



Integration Challenges for DERs in Electricity Markets

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Markets and Distributed Resources

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| *Shaping the future*

Alstom: Three main activities in four sectors

Equipment & services for power generation

Alstom Thermal Power

8.8 b€



Alstom Renewable Power

1.8 b€



Equipment & services for power transmission

Alstom Grid

3.8 b€



Equipment & services for rail transport

Alstom Transport

5.9 b€



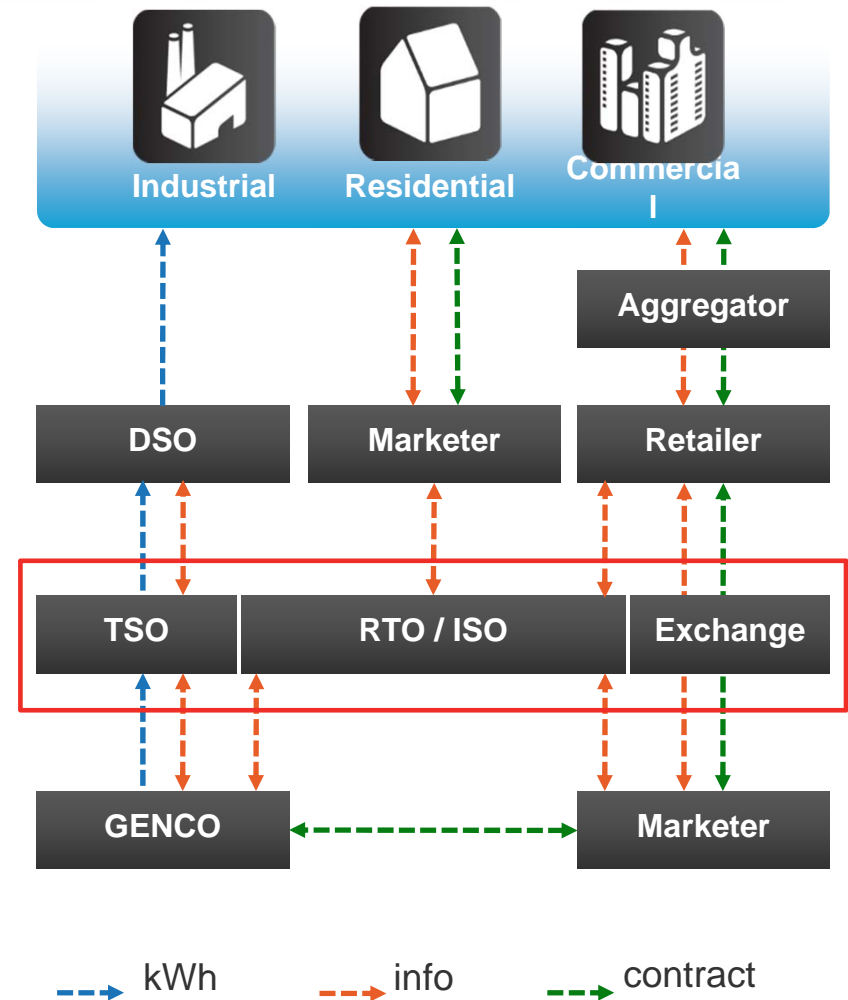
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Alstom Grid - Network Management Systems

Full service market solutions

- Energy Management System
- Network Model Management
- Market Management System
 - Day-Ahead Market
 - Forward Reliability Analysis
 - Real-time Balancing Market
 - Look Ahead UC/Dispatch
 - Forward Capacity Market
 - Financial Transmission Rights
 - Study and Training Tools
- Distributed Resource Management
- Market Settlements and Analytics



Market Systems: Axes of Change

Vertical Alignment

- Gas/fuel coordination
- Generation configuration
- Transmission facilities
- Distribution facilities
- Retail price signaling
- Aggregated resources

Regional Coupling

- Reduce seams
- Forecasting flows
- Improve reserve sharing
- Operational scale economies
- Expand membership
- Regulatory changes
- Local market evolution

Horizontal Integration

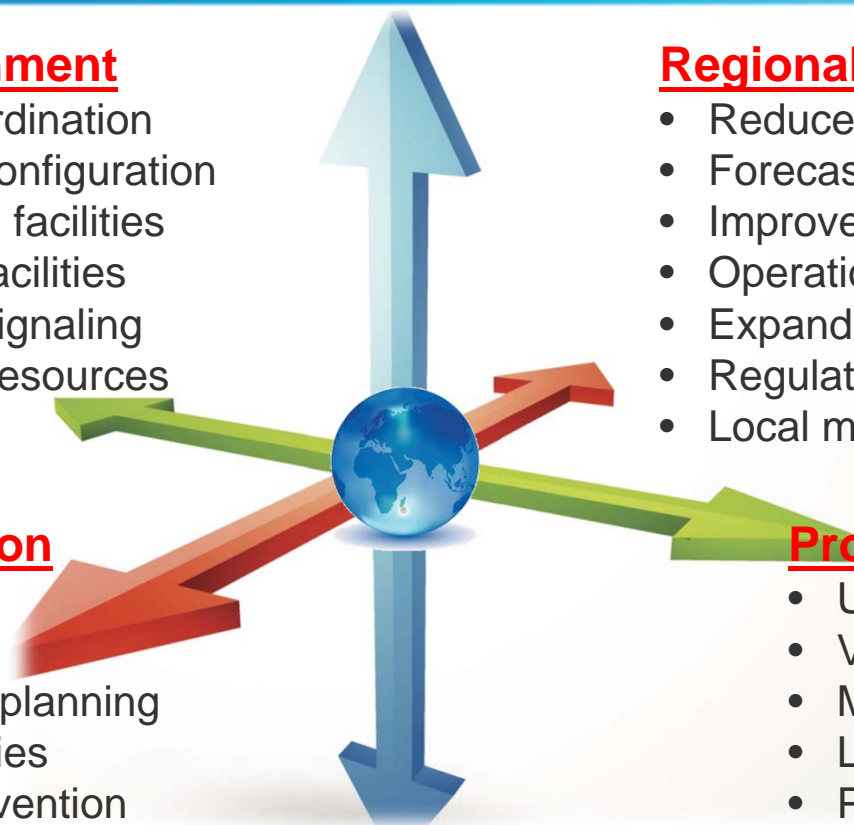
- Adequacy planning
- Capacity reserves
- Network and outage planning
- Operational efficiencies
- Reduce market intervention
- Key performance indicators
- Regulatory compliance
- Member communications

Product Unbundling

- Unbundled grid services
- Volatility hedging products
- Multiple time horizons
- Localized pricing
- Performance classes
- Fuel supply reliability

New Resources

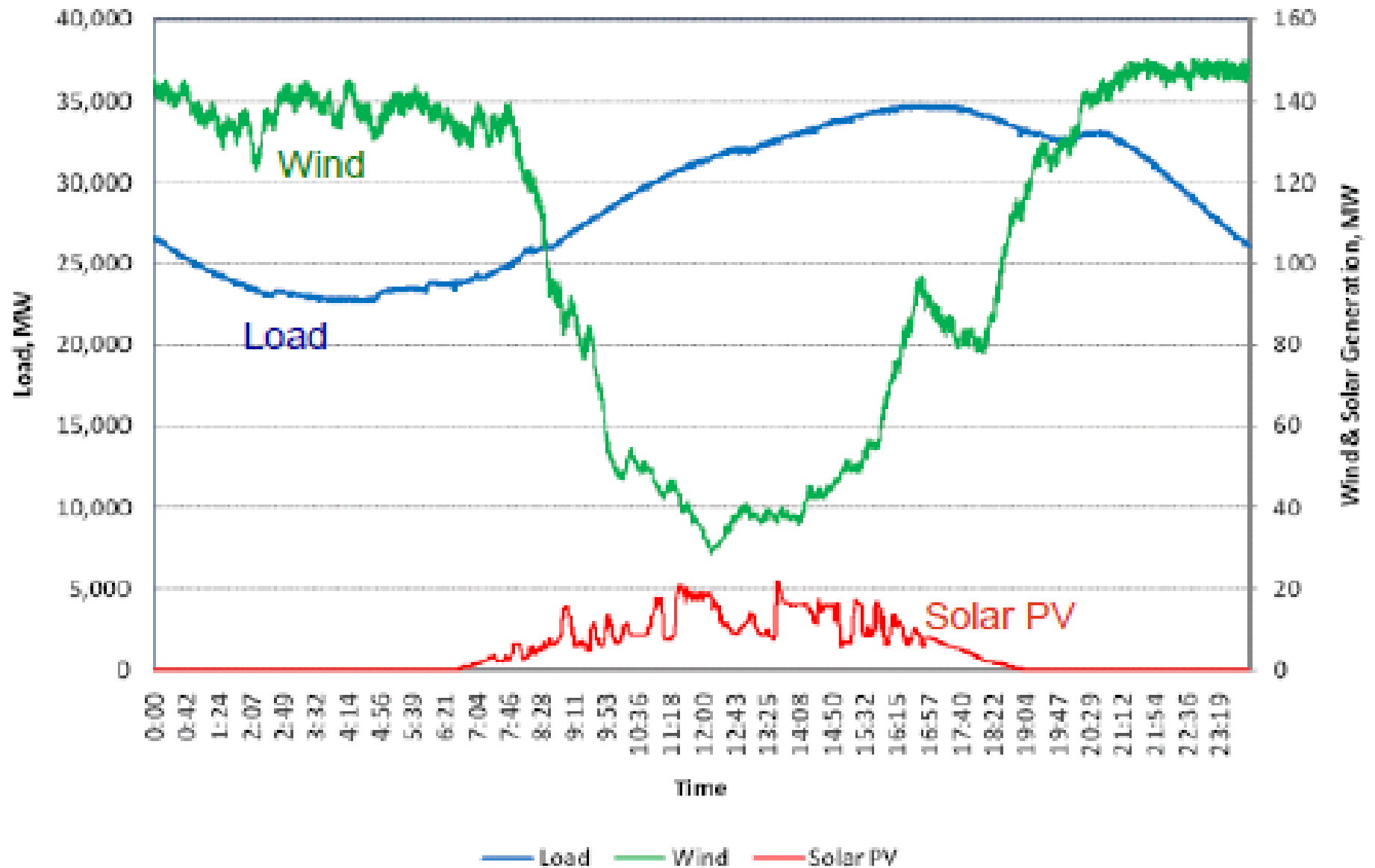
- New asset classes and capabilities
- More small, distributed, intermittent assets
- More dispatching options and constraints
- Operate closer to dynamic limits



