CSIRO Future Grid

P4 - Robust energy policy frameworks for investment into future grids

Jenny Riesz
& UNSW Team including: Iain MacGill, Peerapat Vithayasrichareon, Ben Elliston, Joel Gilmore

Project Aims

- Robust energy policy frameworks for investment in the future grid

Interdisciplinary policy assessment framework

Quantitative policy analysis tool

Application

Useful insights on designing and implementing a coherent & comprehensive energy policy framework

Three Policy Pillars

Comprehensive and **coherent** policy development process

1. Regulation	2. Market Design	3. External Policy Drivers
• Transmission network planning • Distribution network planning • Grid codes	• Fundamental market design • Spot market rules • Ancillary service market rules	• Carbon policies • Renewable & energy efficiency policies • Fuel policies

Robustness and Resilience: ability to perform reasonably well under a wide range of possible futures

Energy White Paper

- Opportunity for implementing an improved policy development process
- May be benefits in:
  - Process being delivered by an independent agency (continuity through changes of government)
  - A formal process for transparency around significant policy changes
    - Eg. Removal of climate change from 2012 to 2014
    - A requirement to reference and build upon previous reports
  - Potential for ongoing "conversation" rather than isolated reports
    - Prevents reports immediately becoming out of date
    - Ability to respond rapidly to unexpected transitions if required
    - Use online tools?
  - Actively facilitate broader stakeholder contributions beyond submission rounds
- Ongoing area of work at CEEM

N. Raffan, I. MacGill, J. Riesz, P. Vithayasrichareon, A. Bruce, "Energy White Paper 2014, Green Paper Submission" (2014)

1. REGULATION

Transmission and Distribution Network Frameworks

Optional Firm Access

- Identified issues with the proposed OFA transition process relating to barriers to exit and entry, and unintended wealth transfers
  - Formal participation in AEMC framework design process
  - Two working papers on the OFA transition process
  - Presentation to AEMC Stakeholder Workshop (Aug 2014)

http://ceem.unsw.edu.au/sites/default/files/documents/CEEM%20submission%20to%20OFA%20First%20Interim%20Report%202014-09-04a.pdf

Aug 2014

Centre for Energy and
Environmental Markets

Second Working Paper on the proposed Optional Firm Access model for the Australian National Electricity Market

by

Dr Jenny Riesz*, Dr Joel Gilmore, Assoc. Prof Iain MacGill

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International Transmission Frameworks

- Significant variation in models for transmission investment implemented internationally
- Many players involved, wide range of organisational models
- A challenging and complex problem, with no clear solutions
  - Given absence of a clearly superior alternative, and downside risk of major policy revolution, perhaps intervention as required is better

21, rue d'Artois, F-75008 PARIS
http : //www.cigre.org

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LUND 2015

Market price signals and regulated frameworks for coordination of transmission investments

F. Regairaz, M.R. Hesamzadeh, A. Di Caprio, A. Balkwill, F-P. Hansen, J. Riesz
RTE, KTH Royal Institute of Technology, PJM, National Grid, TenneT, University of New South Wales
France, Sweden, United States, Great Britain, Germany, Australia

SUMMARY

Large transmission infrastructure investments are needed in many power markets in coming years for

CIGRE Symposium, Lund, Sweden, 2015

Distribution networks: EVs and PV

- Synergies between PV generation and EV charging in minimising electricity industry costs, cost uncertainties and emissions
- Demand side management is essential

http://ceem.unsw.edu.au/sites/default/files/documents/SIW13%20paper%20-%201058.pdf

P. Vithayasrichareon, G. Mills, I. MacGill, ***"Impact of Electric Vehicles and Solar PV on Future Generation Portfolio Investment"***, *IEEE Transactions for Sustainable Energy (under review) (2015).*

Impact of Electric Vehicles and Solar PV on Future Generation Portfolio Investment

P. Vithayasrichareon, *Member, IEEE*, G. Mills, *Student Member, IEEE,* and I.F. MacGill, *Member, IEEE*

***Abstract*—This study assesses the impact of electric vehicle (EV) uptake and large scale PV investment on the economics of future electricity generation portfolios. A Monte-Carlo based portfolio modelling tool was used to assess the expected overall industry cost, associated cost uncertainty and CO_2 emissions of future generation portfolios where EVs and PV generation have both achieved major deployment. The Australian National Electricity Market (NEM) was used as a case study under**

with significant uptake. In this regard, there may be valuable synergies between PV and EVs in a future electricity system which has higher penetrations of both technologies.

