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

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Trade Secret

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Conventional Transactions for Power System Operation

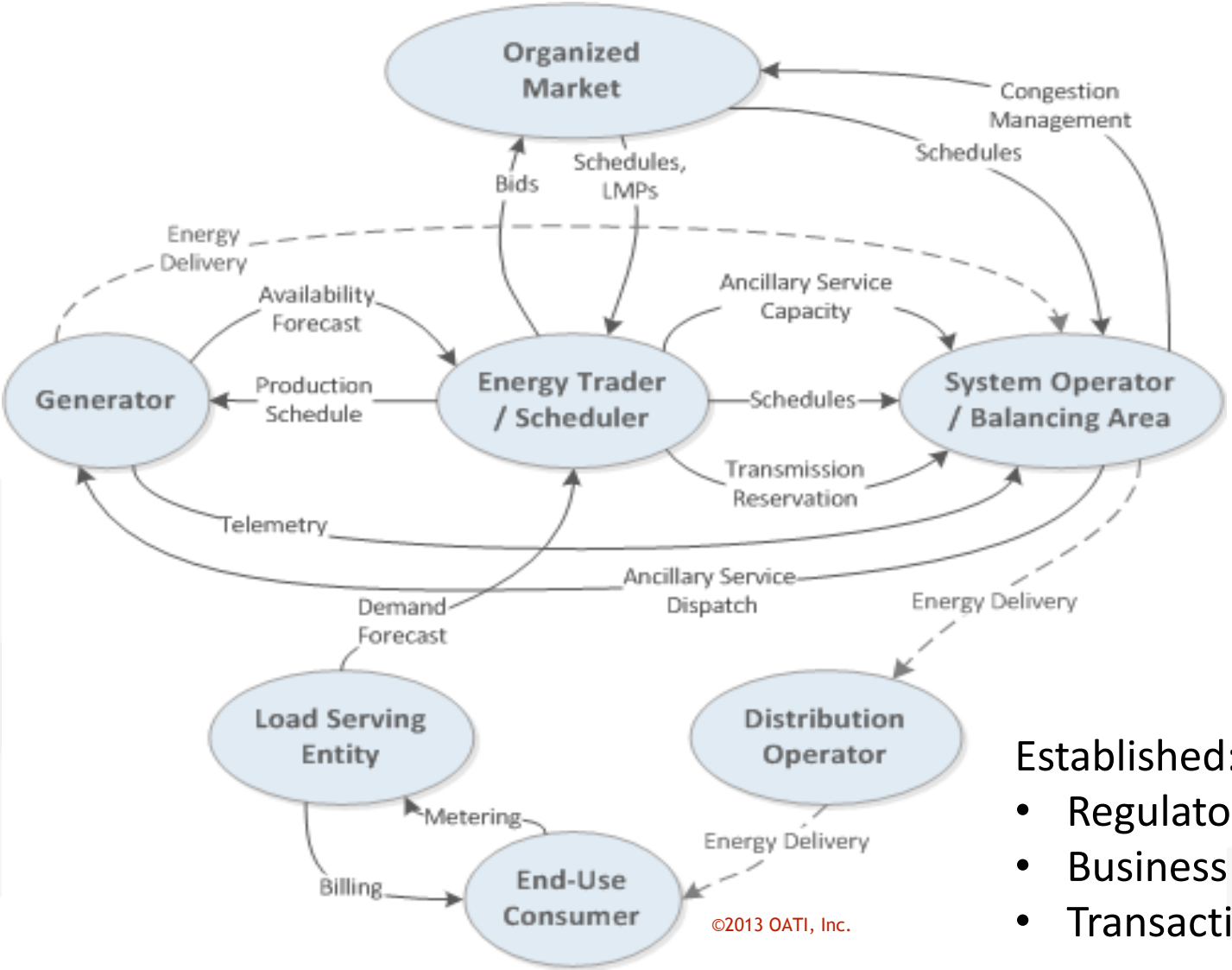
Months Ahead Seasonal	• Resource Adequacy
	  - Energy
	  - Reserves
	• Contracts (Capacity, Generation, Transmission)

Week Ahead	• Load Forecast • Unit Commitment • Interchange Scheduling

Day Ahead
 	
Hour Ahead
	• Load Forecast
	• Economic Dispatch
	  • Energy
	  • Reserves
	• Congestion Management

Real-Time	• System Balancing • Generation Control • Reliability Management
Post Operation	• Metering • Settlements

