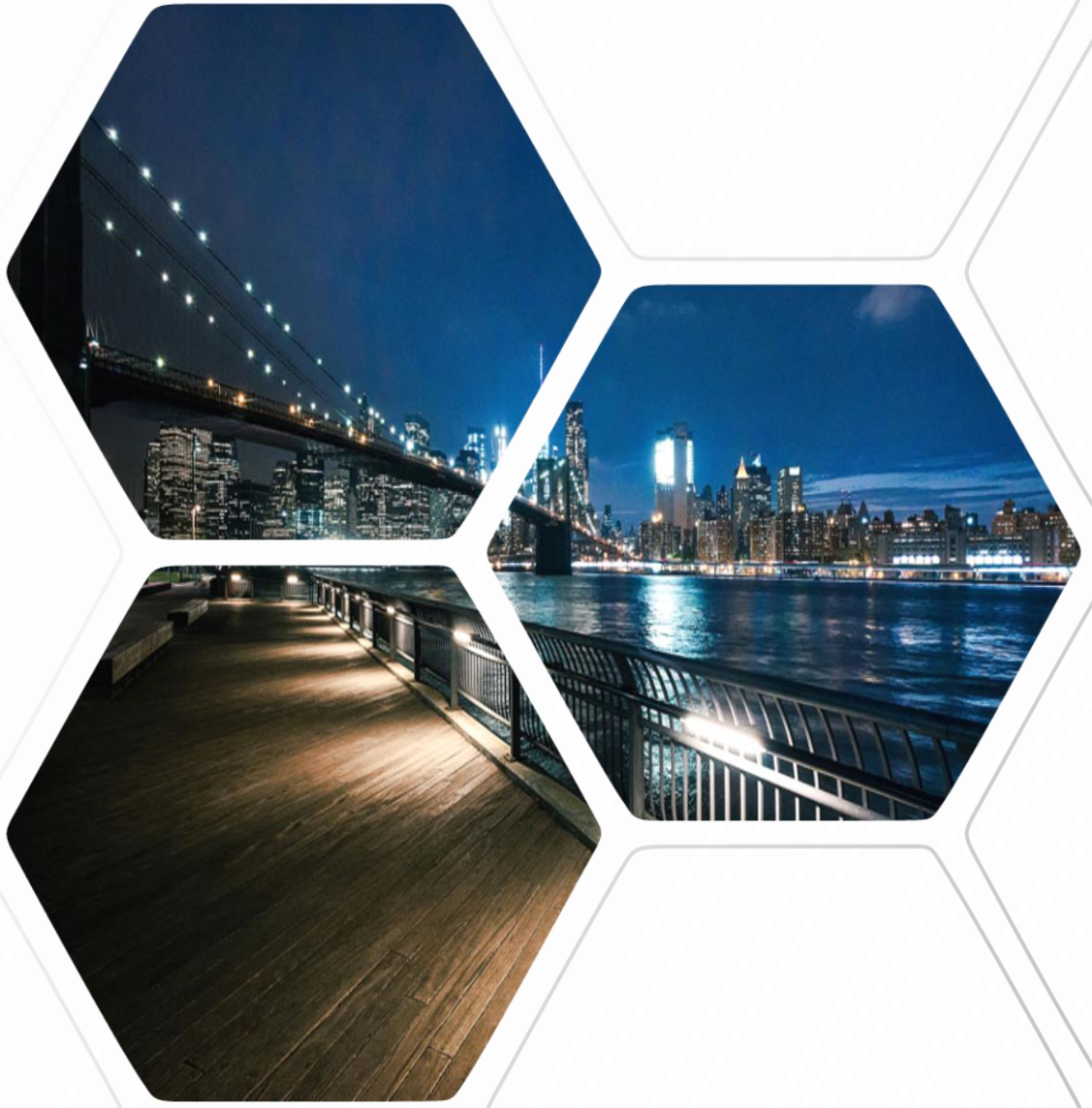
Worldwide Trends of Electricity Market Design and Market Management Systems For Power Grid



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GE Digital

Outline

- Introduction
- Electricity market design and trends: EU & US
- R&D topics and trends
- Characteristics of next generation market system
- Conclusions

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What is GE Digital?

Our mission is

To bring simplicity, speed and scale to your digital transformation with modular software applications that better help you to operate analyze and optimize your business processes

$1.2B

Industrial SWS Business

4000+

Employees, T&D foundational

- Electric Utilities and Telecommunications
- Power generation (gas, steam, and related plant operations)
- Oil & Gas industry and related adjacent markets
- Select manufacturing applications and digital transformation projects