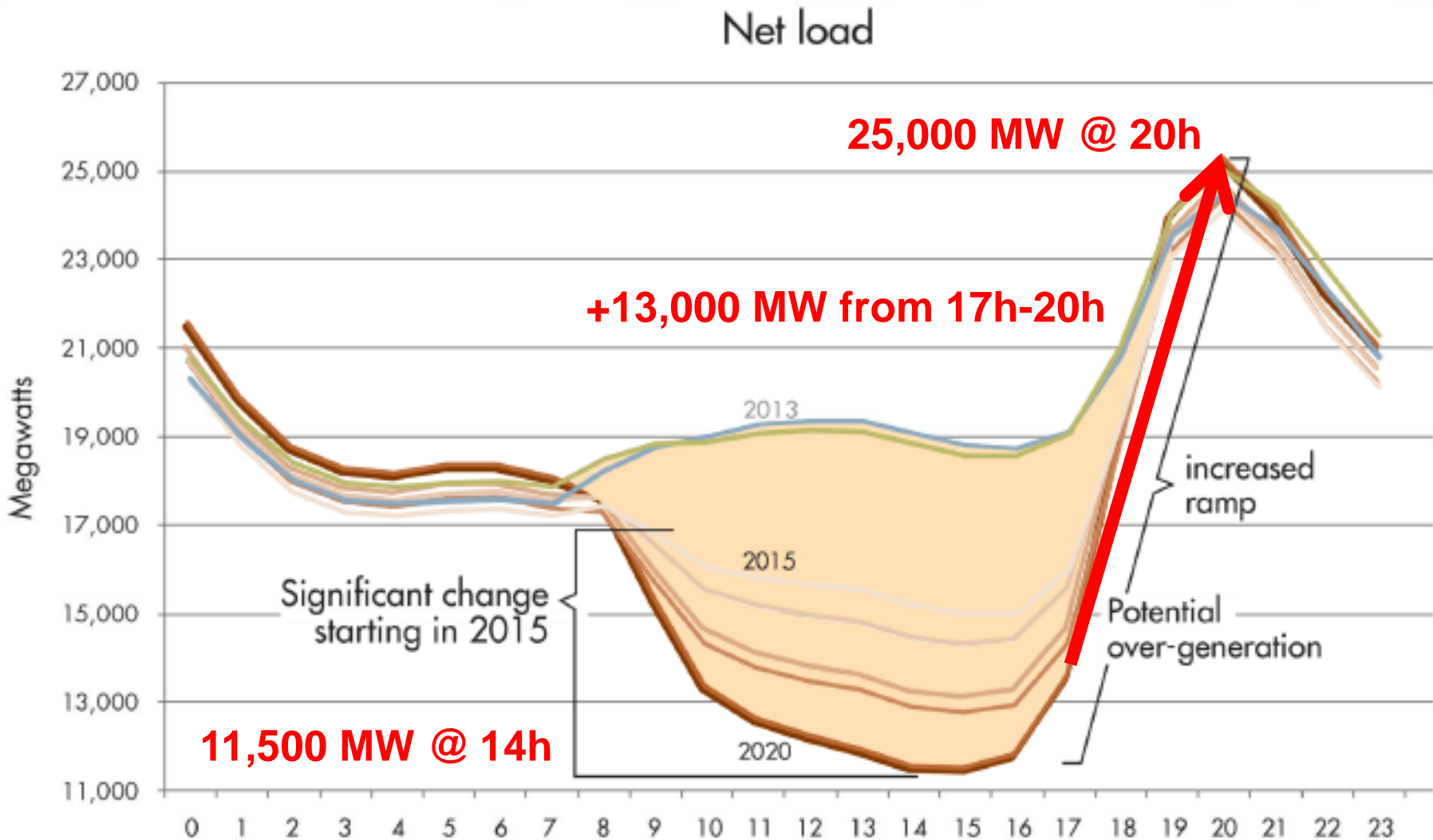
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Renewables complicate Real-time Balancing