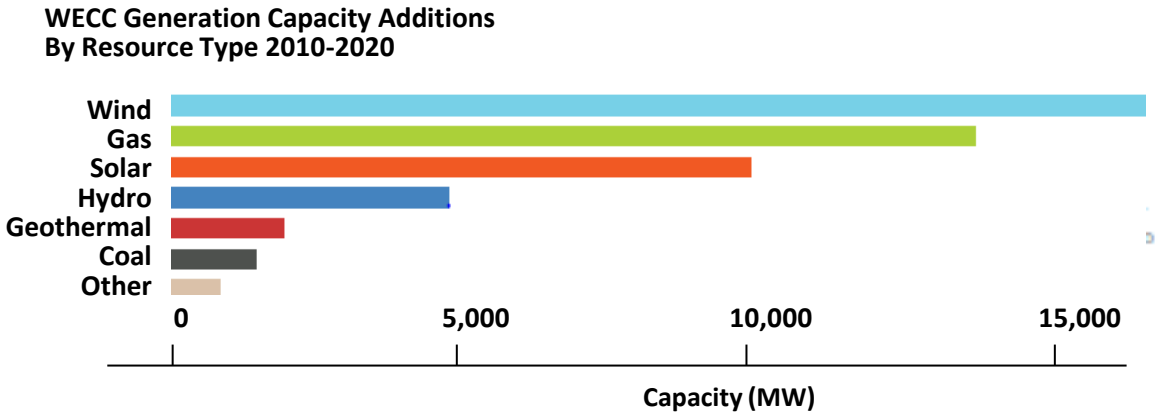
Conventional Power System Operations

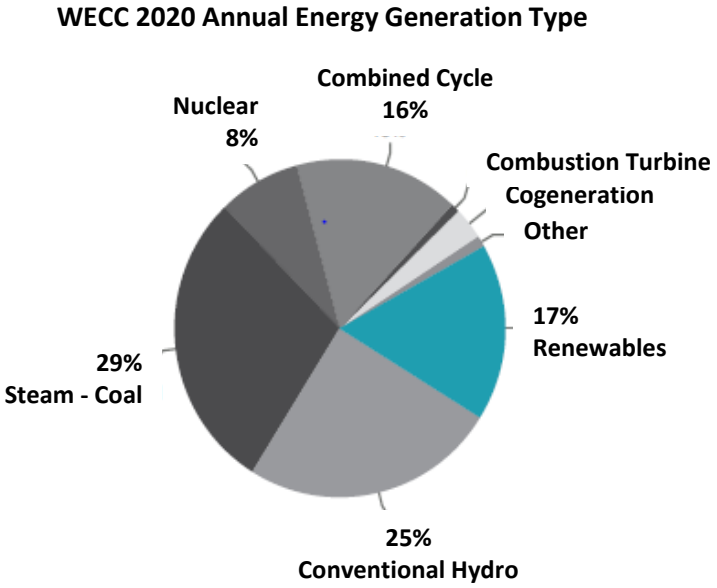


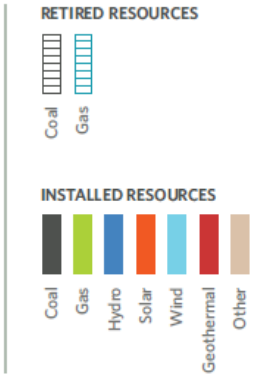
Established:

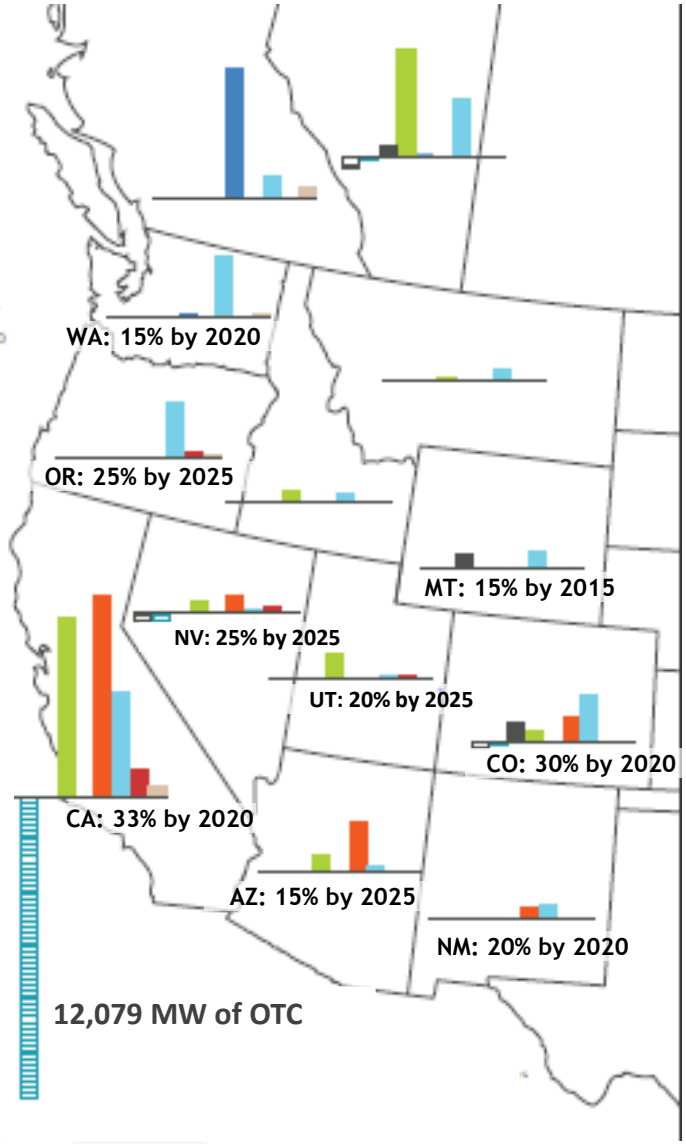
- Regulatory Framework
- Business Practices
- Transactional Framework