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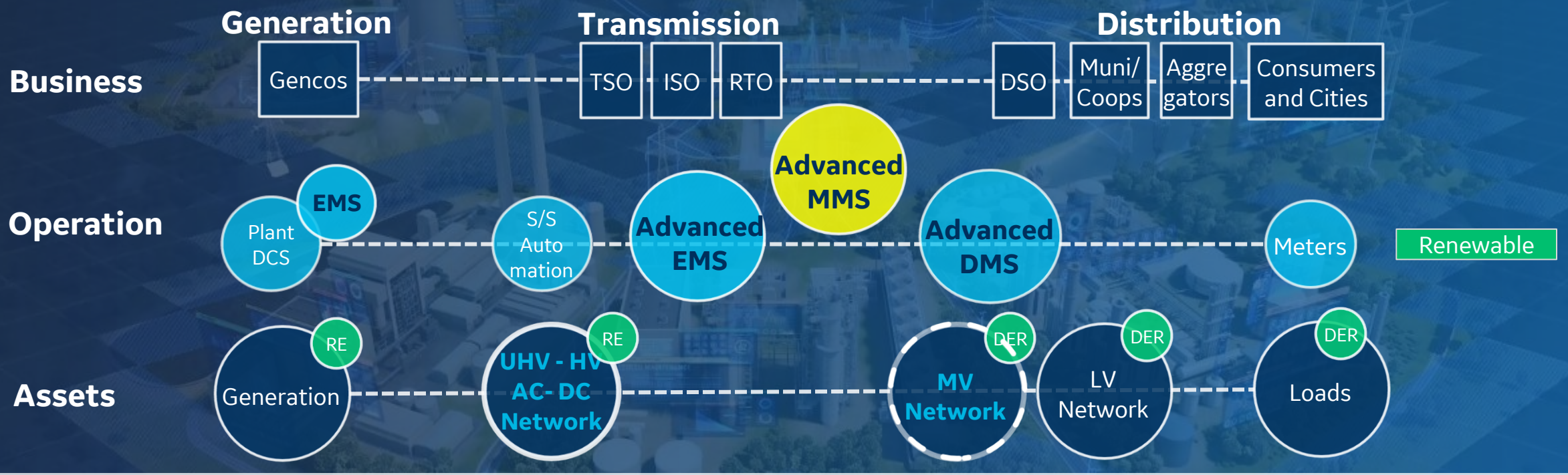
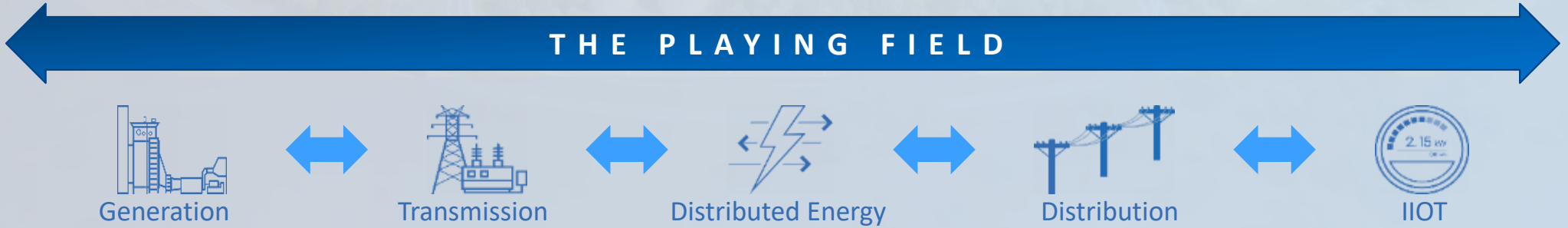
Advanced Energy Management: Market + EMS + DMS

Unprecedented Opportunity to Leverage Value Across the Eco-system





"4D" Megatrends

Driving Change & Disruption in the Utility Sector

Decarbonization

more variability requiring full awareness and encouraging exchanges

Digitalization

enables creation of new transformative energy provisioning business models

Decentralization

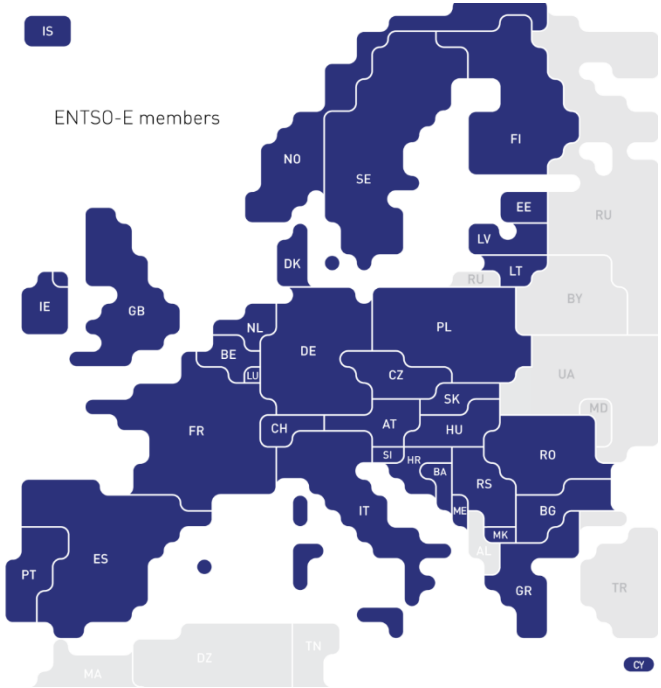
introduces the need for new network operating model

Democratization

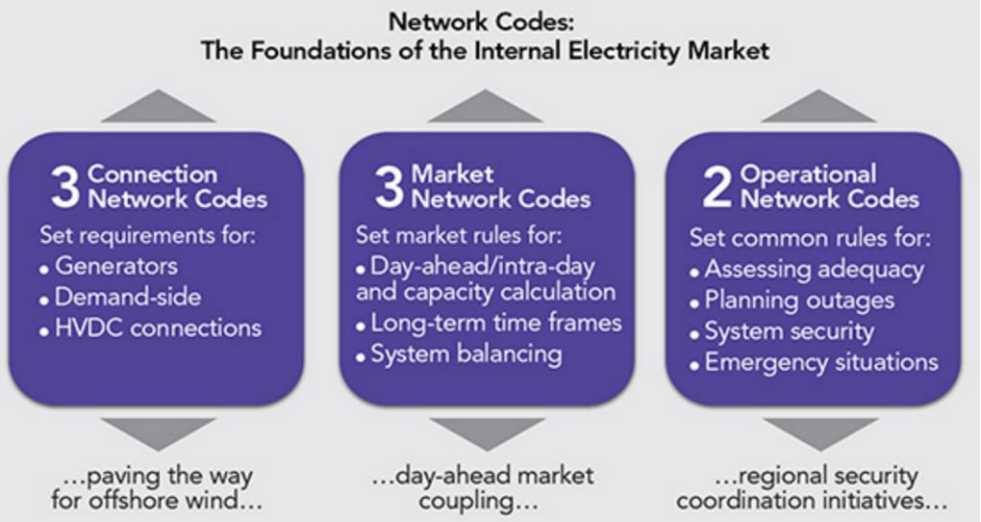
more parties in the energy value proposition and involvement of prosumers

