Texas Freeze – Power Crisis Causes, Effects, Implications TX & Nationally

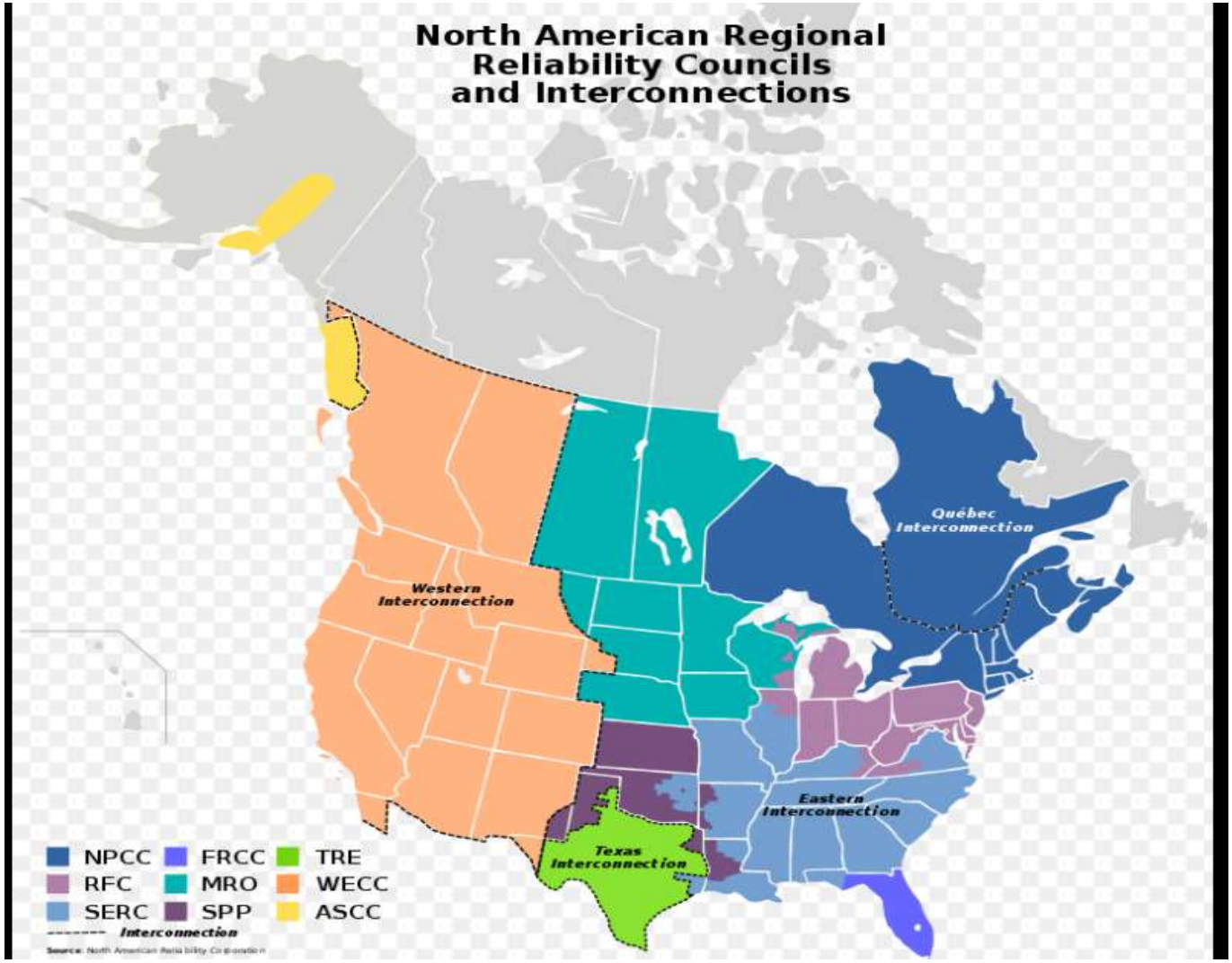
Jay Hofmann
jhofmann@trinityconsultants.com

