SPP's Integrated Marketplace and Renewable Energy Evolution

Nebraska Wind and Solar Conference

October 17th , 2018

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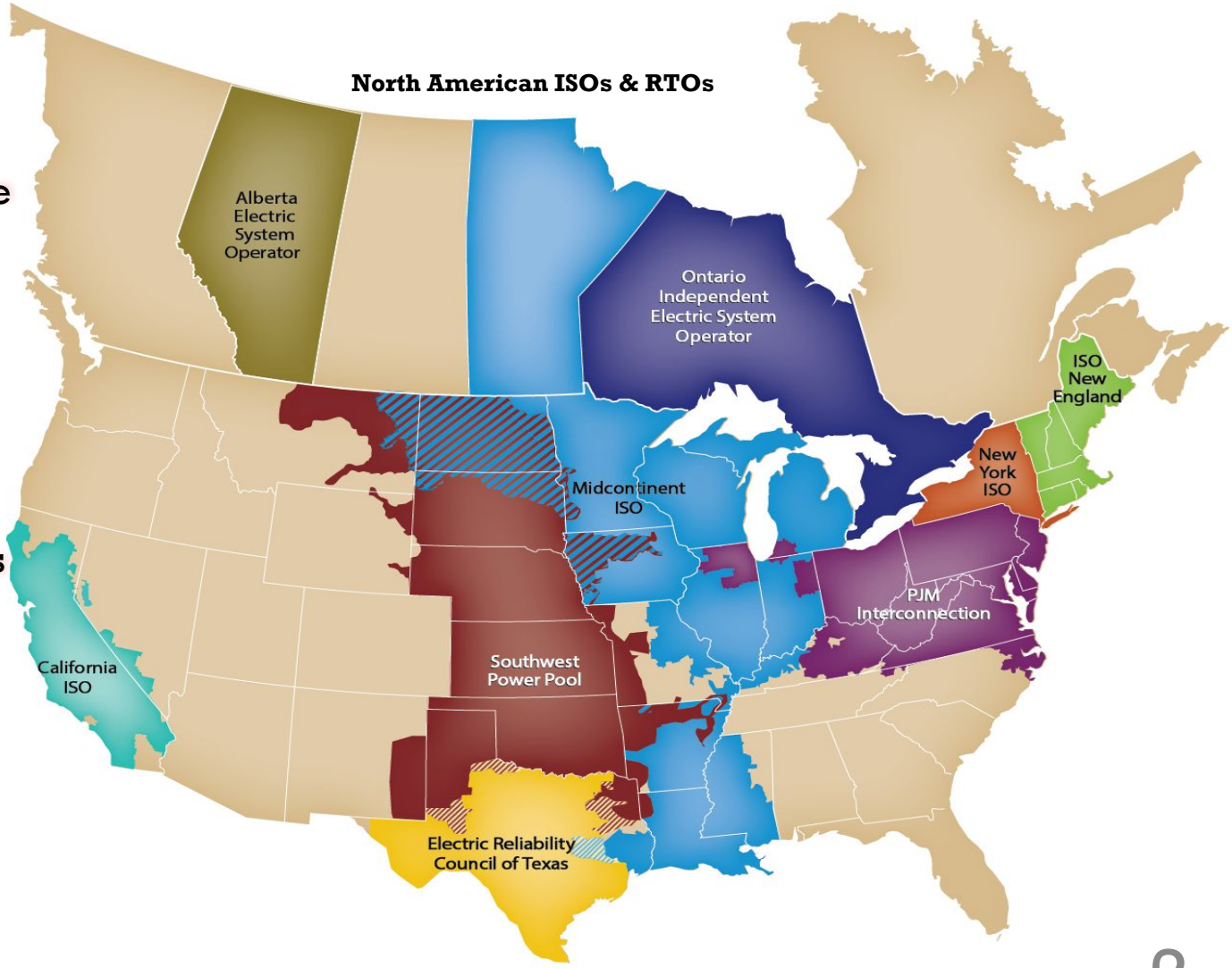
Manager, Market Design
Southwest Power Pool, Inc.

Our Regional Footprint

- FERC-approved RTO
- 14 states
- 546,000 miles of service territory
- 17.5 million end-users
- 97 members
- $15.8 billion market
- 185 market participants
- 50,622 MW peak load
- 726 generating plants
- Accredited generating capacity of 65,410 MW