ENTSO-E Organization

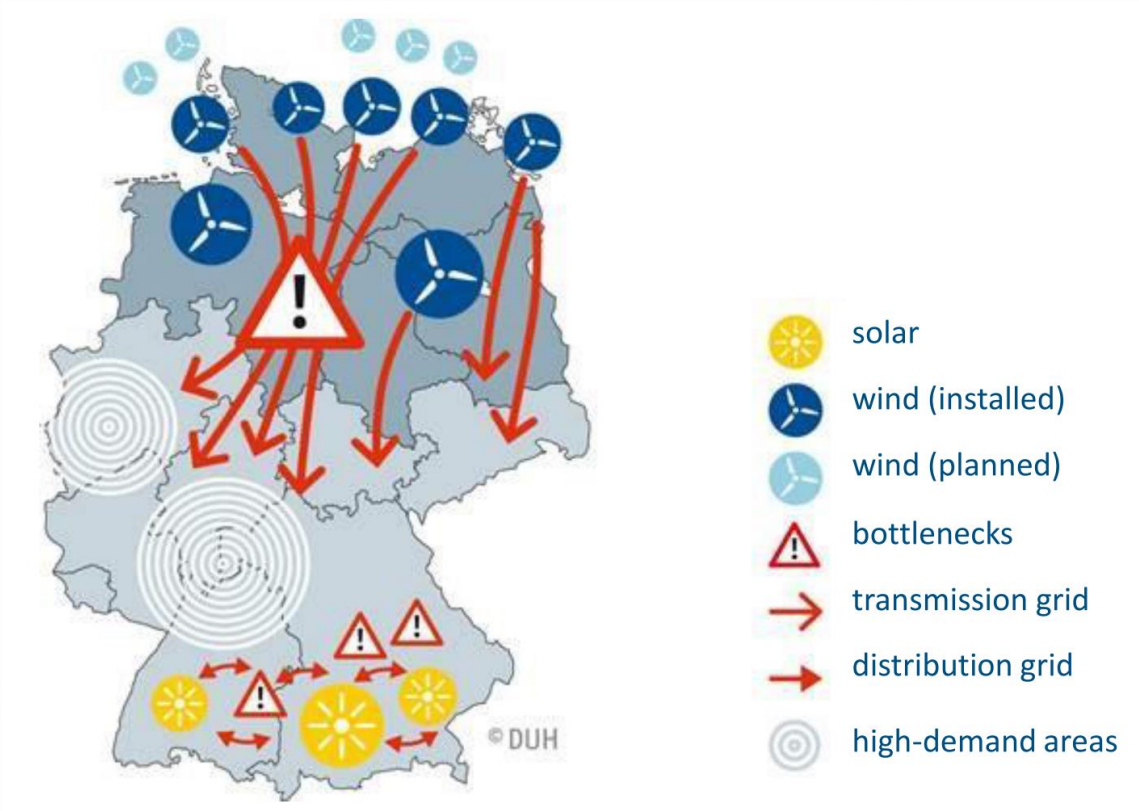
- ENTSO-E - a network of 42 Transmission System Operators, given legal mandates by the EU to liberalize the gas and electricity markets.



- WGs in the Market Committee:
  - WG Market Integration
  - WG Ancillary Services
  - WG EDI Implementations
  - …
- Network codes - Market Rules



European Markets

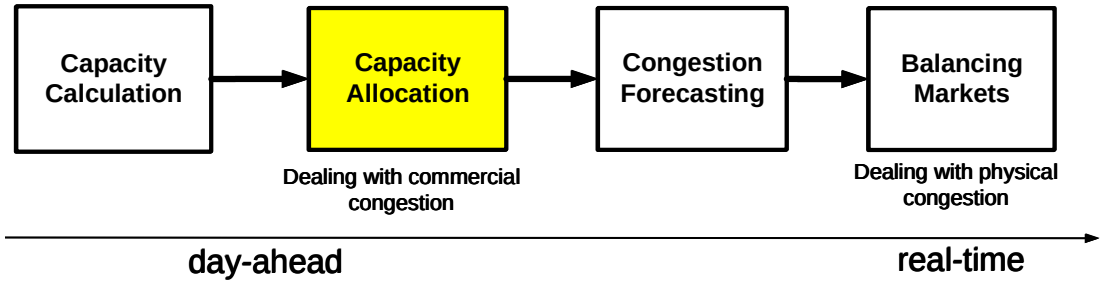


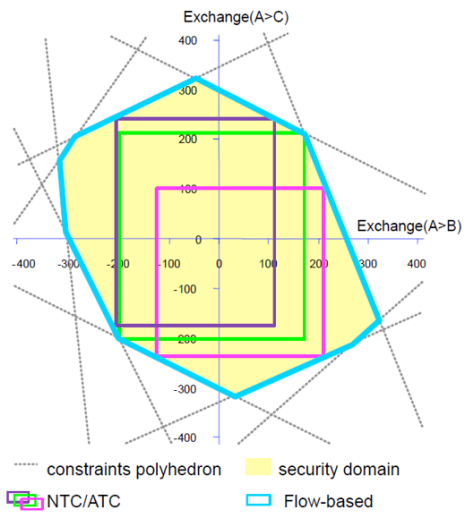
Congestion Management

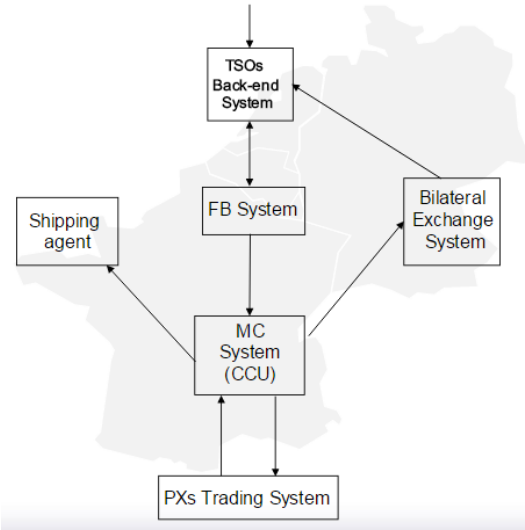
- EU has set out plans to move to an entirely carbon-free power sector by 2050.
- With new energy resources (e.g. offshore wind farms) being far away from load centers, some weaknesses associated with congestion management in the current European systems are exposed.
- Europe **needs a more effective congestion management system**
- Efficient use of allocation of transmission capacity is treated by ENTSO-E as one of the keys to congestion management.

