Transactive Energy for Power System Economics and Reliability

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Vice President
Smart Grid and Green Power

December 2012
WECC Generation Additions and Retirements
2010-2020

WECC Generation Capacity Additions
By Resource Type 2010-2020

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>15% by 2020</td>
</tr>
<tr>
<td>Gas</td>
<td>25% by 2025</td>
</tr>
<tr>
<td>Solar</td>
<td>33% by 2020</td>
</tr>
<tr>
<td>Hydro</td>
<td>15% by 2025</td>
</tr>
<tr>
<td>Geothermal</td>
<td>20% by 2020</td>
</tr>
<tr>
<td>Coal</td>
<td>25% by 2020</td>
</tr>
<tr>
<td>Other</td>
<td>20% by 2020</td>
</tr>
</tbody>
</table>

WECC 2020 Annual Energy Generation Type

- **Renewables**: 25%
- **Conventional Hydro**: 17%
- **Combined Cycle**: 29%
- **Steam - Coal**: 25%
- **Nuclear**: 8%
- **Combustion Turbine Cogeneration**: 16%
- **Other**: 17%


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A Sample CAISO Winter Day in 2020

Total solar capacity = 10,814 MW
(including behind the meter)
Total wind capacity = 5,450 MW
Flexible Resources will be Essential to Meeting the Net Load Demand Curve

- Flexible Generation
- Demand Response (DR), Storage (electric & thermal), Distributed Generation

Total solar capacity = 10,814 MW (including behind the meter)
Total wind capacity = 5,450 MW
Scheduling Practices

Balance Supply and Demand at all Times In all Balancing Areas

- Load Forecast
- VER Forecast

- Capacity
- Energy  
  - Hourly
- Reserves  
  - Non-Spin
  - Spin
- Regulation
- Forecast DR/DER
- Balancing Energy
- Ramping

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DR/DER: “Dancing Partner” of VER

- Under Generation
- Over Generation
- Time Variability

DR
Storage
“Fast” DR/DER (Short Term)
Typical Variable Generation Data

- A 200 MW Wind Farm in Utah
- Data from May 06–June 10, 2010
Hourly vs. Sub-Hourly Scheduling - FERC Order 764

Hourly Scheduling

15 Minute Scheduling

Energy Imbalance Levels

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Distribution/Retail Operational Issues

- Changing Load Profiles
- Demand Response
- Distributed Generation
- Distributed Storage

Distribution Congestion
## Demand-Side Programs to Wholesale Products

### Demand Response

<table>
<thead>
<tr>
<th>Wholesale Products</th>
<th>Vendors</th>
<th>Ancillary Services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grid-Interop 2012</td>
<td></td>
</tr>
</tbody>
</table>

**Grid-Interop 2012**

<table>
<thead>
<tr>
<th>Demand Response</th>
<th>Capacity</th>
<th>Seasonal</th>
<th>Voluntary</th>
<th>Notification</th>
<th>Non-Dispatchable</th>
<th>Dispatchable</th>
<th>Demand-limiting Control</th>
<th>Firm Commitment</th>
<th>Direct Load Control (DLC)</th>
<th>Conservation Voltage Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy</td>
<td>Day Ahead</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Real-time</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ancillary Services</td>
<td>30 Min Non-Spin</td>
<td>May</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>10 Min Non-Spin</td>
<td>May</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>10 Min Spin</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Regulation</td>
<td>May</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Wholesale Products**

- Capacity: Seasonal
- Energy: Day Ahead, Real-time
- Ancillary Services: 30 Min Non-Spin, 10 Min Non-Spin, 10 Min Spin, Regulation

