Natural Gas and Electric Market Coordination

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Electric Gas Coordination Senior Task Force– November 5, 2021

Overview

- Review of Problem Statement and Issue Charge
- Challenges
  - Generation Portfolio Shifts
  - Coordination
  - February events
  - Scheduling Penalties
- Identified Issues
- Areas of Common Understanding
- Potential Enhancements

Natural Gas and Electric Markets
Background

- Natural Gas is a substantial source of power generation in PJM.
  - Increased reliance on gas is expected to continue in the short term.
  - Coal/oil fired plants are retiring.
- Continued increase in intermittent generation in the PJM system is imminent.
- Fueling gas fired units is fundamentally different from onsite fuel sources, such that they require close coordination with pipelines.
- Pipelines are fully subscribed.
- More restrictive operations for gas fired generation with greater frequency of localized Operational Flow Orders (OFO).
- Greater imbalance penalties with more restrictive imbalance provisions.
- Inflexible, ratable contracts requiring natural gas fired generation to hourly burn same quantity of gas throughout gas day.
- Exacerbated with future intermittent resource development.

Continued Misalignment
Problem Statement

Primary Problem
(Market Design)

- Market design discourages fuel procurement.
- Corporate limitations at extreme prices that prevent fuel purchases.
- Market design limitations incentivize burning of back- up fuel for resources with dual-fuel capability.

Secondary Problem
(Coordination and Operations)

- Greater limits on pipeline flexibility consequently limits flexibility provided by natural gas-fired generation.
- High demand, combined with decreased flexibility and onset of intermittent resources requires greater coordination for reliable operation of the electric system.
- Greater natural gas pipeline restrictions will hinder gas-fired generators' ability to operate and provide reserves during critical events.
- Lack of accounting of fuel limitations in economic dispatch signal.
- Persistent misalignment between gas and electric markets puts electric system at risk of failure as more intermittent resources added to the system.

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Issue Charge

Key Work Activity 1

Provide Education on topics:

A. History
B. Natural Gas pipeline tariffs, products, procurement, imbalance charges and penalty structure.
C. Overview of recent events, highlighting coordination failures.
D. Accounting of gas pipeline and fuel procurement in planning and dispatch models.
E. Impact of intermittent generation.

Issue Charge

Key Work Activity 2

Potential Improvements to PJM Market to mitigate the impacts of misalignment:

A. Establish Common Understanding
B. Examine possible improvements to coordination and emergency procedures
C. Examine PJM situational awareness of fuel supply.
D. Examine improvements to PJM's Economic Dispatch Model.
E. Examine improvements to fuel procurement flexibility used in PJM reliability planning.
F. Examine potential market solutions to improve fuel procurement flexibility, modeling and optimize gas and electric market alignment.
G. Identify potential market power and/or manipulation risks.

Issue Charge

Expected Deliverables

1. Account for natural gas transportation, gas procurement, and oil reserves in its economic dispatch signal and reserve calculations, as necessary.

2. Enhance the dispatch rules and energy offers for dual fuel generation resources with alternative fuel (e.g. oil, LNG) back-up under extreme weather events and constrained pipelines, as necessary.

3. Develop PJM market rules that can address challenges of procuring gas over non-peak hours, weekends and holidays, as necessary.

4. Enhance emergency procedures and increase coordination between PJM and natural gas pipelines, as necessary.

5. Develop any additional PJM market rules to address the natural gas and electric coordination, as necessary.

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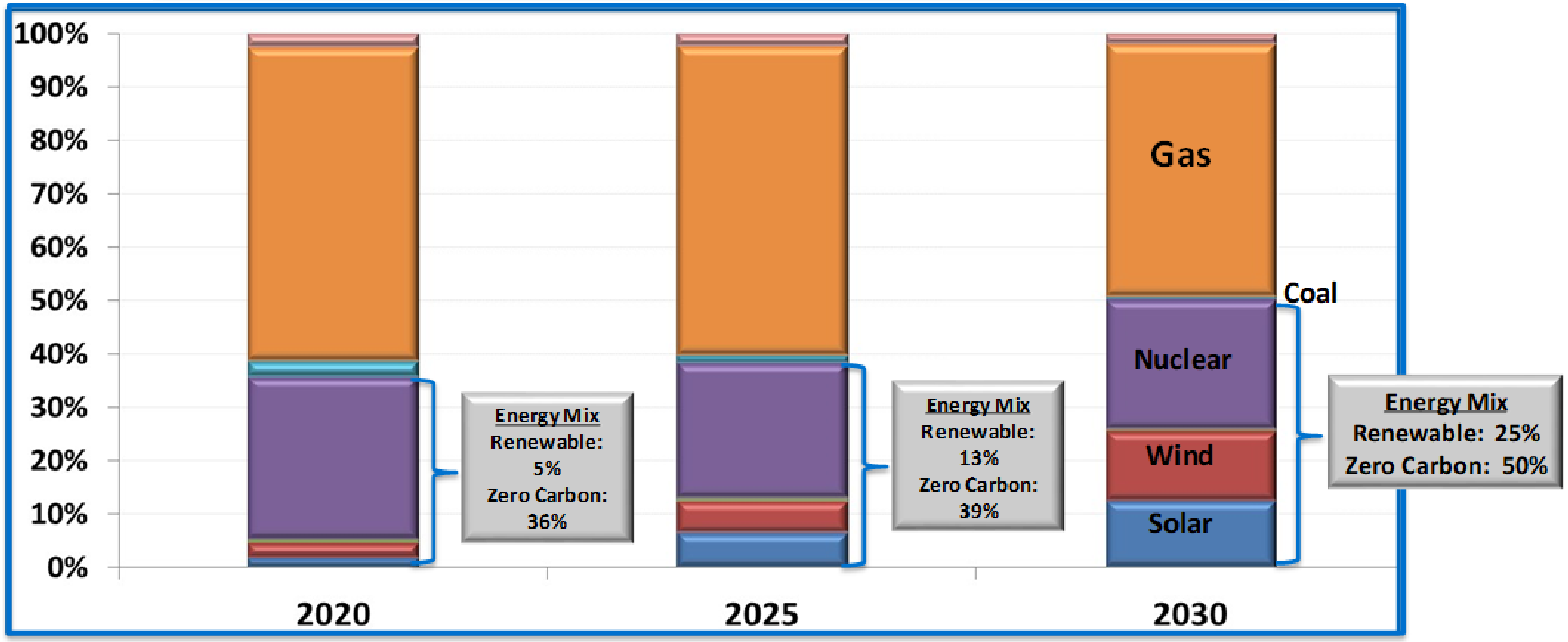
PJM Changing Generation Profile

