WEBINAR: "United States Winter Event"
3:00 - 4:30 pm EDT
October 27, 2021

• AGENDA •

1. Welcome ....Stu Bresler (2 minutes)

2. Context setting ……..……..……Leonard Kula (10 minutes)

- *Weather in southern United States – February 2021*
- *Statistics from the winter event: transmission, generation and load loss*

3. Individual presentations.……..……..……..……..(60 minutes)

Panelists:
- Durgesh Manjure (Director System Operations, MISO; 15 minutes)
- Bruce Rew (Senior VP of Operations, SPP; 15 minutes)
- Peter Cramton (Professor of Economics, Univ. of Maryland, Univ. of Cologne, Former ERCOT Board Member; 30 minutes)

Market design and operations
- Context – existing market mechanisms to acquire capacity, energy and ancillary services
- Effectiveness of existing mechanisms to balance supply and demand during the winter event

Other perspectives…from amongst these topics:

- System operations context
  - Installed capacity
  - Resource mix – including confidence in fuel supply
  - Interties – degree of interconnectedness with neighboring jurisdictions
  - Typical winter demand
- Operational response
  - Planning in advance
  - Operational events, and responses including emergency actions
- Regulatory considerations
  - Extent to which the regulatory environment aided or impeded ability to address the winter supply
- Next steps
  - Reviews, lessons learned and actions undertaken/anticipated

Moderator:
- Leonard Kula (VP - Planning, Acquisition & Operations and Chief Operating Officer, IESO)

4. Discussion/Q&A ..... facilitated by Leonard Kula (15 minutes)

5. Wrap-up ..... Leonard Kula (3 minutes)

2021 Cold Weather Event

Association of Power Exchanges

October 27, 2021

Executive Summary

- Extreme weather events are increasing in frequency and intensity, leading to increased risk of weather-induced events for our industry.
- The effects of the Arctic event were felt across MISO and neighboring systems. MISO's market procedures worked as drilled and designed, limiting the impact of this extreme event.
- Lessons learned from this event build upon several efforts ongoing at MISO.

MISO was well positioned for the Arctic Weather due to on-going actions and leveraging operating procedures before and during the event

MISO regularly coordinates with our neighbors during these events and during normal operations

SYSTEM TOPOLOGY

- Highly inter-connected grid across 15 states and Manitoba
- Diverse generation mix
- Relationships with seams partners

ON-GOING

- Coordinated Seasonal Assessments (Winter)
- Winter Readiness Workshops
- Emergency Procedure Drills

PRE-EVENT

- Issued Informational Advisories & Cold Weather Alert
- Daily coordination with neighbors
- Committed additional gas generation early to secure fuel supply
- Declared Conservative Operations

ARCTIC EVENT

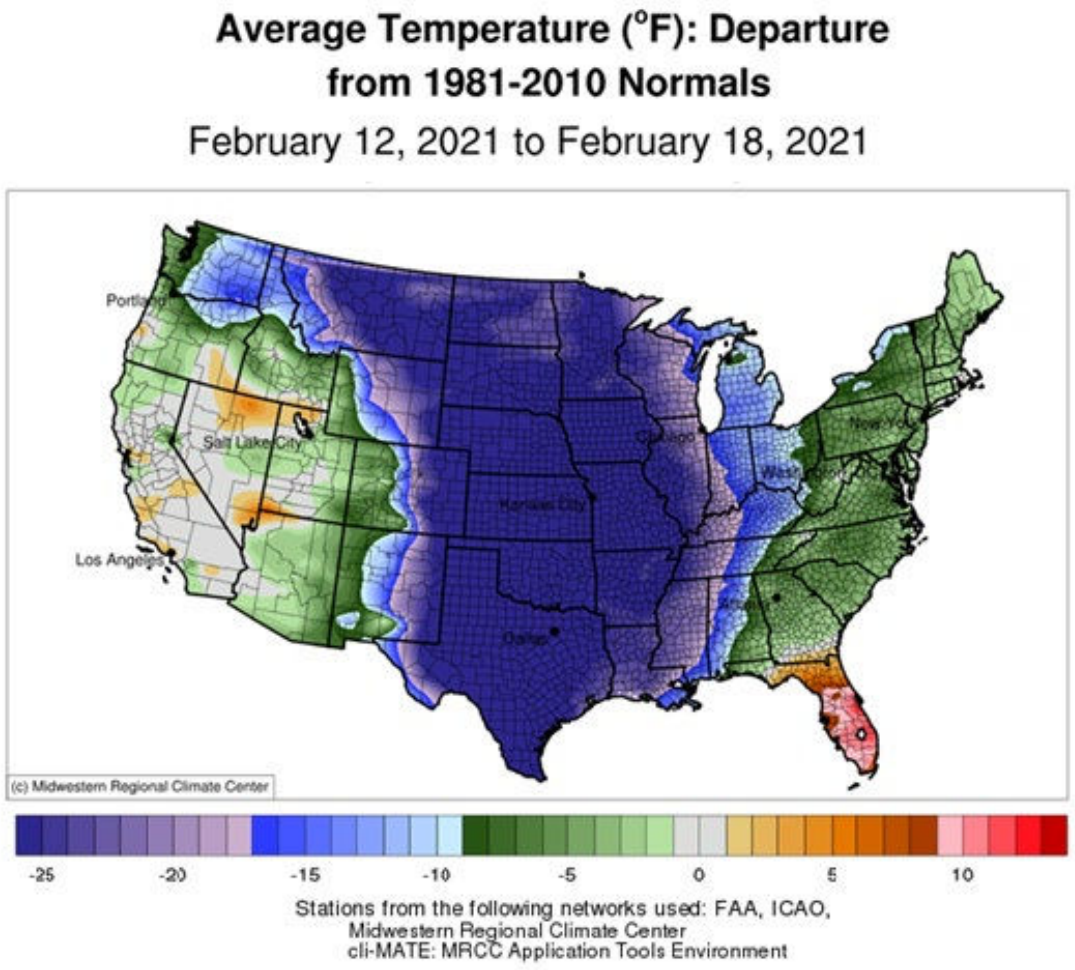
February 15, 2021

- Local Transmission Emergency – Western Load Pocket (SE Texas)

