

Electric Markets: Interface for Sector Convergence

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IESO/NREL Conference

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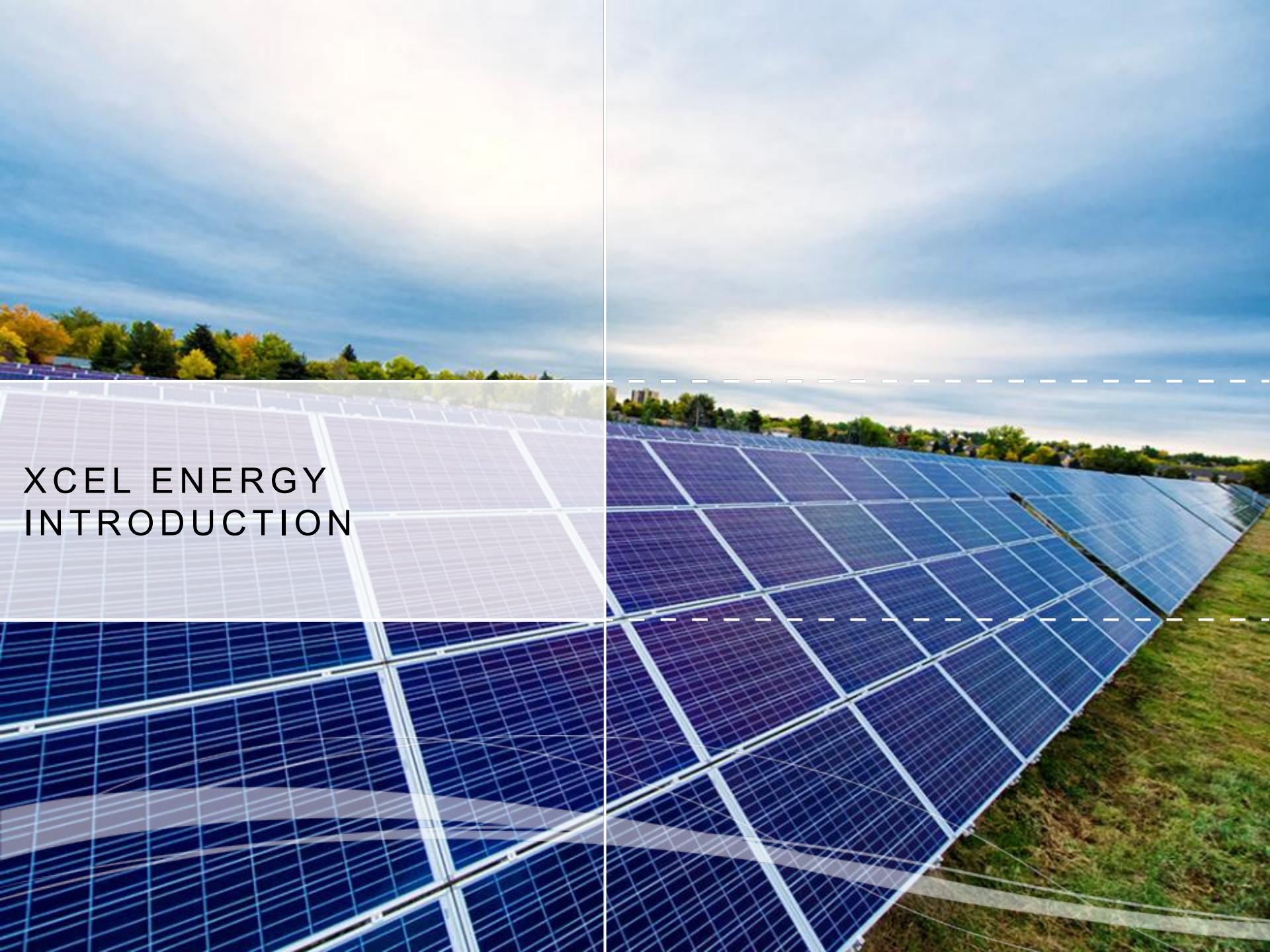
WELCOME TO THE USA!



OUTLINE

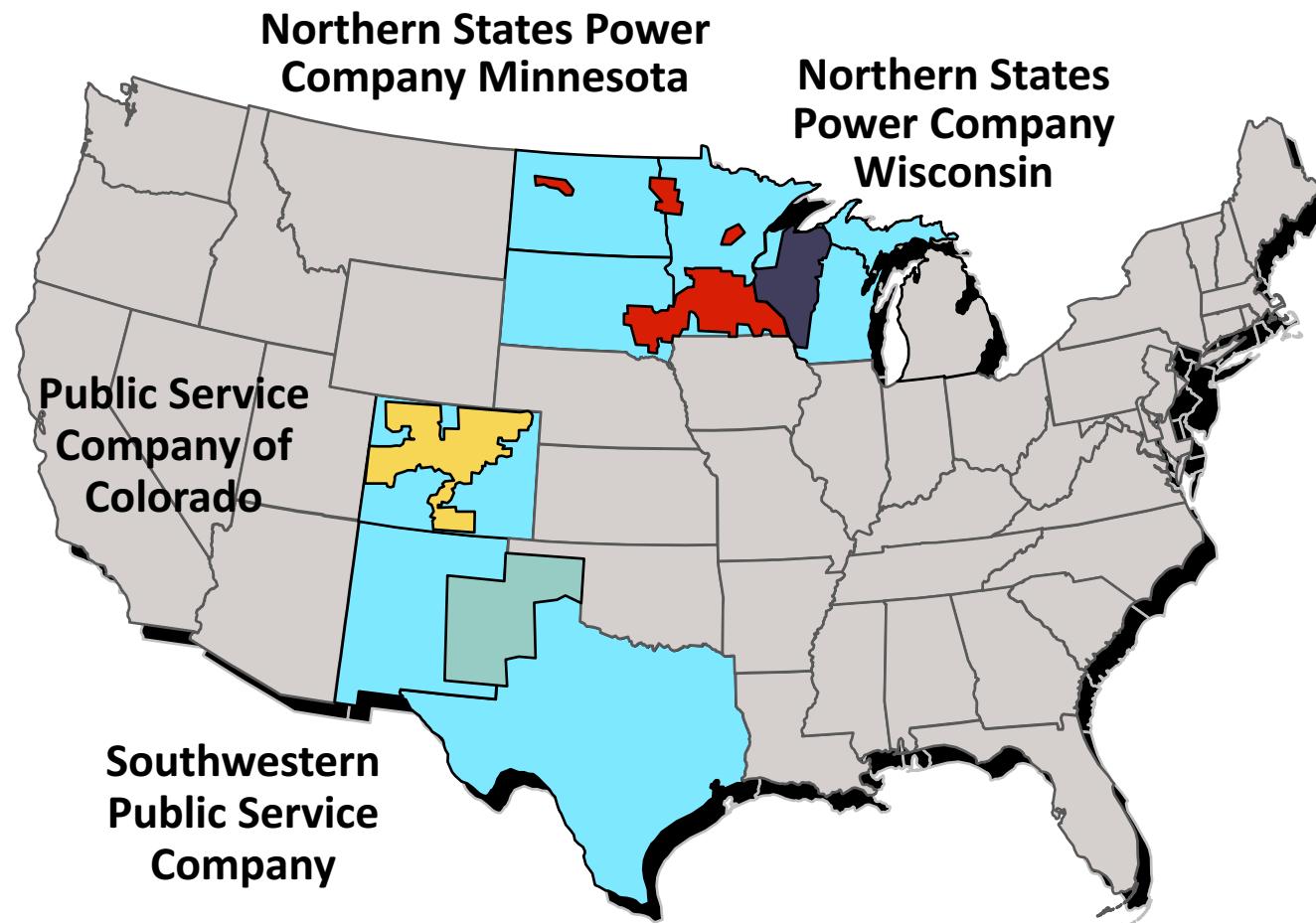


- Xcel Energy Introduction
- Discussion topic:
 - The electricity industry is developing effective interfaces to support broad energy sector convergence
 - Electricity markets are key to this transition
 - Xcel Energy is working on key aspects of this evolution

The image shows a vast solar farm with numerous blue solar panels arranged in long rows. The panels are mounted on a grassy field under a sky filled with scattered clouds. In the background, there are some trees and buildings, suggesting a rural or semi-rural setting.