WECC Generation Additions & Retirements 2010-2020



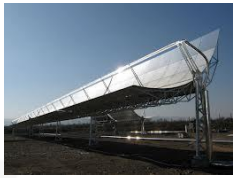


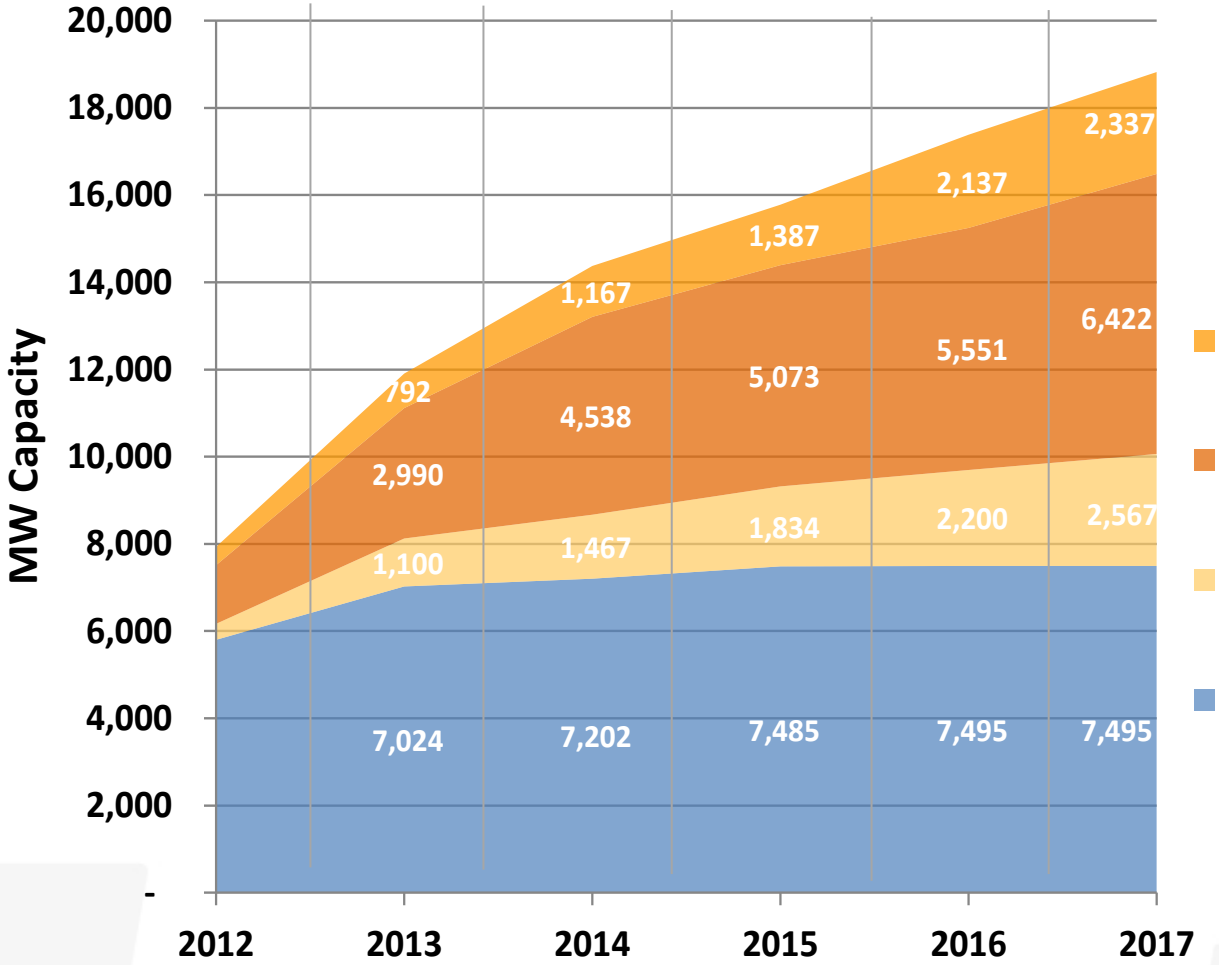




Source: 2011 WECC 10-Year Regional Transmission Plan - Executive Summary - Sept. 22, 2011