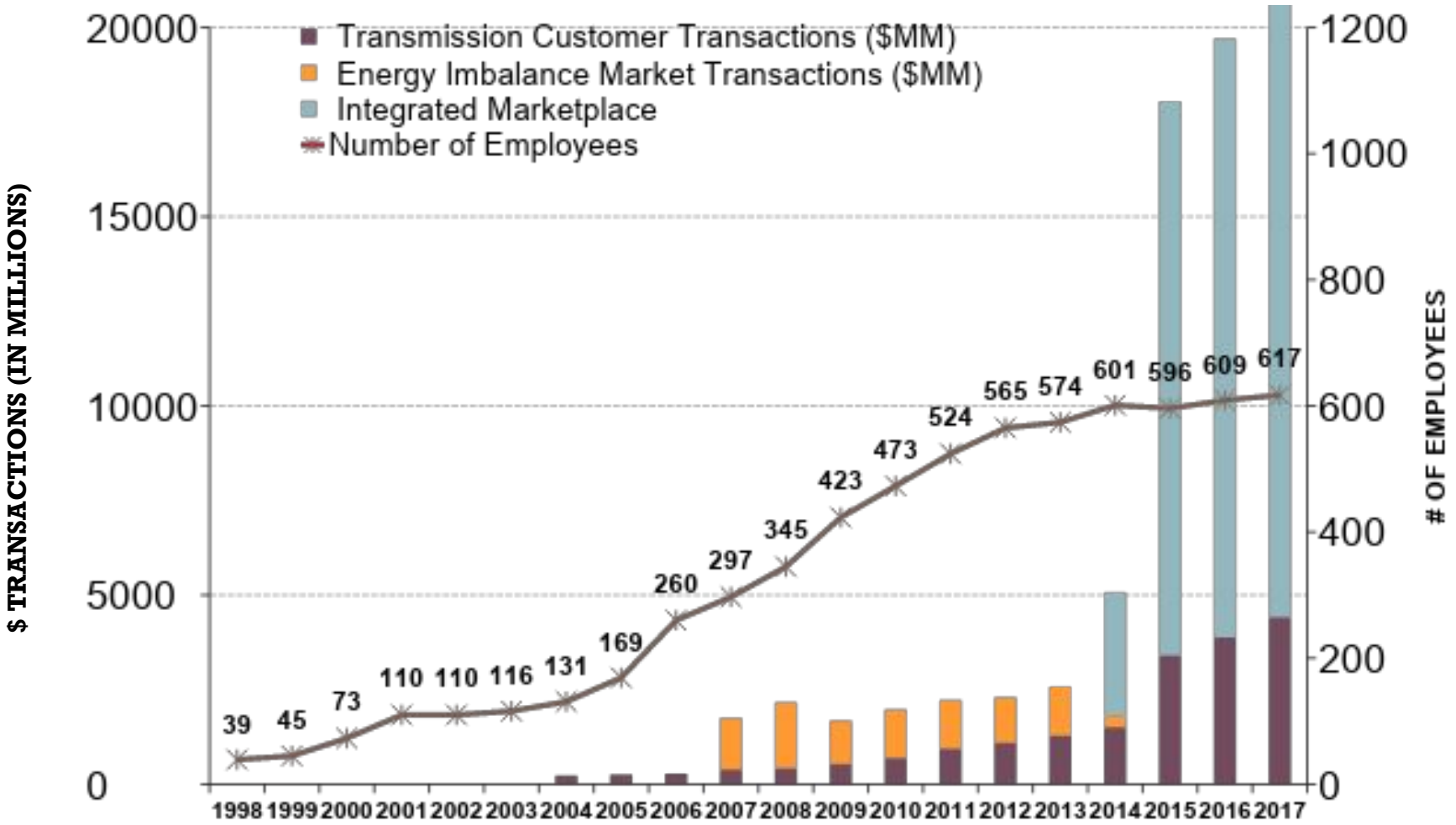
Our Mission

Helping our members work together to keep the lights on …
today and in the future.

The SPP Difference

- Relationship-based
- Member-driven
- Independence Through Diversity
- **Evolutionary vs. Revolutionary**
- **Reliability and Economics Inseparable**

