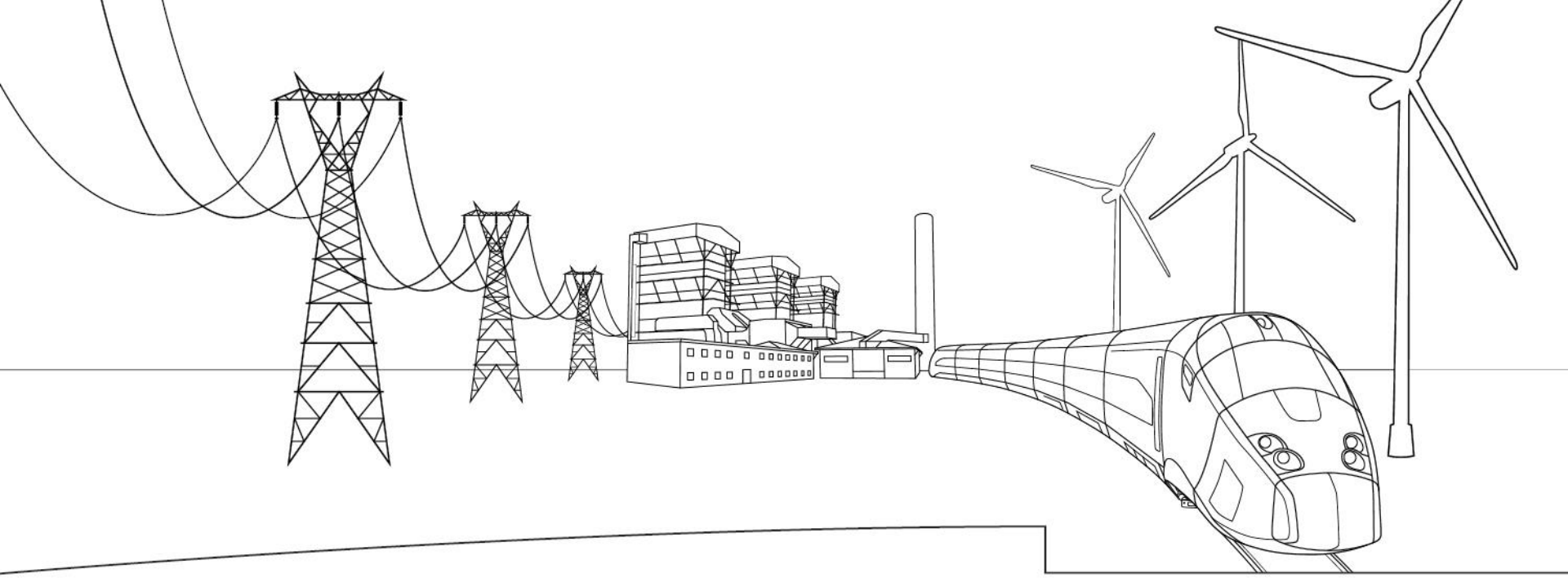

Introduction to US electricity markets

Eric GOUTARD

Paris

12/12/2013

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Shaping the future

- **Regulatory background**
- US market footprint and major RTOs
- Key concepts related to US electricity markets
- Overview of business processes
- Examples of IT implementation
- Recent news

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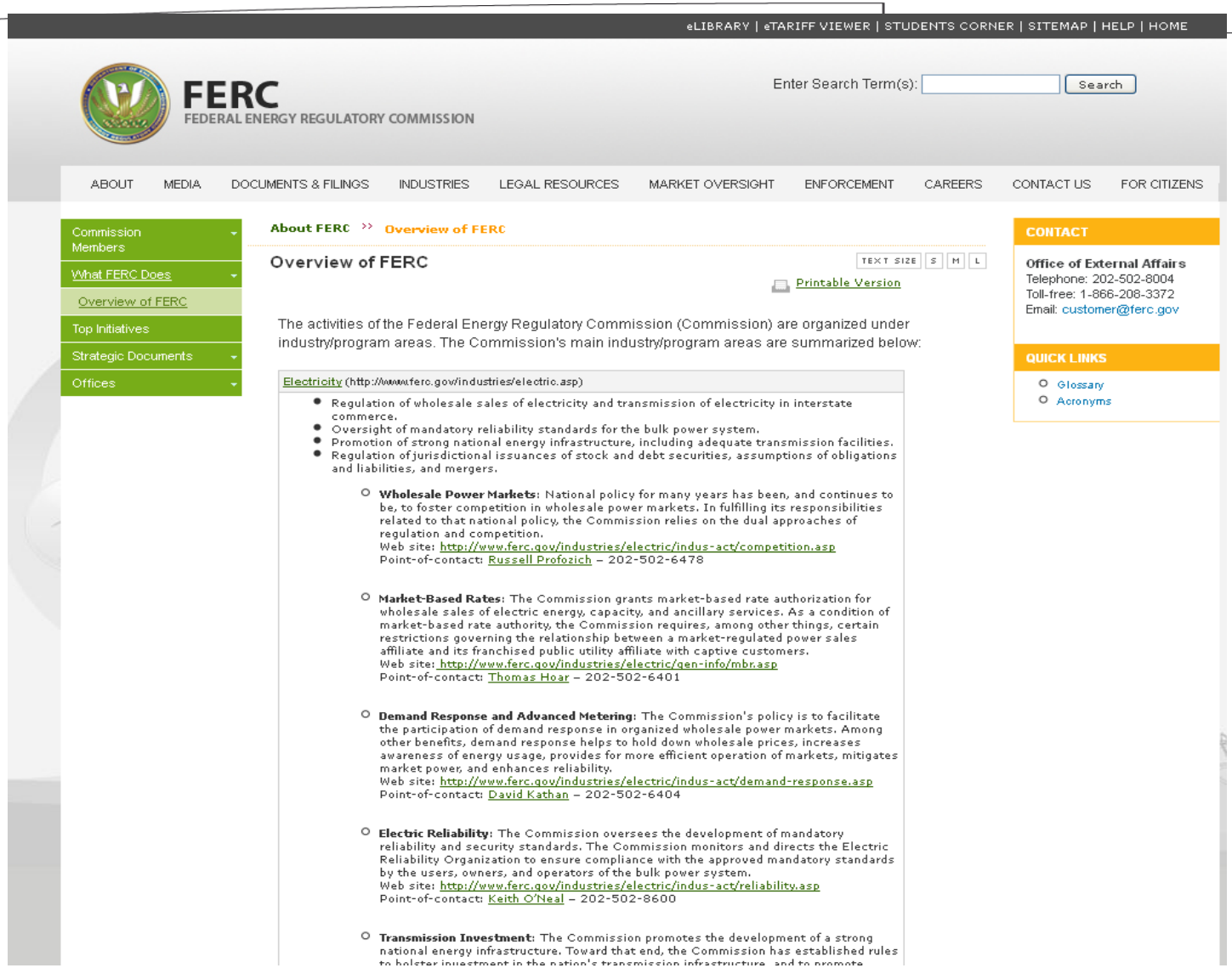
US electricity markets organizations birth

- 1996: FERC Orders 888 and 889
  - barriers to competitive wholesale markets may exist and must be removed
  - allow utilities to recover costs associated with providing open access to transmission grid
  - concept of an Independent System Operator to satisfy the requirement of providing non-discriminatory access to transmission
  - OASIS
- 1999: FERC Orders 2000
  - encouraged the voluntary formation of Regional Transmission Organizations to administer the transmission grid on a regional basis throughout North America (including Canada)

Regulatory structures

- US electricity utilities are regulated by both federal and states regulatory agencies
  - FERC regulates wholesale electricity markets and interstate issues
    - Market structures, transmission planning and cost allocation, bulk power grid reliability (through NERC)
  - State utility commissions regulates everything else
    - Distribution rates, supply rates in integrated states, conditions to procure electricity in deregulated states
- In regulated states, utilities are vertically integrated and prepare integrated resource plans to serve their load.

FERC: Federal regulator



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FERC
FEDERAL ENERGY REGULATORY COMMISSION

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- Commission Members
- What FERC Does
  - Overview of FERC
- Top Initiatives
- Strategic Documents
- Offices

About FERC >> Overview of FERC

Overview of FERC

TEXT SIZE S M L

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The activities of the Federal Energy Regulatory Commission (Commission) are organized under industry/program areas. The Commission's main industry/program areas are summarized below:

Electricity (http://www.ferc.gov/industries/electric.asp)

- Regulation of wholesale sales of electricity and transmission of electricity in interstate commerce.
- Oversight of mandatory reliability standards for the bulk power system.
- Promotion of strong national energy infrastructure, including adequate transmission facilities.
- Regulation of jurisdictional issuances of stock and debt securities, assumptions of obligations and liabilities, and mergers.

  - **Wholesale Power Markets**: National policy for many years has been, and continues to be, to foster competition in wholesale power markets. In fulfilling its responsibilities related to that national policy, the Commission relies on the dual approaches of regulation and competition.
    Web site: http://www.ferc.gov/industries/electric/indus-act/competition.asp
    Point-of-contact: Russell Profozich – 202-502-6478

  - **Market-Based Rates**: The Commission grants market-based rate authorization for wholesale sales of electric energy, capacity, and ancillary services. As a condition of market-based rate authority, the Commission requires, among other things, certain restrictions governing the relationship between a market-regulated power sales affiliate and its franchised public utility affiliate with captive customers.
    Web site: http://www.ferc.gov/industries/electric/gen-info/mbr.asp
    Point-of-contact: Thomas Hoar – 202-502-6401

  - **Demand Response and Advanced Metering**: The Commission's policy is to facilitate the participation of demand response in organized wholesale power markets. Among other benefits, demand response helps to hold down wholesale prices, increases awareness of energy usage, provides for more efficient operation of markets, mitigates market power, and enhances reliability.
    Web site: http://www.ferc.gov/industries/electric/indus-act/demand-response.asp
    Point-of-contact: David Kathan – 202-502-6404

  - **Electric Reliability**: The Commission oversees the development of mandatory reliability and security standards. The Commission monitors and directs the Electric Reliability Organization to ensure compliance with the approved mandatory standards by the users, owners, and operators of the bulk power system.
    Web site: http://www.ferc.gov/industries/electric/indus-act/reliability.asp
    Point-of-contact: Keith O'Neal – 202-502-8600

  - **Transmission Investment**: The Commission promotes the development of a strong national energy infrastructure. Toward that end, the Commission has established rules to bolster investment in the nation's transmission infrastructure, and to promote