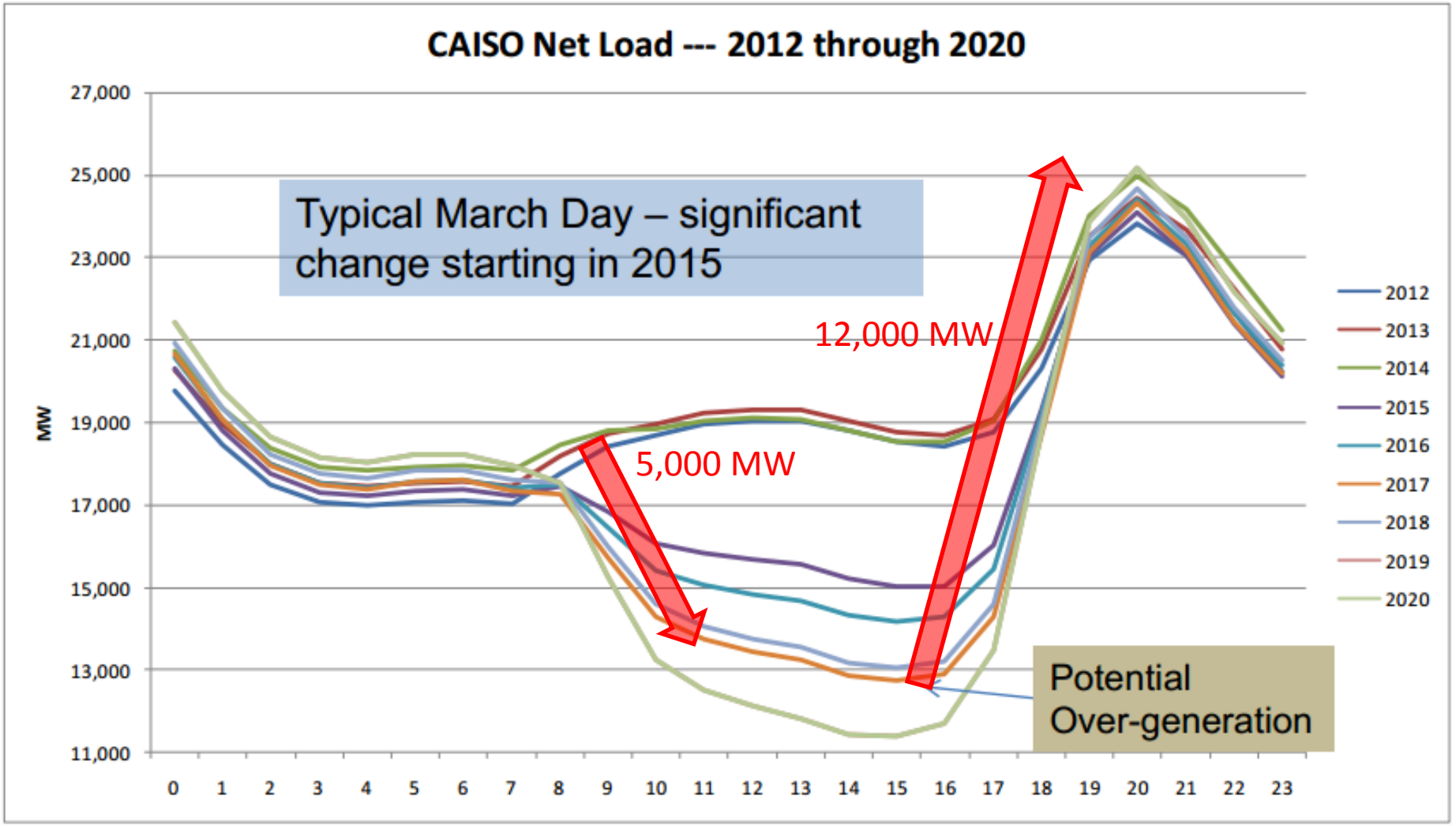
California's Projected Renewable Resources





Source: CPUC LTPP / CAISO

CAISO's Projected Load Shape – The Duck Curve

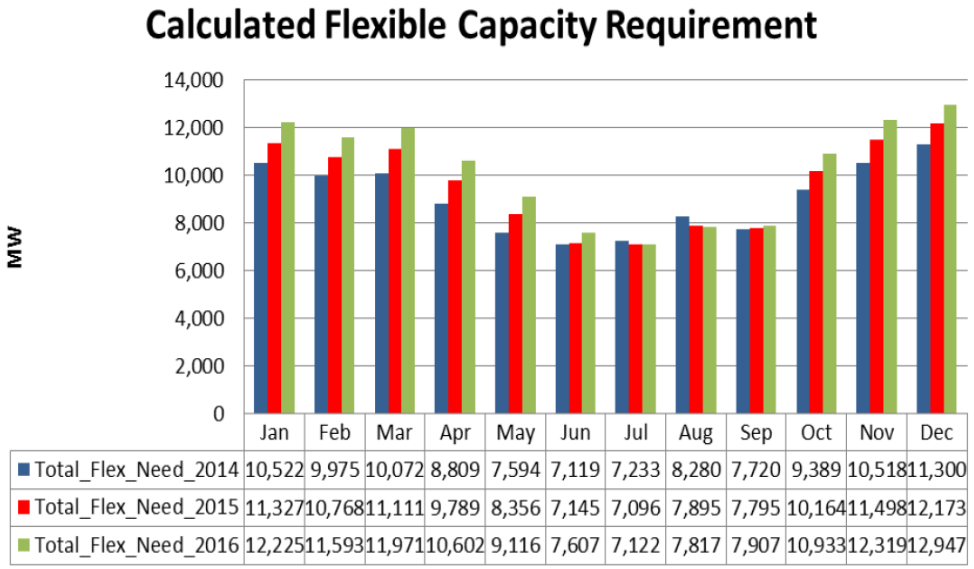


Source: CAISO

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)



