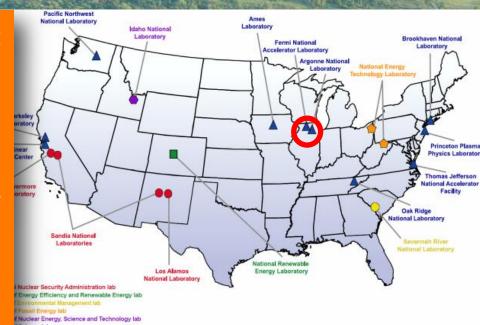
# FEATURES OF ELECTRICITY EXCHANGES:

#### U.S. AND CENTRAL AMERICA

## GUENTER CONZELMANN CENTER DIRECTOR AND GROUP LEADER CENTER FOR ENERGY, ENVIRONMENTAL, AND ECONOMIC SYSTEMS ANALYSIS (CEEESA) ENERGY SYSTEMS DIVISION ARGONNE NATIONAL LABORATORY 9700 SOUTH CASS AVENUE ARGONNE, IL 60439 GUENTER@ANL.GOV; +1-630-252-7173



- Argonne is part of the U.S. Department of Energy (DOE) laboratory complex of 17 National Laboratories
- Managed by UChicago Argonne, LLC
- Main site: 30km southwest of Chicago, Illinois, USA
- Diverse basic and applied research portfolio



\$760M 3,300+ 6,500+ **EXTERNAL USERS OF OPERATING EMPLOYEES BUDGET IN 2016 RESEARCH FACILITIES** 

**IN 2016** 

## ARGONNE HAS EXTENSIVE PORTFOLIO IN ELECTRICITY MARKETS/INTERCONNECTIONS



ANL/ESD-16/1

#### Survey of U.S. Ancillary Services Markets



Contents lists available at ScienceDirect

**Energy Policy** 

journal homepage: www.elsevier.com/locate/enpol

Electricity market design for generator revenue sufficiency with increased variable generation



argonne National Laboratory, Energy Systems Division, 9700 South Cass Avenue, Lemont, IL 60439, United States 💳

Evolution of Wholesale Electricity Market Design with Increasing Levels of Renewable

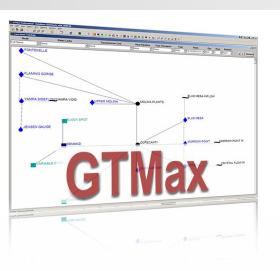
E. Ela, M. Milligan, A. Bloom, A. Botterud, A. Townsend, and T. Levin

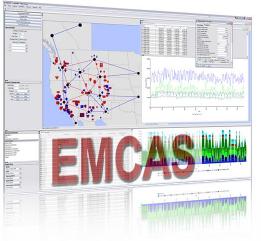
<sup>1</sup> National Renewable Energy Laboratory <sup>2</sup> Argonne National Laboratory

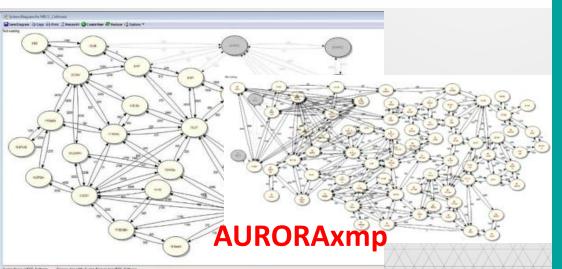
Generation

- Review of current and proposed market designs
- What are the new fundamental challenges and promising solutions to create better incentives and improved market design?
- How to achieve capacity adequacy and revenue sufficiency in the long-run?
- How to ensure and incentivize flexibility in short-run operations?