XCEL ENERGY INTRODUCTION

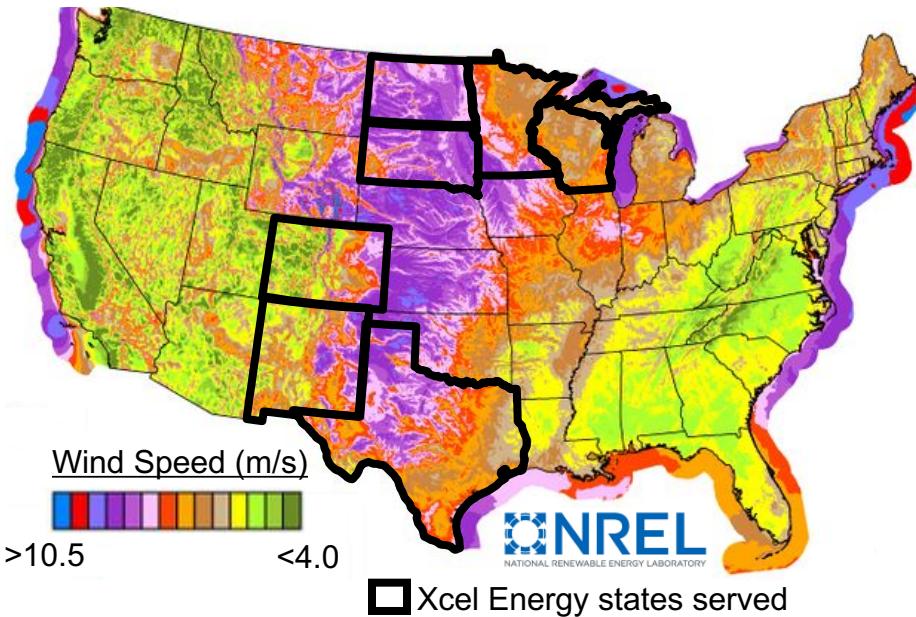
XCEL ENERGY SERVICE AREAS



Advantaged Geography



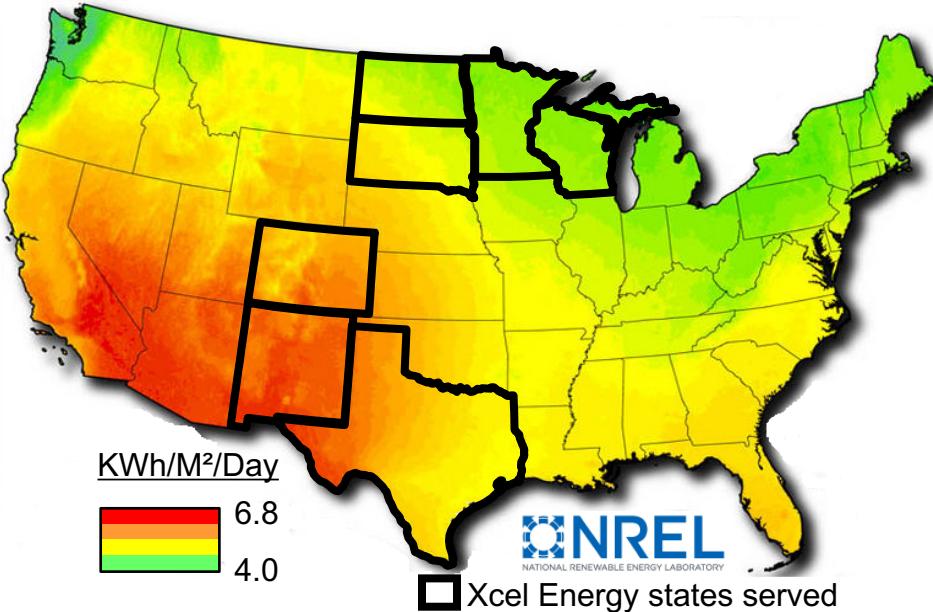
Wind Resource – Annual Average Wind Speed
(at 100 meters)



This map was created by the National Renewable Energy Laboratory for the U.S. Department of Energy with data provided by AWS TruePower, but includes modifications by Xcel Energy.

| Wind | Capacity Factor |
|------|-----------------|
| NSPM | ~50% |
| PSCo | ~45% |
| SPS | ~50% |

Solar Resource – Photovoltaic



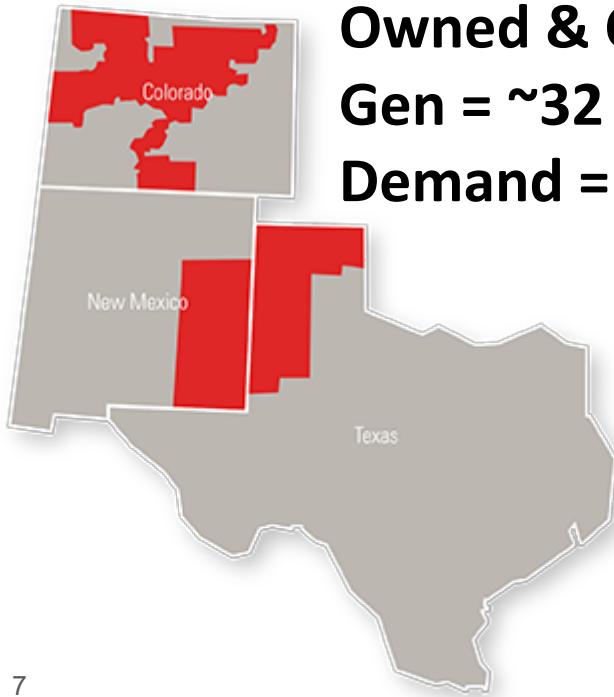
This map was created by the National Renewable Energy Laboratory for the U.S. Department of Energy, but includes modifications by Xcel Energy.

| Large-scale Solar | Capacity Factor |
|-------------------|-----------------|
| NSPM | ~22% |
| PSCo | ~30% |
| SPS | ~34% |

ABOUT XCEL ENERGY



Owned & Contracted
Gen = ~32 GW
Demand = ~ 21 GW



**3.5 million electricity
and 2 million natural gas
customers in 8 states**

- No. 1 utility wind provider for 13 years (AWEA)
- No. 1 renewable energy sales, outside California (Ceres)
- Climate Leadership Award for GHG reductions (EPA)
- Nationally recognized leader in energy efficiency

System Records for Utility-scale Renewables (wind and solar)

| | NSP | PSCo | SPS | XCEL |
|--------------------------------------|------------------|------------------|-------------------|------------------|
| Max Hourly Renewable Gen (MW) | 2,445 | 2,514 | 1,455 | 5,739 |
| Date/Time Occurred | 10/20/17 3:00 PM | 11/24/16 9:00 AM | 3/29/16 5:00 PM | 9/19/17 4:00 PM |
| | | | | |
| Max Hourly % Load | 65.6% | 70.5% | 57.6% | 57.8% |
| Date/Time Occurred | 10/10/16 3:00 AM | 10/14/17 1:00 PM | 4/5/16 4:00 AM | 10/26/17 3:00 AM |
| | | | | |
| Max Daily % Load | 51.8% | 58.6% | 50.8% | 45.7% |
| Date/Time Occurred | October 1, 2017 | April 30, 2017 | November 15, 2015 | March 6, 2017 |
| | | | | |
| Max Monthly % Load | 21.4% | 33.0% | 30.2% | 29.0% |
| Month/Year | November, 2015 | February, 2016 | October, 2016 | Apr-17 |
| | | | | |
| 2016 % Load | 18.1% | 24.5% | 23.4% | 20.8% |

The image shows a vast solar farm with numerous blue solar panels arranged in long rows under a sky filled with scattered clouds. In the background, there are some trees and buildings. A white dashed rectangular box highlights a specific area of the solar panels.

