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Does Wind Need Back-up Capacity?

Modelling the system integration costs of 'back-up' capacity for highly variable generation

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Wind Integration costs

- Conceptually simple and potentially useful:
  - estimation of costs imposed on power system by accommodating wind *or other renewables with highly variable, non-storable primary resource*
  - Policy makers can then be better informed of system-wide costs, benefits of introducing supporting policy and regulations for that technology
- Generally considered to include a range of potential aspects
  - Costs of additional operational/flexibility reserves to manage variability and uncertainty of wind generation.
  - Costs of additional transmission and connection assets.
  - **'back-up' capacity** costs of matching variable capacity wind with some quantity of firm capacity (eg. OCGTs) when it is introduced into power system (eg. for making appropriate LCOE comparisons)

However in practice

- complex and very context specific to calculate
  - industry-wide costs, benefits of any particular generation technology depend upon integrated operation of all generation sources
  - Wind integration costs, benefits depends on rest of generation mix, nature of demand
- not applied equally to other generation technologies
  - Adding wind causes other units to cycle more, increasing their costs.. but so does nuclear, coal baseload by shifting merit order
  - *Where is discussion on integration costs of these technologies?*
- even more challenging to allocate fairly
  - Wind ‘causes’ cycling costs only b/c inflexible thermal plant have high costs associated with cycling process; wind itself highly flexible
  - Instead, can argue that inflexible existing plant with high cycling costs are responsible for imposing these additional costs on system,

A better framework

- Costs caused by system *as a whole*, shouldn't arbitrarily be attributed to any particular participant. Instead, **ideally**
  - variable generators and loads that add net fluctuations to system would internalise (pay) costs associated with that increased variability, encouraging smoother operation if economically efficient.
  - inflexible generators with high cycling costs would pay those costs, encouraging upgrades, operational changes if economically efficient.
- Designing, implementing market that achieves this non-trivial
  - Requires prices that reflect all industry-wide costs, benefits that different participants bring to market, incentivizes them to invest and operate their generation, loads to maximize net system benefit.
  - *In practice, fidelity of commercial arrangements varies greatly; efforts to improve internalization of relevant costs useful, but mustn't discriminate between technologies, or between existing, new participants*

Particular problems with concept of 'Backup' capacity

- *Short term:*
  - Adding wind does not *increase* the firm capacity requirement
  - System with sufficient firm capacity doesn't need more when wind is added
- *Long term:*
  - Generation mix will shift, partnering variable capacity with some quantity of firm capacity
  - Not optimal to operate only with variable generation… but generally *also* not optimal to operate with any single technology (eg. only baseload).
  - Generally a mix of high capital/low operating cost and low capital/high operating cost plant is optimal!
  - *But we don't talk about back-up cost of peaking plant when installing baseload to reflect its inherent economic inefficiency in supplying peak demand.*

Study Aim & Methodology

- Explore concept of "back-up" capacity with illustrative system
  - **Calculate changes in whole-of-system costs as wind is added**
- Model:
  - Conventional deterministic residual load duration curve technique
  - Calculates least cost 'green field' mix of firm generation depending upon technology cost profiles, and a given demand profile
- Assumptions:
  - Half-hourly wind trace (scaled from existing NEM wind farms in 2010)
  - Half-hourly demand trace (Australian NEM in 2010)
  - Technology costs from Aust. Govt. 2012 AETA
  - No carbon price
  - Gas price: $6/GJ (+20% for OCGTS)
  - MPC set for 0.002% USE