## ARGONNE HAS EXTENSIVE PORTFOLIO IN ELECTRICITY MARKETS/INTERCONNECTIONS

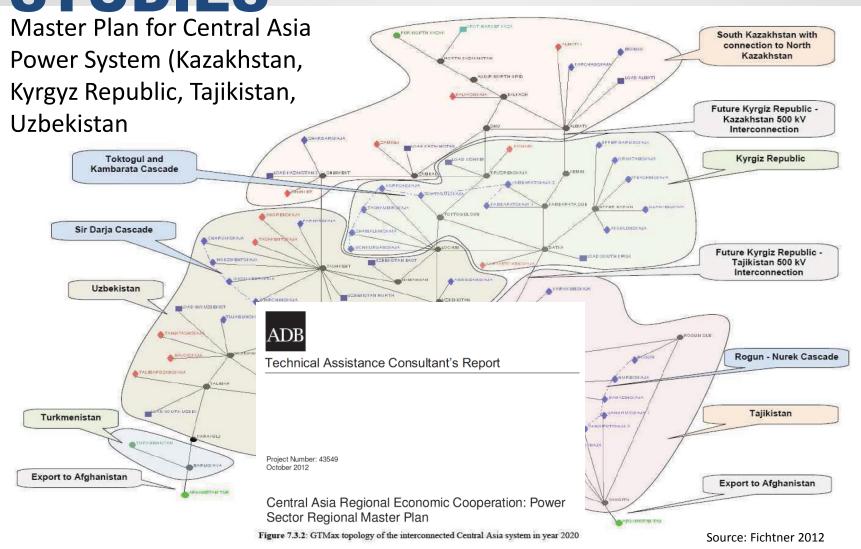






- Developing and using our own tools with unique capabilities to address critical issues (GTMax, EMCAS, CHEERS, etc.); models used around the world
- Using commercial tools (PLEXOS, AURORA) for quick turn-around analyses

## FOR REGIONAL INTEGRATION/POWER MARKET STUDIES



FOR REGIONAL INTEGRATION/POWER MARKET STUDIES

Water Links

None

Water Links

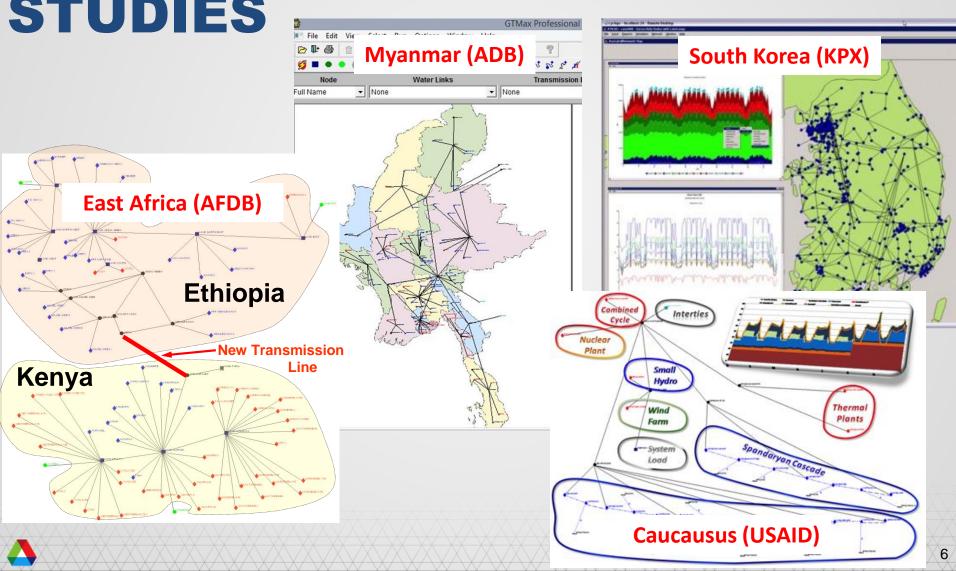
None

None

Water Links

None

South Korea (KPX)



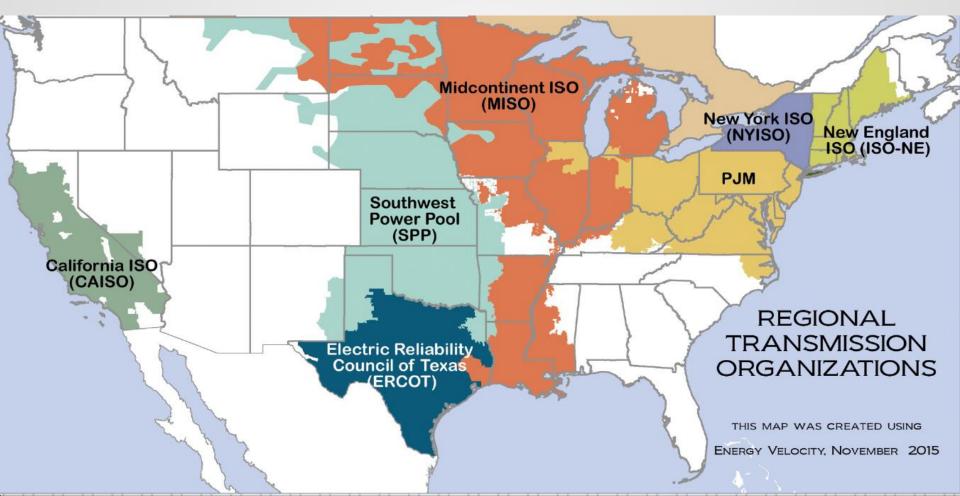
## FOR REGIONAL INTEGRATION/POWER MARKET

