

Renewable Power Integration



Presentation to Indiana Oil and Gas Assn., 4/18/23; by Gregg Goodnight

Integration of Renewables in ERCOT

Power Grid Stability Depends of Fossil Fuels

- **The Climate Change Narrative**
- **ERCOT and the Texas Power Grid**
- **Inherent Wind Variability**
- **The Need for Coal and Dispatchable Power**
- **The War on Coal and Fossil Fuels**

Fossil fuels are essential and is not climate villains!

Gregg Goodnight, CO2 Coalition and TRCS Member

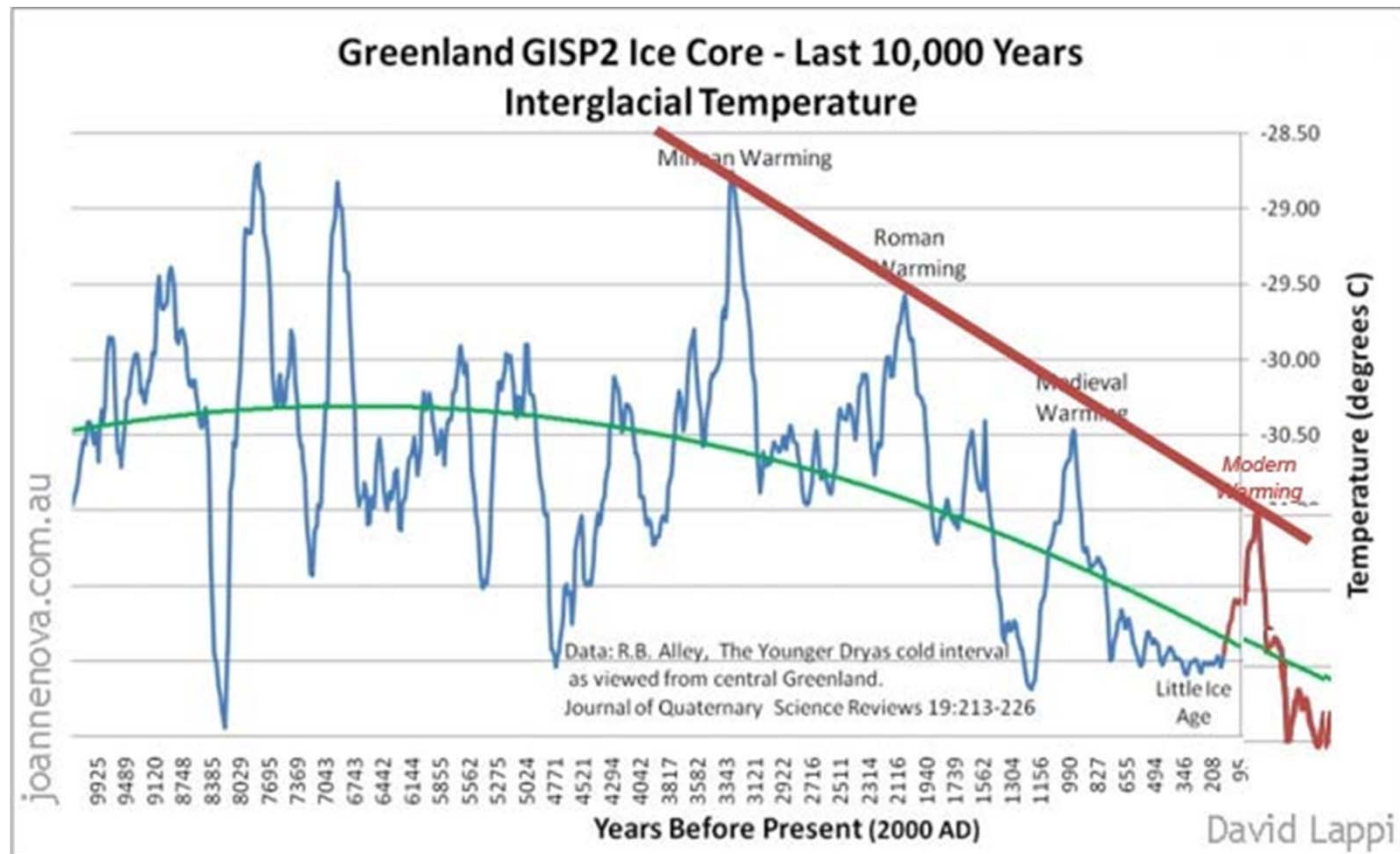
CO2 Coalition – Climate Positions

- Carbon dioxide is an essential trace gas (0.04% or 410ppm)
- The amount of atmospheric warming associated with CO₂ is low, approximately 1C per doubling of CO₂
- Plants benefit from higher CO₂, crop yields improve
- There is no case for demonization of CO₂ or for climate alarmism
- Alarmist public policy is **all** based questionable climate models
- The war on coal and other fossil fuels makes zero sense!

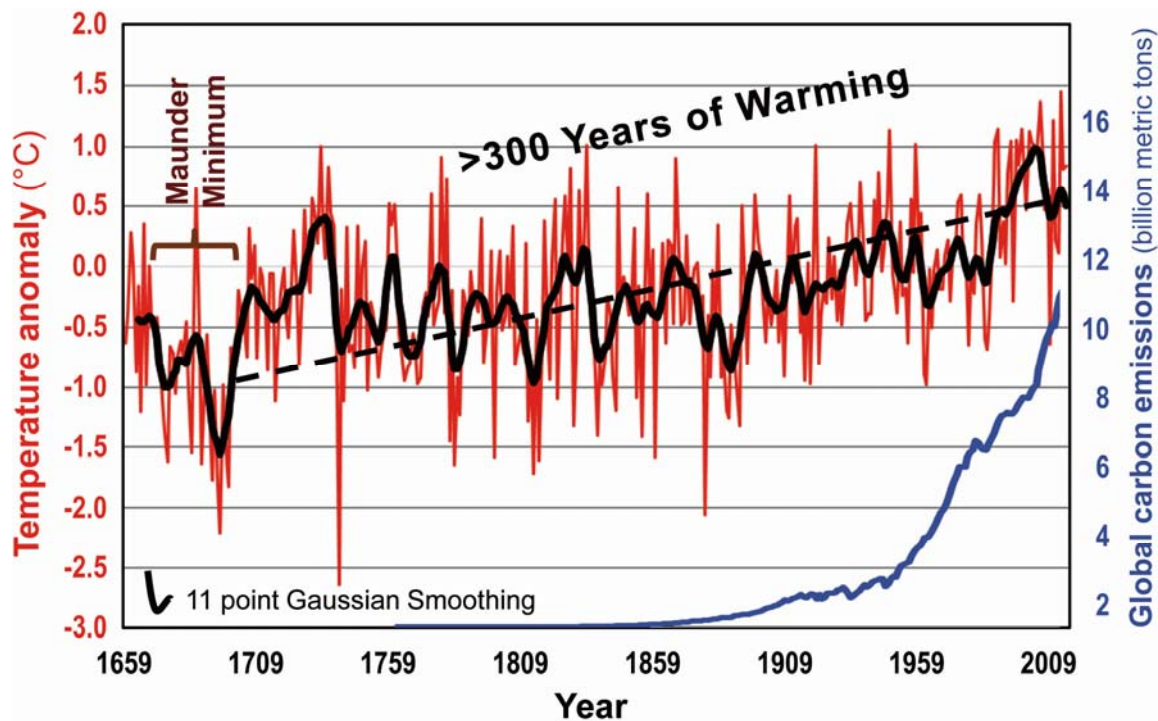
More CO₂ is beneficial for mankind

Gregg Goodnight, CO2 Coalition and TRCS Member

Warm Periods During Holocene



AGW – CO₂ Must Precede Warming!



