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SYDNEY • AUSTRALIA



100% Renewables for Australia?

Challenges and Opportunities

Dr Jenny Riesz

CIDER - Conference on Integration of Distributed Energy Resources, 20th August 2015

Who am I?

Powerlink Queensland

ASI Australian Solar Institute

AGL

Ausgrid

ElectraNet electricity transmission

westernpower

Clean Energy Council

origin

Australian Coal Association

imo Independent Market Operator

RioTinto

AEMC Australian Energy Market Commission

AEMO Australian Energy Market Operator

Delta electricity

The University of Queensland Australia

ROAM Consulting Energy Modelling Expertise

AECOM

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UNSW Australia

Overview

100% renewables – worth thinking about?

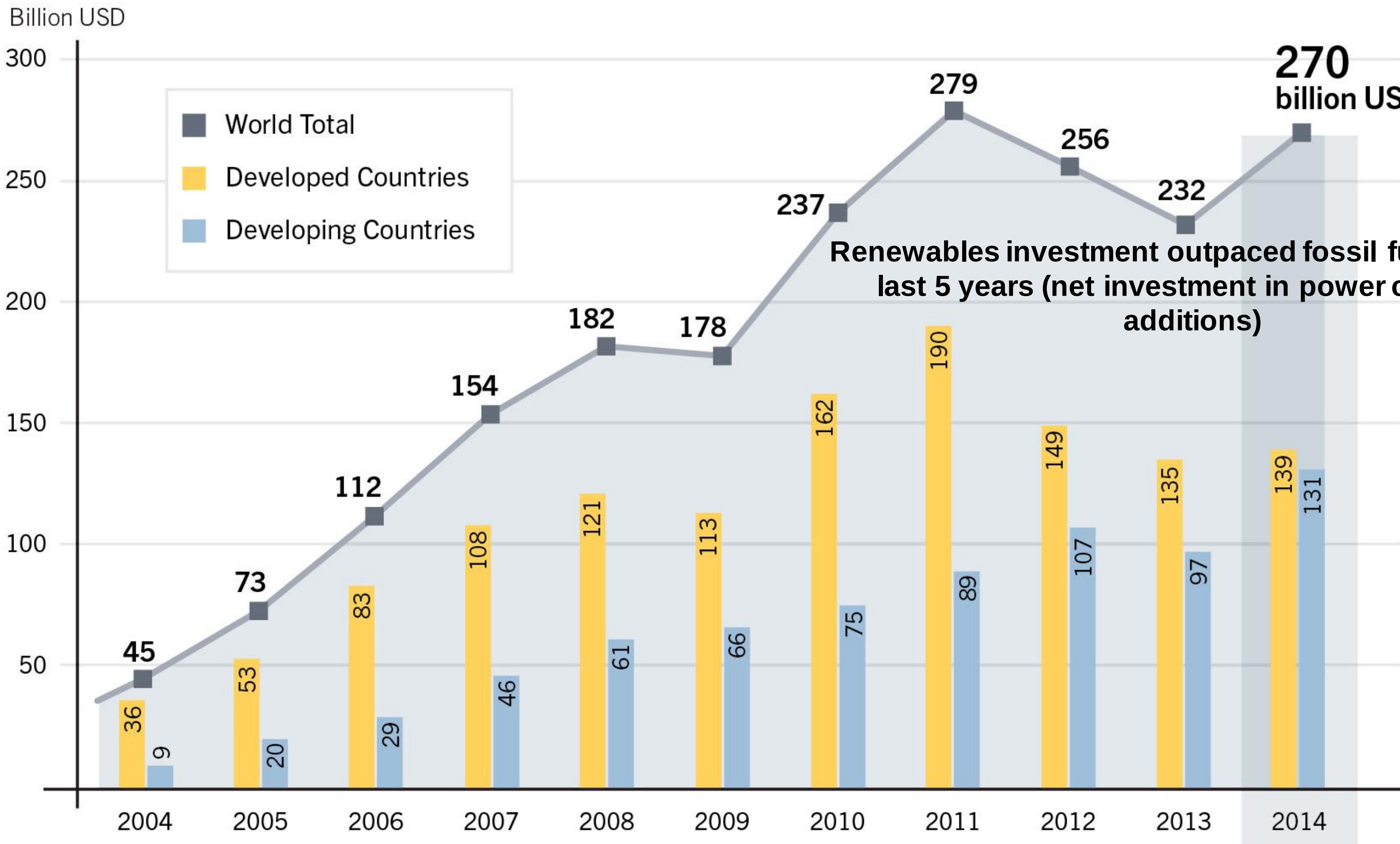
100% renewables – technically feasible?

100% renewables – costs?

100% renewables – will the market work?

Global New Investment in Renewable Power and Fuels,

In 2014, renewables accounted for 59% of net additions to global power capacity.

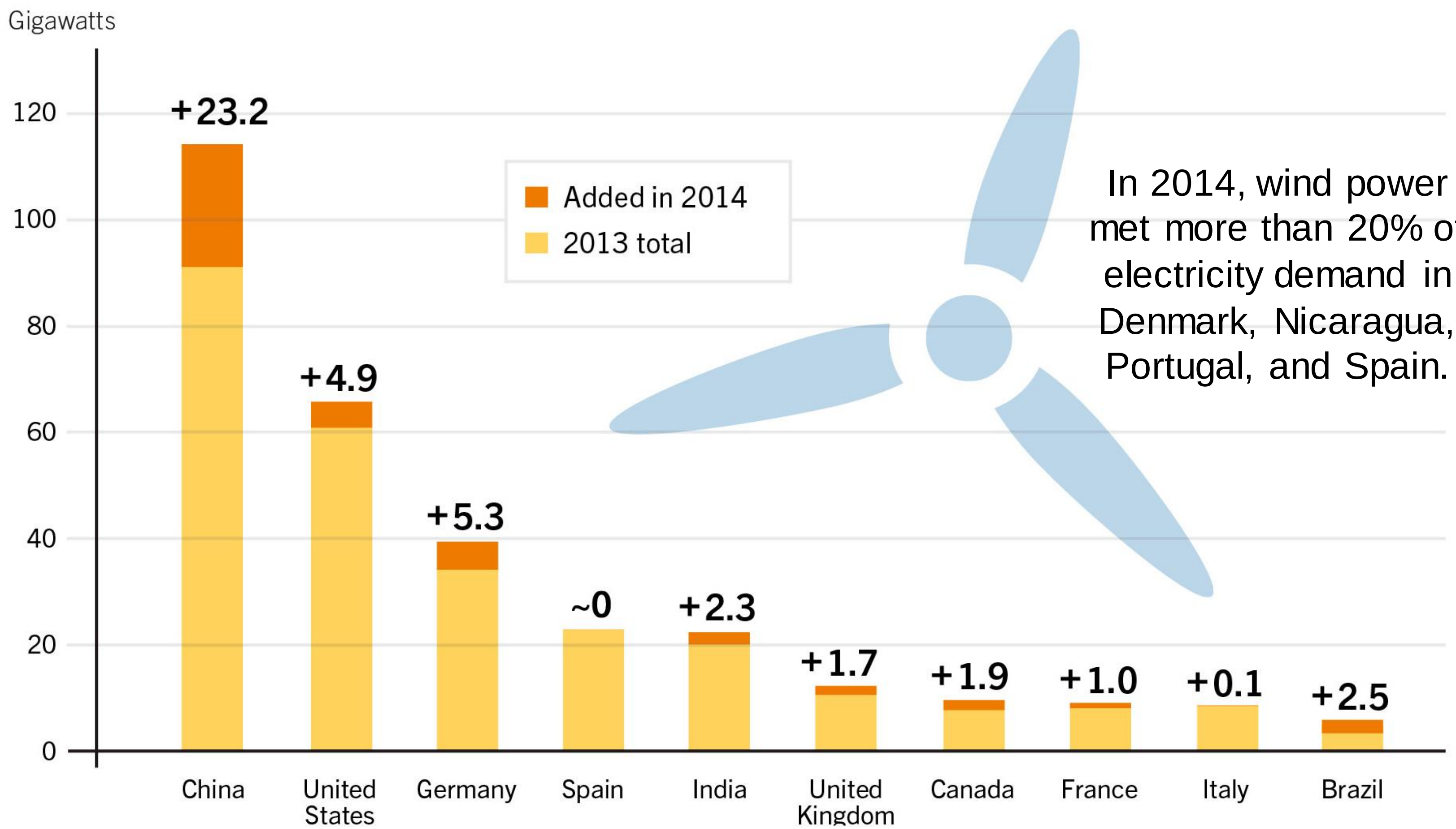


Renewables investment outpaced fossil fuels for the last 5 years (net investment in power capacity additions)

REN21 *Renewables 2015 Global Status Report*

Source: Frankfurt School–UNEP and BNEF

Wind Power Capacity and Additions, Top 10 Countries, 2014



In 2014, wind power met more than 20% of electricity demand in Denmark, Nicaragua, Portugal, and Spain.

Additions are net of repowering.

