ENVERUS

Winter Storm Uri – Natural Gas Analysis

Prepared for: Texas Oil and Gas Association (TXOGA)

TXOGA
TEXAS OIL & GAS ASSOCIATION | SINCE 1919

April 2021

Situational Review and Findings

Texas had one of, if not the, coldest and most impactful winter storms observed in state history during the week of February 12–17. A combination of record winter demand and generation unit outages cascaded into instability and power losses across the ERCOT power grid, resulting in 4.5 million Texans without electricity at the peak.

This cold snap not only impacted Texas (ERCOT) but also Oklahoma and Louisiana. The Southwest Power Pool (SPP) and Midcontinent Independent System Operator (MISO) manage the electricity grid for Oklahoma (SPP) and Louisiana (MISO). In addition, California ISO (CAISO) who manages SP-15's southern California area was impacted by high natural gas prices which sent wholesale prices soaring.

Along with natural gas supply, a dip in power generation resources was observed for every fuel type, including coal, wind, solar and even nuclear.

During the worst of the cold snap, all power generation resources showed a decline in output while demand peaked to unprecedented levels. Although natural gas production fell significantly during this event, the timeline indicates that power outages made this decline worse. Even with this decline, data confirms Texas natural gas supply exceeded Texas demand during this period, although matching the supply to the demand could not be accomplished in all circumstances.

During this event, the peak demand observed was near 70,000 MW on the evening of Sunday, February 14. This level of demand had never been observed before in the winter season in ERCOT.

Planning for this cold snap by ERCOT was based on 2011 events which, in hindsight, was not as extreme as this February 2021 event. ERCOT could have planned for colder weather, potentially using 1989 as its baseline for preparation.

The timelines included illustrate how events unfolded.

Timeline

The following timelines illustrate how events unfolded.

- **First week of February:** ERCOT meteorologists reportedly warns Market Participants and the public of the coldest weather of the year.
- **February 8:** ERCOT issues an Operating Conditions Notice (OCN) for an extreme cold weather system approaching Thursday, February 11 through Monday, February 15 with temperatures anticipated to remain 32° F or below.
- **February 10:** ERCOT issues an Advisory for the predicted extreme weather for the ERCOT Region.
- **February 12**: Governor Greg Abbott declares a state of emergency in all Texas counties ahead of the expected severe winter weather.
- **February 12:** Natural gas supply begins declining through February 15, with February 14 being the most impactful day.
  - Natural gas supply declined ~0.2 Bcf/d and ~0.7 Bcf/d on February 12 and 13, respectively, leading up to February 14.
  - The declines observed on February 12 are within a typical range of drops observed during previous cold weather events.
  - The declines on February 13, although material, were not large enough to cause the power generation failures seen across the board.
- **February 14:** As early as 1:00 AM, power generation reported output limitations or significant capacity was forced offline by the extreme weather. At its highest point more than 48.6% of all generation in ERCOT was in forced outage.
  - Natural gas declines showed ~2 Bcf/d declines. Power generation outages exacerbated the drop in natural gas supply, as reported by oil and gas operators after the event and survey data compiled and presented in this report.
  - Peak demand observed is near 70,000 MW during the evening.
- **February 15:** ERCOT enters Emergency Operations Level 3 at 01:20 AM, and does not return to normal operations until 10:35 AM Friday, February 19.
  - At least 4.5 million customers were without power and more than 13 million customers had water service interruptions.

ERCOT Timeline – What Happened?

Little Time to Prepare

Fri. 03 Feb. 2021

ERCOT meteorologist reportedly warns Market Participants and the public of coldest weather of the year.

Mon. 08 Feb. 2021

ERCOT issues an OCN for an extreme cold weather system approaching Thursday, February 11, 2021 through Monday, February 15, 2021 with temperatures anticipated to remain 32°F or below.

Wed. 10 Feb. 2021

ERCOT issues an Advisory for the predicted extreme weather for the ERCOT Region.

Fri. 12 Feb. 2021

Governor Greg Abbott declares a state of emergency in all 254 Texas counties ahead of the expected severe winter weather.

ERCOT Timeline – What Happened?

Event Overview

Fri. 12 Feb. 2021

Over the week natural gas pipeline flow data shows a significant drop. Spot gas prices soar on Friday to over $150/MMBtu at HSC (other locations experienced prices as high as $1250 according to Natural Gas Intelligence).

Sat. 13 Feb. 2021 04:02

ERCOT notes the first major thermal generator failure at 04:02. Frequency declines to 59.238 Hz, while load was at 55,391 MW.

Sat. 13 Feb. 2021 08:43

ERCOT Physical Responsive Capability (PRC), which is a measure of online capacity that is available to respond quickly to disturbances, falls below 3 GW for the first time during the weekend.

Sun. 14 Feb. 2021

ERCOT issues a Watch for a projected reserve capacity shortage with no market solution available for HE 17:00-21:00, which causes a high risk for an EEA event.

Mon. 15 Feb. 2021

Energy Emergency: EEA Level 1: At 00:15, ERCOT at EEA 1 - Reserves below 2, 300 MW.

EEA Level 2: At 01:07, ERCOT at EEA 2 - Reserves below 1, 750 MW. Load resources are being deployed.

EEA Level 3 With Firm Load Shed: At 01:20, rotating outages are in progress to maintain frequency.

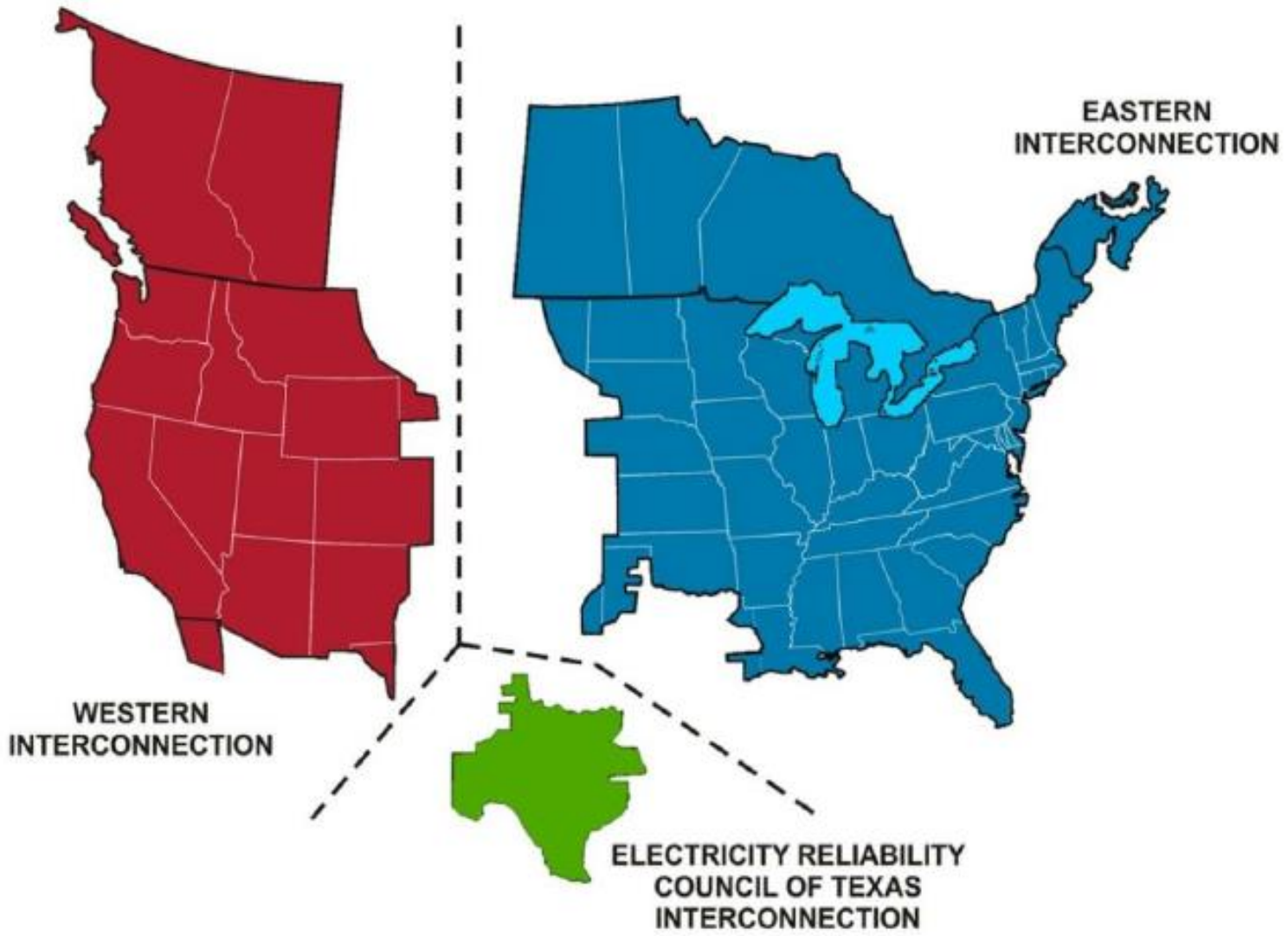
ERCOT Power Grid Outage: What Went Wrong?

Could the other regions have helped ERCOT?

On Sunday, Feb. 14 Eastern Interconnect MISO issues a Max Gen Emergency Alert for Monday, Feb. 15 for the South Region during the on peak hours. Blackouts are experienced on Monday and Tuesday.

On Monday, Feb. 15 Eastern Interconnect SPP issues a Gen Emergency Alert for Tuesday, Feb. 16 for the South Region during the on peak hours. Blackouts are experienced on Tuesday.

Key Takeaway: Interconnections with other non-ERCOT regions don't help in peak load periods. Connection doesn't matter if these other regions don't have power to send.



Primary causes for loss of upstream gas and transmission

Based on survey data whose participants represent over 50% of the natural gas production in Texas, there were several consistent themes that stood out related to causes of supply outages. Both upstream and midstream operators were polled.

Upstream responses identified loss of power and electricity, equipment freeze-offs, and not being able to get production out due to facilities being shut down as the causes that influenced operations the most.

Midstream survey responses identified loss of power and lack of production from upstream as the main causes.

Key Takeaway: The common denominator that caused most disruptions to both upstream and midstream sectors was the loss of power and electricity.

Upstream Analysis

Oil and gas operators that are representative of 51% of natural gas production in Texas were surveyed with questions regarding their experiences during Winter Storm Uri and how their operations were impacted. The focus areas were how much production was affected and the main causes for production levels to fall off, as well as how and why an operator’s hydrocarbon transportation was impacted.

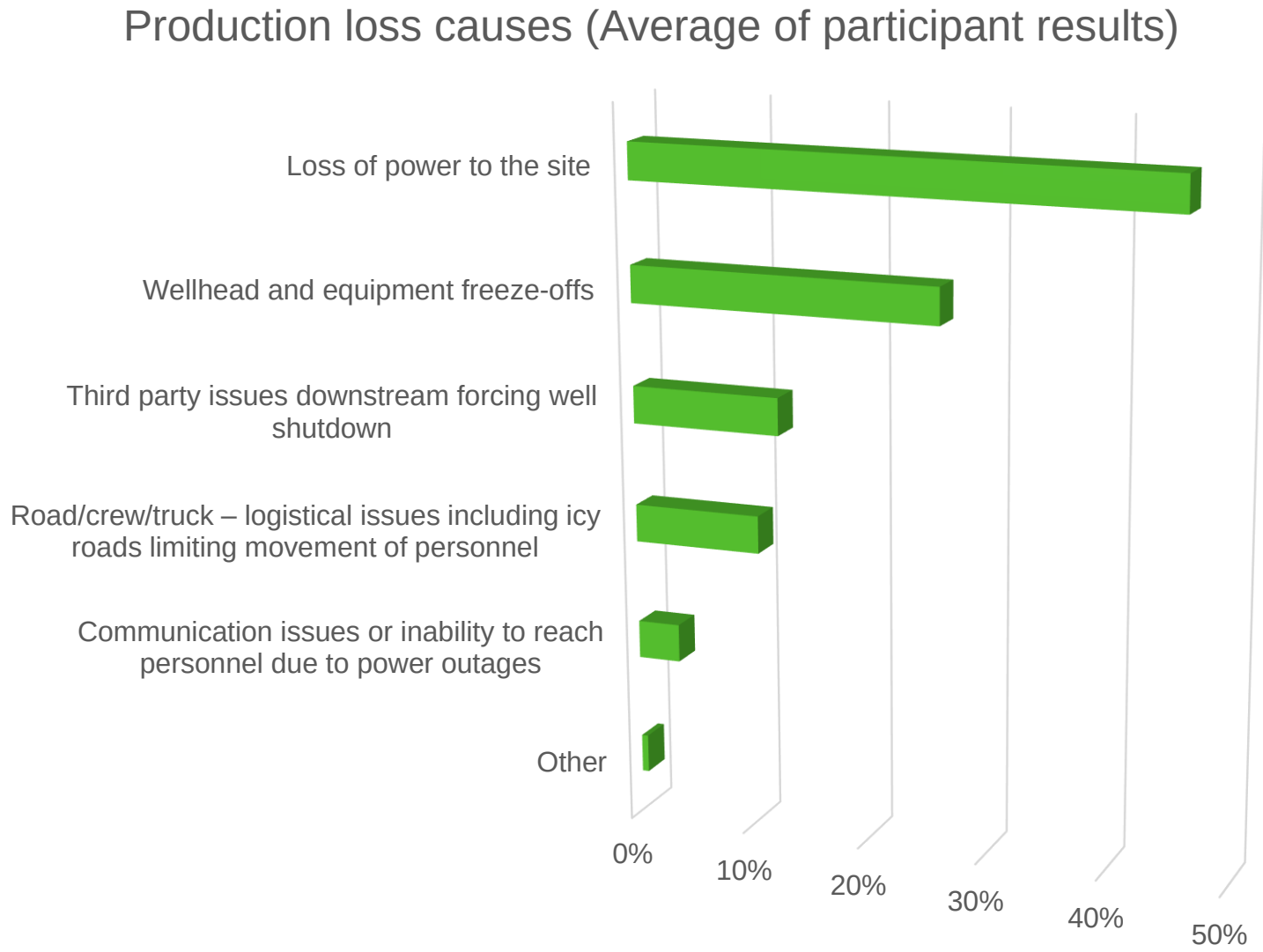
Key Takeaway: Upstream survey responses focused on loss of power (65%), wellhead and equipment freeze-offs (13%) and not being able to get production out due to issues with third-party facilities (pipelines, gathering, transmission, processing facilities, plants) (8.7%) as the main causes that influenced operations.

Upstream Results

This chart shows the average percentage breakdown of causes for the production lost from upstream operators that responded to the data collection survey. Loss of power to the well site and wellhead and equipment freeze-offs are the most frequently cited reasons for significant production losses. Third-party issues downstream forcing well shutdown, and road/crew/truck logistical issues are the third and fourth most common cited reasons, respectively.

In addition to the data, respondents provided several notable comments highlighting logistical issues they experienced. Specifically:

- Road conditions (ice) prevented operators from hauling produced water and oil and limited their ability to get crews out to the production sites to make repairs and mitigate wellhead freeze-offs.
- Production loss would still have happened if only well sites retained electricity service since outages at infrastructure downstream (including pipelines and other facilities) also prevented the flow of production. Stable electricity service from well-site to end user is necessary to facilitate the supply and transport of production.