February 16, 2021

- Local Transmission Emergencies
  - Western Load Pocket (SE Texas)
  - North-Central Louisiana
- Transmission System Emergency – South-Central Illinois
- Maximum Generation Event Step 5 – South Region

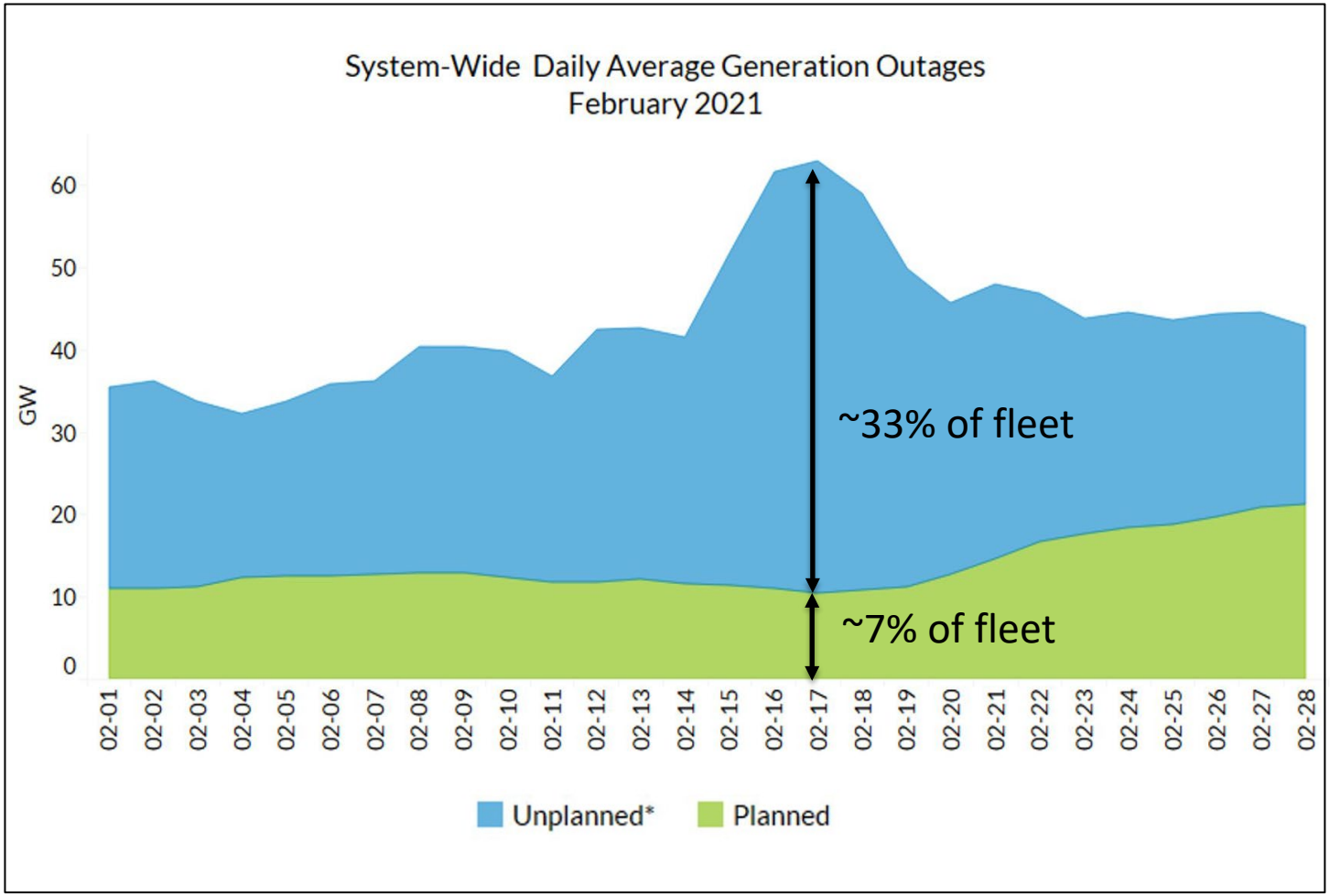
The arctic weather pattern drove widespread extreme cold, with temperatures 20 to 30 degrees below average spanning the entire mid-section of the country



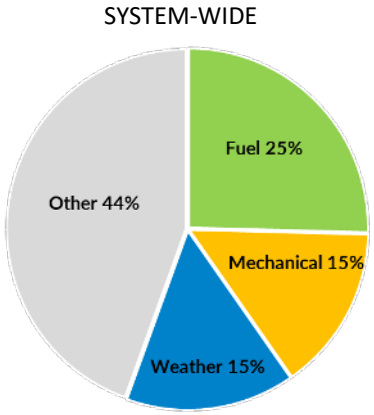
Advance Preparation

- Conducted Winter Readiness Workshops
- Issued Informational Advisories
- Issued a Cold Weather Alert
- Committed additional generation well in advance of need
- Extended the start/stop times for generation resources to avoid start failures due to cold weather
- Confirmed planned outage and return-to-service dates/times for generation and transmission outages

Consequently, approximately 40% of installed resources were unavailable at one point



Daily Average (GW) Unplanned Generation Outages February 17, 2021



Unplanned includes forced outages and derates
Data as of March 1, 2021, as reported in the CROW Outage system

Unprecedented flows across our system that aided the interconnection also contributed to the need for emergency declarations