REN21 *Renewables 2015 Global Status Report*

REN21 Renewable Energy Policy Network for the 21st Century

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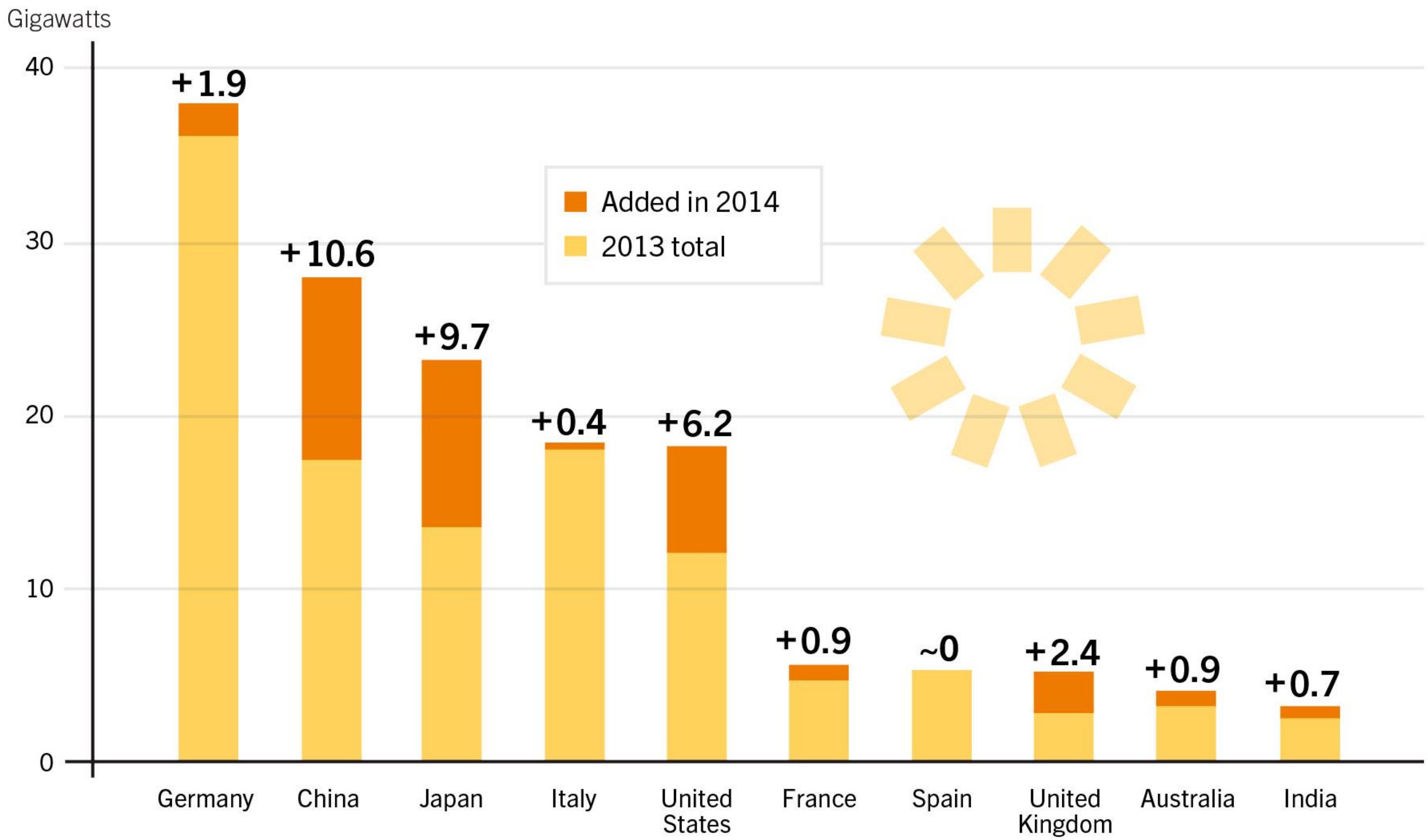
Solar PV Capacity and Additions, Top 10 Countries, 2014



REN21 *Renewables 2015 Global Status Report*

REN21 Renewable Energy Policy Network for the 21st Century

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What about Australia?

Keep using what we've got?	New coal?	Gas?	Nuclear?
• **Ageing generation fleet** • By 2030, 65% of Australia's coal-fired power stations will be over 40yrs old	• **New coal now costs more than renewables** • Regulatory risks means very high cost of capital, if they can get financing at all	• **Baseload CCGT can't get competitive gas supply contracts** • Competition with LNG export market	• **More expensive than renewables** • No existing industry or experience

UK:
Hinkley Point C
$154/MWh
35yr PPA

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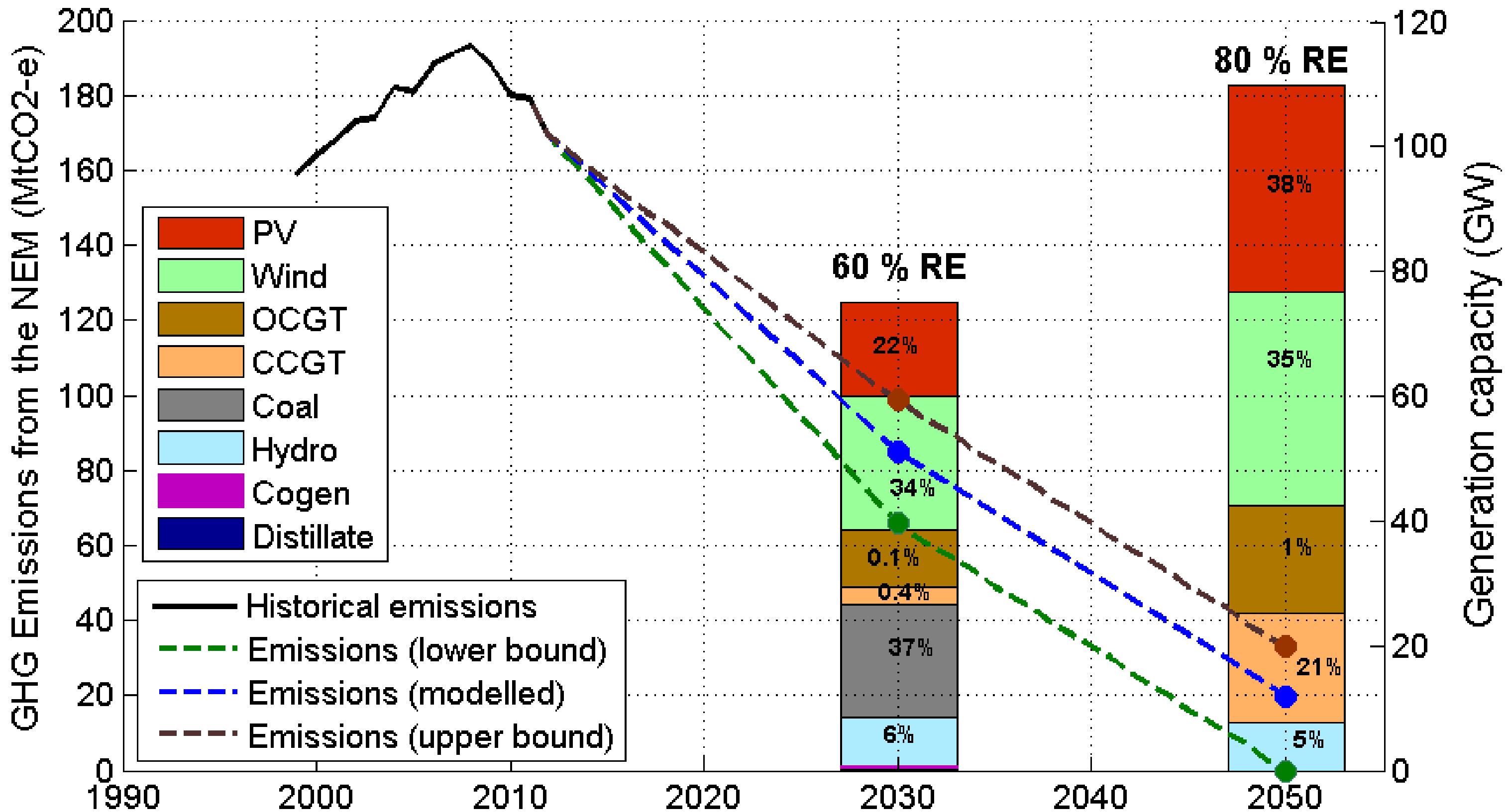
Lowest cost trajectory for the National Electricity Market

Given projected gas and carbon prices, and cost risk profiles



GHG emissions ranges as recommended by the Australian Government Climate Change Authority

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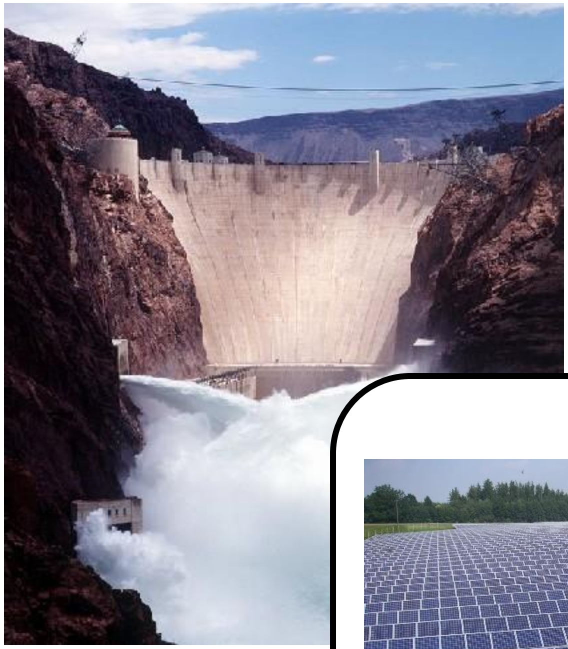
J. Riesz, P. Vithayasrichareon, I. MacGill, (2015) "Assessing "Gas Transition" pathways to low carbon electricity – An Australian case study", Applied Energy, 154, p. 794-804.

- Power systems with very high renewable proportions of renewables appear inevitable
  - It’s not a question of “if”, it’s a question of when.

100% renewables – worth thinking about?

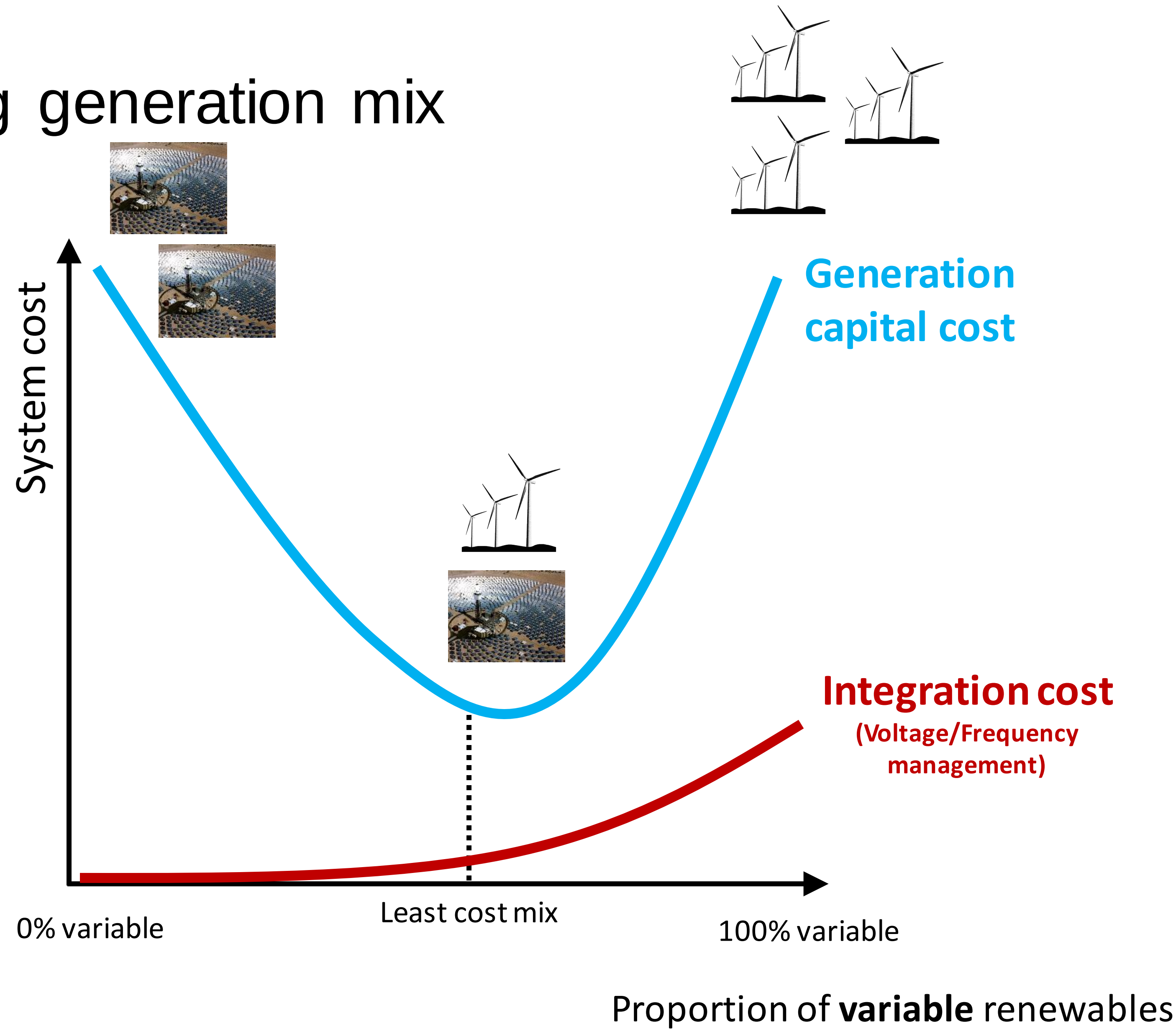
- But is it even technically feasible?!?

