Transactive Energy Case Study: Supply of Ancillary Services & Balancing Energy

Ali Ipakchi
Vice President
Smart Grid and Green Power

December 10, 2013
Trade Secret

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## Conventional Transactions for Power System Operation

| Months Ahead Seasonal | • Resource Adequacy  
|                       |    - Energy  
|                       |    - Reserves  
|                       | • Contracts (Capacity, Generation, Transmission)  
| Week Ahead | • Load Forecast  
|           | • Unit Commitment  
|           | • Interchange Scheduling  
| Day Ahead | • Load Forecast  
|          | • Economic Dispatch  
|          |    - Energy  
|          |    - Reserves  
|          | • Congestion Management  
| Hour Ahead | • System Balancing  
|            | • Generation Control  
|            | • Reliability Management  
| Real-Time | • Metering  
|           | • Settlements  
| Post Operation |  

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Conventional Power System Operations

Established:
- Regulatory Framework
- Business Practices
- Transactional Framework
WECC Generation Additions & Retirements 2010-2020

WECC Generation Capacity Additions By Resource Type 2010-2020

- Wind
- Gas
- Solar
- Hydro
- Geothermal
- Coal
- Other

Capacity (MW)

0 5,000 10,000 15,000

WECC 2020 Annual Energy Generation Type

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

WECC 2020 Generation Additions & Retirements

- CA: 33% by 2020
- OR: 25% by 2025
- NV: 25% by 2025
- UT: 20% by 2025
- CO: 30% by 2020
- NM: 20% by 2020
- AZ: 15% by 2025
- WA: 15% by 2020
- OR: 25% by 2025
- NV: 25% by 2025
- UT: 20% by 2025
- CO: 30% by 2020
- NM: 20% by 2020
- AZ: 15% by 2025
- WA: 15% by 2020

12,079 MW of OTC
California’s Projected Renewable Resources

Source: CPUC LTPP / CAISO
CAISO’s Projected Load Shape - The Duck Curve

Source: CAISO
Flexible Capacity - California

System Operator needs to ensure sufficient **ramping** and **load following** capability is available to satisfy ramping and **multi-hour** and **intra-hour** generation **variability**, while also having sufficient **contingency reserves** to ensure the security and safety of the grid.

- CPUC: Flexible Resource Adequacy Requirements
- CA Loading Order - Preferred Resources
  - EE, DR, Storage, Distributed Generation
- CPUC Storage Requirements Order (IOUs)

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<th>Storage Grid Domain</th>
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<th>2016</th>
<th>2018</th>
<th>2020</th>
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<td>30</td>
<td>45</td>
<td>70</td>
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<td>Total - all 3 utilities</td>
<td>200</td>
<td>270</td>
<td>365</td>
<td>490</td>
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Calculated Flexible Capacity Requirement

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<th>MW</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
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<td>Total_Flex_Need_2014</td>
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<td>9,975</td>
<td>10,072</td>
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<td>7,720</td>
<td>9,389</td>
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<td>7,096</td>
<td>7,895</td>
<td>7,795</td>
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<td>Total_Flex_Need_2016</td>
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Preferred Resources

EE, DR, Distributed Storage, Distributed Generation

I. Load Shape Modifying
   • Energy Efficiency
   • Time of Use and Peak Pricing Demand Response
   • “Prices to Devices”

II. Grid Support & Reliability - Flexible Resources
   • Conventional Ancillary Services:
     ▪ Non-Spin, Spin and Regulation
   •Balancing Energy
   • Ramping
   • Forecastable, Dispatchable/Controllable, Reliable

Transmission versus Distribution Operations
### Demand-Side Programs & Wholesale Products

#### Non-Dispatchable

<table>
<thead>
<tr>
<th>Economic</th>
<th>Voluntary</th>
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<tbody>
<tr>
<td>Capacity</td>
<td>Conventional</td>
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<tr>
<td>Flexible</td>
<td>Yes</td>
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#### Dispatchable

