ERCOT Blackout: Overview and Open Questions

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Background

ICF's energy footprint

We design robust future-focused solutions in response to industry, policy, and market changes.

+50
years of energy work

+1,200
energy experts

Top 50
utilities in North America served

50
GW of annual investment support

+150
DSM programs across North America

8th
largest PR agency in the country

+65
offices

$1.4B
annual revenue

+7K
full and part-time staff

- Gas/power coordination and reliability planning
- Under-estimation of risks outside of typical summer peak
- Market design matters tremendously: esp. in a time of continuing low energy prices
- Caution in overreliance on historical data (climate change, tail-risks not captured in historical record)
- To what extent black swans should be prepared for ($) vs considered acceptable risks
- Caution with respect to possible future plans to rely more and more heavily on the power grid (electrification strategy for decarbonization)

Major Themes of Feb 2021 Blackout

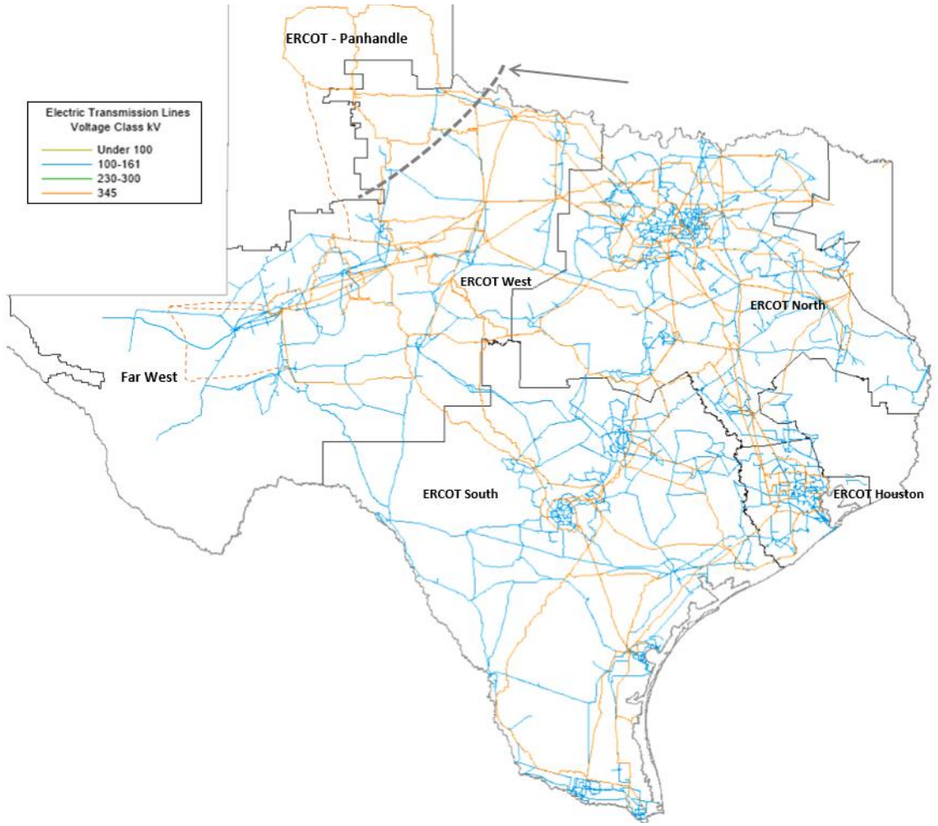
Feb 2021 Blackout

- Single-state market with no AC ties to other grids
  - Not interstate commerce: limited FERC oversight

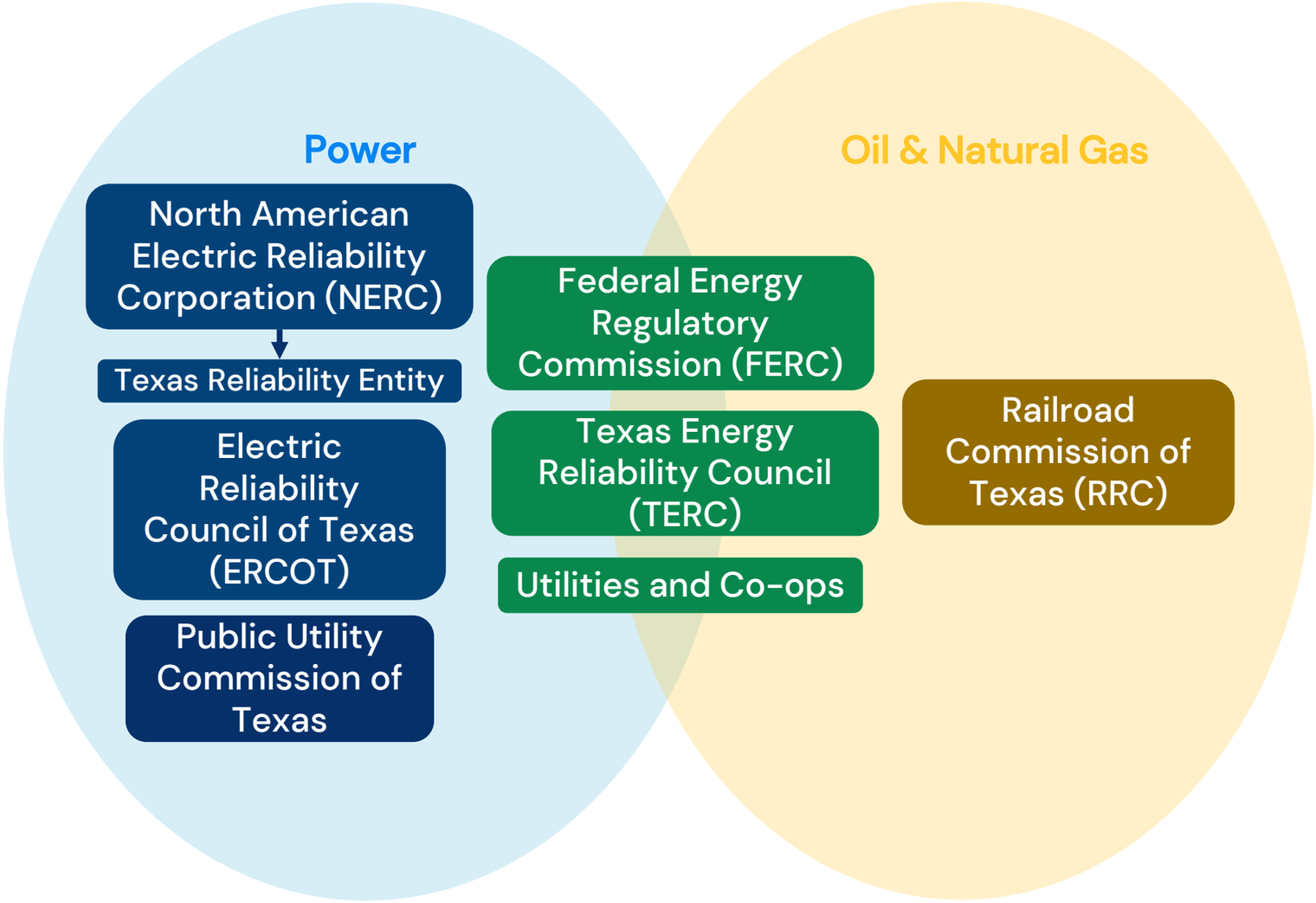
- Fastest demand growth among any major US market: 2-3% annual

