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Solutions for Moving ERCOT Off Fossil Fuel Dependency While Improving Reliability and Keeping Energy Costs Low

By

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Comparing This 2023 Report To 2020

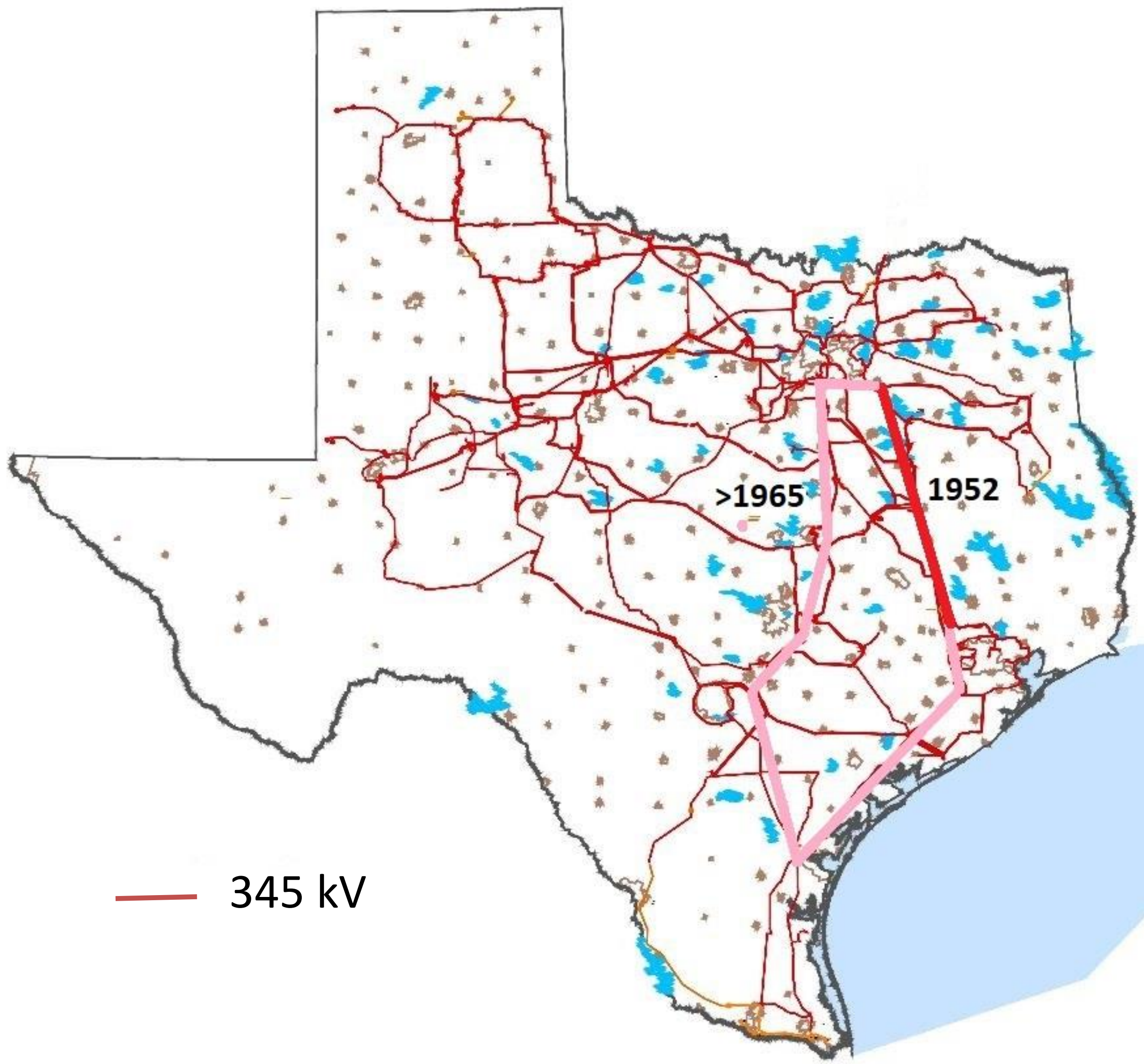
Previously

1. My previous report was about a declining ERCOT reliability when wind and solar are added while not seeing enough new gas generation in ERCOT's data. Just six months after my 2020 report the 2021 Winter Storm Uri caused severe power outages. The 2023 summer shows ERCOT continues to track my 2020 report.