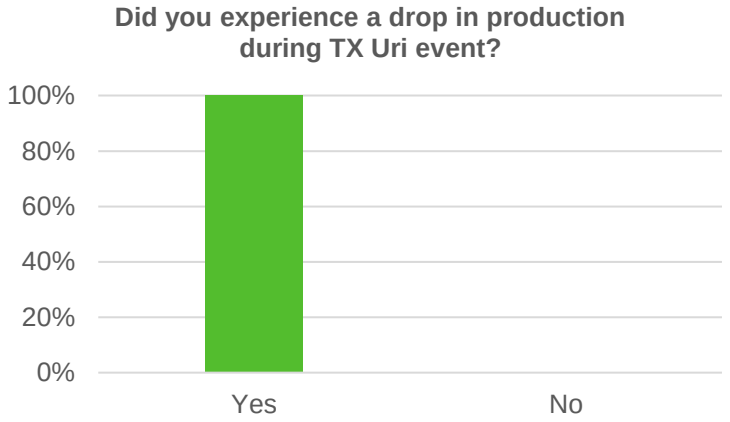
Source | TXOGA Member Responses to Enverus Survey

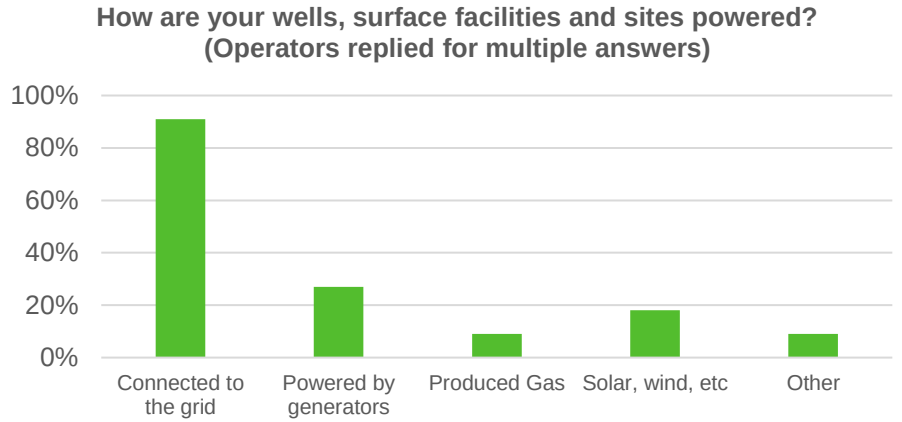
Other includes: Controlled Shut In of Production and downstream facilities going down, having power would not have helped if downstream still lost power

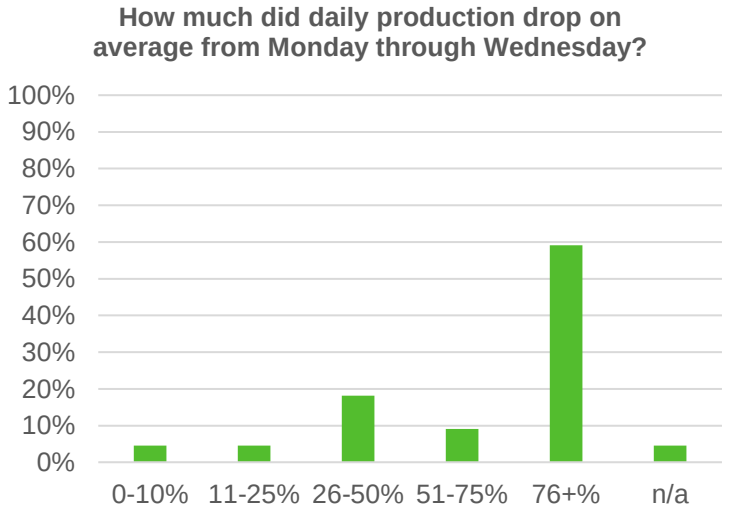
Upstream Results

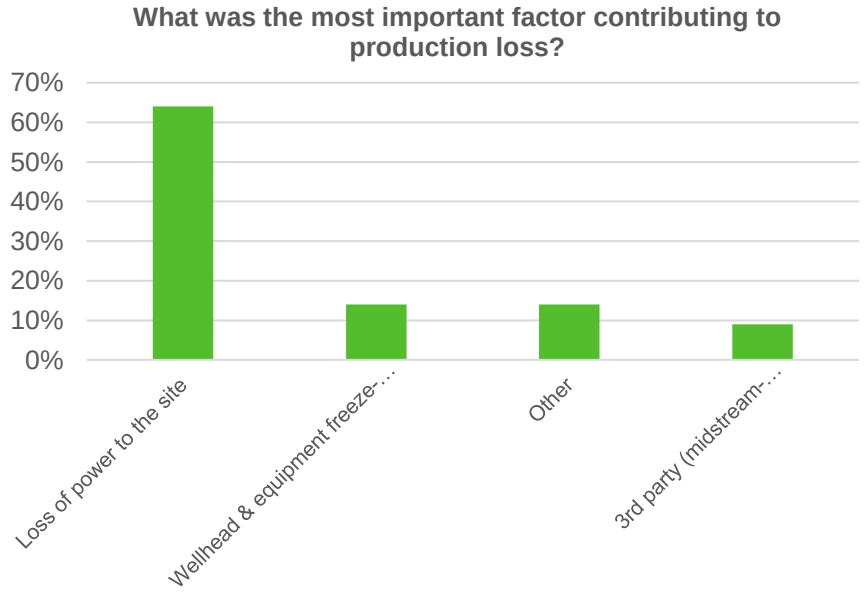
Most of the participants (~91%) are connected to the grid and this is how they operate their sites and facilities, which explains why nearly 60% of the operators lost 76%+ of the production during this weekend, and the main cause they attribute is loss of power and electricity.

Equipment freeze-offs and third-party issues in the midstream sector are also reasons production decreased. According to several responses from oil and gas operators, although equipment freeze-offs forced wells to be shutdown, this would have been only a temporary problem if electricity had been available to power their equipment and they were able to communicate with their crews to dispatch them to well sites to complete repairs. Both challenges impacted their ability to bring production back online quickly.









Source | TXOGA Member Responses to Enverus Survey

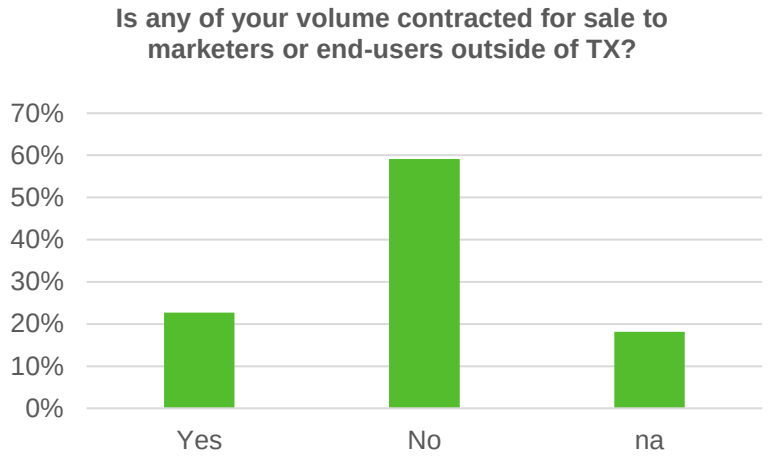
Other for powering sites includes: Combination of electric and natural gas powered
Other for production loss includes: Controlled shut in of production, loss of electricity and third-party takeaway

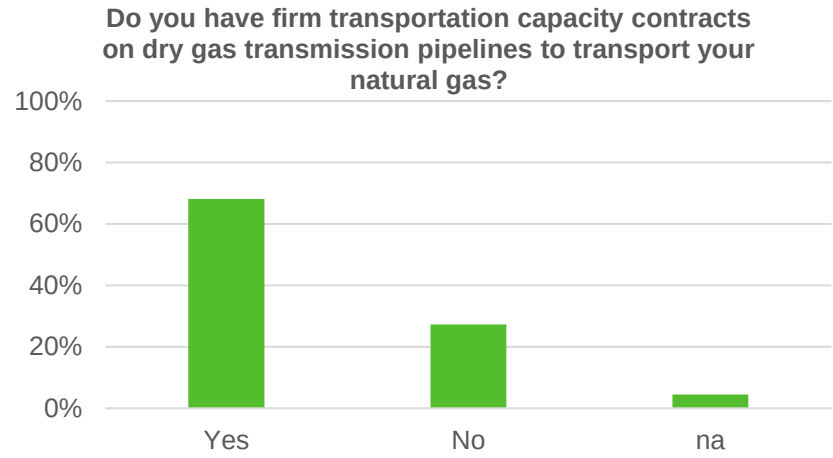
Upstream (Transportation Focus) Results

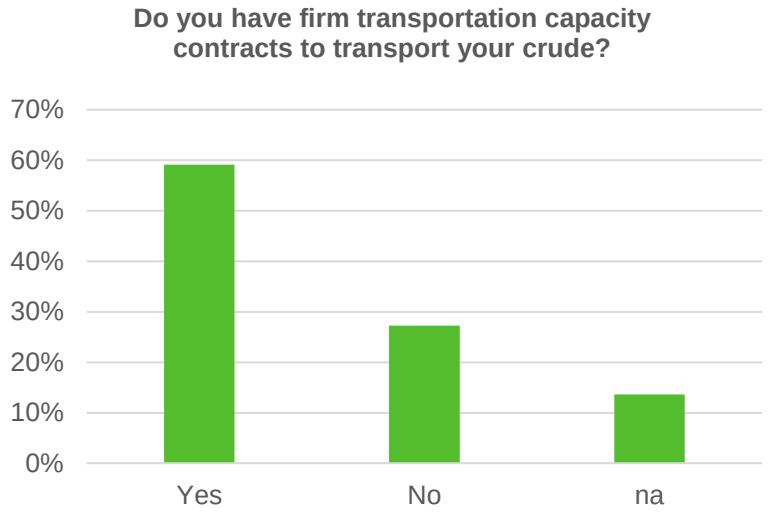
Of all operators surveyed, only a small percentage were contracted to sell their production to marketers or end-users outside of Texas. However, it should be noted that it is typical for operators to enter into agreements to sell their production at locations near gathering and processing, with purchasers often reselling volumes further downstream at markets or locations that may be outside of Texas.

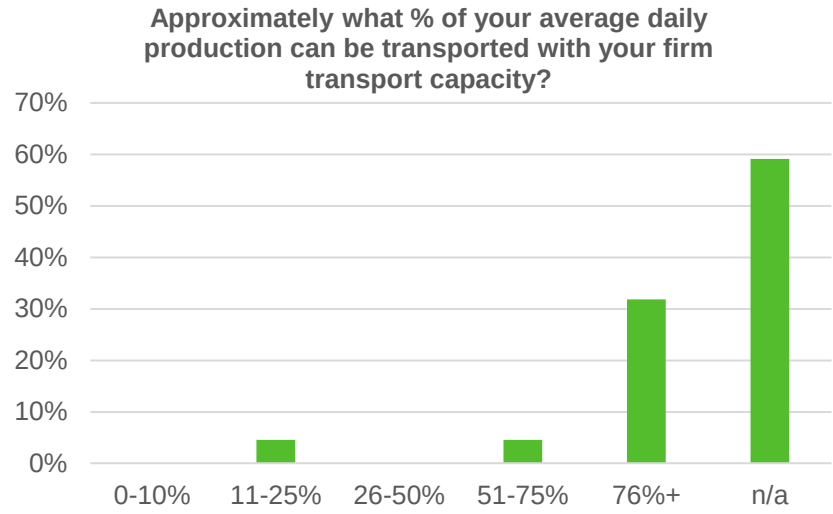
Nearly 70% of respondents reported having firm transport contracts for their dry natural gas production volumes, and 60% reported having firm contracts for their crude oil production volumes. This indicates that operational flow orders on pipelines during the event that restrict service to firm contracts was not likely a significant factor that prevented production transport.

Reported issues with power supply to infrastructure and wellhead freeze-offs were likely the primary factors in the drop in supply.









Source | TXOGA Member Responses to Enverus Survey

Midstream Analysis

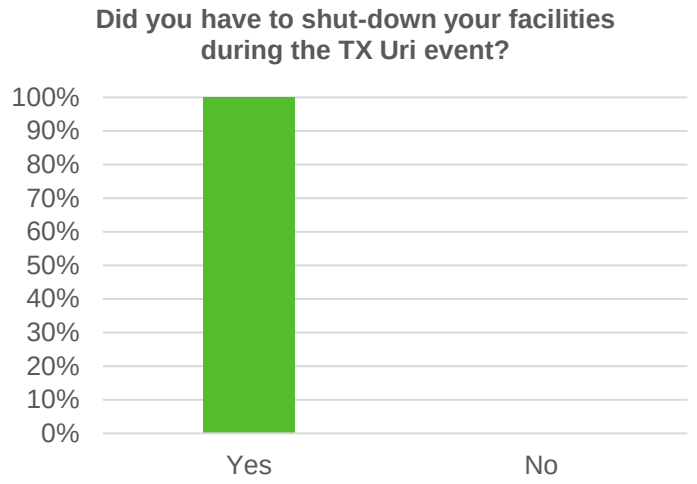
Midstream companies representing different midstream segments responded to survey questions about their experiences during Texas' Winter Storm Uri. The question focus areas were how much throughput was lost and what were the main causes that led to downtime.

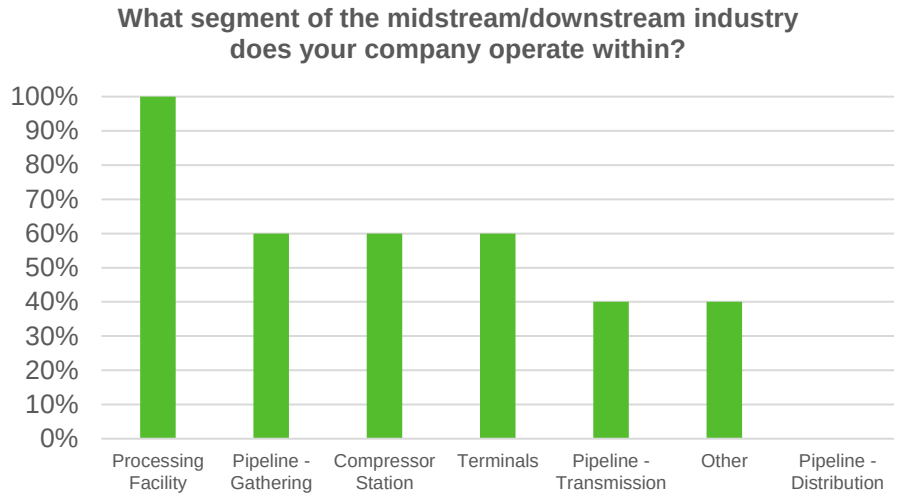
Key Takeaway: Midstream survey responses focused on loss of power and lack of production from upstream as the main causes of downtime for infrastructure.

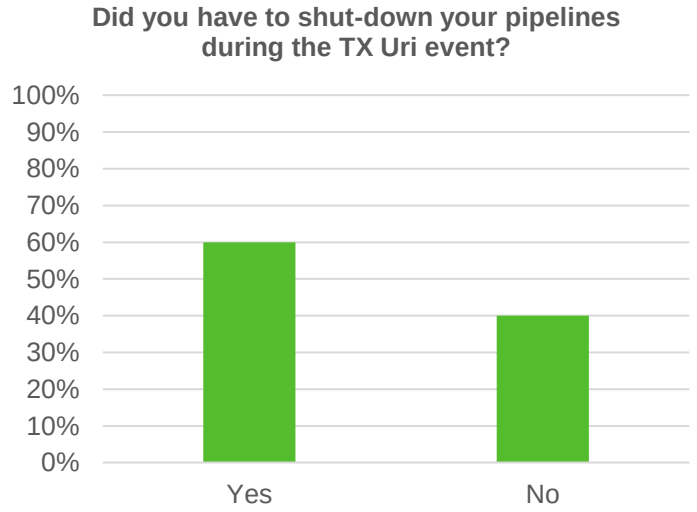
Midstream Results

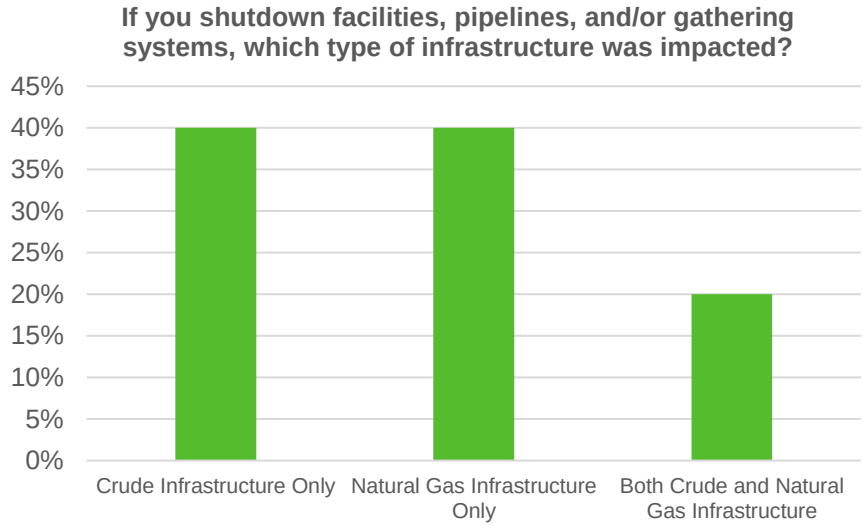
All companies surveyed experienced outages at their facilities at some point during the event, which also impacted upstream operators.

From reported answers, it can also be seen that both crude and natural gas infrastructures were impacted.