CONTACT

Office of External Affairs
Telephone: 202-502-8004
Toll-free: 1-866-208-3372
Email: customer@ferc.gov

QUICK LINKS

- Glossary
- Acronyms

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- Regulatory background
- **US market footprints and major RTOs**
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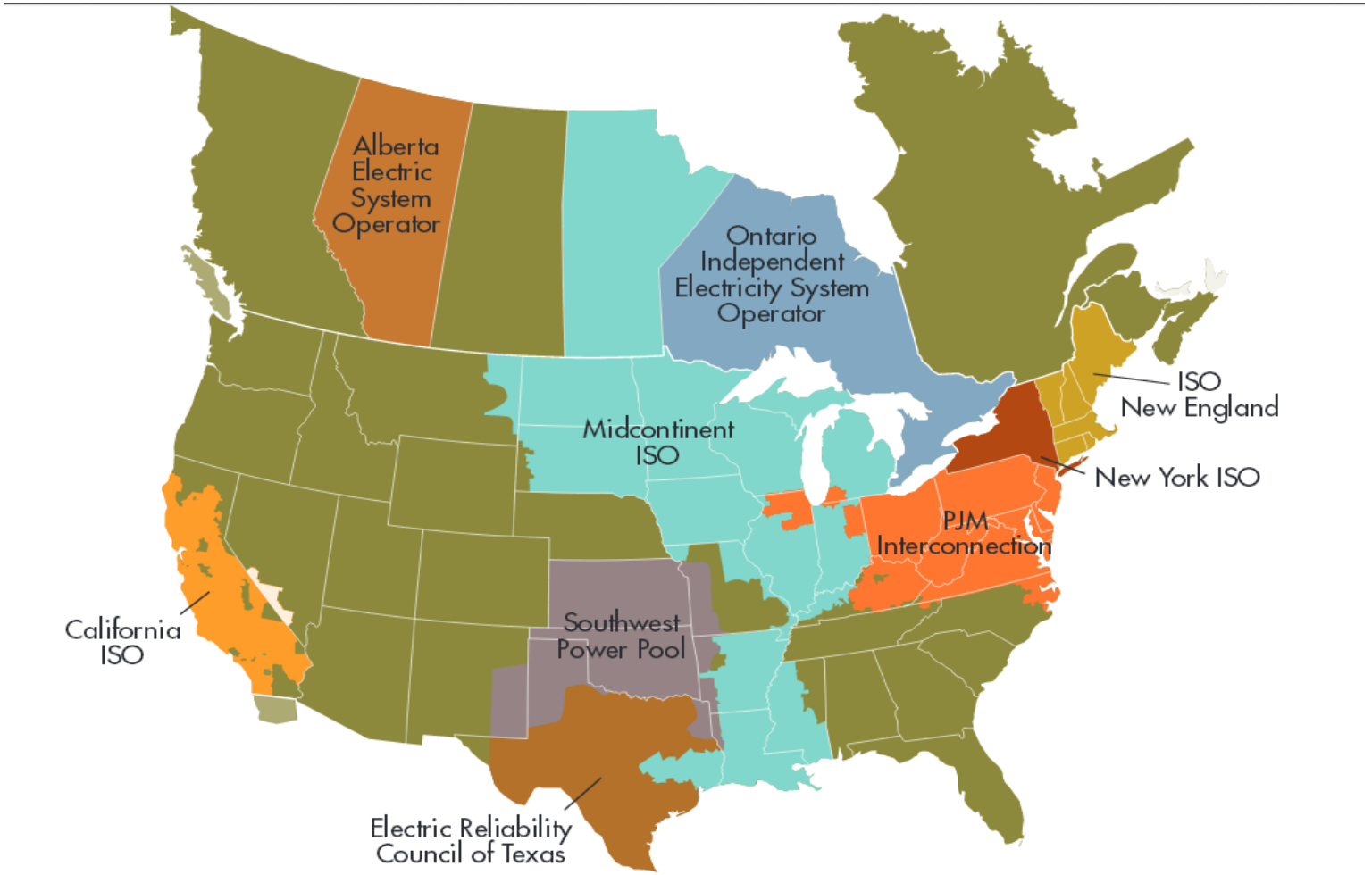
US territory is not fully deregulated



US ISO/RTO history

ISO/RTO	Creation date
ERCOT	1996
PJM	1997 (pool since 1927), RTO (2001)
ISO-NE	1997 (pool since 1971), RTO (2005)
CAISO	1998
MISO	1998 (became RTO in 2001)
NYISO	1999
SPP	2004 (became RTO, pool since 1941)

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PJM

Country: US

Installed capacity: 183 GW

Peak Load: 163 GW

Transmission: 62,500 miles

Market Participants: 750+

# of customers served: 61 Millions

Network model size: 15,000 buses

# of generating Units: 1,300+

2013 - EKPC joins

2011 - ATSI and CPP join PJM

2005 - Duquesne Light and Dominion joined PJM

2004 - American Electric Power (AEP), Commonwealth Edison and Dayton Power & Light joined PJM

2002 - PJM integrated Allegheny Power's five-state transmission system into the PJM system

2001 - PJM became the nation's first fully functioning RTO

1997 - FERC approved PJM as the nation's first fully functioning ISO

1996 - PJM launched first Web site

1993 - PJM Interconnection Association formed

1981 - ACE and DP&L join

1968 - PJM completed its first Energy Management System (EMS)

1965 - PEPCO joins

1962 - PJM installed its first online computer to control generation

1956 - PJM formed - BG&E and GPU join

1927 - P.A. - N.J. Interconnection is world's first continuing power pool

Midcontinent ISO - MISO

Country: US

Installed capacity: 132 GW

Peak Load: 98,5 GW

Transmission: 65,787 miles

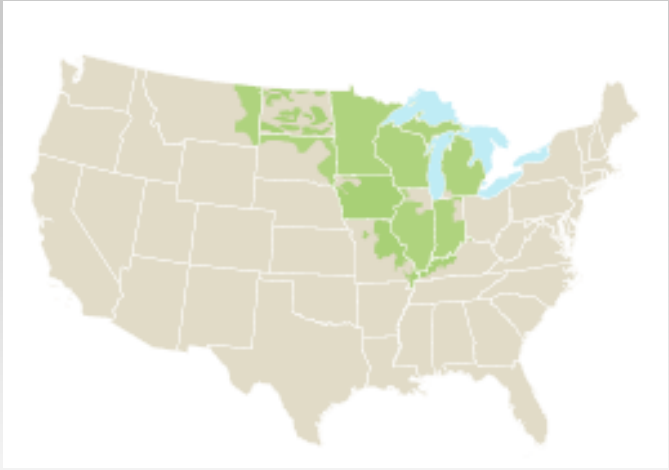
Market Participants: 360+

# of customers served: 48 Millions

Network model size: 43,000+ buses

# of generating Units: 1,270+

Midcontinent ISO – Market Area



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Two settlements system

Two markets: day-ahead, real-time

- Day-ahead Market
  - develop day-ahead schedule using least-cost security constrained unit commitment and security constrained economic dispatch programs that simultaneously optimize energy and reserves
  - calculate hourly LMPs for next Operating Day using generation offers, demand bids, and bilateral transaction schedules
- Real-time Energy Market
  - calculate 5 minute LMPs based on actual operating conditions as described by State Estimator
  - actual financial settlement performed on hourly integrated LMP

Locational Marginal Price - LMP

LMP = Locational Marginal Price

System Energy Price

Represents optimal dispatch ignoring congestion

Transmission Congestion Cost

Represents price of congestion for binding constraints

Calculated using cost of marginal units controlling constraints and sensitivity factors on each bus

Cost of Marginal Losses

Represents price of marginal losses

Priced according to marginal loss factors

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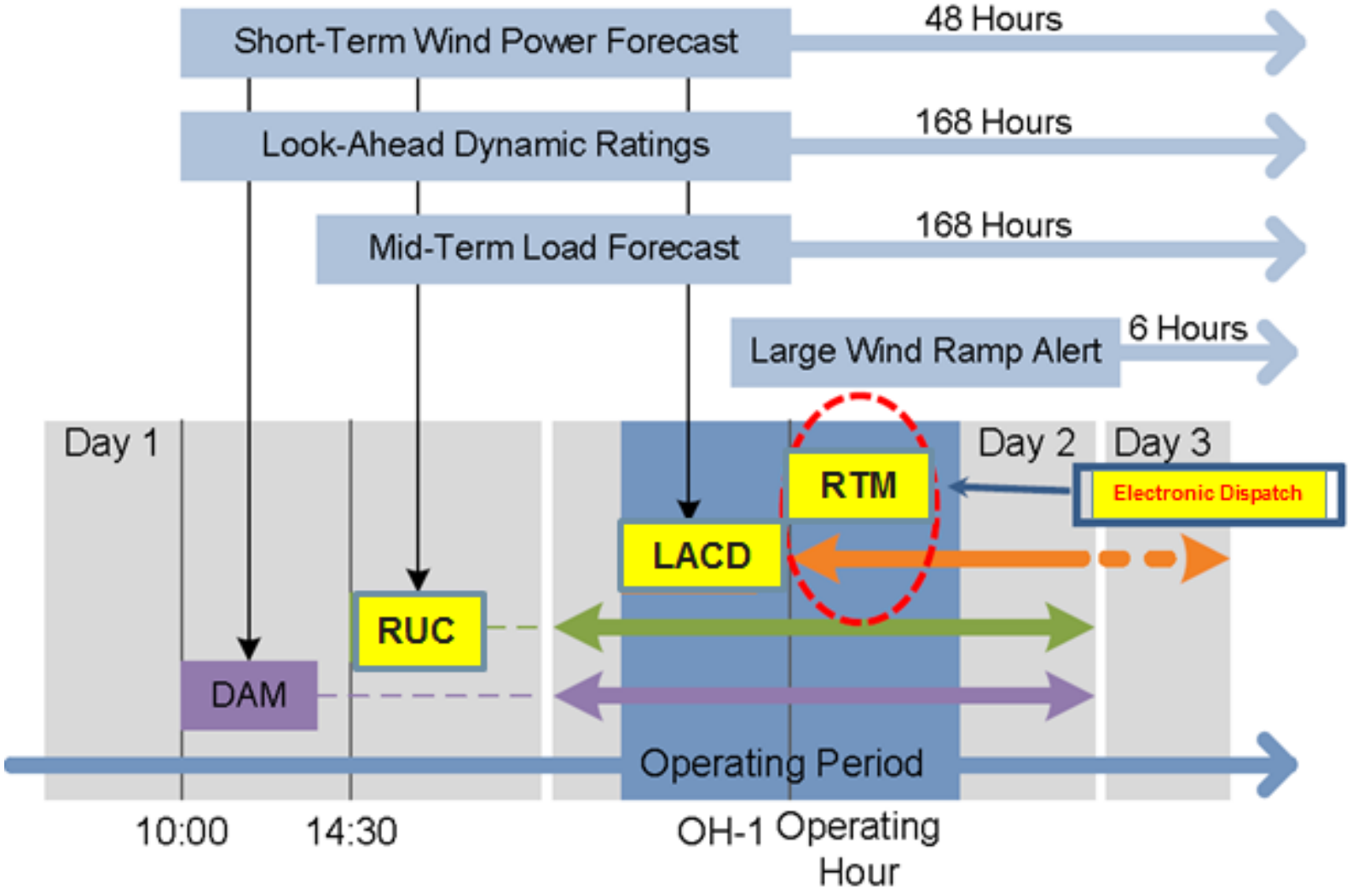
Overall process timeline



