Centre for Energy and Environmental Markets

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA



100% Renewables for Australia?

Challenges and Opportunities

Dr Jenny Riesz

Joint Electrical Institutions Lecture Program – 26th June 2014

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

Delta electricity

AEMC Australian Energy Market Commission

AEMO AUSTRALIAN ENERGY MARKET OPERATOR

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

ROAM CONSULTING ENERGY MODELLING EXPERTISE

Centre for Energy and Environmental Markets

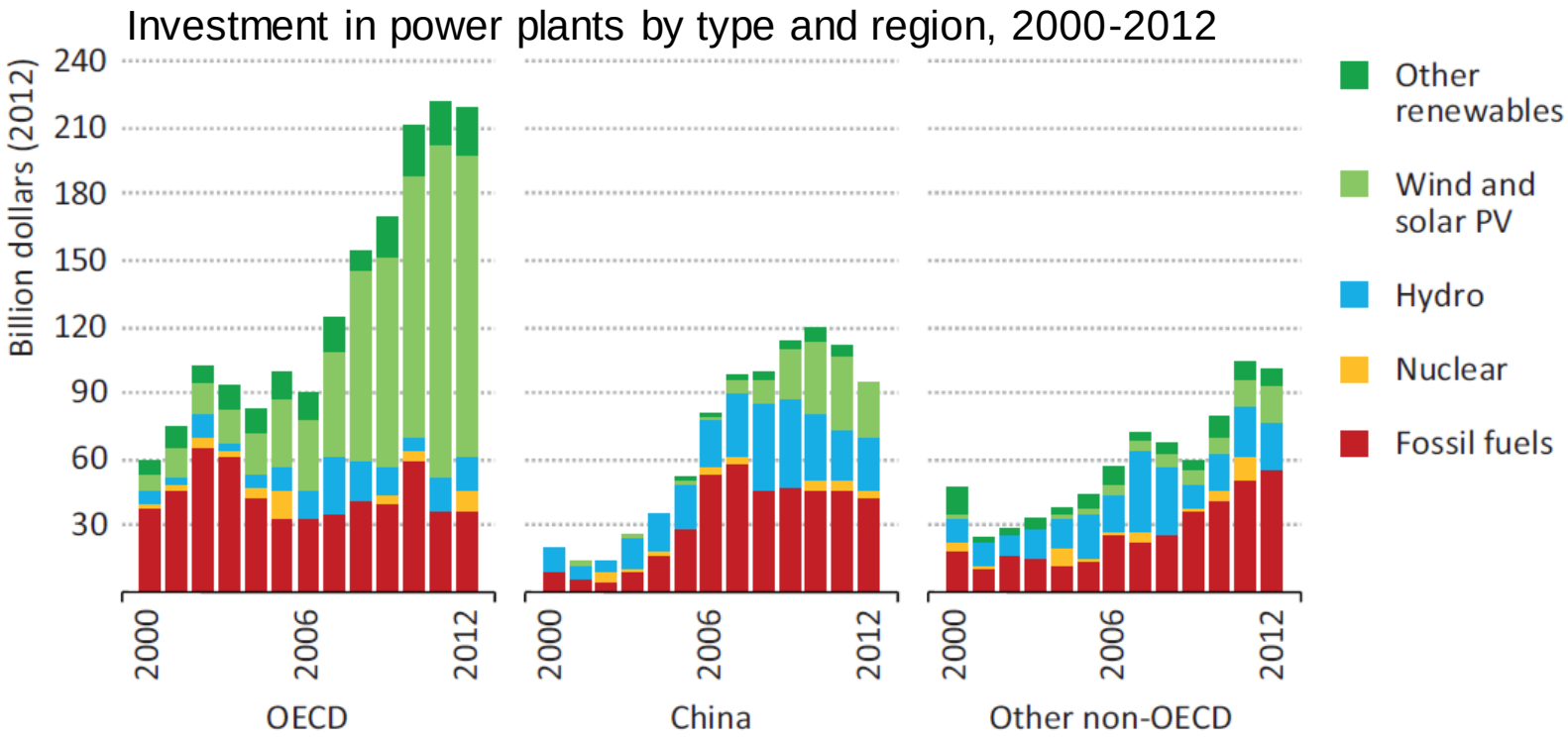
UNSW AUSTRALIA

AECOM

Overview

- 100% renewables – worth thinking about?
- 100% renewables – technically feasible?
- 100% renewables – costs?
- 100% renewables – will the market work?

Global investment in electricity generation



Sources: IEA analysis and IEA (2014a).

More invested in renewables than fossil fuels globally

What about capacity?

In 2013, renewables accounted for more than 56% of net additions to global power capacity

China now adds more renewable capacity each year than fossil fuel and nuclear capacity combined.

What about Australia?

Keep using what we've got?

- **Ageing generation fleet**
- By 2030, 65% of Australia's coal-fired power stations will be over 40yrs old

New coal?

- **New coal now costs more than renewables**
- Regulatory risks means very high cost of capital, if they can get financing at all

Gas?

- **Baseload CCGT can't get competitive gas supply contracts**
- Competition with LNG export market

Nuclear?

- **More expensive than renewables**
- No existing industry or experience

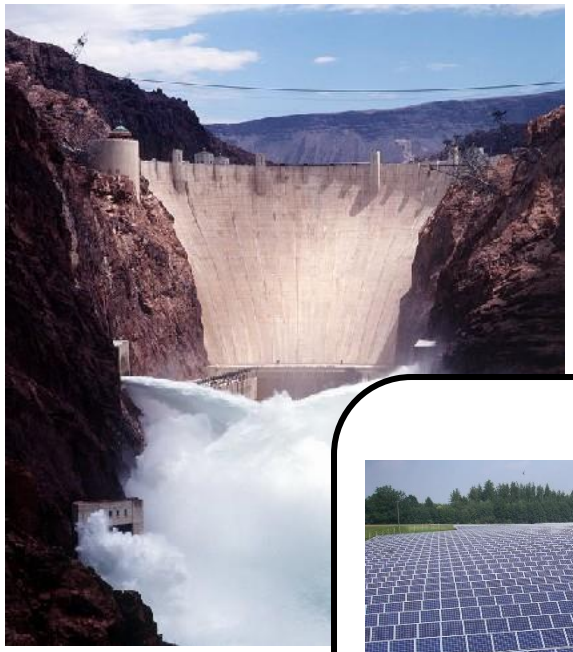
UK:
Hinkley Point C
$154/MWh
35yr PPA

- 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?

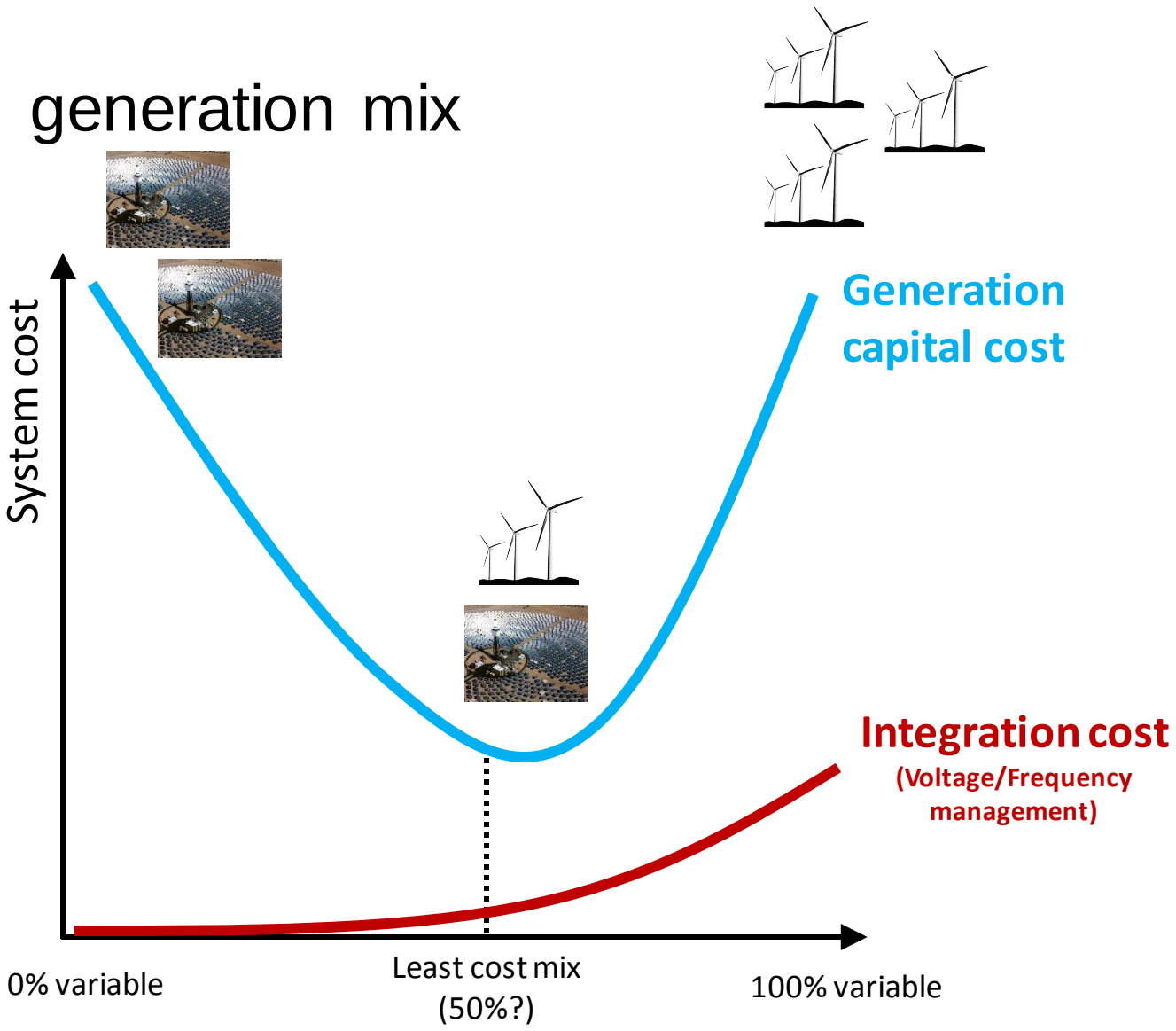
- But is it even technically feasible?!?