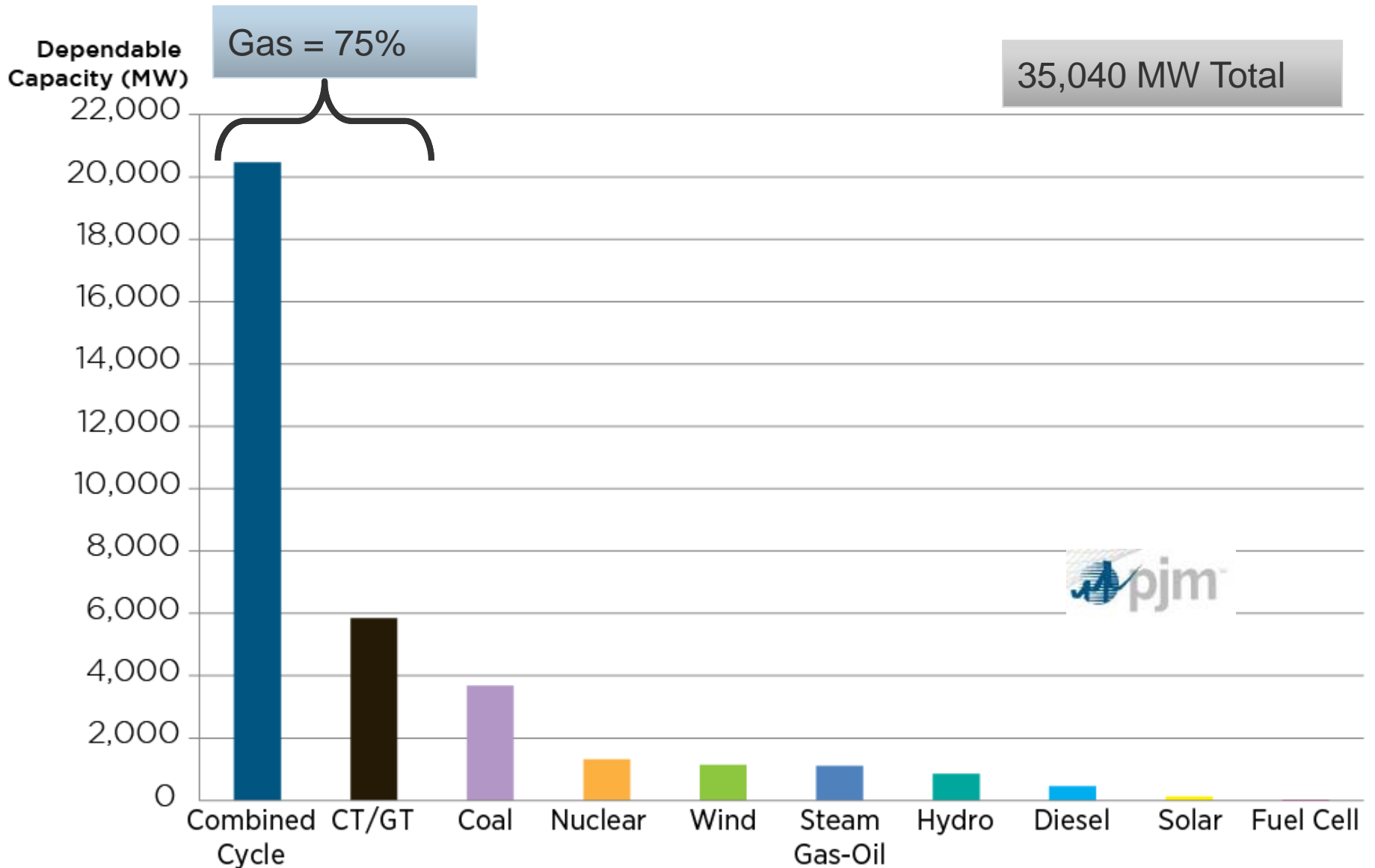


Renewables creating Daily Ramping issues

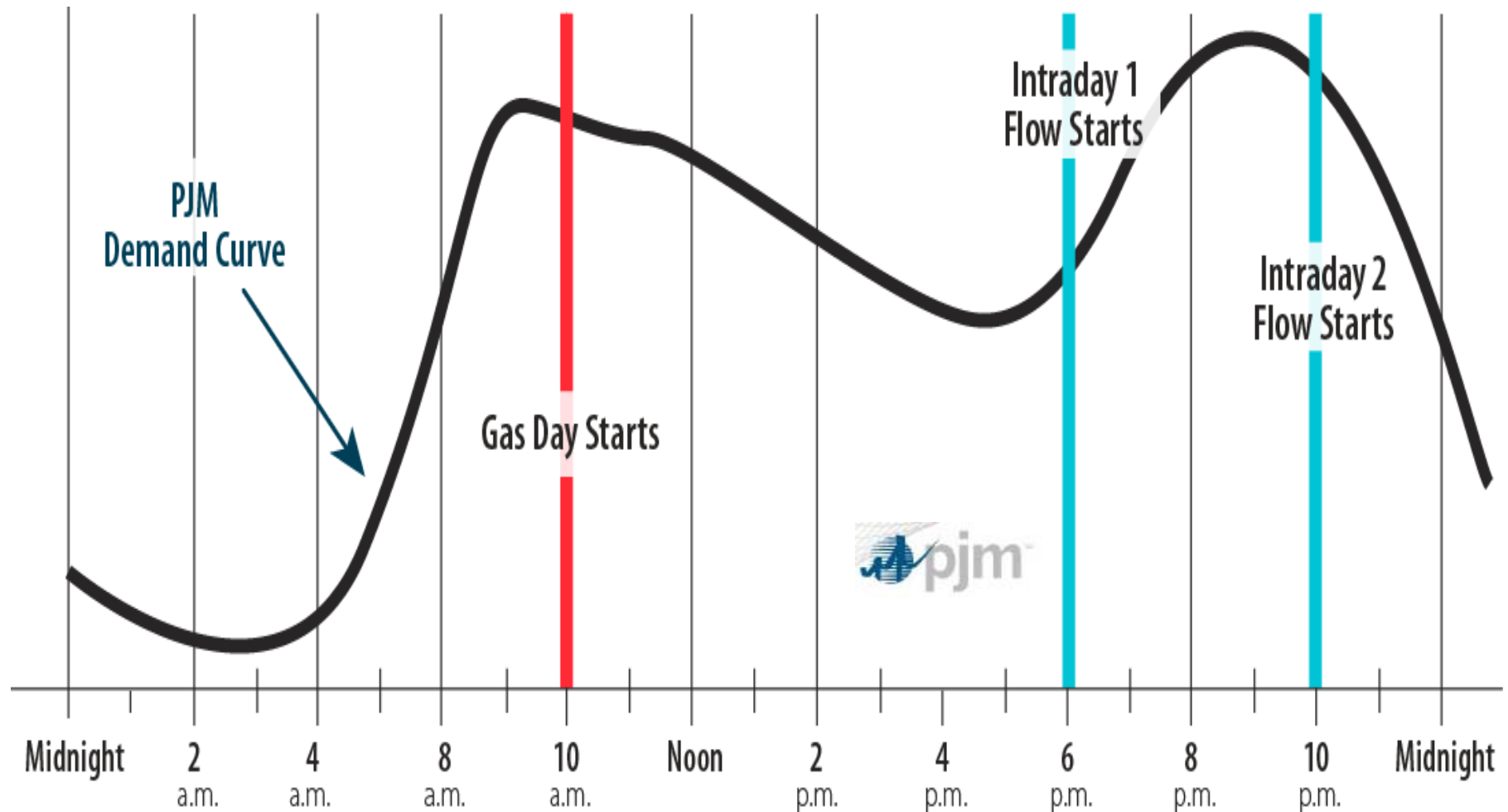


Massive shift into Natural Gas Generation

New Generation in PJM since 2007

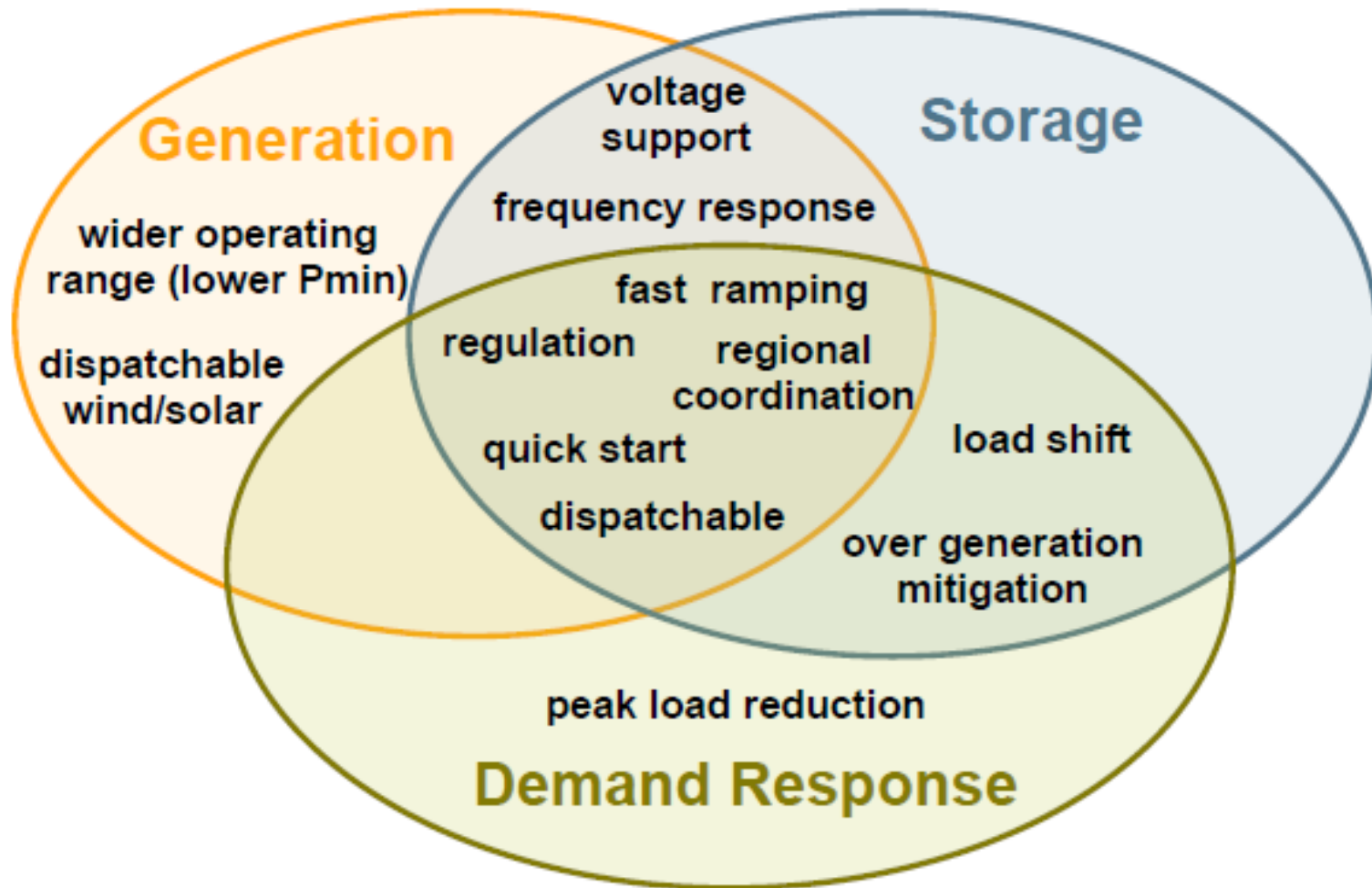


New Winter Peaks, Coincident Gas Shortages, Market Timing Issues, Coal as Peakers?



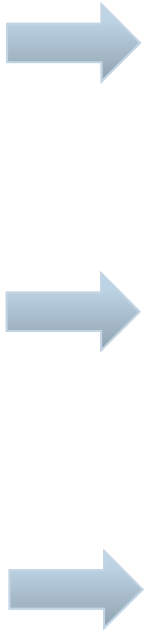
Distributed Resources can provide added Flexibility

Demand Response, Distributed Generation, Storage, ... Microgrids



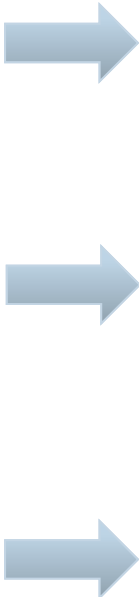
Distributed Resources as 'Virtual Power Plants'

Acting as a VPP, DER can supplement conventional generation

- **Economic energy**
alternative to generation during peak hours
 - **Emergency capacity**
during extreme conditions when reserves are low
 - **Ancillary services**
like spinning reserve and frequency regulation
- 
- **Lower marginal prices**
by shifting the supply / demand balance
 - **Faster, cheaper and greener**
than building new lines or peaker plants
 - **Enhance reliability**
and lower grid ancillary service costs

Distributed Resources as 'Active Demand'

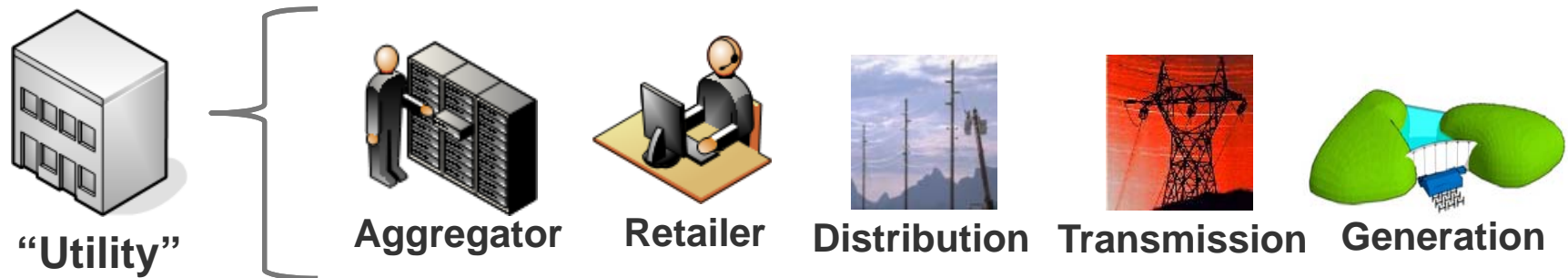
'Active demand' has additional benefits over traditional generation

- **Peak load reduction**
during top hours for the entire system
 - **Surgical flexibility**
to manage load and voltage at specific grid locations
 - **Real-time following**
of intermittent resources and dynamic loads
- 
- **Lower reserve requirements**
and/or transmission access costs for DSOs
 - **Defer capital investment**
on upgrades to transmission, substations, and feeders
 - **Enhanced carrying capacity**
of the network to handle higher EV/PV penetrations

Irony of Deregulation

Where vertically aligned utilities could realize DER benefits...

...they are now spread across the value chain.

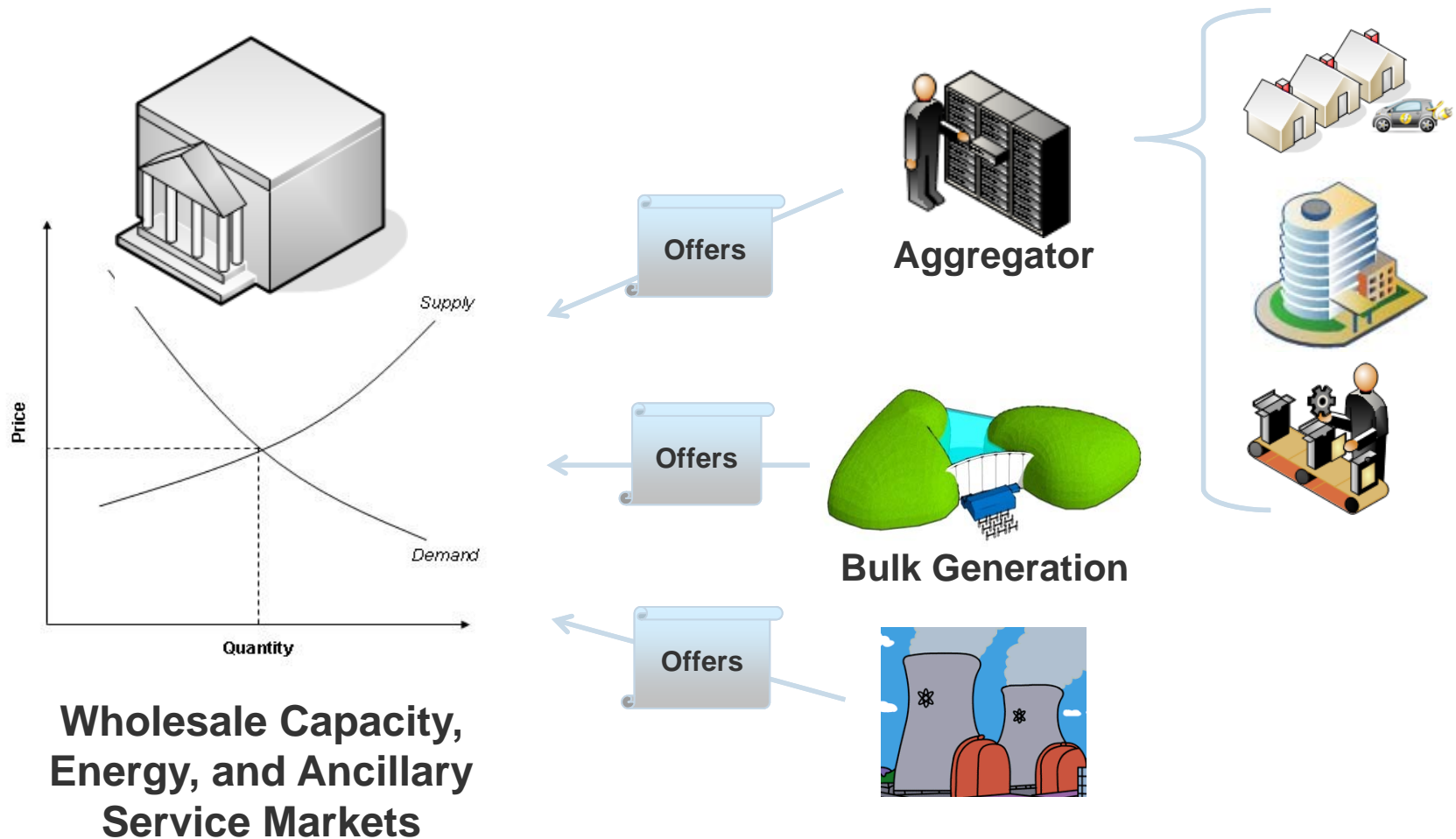


- Lower marginal prices
- Faster, cheaper, greener
- Enhance reliability
- Lower reserve requirements
- Defer capital investment
- Support renewable growth

Difficult for any one player to justify investment, especially without monetization scheme provided by other players (who feel disrupted?)

