Getting Started: Rethinking Utility Regulation in an Era of Exponential Change

RAP Roundtable Webinar

Regulatory Assistance Project
www.raponline.org
Questions?

Please send questions through the Questions pane
Disruptive Forces Transforming Electricity

Compounding Network Effects

- Grid Data Explosion
- Renewable Explosion
- Heat Pumps
- Storage & EV Explosion

Aggregation, Digitization, Ability to Shape Load

Artificial Intelligence, Deep Machine Learning

Source: Chandu Visweswarah, Utopus Insights Inc.
Our experts

Ken Colburn
Richard Sedano
Jim Lazar
Michael Hogan
David Farnsworth
John Shenot
1 Falling Price of Renewables

What this means for costs and consumers
Solar Prices Have Declined

Notes: Solid lines represent median prices, while shaded areas show 20th-to-80th percentile range. Summary statistics shown only if at least 20 observations are available for a given year and customer segment.

Sources: Tracking the Sun 10, Lawrence Berkeley National Laboratory and U.S. Department of Energy SunShot program
Declines Have Continued Into 2017

Q3 2017 Quoted PV Prices

Sources: GTM Research and Solar Energy Industry Association
Wind Cost Per kWh (US)

$0.55 / kwh

10x Price Decline

$0.05 / kwh

Global Best of Class: 2015

Solar PV

- Country: UAE
- Bidder: AQWA
- Signed: January 2015
- Construction: 2017
- Price: US$ 5.84 c/kWh

Onshore wind

- Country: USA
- Bidder: Various
- Signed: 2015
- Construction: 2016
- Price: US$ 4.5 c/kWh

Source: Michael Liebreich, presentation to California ISO, October 18, 2017. Data from Bloomberg New Energy Finance; images from Siemens, Wikimedia Commons, and Electrek
Global Best of Class: 2016

**Solar PV**
- Country: Mexico
- Bidder: FRV
- Signed: 2016
- Construction: 2019
- Price: US$ 2.69 c/kWh

**Onshore wind**
- Country: Morocco
- Bidder: Enel Green Power
- Signed: 2016
- Construction: 2018
- Price: US$ 3.0 c/kWh

Source: Michael Liebreich, presentation to California ISO, October 18, 2017. Data from Bloomberg New Energy Finance; images from Siemens, Wikimedia Commons, and Electrek
Global Best of Class: 2017

Solar PV

Country: Saudi Arabia  
Bidder: Masdar  
Signed: 2017  
Construction: 2019  
Price: US$ 1.79 c/kWh*

Onshore wind

Country: India  
Bidder: ReNew Power  
Signed: 2017  
Construction: 2019  
Price: US$ 2.0 c/kWh

*Headline figure only - may include elements of subsidy, price support or price escalation; not final

Source: Michael Liebreich, presentation to California ISO, October 18, 2017. Data from Bloomberg New Energy Finance; images from Siemens, Wikimedia Commons, and Electrek
### Xcel Energy All-Source Bids, December 2017