Renewable technologies



Variable & non-synchronous

Optimising generation mix



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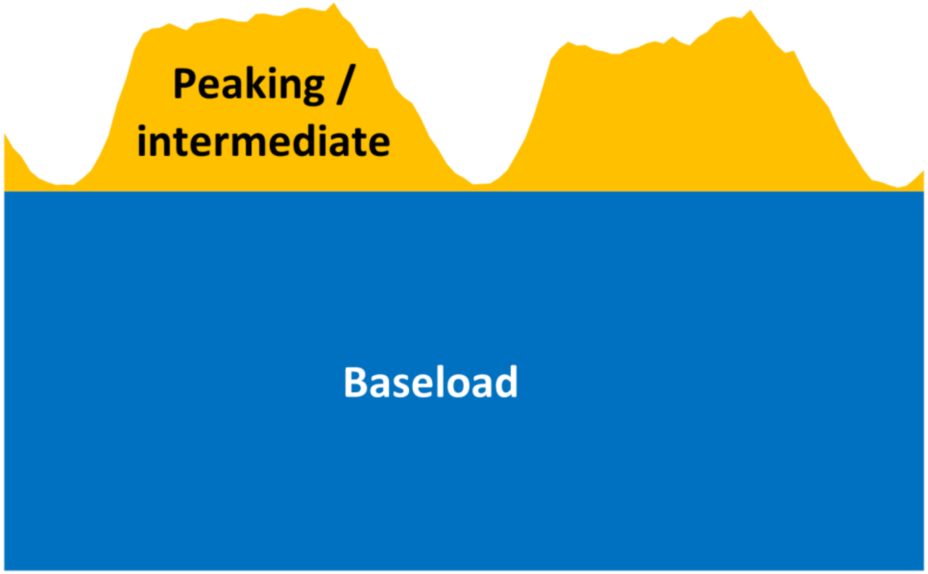
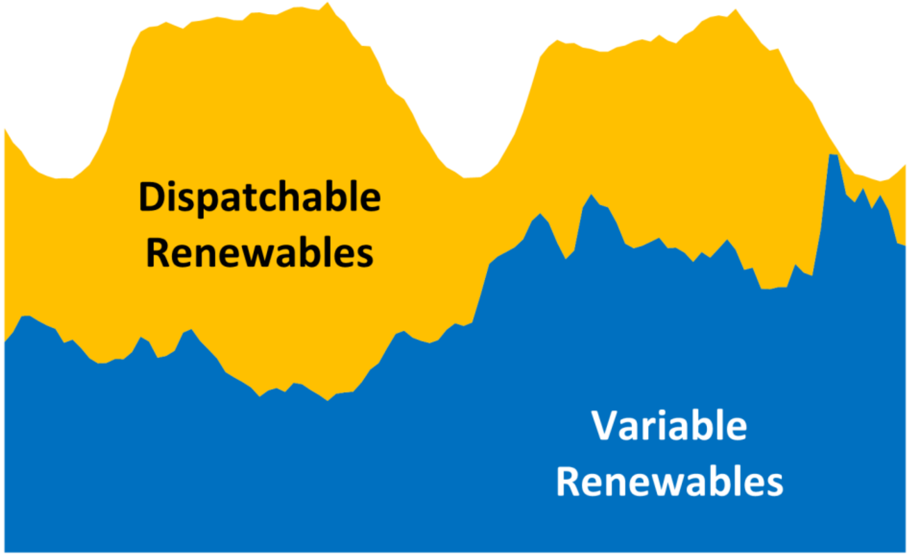


A new power system paradigm



Wind displaces baseload generation

J. Riesz, J. Gilmore, (2014) "Does wind need "back-up" capacity – Modelling the system integration costs of "back-up" capacity for variable generation". International Energy Workshop (Beijing)

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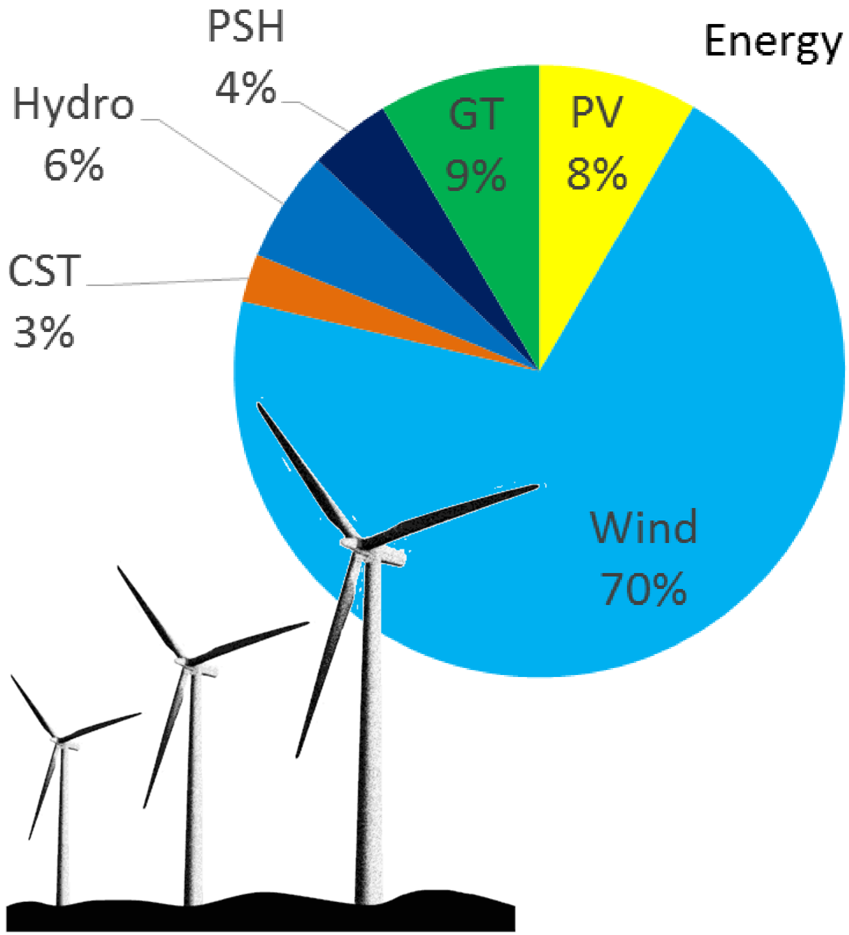
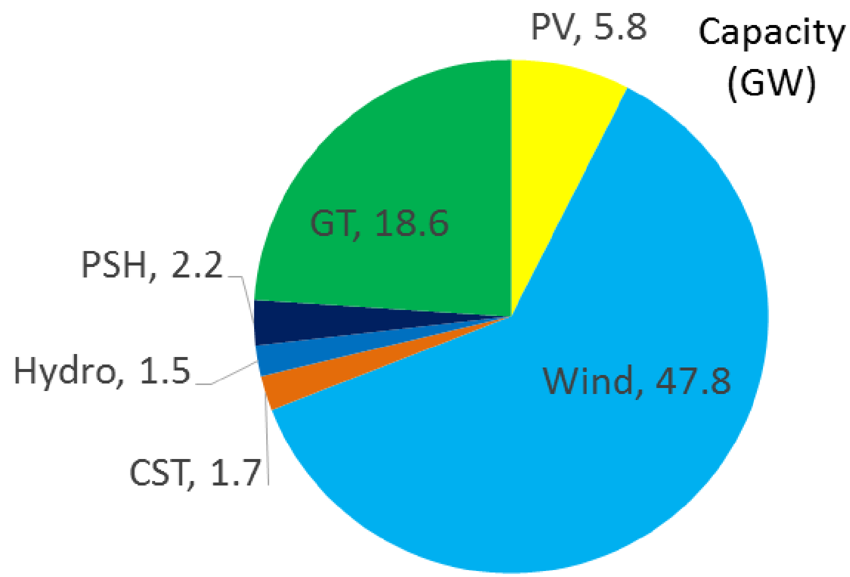
Least Cost Mix (UNSW modelling)

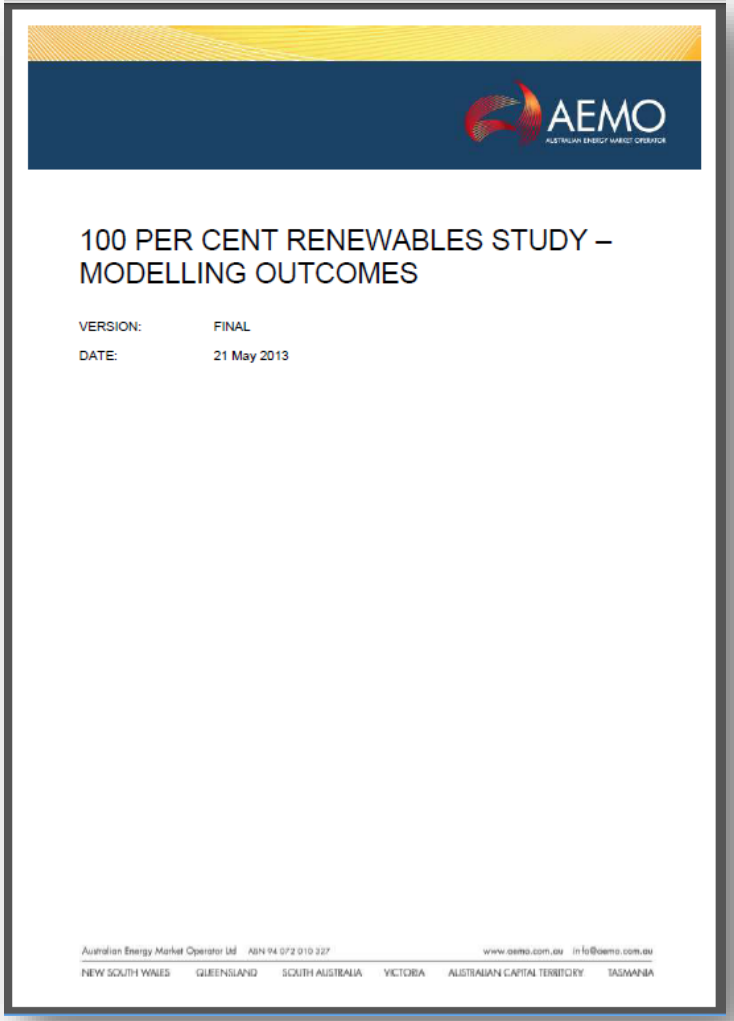




J. Riesz, B. Elliston, "The impact of technology availability on the costs of 100% renewable electricity generation scenarios for Australia", 38th IAEE International Conference, Antalya, Turkey, May 2015.