Global temperatures have been increasing since the end of the Little Ice Age

An effect (global warming) cannot precede a cause (rising CO₂ emissions)

AGW → Anthropogenic (man-made) global warming

The ERCOT System

ERCOT is a large independent power system and thus represents a national test case for the integration of renewable power. Lessons on grid stability, pricing policy, weather dependency, and power costs are obtained through critical analysis of this system

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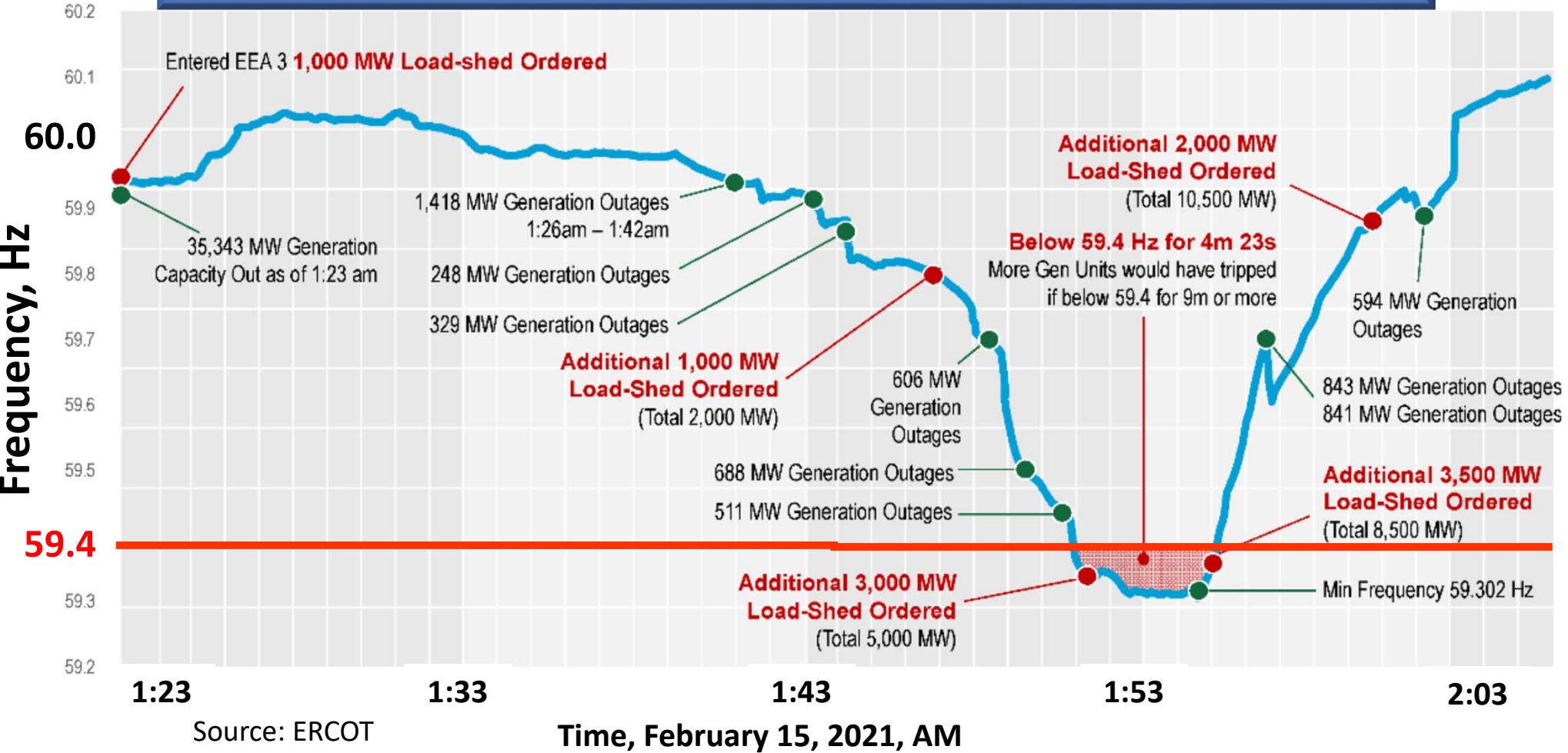
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ERCOT Power Supply – 2022

Source	Capacity, GW	Avg. Utilization	TWh	Avg. GW	% Nominal Capacity	% of Delivered Power
Wind	35.4	34.6%	107.3	12.2	27.3%	25.1%
Solar	13.4	20.6%	24.2	1.0	2.8%	5.7%
Hydro	1.2	3.2%				
Coal	15.5	52.7%				
Natural Gas	59.3	35.2%				
Nuclear	5.1	93.3%				
Total	129.9	38.9%	428.5	43.4	100%	100%

Texas leads the nation in wind capacity, and solar is projected to grow from 4GW in 2021 (pre-Uri) to 30 GW by mid-decade.

Loss of Frequency Control



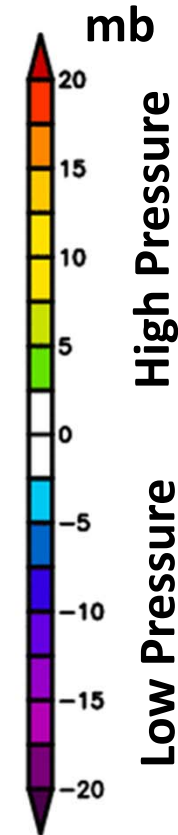
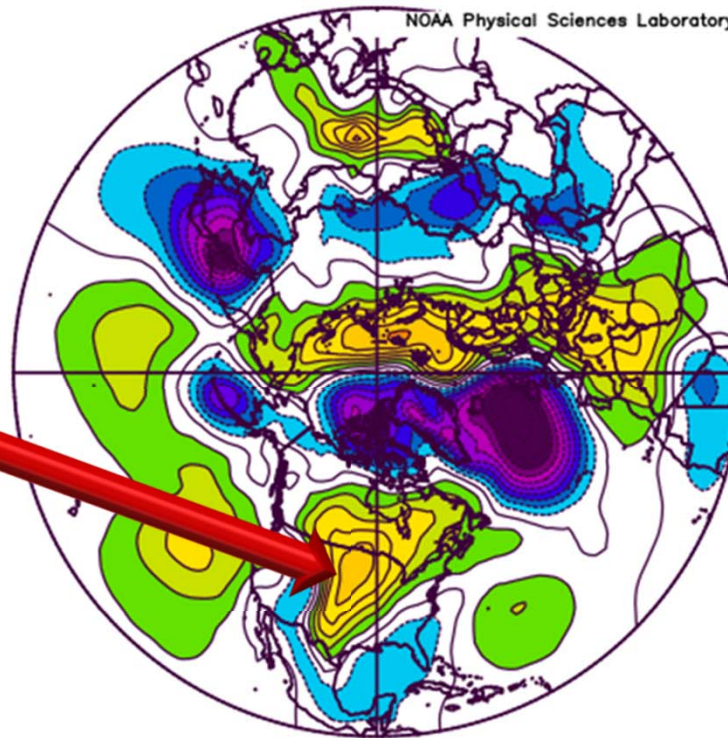
Source: ERCOT