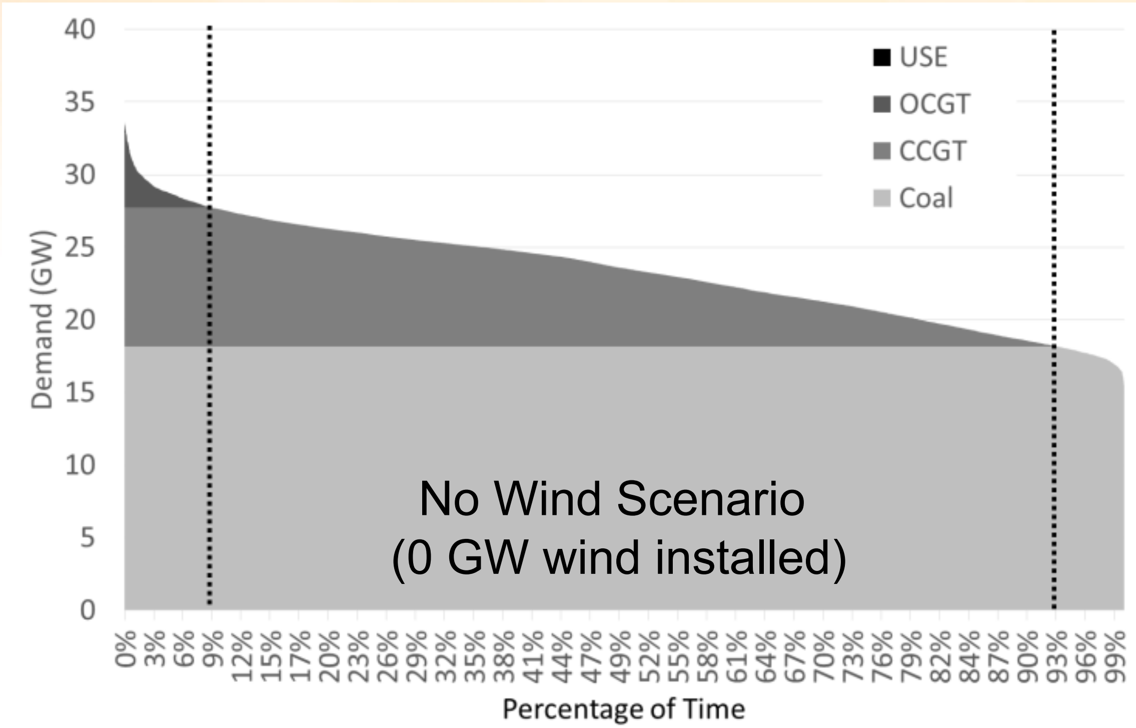
	Capital + FOM ($k/MW/yr)	SRMC ($/MWh)
Wind	197	0
Coal	254	26
CCGT	79	48
OCGT	51	84
USE (MPC)	-	4,300

Results – No Wind

- Reference Scenario

- Least cost mix:

	Capacity (GW)
Wind	0
Coal	18
CCGT	9.5
OCGT	5.2

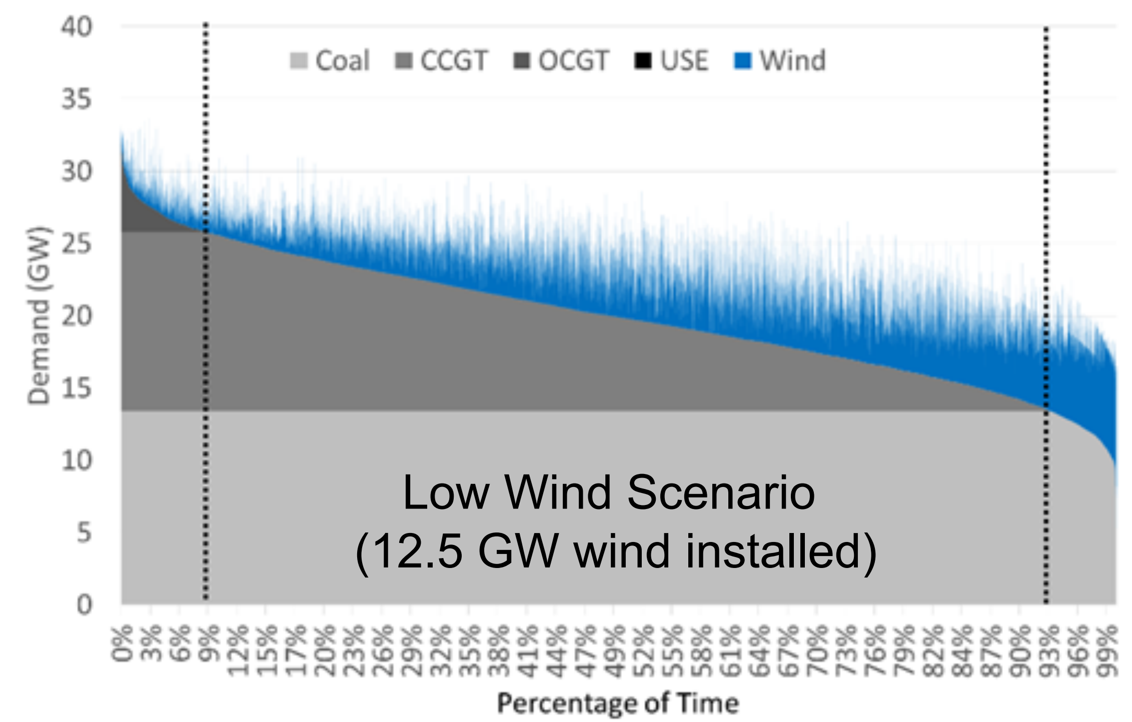


Results – Low Wind Scenario

- Assume external mechanism supports development of 12.5 GW of wind (15% of energy)

- Least cost mix:

	Capacity (GW)
Wind	12.5
Coal	13.4 (*Decreased from 18*)
CCGT	12.3 (*Increased from 9.5*)
OCGT	5.4



Wind acts to shift firm generation mix from baseload to intermediate

Results – High Wind Scenario

- Assume external mechanism supports development of 25 GW of wind (29% of energy)

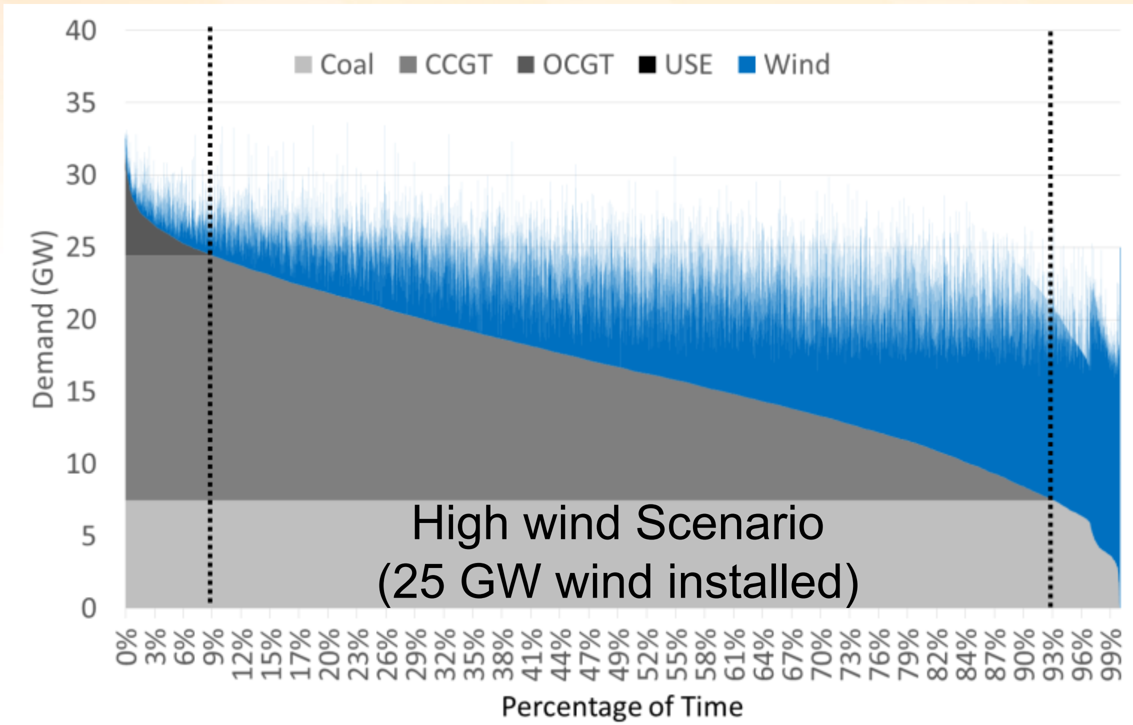
- Least cost mix:

	Capacity (GW)
Wind	25
Coal	7.5
CCGT	17
OCGT	5.9

Decreased from 13.4 (Coal)

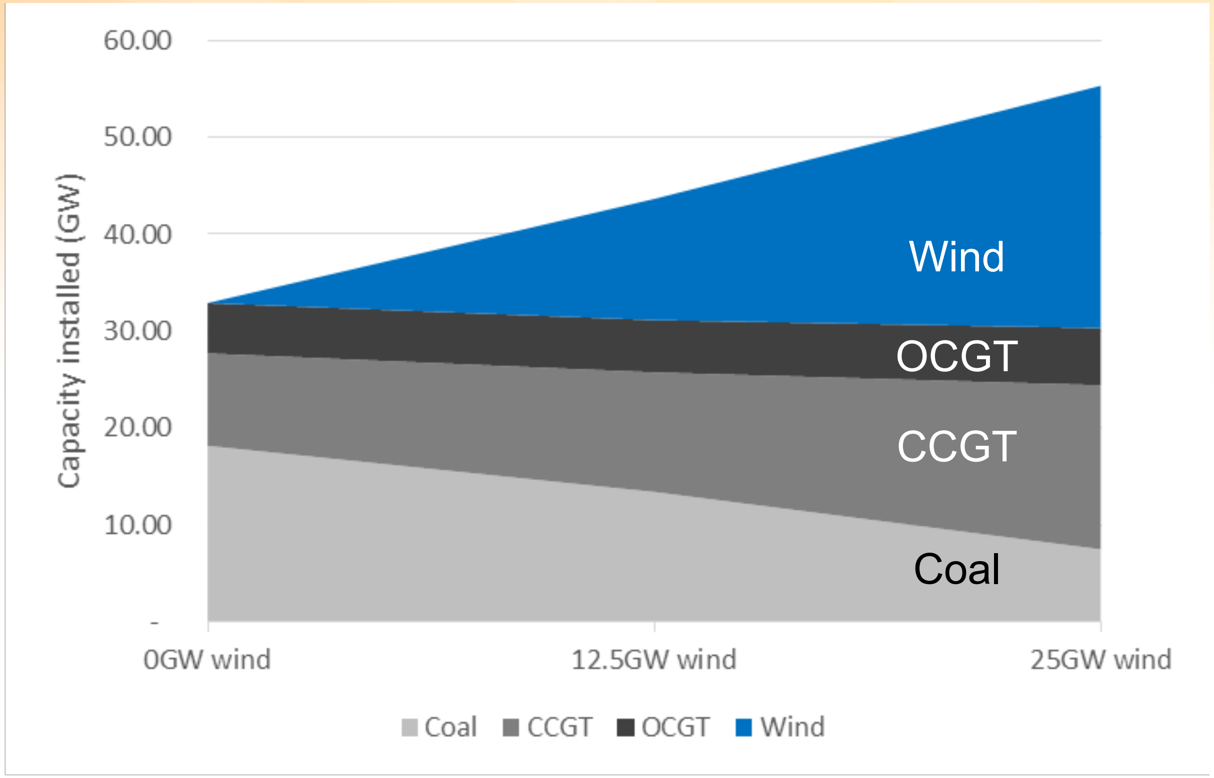
Increased from 12.3 (CCGT)