- No resource adequacy (RA) or capacity market structure
  - Relies on scarcity pricing up to $9,000/MWh; highest of any market

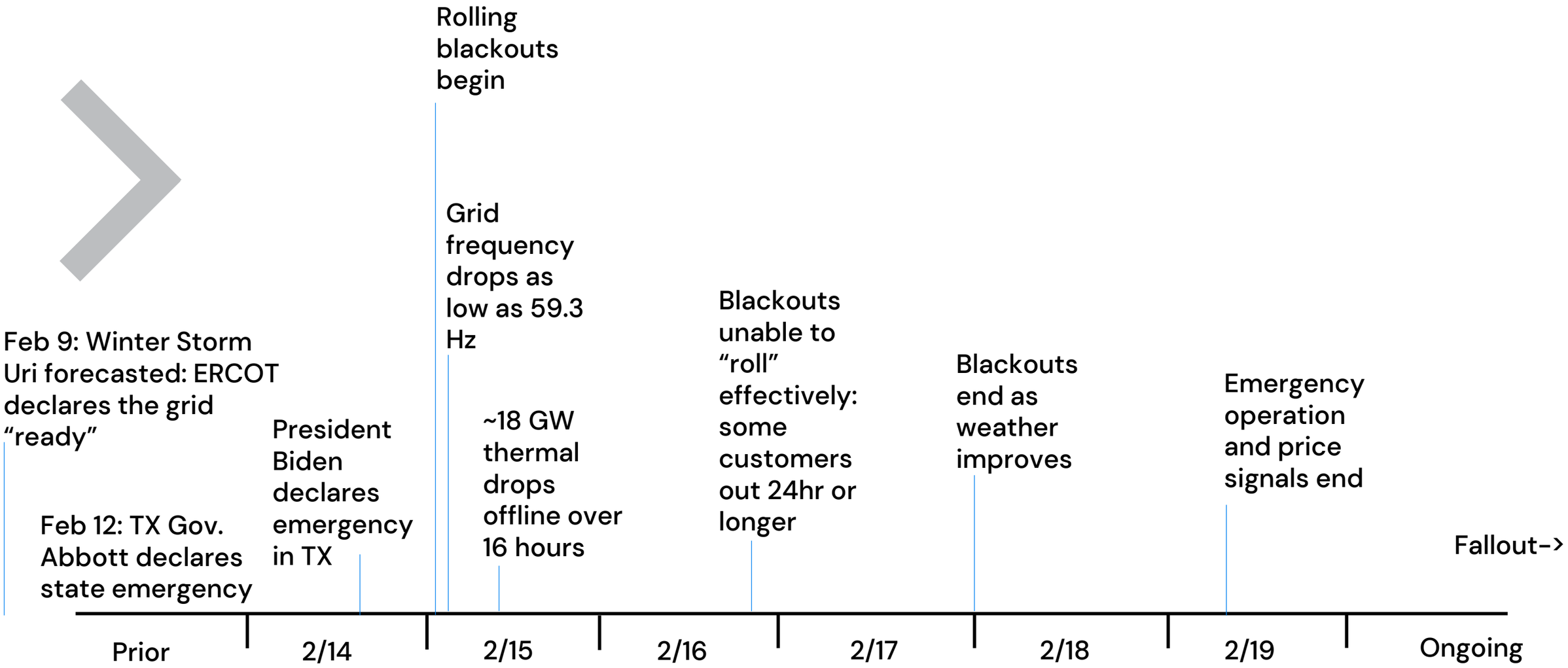
- Most “deregulated” market: competitive retail covers 75% of load



ERCOT Grid and Context



Texas Energy Regulatory Structure



Timeline of Events

- 70 deaths linked to winter storm; many tied to power outages
- Damage estimated at between $10-200B
- All three PUCT commissioners resign, five of fifteen ERCOT board members resign, ERCOT CEO fired
- NRG and Vistra (largest utilities in ERCOT) losses ~ $1B each
- Hundreds of lawsuits:
  - Civil suits against power companies by individuals harmed
  - Force Majeure claims by generators
  - Suits from public power entities (e.g. CPS, Denton) against ERCOT
- State and federal investigations ongoing