STIINIFS Southeast Europe (USAID) ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAMM **Development of Power Generation** IMPLICATIONS FOR INVESTMENTS I Volume 3: Generation and transmission main report 31 December 2004

- Regional Electricity Market (REM) provides for better utilization of hydro power for ancillary services
- REM leads to significant savings in all seasons and under all hydrological conditions: total benefits of the regional market operation reaching up to 10-15% in certain periods
- Considerable volume of power transactions among the utilities in the region
- Potential zones of congestion and higher LMPs identified
- Several follow-on studies with Argonne tools (Price Waterhouse Coopers) funded by EU

### U.S.: ONE COUNTRY - MANY POWER POOLS/RTOS

- Colors: Centralized wholesale markets
- White: Traditional bilateral wholesale markets



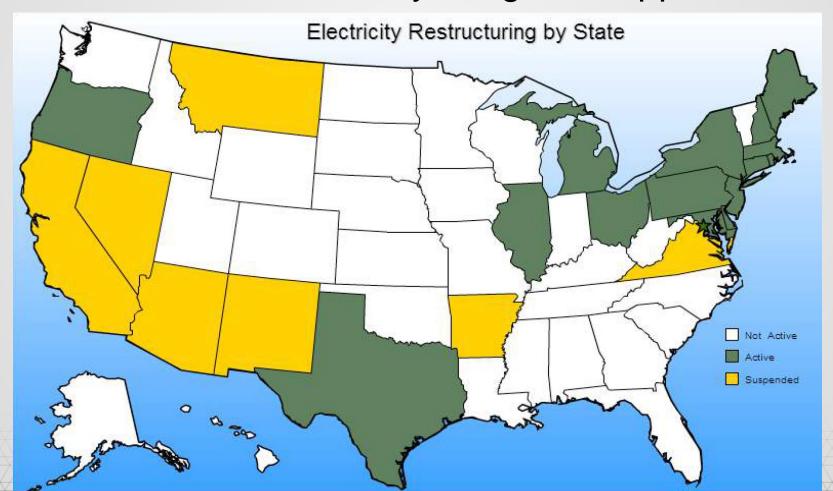
### U.S.: ONE COUNTRY – MANY POWER POOLS/RTOS

- Common features for most markets with variations in details
  - Energy markets: Day-ahead, real-time
  - Ancillary services
  - Capacity markets
  - Financial transmission rights
  - Regional generation and transmission expansion planning processes to ensure future reliability
- In addition, participants engage in bilateral contracting on Intercontinental Exchange (ICE), via broker, or direct (dominant in non-RTO regions)

Market	Peak Load (GW)	Installed Cap (GW)	Annual Volume (TWh)	Transmission (Miles)	Other
PJM	165	176	792	82,550	1400 generators, 65 million people in 13 States; 990+ members
MISO	127	175	594	65,800	6,500 generators, 42 million people in 15 States, 440 members

## U.S.: SIMILARLY, RETAIL SIDE VARIES WIDELY AS WELL

- Colors: Retail choice
- White: Traditional vertically integrated approach



## U.S.: YET, ONCE UPON A TIME, WE HAD A VISION (2002)



UNITED STATES OF AMERICA FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Joseph T. Kelliher, Chairman;

Nora Mead Brownell, and Suedeen G. Kelly.

