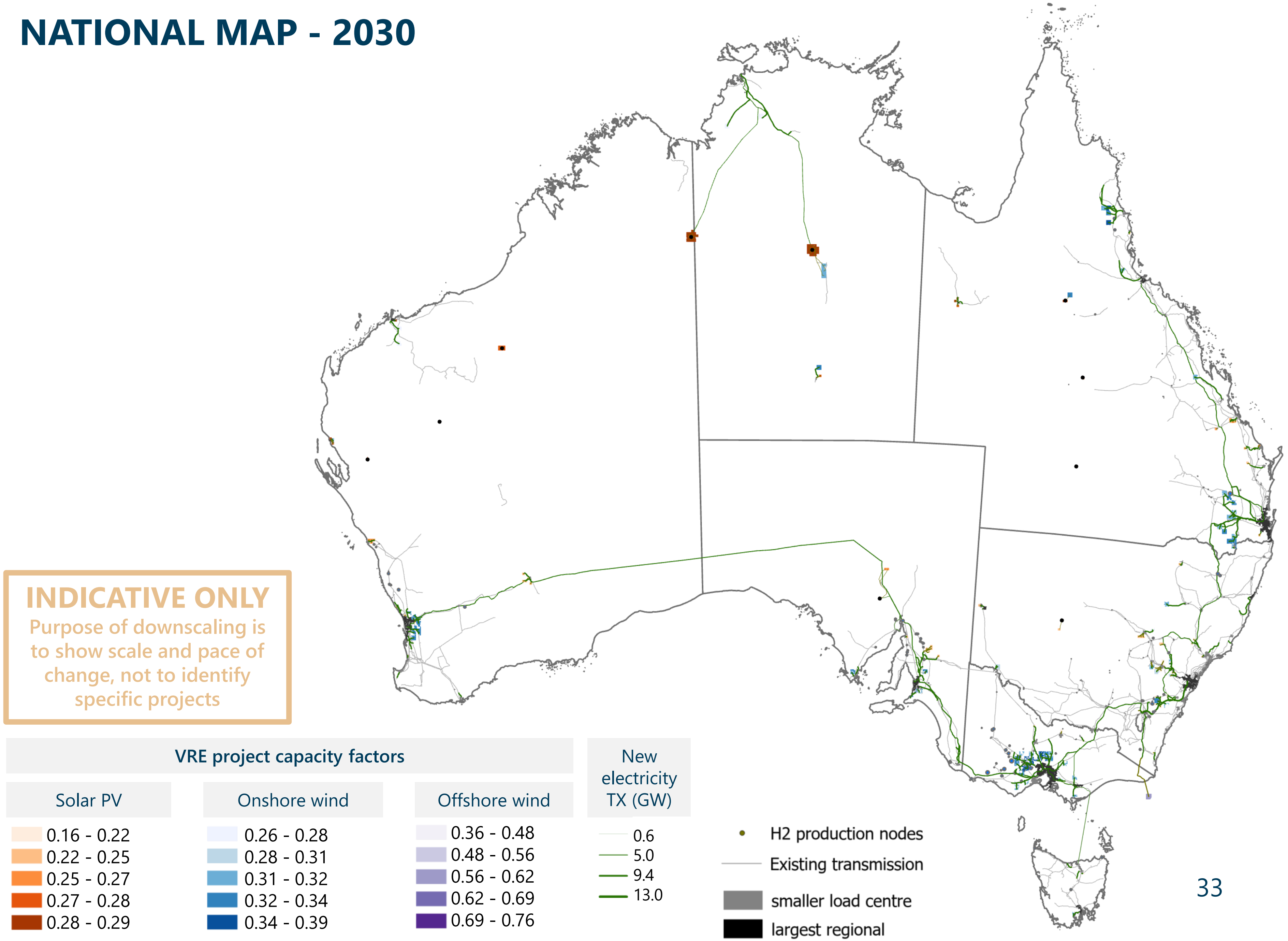
196 pre-existing operating VRE projects

Net Zero Australia projects:

- 98 GW solar PV (135 projects)
- 49 GW onshore wind (79 projects)
- 0.5 GW offshore wind (1 projects).

Electricity generation is about **3x the capacity of the National Electricity Market** (in 2022).

NATIONAL MAP - 2030



Early downscaling

E+ in 2040, solar and wind with transmission

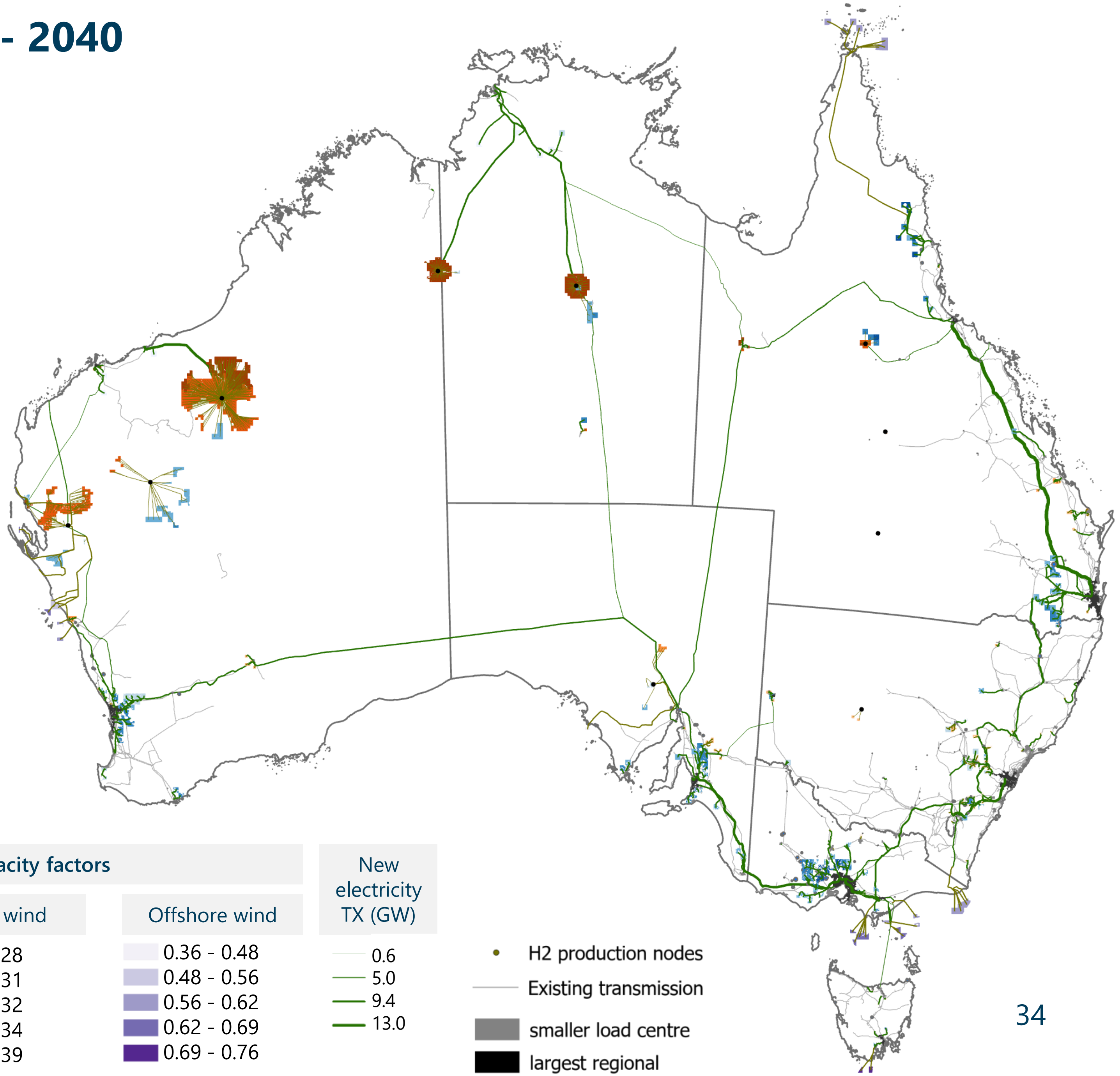
Net Zero Australia projects:

- 654 GW solar PV (782 projects)
- 130 GW onshore wind (187 projects)
- 41 GW offshore wind (35 projects).

Electricity generation is about **15x the capacity of the National Electricity Market** (in 2022).

NATIONAL MAP - 2040

INDICATIVE ONLY
Purpose of downscaling is to show scale and pace of change, not to identify specific projects



Early downscaling

E+ in 2050, solar and wind with transmission

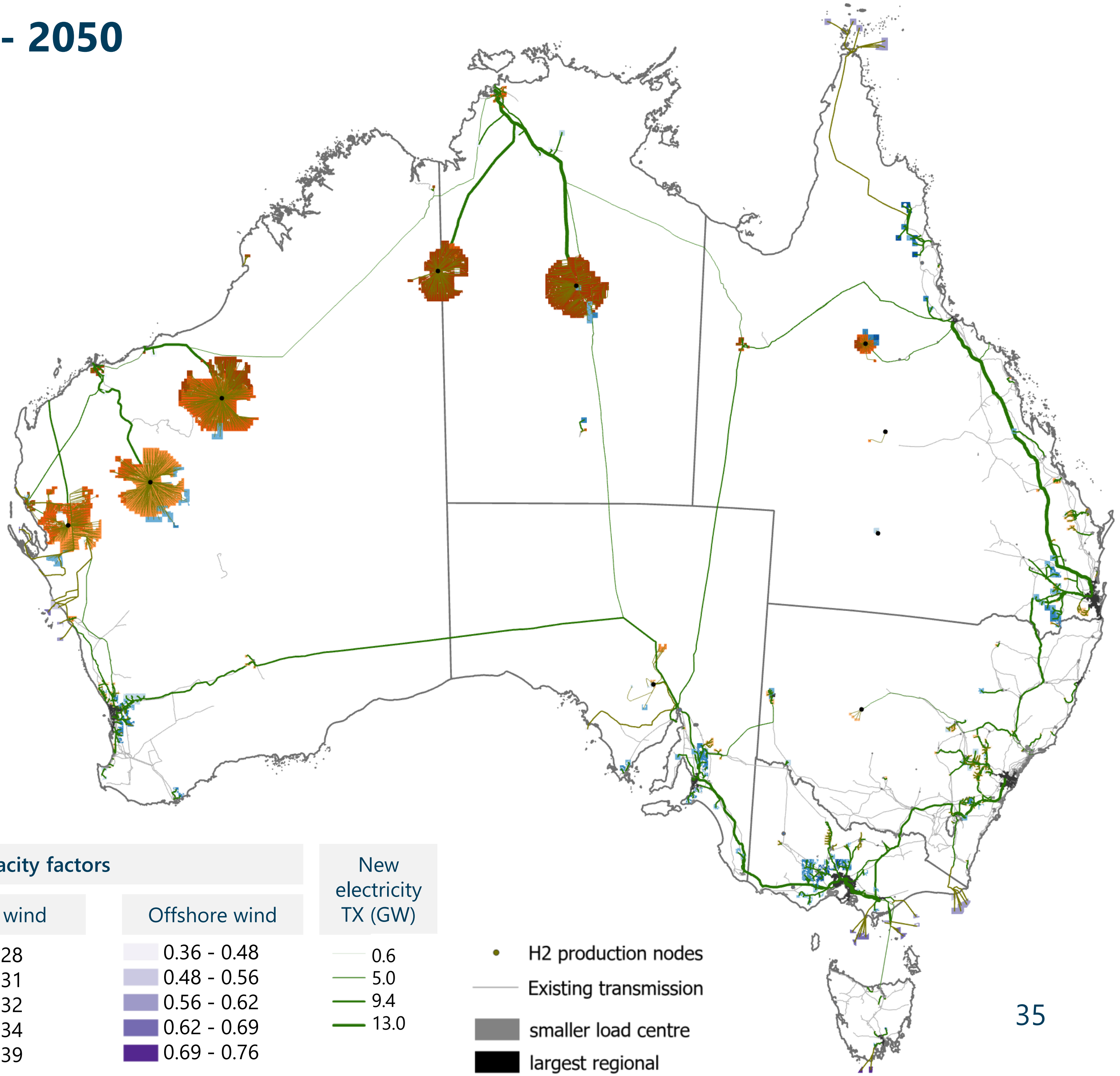
Net Zero Australia projects:

- 1.9 TW solar PV (2,242 projects)
- 132 GW onshore wind (194 projects)
- 42 GW offshore wind (36 projects).

Electricity generation is about **40x the capacity of the National Electricity Market** (in 2022).