Cross-Border (XB) Capacity Allocation (CA) and Balancing Markets

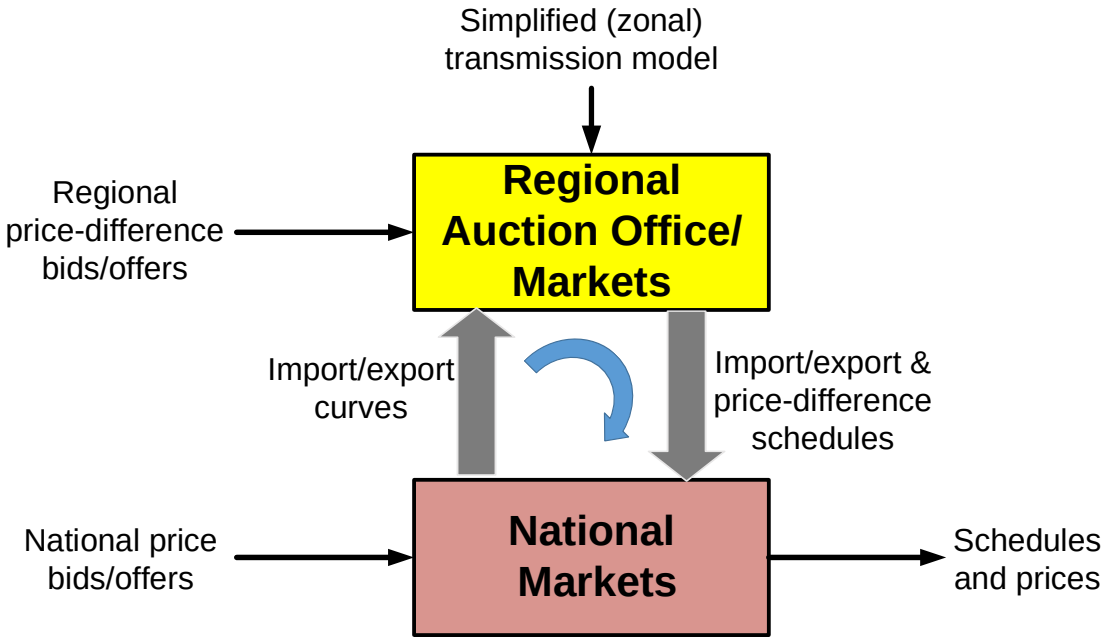
Flow-based Market Coupling (Getting more Physical from Day-Ahead to Real-Time)







Sources: Powernext & RTE



XBCA has been a good step towards market-based congestion management

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Joint Allocation Office (JAO) – EU (Lux.)

ID card

- ✓ Allocation of transmission capacities in EU **25 TSOs(*) from 19 countries, +40 European borders**
- ✓ Now appointed as the **Single Allocation Platform (SAP) in Europe**
- ✓ More than **400GW allocated, +1Mds €** traded per year

Vision and challenges :

As daily operations:

- **Wide collection of information** on transmission capacity and allocation constraints to be offered
- **Run multiple auction processes** on all borders, all horizons (Y,Q,M,D), multiple specificities (rules, timings)

Preparing the future by,

- **Pursuing the continental extension** of JAO's services in EU
- **Playing as an harmonizer** to accompany EU TSOs to converge on common rules
- **Supporting the evolution of EU Energy Balancing guidelines** increasing of bidding zones

* 50Hertz (DE), IPTO (GR), Amprion (DE), APG (AT), ČEPS (CZ), CREOS (LU), ELES (SI), ELIA (BE), EnerginetDK (DK), HOPS (HR), MAVIR (HU), PSE (PL), RTE (FR), SEPS (SK), Statnett (NO), Swissgrid (CH), TenneT (DE), TenneT (NL), Terna (IT), TransnetBW (DE), Moyle (N-IRL), Eirgrid (IRL)

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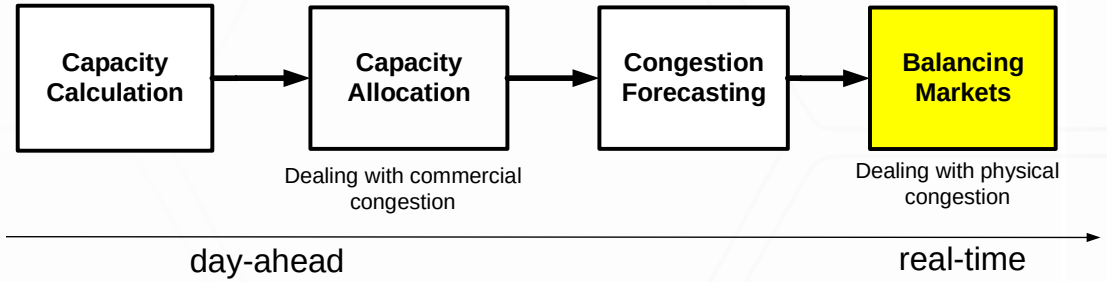
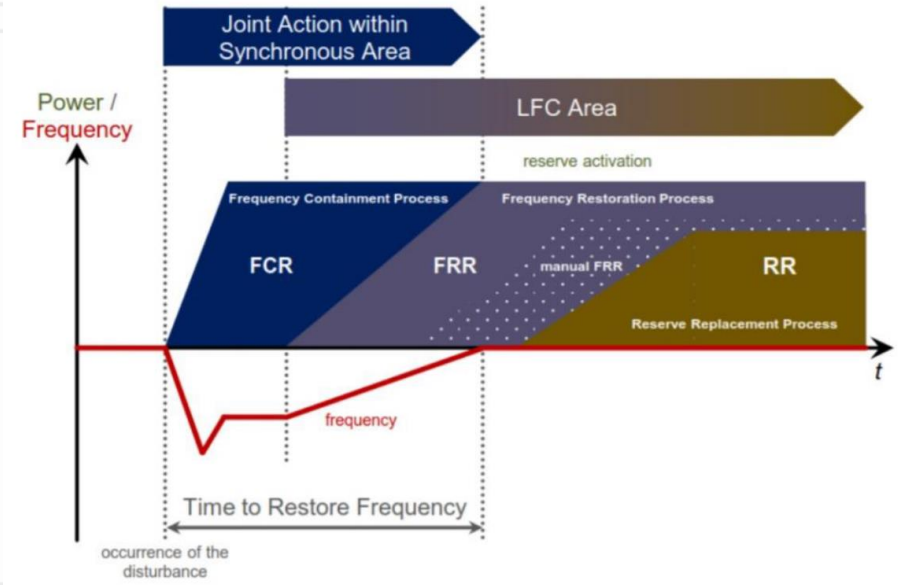
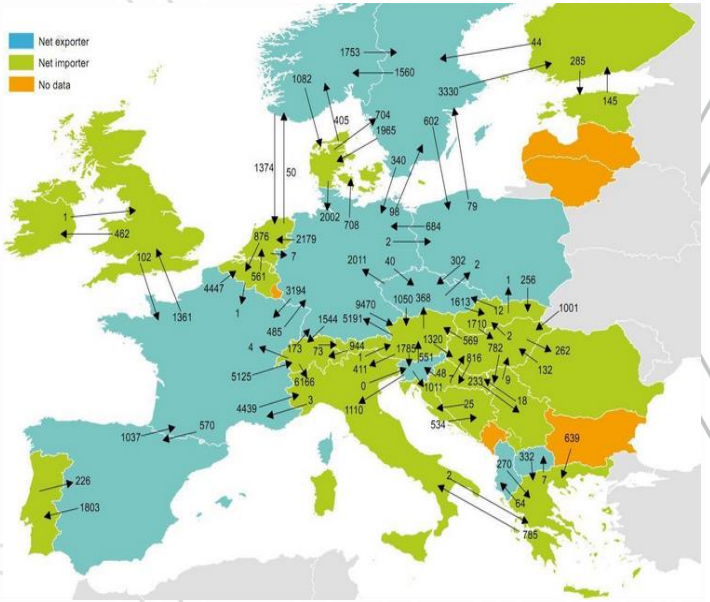
Balancing Markets