What's New

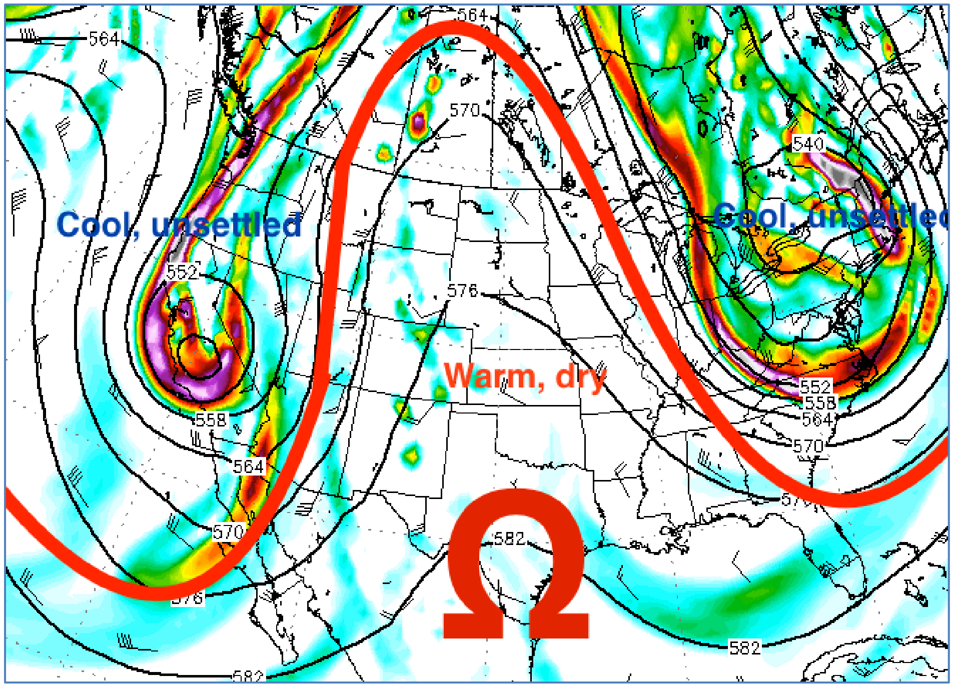
2. A new Excel simulation tool https://egpreston.com/ERCOT22A.xlsx has been developed to capture ERCOT's historical wind, solar, and storage hourly dispatch.
3. The tool allows us to study a future using only renewables for CO_2 reduction as well as a future pathway that also adds nuclear power.
4. Gas peaking generation is automatically added to ensure grid reliability as wind, solar, and nuclear sources of power are added to achieve lower CO_2 objectives.

Before 1952 There Were No 345 kV Lines

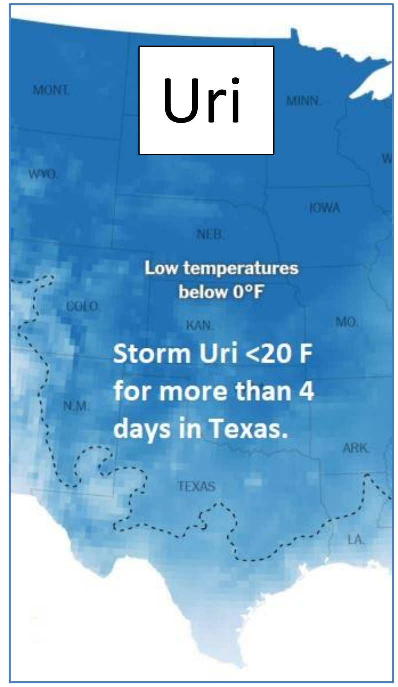


5. Prior to 1952 generation was located near cities. Power lines tying cities together were weak. The 1965 NYC blackout made FERC (Federal Energy Regulatory Commission) issue an order for cities to build interconnecting power lines.
6. By 1970 a 345 kV extra high voltage (EHV) loop connected major Texas load centers together.
7. The map shows an initial 345 kV line in 1952 and a loop was built after 1965.
8. The 345 kV loop only carried power intermittently and on for reliability.
9. The 1973 oil and gas shortages resulted in a program of building new coal and nuclear power plants remote from cities which loaded up the 345 kV lines.
10. In recent years wind and solar far from load centers are being added while gas and coal plants inside and near load centers are being retired. This has caused a huge increase in the amount of power flowing over 345 kV lines.
11. Wind and solar are using up transmission capacity making it impossible for new gas and nuclear plants to plan for transmission access they need to run their plants.
12. The best place to build new generation is near the load center it will serve. This minimizes the number of EHV transmission lines needed.

Extreme Weather Increases Demand



Many 109F days in 2011, 2022, 2023.