NATIONAL MAP - 2050

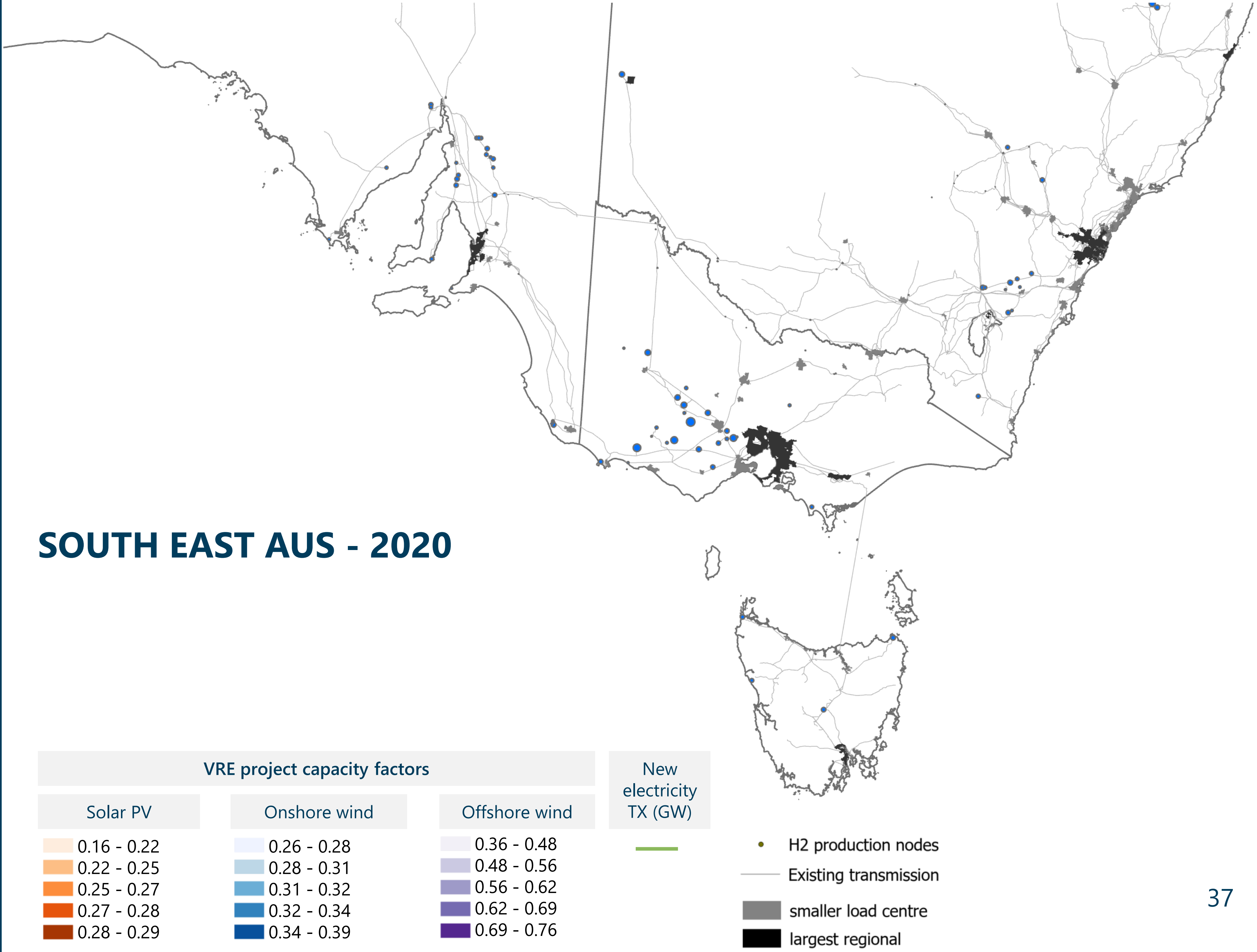
INDICATIVE ONLY
Purpose of downscaling is to show scale and pace of change, not to identify specific projects