Net Scheduled Interchange (GW)

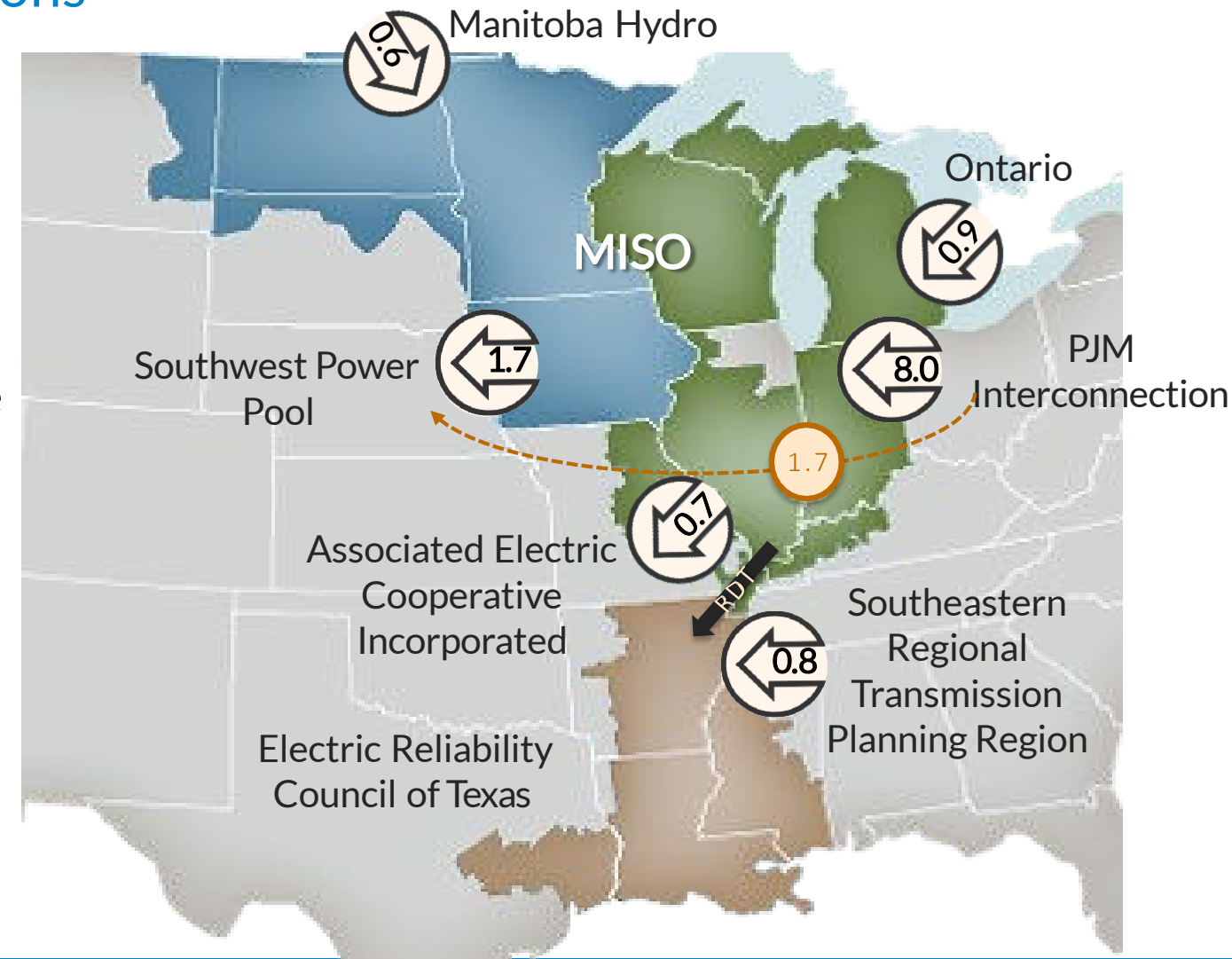
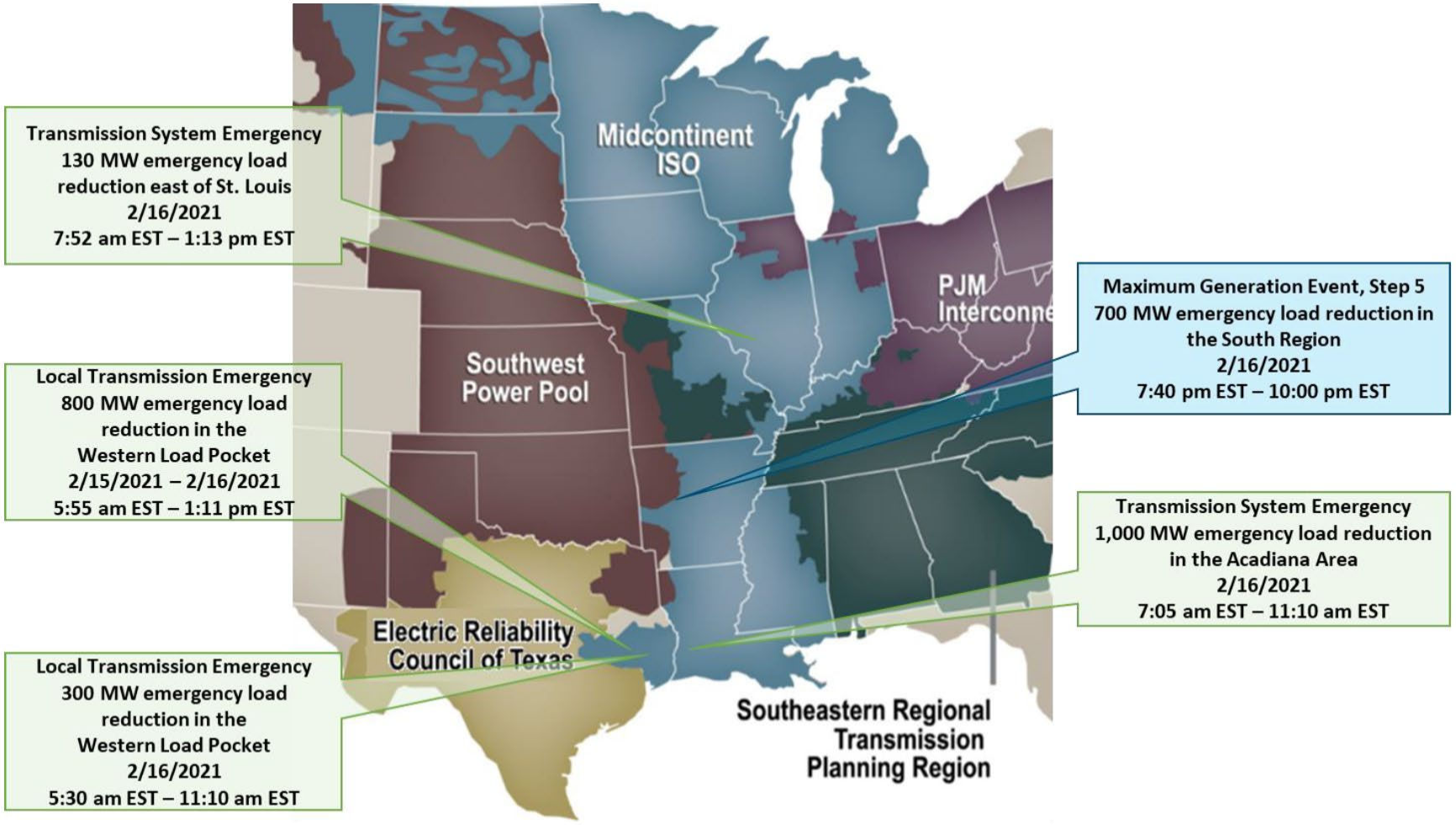