Fallout

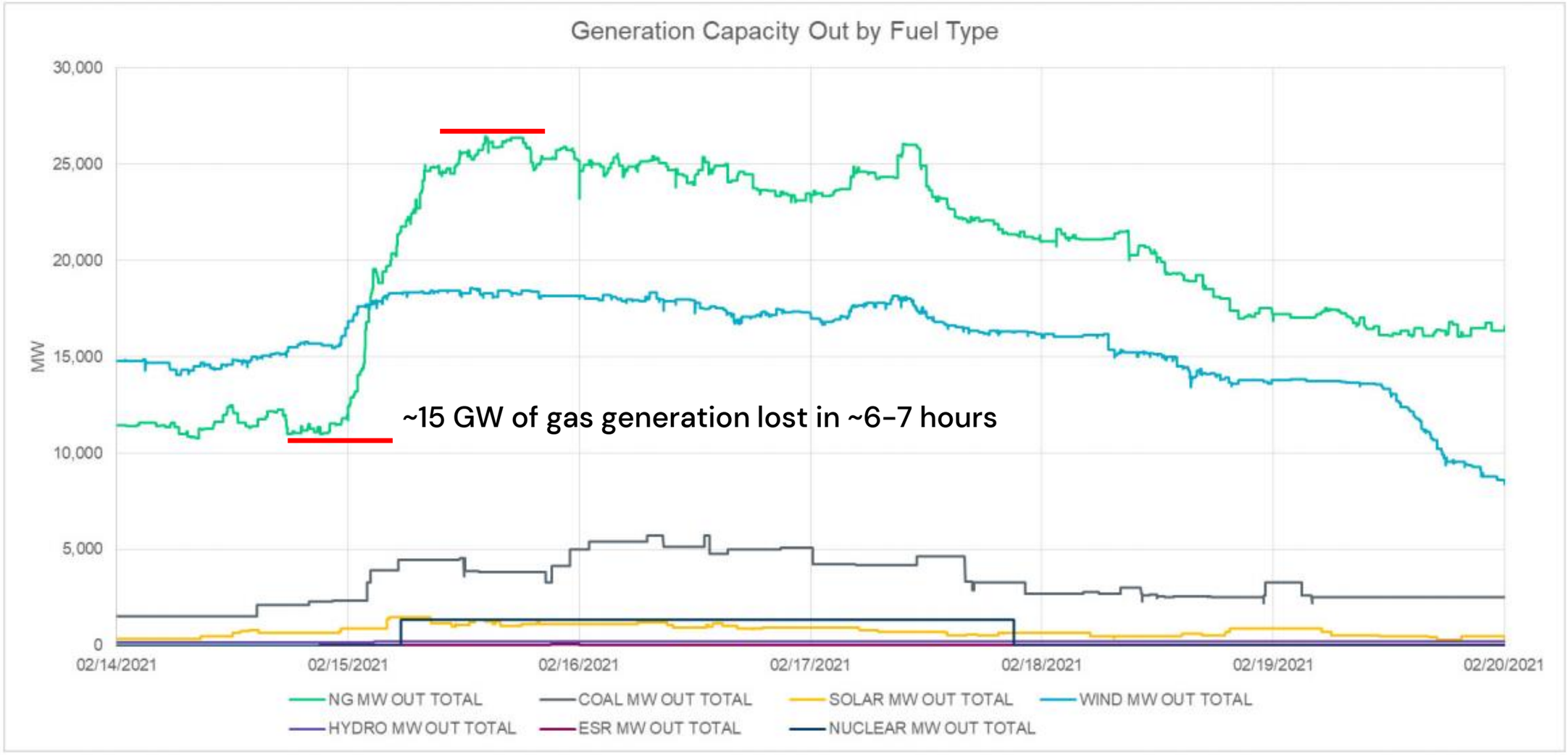
Capacity, GW	Expected Forecast	Extreme/Contingency Forecast	Actual Conditions (8am CST 2/15/21)
Peak Load	57.7	67.2	74.5
Resource Outages	8.6	14.0	26.6
Wind Output	7.1	1.8	4.5
Solar Output	0.3	[0]	0
Total Generating Capacity	73.1	68.6	53.4
Remaining Reserve Capacity	16.2	1.4	-21.1
Operational Conclusion	Normal operations	Emergency measures	Widespread outages

Peak load estimated at 76.8 GW if not for load shed: would be all-time record

No generating technology type emerges broadly unscathed from outages: all had issues

Proximate causes

Source: ICF using data from SARA Winter 2020/21 and other ERCOT data sources



Outages by Fuel Type

Source: ERCOT Review of Feb 2021 Extreme Cold Weather Event

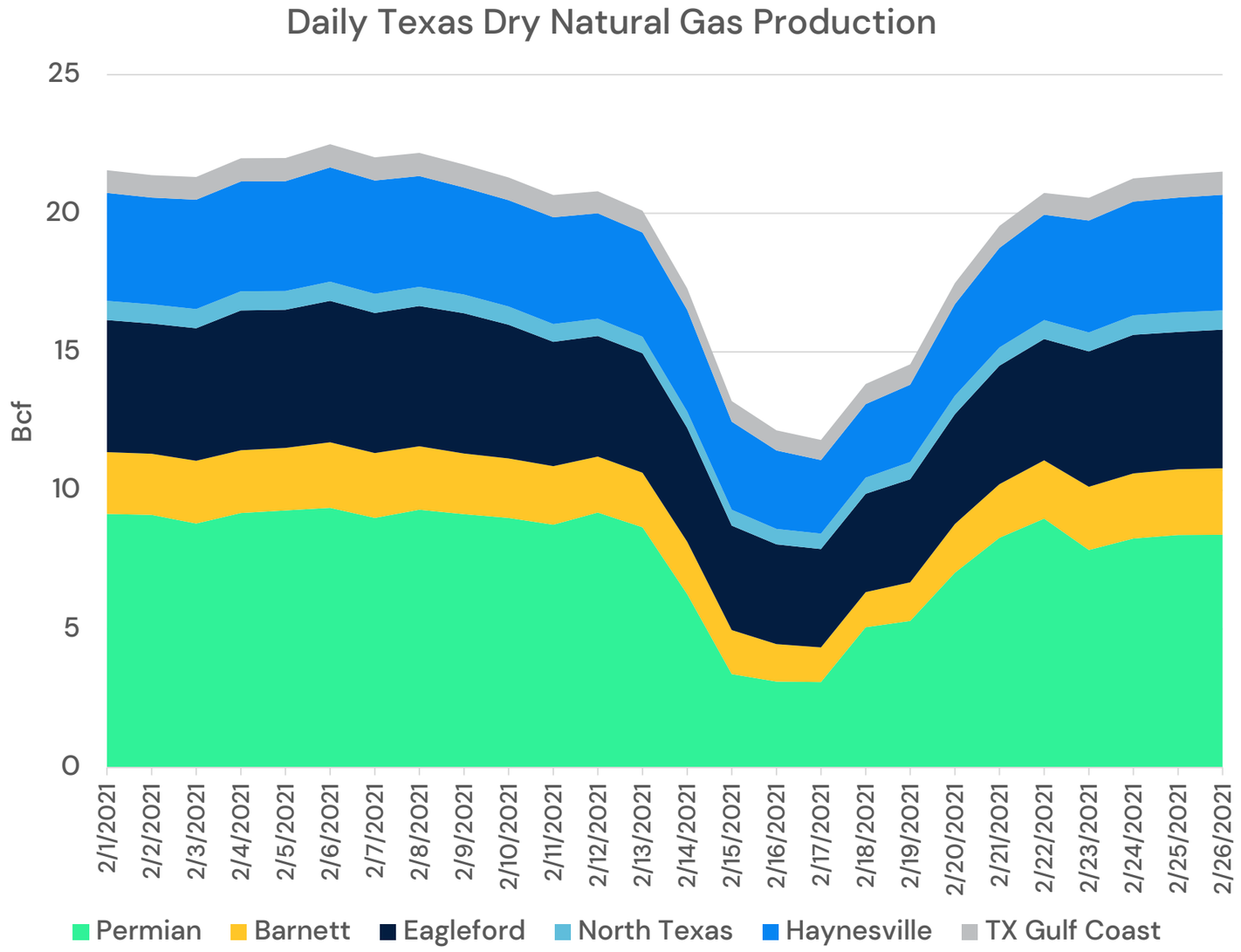
Fuel Type	Installed GW (Winter Rating)	Approx. Max GW on Outage	Approx. % Out	Major Technical Issues
Gas	51.5	27.0	52%	Mechanical and water issues, interruption in gas supply
Coal	13.6	5.5	40%	Mechanical and water issues, interruption in coal supply
Nuclear	5.2	1.4	27%	Feedwater pump trip
Wind	29.1	17.8	61%	Icing on blades, temps below operating minimums
Solar	4.4	1.2	27%	Snow cover, mechanical issues, site access difficulties
Total installed	**107.5**	**52.3**	**49%**	