While the interaction between PV and EVs might offer value, estimating and maximizing these benefits is a challenge for existing electricity industry planning and operational tools. Both technologies have rather different technical and economic characteristics from conventional generation technologies and

Rethinking network business models

- Retail market design matters
  - Currently far less sophisticated than wholesale market design
- Technology impacts depend upon context
  - Technical implications of PV caused at least in party by arrangements intended to accommodate air-conditioning
  - Revenue implications of PV are fundamentally different to energy efficiency or air-conditioning
- Need a distributed energy market
  - Appropriately capture costs and benefits of a wide range of different technologies and behaviours

http://sites.ieee.org/pes-enews/2015/03/12/photovoltaics-in-australia/

96 IEEE power & energy magazine march/april 2015

in my view

Iain MacGill and Anna Bruce

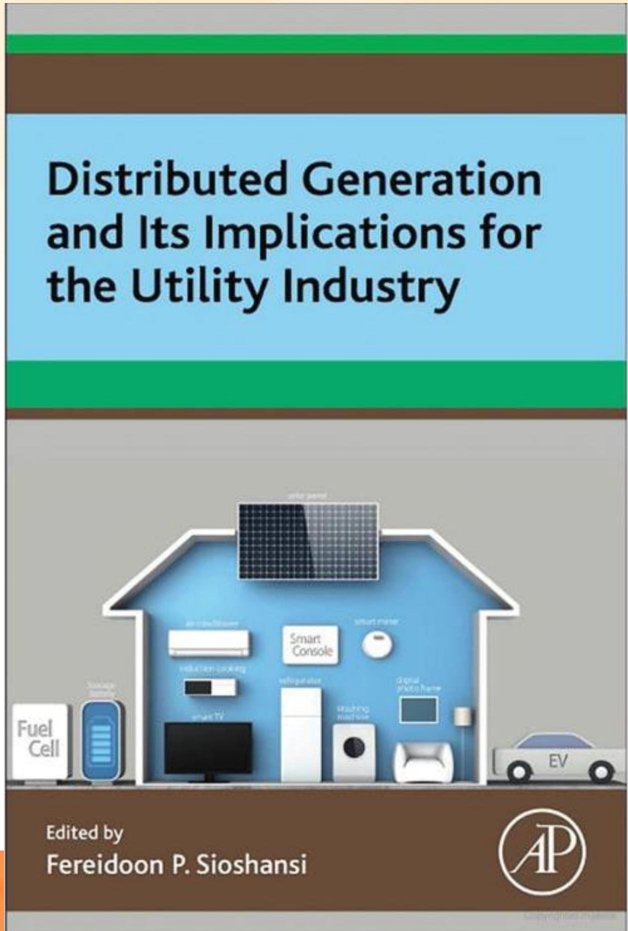
photovoltaics in Australia

time for a rethink

THE CAPACITY OF INSTALLED photovoltaics (PVs) in Australia has expanded from around 50 MW to 4 GW over the past five years, an 80-fold increase. This has been driven by a be purchased at prices below AU$2/W (US$1.60/W) installed (indeed as low as AUS$1/W after capital subsidy), they can represent an excellent financial investment, depending on household the NEM, these are economically regulated monopoly wires businesses, quite separate from the retailers who buy power from the wholesale electricity market to on-sell to energy end-users

Rethinking network business models

- NSPs may need to consider "shadow pricing" against storage alternatives



http://www.researchgate.net/profile/Chris_Riedy/publication/263586950_Perfect_storm_or_perfect_opportunity_Future_scenarios_of_the_electricity_sector_and_their_implications_for_utilities/links/53ed348c0cf23733e809112e.pdf

J. Riesz, M. Hindsberger, J. Gilmore, C. Riedy, ***Perfect storm or perfect opportunity? Future scenarios of the electricity sector and their implications for utilities*** *(July 2014), in "The Rise of Decentralized Energy - What is at stake for the electricity supply industry?", Edited by Fereidoon P. Sioshansi.*