Growth in Responsibilities

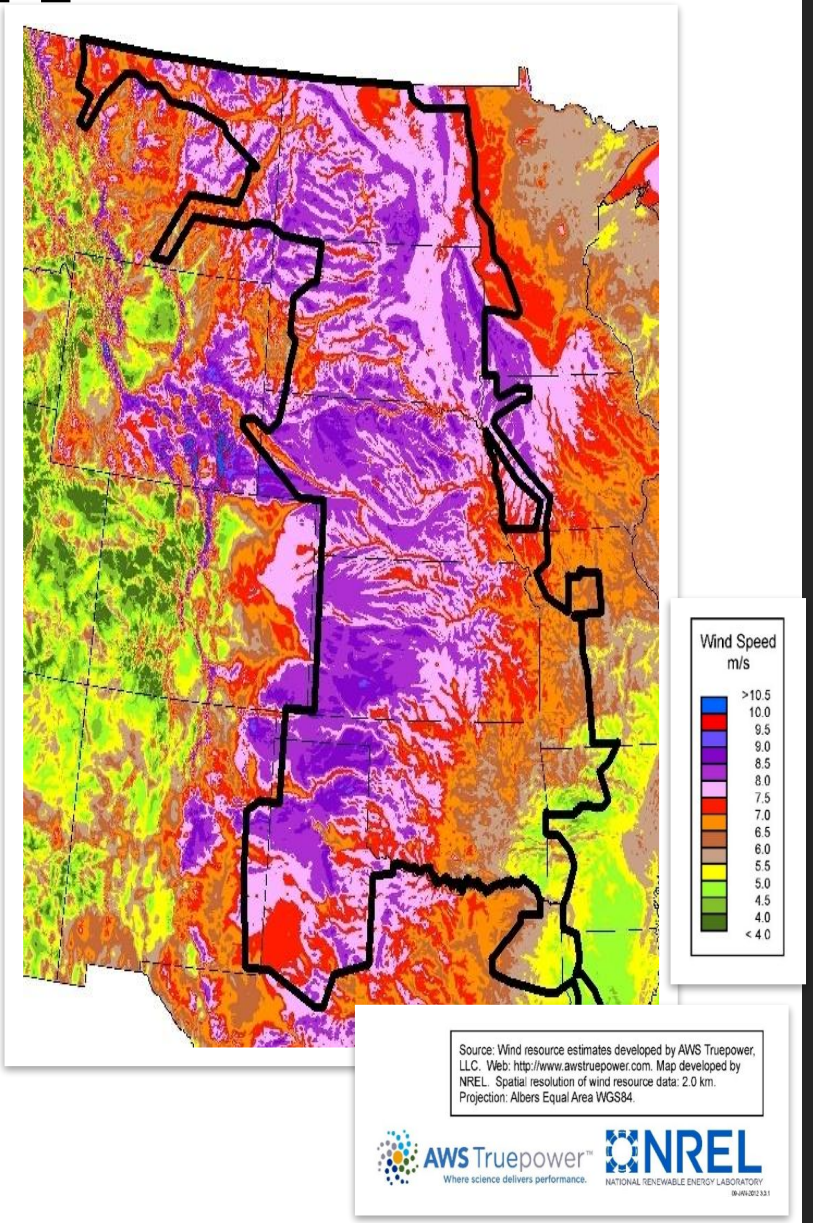


Wind and Solar Statistics

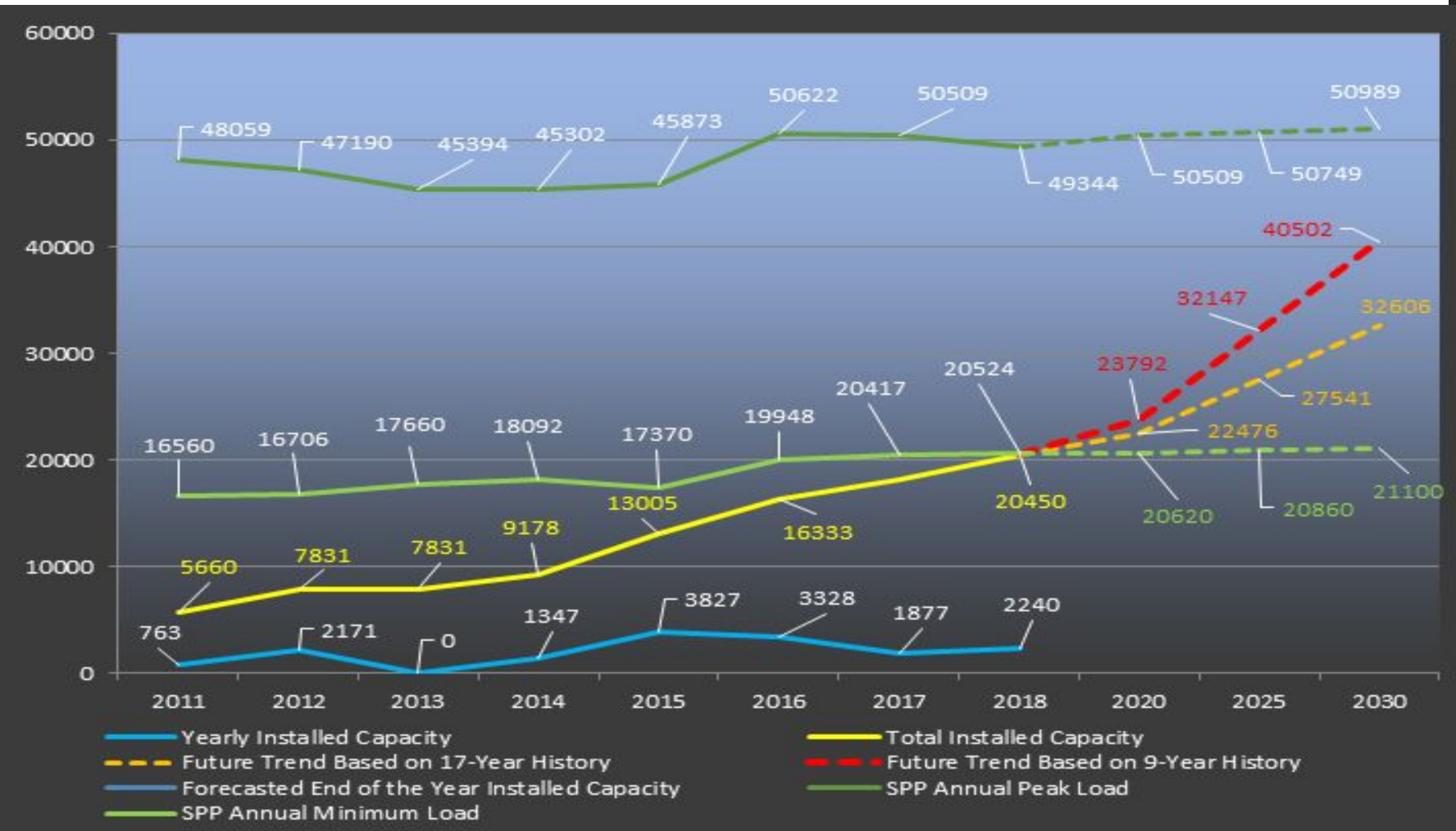
- **Wind**
  - 23% of 2017 SPP Energy Production
  - In SPP Market now: 19,835 MW
  - Pseudo-tied out of SPP Market: 605 MW
  - Total (SPP Market + pseudo-tied): 20,435 MW
  - Individual Turbines: 10,000
  - Wind Peak: 15,690MW 12/15/2017
  - Wind Penetration Record: 63.96% 4/30/2018
  - GI Queue: 51.3GW 6/01/2018
- **Solar**
  - SPP Market: 215MW
  - GI Queue: 17.8GW 06/13/2018
- **Energy Storage**
  - GI Queue: 2.5GW 06/13/2018
- **Total Renewable Energy Penetration**
  - (Wind + Hydro) 69.45% 4/29/2018