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<tr>
<th>Economic</th>
<th>Voluntary</th>
<th>Demand-limiting Control</th>
<th>Firm Commitment</th>
<th>Direct Load Control (DLC)</th>
<th>Conservation Voltage Regulation</th>
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<tr>
<td>Flexible</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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#### Ancillary Services

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<tr>
<th>Reliability</th>
<th>Demand-Side Programs</th>
<th>Wholesale Products</th>
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<tr>
<td>30 Min Non-Spin</td>
<td>Maybe</td>
<td>Yes</td>
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<td>10 Min Non-Spin</td>
<td>Maybe</td>
<td>Maybe</td>
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<tr>
<td>10 Min Spin</td>
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<td>Maybe</td>
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<tr>
<td>Regulation</td>
<td>Maybe</td>
<td>Yes</td>
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<tr>
<td>Balancing (New)</td>
<td>Ramping</td>
<td>Maybe</td>
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<tr>
<td>Flexibility Reserve</td>
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# Technical Requirements

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<tr>
<th>Products</th>
<th>Response Time</th>
<th>Telemetry</th>
<th>Interval Metering (Aggregate)</th>
<th>Baseline Estimation (Aggregate)</th>
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<td>Individual Asset</td>
<td>Aggregate</td>
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<tr>
<td>Capacity</td>
<td>Conventional</td>
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<td>Flexible</td>
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<td><strong>Energy</strong></td>
<td>Day Ahead</td>
<td>Hourly</td>
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<tr>
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<td>10 Minutes</td>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>10 Min Spin</td>
<td>10 Minutes</td>
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<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Regulation</td>
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<td><strong>Reliability</strong></td>
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The Emerging Transactive Requirements: Sample Transactions

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# New Operational Requirements

| Months Ahead | • Resource Adequacy  - Demand-Side Resources  
|             |   - Energy  
|             |   - Reserves  
|             | • Contracts (Capacity, Generation, Transmission)  - Retail  - Distribution  
| Seasonal    |                                                                  
| Week Ahead  | • Load Forecast  - DR-DER-VER Forecast   
|             | • Unit Commitment  - Coordinated with DR-DER Commitment  
|             |   Aggregation and Productization  
|             | • Scheduling  - DR-DER Schedules  
| Day Ahead   |                                                                  
| Day Ahead   | • Load Forecast  - DR-DER-VER Forecast   
|             | • Economic Dispatch  - Extended with DR-DER  
|             |   - Energy  
|             |   - Reserves  
|             | • Congestion Management  - Distribution Reliability  
| Hour Ahead  |                                                                  
| Hour Ahead  |                                                                  
| Real-Time   | DR-DER Provision of Balancing Services  
|             | Coordinated DR-DER Dispatch & Control  
|             | Distribution “Congestion” Management  
|             | • System Balancing  
|             | • Generation Control  
|             | • Reliability Management  
| Post Operation | Interval Metering, Aggregation, Products/Services  
|             | Baselines  - M & V and Settlement Rules  
|             | • Metering  
|             | • Settlements  

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Inter- & Intra- Domain Transactions
## Operational Domains

<table>
<thead>
<tr>
<th>Operational Domains</th>
<th>Registration &amp; Qualification</th>
<th>Reservation</th>
<th>Forecasting</th>
<th>Scheduling &amp; Bidding</th>
<th>Clearing, Dispatch &amp; Control</th>
<th>Measurement &amp; Verification</th>
<th>Settlement</th>
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### Operational Lifecycle

- **Bulk Power**
- **Retail Power**

**Bilateral Decentralized**

- Centralized

- Transactive Energy - Seams Issues

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Transactive Energy Framework Considerations

Operational Layers

- Wholesale Markets & Balancing Authorities
- Generation
- Transmission
- Trading
- Customer Services
- Distribution
- Retail Markets
- Consumers
- DER Assets Microgrids
- DR Assets