EVOLUTION ISSUES



GENERATION

GENERATION ISSUES



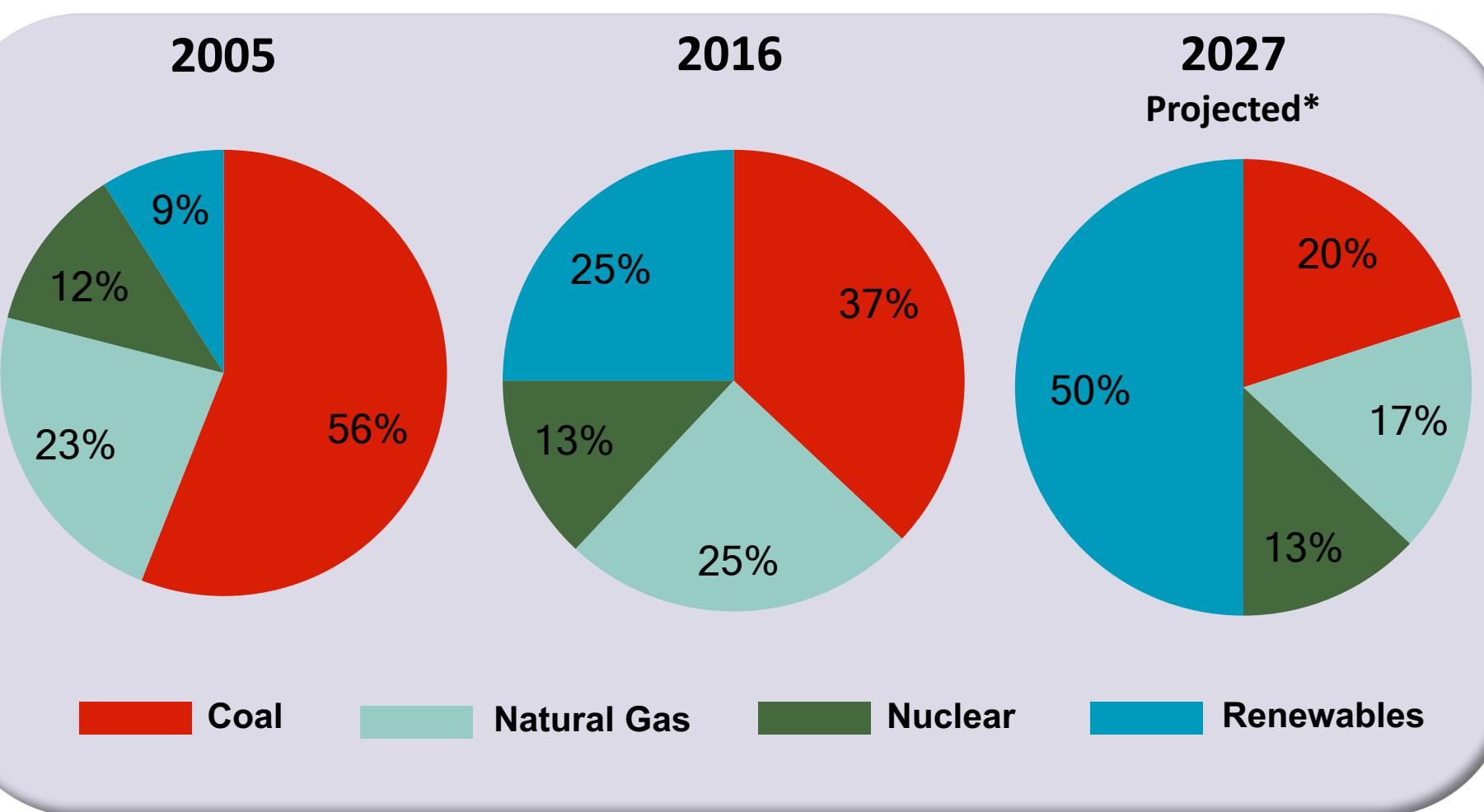
- **Forecasts:**
 - More renewables and storage will be part of the mix
 - Inverter-connected resources will see expanded use for ancillary service products in regional energy markets (wind / solar / storage)
 - More distributed resources will develop, creating the need to coordinate with T/D interface access and clarify resource adequacy policy
 - Less synchronous machine support will create new challenges
- **Actions:**
 - To address minimum load/oversupply, need expanded market de-commit window and develop a risk hedge for thermal owner opportunity cost
 - Need to develop capacity accreditation for battery storage
 - Resolution on forecast reliance in market settlements
 - Greater demand for pooled regional dispatch optimization and flexibility in non-market areas
 - Production cost competition impact to fuel supply contracting and pressure on resource flexibility
 - Regional “experiments” with public policy for capacity adequacy, investment and integration

XCEL ENERGY ACTIVITY



- Generation:
 - Changing resource mix; replacing thermal with renewables (next slide)
 - Seeking ongoing market design improvements for improved efficiency
 - Example: market development and expansion in Western Interconnection
 - Example: regional market use of wind resources for regulation service
 - Example: multi-day commit policy
 - Achieving greater flexibility from our existing thermal fleet