Trinity Consultants
trinityconsultants.com

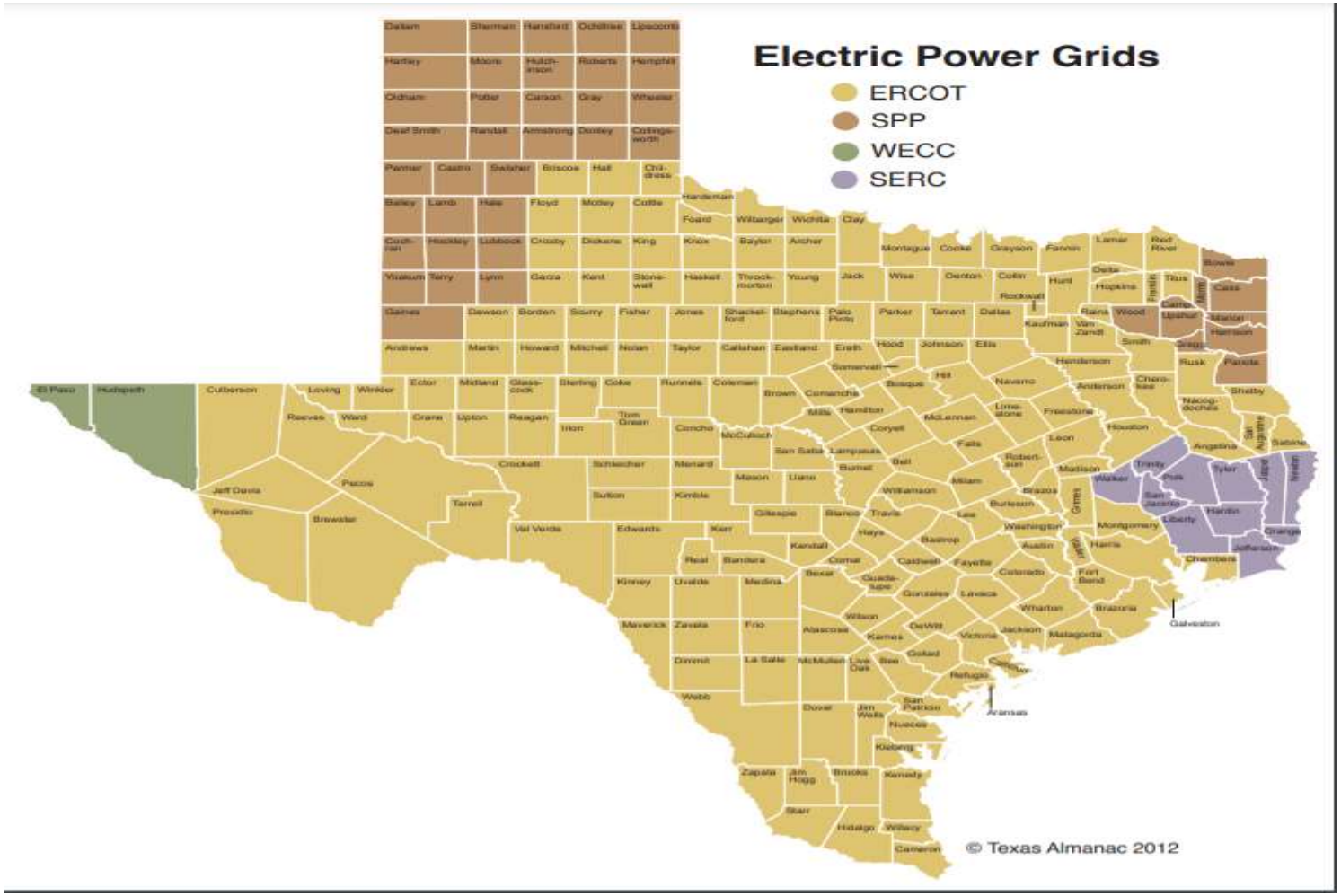
Agenda

1. Texas Power Grid (Texas Reliability Entity)
2. Texas Power Facts and Figures
3. ERCOT Real-time Data and Rising Wind
4. February 2021 Freeze
5. ERCOT's April 6, 2021, Preliminary Report
6. Report on 2011 Southwest Cold Weather Event

Trinity Consultants



Trinity Consultants



Trinity Consultants

Texas Power Facts and Figures

- Texas is the nation's largest electricity consumer, but its per capita use is less than in about 30% of the states.
- Texas also leads the nation in residential sector electricity consumption.
- The state's residential per capita consumption is less than almost one-third of the states.
- The largest share of the state's electricity goes to the residential sector, where three in five Texas households use electricity as their primary source for home heating.
- However, the state's electricity demand typically peaks during the hot summer days/months with the increased use of electricity for air conditioning.

Trinity Consultants

Texas Power Facts and Figures

- Texas produces more electricity than any other state, generating almost twice as much as the second-highest electricity-producing state, Florida.
- Natural gas-fired power plants supplied more than half the electricity generated in Texas in 2020.
- Natural gas fuels more megawatts in Texas than in any other state and accounts for 15% of all U.S. natural gas-fueled power.
- In 2020, wind supplied about one-fifth of Texas' in-state utility-scale (1 megawatt or larger) generation, and wind provided more of Texas' in-state generation than coal for the first time.
- Retirement of almost 6,000 megawatts of coal-fired generating capacity since 2016.
- Coal-fired power plants supplied one-sixth of state generation in 2020, down from three-tenths in 2017.
- Two operating nuclear power plants usually supply almost one-tenth of the state's electricity net generation. Most of the rest of the utility-scale generation in Texas is from renewable resources other than wind and from gases that are refinery byproducts.

Trinity Consultants

Texas Power Facts and Figures

- By the end of 2020, Texas had more than 30,000 megawatts of wind capacity, is more than 20% of the state's total generating capacity and almost 90% of the renewable capacity.
- Wind power has been the fastest-growing source of energy in Texas' power grid. In 2015, wind power generation supplied 11% of Texas' energy grid. Last year (2020) it supplied 23% of the system's power.

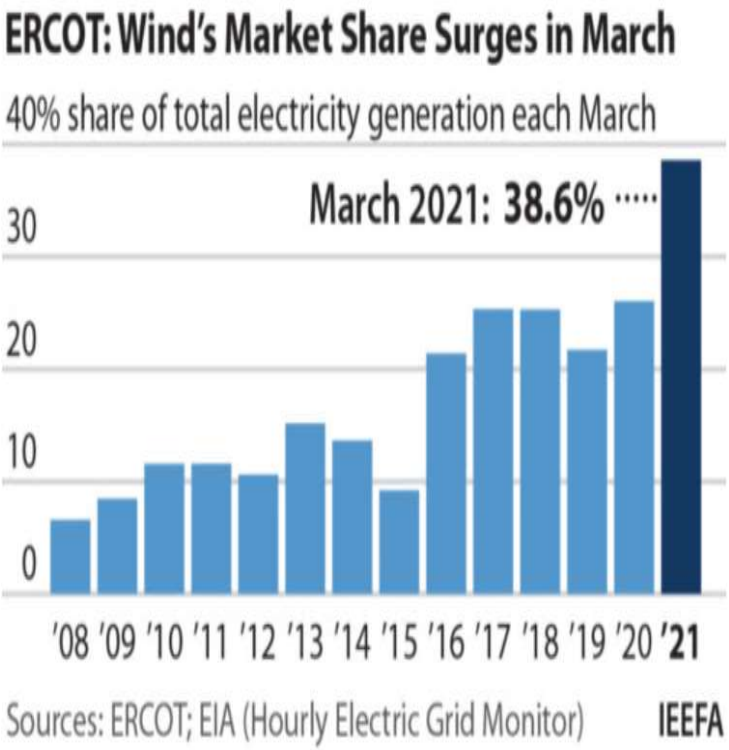
Trinity Consultants

Texas Power Facts and Figures

In March, Texas grid operator ERCOT's wind power generation smashed its previous record. Wind topped 10.4 million megawatt-hours (MWh) during the month (nearly 40% of the total), which is 2 million MWh above its previous high set in December 2020, according to data from the Energy Information Administration's hourly electric grid monitor.