Time, February 15, 2021, AM

Northern Hemisphere Pressure Anomaly

Sea Level, Feb. 14-18, 2021

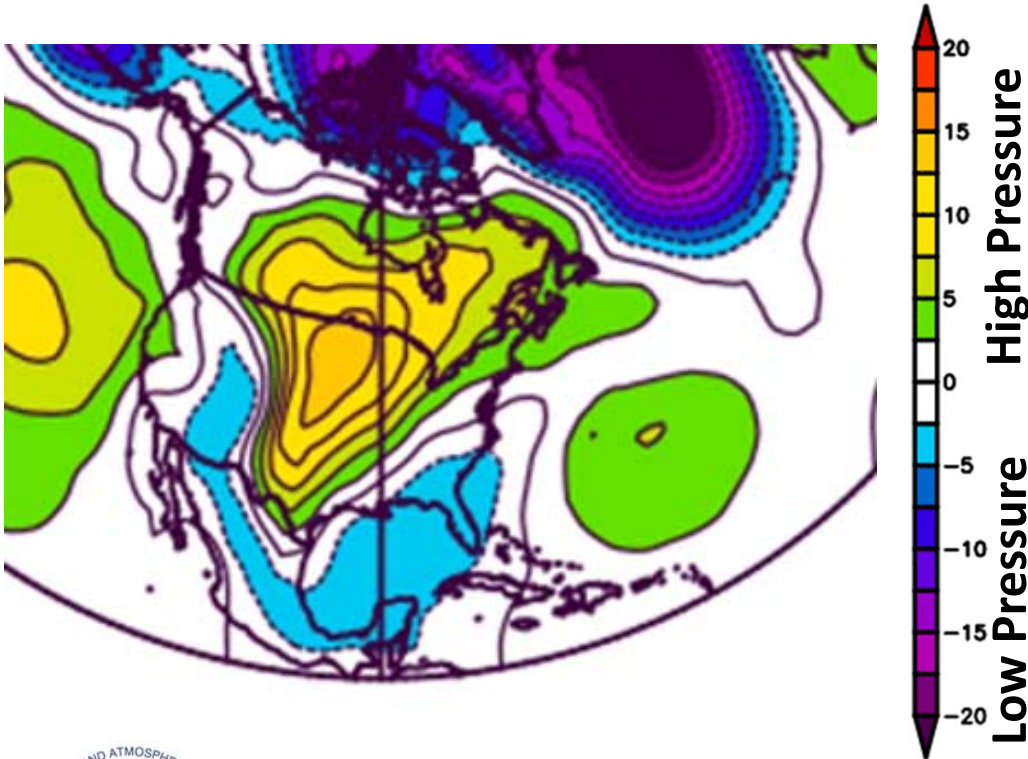
North
America



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



Uri High Pressure Anomaly



- Storm Uri, stable HP-front over Middle America
- Idled turbines in up to Canada...
- Elliott also saw a wind power sag



Reported Power During Elliott

megawatthours

60,000

Gas compensates for lack of wind

40,000

20,000

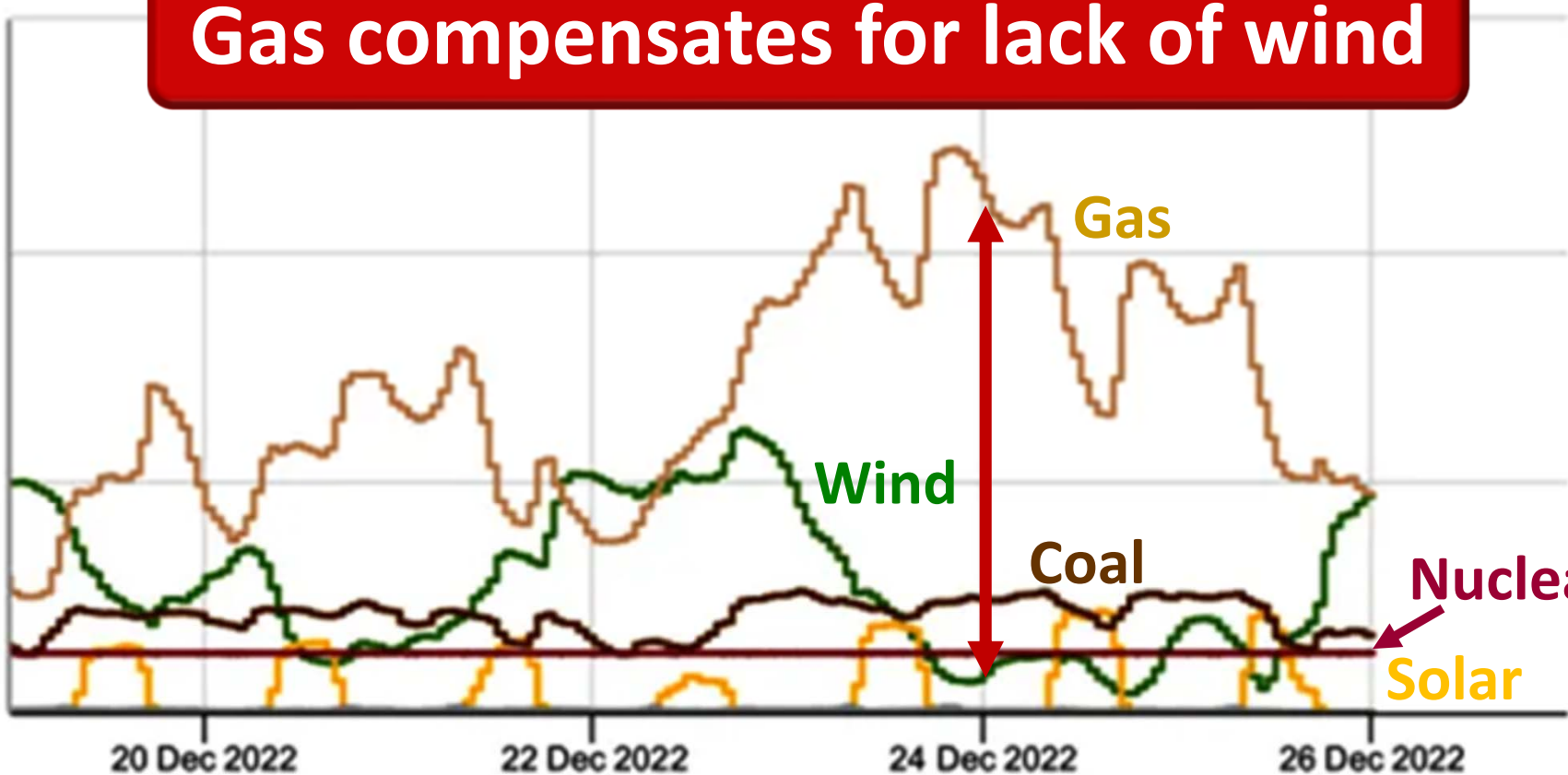
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20 Dec 2022

