The Cold Hard Facts: Lessons from Texas Informing a National Strategy for Electric Emergencies

Mike Sloan,
Chief Strategy Officer
Synergetic

The Great Electrification Debate:
Too Green, Too Fast, or Not Fast Enough

Experience POWER
San Antonio, Texas
October 19, 2021

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Version for Handouts – Oct. 20, 2021

February 2021 at my 1850's Frontier House in San Antonio

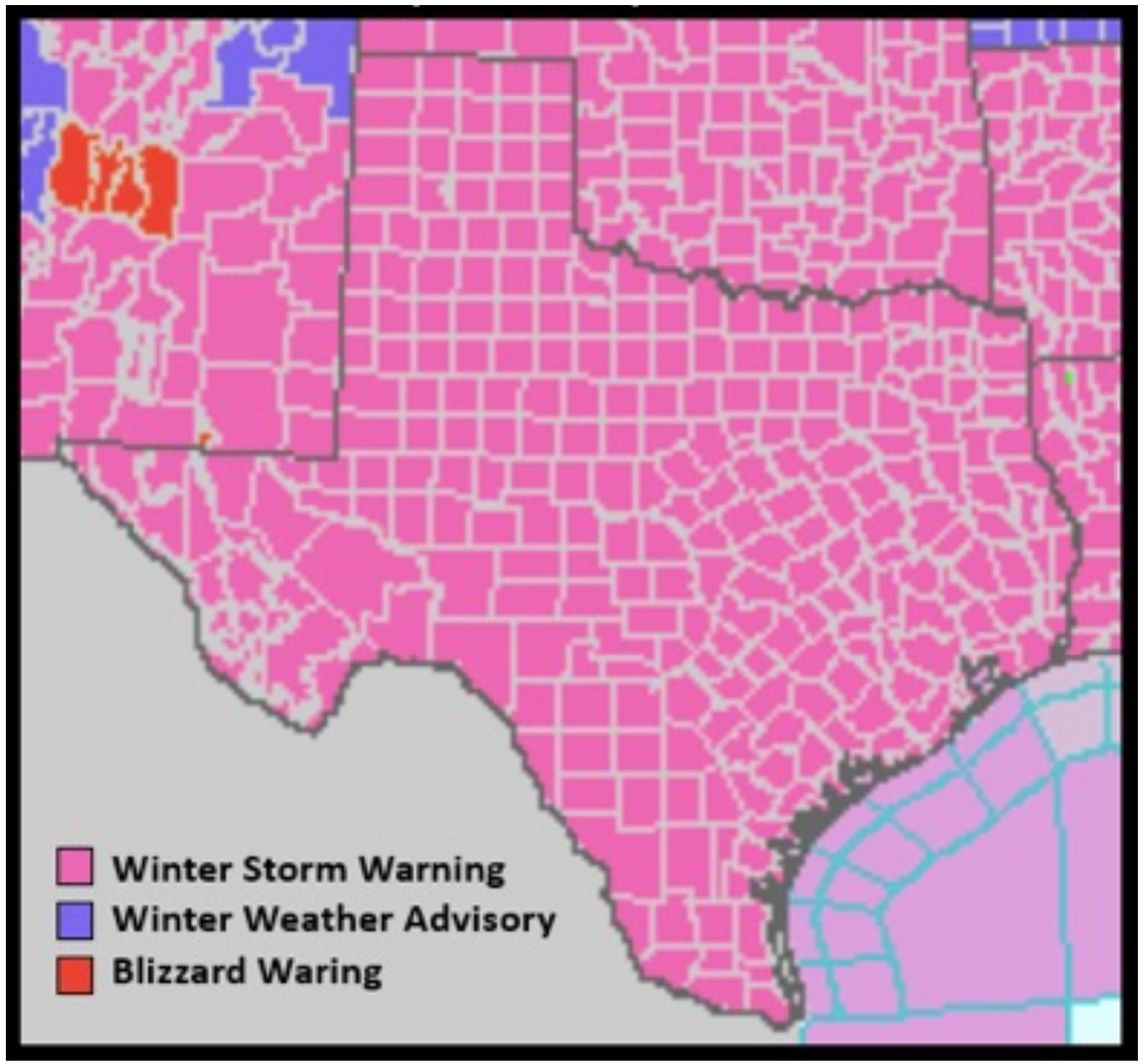
Lost Power 3 days / Internet 4 days / Water 5 days

(Mine is a common story – millions of Texans had extended outages)

Started out cozy

hard on house plants

hard on Plumbing



https://www.weather.gov/hgx/2021ValentineStorm

The Entire State of Texas was under a Winter Storm Warning on Sunday February 14, 2021

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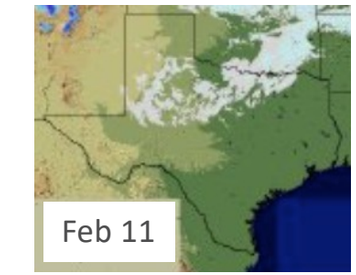
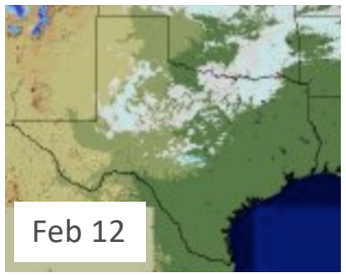
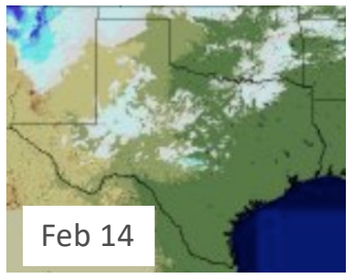
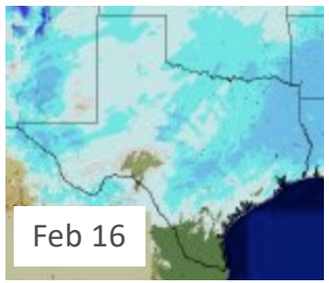
Snow Depth Daily Maps

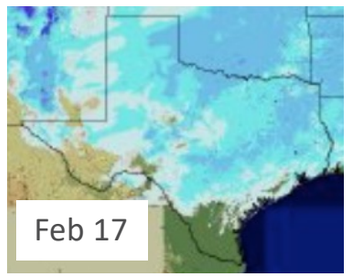
Beginning Feb. 11, Texas was hit with multiple waves of moisture. Some areas in North-Central Texas had ice/snow accumulation persist more than one week. Some communities set all-time snowfall records *(e.g. Abilene, San Angelo, Del Rio, Texarkana).*

