Electricity markets reimagined for flexible, low-carbon grids

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7 June 2017

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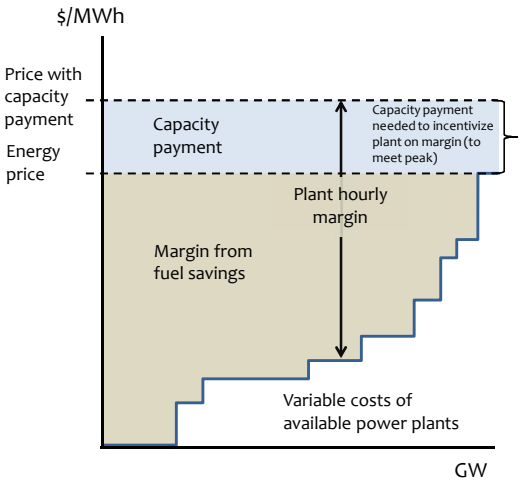
Why do we need market redesign? A near-total variable renewable system will be cheaper in future than a new fossil fuel-based system – but low costs are not enough

Total cost of generation from renewables and CCGT-based systems including flexibility (no carbon price)

Power generation and balancing cost
$/MWh, excluding carbon price

Sources:
CPI Analysis, based on Germany load and resource profiles at 100% renewables (with wind (64%), solar (34%) and run of river hydro (2%), before any shifting or curtailment)
Variable RE Costs: $60/MWh today, $40/MWh post-2030; *CCGT Costs:* $50/MWh variable cost, $20/MWh emissions cost, and $140/kW-year fixed capital and O&M costs; *Lithium Ion Battery Costs:* $160/kW-year (based on $150/kWh capital cost for 6-hour battery plus fixed O&M), plus 8% round-trip losses at RE cost

The current market model has developed in way that's ill-suited to a renewable system



But for the low carbon world, these concepts are becoming outdated because:

1. With central system demand flat or declining due to energy efficiency and distributed generation, there is little need to build plant purely for the sake of meeting peak needs.
2. A future low carbon power system is likely to be made up in large part by resources that are capital intensive and have zero or minimal operating cost.
3. Renewables have become exposed to policy to fuel price risks that they have no control over, or can't benefit from. And as more renewable were added to the system, the marginal value of renewable energy declines.
4. With greater demand participation and local storage options, the consumer side should be at least as important as supply in meeting peaks.

What must a new electricity market design achieve – and how is it best achieved?

1. Efficient signals for investment *Markets should provide a basis for investment in low-carbon energy sources.*	➢ Market mechanisms that drive efficient investment in new generation, flexibility and infrastructure
2. Efficient signals for flexible operations *Markets should ensure that flexibility resources are operated efficiently.*	➢ Real-time and locational price signals that incentivize the provision of flexibility when and where it is most valuable. ➢ Price signals to electricity consumers or aggregators to encourage energy shifting and other flexibility services from the demand side.
3. Appropriate allocation of risk *Markets should allocate risks (eg fuel price volatility or resource variability) to those actors best suited to manage or control them*	➢ Allocation of risks, such as fuel price volatility or resource variability, to those actors best suited to manage or control them.
4. Support decarbonization goals *Markets should be designed to minimize the cost of decarbonizing the electricity system*	➢ Internalising carbon costs into operations and investment decisions.

The concepts of how energy is supplied, delivered and consumed are changing, requiring the creation of two main markets: energy market & delivery market

Key elements of energy market:

- A market for kWhs as a product or commodity under long-term contracts, priced independently of timing or location
- Long-term contracts set at auction would replace the wholesale market with more stable price signals.