- Balancing market is the institutional arrangement that establishes market-based balance management in an unbundled electricity market.
- It can be considered the last in a sequence of electricity markets, after year-ahead, month-ahead, day-ahead and intra-day markets.
- The design of the balancing market is more intricate, as it lies at the junction of financial transactions and physical exchanges.
- Starting with implementation of national balancing markets
- **Balancing markets integrated across a larger region to achieve high market efficiency**



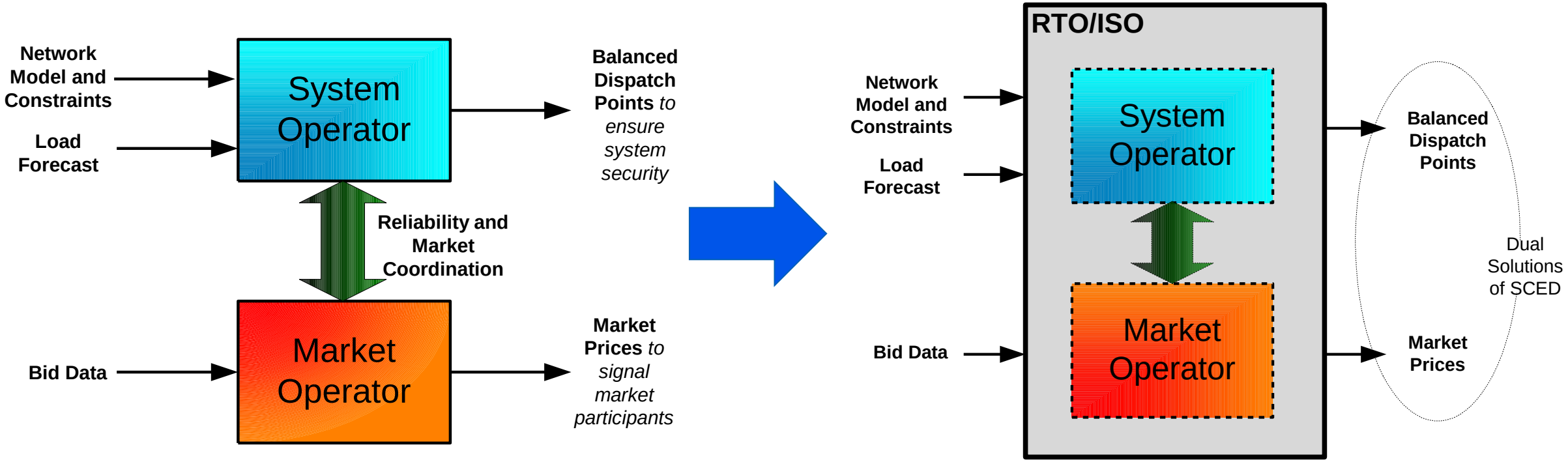
US Markets

Source: isorto.org

In North America, Regional Transmission Organization (RTO) or Independent System Operator (ISO) is responsible for:

- Operate a power grid securely with minimum costs
- Schedule and dispatch resources to satisfy market demand with economic efficiency
- Purchase ancillary services for the benefit of grid reliability
- Disseminate open market information to participants