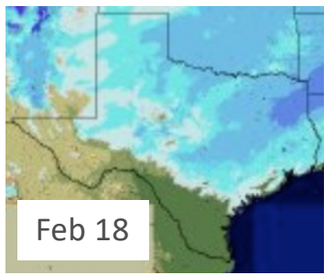


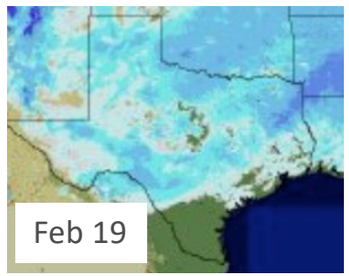


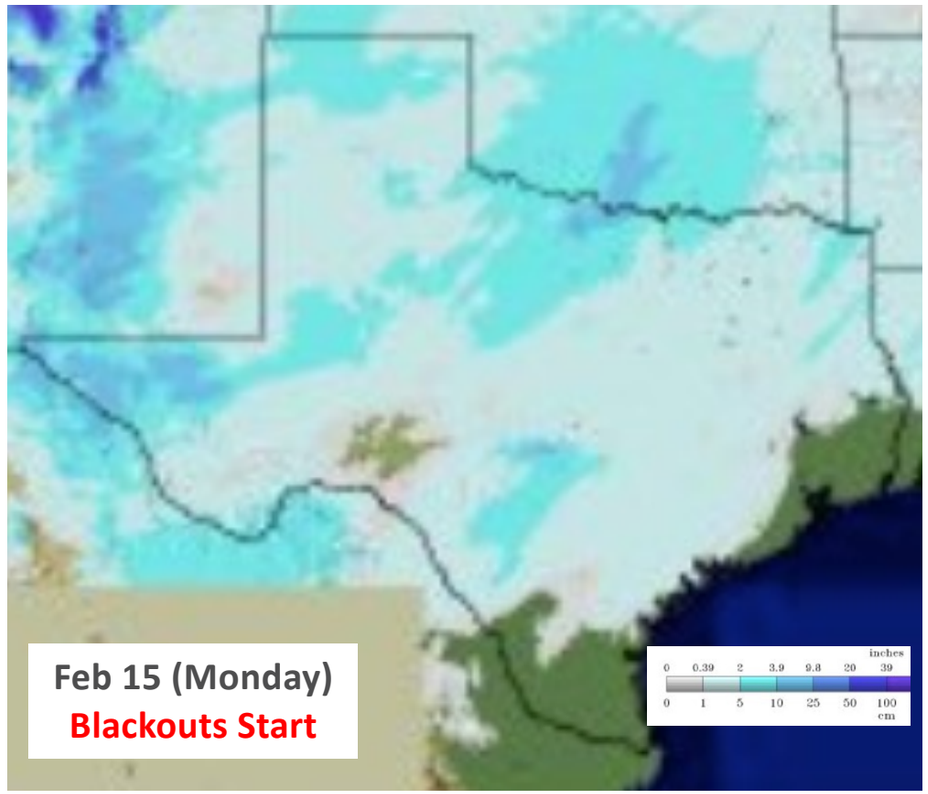












https://www.nohrsc.noaa.gov/nsa

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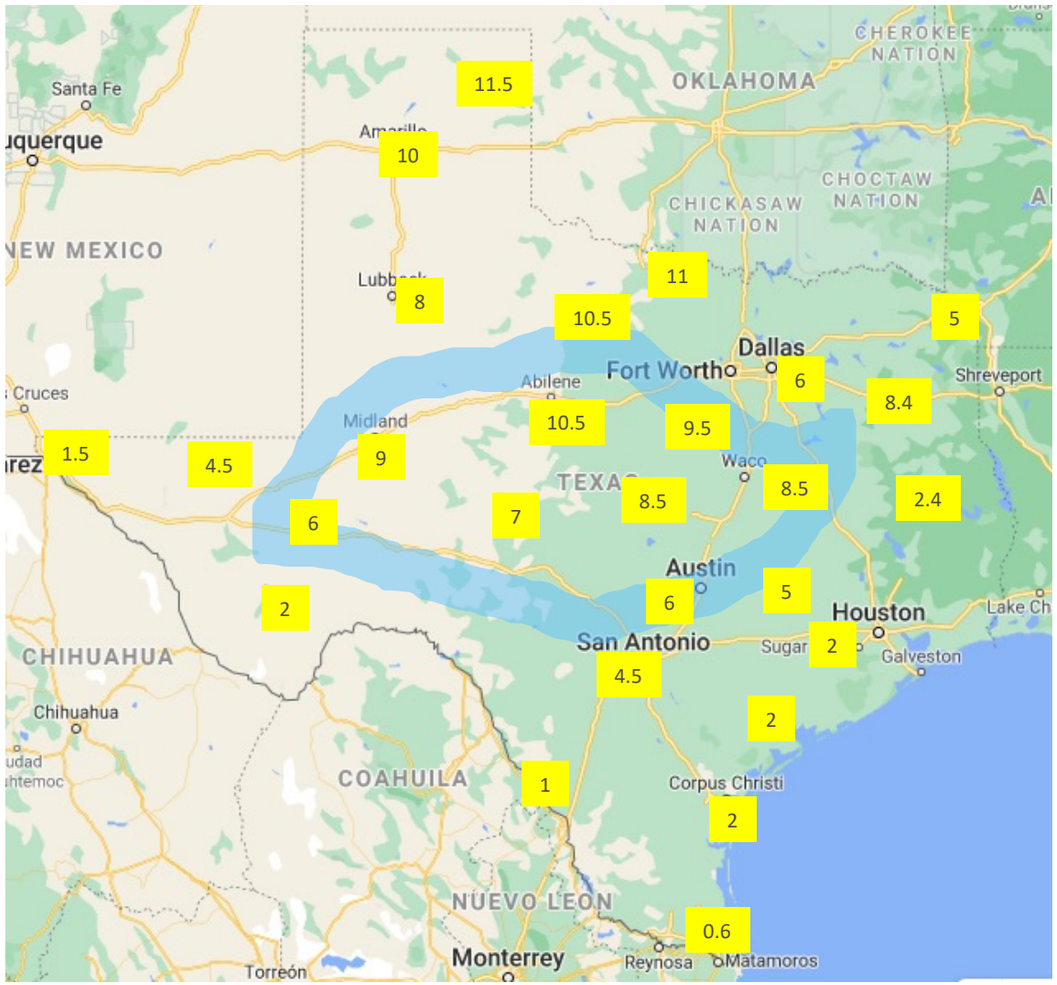
Central Texas Set All-Time Record for Longest Duration Freeze



Sources: from various media and NWS weather records and weatherunderground.com in rural areas

February 2021

Some communities set all-time Lows:
e.g. Tyler, Longview, Denison, Sherman

Duration of Freezing Temperatures (Days)

All time record duration of freezing
some weather stations that set all-time records have extremely long periods of record, e.g.

Abilene = 135 years
Austin (Mabry) = 124 years
Waco = 120 years
College Station = 111+ years

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Electricity is Increasingly Essential – including for Home Heating

Texas' use of Electricity to heat houses has increased tremendously. Most Natural Gas home furnaces no longer have pilot lights and now require electricity to operate.

The vast majority of Texas homes need electricity to heat.

Texas Home Heating with Electricity

1950 - Less than 1%
1989 ~ 40%
2018 – 61%

*Coupled with Texas population growth, Home Heating with Electricity has grown more than **200X** since 1950.*

Energy Source Used for Home Heating (share of households)	Texas
Natural Gas	35.0 %
Fuel Oil	0.1 %
Electricity	61.1 %
Propane	2.8 %
Other/None	0.9 %

Source: 2018 EIA data

If electricity is out, most homes with gas heaters get cold.

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Texas Freeze 2021 – What Happened at ERCOT?

Sat, Feb 13, 11:39 AM

Good luck to you and your colleagues holding things together this next week. This cold blast is extraordinary, and wind, solar, and batteries are not going to be helping much… Hopefully the improvements to the natural gas system made after the last big freeze are up to the challenge. Peak pressure on the grid looks like it hits right about the time the RPG meeting starts.

Text sent to a friend at ERCOT two days before emergency

The problems that ERCOT would face were foreseeable

How "ERCOT" performed during this event is a function of the combined efforts of many individual companies. Failure of market participants were widespread – but failures of systems counted on to be "reliable" had more negative impact than low-cost renewable resources used "as available".

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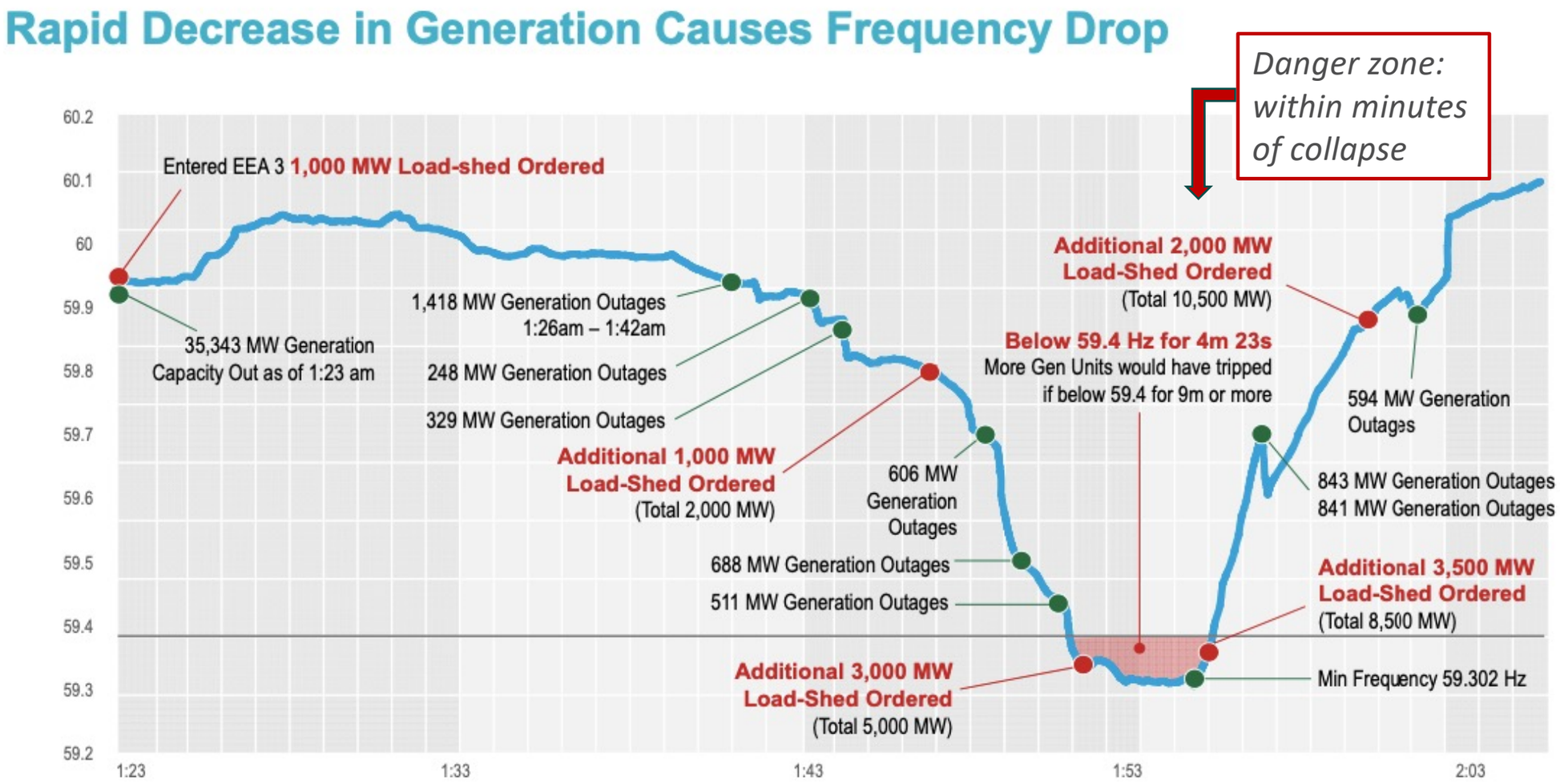
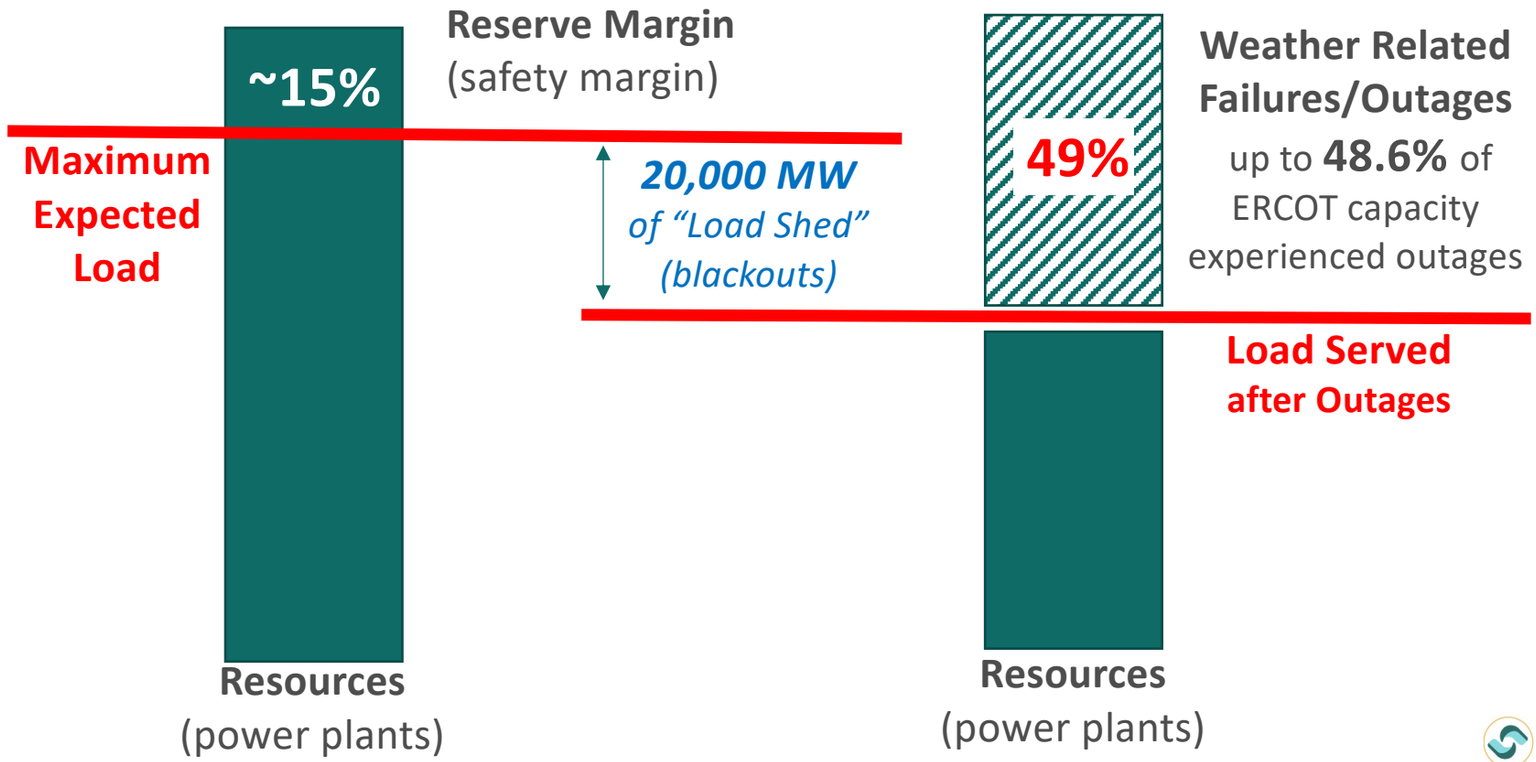
Texas Freeze 2021 – Very close to total collapse (Feb. 15)