Wind Energy in SPP

- Maximum wind penetration:
  - Instantaneous: 63.96% (4/30/18)
  - Hourly Average: 62.89% (4/29/2018)
  - Daily Average: 54.1% (4/29/2018)
  - 2018 up to May 8th:
    - >60%, 6 days
    - >50%, 40days
- Max wind swing in a day: >10 GW (12.5 GW to 2 GW back to 12 GW)
- Max 1-hour ramp: 3,700 MW

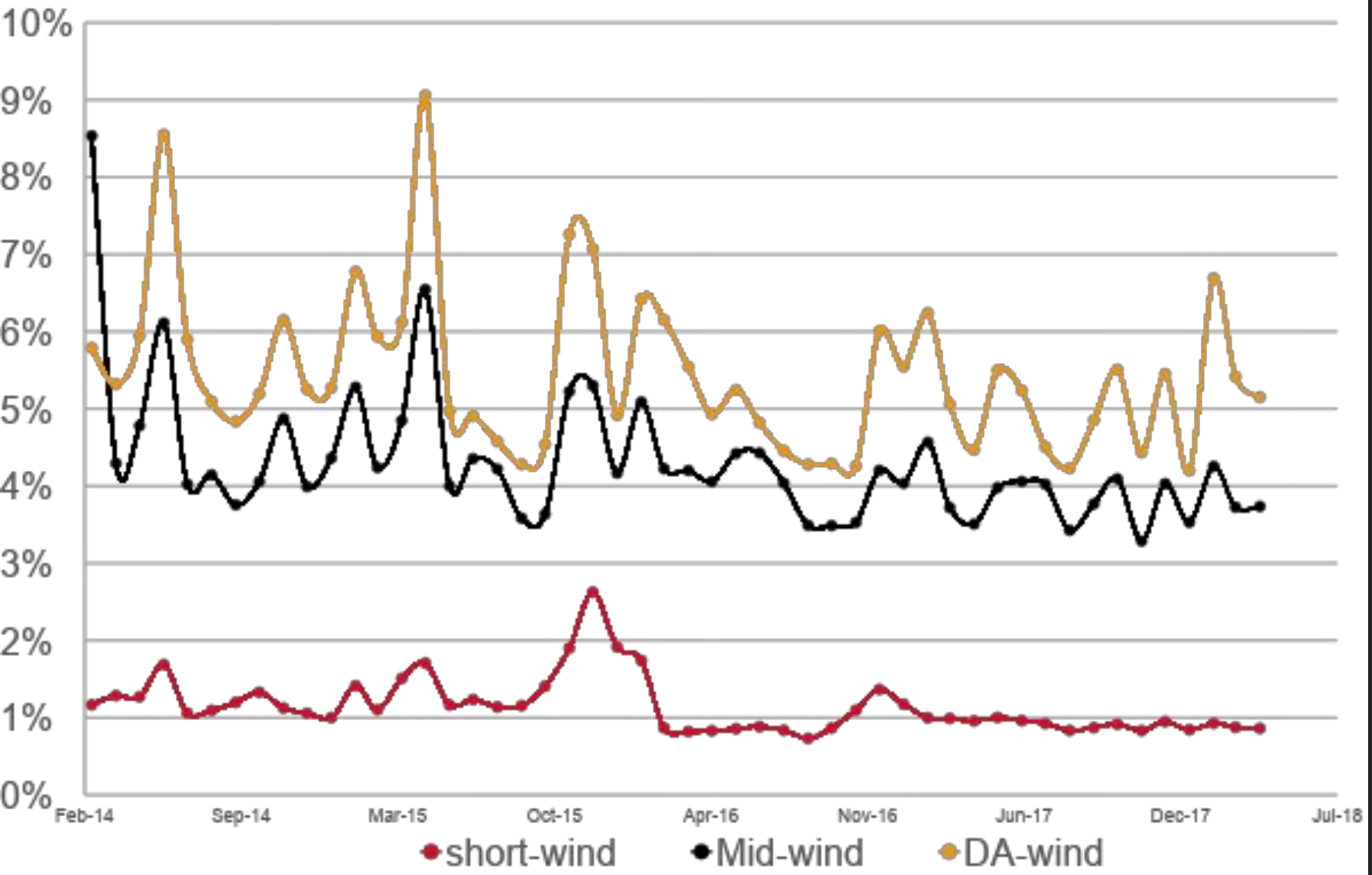


Wind Installation Projections



Wind Forecast Error

DA [24-hrs out]
Mid [4-hrs out]
Short-term [10-mins out]