Renewable technologies



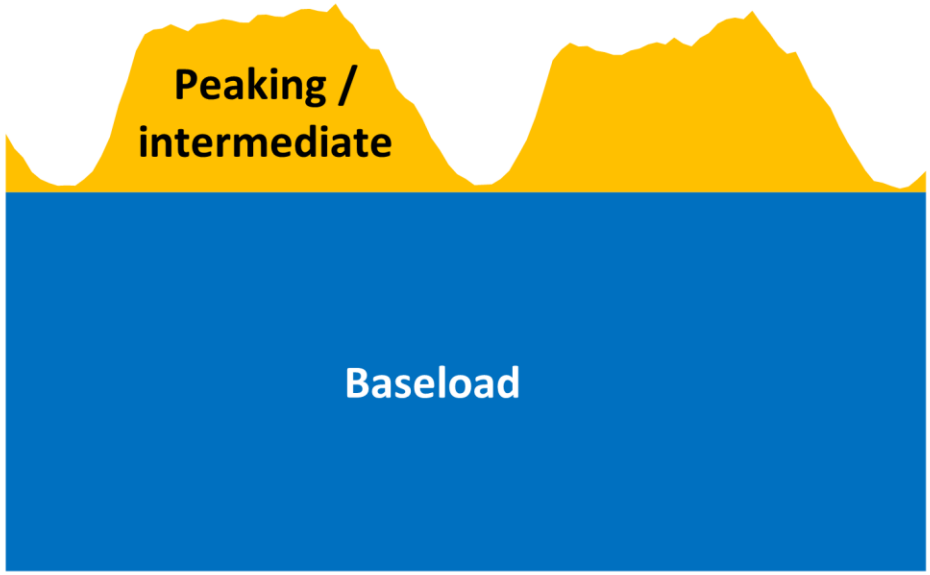
Variable & non-synchronous

Optimising generation mix

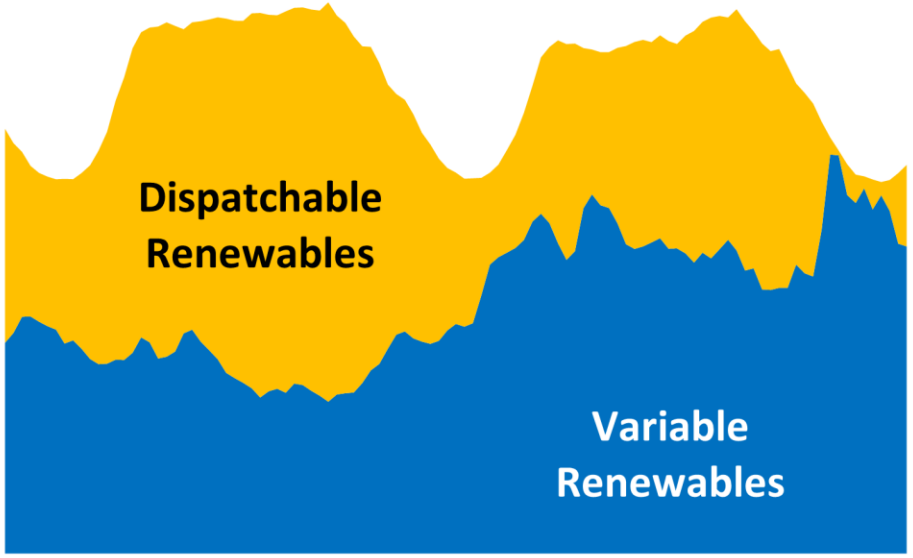


UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and Environmental Markets



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". Accepted for presentation at the 2014 International Energy Workshop (Beijing)

UNSW THE UNIVERSITY OF NEW SOUTH WALES

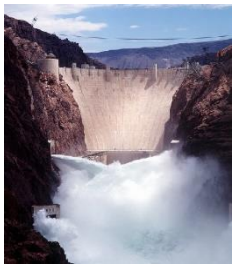
Centre for Energy and Environmental Markets

Least cost mix

45% - 60%
wind

14% - 22%
Solar thermal

15% - 20%
PV



5%
Hydro
(existing)

6%
Biomass

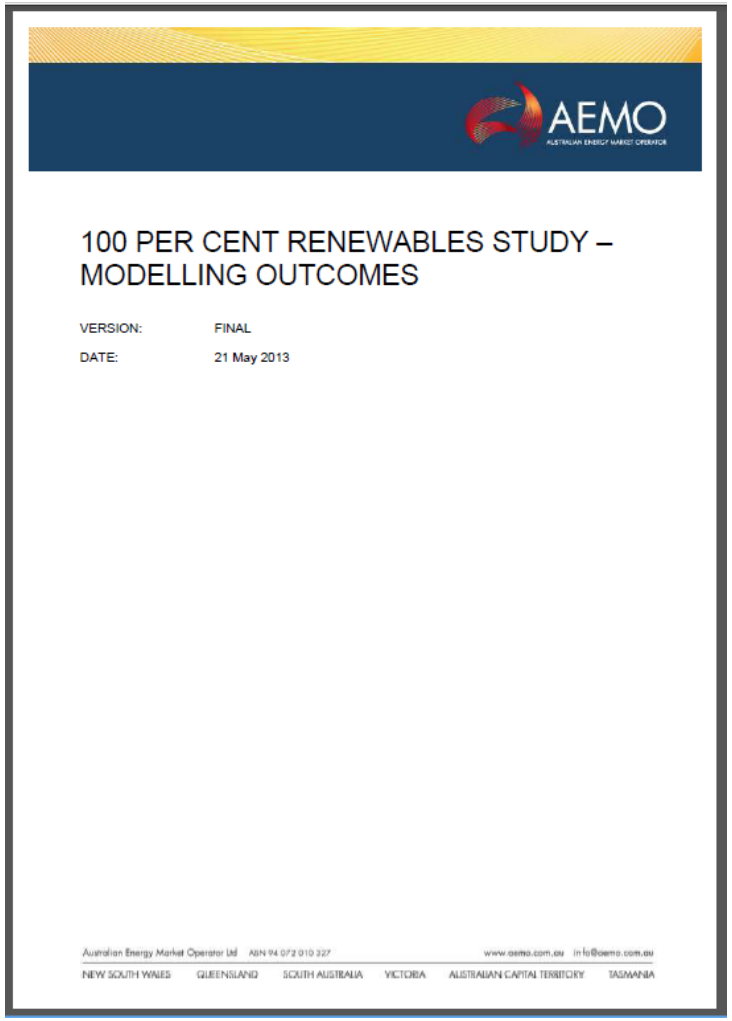
UNSW
THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and
Environmental Markets

Elliston, B; MacGill, I; Diesendorf, M (2013) Energy Policy, "Least cost 100% renewable electricity scenarios in the Australian NEM"

