Electricity Market Design: Learning from experience

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Reliability is essential; meeting a clear standard of reliability at least cost should be the goal.

The “EOM vs. CRM” debate is fascinating but typically ignores a more fundamental question...

Is the market driving the right investments to ensure reliability at least cost? Especially in a low-carbon transition?
Resource adequacy at least cost: generation
First things first – what’s “adequate”?

1) Clear, objective standards: e.g., (“value of lost load”)/(levelized cost of marginal resource) = “loss of load expectation”

2) Couple balancing areas and assess adequacy independently & transparently over the largest practical footprint

3) Account for all cost-effective sources of capacity equitably & transparently
Experience with various “CRMs”

Extent of capacity intervention

<table>
<thead>
<tr>
<th>Region</th>
<th>Avg Annual New-Build as % of 2014 Peak</th>
<th>Ratio of Actual to Target Reserve Margins (2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERCOT</td>
<td>4.0</td>
<td>North America, Australia</td>
</tr>
<tr>
<td>NYISO</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>PJM</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>ISO-NE</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>NEM</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>SWIS</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

Source: RAP, from published system operator data
“How much?” depends on “what kind?”

Source: Adapted from *The Power of Transformation* (IEA, 2014)
PJM: a decade of lessons learned

Source: Brattle Group
PJM Capacity Market 2007

Supply

Demand

Capacity – single product
PJM Capacity Market 2011

Supply

Capacity – single product

Annual DR

Extended Summer DR

Limited DR
PJM Capacity Market 2014 (proposed)

Qualified generation

Annual DR

Non-qual. Extended Limited Non-CP
 generation Summer DR capacity

“Capacity Performance”
capacity
PJM Capacity Market 2016

Capacity Performance (Supply and Demand)

Capacity – single product

...the new business case for investors is looking a lot more like an energy-only market
What really drives investment?

1) PJM: Capacity market, but prices fixed only one year at a time in rolling annual auctions
2) ERCOT: no capacity market, administrative reserve shortage pricing mechanism
3) Australia NEM: no reserve shortage pricing, only co-optimization of energy & reserves markets
4) Yet all three have been consistently successful in attracting new investment over many years
5) Common themes? All three market designs have been relatively stable for a decade or more with transparent, independent market operation and price formation
Cheap (and effective) alternatives to generator capabilities
Generation: just one piece of the puzzle

Source: US Dept. of Energy, National Renewable Energy Laboratory
Complementary sources of capabilities

- Grids
- Interconnectors

Generation
Complementary sources of capabilities

- Generation
- Grids
- Inter-connectors
- Market geography
- Market operations
Complementary sources of capabilities

- Grids
- Inter-connectors
- Market geography
- Market operations
- Generator flexibility
- Energy & services markets
- Capability-driven FCMs
Complementary sources of capabilities

Grids
Inter-connectors

Generator flexibility

Market geography
Market operations

Energy & services markets
Capability-driven FCMs

Demand participation
Electricity storage
Market operations, market geography, and grids
“Bigger,” “faster” markets

Source: National Renewable Energy Laboratory (U.S.), 2013
Regional independent market governance

Markets that reduce grid congestion

Record demand: ERCOT, August 2011

Record demand: ERCOT, August 2016

Source: ERCOT data via SNL Energy
Tapping the untapped flexibility of demand
3 pillars of an effective energy market

- Competition/market monitoring
- Enable demand response/aggregation
- Better shortage pricing
Demand-side flexibility

Demand-side flexibility

Source: G. Strbac, Imperial College London
Demand-side flexibility

Cost per Unit of Performance for Various System Flexibility Options

Source: Sandia National Laboratory, Energy Storage Association & Ecofys
4 keys to effective demand participation

- Aggregation
- Automation/Control Technology
- Integrated energy & reserves pricing
- Dynamic retail prices
Energy pricing that exposes the value of investment in flexibility
### Full range of marginal costs

<table>
<thead>
<tr>
<th>System Resource</th>
<th>Full marginal cost (€/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation capacity (&quot;firm&quot; or &quot;de-rated&quot;)</td>
<td>20-250</td>
</tr>
<tr>
<td>Imports</td>
<td>20-1000</td>
</tr>
<tr>
<td>Secondary (operating) reserves</td>
<td>250-5000</td>
</tr>
<tr>
<td>Emergency generation</td>
<td>500</td>
</tr>
<tr>
<td>Primary (regulation) reserves</td>
<td>500-9000</td>
</tr>
<tr>
<td>30-minute responsive back-up</td>
<td>1400</td>
</tr>
<tr>
<td>30-minute controllable demand response</td>
<td>2400</td>
</tr>
<tr>
<td>10-minute controllable demand response</td>
<td>2600</td>
</tr>
<tr>
<td>10-minute responsive back-up</td>
<td>3700</td>
</tr>
<tr>
<td>Emergency load-shedding</td>
<td>9000</td>
</tr>
</tbody>
</table>

*Source: Adapted from Brattle Group & Astrape Consulting (2014 report to Public Utilities Commission of Texas & 2013 report to the Federal Energy Regulatory Commission)*
Energy price formation: legacy

Energy price formation: corrected

Energy price formation: evolved

Administrative reserve shortage pricing

Example: ERCOT Operating Reserve Demand Curve

Source: ERCOT
Administrative reserve shortage pricing

Source: ERCOT
Sharper prices ≠ higher prices

Average annual wholesale energy prices (2015)

Source: Ventyx (via Brattle Group) & Northbridge
Evolution away from binary model

Market driven, time varying

- Rudimentary ‘EOM’
- Ancillary svcs market reforms
- Energy market improvements
- Reserve shortage pricing intervention
- Growing consumer empowerment
- Phase out capacity market

Administrative, fixed

- Fixed single-product CMs
- Ltd. segmentation (e.g., DR)
- Single-product with major ‘scarcity event’ risk/reward
- Evolving definitions of adequacy

Time
But can it work? Does it work?
ERCOT average annual wholesale price 2005-2015

ERCOT seasonal demand variability

Source: ERCOT
ERCOT wind generation as % of total generation

Source: ERCOT
ERCOT on-peak & off-peak forward prices 2016-2022

Source: SNL Financial courtesy of IEEFA
ERCOT forecasted reserve margins 2013-2016

Source: ERCOT Capacity & Demand reports May 2013 to May 2016
ERCOT forecast retirements & additions 2017-2031

- 10-24% of capacity (33-75% of “baseload”) expected to retire before 2031
- No capacity market
- Low average wholesale prices
- No problem

Reliability is essential, but reliability at the lowest reasonable cost is a matter of capabilities, not capacity; paying for too much of the wrong kind of capacity depresses wholesale prices, raises costs to consumers & does nothing for reliability.
Capacity markets are poor at valuing capabilities, and to work better they have to work more and more like an energy-only market; many options for increasing needed capabilities are faster to implement & more cost-effective than generation.
Well-administered, regionally integrated energy and balancing services markets are capable of supporting needed investment and are irreplaceable as drivers of investment in the most cost-effective sources of resource capabilities.
About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power sector. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

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