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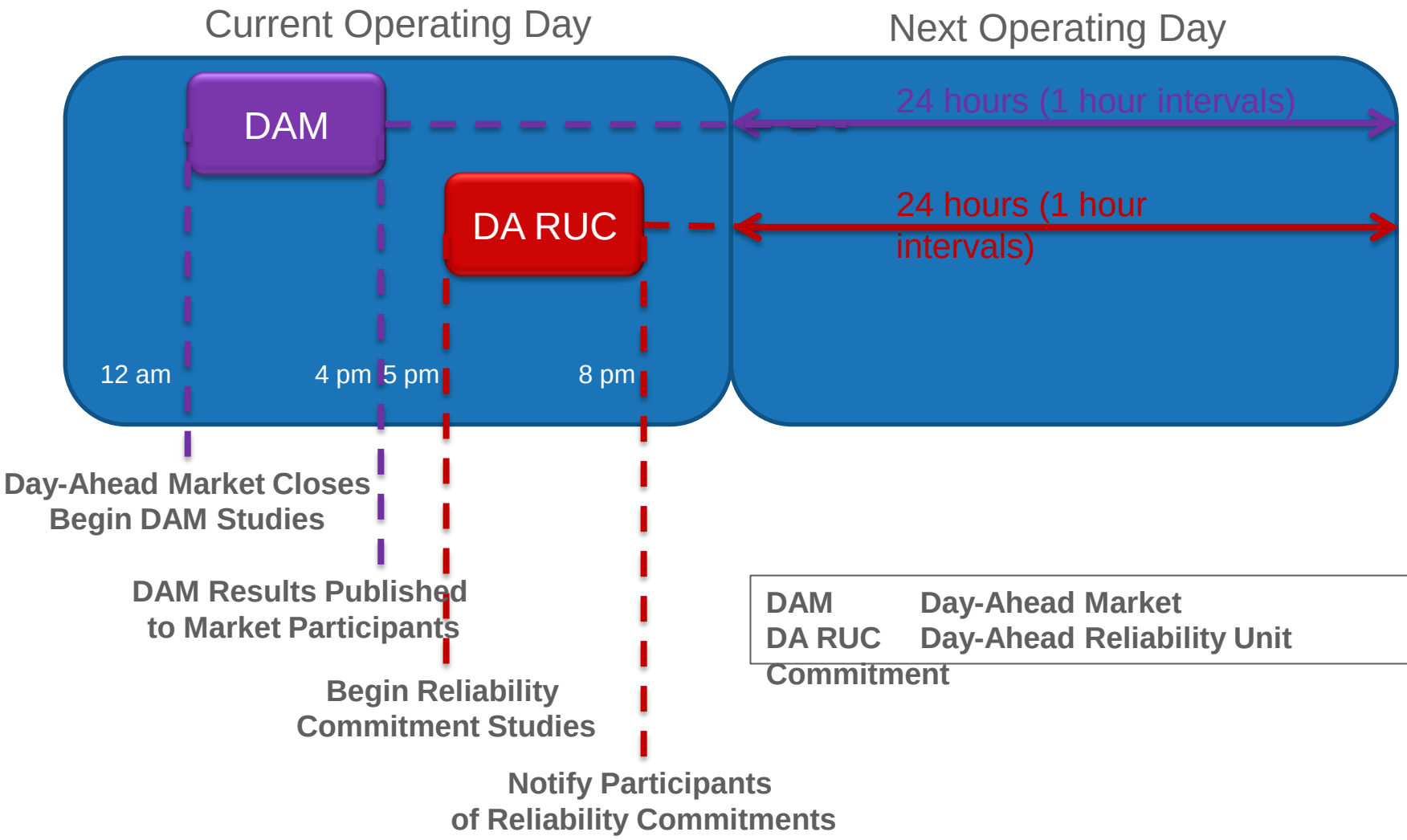
Day-Ahead Scheduling and Commitment Process



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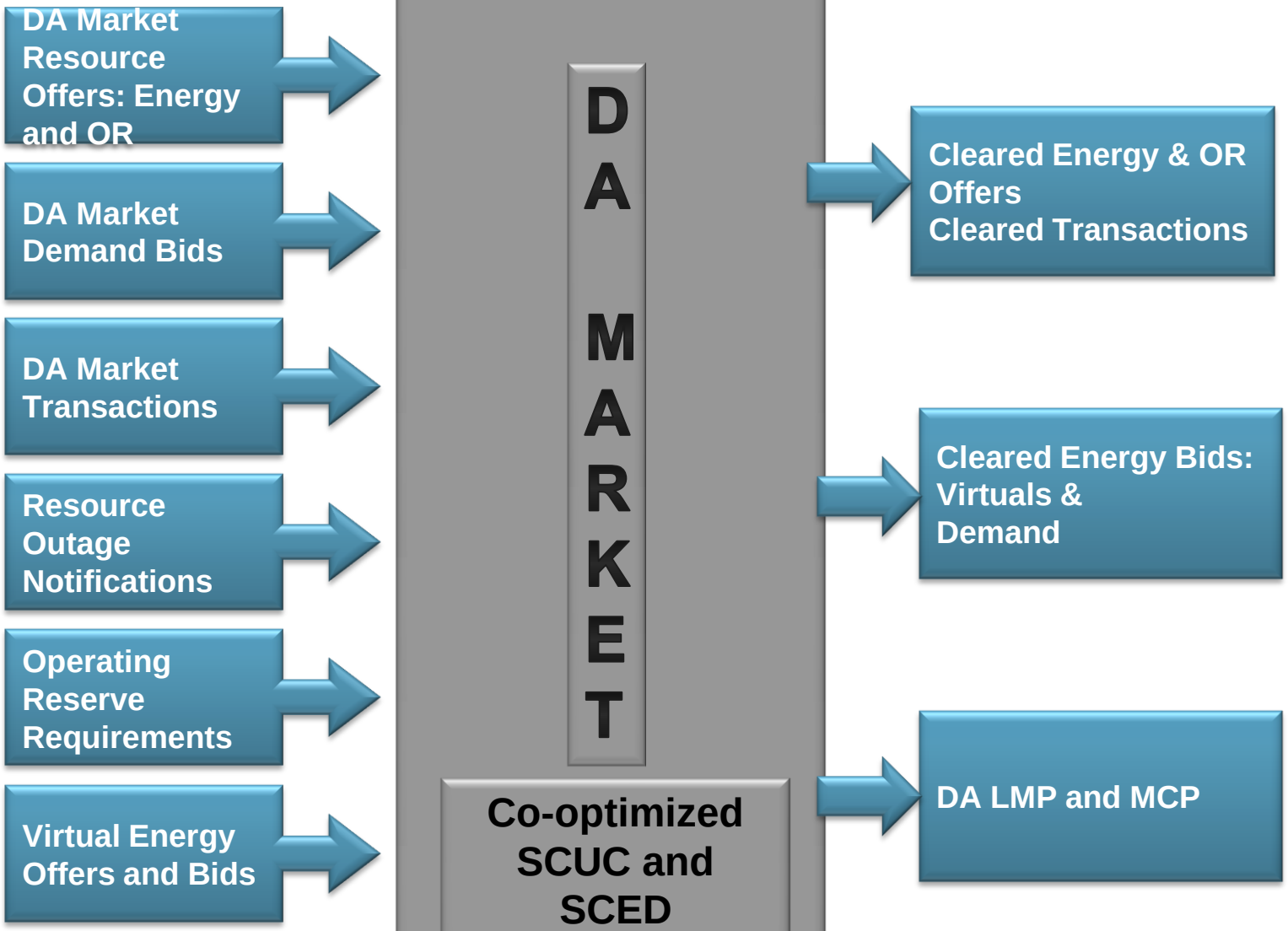
Day-Ahead market



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Day-Ahead Market Features

- Co-optimized energy and ancillary services market
- Inputs:
  - Demand bids and virtual bids as load
  - Historical load distribution
  - Outages and overrides
- Outputs:
  - Commitment plan for each resource
  - Dispatch MW for each resource for each hour
  - Reserve assignment MW for each resource for each hour
  - Energy price at each price node
  - Ancillary service prices for system and zonal products
  - Contingency analysis to ensure network security
  - Supports study-specific outages, constraints, limit overrides