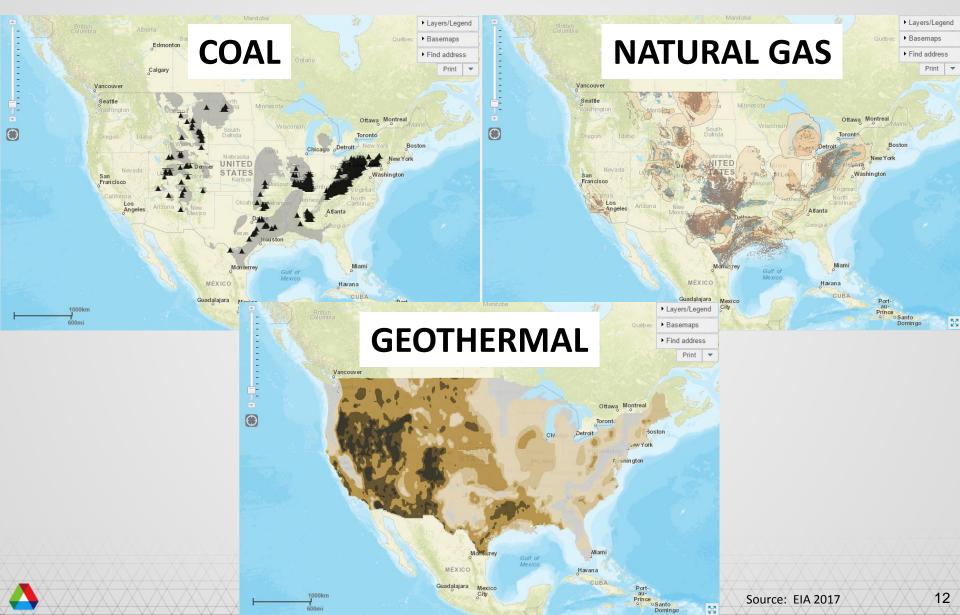
Remedying Undue Discrimination through Open Access Transmission Service and Standard Electricity Market Design Docket No. RM01-12-000

ORDER TERMINATING PROCEEDING

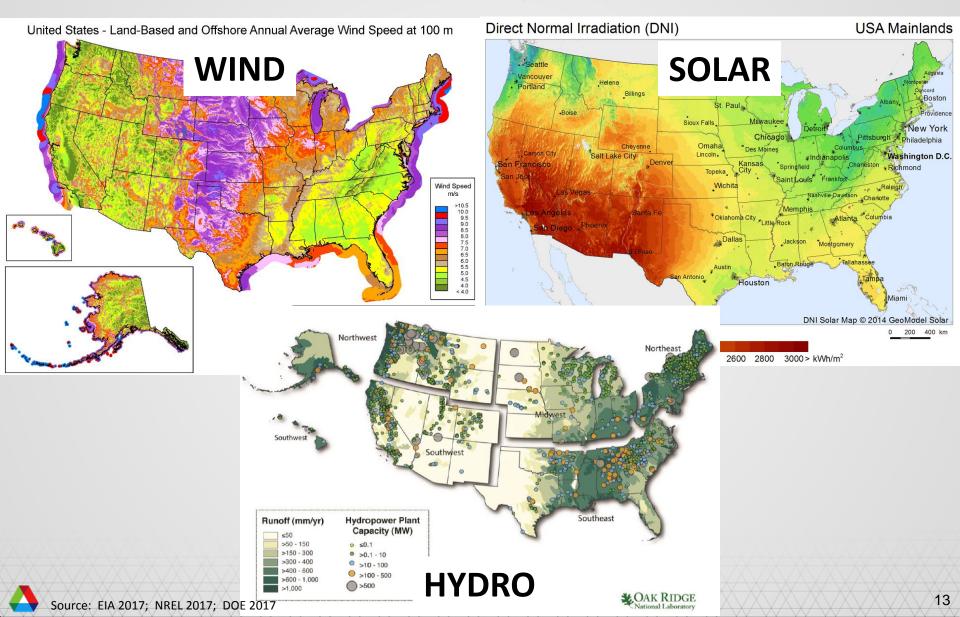
(Issued July 19, 2005)

1. In 2002, the Commission issued the Standard Market Design (SMD) Notice of Proposed Rulemaking (NOPR) in this proceeding. For the reasons given below, we are exercising our discretion to terminate this proceeding.