AEMO Modelling of 100% Renewables

- Australian Energy Market Operator (AEMO)
  - Landmark modelling study in 2013
  - Most detailed analysis of 100% renewables to date
  - First time 100% renewables considered by an official planning body in Australia


AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

100 PER CENT RENEWABLES STUDY – MODELLING OUTCOMES

VERSION: FINAL

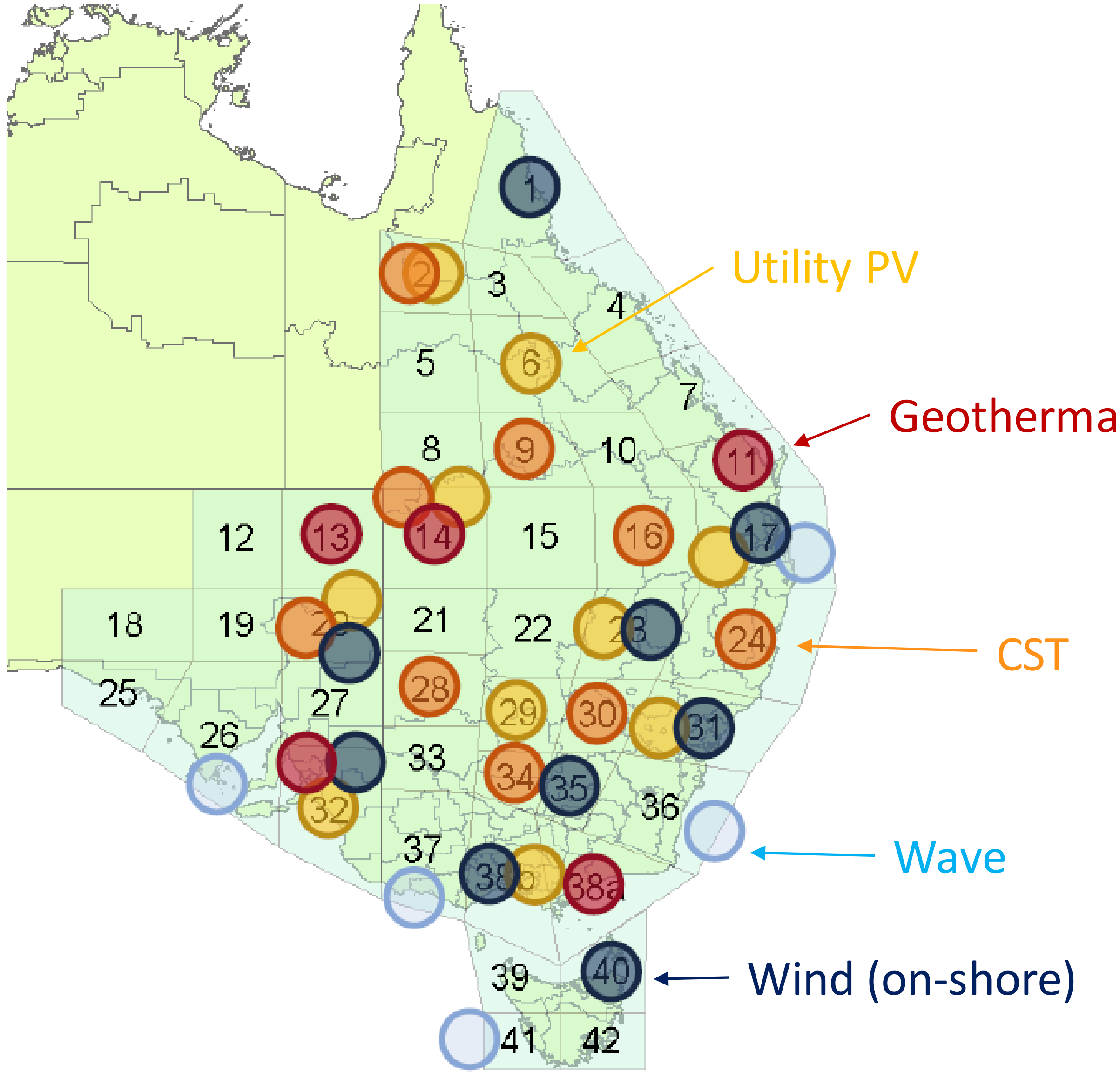
DATE: 21 May 2013

Australian Energy Market Operator Ltd ABN 94 072 010 327 www.aemo.com.au info@aemo.com.au

NEW SOUTH WALES QUEENSLAND SOUTH AUSTRALIA VICTORIA AUSTRALIAN CAPITAL TERRITORY TASMANIA

A massive data collection process

Hourly traces for wind/solar technologies developed based upon historical observations (2003-04 to 2011-12)



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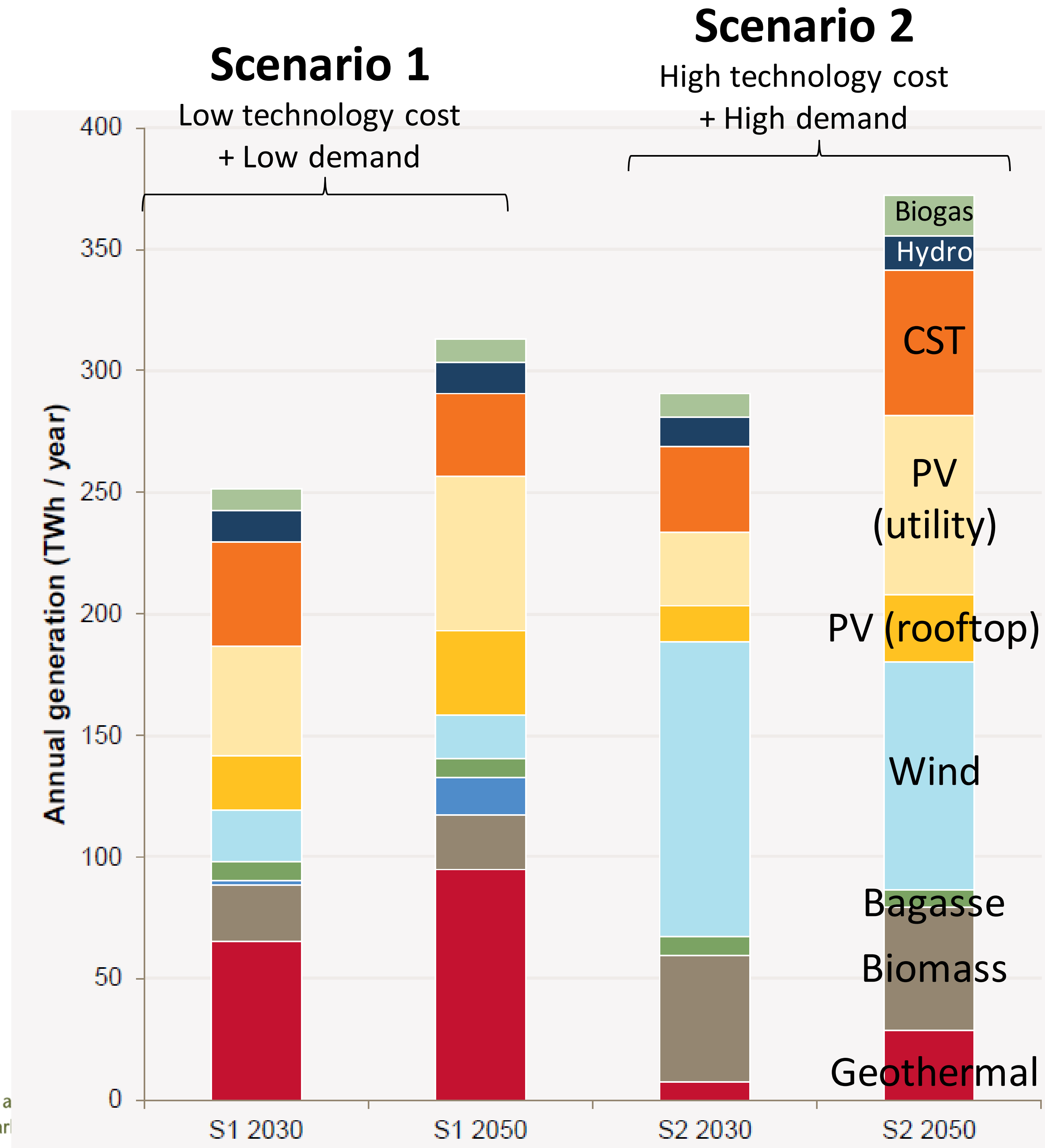
- Generation mix to meet the Reliability Standard:
- Diverse portfolio is key



