Centre for Energy and Environmental Markets

UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • AUSTRALIA



Market Design for integrating wind

Accessing flexibility through good market design

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April 2014

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ASI Australian Solar Institute

AGL

Ausgrid

ElectraNet electricity transmission

westernpower

Clean Energy Council

origin

Australian Coal Association

imo Independent Market Operator

RioTinto

Australian Energy Market Commission AEMC

AEMO Australian Energy Market Operator

Delta electricity

The University of Queensland Australia

ROAM Consulting Energy Modelling Expertise

AECOM

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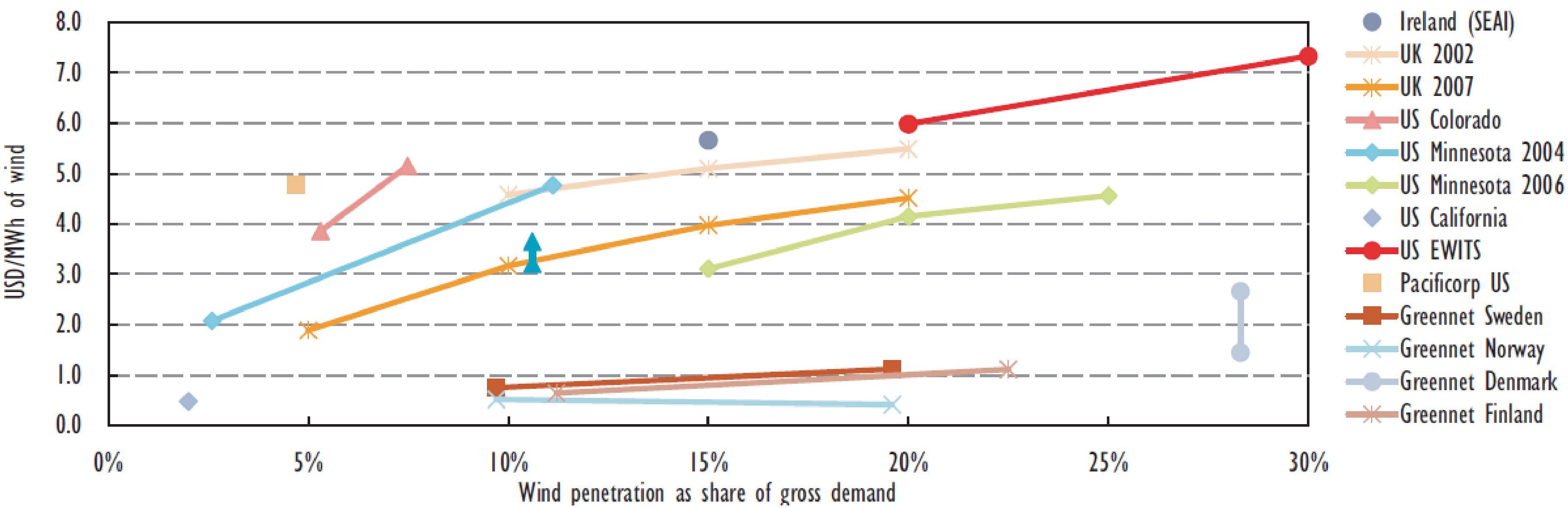
Balancing costs

- Majority of the “integration costs” of variable renewables are in balancing costs
  - Managing increased variability & uncertainty
- Balancing costs are highly system specific



- Balancing costs depend upon combination of:

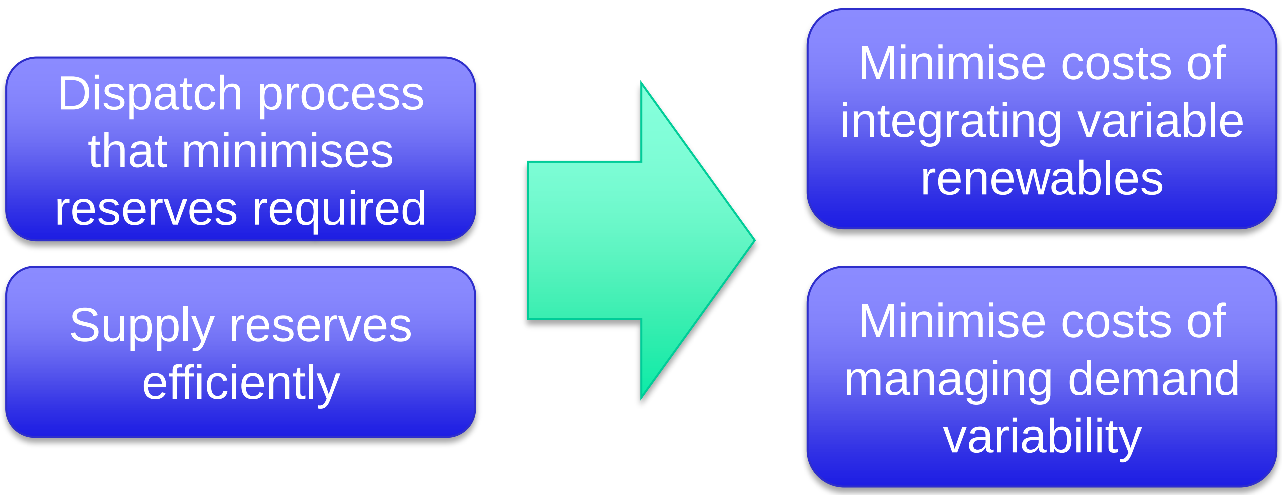
Hard to change — • Technical characteristics of system