Source | TXOGA Member Responses to Enverus Survey

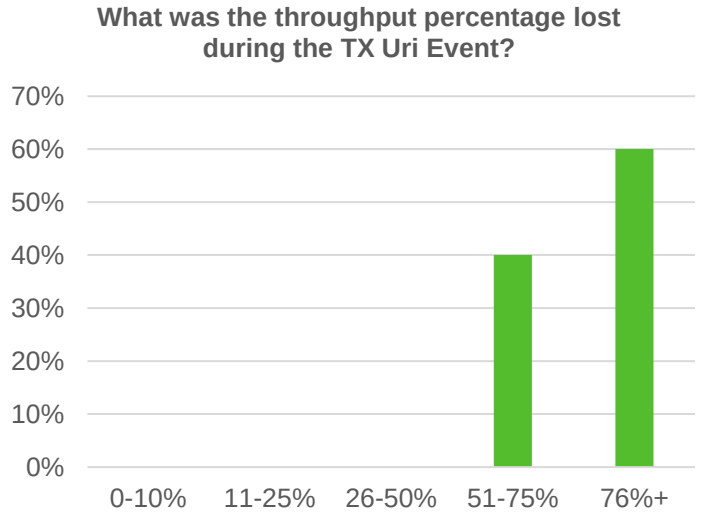
Other includes: Nat. Gas Pretreatment Facility & LNG Liquefaction Terminal and Fractionators, refineries, co-gen facilities

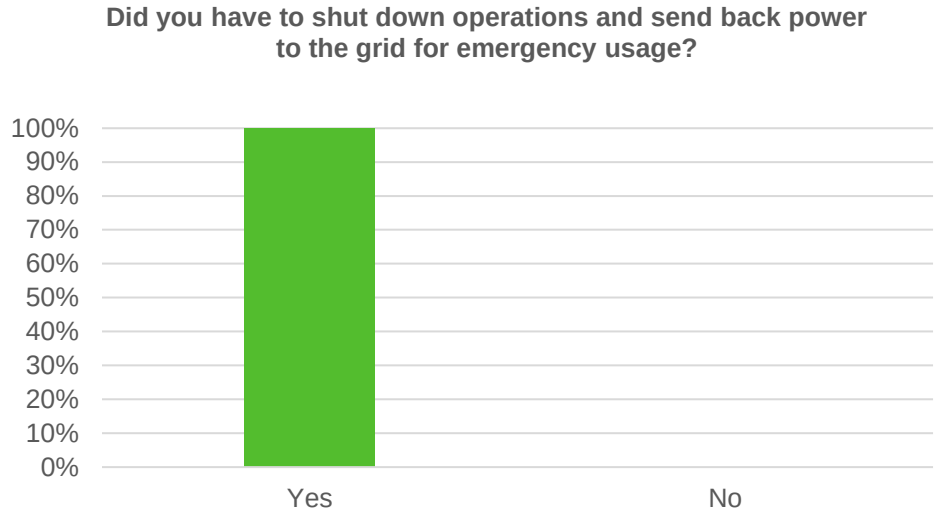
Midstream (Transportation Focus) Results

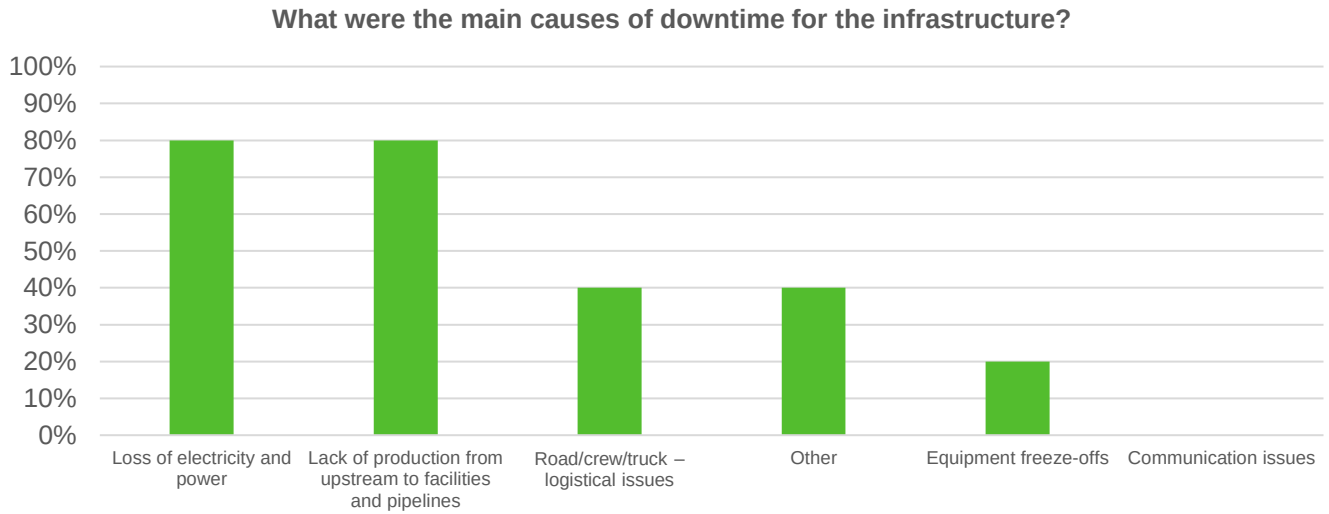
When these midstream operators were asked to quantify the volume scope of the outages, all responses are in the 51-75% and 76%+ range.

The reported causes of outages/downtime are highly attributed to loss of electricity and lack of production from other upstream facilities and pipelines.

These responses are generally in line with responses from upstream oil and natural gas survey data.







Source | TXOGA Member Responses to Enverus Survey

Other in causes includes: Voluntary shutdown, equipment malfunction (potentially due to weather) and loss of essential inputs from other facilities like nitrogen and steam.

Power Generation – ERCOT Demand Load

A combination of record winter demand and power unit outages cascaded into instability and outages across the ERCOT power grid, resulting in 4.5 million Texans without electricity at the peak.

Key Takeaway: Based on our assessment of available data and the timing of outages, it is likely the issues started at power generation units.

Key Takeaway: Once power outages began, natural gas production was impacted because surface facilities and infrastructure relies heavily on electricity for operations, which then exacerbated the ability for power generators to receive natural gas supplies.

ERCOT Power Grid Outage: Power Load/Demand

Texas was hit with one of the coldest winter events in its history. On Tuesday, Feb. 16, Dallas recorded temperatures as low as -2° F.

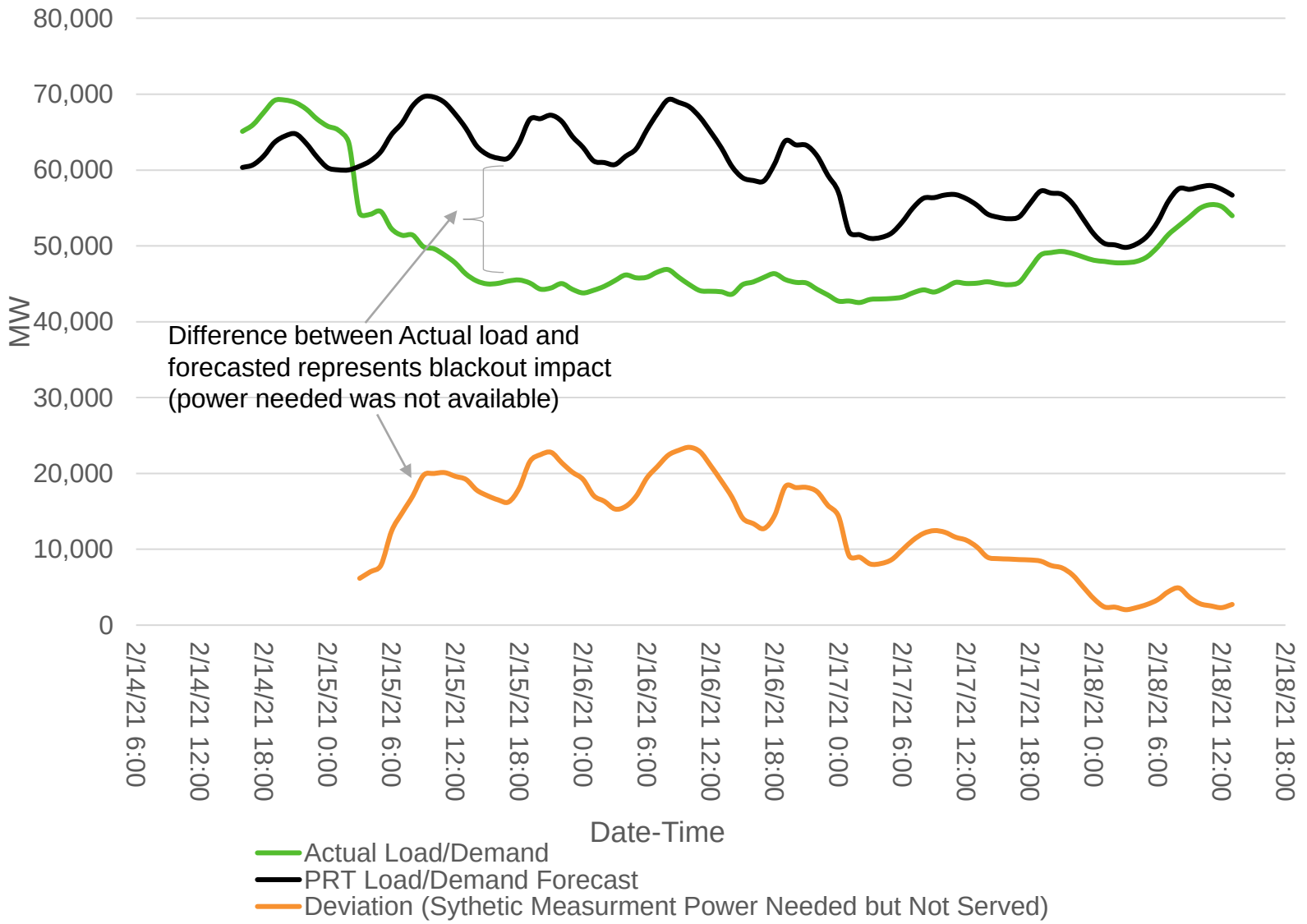
ERCOT reports, as early as 01:00 AM on Saturday, Feb. 14, a cascade of power generation reported output limitations or were forced offline that was impacted by the extreme weather. At its highest point, more than 48.6% of all generation in ERCOT was in forced outage.

At least 4.5 million customers were without power during the event. More than 13 million customers had water service interruptions.

ERCOT entered Emergency Operations Level 3 at 01:20 AM Monday, Feb. 15 and did not return to normal operations until 10:35 AM Friday, Feb. 19.

ERCOT ordered firm-load shed, cutting off customers' power from 01:20 AM Monday, Feb. 15 through the evening of Thursday, Feb. 18.

Load/Demand and Synthetic Measurement of Power Needed but Not Served



Source | ERCOT

Note: As early as 01:00 on 2/14/2021, two units at NRG's WA Parish Power Plant reported output restrictions (capacity derates).

ERCOT Power Grid Outage: Temperature Overview

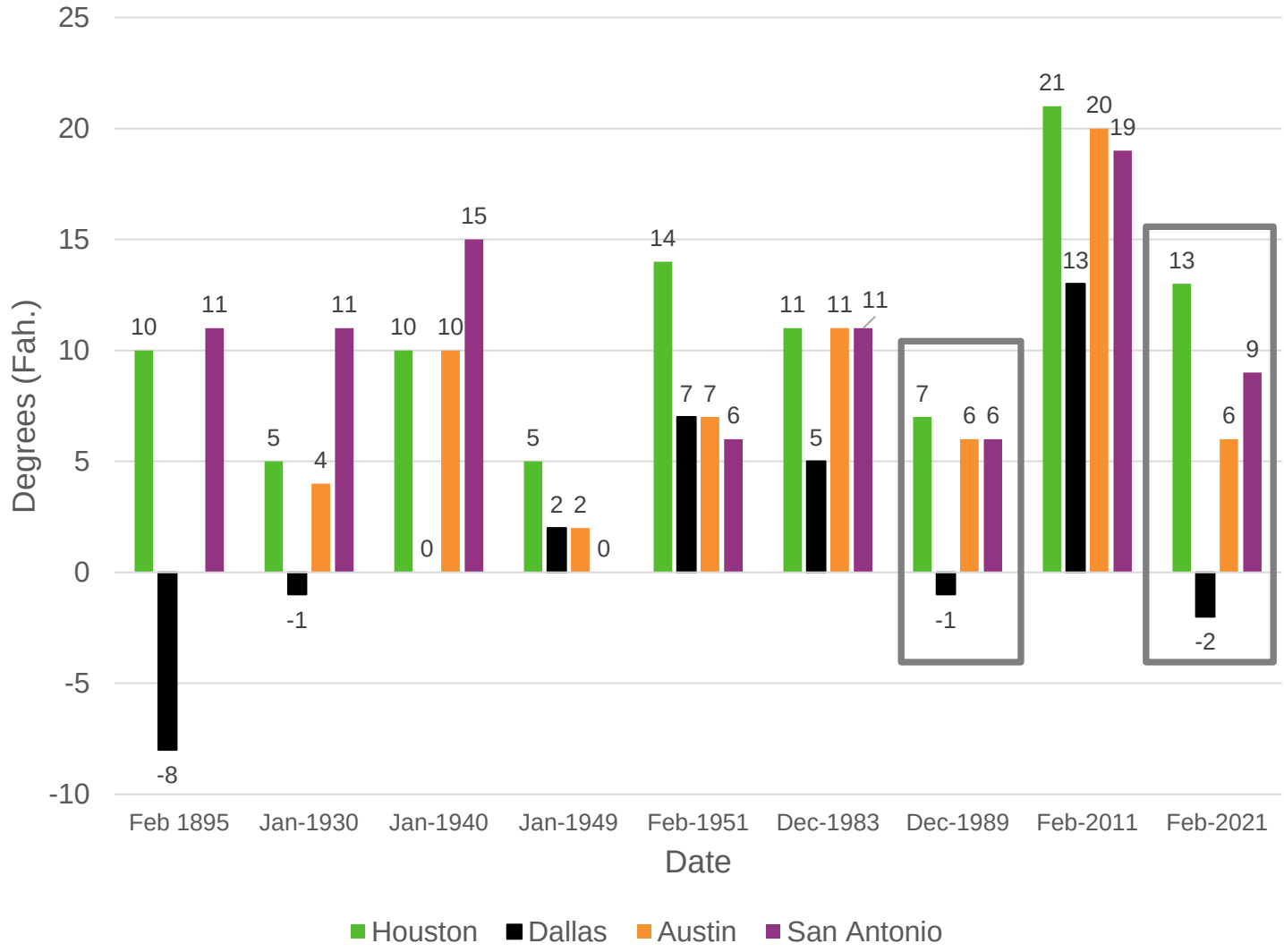
The Seasonal Assessment of Resource Adequacy (SARA) for the ERCOT Region Winter 2020/2021 used 2011 as the load comparison.

This chart illustrates lowest minimum temperatures for the four main cities in Texas for the 2021 cold snap event and the eight other events in history.

The low temperature for 2011, on a historic perspective, was relatively warm compared to other events.

The event in 1989, adjusted for current load, transmission, population, and resource variables, may have been a better option for extreme winter demand (load) planning.

Minimum Low Temperature For Uri Event By Largest City



Source | NOAA, National Weather Service

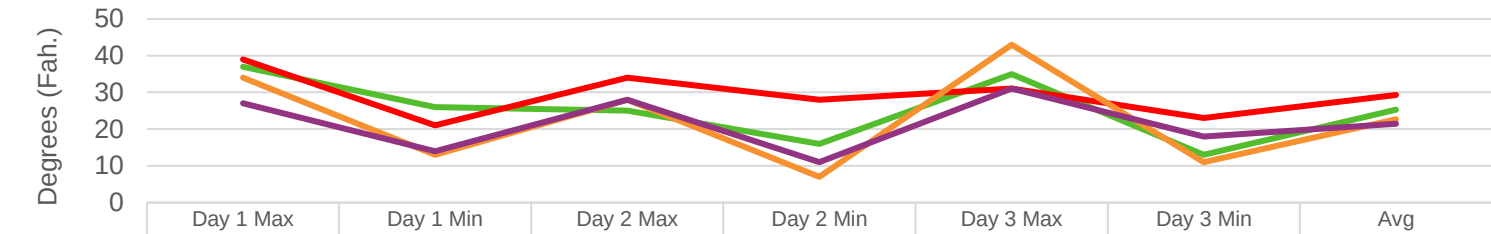
ERCOT Power Grid Outage: Temperature Overview

ERCOT Based the 2020/21 Extreme Winter Peak on the 2011 Winter

This weather comparison illustrates max/min trends across three days of the cold snap events for the four most recent events.

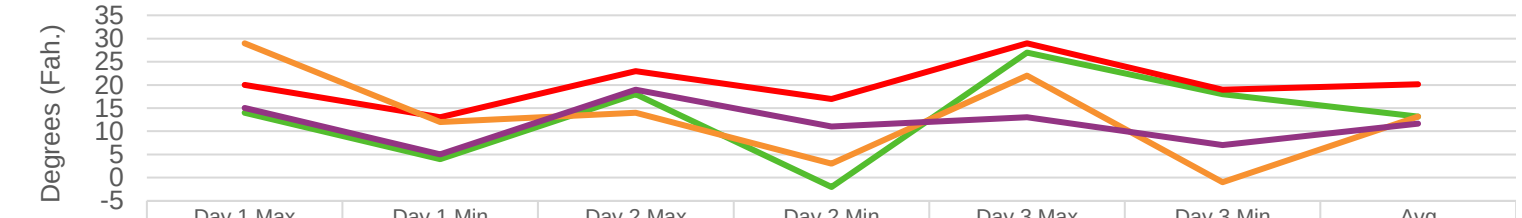
These comparison charts show 2011 was warmer during almost every day during these cold snap periods too.