Source: Bill Magness, ERCOT Urgent Board of Directors Meeting, Feb. 24, 2021, p. 12

The Texas Energy Industry Failed to Serve Customers

Utility planning for many decades has prepared for extreme weather by ensuring a "reserve margin" of extra power plants *(about 15% more than expected).* All types of power plants underperformed -- from variable "as available" wind and solar, to power plants considered "reliable" *(gas, coal, nuclear),* to the especially critical "Black Start" plants paid extra to be available to re-boot the grid after a blackout.



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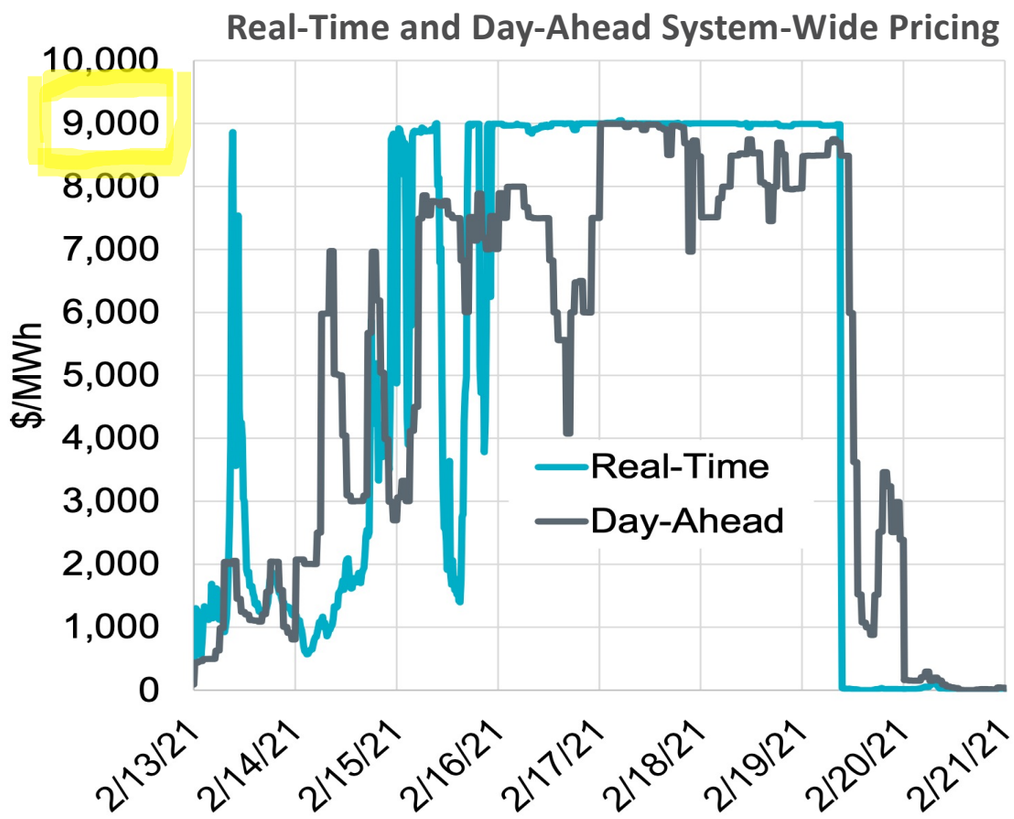
Market didn’t respond to “Defibulator” Price Cap

Many controllable power plants could not respond to $9,000/MWh price signals for lack of fuel. ERCOT has no control of fuel delivery.



Source: Bill Magness, ERCOT Urgent Board of Directors Meeting, Feb. 24, 2021, p. 22

Impacts

Electricity Costs: **$50 Billion** in 5 days

Deaths: **210** (official)
(other sources up to 978 deaths)

Electric Outages: **4.5 million** customers

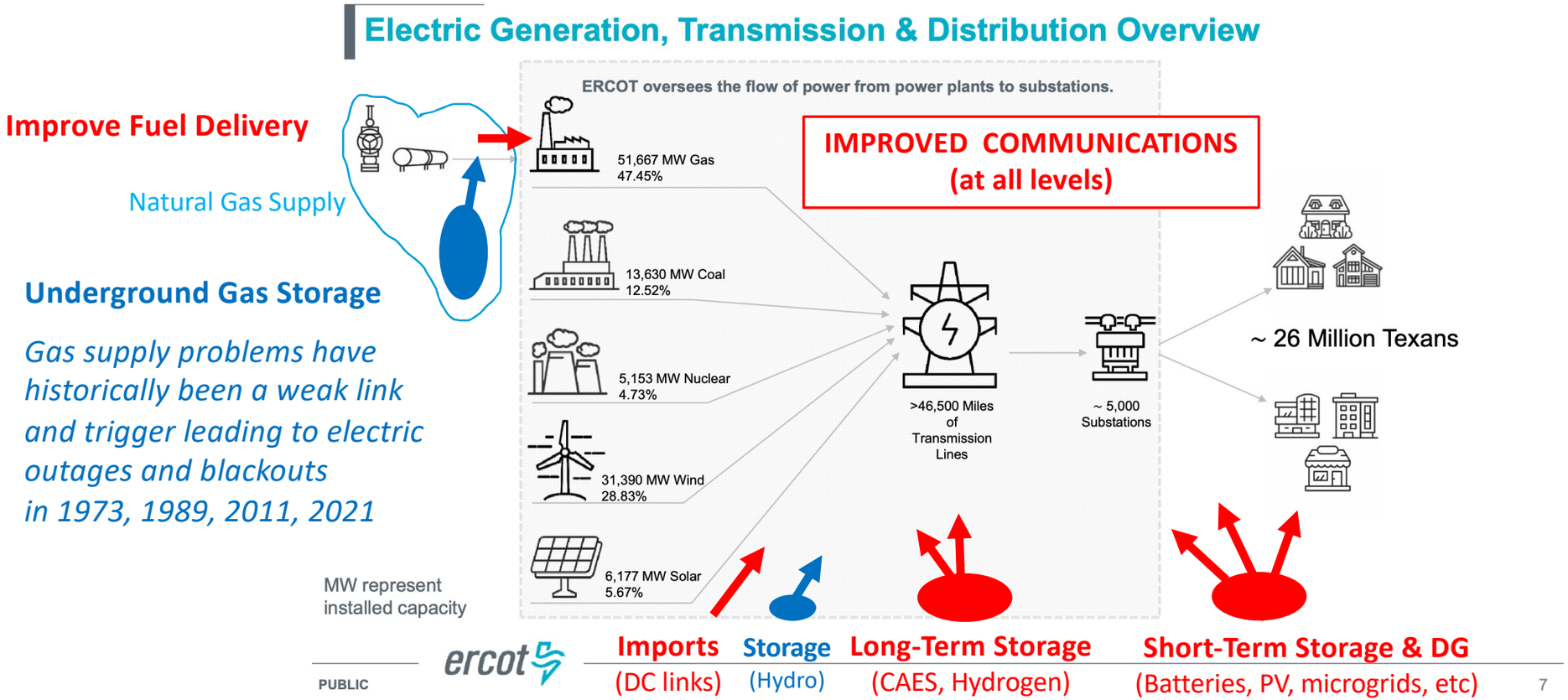
Economic Losses: up to **$293 Billion**

https://uh.edu/news-events/stories/2021/march-2021/03292021-hobby-winter-storm.php#:~:text=Winter%20Storm%20Uri%20began%20to,estimated%20%24295%20billion%20in%20damage.