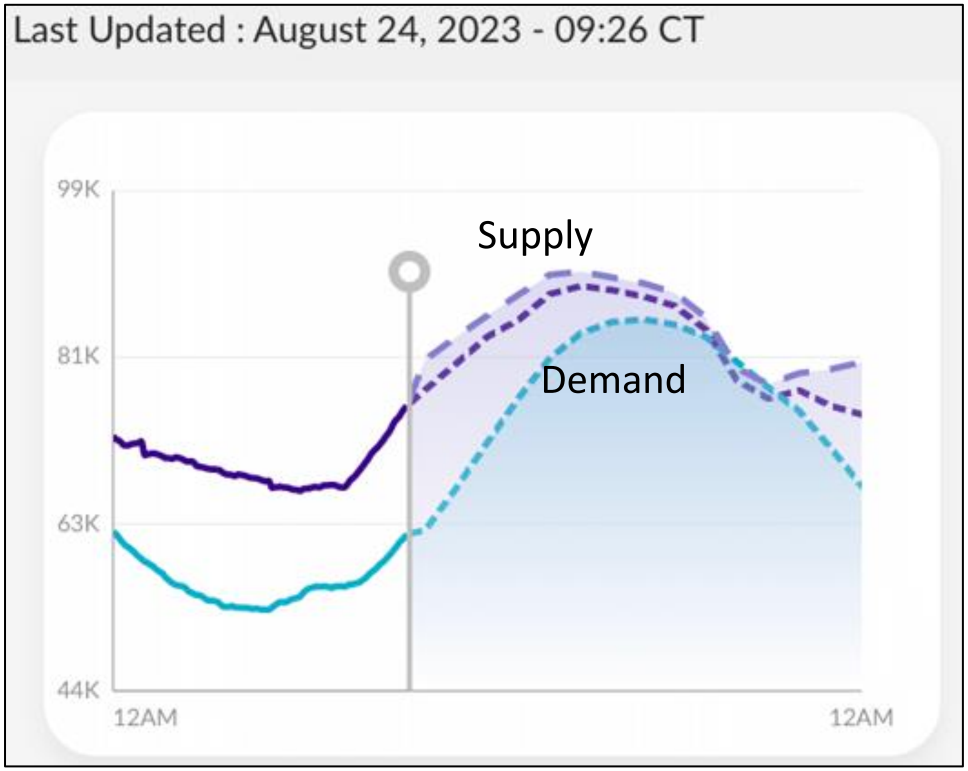


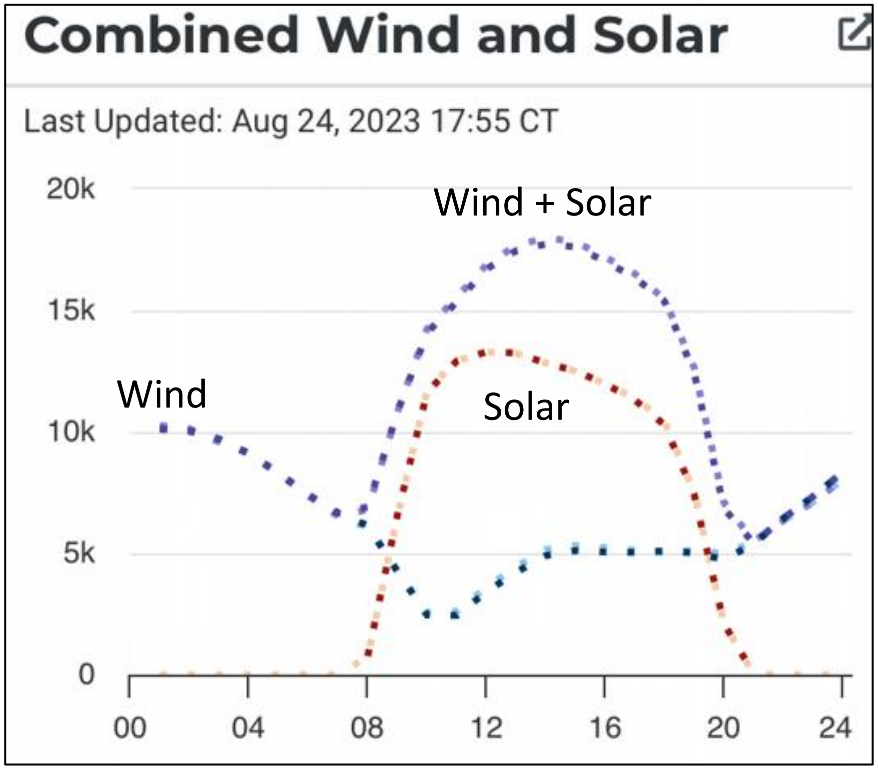
A very cold 2021.

Normal cold 2022.