Houston



	Day 1 Max	Day 1 Min	Day 2 Max	Day 2 Min	Day 3 Max	Day 3 Min	Avg
Feb-21	37	26	25	16	35	13	25
Feb-11	39	21	34	28	31	23	29
Dec-89	34	13	28	7	43	11	23
Dec-83	27	14	28	11	31	18	22

Dallas



	Day 1 Max	Day 1 Min	Day 2 Max	Day 2 Min	Day 3 Max	Day 3 Min	Avg
Feb-21	14	4	18	-2	27	18	13
Feb-11	20	13	23	17	29	19	20
Dec-89	29	12	14	3	22	-1	13
Dec-83	15	5	19	11	13	7	12

Source | NOAA, National Weather Service

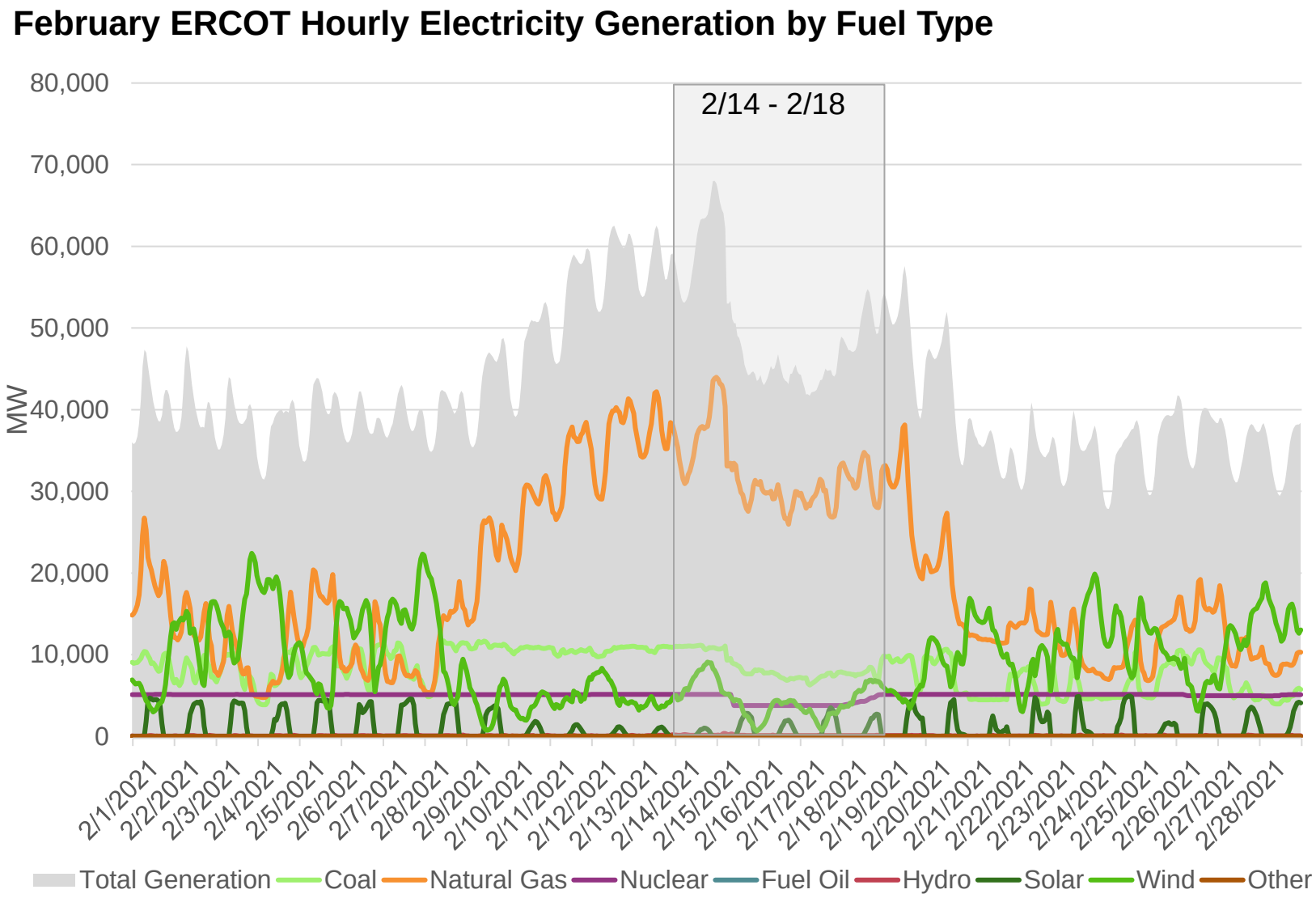
ERCOT Power Grid Outage: Electricity Generation

During this event, the peak was observed Sunday evening near 70,000 MW. This level of demand has never been observed before in the Winter season in ERCOT.

Traditional resources began going offline rapidly on Monday morning (see the dip in the gray area in the chart).

A dip in resources was observed in every fuel type, even nuclear. During this event, natural gas (orange) provided the majority of generation but also represented the largest share of outages. Wind and solar generation also dipped during this time as a result of weather, equipment freeze-offs, and transmission congestion.

At the peak of the event, 20,000 MW of natural gas generation came offline, followed by 6,000 MW of coal, 4,000 MW of wind, and 1,000 MW of nuclear.



Seasonal Assessment of Resource Adequacy (SARA) for the ERCOT Region Winter 2020/2021 Final Version Released 11/5/2020 vs. How Much Power Was Produced by Fuel Type

Early Monday morning (Feb. 15) power units of all types began tripping offline.

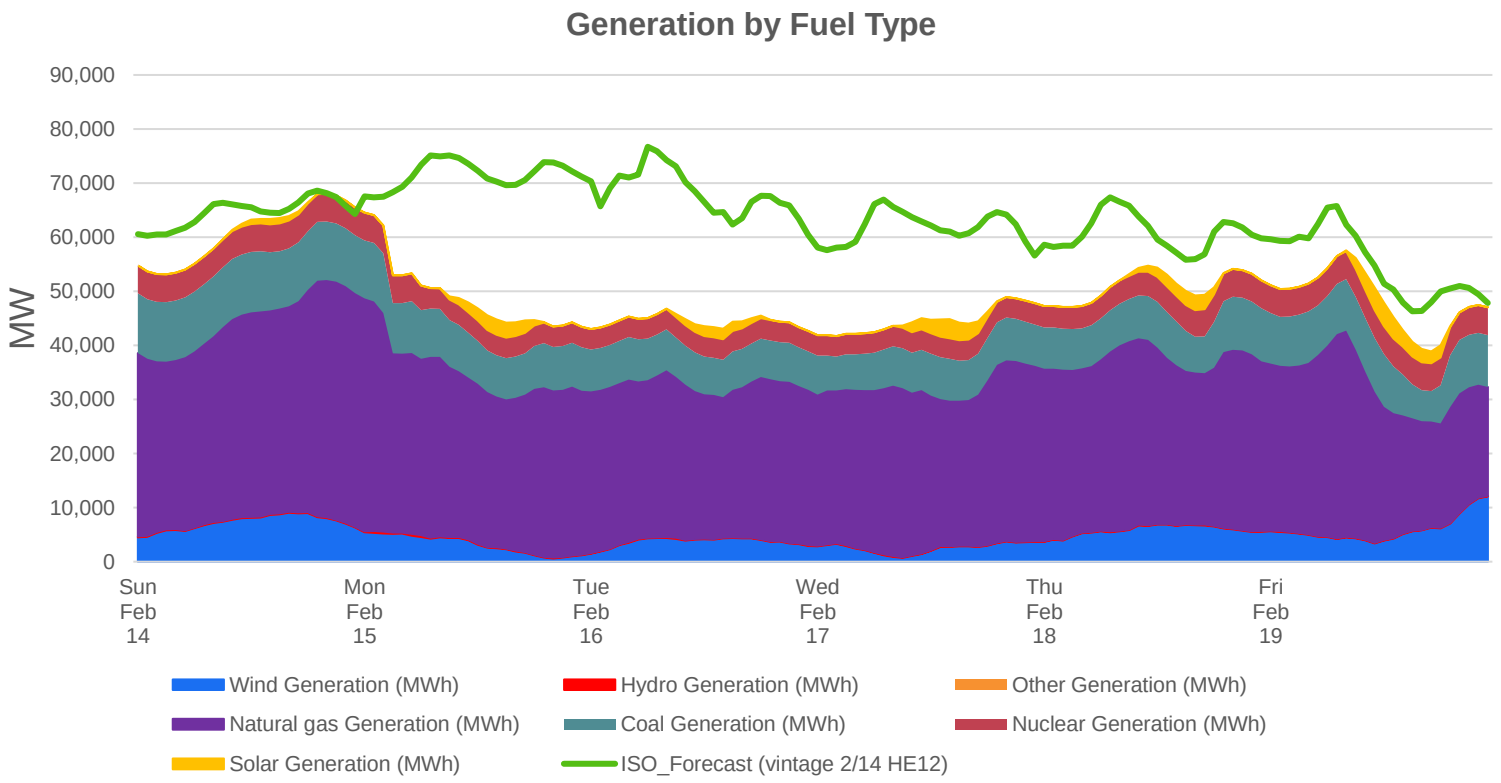
Approximately 48.6% of generation was forced out at the highest point due to the impacts of various extreme weather conditions.

Controlled outages were implemented to prevent a statewide blackout.

The ERCOT SARA report expected 67.2 GW of peak load which was based on the 2011 cold snap. The total resources that were expected to be available during such an event were 71.3 GW, which would have been adequate to meet that load. The top table shows the expected capacity by fuel type. The table in the next slide shows the power actually produced by each fuel type during the 2021 event.

However, the 2021 winter event was much colder. ERCOT forecasted load reached 75.8 GW, which far exceeded the resources available. ERCOT's planning group should have used the 1989 winter temperatures (see page 17).

ERCOT SARA-FinalWinter2020-2021 Forecasted Peak Capacity (GW)	
Natural Gas 48.4	Wind 6.1
Coal 10.9	Solar 0.3
Nuclear 5.2	Hydro 0.4
Extreme Peak Winter Load Forecast: 67.2 GW (Based on 2011 winter with revised economic growth)	



Source | EIA, ERCOT

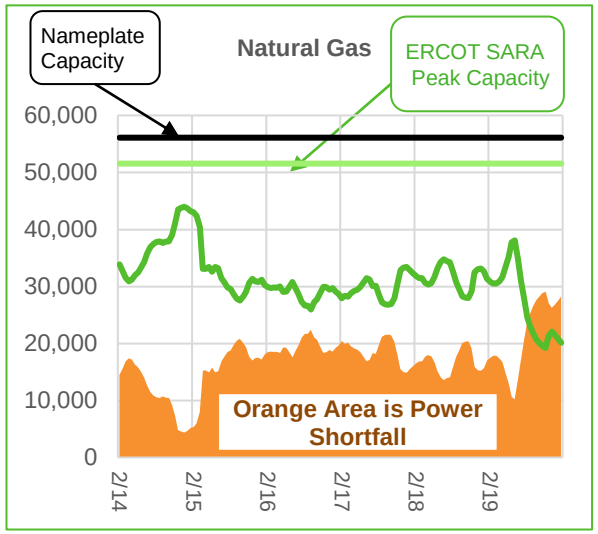
Power Generation by Fuel Type

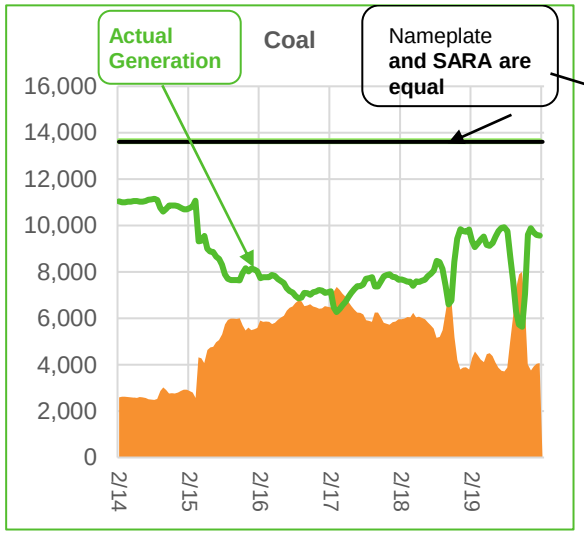
All major power generation fuel types underperformed the expected winter capacity rating that was planned in the SARA.

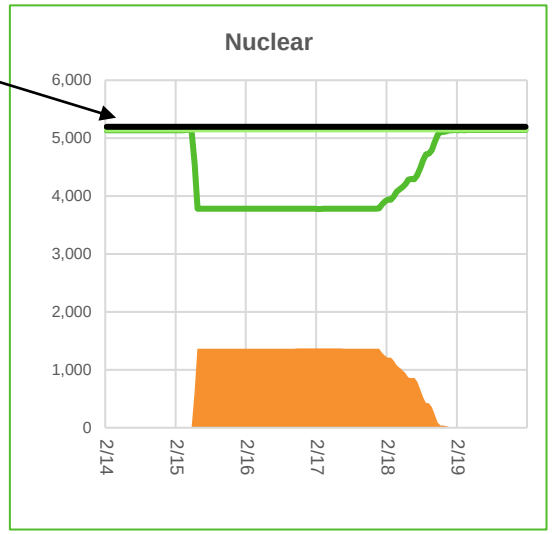
Actual generation was less than 50% of the planned generation for an extreme winter event.

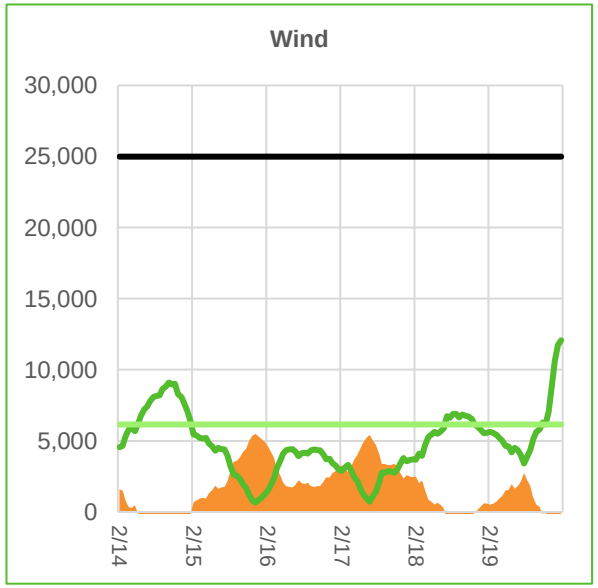
Natural gas power generation units were the worst performing of all fuel types. However, this illustration does not point to why the gas plants performed worse.

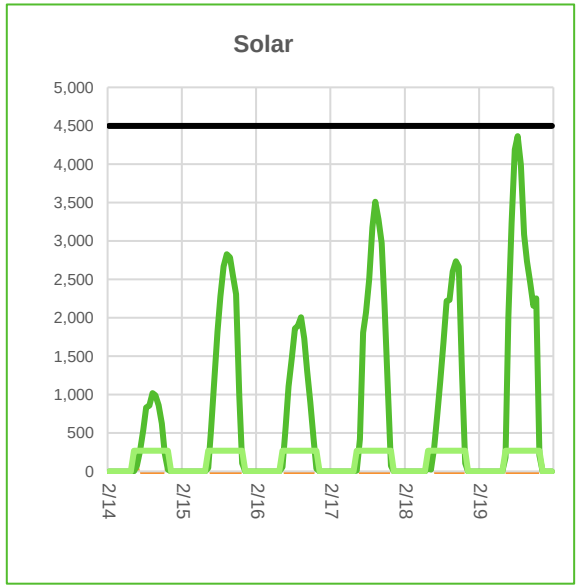
Fuel Type	SARA/Short of SARA Expectations (Average)	Nameplate Capacity/% SARA
Nat. Gas	48.4/17.3 GW	56.1/92% GW
Coal	10.9/5.1 GW	13.6/100% GW
Wind	6.1/1.4 GW	25.0/24% GW
Nuclear	5.2/0.7 GW	5.2/100% GW
Hydro	0.4/0.1 GW	0.5/80% GW

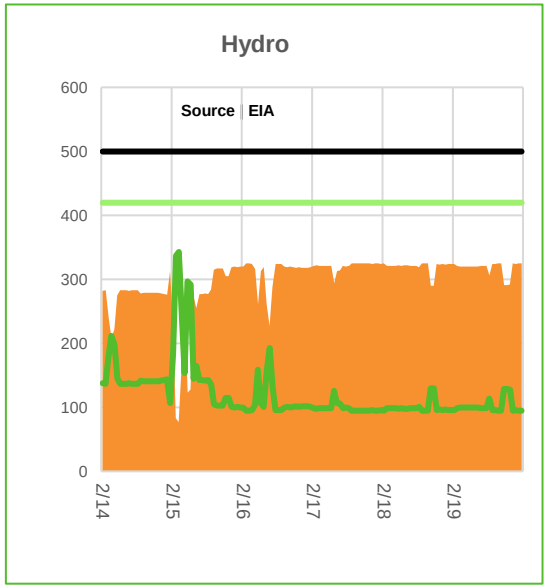












Storage and Natural Gas – ERCOT Demand Loads

The entire energy infrastructure chain was under significant stress during the storm. Texas lost significant natural gas production while local demand increased.

Key Takeaway: Even with these challenges, Texas natural gas production exceeded Texas demand during the storm, yet matching supply with demand proved challenging.

Key Takeaway: Natural gas storage withdrawals increased, however, some facilities faced power outages and were not able to operate at maximum levels.

Key Takeaway: Natural gas deliveries to LNG terminals, exports to Mexico, and exports to other neighboring regions were decreased and a significant amount of the natural gas available was used to meet demand within Texas.

