Transactive Energy for Power System Economics and Reliability

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December 2012

Trade Secret

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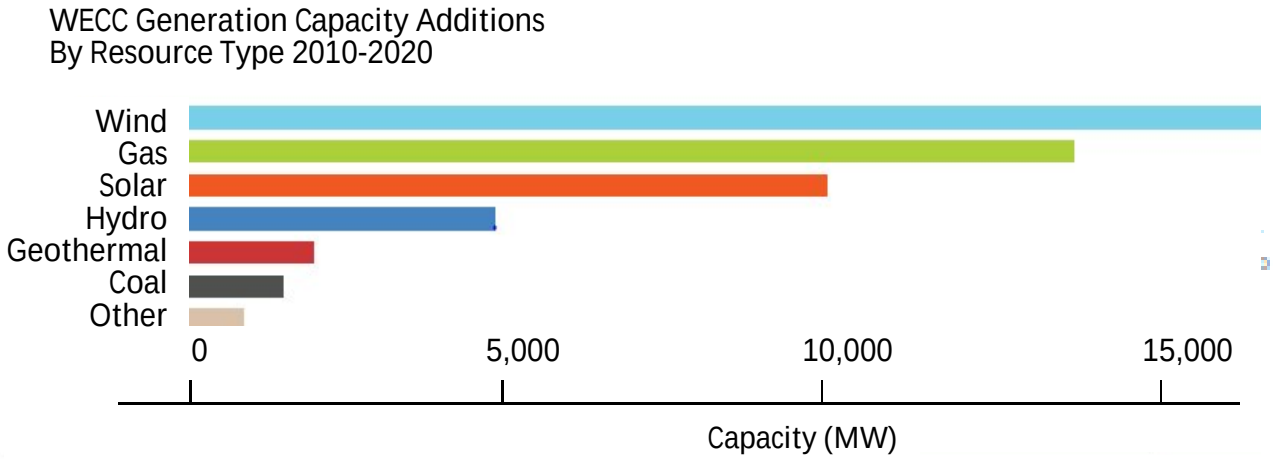
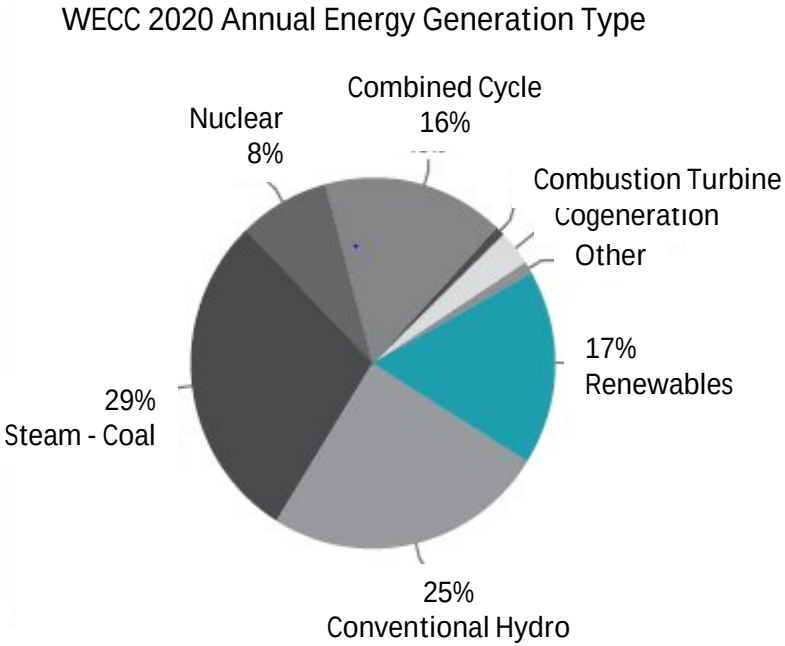
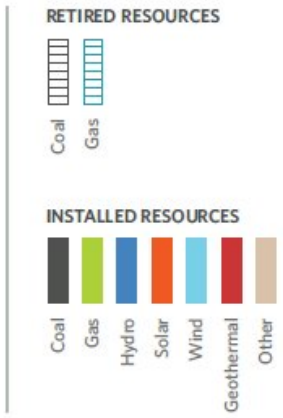
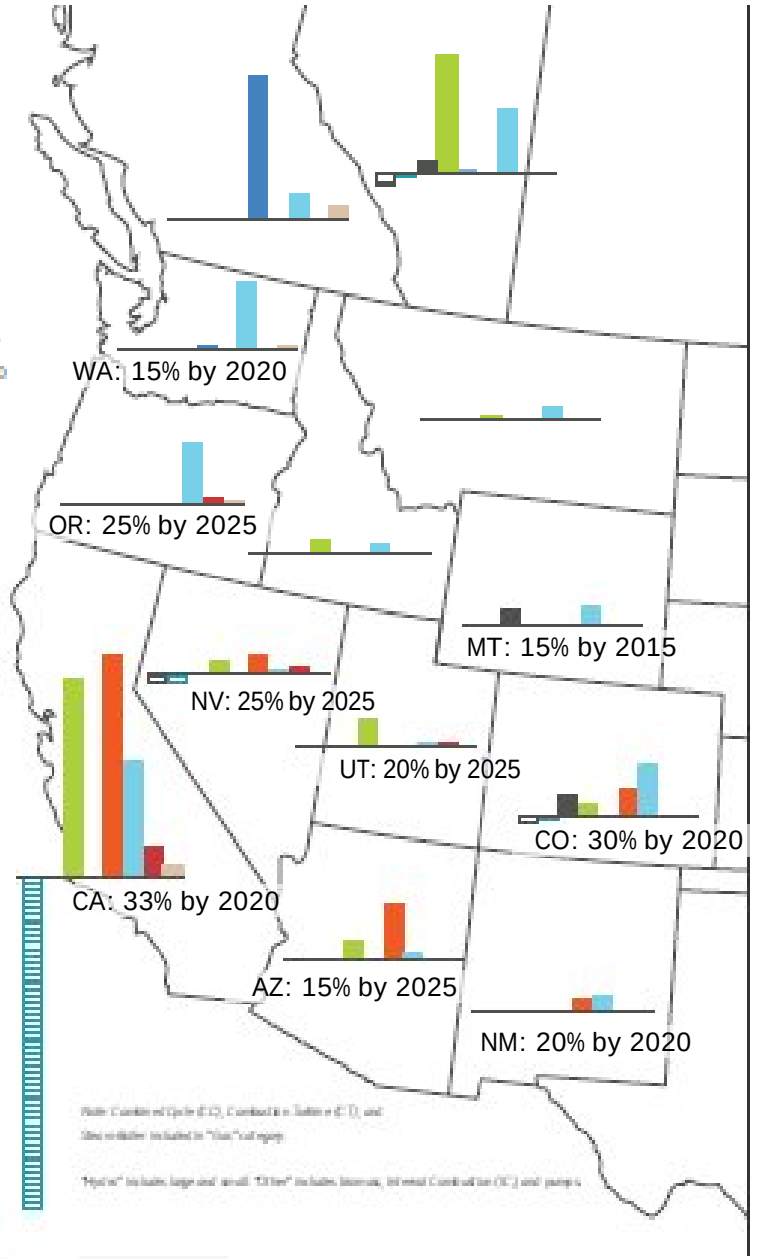
Proprietary Notice