#### RFP Responses by Technology

<table>
<thead>
<tr>
<th>Generation Technology</th>
<th># of Bids</th>
<th>Bid MW</th>
<th># of Projects</th>
<th>Project MW</th>
<th>Median Bid Price or Equivalent</th>
<th>Pricing Units</th>
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</thead>
<tbody>
<tr>
<td>Combustion Turbine/IC Engines</td>
<td>30</td>
<td>7,141</td>
<td>13</td>
<td>2,466</td>
<td>$4.80</td>
<td>$/kW-mo</td>
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<tr>
<td>Combustion Turbine with Battery Storage</td>
<td>7</td>
<td>804</td>
<td>3</td>
<td>476</td>
<td>6.20</td>
<td>$/kW-mo</td>
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<tr>
<td>Gas-Fired Combined Cycles</td>
<td>2</td>
<td>451</td>
<td>2</td>
<td>451</td>
<td></td>
<td>$/kW-mo</td>
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<tr>
<td>Stand-alone Battery Storage</td>
<td>28</td>
<td>2,143</td>
<td>21</td>
<td>1,614</td>
<td>11.30</td>
<td>$/kW-mo</td>
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<tr>
<td>Compressed Air Energy Storage</td>
<td>1</td>
<td>317</td>
<td>1</td>
<td>317</td>
<td></td>
<td>$/kW-mo</td>
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<tr>
<td>Wind</td>
<td>96</td>
<td>42,278</td>
<td>42</td>
<td>17,380</td>
<td>18.10</td>
<td>$/MWh</td>
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<tr>
<td>Wind and Solar</td>
<td>5</td>
<td>2,612</td>
<td>4</td>
<td>2,162</td>
<td>19.90</td>
<td>$/MWh</td>
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<tr>
<td>Wind with Battery Storage</td>
<td>11</td>
<td>5,700</td>
<td>8</td>
<td>5,097</td>
<td>21.00</td>
<td>$/MWh</td>
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<tr>
<td>Solar (PV)</td>
<td>152</td>
<td>29,710</td>
<td>75</td>
<td>13,435</td>
<td>29.50</td>
<td>$/MWh</td>
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<tr>
<td>Wind and Solar and Battery Storage</td>
<td>7</td>
<td>4,048</td>
<td>7</td>
<td>4,048</td>
<td>30.60</td>
<td>$/MWh</td>
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<tr>
<td>Solar (PV) with Battery Storage</td>
<td>87</td>
<td>16,725</td>
<td>59</td>
<td>10,813</td>
<td>36.00</td>
<td>$/MWh</td>
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<tr>
<td>IC Engine with Solar</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td></td>
<td>$/MWh</td>
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<tr>
<td>Waste Heat</td>
<td>2</td>
<td>21</td>
<td>1</td>
<td>11</td>
<td></td>
<td>$/MWh</td>
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<td>Biomass</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>9</td>
<td></td>
<td>$/MWh</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>430</strong></td>
<td><strong>111,963</strong></td>
<td><strong>238</strong></td>
<td><strong>58,283</strong></td>
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</tr>
</tbody>
</table>

Source: Xcel Energy, 2018

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Regulatory Assistance Project (RAP)®
Xcel bid median prices $/MWh

$30

SOLAR

$18

WIND
Existing power plant operating costs per USEIA

Existing Plant Average Fuel and O&M from USEIA Table 8.4 Electric Power Annual 2016
Existing plants vs. Excel bids

Existing Plant Average Fuel and O&M from USEIA Table 8.4 Electric Power Annual 2016
Xcel Was Not Alone

Oklahoma, 2017
Wind Catcher
2,100 MW
$7 billion in savings

Mexico, 2017
Solar: $17.70/MWh
Wind: $22/MWh

Photo: GE Renewable Energy
Flexibility and Pricing

The evolving value of investment
Key Points

• Flexible services moving to center stage
• Greater range of services required
• Shifting money from capacity remuneration to remuneration for energy and services…
• …amplifying real-time prices to better capture the value of flexible resources - supply & demand side
• C&I customers and retail aggregators should see more opportunity to reshape the demand curve
Wind Production in Ireland

Nov-Dec 2016 non-synchronous infeed to All-Ireland Grid

Source: EirGrid
More Capital-Intensive…in *Energy Services*
Demand for Wider Range of Energy Services

Current
- Regulation Up
  - Fast-Responding Regulation Up
- Regulation Down
  - Fast-Responding Regulation Down
- Responsive
- Non-Spin

Proposed
- Regulation Up
- Fast-Responding Regulation Up
- Regulation Down
- Fast-Responding Regulation Down
- Fast Frequency Response 1
  - 59.8 Hz, Limited duration
- Fast Frequency Response 2
  - 59.7 Hz, Longer duration
- Primary Frequency Response
- Contingency Reserves 1
- Contingency Reserves 2
- Supplemental Reserves 1
- Supplemental Reserves 2
- Synchronous Inertial Response
  - Ongoing development

Mostly unchanged

Source: ERCOT Future Ancillary Services
“New resource mix will change both the need for [ancillary services] and the capabilities of resources providing [ancillary services].”

ERCOT Presentation
September 2017
Improving Price Formation

ELMP complements products like ramp by better pricing the total production costs to meet an operating need indicated by a product.

- Without ELMP, Ramp reflects only marginal cost.
- Without Ramp, ELMP reflects only energy needs.
Hourly Balancing Reserves Requirement

ISO supports the Western Grid when the blue bars are above 100% (green line). ISO leans on other BAs when the red bars are less than 100%.