Trinity Consultants

ERCOT Power Mix



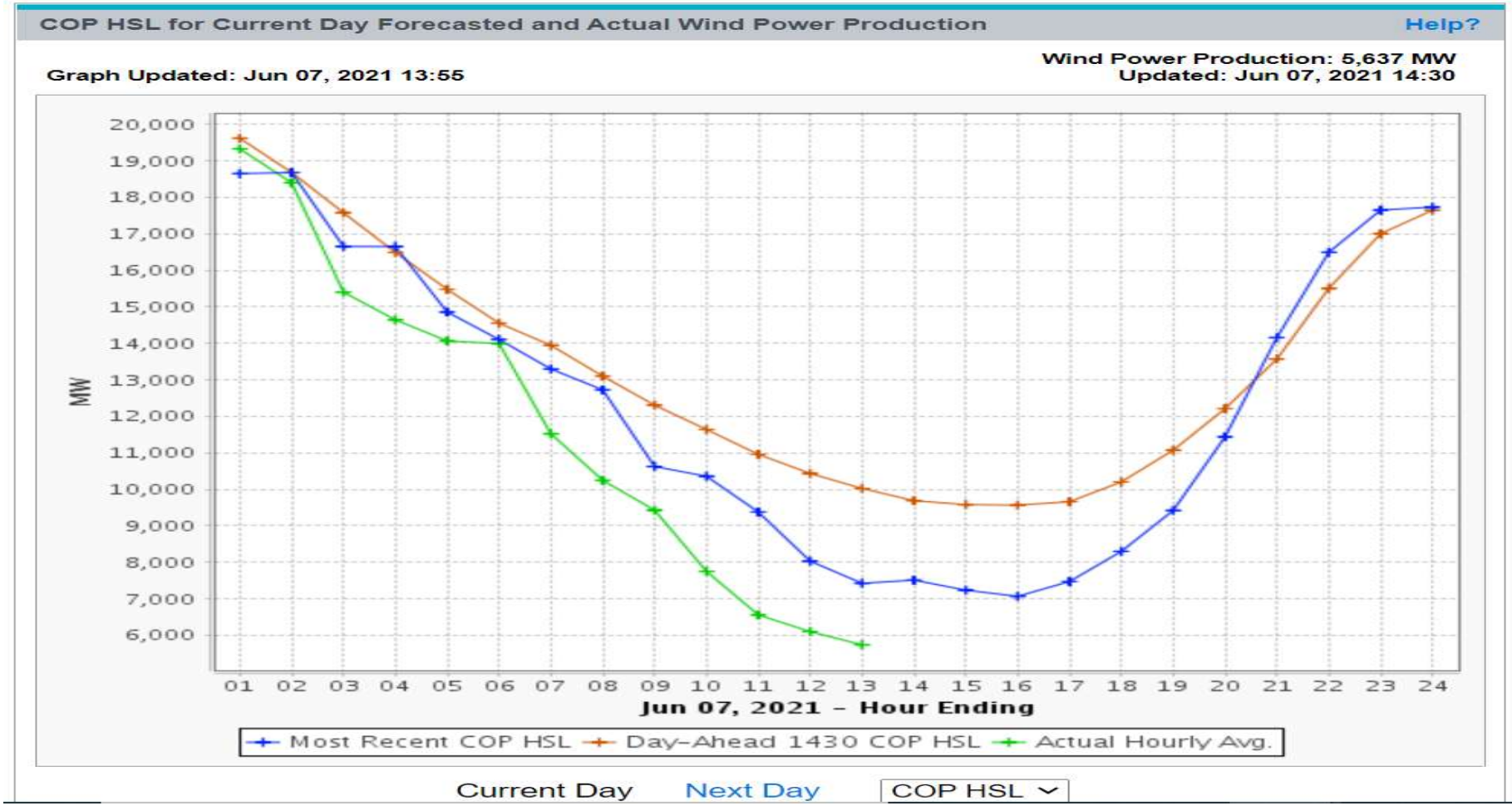
Real-Time System Conditions

Help?

Last Updated: Jun 07, 2021 14:44:57

Frequency	
Current Frequency	60.017
Instantaneous Time Error	-1.999
Consecutive BAAL Clock-Minute Exceedances (min)	0
Real-Time Data	
Actual System Demand	55521
Total System Capacity (not including Ancillary Services)	61200
Total Wind Output	5660
Total PVGR Output	5499
Current System Inertia	290848
DC Tie Flows	
DC_E (East)	-446
DC_L (Laredo VFT)	0
DC_N (North)	0
DC_R (Railroad)	0
DC_S (Eagle Pass)	0

Trinity Consultants


COP HSL for Current Day Forecasted and Actual Wind Power Production
Help?
Graph Updated: Jun 07, 2021 13:55
Wind Power Production: 5,637 MW
Updated: Jun 07, 2021 14:30
MW
20,000
19,000
18,000
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Jun 07, 2021 - Hour Ending
Most Recent COP HSL
Day-Ahead 1430 COP HSL
Actual Hourly Avg.
Current Day
Next Day
COP HSL