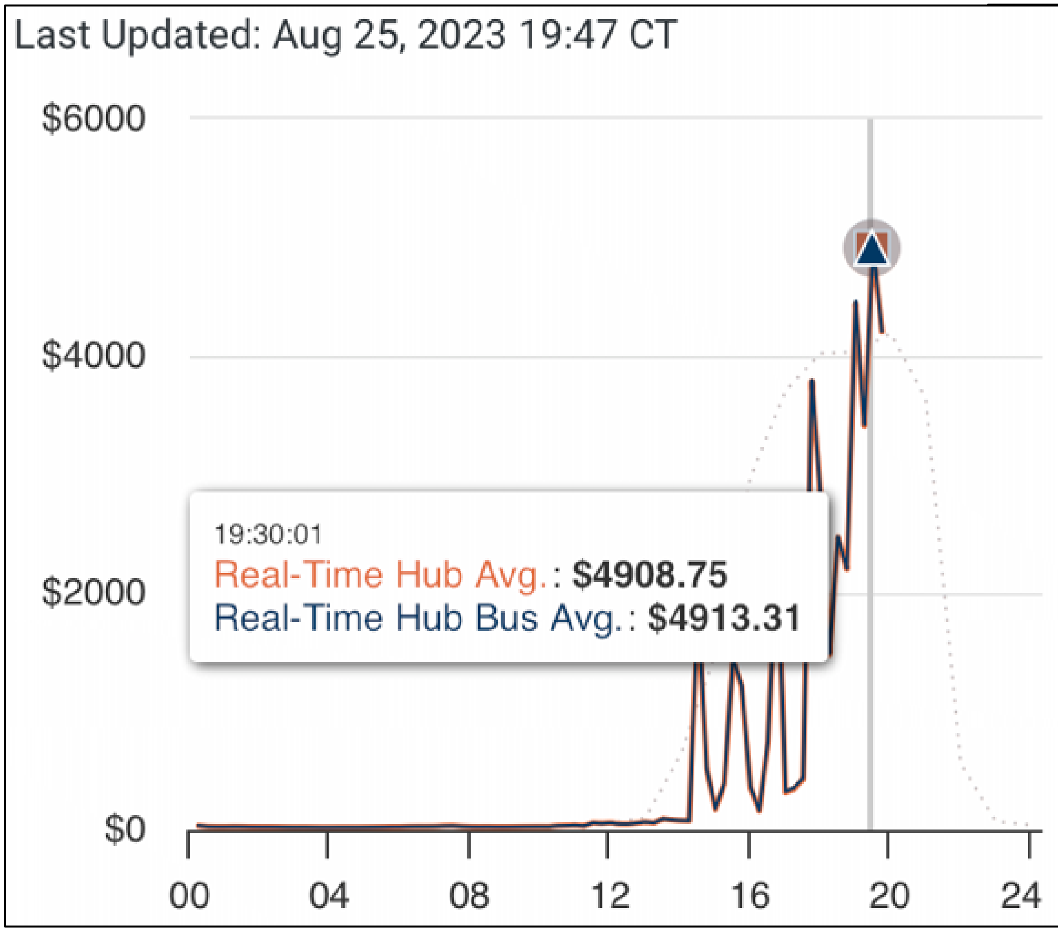
13. The ERCOT summer peak demand was 80 GW in 2022 and ~86 GW in 2023.
14. 2022 Winter Storm Elliott in ERCOT was a normal winter peak of only a few days. The winter and summer gas peak capacity needed was approximately the same.
15. 2021 Winter Storm Uri was four days longer than Elliott and was much colder. Both the gas capacity and the gas stored energy supplies were insufficient.

Screenshots of when ERCOT is deficient

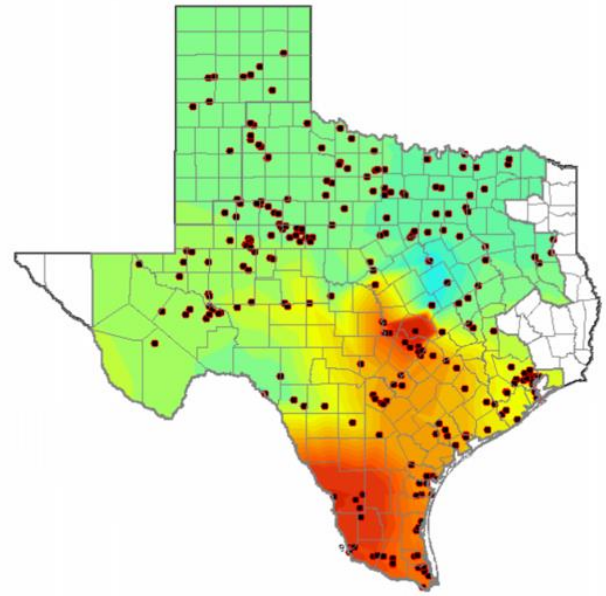




16. August 24, 2023 there is not sufficient generation capacity between 7 and 9 pm.
17. The wind capacity is too low. The wind had been strong each day for a couple of months prior to now. As the summer is ending the omega high pressure is losing its wind strength and the winds die down. It’s common for winds to die down at the end of a windy period. This also happened at the end of Uri.