DER in Wholesale Energy Markets

Opening markets is needed to incentivize flexibility investment

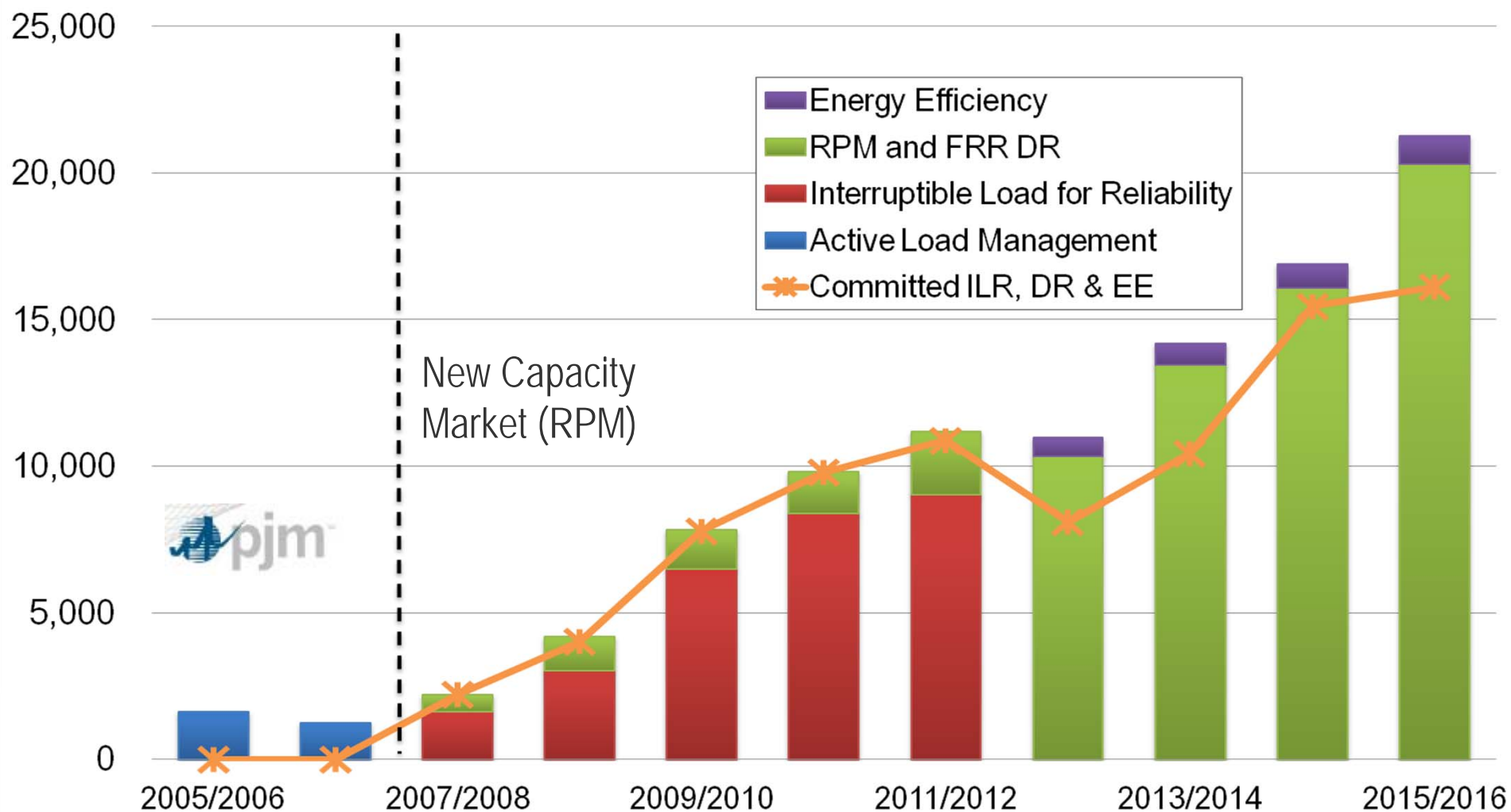


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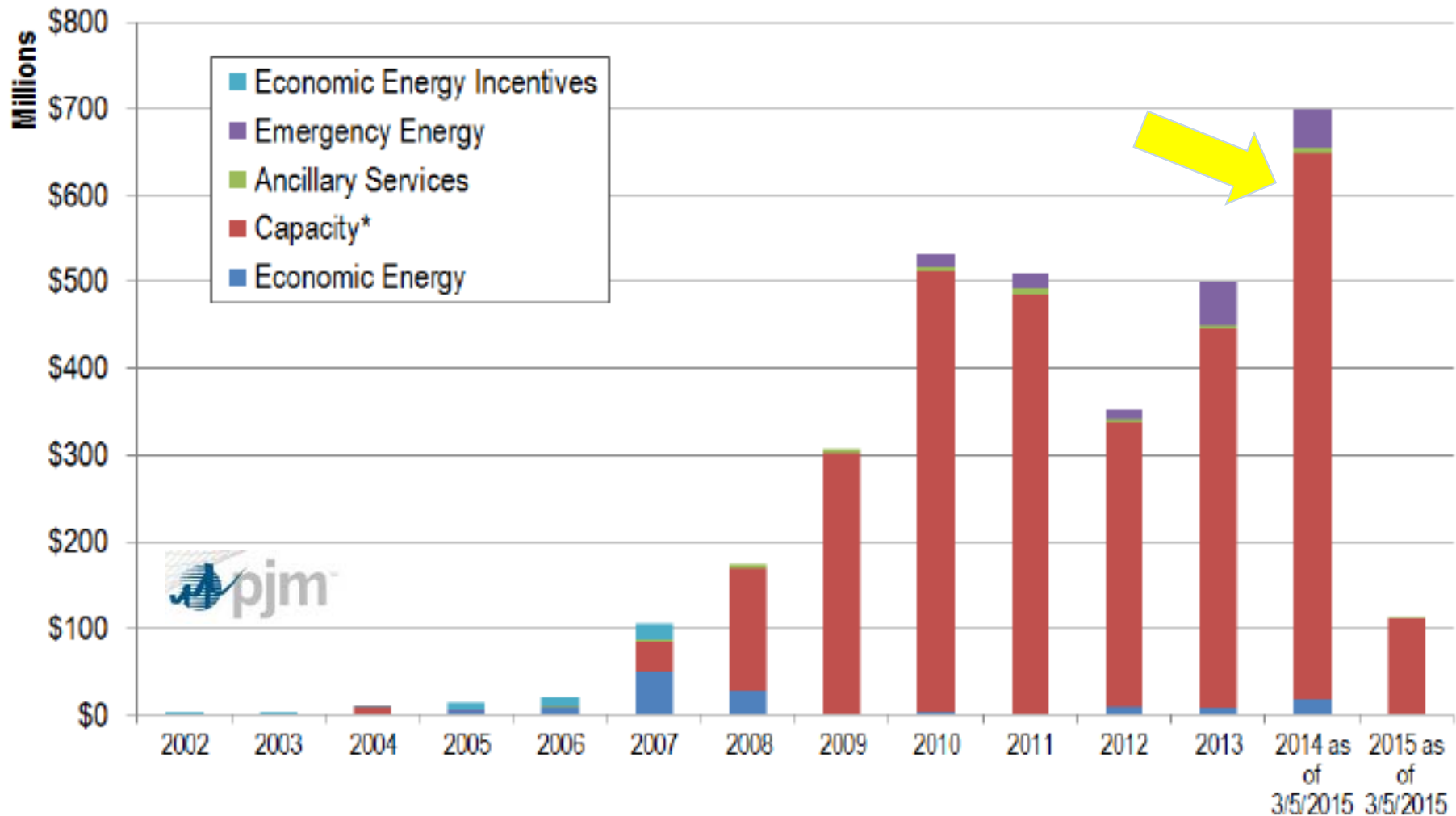
PJM manages ~15GW of DER (DR and DG)

35% CAGR since new capacity market opened in 2007



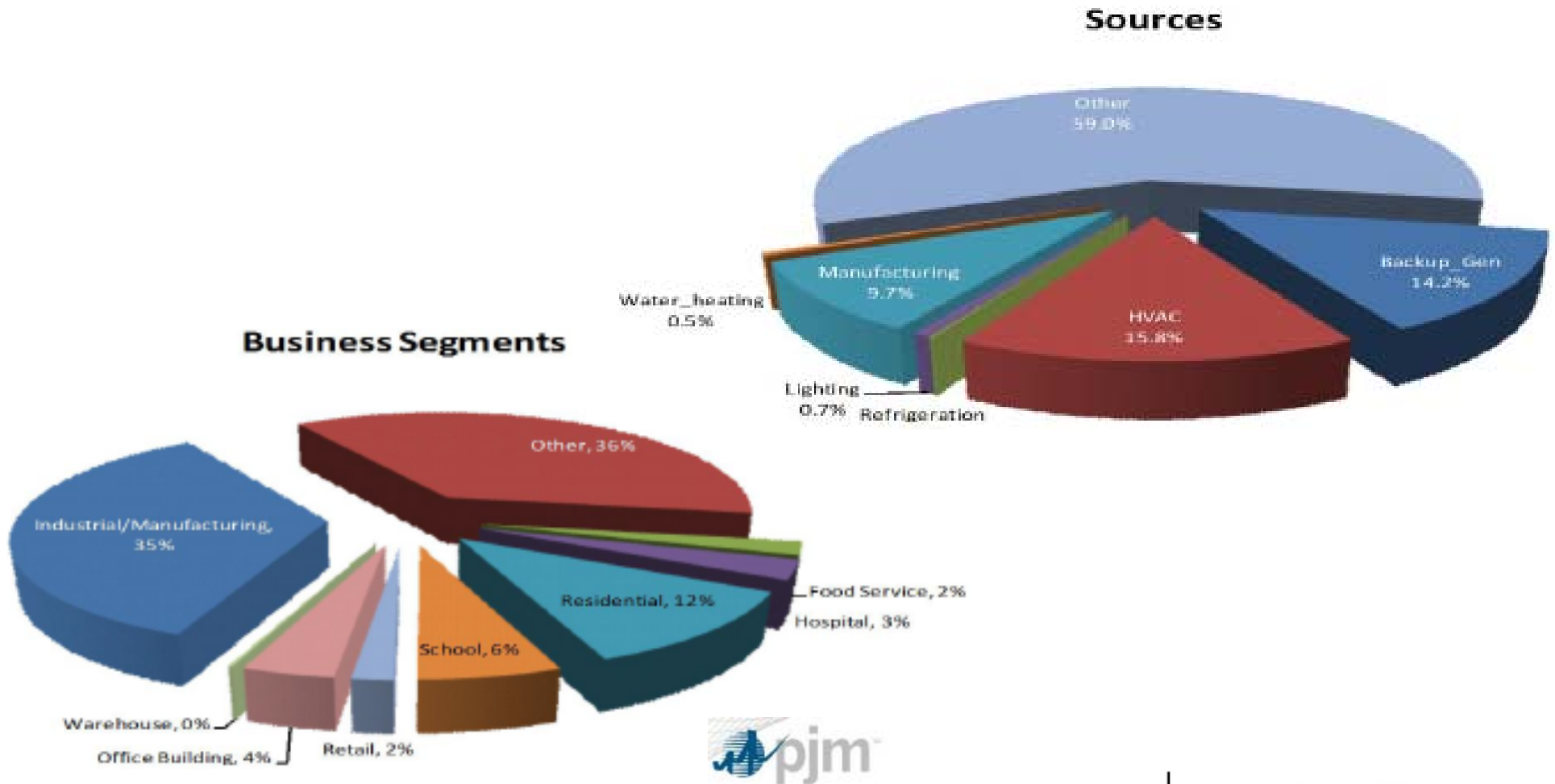
PJM is a \$700M market for *transmission* level DER