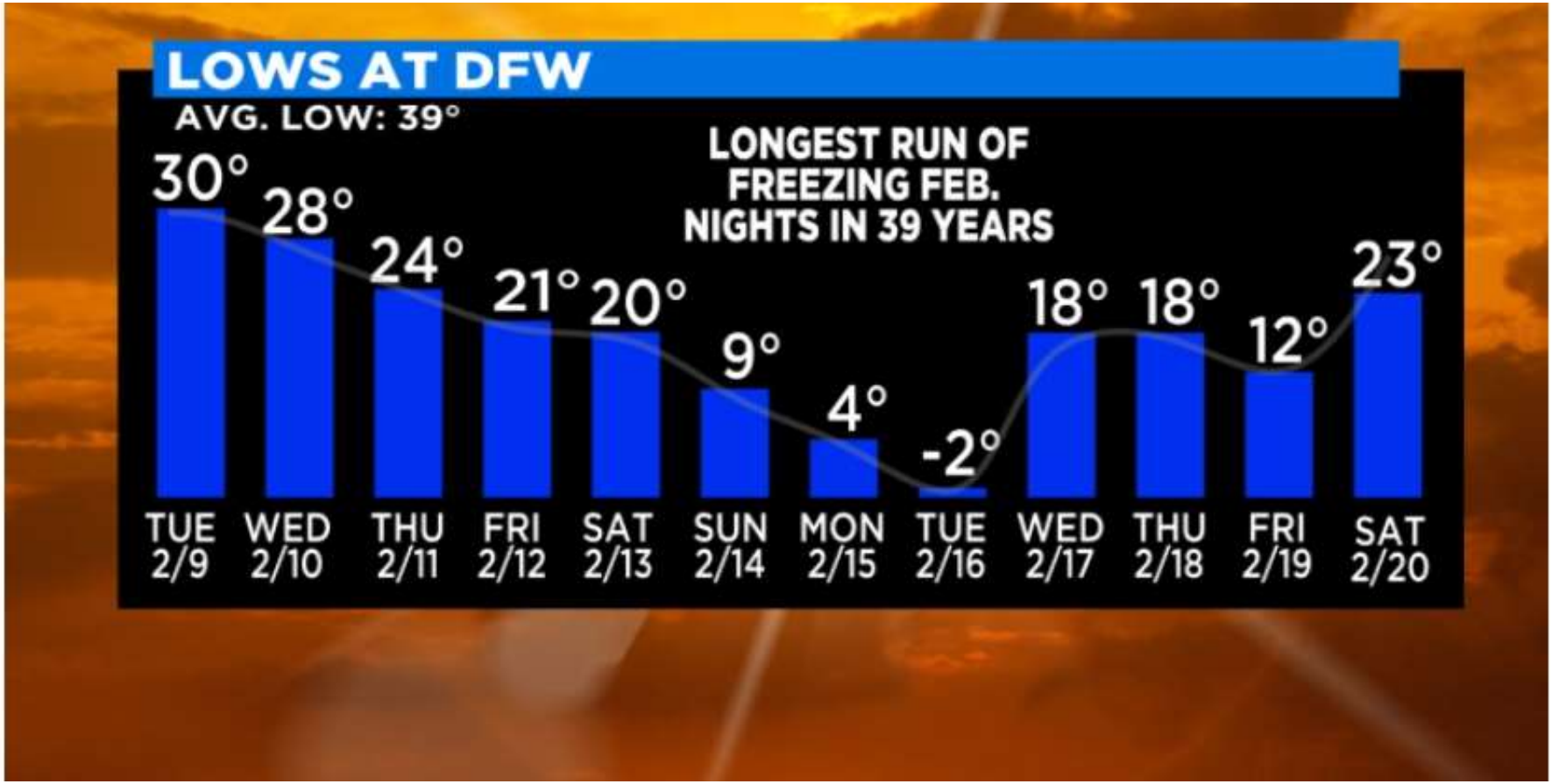
February 2021 Freeze

Trinity Consultants

Facts about the February 14-17th Winter Storm across North and Central TX

- The official event snowfall for DFW International Airport was **5.0"**.
- The official event snowfall for ACT (Waco Airport) was **4.6".**
- *Consecutive hours at or below freezing for DFW Airport:*
  - **93 hours:** 5 pm Feb 9th - 2 pm Feb 13th
  - **139 hours:** 5 pm Feb 13th - Noon Feb 19th (ties for 5th place for most consecutive hours *below freezing,* and ties for 8th place for most consecutive hours *at or below freezing*) - Note: The temperature climbed to 33 degrees briefly from 2 to 5 pm on February 13th.
- *Consecutive hours at or below freezing for ACT (Waco Airport):*
  - **205 hours:** 10 pm Feb 10th - 11 am Feb 19th (new record)
- During February 14th, every county in Texas was under a winter storm warning. First time ever.

Trinity Consultants

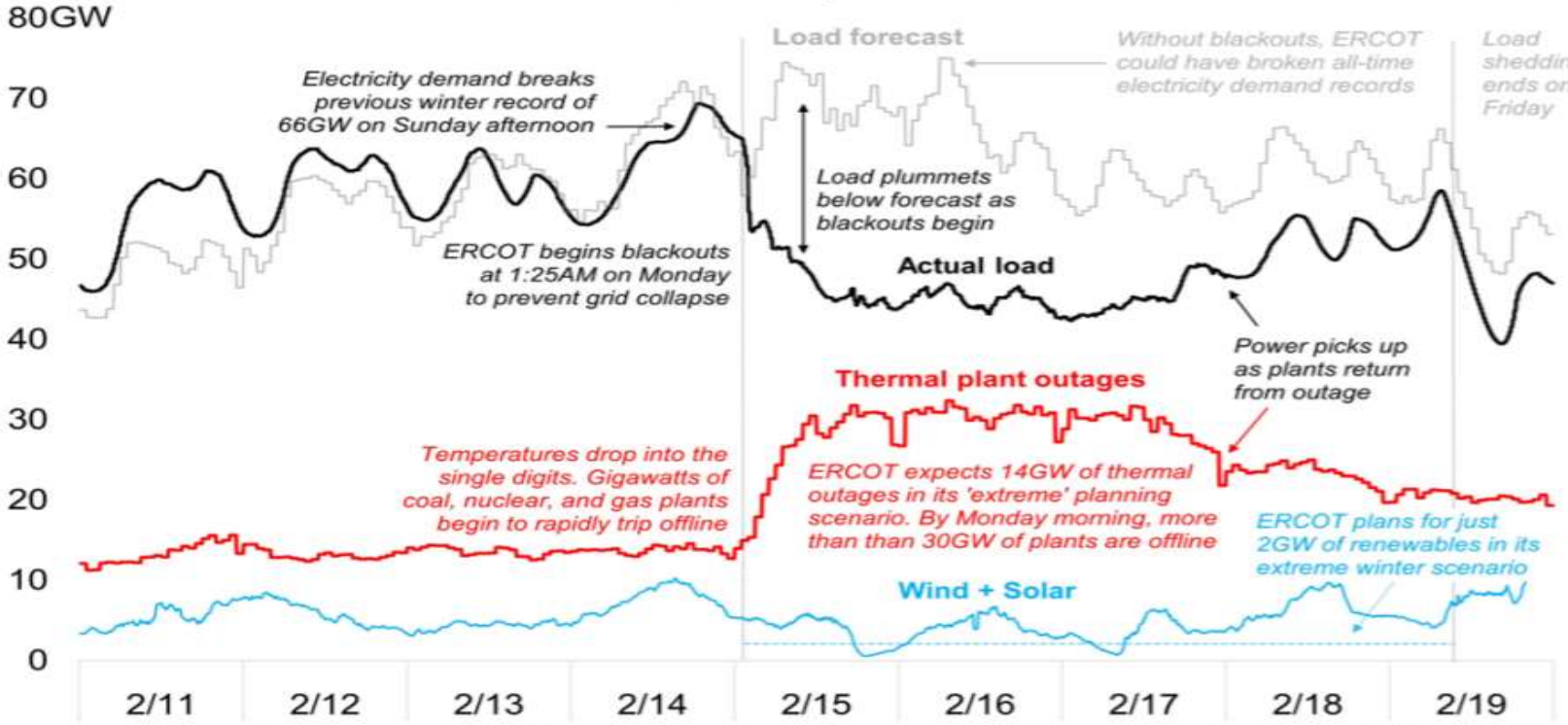


Trinity Consultants

Feb 15 2021 01:25:40 CST	**EEA Level 3 With Firm Load Shed:** At 01:20, Rotating outages are in progress to maintain frequency. ERCOT is asking consumers and businesses to reduce electricity use.	Emergency Notice	Active
Feb 15 2021 01:12:06 CST	**EEA Level 2:** At 01:07, ERCOT at EEA 2 - Reserves below 1, 750 MW. Load resources are being deployed. There may be a need to implement rotating outages. ERCOT is urging consumers and businesses to reduce electricity usage.	Emergency Notice	Active
Feb 15 2021 00:43:44 CST	No sudden loss of generation greater than 450 MW occurred on February 14, 2021.	Operational Information	Active
Feb 15 2021 00:17:45 CST	**EEA Level 1:** At 00:15, ERCOT at EEA 1 - Reserves below 2, 300 MW. No rotating outages at this time.	Emergency Notice	Active
Feb 15 2021 00:12:39 CST	ERCOT is issuing a Watch for Physical Responsive Capability less than 2500 MW.	Watch	Active
Feb 14 2021 23:32:49 CST	ERCOT is issuing an Advisory for Physical Responsive Capability less than 3000 MW.	Advisory	Active