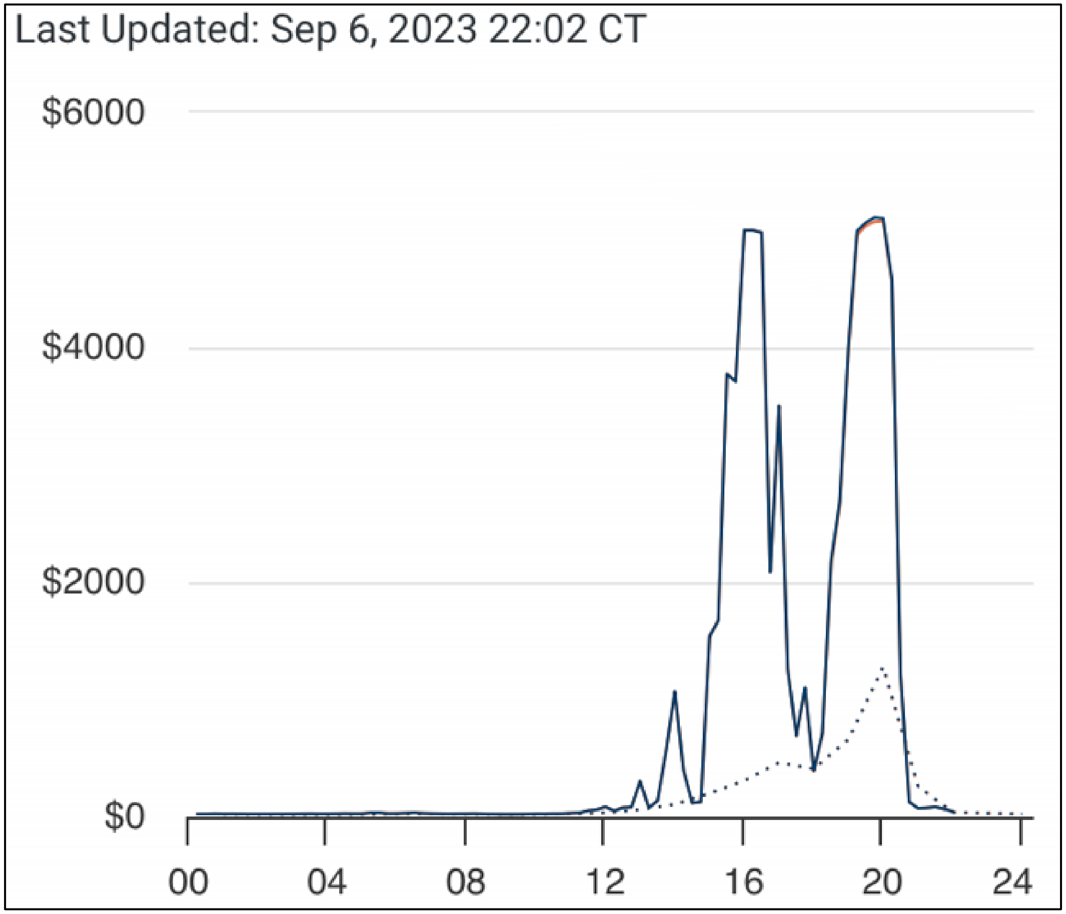


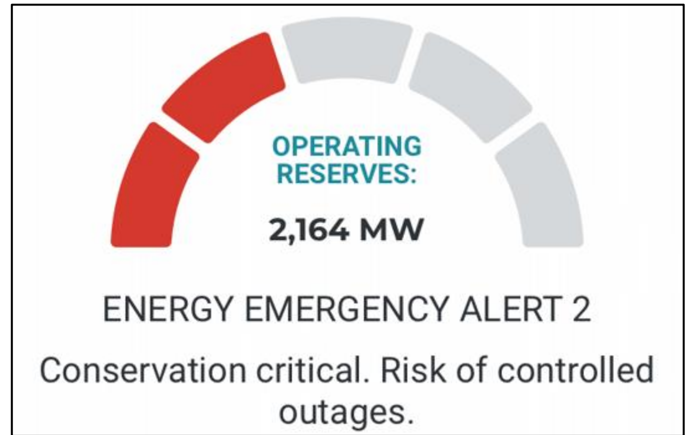
Natural Gas		
50,597 MW (66.6%)	53,446 MW	69,890 MW
Coal and Lignite		
11,943 MW (15.7%)	13,568 MW	14,321 MW
Nuclear		
4,940 MW (6.5%)	4,973 MW	5,448 MW

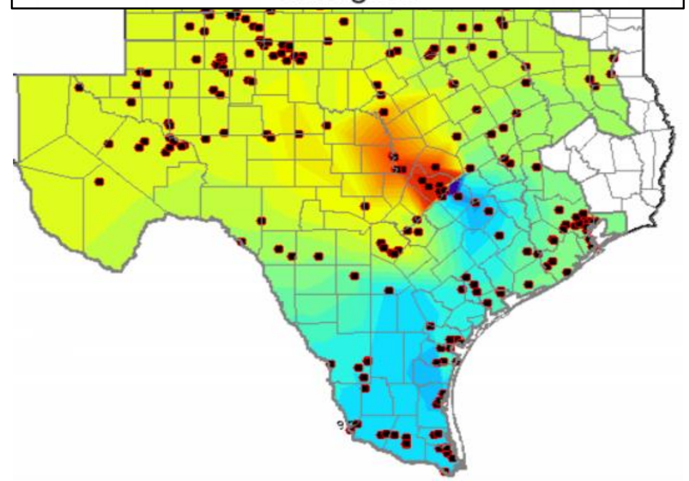


18. August 25, 2023 there is not sufficient capacity which results in very high nodal grid prices. The high prices are to get more capacity on line. However, there appears to be 2.8 GW of gas capacity and 1.6 GW of coal capacity unavailable.