22 Dec 2022

24 Dec 2022

26 Dec 2022



Wind

Gas

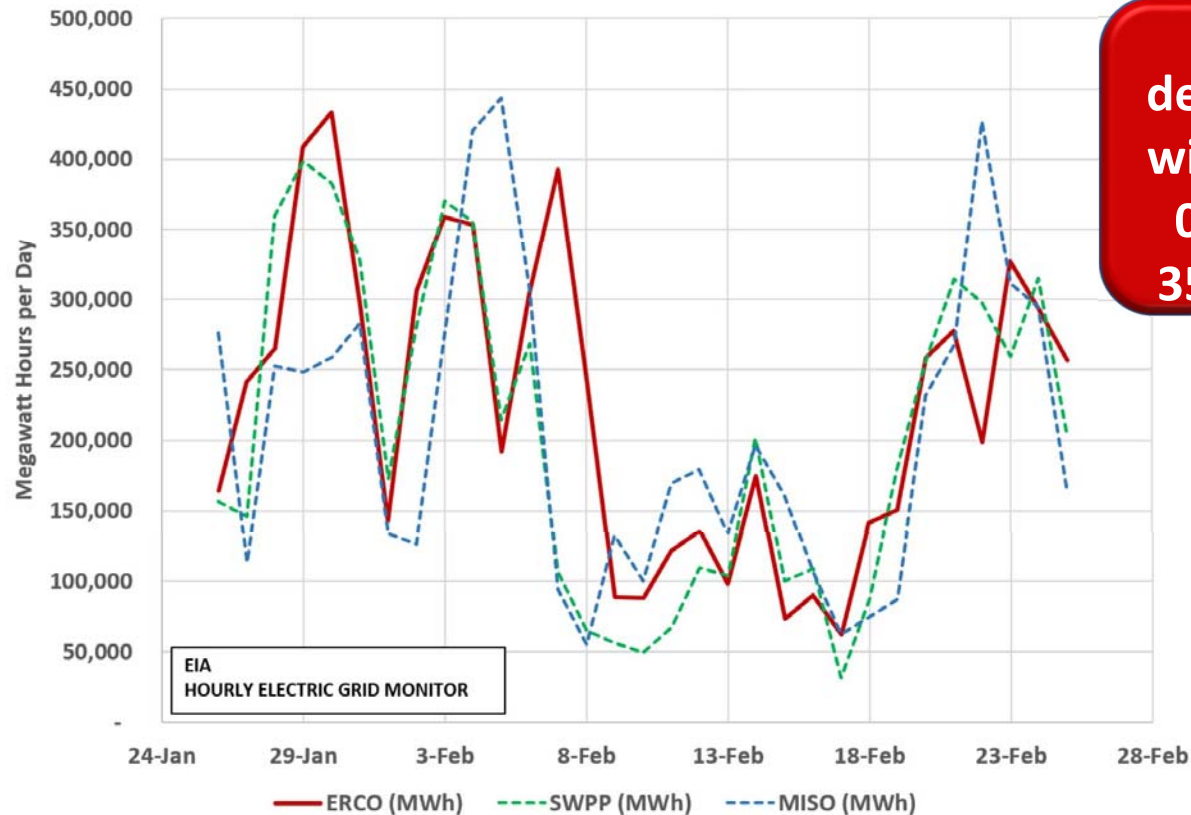
Coal

Nuclear

Solar

US Wind Power Output During Uri

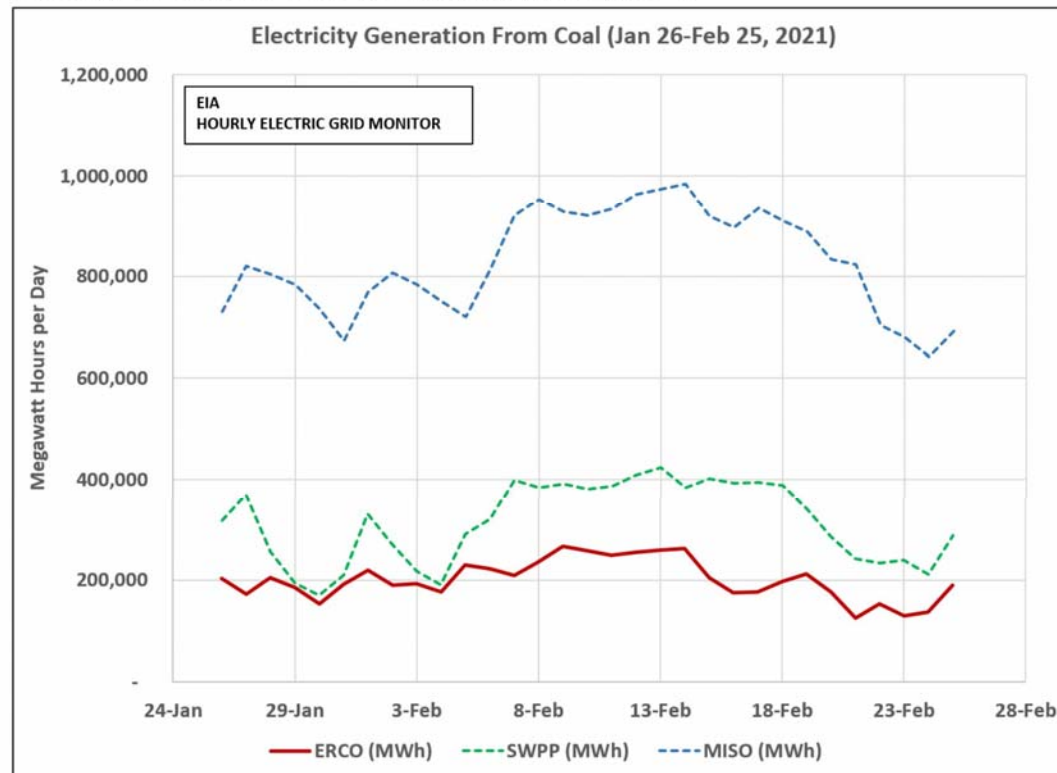
Electricity Generation From Wind Power (Jan 26-Feb 25, 2021)



**On 2/15/21,
delivered ERCOT
wind power was
0.8 GW out of
35G W capacity**

Coal Saved the Day in MISO and SWPP

MISO and SWPP didn't experience as severe power failures because they have far more coal-fired generation than ERCOT.



Wind and Solar Drawbacks

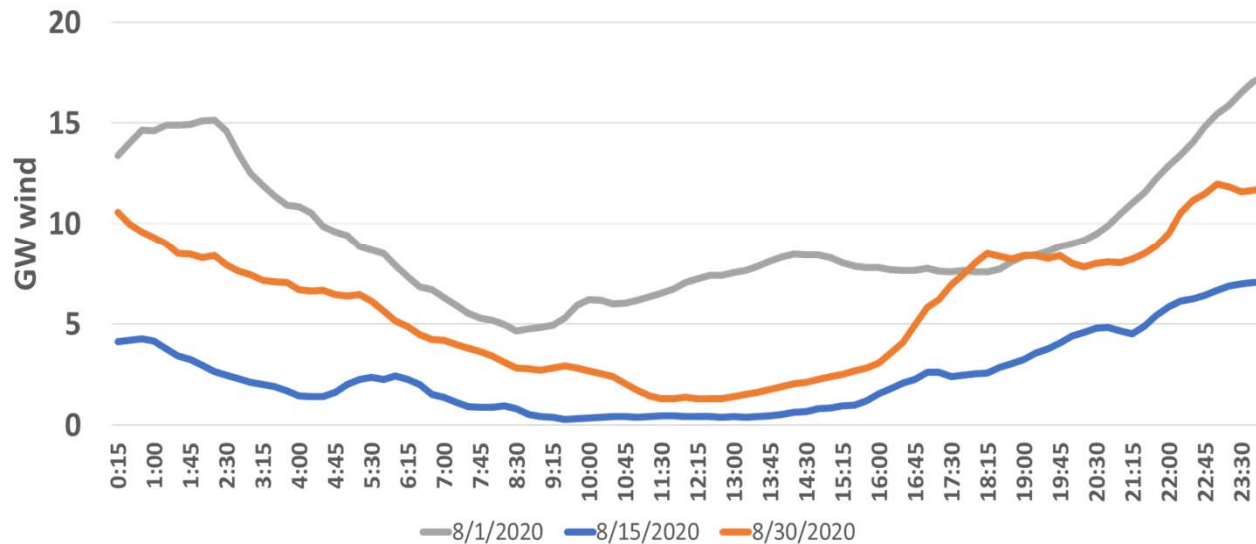
The installation of wind and solar power is not a direct replacement of dispatchable natural gas/coal/nuclear based power.