South East Australia

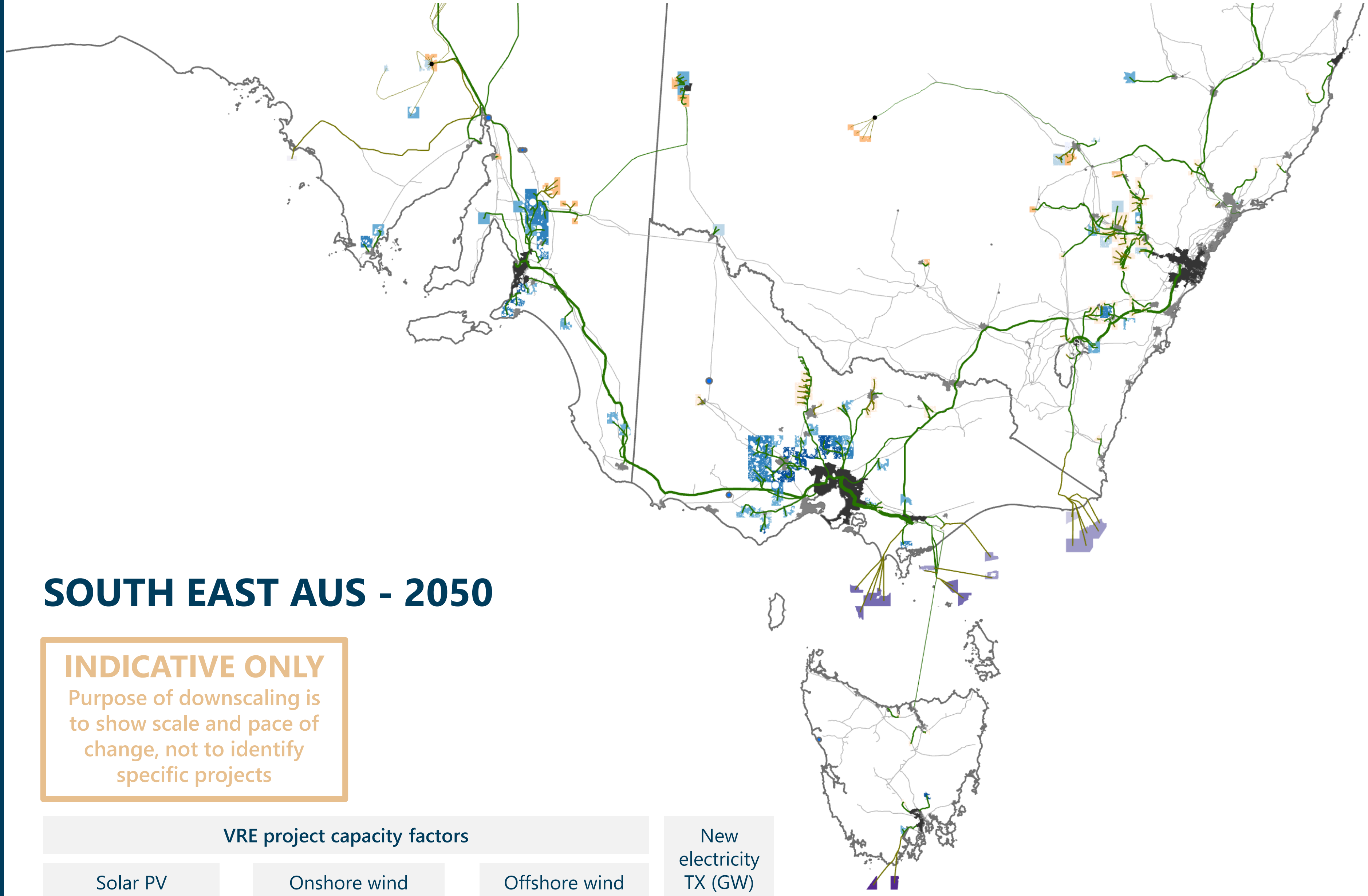
Early downscaling

E+ in 2020, solar and wind with transmission



Early downscaling

E+ in 2050, solar and wind with transmission



SOUTH EAST AUS - 2050

INDICATIVE ONLY
Purpose of downscaling is to show scale and pace of change, not to identify specific projects

VRE project capacity factors			New electricity TX (GW)
Solar PV	Onshore wind	Offshore wind	
0.16 - 0.22	0.26 - 0.28	0.36 - 0.48	
0.22 - 0.25	0.28 - 0.31	0.48 - 0.56	
0.25 - 0.27	0.31 - 0.32	0.56 - 0.62	
0.27 - 0.28	0.32 - 0.34	0.62 - 0.69	
0.28 - 0.29	0.34 - 0.39	0.69 - 0.76	

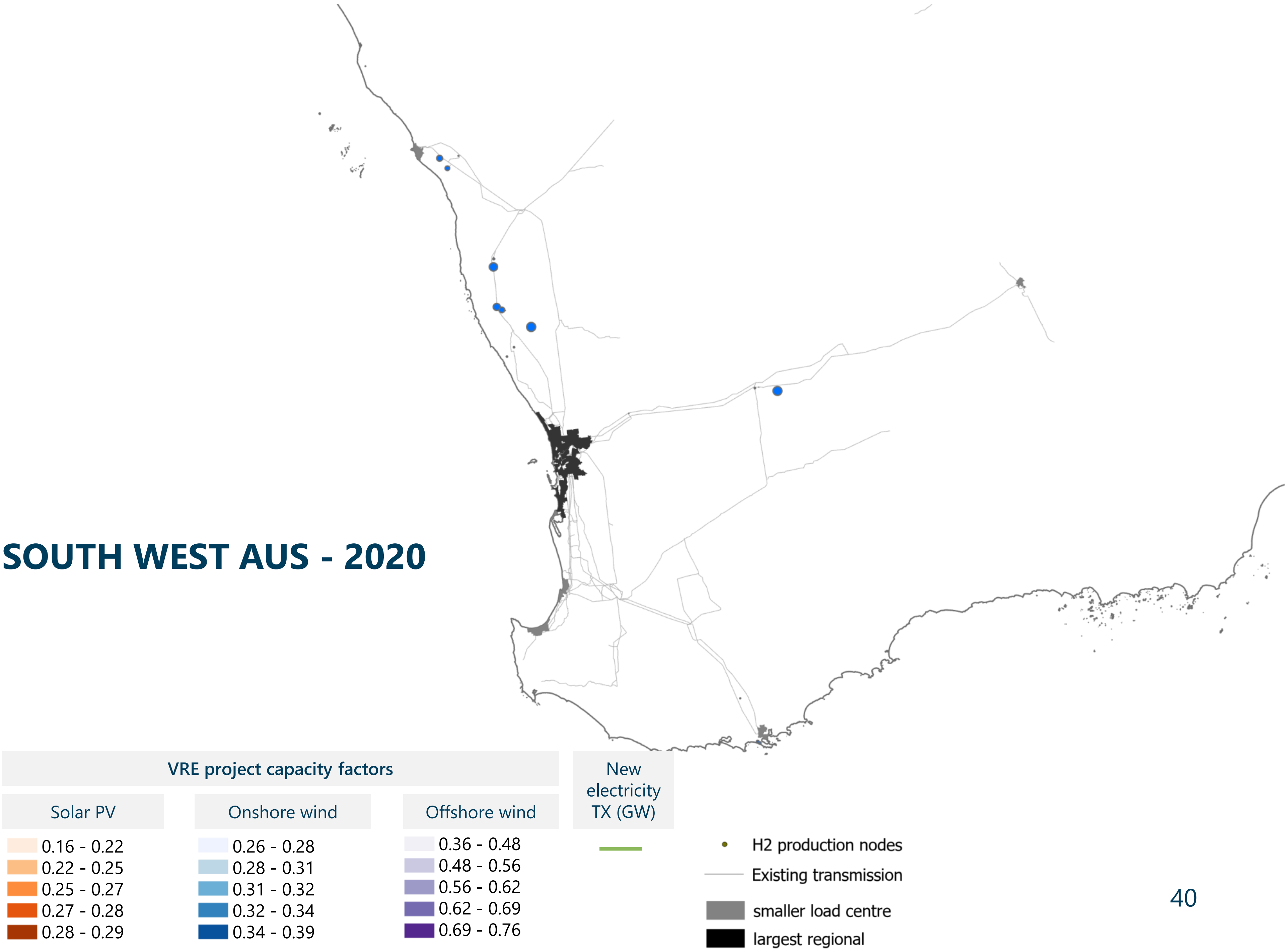
H2 production nodes
Existing transmission
smaller load centre
largest regional