19. The red area in the Valley shows a deficiency in generation. The Austin area has import of power transmission constraints. North Texas has sufficient generation.







20. September 6 there is not sufficient capacity resulting in very high nodal grid prices.

21. ERCOT stage 2 emergency resulted from curtailing 1000 MW Valley sent north.

22. The blue area in the Valley shows an excess of generation which is being sent northward. A line might overload near San Antonio if another line had tripped.

23. Note that the Austin area has import of power transmission constraints.

Study Assumptions And Procedures

24. Use actual ERCOT hourly historical 2021 and 2022 raw data without modification.
25. Future load growth will be in terms of 10 GW peak demand steps instead of years.
26. Targets for decarbonization are in terms of ERCOT's percent fossil fuel energy for future peak demands: 60% at 80 GW (in 2022), 45% at 90 GW, 30% at 100 GW, 10% at 110 GW, and 5% at 120 GW. As percentage goes down difficulty increases.
27. Decarbonization targets are met by increasing non CO2 energy sources as needed.
28. Generation reliability is maintained by installing gas peaking generation as needed.
29. Generation dispatch order: nuclear, wind, solar, and fossil (gas peaking) as needed.
30. National Renewable Energy Lab (NREL) capital and operating cost data is used.
31. NREL cost data is used to estimate investment costs in $bn and energy cents/kWh.
32. Because battery capital cost is high, a minimum amount of Li battery storage is used to achieve the decarbonization target.
33. Wind and solar in ERCOT are approximately optimum with equal amounts added.

Hourly Simulation Model

34. Start with a historical year such as 2022 ERCOT Demand, Wind, and Solar Profiles
    https://www.ercot.com/mp/data-products/data-product-details?id=PG7-126-M

		Hourly Demand and Variable Resources Input					
Base Nucl MW =		5,000					
		PeakMW=	80,000	WinPmx=	36,000	SolPmax=	12,000
YYYYMMDDHH	D	load pu	loadMW	wind pu	windMW	solar pu	solarMW
2022010101	7	0.47757	38,206	0.35313	12,713	0.00000	0
2022010102	7	0.46503	37,202	0.37703	13,573	0.00000	0
2022010103	7	0.45017	36,014	0.42041	15,135	0.00000	0
2022010104	7	0.44009	35,207	0.48177	17,344	0.00000	0
2022010105	7	0.43346	34,677	0.53661	19,318	0.00000	0
2022010106	7	0.43155	34,524	0.53149	19,134	0.00000	0
2022010107	7	0.43306	34,645	0.54249	19,530	0.00000	0
2022010108	7	0.43386	34,709	0.53572	19,286	0.00080	10
2022010109	7	0.44600	35,680	0.50624	18,225	0.14415	1,730
2022010110	7	0.47494	37,995	0.49502	17,821	0.37098	4,452
2022010111	7	0.50090	40,072	0.51769	18,637	0.34787	4,174
2022010112	7	0.52403	41,922	0.52035	18,733	0.28867	3,464
"	"	"	"	"	"	"	"

35. Then serve the load in the order of nuclear, wind, solar, and finally unserved load which will be served by storage of excess energies and finally from fossil fuels.

Hourly Dispatching of All Resources and Battery Storage								
Base	Direct	Direct	Direct	Excess	Excess	Excess	Excess	Unserved
Nuclear	Nuclear	Wind	Solar	Nuclear	Wind	Solar	Total	Load
Per Unit	MW	MW	MW	MW	MW	MW	MW	MW
1.00	5,000	12,713	0	0	0	0	0	20,493
1.00	5,000	13,573	0	0	0	0	0	18,629
1.00	5,000	15,135	0	0	0	0	0	15,879
1.00	5,000	17,344	0	0	0	0	0	12,863
1.00	5,000	19,318	0	0	0	0	0	10,359
1.00	5,000	19,134	0	0	0	0	0	10,390
1.00	5,000	19,530	0	0	0	0	0	10,115
1.00	5,000	19,286	10	0	0	0	0	10,413
1.00	5,000	18,225	1,730	0	0	0	0	10,726
1.00	5,000	17,821	4,452	0	0	0	0	10,723
1.00	5,000	18,637	4,174	0	0	0	0	12,261
1.00	5,000	18,733	3,464	0	0	0	0	14,726

36. In 2022 the first 12 hours of the year had no unused non fossil fuel sources.

37. The nuclear per unit column of 1’s is for scheduled maintenance in the spring.

38. The Li Battery storage is charged up from the excess of power in the non CO2 sources and discharged as rapidly as possible to prevent burning of fossil fuels.