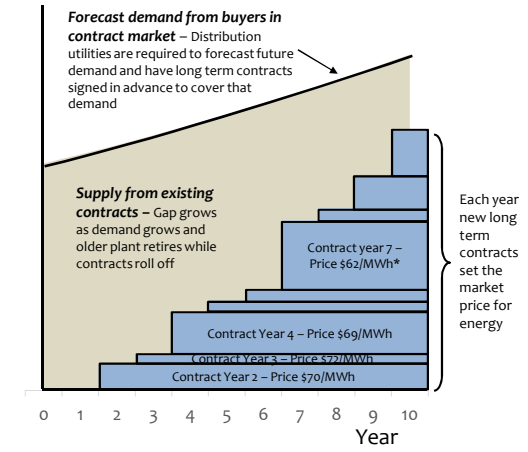
Key elements of delivery market:

- Delivery charges are added (or subtracted in some market conditions) to incorporate the marginal cost of shifting energy delivery to a given time and location, including:
  - Contribution to capital and operating costs of transmission
  - Contribution to systemwide electricity losses
  - The cost of shifting energy to (or from) the given hour with storage, operation of higher cost, flexible plant, curtailment, incentives for load shifting, etc

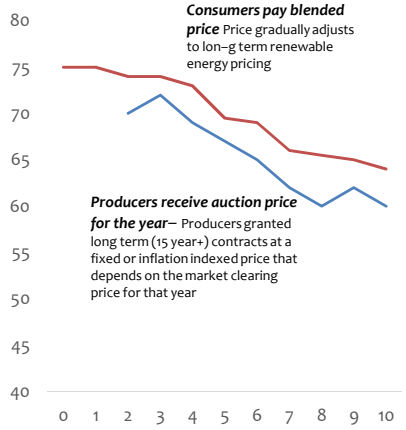
Energy market would be based on auctions for long-term contracts

Long-term markets already exist, but not ones that separate energy from delivery/ resource adequacy or flexibility

Annual auctions to meet forecast demand



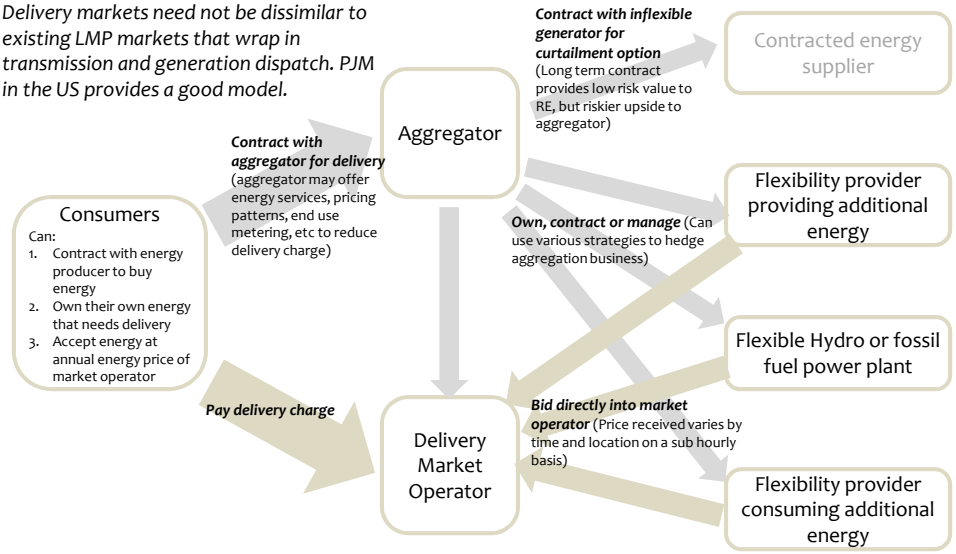
Consumers and producers receive energy prices based on that auction



* Prices are for illustration only

Delivery market pays to deliver energy purchased to a specific time and place

Delivery markets need not be dissimilar to existing LMP markets that wrap in transmission and generation dispatch. PJM in the US provides a good model.



Key benefits of separate energy market & delivery market

Key benefits of energy market:

- Unbundling of delivery and the commodity reduces the risk to producers that cannot control timing of delivery or location once the plant is built
- Long term contracts and load differentiation charges will provide longer term incentives to generators to optimize location and load shape prior to building and financing the plant
- The cost of low carbon electricity will fall as the delivery risk is removed and concentrated on those who can absorb and optimize that risk

Key benefits of delivery market:

- Any consumer or generator could participate in this market, but only flexible generation, consumers and storage and their agents are likely to benefit.
- The base price for delivery markets could be near zero with prices swinging positive and negative depending on congestion. Delivery charges would be added to energy charges for consumers.
- Traders could also harness curtailment of non-dispatchable generation to provide value, but that would not affect the basic economics of the low carbon energy supply.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