WECC Generation Additions and Retirements 2010-2020



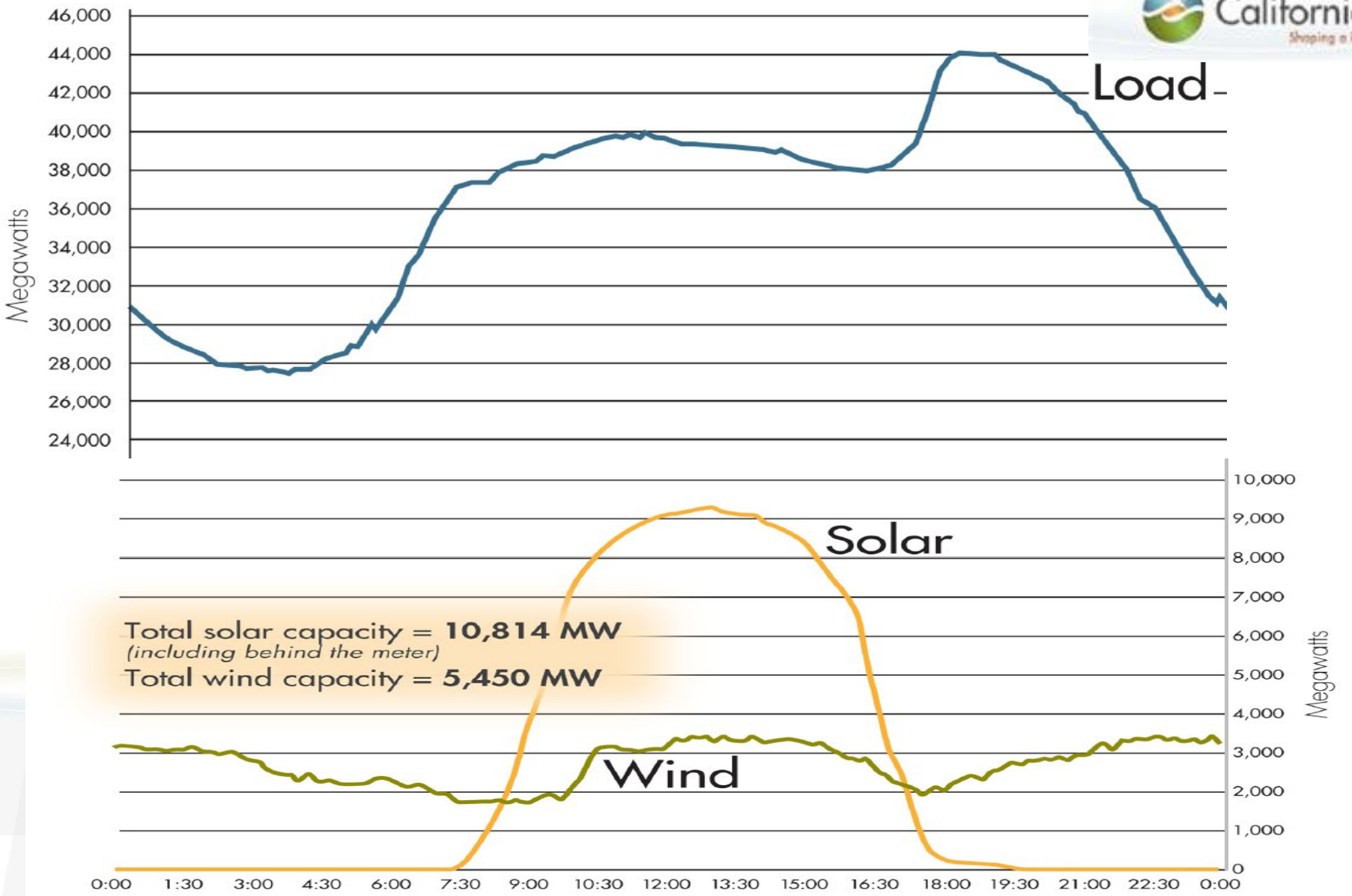




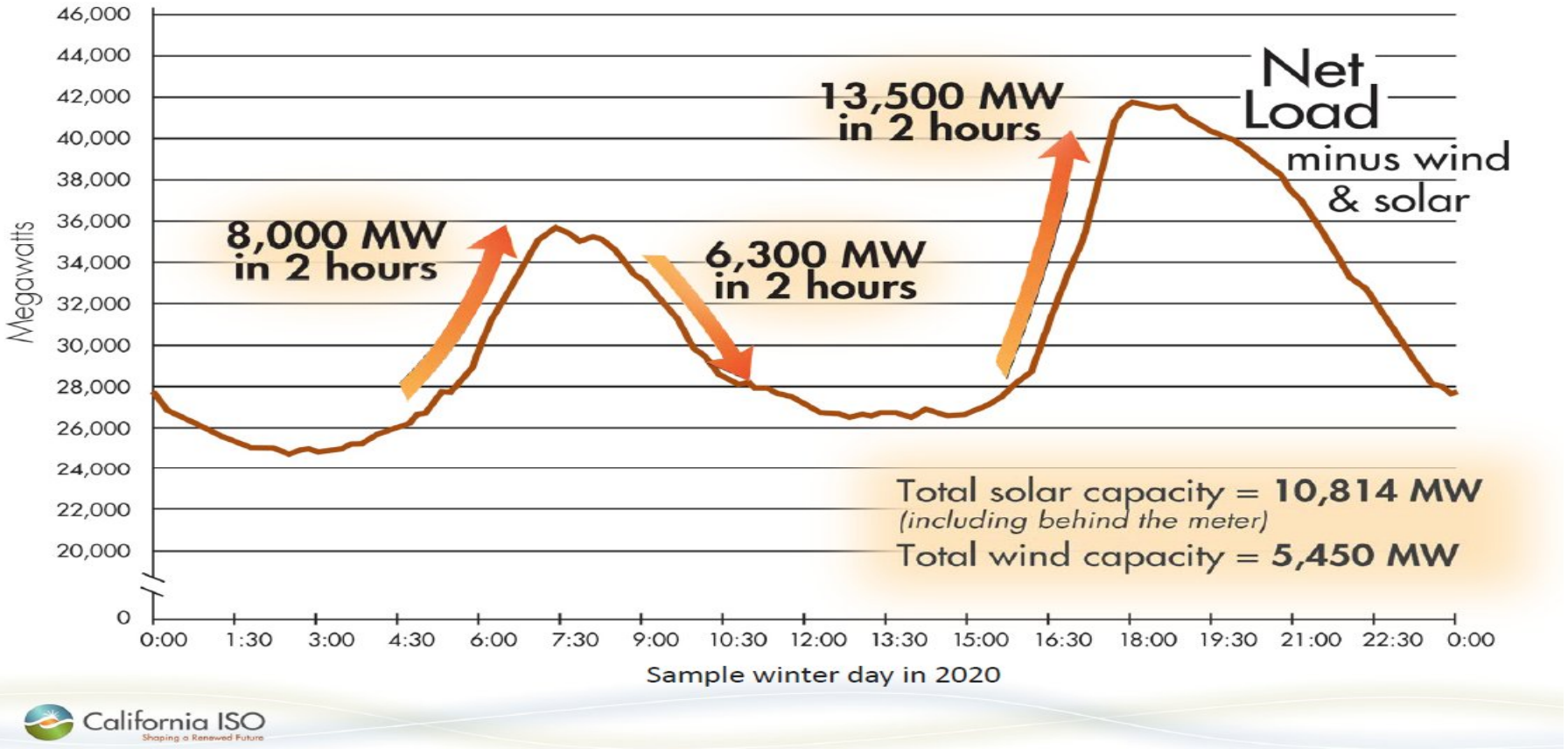


Source: 2011 WECC 10-Year Regional Transmission Plan - Executive Summary - Sept. 22, 2011

A Sample CAISO Winter Day in 2020