https://www.forbes.com/sites/jemimamcevoy/2021/05/27/report-finds-hundreds-more-died-in-texas-winter-storm-than-state-says/?sh=5f9c5fb252cc

What is Needed to Better Prepare ERCOT for the Future?

"Advanced Tech" like DC Imports and Electric Storage can be big in the future, but were minimal in 2021



SOURCE: Slide from ERCOT Presentation – Feb 24, 2021 augmented by Mike Sloan

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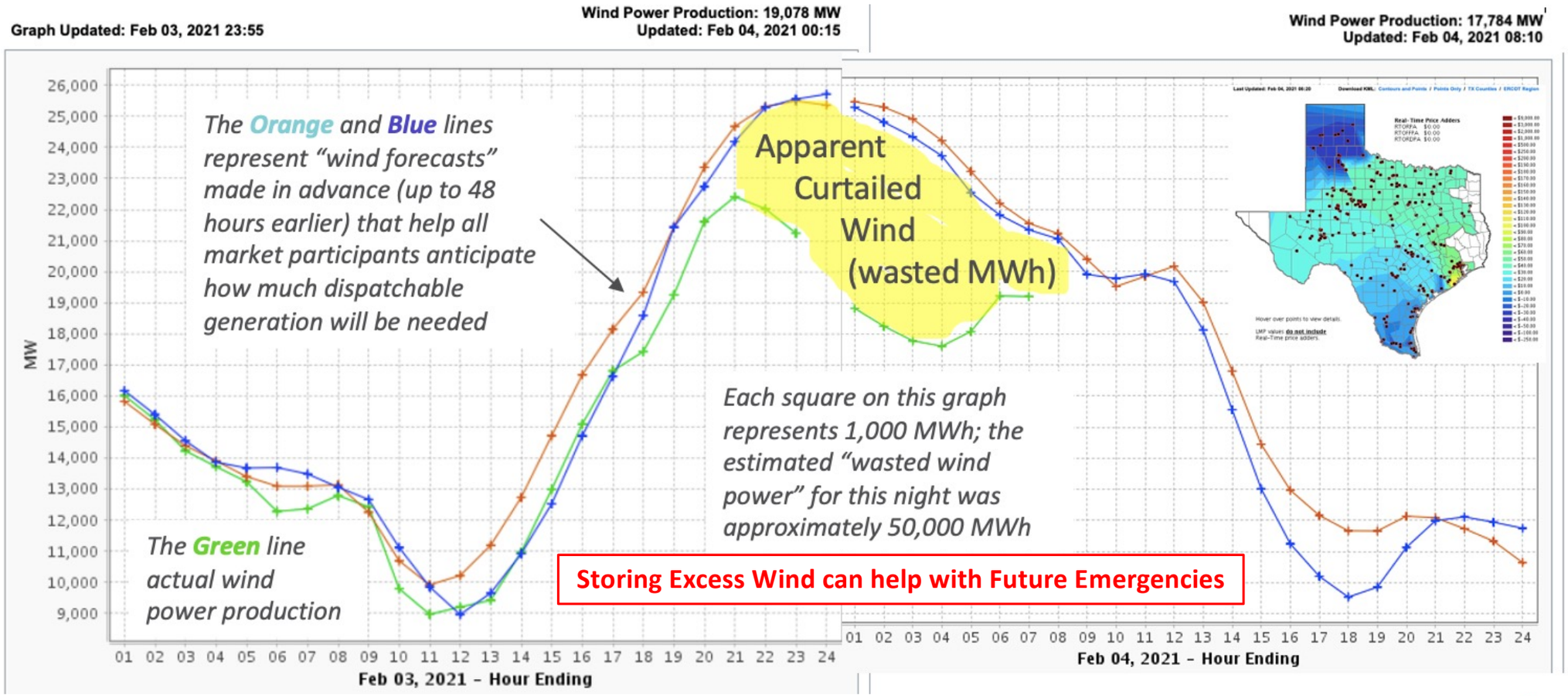
Storage: Curtailed Wind Power is a Long-Term Opportunity

Example: Evening of Feb. 3, 2021. Heavy congestion. 50,000 MWh of wind power production discarded for lack of transportation.



SOURCE: annotated version of two standard graphs from ERCOT website for February 3 and February 4, 2021.
http://www.ercot.com/content/cdr/html/CURRENT_DAYCOP_HSL.html?uniquenessFactor=1614649849251

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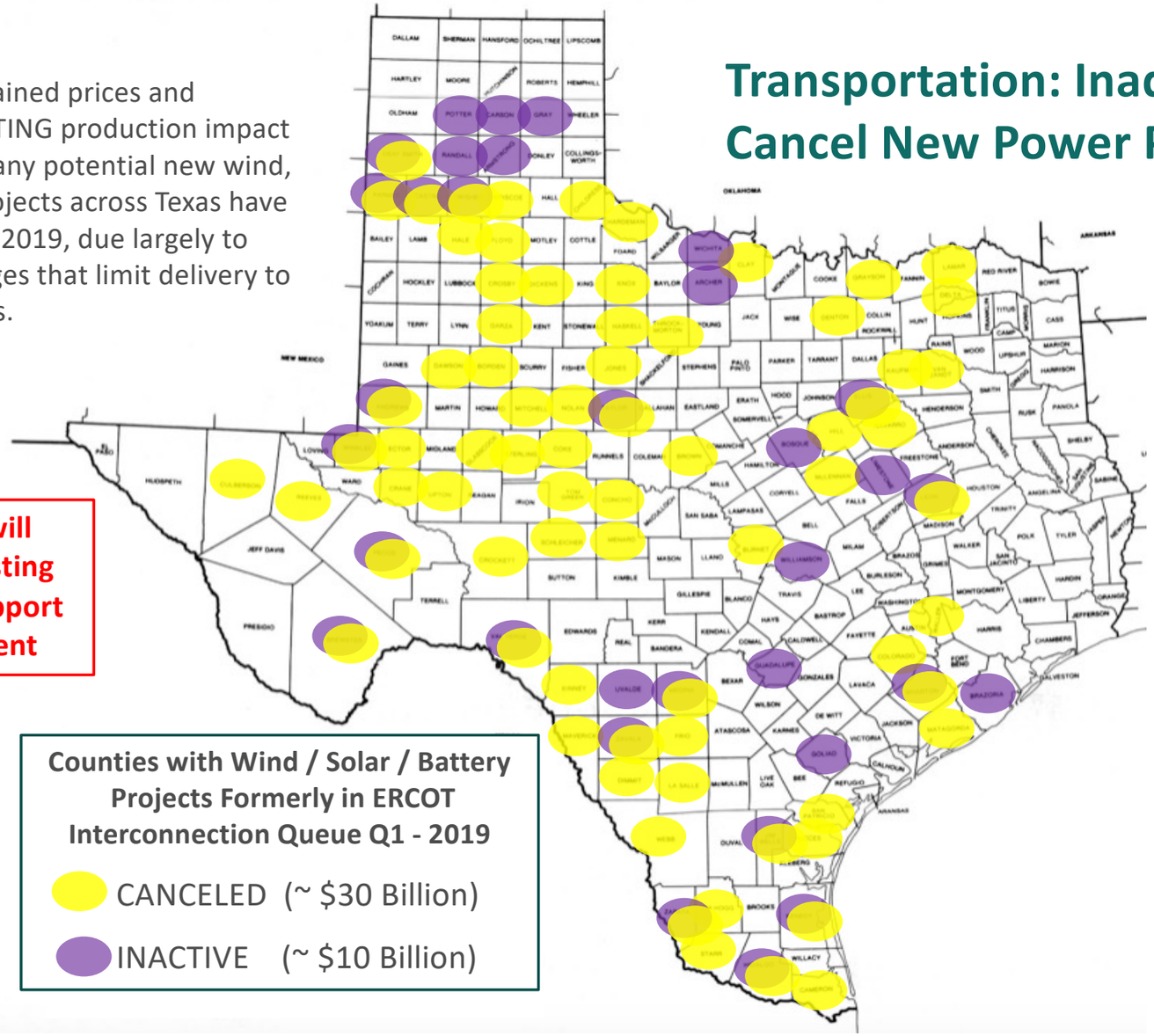
Transportation: Inadequacies Cancel New Power Production

Transmission-constrained prices and curtailments of EXISTING production impact FUTURE projects. Many potential new wind, solar and battery projects across Texas have been canceled since 2019, due largely to transmission shortages that limit delivery to interested customers.