Image represents average flows into, out of and through MISO over 3 days (February 15-17, 2021)

RDT = Regional Dispatch Transfer, which has a North-South limit of 3 GW

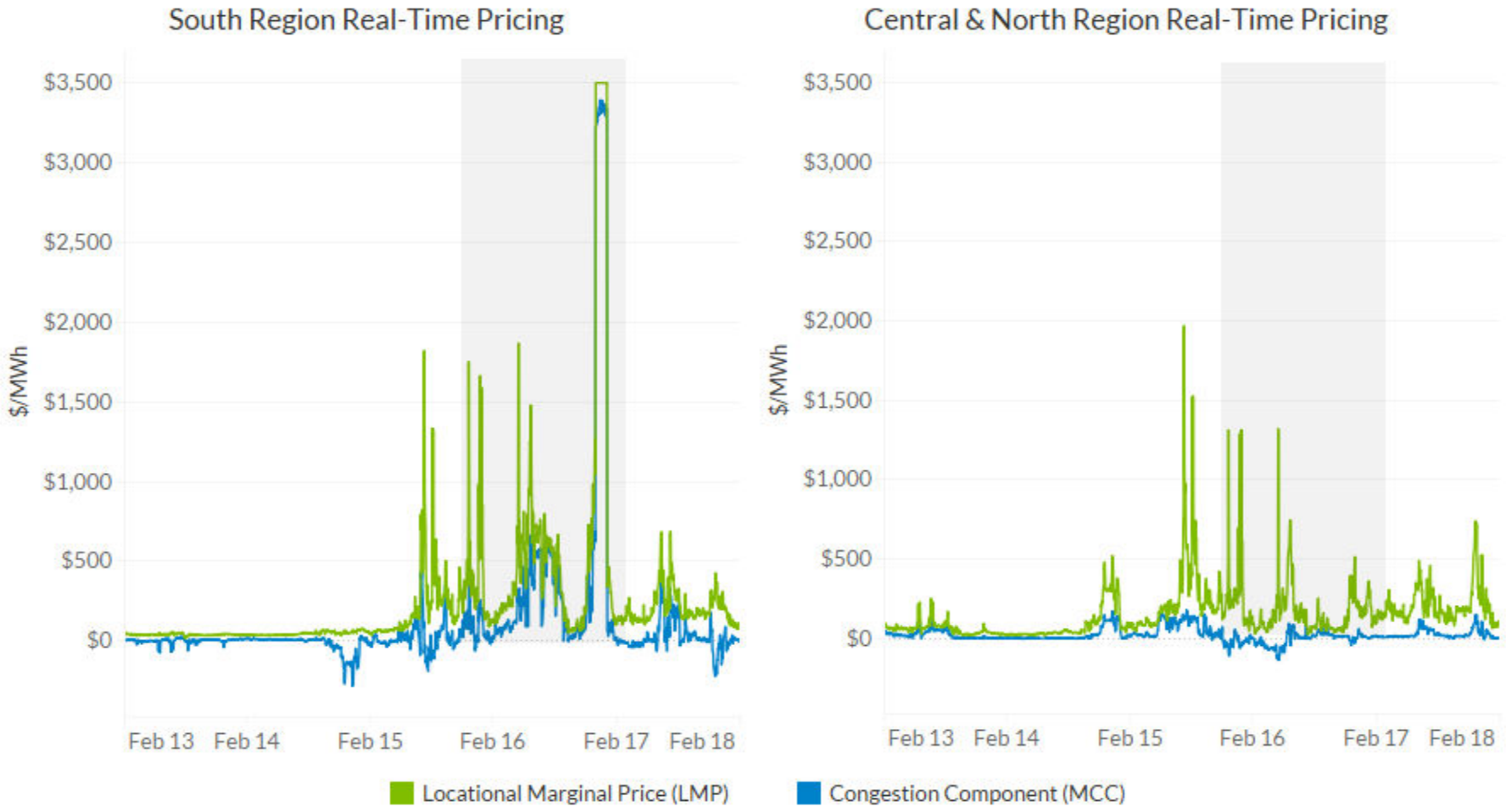
These flows combined with generation and transmission outages drove real-time overloads and emergency load reductions