2. MARKET DESIGN

Operational considerations with high renewables

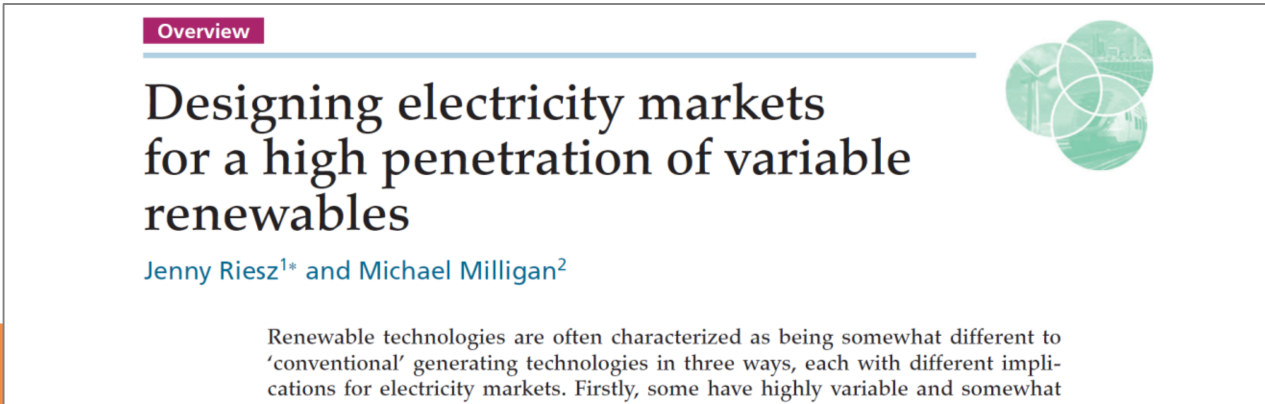
Market design for high renewables

- Markets should be:
  - Fast
  - Large
  - High DSP
  - Expose renewables to market signals
  - Have sophisticated FCAS markets

Renewable technologies can be:		Therefore markets should ensure:
Variable & Uncertain	→	Flexibility
Low SRMC	→	Effective investment signals
Non-synchronous	→	Suitable grid codes

http://onlinelibrary.wiley.com/doi/10.1002/wene.137/abstract

*J. Riesz, M. Milligan, (2014) "**Designing electricity markets for a high penetration of variable renewables**", Wiley Interdisciplinary Reviews: Energy and Environment*


Overview

Designing electricity markets for a high penetration of variable renewables

Jenny Riesz[1]* and Michael Milligan[2]

Renewable technologies are often characterized as being somewhat different to 'conventional' generating technologies in three ways, each with different implications for electricity markets. Firstly, some have highly variable and somewhat

Operational constraints

- Examined impacts of operational constraints at 85% renewables
  - Ramp rates, minimum operation levels, start-up costs, minimum synchronous generation levels
- Modelling across a range of tools suggests operational constraints have minimal impact (< 2%) on portfolio costs with high renewables
  - May not capture full costs of ramp rate limitations
- Minimum synchronous generation constraints are the exception, and can increase costs significantly

http://ceem.unsw.edu.au/sites/default/files/documents/PES%20GM%202015%20-%20Op%20constraints%20-%20revised%20Jan%2015.pdf

*P. Vithayasrichareon, T. Lozanov, J. Riesz, and I. MacGill, "**Impact of Operational Constraints on Generation Portfolio Planning with Renewables**", IEEE PES General Meeting, Denver, 2015.*

Impact of Operational Constraints on Generation Portfolio Planning with Renewables

P. Vithayasrichareon, *Member, IEEE*, T. Lozanov, *Student Member, IEEE*, J. Riesz, *Member, IEEE* and I. MacGill, *Member, IEEE*

***Abstract*—Increasing variable renewable generation penetrations will cause increased cycling operation for conventional generating plants. Not all of these plants are necessarily well suited to such operation. Traditional long-term generation planning frameworks often neglect these operational characteristics and therefore do not reflect the operational constraints and costs associated with cycling of generating plants.**