Emerging Capabilities

- Economic/Regulatory Policy
- Business Objectives
- Business Procedures
- Business Context
- Semantic Understanding
- Syntactic Interoperability
- Network Interoperability
- Basic Connectivity

Operational Lifecycle

- Registration & Qualification
- Reservations
- Forecasting
- Scheduling / Bidding
- Clearing, Dispatch & Control
- Measurement & Verification
- Settlements

Interoperability

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Case study characteristics and objectives:

- Motivated by the Industry’s Business and Operational Needs
- Initiated and funded by OATI in conjunction with several utility projects

  - **Primary objective:** Integrate Demand-Side Capabilities with System Operations within existing utility business and operating framework
  
  - **Secondary Objective:** Advance Transactive Techniques and address Interoperability for End-to-End operations – use cases, data flows, etc.
Case Study Information

• Transactive Energy Attributes
  – **Architecture:** Distributed/Decentralized architecture with bilateral transactions connecting operational entities – backed by a unified information and transactional model

  – **Extents:** End-to-end power system operations from demand-side resources to bulk power markets, including all intermediary entities: DRP, UDC, LSE, Merchant, Grid & Market Operator; covering Life Cycle phases from registration, to forecasting, bidding, scheduling, dispatch/control, measurement, verification, and settlements.
Transactive Energy Attributes (Cont’d)

- **Transactions**: The commodities transacted include primarily energy (kWh/MWh), but may also include capacity (kW/MW), conventional reserves (Non-spinning, Spinning, Regulation), and new reserve products (Flexibility Reserves, Ramping, Load Following, etc.).

- **Transacting parties**: Transacting parties may include human participants/actors or intelligent systems/devices.

It covers retail customers, including residential, C&I, microgrids, as well as business and operational entities including CSP/DRPs, UDCs, LSEs, Energy Trading, transmission operators and balancing authorities, and wholesale market operators.
Case Study Information

• Transactive Energy Attributes (Cont’d)
  – Temporal variability: The transaction time scales range from multi-day, multi-hour to sub-hourly (5 minute). The deployment/delivery of the transaction may be time-triggered, event-triggered, or on demand.
  – Interoperability: Technical, Informational and organizational interoperability (GWAC Stack) are addressed. Where relevant, interoperability standards are used.
  – Value discovery mechanisms: The value discovery is based on the economic and reliability services offered to power system, at retail power/distribution, and at bulk power/transmission levels.

Significant value can be captured in mitigating the impact of variable generation both at distribution and transmission levels. The value discovery is affected either based on reference market or hub prices or through bilateral bid/ask mechanisms.
Case Study Information

• Transactive Energy Attributes (Cont’d)
  
  – **Value assignment:** Based on energy and ancillary service products offered/delivered.
  
  – **Alignment of objectives:** Defining required DR-DER characteristics for supply of capacity, energy and ancillary service products, and creating clearing process for such products.
  
  – **Stability Assurance:**
    
    – End-to-end alignment with power system operational life cycle;
    
    – Economic incentives/prices aligned with system level and physical grid requirements and constraints.
    
    – Life cycle operational and temporal rules, e.g., qualifying, forecasting, offering, scheduling, coordinated (hierarchical) clearing times, and penalties for lack of performance
**Case Study Information**

- **Participating agencies and organizations:**
  - OATI DR-DER Customers
  - OATI Bulk Power Customers
    - FERC & NERC Rules and Operating Guides

- **References:**
  - OATI Customers
  - Various Presentations and Publications
Conclusions

• Environmental regulations causing greater levels of variable generation
• Cost Parity of demand-side and distributed resources for supply of energy and balancing services
• Demand-side and Distributed Resources are becoming an integral part of power system operations
  – Capacity, Energy, Balancing and Ancillary Services
• Benefits are realized through end-to-end and operational life-cycle integration
• Transactive Techniques enable such Integrations
• Significant momentum is building up
Thank You

Ali Ipakchi
sales@oati.com
763.201.2000