Performance Target

Source: California Independent System Operator via Calpine
Price Duration in a 70% RES Grid

2015 – over-supply, prices not set by marginal cost

20XX: Inflexible surplus retired, full marginal cost pricing

Source: Ea Energy Analyses for Denmark’s Orsted power utility
Managing Load

Flexibility Changes Everything
Changes in the Electric Industry

• New technologies
  • EVs, heat pumps, and HP water heaters
• New interactive choices for utility customers to consume and produce
Beneficial Electrification Defined

- Electrification is beneficial if it meets one or more of three conditions, without adversely affecting the other two:
- Saves consumers money over the long run;
- Reduces environmental impacts; and
- Enables better grid management.
What Sort of Load are we Talking About?

- Relative Efficiency of Electrification Load
  - Heat pump water heaters move heat instead of generating it – 1.5 - 3X more efficient
  - EVs vs. gasoline passenger cars (60% vs. 20%)
What Sort of Load are we Talking About?

• More Flexible Load:
  • Traditionally, generation followed load for virtually immediate consumption
  • Today, because it can be stored (thermally or electrically) some load can follow generation
  • Flexible load is valuable
Unlike this Inflexible Load ...
... BE Load Can Fill Valleys and Shave Peaks

Source: E Source, adapted from Integral Analytics Inc.
A Natural Tool for Grid Management

California Independent System Operator Duck Curve

Net load - March 31

Ramp need ~13,000 MW in three hours

Overgeneration risk

12am 3am 6am 9am 12pm 3pm 6pm 9pm

Megawatts

28,000 26,000 24,000 22,000 20,000 18,000 16,000 14,000 12,000 10,000 8,000 6,000 4,000 2,000 0
Valuable for Reducing Curtailments

Note: All curtailment percentages shown in the figure represent both forced and economic curtailment. PJM's 2012 curtailment estimate is for June through December only.

Virtual Power Plants: The Business of Aggregating Buildings with Batteries
Capabilities

August 28, 2017 Stem dispatches 14 *Virtual Power Plants* (VPPs) to support the grid during a heatwave.

Source: Stem
SmartCharge New York

Source: https://www.fleetcarma.com/smartchargenewyork/
SmartCharge New York

Source: https://www.fleetcarma.com/smartchargenewyork/
4 Resilience

What goes down, must come up
What is Resilience?

- The ability to withstand and reduce the magnitude or duration of disruptive events
- Anticipate, adapt, and rapidly recover

This map denotes the approximate location for each of the 16 billion-dollar weather and climate disasters that impacted the United States during 2017.
The Grid Resiliency Pricing Rule
24% of North American utility executives believe there is a “significant likelihood” (>20%) of a cyber attack interrupting electricity supply in the next 5 years.

Source: Accenture Consulting (2017), Outsmarting Grid Security Threats
Beneficial Electrification Makes Us *Even More Dependent on the Grid*
JFTB LOS ALAMITOS, CA • Microgrid

2.1 MW Contingency Microgrid
4 MW Combust. Gen./16 MW Solar
14 Day Minimum Capability
Example: Salt Lake City

• First “net zero energy” public safety building in US (pictured)
• 30% of panels wired to provide electricity to the building during grid outages
Example: Duluth

- Hartley Nature Center (city-owned facility) retrofitted with solar+storage
- Serves as Emergency Base of Operations for the city
DOE Toolkit: Building Resilience with Solar+Storage

Compendium of resources and case studies at:

http://solarmarketpathways.org/innovation/resilience/
Examples of Resilience Issues for State Utility Regulators

- Prudence of grid-hardening investments
- Distribution system planning/grid modernization
- Utility vs. third-party ownership of distributed generation, storage, and microgrids
- Tariff design for microgrids
- Interconnection standards and processes
Questions?

Please send questions through the Questions pane
Conclusions

Where regulators can align power sector transformation with the public interest:

• In structuring and operation of more open, transactive electricity markets;

• In new approaches to rate design and transparent price formation; and

• In business models used to provide clean, affordable, and resilient energy services to consumers.
About RAP

The Regulatory Assistance Project (RAP)® is an independent, non-partisan, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future.

Learn more about our work at raponline.org

Contact us at info@raponline.org