Wind acts to shift firm generation mix from baseload to intermediate



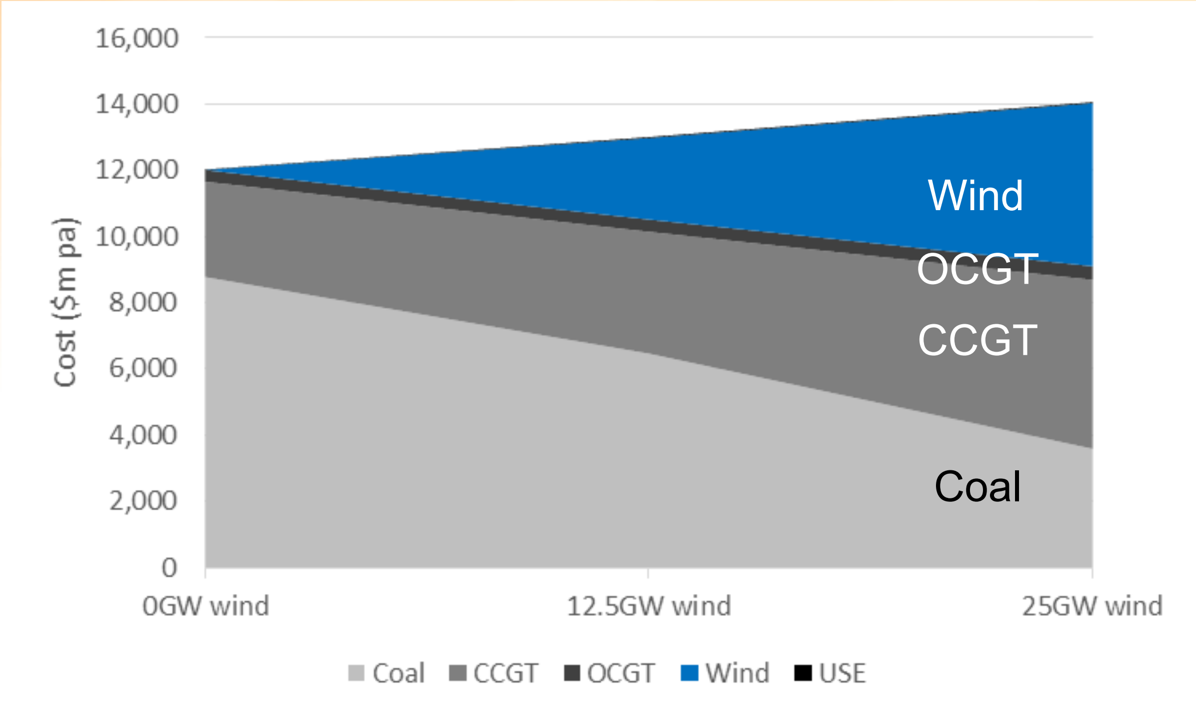
Summary – Installed capacity

- Increasing wind capacity drives displacement of baseload coal plant with intermediate CCGT



