

The Feb '21 ERCOT Grid Failure and Lessons



Presentation by Gregg Goodnight at IOGCC Santa Fe Conference, 11/9/21



The Feb '21 ERCOT Grid Failure Focus of Today's Presentation

- Review of Causes, Immediate and Systemic
- Renewable Energy Intermittency
- Future of Texas Grid and Public Policy Impacts

Dispatchable power: When You Need it, You Need it!

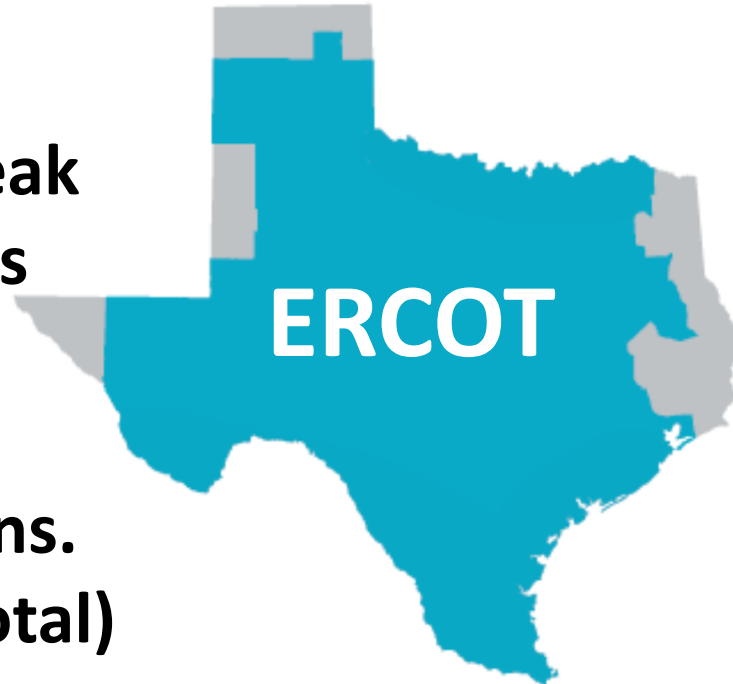
Feb '21 Outage – TRCS Lessons Learned

- 1. Reliability of the ERCOT electrical grid is being slowly compromised by the cumulative impact of public policy favoring renewable energy additions**
- 2. Intermittency is an inherent aspect of renewable power and needs to be addressed by public policy**
- 3. Adequate levels of dispatchable power need to be maintained through appropriate policy for power pricing**

The ERCOT System

Grid Facts

- + 1,800 Participants**
- 86 GW demand at peak**
- +710 generation units**
- +46,500 miles HV transmission lines**
- + \$0.7 billion new trans. projects 2020 (\$8B total)**



Renewables

- Texas leads US in wind capacity (30GW); 20% of US**
- 13,000 turbines, 150 farms**
- Record 23.6 GW (25Jun21)**
- Grid solar 4.9 GW capacity (growing to 19 GW by '25)**
- Batteries 0.3 GW capacity**

ERCOT Power Supply - 2020

Source	Capacity, GW	Avg. Utilization	TWh/yr	Avg. GW	% Nominal Capacity	% of Delivered Power
Wind	31.4	31.7%	871	9.9	28.1%	22.9%
Solar	4.9	20.3%	87	1.0	4.4%	2.3%
Hydro	0.5	26.5%	12	0.14	0.5%	0.3%
Coal	13.5	57.7%	685	7.8	12.1%	18.0%
Natural Gas	56.1	35.3%	1,738	19.8	50.3%	45.6%
Nuclear	5.1	91.8%	415	4.7	4.6%	10.9%
Total	111.7	38.9%	3,809	43.4	100%	100%

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Hydro	Average load is 43GW and capacity is 112GW, the issue is generating power as you need it and where you need it					0.3%
Coal						18.0%
Natural Gas						45.6%
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**Intermittent power
was 25% of delivered
power in 2020**

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Hydro	0.5	26.5%	Natural gas expected to be <30% by 2025			0.3%
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Coal	13.5	57.7%	Nuclear supplies baseload power			18.0%
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Current PUC Pricing Policy

Along with the PTC and Carbon Offset pricing, Federal Investment Tax Credits of 26-30% over the last 20 years has had a cumulative impact on pushing new capacity almost exclusively towards renewable power additions

2021 Grid Outage- Big Picture

Pre-storm Activity

- **The week ahead – warnings that this was going to be bad!**
- **Maintenance outages for coal/gas deferred from fall '20 – lack of manpower due to COVID restrictions (10-12GW unavailable power from thermals including coal, and gas)**