Capacity payments represent the vast majority of revenues



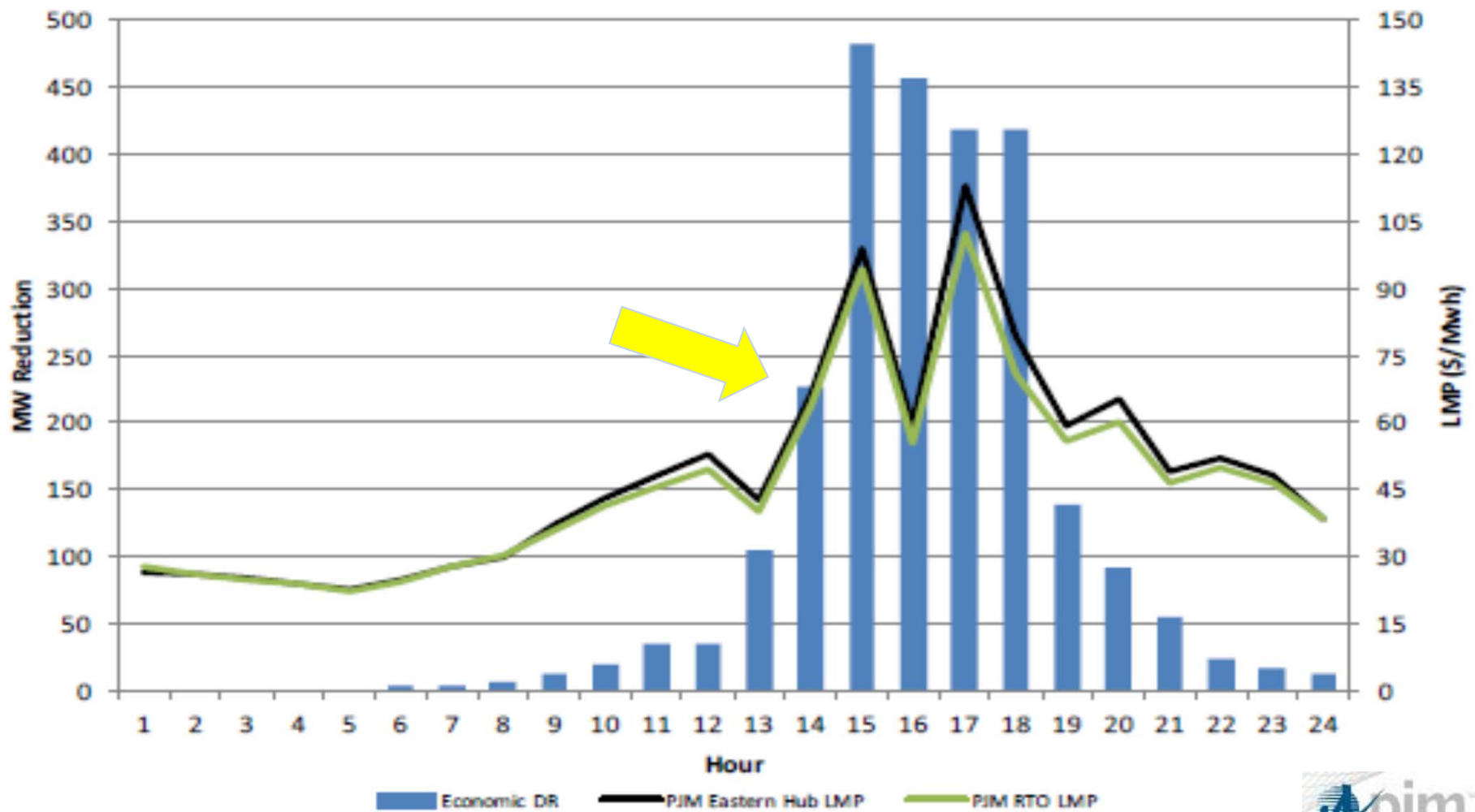
PJM Resource Variety

Market has attracted a wide variety of customer types and loads



Direct economic market participation shifts the supply/demand balance

7/16/2012: ~500MW of economic DR helps limit price spikes

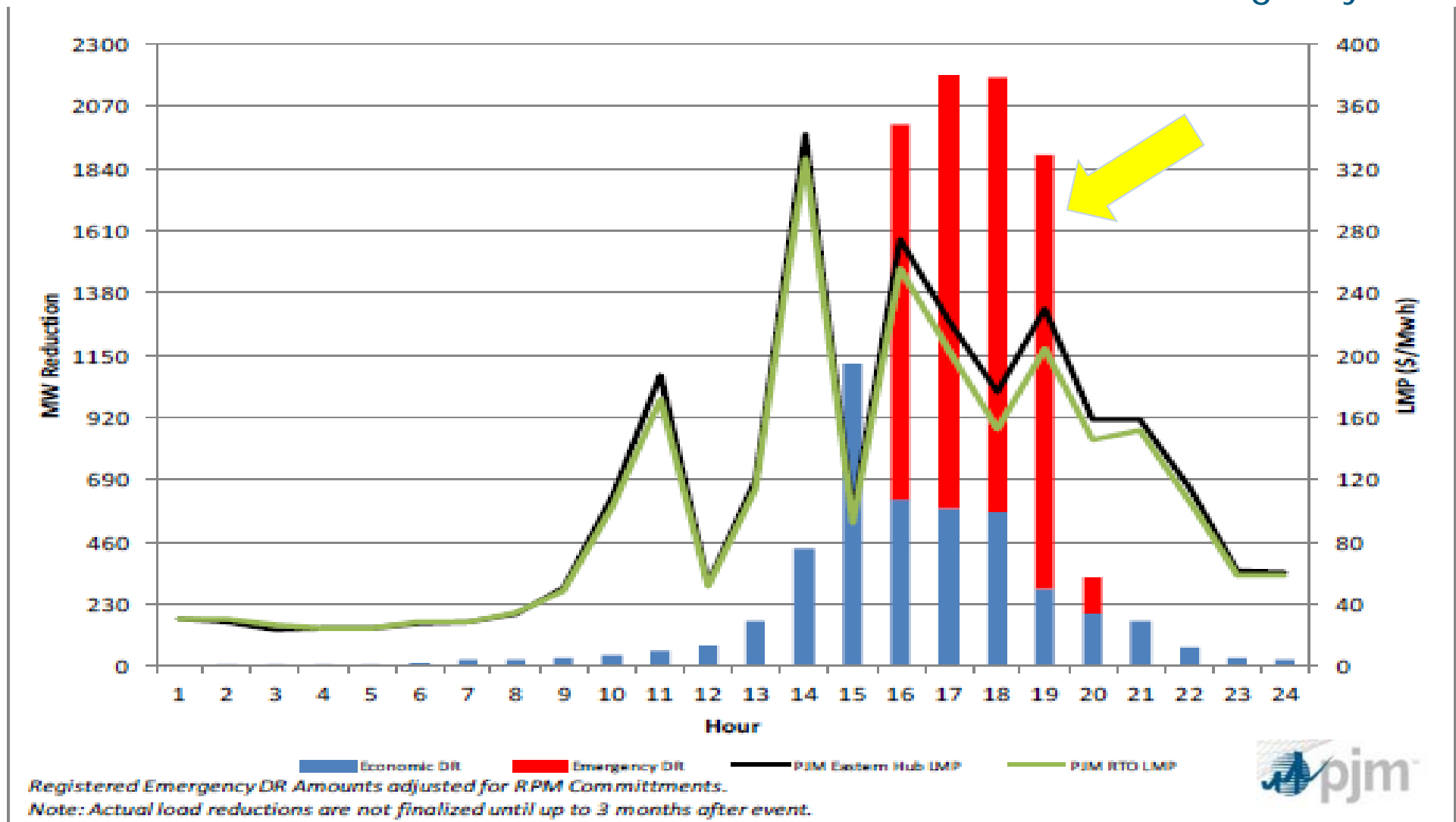


Note: Participants have up to 60 days to submit their load data.



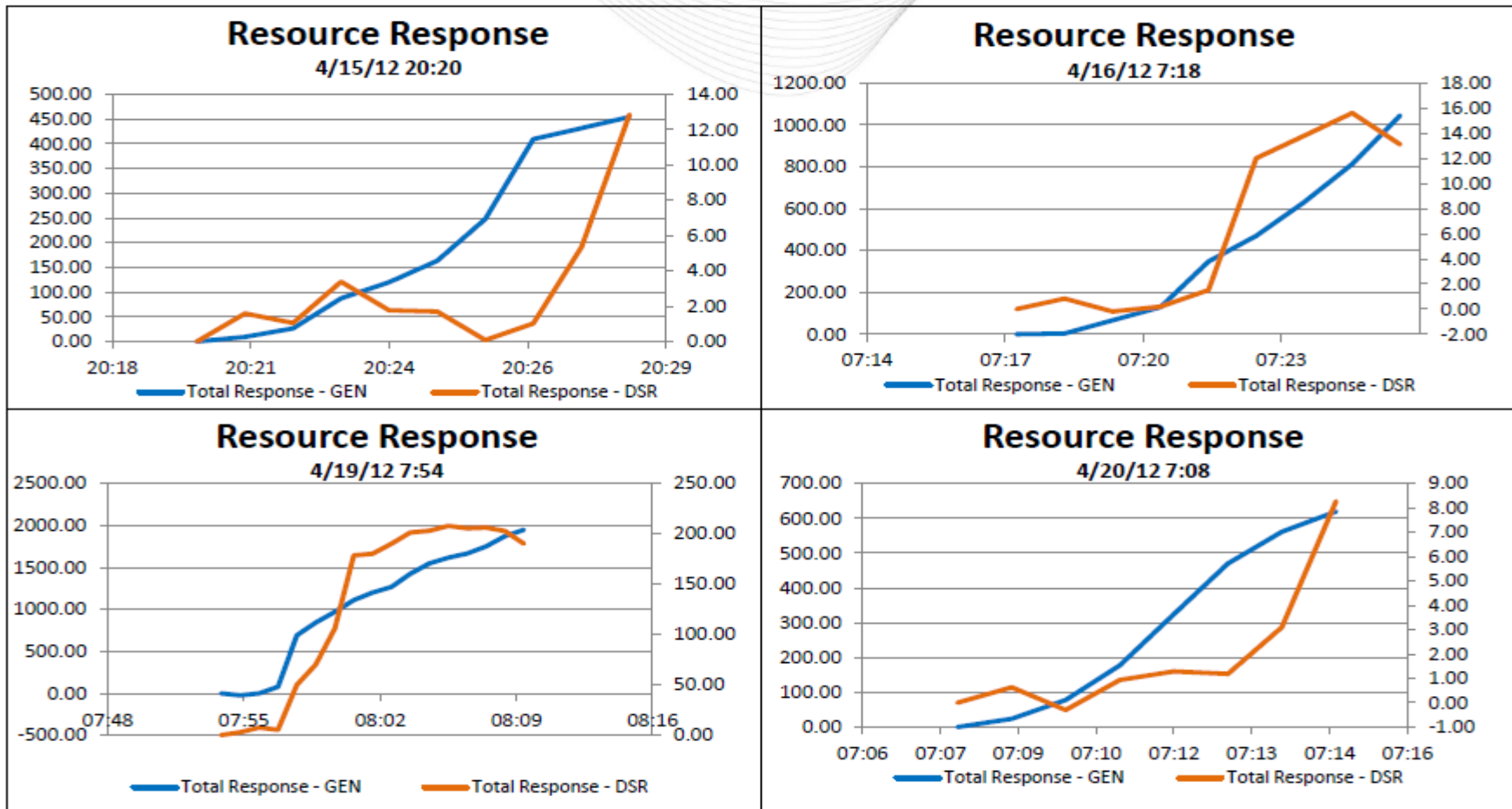
Emergency capacity reserves are a *surgical balancing* option