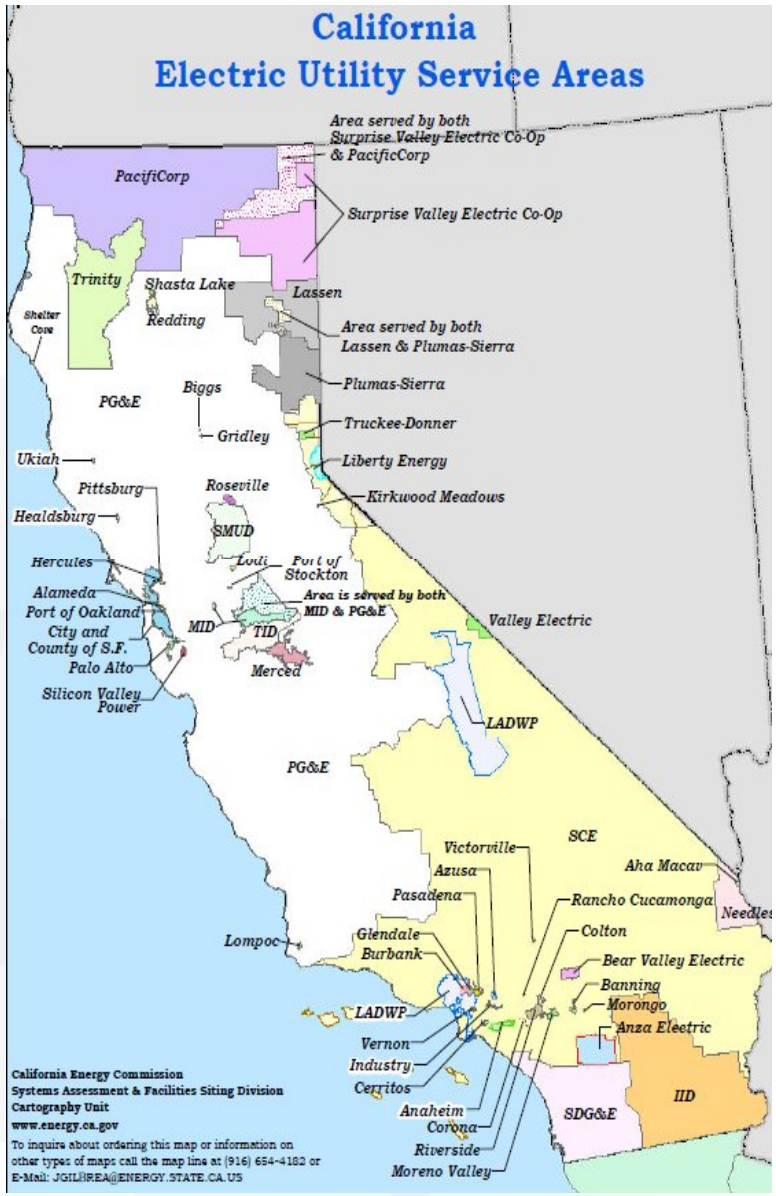


Flexible Resources will be Essential to Meeting the Net Load Demand Curve

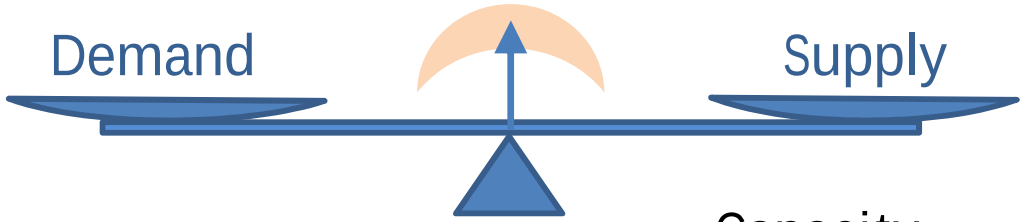


- Flexible Generation
- Demand Response (DR), Storage (electric & thermal), Distributed Generation