More Transmission will deliver more from existing power projects and support additional development



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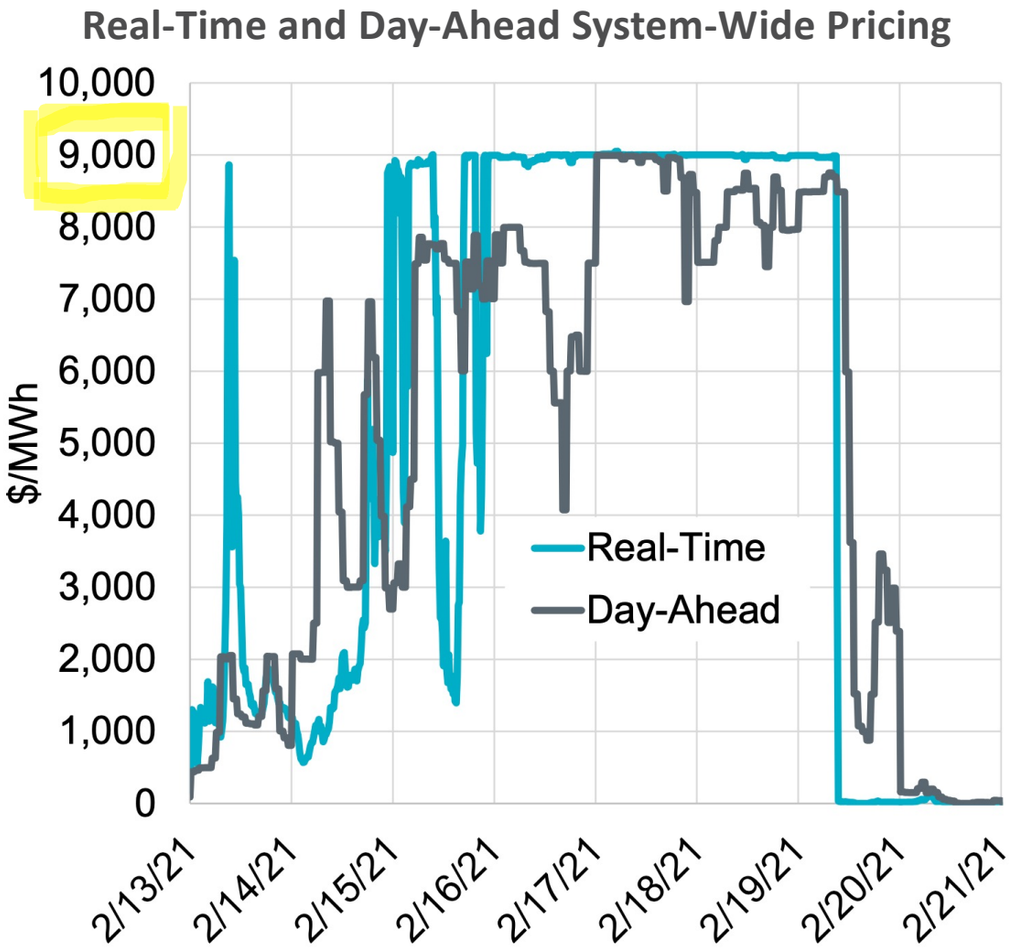
Recommendations from Former Texas PUC Commissioners



Source: Bill Magness, ERCOT Urgent Board of Directors Meeting, Feb. 24, 2021, p. 22

former Texas Public Utility Commissioners Robert Gee, Becky Klein, Brett Perlman, Judy Walsh and Pat Wood, and former PUC adviser Alison Silverstein

"additional transmission lines …could help to prevent or ameliorate future grid operational problems, particularly black-start energy "

"the Legislature should clearly define **"price gouging" for electric emergencies** and set an appropriate limit on how high gas market participants can raise natural gas forward and real-time prices during emergency conditions."

"We should also confirm **who profited from the $50 billion** spent on power during the four-day-long outages—six times more than the cost of power in all of ERCOT in 2020."

https://hepg.hks.harvard.edu/links/never-again-how-prevent-another-major-texas-electricity-failure

What about a

NATIONAL STRATEGY

for Energy Emergencies ?

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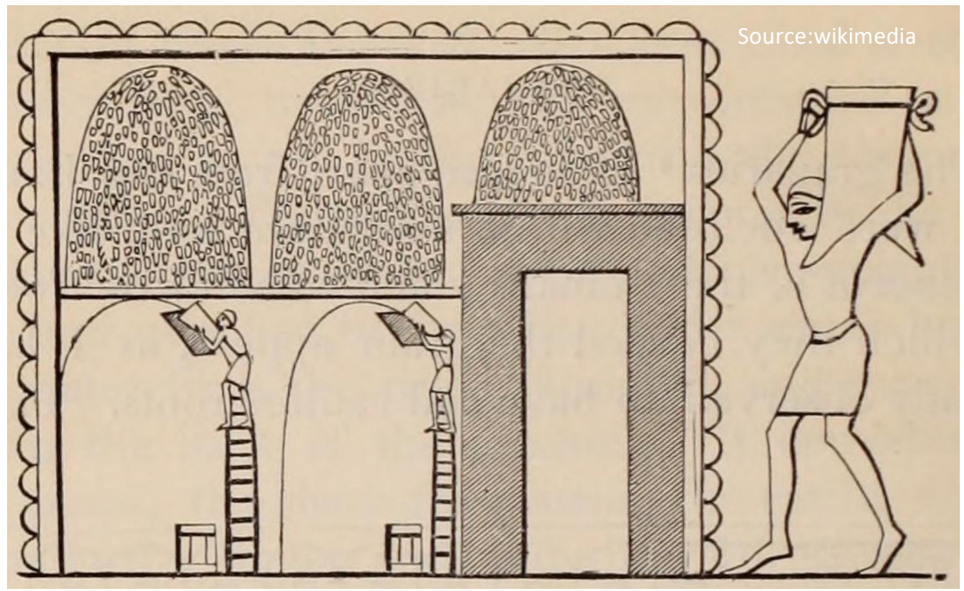
Historical examples of Strategies for Energy Emergencies

The Energy Source for Ancient civilizations was Food (primarily grain) that fueled human labor. Successful cultures from antiquity undertook extensive infrastructure projects to transport and store energy.

TRANSPORT ENERGY: China's Grand Canal

- 1,100 miles long connects Yellow & Yangtze Rivers
- Built between ~600 BC and ~600 AD (~1,200 years)
- Maximum elevation lift: 138 feet

STORE ENERGY: Ancient Egypt (~ 2500 BC)



- Djoser "Famine Stella" speaks of 7 year drought
- Extensive grain storage developed 4,500 years ago

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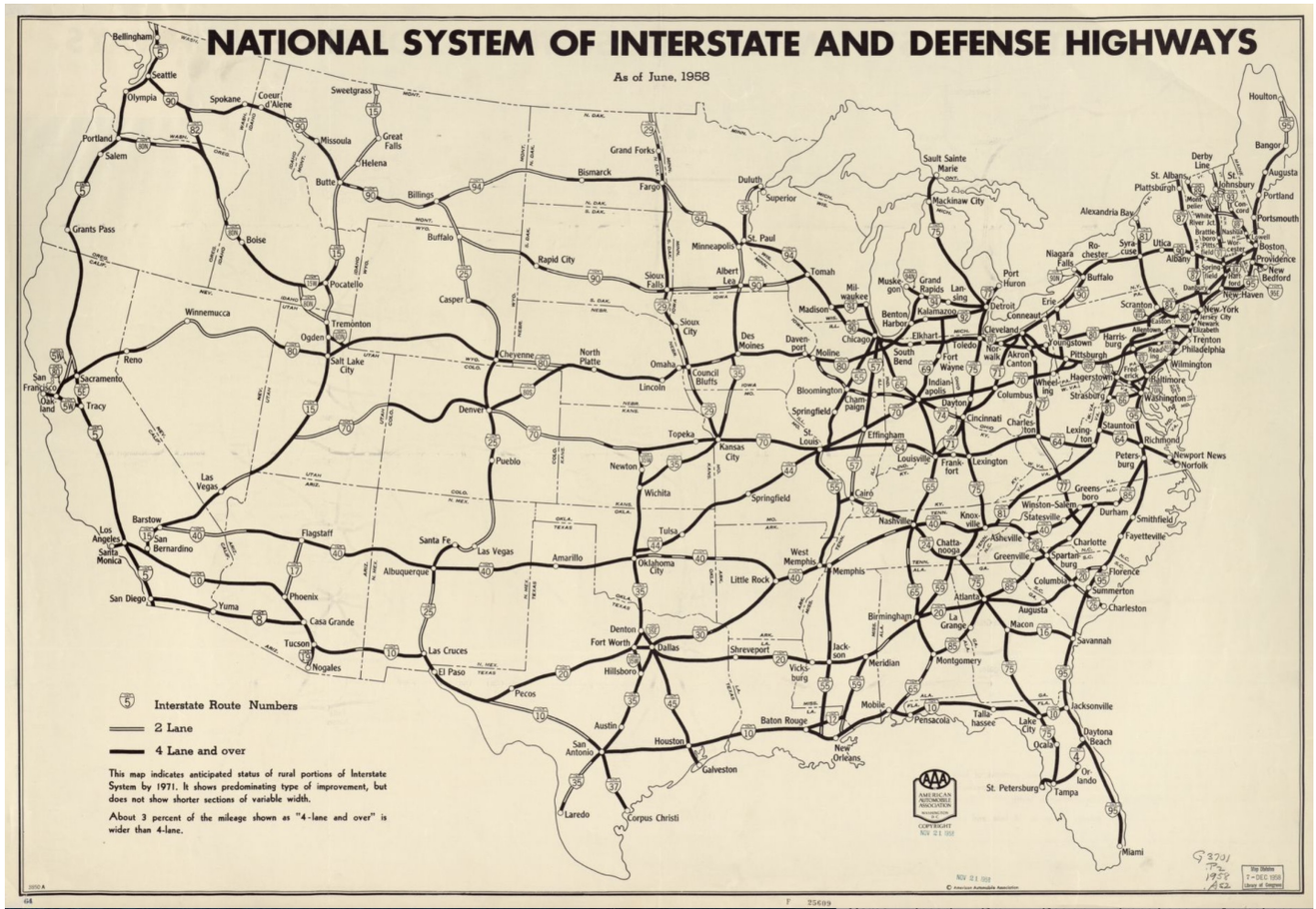
What about a NATIONAL Strategy for Energy Emergencies ?