Snapshot of Outages by Fuel Type (Feb 15-17)

Source: ERCOT Review of Feb 2021 Extreme Cold Weather Event and generator outage data

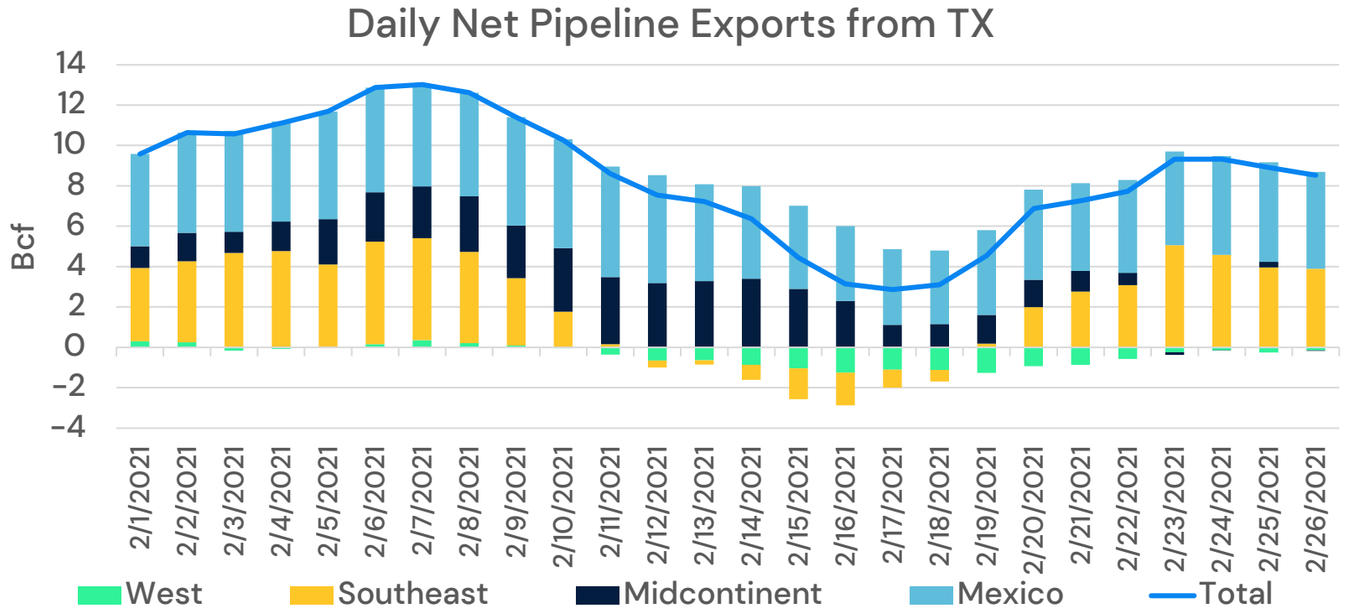
Natural Gas Issues

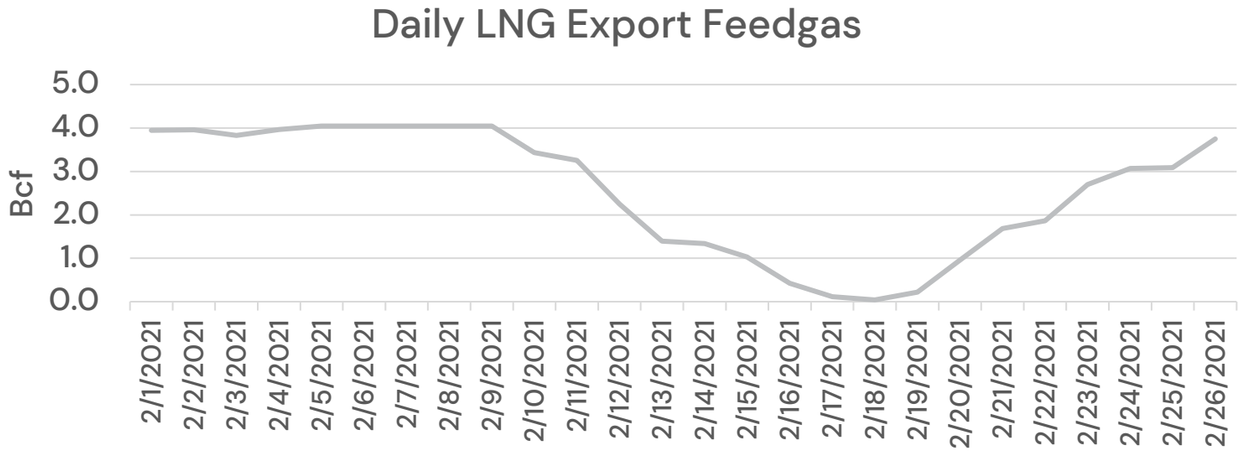
- Oil & gas well and processing plant freeze-offs led to declines in production
- On 2/16/21, natural gas production in Texas dropped to 53% of where it was earlier in the month
- Interstate pipeline receipts from natural gas processing facilities dropped to 16% of their previous levels
  - Some gas power plants received “wet” gas with too high of a BTU content
- Production recovered rapidly



Natural Gas Production

- Texas began importing gas from the West and Southeast US
- Governor Abbott's 2/17/21 order to stop exporting was followed by the LNG exporters on 2/18/21 but other gas producers and pipelines had contractual obligations to export gas
- Net pipeline exports dropped from 13 Bcf/d to 3 Bcf/d