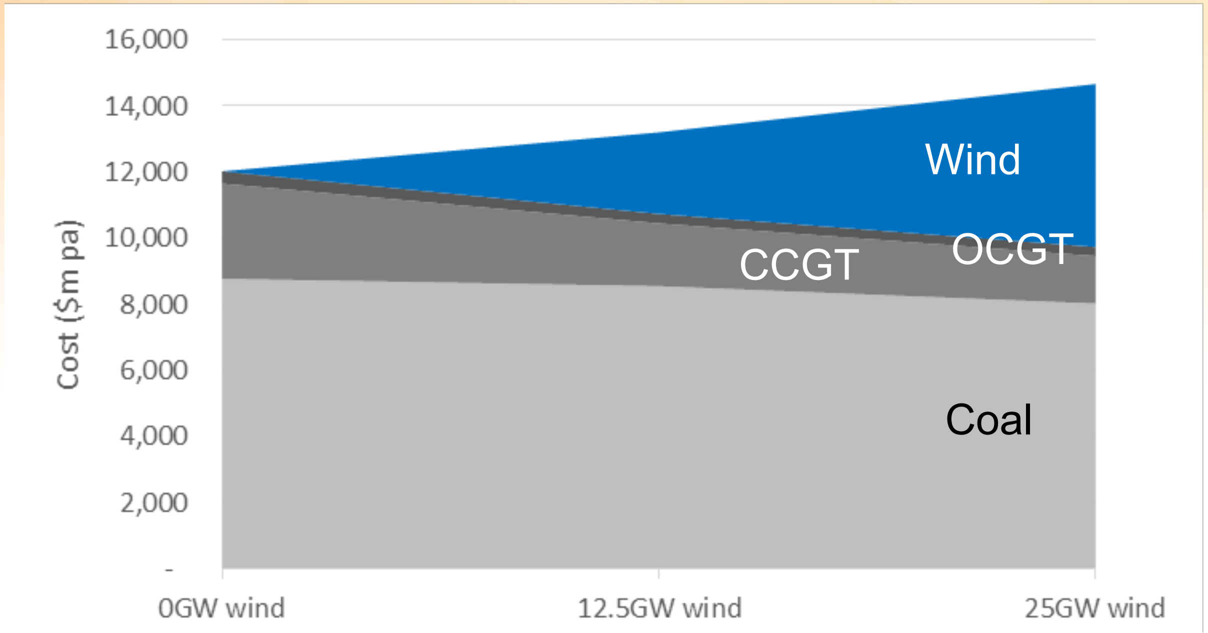
Summary – System Costs

- Wind generation acts to significantly reduce balance of system costs
  - Adding 12.5 GW of wind reduces other costs by $1.5 bn (12%)
  - Adding 25 GW of wind reduces other costs by $2.9 bn (24%)
  - Of $4.9 bn invested in constructing 25GW of wind, **59% is offset by reduction in balance of system costs**



Sunk costs

- What if wind is added to system with existing generation assets?
  - Fix generation mix at optimal levels, then add wind without generation mix adjustment
- Wind generation *still* acts to significantly reduce balance of system costs
  - Adding 12.5 GW of wind reduces other costs by 11%
  - Adding 25 GW of wind reduces other costs by 19%
  - Of $4.9 bn invested in constructing 25GW of wind, **46% is offset by reduction in balance of system costs**



A real system will lie between these two extremes
(depending upon demand growth, age of plant, etc).
Reasonably expect cost of wind generation to be 46 – 59% offset by reduction in balance of system costs

