Wind as the new “Base Load”

The role of wind in future electricity markets

Dr Jenny Riesz
April 2014
A new power system paradigm

Use cheapest technologies first:
- Wind
- Solar PV
- Run of river hydro
- Geothermal?

Top up with dispatchable renewables
- Hydro with storage
- Geothermal?
- Biomass
- Solar thermal with storage
Wind displaces baseload generation

Least cost optimum generation mix:

![Diagram showing least cost optimum generation mix with different wind percentages.](image)

Optimal capacity of coal-fired generation (baseload) declines as wind is added.

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)
Flexibility of existing power systems

- IEA study: All regions studied have sufficient flexibility to support 25% - 40% variable renewables
- If accept a few hours of curtailment per year numbers increase considerably (>50% in some systems)
- Low “turn down” levels are important
- Increasing technical flexibility (e.g., Batteries, flexible plant) increases potential penetration of VRE further

Possible 100% Renewables technology mix (NZ)
(by capacity)

20-30% Wind

40-50% Hydro (status quo)

10-20% Geothermal

10-20% Pumped hydro storage

1% Biomass

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
Managing system adequacy in energy-only markets

- In theory:

Customers individually choose desired level of reliability (price at which no longer prepared to pay)

Generators invest when prices sufficient for profitability

Shifts supply curve (prices fall)

New equilibrium (based upon customer willingness to pay for reliability)

Contracting between customers and generators allows risk management (more certain revenues for generators, and more certain reliability for customers)

This requires full demand side participation!
Managing system adequacy in energy-only markets

- In reality:
  - No market has widespread demand side participation
    - Although growing in some (eg. PJM)
  - Regulator sets market price cap, based upon assumed customer willingness to pay (eg. Australian NEM)
  - Price cap must be high enough to ensure sufficient generation investment, even when scarcity occurs rarely
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)

Fixed payment ($/MW)

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

Retailer

$700 /MWh

Generator

Pool

$1,000 /MWh

$1,000 /MWh

$700 /MWh
Impact of renewables

- Increase maximum allowed prices during scarcity events
- Conventional market
- Renewables
- 100% renewables

Percentage of time (%)
How much would scarcity prices need to increase?

- Analysis for Australian NEM:

<table>
<thead>
<tr>
<th></th>
<th>MPC ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Market Price Cap (MPC)</td>
<td>$13,100</td>
</tr>
<tr>
<td>To maintain historical aggregate revenues (with move to 100% renewables)</td>
<td>~$30,000</td>
</tr>
<tr>
<td>Sufficient aggregate revenues to support 100% renewables</td>
<td>~$60,000 to $80,000</td>
</tr>
</tbody>
</table>

For New Zealand – will need to accept increasingly extreme scarcity prices
Perhaps this isn’t crazy…

Process applied in the Australian NEM:

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

Theoretical “best practice”:

1. Determine value of customer reliability
2. Apply as MPC
3. Allow resulting USE levels to occur

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

<table>
<thead>
<tr>
<th></th>
<th>Value of Customer Reliability ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>20,710</td>
</tr>
<tr>
<td>Small business</td>
<td>413,120</td>
</tr>
<tr>
<td>Large business</td>
<td>53,300</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>94,990</strong></td>
</tr>
</tbody>
</table>
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
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.
Will energy-only markets work with high renewables?

- Significant market concentration?
  - YES: Market participants exercise market power to raise prices
  - NO: Significant DSP?
    - YES: Regulated market price cap becomes irrelevant
    - NO: Increase allowed scarcity prices?
      - YES: Strong contracts market?
      - NO: Investment incentives too low
        - YES: Market continues to work effectively
        - NO: Market participants can’t manage risk

Constant monitoring is wise – new issues will arise over time.
Issues for New Zealand

Increasing importance of contracts/futures market

- Consider mechanisms to increase participation in futures markets
- Disincentivise vertical integration? (reduces liquidity and contracting options)

Increasing importance of Demand Side Participation

- DSP allows customers to individually choose their desired level of reliability – reduces need for regulatory intervention
Operational considerations – market design

- Lots of other considerations in market design for integrating variable renewables
  - Accessing flexibility on operational and investment timeframes

- Discuss at 1.45pm
  - “The Market & Wind” parallel session
Thank you

jenny.riesz@gmail.com

www.ceem.unsw.edu.au