South West Australia

Early downscaling

E+ in 2020, solar and wind with transmission

SOUTH WEST AUS - 2020

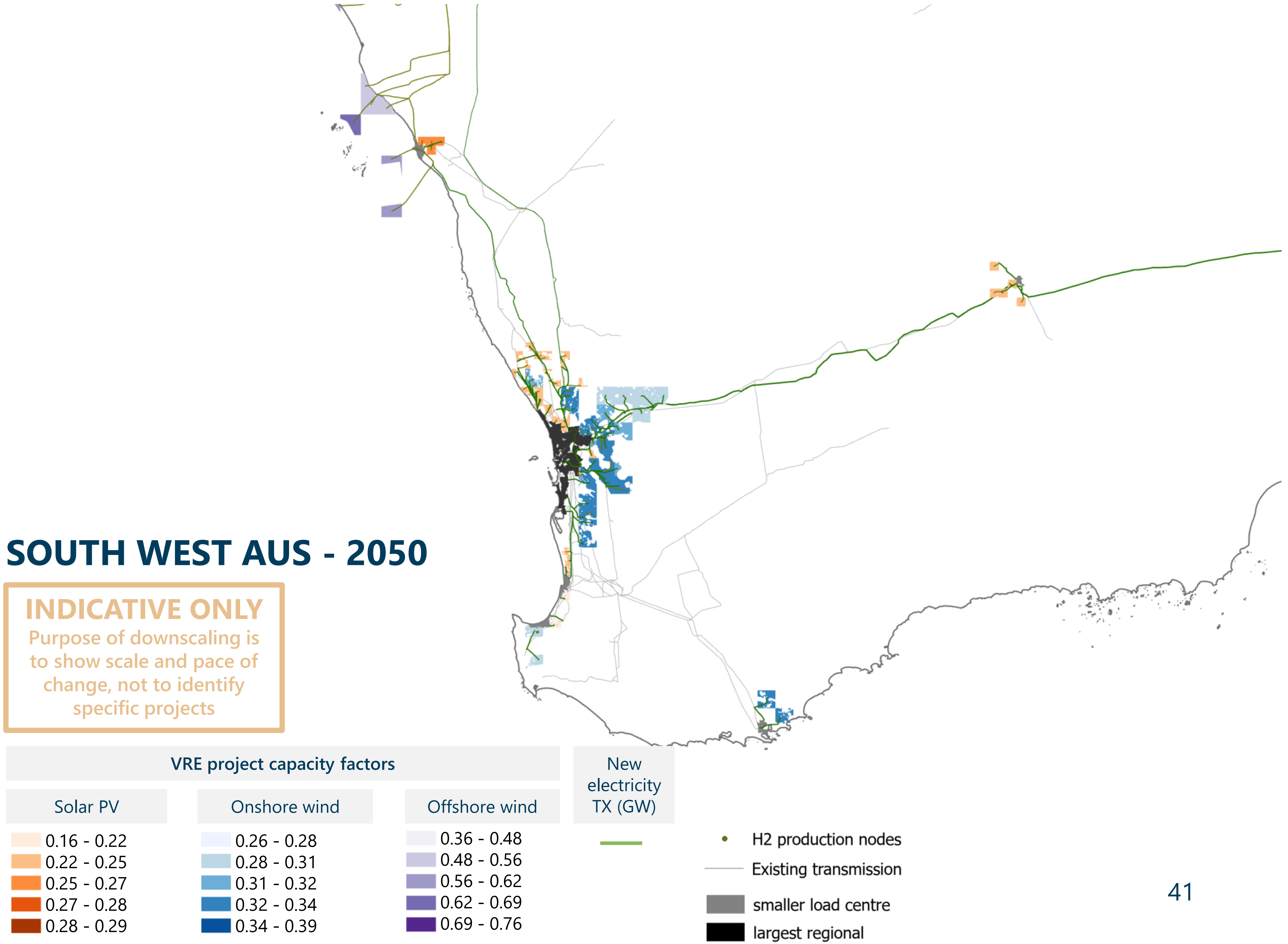


Early downscaling

E+ in 2050, solar and wind with transmission

SOUTH WEST AUS - 2050

INDICATIVE ONLY
Purpose of downscaling is to show scale and pace of change, not to identify specific projects