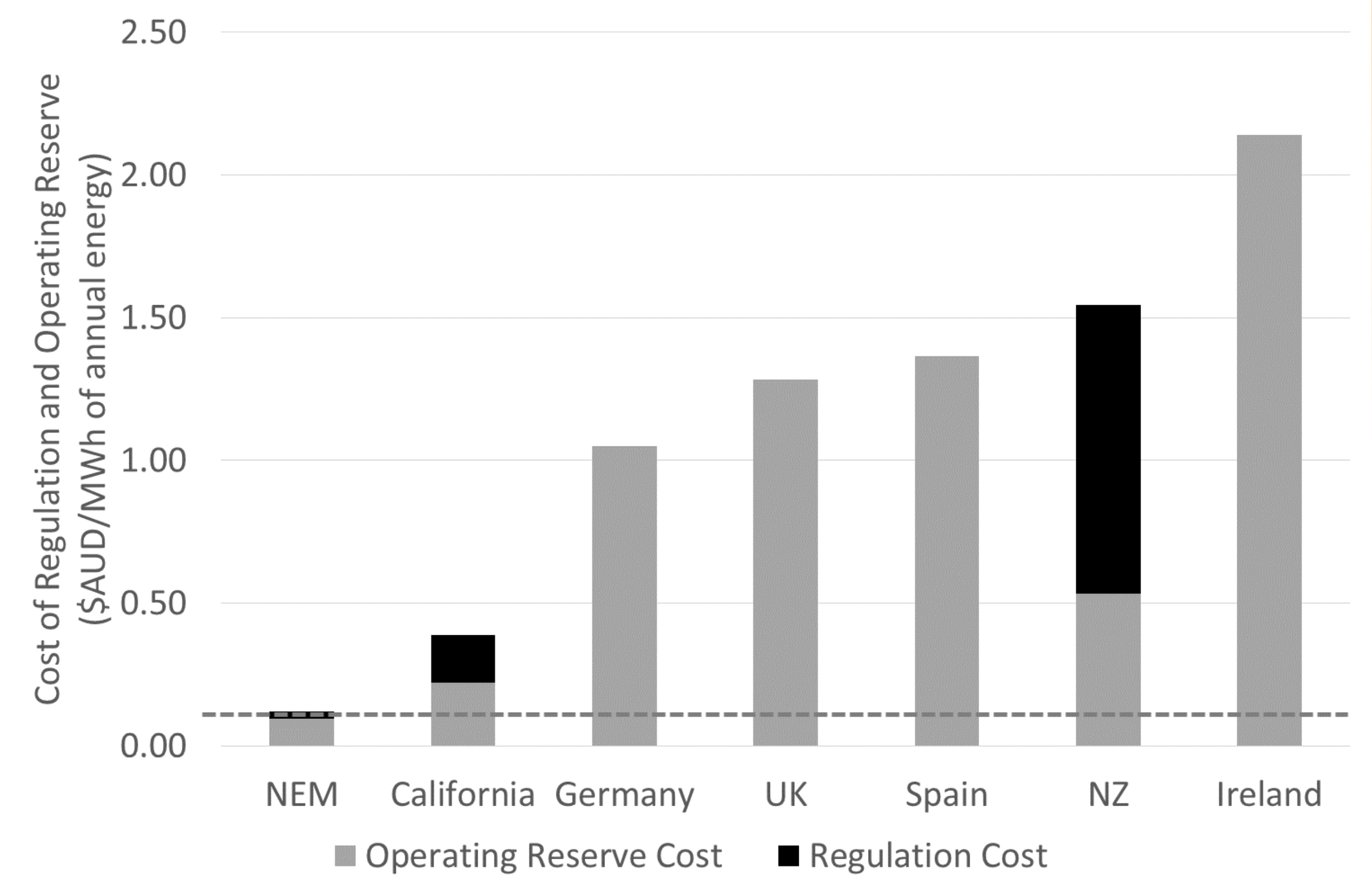
operating characteristics include minimum generation levels, startup times and costs, ramp rate limits, and minimum up/down times. Given the associated complexities and the long time horizon involved, traditional long-term generation planning frameworks often ignore these operational constraints, and the costs associated with them. However, this may mean that generation portfolios calculated to be optimal

FCAS markets with high renewables

- Australian NEM FCAS market can serve as a model for others seeking to integrate more renewables?

1. Dynamic regulation reserve setting
2. Causer pays cost recovery
3. Fast primary frequency response service

http://ceem.unsw.edu.au/sites/default/files/documents/WIW13_Riesz-FCAS-2013-09-02a.pdf



J. Riesz, J. Gilmore, I. MacGill (2015) "***Frequency Control Ancillary Service Market Design – Insights from the Australian National Electricity Market'***, *The Electricity Journal (in press)*

2. MARKET DESIGN

System Adequacy with high renewables

System adequacy in energy-only markets with high renewables

- Identified no "hard" barriers to system adequacy mechanisms operating successfully in energy-only markets with high renewables
- All system adequacy models (both EOM & capacity markets) are likely to be increasingly strained