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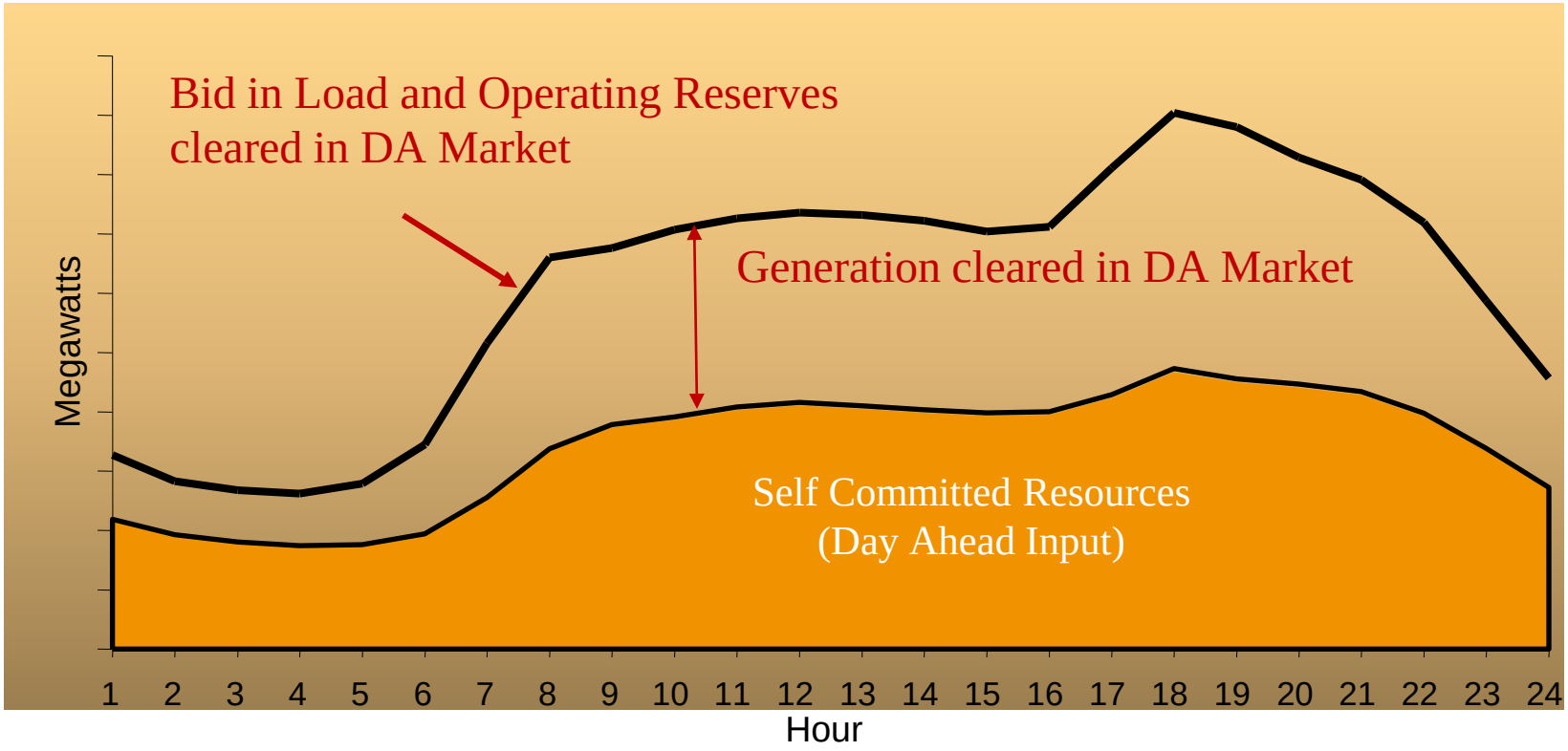
Day-Ahead Market Clearing



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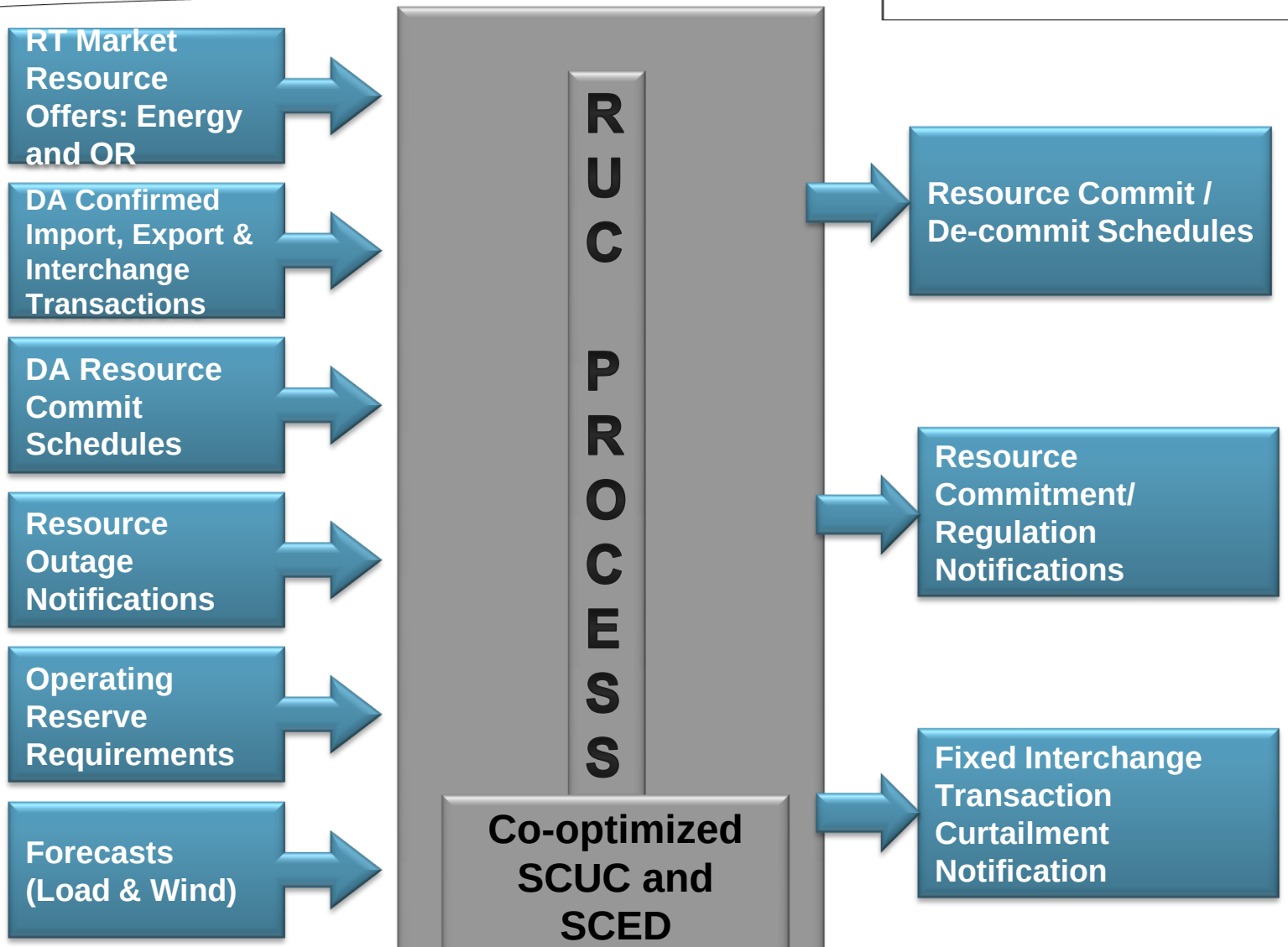
Reliability Unit Commitment



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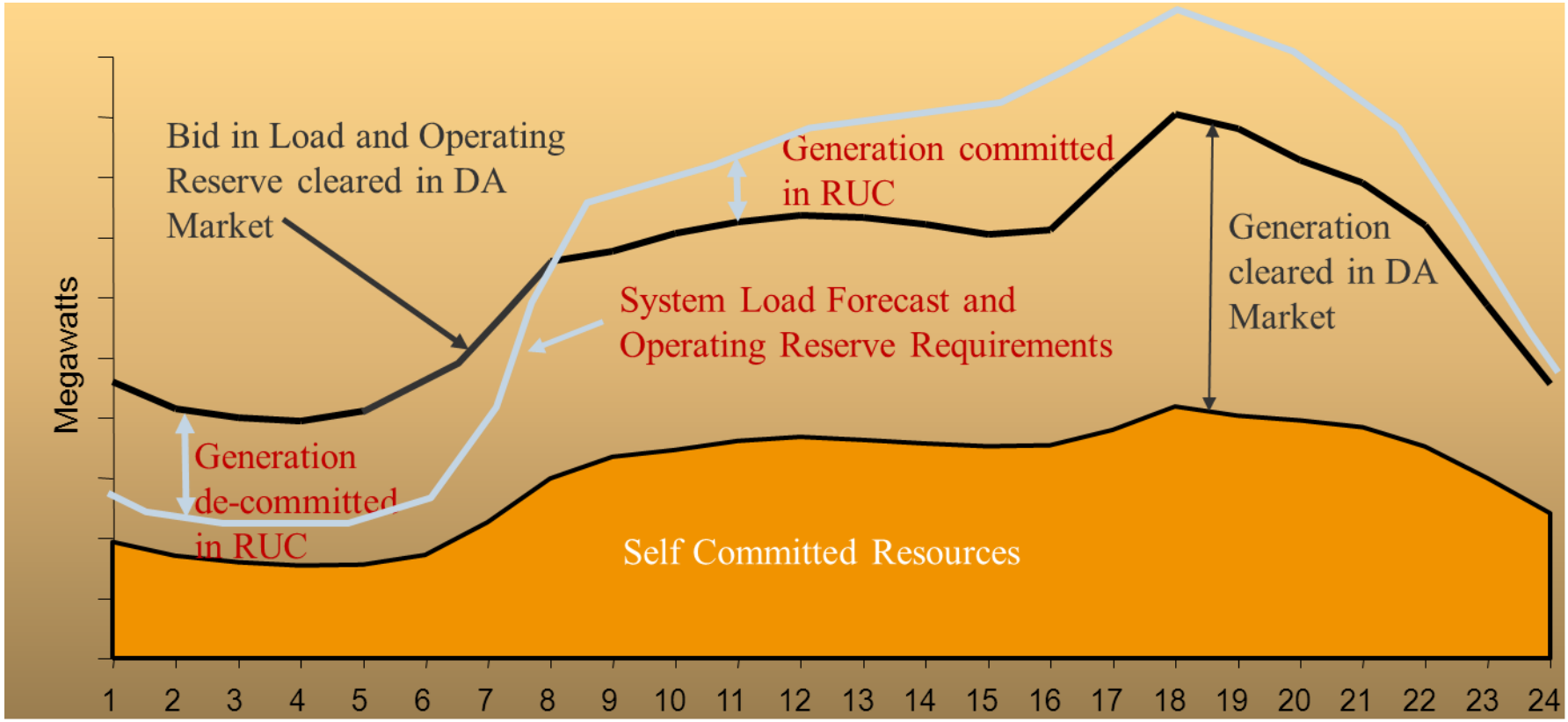
RUC Clearing