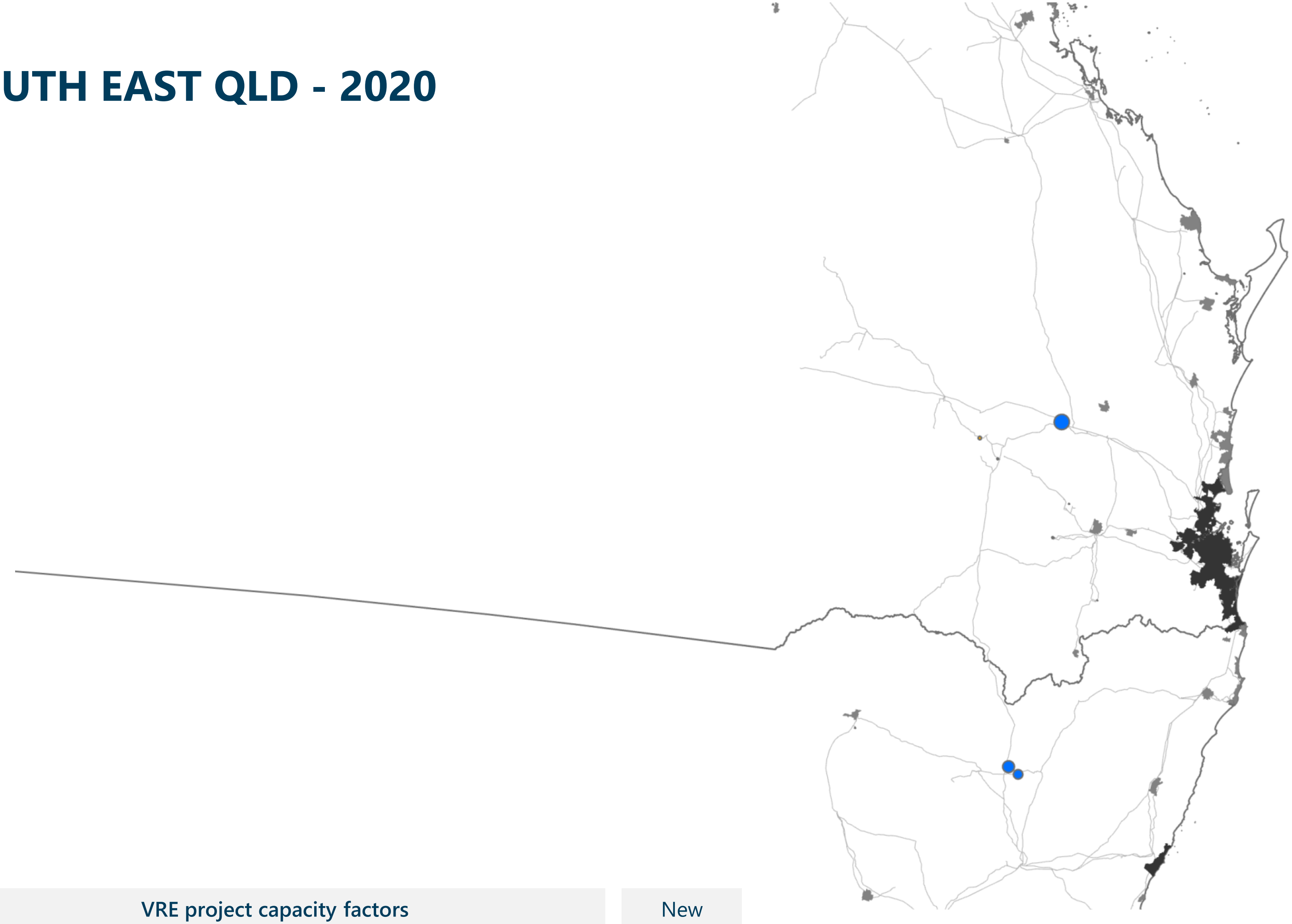


South East Queensland

Early downscaling

E+ in 2020, solar and wind with transmission

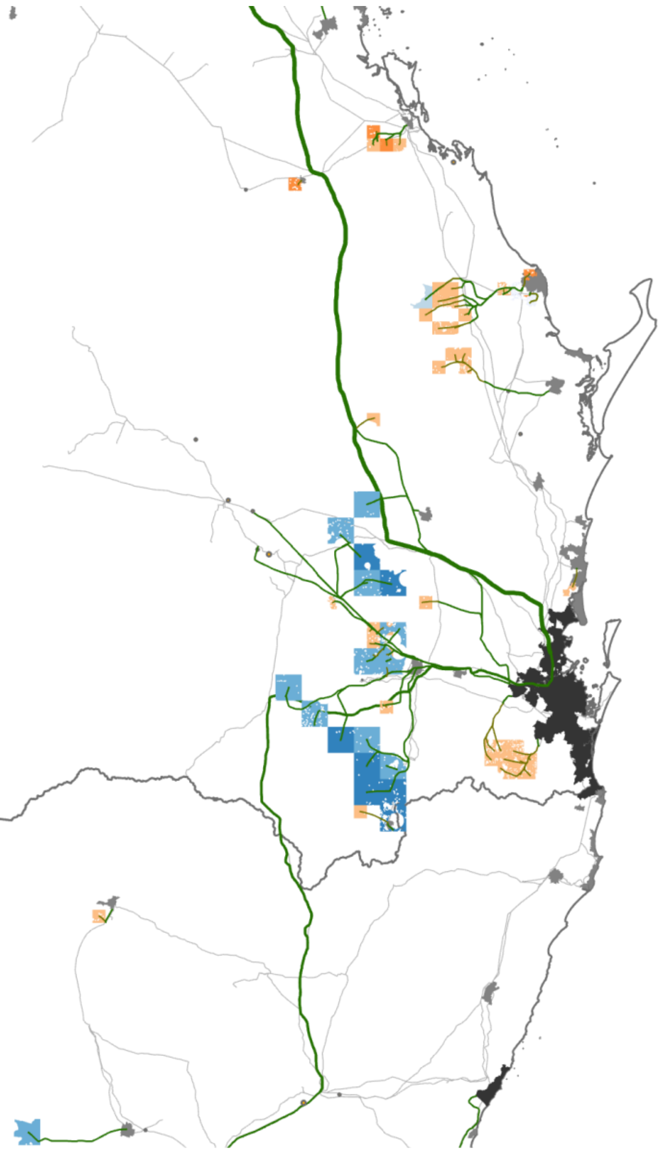
SOUTH EAST QLD - 2020



Early downscaling

E+ in 2050, solar and wind with transmission

SOUTH EAST QLD - 2050



INDICATIVE ONLY

Purpose of downscaling is to show scale and pace of change, not to identify specific projects

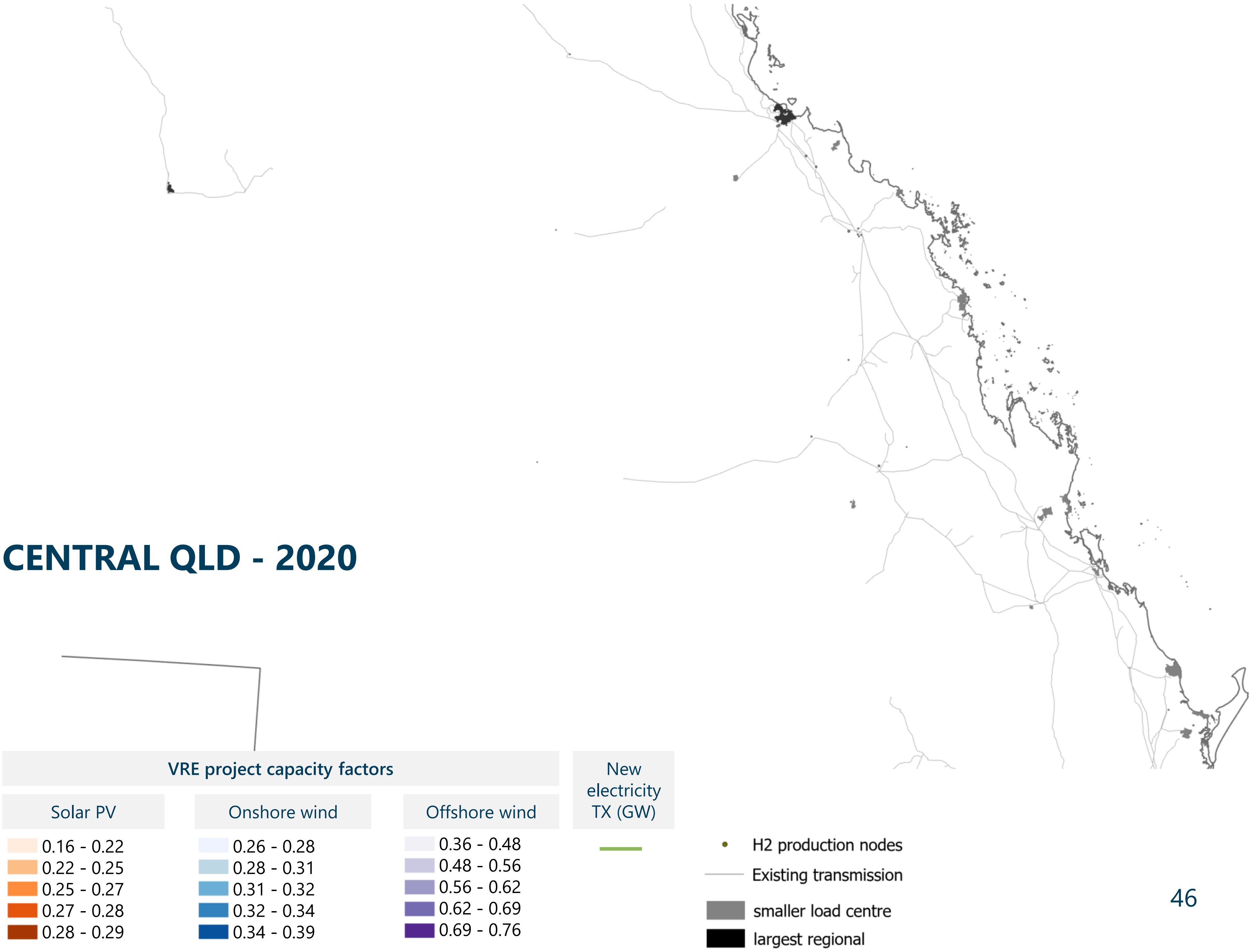
VRE project capacity factors			New electricity TX (GW)
Solar PV	Onshore wind	Offshore wind	
0.16 - 0.22	0.26 - 0.28	0.36 - 0.48	(green line)
0.22 - 0.25	0.28 - 0.31	0.48 - 0.56	
0.25 - 0.27	0.31 - 0.32	0.56 - 0.62	
0.27 - 0.28	0.32 - 0.34	0.62 - 0.69	
0.28 - 0.29	0.34 - 0.39	0.69 - 0.76	