Easy to change? — • Market Design

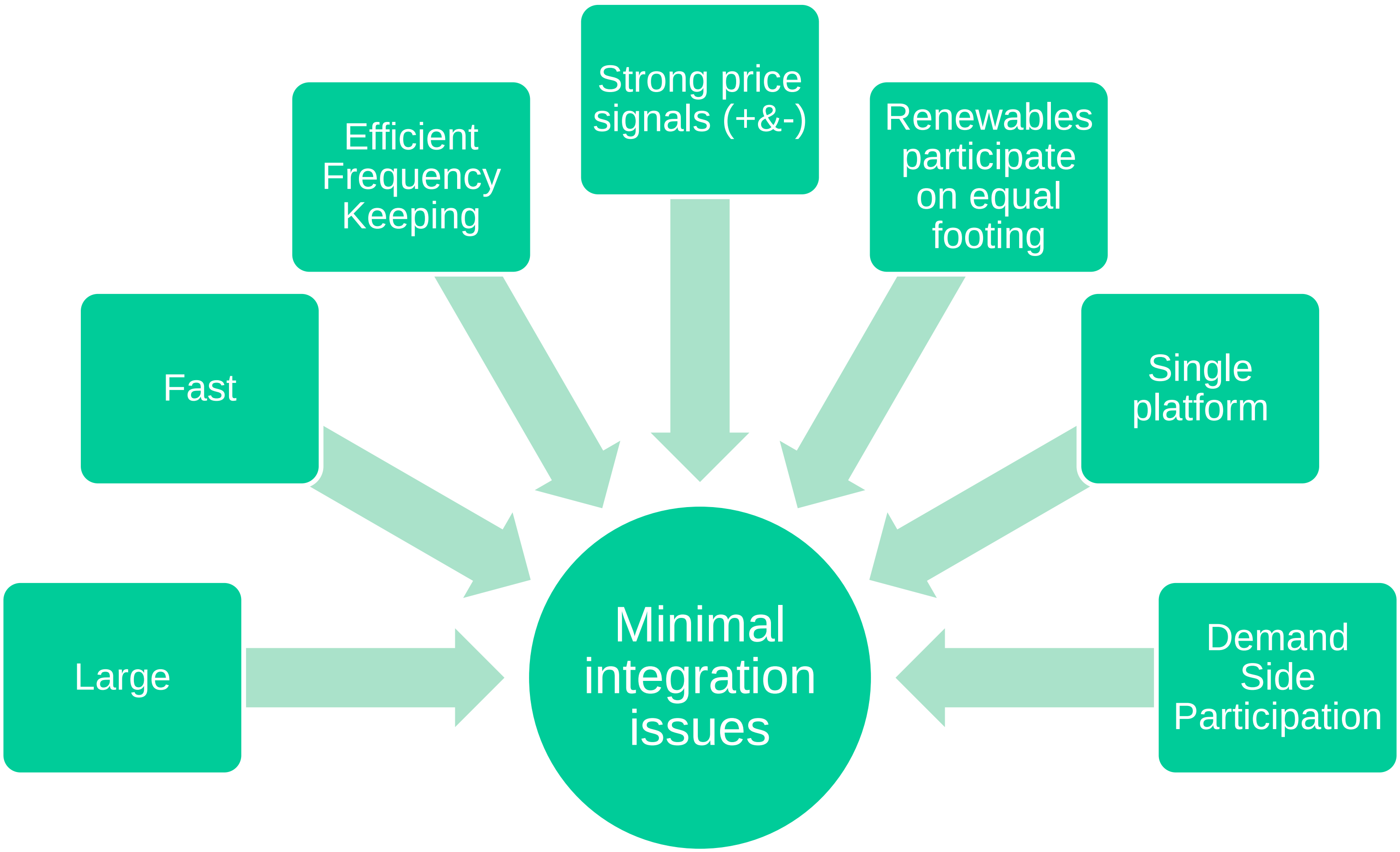
International Energy Agency (2014) “The Power of Transformation: Wind, Sun and the Economics of Flexible Power Systems”

Market design to minimise balancing costs

- Variability & uncertainty are managed via:
  - System dispatch processes
  - Reserves (eg. Frequency keeping, load following, regulation)



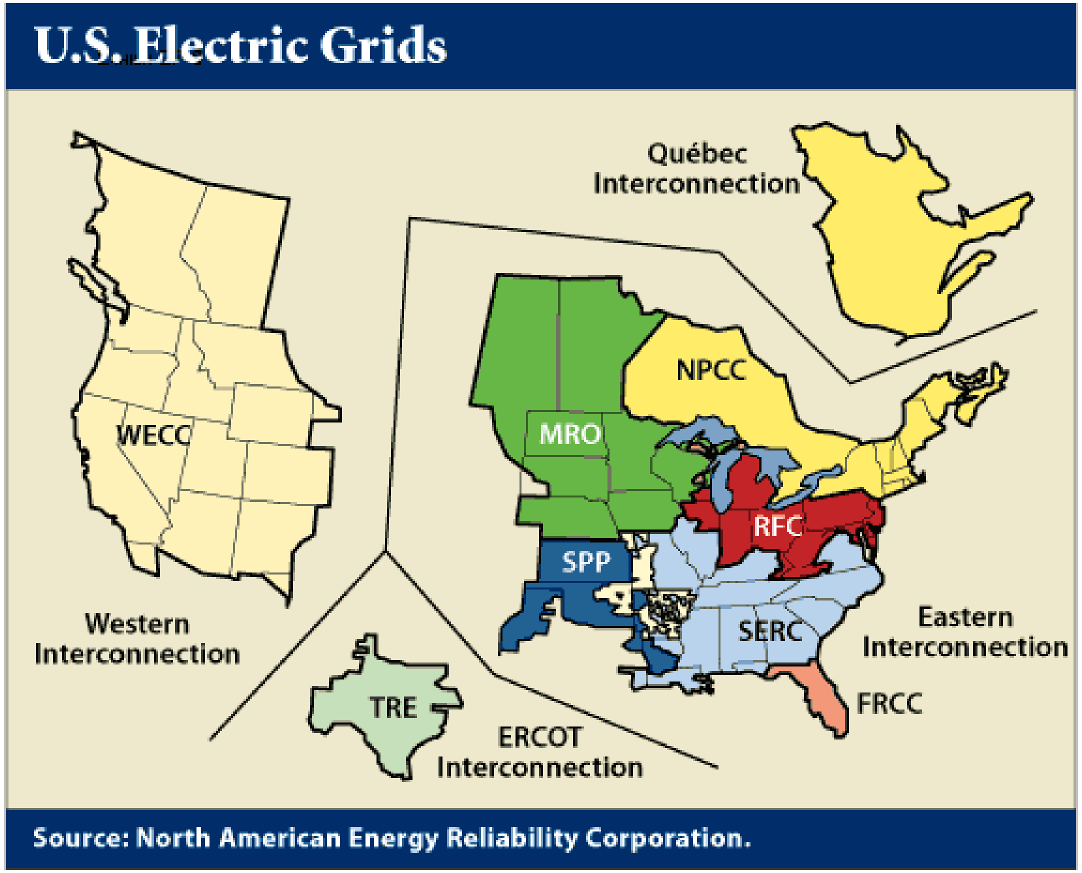
Market design to minimise balancing costs