Annual Energy Mix Including State RPS Requirements

- As intermittent generation becomes more pervasive, gas units will be called on more often to provide flexible electricity production.
- Ironically, such reliance comes at a time when gas supply is becoming less flexible.
- As the ERCOT experience demonstrates, during extreme weather events, such dichotomy can pose reliability challenges.

PJM Future Energy Source Projection
Increasing Reliance on Non-Dispatchable Generation



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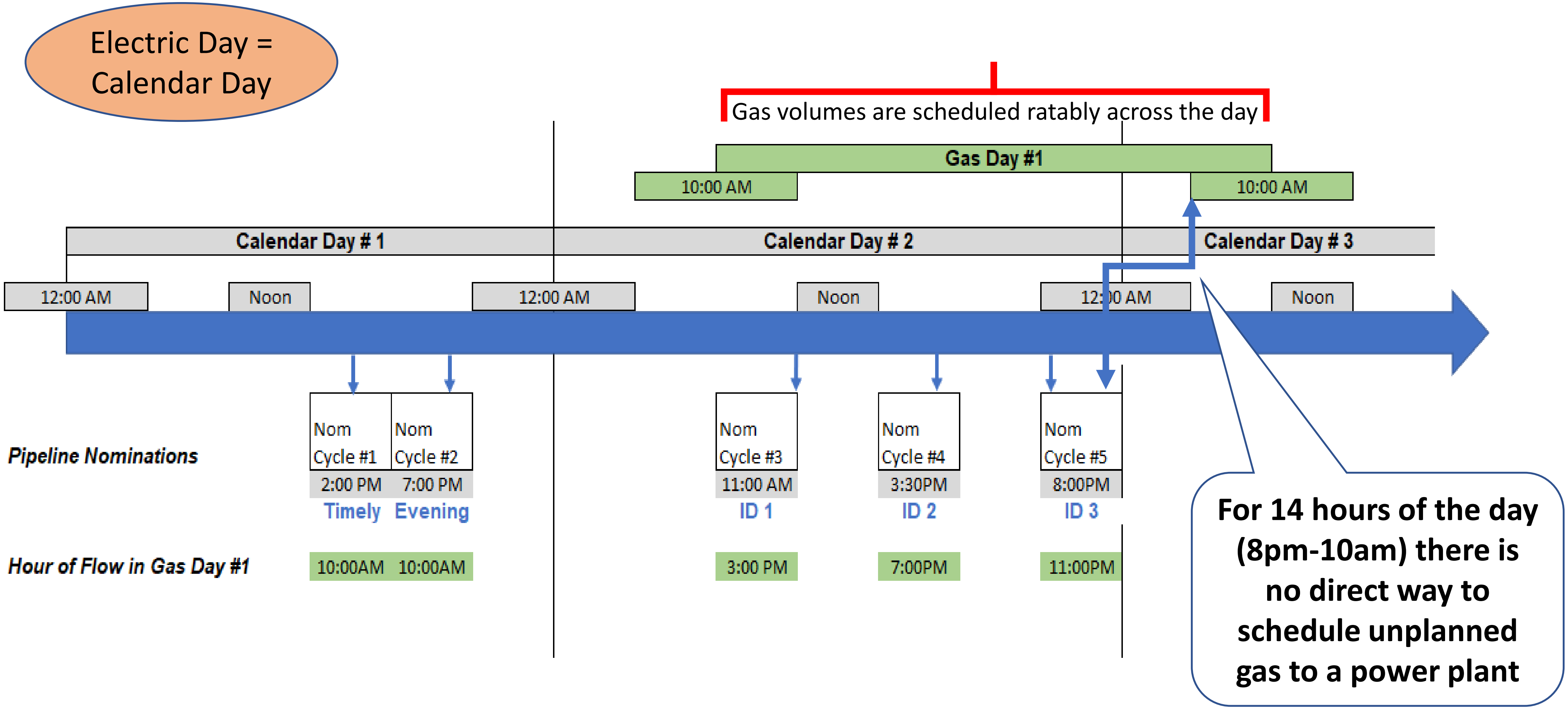
Coordination issues begin with mismatched scheduling days

Gas Day vs. Electric Day



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Procuring gas outside of the DA timely nomination cycle carries high unavailability risk

Vast majority of gas is nominated in the DA timely cycle (2PM prior to day of flow)