2021 Grid Outage- Big Picture

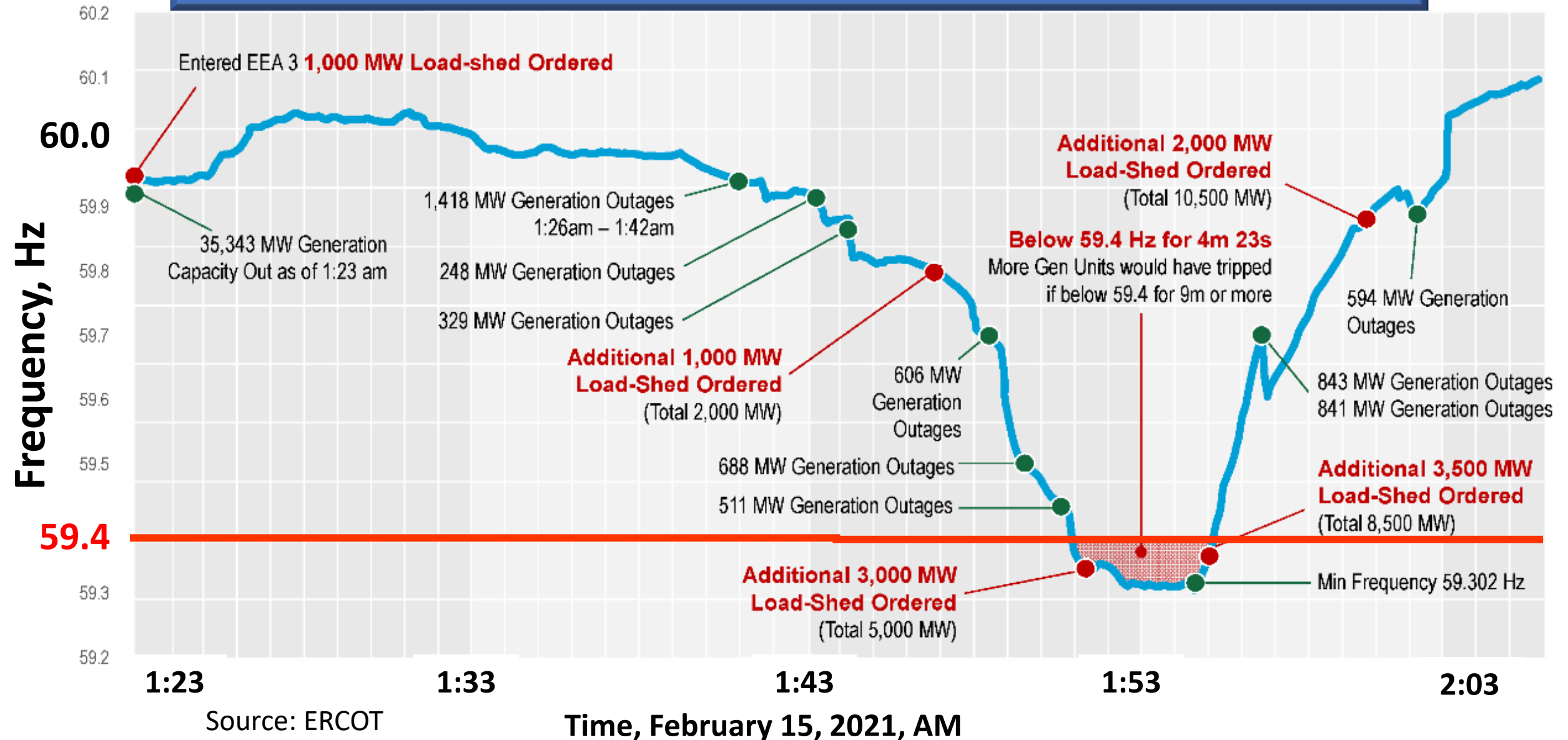
Critical Period



Storm Uri Late 2/14 to Early 2/15

- **76.8GW Load seen! Load shedding late evening → Ramp up of dispatchable power as wind and solar 9.1GW→ 5.3GW**
- **Dispatchable power supply trips**
- **Loss of frequency control**

Loss of Frequency Control



Immediate Cause of Failure

During critical period from 01:00AM to 02:00AM on 2/15/21, lack of dispatchable power combined with increasing system load and loss of power from wind resulted in loss of control of system frequency

Spin and Public Perception

“The focus on wind is a red herring” - Dan Cohan, Rice U.

“The extreme cold is causing the entire system to freeze up” – Jason Bordoff, Columbia U.

“...take a hard look at the state’s deregulated marketplace and fix its flaws”. - Dave Lieber, Dallas Morning News, 2/19/21

“The blame falls on Abbott.” “Please do not fall for Abbott’s tricks” – Democratic Party Chair Gilberto Hinojosa

Texas legislative hearings → focus on lack of winterization following the 2011 freeze: not mandatory, not strong enough