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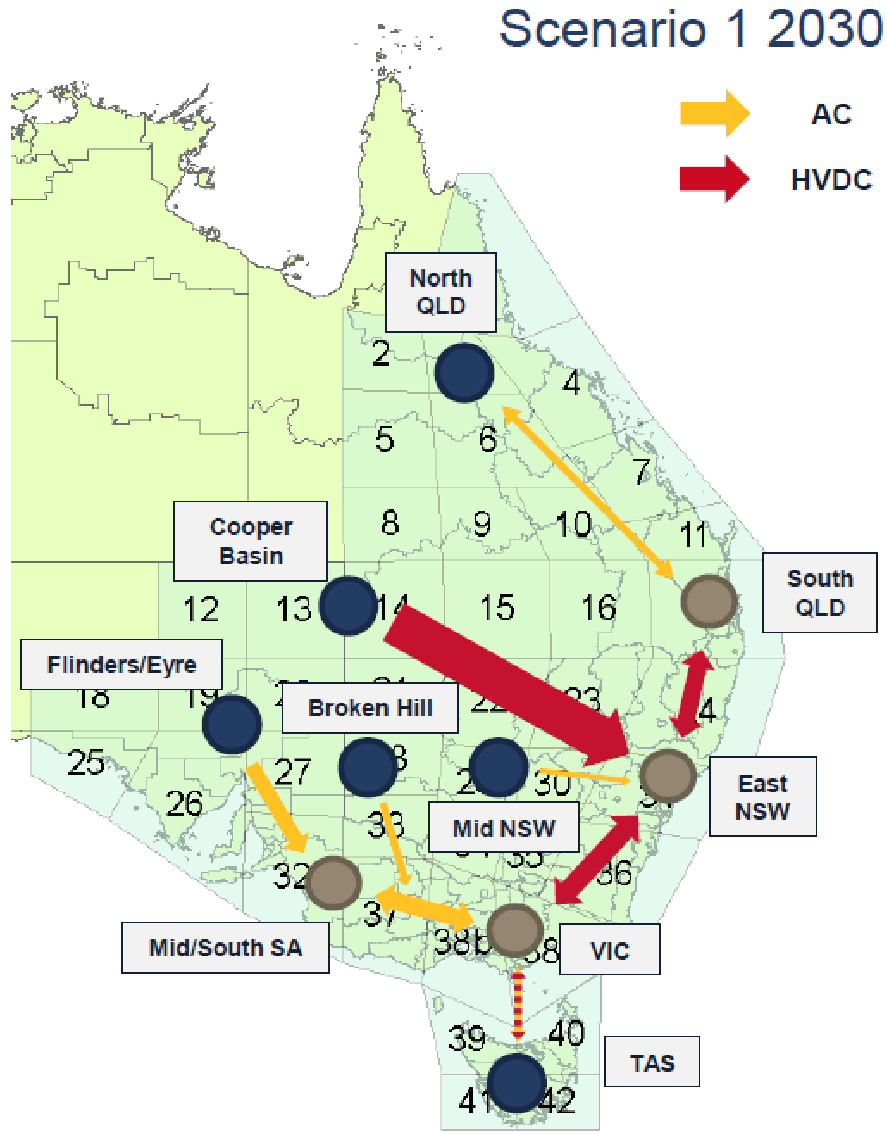
New transmission



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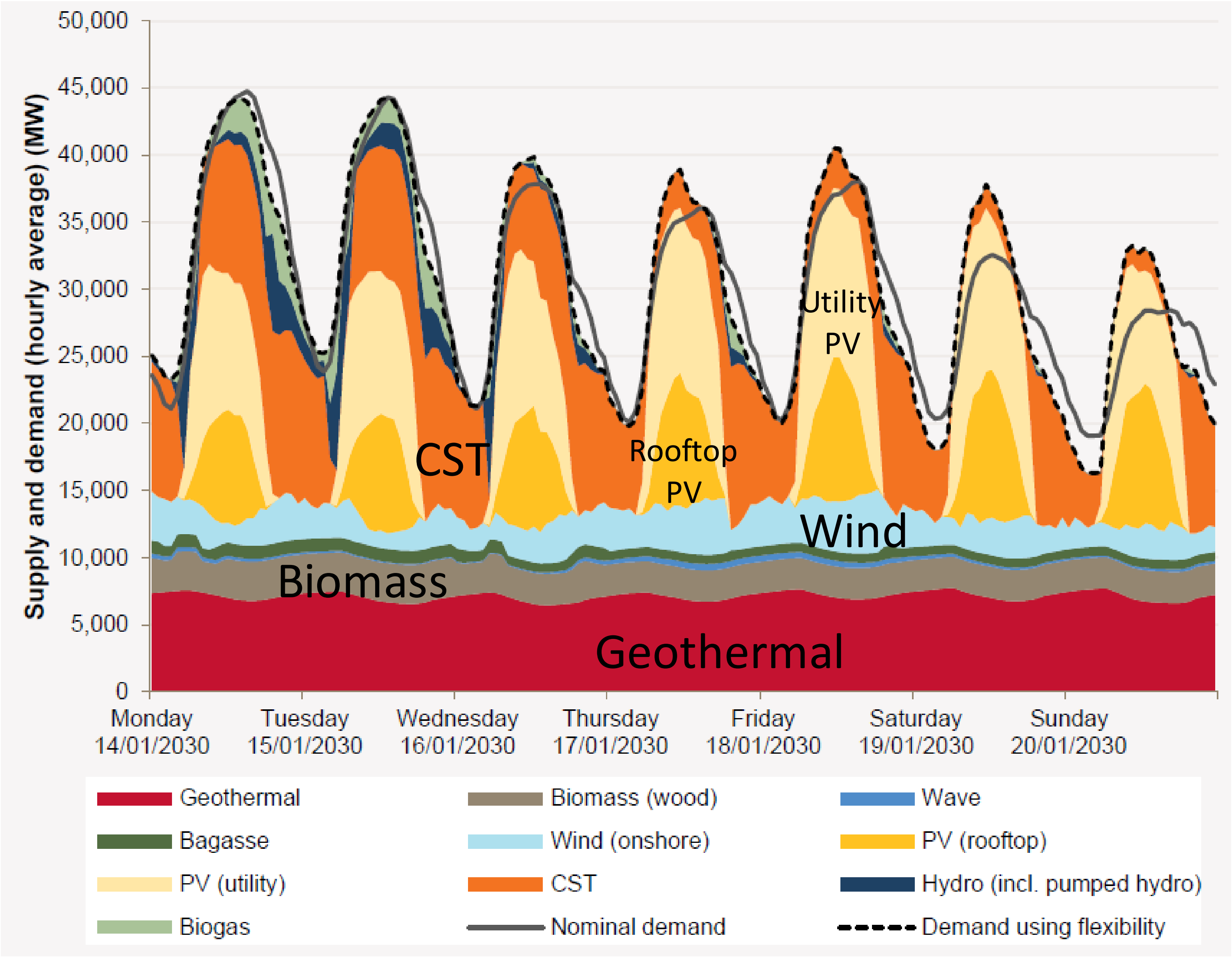
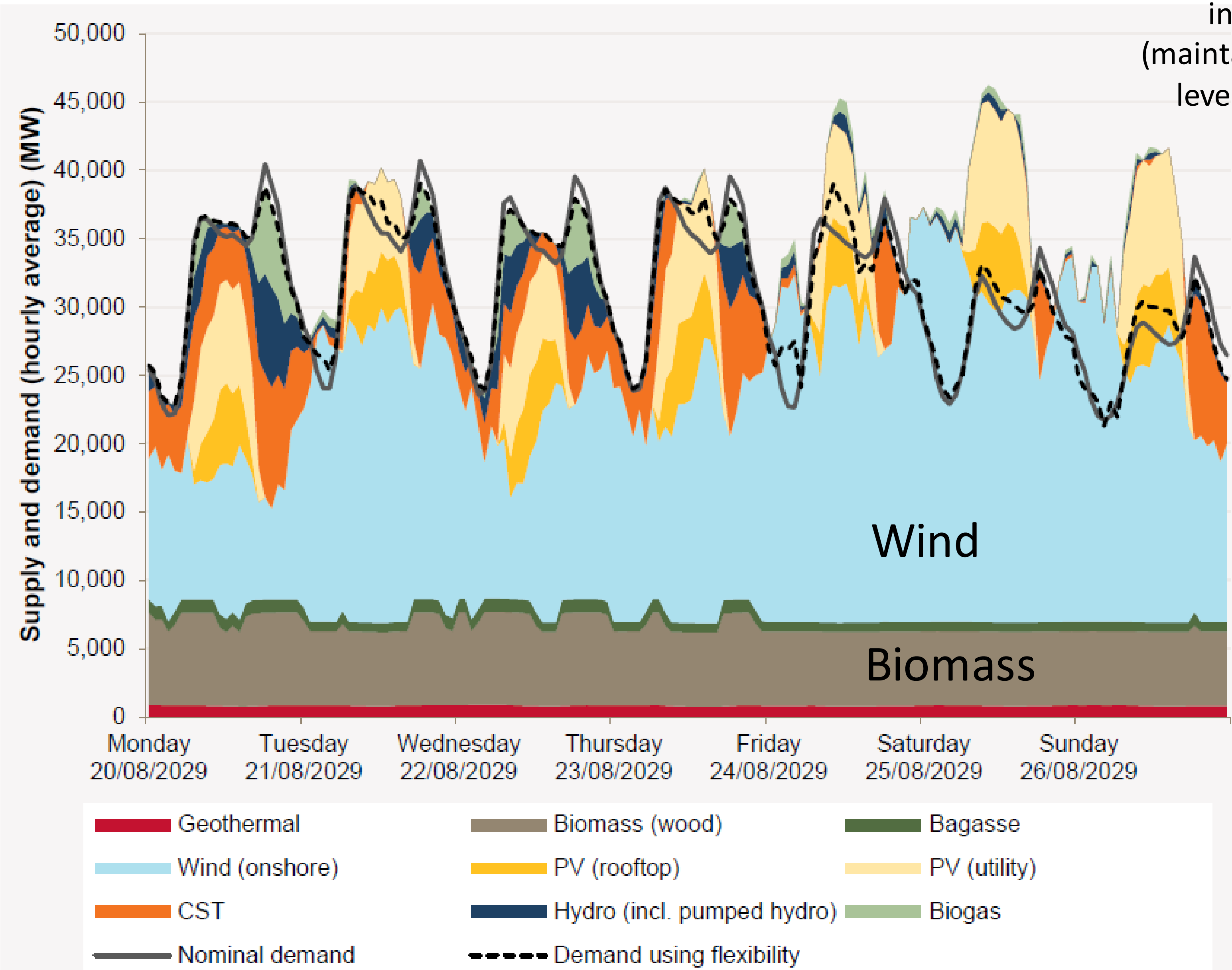
Example: Summer, Scenario 1, 2030



Example: Winter, Scenario 2, 2030

Model constrained to minimum 15% synchronous generation in all periods (maintain inertia, fault level feed-in, etc)



AEMO's assessment

- Reliability standard maintained
- Operational issues "appear manageable" (high level review, based upon international research)

"High penetrations of semi-scheduled and non-synchronous generation would constitute a system that may be **at or beyond the limits of known capability and experience anywhere in the world to date…**"

but…

"There are **no fundamental technical limitations** to operating the given 100 per cent renewable NEM power system generation portfolios that have been identified."