Transco scheduled volumes (Dth) Nov 2020-Mar 2021

Very little incremental gas is available after timely cycle

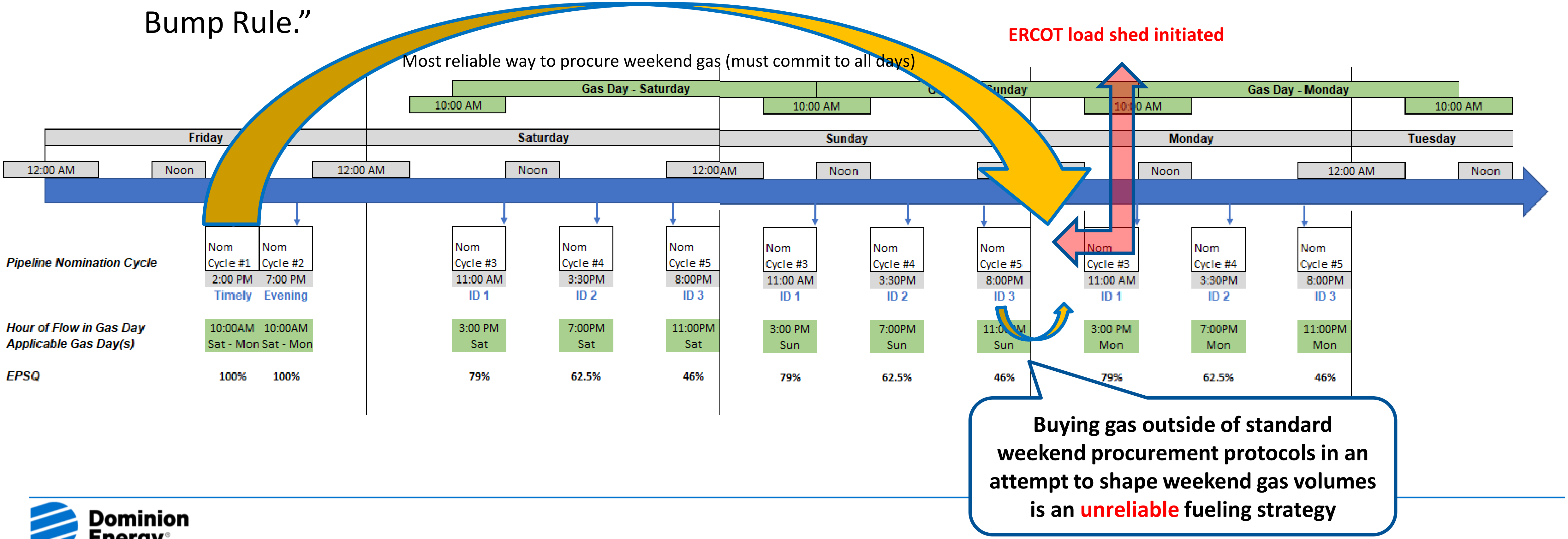
	Timely	Evening	Intraday 1	Intraday 2	Intraday 3	Timely % of final cycle
Zone 5 - winter	2,010,785,229	2,004,251,117	2,026,415,561	2,041,181,025	2,047,413,166	98%
Nov	429,526,701	432,140,242	438,363,350	442,779,107	444,590,260	97%
Dec	493,427,228	490,253,594	497,139,476	501,068,350	501,613,222	98%
Jan	455,407,438	452,781,687	457,532,658	460,707,179	461,443,827	99%
Feb	319,959,520	316,919,648	317,630,864	319,354,094	320,899,302	100%
Mar	312,464,342	312,155,946	315,749,213	317,272,295	318,866,555	98%

Sources: Energy Velocity

Weekend gas is traded/scheduled in fixed volumes across all days of a weekend (no shaping)

Friday - Before A Weekend

- Natural gas is traded and scheduled for 3 days: Saturday, Sunday, and Monday.
- Saturday, Sunday and Monday incremental supplies, sales opportunities and flexibility are limited by intra-day market availability and nomination cycle EPSQ %, and ID 3 "No Bump Rule."