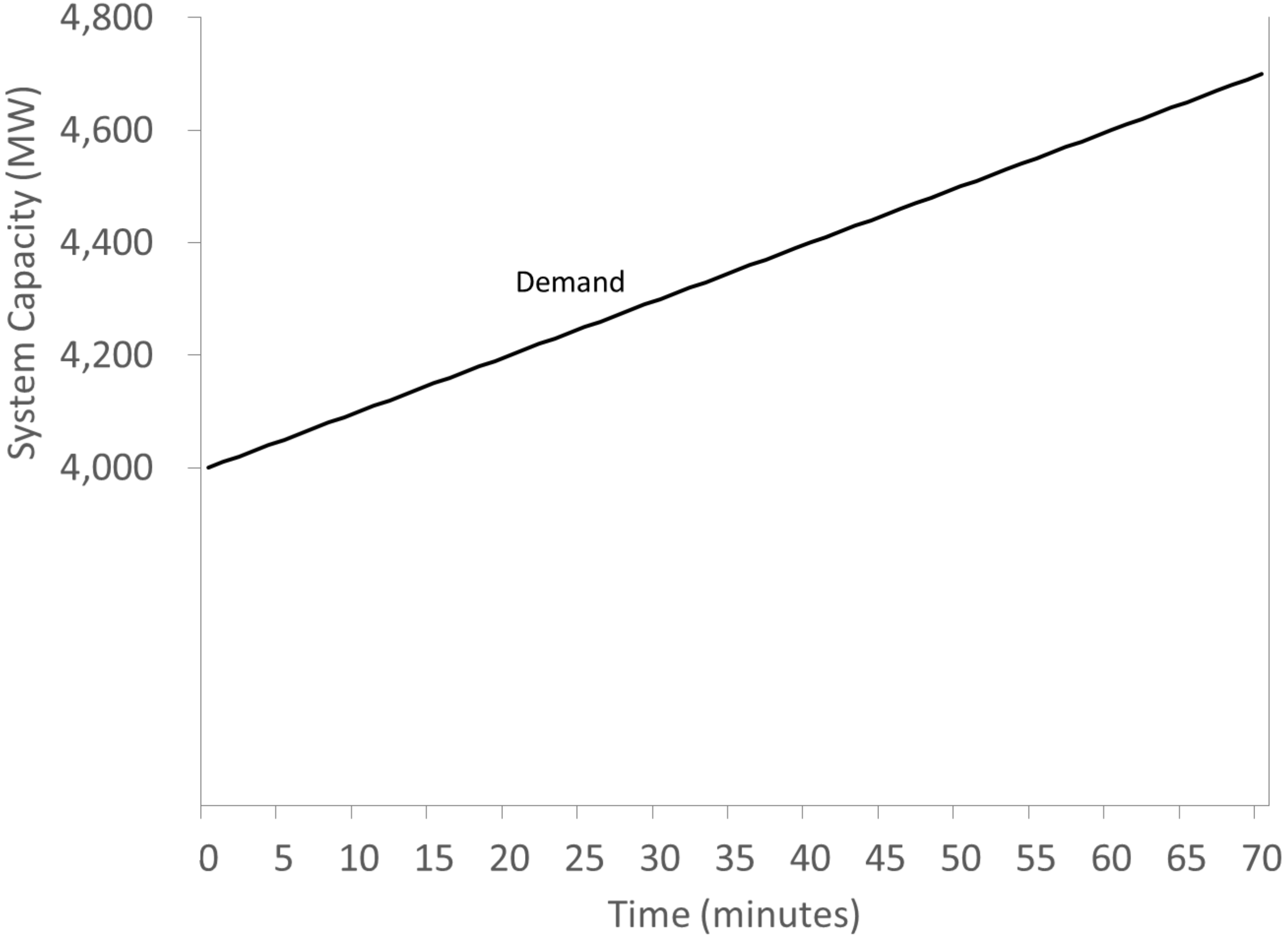
Large: Maximise balancing area

- Optimise dispatch over full physically connected area
  - Balancing within smaller areas artificially increases reserve requirements

- Geographical smoothing of variable renewables & demand
- Reduce forecast errors
- More plant available to provide reserves & flexibility