Scheduling Practices



Balance Supply and Demand at all Times In all Balancing Areas

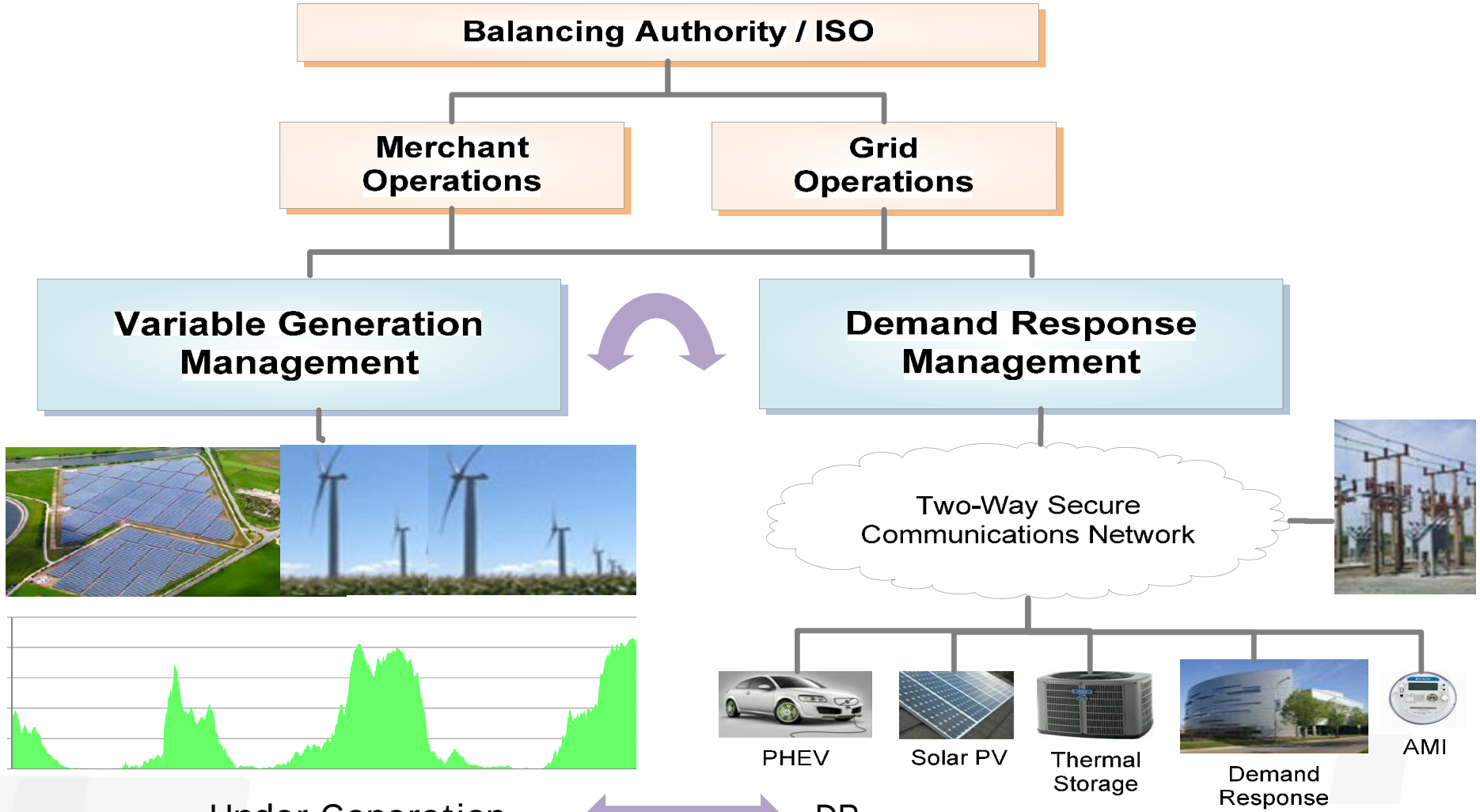


- Load Forecast
- VER Forecast
- Capacity
- Energy
  - *Hourly*
- Reserves
  - *Non-Spin*
  - *Spin*
- Regulation

New

- Forecast DR/DER
- Balancing Energy
- Ramping

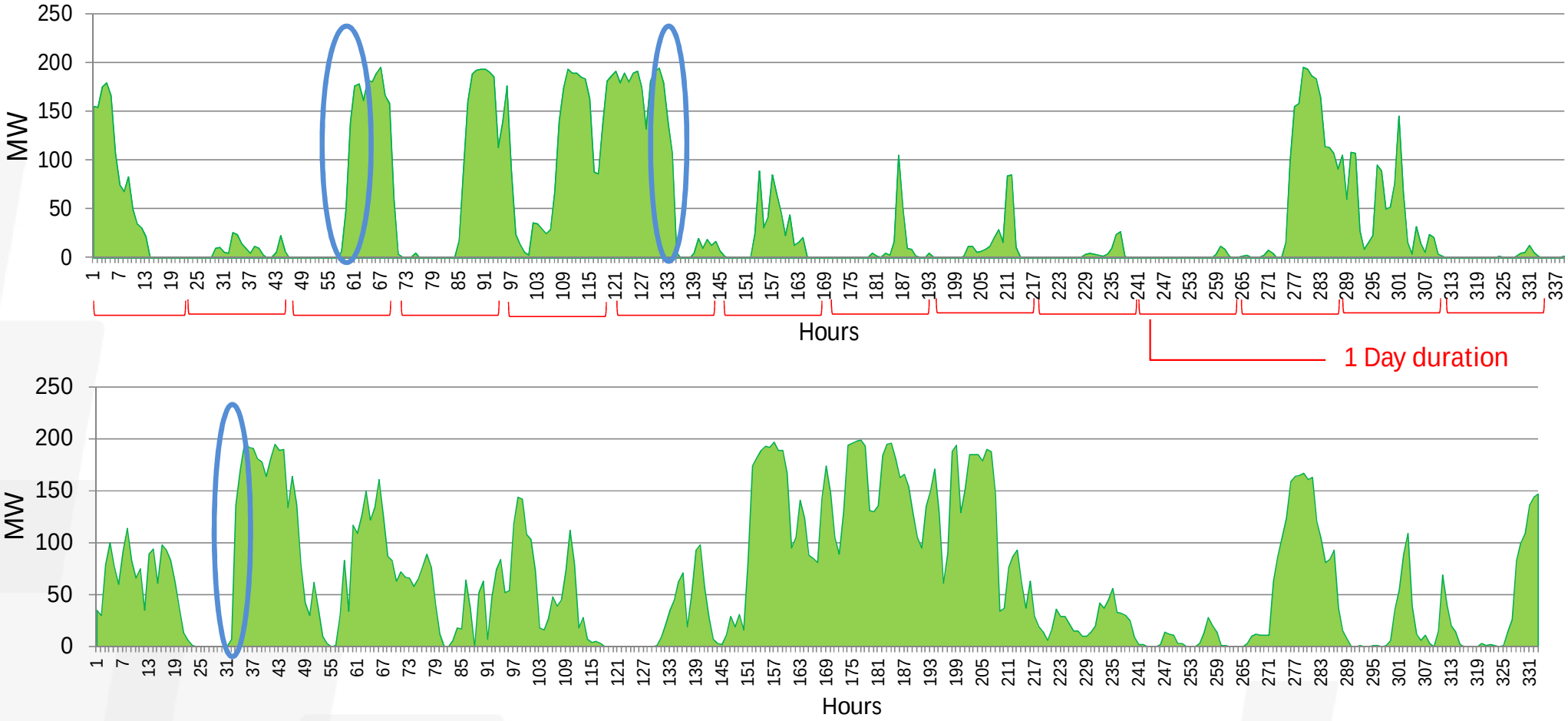
DR/DER: "Dancing Partner" of VER



- Under Generation ⟷ DR
- Over Generation ⟷ Storage
- Time Variability ⟷ "Fast" DR/DER (Short Term)