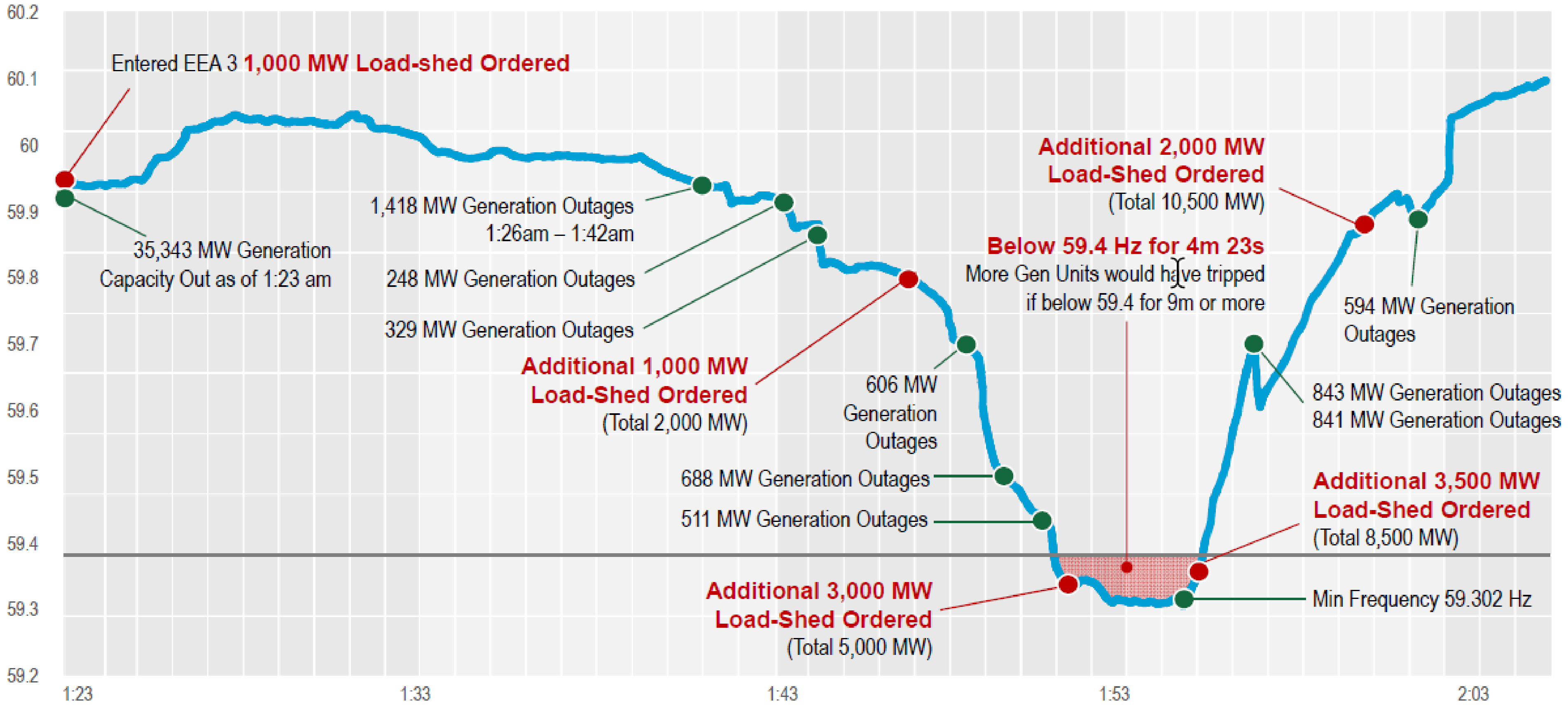
ERCOT Winter Failure – 2021

General Overview

ERCOT system was nearly lost for 30 days

Monday 2/15/2021

Rapid Decrease in Generation Causes Frequency Drop

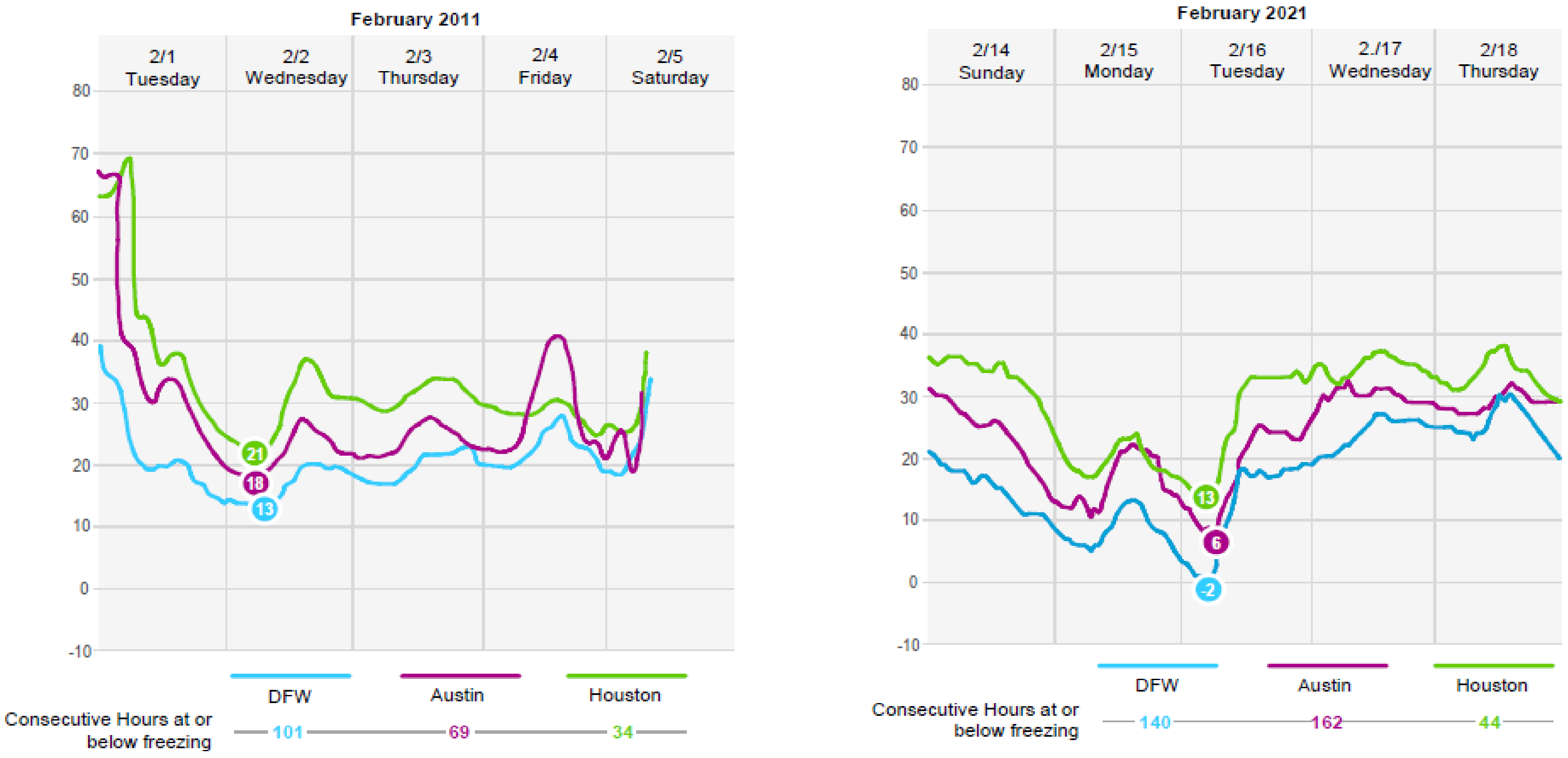


Sources: ERCOT website. Texas Legislative Hearings presentation February 25, 2021.

ERCOT System Failure

Summary

2011 vs. 2021 Event Temperature Comparison



ERCOT System Failure provides real-life scenario.