- H2 production nodes
- Existing transmission
- smaller load centre
- largest regional

Central Queensland

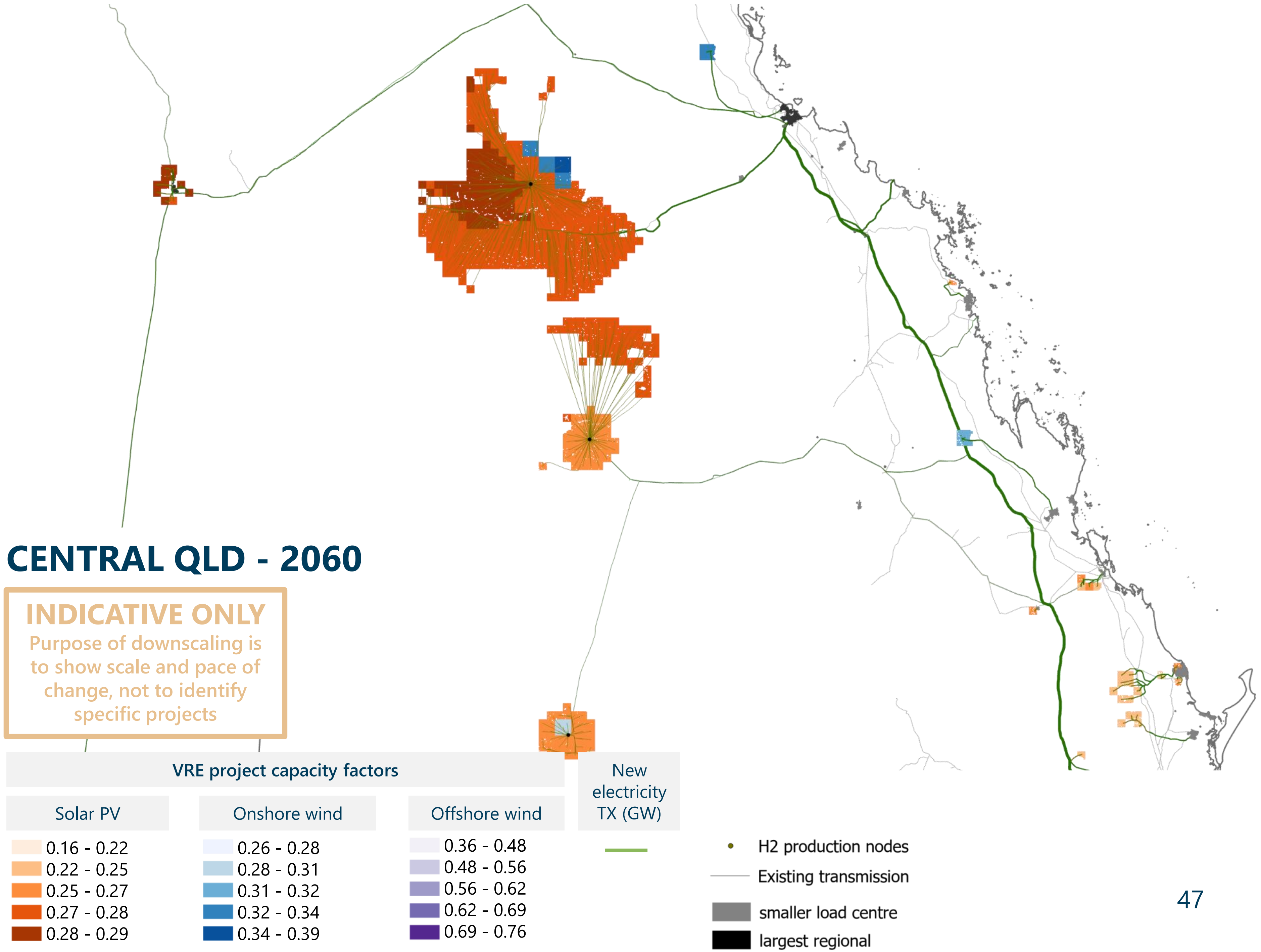
Early downscaling

E+ in 2020, solar and wind with transmission



Early downscaling

E+ in 2060, solar and wind with transmission



This figure shows 2060 instead of 2050, unlike other snapshots. 2060 is chosen for this snapshot as it includes a major export energy zone which is fully developed in 2060.