39. A case is shown below where the storage is in action of charging and discharging.

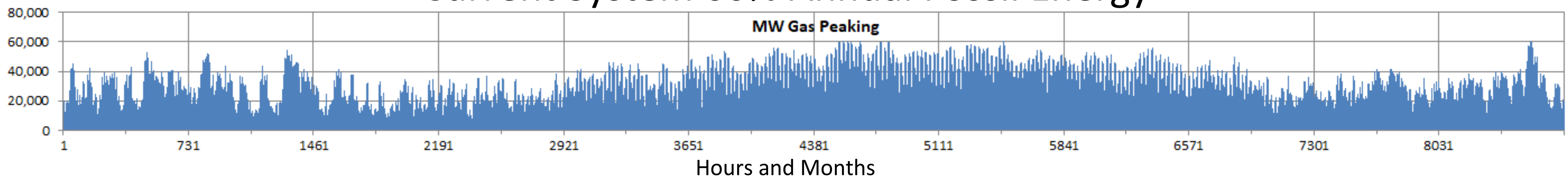
40. Fossil fuels are automatically calculated if there is any remaining load to be served.

Hourly Dispatching of All Resources and Battery Storage													
Direct Nuclear MW	Direct Wind MW	Direct Solar MW	Excess Nuclear MW	Excess Wind MW	Excess Solar MW	Excess Total MW	Unserved Load MW	Maximum Battery MWh 100,000	Battery Discharge MW	Battery Nuclear MW	Battery Wind Chg MW	Battery Solar Chg MW	Peaking Fossil MW
52,000	7,608	31,772	0	0	0	0	1,150	40,390	1,150	0	0	0	0
52,000	8,521	24,004	0	0	0	0	5,066	35,324	5,066	0	0	0	0
52,000	9,670	7,907	0	0	0	0	16,598	18,726	16,598	0	0	0	0
52,000	10,081	298	0	0	0	0	20,566	0	18,726	0	0	0	1,840
52,000	10,465	0	0	0	0	0	17,588	0	0	0	0	0	17,588
52,000	10,437	0	0	0	0	0	13,082	0	0	0	0	0	13,082
52,000	10,867	0	0	0	0	0	7,709	0	0	0	0	0	7,709
52,000	11,825	0	0	0	0	0	2,675	0	0	0	0	0	2,675
52,000	11,119	0	0	1,461	0	1,461	0	1,242	0	0	1,242	0	0
52,000	8,421	0	0	3,325	0	3,325	0	4,068	0	0	2,826	0	0
52,000	6,843	0	0	3,565	0	3,565	0	7,099	0	0	3,030	0	0
52,000	6,002	0	0	3,719	0	3,719	0	10,260	0	0	3,161	0	0
52,000	5,808	0	0	3,509	0	3,509	0	13,242	0	0	2,982	0	0
52,000	5,893	0	0	975	188	1,163	0	14,231	0	0	975	14	0
52,000	6,626	599	0	0	5,225	5,225	0	18,672	0	0	0	4,441	0
52,000	5,609	5,064	0	0	13,677	13,677	0	30,298	0	0	0	11,626	0

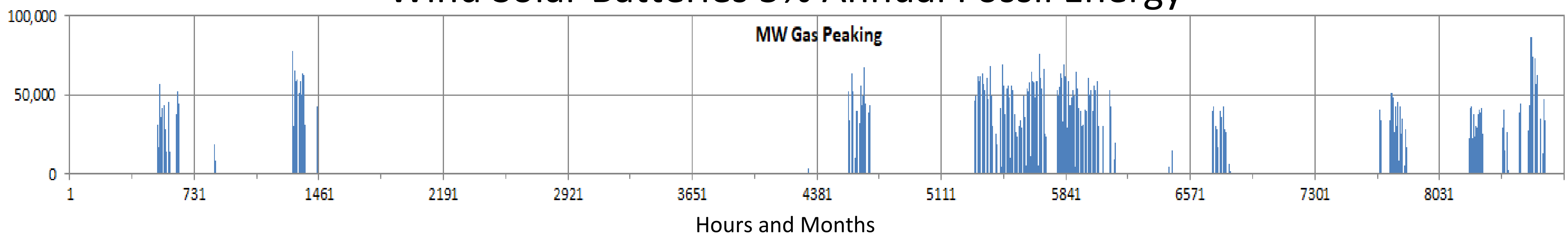
41. The top shows discharge of storage until it runs out and fossil generation is used until enough excess wind and solar is seen charging up the storage at the bottom.