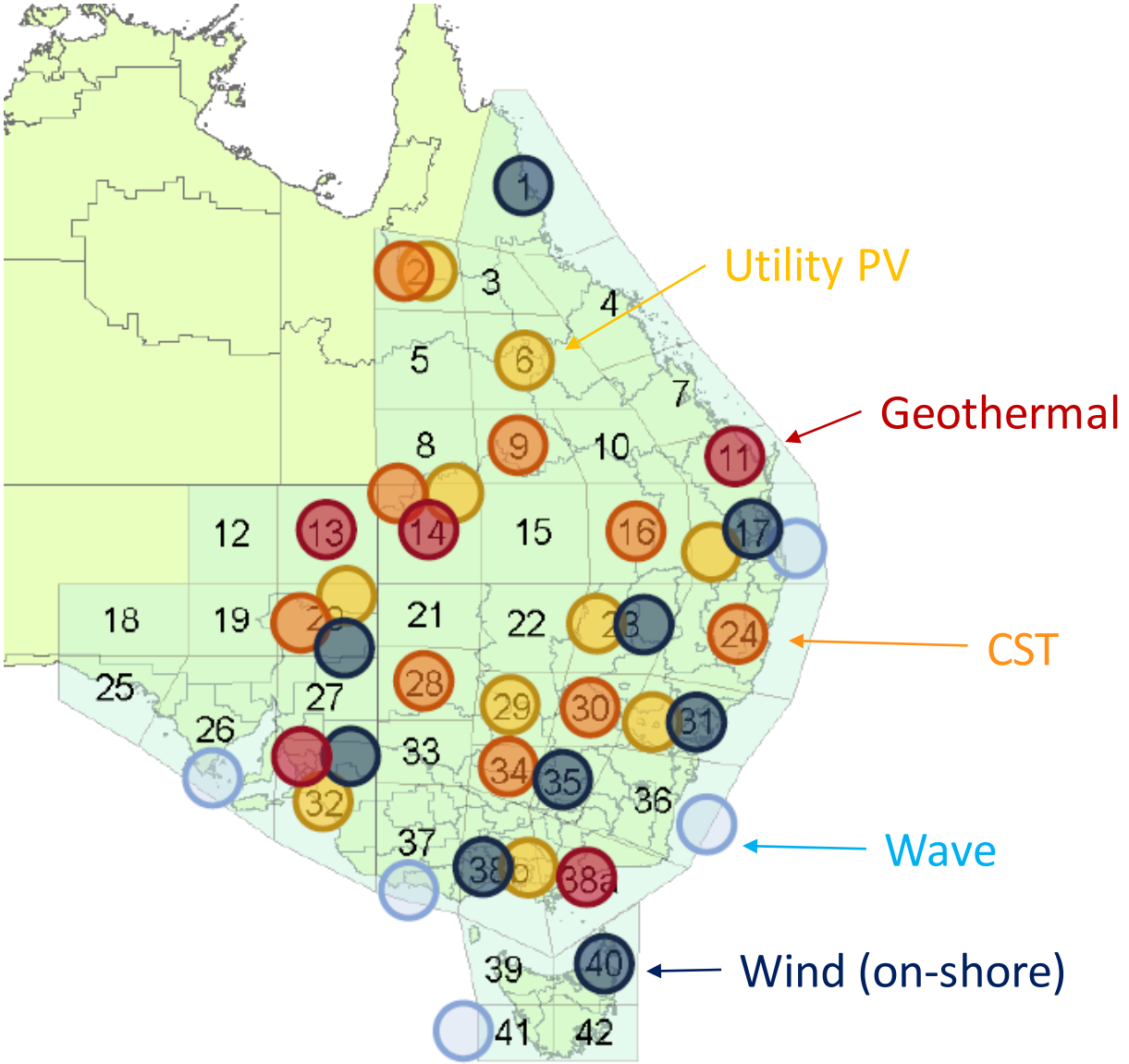
Modelling of 100% Renewables

- 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



A massive data collection process

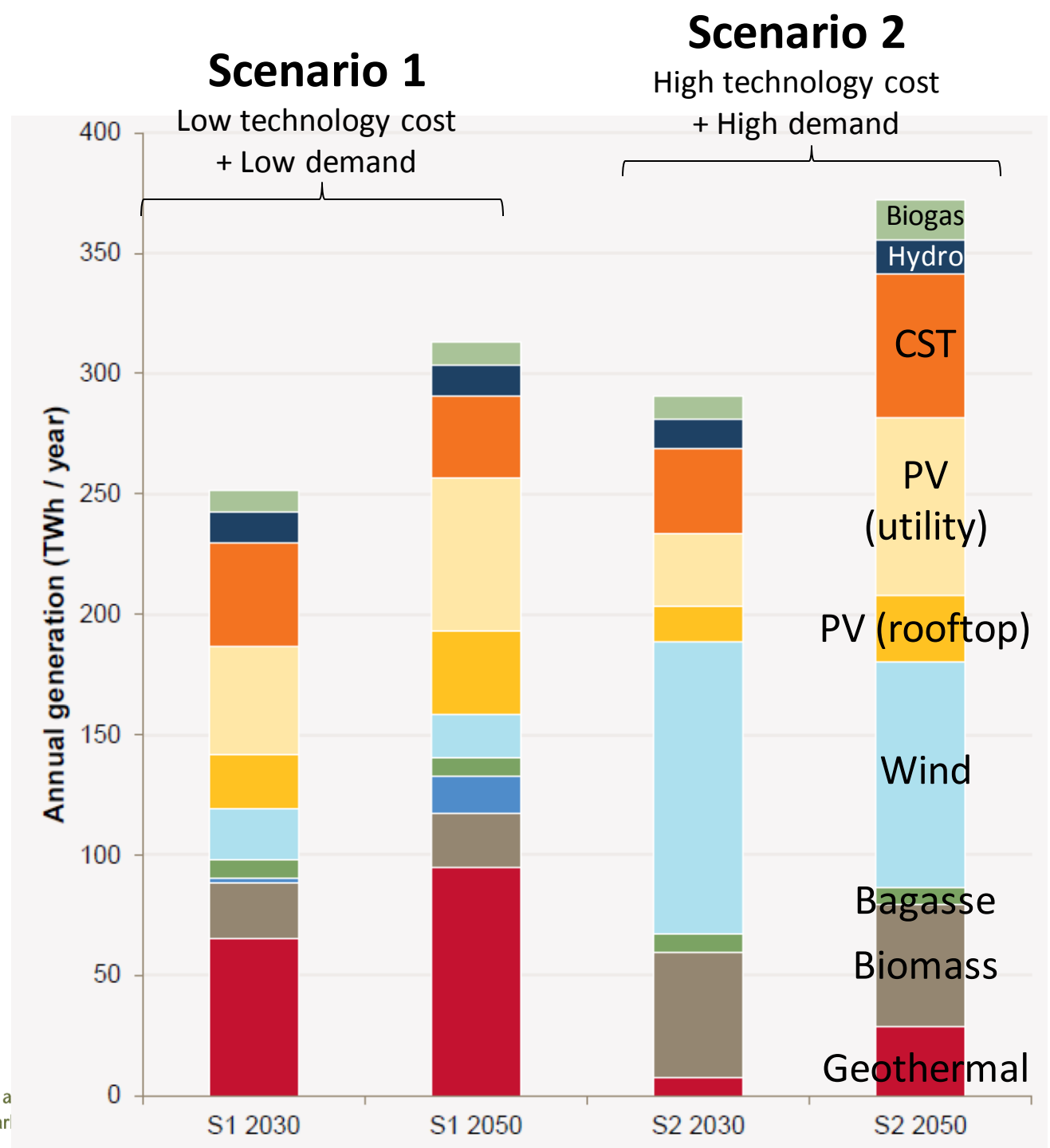
Hourly traces for wind/solar technologies developed based upon historical observations (2003-04 to 2011-12)



UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and Environmental Markets

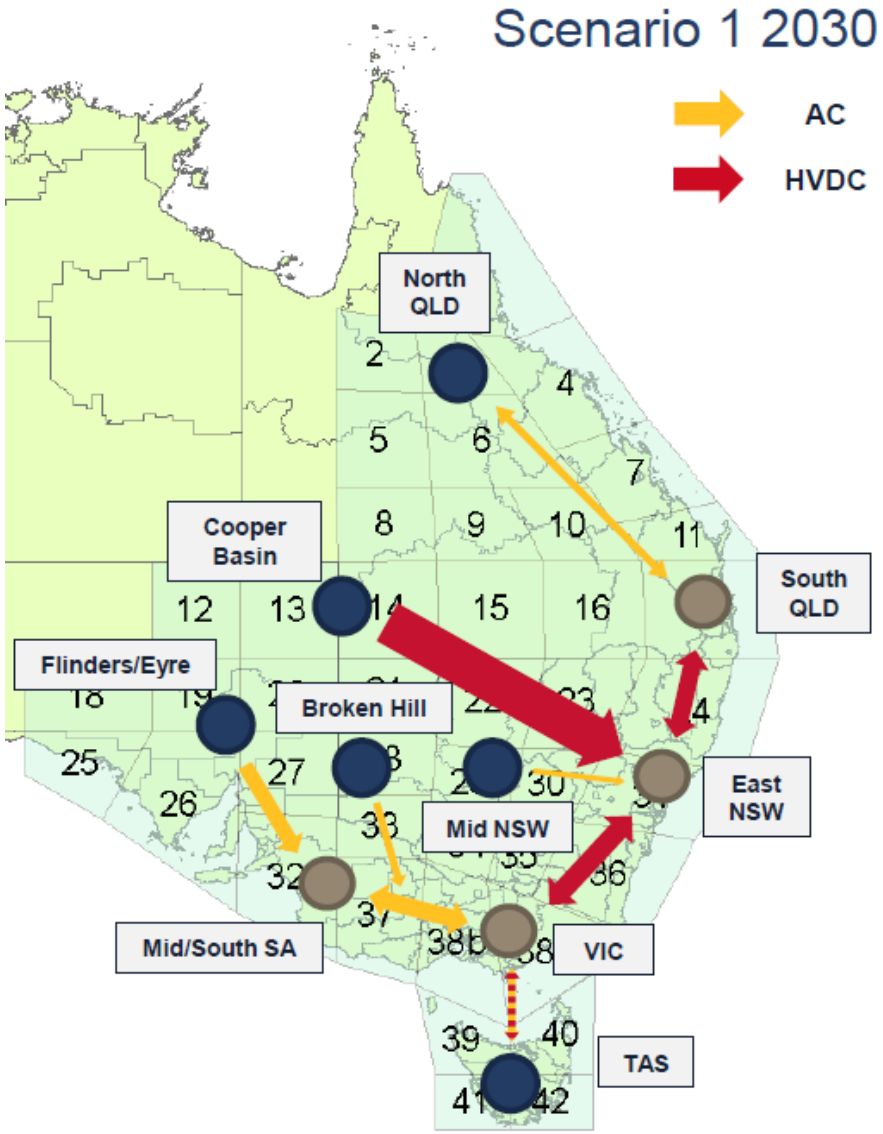
- Least cost generation mix to meet the Reliability Standard:
- Diverse portfolio is key



UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy a
Environmental Mar

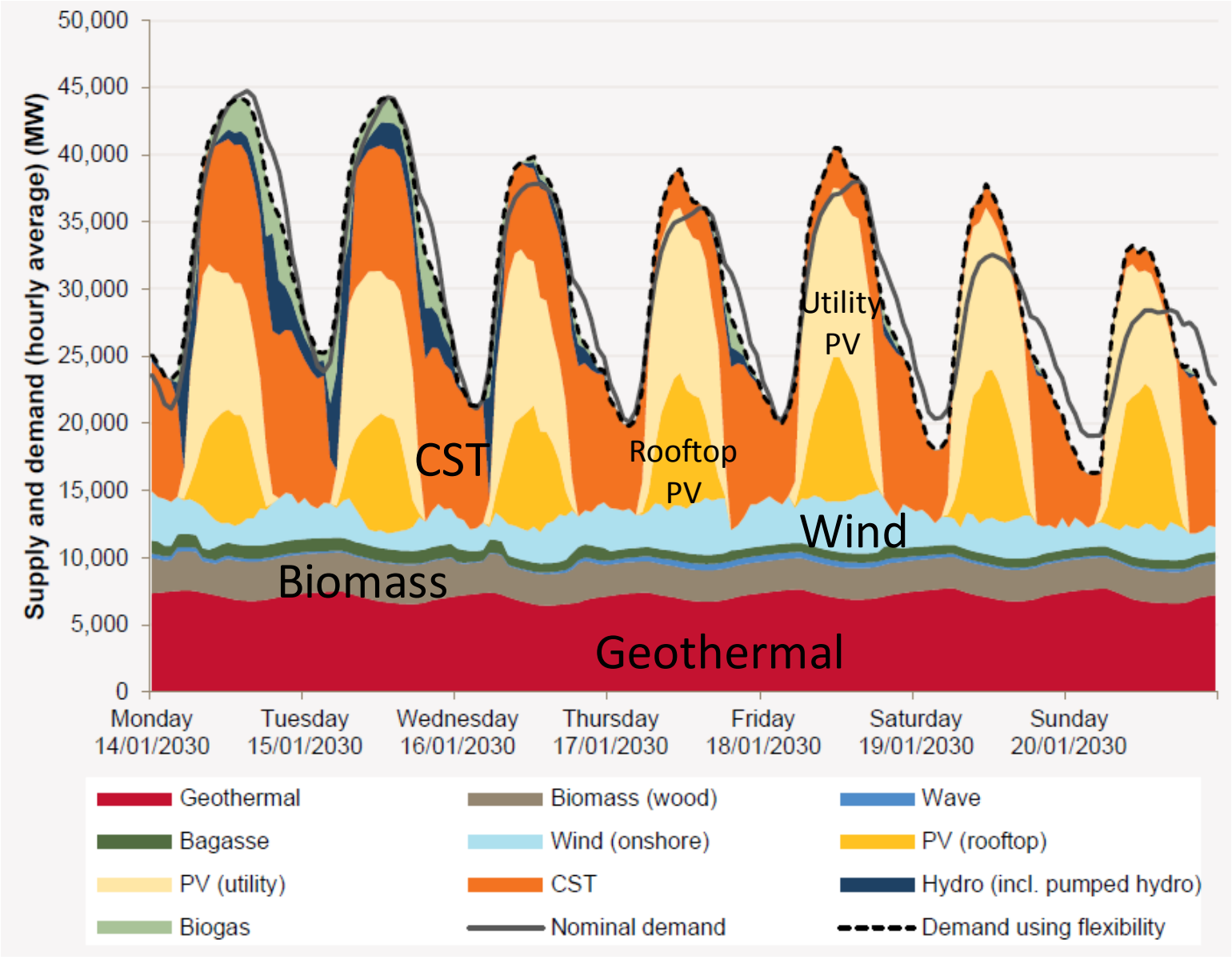
New transmission



UNSW THE UNIVERSITY OF NEW SOUTH WALES

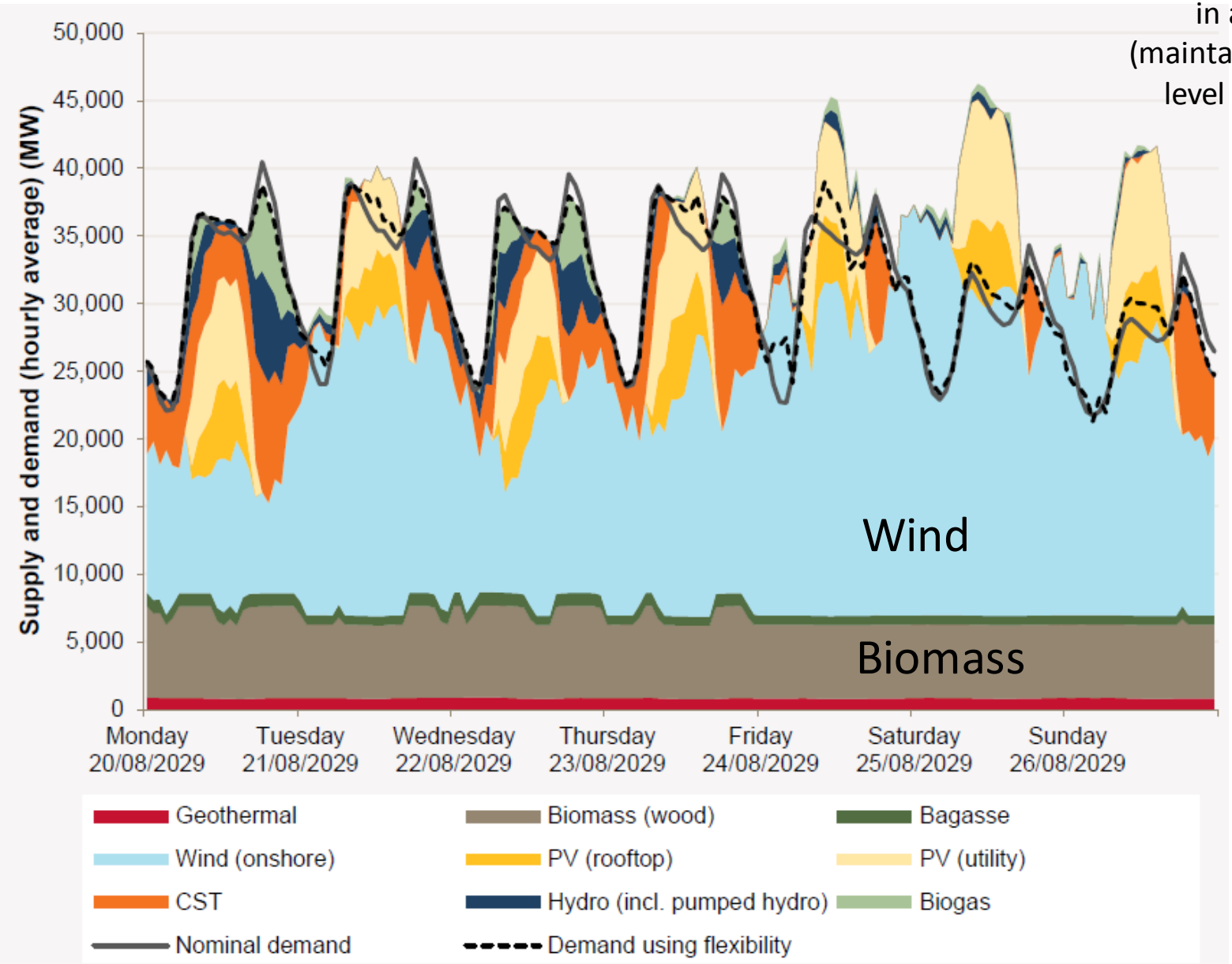
Centre for Energy and Environmental Markets

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)



Technical feasibility of 100% renewables

- AEMO's assessment:
  - Reliability standard maintained
  - Operational issues "appear manageable"
    - High level review, including inertia, frequency management, fault feed-in levels, voltage management, etc, based upon international research.
- Agrees with previous analysis (UNSW, Uni of Melb/BZE)

100% renewables – Technically feasible?

- A question of cost

Cost – AEMO Modelling

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

- Current average wholesale price ~$55/MWh
  - 100% renewables requires doubling of this