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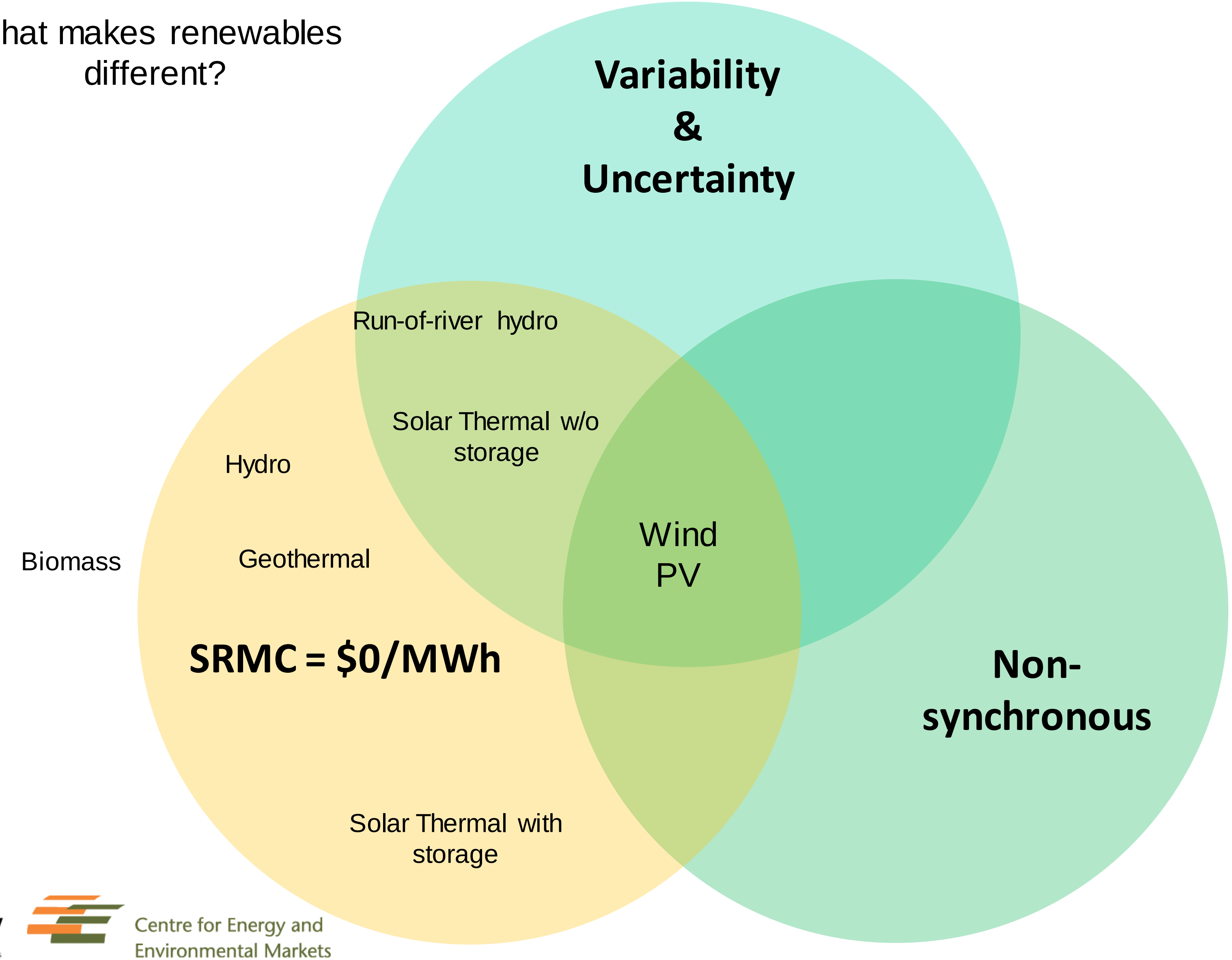
AEMO (2013), "100 per cent renewables study – Modelling outcomes".

Renewable integration challenges

What makes renewables different?



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Engineering challenges identified by AEMO

Variability and Uncertainty

Frequency control - seconds (inertia)	Frequency control - minutes (regulation)	Frequency control - hours (ramping)
• Displacement of synchronous generation	• Increasing variability and uncertainty → increase in regulation reserves	• Managing long wind & PV ramps

Fault level in-feed	Grid code performance standards	Reliability and Resource Adequacy
• Non-synchronous technologies don't provide sufficient fault feed-in • Protection systems may no longer be able to determine when and where a fault has occurred	• New reactive power and voltage support capabilities required during disturbances	• Need to assess differently to present

AEMO Conclusions:

"Many issues remain to be determined without doubt, but it is valuable to note that this operational review has uncovered no fundamental limits to 100% renewables that can definitely be foreseen at this time."

- Transition will occur dynamically over time, allowing proper scope for learning and evolution with additional experience gained.

100% renewables – Technically feasible?

A question of cost…

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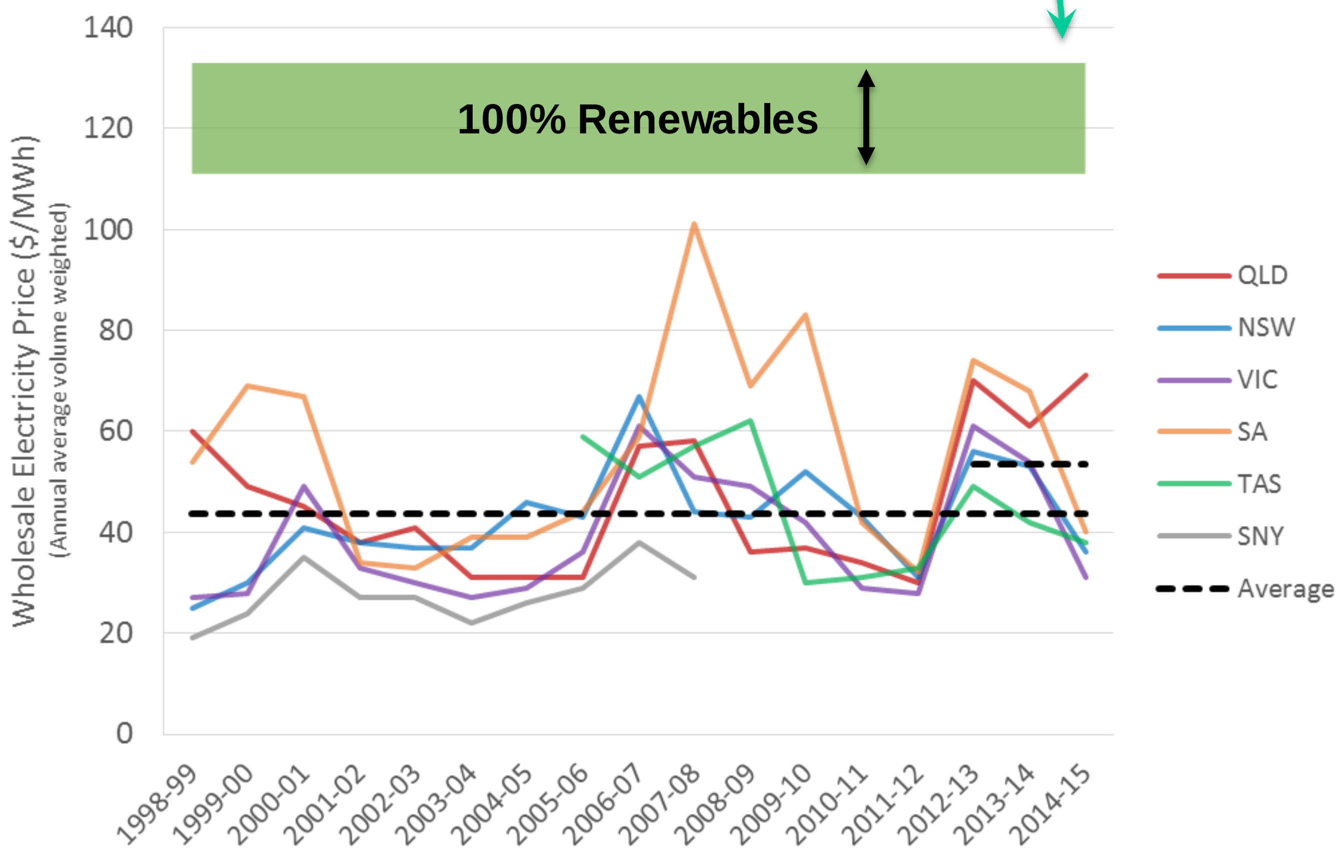
	Cost for 100% renewables (AEMO)
Total capital cost including transmission	$219 - 332 billion
Wholesale cost including opex	$111 - 133 /MWh



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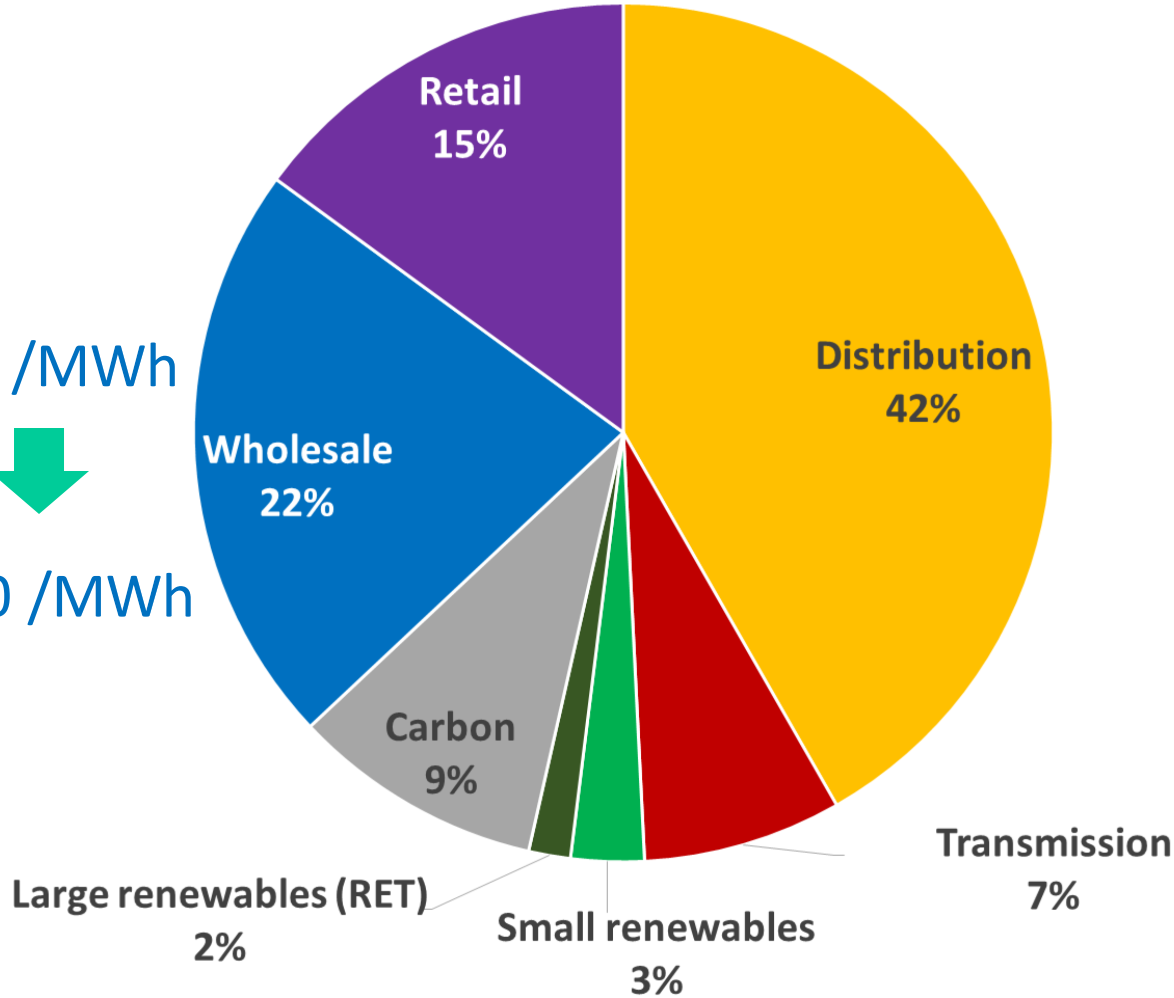
Components of retail prices