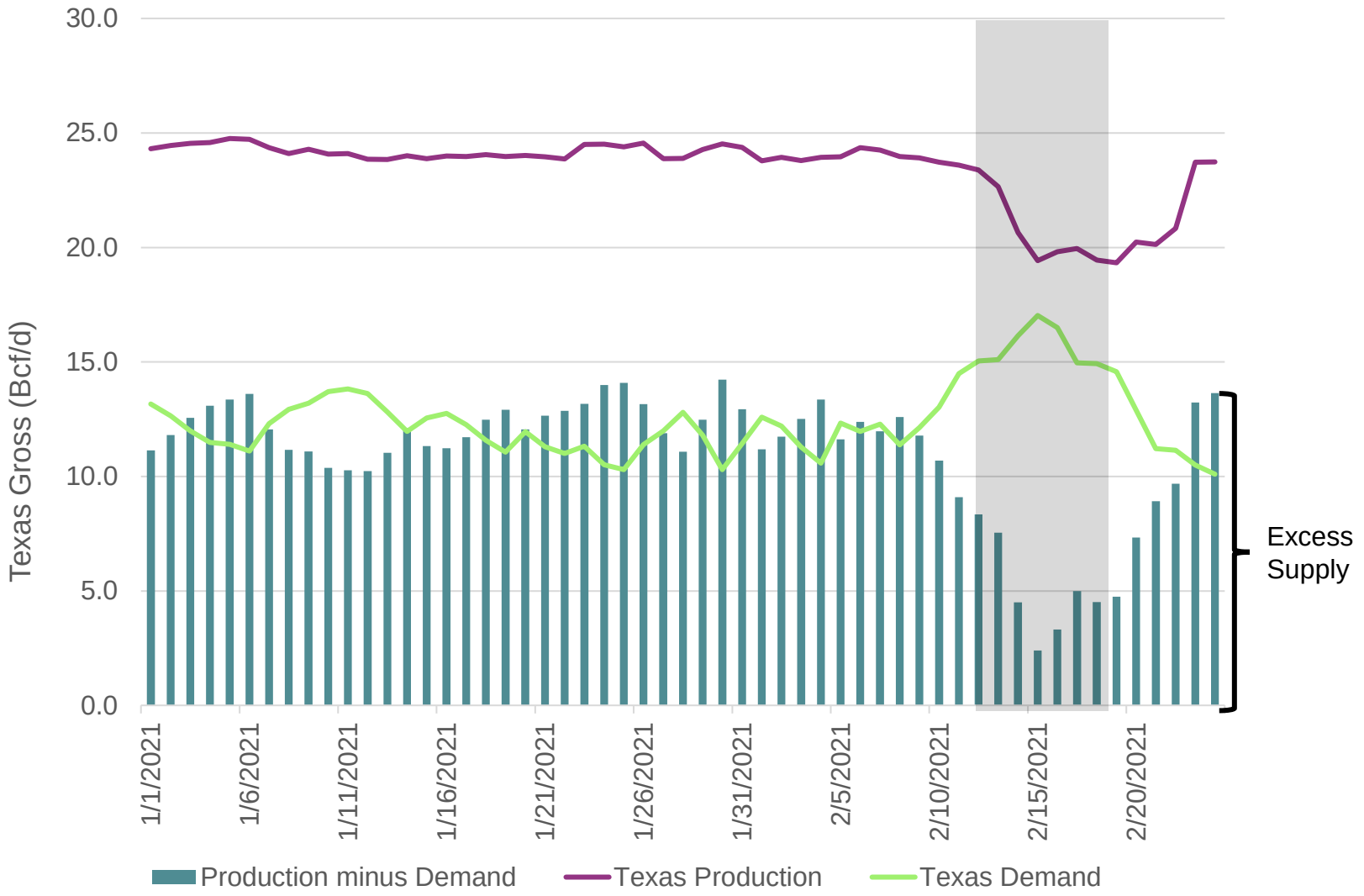
Texas Natural Gas Supply/Demand Balance and Pricing

Daily cash prices set all-time records across much of the U.S. in mid-February, with the Intercontinental Exchange (ICE) lifting its $999/MMBtu price cap as some hubs saw transactions at that level.

The supply shortage occurred due to shut-ins across the western half of the U.S. and extended to markets served by central and western U.S. supplies, including Chicago and SoCal but not areas served by WCSB, Haynesville or Appalachian supplies on the margin, such as Transco Zone 6 or Henry Hub.

In Texas specifically, production dropped while demand spiked [see Texas supply vs demand bar in chart], causing exports via LNG and pipelines from the state to be curtailed. Like the rest of the U.S., cash prices jumped to record-high levels, as shown in the chart on the next page. Houston Ship Channel (HSC) traditionally trades near Henry Hub or a cash basis of +/- $0.05/MMBtu. However, during the mid-February events, the HSC basis traded as high as $385/MMBtu (basis is the difference between the Henry Hub benchmark and the regional price hub).

Texas Production, Demand and Prices

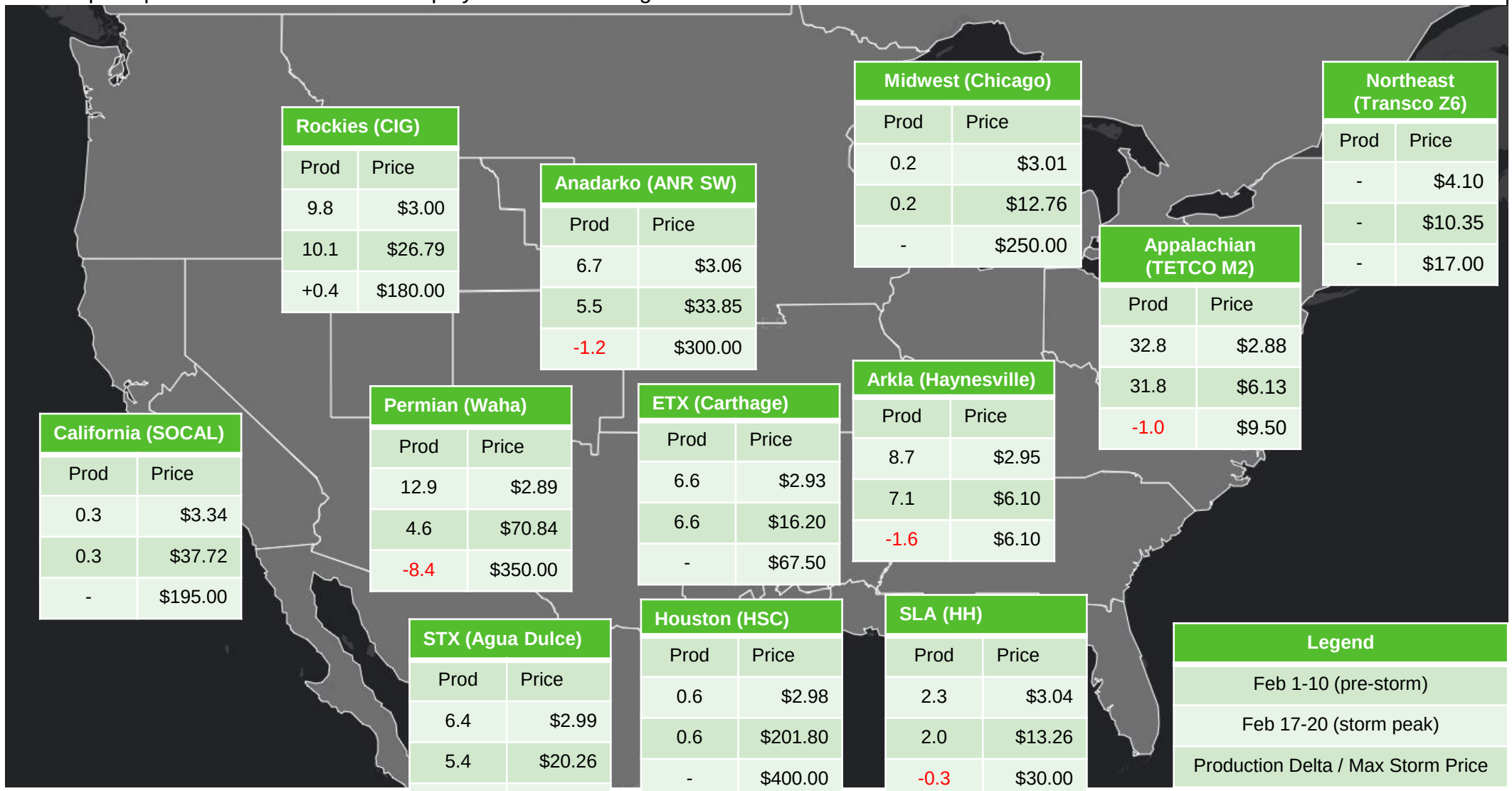


Source | Enverus OptiFlo Gas

Production and Price Activity Around the Storm

Each table displays average daily production and prices in key basins over two different periods in February (see legend in lower right).

- The intent is to highlight pre-storm or normal levels as compared to elevated levels experienced during the storm.
- Production (or 'Prod') is the Enverus modeled estimate which is grossed up from the observable interstate pipeline sample.
- The peak price for each hub is also displayed in the lower right of each table.



Rockies (CIG)	
Prod	Price
9.8	$3.00
10.1	$26.79
+0.4	$180.00

Anadarko (ANR SW)	
Prod	Price
6.7	$3.06
5.5	$33.85
-1.2	$300.00

Midwest (Chicago)	
Prod	Price
0.2	$3.01
0.2	$12.76
-	$250.00

Northeast (Transco Z6)	
Prod	Price
-	$4.10
-	$10.35
-	$17.00

Appalachian (TETCO M2)	
Prod	Price
32.8	$2.88
31.8	$6.13
-1.0	$9.50

California (SOCAL)	
Prod	Price
0.3	$3.34
0.3	$37.72
-	$195.00

Permian (Waha)	
Prod	Price
12.9	$2.89
4.6	$70.84
-8.4	$350.00

ETX (Carthage)	
Prod	Price
6.6	$2.93
6.6	$16.20
-	$67.50

Arkla (Haynesville)	
Prod	Price
8.7	$2.95
7.1	$6.10
-1.6	$6.10

STX (Agua Dulce)	
Prod	Price
6.4	$2.99
5.4	$20.26
-1.0	$125.00

Houston (HSC)	
Prod	Price
0.6	$2.98
0.6	$201.80
-	$400.00

SLA (HH)	
Prod	Price
2.3	$3.04
2.0	$13.26
-0.3	$30.00

Legend
Feb 1-10 (pre-storm)
Feb 17-20 (storm peak)
Production Delta / Max Storm Price

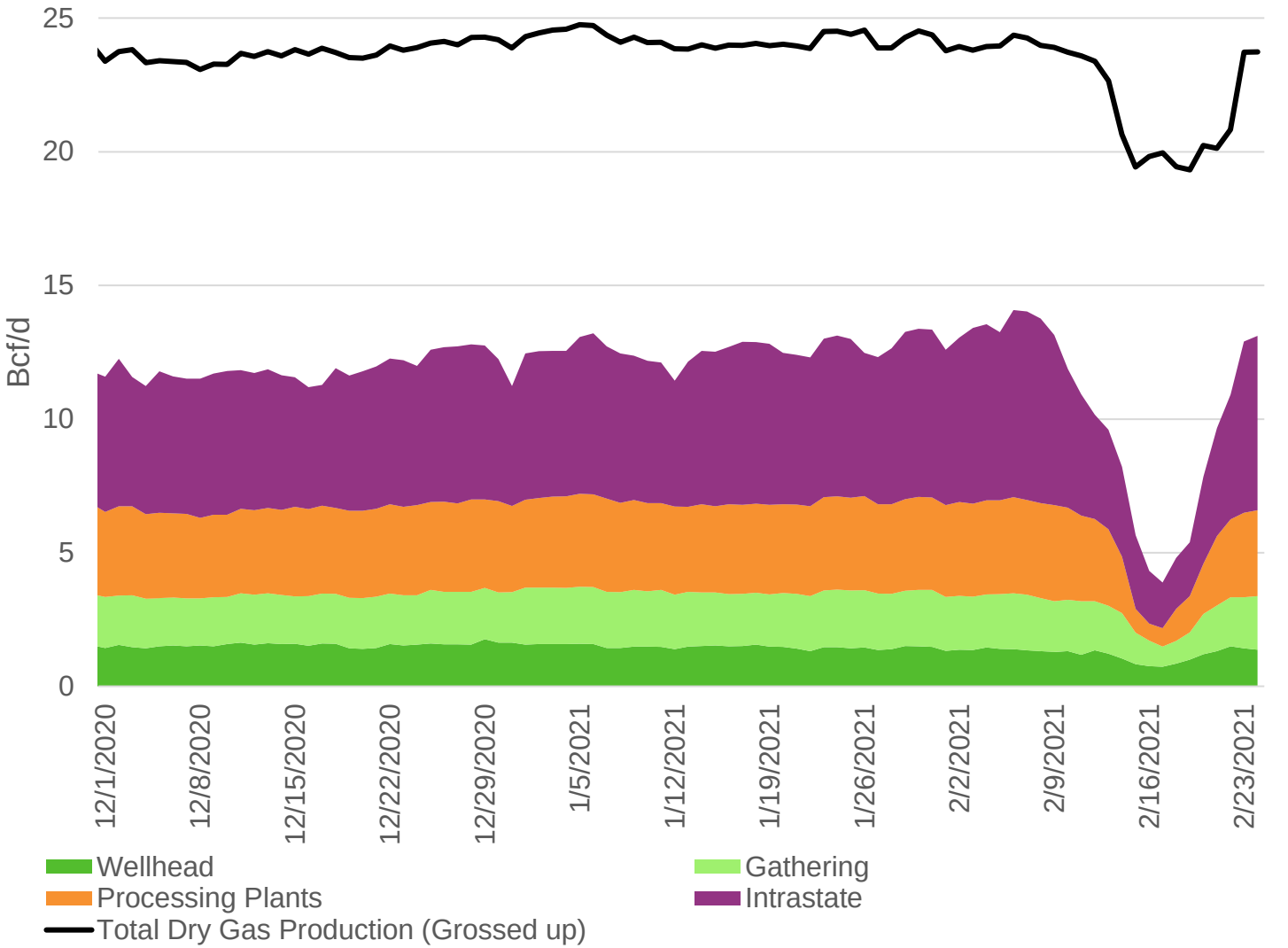
Texas Natural Gas Production

Because intrastate pipelines deliver so much Texas supply to markets, tracking daily production levels is more challenging in the state than in markets served by interstate pipelines.

Based on Enverus's sample of interstate receipts and deliveries, grossed up to account for intrastate volumes, natural gas production began to drop off on Feb. 12, when temperatures dropped below freezing in Dallas and Austin. As the deep freeze extended to all counties in Texas, ~5 Bcf/d of supply was offline. Freeze-offs and pipeline force majeures cut production.

Based on our samples, the cuts were steepest in the Permian. Although production has been almost fully restored, the collapse in completions and a slower recovery in frac activity could slow supply recovery in the basin in the months ahead.

Texas Production Sample by Facility Type and Total Dry Gas (Grossed Up)



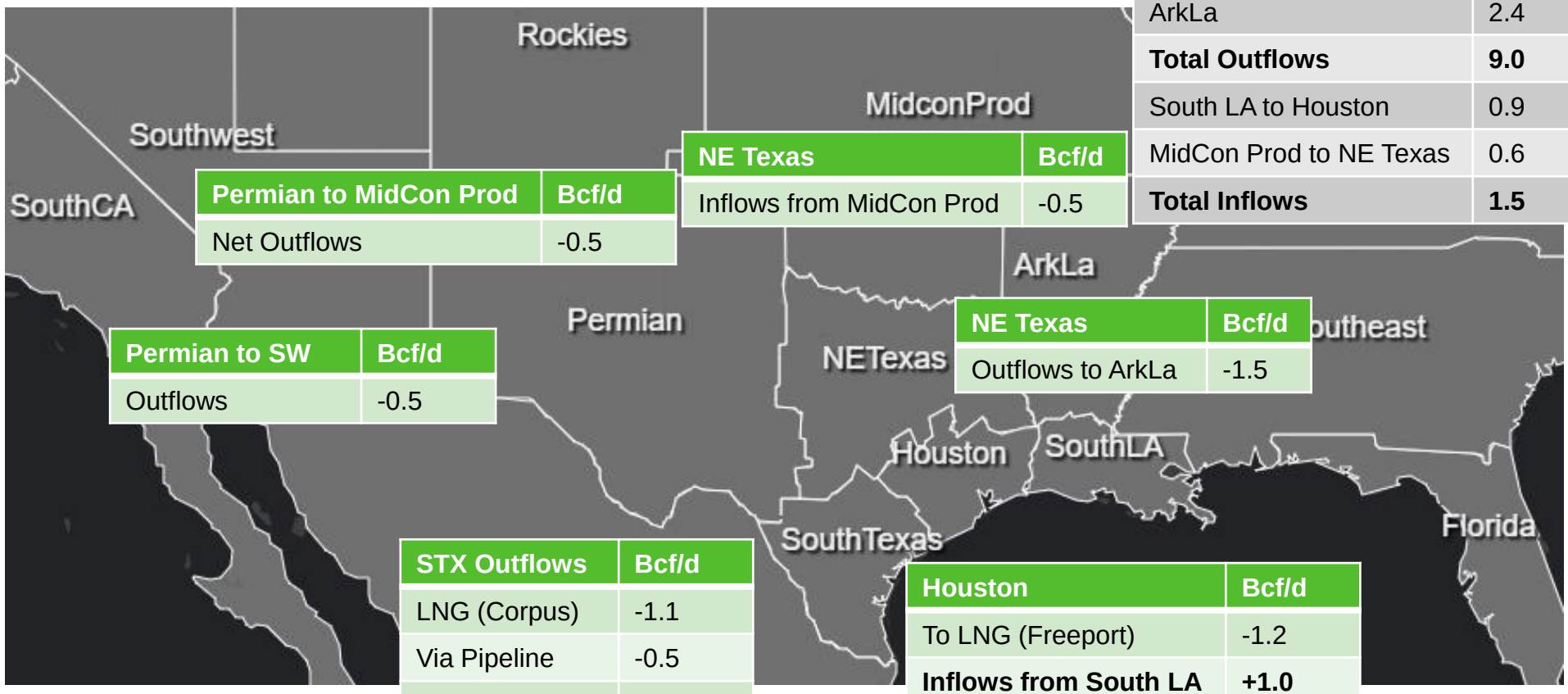
Source: Enverus OptiFlo Gas

Texas Natural Gas Inflows/Outflows Deltas

The tables show natural gas pipeline flow changes between the peak of the storm (Feb. 17-20) vs. pre-storm levels (Feb. 1-10):

- For the most part, Texas sent less natural gas out, which is represented by outflows showing negative figures. Therefore, Texas sent less natural gas out to LNG, Mexico and the West (SW toward California).
- Texas only received more natural gas from South LA (+1 Bcf/d), specifically from TETCO and Transco pipelines.