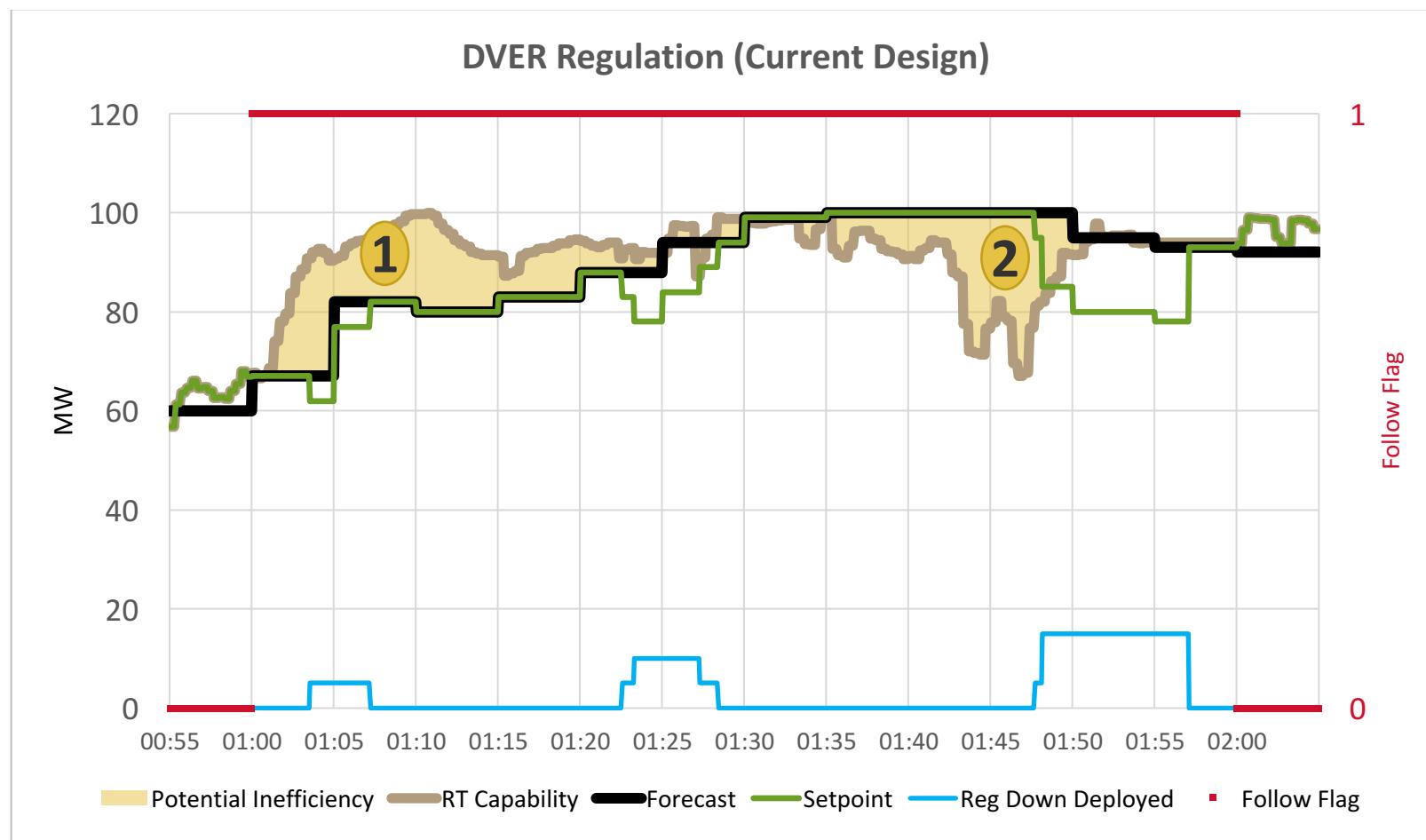
Our Changing Energy Mix



DESIGN EXAMPLE – WIND RULES CURRENT



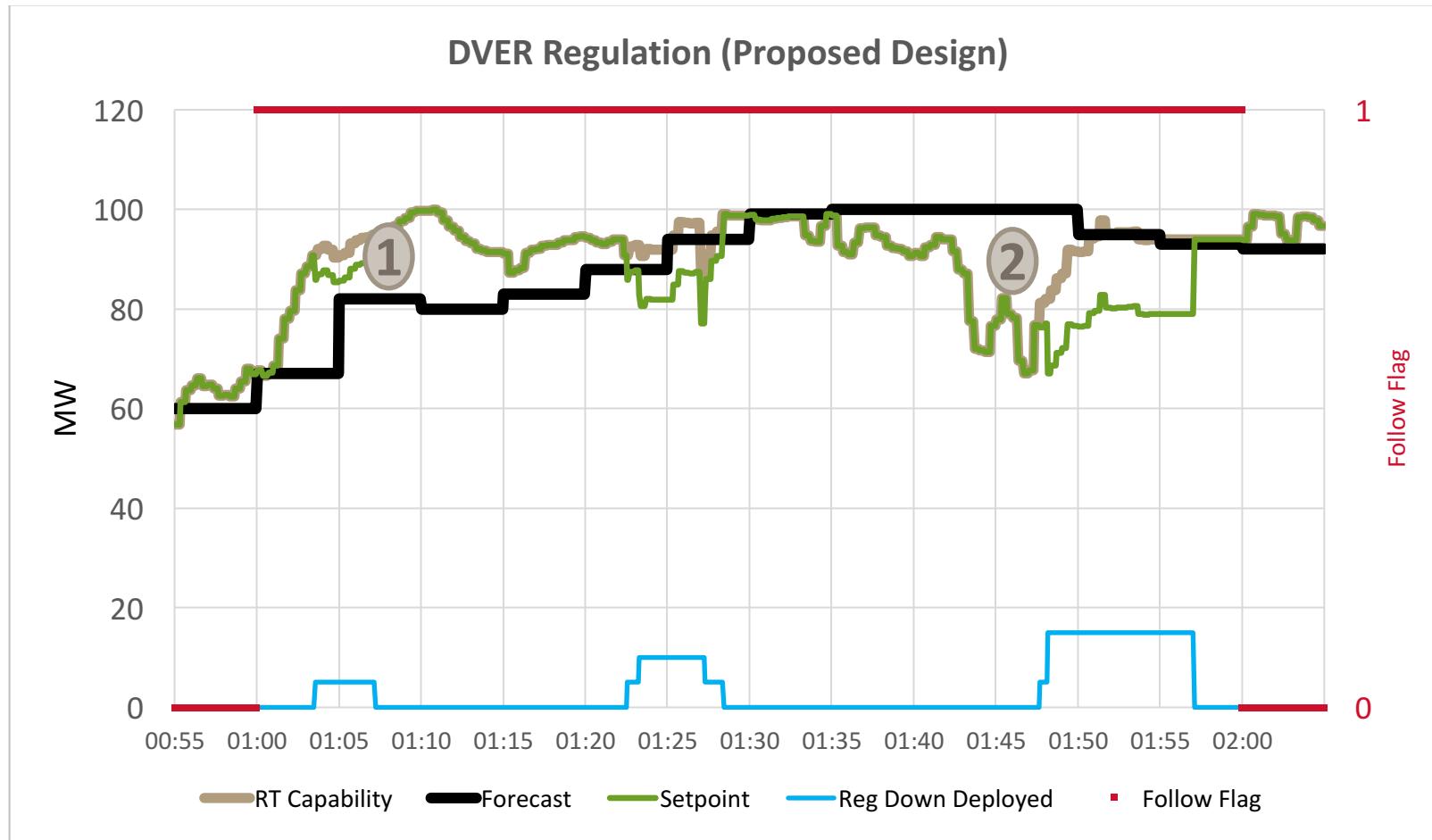
1. Potential inefficiency when RTBM forecast is wrong on low side: DVER is forced to follow down to the RTBM Forecast and misses potential energy opportunity
2. Potential inefficiency when RTBM forecast is wrong on high side: DVER is forced to follow up to the RTBM Forecast though it may not have capability, and can incur URD



DESIGN EXAMPLE – WIND RULES PROPOSED



1. No potential inefficiency when RTBM forecast is wrong on low side since AGC system will use RT Capability as the basepoint instead of the RTBM Forecast
2. No potential inefficiency when RTBM forecast is wrong on high side since AGC system will use RT Capability as the basepoint instead of the RTBM Forecast





TRANSMISSION

TRANSMISSION ISSUES



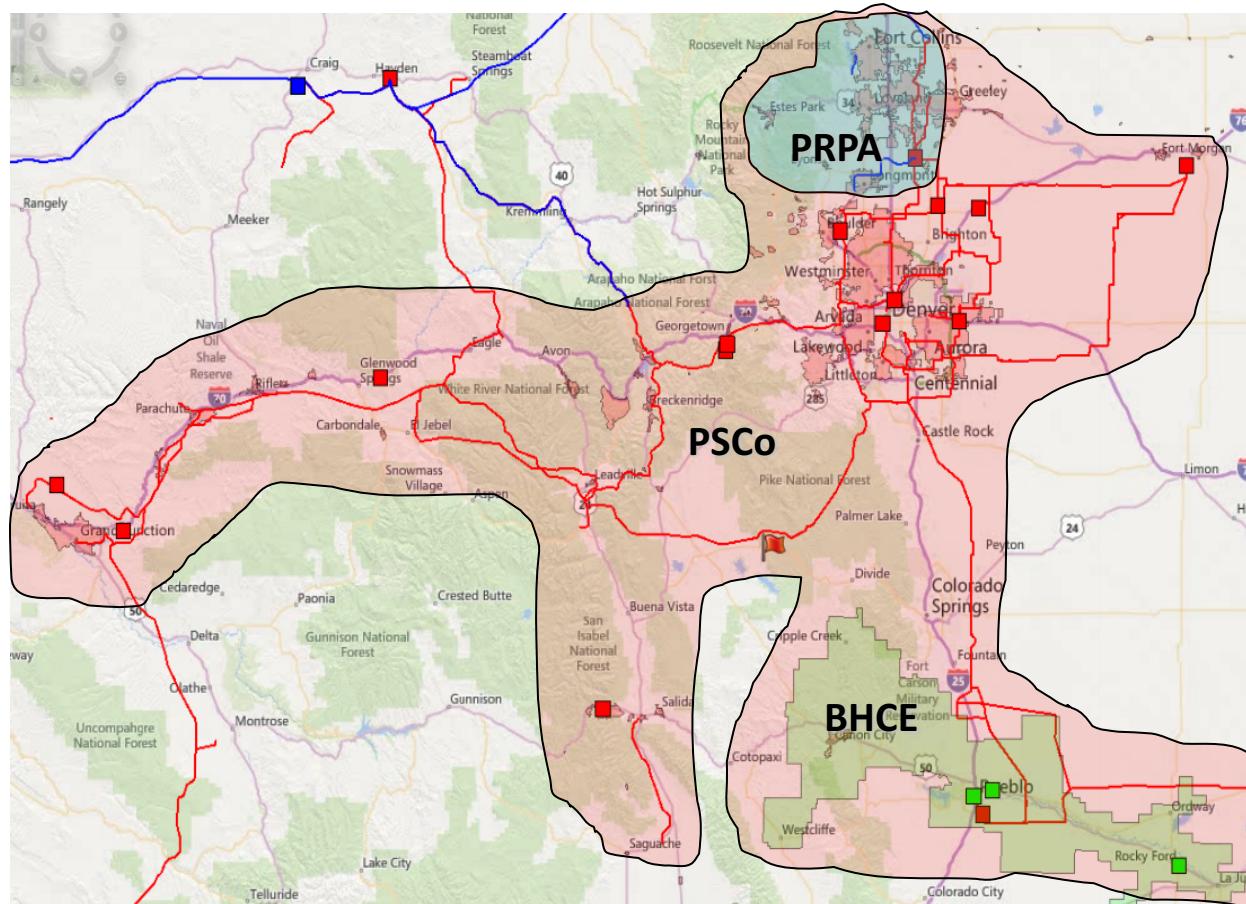
- **Actions:**
- Need more efficient grid utilization
- Need interconnection process improvements
- Need appropriate transmission cost allocation tied to regional planning process
- Need to avoid bulk grid “net metering” problems
- Need to anticipate reduced short-circuit current impacts on system protection design
- Promote delivery operations that use of flow-based transmission; move beyond contract path concepts
- Evolve to more stochastic evaluations of planned grid use
- Address firm gas delivery issues for electric reliability
- Increasing focus on mitigation of congestion price risks
- Standardization on seams policy between markets and at T/D edges
- Freeze date concepts should be scrapped and replaced with more deterministic methods