## U.S.: ONE COUNTRY - MANY REGIONAL RESOURCES

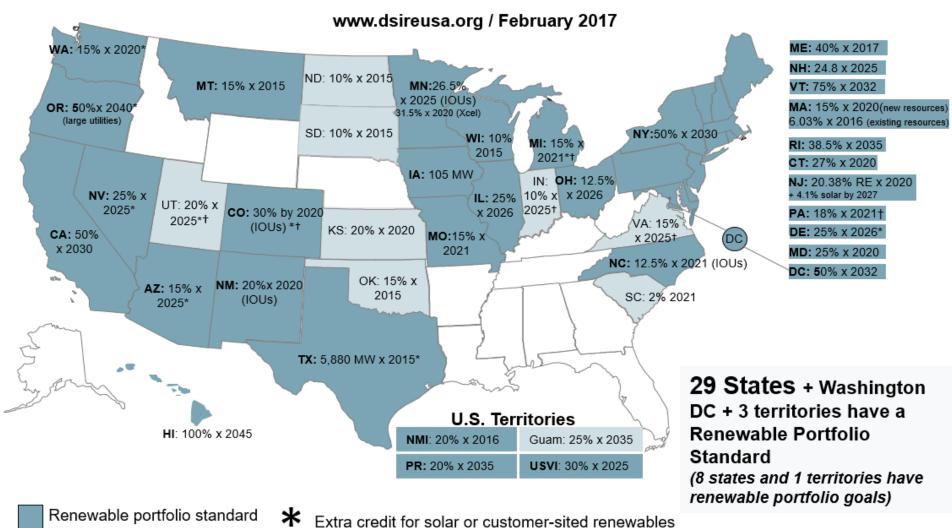


## U.S.: ONE COUNTRY - MANY REGIONAL RESOURCES



### U.S.: ONE COUNTRY - MANY REGIONAL INCENTIVES

#### Renewable Portfolio Standard Policies



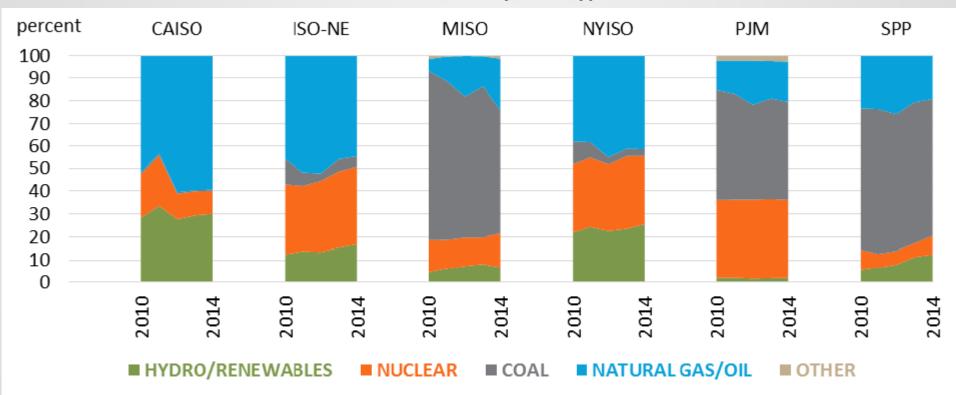
Includes non-renewable alternative resources