Timeline

February 2021 TX Severe Weather Event

Monday, Feb. 8th:
ERCOT issued Operating Condition Notice, extreme cold weather, anticipate the coldest weather experienced in decades

- ERCOT anticipated new all-time winter load peaks
- Generators asked to take necessary steps to prepare facilities for expected cold weather

Sunday, Feb. 14th:
ERCOT requested energy conservation to maintain system reliability

- Experienced record-breaking electric demand
- Higher-than-normal generation outages, frozen wind turbines and limited natural gas supplies

Monday, Feb. 15th:
ERCOT calls for rotating outages and **sheds over 10 GW of load**

- Over 30 GW of generation off the system due to mechanical and fuel related issues

Wednesday, Feb. 17th:
ERCOT **sheds over 14 GW of load, 2.8 million households**

- At this point 185 generation units had tripped off-line, 46 GW of capacity
- 28 GW of thermal, 18 GW of wind and solar

Thursday, Feb. 18th:
Majority of customers able to be restored, however many customers remain without electricity due to ongoing transmission and distribution repair

- Load declines with warmer weather
- Significant generation outages remain

Friday, Feb. 19th:
Grid mostly restored, but nearly **36 GW remained on forced outage** – 21 GW thermal and 15 wind/solar

Monday, 2/8 → Sunday, 2/14 → Monday, 2/15 → Wednesday, 2/17 → Thursday, 2/18 → Friday, 2/19

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Sources: ERCOT website, equity research.

Market Signals

ERCOT 2021

Poor risk/reward discourages gas procurement when most needed

ERCOT hypothetical 10 heat rate CT peaking facility (~650MW)

Gas purchase volumes left to market participants with least information regarding overall system needs

	Gas cost	Power revenue	Profit/(loss)
Saturday, February 13, 2021	$ (57,079,450)	$ 17,293,680	$ (39,785,770)
Sunday, February 14, 2021	$ (57,079,450)	$ 57,195,176	$ 115,726
Monday, February 15, 2021	$ (57,079,450)	$ 95,885,725	$ 38,806,275
Tuesday, February 16, 2021	$ (57,079,450)	$ 100,753,047	$ 43,673,597
Wednesday, February 17, 2021	$ (146,421,197)	$ 128,222,773	$ (18,198,423)
Thursday, February 18, 2021	$ (185,066,156)	$ 117,525,885	$ (67,540,271)
	$ (559,805,151)	$ 516,876,286	$ (42,928,865)

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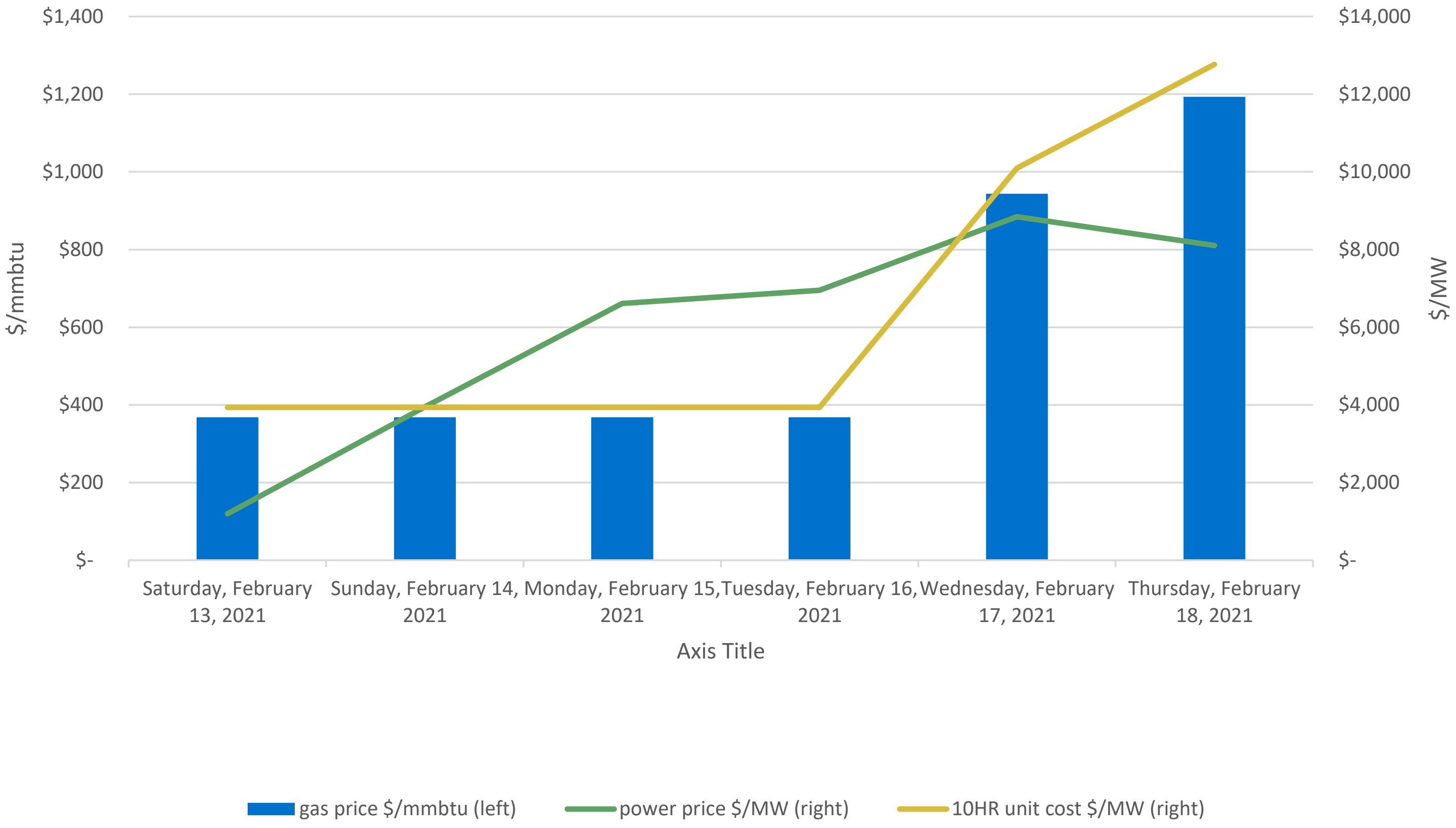
Sources: ERCOT website, energyonline.com, Platts Oneok DA gas prices