XCEL ENERGY ACTIVITY



- Transmission:
 - NSP Company in MISO
 - SPS Company in SPP
 - PSCO active in market development efforts

PSCO JOINT DISPATCH FOOTPRINT

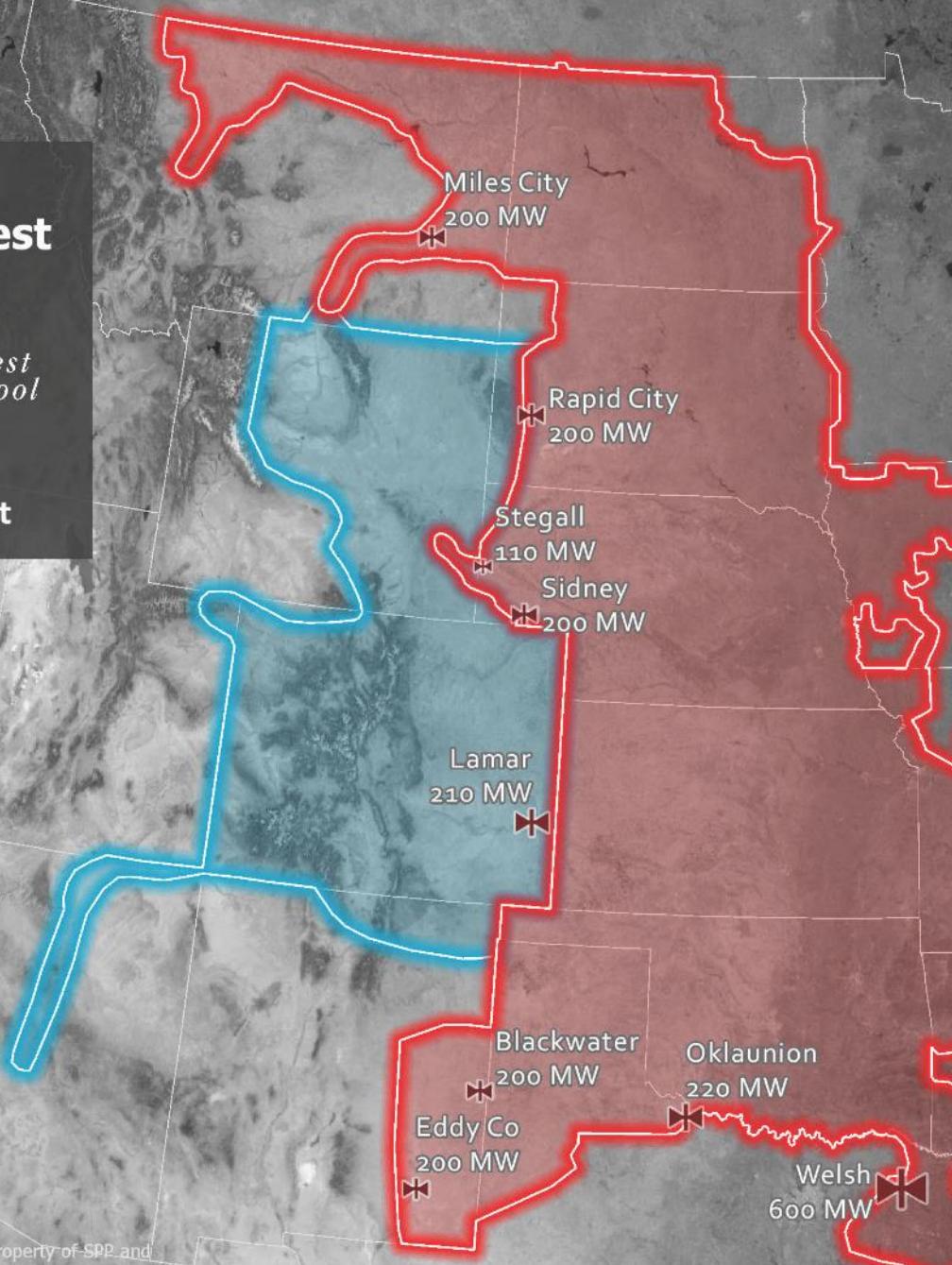


SPP & Mountain West Footprint

 **SPP** Southwest Power Pool

 **SPP**

 **Mountain West**



| | SPP | MWTG |
|-----------------------|-----------|-----------|
| Square miles | 546,000 | 165,000 |
| Miles of transmission | 65,755 | 16,000 |
| Population | 17.5 mil | 6.4 mil |
| Generating capacity | 83,945 MW | 21,000 MW |

The image shows a vast solar farm with numerous blue solar panels arranged in long rows under a sky filled with scattered clouds. In the background, there are some trees and buildings. A dashed white line runs horizontally across the middle of the panels.

DISTRIBUTION

DISTRIBUTION ISSUES



- **Actions:**
- **Greater need for increased observability and distribution control systems integration**
- **Greater need for two-way flow planning**
- **Distribution grid protection adaptations to two-way flow; (aka: life after fuses)**
- **Distribution access: a rate pancake for wholesale market interface? Concepts of local access markets do not match federal policy for grid cost allocation**
- **Greater need to accommodate and properly cost allocate distributed production peak impacts; cases where DG increases need for distribution upgrades**
- **Resource adequacy treatment for BTMG and DER should be addressed comprehensively with bulk system**

- Distribution:
 - Interconnection and hosting policy
 - Infrastructure modernization initiative (next slide)

Advanced Grid Intelligence and Security

*Strengthen the grid so that our customers view
Xcel Energy as their long-term energy solutions provider*



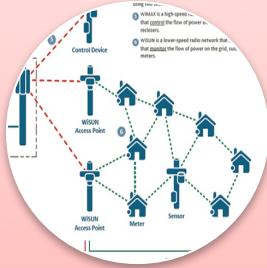
Advanced Distribution Management System (ADMS)



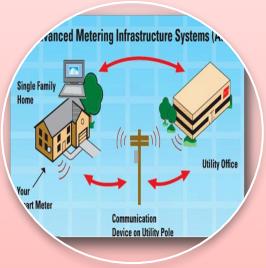
Fault Location, Isolation, and Service Restoration (FLISR)



Integrated Volt-VAr Optimization (IVVO)



Field Area Network (FAN)



Advanced Meter Infrastructure (AMI)



Emerging Technologies

Technology Suite – Enabling Customer Experience, Choice, Control & Enhancing Grid Operability

Security and Data Solutions

Process Integrations, Change Management, Talent Strategy, Communications, Governance



LOAD

- **Forecasts:**
- **Increased utility incentives for flexible rate of consumption and other demand-based interactions with retail/wholesale energy and capacity products**
- **Increased customer interest in supply resource selection and in status updates from utility supplier**
- **Actions:**
- **Improve products for novel energy utilization and for tailored resource selection as part of convergence from other energy sectors**