Source: http://www.dsireusa.org

Renewable portfolio goal

#### U.S.: ONE COUNTRY - MANY REGIONAL GENERATION MIXES

#### Share of Total Generation by Fuel Type, 2010-2014





Source: FERC 2016 15

### GENERAL DIFFERENCES IN ELECTRICITY MARKETS

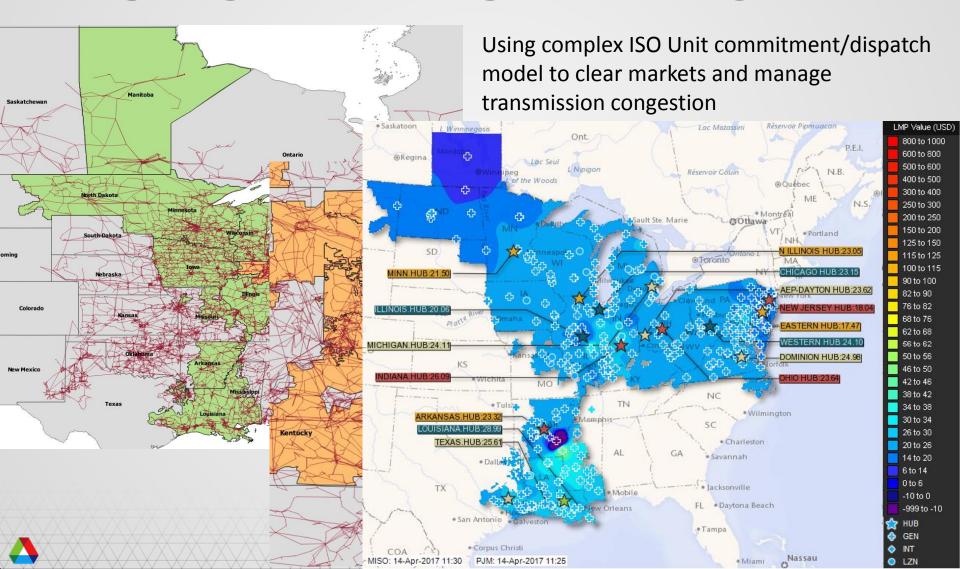
#### **UNITED STATES**

- Built into existing system operators (ISOs)
  - Emphasize physics of the power system
  - Short-term system operation
  - ISOs do not own transmission system
- Market design elements (United States)
  - Day-ahead market (ISO hourly)
  - Real-time market (ISO 5 min)
  - Complex bids/ISO UC
  - Locational marginal prices
  - Co-optimization of energy and reserves

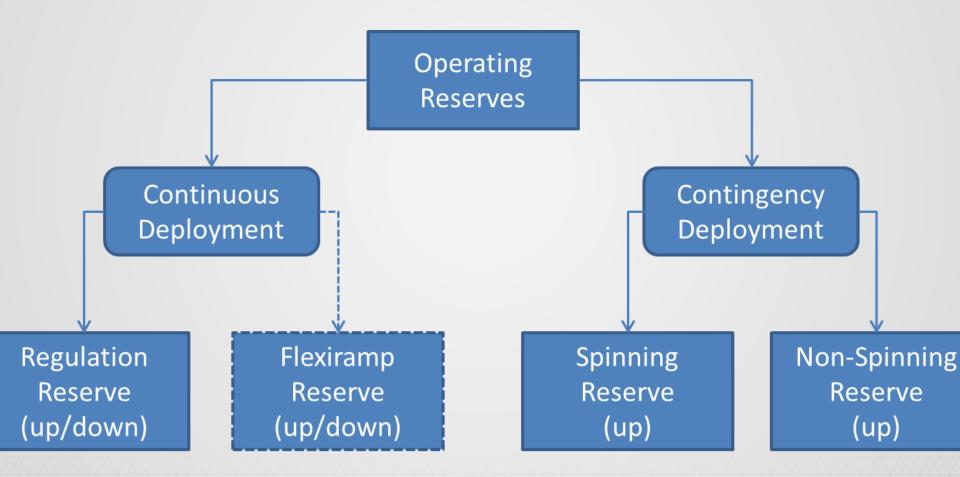
#### **EUROPE**

- Introduced new power exchanges (PXs)
  - Emphasize markets and economics
  - Includes long-term contracts
  - TSOs typically own transmission system
- Market design elements (Europe)
  - Day-ahead market (PX)
  - Real-time balancing (TSO)
  - Simple bids/generator UC
  - Zonal pricing/market coupling
  - Sequential reserve (TSOs) and energy markets (PXs)