Sufficient gas supply must be procured in a coordinated fashion well ahead of demand

ERCOT market signals discouraged advanced gas purchases for many plants

Hypothetical ERCOT 10 Heat Rate CT peaking plant

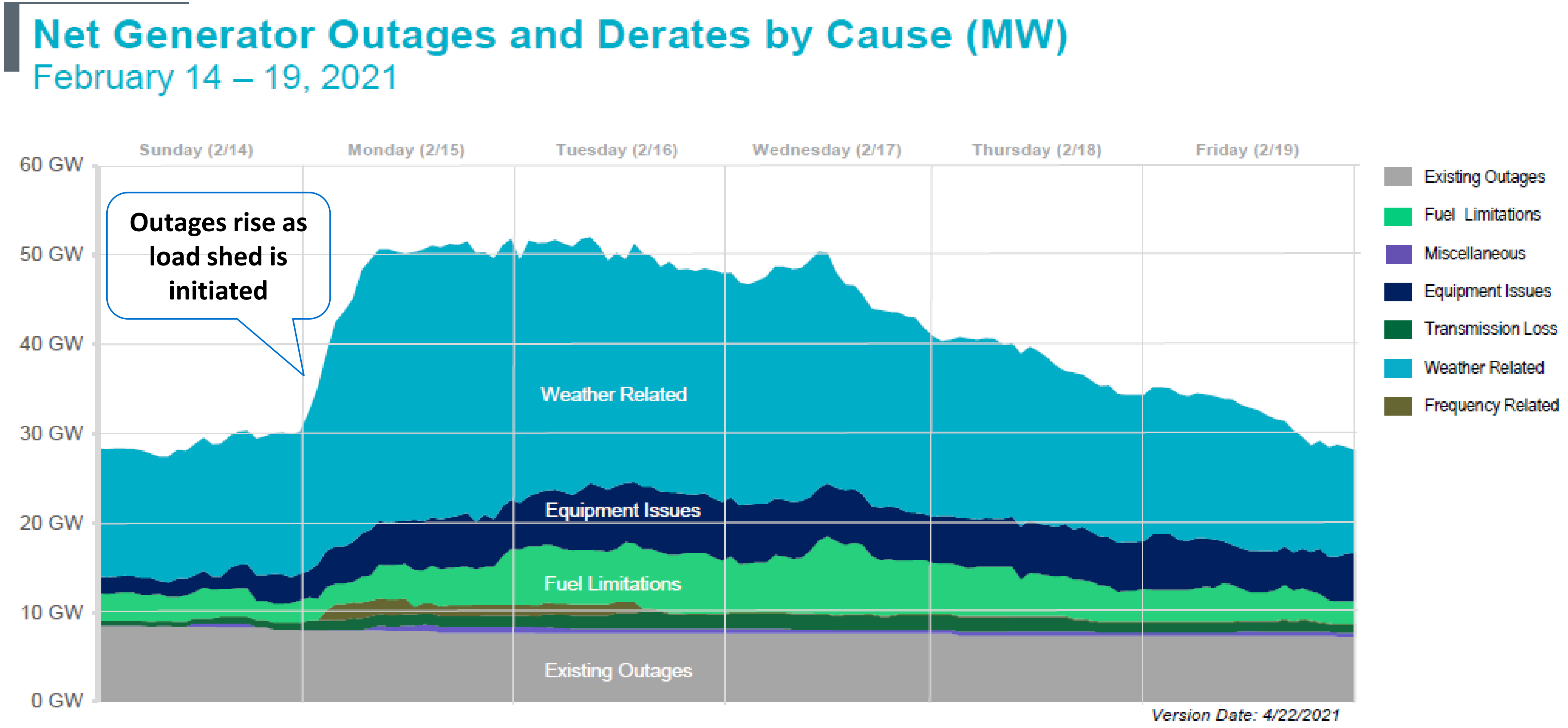


Generation & Load

ERCOT 2021

Rapid increase in outages appear to be failures to start

Summary



Net generator outages at the beginning of each hour on February 14-19, 2021, by cause category.

Sources: ERCOT website. **Update to April 6, 2021 Preliminary Report on Causes of Generator Outages and Derates During the February 2021 Extreme Cold Weather Event, April 27, 2021**

ERCOT forced outages appear to be failures to start vs online trips

Monday 2/15/2021

2011 vs. 2021 Event Comparison

	2011	2021
Maximum generation capacity forced out at any given time (MW)	14,702	52,277
Generation forced out one hour before start of EEA3 (MW)	1,182	2,489
Cumulative generation capacity forced out throughout the event (MW)	29,729	46,249*
Cumulative number of generators outaged throughout the event	193	356
Cumulative gas generation de-rated due to supply issues	1,282	9,323
Lowest frequency	59.58	59.30
Maximum load shed requested (MW)	4,000	20,000
Duration load shed request (hours)	7.5	70.5
Estimated peak load (without load shed)	59,000	76,819