Storage Grid Domain (Point of Interconnection)	2014	2016	2018	2020	Total
Southern California Edison					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal SCE	**90**	**120**	**160**	**210**	**580**
Pacific Gas and Electric					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal PG&E	**90**	**120**	**160**	**210**	**580**
San Diego Gas & Electric					
Transmission	10	15	22	33	80
Distribution	7	10	15	23	55
Customer	3	5	8	14	30
Subtotal SDG&E	**20**	**30**	**45**	**70**	**165**
Total - all 3 utilities	**200**	**270**	**365**	**490**	**1,325**

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

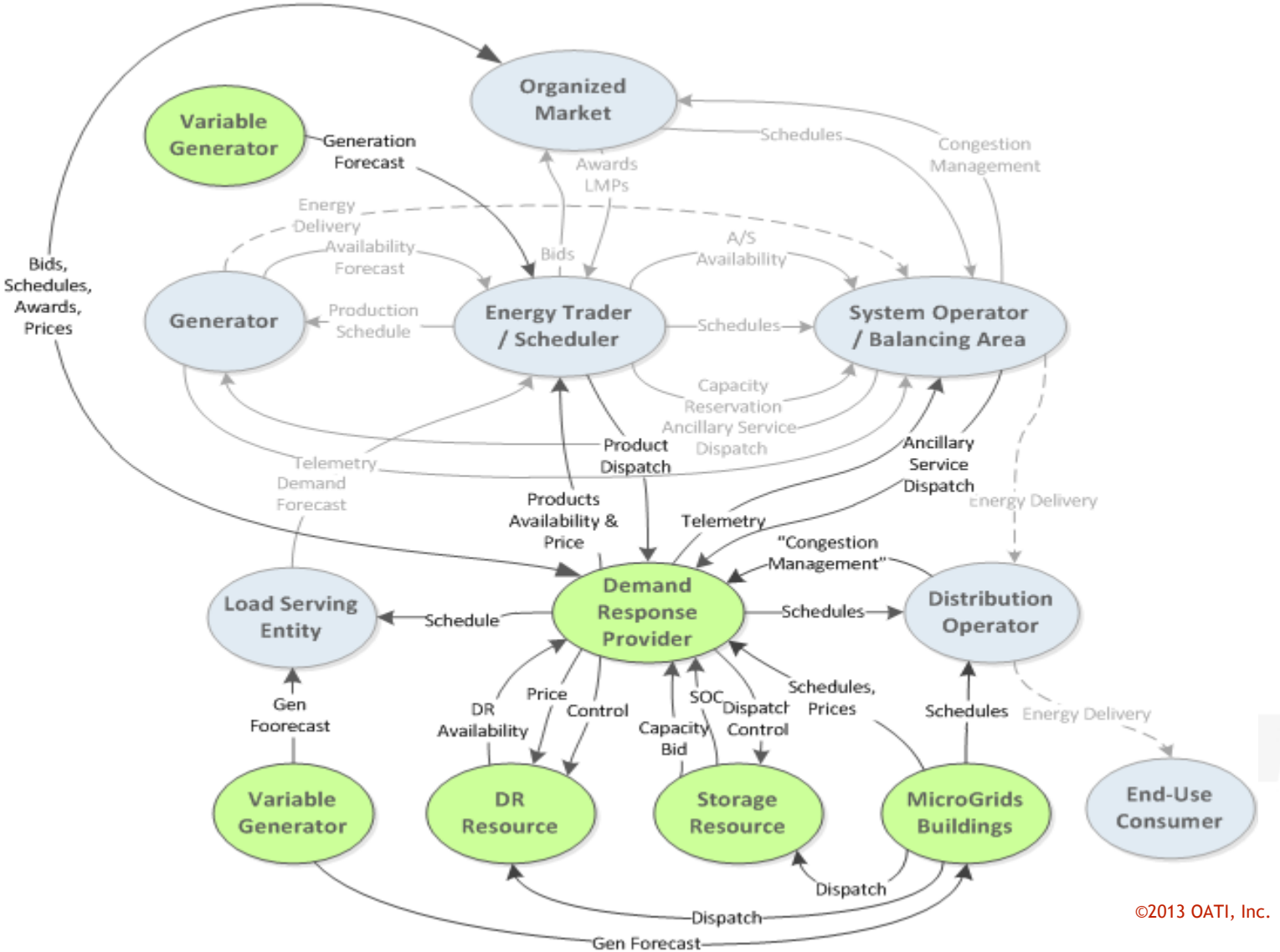
Demand-Side Programs

Wholesale Products			Non-Dispatchable			Dispatchable				
			Voluntary		Demand-limiting Control	Firm Commit-ment	Direct Load Control (DLC)		Conservation Voltage Regulation
				Noti-fication		Notification			
Economic	Capacity	Conventional	Maybe	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Flexible	Maybe	Maybe	Yes	Yes	Yes	Yes	Yes	Yes
	Energy	Day Ahead	Maybe	Maybe	Maybe	Yes	Yes	Yes	Yes	Yes
		Real-time				Maybe	Yes	Yes	Yes	Yes
Reliability	Ancillary Services	30 Min Non-Spin				Maybe	Yes	Yes	Yes	Yes
		10 Min Non-Spin				Maybe	Maybe	Yes	Yes	Yes
		10 Min Spin						Yes	Yes	Yes
		Regulation						Maybe	Yes	Maybe
	Balancing (New)	Ramping						Maybe	Yes	Maybe
		Flexibility Reserve						Maybe	Yes	Maybe