## U.S. MARKETS DETERMINE DAY-AHEAD AND REAL-TIME PRICE OF ENERGY BY NODE



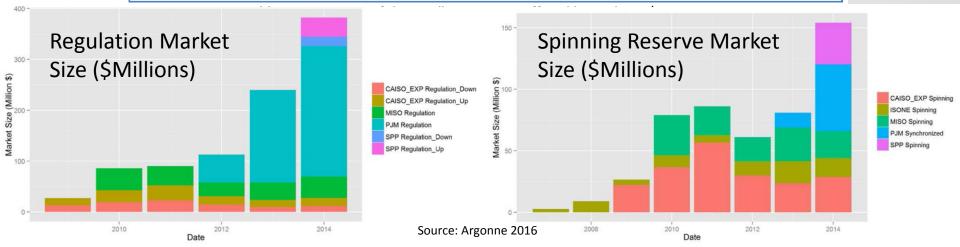
## U.S. MARKETS OFFER DIFFERENT PRODUCTS: ANCILLARY SERVICES



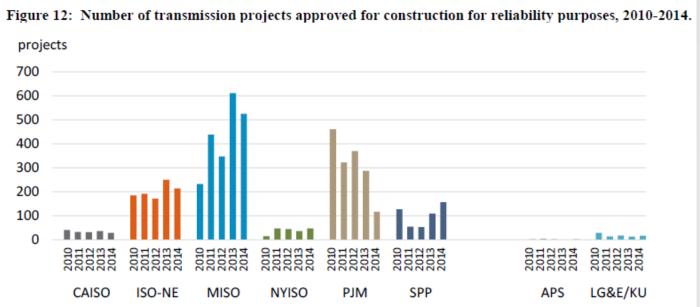


## U.S. MARKETS OFFER DIFFERENT PRODUCTS: ANCILLARY SERVICES

	Spinning Reserves	Non-spinning Reserves	Regulation
CAISO	Spinning	Non-spinning	Regulation-up
			Regulation-down
			Regulation Mileage-up
			Regulation Mileage-down
ERCOT	Responsive	Non-spinning	Regulation-up
			Regulation-down
ISO-NE	Ten-minute Synchronized	Ten-minute Non-synchronized	Regulation
		Thirty-minute Operating	
MISO	Spinning	Supplemental	Regulation
NYISO	Ten-minute Spinning	Ten-minute Non-synchronized	Regulation
	Thirty-minute Spinning	Thirty-minute Non-synchronized	
PJM	Synchronized	Primary	Regulation
SPP	Spinning	Supplemental	Regulation-up
			Regulation-down



#### LONG-TERM PLANNING: TRANSMISSION

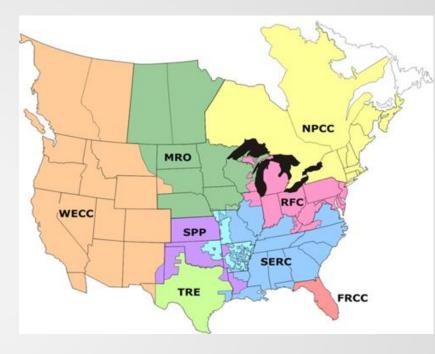


- Per FERC order (890/1000), RTOs coordinate and administer a centralized regional transmission planning process
- Several RTOs adopted a competitive solicitation process to identifying viable transmission solutions
  - Typically, transmission owners submit their transmission construction plans to RTO for evaluation and possible inclusion in the RTO Transmission Expansion Plan
  - After evaluation, projects identified as the best solution for a particular issue or opportunity are included in the report and recommended for approval by the RTO Board of Directors

Source: FERC 2016 20

#### LONG-TERM PLANNING: GENERATION

- Mandatory reliability standards developed by NERC and approved by FERC
- NERC delegated authority to monitor and enforce to its 8 regional entities
- Markets must comply with all approved standards
- In states with vertically integrated companies, States oversee a utility's resource planning and procurement

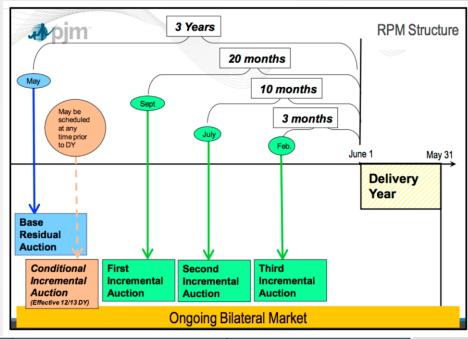


- RTOs/FERC have challenge of aligning transmission planning with procurement of market-driven solutions (generation, demand response) to induce the most efficient outcome
- Struggle between the states: had historically regulatory responsibility for assuring generation resource adequacy; and still have in non-RTO regions



#### LONG-TERM PLANNING: GENERATION: CAPACITY MECHANISMS

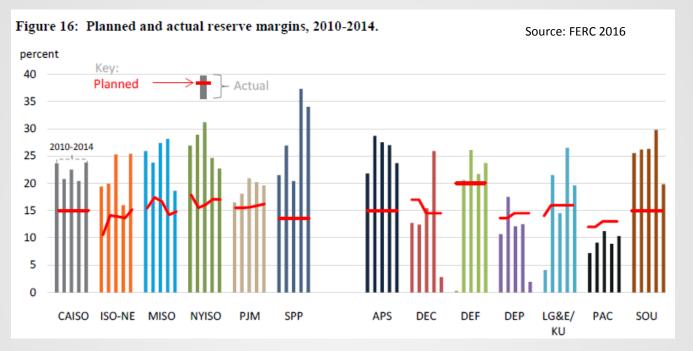
- Capacity markets: PJM, MISO, ISO-NE, NYISO
- Capacity obligation: CAISO
- Integrated resource planning in non-RTO/ISO regions (vertically integrated utilities)