Source: Library of Congress

The best example of a nationwide infrastructure “master plan” in the U.S. is the Interstate Highway System

While expediting the flow of goods and services, it also had a national defense imperative.

If “climate chage ” is deemed important enough, it too could motivate national planning with a national defense imperative.

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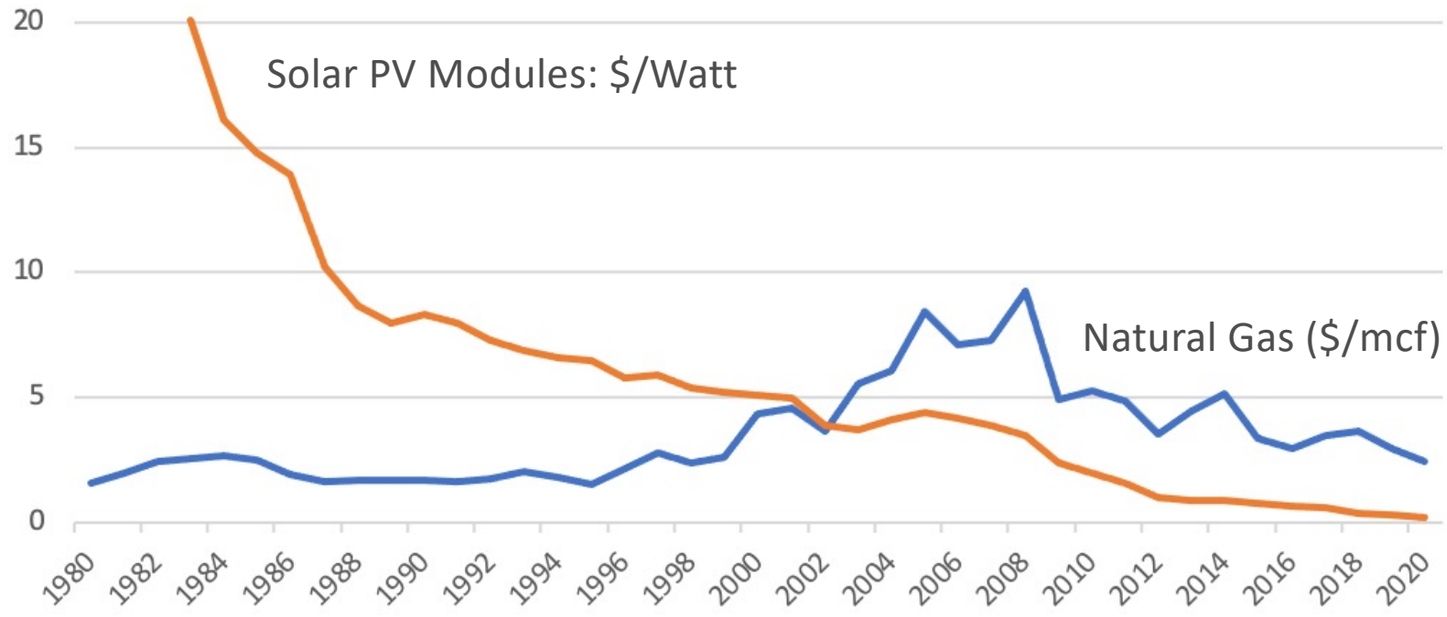
Relative Energy Cost Trends: Natural Gas versus Solar

In 63 years, photovoltaic module costs have dropped by 99.9%; meanwhile natural gas prices during the freeze (deregulated) peaked at more than 2,000 X the price of regulated natural gas in 1958.

Solar PV $300/W

Nat Gas $386/mmBTU (highest price during freeze paid by CPS)



Nat Gas ~$6/mcf

Solar PV $0.25/W

Nat Gas $0.16/mcf

1958

2021

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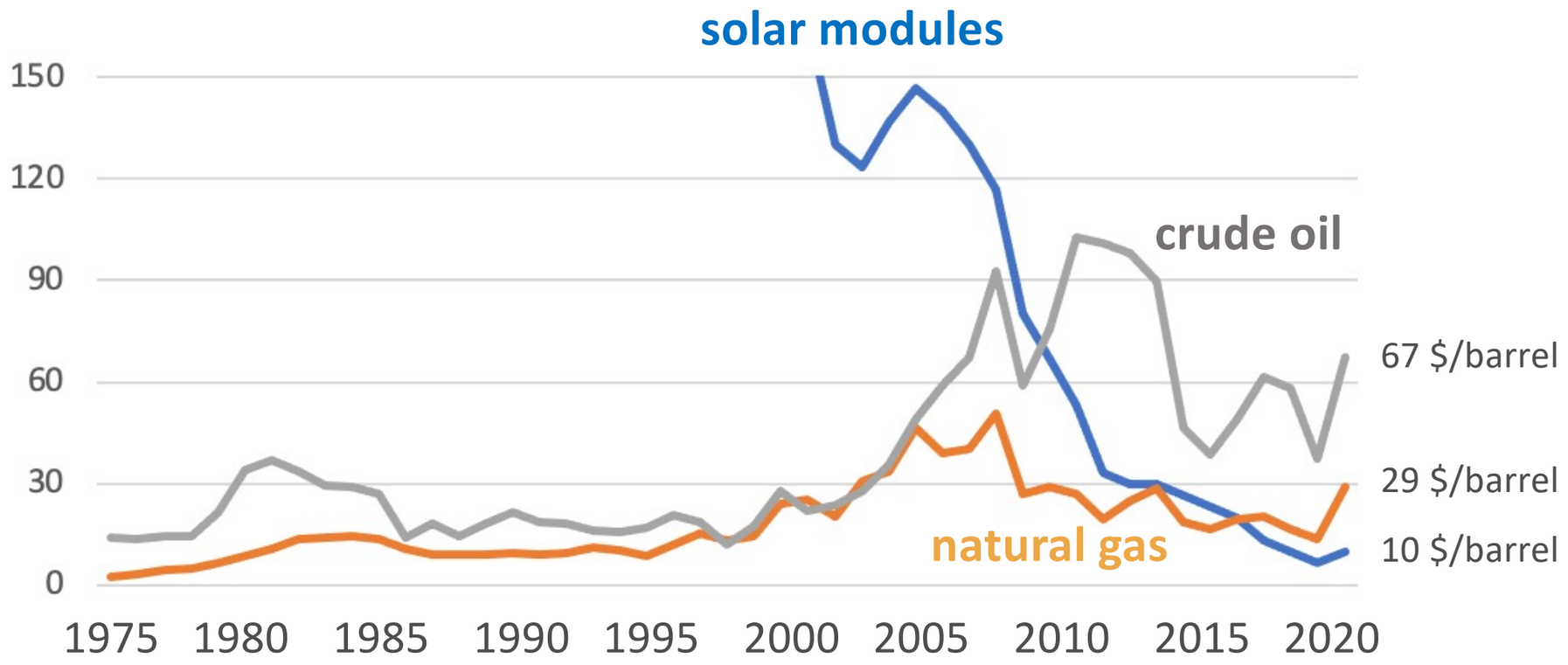
Relative Energy Costs in $/Barrel

When evaluating on a common energy basis – solar modules are now lower cost energy than oil and gas



Sources: EIA, IEA (solar module energy assumes 25% initial capacity factor but only the *warrantied* production of PV modules)

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When Energy Density is Required: Advantage Molecules

How best to Decarbonize Long-Distance Aviation?

http://www.boeing-747.com/boeing-747-internals/fuel-system.html
https://www.cargolux.com/Our-Expertise/cargo-equipment/aircraft/747-400f-specifications

Specs for 747-400

Max Take Off Weight = **875,000** pounds

Max Revenue Cargo = **292,000** pounds

Max Fuel = **380,000** pounds

Li-ion batteries weigh about
50-100 times more *than Jet Fuel on an energy density basis*

Aviation will be very difficult to electrify; green molecules like Hydrogen are a more likely path to decarbonization.