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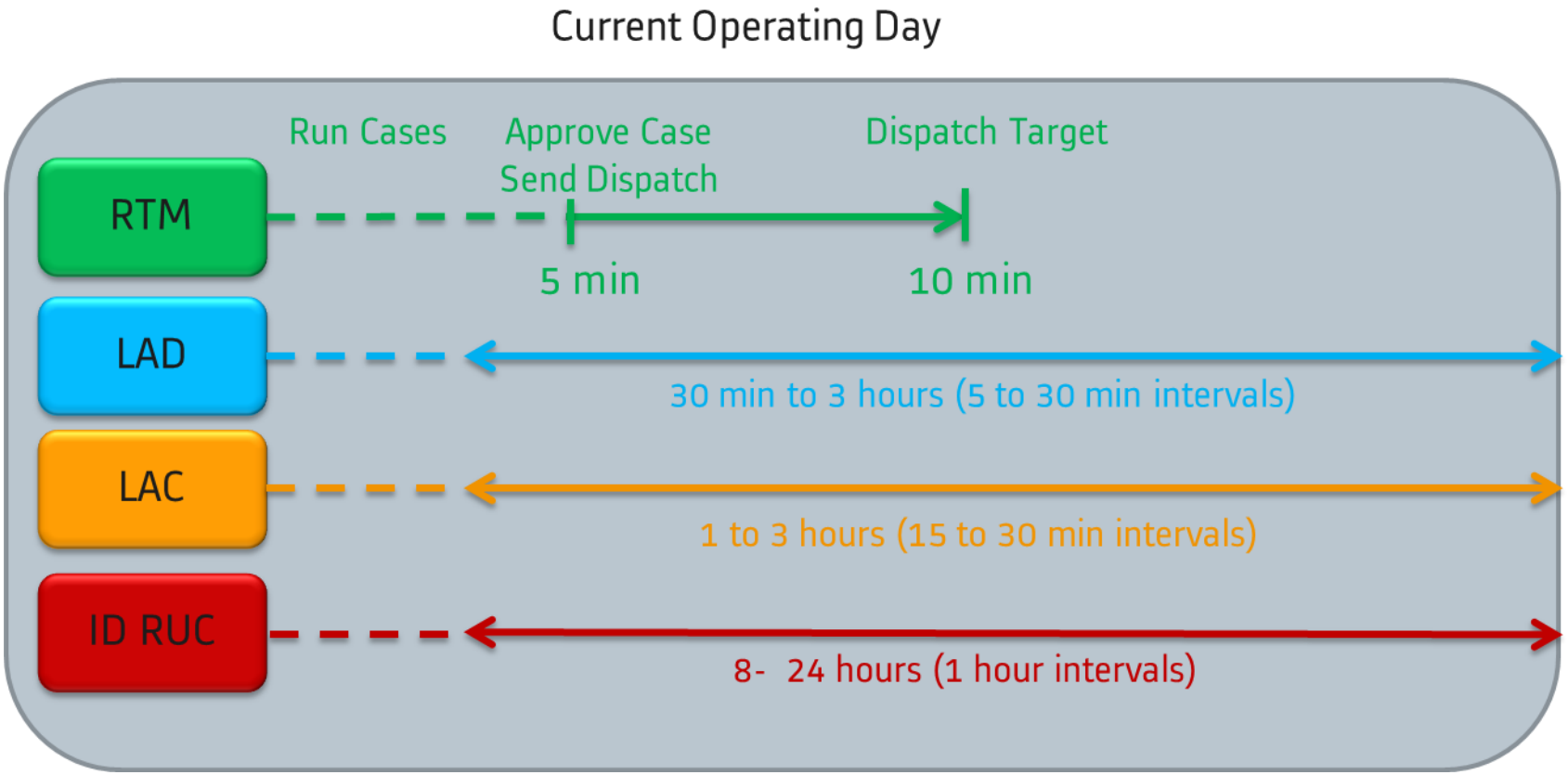
Real-Time Dispatch Process



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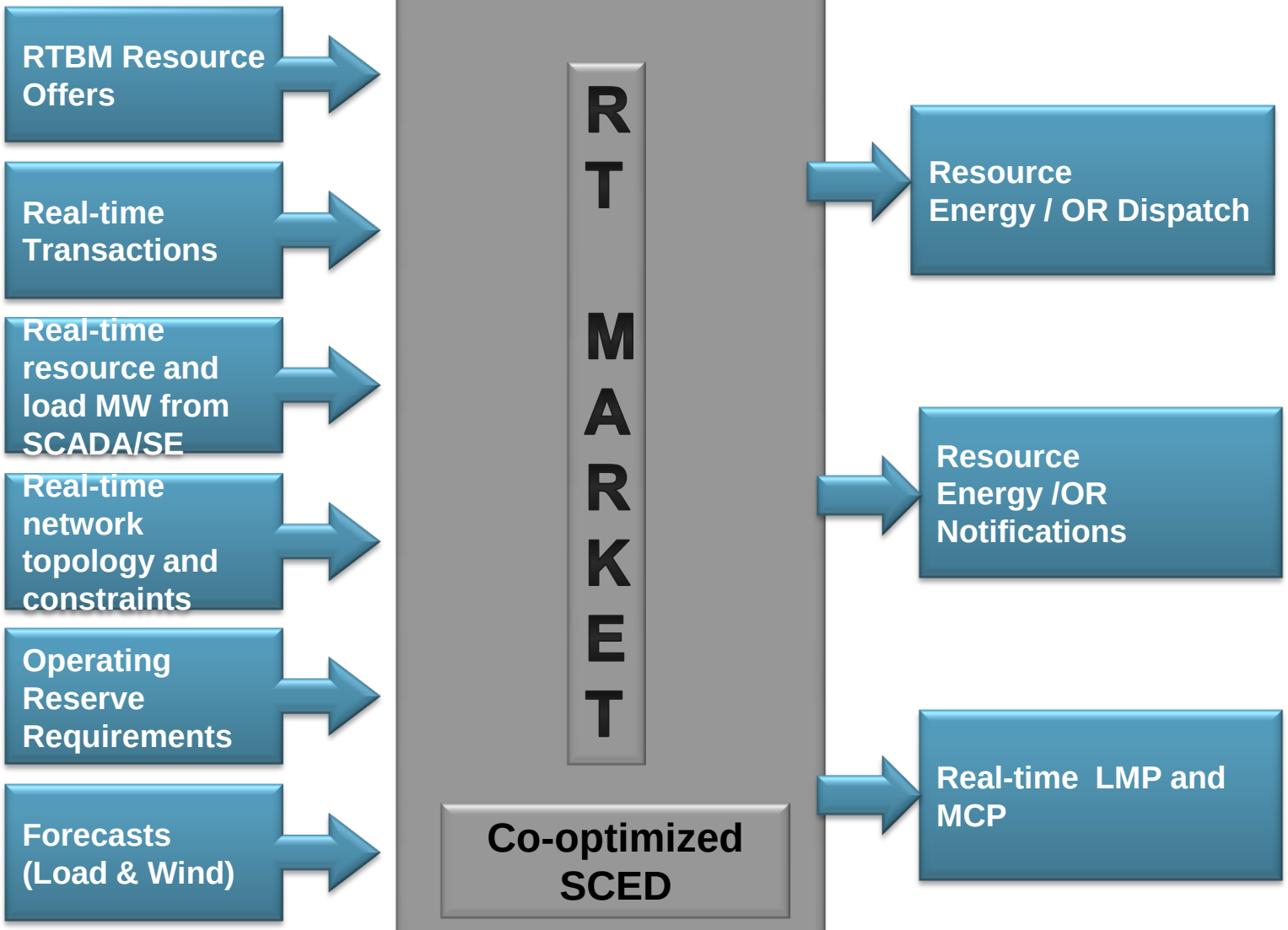
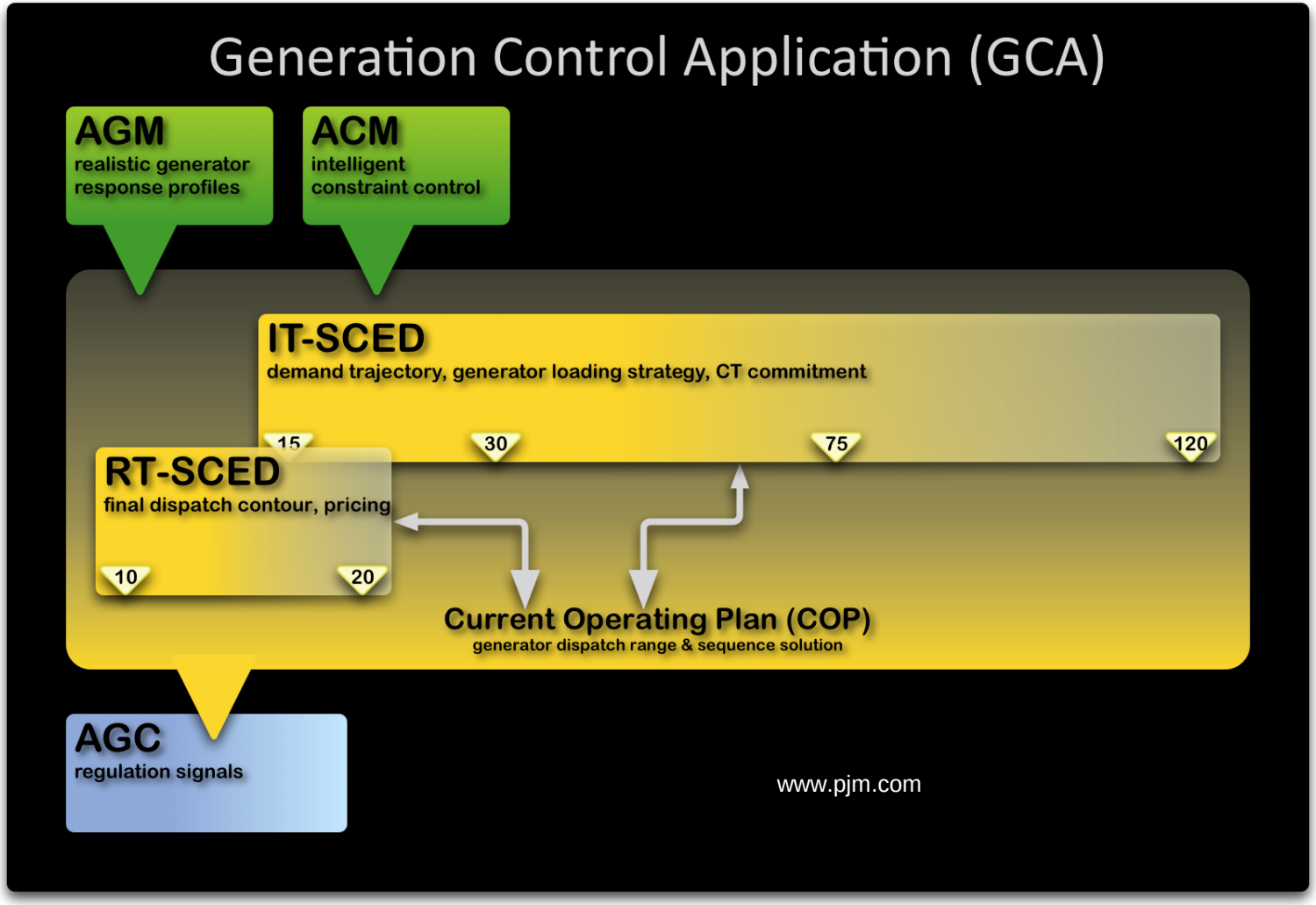
Real-Time market