Technical Requirements

		Products	Response Time	Telemetry		Interval Metering (Aggregate)	Baseline Estimation (Aggregate)
				Individual Asset	Aggregate		
Economic	Capacity	Conventional	Contract	No	No	Yes	Yes
		Flexible	Various	No	No	Yes	Yes
	Energy	Day Ahead	Hourly	No	No	Yes	Yes
		Real-time	5 Minutes	No	No	Yes	Yes
Reliability	Ancillary Services	30 Min Non-Spin	30 Minutes	No	Yes	Yes	Maybe
		10 Min Non-Spin	10 Minutes	No	Yes	Yes	Maybe
		10 Min Spin	10 Minutes	Maybe	Yes	Yes	Maybe
		Regulation	4 Sec to 5 Min	Yes	Yes	No	No
	Balancing	Ramping	5 Minutes	Maybe	Yes	Yes	Maybe
		Balancing Energy	5-15 Minutes	Maybe	Yes	Yes	Maybe

The Emerging Transactive Requirements: Sample Transactions



New Operational Requirements

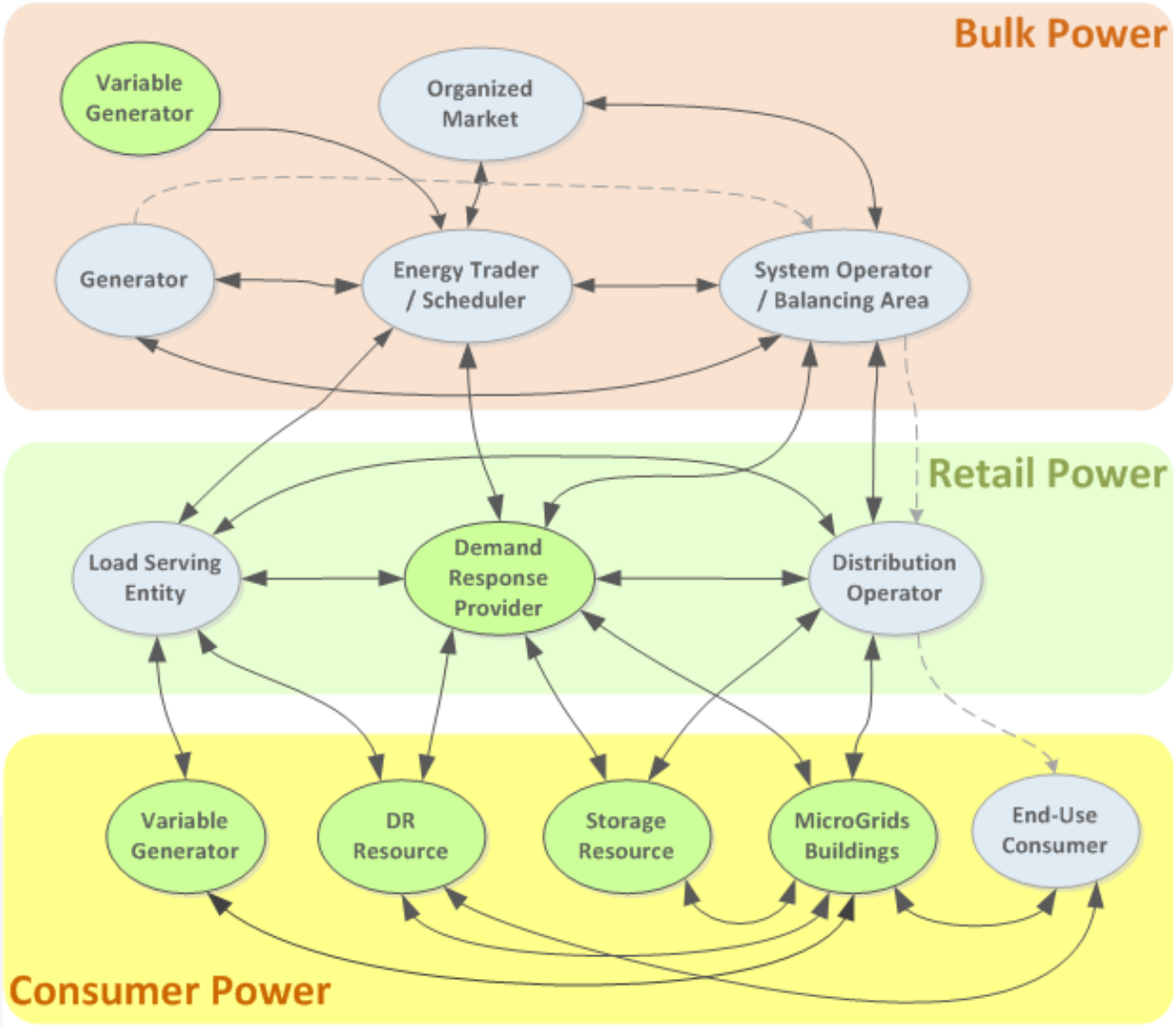
Months Ahead Seasonal	• Resource Adequacy - Demand-Side Resources
	  - Energy
	  - Reserves
	• Contracts (Capacity, Generation, Transmission) – Retail - Distribution