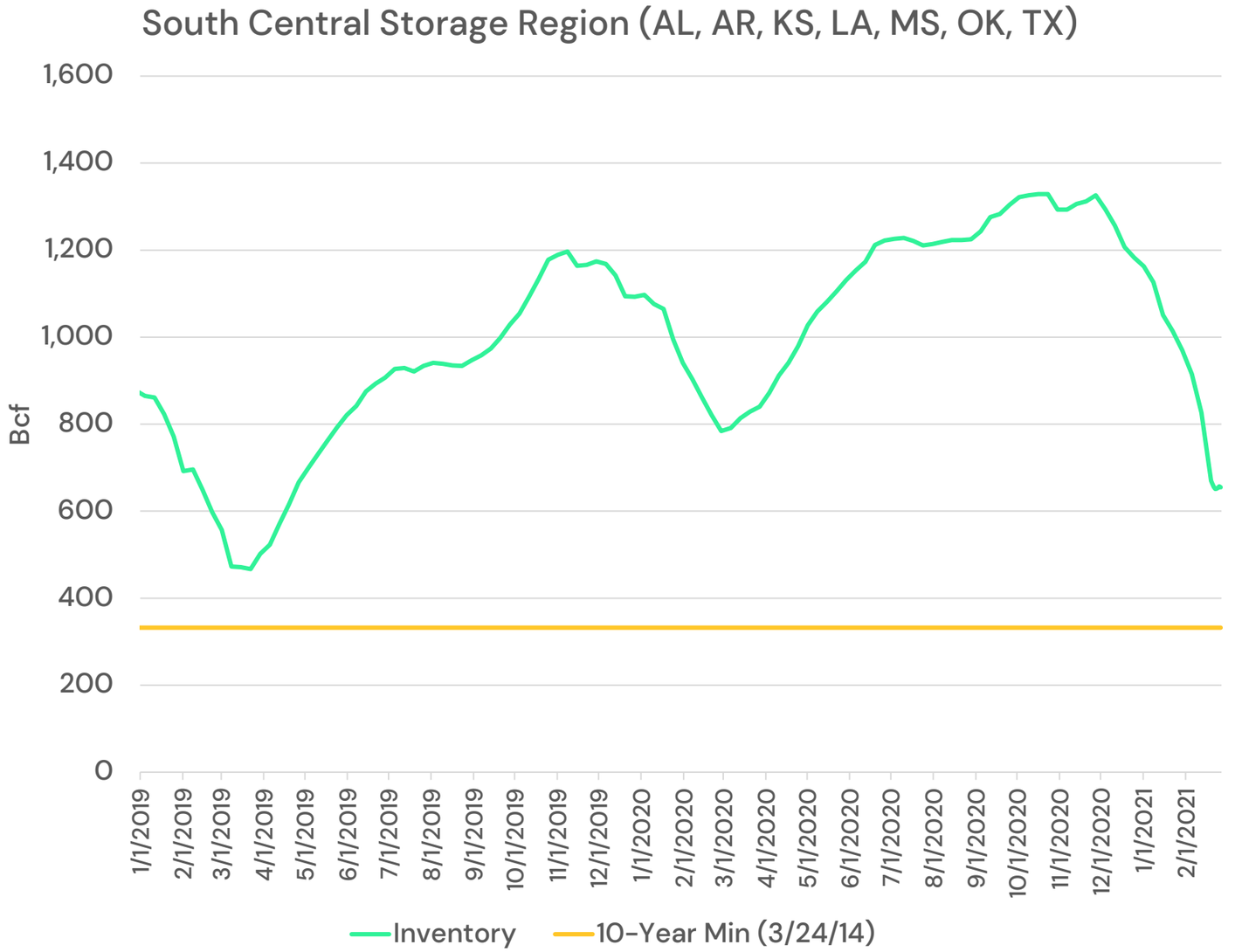




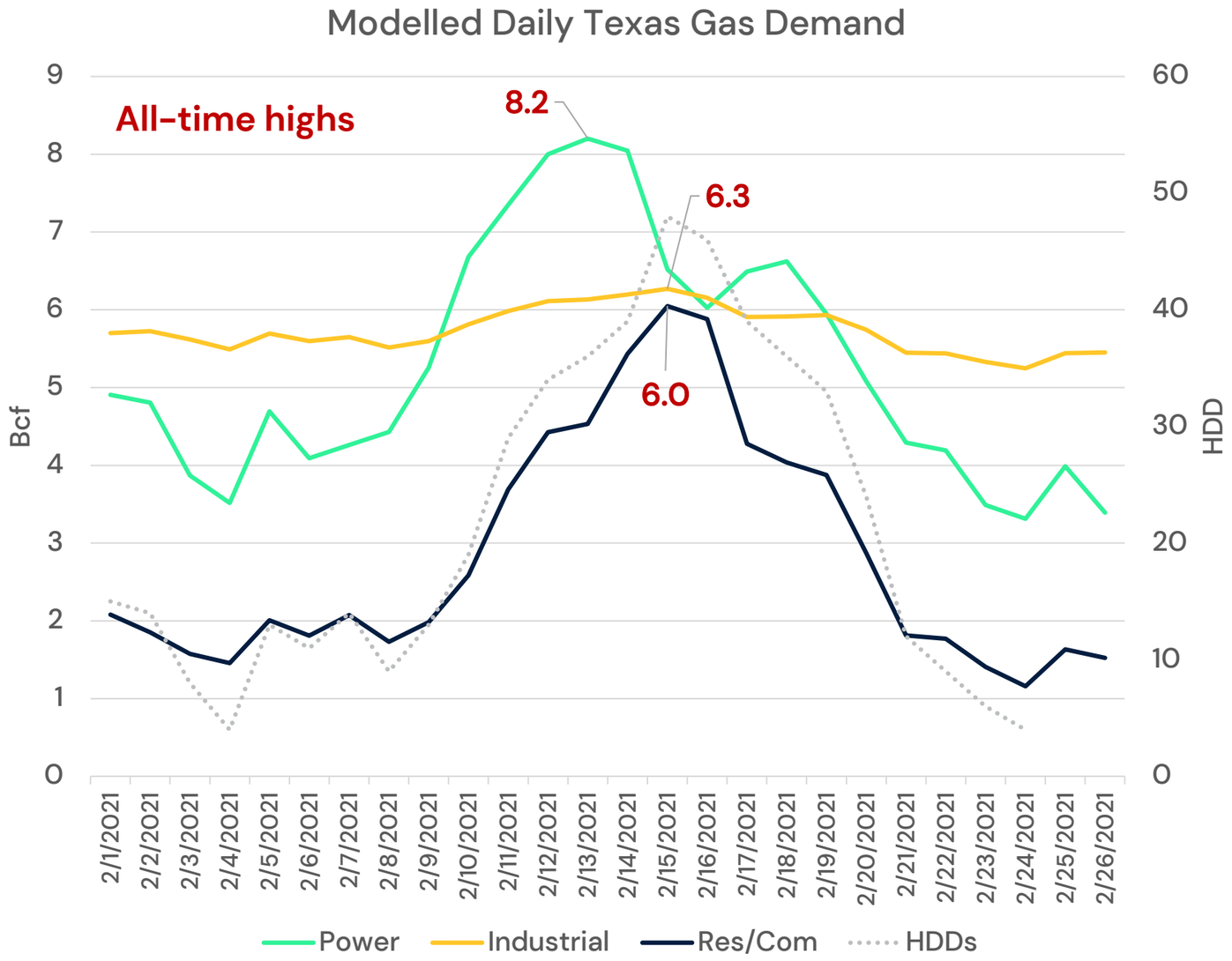
Natural Gas Exports

Natural Gas Storage

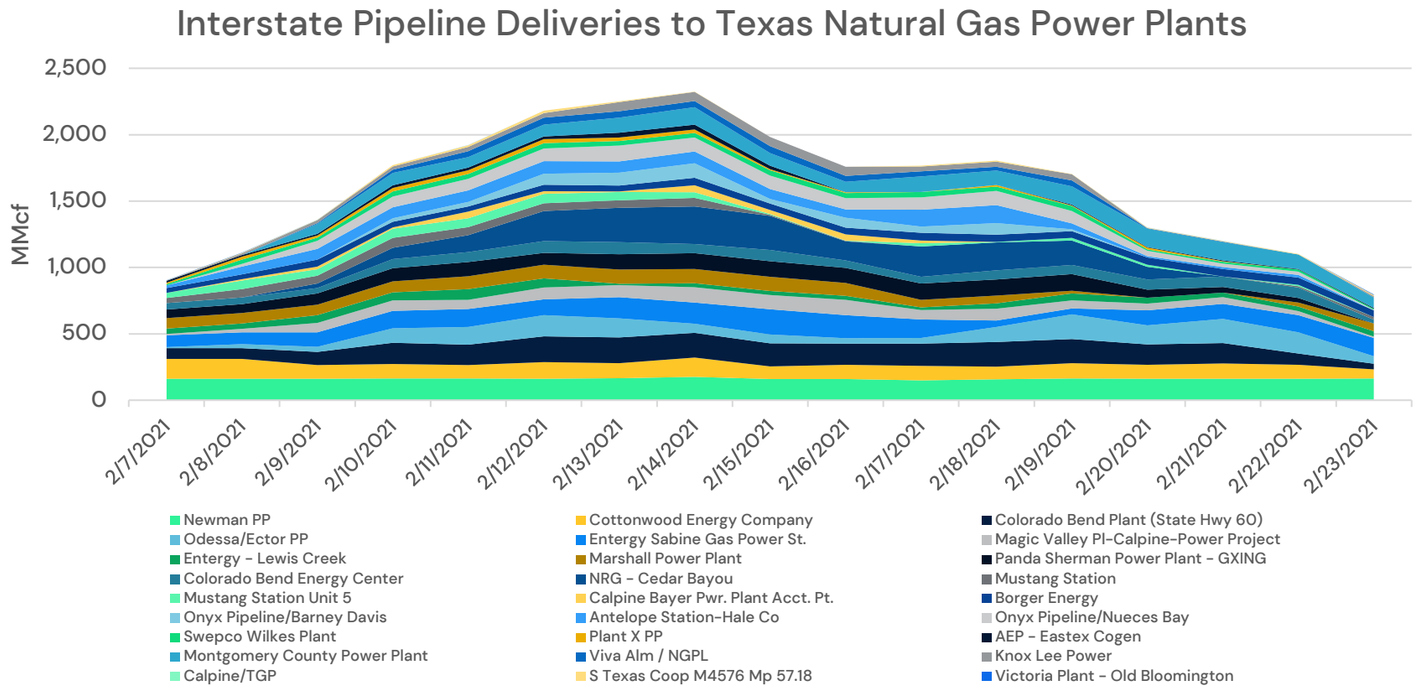
- Natural gas storage was relied on heavily to make up for lost production
- Between, 2/12/21 and 2/18/21, 23 Bcf/d of gas was withdrawn from storage in the South Central storage region
- In December and January, storage withdrawals averaged 6 Bcf/d



- Power generation, industrial, and res/com demand all saw record highs
- On 2/12/21, the Texas Railroad Commission ordered that deliveries of natural gas should prioritize residences, hospitals, schools, and other human needs customers served by gas utilities
- Gas utilities accrued huge costs in order to supply their customers
  - Atmos Energy, a utility with $3B in liquidity, spent $2.5-$3.5B on natural gas in one week



Natural Gas Demand



- Deliveries to gas power generators from the interstate pipelines in Texas set a record on 2/14/21