	PJM	MISO	NYISO	ISO-NE
Procurement Framework	Reliability Pricing Model ( <b>RPM</b> )	Resource Adequacy Requirement ( <b>RAR</b> )	Installed Capacity Market (ICAP)	Forward Capacity Market ( <b>FCM</b> )
Year Implemented	2007/2008	2013/2014	2006/2007	2010/2011
Most Recent	167,003.7 MW	136,912 MW	3290 MW / 2619.4 MW	33,712 MW
Volume Cleared*	(Cleared in BRA for 17/18 DY**)	(Cleared in PRA for 14/15 DY**)	(Cleared in Summer 14 / Winter 13-14 Strip Auctions)	(Cleared in FCA for 17/18 CCP**)



### LONG-TERM PLANNING: GENERATION

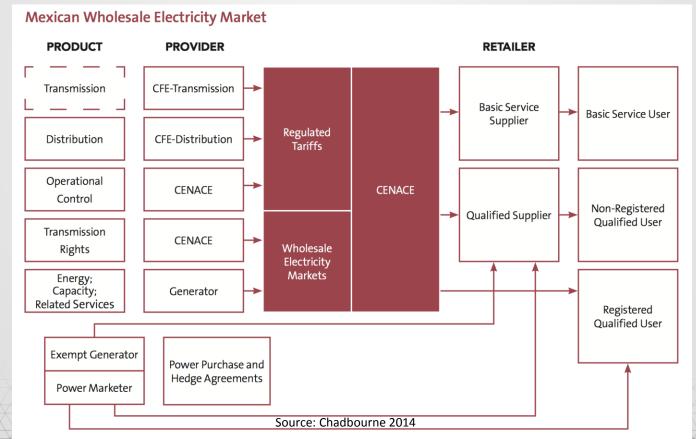


- Each RTO establishes planned reserve margin; compares with actual reserve margin to see how well generation resource planning processes are ensuring long-term resource adequacy and reliability (1 day in 10 years LOLE)
- Processes include: Market-driven resource adequacy (capacity markets), administrative capacity mechanisms (capacity obligation); dynamic operating reserve demand curves, etc.

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### MEXICO'S NEW POWER MARKET

- State-owned CENACE manages the grid as an ISO and also runs the wholesale electricity market (started in 2016)
- Ministry of Energy and the Comisión Reguladora de Energía (CRE) has regulatory and supervisory authority; CRE will be responsible for setting tariffs for transmission, distribution and basic retail services





### MEXICO'S NEW POWER MARKET

- Includes day-ahead and real-time market, as well as mid-term and long-term energy and capacity auctions
  - The Mid-Term auction is carried out yearly with the auctioned products to be delivered over the next three years
  - The Long-Term auction considers delivery periods of up to 20 years.
- Short-term, bilateral financial rights trading is available for hedging purposes
- Clean energy certificate market targeted for 2018
- Discussion to create a NERC-affiliated Electric Reliability Organization for closer coordination with U.S. reliability standards





#### **IN SUMMARY**

- U.S. power markets keep evolving; upcoming FERC conference on attempt to reconcile State policies with market operations
- Challenges
  - Renewables and impact on prices and revenue sufficiency of existing fleet
  - Better coordination across RTOs/ISOs
  - Implementation of intra-day balancing market
  - Higher time-resolution of real-time markets
- A step-by-step implementation might be the most prudent pathway forward



State Policies and Wholesale Markets Operated by ISO New England Inc., New York Independent System Operator, Inc., and PJM Interconnection, L.L.C.

**Technical Conference** 

Docket No. AD17-11-000 May 1, 2017 and May 2, 2017

Electric Grid Study Ordered by U.S. Energy Chief to Boost Coal

Saturday, April 15, 2017

### FOR MORE INFORMATION PLEASE CONTACT:



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guenter@anl.gov