Components of retail prices

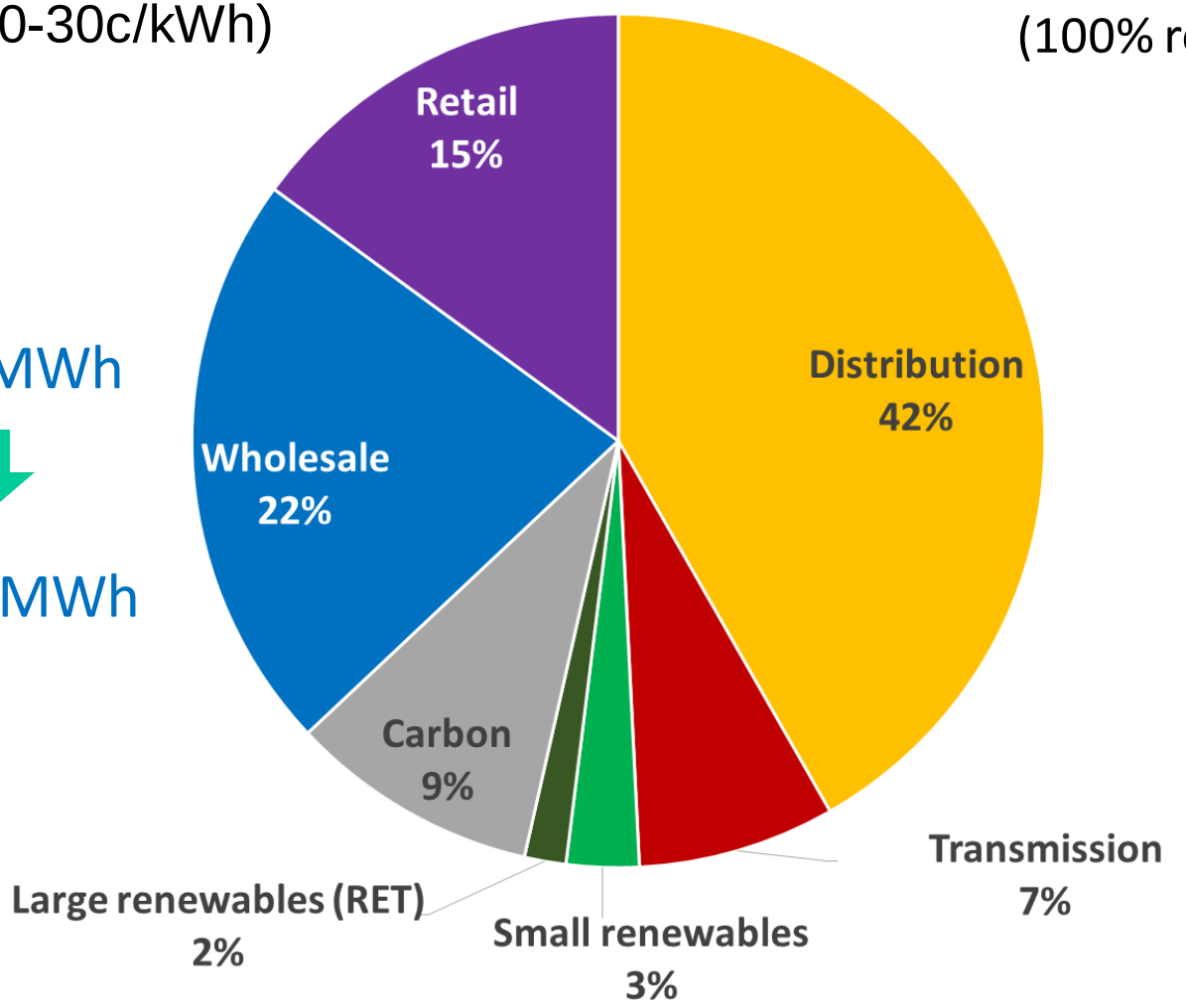
$300 /quarter

$390 /quarter
(100% renewables)

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

$55 /MWh

$110 /MWh



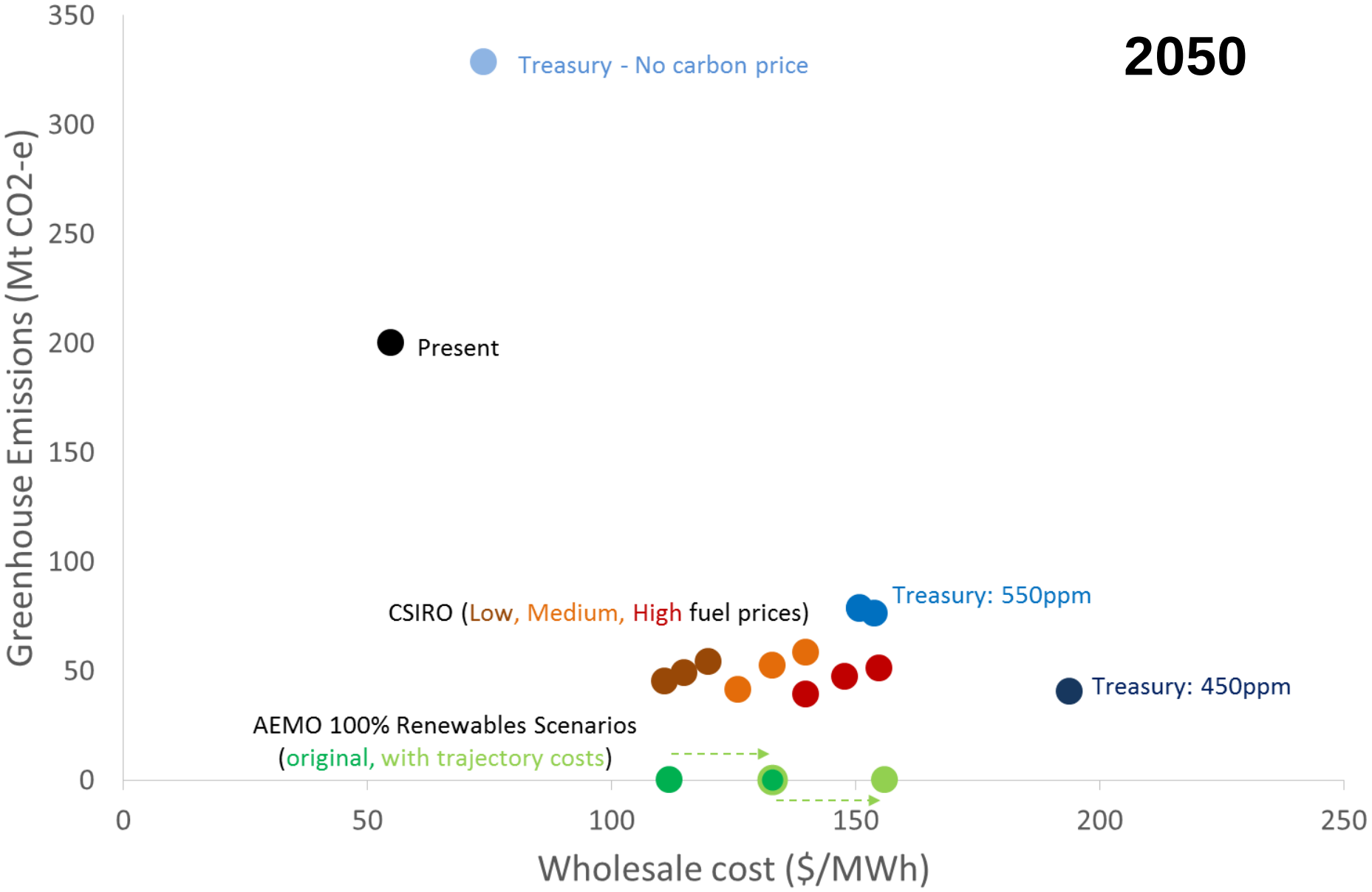
UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and Environmental Markets

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

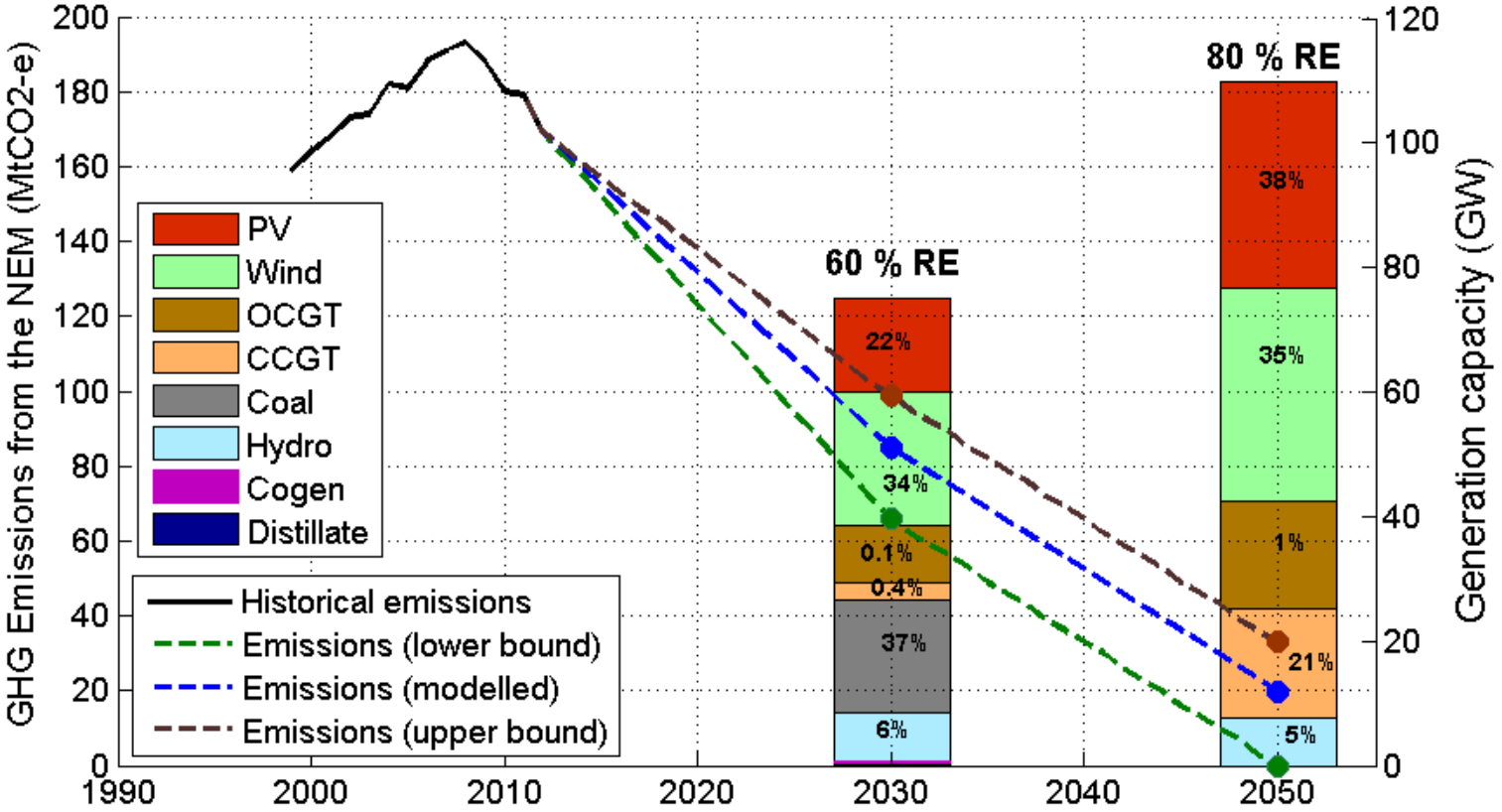
How much will electricity prices go up anyway?