Inflows/Outflows (Bcf/d)	Feb 1-10	Feb17-20	Delta
Permian to SW	0.6	0.1	-0.5
Permian to MidCon Prod	1.0	0.5	-0.5
LNG	3.3	1.0	-2.3
Mexico	1.7	1.2	-0.5
ArkLa	2.4	0.9	-1.5
Total Outflows	**9.0**	**3.7**	**-5.3**
South LA to Houston	0.9	1.9	+1.0
MidCon Prod to NE Texas	0.6	0.1	-0.5
Total Inflows	**1.5**	**2.0**	**+0.5**



Permian to MidCon Prod	Bcf/d
Net Outflows	-0.5

NE Texas	Bcf/d
Inflows from MidCon Prod	-0.5

Permian to SW	Bcf/d
Outflows	-0.5

NE Texas	Bcf/d
Outflows to ArkLa	-1.5

STX Outflows	Bcf/d
LNG (Corpus)	-1.1
Via Pipeline	-0.5
Total	**-1.6**

Houston	Bcf/d
To LNG (Freeport)	-1.2
Inflows from South LA	**+1.0**

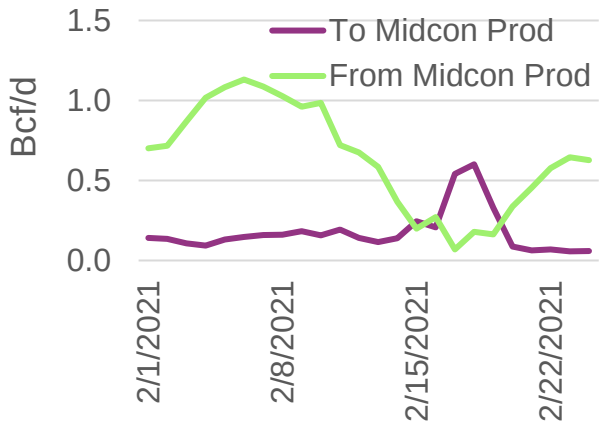
Source: Enverus OptiFlo Gas

Texas February Inflows and Outflows

Texas is a net supply state, meaning it produces more than its local demand. Gas moves out of the state via pipelines and LNG terminal facilities. During the recent storm, these paths were largely impacted.

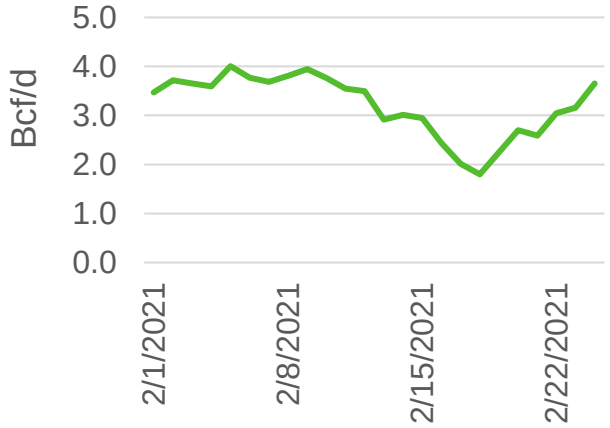
Permian to Southwest

Permian

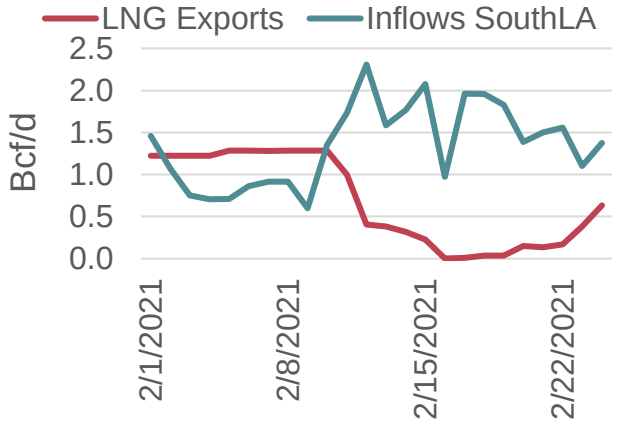


Midcon Prod to NE Texas

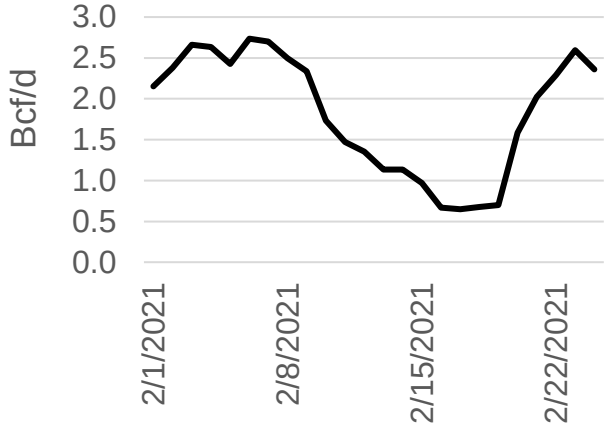
South Texas to LNG and MX



Houston



NE Texas to ArkLa

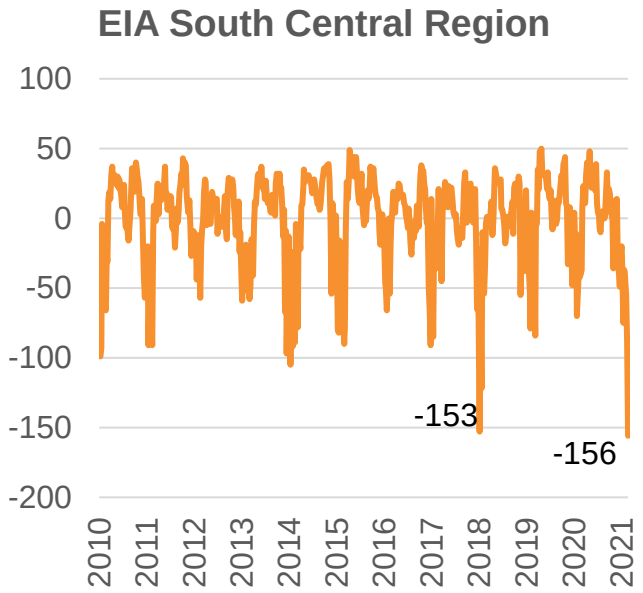


Source | Enverus OptiFlo Gas

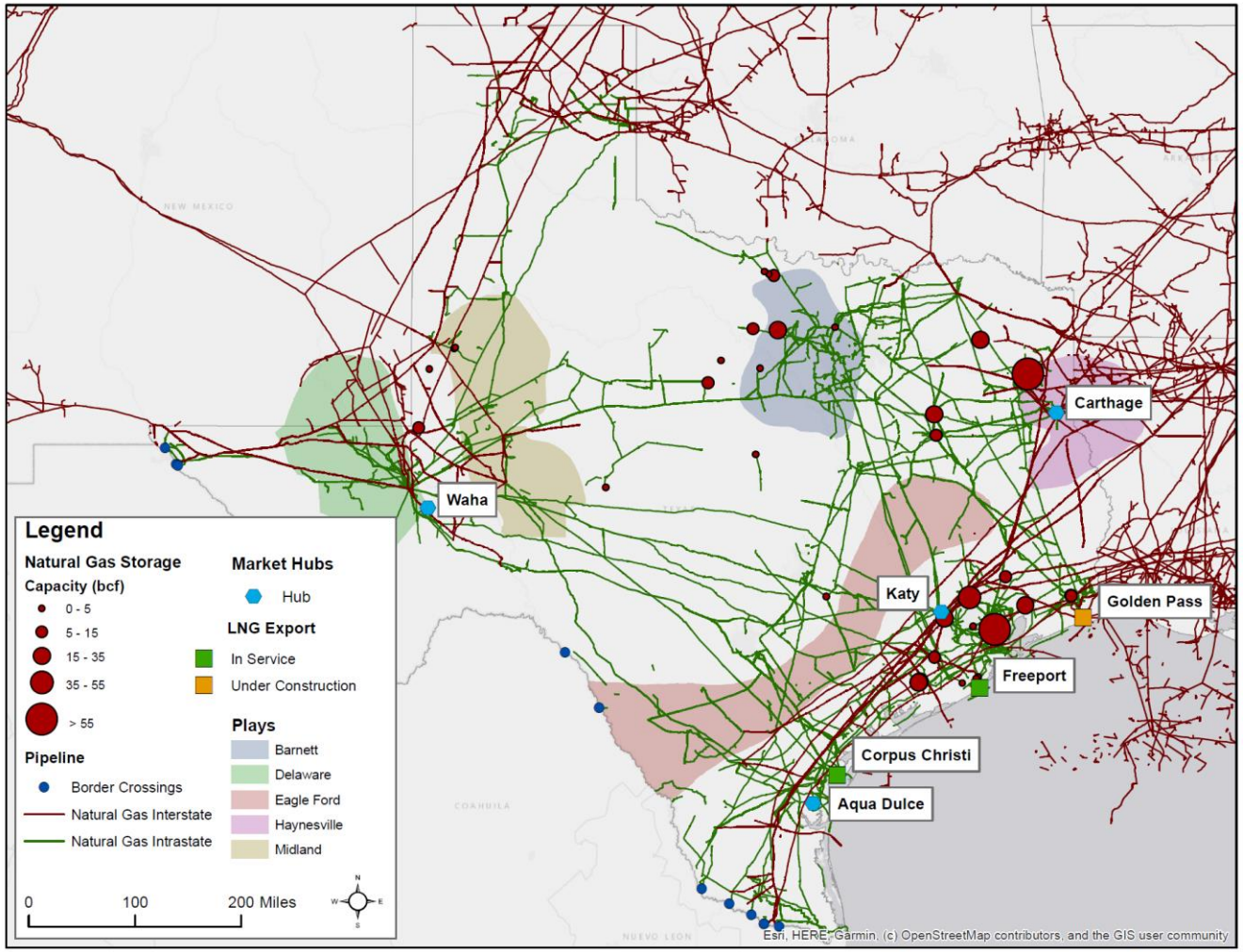
Underground Natural Gas Storage

EIA South Central Region comprises the states of TX, LA, OK, KS, AR, MS and AL. Texas has 30 storage fields, which represent 35% of the working gas capacity of the region.

A record-high withdrawal of -156 Bcf was reported by EIA for the week ending Feb. 19. This withdrawal could have been higher, but power outages and other operational conditions due to the extreme temperatures limited the ability to bring more natural gas to the market.



Texas Gas Infrastructure Map



Source | Enverus OptiFlo Gas, EIA

Texas Storage Sample from Pipeline Data

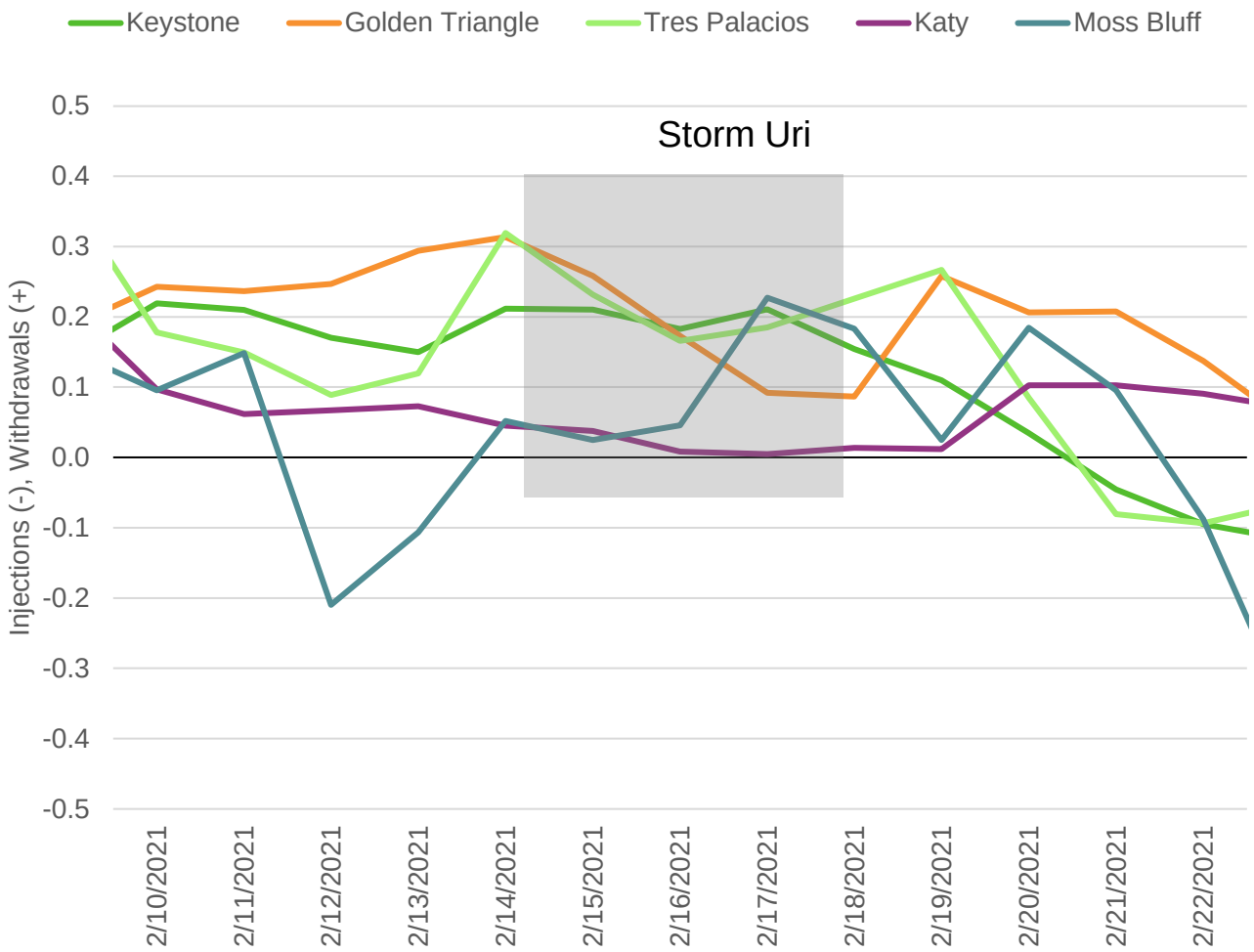
There are five natural gas storage facilities observable in the pipeline flow data. Storage activity around Winter Storm Uri is shown in the chart.

Even though the sample is small (~15%), it provides some insight into how storage facilities responded during this critical time.

Three out of the five fields reported lower withdrawals during the storm. Tres Palacios was one of these facilities and a Critical Notice was issued indicating loss of power as the reason.

The other two fields, Keystone and Moss Bluff, did report higher withdrawals during the storm, providing much-needed supply to the Texas market.

Texas Gas Storage Facilities – Net Storage Withdrawals



Source | Enverus OptiFlo Gas

Pipeline Notices

Pipeline notices are published in natural gas pipeline portals called EBBs (Electronic Bulletin Boards) to communicate with shippers and natural gas market players.

A summary of these notices is included in the table:

- Pre-Storm (Weather Alerts): Some pipelines sent critical notices as early as Feb. 2nd notifying of the colder-than-normal temperatures in the forecast.
- Pipelines in stress. Due to the storm, most pipelines declared either an OFO (Operational Flow Order), SOC/COC (Strained and Critical Operating Condition) or FM (Force Majeure). During these events, only firm and primary receipt and delivery nominations are accepted.
- During the Storm: Notices about pipeline imbalances and lack of supply.
- Loss of power was only announced at 2 of the 24 systems reviewed: Golden Pass and Tres Palacios.