- *J. Riesz, J. Gilmore, I. MacGill (2014) "**Assessing the viability of Energy-Only Markets with 100% Renewables - An Australian National Electricity Market Case Study**", under review with International Agency on Energy Economics (IAEE) journal Economics of Energy and Environmental Policy (EEEP)*
- *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. Selected as one of six "Best Papers" from the conference.*
- *J. Riesz, I. MacGill, J. Gilmore, **"Examining the viability of energy-only markets with high renewable penetrations"** IEEE Power and Energy Society meeting, Washington DC, July 2014.*
- *J. Riesz, J. Gilmore **"Does wind need "back-up" capacity – Modelling the system integration costs of "back-up" capacity for variable generation"**. 2014 International Energy Workshop, Beijing, 2014.*

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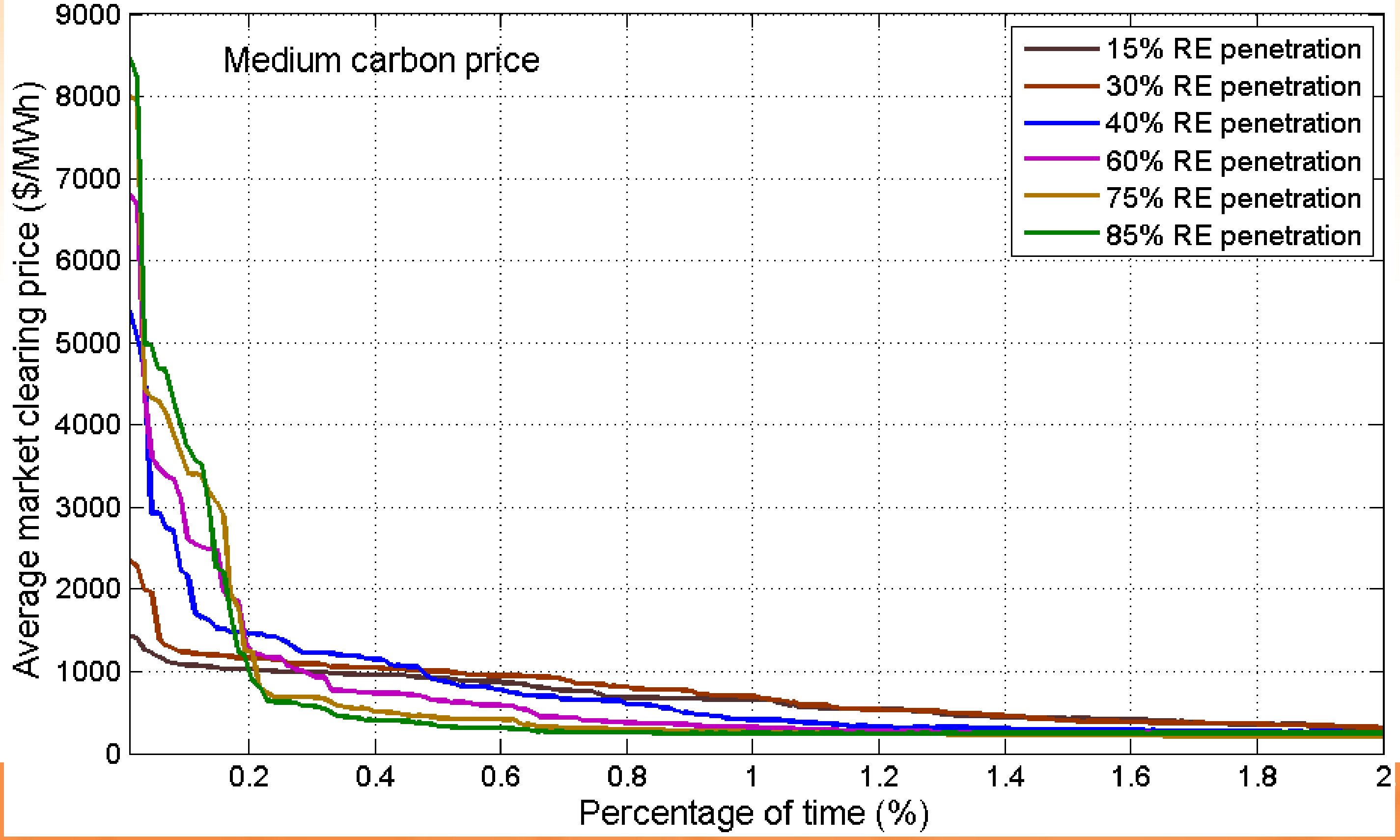
Market modelling with high renewables