- Load:
 - **Forecasted Demand Response and Storage Capacity 2018:**
 - NSP System ~ 867 MW
 - PSCO System ~ 514 MW + 350 PSH MW
 - SPS System ~ 42 MW
 - **Battery storage pilots (small) on NSP and PSCO systems**
 - **Developed “Renewable Connect” and other renewable energy supply programs for our customers**
 - **Developed mobile application for customers to monitor their energy use and get updates on outage/restoration status**



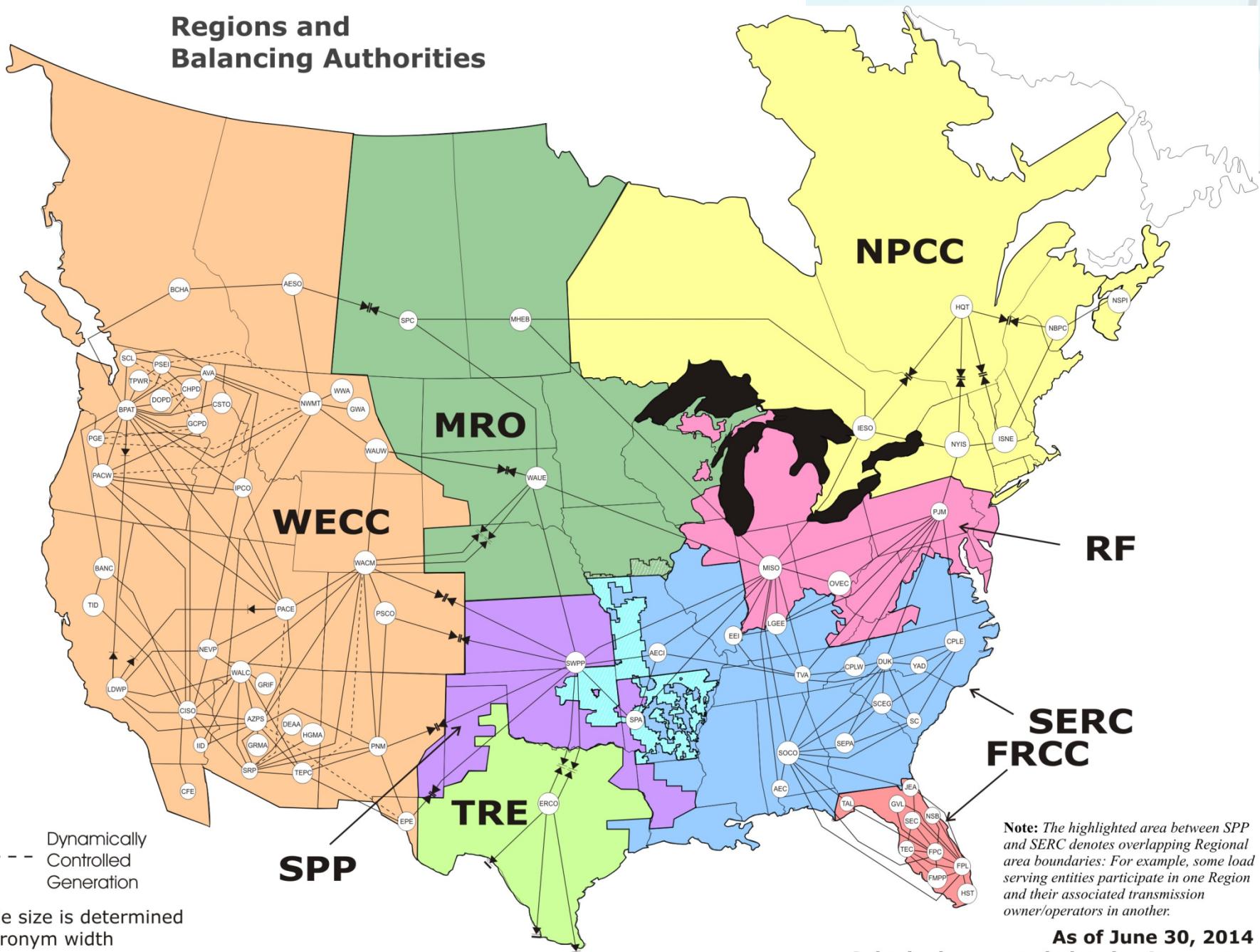
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Bonus Discussion and Reference Materials