Dispatchability is a Key Component of Power!

Europe has learned this the hard way. Power prices have skyrocketed, coal and nuclear have been restored and shutdowns delayed

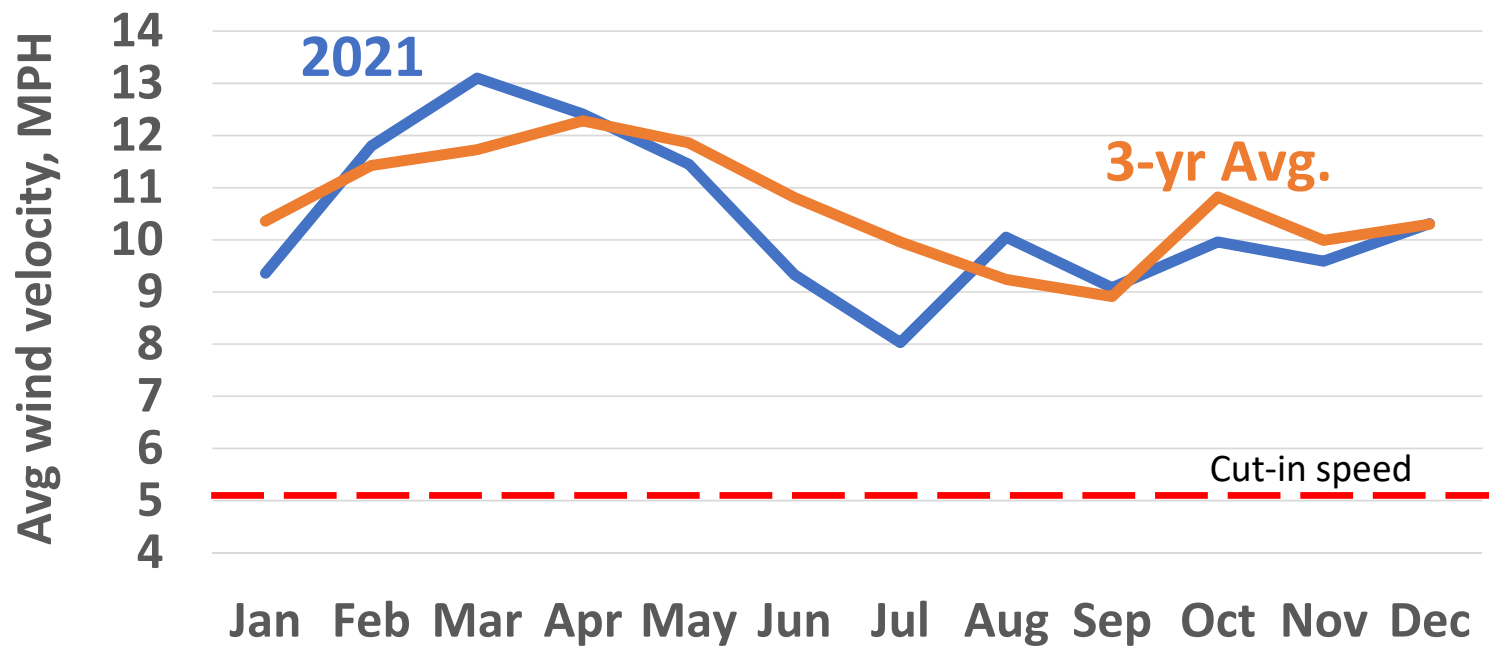
Wind Power Variability

Reported Wind Power for ERCOT, August 2020



- The power that can be generated by wind turbines is proportional to the cube (that is V^3) of wind velocity, this amplifies wind power's generation variability
- You cannot assure adequate wind power by adding more turbines; wind outages are regional in nature

Seasonal Wind Speed Abilene, Tx



Source: wunderground.com
monthly averages 2021

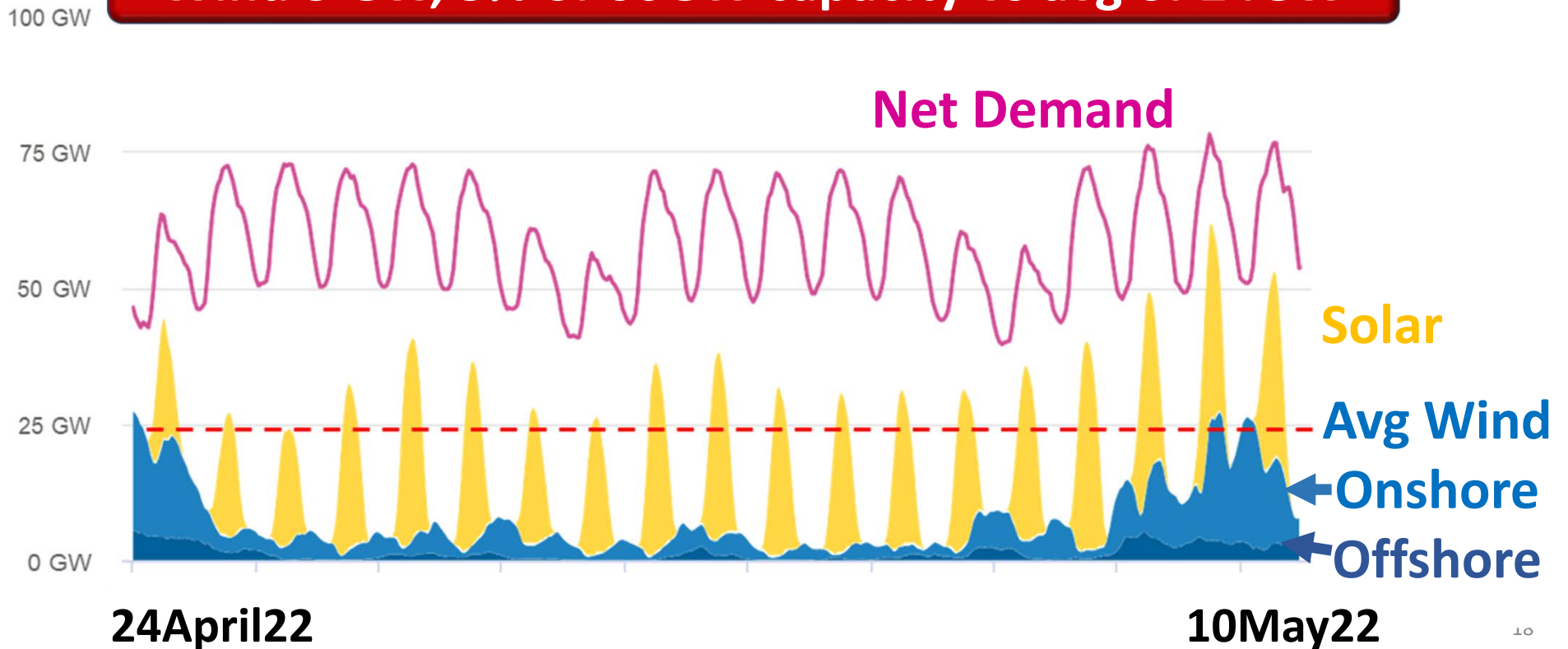
Global Wind Droughts

- **Seen in all geographic regions**
- **Associated with stable high-pressure systems both summer and winter → little wind**
- **Uri saw a prolonged 5-day period**
- **Germany saw a wind drought in the spring of 2022**
- **The UK saw a wind drought in the fall of 2021**