Real-Time Market Features

- Co-optimized energy and ancillary services market
- Inputs:
  - Current network state (state estimator)
  - Short-term load forecast (STLF)
- Outputs:
  - Target dispatch MW for each resource
  - Reserve assignment MW for each resource
  - Energy prices at each price node
  - Ancillary service prices for system and zonal products
- Up to 6 simultaneous demand forecast scenarios

General Control Application



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Industry driver for Market Management Systems (MMS) applications

IT Architecture & Services
Flexibility (rules, BPM), modularity

Transparency & Auditability

Cyber-Security

Renewable integration
under severe Supply Constraints

Social Welfare
Minimize electricity costs for end users

Resource adequacy
Make sure enough capacity is built

Business Model Change
New regulation

System reliability
Ensure financial contracts translates flow safely

System Scalability
Distributed Energy Resources

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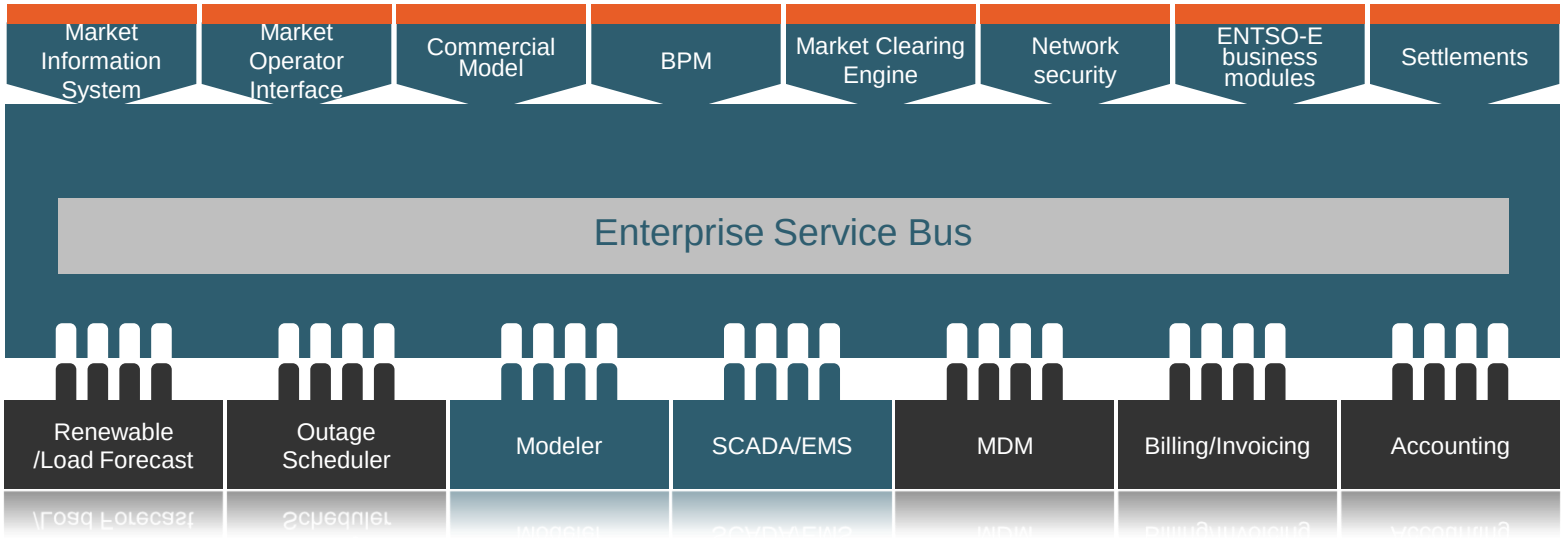
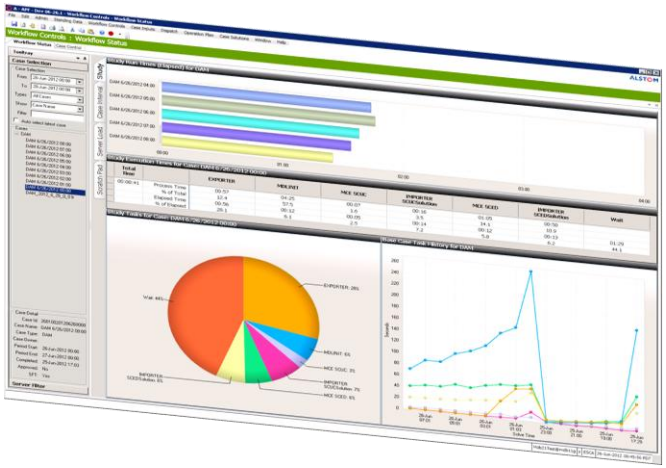
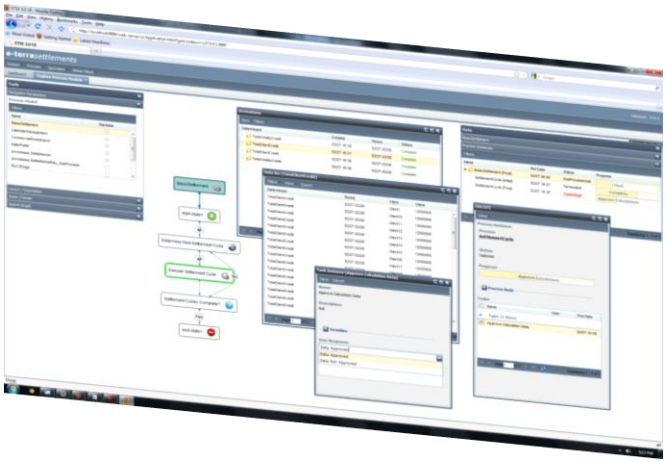
High level architecture







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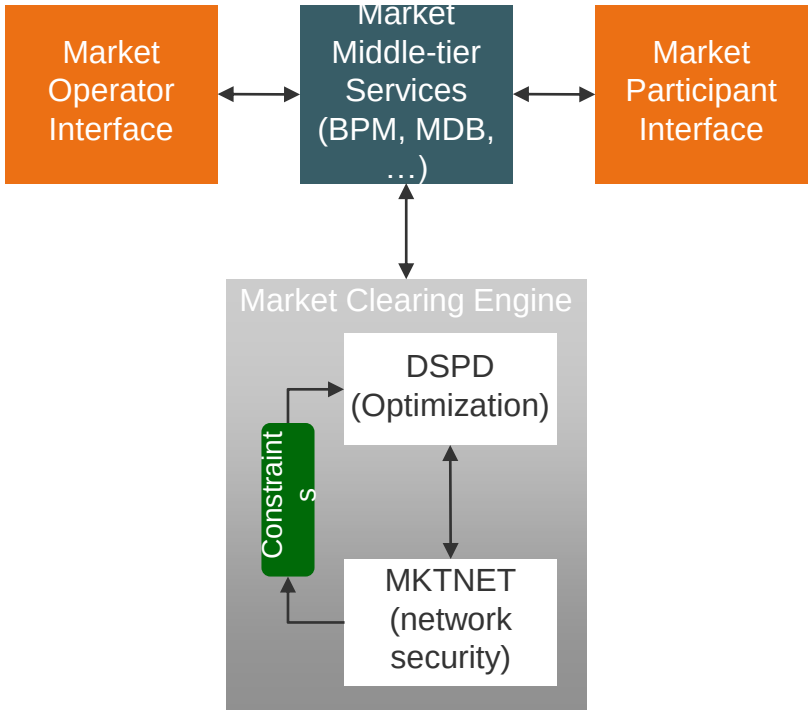
High level MMS architecture

- Market Middle-tier Services
- Market participant User Interface and services (MUI)
- Market Operator Interface (MOI)
- Market Clearing Engines (MCE)



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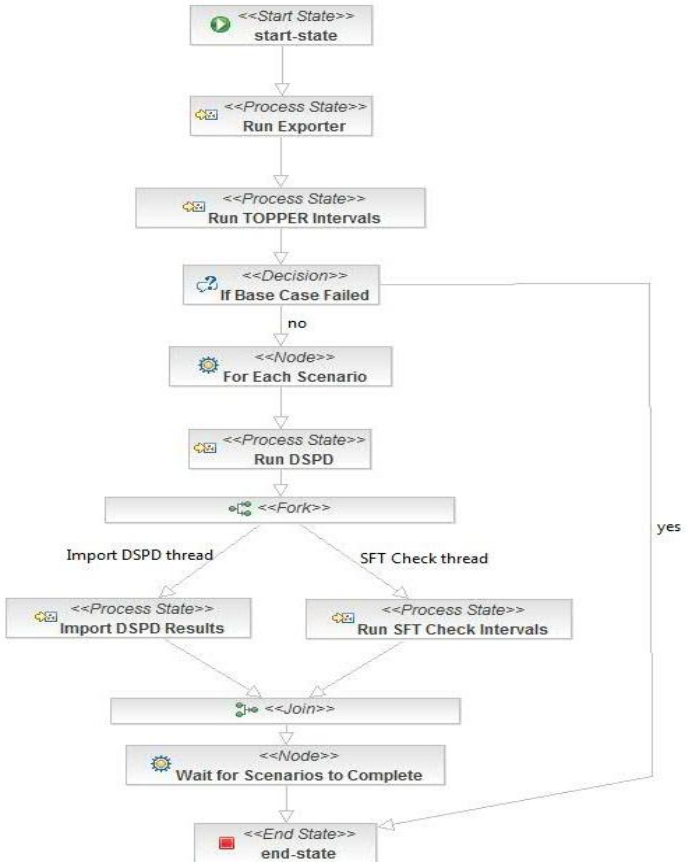
MMS Middle-tier Services – Market Control Business Process Management (BPM)