Week Ahead	• Load Forecast – DR-DER-VER Forecast • Unit Commitment - Coordinated with DR-DER Commitment Aggregation and Productization • Scheduling - DR-DER Schedules

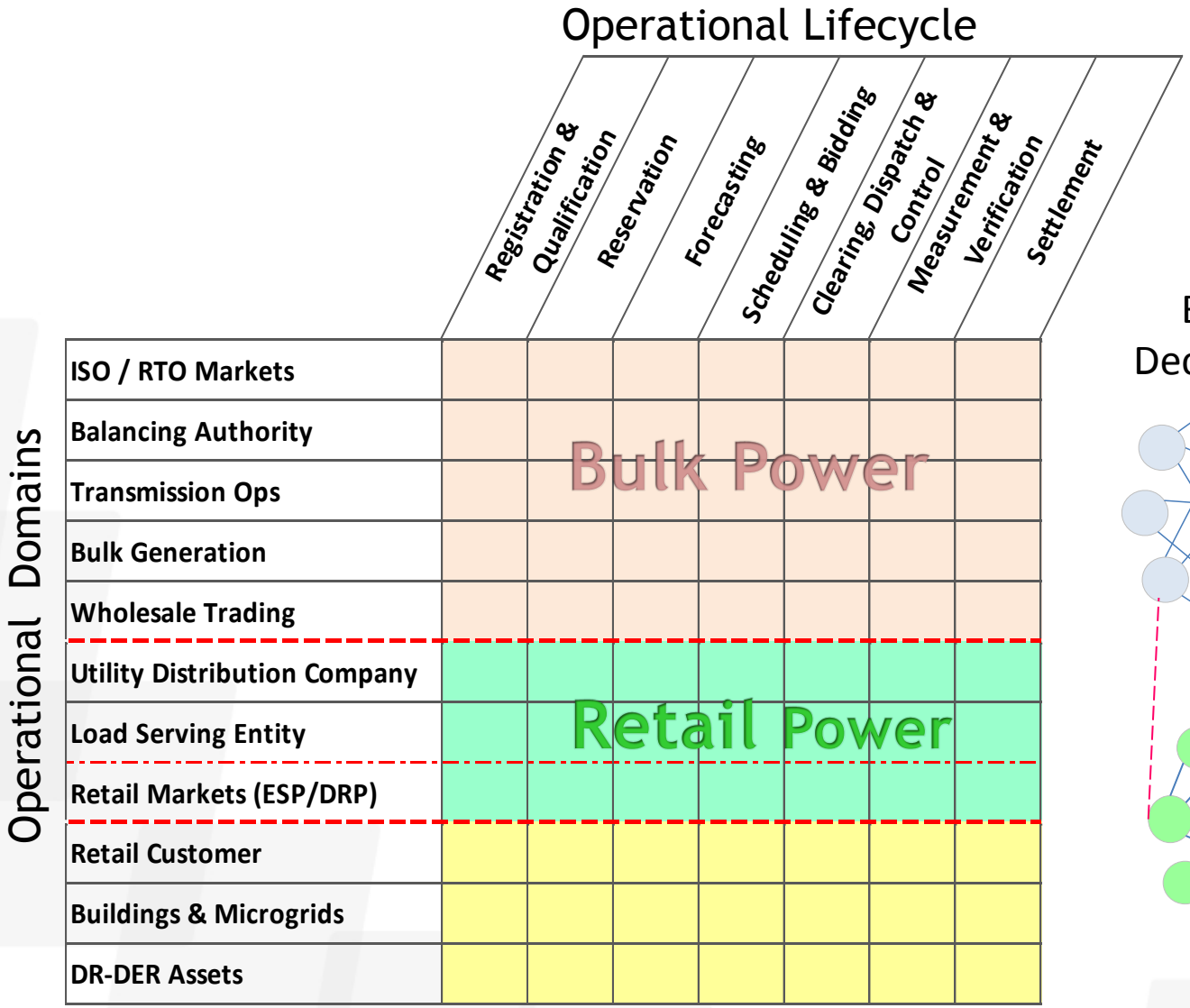
Day Ahead
Hour Ahead
	• Load Forecast – DR-DER-VER Forecast
	• Economic Dispatch – Extended with DR-DER
	  • Energy
	  • Reserves
	• Congestion Management – Distribution Reliability