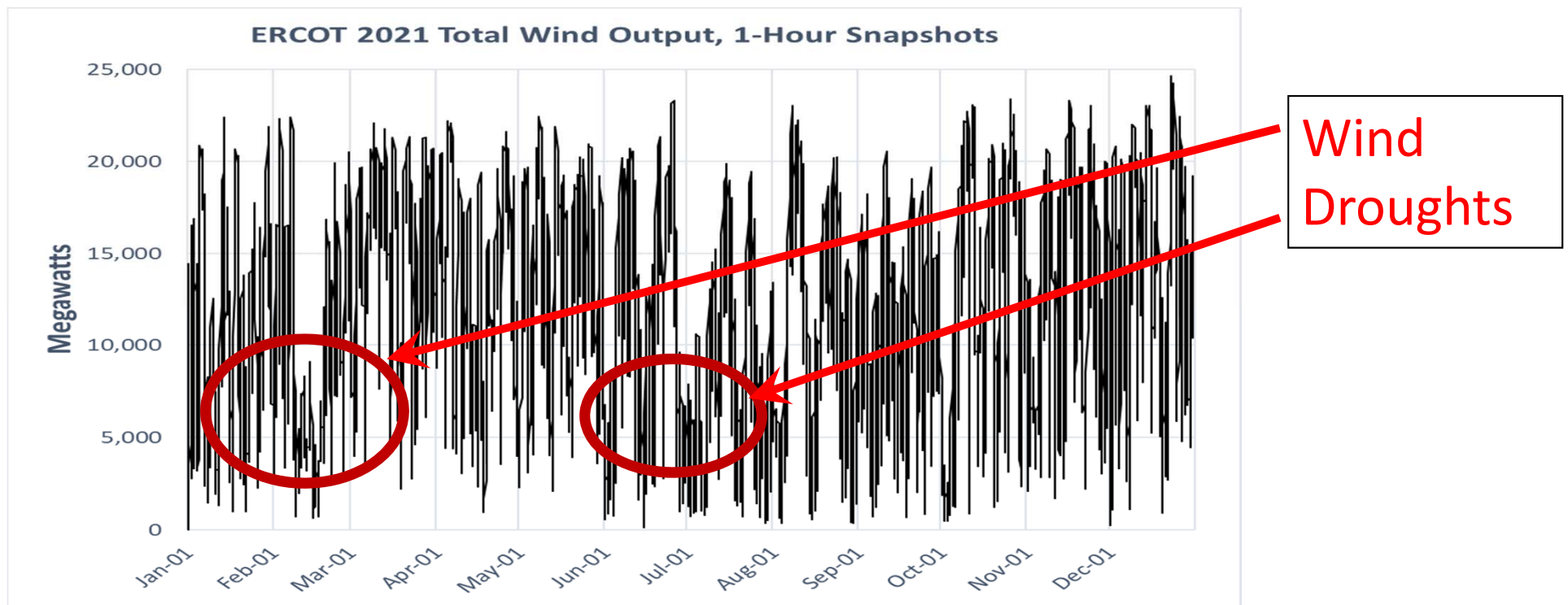
German Wind Drought 2022

Wind 3 GW, 5% of 60GW capacity vs avg of 24GW

Power Generation & Demand



Daily Wind Power Output



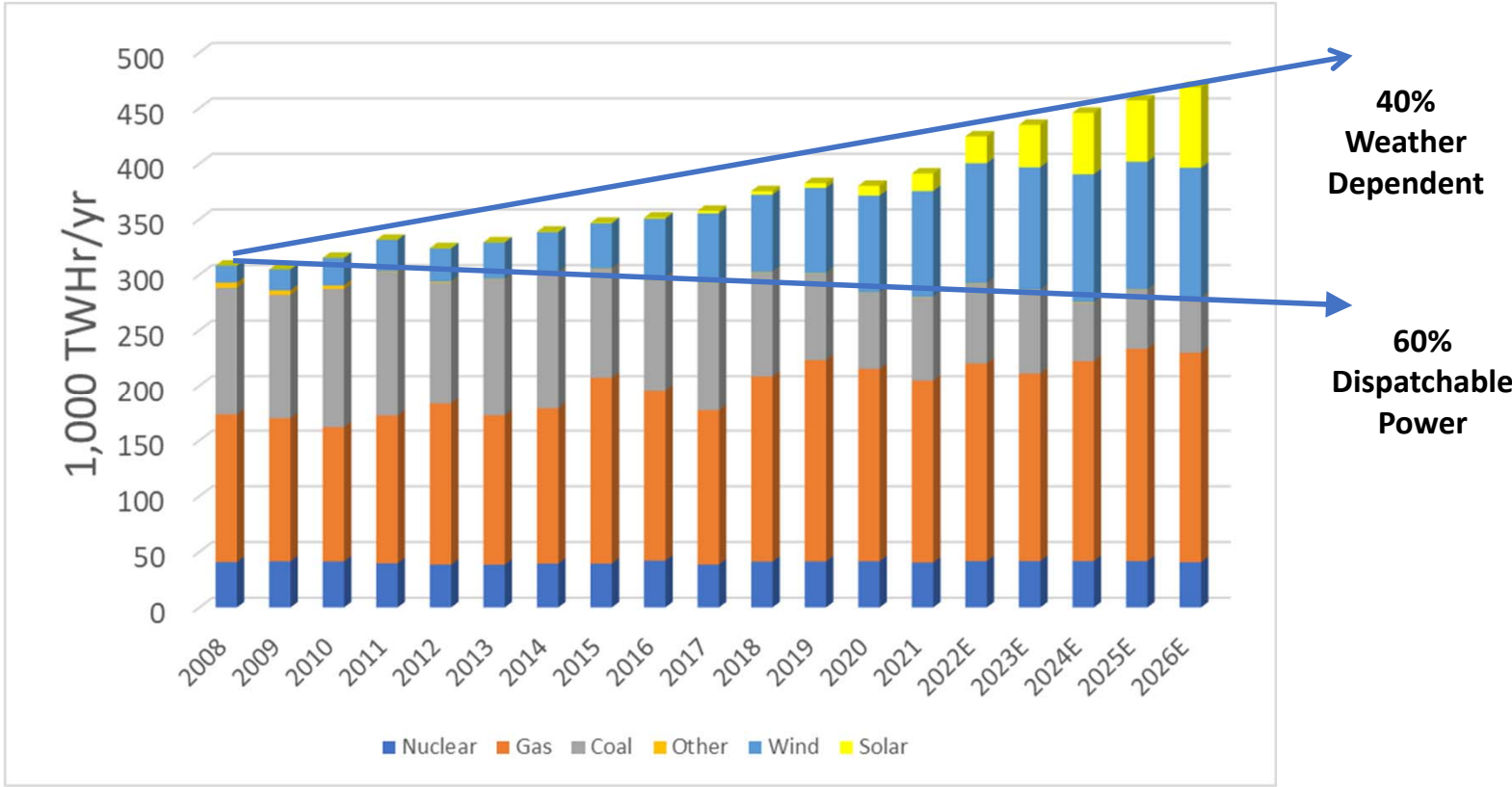
Source: ERCOT 2021 Hourly Wind and Solar Output