- Increase of 6-8c/kWh on retail tariffs (20-30c/kWh)
- 20% increase

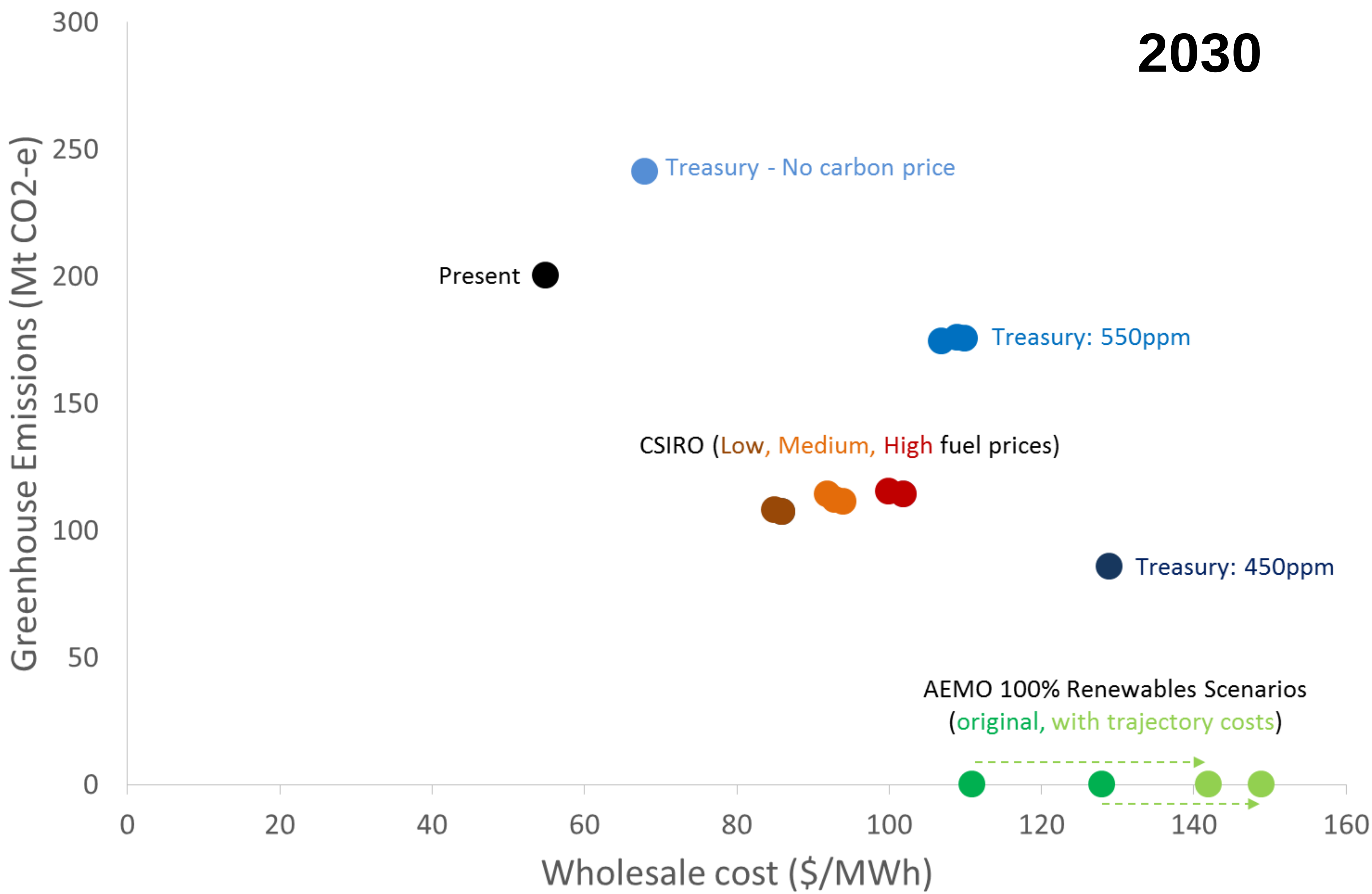
$55 /MWh

$110 /MWh



AEMC, Electricity Price Trends Final Report, March 2013, Results for QLD in 2012-13.

How much will electricity prices go up anyway?



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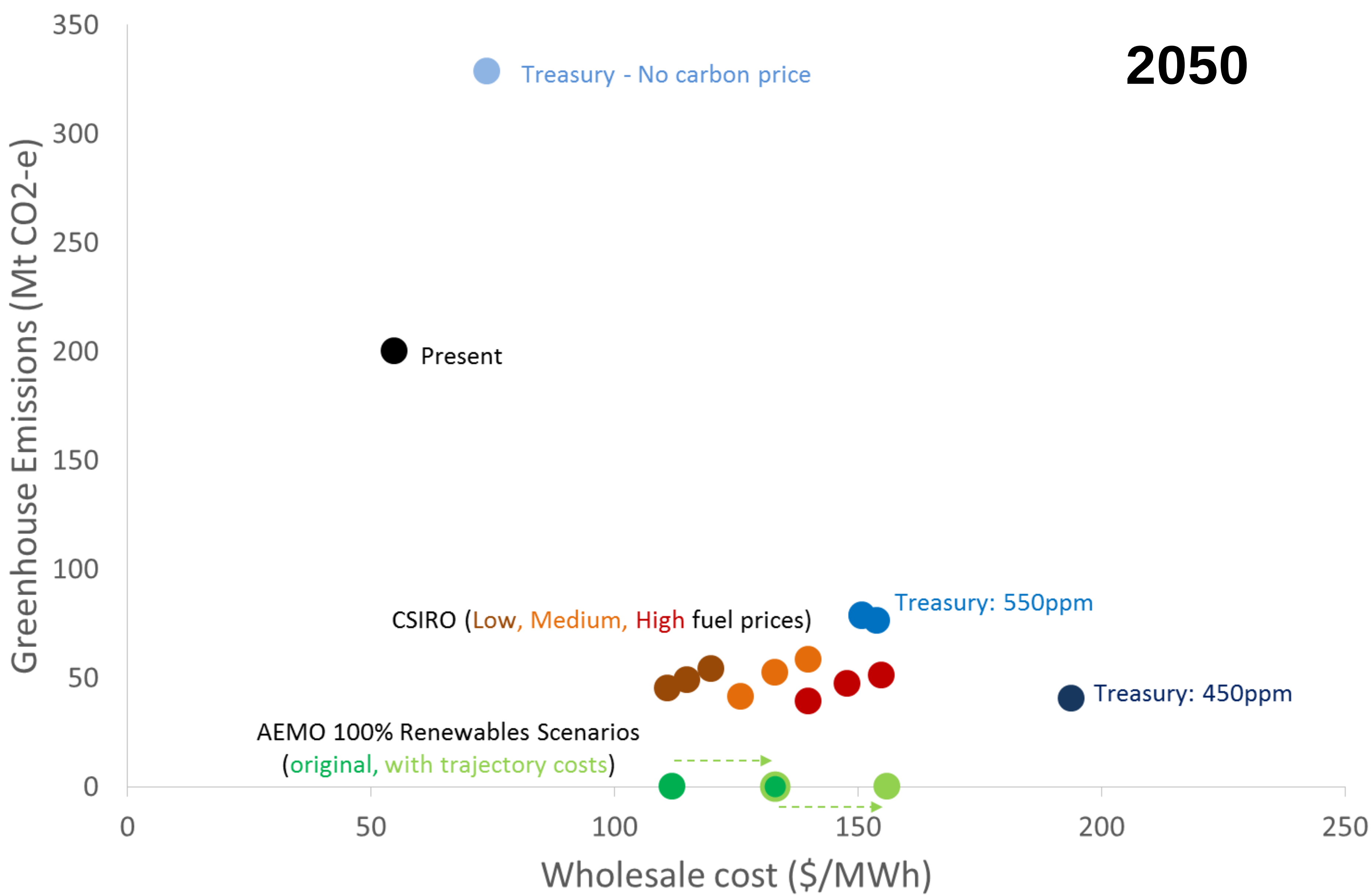
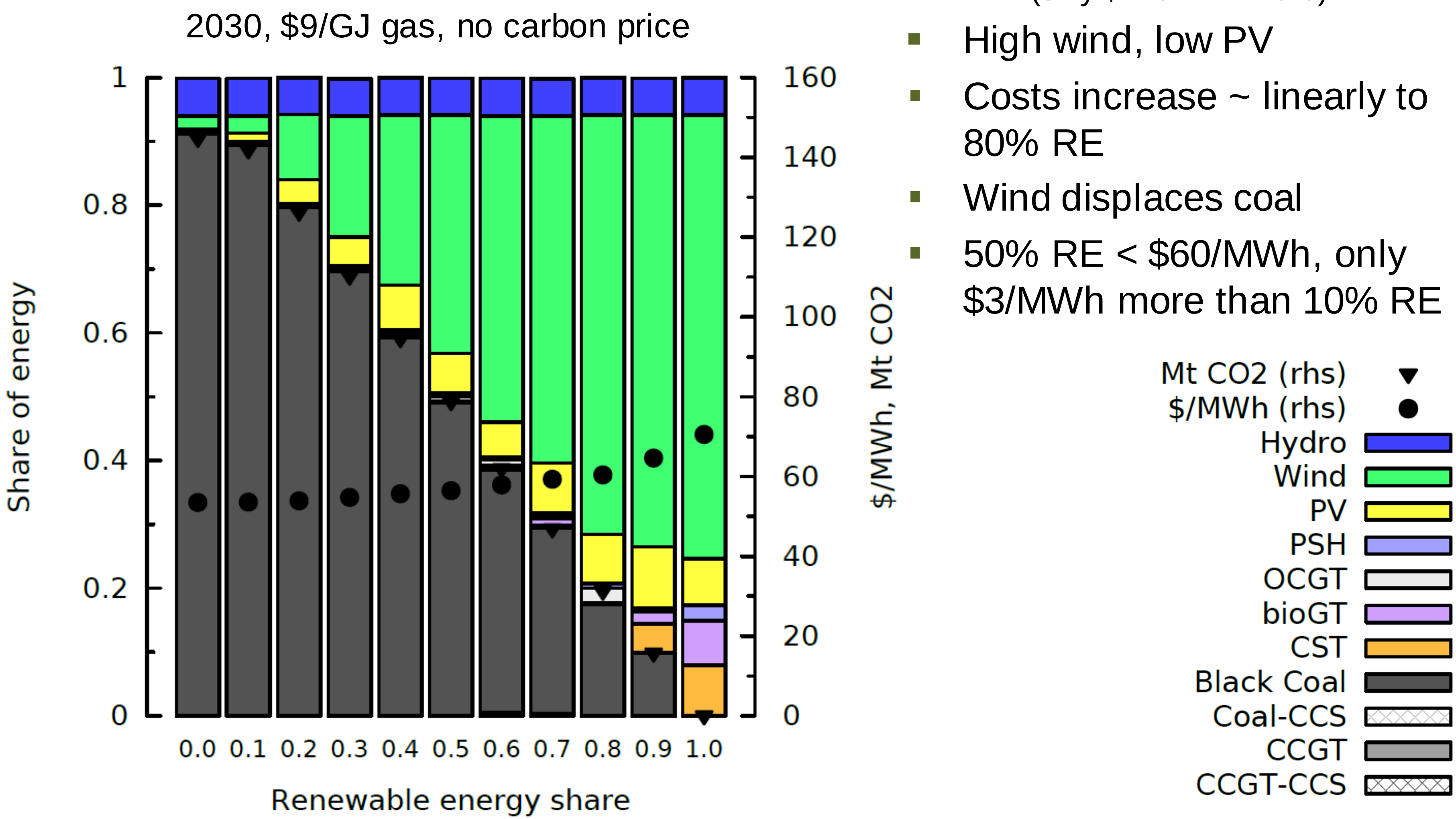