- About two thirds of the gas generators in Texas are on **intra**state pipelines
- There are reports that many gas generators in the state do not have firm transportation and firm supply contracts

Sample of ERCOT Gas Power Plant Interstate Pipelines Deliveries (MMcf)												
Plant	**Pipeline**	**Firm Transportation**	**2/6/2021**		**2/13/2021**	**2/14/2021**	**2/15/2021**	**2/16/2021**	**2/17/2021**	**2/18/2021**		**2/23/2021**
Colorado Bend (Hwy 60)	**Gulf South**	**185**	80		192	186	174	160	167	188		42
Odessa/Ector PP	**EPNG**	**100**	27		145	68	66	41	42	113		56
Magic Valley-Calpine	**TETCO**	**90**	20		90	115	108	115	70	90		10
Panda Sherman	**Gulf South**	**None***	67	...	115	119	117	112	124	120	...	0
Colorado Bend	**Gulf South**	**70**	50		90	69	85	57	51	68		28
NRG - Cedar Bayou	**TETCO**	**100**	0		259	282	256	143	228	210		0
Calpine Bayer	**TETCO**	**90**	0		4	54	30	45	20	0		0
Barney Davis	**TETCO**	**None***	0		96	110	34	74	46	86		0
Nueces Bay	**TETCO**	**65**	0		118	105	102	84	93	109		4
	HDDs		11		36	39	48	46	39	36		6