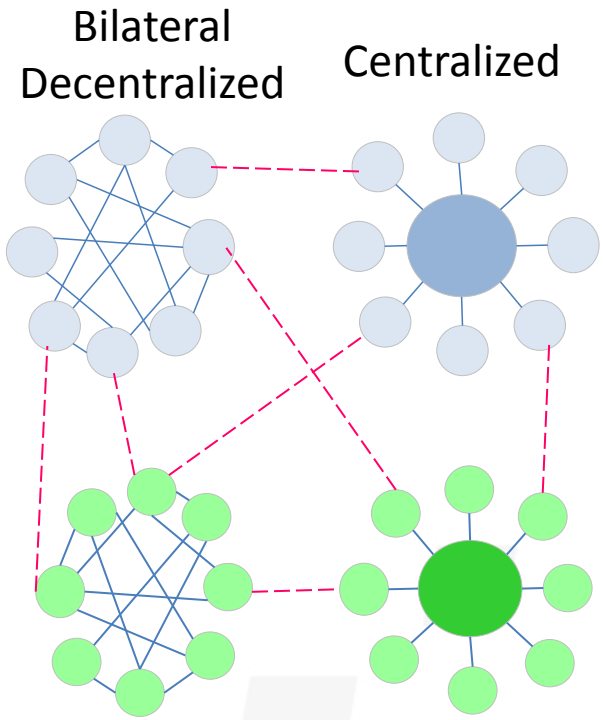
Real-Time	DR-DER Provision of Balancing Services Coordinated DR-DER Dispatch & Control Distribution "Congestion" Management • System Balancing • Generation Control • Reliability Management
Post Operation	Interval Metering, Aggregation, Products/Services Baselines – M & V and Settlement Rules • Metering • Settlements

Inter- & Intra- Domain Transactions

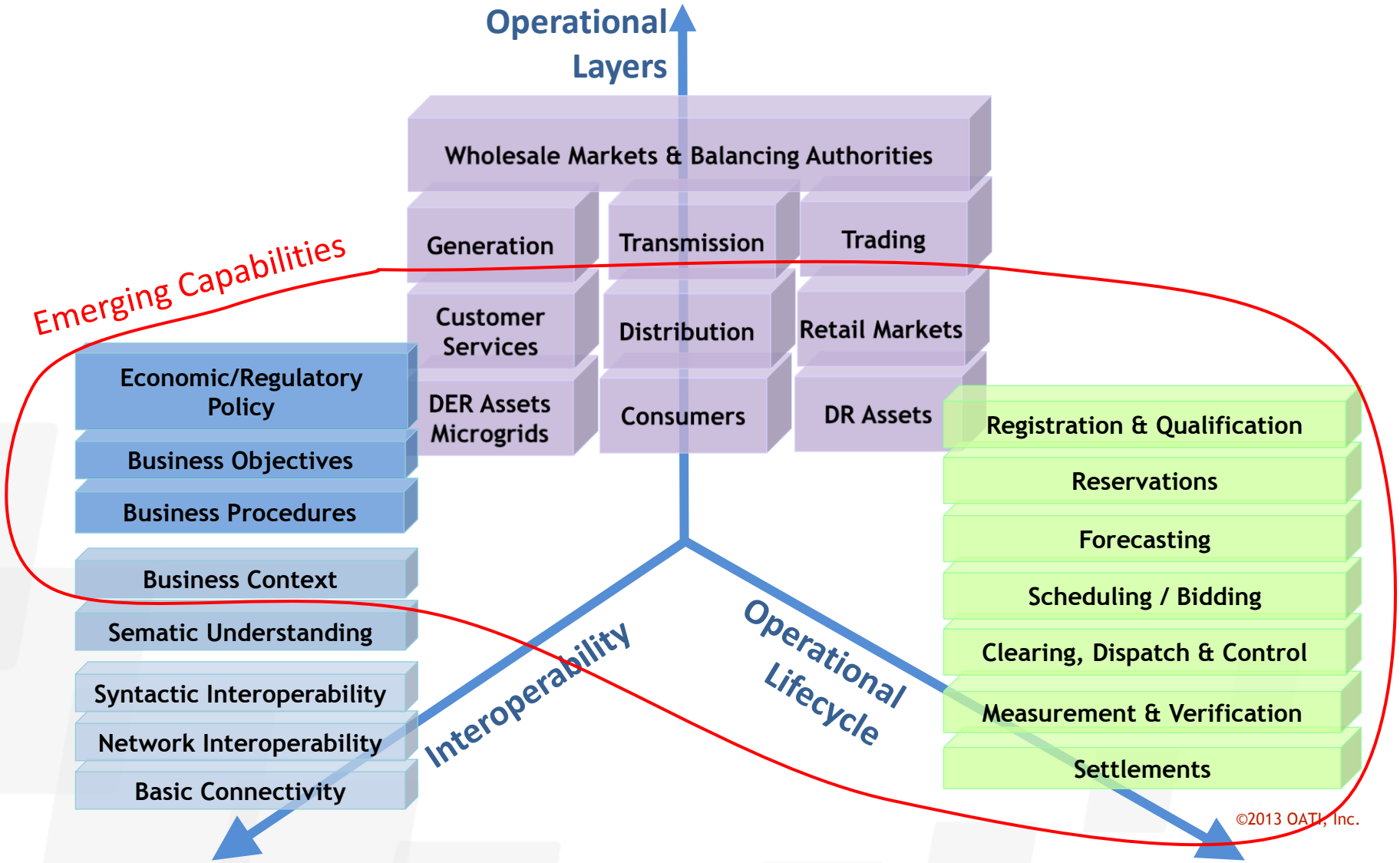


Transactive Energy – Seams Issues





Transactive Energy Framework Considerations



Case Study Information

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.

Case Study Information

- **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

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