Fast: Shorter dispatch intervals reduce reserve requirements



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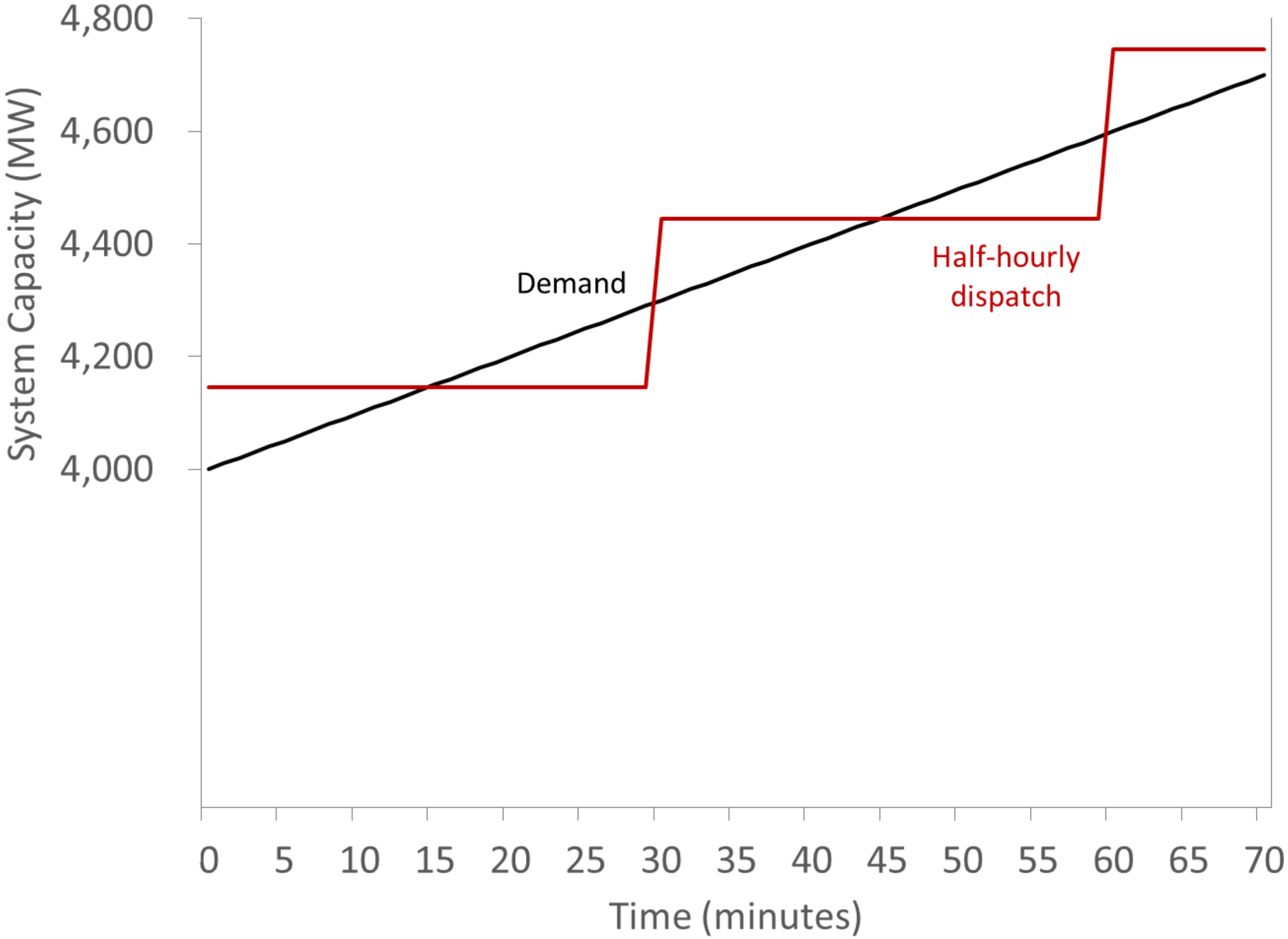
Fast: Shorter dispatch intervals reduce reserve requirements



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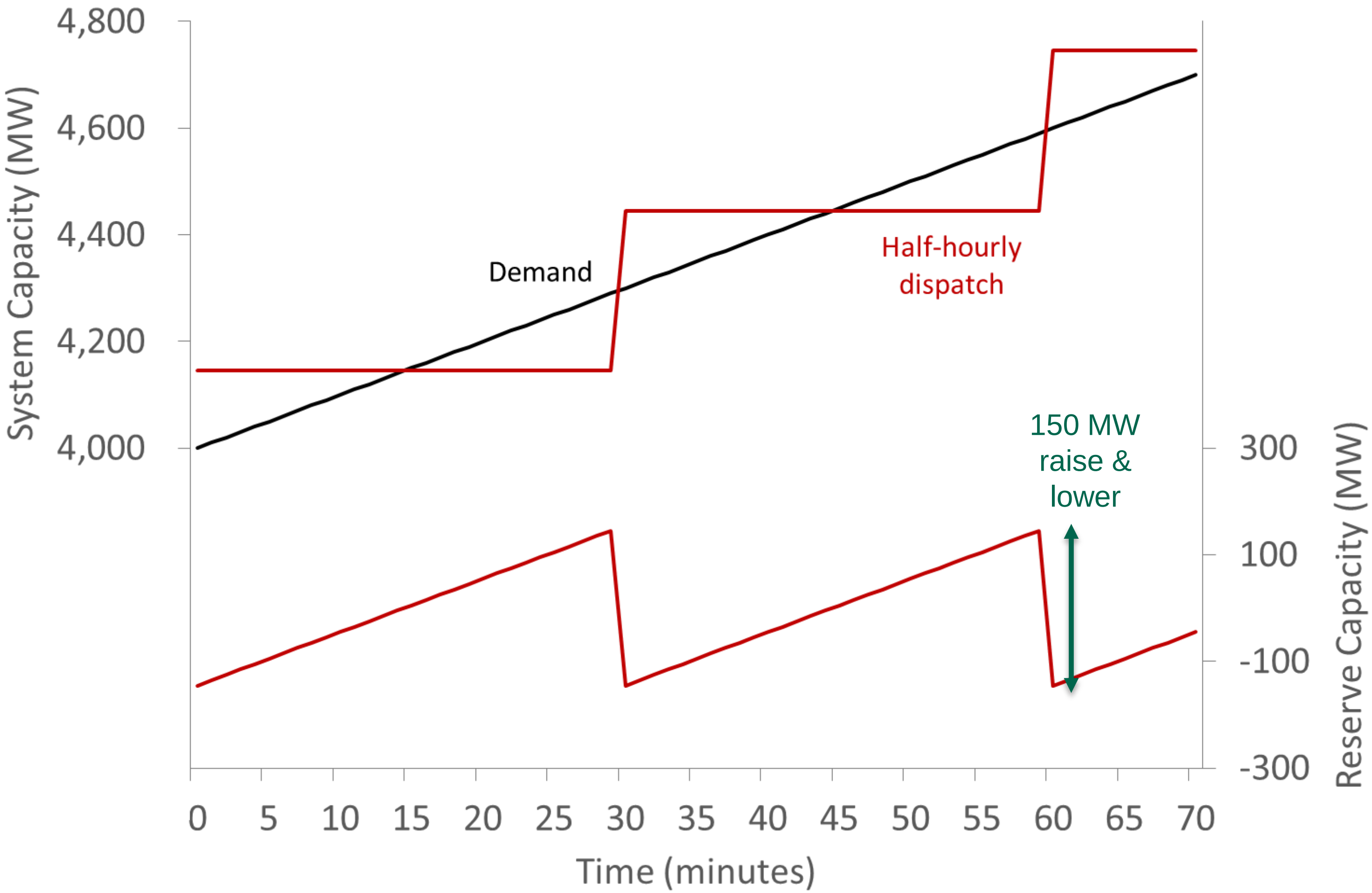
Fast: Shorter dispatch intervals reduce reserve requirements