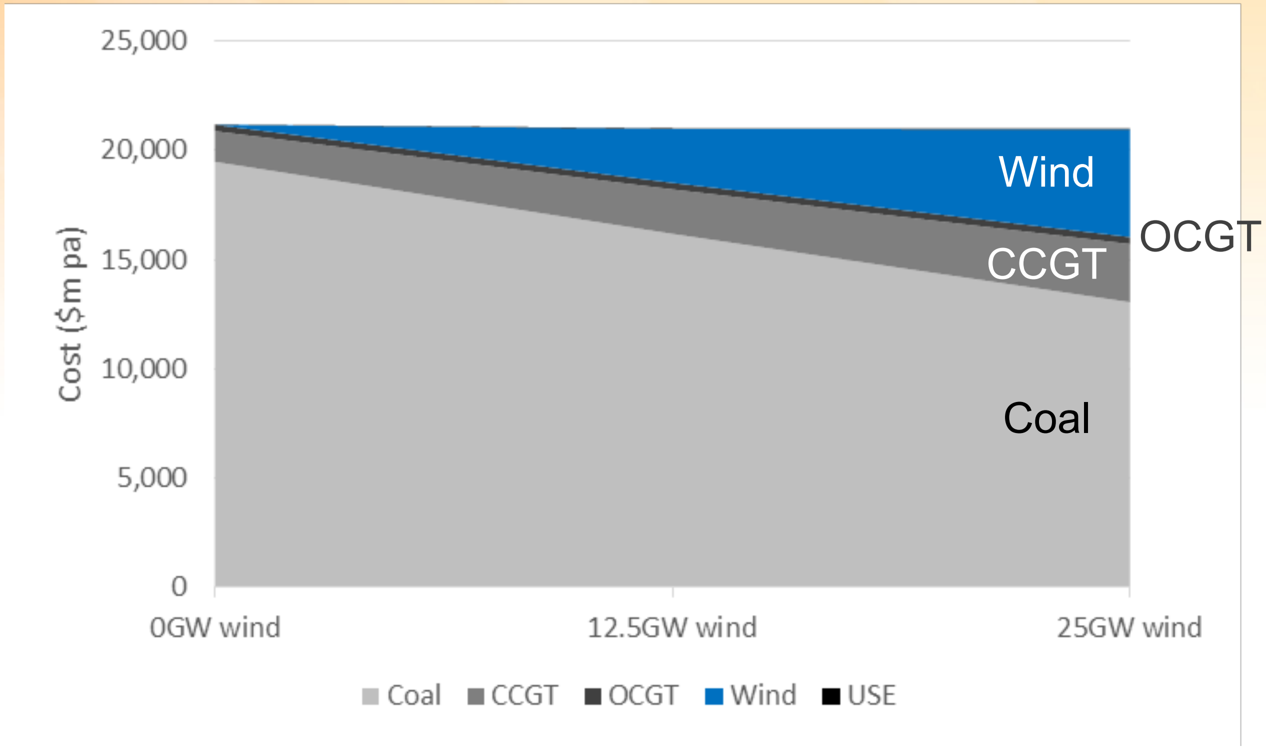
Capacity value of wind

Wind capacity	Reduction in capacity requirement for balance of system	Capacity value of wind (% of nameplate capacity)
12.5 GW	1.8 GW	14%
25 GW	2.6 GW	10%

- Consistent with other studies
  - Using multiple years of data
- Repeated analysis assuming a zero capacity value for wind
  - Increased OCGT capacity as a non-operational reserve
  - Increased total costs by 0.7% and 0.9% (Low & High wind scenarios respectively)
  - Even in this very conservative case, 56% of cost of wind is offset by reduced cost for balance of system (compared with 59% without reserves)

Sensitivity – C price ($55/t$CO_2$)+$12/GJ gas

- Possible future costs in Australia
  - High gas price
  - Meaningful carbon price
- Under these conditions, **least cost mix includes 19GW of wind generation (22% of energy)**
  - *Total* system costs reduce as wind is added up to 19 GW
  - Reduction in balance of system costs more than offsets capital cost of wind investment