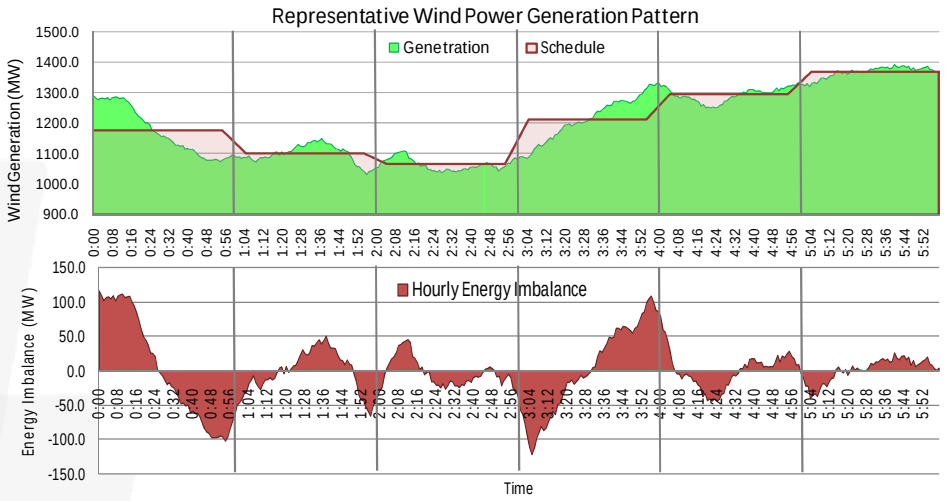
Typical Variable Generation Data

- A 200 MW Wind Farm in Utah
- Data from May 06–June 10, 2010

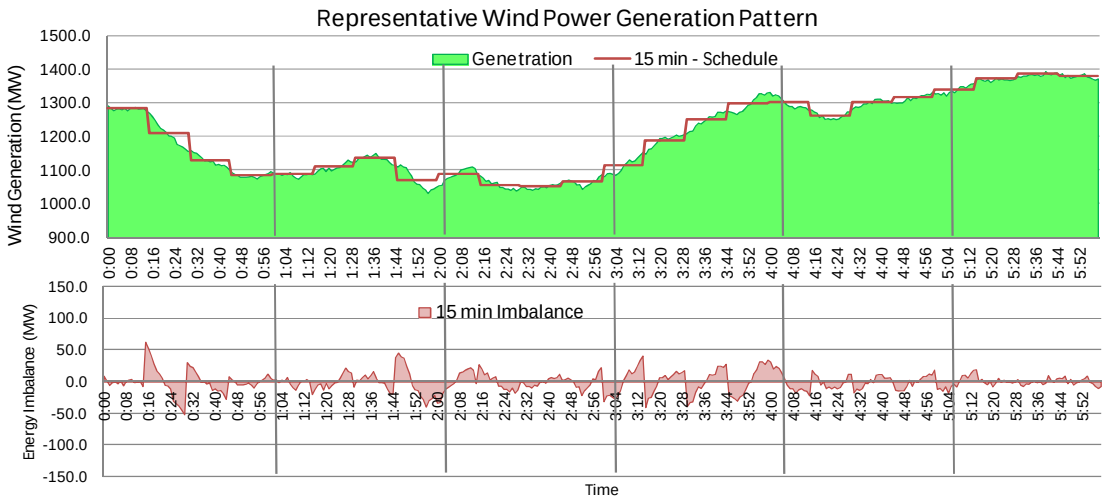


Hourly vs. Sub-Hourly Scheduling – FERC Order 764

Hourly Scheduling



15 Minute Scheduling

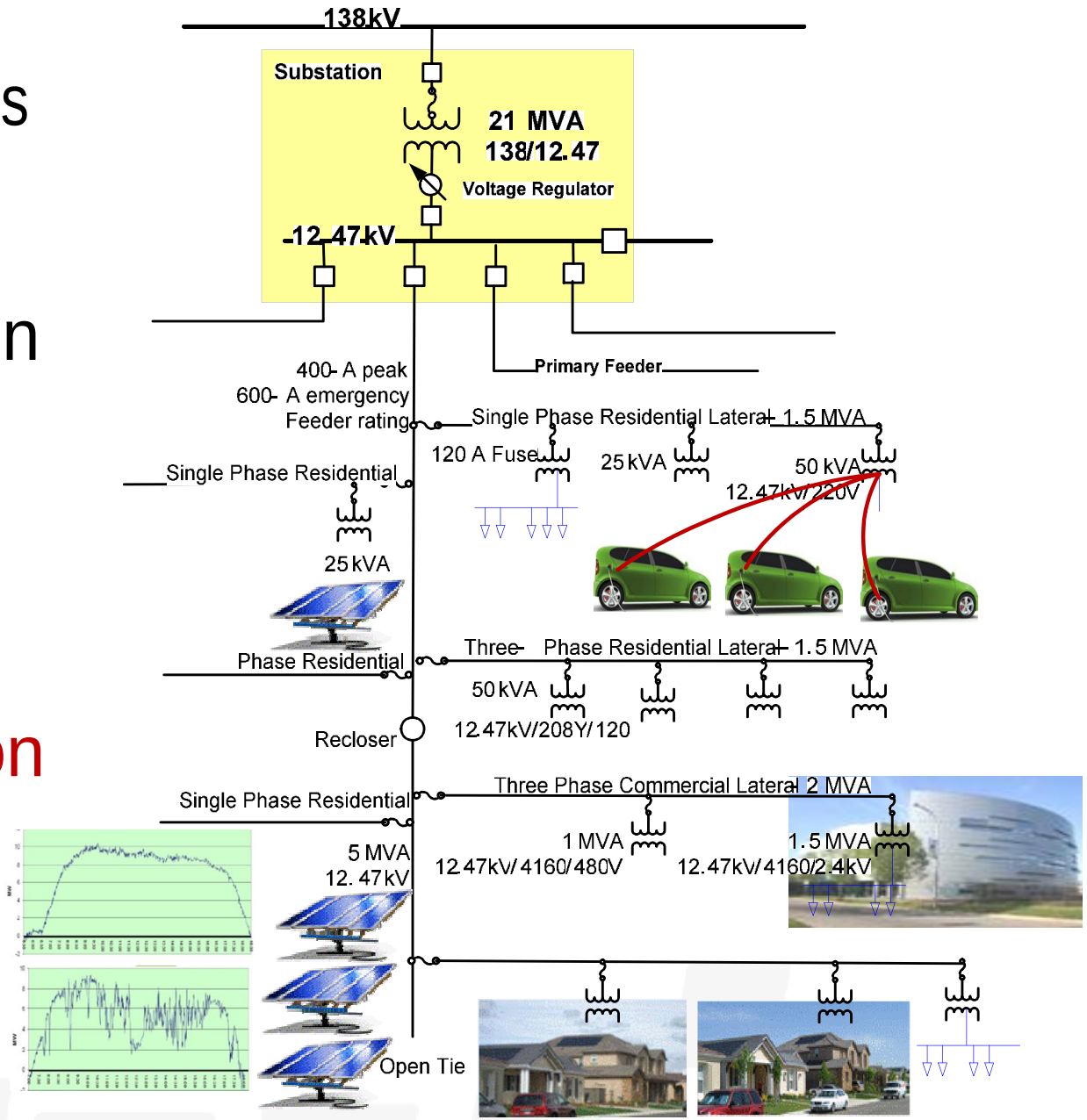


Energy Imbalance Levels

Distribution/Retail Operational Issues

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

Distribution Congestion



Seams Between Bulk Power & Retail Operations

Physical

Bulk Generation

Electric Power

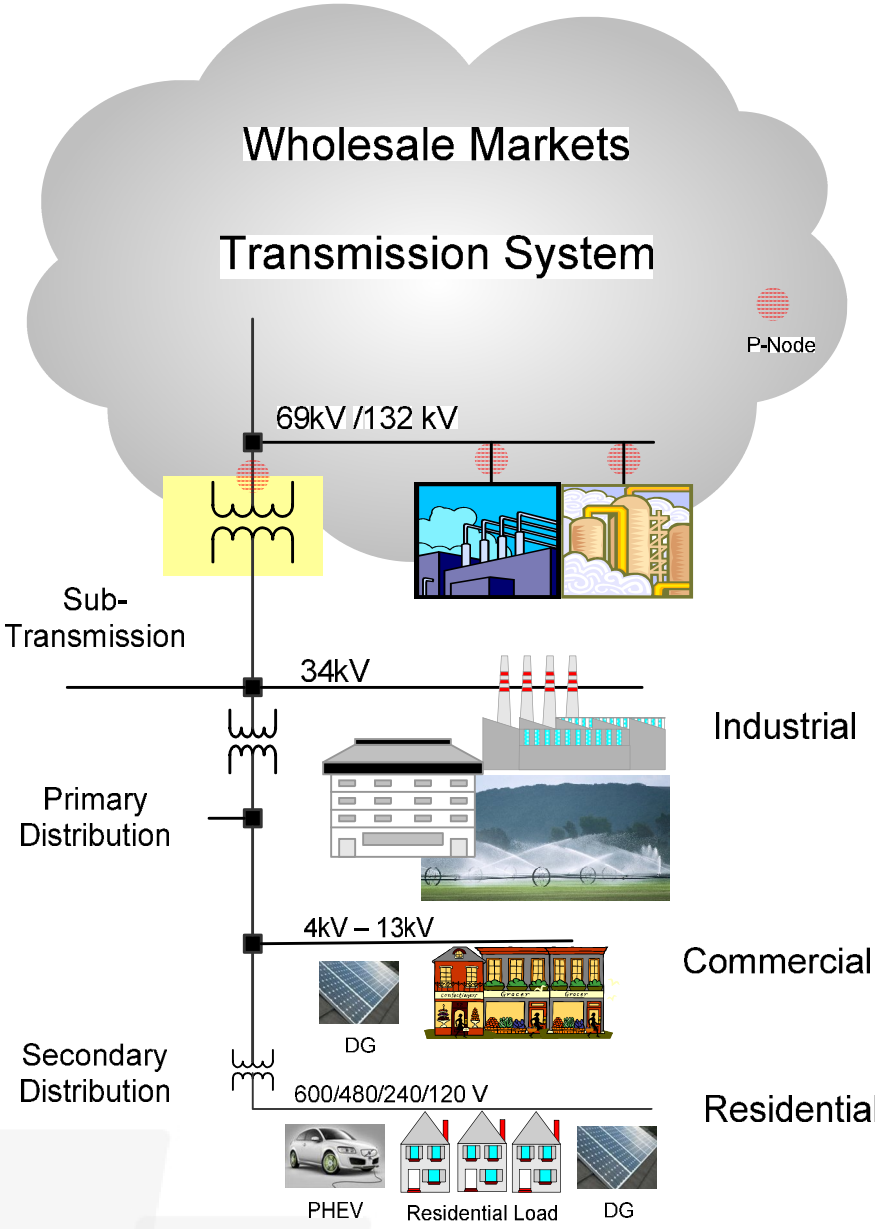
Transmission

Distribution

Electric Power