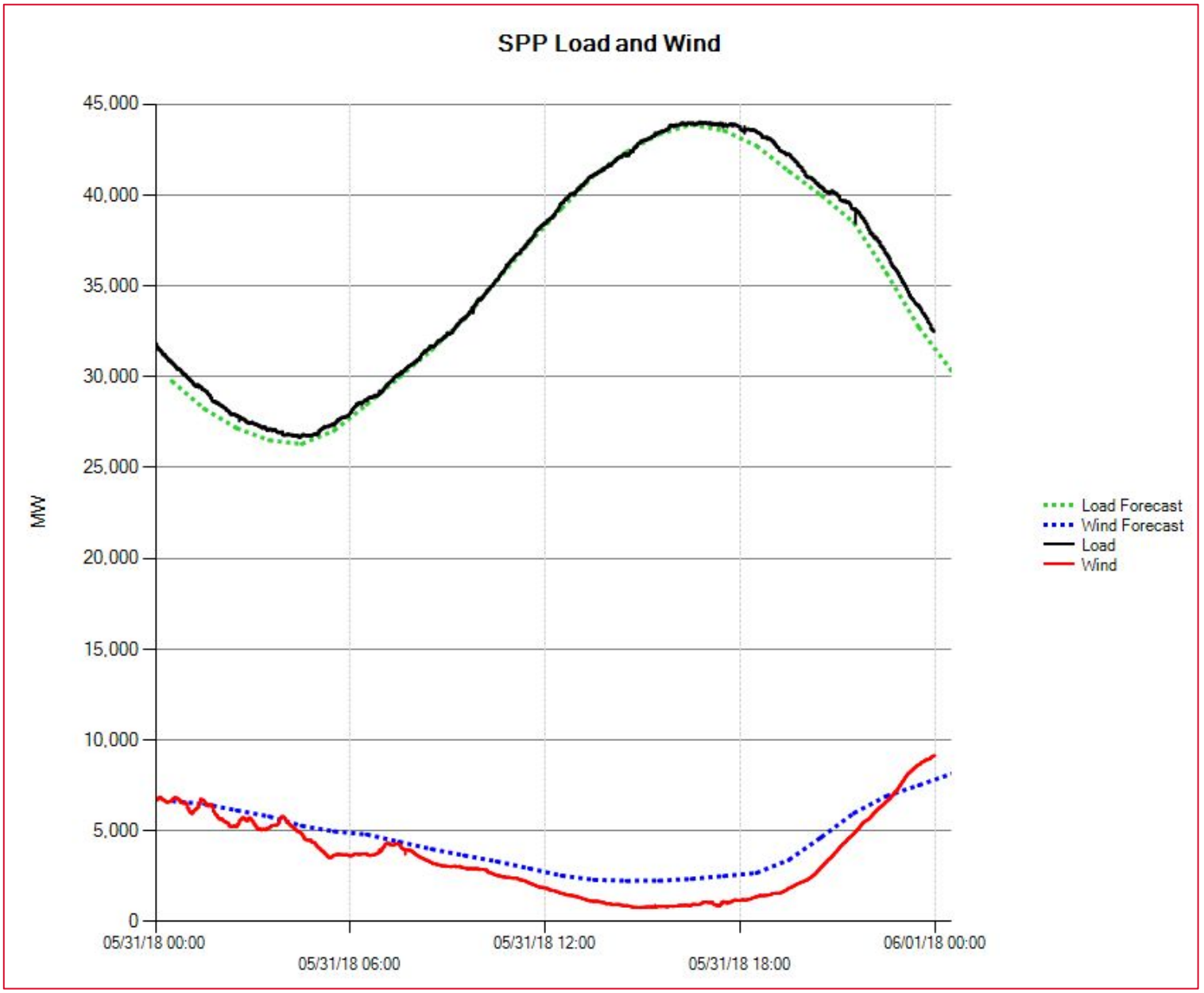
Resource Intermittency Concerns

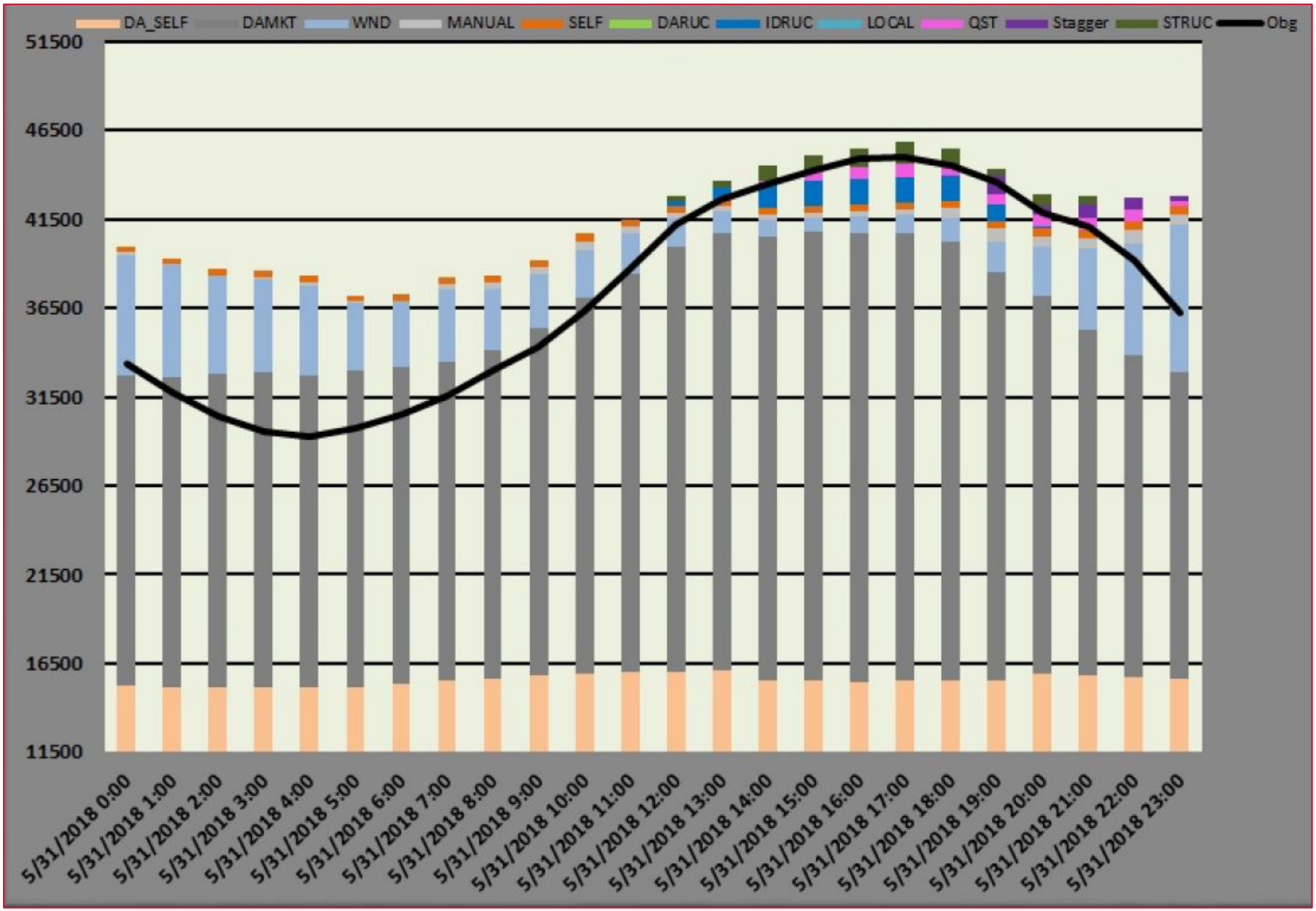
- **Renewables (mainly wind in SPP) can move by large amounts in a very short amount of time**
  - Sudden drops in wind are generally far more concerning than jumps as the timely replacement of lost generation can be difficult
- **Normally, quick-starts & other short-lead resources can be used to counteract the sudden loss of wind generation**
  - However, we've seen certain recent scenarios where quick-starts were economically committed in the DAMKT and we did not have enough remaining quick-starts and short-lead resources to replace the lost wind

Wind Intermittency Example: Running out of quick-starts on 5/31/18

- **Event Details**
  - SPP issued a hot weather alert 5/31/18 @ 15:38 effective 5/31/18 16:00 through 6/1/18 20:00
  - Wind came in under forecast by ~1,200 MW at peak
  - DAMKT ran and economically committed several quick-start units for the day, which made them unavailable for use in mitigating the sudden drop in wind as they were already online
  - DA_MKT, IDRUC and STRUC kept recommending quick-starts throughout the OD
    - Eventually we ran out of what was left of our quick-starts
- **Issues**
  - Too much reliance on quick-starts through peak
  - Higher load than previous years
  - Higher amount of generation outages than previous years