Optimization-based Integrated Approach to Market Design



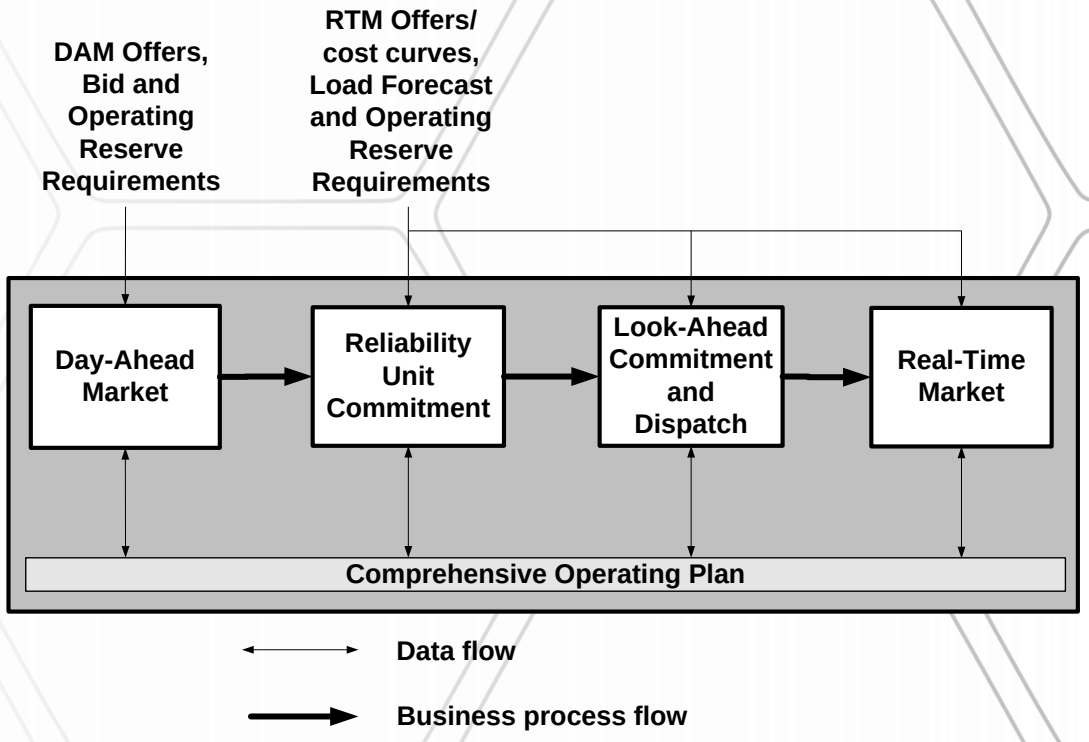
Consistent dispatch signals and price signals based on

- *Security constrained economic dispatch (SCED)*
- *Locational Marginal Pricing (LMP)*

Joe H. Chow, Robert deMello, Kwok W. Cheung, "Electricity Market Design: An Integrated Approach to Reliability Assurance"", *Invited Paper, IEEE Proceeding (Special Issue on Power Technology & Policy: Forty Years after the 1965 Blackout), vol.93, no. 11, pp.1956-1969, November 2005.*

Standard Market Design (SMD) in the US

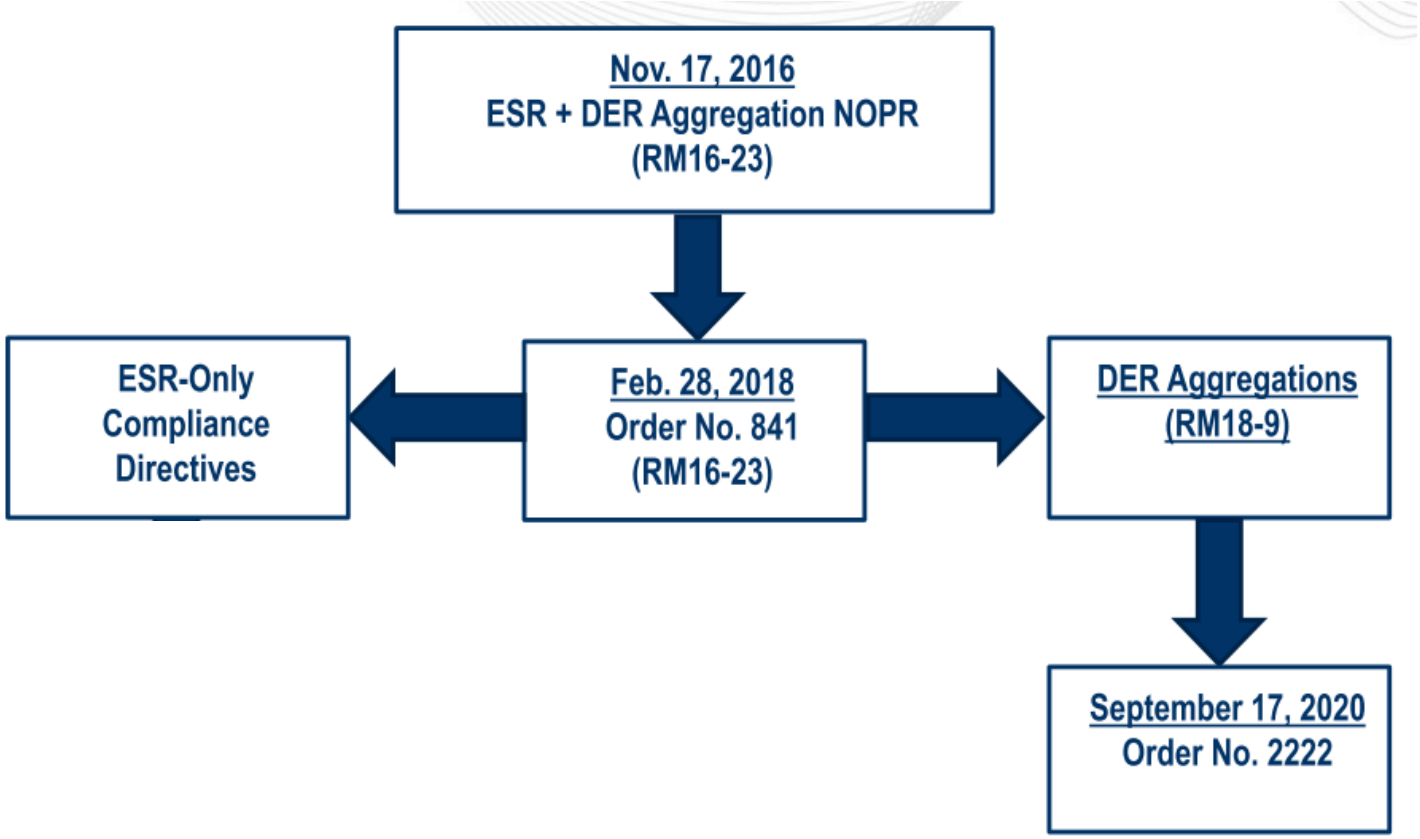
- In late 90s and early this century, FERC pushed for a common market design framework - **Standard Market Design**
- Multi-Settlement System
  - Day-ahead Market
  - Real-time Market
- Locational Marginal Pricing
  - Market-based Congestion Management
  - Financial Transmission Rights
- Co-optimization of Energy and Ancillary Services Reliability Assurance Business Processes
  - Reliability Unit Commitment (DA, Intra-day)
  - Look-Ahead Commitment and Dispatch



FERC Order 2222

A New Day for Distributed Energy Resources

- **FERC Order 2222** (Issued September 17, 2020) enables **distributed energy resource (DER) aggregators** to compete in all regional organized wholesale electric markets enhancing competition, encouraging innovation and driving down costs for consumers.