Approach to mobilisation

We will identify and assess action that may be taken to achieve these four crucial goals

MOBILISE INTEGRATED DEPLOYMENT, AT PACE

Pace of deployment (assets and capital)

Coordinate deployment and withdrawal

MANAGE WORKFORCE & REGIONAL CHANGE

Fair transition of workforces

Grow workforces

MOBILISATION GOALS

MANAGE IMPACT ON ENVIRONMENTS

Enhance environmental outcomes

ENGAGE & SUPPORT THE PUBLIC

Maximise landowner and community benefits

Support householders

Our mobilisation work includes three principal activities

1

ILLUSTRATE

Translate the modelling into **decarbonisation timelines** that illustrate the sequence and pace of transition – economy-wide and for selected cohorts, sectors and regions

2

ANALYSE

Identify and assess **methods and strategies** that could mobilise the required investment, mitigate its adverse impacts and secure public support

3

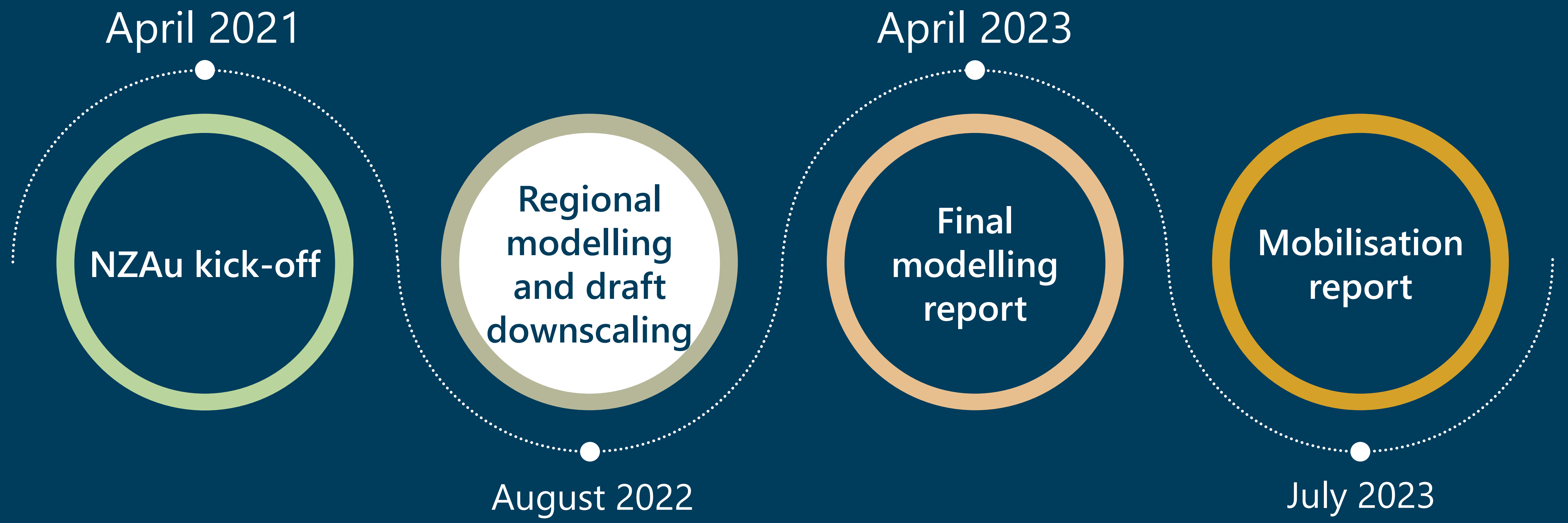
ADVISE

Develop **insights and guidance** for governments, households, communities, industries and unions to mobilise and manage the transition

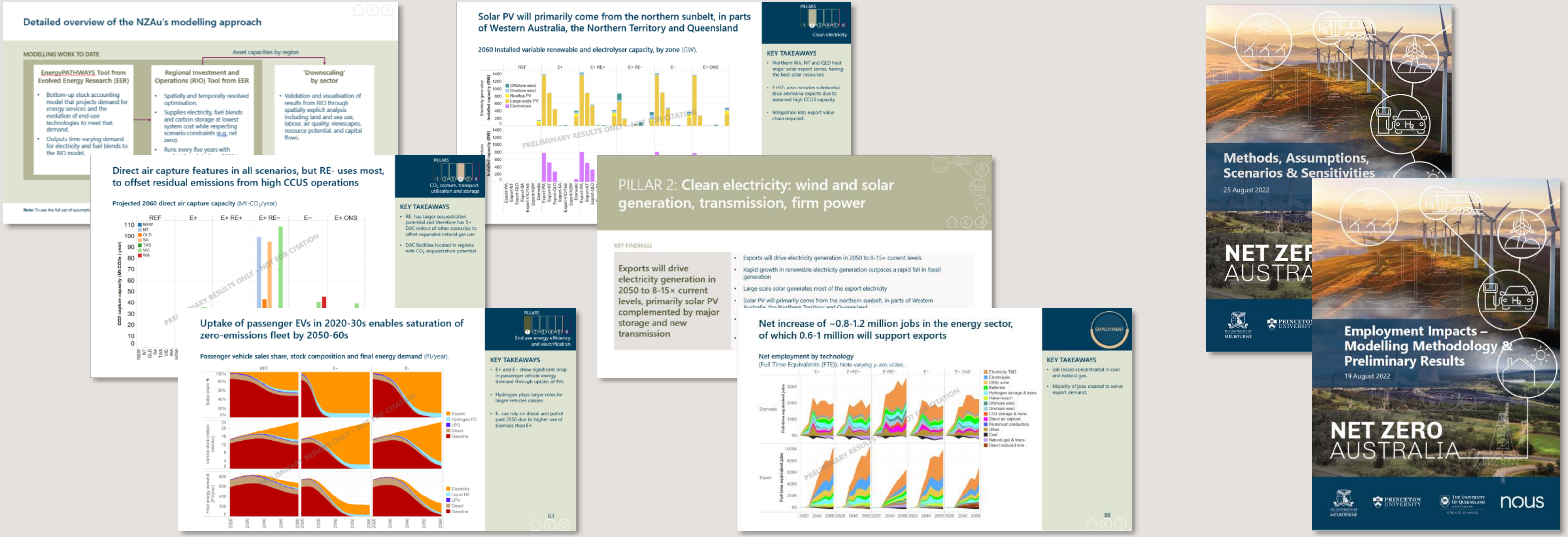
Next steps

This was the first of our public results

NET ZERO AUSTRALIA STUDY TIMELINE



Additional information and results are on our website



netzeroaustralia.net.au

Panel discussion

Panel discussion with the Steering Committee

Robin Batterham
University of Melbourne and Chair

Katherin Domansky
Independent Member

Michael Brear
University of Melbourne

Simon Smart
University of Queensland

Chris Greig
Princeton University

Richard Bolt
Nous Group

netzeroaustralia.net.au

NET ZERO AUSTRALIA

The University of Melbourne

The University of Queensland Australia
Create Change

Princeton University

nous