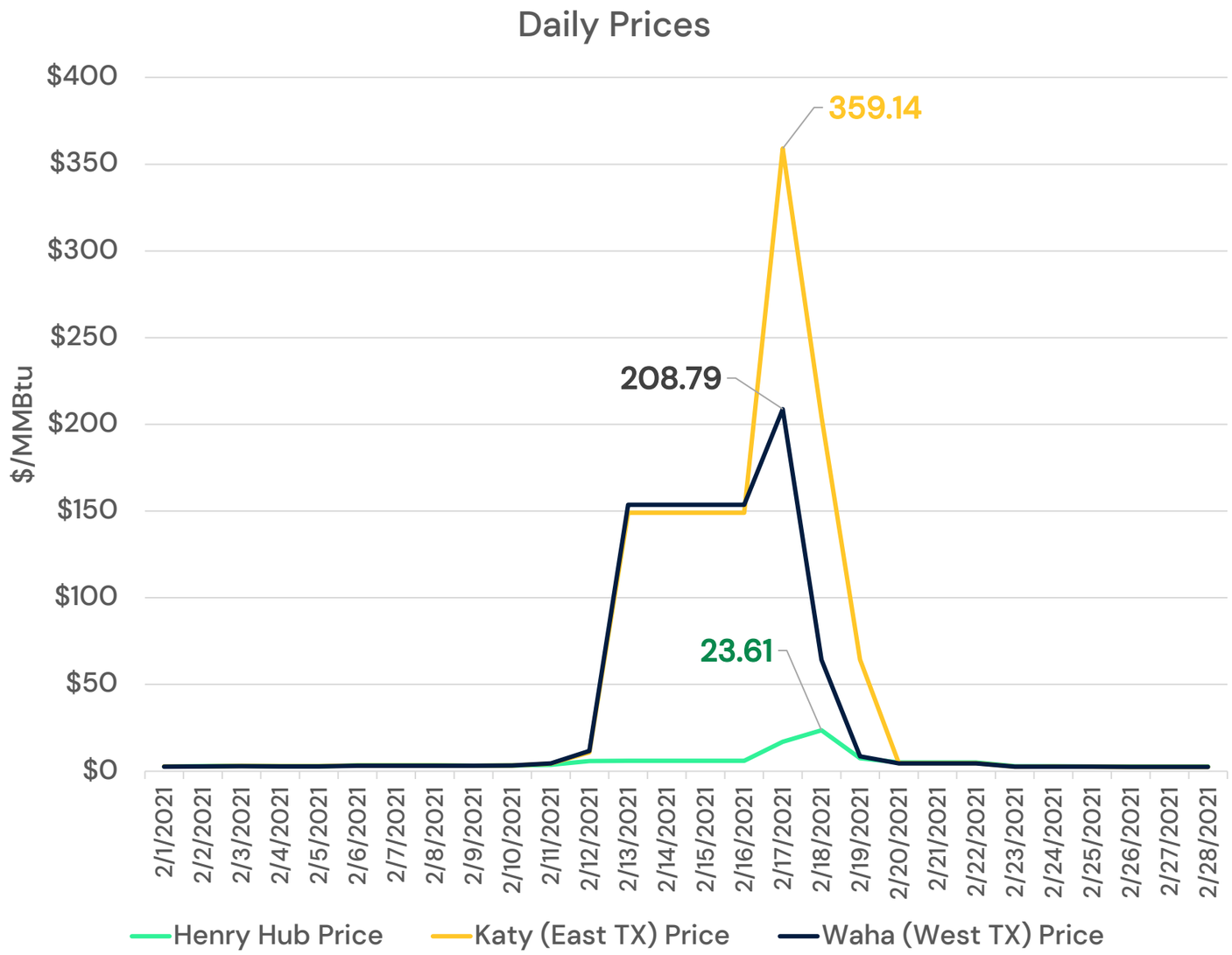
*No contracted capacity for this plant's meter. Could have received gas through another firm contract.

Natural Gas Power Generation

Natural Gas Prices

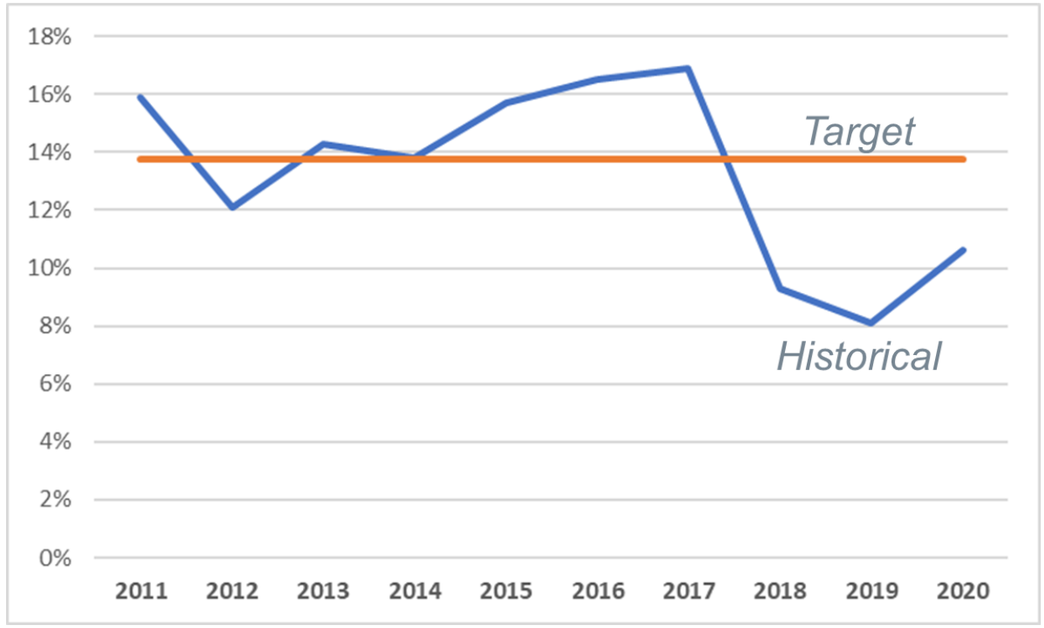
- Day ahead prices hit record highs in many parts of Texas and the Midcontinent
- Trade volumes remained at or above their average levels
- There was very high volatility in the NYMEX

	NYMEX (2/1/21)	NYMEX (2/17/21)	NYMEX (2/25/21)
Mar-21	2.85	3.22	2.85
Apr-21	2.82	3.03	2.78
May-21	2.84	3.04	2.81
Jun-21	2.88	3.07	2.86
Jul-21	2.94	3.11	2.91
Aug-21	2.95	3.12	2.93
Sep-21	2.94	3.10	2.92
Oct-21	2.96	3.11	2.93
Nov-21	3.01	3.16	2.98
Dec-21	3.12	3.28	3.11
Jan-22	3.20	3.36	3.20
Feb-22	3.14	3.30	3.12
Avg	2.97	3.16	2.95