FIGURE 4: EXTREME WEATHER, EXTREME OUTAGES IN TEXAS

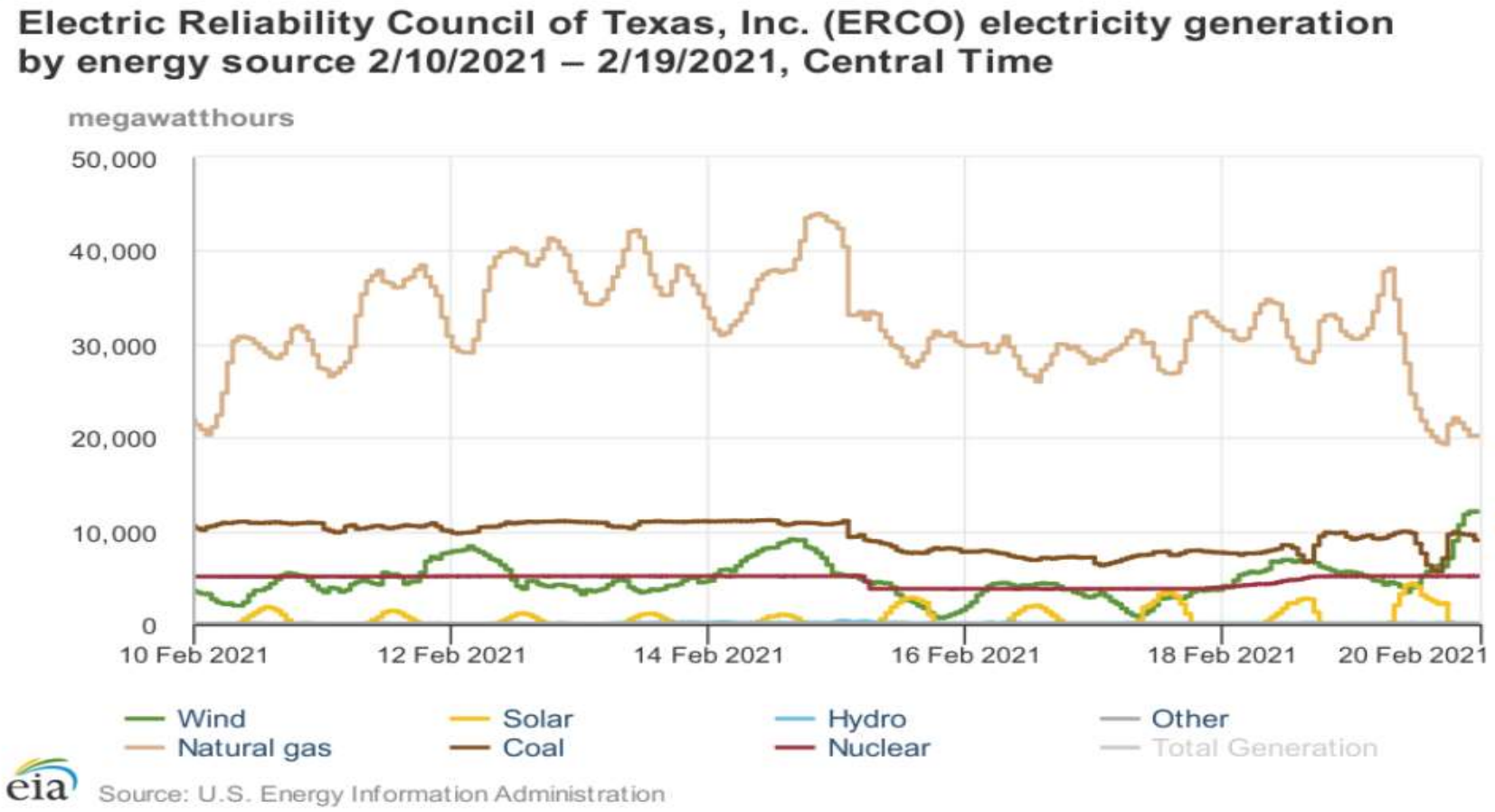
ERCOT electric load, load forecasts, thermal plant outages, and renewables



Source: Brian Bartholomew, energy analyst, https://twitter.com/BPBartholomew/status/1364446059028750337