Pipeline	Pre- Storm (Weather Alerts)	OFO/FM	During the Storm	Power Outage
El Paso	2/10	SOC/COC: 2/12-18	Washington gas storage (NM) on maximum withdrawal. Permian basin supply losses due to freeze offs	-
NGPL	2/10-High demand	-	Various locations at risk for transport. IT storage also limited.	-
Tennessee	-	OFO: 2/12-2/20	-	-
Texas Eastern	-	OFO: 2/12-2/20	Restricted IT and secondary out of path volumes.	-
Texas Gas	2/10	-	-	-
Transco	-	-	Notices of some Texas meters having capacity reduced.	-
Black Marlin	-	-	-	-
Cimarron	2/15	-	2/15-2/23: lack of supply volumes	-
Golden Pass	-	FM: 2/16-2/17	-	2/16
Golden Triangle	-	-	-	-
Gulf States	-	-	-	-
High Island	-	-	-	-
Tiger	-	-	Underperforming meters in LA	-
Tres Palacios	-	FM: 2/15-2/18	-	2/15-2/17
ANR	-	-	-	-
Enable	-	OFO: 2/10-2/18	Supply advisory, Human needs requirements	-
Florida Gas	2/2: Operational Alerts	-	Operational alerts: tolerance 5-15%	-
Gulf South	-	-	-	-
MRT	-	OFO: 2/11-2/18	-	-
Panhandle	2/3	OFO: 2/15-2/18	-	-
Northern Natural	-	FM: 2/15-2/16	-	-
Southern Star	2/2	OFO Storage: 2/15-2/17	Underperforming notices due to imbalances	-
Transwestern	2/11	-	-	-
Trunkline	2/3	OFO: 2/17-2/19	-	-

Source | Enverus, Pipeline EBBs

Note: Primary receipt and delivery meters are defined in contracts. During OFO events shippers can only nominate to/from, from these primary meters and lose flexibility to nominate to other meters (or out of path meters).

Power Demand for Natural Gas During the Storm

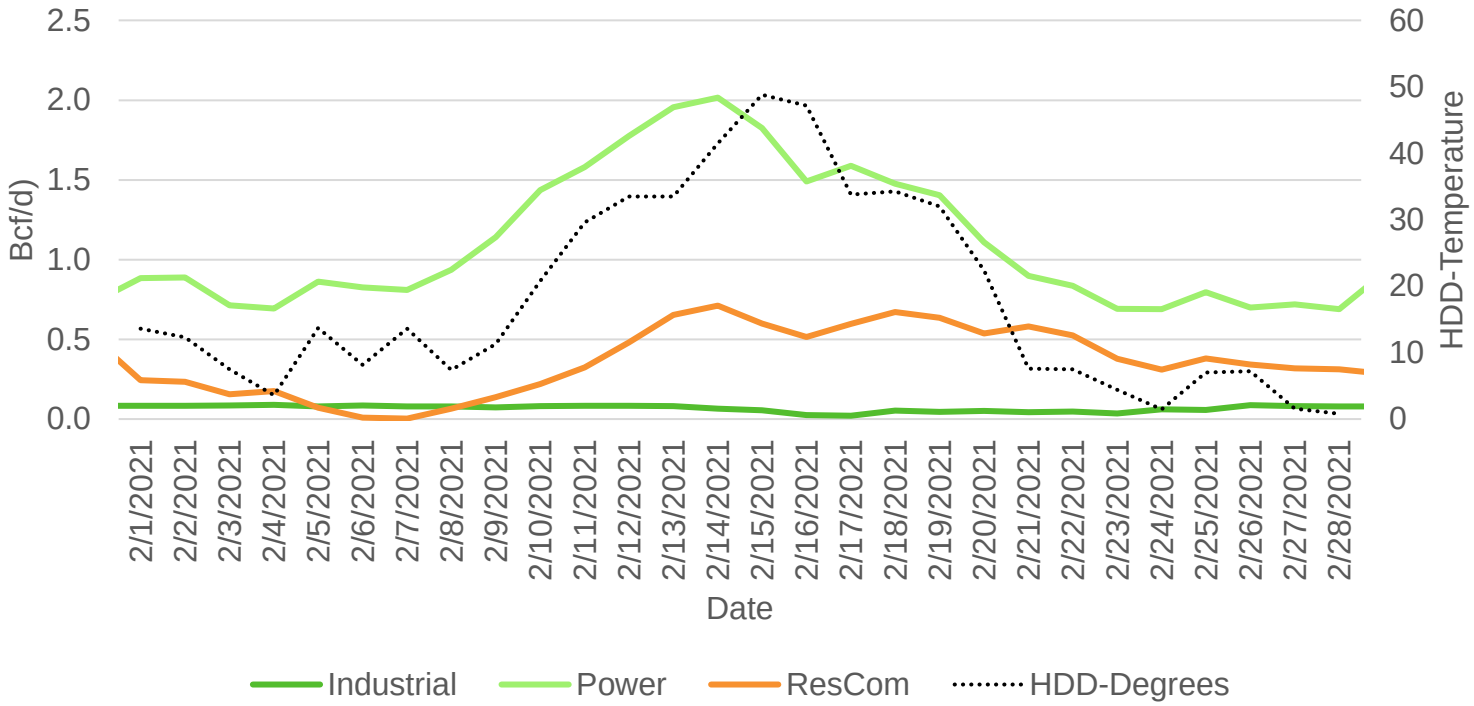
Natural gas pipeline data indicates power and residential/commercial meters were up significantly during the peak of the storm (Feb. 17-20) compared to pre-storm levels (Feb. 1-10) and post-storm levels.

However, power demand after Feb. 14 declined, as power service necessary for natural gas midstream infrastructure to operate was offline and remaining available natural gas supplies were prioritized for home heating. Residential/commercial natural gas demand was more consistent through the peak period.

The industrial facility sample decreased over the same time period, as service to homes for heating and power plants was prioritized.

Definition of Heating Degree Day (HDD): The number of heating degrees in a day is defined as the difference between 65°F and the mean temperature (average of the daily high and daily low).

Demand by Sector - Pipeline Sample



Feb. 17-20 vs Feb. 1-10	Bcf/d	%
Industrial	-0.03	-43%
Power	+0.15	+12%
Residential/Commercial	+0.32	+112 %
Total Inflows	**+0.45**	**+28%**

Source | Enverus OptiFlo Gas

Generator Failures

Power generators across the state of Texas failed.

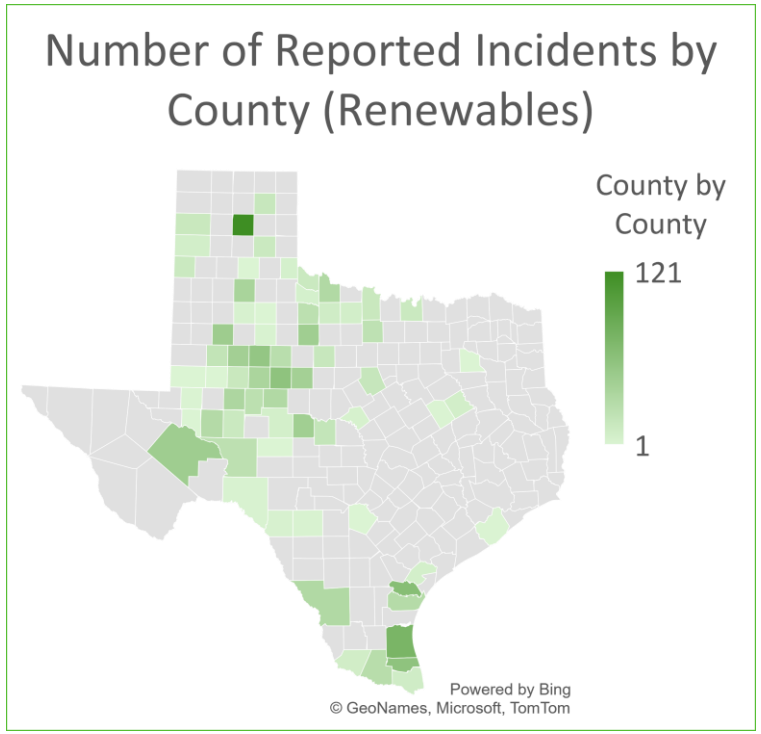
Key Takeaway: Power generators in South Texas were more suspectable to outages as their tolerance for cold weather is lower. Power plants around the Houston area were also especially vulnerable to the cold weather. In addition, some of the older wind generators in West Texas saw heavy capacity reductions.

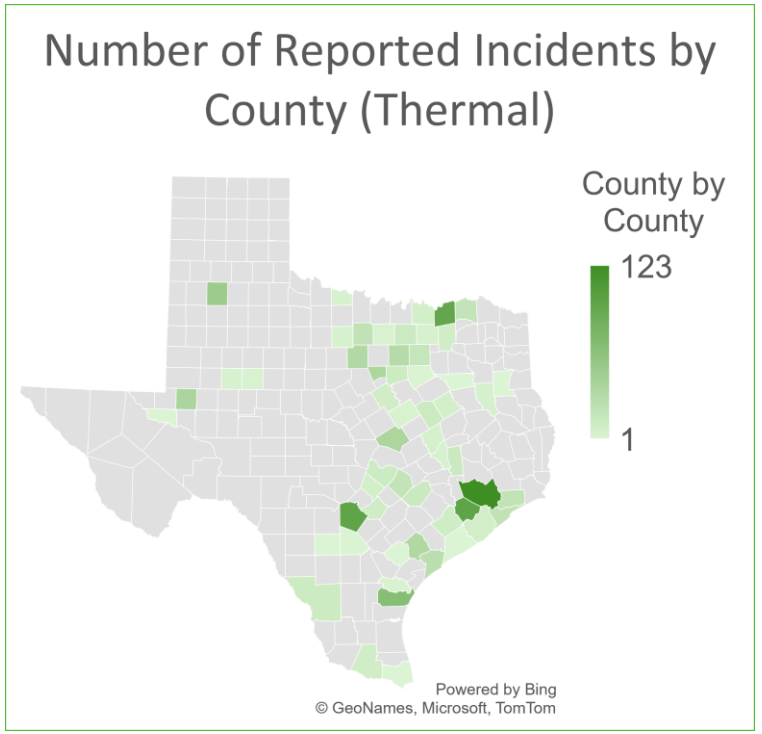
Capacity Reduction Incidents (Derate/Outages) by Resource Class from February 10 – 19, 2021

Widespread issues were observed in South Texas. Kenedy County appeared to have a disproportionate number of issues during the event.

Older wind farms in West Texas near Scurry and Nolan Counties also appear to have had an inordinate number of reported capacity related incidents.

Thermal resource incidents and outages were heavily focused in the Houston area. Harris and Fort Bend Counties experienced a significant number of capacity incidents.





Capacity Reduction Incidents (Derate/Outages) of Units by Resource Class February 15 00:00-02:00

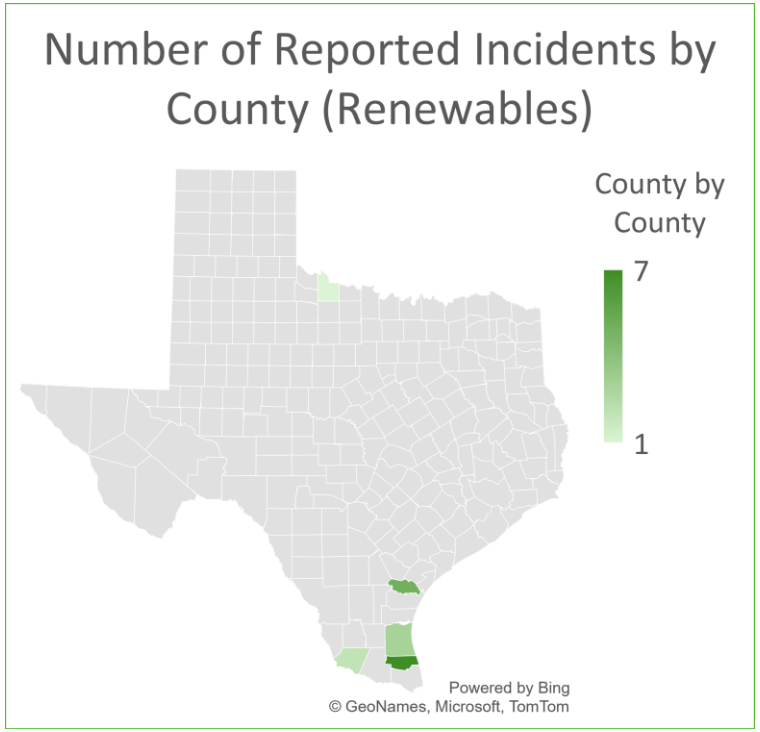
Between Midnight and 02:00 AM, the power units that tripped offline were localized south of Austin.

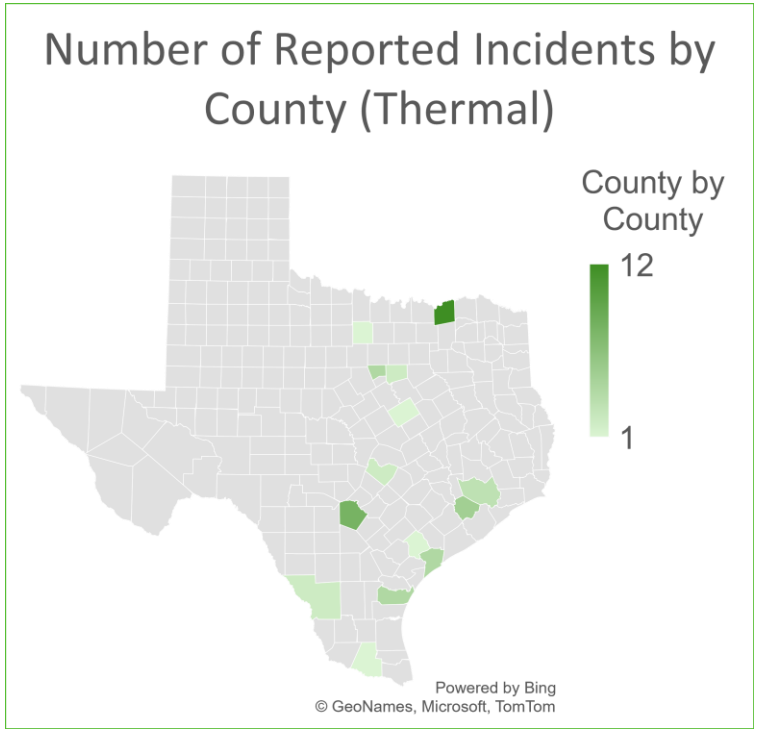
A large unit in North Texas tripped with a significant amount of capacity offline at 13,700 MW.

KIAMICHI ENERGY FACILITY reported several incidents at 00:30 AM.

South Texas wind farms comprised the majority of renewable capacity reductions during this time.

The quick succession of outage observed in this limited timeframe, combined with the wide geographic location of these outages indicates the initial problems did not occur as a result of natural gas supply outages, but instead likely occurred due to other reasons at the power generation level.

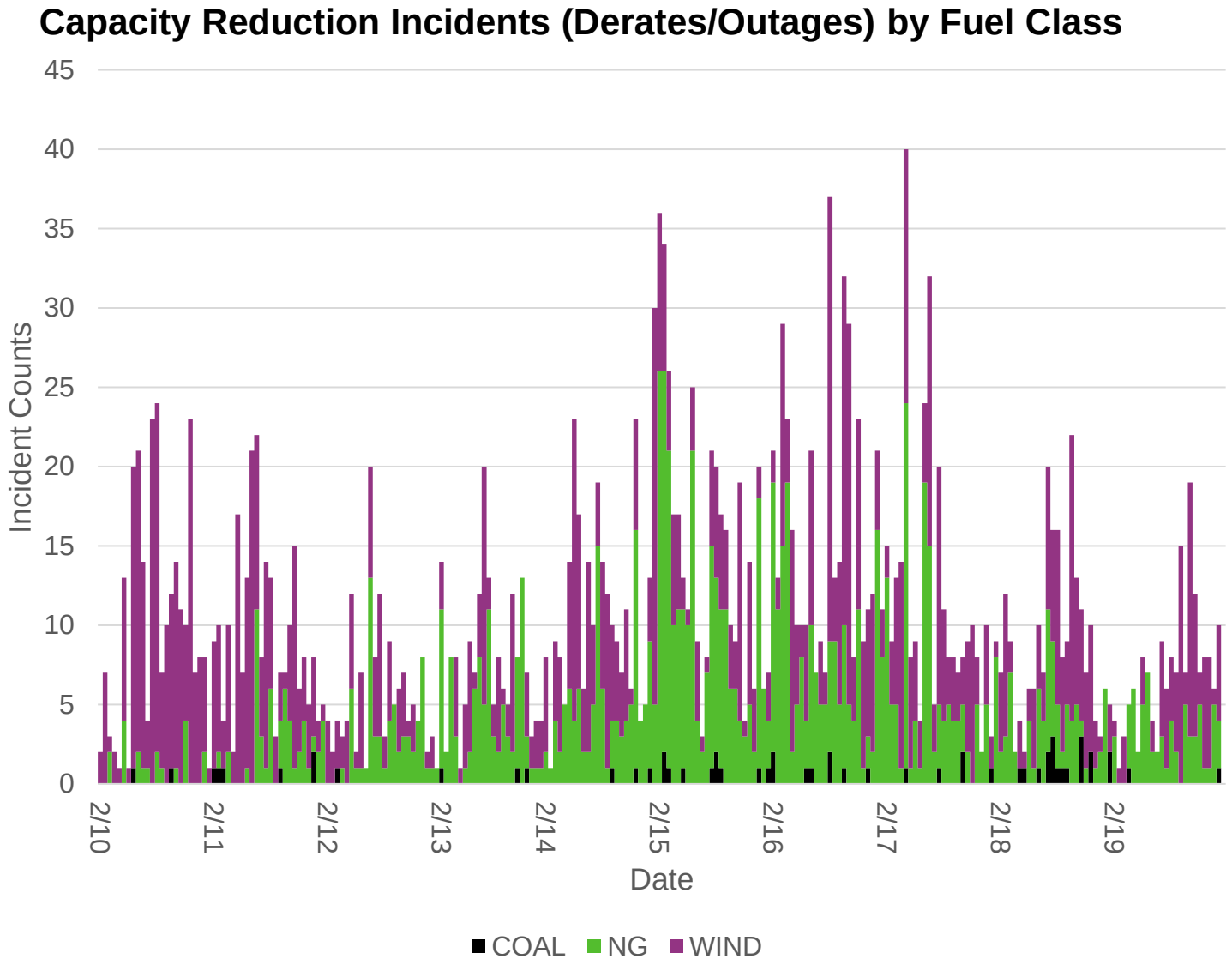




Capacity Reduction Incidents (Derate/Outages) of Units by Fuel Class from February 10 – 16, 2021

Wind units were reporting capacity reductions as early as Wednesday, Feb. 10, likely due to icing of the turbine blades and similar weather-related issues.