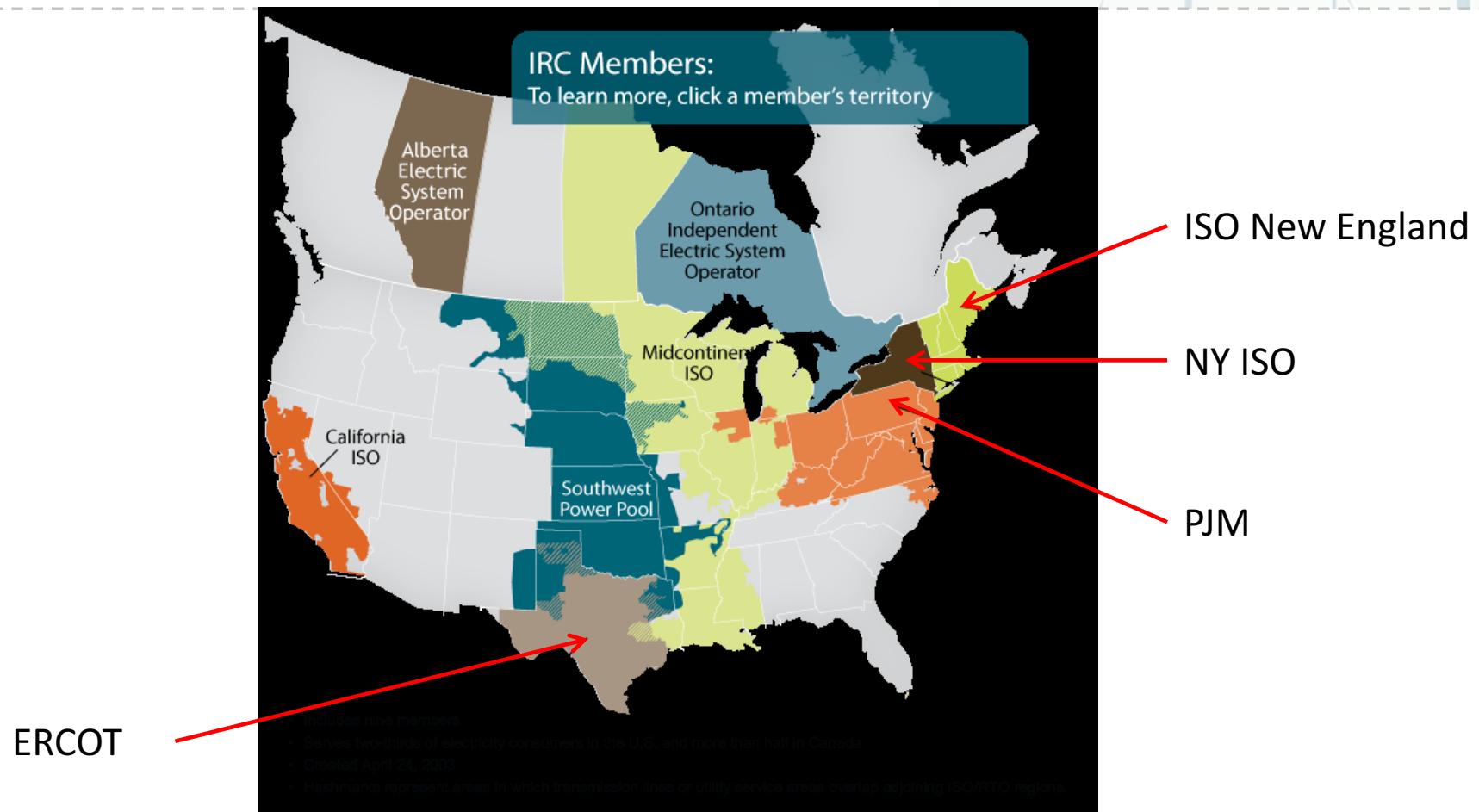


Regions and Balancing Authorities



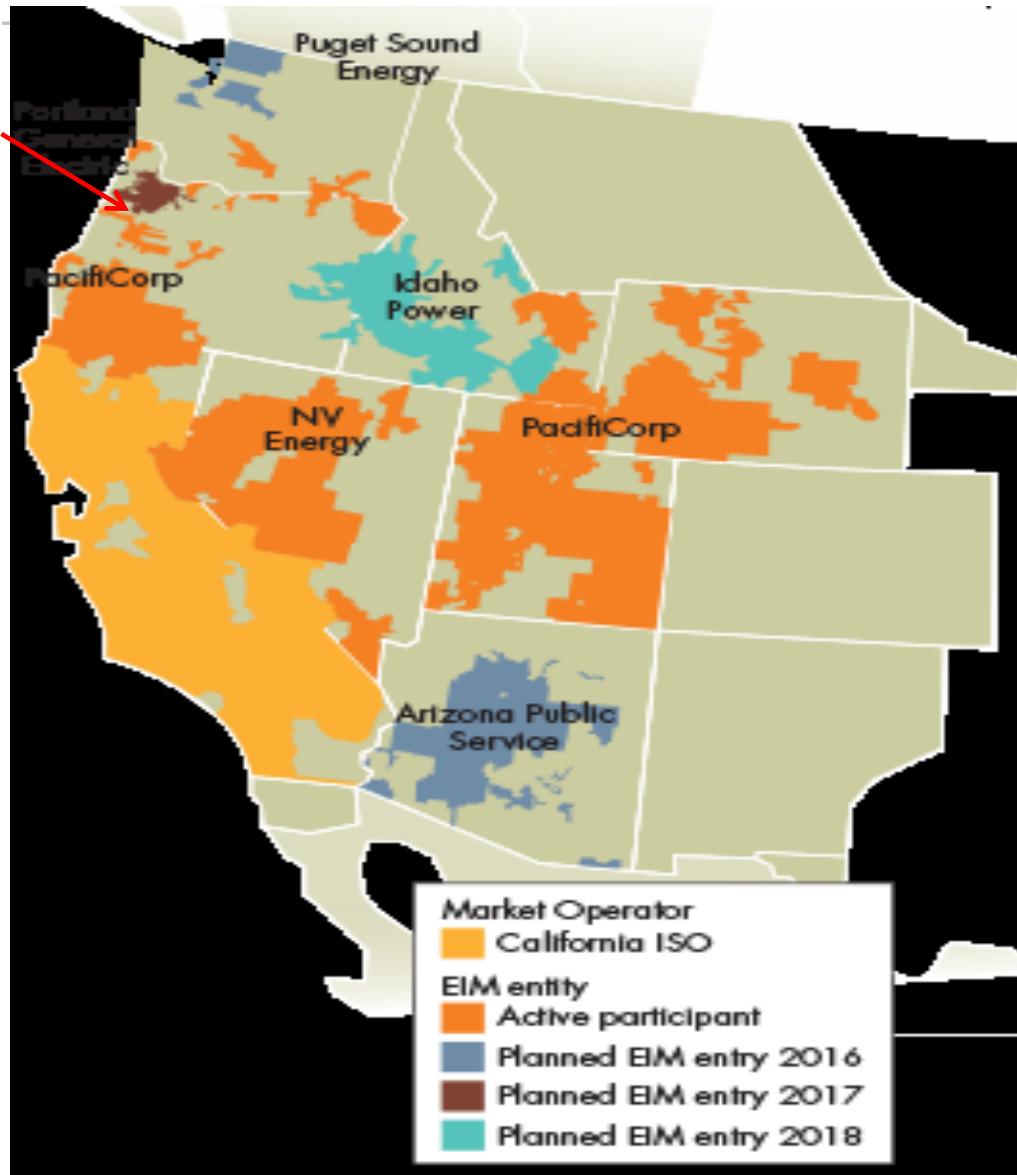
As of June 30, 2014
Submit changes to balancing@nerc.com

RTO FOOTPRINTS TODAY...



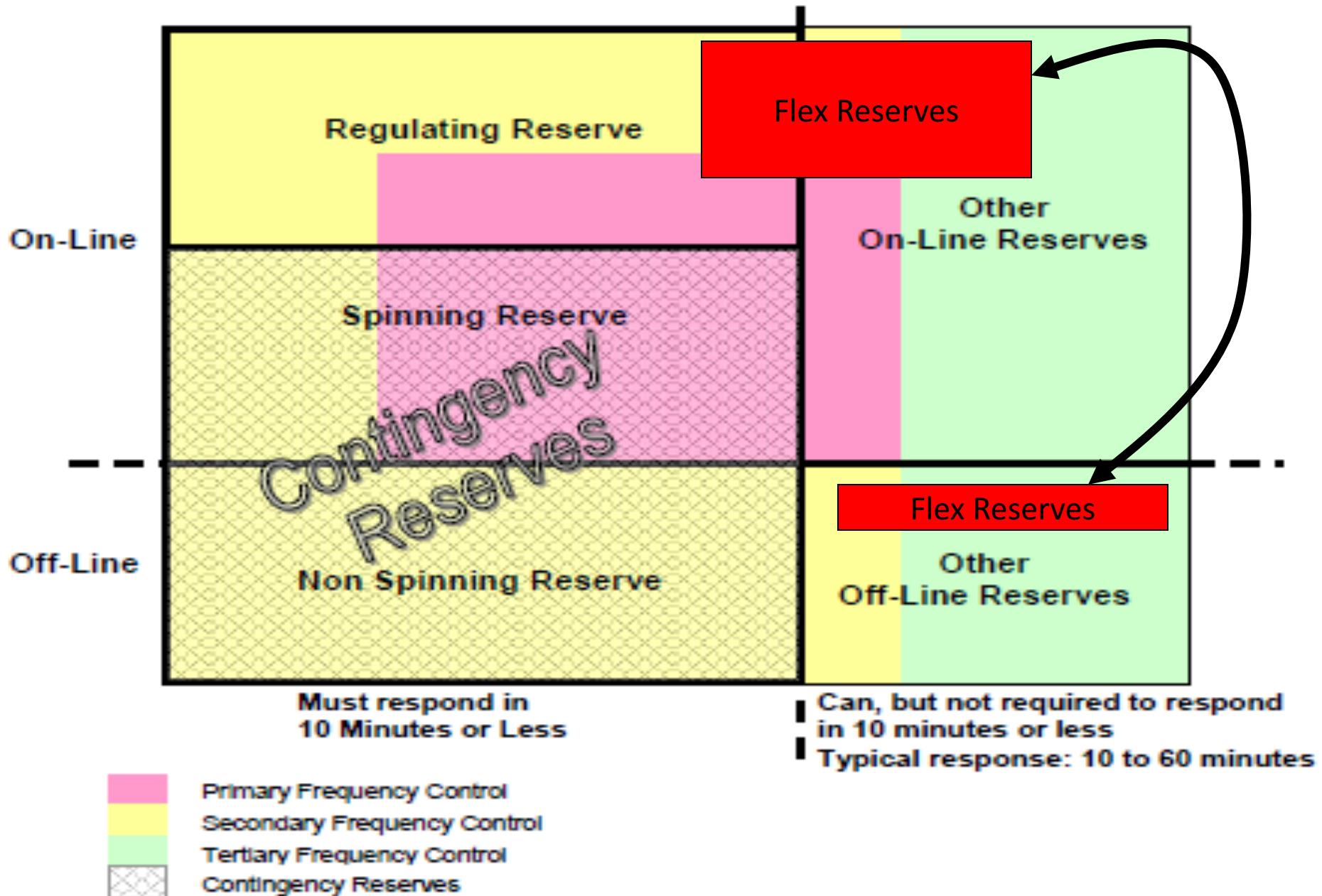
Source: <http://www.isorto.org/About/Members/allmembers>