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## Technical Requirements for Energy Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Response Time / Notice</th>
<th>Baseline Estimation</th>
<th>Telemetry</th>
<th>Real-Time Metering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional Energy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>Seasonal</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Day-Ahead Energy</td>
<td>A day</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Real-Time Energy</td>
<td>1 hour</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Interruptible Load</td>
<td>10-30 minutes</td>
<td>Maybe</td>
<td>No</td>
<td>Maybe</td>
</tr>
<tr>
<td><strong>Conventional Ancillary Services</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability Capacity</td>
<td>30 minutes to 2 hrs</td>
<td>Maybe</td>
<td>Maybe</td>
<td>No</td>
</tr>
<tr>
<td>30 minute Non-Spin</td>
<td>30 minutes</td>
<td>No</td>
<td>Maybe</td>
<td>Maybe</td>
</tr>
<tr>
<td>10 minute Non-Spin</td>
<td>10 minutes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10 minute Spin</td>
<td>10 minutes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Regulation</td>
<td>4 sec to 5 min</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>New</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ramping</td>
<td>5 minutes</td>
<td>No</td>
<td>?</td>
<td>Yes</td>
</tr>
<tr>
<td>Balancing Energy</td>
<td>5-15 Minutes</td>
<td>No</td>
<td>?</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Pricing Predicament

Wholesale Markets - ISO/RTOs

- Capacity
  - Seasonal Cap-Zones
- Energy
  - Day-Ahead Real-Time Locational
- Reserves
  - Day-Ahead Real-Time Zonal
- Regulation
  - Day-Ahead Real-Time Zonal

+ Uplifts:
  - Delivery Services Charges
  - Distribution Capacity Charges
  - Power Quality Charges
  - Loss Compensations
  - Incentives & Penalties
  - Etc.

Wholesale Prices

Retail Rates

End-Use Consumers

- Fixed
  - Tired
- TOU
- CPP/PTR
- RTP
- Net-Metering
- Feed-in

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Solution To Pricing Predicament

• Define “Services” from demand-side resources

• Different Pricing for Energy Consumption than Dispatched Services
  – *Energy Consumption*
    • Fixed, Tiered, Dynamic Rates
  – *Dispatchable Services (Energy, Ancillary Services, …)*
    • Price (Rate) for the DR “Services”
      – *Fixed Incentive, Pay-for-Performance, etc.*
      – *Enables creating wholesale products, e.g., Balancing Energy*
        » Response Time
        » Sustained Duration
      – *Measurement and Verification, and Settlement rules*

• FERC Order 745 - LMP Compensation for DR
End-to-End Integration & Interoperability
Transactive Operations Across The Operations Value Chain

**Wholesale Markets**
- Forecasting
- Market Clearing
- Settlements

**Balancing Area**
- Adequacy Assessment
- System Security
- System Balancing

**Power Marketing**
- Forecasting
- Scheduling Optimization
- Settlements

**Transmission Operation**
- EMS
- SCADA
- AGC
- Reserves Management

**Distribution Operation**
- SCADA / DMS
- GIS
- Forecasting Scheduling

**Customer Services**
- CIS
- MDMS
- AMI

**End-User Interfaces**
- Customer Portals
- Mobile Access

**DR-DER Management Functions**

**Secure Broadband / Cellular Wide-Area Communications**

**Utility AMI Communications**
- Utility Provisioned HAN or Customer Supplied HAN

**Industrial Control Systems**
- Utility Owned Assets

**Building Mgmt Systems**
- Industrial
- Commercial
- Generation
- Electric Storage
- Transportation
- Thermal Storage
- Residential
“Transactive” Operations

• Typical Transactions for E2E DR Operations
  – Registration and Qualifications
    • Modeling Parameters
  – Forecast of Available Capacity
  – Scheduling - Bids and Offers
    • By “Product” Type
  – Pricing / Notification Signals
  – Dispatch & Controls
  – Telemetry and Metering
  – Settlements
Some of Our Current Challenges

- **Seams between Wholesale and Retail Markets**
  - *Operational*
    - Modeling Parameters of Retail Assets
    - Accurate Forecasting of Available Capacity
    - Mapping to Wholesale Products
    - Metering and Telemetry
    - Scheduling protocols
  - *Pricing*
    - LMPs vs. Retail Pricing Signals
    - Distribution Charges
  - *Distribution Congestion*
    - Coordination with Distribution Operation
  - *Regulatory Framework*
    - Bulk Power
    - Retail
THANK YOU

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