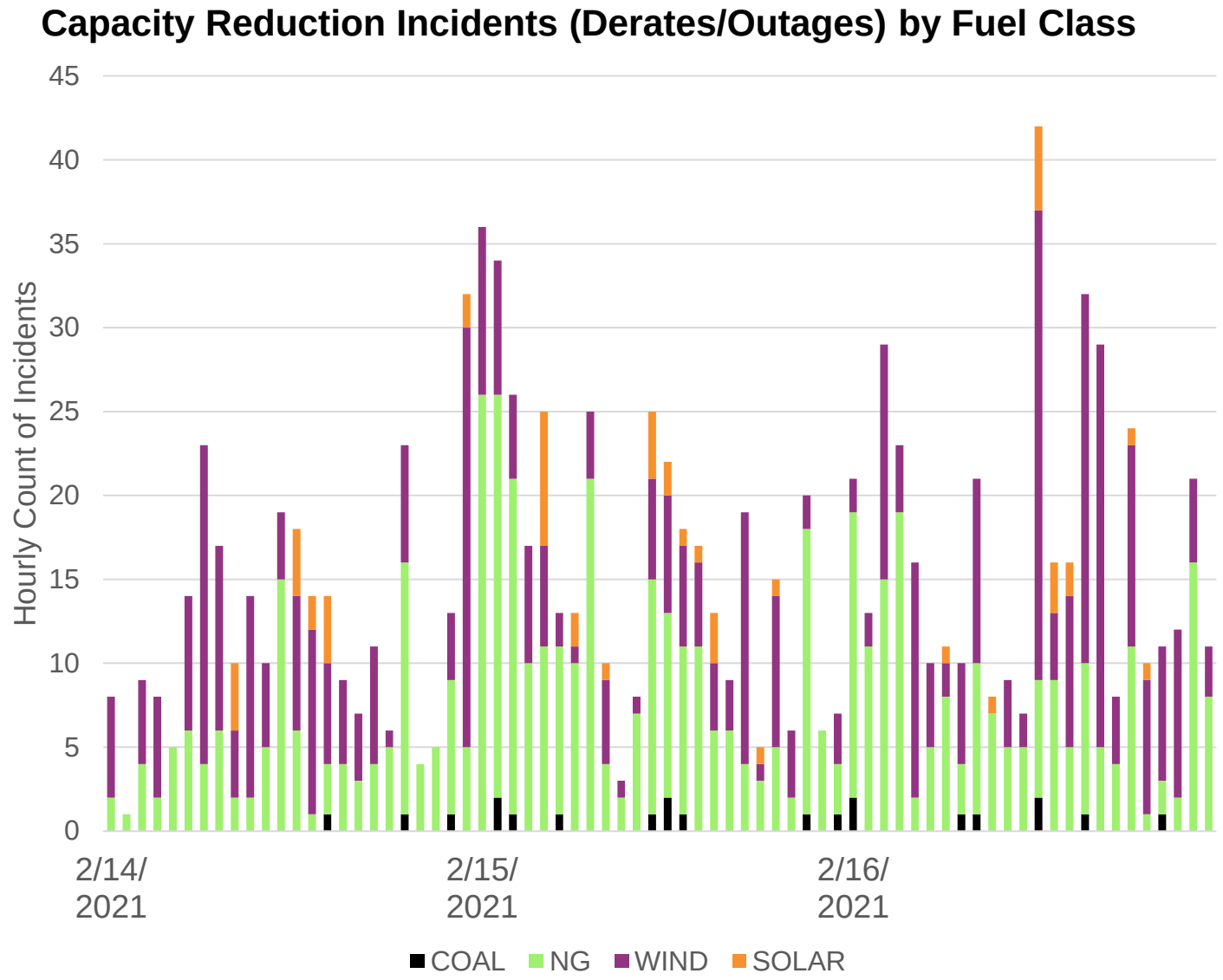
These issues with the wind farms persisted through the cold snap event and contributed to grid instability.



Capacity Reduction Incidents (Derate/Outages) by Fuel Class from February 14 – 16, 2021

Natural gas was the dominant fuel class to report capacity reductions for power generation during the event, followed by derates/outages at wind farm sites.

Capacity reductions at coal plants increased during the peak of the blackouts.



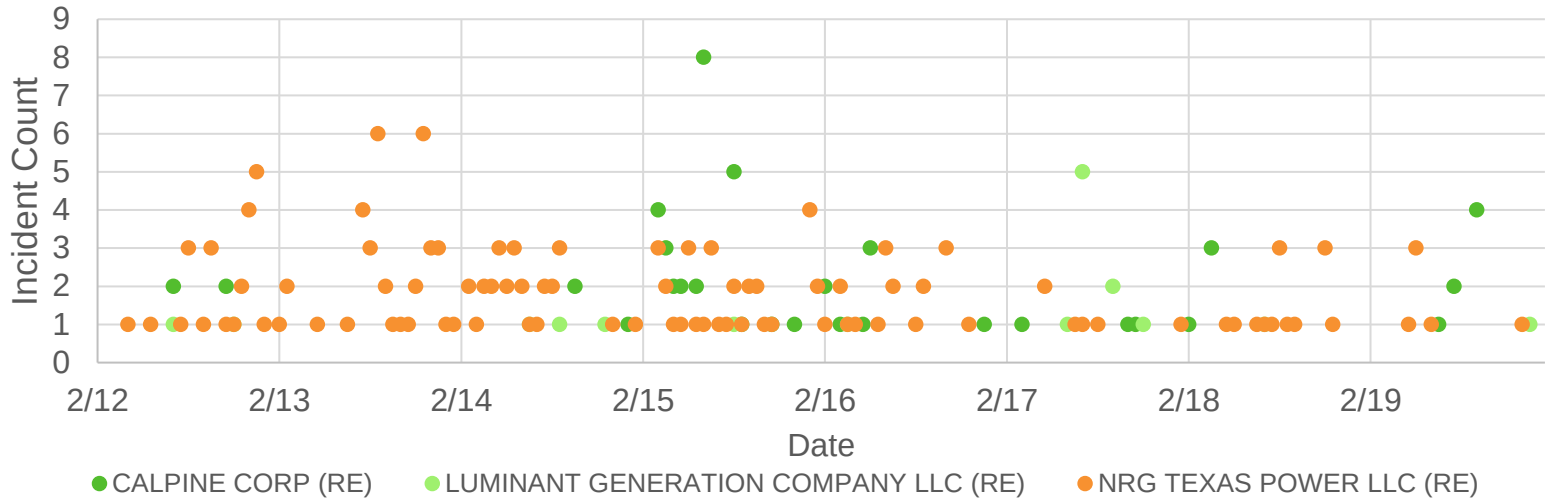
Capacity Reduction Incidents (Derate/Outages) by Generator Owners from February 12 – 19, 2021

NRG in the Houston area had a large number of capacity related issues over the course of the event.

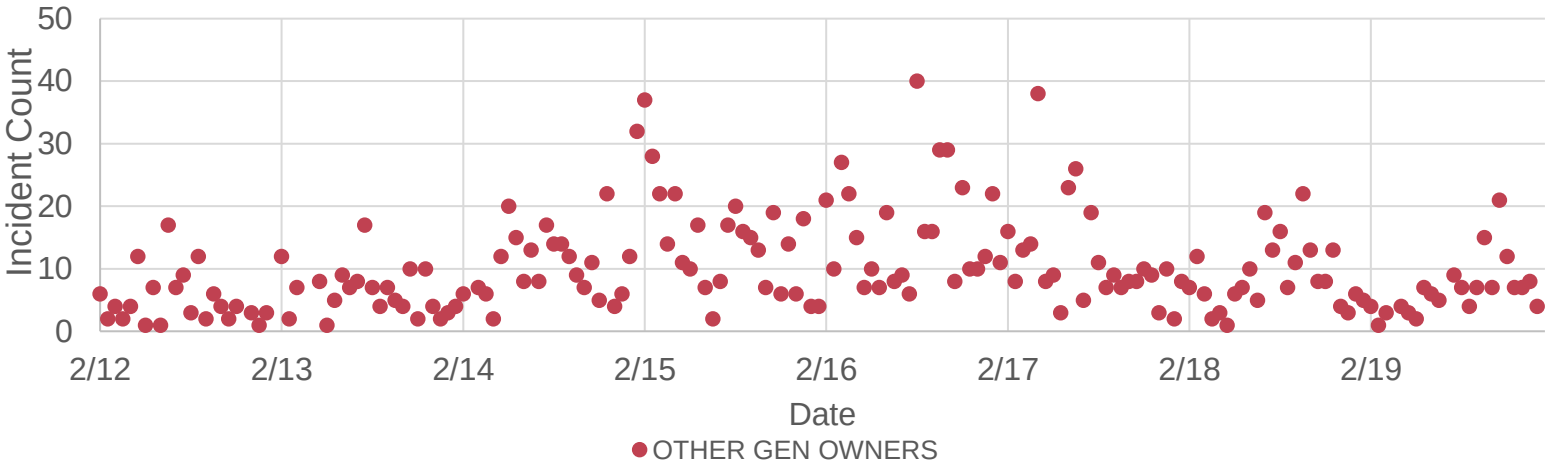
The other two top generation owners show increased capacity related issues later in the week.

For all other Generation Owners, the capacity related issues increased substantially during the heart of the blackout event. This data represents an aggregation of incidents for each hour; the high incident count in the bottom chart is a result of the large number of individual plant operators.

Top 3 Generation Owners in ERCOT

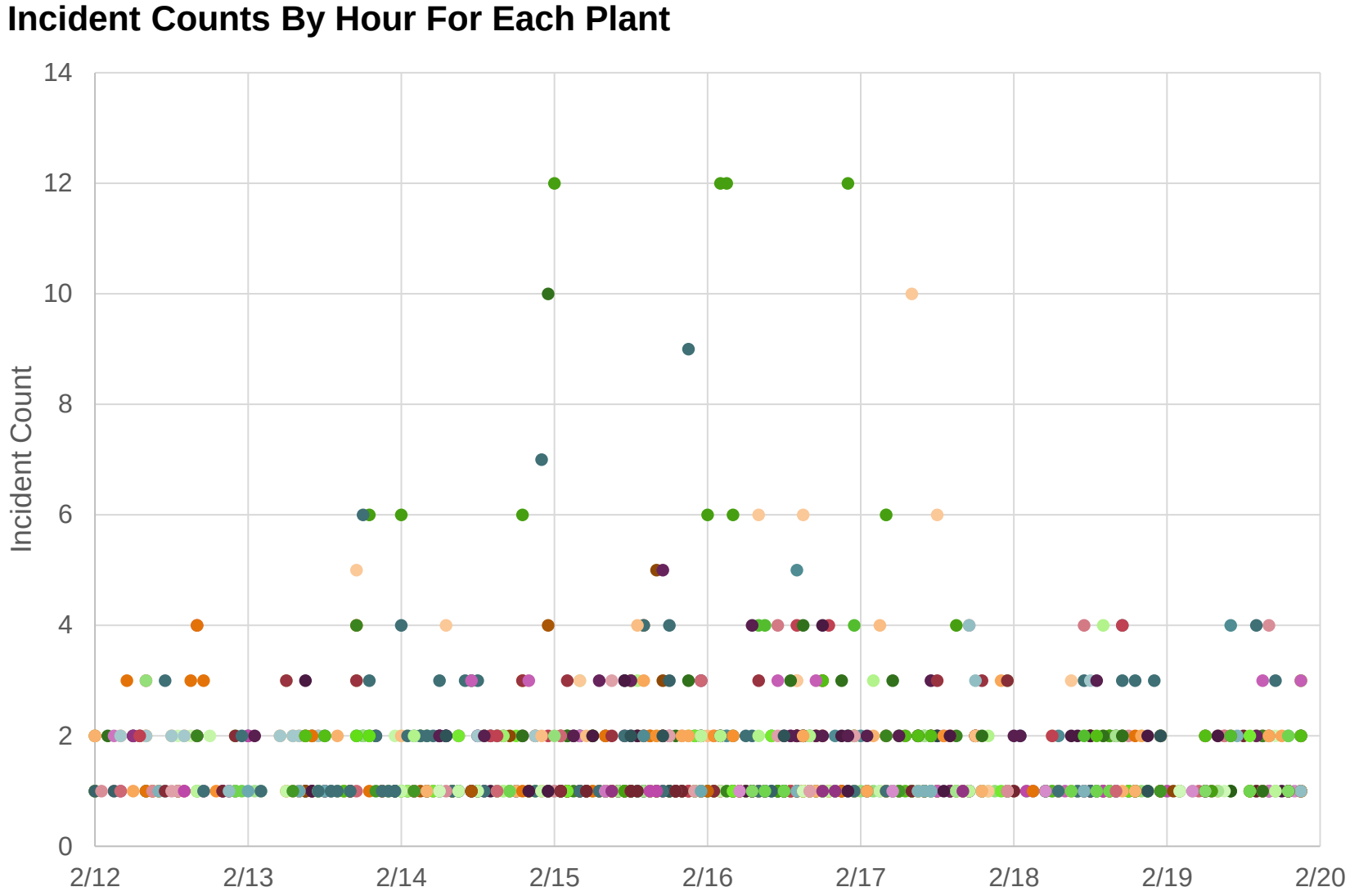


All Other Generation Owners in ERCOT



Capacity Reduction Incidents (Derate/Outages) by Plant from February 12 – 19, 2021

This chart illustrates the count of incidents by plant and by hour. You can see issues in a large number of plants across the cold snap event, with some facilities even experiencing up to 12 incidents in one hour during the peak outage period of Feb. 15-17.



Key Takeaways

- Based on our assessment of available data and the timing of outages, it is likely the issues started at power generation units.
- Once power outages began, natural gas production was impacted because surface facilities and infrastructure relies heavily on electricity for operations, which then exacerbated the ability for power generators to receive natural gas supplies.
- Power generators across the state of Texas failed. Power generators in South Texas were more suspectable to outages as their tolerance for cold weather is lower. Power plants around the Houston area were also especially vulnerable to the cold weather. In addition, some of the older wind generators in West Texas saw heavy capacity reductions.
- Interconnections with other non-ERCOT regions don’t help in peak load periods. Connection doesn't matter if these other regions don't have power to send.
- The entire energy infrastructure chain was under significant stress during the storm. Texas lost significant natural gas production while local demand increased. Even with these challenges, Texas natural gas production exceeded Texas demand during the storm, yet matching supply with demand proved challenging.
- Natural gas storage withdrawals increased, however, some facilities faced power outages and were not able to operate at maximum levels.
- Natural gas deliveries to LNG terminals, exports to Mexico, and exports to other neighboring regions decreased and a significant amount of the natural gas available was used to meet demand within Texas.
- The common denominator that caused most disruptions to both upstream and midstream sectors is the loss of power and electricity.
  - Upstream survey responses focused on loss of power (65%), wellhead and equipment freeze-offs (13%) and not being able to get production out due to issues with third-party facilities (8.7%) as the main causes that influenced operations.
  - Midstream survey responses focused on loss of power and lack of production from upstream as the main causes of downtime for infrastructure.

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Power Generation Sources

Data

File Name : ***Unit_Outage_Data_20210312.xlsx***

- Source: http://ercot.com/content/wcm/lists/226521/Unit_Outage_Data_20210312.xlsx
- Description: ERCOT disclosure of all generator outage data from the winter storm.
- Page Reference: Pg.1

File Name : ***EIA_930_data_through_2021-02-19.csv***

- Source: https://www.eia.gov/beta/electricity/gridmonitor/dashboard/electric_overview/US48/US48
- Description: Hourly generation data for each fuel type through the winter event.
- Page Reference: Pg.5, Pg.6

File Name : ***ERCOT_Operations_Messages_through_2021-02-19.xlsx***

- Source: http://www.ercot.com/services/comm/mkt_notices/opsmessages
- Archived: February 19, 2021 09:10 AM
- Description: All ERCOT Operation messages though the winter event.
- Page Reference: Pg.4, Pg.5

File Name : ***ERCOT_SARA-FinalWinter2020-2021.xlsx***

- Source: http://www.ercot.com/gridinfo/resource
- Description: ERCOT Winter 2020-2021 Seasonal Assessment of Resource Adequacy (SARA), Final Version.
- Page Reference: Pg.4, Pg.5

Report

File Name: ***ERCOT_Urgent_Board_of_Directors_Meeting_2-24-2021.pdf***

- Source: http://www.ercot.com/content/wcm/key_documents_lists/225373/Urgent_Board_of_Directors_Meeting_2-24-2021.pdf
- Description: Review of February 2021 Extreme Cold, Weather Event – ERCOT Presentation
- Page Reference: Pg.1, Pg. 4, Pg. 5