Trinity Consultants

FIGURE 5: TEXAS ELECTRICITY GENERATION BY SOURCE DURING TEXAS OUTAGES



ERCOT's Worst Case Projections

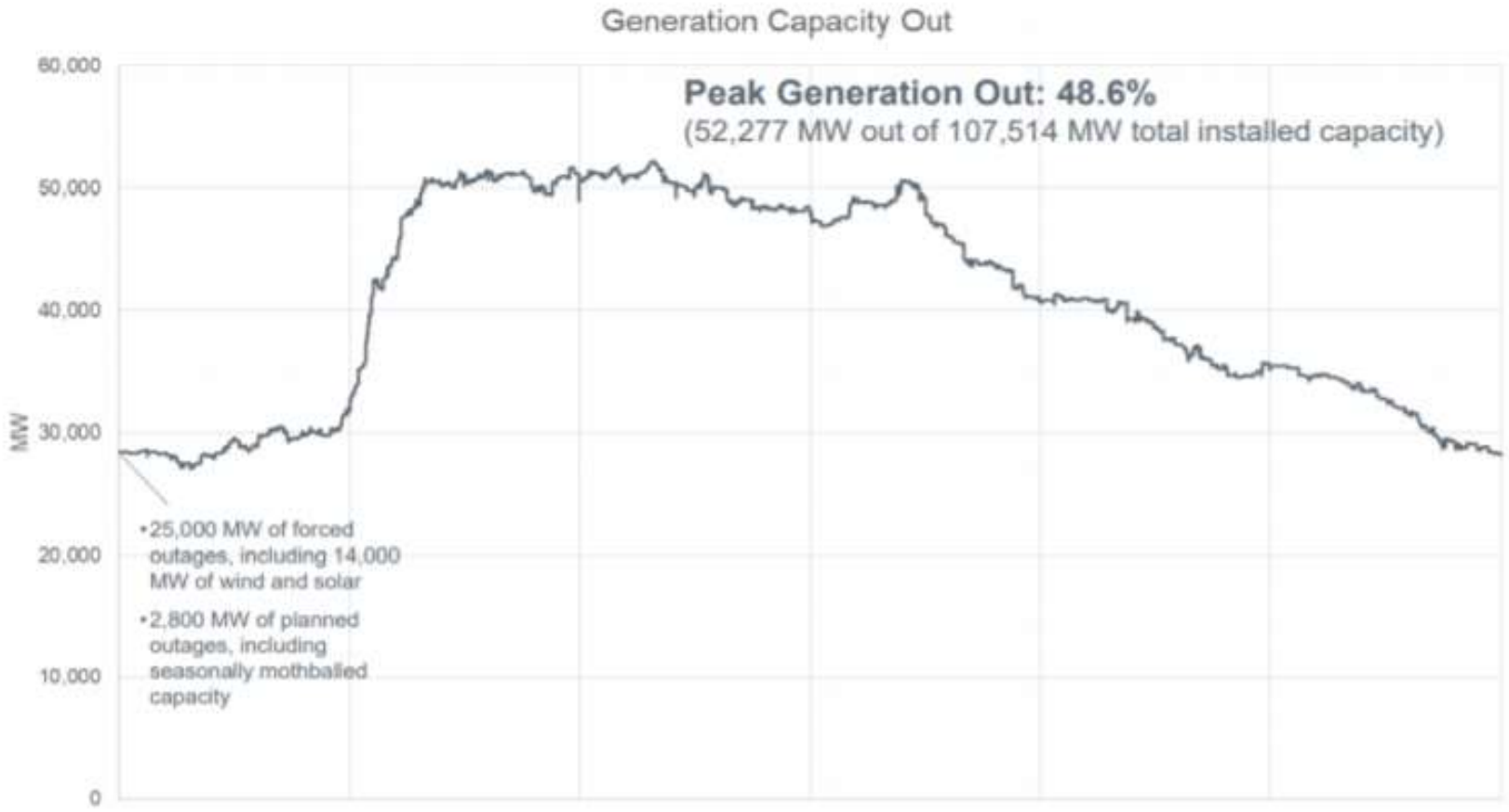
- ERCOT had concluded that the Texas power system was prepared for winter.
- Its regularly scheduled seasonal reliability check published in November, projected a worst-case scenario of customer demand just over 67,000 MW at a time with as much as 14,000 MW of generating capacity offline.
- 82,513 MW of generating capacity available, the loss of 14,000 MW of supply would leave the system perilously close to being unable to meet demand. But, worst case, the system was expected to continue serving all customers.

Trinity Consultants

February, 2021 Freeze Reality

- The reality was much worse than ERCOT's worst-case plan. At its peak on Sunday, February 14th, ERCOT oversaw delivery of 69,150 MW of power (just prior to initiating load shed). Had the system been capable of delivering it, ERCOT's forecast had predicted demand would reach 76,819 MW on Tuesday (2/16), higher than the all-time summer peak demand of 74,531 MW.
- The demand side forecast was short, but the supply-side forecast more seriously missed the mark.
- ERCOT reported that 356 generation units had gone offline during at least a portion of the event, representing 52,277 MW—nearly half—of possible production
- "It appears that a lot of the generation that has gone offline today has been primarily due to issues on the natural gas system," Woodfin said Tuesday, noting that thermal sources accounted for nearly double the number of gigawatts offline compared with renewable sources like wind.

Trinity Consultants



Trinity Consultants

Electricity Pricing During the Freeze

- Prices in ERCOT's real-time market reached the $9,000 MWh cap when rolling outages were called.
- Early in the event, real-time market prices began falling even as rolling outages continued.
- The Texas PUC issued an emergency order to force the price back to the $9,000 MWh.
- The ERCOT system had only reached the $9,000 MWh cap once before, for three hours during the summer of 2019.
- In February 2021, under the order from the PUC, ERCOT's price stayed at the cap for about 90 hours.

Trinity Consultants

ERCOT April, 6, 2021 Preliminary Report

- Preliminary Report on Causes of Generator Outages and Derates For Operating Days February 14 – 19, 2021 Extreme Cold Weather Event
- www.ercot.com/content/wcm/lists/226521/51878_ERCOT_Letter_re_Preliminary_Report_on_Outage_Causes.pdf

Trinity Consultants

April 6, 2021

Public Utility Commission of Texas
Chairman Arthur C. D'Andrea
1701 N. Congress Ave.
Austin, Texas 78711

Re: PUC Project No. 51878, Reports of the Electric Reliability Council of Texas for Calendar Year 2021

Preliminary Report on Causes of Generator Outages and Derates For Operating Days February 14 – 19, 2021 Extreme Cold Weather Event

Dear Chairman D'Andrea:

Electric Reliability Council of Texas, Inc. (ERCOT) submits the attached preliminary report on the causes of generator outages and derates during the February 14-19, 2021 extreme cold weather event. The report provides information on the causes of the outages and derates throughout the weather event based on ERCOT's review of information submitted by Qualified

Outage Categories

- **Existing Outages**: Generator outages or derates that started before the issuance of the Operating Condition Notice on February 8, 2021; includes ongoing planned and forced outages as well as seasonally mothballed units. Some existing outages ended before or during the event, allowing the unit to return to service.
- **Fuel Limitations**: Generator outages or derates due to lack of fuel, contaminated fuel, fuel supply instability, low gas pressure, or less efficient alternative fuel supply.
- **Weather Related**: Generator outages or derates explicitly attributed to cold weather conditions in the RFI responses. This includes but is not limited to frozen equipment—including frozen sensing lines, frozen water lines, and frozen valves—ice accumulation on wind turbine blades, ice/snow cover on solar panels, exceedances of low temperature limits for wind turbines, and flooded equipment due to ice/snow melt.