7/17/2012: 1000MW of economic DR, then 1500MW of emergency



Fast reserves perform similarly to generation

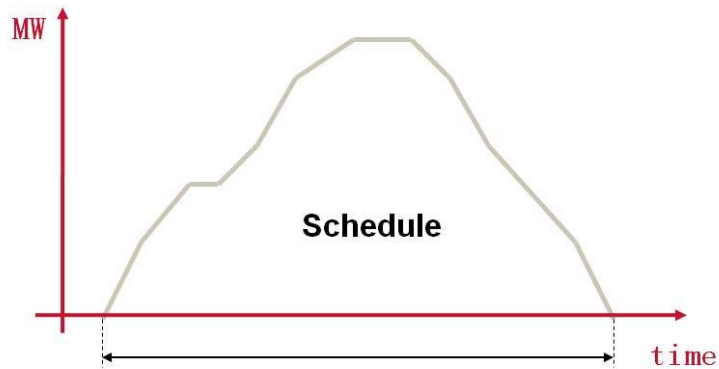
4/2012 - Generation vs Demand Side Fast Reserve Response



DER Integration Requirements

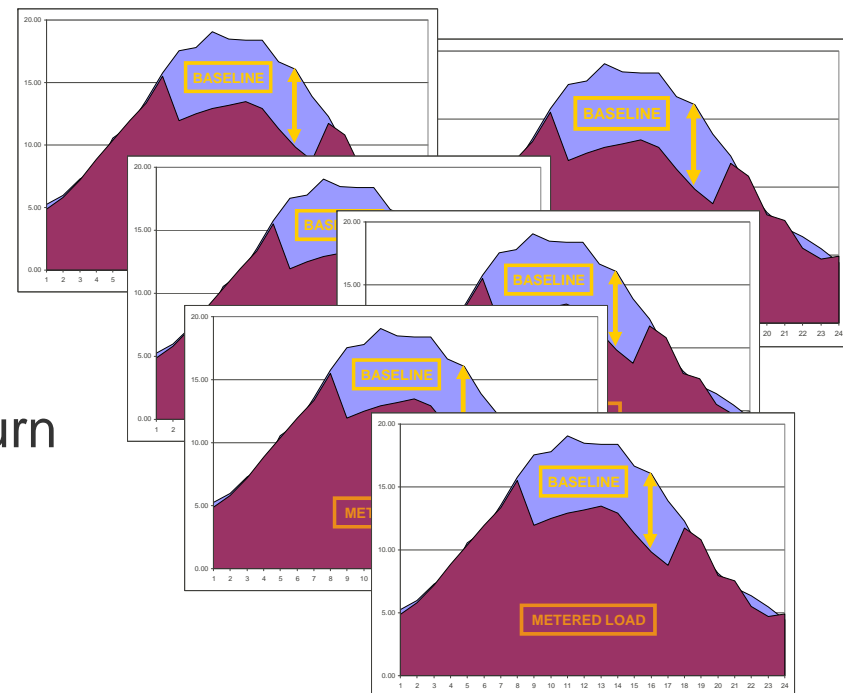
Traditional markets not designed to handle direct retail integration

Traditional Generation



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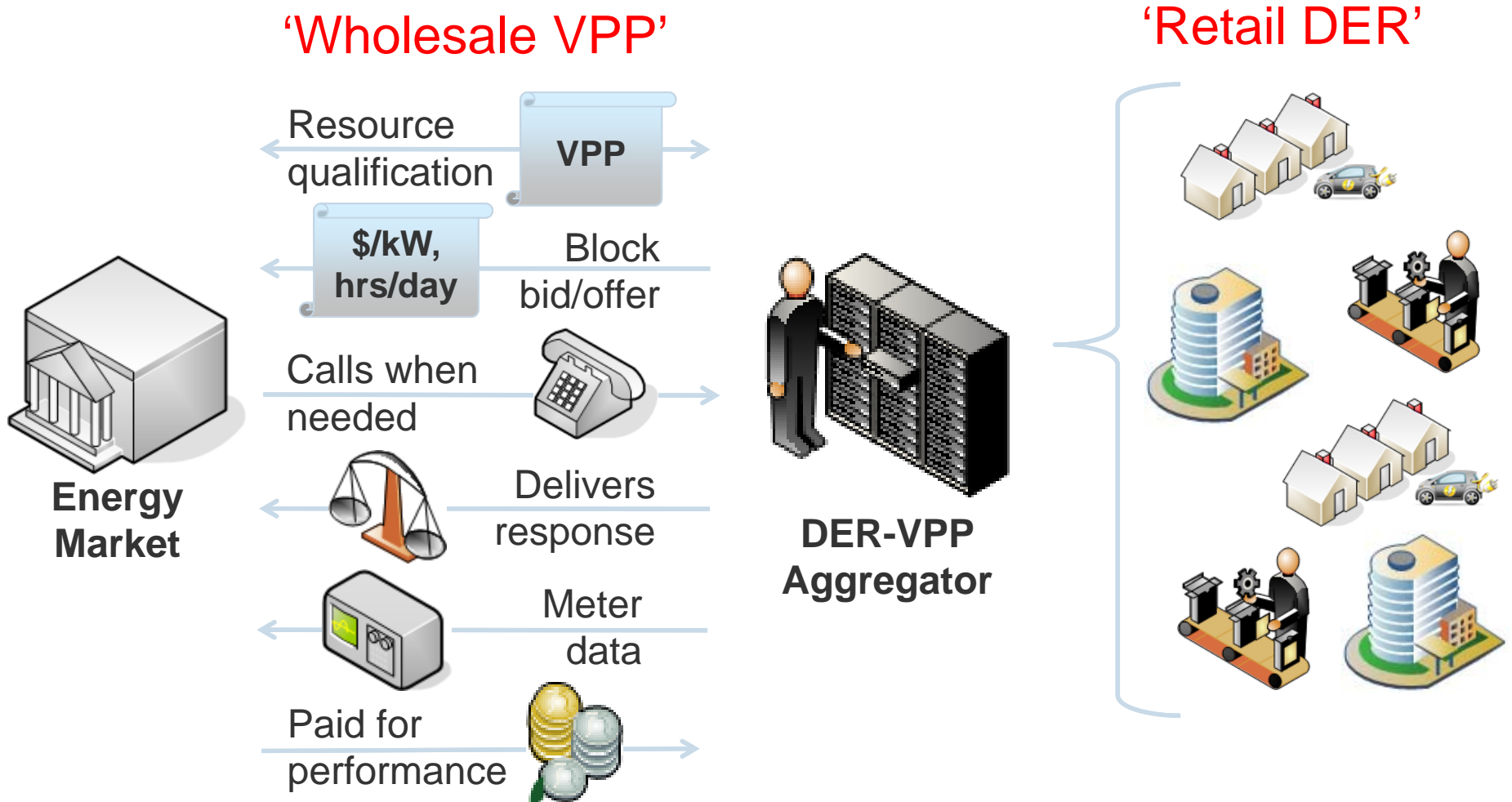
Distributed Resources



- Resource volumes and churn
- Availability forecasting
- Optimization constraints
- Dispatching granularity
- Automation and telemetry
- Fatigue, attrition, snapback
- Performance measurement
- Payments and penalties