Thursday May 31st, 2018

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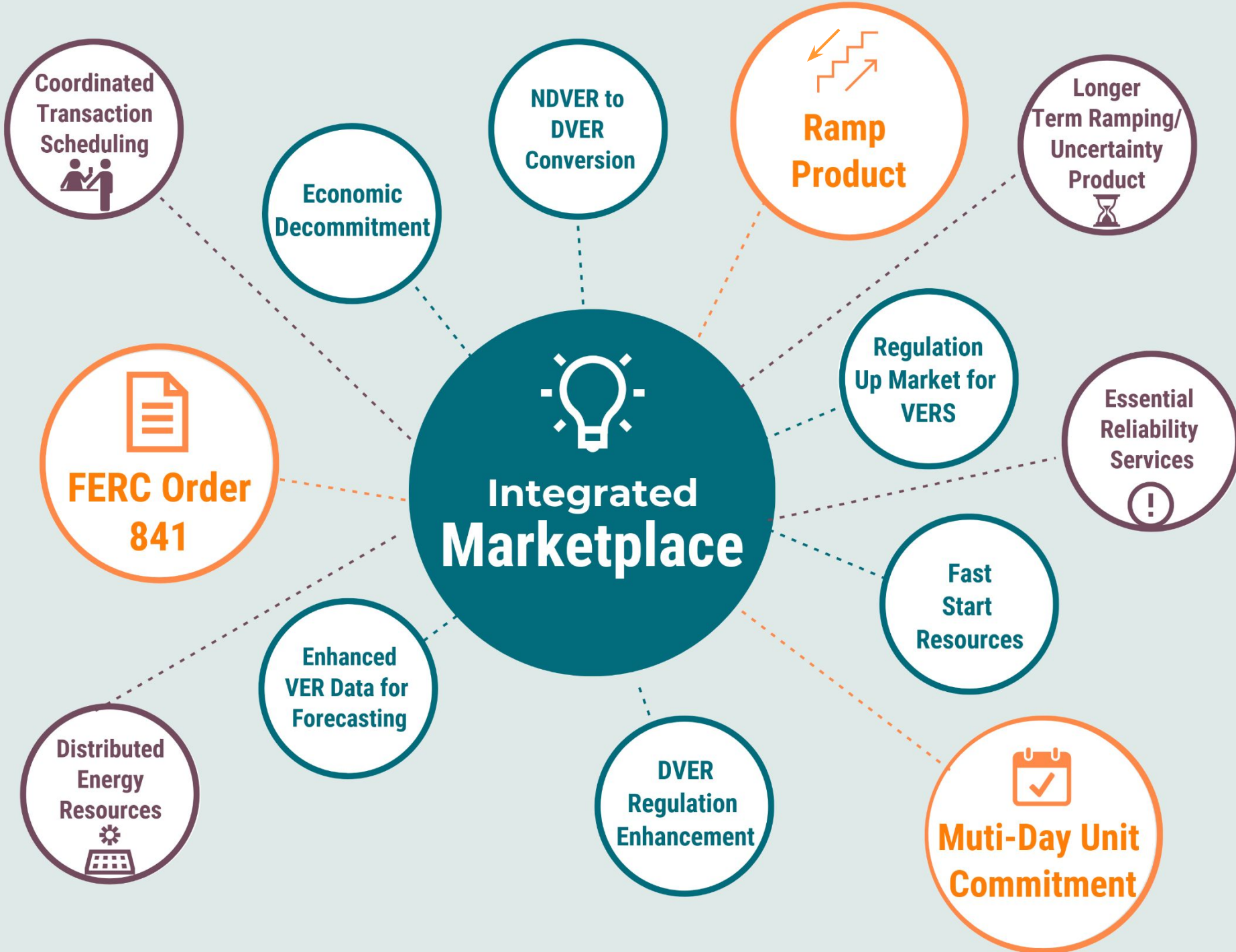
Integrated Marketplace Overview