Grid Inertia Considerations

- Frequency control (60Hz) is essential
- No mention in E3 Report (consultant contracted by PUC to study pricing options)
- ‘Spinning reserve’, from thermal power generators
- Renewable power sources are non-synchronous;
do not contribute to frequency or voltage control
- ERCOT is very familiar with this; politicians not so much
- As more renewable power is added to the grid,
frequency control is increasingly difficult



Power Generation

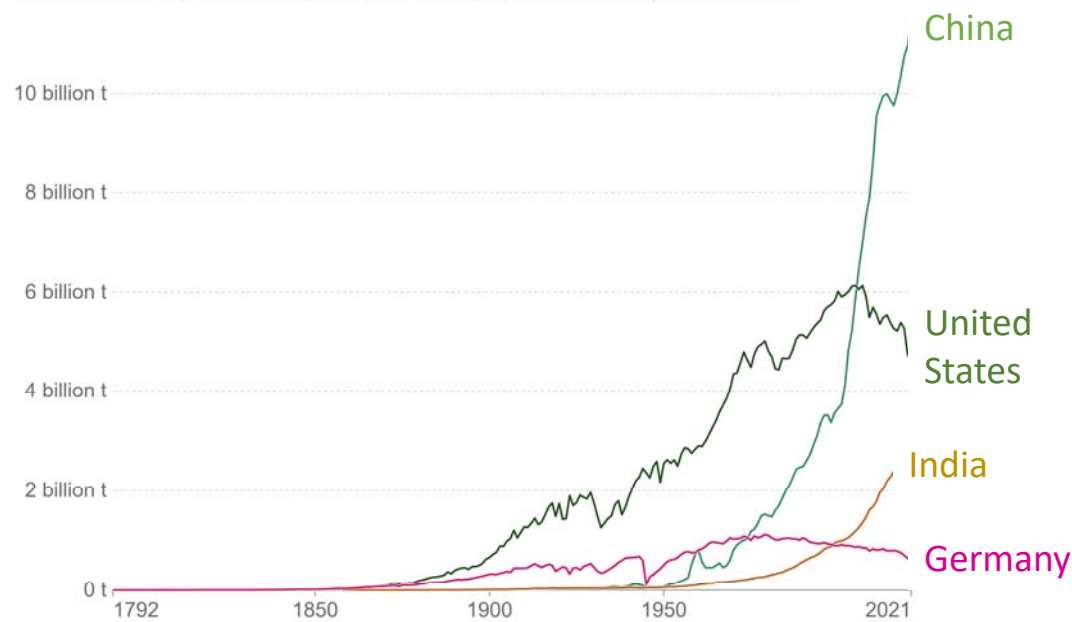


Source: ERCOT, EIA, E3, TRCS projections

CO2 Emissions per Country (GT/yr)

Annual CO2 emissions

Carbon dioxide (CO₂) emissions from fossil fuels and industry¹. Land use change is not included.



Source: Our World in Data based on the Global Carbon Project (2022)

OurWorldInData.org/co2-and-greenhouse-gas-emissions • CC BY

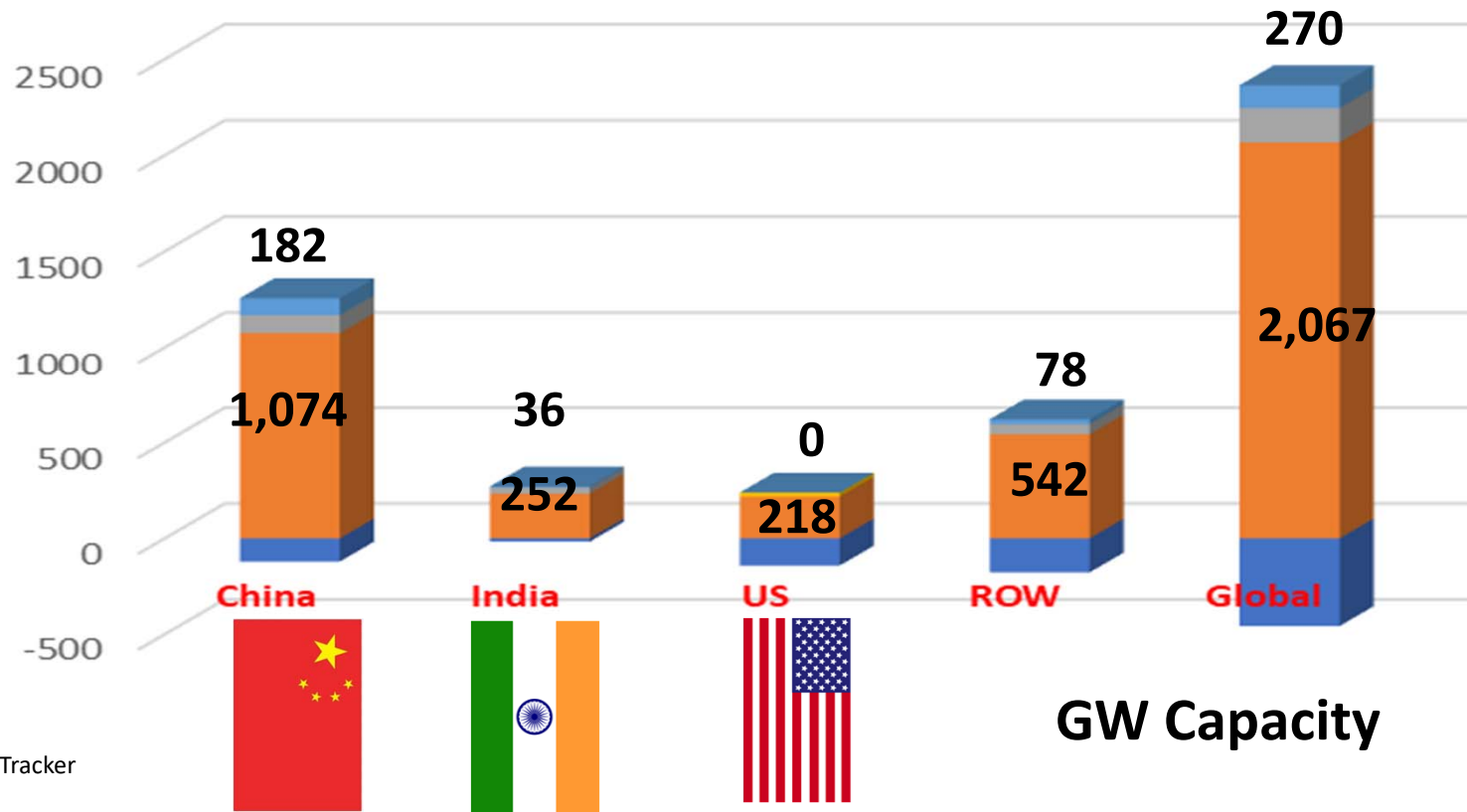
¹ **Fossil emissions:** Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Country	GT/yr (2021)	Percent
China	11.5	31.2%
US	5.1	13.6%
India	2.71	7.4%
Others	17.5	47.8
World	36.8	100.0%

Source: Our World Data

Global Coal Power Trends

Operating Construction Announced Retired



Source: Global Coal Plant Tracker

Our Secretary of Energy – Is Correct!