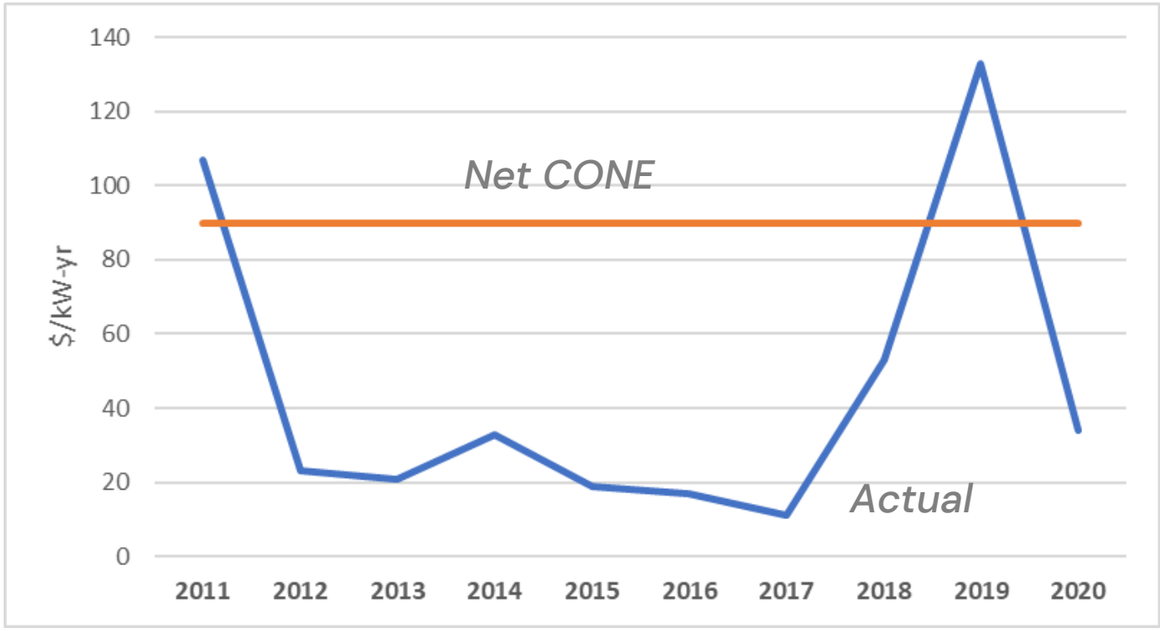


Precedents, Takeaways, and Lessons Learned So Far

ERCOT Planning Reserve Margin



Scarcity Revenues



Low payouts for capacity over 2012-2017, despite reserve margins of just 14-17%

Large retirements in 2017-2018 lead to <10% RM; historically unprecedented in large markets

Would a capacity market have helped? Open question

Precedents: Market Design and Low Reserves

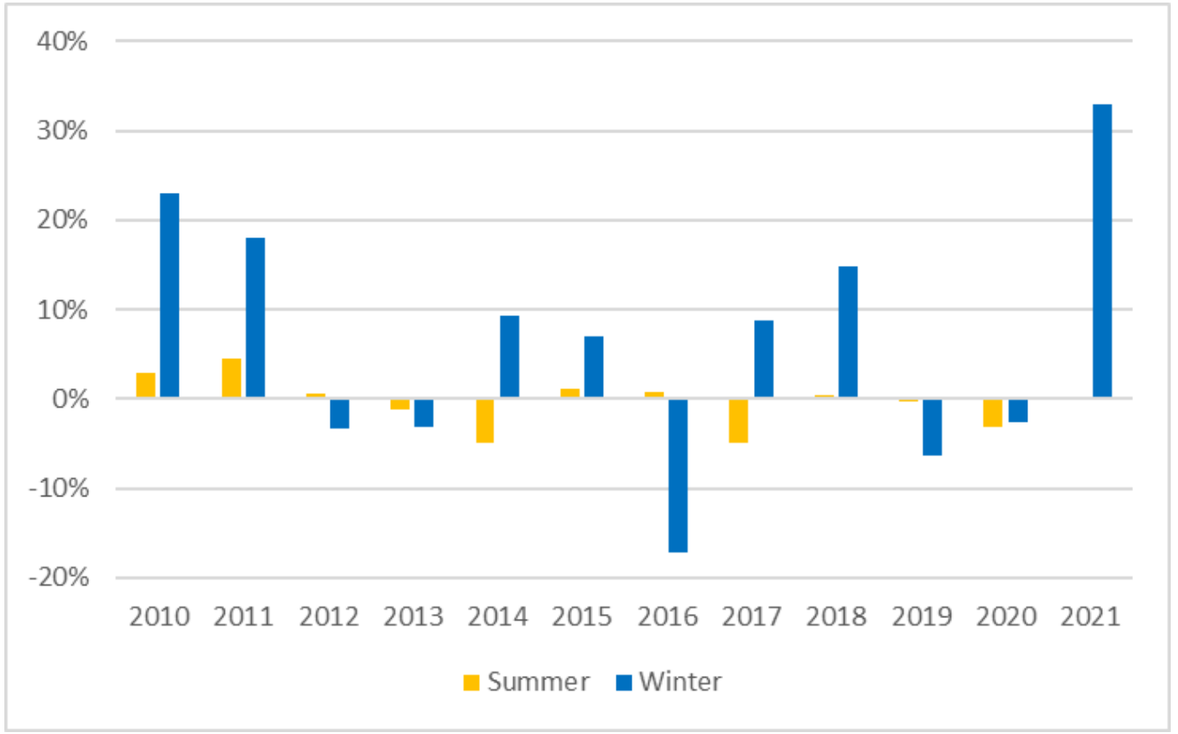
Planning is heavily summer-focused.

However, of the three blackouts in ERCOT history, none occurred summer: 2006 (April), 2011 (Feb), 2021 (Feb)

Increasing weather variability? 2011 weather was estimated to be 1-in-100 probability at the time, but now is called 1-in-10

Winter peak significantly more variable than summer peak

Peak-demand forecast error



Std. dev. of peak forecast error:
Summer = 3%
Winter = 14%

Precedents: Planning and Historical Data

Note: Winter bars denote Jan/Feb of the given year and Dec of previous year. Reference forecast is based on prompt-year CDR peak demand

Thermal power failed spectacularly: but a heavily renewable/storage system as commonly planned would have fared no better

Duration of the outage – 71 hours – far outside of the expected range of Li-ion battery storage capabilities

Electrification of heating demand could double the winter peak

~60% of TX homes heated by electricity, remaining by gas

Suggests caution - particularly with respect to generator retirements

Challenges for Decarbonization

- ERCOT has historically relied heavily on financial incentives and voluntary standards:
  - No enforced minimum reserve margins
  - No requirement for firm fuel supply
  - “Soft” standards for winterization

- Senate Bill 3 would increase regulatory oversight & coordination, and enforce minimum standards in many areas (fuel, winterization – but not reserves)
  - Who is responsible for the cost? Could accidentally make problem worse

- NERC and FERC have been working on mandatory and auditable weatherization standards since 2018

Precedents: Mandatory vs Incentivized

- Significant portions of the natural gas and power generation sectors rely on each other to supply energy
  - Almost all natural gas wells and some processing plants and pipeline compressors use offsite electricity
- Much of the natural gas infrastructure in Texas is not classified as “critical infrastructure”, which has priority to receive electricity during outages
  - Hundreds of natural gas facilities have been added to the list of critical infrastructure sites since February
- Texas’ energy infrastructure is designed to withstand extreme heat, not extreme cold
  - This is true for Texas’ transportation and building infrastructure too
- Gas producers and transportation companies may have to continue to prioritize deliveries to natural gas utilities in a crisis
  - Both policy-makers and contractual obligations make this a reality
- Winters and summers are getting warmer, *on average*. Peak/design day that we have to for plan for might be getting colder if polar vortexes happen with more frequency, especially in regions of the country that didn't used to have them

Power & Natural Gas Interdependence

Questions?