- Configurable Workflow Framework
- Automated Scheduling of Market Case studies
- Workflows can be tailored to specific customer business logic
- Additional custom code can also be added to the workflows
- Calls can be made to arbitrary customer systems



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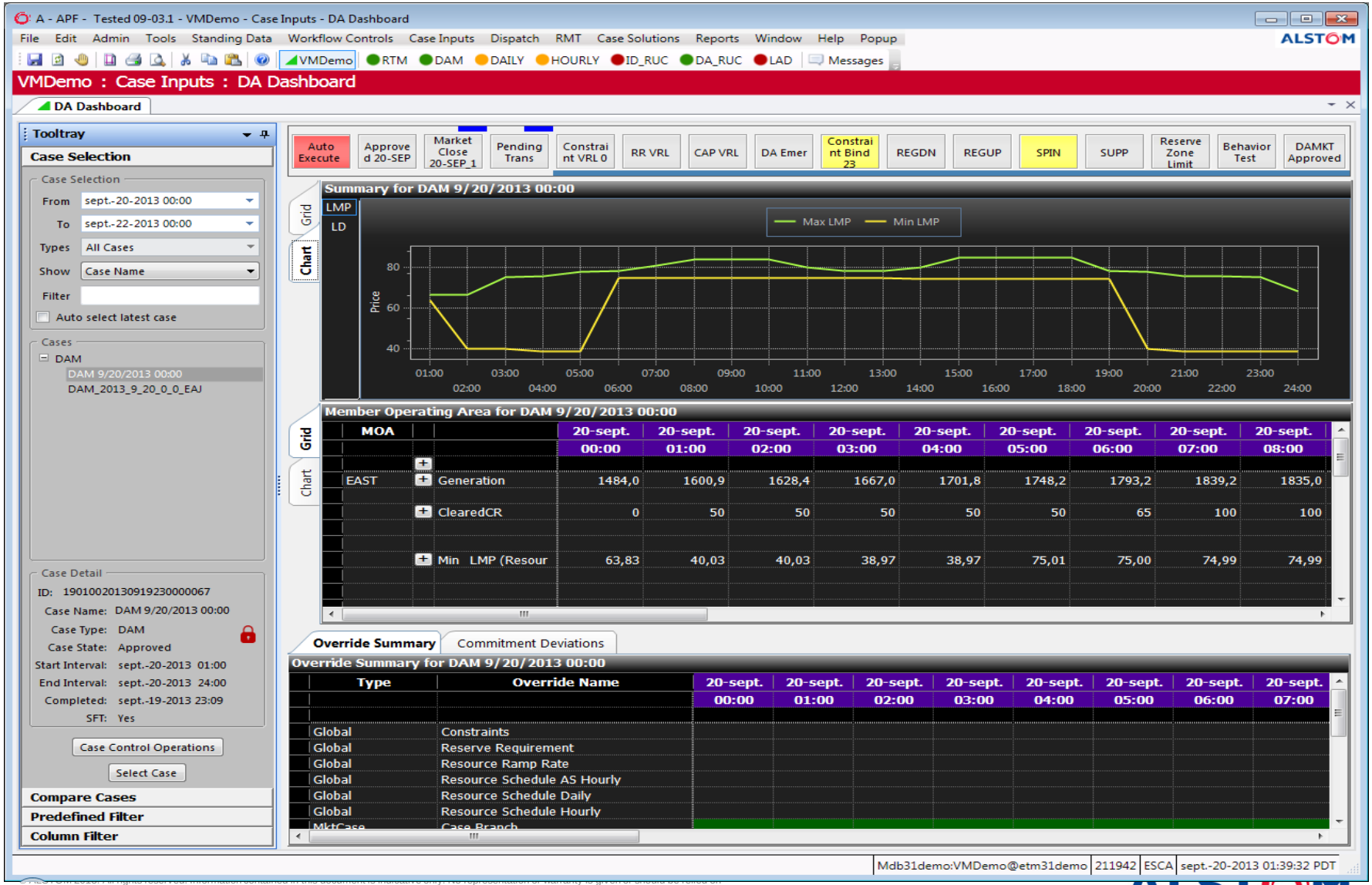
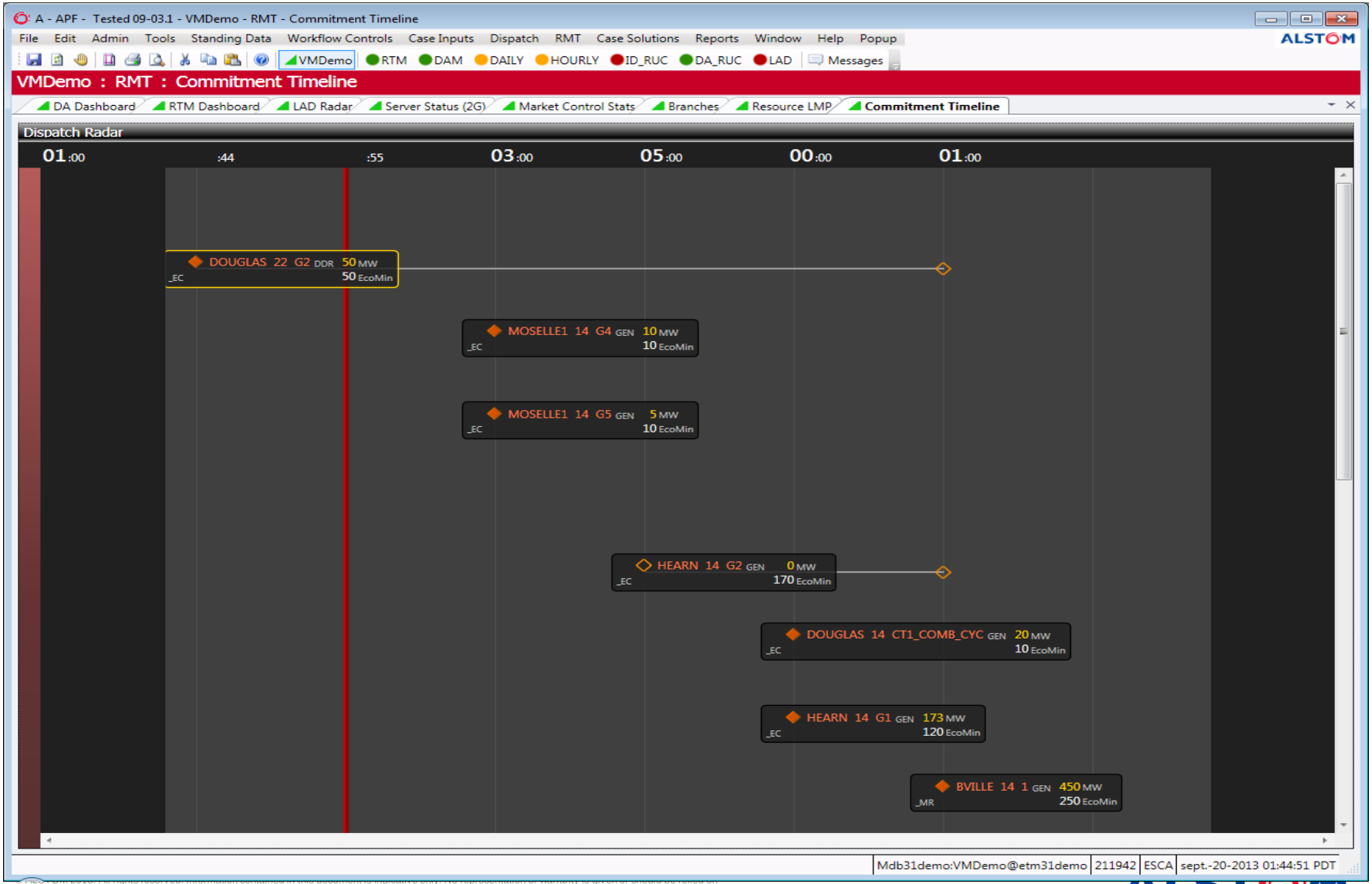
User interface examples: Dashboard