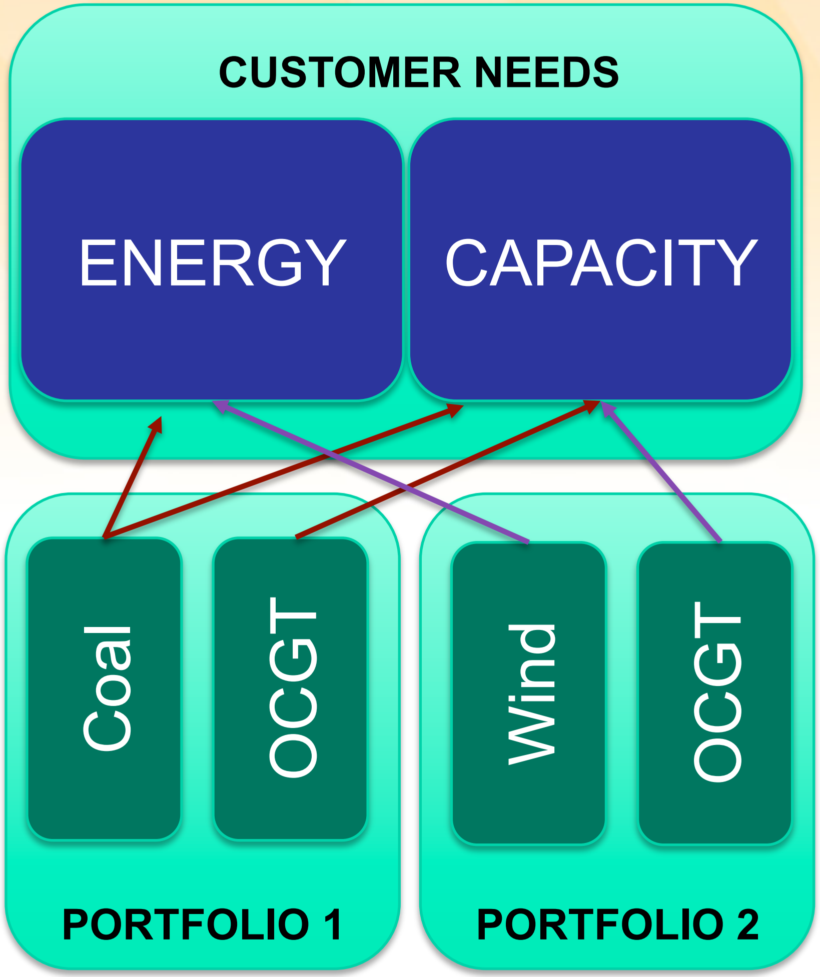


"Back-up" capacity concept

- Not meaningful to ascribe cost of 'back-up' capacity to wind generation
  - Adding wind does not create a requirement for additional capacity
  - Total capacity requirement of the system is not related to entry of wind
- Integration costs can be ascribed to *any* new entrant
  - Not just wind
- And cannot be allocated to any particular generator or technology
  - Costs will depend heavily upon the nature of the system itself, as well as the new entrant
- Must consider system as a whole

A more useful framework

- Consider capacity and energy requirements of a system to be properties of the *demand* profile
  - Requirement for capacity is created by *demand*, not the addition of wind
- Then compare different generation mixes that can best meet customer requirements for capacity and energy
  - Since customers ultimately create need for capacity and energy, they should pay for it, and generation options should be competing to provide these services most cost effectively
  - Generation options provide different mix of services, should be paid for what they provide (not penalised for what they don't)



System integration costs

- Aim should be to internalise system relevant effects as a price signal for generators
- Adding costs of one technology (eg. OCGTs) to another (eg. Wind) does not achieve this
  - OCGTs provide capacity without much energy, while wind provides energy without much capacity
  - They simply provide different services, and should be paid for what they provide (not penalised for what they don't provide)

Conclusions

- Wind acts to displace baseload capacity
  - Shifts investment to intermediate and peaking plant
  - Investors should cautiously assess any perceived need for baseload capacity when wind is being deployed
- Wind can significantly reduce balance of system costs over longer-term
  - ~45-60% of cost of wind generation offset by reduced balance of system costs.
- Concept of ‘back-up’ capacity as a system integration cost for wind is not meaningful, hence not useful
- Applying an additional “fee” to wind plants related to ‘back-up’ capacity does not appear to be an effective way of internalizing system costs
- A better approach:
  - Whole-of-system analysis, examining the implications of various technology mixtures for meeting the required demand profile
- Don’t oversimplify
  - It’s difficult to compare firm technologies (such as nuclear) and variable technologies (such as wind), and adding a simple “integration cost” is far too simplistic

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