How much will electricity prices go up anyway?



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

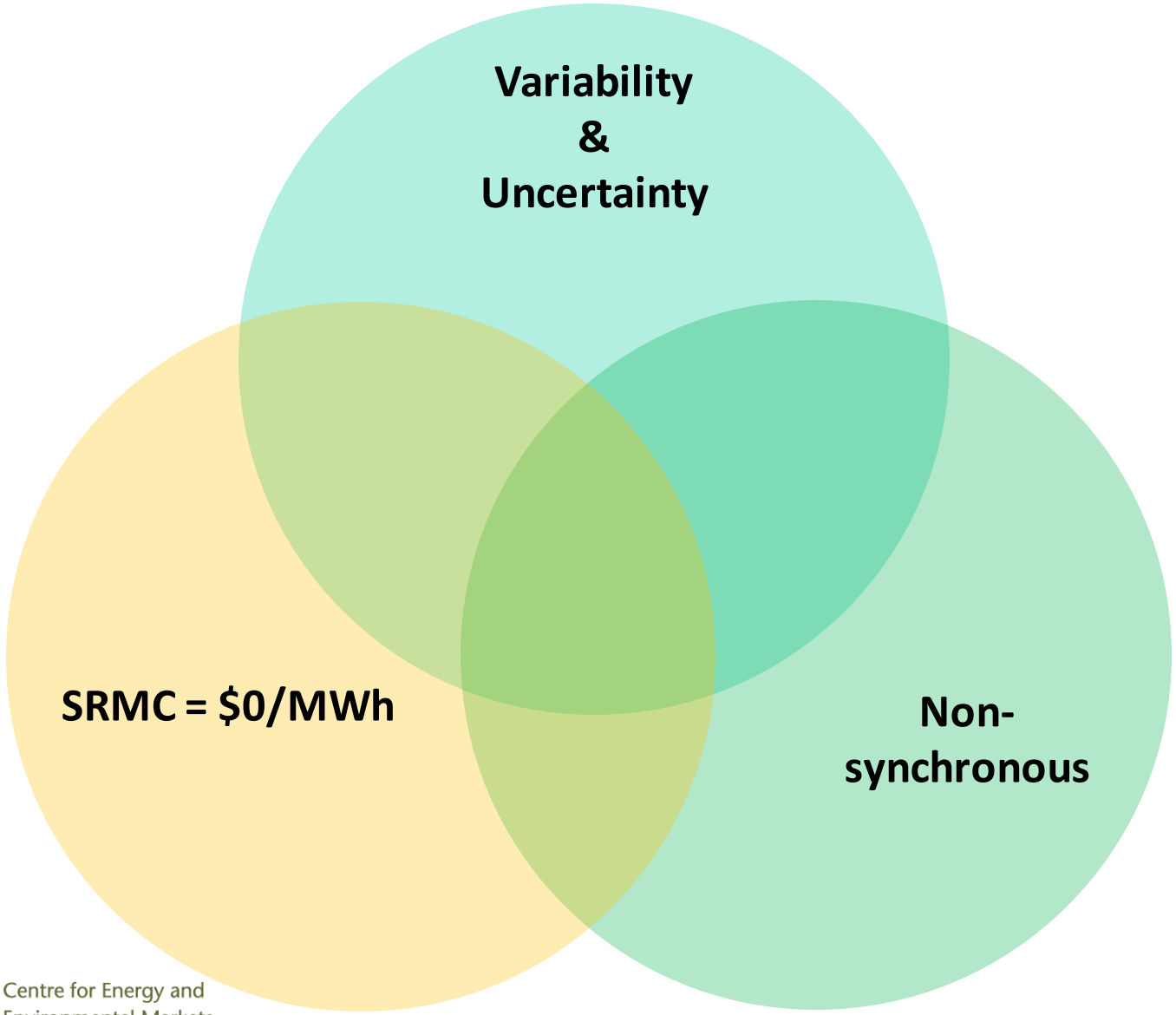
- 100% renewables (or very high renewables) appears similar in cost to other possible power systems in the future

100% renewables – Cost competitive?

100% Renewables

MARKET VIABILITY?

What makes renewables different?



What about the *market?*

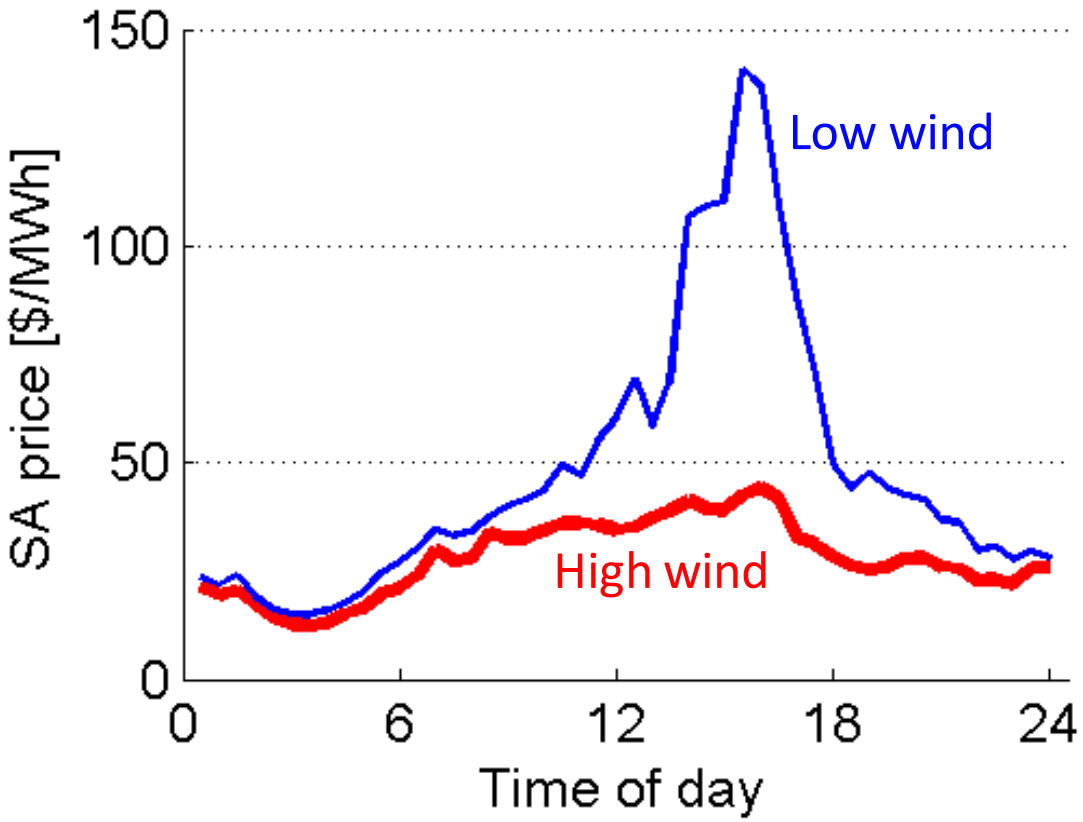
Competitive market → Generators offer close to SRMC → Price close to zero in majority of periods

How do generators recover costs?

How do we maintain accurate investment incentives?