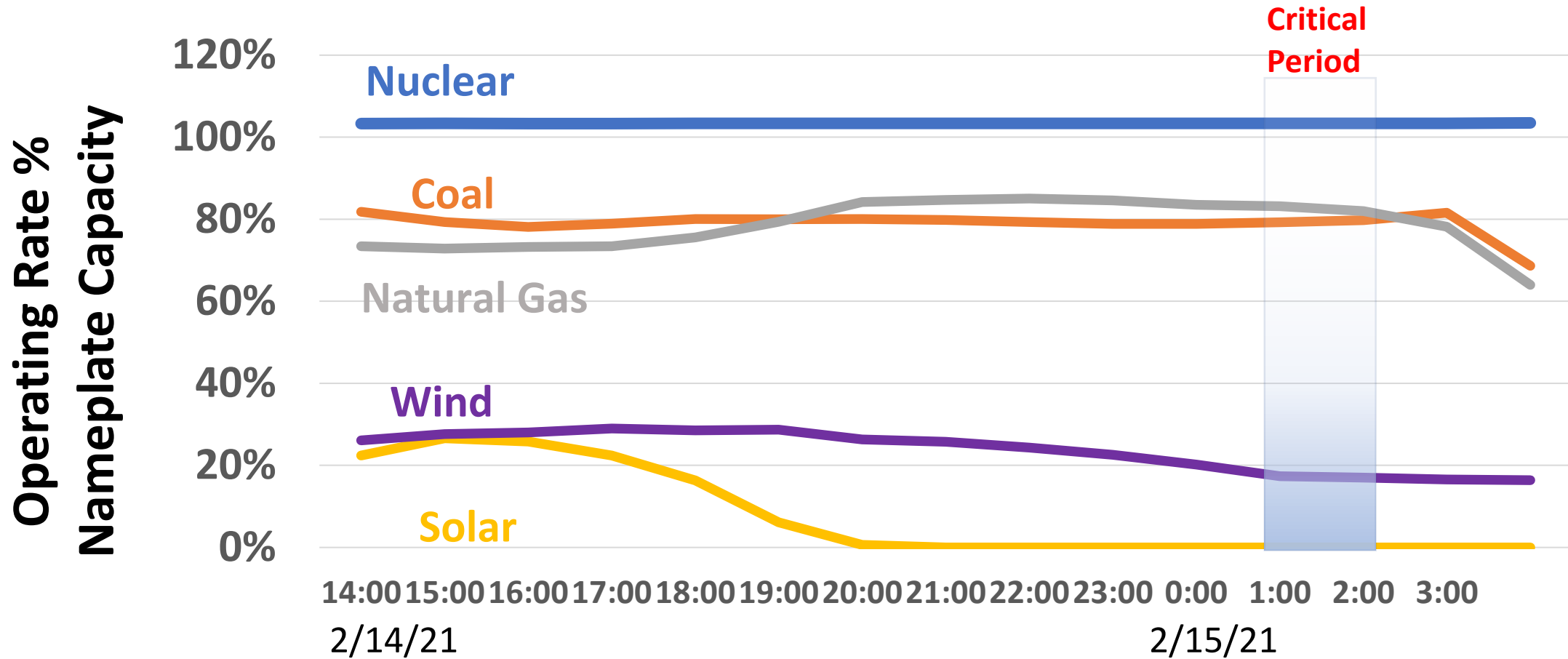
Spin and Public Perception



Senator Joe Manchin, D, West Virginia

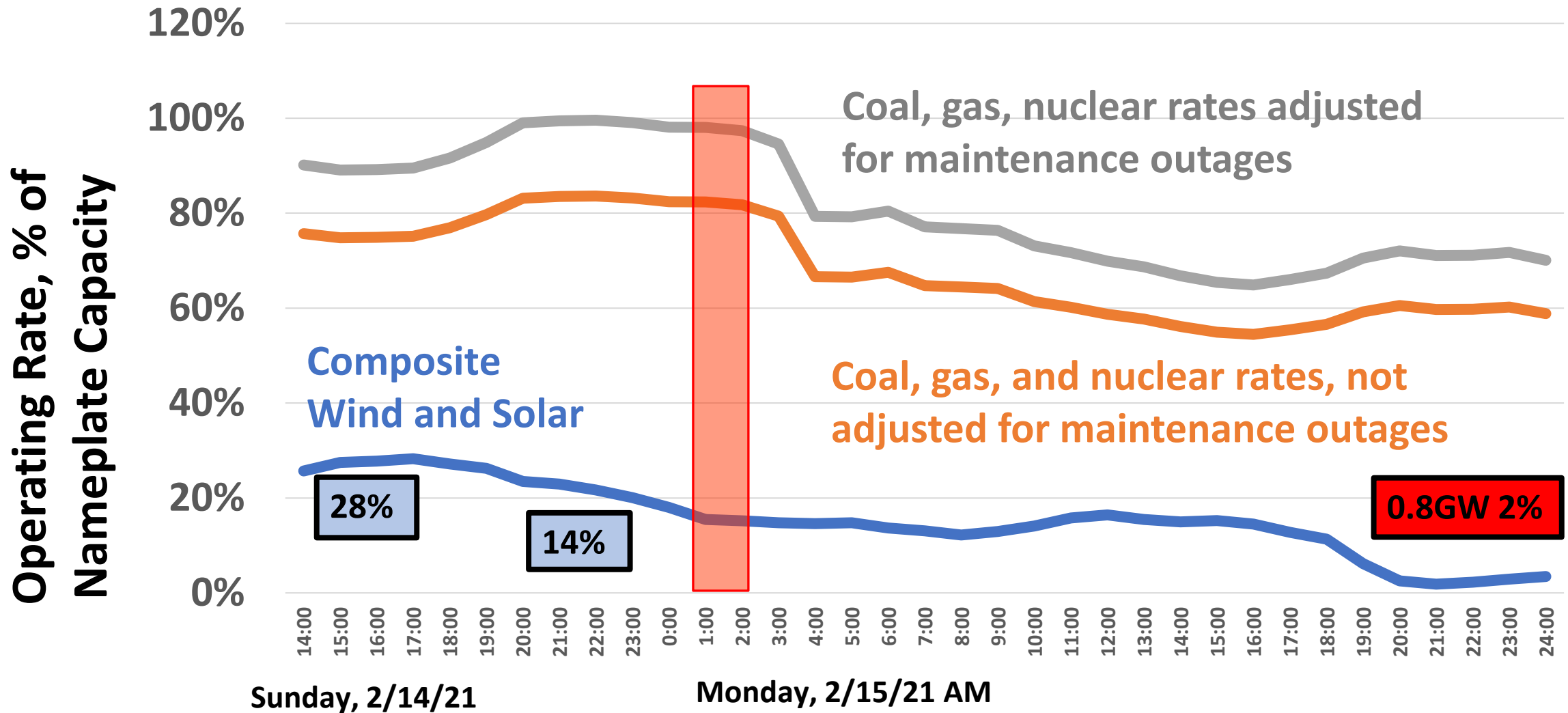
“... it was natural gas that basically shut down in Texas that caused all of that of that horrible carnage for people, it was awful.” CNN Interview – 9/12/21