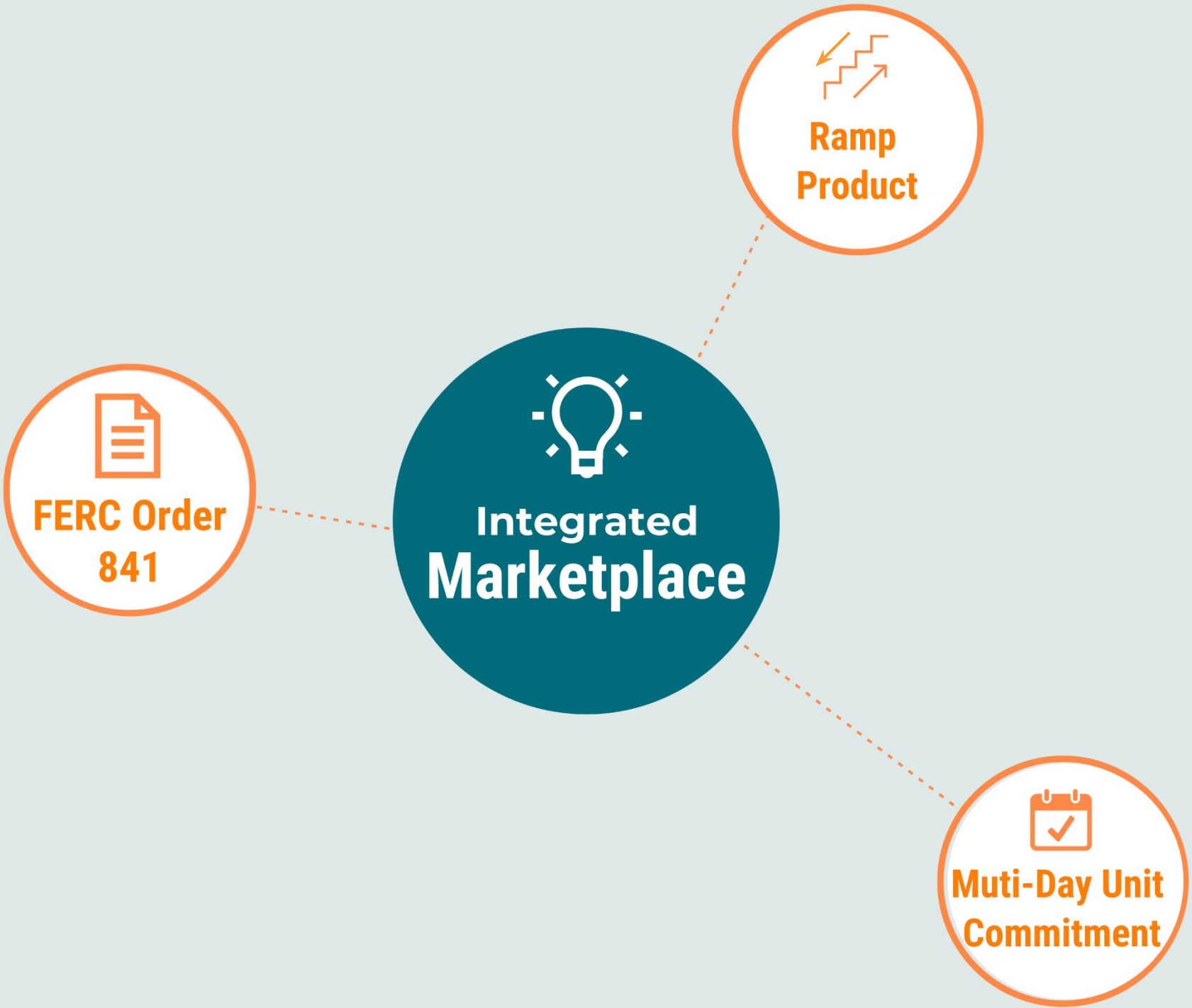
Key Components

- Day-Ahead Market
- Real-Time Balancing Market
- Transmission Congestion Rights Market

Products

- Energy
- Operating Reserve
  - Regulation Up
  - Regulation Down
  - Spinning
  - Supplemental
- Congestion Rights


Integrated Marketplace
Coordinated Transaction Scheduling
Economic Decommitment
NDVER to DVER Conversion
Ramp Product
Longer Term Ramping/ Uncertainty Product
FERC Order 841
Regulation Up Market for VERS
Essential Reliability Services
Fast Start Resources
Enhanced VER Data for Forecasting
Distributed Energy Resources
DVER Regulation Enhancement
Muti-Day Unit Commitment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Reference

Other Notable Market Initiatives

NDVER to DVER Conversion

- ~7900 MW of Non-Dispatchable Variable Energy Resources
- SPP's only mechanism to control NDVER output is through out-of-market actions
- Conversion results in increased reliability and market efficiencies

Enhanced VER Data for Forecasting

- Individual wind turbine location data
- Mid-point and corner location data for solar farms
- Inverter technology and controls information
- Improved forecasting of VERs results in better unit commitment and dispatch, lower production costs, and increased reliability

Economic Decommitment

- Resources committed in the Day-Ahead Market are not typically decommited unless a reliability need arises that requires it
- Establishment of an economic de-commitment process could alleviate prolonged periods of excess generation which creates severe depression on LMPs

Regulation Up Market for VERS

- VERs precluded from participating in 'Up' products, except for Energy, because of fuel source uncertainty
- Would allow for additional competition in the regulation up product
- Addresses potential scenarios where grid is primarily renewable

DVER Regulation Enhancement

- SPP has some inefficiencies in the clearing of Regulation and the requirements for DVERs
- Introduces use of real-time capability in real-time market for VERs

Fast Start Resources

- FERC 206 proceeding
- Delays commitment of Quick Start Resources until Real-Time Balancing Market

Future Market Initiatives

Longer Term Ramping/ Uncertainty Product

- Builds on current short term ramping product
- With more renewables, SPP's forecasting and uncertainty issues continue to grow past short-term into longer than 10-15 minute issues

Distributed Energy Resources

- Awaiting FERC Order
- Should allow for a broader spectrum of participation in SPP
- More flexibility is essential for coming changes

Coordinated Transaction Scheduling

- Most real time transactions in SPP are fixed transactions. Allowing transactions to be cleared by Market creates value for all participants.
- Should increase price convergence between seams with other RTOs