DER Aggregators and Virtual Power Plants

Aggregators hide some of this complexity via VPP abstraction



DER Market Operation Processes

Lessons learned from wholesale demand response markets



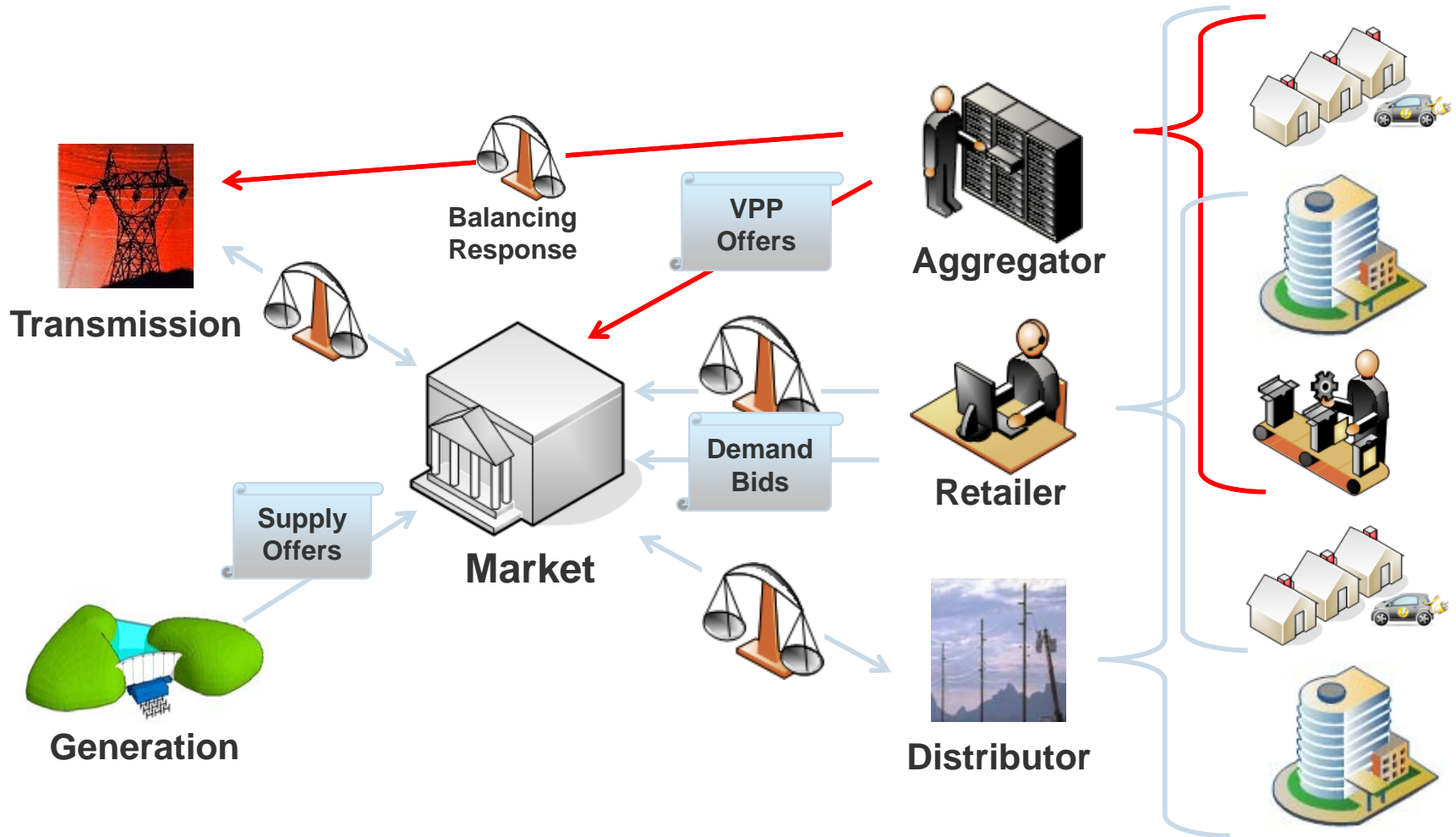
- ✓ Multiple programs/products/regional rules
- ✓ Resource qualification, provisioning, and testing
- ✓ Aggregate into virtual power plants; grouped by location, capability, counterparty
- ✓ Commercial and network modeling of VPPs
- ✓ Daily and seasonal constraint tracking
- ✓ Track available flexibility – ie, virtual ‘nameplates’
- ✓ Co-optimization of energy, reserves, and regulation
- ✓ Telemetry and dispatch communications to each counterparty and resource – outside of SCADA
- ✓ Monitor per-resource and aggregate VPP response
- ✓ Collect actual meter data for each resource
- ✓ Calculate historical baselines, subtract load, and estimate the virtual power plant generation
- ✓ Adjust schedule imbalances of other counterparties
- ✓ Reconstitute avoided system load

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Key Complexity: Tri-Party Relationships

VPP only represents the 'Flexible' part of load or resource

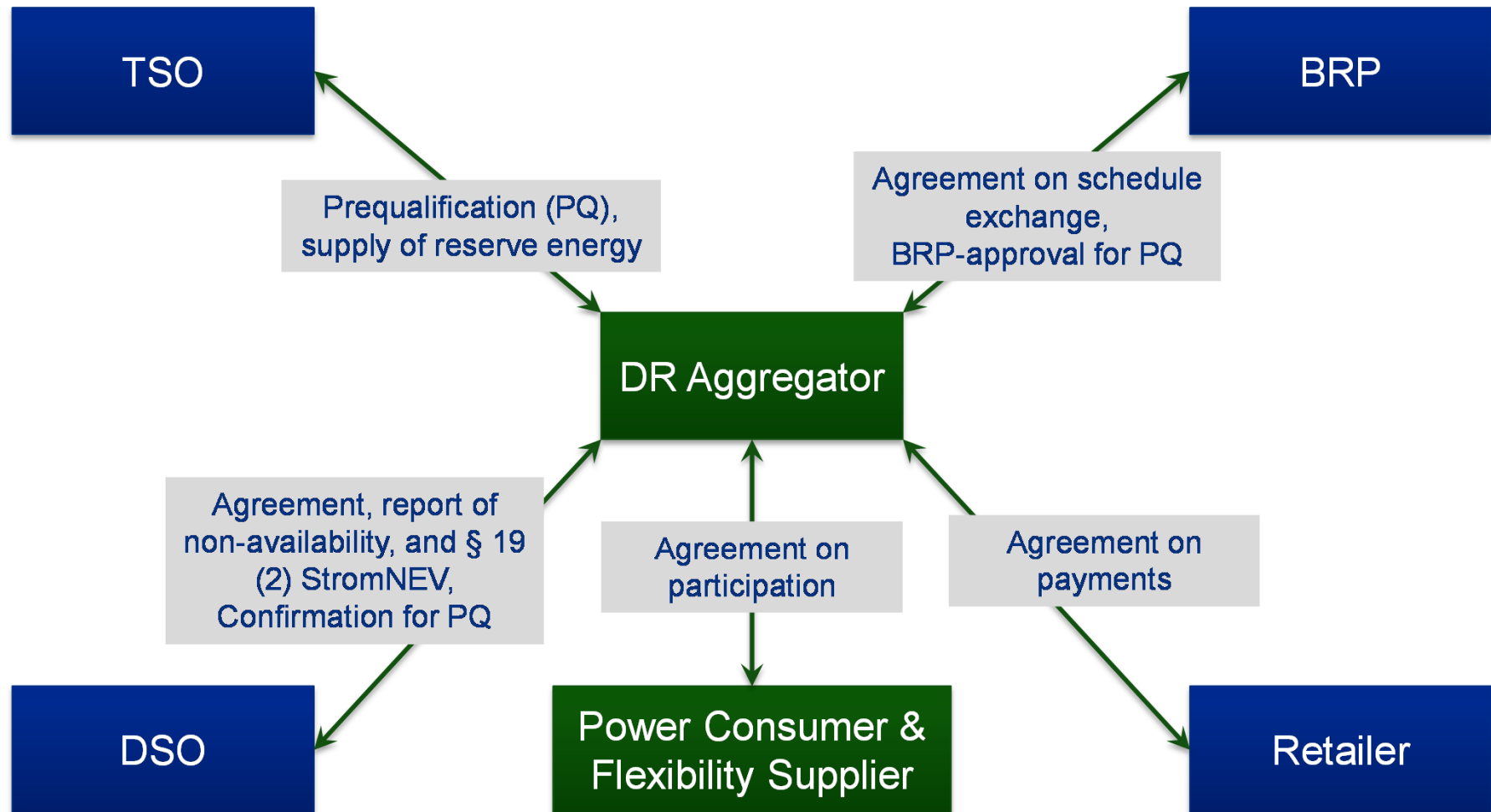


Issues with Tri-Party System

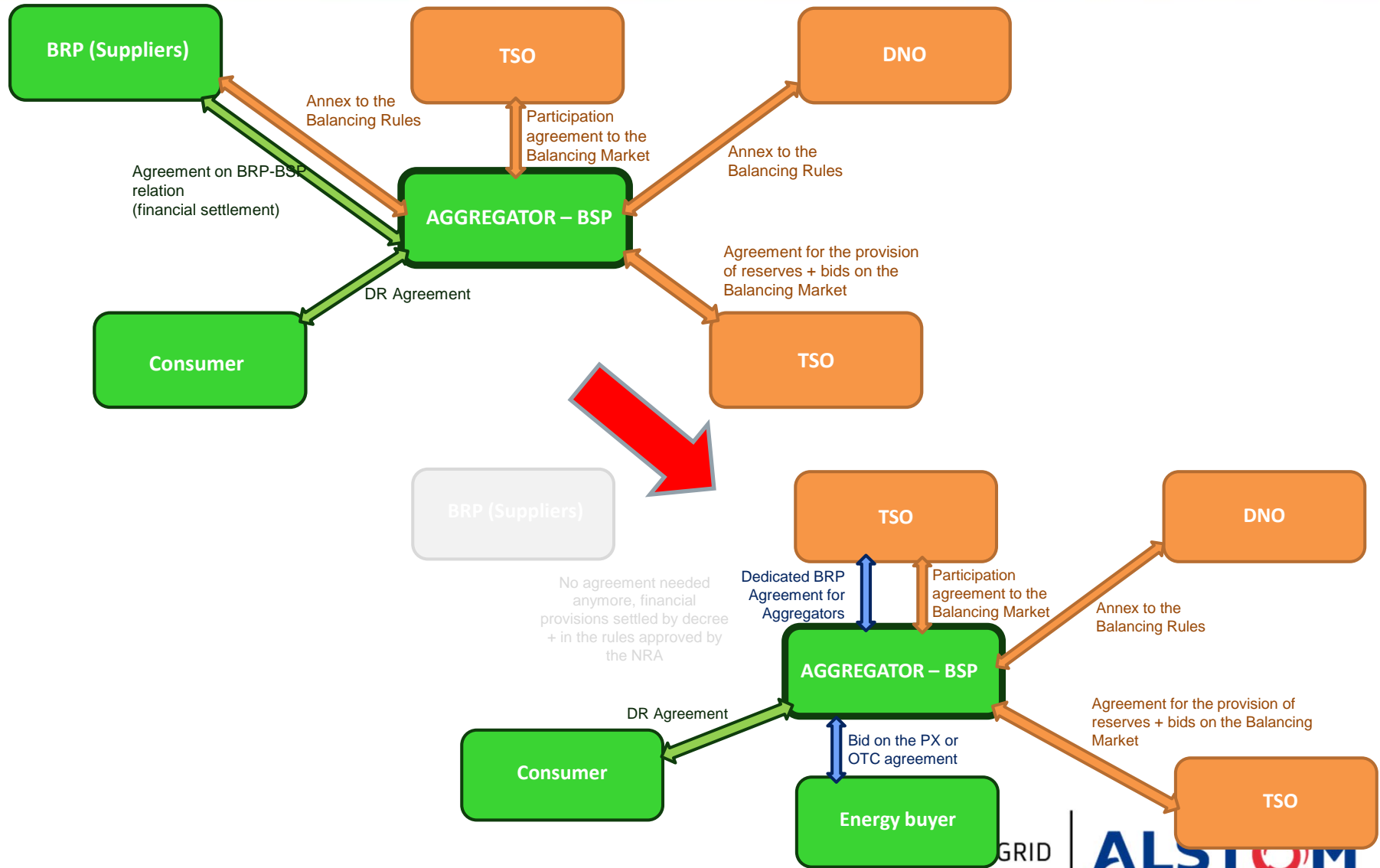
Aggregator/Retailer/Distributor sharing the same resource

- **Logistical challenges** – communicating and reconciling how the behavior of one party affects others – dual representation of same kW
- **Missing money problem** – not enough revenue in energy arbitrage – hence capacity payments and economic full-LMP
- **Conceptual challenges** – how does an aggregator sell energy at full LMP without buying it first at the DA or RT rate?
- **Competitive conflicts** – each party is expanding into other businesses, especially Retailer-Aggregator convergence as Retailers see additional value in expanded energy services and price risk mitigation
- **Regulatory jurisdiction** – US courts rule that FERC lacks authority to incentivize customers to bypass retailers (but note this was a case instigated by generators over DER competition)