Power Contributions

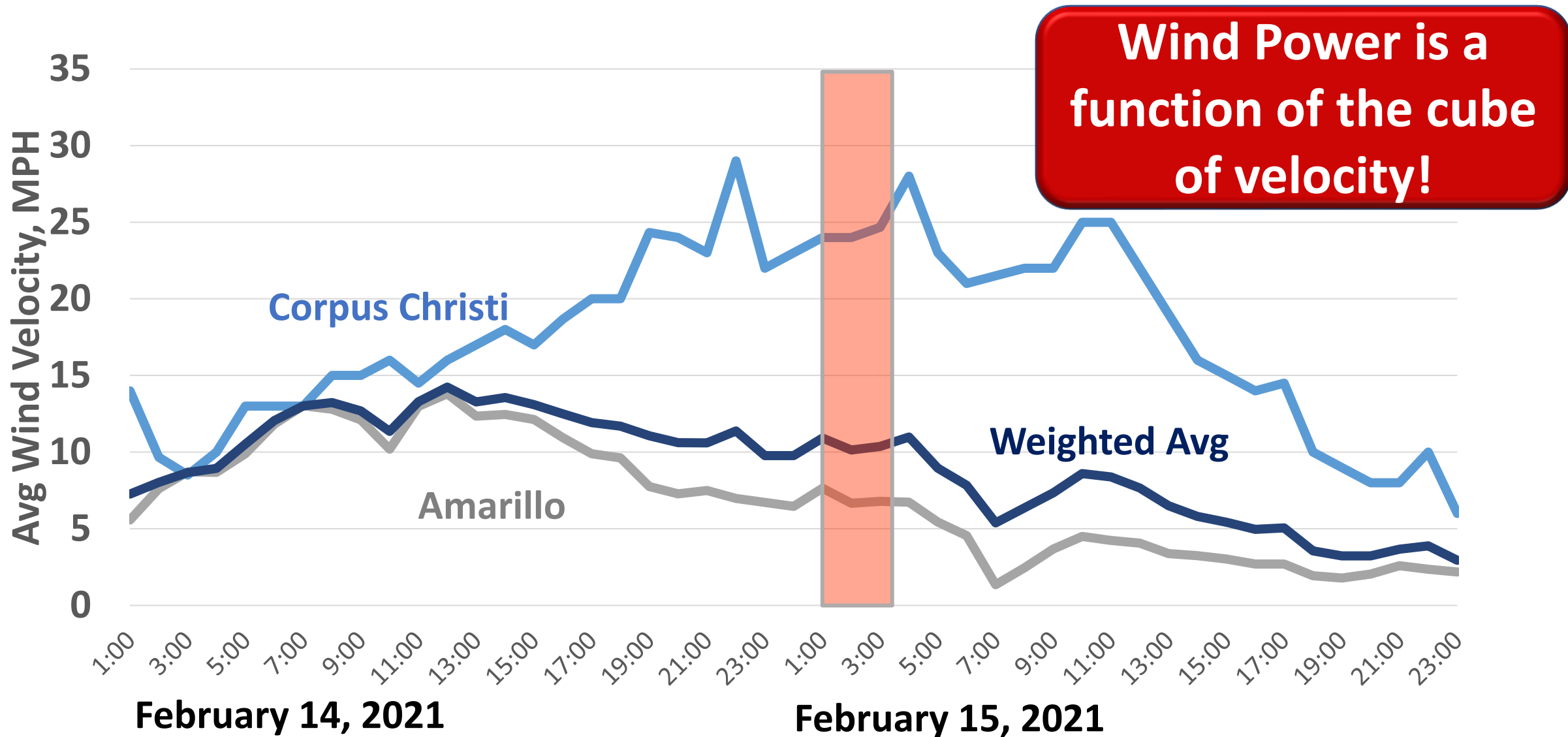


Source: ERCOT data and TNRCC calculations

Dispatchable vs Weather Dependent Power



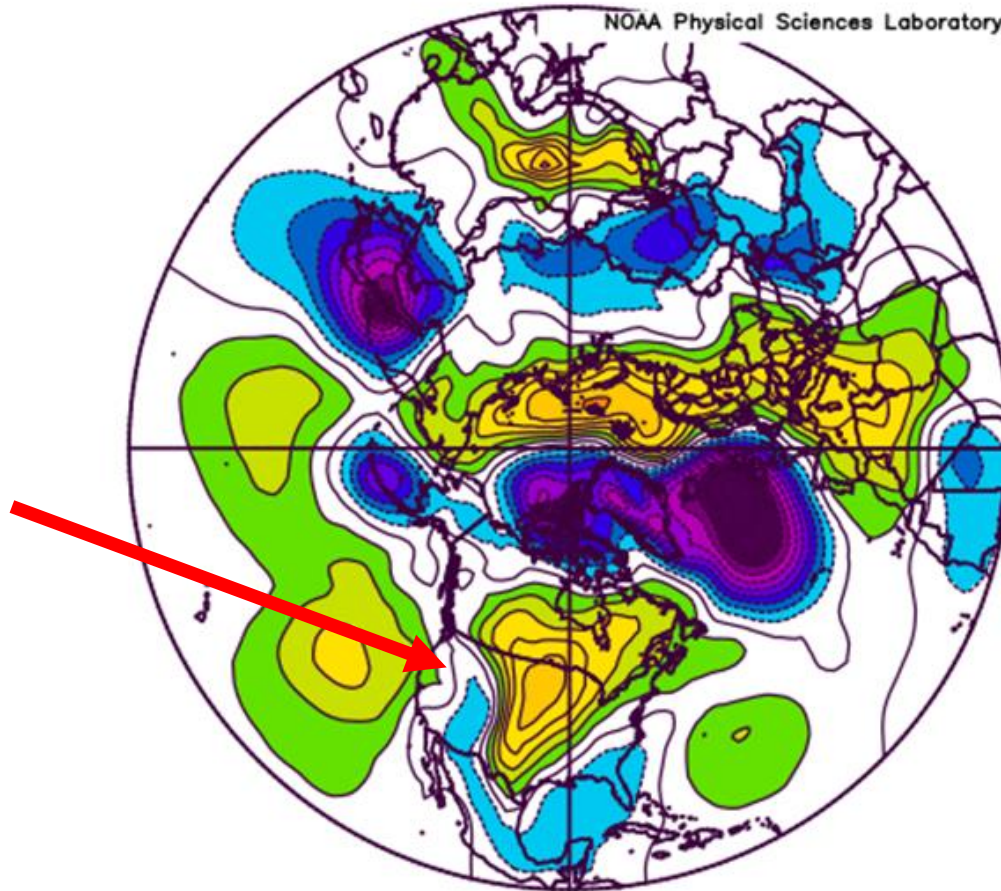
Texas Wind Impact during Storm Uri



Northern Hemisphere Pressure Anomaly

Sea Level, Feb. 14-18, 2021

North America



mb

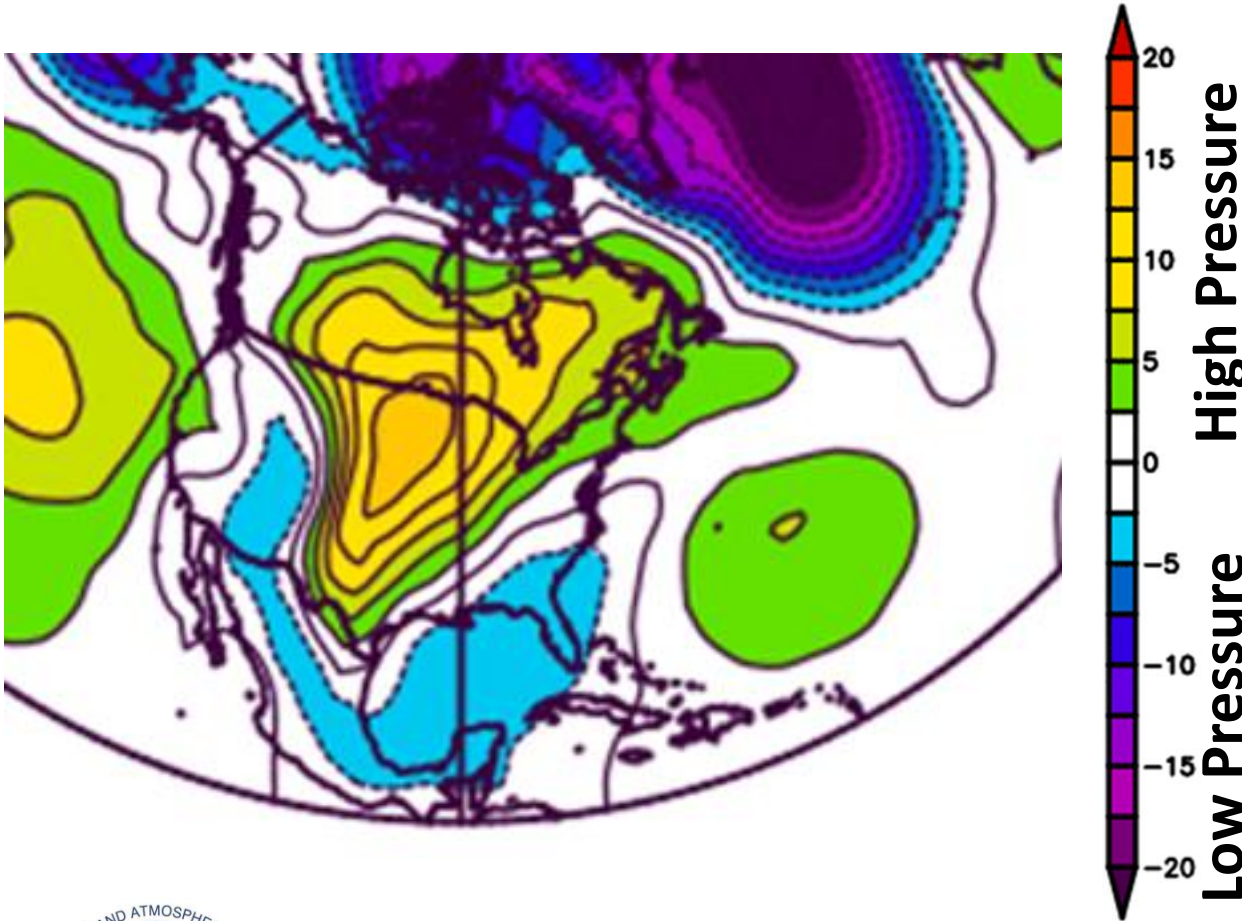
High Pressure

Low Pressure



Sea Level Pressure (mb) Composite Anomaly (1981–2010 Climatology)
2/14/21 to 2/18/21
NCEP/NCAR Reanalysis

High Pressure Over North America



- A high-pressure front stabilized over Texas and the US plains region
- After Uri moved through, wind turbines were idled all the way up to Canada, including fully winterized units
- High pressure weather patterns are common in both winter and summer and impact wind velocities

Instability - Minor Contributors

- Freezing of wind turbines
- Freezing of gas wells
- Nuclear reactor outage
- ERCOT not connected to national grids

Issues with Thermal Power

- **Lack of proper prioritization of supply of electricity to NG supply chain, heat tracing/compressors. Magnitude?**
- **Natural gas supply to a power plant was shut due to interruptible power contract**
- **One plant incurred low voltage trip ahead of a frequency trip**
- **Coal in railroad cars iced over**
- **Poor timing of shutdowns, e.g. pigging of NG supply line**
- **Net impact of low NG header pressures?**
- **Too many plants in planned outages**

Calls to Fix the Grid

- Hearings held in Texas House (2/25-26) and US House (3/24)
- Focus on 2011 freeze and need for “winterization”
- Texas Legislature passes non-prescriptive SB3, (‘fix the grid’ bill).
 - broad authority to PUC to **restructure power pricing policy.**
- Gov. Greg Abbott issues a strong directive to fix underlying issues
- Multiple Federal initiatives in Washington have the potential to totally impact the reliability of the ERCOT grid, especially a national renewable mandate (100% by 2035?)

Intermittency of Renewables

Take-home messages for today!

- Renewable intermittency was one of the three major components of ERCOT February '21 crash
- Wind and solar fed to the grid on an “as-available” basis
- Who owns this intermittent nature of renewables? – In practice, costs and risks are socialized. Grid customers pay for the excess costs and bear incremental risks
- Who benefits? – In practice, electricity providers that market “100% renewable energy” packages. Companies that tout 100% “clean” power.

Intermittency of Renewables

- Wind and solar advocates argue that all power sources are intermittent; they cite planned and unplanned thermal outages (gas/coal/nuclear)
- This is a false equivalence
- Intermittent nature of wind and solar are weather-related and non-controllable. They are routine on a daily, monthly, and seasonal basis. This is in addition to operational outages