Note: time frames represent the duration from when emergency load reduction was ordered through release of the full amount of load

* Load was incrementally released to return to service as conditions warranted

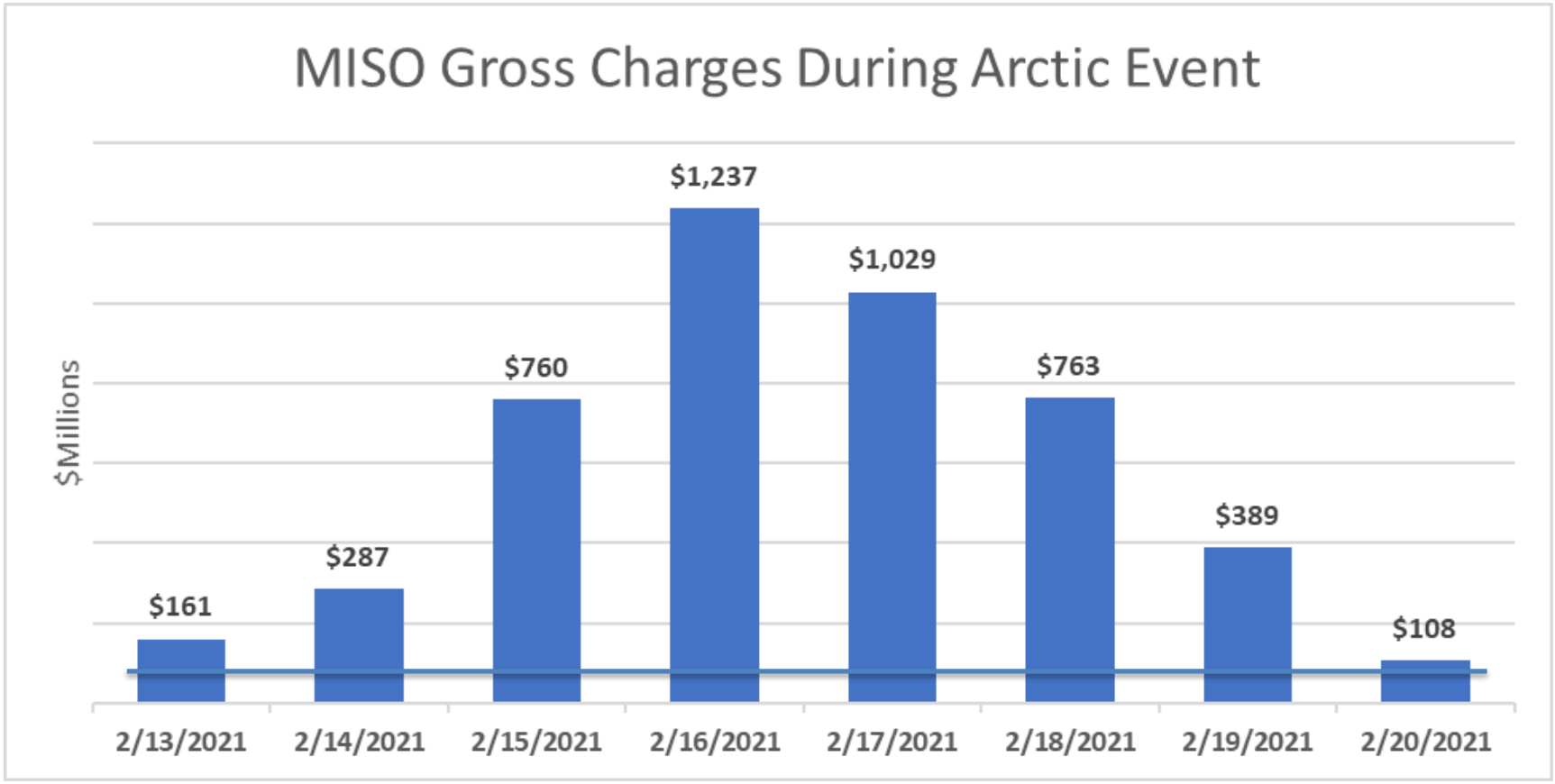
Emergency Pricing was activated in alignment with the appropriate Maximum Generation declarations (regional prices)