- As renewable penetrations increase, spot revenues are are earned in increasingly rare periods
- Will need to increase the MPC to maintain the same reliability standard

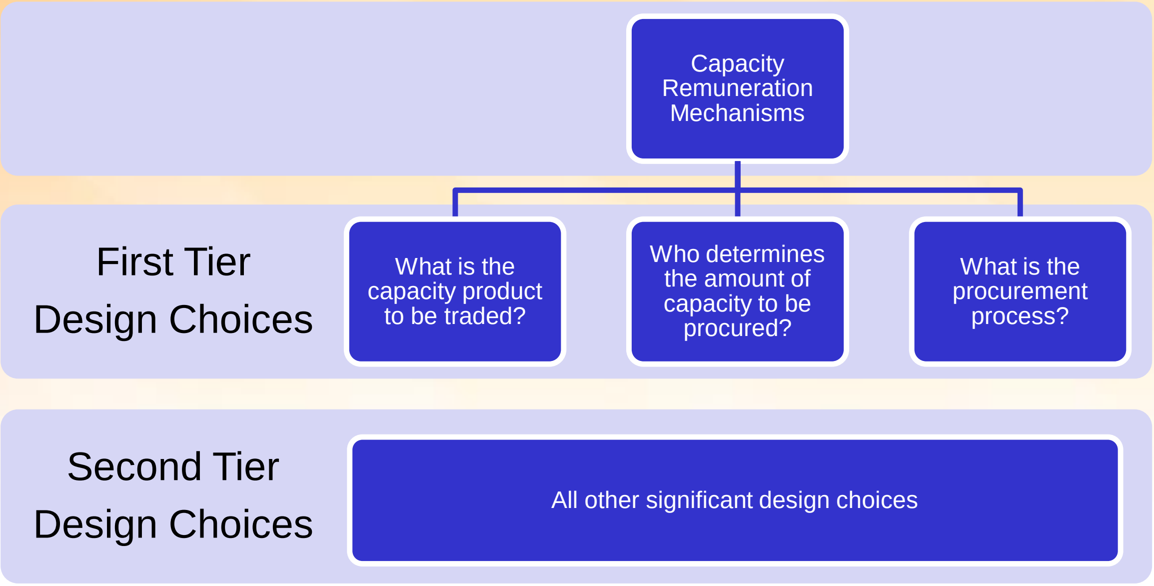
http://ceem.unsw.edu.au/sites/default/files/documents/IAEE15%20abstract%20-%20final.pdf

*P. Vithayasrichareon, J. Riesz, I. MacGill, "**Market Pricing and Revenue Outcomes in an Electricity Market with High Renewables – An Australian Case Study**", IAEE International Conference, Antalya 2015.*



Capacity market design

- 2 tier design framework for capacity market design
- Applied to characterise international models
- Basis for market design workshop in Switzerland
- CIGRE collaboration



http://ceem.unsw.edu.au/sites/default/files/documents/IAEE2015-CRMDesign-2014-12-19b.pdf

38th IAEE International Conference, Antalya, Turkey, May 2015.

A FRAMEWORK FOR DESIGNING & CATEGORISING CAPACITY MARKETS – INSIGHTS FROM AN APPLICATION TO EUROPE

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Overview

Resource adequacy in electricity markets refers to the mechanisms that manage the capacity of installed generating technology, and the adequacy of that generation to meet anticipated demand. Electricity markets around the world are currently facing new pressures that exacerbate challenges around market mechanisms for maintaining resource adequacy. Plateauing or reducing demand in many nations is combined with policies intended to drive investment in renewable and other clean technologies, many of which have highly variable availability (such as wind and solar photovoltaics). Both of these factors are likely to create a more challenging investment environment, with less certainty around the future market revenues that drive investment in new generation.