Engineering the Grid for Reliability

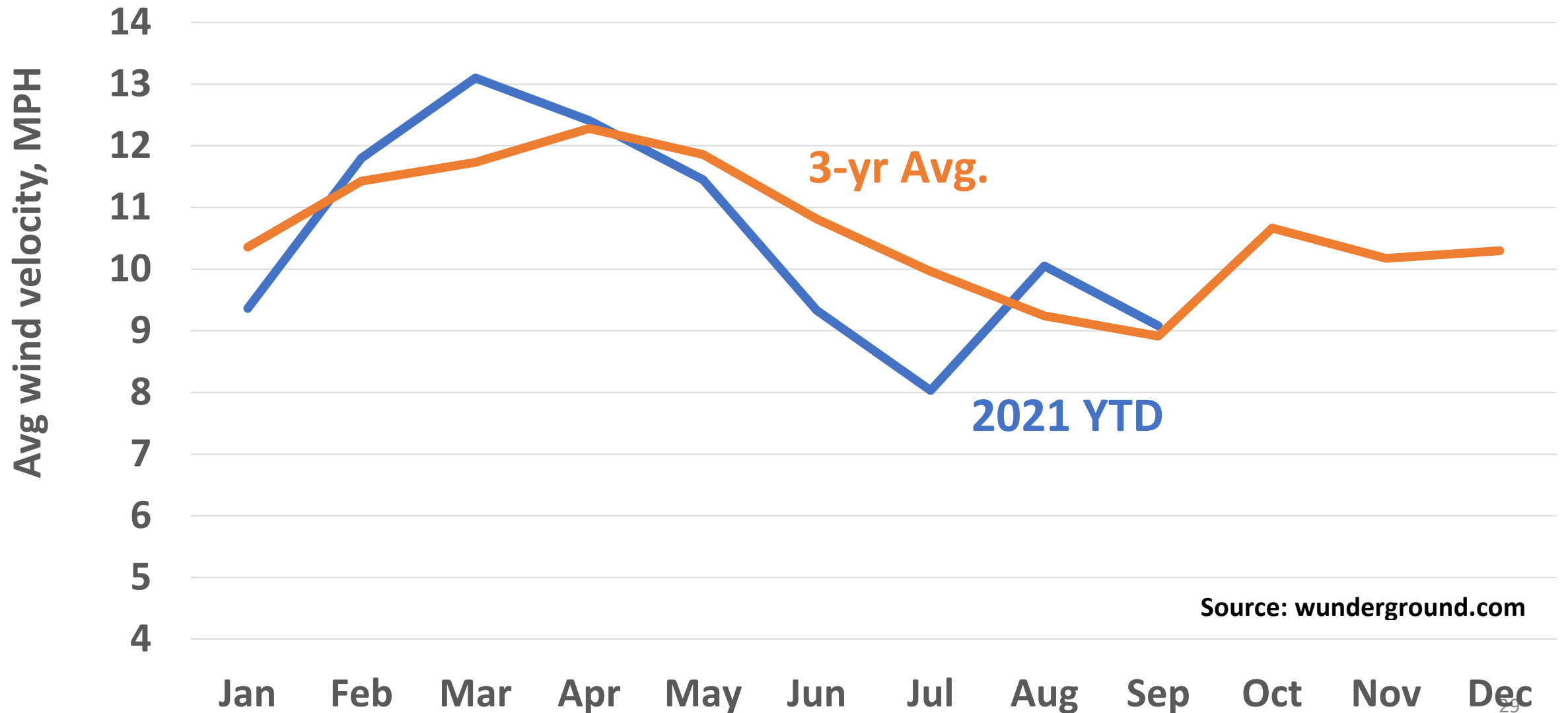
- Intermittency of renewables must be addressed!
- ERCOT is short a minimum of 10GW of dispatchable power
- Berkshire Hathaway pitched addition of 10GW natural-gas fired power **if profitability is guaranteed**
- Best technical solution may be RICE (Reciprocating Internal Combustion Engines) like those seen at South Texas Electrical Co-op and City of Denton
- Requirements for new weather-dependent power sources to provide back-up at their own expense



Feeding Electrons into the Grid; Are All Electrons the Same?

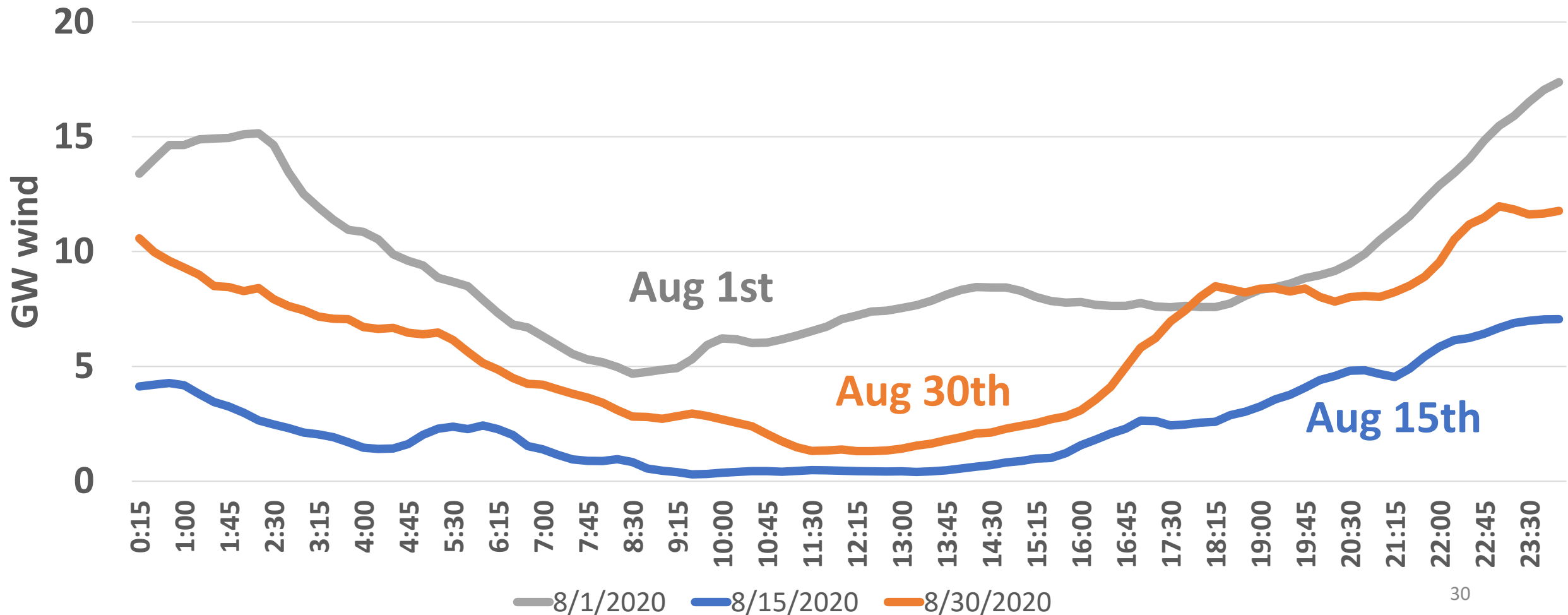
Current PUC pricing policy: All electrons fed into the grid are priced the same. There is no premium for consistency of output or dispatchability. External support from PTC's and carbon credits tilt playing field