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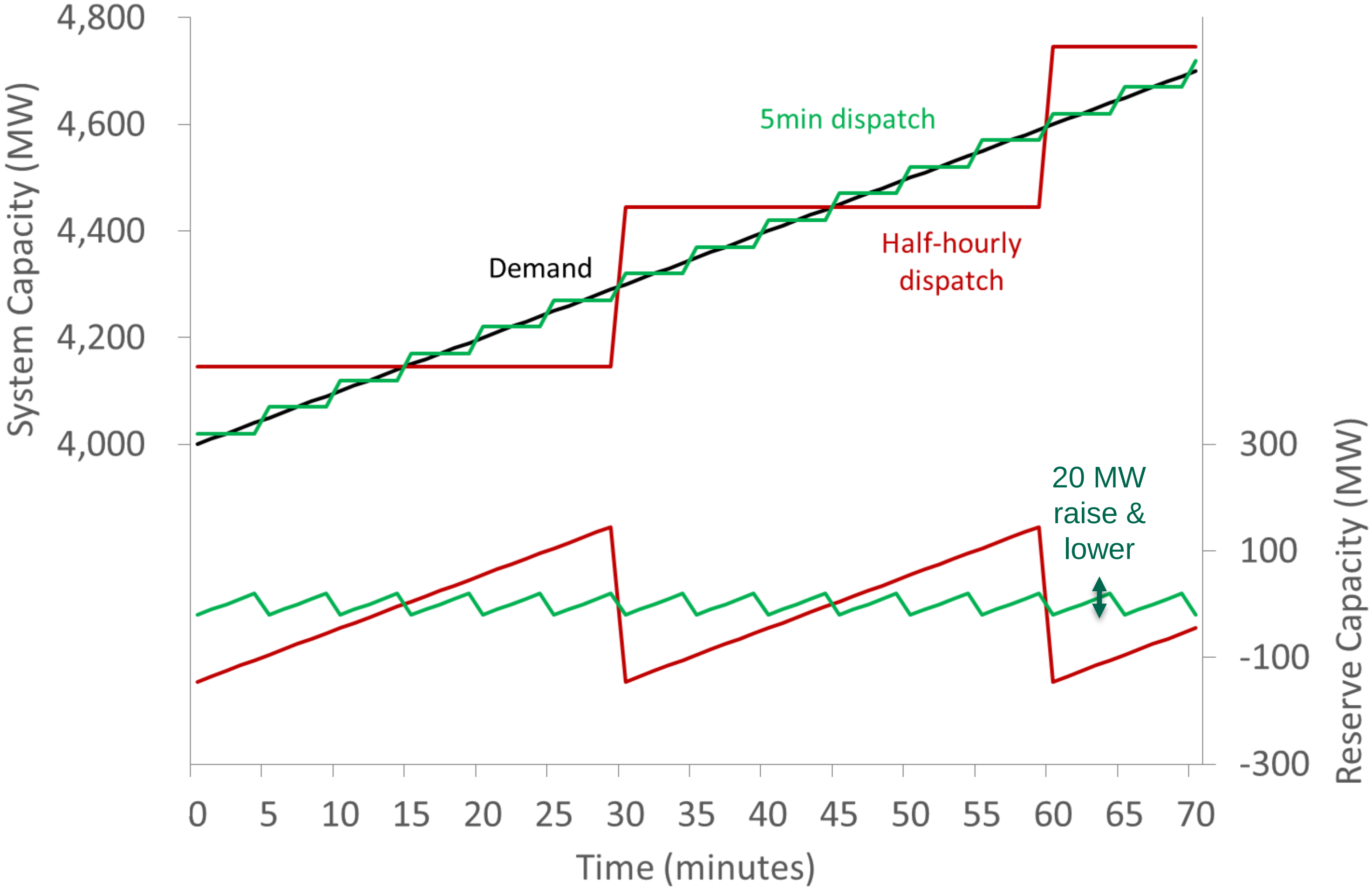

- Longer dispatch intervals “artificially” limit system flexibility
- > 2/3 of US demand is now covered by 5min markets