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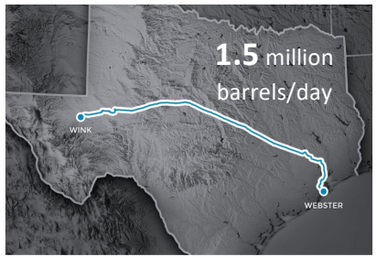
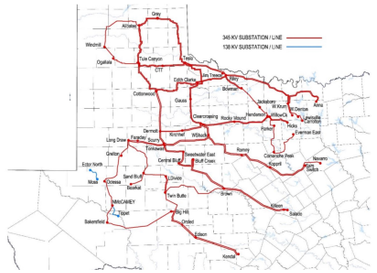
Pipeline-vs-Electric: Higher Volume / Lower Cost / Faster Build

	Wink-to-Webster Crude Oil Pipeline	CREZ AC Network Upgrade
		
Length (miles)	650	~300**
Cost ($ billion)	2.5	7
Energy Throughput	**104** GW-thermal	~10 GW-electric
Unit Cost* ($/GW-**thermal**/mile)	37,000	2,300,000 **(60x)**
($/GW-**electric**/mile)	**110,000**	2,300,000 **(20x)**
First Year In Service	2021	2014
Time to Develop	**5** years	10 years

Pipelines generally transfer more energy at lower cost than wires. The advantage in development time stems from regulatory advantages for oil and gas relative to electricity. This big advantage for carbon fuels could be changed with political will to do so.

* Unit Cost comparison assumes 1:1 convertion for electric to thermal (heating applications) and 3:1 for conversion of thermal energy to electricity
www.houstonchronicle.com/business/energy/article/Two-proposed-pipelines-to-bring-1-3-million-13575427.php

** Total curcit miles = 3,589 ; ~ 7 pathways; net W-to-E transfer = ~300 miles www.bakerinstitute.org/media/files/files/eb251d15/ces-pub-texascrez-111720.pdf

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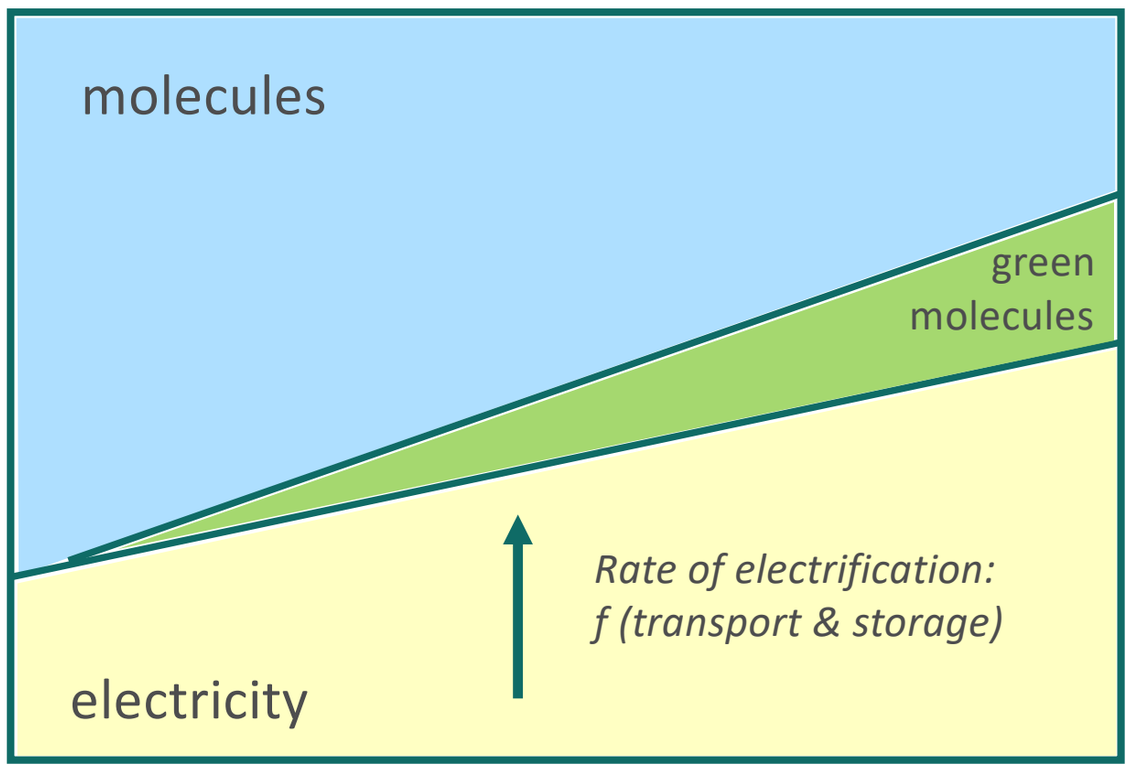
Decarbonizing the Future



There will be efforts to
electrify most energy uses

Rate of success determined by
transportation & long-term storage

Energy sectors requiring high
energy density will favor molecules

Green molecules
(hydrogen & ammonia)
will accelerate decarbonization

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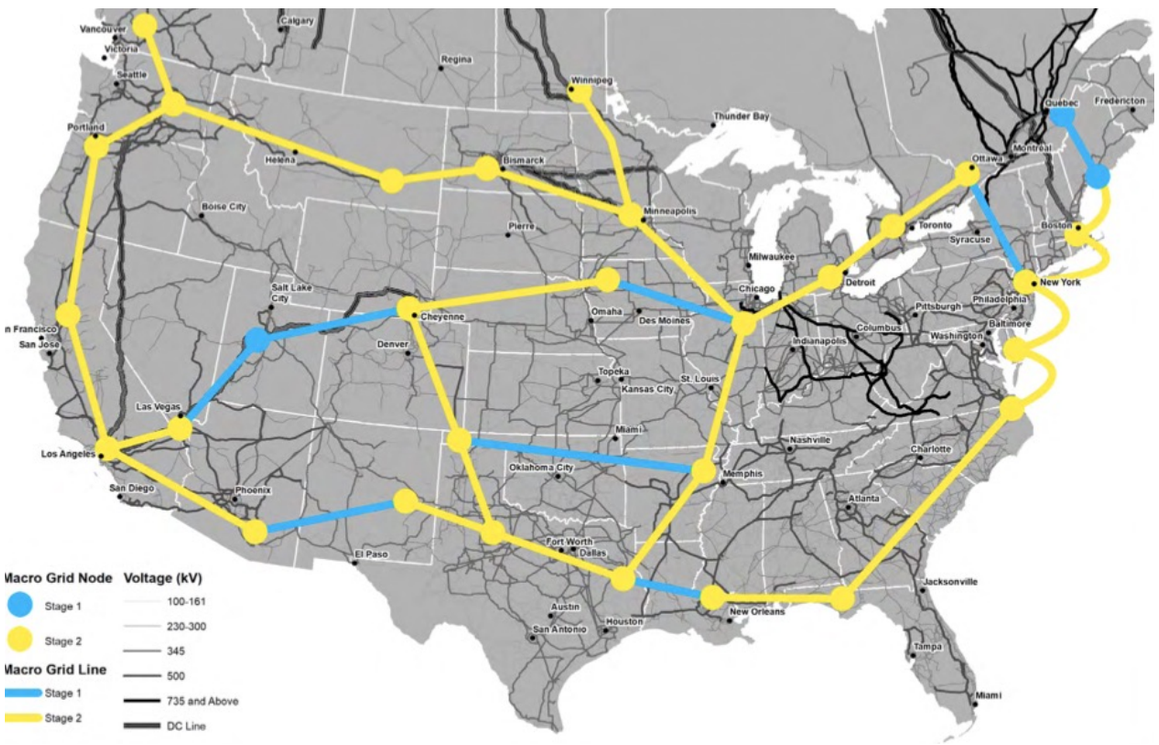
New Superhighway Network for Electricity

- Allows interstate / national trade of electricity across USA
- Rapid response in Emergencies across multi-state weather systems
- DC network provides Blackstart capability and precise delivery of electricity



Source: Energy Systems Integration Group, Feb. 2021

Europe & China already have High Voltage Direct Current (HVDC) networks capable of transfer high volumes of electricity long distances.

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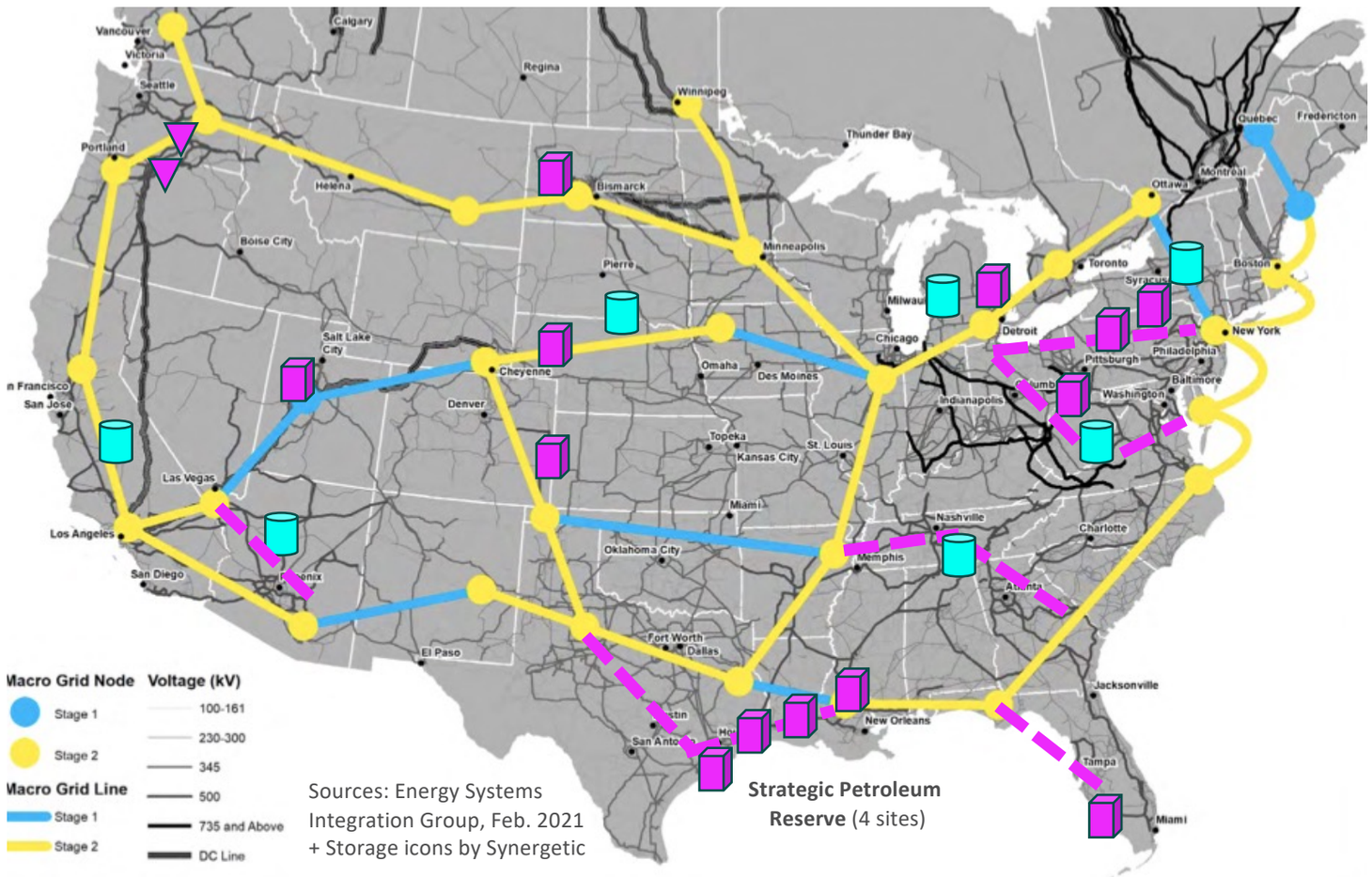
BIG IDEA #1 - New Electric Superhighway + Storage