Monthly Abilene Wind Speed



Example: August Doldrums

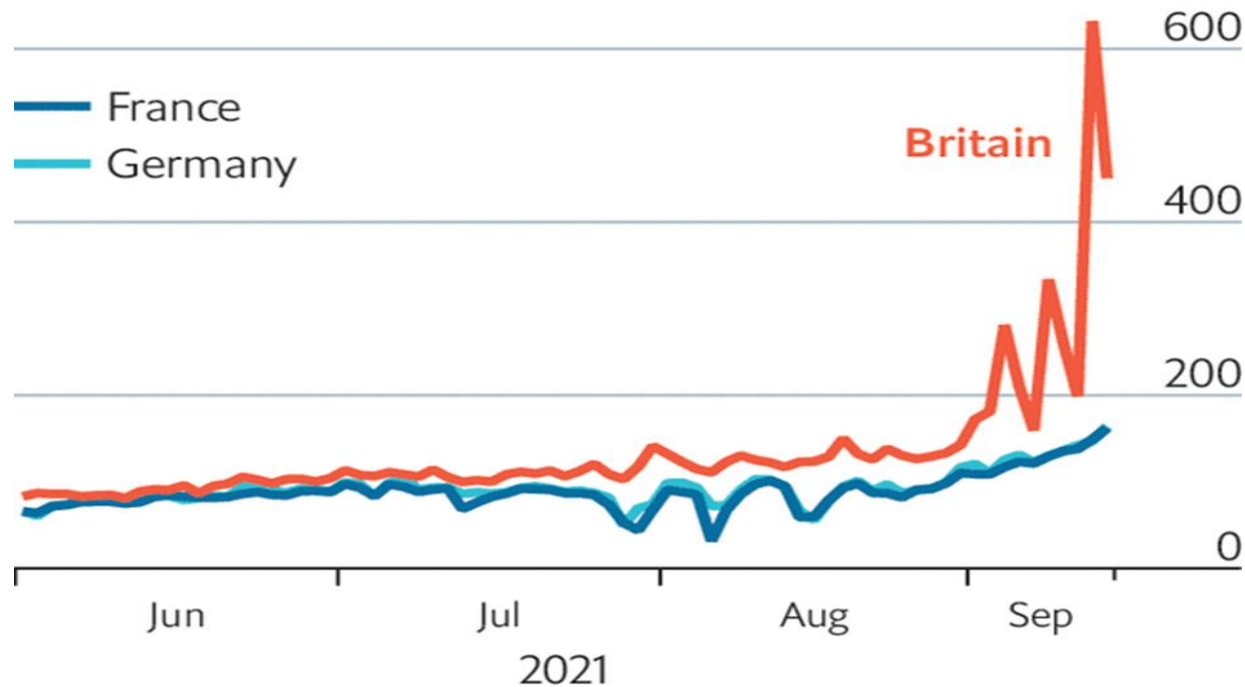
Reported Wind Power for ERCOT, August 2020



UK Power Prices, 2021

Highly charged

Day-ahead wholesale baseload power prices
€ per MWh



Source: ICIS

The Economist

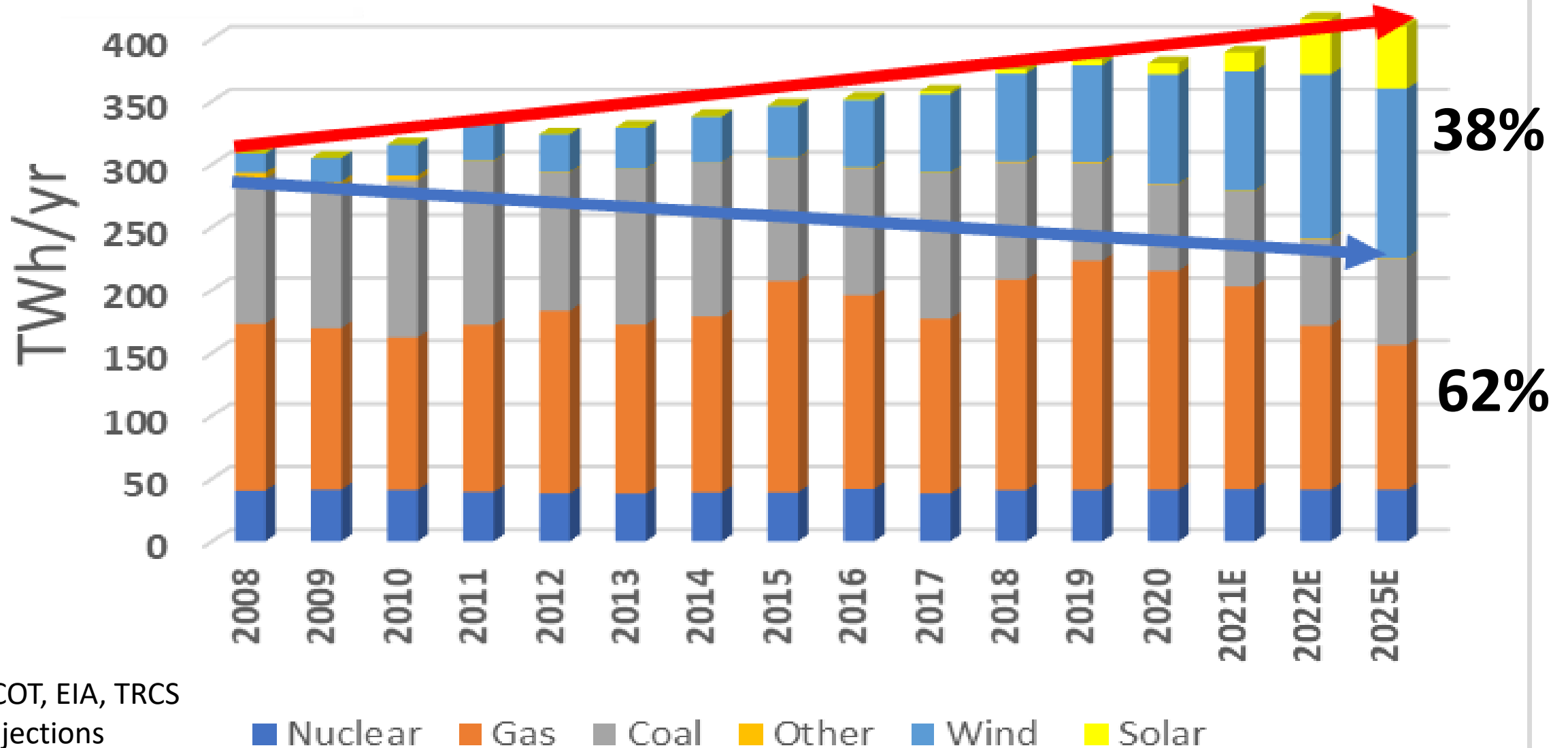
- UK coal consumption in '06 was 51MM MT, in '19 was 10MM MT with 70% imported
- UK power depends on wind turbines in North Sea
- Gas is the primary energy back-up for both UK and Europe
- Lack of power from low wind resulted in high demand for natural gas that was costly and unavailable
- Typical residential prices for power have been Euro100-200/MWh
- Gas-based chemical industry in the UK shut down due to non-competitive position