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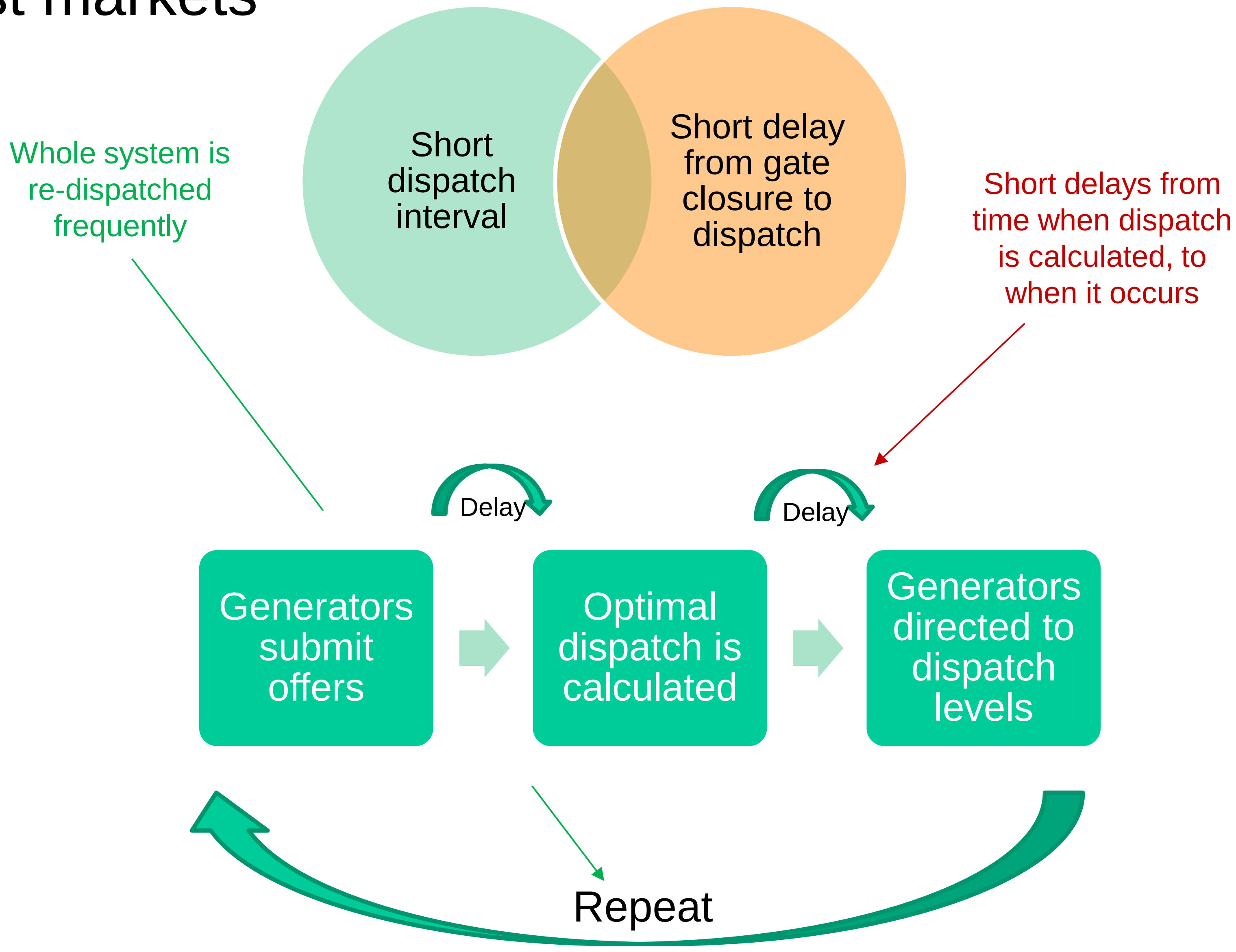
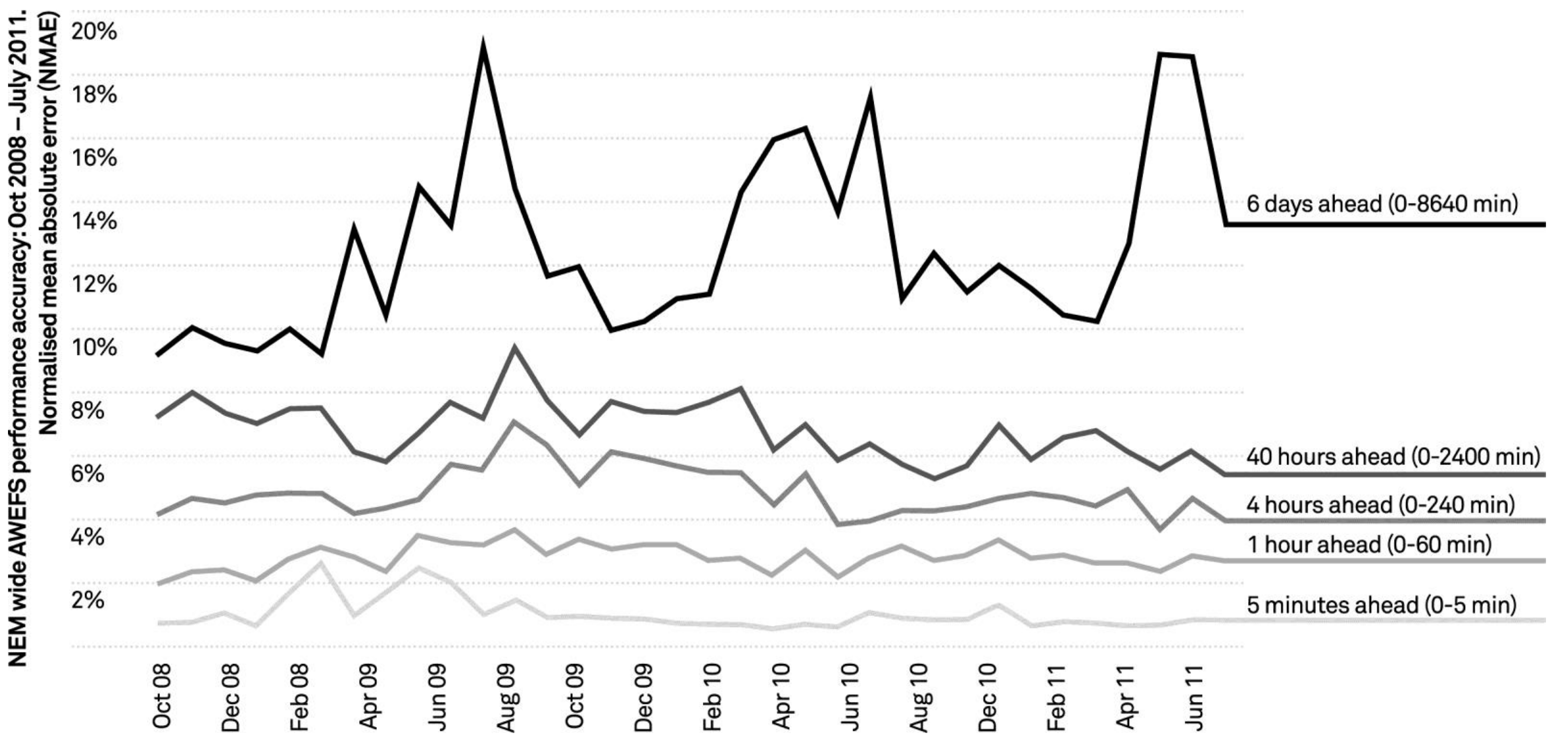
Fast markets