- **Include STORAGE** – Thoughtfully connect generation, load and storage zones nationwide
- Rapid response during Emergencies across multiple states *(weather, cyber, etc)*



Sources: Energy Systems Integration Group, Feb. 2021
+ Storage icons by Synergetic

Strategic Petroleum Reserve (4 sites)

Hypothetical layout

(real plans must factor in technical, economic, and political issues)

STORAGE SITES
(illustrative)

- pumped hydro
- salt cavern
- underground
- DC line

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Why Stockpile Carbon for a Decarbonized Future?

Strategic Petroleum Reserve

Protects against global disruptions in oil supply by storing large volumes of oil underground since the 1970's.

Emergency Uses: 3 times in 45 years
current storage: 617 million barrels
current value of oil **~ $50 Billion**

How can America get more Value from SPR?

The **U.S. is now the world's largest oil producer** and no longer highly dependent on oil imports. (In 2005 the US imported more than 60% of its oil supply)

Stored chemical energy is necessary to complement weather-derived energy sources like wind and solar.

But the nation should challenge the Hydrocarbon industry: **More Hydrogen, Less Carbon.**

The Strategic Petroleum Reserve has served its purpose (protecting against global oil disruptions) and could be modernized to better serve our electric-intensive digital economy.

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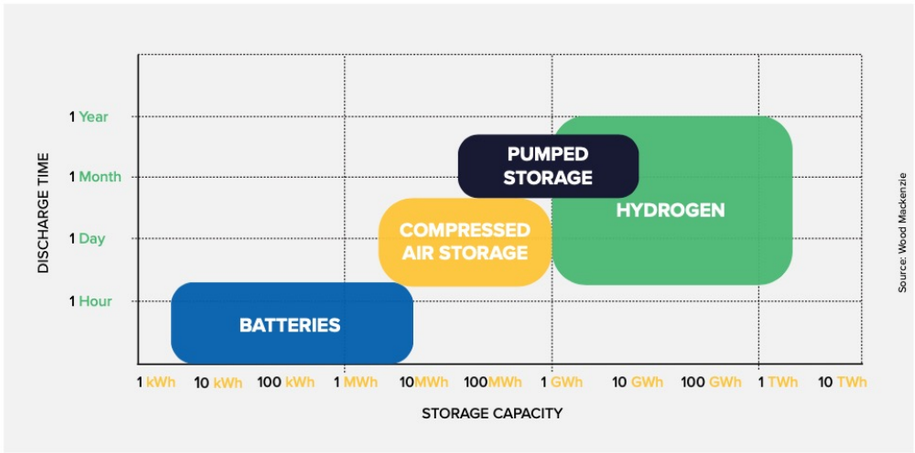
BIG IDEA #2: SPR for Electric Resilience (Bryan Mound Pilot)

Create a Strategic Hydrogen Reserve

- Diversify Electric Emergency response capability
- Spur advancement of the Hydrogen Economy
- Need traditional jobs like drillers & pipefitters
- Energize storage opportunities for wind & solar
- Significantly accelerate Decarbonization

STORAGE CAPACITY VS. DISCHARGE TIME FOR COMMERCIALLY AVAILABLE STORAGE SOLUTIONS



Source: Green Hydrogen Coalition, Guidebook

- In **ERCOT near Houston**
- **Largest chemical storage facility** in the world (up to 247 million barrels of oil)
- **19 storage caverns** (7-37 mmBBL each)
- Explore if some **caverns can be converted** to support 1) electricity 2) decarbonization
- Options to evaluate could include: **compressed air, ammonia, hydrogen**

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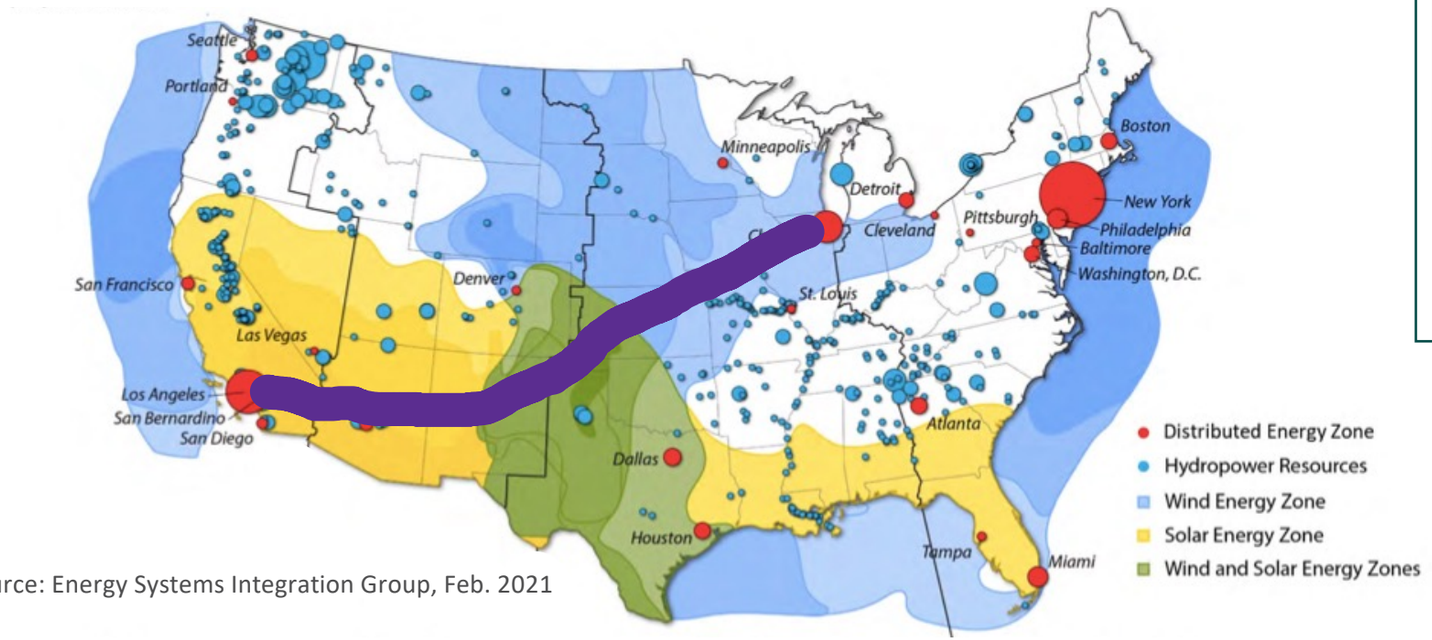
Big Idea #3: Infrastructure Corridor with Multiple Solutions

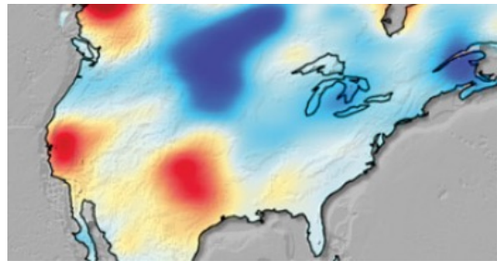
- Connect LA to Chicago with corridor for Electricity, Hydrogen, Data & Water
- Route through best wind & solar production areas in the USA
- Two-way water pumps: variable load for surplus wind & solar or generate when power needed

This massive project is NOT about BULK TRANSFER of Water but rather about ENERGY MANAGEMENT of weather-dependent resources – a valuable infrastructure backbone in times of emergency (drought/power outages)



Source: Energy Systems Integration Group, Feb. 2021

Future Water



Northern states expected to get wetter while Southwest gets drier.

https://www.pewtrusts.org/trend/archive/spring-2019/the-future-of-water

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Thank you for listening!

Contact me to continue the conversation:

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