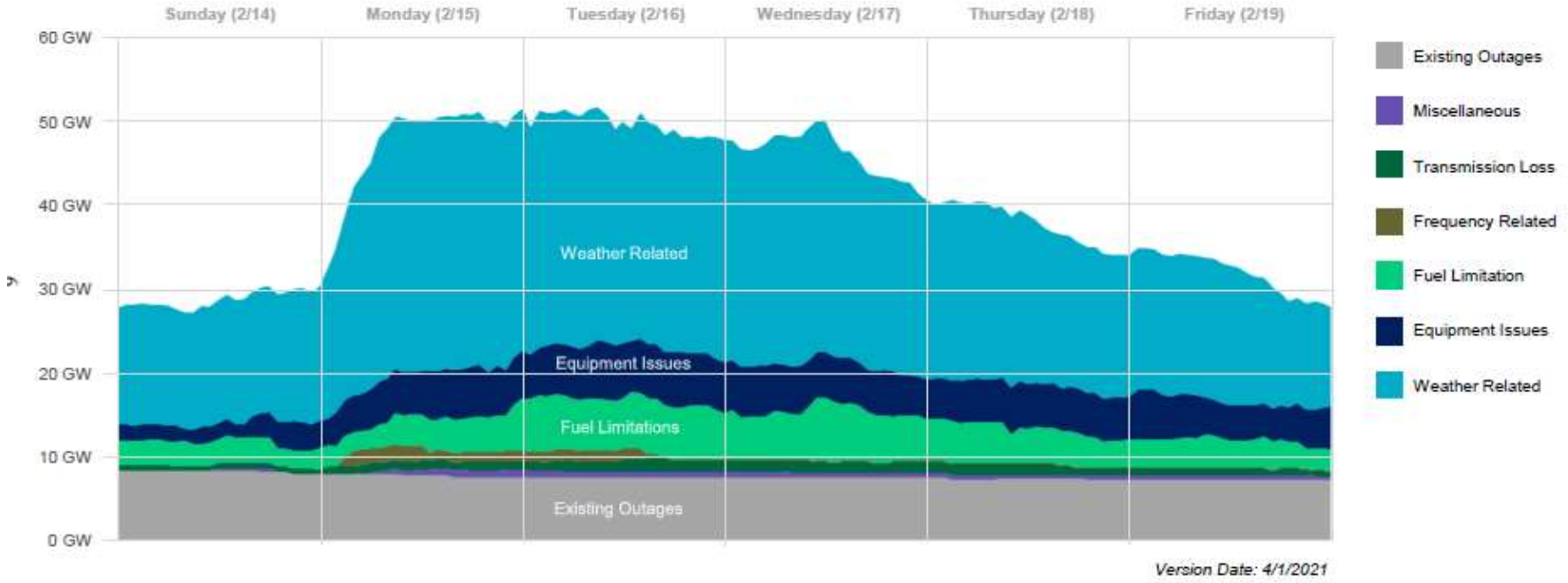
Trinity Consultants

Outage Categories (cont.)

- **Equipment Issues**: Generator outages or derates due to facility equipment failures or malfunctions not explicitly attributed to cold weather in the RFI response. This includes trips and derates related to control system failures, excessive turbine vibrations, or other equipment problems.
- **Transmission Loss**: Generator outage or derates due to forced outages on directly connected transmission facilities.
- **Frequency Related**: Generator outage or derates attributed to frequency deviations from 60Hz; includes automatic tripping due to under-frequency protection relays and any automatic or manual tripping attributed to plant control system issues related to frequency deviation.
- **Miscellaneous**: Other generator outages or derates not linked to one of the above causes, including outages for which a cause is yet unknown.

Net Generator Outages and Derates by Cause (MW)

February 14 – 19, 2021



Version Date: 4/1/2021

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

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- Report on Outages and Curtailments During the Southwest Cold Weather Event of February 1 to 5, 2011
  - Report prepared by staffs of FERC and the North American Electric Reliability Corporation
  - Dated August, 2011
  - www.ferc.gov/sites/default/files/2020-04/08-16-11-report.pdf
- Key Findings and Recommendations
  - The Electric Industry (26 Recommendations)
  - The Natural Gas Industry (6 Recommendations)

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- Electric Industry Findings
  - The reason blackouts had to be initiated was that over 29,000 MW of generation that was committed in the day ahead market or held in reserve either tripped, was derated, or failed to start. This was the largest loss of generation in ERCOT's history.
  - ERCOT and the generators within ERCOT could better coordinate generator scheduled outages, both in terms of the total amount of scheduled outages at a given time and their location. A substantial amount of generation (11,566 MW) was on scheduled outage going into the cold weather event.
  - Load shedding by the transmission and distribution operators in ERCOT's footprint was generally carried out in a timely and effective manner.
  - Transmission operators and distribution providers generally did not identify natural gas facilities such as gathering facilities, processing plants or compressor stations as critical and essential loads.
  - Balancing authorities, reliability coordinators and generators often lacked adequate knowledge of plant temperature design limits, and thus did not realize the extent to which generation would be lost when temperatures dropped.

Report on 2011 Southwest Cold Weather Event

- Electric Industry Findings
  - The lack of any state, regional or Reliability Standards that directly require generators to perform winterization left winter-readiness dependent on plant or corporate choices. While Reliability Standard EOP-001 R.4 and R.5 refer to winterization as a consideration in emergency plans, these requirements apply only to balancing authorities, transmission owners, and transmission operators.
  - Generators were generally reactive as opposed to being proactive in their approach to winterization and preparedness. The single largest problem during the cold weather event was the freezing of instrumentation and equipment. Many generators failed to adequately prepare for winter, including the following: failed or inadequate heat traces, missing or inadequate wind breaks, inadequate insulation and lagging (metal covering for insulation), failure to have or to maintain heating elements and heat lamps in instrument cabinets, failure to train operators and maintenance personnel on winter preparations, lack of fuel switching training and drills, and failure to ensure adequate fuel.

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- Electric Industry Findings
  - Gas curtailment and gas pressure issues did not contribute significantly to the amount of unavailable generating capacity in ERCOT during the event. The outages, derates, and failures to start from inadequate fuel supply totaled 1282 MW from February 1 through February 5, as compared to an overall peak net generating capacity reduction of 14,702 MW.
- Selected Electric Industry Recommendations
  - Balancing Authorities, Reliability Coordinators, Transmission Operators and Generation Owner/Operators in ERCOT and in the southwest regions of WECC should consider preparation for the winter season as critical as preparation for the summer peak season.
    - The large number of generating units that failed to start, tripped offline or had to be derated during the February event demonstrates that the generators did not adequately anticipate the full impact of the extended cold weather and high winds.

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- Selected Electric Industry Recommendations
  - Balancing Authorities, Reliability Coordinators, Transmission Operators and Generation Owner/Operators in ERCOT and in the southwest regions of WECC should consider preparation for the winter season as critical as preparation for the summer peak season.
    - The large number of generating units that failed to start, tripped offline or had to be derated during the February event demonstrates that the generators did not adequately anticipate the full impact of the extended cold weather and high winds.
  - Planning authorities should augment their winter assessments with sensitivity studies incorporating the 2011 event to ensure there are sufficient generation and reserves in the operational time horizon.
    - Both ERCOT and the Southwest regions of WECC undertake planning studies to ensure that sufficient reserves are available to meet seasonal peak loads. However, the forecasted peak demand in the winter assessments for 2010/2011 was not as high as that actually experienced in early February.