SYSTEM ADEQUACY

Merit Order Effect - Observed

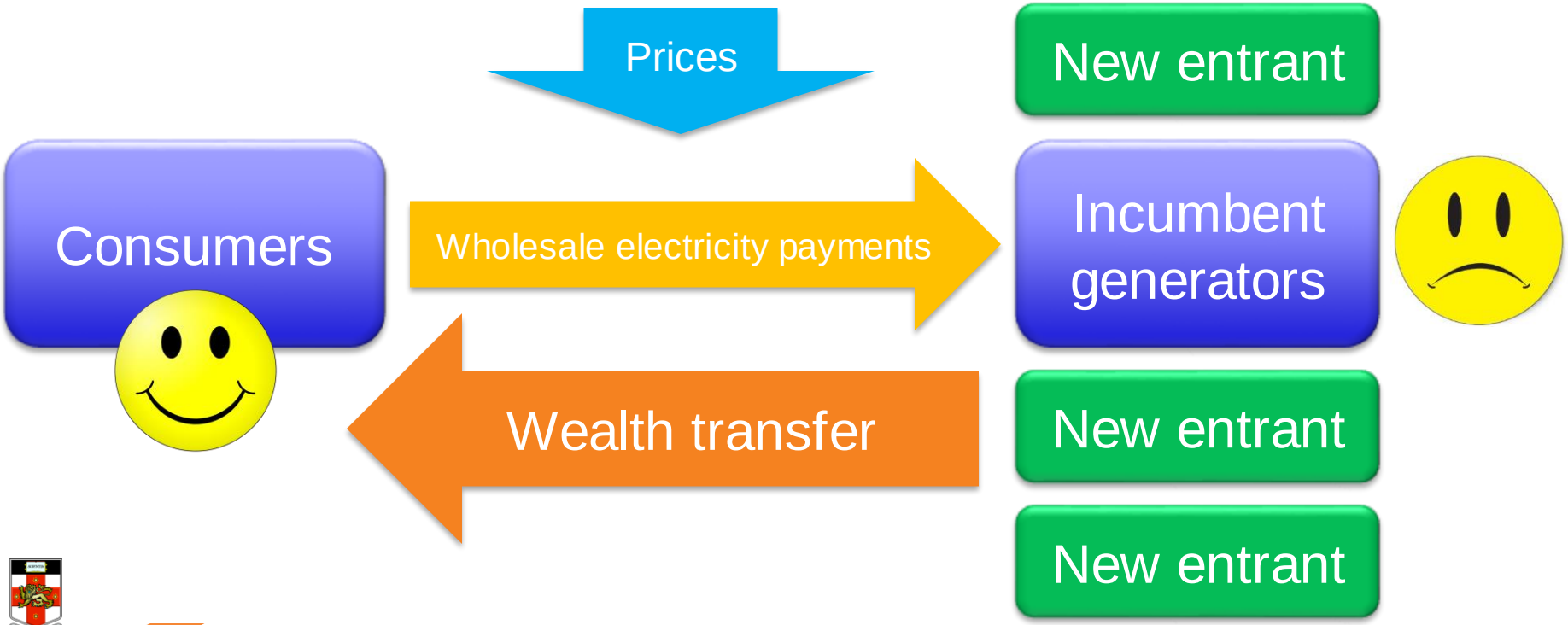


- Also in international markets
  - Texas (ERCOT), Denmark, Spain, Ireland

Cutler NJ, Boerema N, MacGill IF, and Outhred HR, (2011). High penetration wind generation impacts on spot prices in the Australian national electricity market, Energy Policy 39, 5939-5949.

Debate on the Renewable Energy Target (RET)

- Multiple credible studies show that the RET decreases electricity costs for consumers
  - But how can adding more expensive renewable generation *decrease* costs?



Managing system adequacy in the NEM

Determine Market Price Cap (MPC)

- Simulate future market
- adjust installed capacity to meet 0.002% USE
- Adjust MPC to allow last generator to meet costs

Market participants make investment decisions

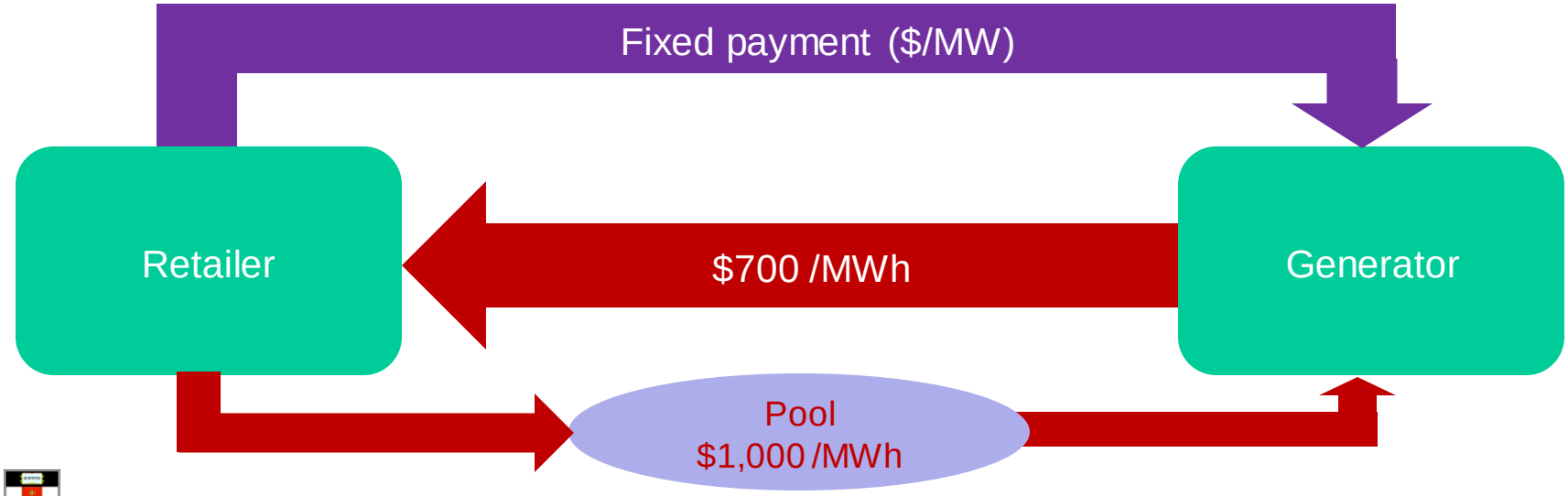
- Higher MPC rewards more investment

Managing price volatility

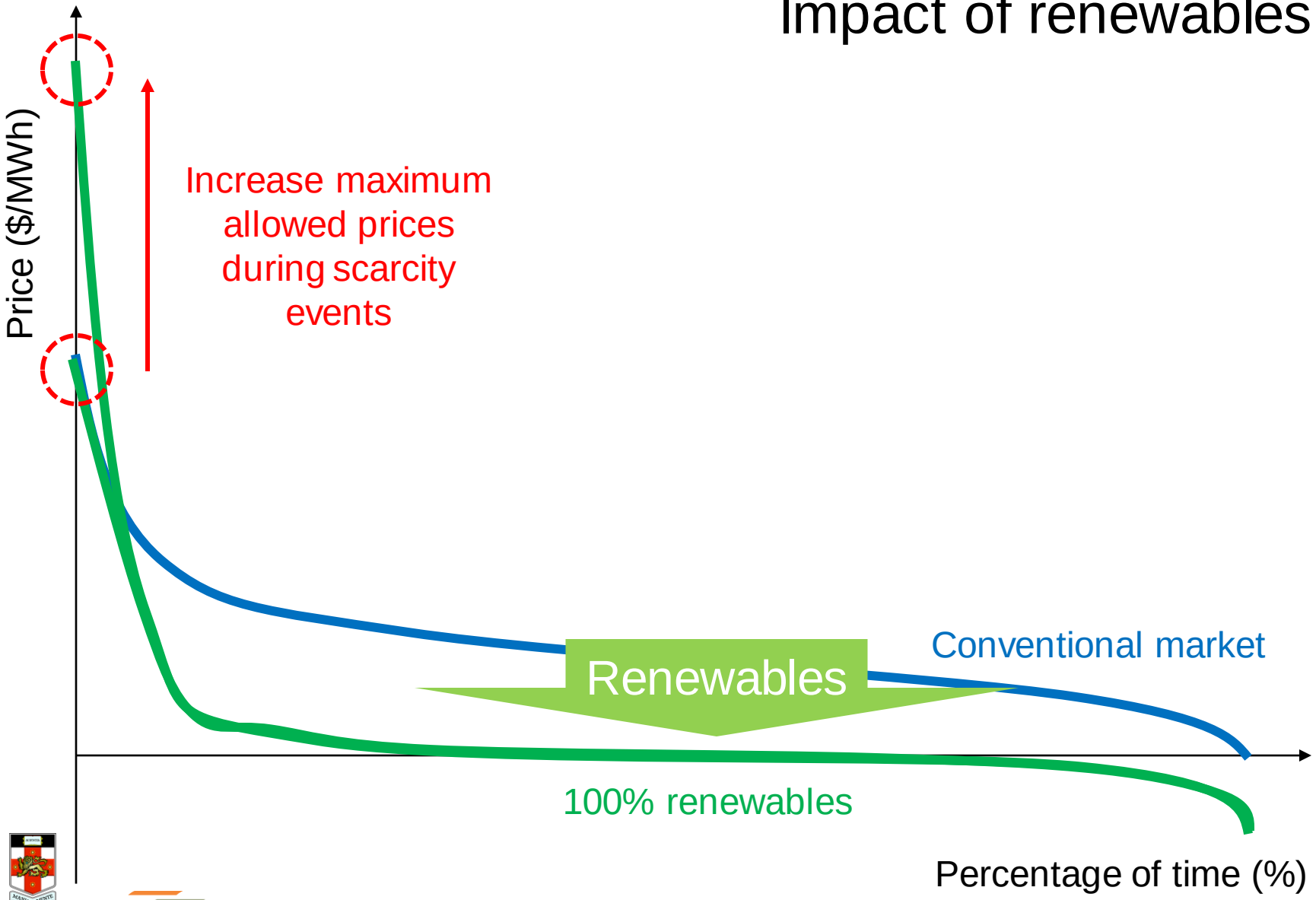
- Energy-only markets should exhibit high price volatility
  - Periods of extreme prices necessary for recovery of fixed costs
- Market participants manage price volatility via:
  - Contractual arrangements – mature derivatives market, or
  - Vertical integration

Cap contract:
($300 strike price)

Provides many of the benefits of a capacity market, but market participants retain decision making



Impact of renewables



How much would scarcity prices need to increase?

- Analysis for Australian NEM:

	MPC ($/MWh)
Present Market Price Cap (MPC)	$13,100
To maintain historical aggregate revenues (with move to 100% renewables)	~$30,000
Sufficient aggregate revenues to support 100% renewables	~$60,000 to $80,000

J. Riesz, Iain MacGill, "100% Renewables in Australia – Will a capacity market be required?" Proceedings of the 3rd International Workshop on the Integration of Solar Power into Power Systems, London, October 2013.