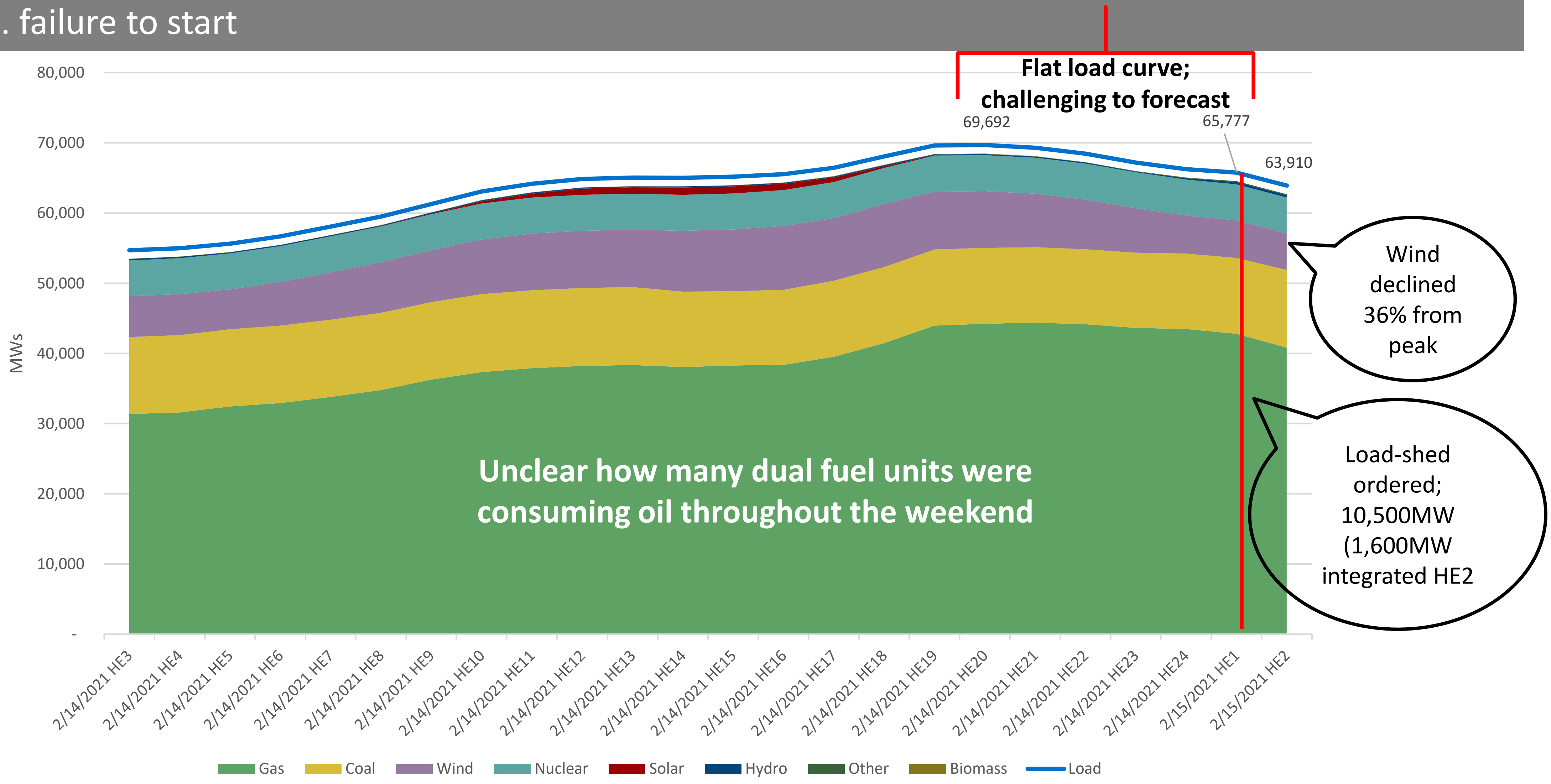
*Note: "Cumulative" values for 2021 were calculated using NERC 2011 report methodology. Cumulative amount for 2021 starts at 00:01 on February 14, 2021

Sources: ERCOT website. Texas Legislative Hearings presentation February 25, 2021.

Initial load shedding occurred at levels well below peak planning scenarios

Load shedding did not begin at peak load – rate of change may have driven unexpected need

Unit trips vs. failure to start



Sources: ERCOT Capacity Demand & Reserves Report; ERCOT Fuel Mix Report April 7th, 2021; ERCOT Native_Load_2021

February 2021 Severe Weather Event

Observations of Texas Event

- Observed gas prices hit $1,250 per DTh in OK
  - For context, a large Combined Cycle plant would be asked to buy ~$300M worth of fuel for one day.
  - High gas prices result in terrible risk/reward for securing gas.
  - Extreme fuel prices, corporate designs are stressed and begin to fail.
  - Strong signal not to produce MWs at most critical time.
- ERCOT, SPP and MISO all had rolling blackouts.

Experience in VA when weather hit PJM

- Oil CTs were called on day after day.
- Single day market optimization does not account for extended weather and increases the risk of failure and fuel depletion.
- Reserve margins are not meaningful if fuel constraints are not applied in the calculation.
- Unit EFOR during peak cold is likely much higher than average annual EFOR.

Flexibility Limitations on Interstate Pipelines

Ratable Take Tariff Restrictions

- Pipelines designed for 24 hour equal 'takes' and not for 'shaped' consumption, which is more characteristic of power generation.
- Ratable restrictions require shippers to deliver the peak consumption volume over the entire 24-hour Gas Day many times resulting in excessive, over deliveries (positive imbalances) on pipelines.

Increased OFO Instances

- As of April 2019, Transco invoked its Tariff OFO rules holding shipper and/or location specific imbalances to +/- 10% daily or 5% cumulative. Non-compliance penalties calculated using the higher of $50/dth/day or 3x applicable Gas Daily price of the rate zone in which the imbalance resides.