3. EXTERNAL POLICY DRIVERS

Risk management in generation portfolios

Renewable Energy Targets

- Renewables can hedge against extreme and uncertain electricity prices caused by extreme and uncertain carbon and gas prices
- 75% renewables in 2030 is optimal, in terms of cost, cost risk and emissions
  - Based upon BREE costs in AETA and Treasury projections of carbon price applied as a probability distribution
- Suggests current policy debate about RET is focused far too low

http://www.sciencedirect.com/science/article/pii/S0301421514005606

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journal homepage: www.elsevier.com/locate/enpol

ELSEVIER

Using renewables to hedge against future electricity industry uncertainties—An Australian case study

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HIGHLIGHTS

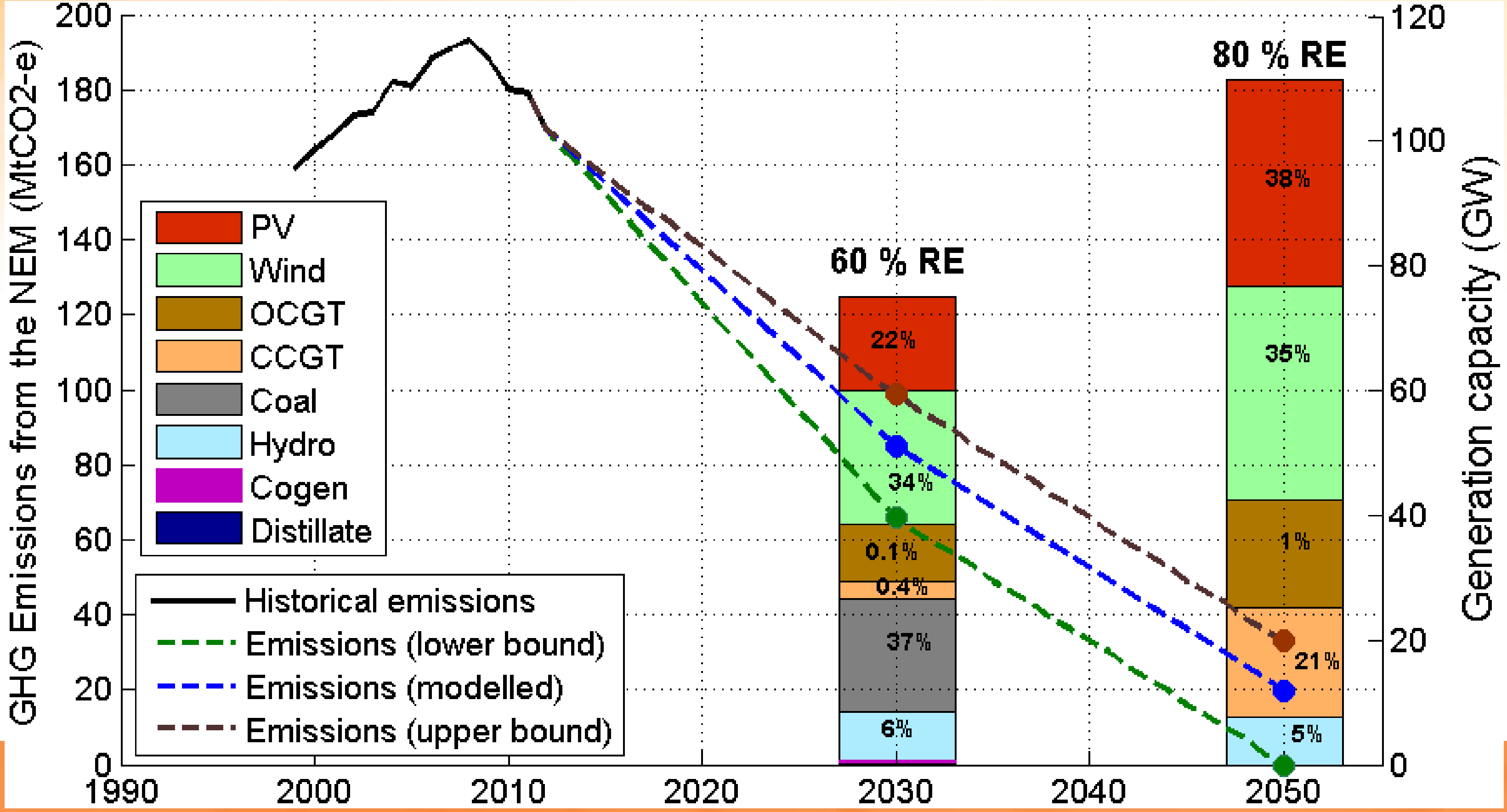
- A generation portfolio with 75% renewables in 2030 is the most optimal in terms of cost, cost risk and emissions.
- Investment in CCGT is undesirable compared to renewables given the cost risk due to gas and carbon price uncertainties.
- Renewables can hedge against extreme electricity prices caused by high and uncertain carbon and gas prices.