Report on 2011 Southwest Cold Weather Event

- Selected Electric Industry Recommendations
  - ERCOT should reconsider its protocol that requires it to approve outages if requested more than eight days before the outage, consider giving itself the authority to cancel outages previously scheduled, and expand its outage evaluation criteria.
  - Transmission Operators, Balancing Authorities, and Generation Owner/Operators should consider developing mechanisms to verify that units that have fuel switching capabilities can periodically demonstrate those capabilities.
  - Balancing Authorities, Transmission Operators and Generator Owners/Operators should take the steps necessary to ensure that black start units can be utilized during adverse weather and emergency conditions.
  - WINTERIZATION
    - States in the Southwest should examine whether Generator/Operators ought to be required to submit winterization plans, and should consider enacting legislation where necessary and appropriate.

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- Selected Electric Industry Recommendations
  - WINTERIZATION
    - States in the Southwest should examine whether Generator/Operators ought to be required to submit winterization plans, and should consider enacting legislation where necessary and appropriate.
    - The Texas Legislature passed a law in 2011 requiring power companies to file regular reports with the Texas Public Utility Commission about their weatherization efforts.
      - In 2021, the Texas State Comptroller (Glenn Hegar), who authored the 2011 bill, questioned whether the measure had gone far enough.
  - PLANT DESIGN
    - Consideration should be given to designing all new generating plants and designing modifications to existing plants (unless committed solely for summer peaking purposes) to be able to perform at the lowest recorded ambient temperature for the nearest city for which historical weather data is available, factoring in accelerated heat loss due to wind speed.

Report on 2011 Southwest Cold Weather Event

- Selected Electric Industry Recommendations
  - Maintenance/inspections generally
    - Generator Owner/Operators should ensure that adequate maintenance and inspection of its freeze protection elements be conducted on a timely and repetitive basis.
  - Specific Freeze Protection Maintenance Items
    - Heat tracing
    - Thermal Insulation
    - Use of Wind breaks/enclosures
    - Training
    - Transmission Facilities

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- The Natural Gas Industry – Key Findings
  - Extreme low temperatures and winter storm conditions resulted in widespread wellhead, gathering system, and processing plant freeze-offs and hampered repair and restoration efforts, reducing the flow of gas in production basins in Texas and New Mexico by between 4 Bcf and 5 Bcf per day, or approximately 20 percent, a much greater extent than has occurred in the past.
  - The prolonged cold caused production shortfalls in the San Juan and Permian Basins, the main supply areas for the LDCs that eventually curtailed service to customers in New Mexico, Arizona, and Texas.
  - Wellhead freeze-offs normally occur several times a winter in the San Juan Basin but are not common in the Permian Basin, which is the supply source that LDCs in the Southwest region typically rely upon when cold weather threatens production in the San Juan Basin.
  - Electrical outages contributed to the cold weather problems faced by gas producers, processors, and storage facilities in the Permian and Fort Worth Basins, with producers being more significantly affected by the blackouts; however, the task force concluded that the effect of electric blackouts on supply shortages was less important than the effect of freezing temperatures.

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- The Natural Gas Industry – Key Findings
  - The combination of dramatically reduced supply and unprecedented high demand was the cause of most of the gas outages and shortages that occurred in the region.
  - The extreme cold weather also created an unprecedented demand for gas, which further strained the ability of the LDCs and pipelines to maintain sufficient operating pressure. The combination of dramatically reduced supply and unprecedented high demand was the cause of most of the gas outages and shortages that occurred in the region.
  - Some local distribution systems were unable to deliver the unprecedented volume of gas demanded by residential customers.

Report on 2011 Southwest Cold Weather Event

- Recommendations – Natural Gas
  - Lawmakers in Texas and New Mexico, working with their state regulators and all sectors of the natural gas industry, should determine whether production shortages during extreme cold weather events can be effectively and economically mitigated through the adoption of minimum, uniform standards for the winterization of natural gas production and processing facilities.
  - The gas and electric sectors should work with state regulatory authorities to determine whether critical natural gas facilities can be exempted from rolling blackouts.
  - State utility commissions should work with LDCs to ensure that voluntary curtailment plans can reduce demand on the system as quickly and efficiently as possible when gas supplies are disrupted.
  - State utility commissions should work with balancing authorities, electrical generators, and LDCs to determine whether and under what circumstances residential gas customers should receive priority over electrical generating plants during a gas supply emergency.

Report on 2011 Southwest Cold Weather Event

- Recommendations – Natural Gas
  - State utility commissions and LDCs should review the events of early February 2011 and determine whether distribution systems can be improved to increase flows during periods of high demand.
  - State utility commissions should work with LDCs to determine whether the LDC distribution systems can be improved so that curtailments can be implemented, when necessary, in a way that improves the speed and efficiency of the restoration process.

Trinity Consultants

Report on 2011 Southwest Cold Weather Event

- Recommendations – Natural Gas
  - Lawmakers in Texas and New Mexico, working with their state regulators and all sectors of the natural gas industry, should determine whether production shortages during extreme cold weather events can be effectively and economically mitigated through the adoption of minimum, uniform standards for the winterization of natural gas production and processing facilities.
  - The gas and electric sectors should work with state regulatory authorities to determine whether critical natural gas facilities can be exempted from rolling blackouts.
  - State utility commissions should work with LDCs to ensure that voluntary curtailment plans can reduce demand on the system as quickly and efficiently as possible when gas supplies are disrupted.
  - State utility commissions should work with balancing authorities, electrical generators, and LDCs to determine whether and under what circumstances residential gas customers should receive priority over electrical generating plants during a gas supply emergency.

Batteries and Microgrids?

- Battery storage remains too expensive to be of much use for power system challenges of the scope seen in February 2021. Costs are falling but current battery technology will relegate the technology to a bit part in energy emergencies for at least a decade.
- Microgrids are small networks connecting both power generators and load, connected to the regional power grid but capable of operating independently. When the regional power grid runs into trouble, the microgrid can safely disconnect from the regional grid, allowing local service to continue and protecting equipment from voltage or other threats from the outside grid.
- Microgrids can be particularly useful for business or industrial parks requiring very high degrees of electrical reliability. In addition, microgrids can provide public service through support of critical infrastructure technologies should the regional grid fail.

Discussion and Questions

Trinity Consultants