User interface examples: Commitment radar



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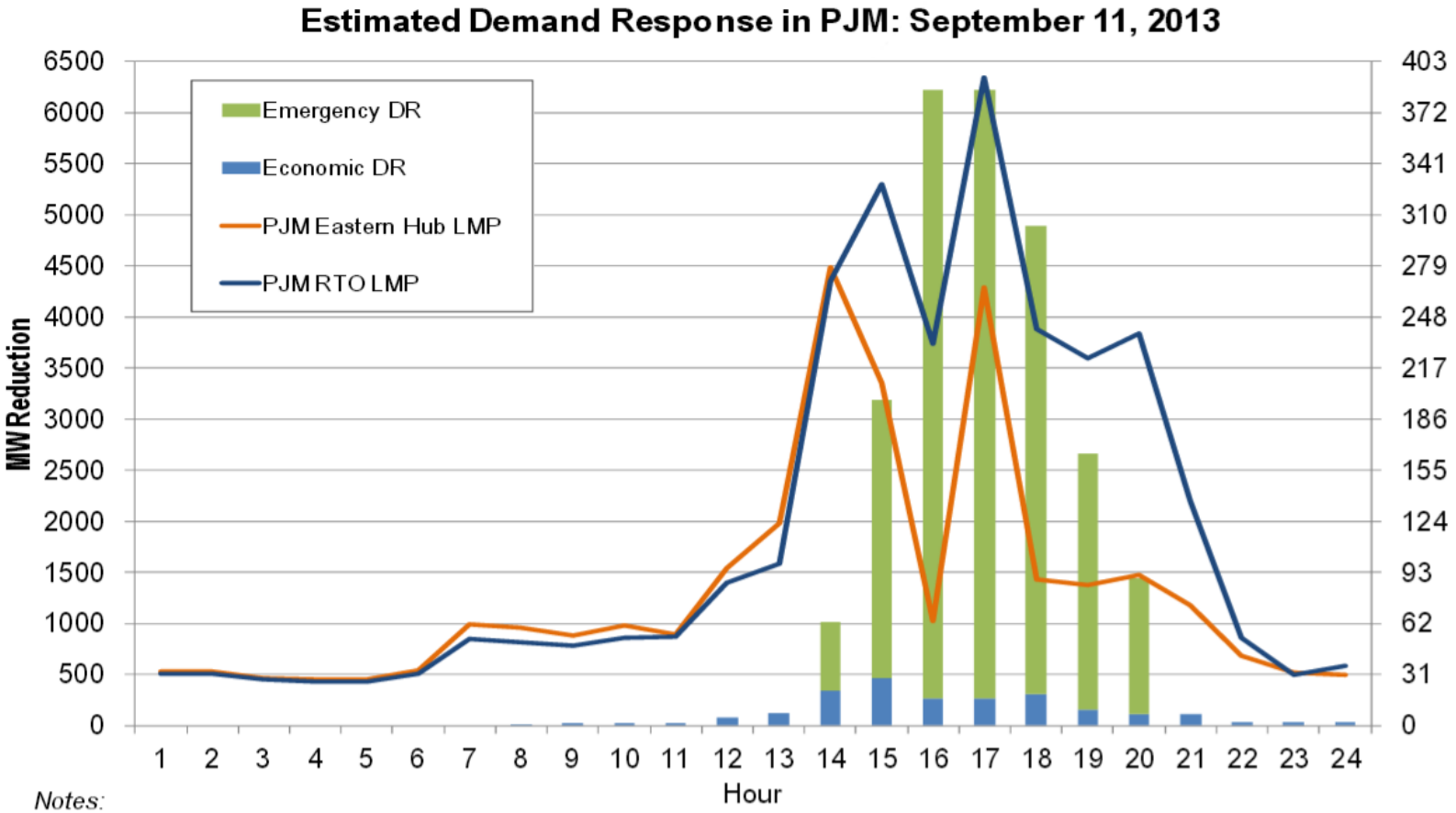
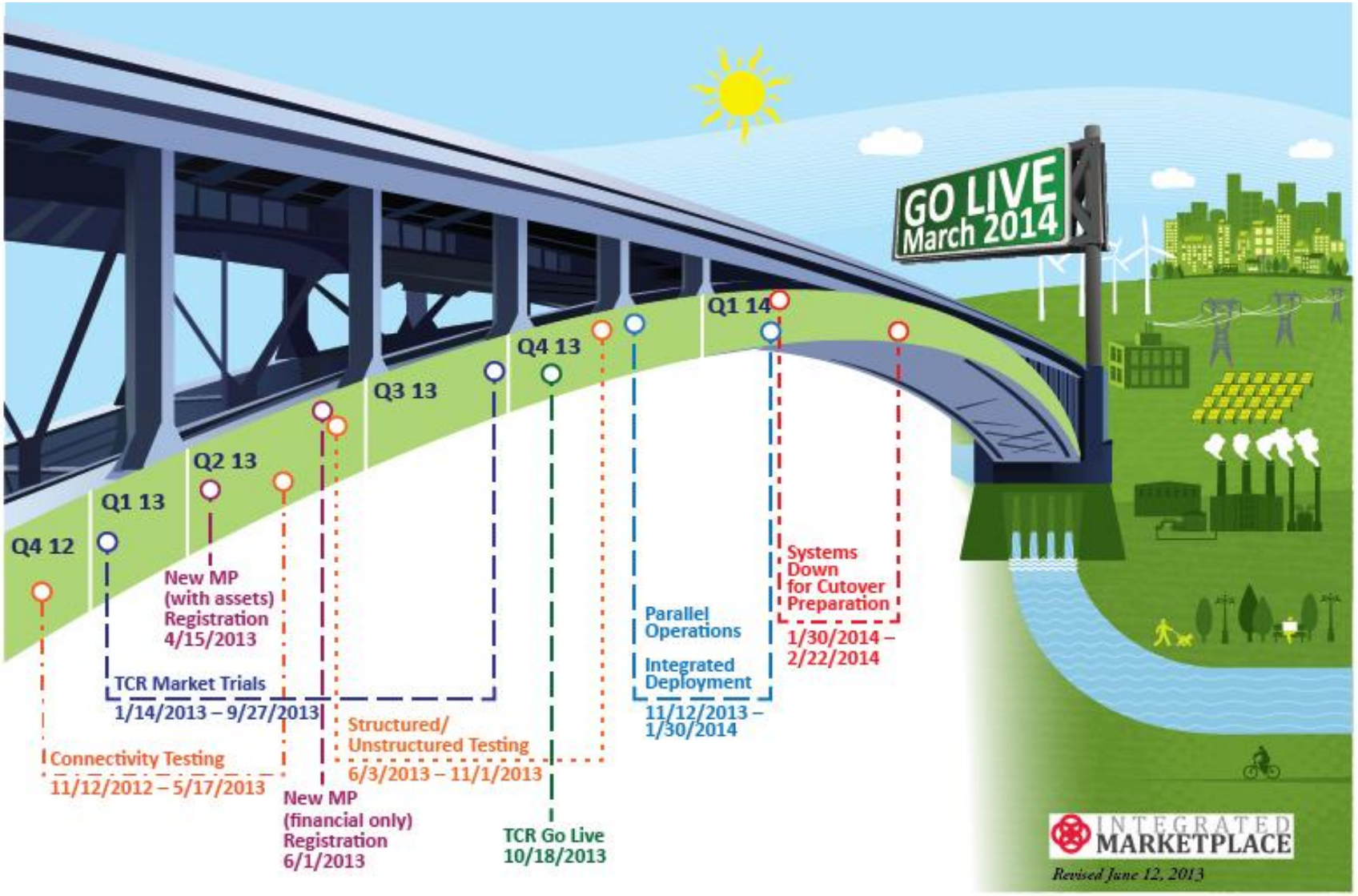
Demand response in electricity markets



Notes:
Registered Emergency DR Amounts adjusted for RPM Committments (do not represent actual energy reductions).
LMPs included to represent energy market conditions on the operating day and not a relationship between dispatched DR and pri
Actual load reductions are not finalized until up to 3 months after event.

Source: http://www.pjm.com/~/media/markets-ops/demand-response/pjm-hot-days-reports-for-20130910-20130911.ashx

SPP Integrated Marketplace: last RTO moving to nodal



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Some recent topics

- Market seams coordination: e.g. PJM, NYISO, MISO
- Alignment between Gas and Electricity markets (e.g. introduction of hour-ahead market at ISO-NE)
- Day-Ahead case re-run (driven by FERC)
- Capacity markets
- Stochastic optimization

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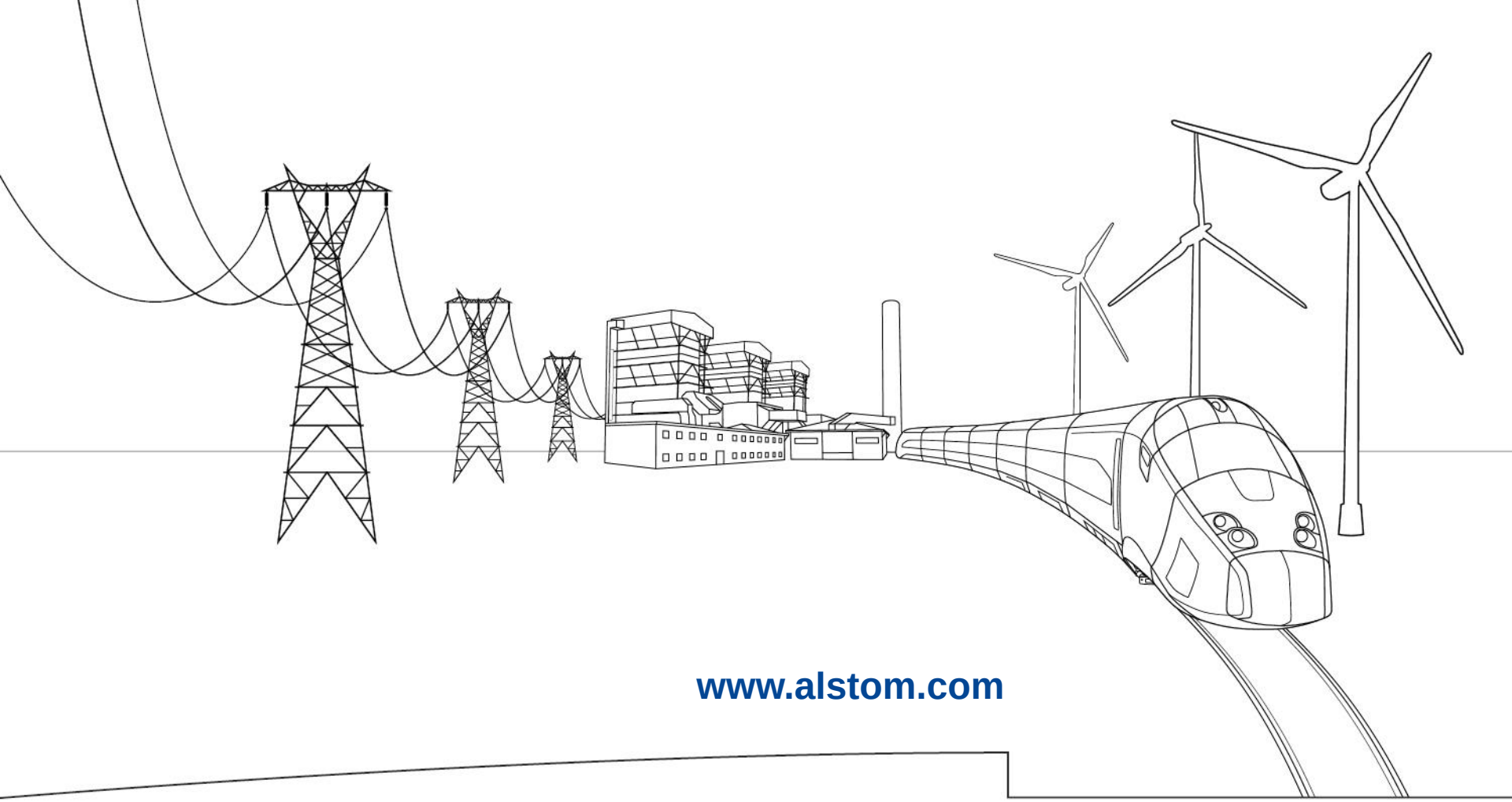

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