Is the Electricity Spot Market Robust to Particular Prospective Change?
Question

Does an increasing share of renewable generation imply

• difficulties for the operation of the spot market and/or

• insufficient investment for efficient generation capacity of the industry?

Where renewable generation has zero marginal cost and volatile fuel supplies
Agenda

- The Future
- The essence of a "normal" wholesale market
- Role of storage, present and future technologies in providing discretion
- Discretion of electricity suppliers (offers) and demanders (bids) and the spot market
- Operation of the spot market and investment in capacity
- Capacity Market comment
The Future

not forecasts but (and not all) possibilities

• A variety of sources of change
• Climate and renewables (variance higher?)
• Technological change – efficiency in energy use, instant communication/control, demand, etc., etc..
• Batteries store electricity
  – Act as reservoirs for electricity
  – managed as reservoirs
  – have frictions and costs to be determined
Wholesale Market

Spot and hedge markets sit on a national platform

Transacts electricity between demand and supply

Combines hedge (long term) and spot (very short term) transactions:

Spot enables demand = supply at each instant in time, for all market participants

Hedge provides long term prices (by contract or ownership)
Spot Market Operation

- Spot market: all electricity exchanged across the platform must go through the spot market
- Operated by System Operator subject to rules
- Operation requires individual market participant have discretionary actions:
  - Participate or not
  - Some ability to vary demands/supplies,
  - Driven by a profit motive
- Operation provides electricity pool with certain qualities (security, voltage/cycles)
The Hedge (Capacity Investment) Market

Criterion for entry of generation plant is (in expectations)

- Hedges earn net PV of their costs
- Efficient in the hedge market requires that the prices of hedges are approximately equal to the price of the cheapest new plant

Financial (operational) cost

Existing plant

Existing plant
Volatile and Spot Market

*The wholesale market must have a spot market*

- Supply = demand in real time
- $\frac{1}{2}$ hour wholesale price 85% hedge 15% spot
- Volatility higher with renewables?
- Capacity investment has same criterion
Generation in the wholesale market:

spot, hedge/forward and capacity: timing matters

Anticipated Spot price characteristics

Supply cost of generation plant/fuel, Demand, Climate and events

Capacity Investment

Forward/Hedge decisions Prices & amount

• Short term demand
• Expected spot prices
• Existing hedges
• Inflows, Storage, plant capacity etc
• Supply and transmission events

The Future

The Present
-> Spot offers
Spot Market

In ½ hr trading period

Offers to the spot market: sum is variable cost of production

Uniform price

Demand

Electricity volume
Efficient Spot market

Induced by competition and a common price

Requires

a) demand equals supply at the market clearing spot price at each node; and

b) that offers to the market are based upon opportunity cost of the generation offered

In a ½ hour snapshot of time in which market rules and infrastructure are fixed: what is opportunity cost?
Opportunity Cost
(allocation across resources and time)

The cost of generating in a trading period is
• The financial (operational) cost of resources used: eg oil purchased

Plus
• The value of the option to delay generation to a future trading period
Delay Options I

(allocate resource use across time)

Rule with option to delay: generate now if and only if the price of electricity now exceeds the expected price in some future period

Requires: ability to store *fuel* and/or *electricity* for future use
- hydro water reservoirs
- gas pipeline/reservoirs
- batteries are reservoirs for electricity

Delay options generally economically efficient
Delay Options II

Storage provides generator *discretion* and valuable *options*

Hydro with reservoirs have zero operational marginal cost, but (almost) never offer in at zero price: rather offers in at the value of storing water.

Hydro is typically marginal generation and (with zero operational marginal cost) the observed NZ spot price is the value of the option to delay use of water.

Run of river and wind power generation have no delay options and negligible operational marginal cost so offer “all” to the market at zero price.
Delay Option Value of unit of water in a trading period

\textit{ie electricity price}

Source a model calibrated to NZEM and simulated for trading periods for 200 years (Evans and Guthrie)

$\text{value of unit of stored water:} \quad \begin{aligned} & \text{Empty} \\ & \text{Very High Inflow} & 97.5\%* \\ & \text{Very Low Inflow} & 2.5\%* \\ & \text{Full} \end{aligned}$

* Percentile of unconditional inflow distribution
Spot Market

Composition of generation

What generation lies at \( ? \)
at \( ? \)

Demand

Uniform price

Electricity volume

Offers to the spot market: sum is total variable cost of production
Delay Options III

Battery management has the same general principles as water/gas reservoirs

Batteries are reservoirs for electricity, and complement generation plant

Separate generation and supply: e.g. wind power plus batteries would provide delay options that the market operator would see. Batteries provide generator (demand) discretion regarding transactions with the spot market

Rule: Invest in storage (reservoirs) if the expected present value of delay options it provides exceeds its cost
Implications for the Wholesale Market of substituting zero-operational-marginal cost generation for fossil fuel

I Spot Market Operation

• Sufficient share of hydro generation enables operation with zero price offers.

• For markets of wholly renewables
  • batteries would be important: particularly with small share of hydro
  • Operation will reflect the wide holding of batteries
    • Participants will to an increased extent internalise/manage shocks to supply and demand, and
    • Render the market operator’s task different as management of shocks will depend more on participant actions than formerly.
Implications for the Wholesale Market of substituting zero-operational-marginal cost generation for fossil fuel

II Hedge/Capacity investment

- The decision rule whether to build/buy hedges is the same whether or not operational marginal cost is zero and volatility is higher

- Increased market volatility would affect decisions taken.
  - Without batteries likely induce investment delays, ceteris paribus; BUT
  - Will also improve the economics of batteries
  - Net effect????????
Capacity Market

as well as spot and hedge markets?

• Capacity markets are additional to the spot market: entail capacity provision and funding separately
  • Capacity (additional) determined by central planner and
  • Provision of a level of capacity a condition of participation in the energy/spot market, or
  • provided by a procurement auction

• Capacity market performance has significant gaming and unstable rules: performance is at best chequered

• The operation of the spot/energy markets can be treated as if for the normal (energy only) market form
Capacity

• Capacity is influenced by a range of interventions: including in energy only markets

• Capacity markets polar case where marginal capacity is determined by a central planner but can happen in different ways (eg CA)/UK-Germany

• Is such intervention implied by increased renewables? no *prima facie* case
Some Sources


• The Economist 25/2/2017: “Renewable energy. A world turned upside down. Wind and solar energy are disrupting a century-old model of providing electricity. What will replace it?


• Evolving US Utilities Batteries Position: batteries instead of peakers (LA) [https://www.scientificamerican.com/article/worlds-largest-storage-battery-will-power-los-angeles/](https://www.scientificamerican.com/article/worlds-largest-storage-battery-will-power-los-angeles/)
Thank you for your attention