Fast: Minimise gate closure time interval

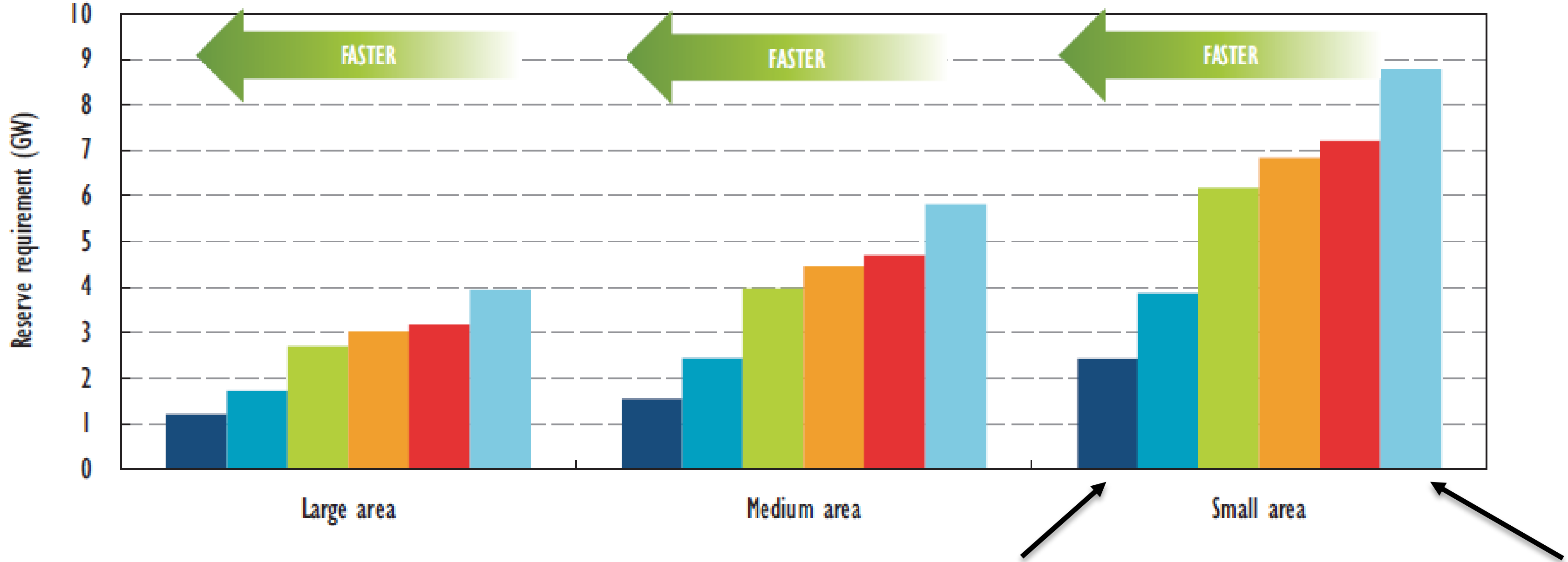
- Short delays from gate closure to dispatch minimise forecast errors
- Lower errors → less reserves required → lower costs



J. Riesz, J. Gilmore, M. Hindsberger, Market Design for the Integration of Variable Generation (Elsevier, March 2013) in "Evolution of Global Electricity Markets: New paradigms, new challenges, new approaches". Edited by Fereidoon P. Sioshansi.

Large & Fast

- Frequency keeping reserves are minimised by:
  - Expanding geographic area for balancing (whole grid optimised together)
  - Reducing gate closure times (2hrs → 5min)
  - Reducing dispatch intervals (30min → 5min)



	■ (dark blue)	■ (teal)	■ (green)	■ (orange)	■ (red)	■ (light blue)
Dispatch interval	10 min	10 min	30 min	60 min	40 min	60 min
Gate closure lead time	10 min	30 min	30 min	10 min	40 min	40 min

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International Energy Agency (2014) "The Power of Transformation: Wind, Sun and the Economics of Flexible Power Systems"

1

- Minimise reserve requirement

2

- Procure reserves efficiently

Frequency Keeping Ancillary Services

Determine quantity

- Continuously & dynamically

Procurement

- From active markets (many participants)
- Co-optimise with dispatch every 5 minutes