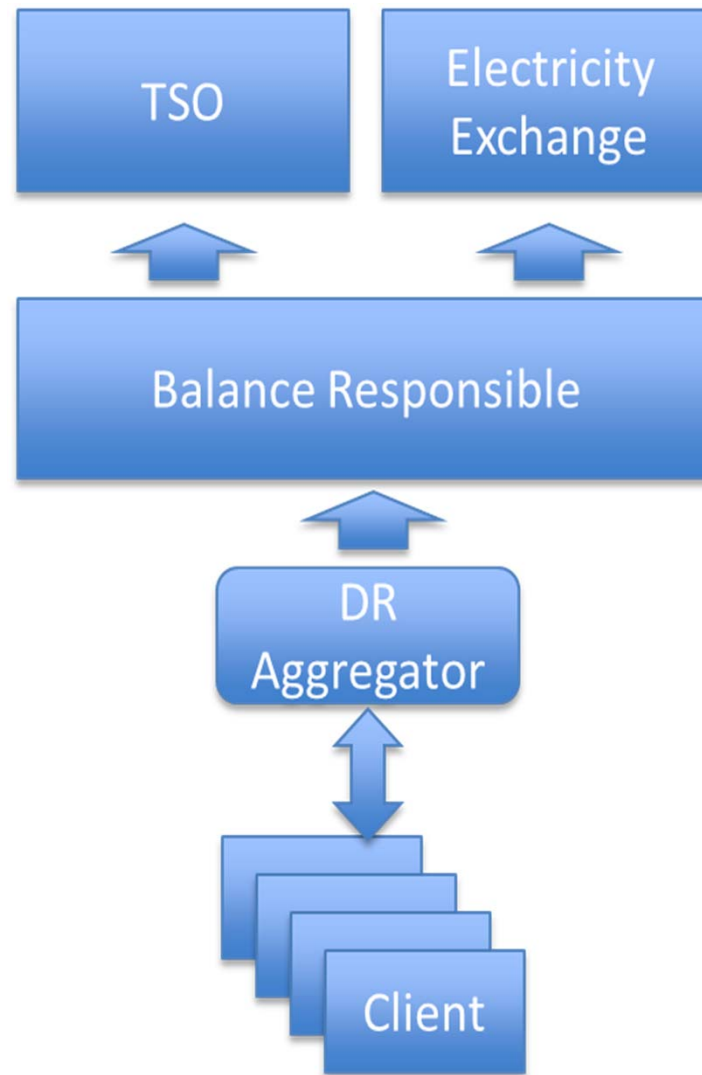
Germany: Too many parties (5!) and unstructured bilateral contracts slow down market entry of DR/DERs



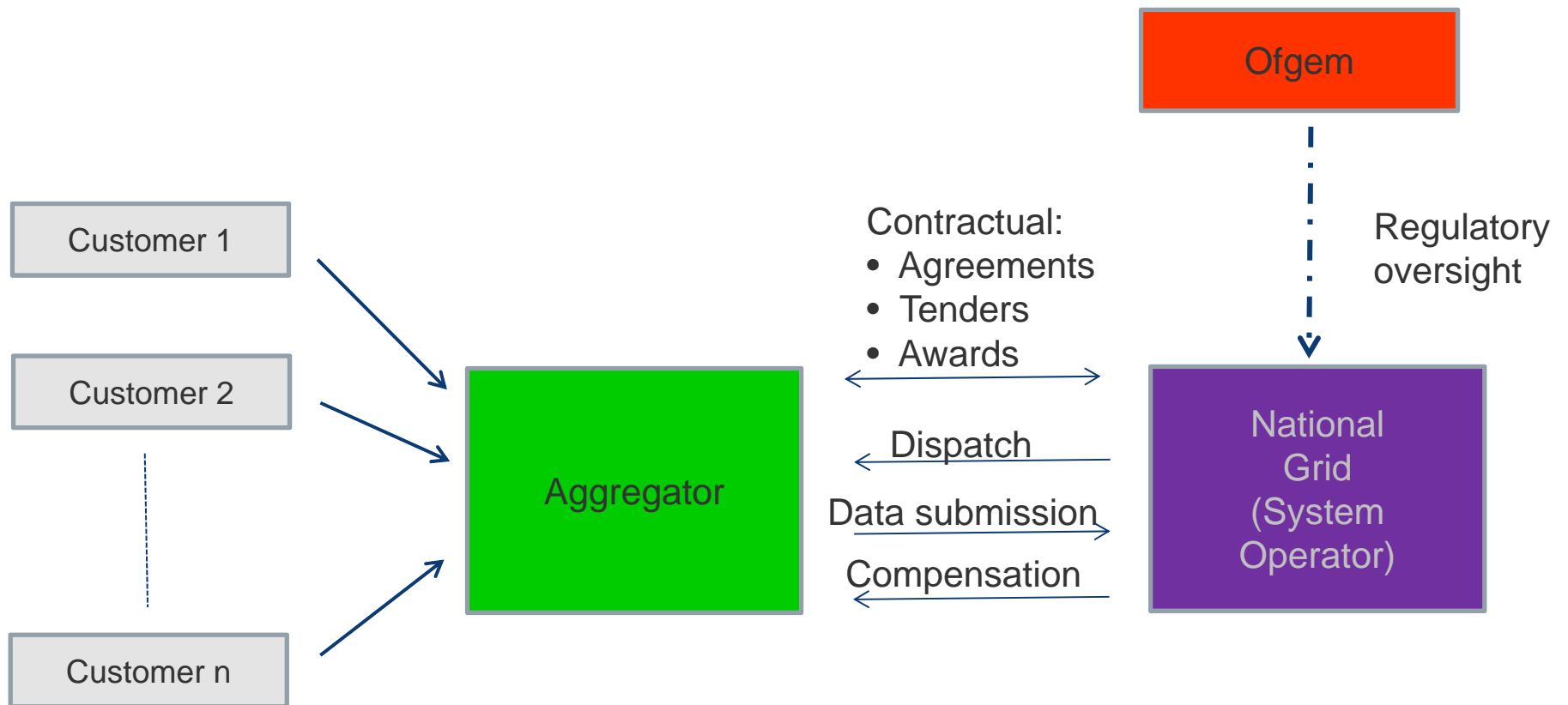
France: Requires a contract between Aggregator and Retailer/Buyer to pay for energy sold



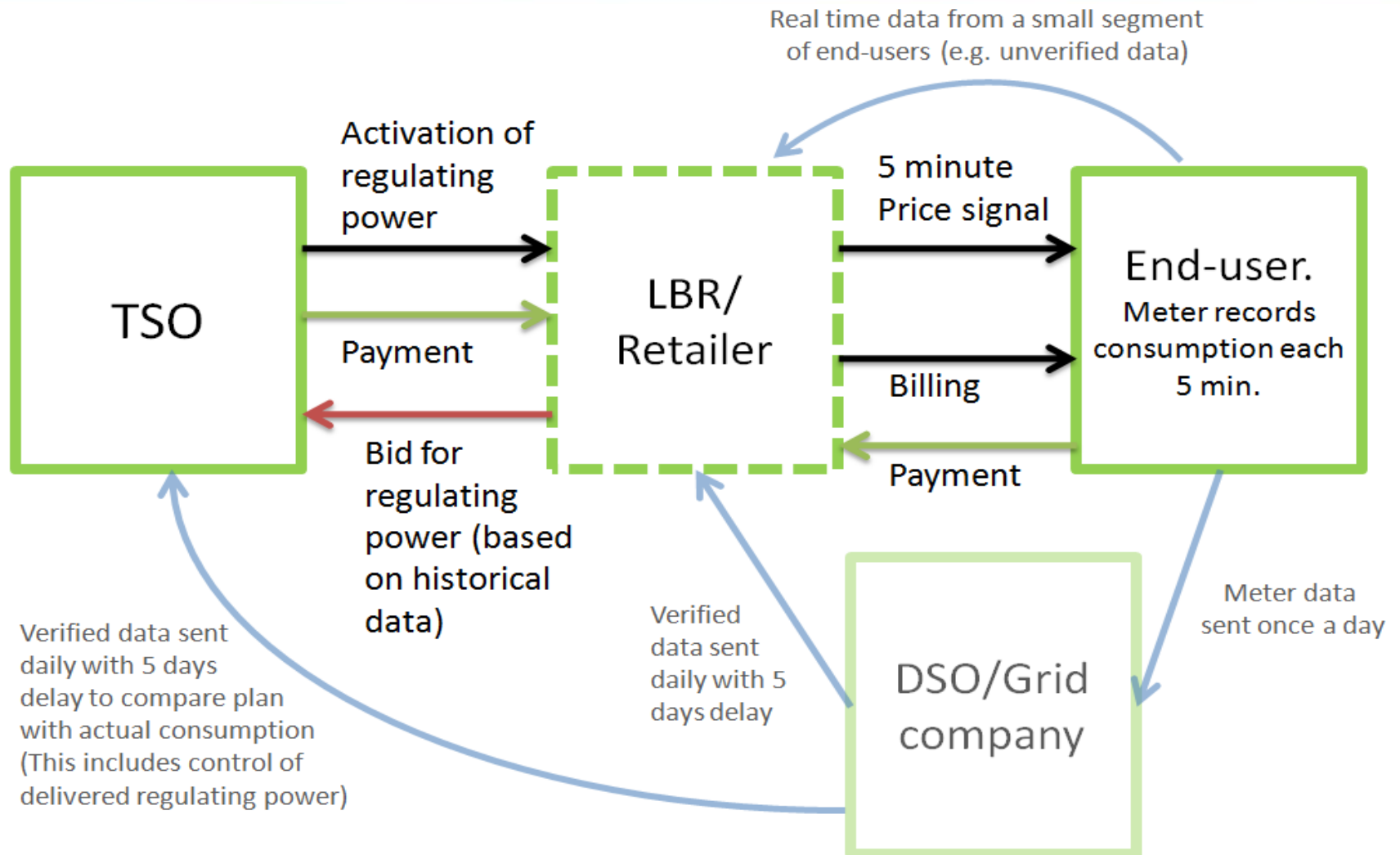
Finland: Testing Aggregator as a sub-contractor to BRP/Retailer



UK: Looks simple, but is largely a DG market due to technical program requirements



Denmark: Experimenting with Retailer as Aggregator



Potential Solutions

- **Merge Retailer/Aggregator roles** – Eliminate complexity of dual representation of the same kW, return to safe jurisdictional bounds where markets incentivize DER participation via retailer channels
- **Technical aggregator role** – Essentially a specialist in DER technology installation and operations, but with no market role. Sub-contracts to Customers, Retailers, or Distributors as necessary.
- **Localized, low voltage flexibility markets** – encourage Distributors to utilize DERs for local reliability (NY REV, CA CPUC) and create more opportunities for Retailers to monetize flexibility investments
- **Forward capacity options** – transition capacity markets into something like an ‘options’ market with varying degrees of commitment and reliability, to incentivize investment in MW quality by all asset types