Costs of Intermittent Operations

**Levelized Costs (LCOE)
(from EIA or IRENA)
Estimates do not include
these socialized costs**

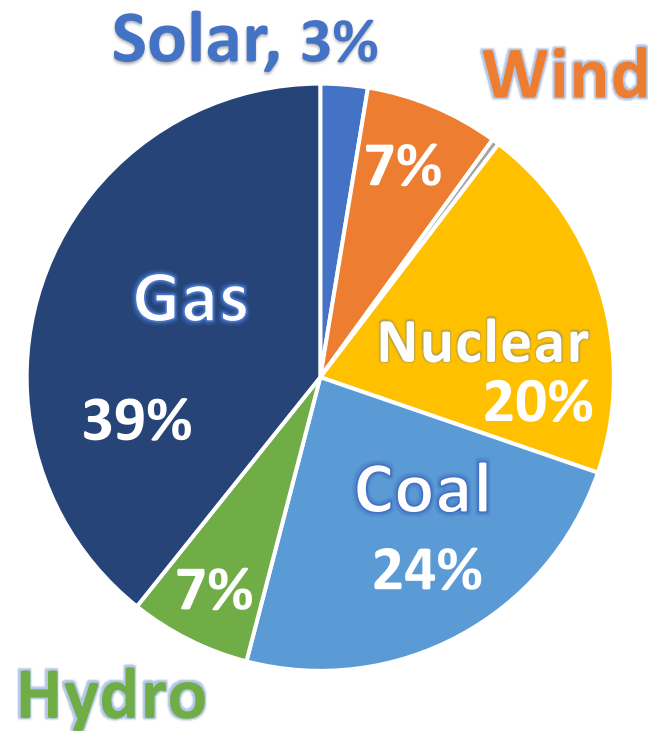


Power Generation



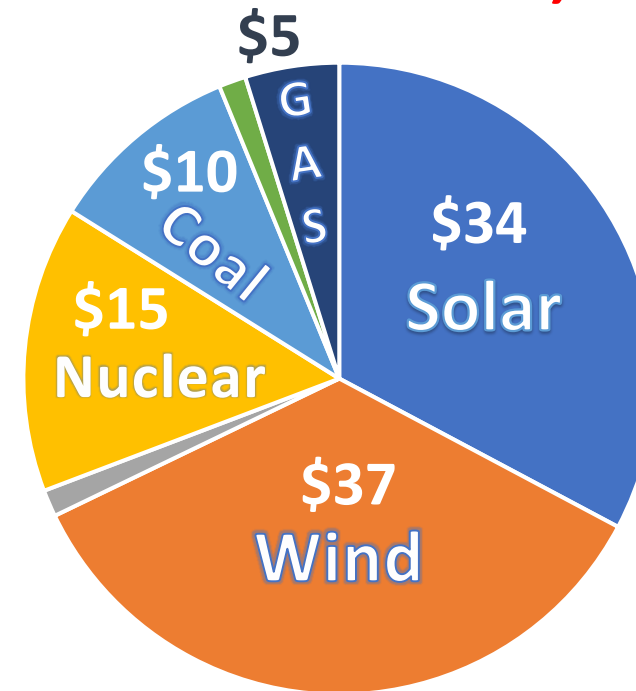
Federal Subsidies for Electrical Power

US Power Supply, TWhr



Source: EIA, 2019 basis

\$B Total Subsidies, 2010-2019



Source: TPPF, Federal Energy Subsidies and Support from 2010 to 2019, July 2020

Conclusions 1

- The Feb. '21 ERCOT grid outage had 3 immediate causes
- Such an event was likely inevitable due to replacement of dispatchable power for intermittent power supply
- Favorable public policy → explosive growth of wind and solar to 25% of total power (2020), → +38% (2025)
- Deregulated power in Texas is not a free market
- **“Temporary” Federal and State incentives have been institutionalized**

Conclusions 2

- **Growth of rooftop solar in Texas (ERCOT - 6GW) will provide additional challenges to balancing the grid**
- **The rush to shut down coal power must be stopped**
- **New federal legislation targeting 80% renewable power by 2030 and 100% by 2035. This is suicidal!**

Gregg A. Goodnight

Personal

Born in Houston, TX, 70 years old. Retired, married to Nancy Hofer from PA, 46 years, 3 grown children

Education

BS in Chemical Engineering, U. of Texas 1973
MS in Chemical Engineering, U. of Pennsylvania, 1976

Employment

E.I. DuPont in Philadelphia, PA and LaPorte, TX (1973-1978)
Monsanto/Solutia, Chocolate Bayou, TX (1978-2000)
UBS Chemical Equity Analyst, Houston Tx, 2000-2013
TZMI, Industry consultant for Chemicals, 2014-2017

Current Interests

Climate change science and public policy implications, green energy impacts on society, alumni support for UT Dept of Chemical Engineering, TRCS and CO2 Coalition membership

Hobbies

Classical music and music performance, 40-year member and cello player for the Galveston Symphony Orchestra

Nov 3, 2021