Payment recovery

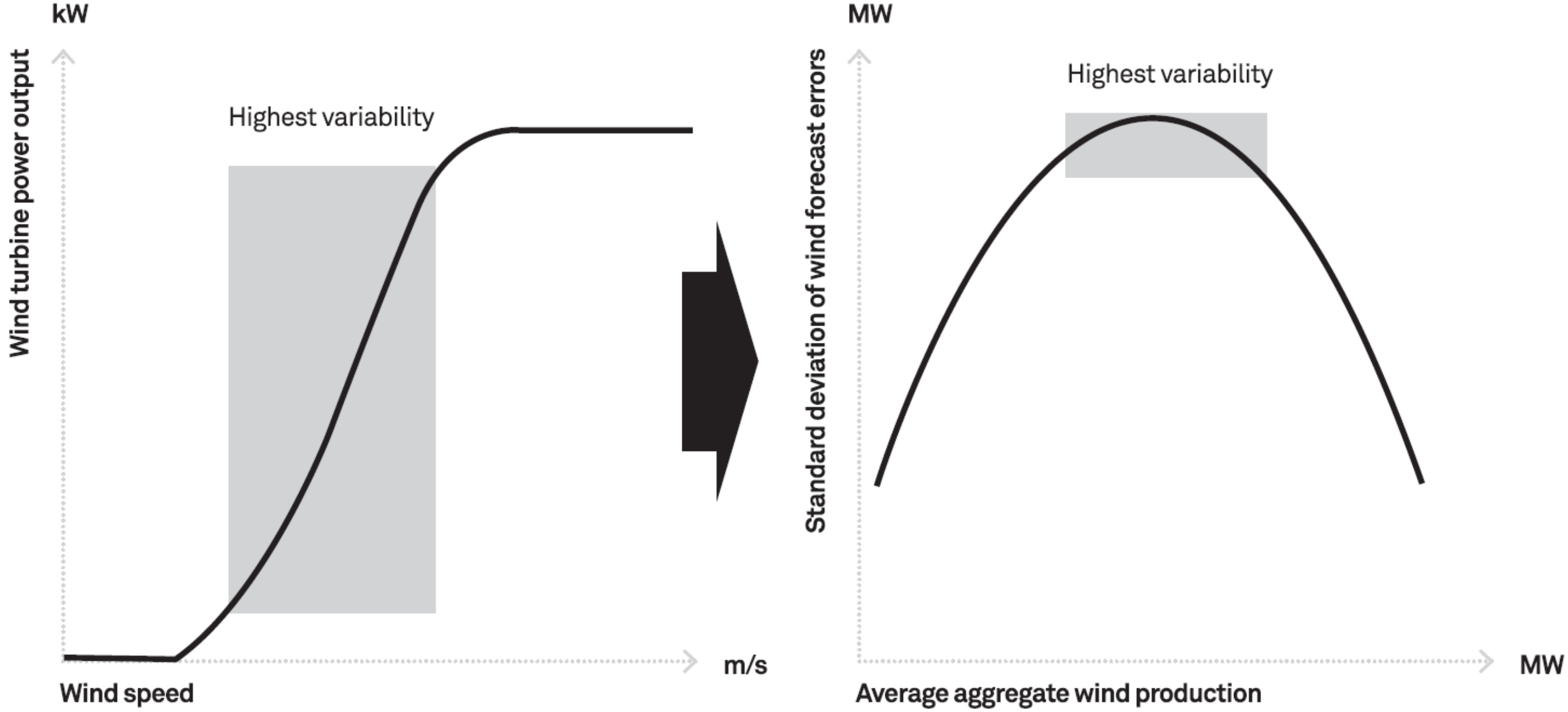
- Causer Pays basis

Static frequency keeping reserve requirements

Region	Separate/ Combined	Rule
PJM	Combined	Based on 1% of the peak load during peak hours and 1% of the valley peak during off-peak hours.
NYISO	Combined	Set requirement based on weekday or weekend, hour of day, and season.
ERCOT	Separate	Based on 98.8th percentile of regulation utilized in previous 30 days of same month of previous year and adjusted by installed wind capacity.
CAISO	Separate	Use a requirement floor of 350-MW up and down regulating reserves which can be adjusted based on load forecast, must-run instructions, previous CPS performance, and interchange and generation schedule changes.
MISO	Combined	Requirement made once a day based on conditions and before the day-ahead market closes.
ISO NE	Combined	Based on month, hour of day, weekday/sat/sun.

NREL, E. Ela et al, 2011, Effective Ancillary Services market Designs on High Wind Power Penetration Systems

Dynamic frequency keeping reserve



Wind turbine power curve – highest variability in the central region

Wind likely to be most variable when operating in the central range

Set reserves dynamically to reduce costs

NREL, Enernex Corporation, Eastern Wind Integration and Transmission Study, 2011

Frequency Keeping reserve setting in the Australian NEM

- Set dynamically by the “time error”
  - Accumulated deviation of frequency over time from 50Hz
  - Will schedule more reserves if frequency deviates a lot, or for a long time

Default:

130 MW raise
120 MW lower

Time error exceeds ±1.5 seconds?

Add 60 MW reserve per 1 second deviation

Upper limit 250 MW

Only carry required reserves, automatically adjusts to wind variability, demand variability, inertia, etc.

Cost recovery

- Who pays for reserves?
  - In most systems all reserve costs are allocated to loads
  - Removes price signals for market participants to manage variability and uncertainty they add to the system

Payment for reserves (Australian NEM)

Paid for by:

Contingency Raise (Spinning Reserve) → **Generators**

- Need is caused by generators
- Pro-rata by energy generated in that trading interval

Contingency Lower (Load Rejection) → **Loads**

- Need is caused by loads
- Pro-rata by energy consumption in that trading interval

Regulation (Frequency Keeping) → **Causer Pays**

- Paid for by loads/generators whose variability contributes to system frequency deviations

Causer Pays

Contribution factors:
Deviation from expected dispatch
Positive – Assisting in correcting system frequency
Negative – Causing deviations in system frequency

Attribution of frequency keeping reserve costs:

Calculate "**contribution factors**" for each load/generator every 4 seconds

Generators/Loads with negative contribution factors pay relative proportion of reserve cost (aggregated over 1 month)

Aggregated by portfolio (beneficial operation of one unit can correct for deviations in another)

Benefits of causer pays methodology

More cost reflective signals

- To wind farms (and other generators)

Incentives to manage variability & uncertainty

- Select less variable sites or technologies?
- Self-imposed occasional curtailment to limit unanticipated ramps?

More economically efficient outcomes

- Stronger incentives to reduce variability when reserves are expensive

Technology neutral

- Eg. Biomass and landfill gas observed to be significant contributors to variability, pay their share of reserve costs
- Variable loads pay more

Other valuable aspects of market design:

Significant negative prices	• Reduce generation during oversupply events • Reduce minimum loads
Technology neutrality - Dispatch	• Variable renewables fully participate in market dispatch process • Equal footing with other generation types
Technology neutrality – frequency keeping reserves	• Variable renewables able to provide frequency control reserves (where technical capability demonstrated)
Single platform market	• No day ahead market (real time only) • Reserves set dynamically in real time, based upon latest information
Enable Demand Side Response	• Access to demand side flexibility

Market design matters!

Minimising wind integration costs in NZ:

5min dispatch

- Minimise reserves → Reduce costs

5min gate closure time

- Minimise forecast errors → Reduce reserves → Reduce costs

Real time frequency keeping market

- Procure reserves dynamically & efficiently,
- Allocate costs on causer pays basis
- Allow variable renewables to provide frequency keeping (where technically viable)

Negative prices

- Avoid minimum load issues

Wind to fully participate in bidding

- Technology neutral participation in the market for economic efficiency

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Thank you

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