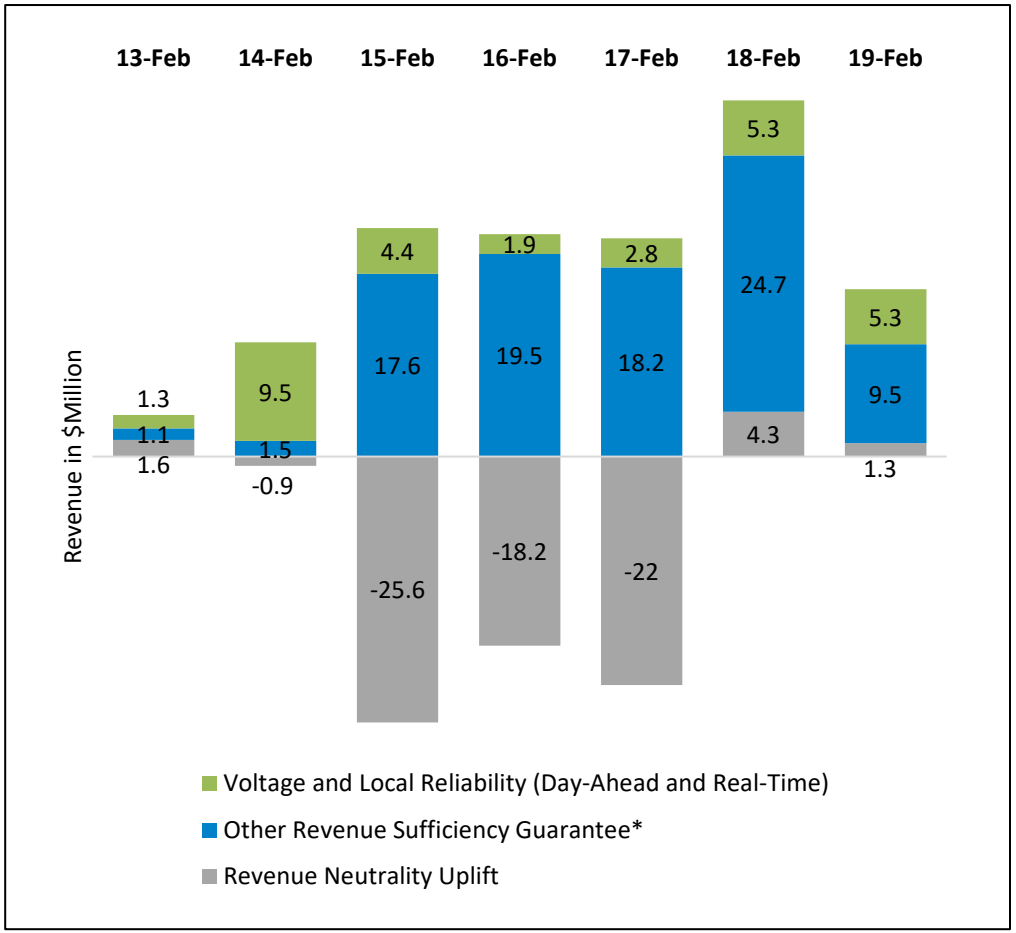
Tier 1, Tier 2 and VOLL pricing was in effect at some time over the period of 02/15 18:00 EST - 02/17 02:00 EST when MISO declared a Max Gen Warning, into a Max Gen Step 5

System-wide prices after emergency pricing activated in alignment with the Maximum Generation declarations

A large magnitude of dollars were settled during the event



Uplift of $122 million was charged back to parties responsible for those costs, while $59 million of revenue surplus was credited to Load Serving Entities



- Approximately $90 million of Revenue Sufficiency Guarantee* payments were charged to generation and load that deviated from their day-ahead schedules, which required real-time generation commitments
- Revenue Neutrality uplift, which collects uplift charges that cannot be clearly assigned to a market participant, produced a $59 million surplus and was distributed across all load

* Other Revenue Sufficiency Guarantee (RSG) payments includes all RSG that can be charged to responsible market participants other than VLR charges, which are shown here explicitly

Some lessons learned and recommendations from the Arctic Event

Market design and operations

- Improve procedures to invoke transmission line-loading relief (TLRs) earlier in advance of a transmission emergency and associated actions.
- Increase Transmission Constraint Demand Curves during emergencies to ensure pricing and dispatch reflects the emergency conditions.
- Ensure that emergency pricing and shortage pricing is applied consistently in capacity and transmission emergencies.

Resource Adequacy

- Create s*easonal*/Resource Adequacy requirements
- Improve accreditation to provide stronger alignment between accredited value and resource availability in tightest operating hours
- Needs for reforms and acceleration where possible, including review of winterization and fuel assurance information sharing

Additional information can be obtained from the presentation by MISO's Independent Market Monitor, which is available here

Lessons learned expand upon several ongoing initiatives at the Market and Resource Adequacy Subcommittees*

- Application of the Value of Lost Load
- Implementation of Short-Term Reserves
- Improvements to Emergency Pricing
- Improvements to Scarcity Pricing and Price Formation
- Identification of cost causers during a capacity emergency
- Development of Multi-Day Operating Margin Forecast
- Reliability requirements and Sub-annual construct

*Open stakeholder committees. More information available at MSC. RASC

Additional Resources

MISO Mobile application for Apple and Android devices

Available from the Google Play store or the Apple App store

Reports *(available on the MISO public website: www.misoenergy.org)*

2021 Arctic Event Report

Renewables Integration Impact Assessment (RIIA)

MISO's Response to the Reliability Imperative

Resource Availability and Need (RAN) Report

MISO Forward (2021, 2020, and 2019 reports)