UNSW modelling



- 10-20% RE: $54 /MWh
- 100% RE for $71 /MWh
  - (only $17 /MWh more)
- High wind, low PV
- Costs increase ~ linearly to 80% RE
- Wind displaces coal
- 50% RE < $60/MWh, only $3/MWh more than 10% RE

B. Elliston, J. Riesz, I. MacGill, (2015) "What cost for more renewables? The incremental cost of renewable generation - an Australian National Electricity Market case study"

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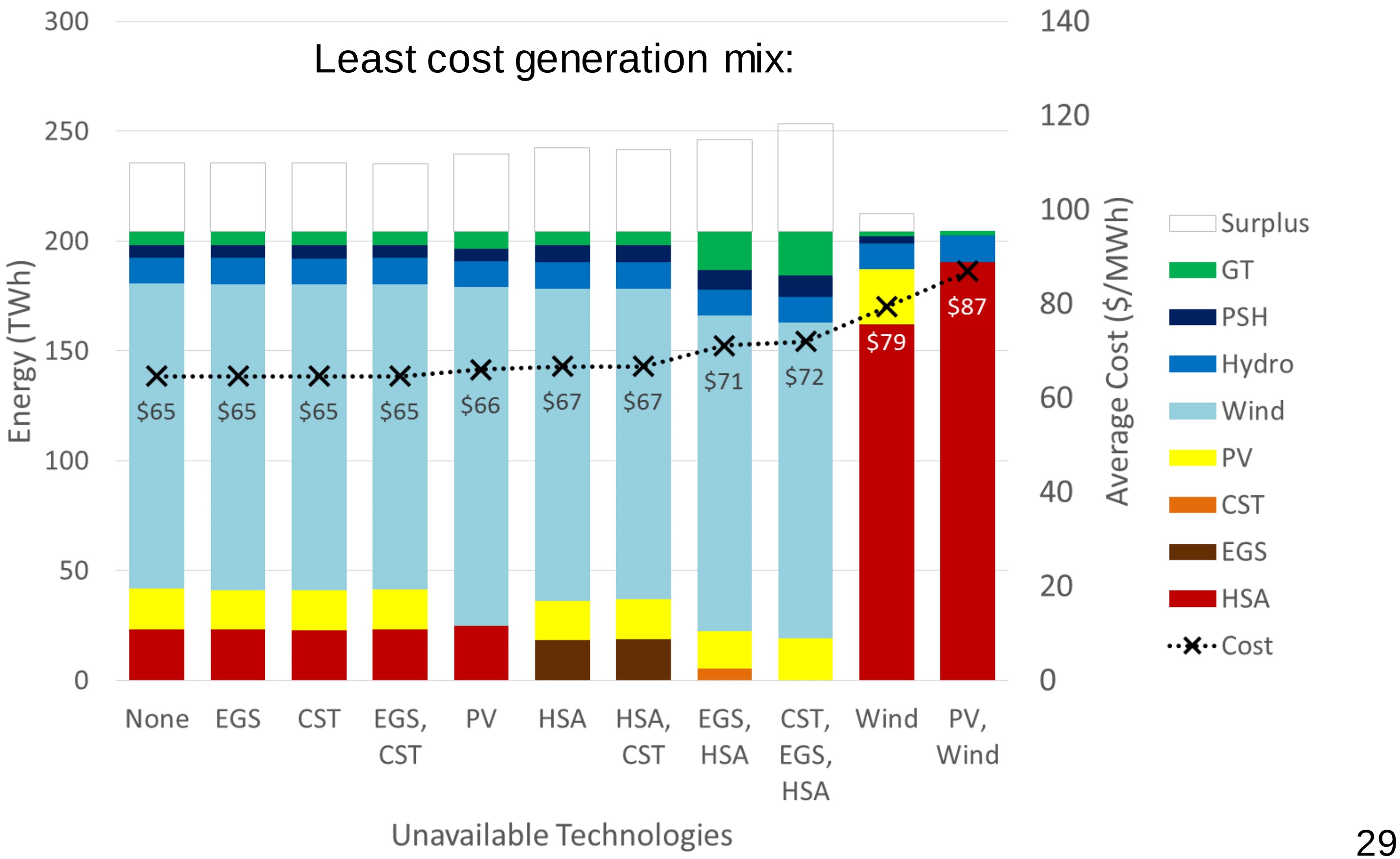
Technology availability

- Can meet reliability standard with various technologies unavailable
  - Robust ability to achieve 100% RE
- Costs $65 - $87 /MWh
  - Wind typically provides ~70% of energy, most expensive scenarios don't have wind

J. Riesz, B. Elliston, "The impact of technology availability on the costs of 100% renewable electricity generation scenarios for Australia", 38th IAEE International Conference, Antalya, Turkey, May 2015.



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- 100% renewables (or very high renewables) appears similar in cost to other possible power systems in the future

100% renewables – Cost competitive?

What about the *market?*

Competitive market

Generators offer close to SRMC

Price close to zero in majority of periods

How do generators recover costs?

How do we maintain accurate investment incentives?

SYSTEM ADEQUACY

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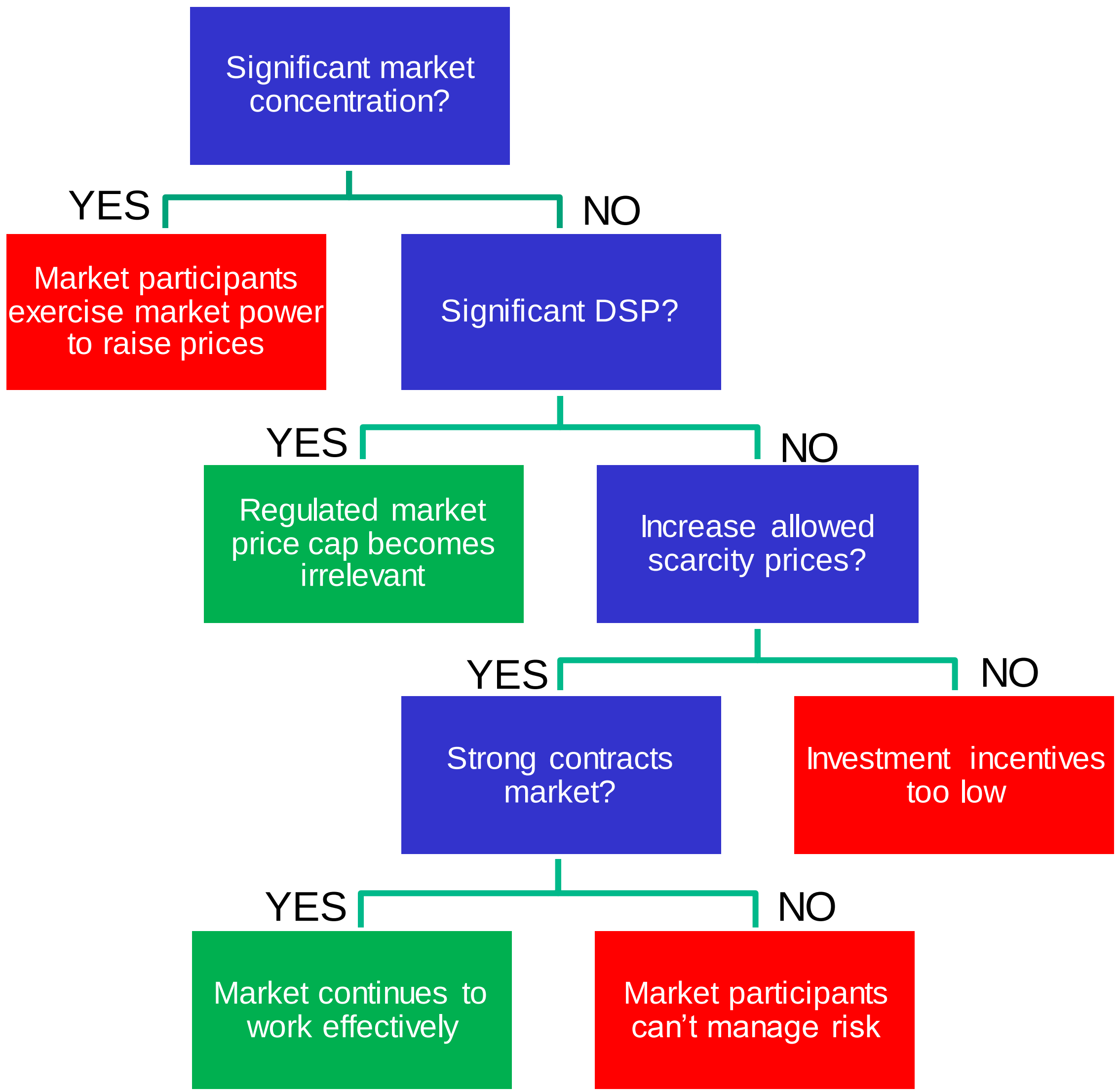
Will the market work with high renewables?



Constant monitoring is wise – new issues will arise over time

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Summary

100% renewables – worth thinking about?

- Inevitable - a question of when

100% renewables – technically feasible?

- Yes, with high confidence, although many technical issues to address

100% renewables – costs?

- Appear manageable, and likely lower than other generation types (given anticipated gas and carbon costs)

100% renewables – will the market work?

- Will challenge existing market models, but dramatic market reform is unlikely to be warranted at this time.

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Thank you

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