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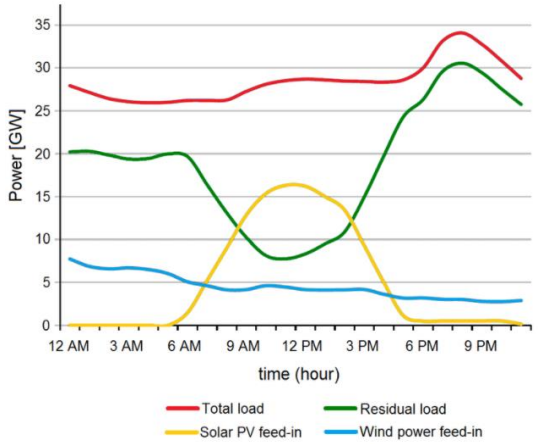
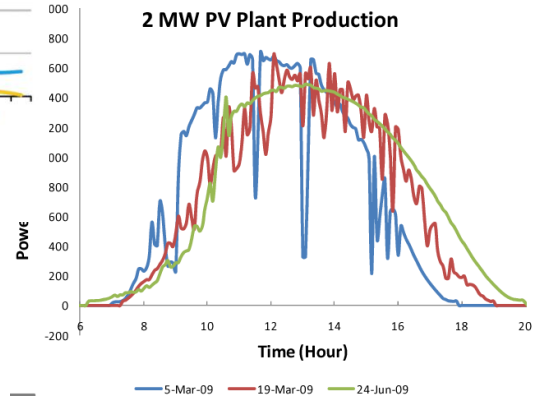
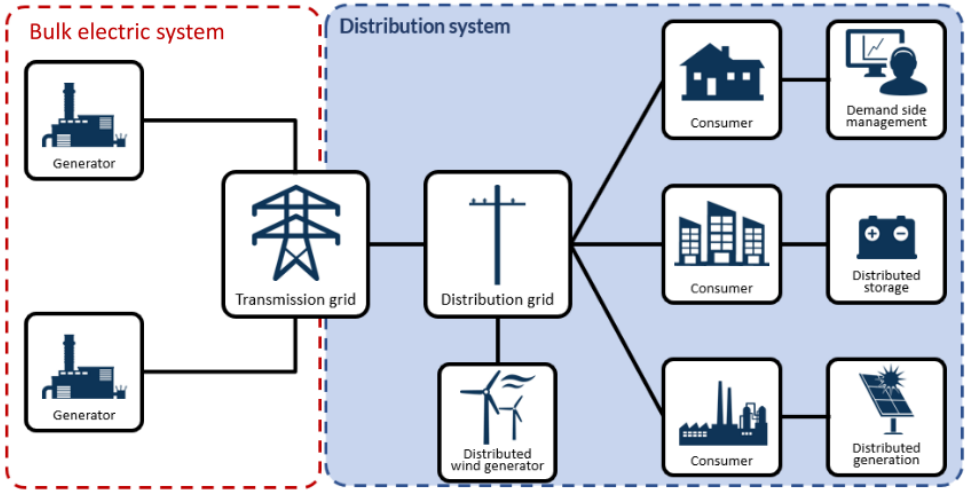
FERC Order 2222

Challenges and Opportunities

- Participation model for aggregated DERs
  - Heterogenous aggregates of DR, storage, Solar, DG, EV etc
  - Multi-node aggregation
  - Dynamic distribution factor
- Monitoring and control of aggregated DERs
- Visibility of DERs
- Two-way power flows
- Reliability implications of increased real-time variability and uncertainty
- Changing net load patterns; degrading load forecast
- **Integration models**
- **Coordination/communication between the ISOs, DER aggregators (DERA) and distribution companies**



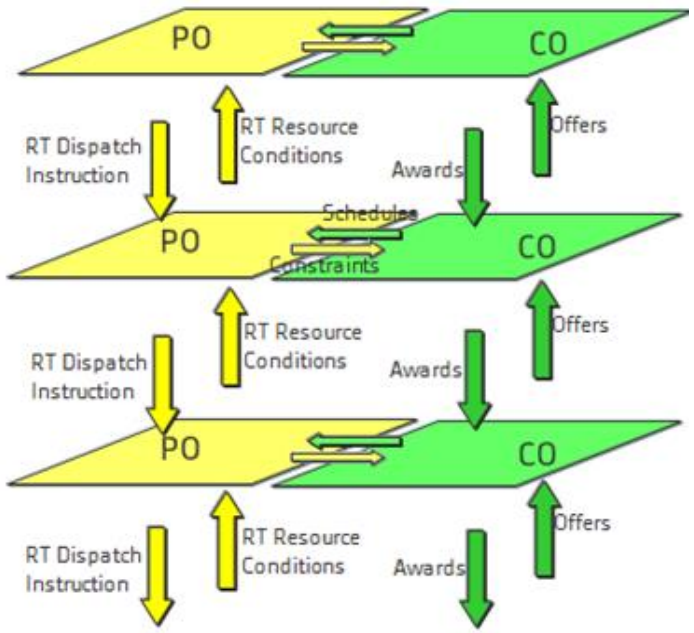


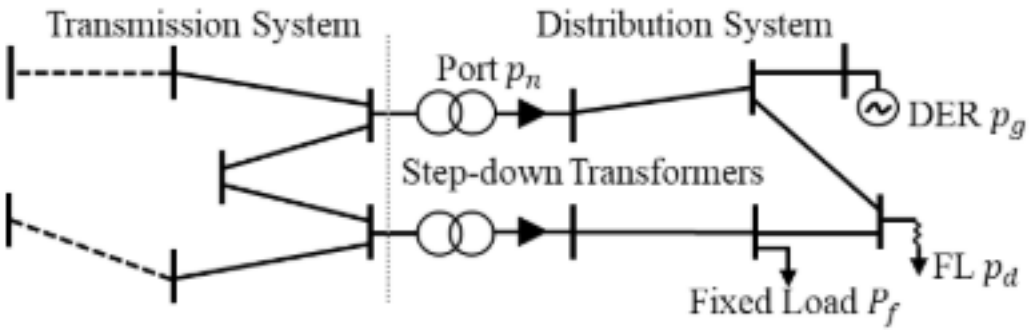


FERC Order 2222

Market Clearing Models to Incorporate DERA

1. Full model with distribution systems with DERs inside them
   - Large problems – many resources, huge network
   - Issue of model fidelity
   - Observability and controllability issues
2. ISO-DSO coordination
   - Decompose the problem
   - Bilevel models – solved iteratively
3. Power exchange models