CAISO/EIM EXPANSION

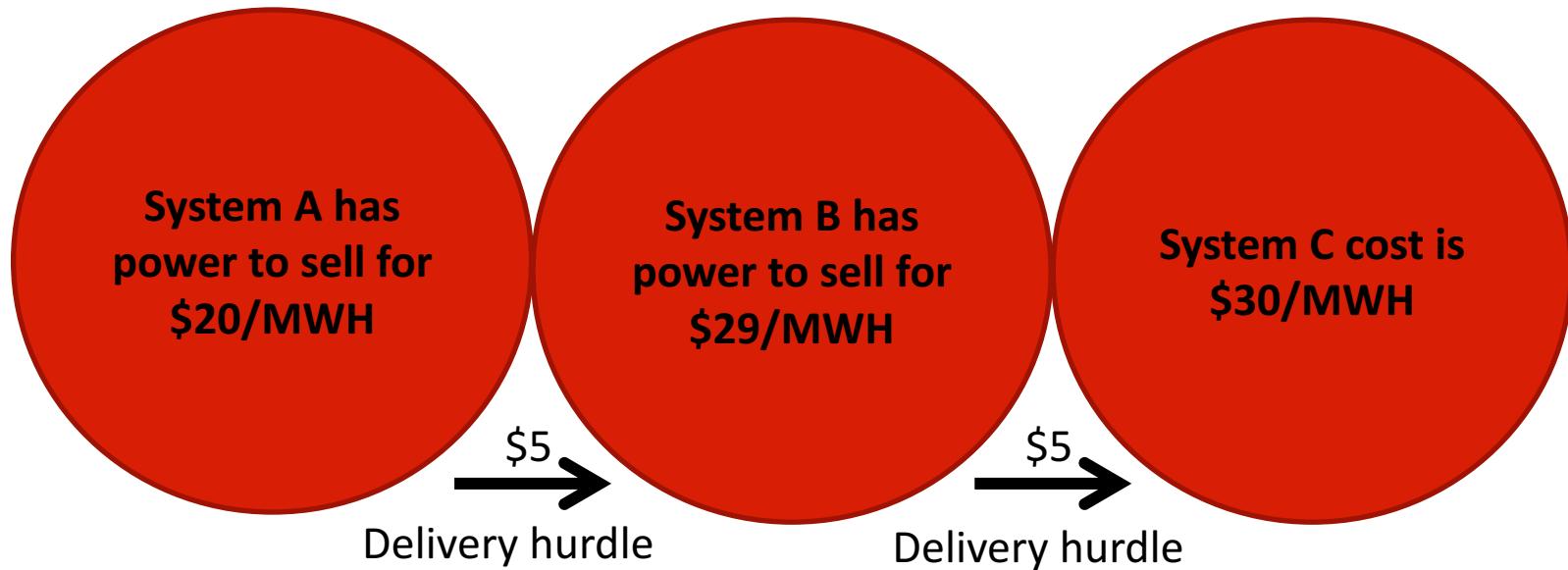


Source:
<https://www.caiso.com/informed/Pages/EIMOverview/Default.aspx>

View of Operating reserves, including Flex Reserves:

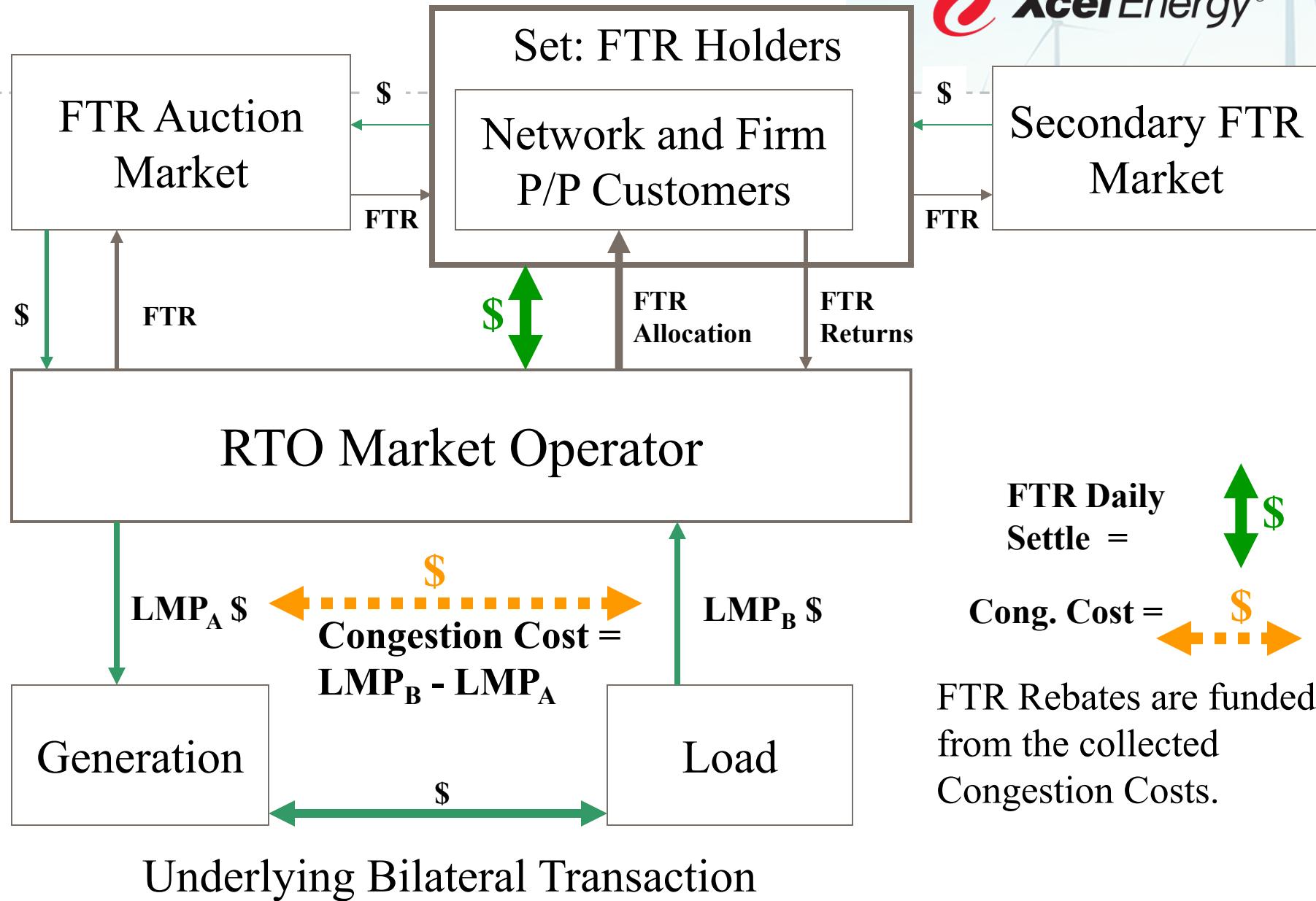


OLD STYLE COST TO TRANSACT



Should System C purchase from System A? Yes, but unfortunately under today's bilateral market process, System C would purchase from neither system. The costs to transact the energy are too high.

Generic Example: Financial Transmission Rights -Follow the Money-



REFERENCES AND ADDITIONAL READING



- Western Interconnection discussions:
 - Mountain West Transmission Group / RTO Expansion in Western Interconnection
 - www.spp.org
 - CAISO Energy Imbalance Market (EIM) information
 - <http://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyImbalanceMarket.aspx>
- CAISO discussions on sector convergence:
 - <https://www.caiso.com/informed/Pages/MeetingsEvents/StakeholderSymposium/SymposiumLiveStreaming.aspx>
 - <http://energy.ca.gov/cgbec/presentations/Lovins.pdf>
- NARUC References:
 - Seams coordination: <http://pubs.naruc.org/pub/536EF504-2354-D714-51F0-1BD9D04A5F7E>
 - Resource Adequacy issues:
http://www.ercot.com/content/gridinfo/resource/2015/mktanalysis/Brattle_ERCOT_Resource_Adequacy_Review_2012-06-01.pdf
- Overview of wholesale market design issues by former FERC and ND PSC Commissioner Tony Clark:
 - [http://www.wbklaw.com/uploads/file/Articles-%20News/2017%20articles%20publications/Market%20Identity%20Crisis%20Final%20\(7-14-17\).pdf](http://www.wbklaw.com/uploads/file/Articles-%20News/2017%20articles%20publications/Market%20Identity%20Crisis%20Final%20(7-14-17).pdf)



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