Electrification Insights Report

Other Resources

MISO Reliability Operating Procedures

IMM Seasonal Review of Markets

SPP Southwest Power Pool

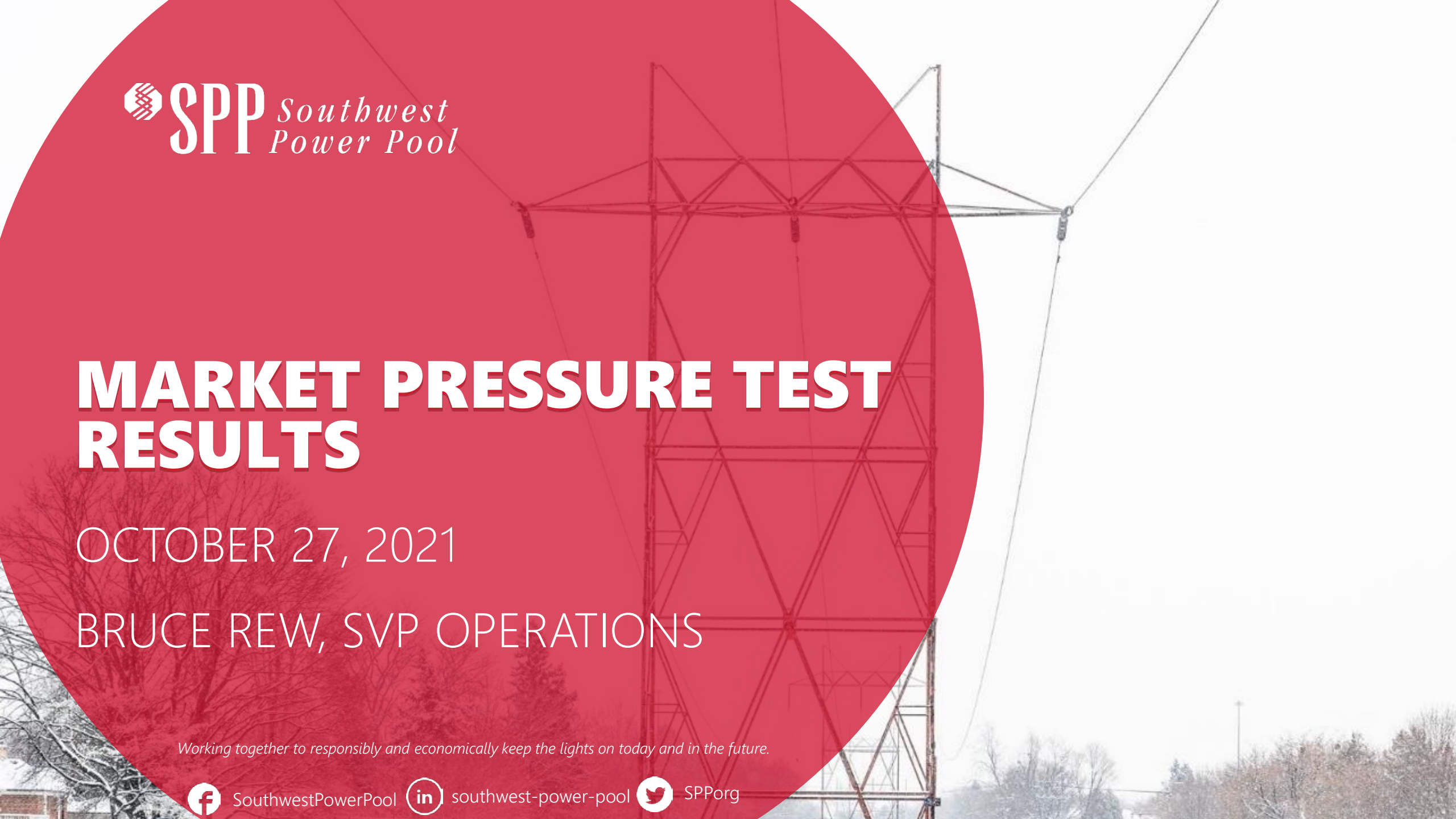
MARKET PRESSURE TEST RESULTS

OCTOBER 27, 2021

BRUCE REW, SVP OPERATIONS

Working together to responsibly and economically keep the lights on today and in the future.

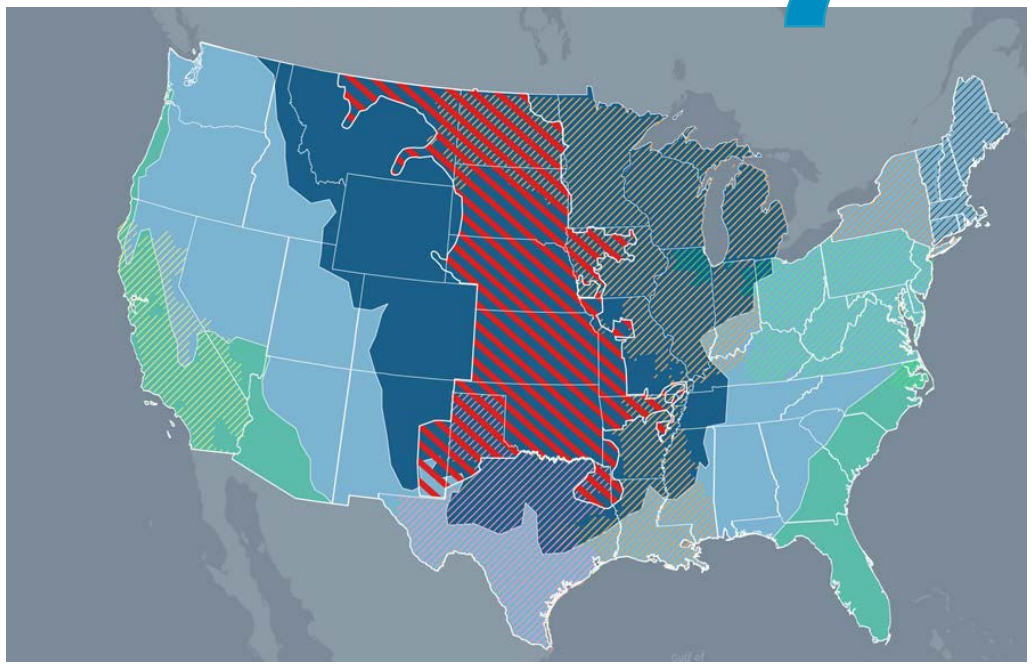
SouthwestPowerPool southwest-power-pool SPPorg



HOW TO PRESSURE TEST A MARKET

Apply extreme temperatures to your entire market area

Test Case 1: extreme cold temperatures (below -18 degrees C)



MARKET IMPACTS FROM PRESSURE TEST

- Multi-Day reliability unit commitment in a Day-Ahead and Real-Time Market
- Price spike impacts on Market price cap designs
- Natural gas price spike impacts on credit
- Market settlements are included in the pressure test

MULTI-DAY RELIABILITY UNIT COMMITMENT

- Four days prior to highest load forecast began committing units to have higher probability of generation being on-line
  - Committed units on Thursday for Monday (US Holiday)
- Key market design Questions
  - SPP has a DA market not multi-day, when is unit committed?
  - What happens if generation unit goes on outage?
  - How is the pricing of the generation? Fixed or variable?
  - Are generators selected for MDRUC made whole?