Month-End Imbalance Costs

- Shippers exposed to various month-end imbalance resolution mechanisms including:
  - Month-End Cash Out pricing that disincentivizes positive or negative imbalances.
  - No month-end imbalance allowance – due to strict daily imbalance restrictions.
  - Accumulated imbalance resolution restrictions that are only lifted during periods of non-constraint.

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Identified Issues

- Economic Dispatch signal used by PJM does not account for fuel limitations.
- PJM Reliability Planning makes inaccurate assumptions of pipeline flexibility.
- Despite Coordination efforts there is still significant misalignment.
  - Natural Gas is batch scheduled a few times a day.
  - No clear emergency protocols.
  - Little to no gas-electric optimization and coordination.
  - Pipeline tariff and rate cases change without PJM coordination or input.
  - No significant capacity and reliability coordination between pipelines and RTOs

Identified Issues continued…

- Current PJM tools assist fuel management (e.g. Fixed generation, changing turndown ratios etc.) are insufficient.

- Increasing intermittent generation such as wind and solar will require increased flexibility from gas generation.

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Solutions Development: Areas of Common Understanding

NO PARTY WANTS TO VIOLATE FERC REGULATED ENTITY MANDATES

PJM LIKELY HAS THE MOST INFORMATION RELATING TO OVERALL BULK ELECTRIC SYSTEM NEEDS

NO ONE WANTS A RELIABILITY EVENT

CREDIBLE/LEVEL PLAYING FIELD IS DESIRABLE

MARKET SOLUTIONS ARE LIKELY THE BEST APPROACH

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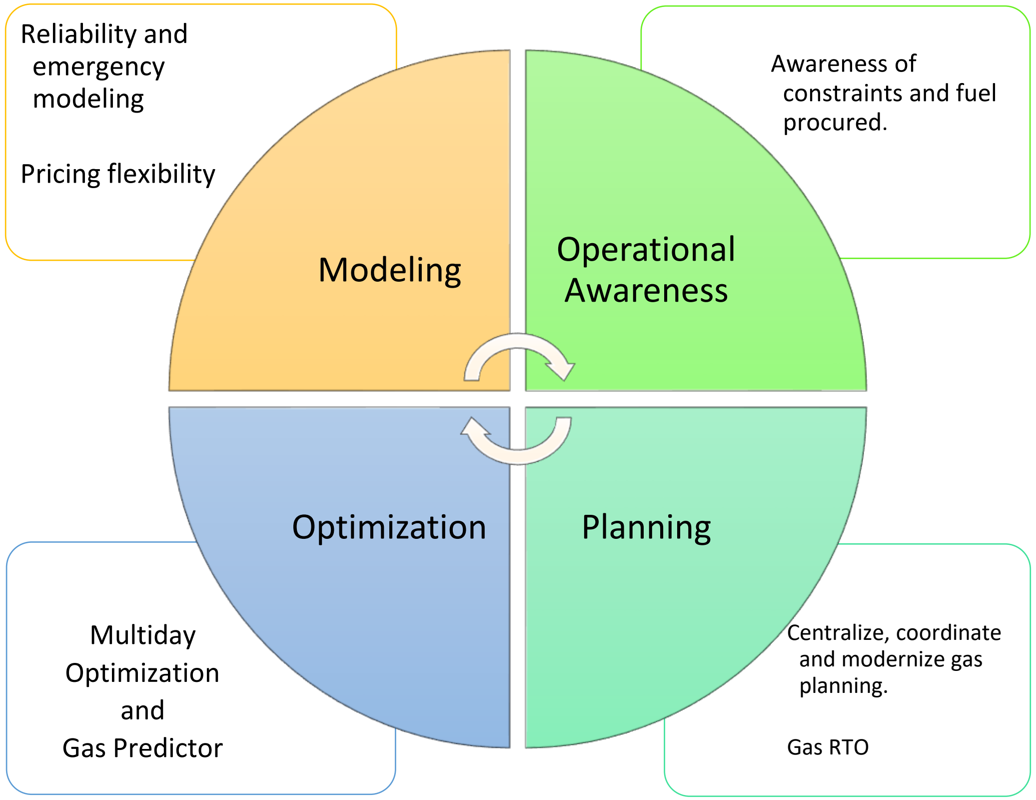
Potential Enhancements for Discussion



<u>PJM Modeling:</u>
- N-1 reliability and emergency spin reserves to consider fuel limitations

<u>Pricing Flexibility</u>
- Incorporating adders into the fuel cost for flexibility (post cycle, storage, park & loans etc.) as an additional cost of the fuel much like transportation.

<u>Multiday Optimization and Gas Predictor</u>
- PJM would model MWs over multiple days and provide a gas volume commitment
- Natural gas purchased in advance of DA per PJM volume commitment and MW projection
- PJM DA awards would reflect the gas volume previously committed
- PJM RT dispatch would factor in gas commitment and pipeline restrictions in place
- Include a fuel security program where the generator receives a make-whole payment above a certain tolerance of volume deviation, or other incentives/mechanism to reward flexibility

<u>Settlement/Market Solution for Flexibility</u>
- Creating an ancillary product for purchasing options to protect against volatile generation
  - Solar/Wind Substitute
    - Allowing power producers to purchase solar/wind substitutes, where available, for balancing PJMs system instead of using combined cycle gas units
  - Gas storage or other pipeline flexibility services
- PJM pricing/recognizing the next reliable MW, in addition to the next cheapest MW and creating a settlement cost for displacement

<u>Modernize current gas capacity planning</u>
- Central/coordinated gas transportation planning
- Gas capacity requirements identified to support power generation capacity
- Develop construct to clear natural gas capacity requirements
- Modernize approach to physical allocation of gas transport source-sink capability (somewhat analogous to the ARR construct for electric transmission capacity)

<u>Gas RTO</u>
- Real Time Gas systems to coordinate with PJM power desk
- Integrated control of fuel and MWs
- Longer term solution

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