Perhaps this isn't crazy…

Process applied in the Australian NEM:

- Determine desired Reliability Standard (Unserved Energy)
- Modelling to determine MPC to achieve this level of USE
- Allow resulting cost of reliability to be passed on to consumers

Invert the process

Theoretical "best practice":

- Determine value of customer reliability
- Apply as MPC
- Allow resulting USE levels to occur

Renewables don't affect VCR, so shouldn't affect MPC

	Value of Customer Reliability ($/MWh)
Residential	20,710
Small business	413,120
Large business	53,300
Average	**94,990**

UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and Environmental Markets

Oakley Greenwood, "NSW Value of Customer Reliability", Australian Energy Market Commission, 2012

Issues with allowing higher extreme prices

Increased costs of hedging

Increased prudential obligations

- Increased barriers to entry for retailers

Discouragement of inter-nodal contracting

- May interfere with generation locational decisions in the absence of perfect hedging with FTRs

Increasing importance of the contracts market

Consider:

- Close monitoring
- Mechanisms for increased transparency
- Disincentivise vertical integration?
  - Reduces liquidity and contracting options

Demand Side Participation

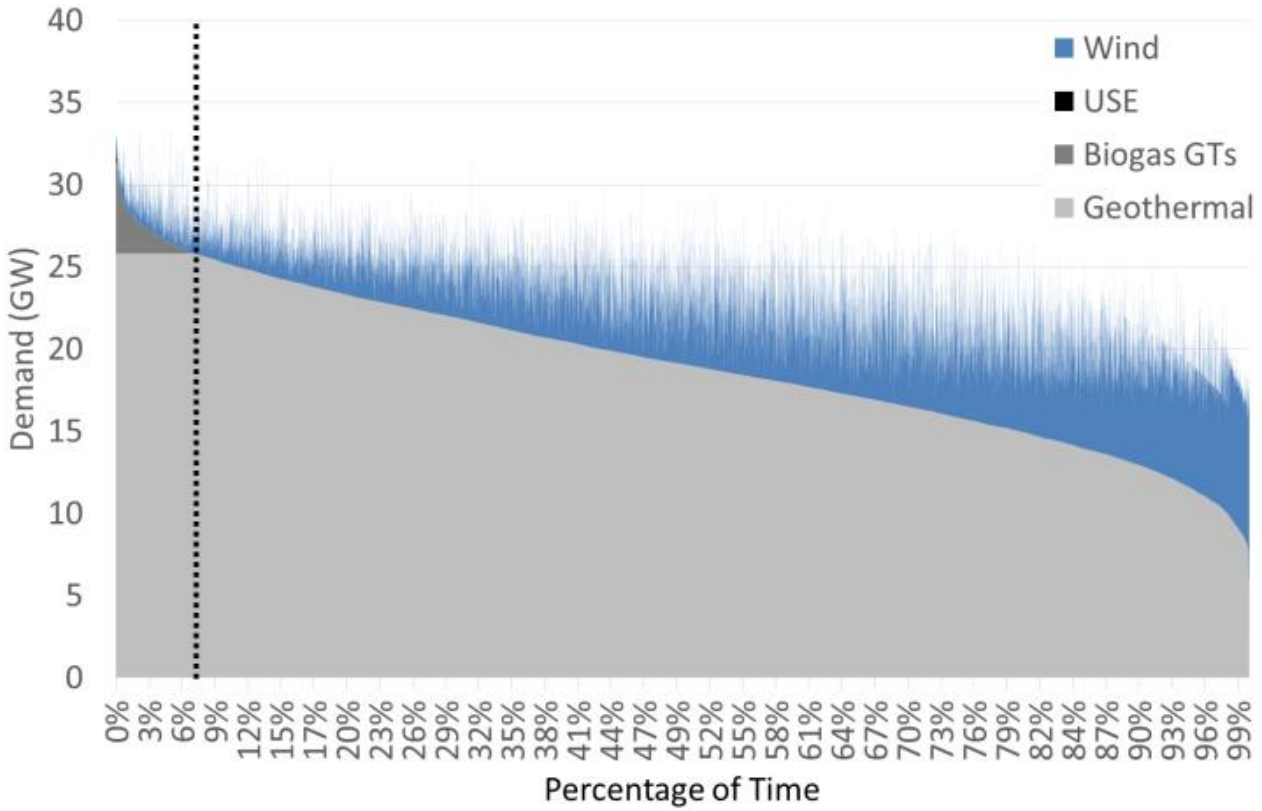
Why have a Market Price Cap?

- Demand is inelastic
- Need to protect consumers

Increase DSP sufficiently → True representation of "value of lost load" in market, for each consumer → No MPC required

Cost recovery – variable renewables?

If generation mix is least-cost optimised, all generator types earn revenues that precisely cover costs (in theory)

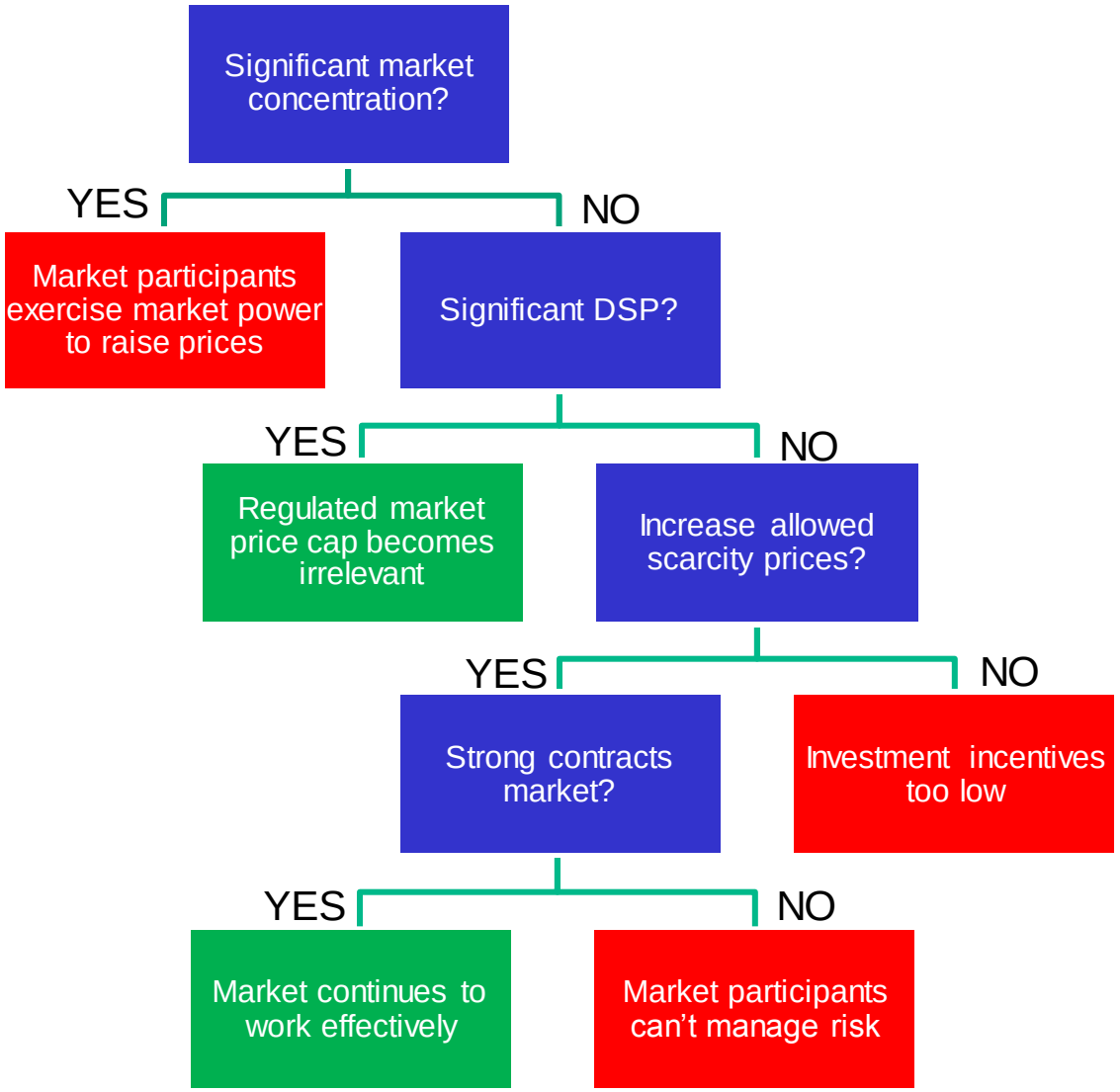


J. Riesz, I. MacGill, J. Gilmore, "Examining the viability of energy-only markets with high renewable penetrations", Accepted for presentation at the IEEE Power and Energy Society meeting, Washington DC, July 2014.

UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and Environmental Markets

Will the market work with high renewables?



Constant monitoring is wise – new issues will arise over time

UNSW THE UNIVERSITY OF NEW SOUTH WALES

Centre for Energy and Environmental Markets

Summary

100% renewables – worth thinking about?

- Inevitable - a question of when, not if

100% renewables – technically feasible?

- Yes, with high confidence

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 – monitoring and increased transparency is wise.

Centre for Energy and Environmental Markets

UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • AUSTRALIA

Thank you

ceem.unsw.edu.au

jenny.riesz.com.au