PRICE SPIKES ON MARKET DESIGN

- US Markets have Order 831 price caps that require Market Monitoring Unit (MMU) to approve offer cap exceedance
- Key market design questions?
  - How does market handle price cap exceedances?
  - What volume of price cap exceedances is market designed for?
  - Impacts of Day-Ahead much higher than Real-Time?
  - What happens when generators get cap exceedances denied?
  - How do high prices affect the creditworthiness of Market Participants?

NATURAL GAS PRICE

- Natural Gas prices spiked from 2-3$ MMBTU to over $1000 MMBTU
- What are the key impacts from gas price spike?
  - Gas pipelines are not specific to SPP region and we were impacted by ERCOT's gas consumption
  - Rapid spike in SPP's market prices raised concerns about market participants' liquidity & exponentially increased short-term credit exposure. Generators were at risk of getting gas cutoff.
  - Overall good coordination with key gas pipelines beneficial

SETTLEMENTS

- After the event everything has to be financially settled!
- What are the biggest settlement concerns?
  - Big dollars during event means big scrutiny of invoices
  - How do we handle the disputes in a timely fashion
  - Impacts of disputes and potential resettlements
  - What are the credit limits and exposure for market participants in the future? (how event affects future credit requirements)

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Q&A from my talk at the 27 October 2021 APEX meeting: Fostering resiliency with good market design: Lessons from Texas

Peter Cramton[1]
28 October 2021 (*Research on electricity market design*)

Q: Can the energy or gas market be suspended when a winter event causes prices to rise to unbearable levels? Market suspension can avoid high costs and limit defaults.

Financial markets have circuit breakers that trigger market suspension if prices move too quickly or other abnormalities occur. The market pauses for a period until the issue is addressed and the market restarts, typically with an opening auction, which is a uniform-price double auction. No trade occurs during the pause.

Unfortunately, it is not possible to suspend the energy market because the real-time market must continue. Instead, circuit breakers are needed to adjust shortage pricing in the event of a sustained shortage. The $9000 ERCOT shortage price was essential initially to make sure that market participants are doing everything possible to increase supply and reduce demand during the shortage. However, after an extended period, such as 24 hours, it is desirable for the circuit breaker to trigger a lower shortage price, such as $2000. The main challenge is that in a winter shortage it is likely that the gas price is extremely high. It is essential that the gas price has a similar circuit breaker, such as $2000/15, so that all generators with a heat rate of less than 15 can profitably buy gas despite the $2000 shortage price. ERCOT had a summer circuit breaker but not a winter circuit breaker. Moreover, there is no analogous shortage price and circuit breaker in the gas market. The PUC is working on a winter circuit breaker. My hope is that Texas regulators will recognize the need for such a mechanism in the gas market.

Q: How are gas prices set? How does the gas market balance supply and demand?

The gas market in Texas is a brokered market. You call you broker and say, "Hey Joe, I need gas. What sort of price can you give me?" "Peter, the market is super tight. I am afraid the best I can do is $685 but I am not sure I can get the quantity you need." The market has none of the protections and transparency of the centrally cleared energy market. This is possible because gas does not need to balance supply and demand every second. There is sizeable storage of gas and imbalances cause a manageable variation in gas pressure—device tolerances are much greater for gas than electricity.

Gas markets need reform. However, it is extremely difficult to reform brokered markets. The brokers and major incumbents make lots of money from the inefficiencies of the status quo. The big winners in the Texas crisis were the gas suppliers, both production and delivery. They also were the proximate cause of the crisis.

Q: According to some news, El Paso, Texas, did not have the major problems experienced in other places like Austin, Texas. Do you know why there was a difference in impact?

[1] Peter Cramton is Professor of Economics at the University of Cologne and the University of Maryland (emeritus since 2018). He was an independent director of the ERCOT board from 2015-2021. His research focuses on the design of complex markets in electricity, communications, finance, and other sectors.

News during the crisis was extremely poor. Neither the public nor the journalists understand electricity well. Misinformation was rampant. Still, there was wide variation in the impact of the storm among and within distribution systems. Variation among distribution systems was primarily due to gas and transmission constraints. Variation within distribution systems was due to the location of essential facilities. If you were on the same circuit as a hospital, you typically did not lose power.

One issue was the poor granularity of circuits for controlled outages. With outages in the 20-35% range it became impossible to rotate outages in a controlled way. This is why so many went without power for multiple days.

Q: How can we transition from resource adequacy based on a forward energy market instead of a capacity market? Is there a problem with removing the training wheels on the bike too quickly?

I am working on a paper that fully describes the forward energy market, how it can be used to manage risk, support resource adequacy, and eventually replace capacity markets. The paper will explain transition paths for various markets. The easiest is a market like ERCOT. Then the forward energy market can be introduced as a purely voluntary market like the day-ahead market. For markets with a capacity market, such as the East Coast markets, the forward energy market can be mandatory and replace the capacity auction. The capacity products would gradually be replaced with forward energy as the commitment periods are reached. My paper on the forward energy market will be available by the end of the year. Until then, you can read Budish, et al. (2021), which provides the trading methodology.

A few other papers of interest are below.

References

Budish, Eric, Peter Cramton, Albert S. Kyle, Jeongmin Lee, and David Malec (2021) "Flow Trading," Working Paper, University of Cologne.

Cramton, Peter (2017) "Electricity Market Design," *Oxford Review of Economic Policy*, 33:4, 589–612.

Cramton, Peter, Emmanuele Bobbio, David Malec, and Pat Sujarittanonta (2021) "Electricity Markets in Transition: A multi-decade micro-model of entry and exit in advanced wholesale markets" Working Paper, University of Cologne.