Gas risk

http://ceem.unsw.edu.au/sites/default/files/documents/Gas%20Transition%20-%20Working%20Paper%20-%202014-06-30b.pdf

- High gas portfolios are high risk

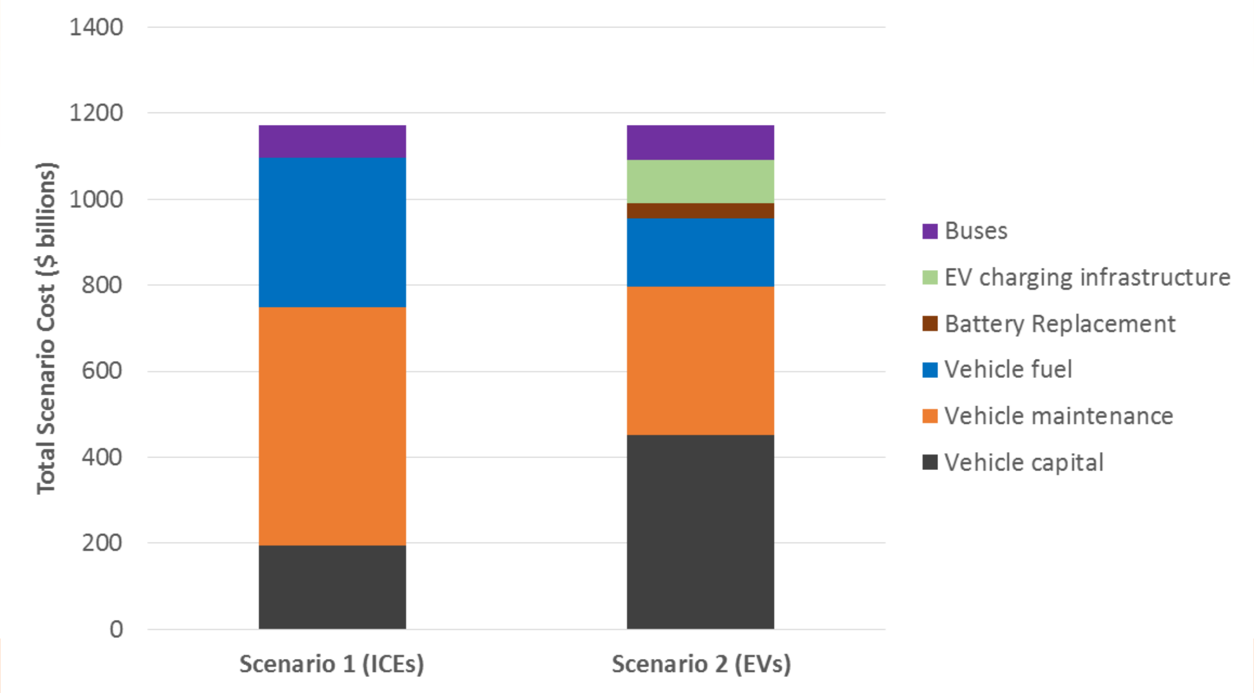
*J. Riesz, P. Vithayasrichareon, I. MacGill, "**Assessing "Gas Transition" pathways to low carbon electricity – An Australian case study**", Submitted to Applied Energy, 2015.*



CURRENT & UPCOMING WORK

Electric Vehicles

- Under certain conditions, a very rapid (10 year) transition to 100% EVs could cost the same as BAU
  - EV capital costs reduce at rapid end of projections
  - US DOE meets targets for battery cost reductions
  - EV maintenance costs at low end of projections
  - Fuel costs at high end of projections
- Suggests urgency around policy & regulatory frameworks for managed charging
  - Potential for rapid transformation



Market outcomes with 100% renewables

Revenue and market price modelling

- How will market prices evolve as the proportion of renewables increases?
- How high might the MPC need to be to ensure system adequacy?

Trading simulations with high renewables

- Experimental economics study using NEM traders in a simulated “game” environment
- Examine novel trading strategies that might arise as the proportion of renewables increases in the market
- Determine how electricity prices might evolve with “real” trading behaviours

BEYOND THE PROJECT

Further work beyond the Project

Integration of renewables

- Need to think about complementary resources in a whole-system sense (storage, DSP, synchronous condensors, EVs, etc)

Coherent interface between distributed and centralised resources

- Bringing together retail and wholesale markets

Stranded network assets

- Competition coming to the network businesses
- New business models required

Robust market design for transformation

- Robust to uncertainty and potential for rapid transitions

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Thank-you

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