Recent Market Development/Research Trends

- Energy price formation
- Convergence of reserve market design and implementation
- Flexibility products
- Integration of energy storage
- Configuration-based combined cycle
- Multi-day markets and projections
- Integration of distributed energy resources/VPP
- Risk-based market clearing
- Topology and flow control
- HVDC and advanced loss model
- Angular and voltage stability limit consideration
- Retail Market - Distributed System Platform

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Advanced MMS

Performance and Scalability

- Re-engineering the Market Clearing Engine for superior performance
- Micro services ecosystem
- Advanced messaging and data transfer infrastructure
- Highly scalable architecture for diverse system footprints

Flexibility

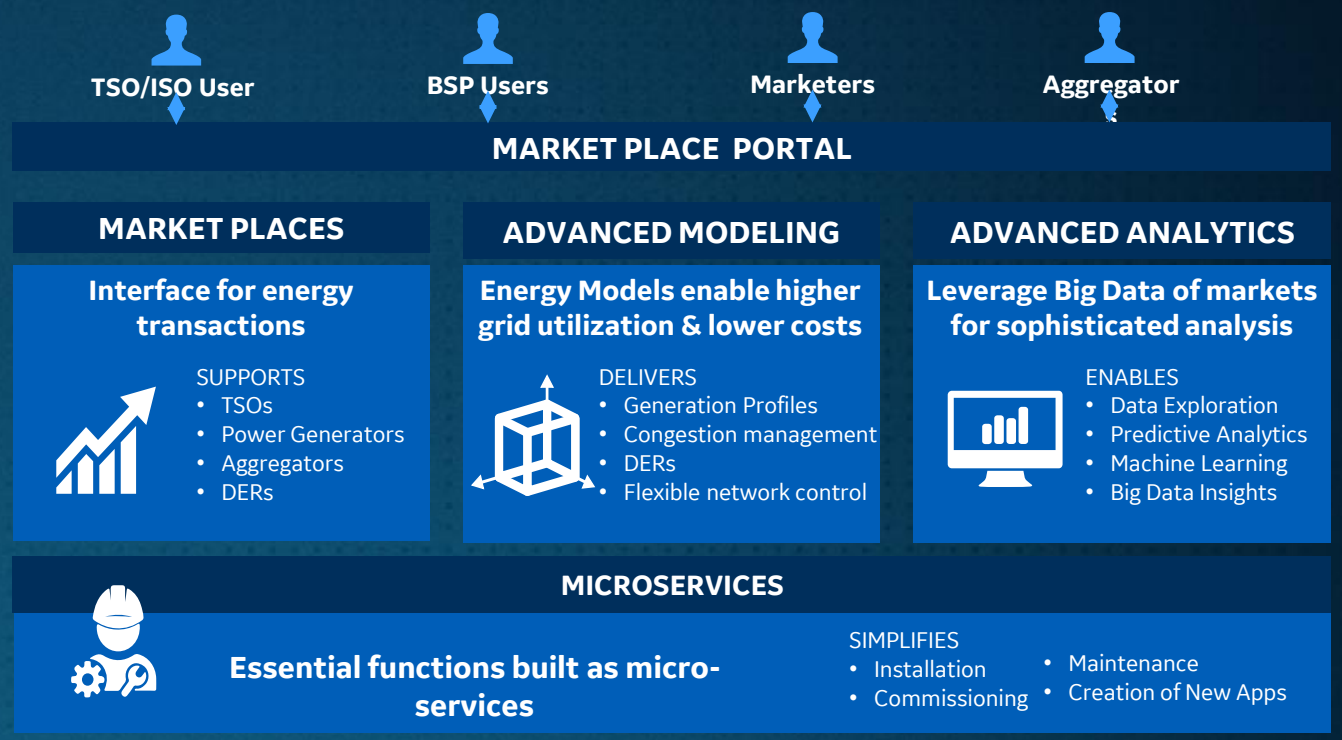
- Modular applications easily configured to meet rapidly changing business requirements
- Solution framework allows for an easy integration of the needed business modules and interface with external systems

Advanced Capabilities

- Complex modeling
- Regional balancing and reserve sharing
- Energy price formation
- Congestion management leveraging world-class Network Apps

Advanced Analytics

- Leveraging Big Data and AI for business returns



Summary: Market drivers & industry trends of Markets

	Market efficiency & operational excellence	Flexibility & scalability	Grid modernization & cyber-physical security	Environment & regulations
Macro Factor				
Impact	Maximizing social welfare while maintaining system reliability and improving resilience	Resource/grid scheduling and dispatch challenges due to significant penetration of renewables and DERs	New devices and infrastructure and heightened level of cyber-physical security concerns	Aggressive environmental targets and fast evolving regulations
Industry Trend	• **Proper market signals** • **Larger-scale resource and grid optimization** • Dynamic line ratings • Flow control devices • Improve system resiliency • Market coordination • Mitigate root-causes for dispatch deficiencies	• From centralized to more decentralized solution framework • **Demand for high performance computing and algorithmic breakthrough** • Situation awareness and look-ahead capability	• Industrial internet of things (IIoT) for energy • Smart devices with distributed intelligence • **Coordinated decision making across the hierarchy of T&D** • **Analyze / mitigate cyber-physical security risk** • Converging of OT with IT	• Emphasis on low carbon energy mix and demand response. • **Integration of large amount of renewable power, DER & storage.** • **New FERC orders** • **EU Clean Energy package** • New business model • Retail market

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