Electric Power

DR / DER Assets



Operational & Commercial

Wholesale Markets & Balancing Areas

- Day-Ahead
- Real-Time
- Energy
- Ancillary Services
- Capacity

Bids & Offers

Awards & Dispatch

Wholesale Prices

Power Marketing & Transmission Operations

Resource Capability

Dispatch Signals

Settlement Charges

LSEs / UDCs

CSRs

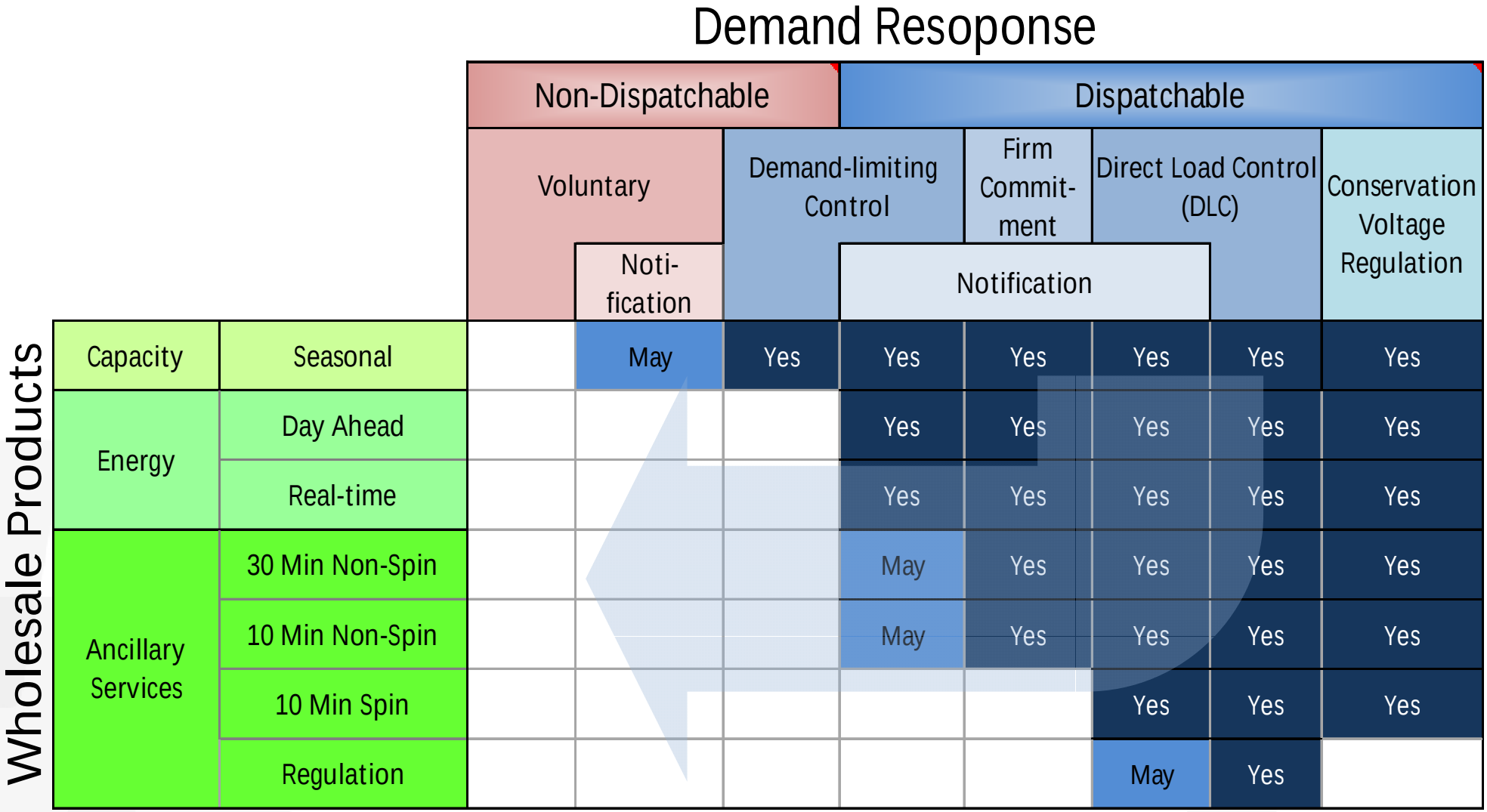
Capability Info.

Dispatch Signals

Retail Price Signals

Retail Customers

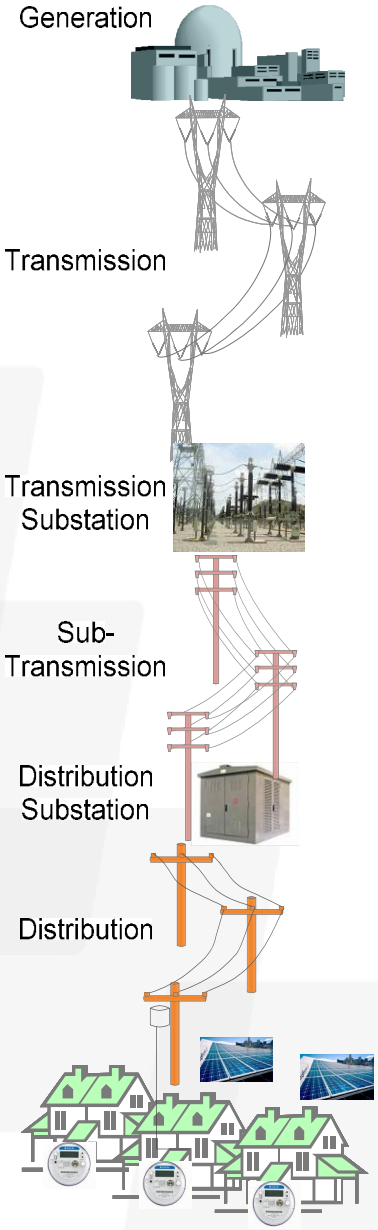
Demand-Side Programs to Wholesale Products



Technical Requirements for Energy Products

Product			Response Time / Notice	Baseline Estimation	Telemetry	Real-Time Metering
Conventional	Capacity		Seasonal	Yes	No	No
	Energy	Day-Ahead Energy	A day	Yes	No	No
		Real-Time Energy	1 hour	Yes	No	No
		Interruptible Load	10-30 minutes	Maybe	No	Maybe
	Ancillary Services	Reliability Capacity	30 minutes to 2 hrs	Maybe	Maybe	No
		30 minute Non-Spin	30 minutes	No	Maybe	Maybe
		10 minute Non-Spin	10 minutes	No	Yes	Yes
		10 minute Spin	10 minutes	No	Yes	Yes
		Regulation	4 sec to 5 min	No	Yes	Yes
New		Ramping	5 minutes	No	?	Yes
		Balancing Energy	5-15 Minites	No	?	Yes

Pricing Predicament



Wholesale Markets - ISO/RTOs

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

Wholesale Prices

+ Uplifts:

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

LSE

UDC

ESP/CSP

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

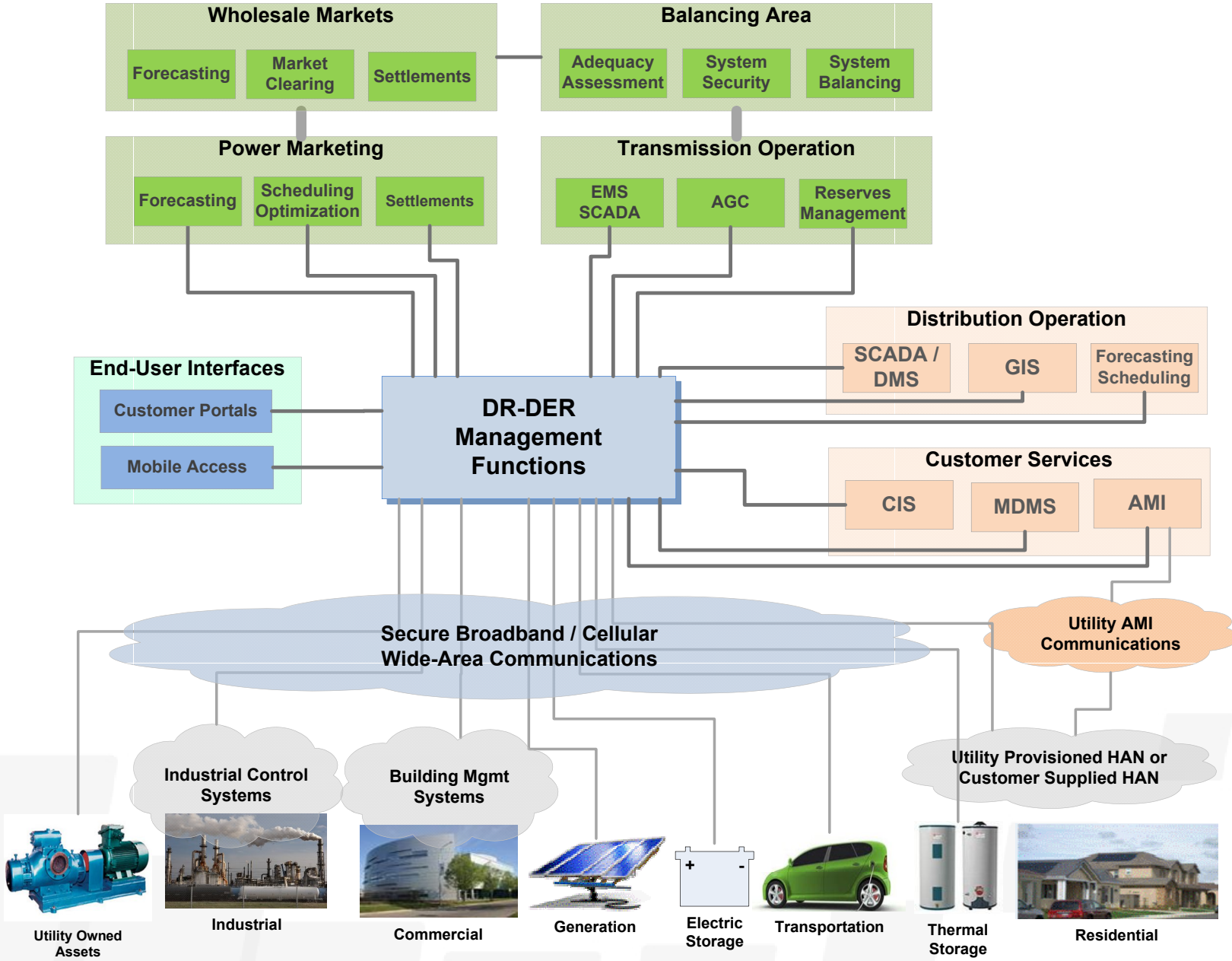
Retail Rates

End-Use Consumers

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

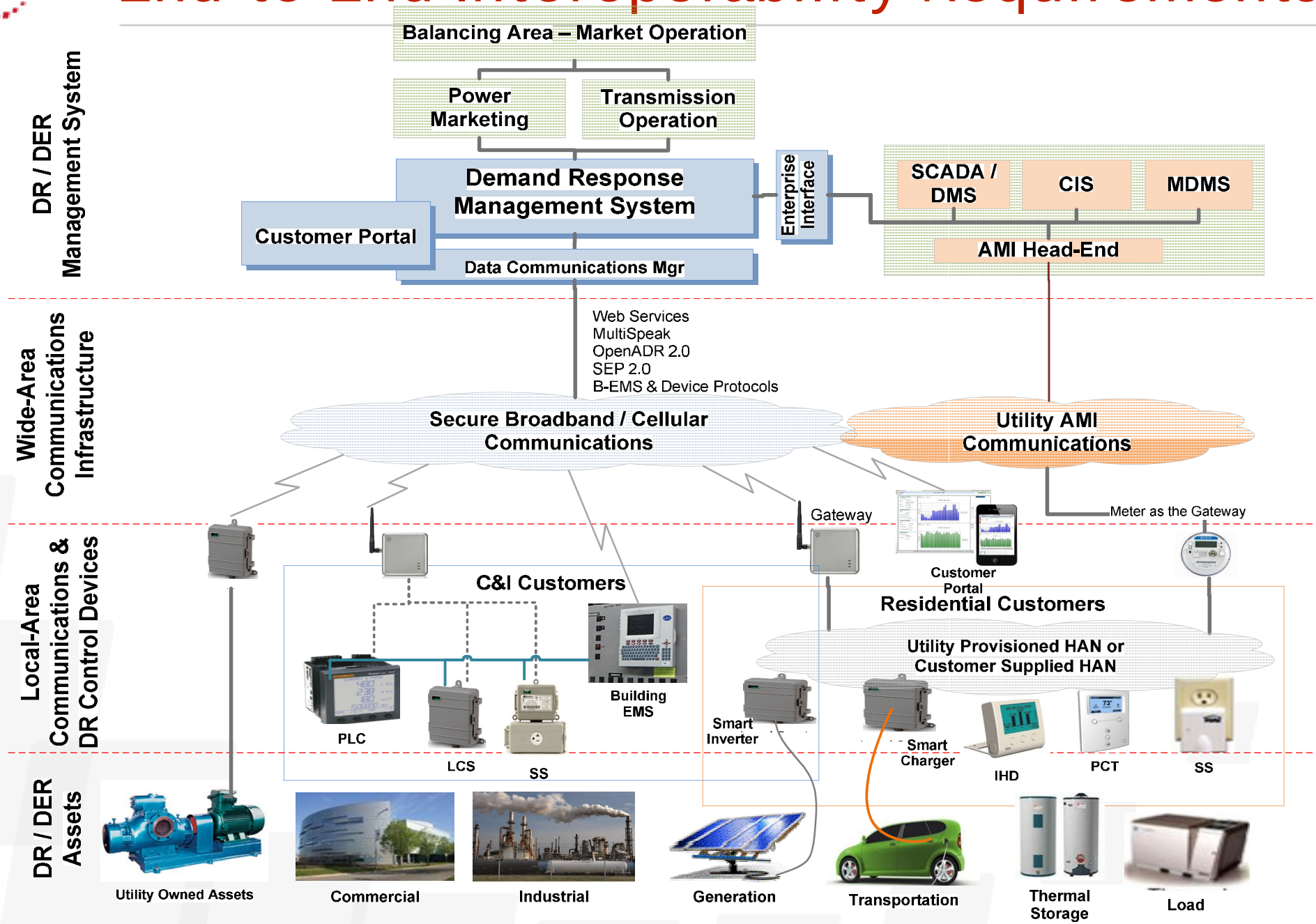
End-to-End Integration & Interoperability
Transactive Operations Across The Operations Value Chain



"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*

End-to-End Interoperability Requirements



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

Grid-Interop

Driving to Grid 2020

THANK YOU

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