FILE PHOTO: U.S. Secretary of Energy Jennifer Granholm hosts a U.S. Department of Energy news conference in Washington, U.S., December 13, 2022. (REUTERS/Mary F. Calver/File Photo)

“... I think China has done, has been very sensitive, and has actually invested a lot in their solutions, to achieve their goals.” Granholm added, “So we’re — we’re hopeful that, you know, **we can all learn from what China is doing.**”

Texas Public Policy Foundation chief national initiatives officer Chuck DeVore told Fox News Digital in February that **China’s climate change initiatives are “merely a device to engage gullible Westerners into thinking that somehow we can get meaningful cooperation.**

Source: Fox News, 3/10/23

ERCOT Capacity Since Deregulation

Dispatchable Power

Weather-dependent Power

Coal Power					Wind Power				
		Percent	Additions	Percent			Percent	Additions	Percent
2007	15.8 GW				2007	4.5 GW			
2020	13.6 GW	-13.9%	-2.2	-13.9%	2020	31.3 GW	596%	26.8	595.6%
2025	11.9 GW	-24.7%	-3.9	-28.7%	2025	40.0 GW	789%	35.5	788.9%
Nuclear					Solar Power				
		Percent	Additions	Percent			Percent	Additions	Percent
2007	5.1 GW				2007	0.0 GW			
2020	5.1 GW	0.0%	0.0	0.0%	2020	4.9 GW	N/A	4.9	#DIV/0!
2025	5.1 GW	0.0%	0.0	0.0%	2025	22.8 GW	366.1%	22.8	#DIV/0!
Gas Power					Total Renewable				
		Percent	Additions	Percent			Percent	Additions	
2007	54.7 GW				2007	4.5 GW			
2020	56.1 GW	2.6%	1.4	2.6%	2020	36.2 GW	704.4%	31.7	704.4%
2025	53.9 GW	-1.5%	-0.8	-1.5%	2025	62.8 GW	73.6%	26.6	592.0%
Dispatchable					Total Renewable				
		Percent	Additions	Percent			Percent	Additions	
2007	75.6 GW				2007	4.5 GW			
2020	74.8 GW	-1.0%	70.3	93.0%	2020	36.2 GW	704.4%	31.7	704.4%
2025	70.9 GW	-6.2%	66.4	87.8%	2025	62.8 GW	73.6%	26.6	592.0%

Bottom line: Favorable federal treatment has resulted in only wind and solar additions (ITC's, PTC's)

Biden Administration Strategy

- It is easier to tighten regulations to a point where certain technologies are economically unviable rather than to pass new laws
- Cost/benefit analysis required by Congress for new and revised regulations is gamed with questionable calculations; Biden's Executive Order 13999 signed in January 2021 states that costs are no longer to be considered in the case of environmental impact
- The EPA is supposed to represent the best interests of all citizens, has become politicized. In reality, revised regulations reflect partisan policy choices
- There is a "revolving door" with the green industry NGO's (example - NRDC and Gina McCarthy, former Obama head of EPA and current Biden admin.)
- **Congress has mandated cost/benefit analysis (Circular A4) – is this what is happening? Real costs, imaginary benefits!**

The Green New Deal Revisited

- According to the DOE, the Inflation Reduction Act of 2022 represents a \$369B investment in the “modernization of the American Energy system”
- This is in addition to funds from the Bipartisan Infrastructure Law of 2021
- Biden’s 2021 re-entry into the 2015 Paris Agreement saw the doubling of CO2 reduction targets, from a reduction of 1.6GT/yr to a reduction of 3GT/yr from the 2005 base of 5.2GT/yr
- The new target represents a 50-52% reduction from actual 2005 CO2 emissions compared to 26-28% prior.
- **The only way to achieve these targets is through significant cuts in coal power capability and rapid expansion of weather-dependent renewables**

Bidens War on Coal through Regulations

Name	Potential Shutdowns	GW shuttered	Regulation Change	Comments
Good Neighbor Rule	22 states including Texas, PA, LA, KY and WV	14-23	Trace amounts of pollutants crossing state lines	Cross-state rule; ozone model based
Waste Water – Effluent Limitations	75 plants impacted; 26 plants in 14 states		Increase standards on ash ponds	Impacts coal ash ponds
Coal Ash Rule	6	12	PM2.5: 12→8 mg/m ³	Not science based
MAT (mercury & air toxics rule)			0.04→0.013→0.0012 lb/GWhr	Mercury down to 86.5 lb/yr in US
Effluent limitations	Impacts both gas and coal fired power	Tgt of 30GW coal by 2040 (90% reduction)	Effectively mandates carbon capture	BSEER used for CO ₂ capture?

Reference point: 210 coal-fired plants in US totaling 205GW capacity

Has the EPA Lost its Way?

The EPA was created by Nixon in 1970 without a mandate; now \$10B budget 40k employees

It derives much of its power from the Clean Air Act of 1970, amended in 1977 and 1990

The EPA's task was to improve ambient air quality through cost-effective reduction of priority pollutants

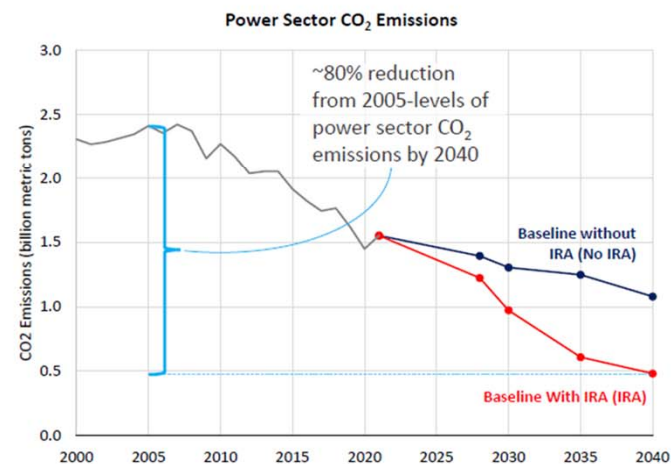
The "Climate Change" industrial complex hijacked the EPA's mission to declare war on CO₂



EPA's Integrated Planning Model

Introduction

- IRA is expected to greatly drive down power sector CO₂ emission in the coming decades
- EPA modeling of IRA impacts show major growth in clean and renewable technologies, driven by tax credit incentives, resulting in decreases in fossil fuel use
- Modeling results presented today are used to establish EPA's power sector baseline and are useful in informing EPA regulatory actions
- Ongoing analyses examine use of more advanced technology assumptions



Note: Results from the Baseline with IRA are pending publication.
Results from the Baseline without IRA can be found here:
www.epa.gov/power-sector-modeling/pre-ira-2022-reference-case

Source: EPA presentation, Cara Marcy 2/15/23

Thank You!

Thank you for your attention and I look forward to your questions during our Q&A

Gregg A. Goodnight

Personal

Born in Houston, TX, 72 years old. Retired, married to Nancy Hofer from PA, 47 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

April 18, 2023