Fossil Generation Provides Reliability**

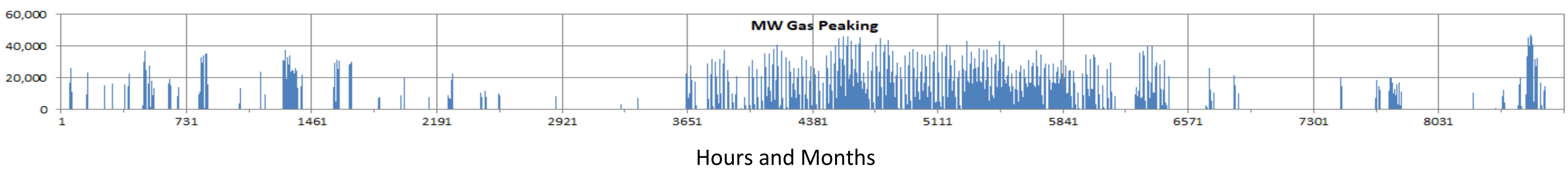
Current System 60% Annual Fossil Energy



Wind Solar Batteries 5% Annual Fossil Energy

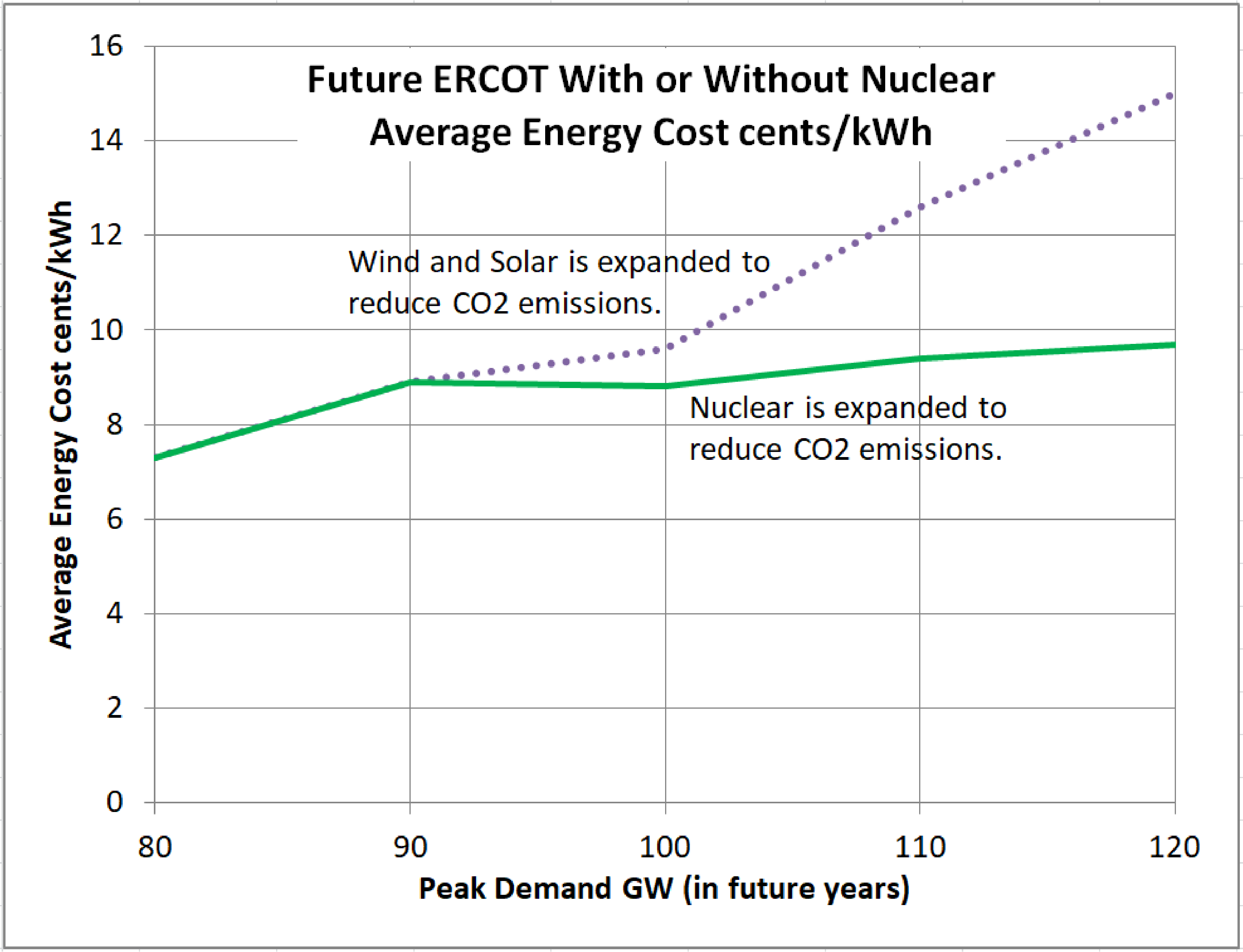


Nuclear Wind Solar Batteries 5% Annual Fossil Energy



** Fossil is mostly gas with some coal in the current system.

Adding Nuclear Power Lowers The Energy Cost



The Renewables, Batteries, and Gas Peaker Plan

42. A 5% fossil fuel energy at 120 GW peak demand plan needs 140 GW wind, 140 GW solar, 950 GWh batteries, and 87 GW gas peaking generation (see the appendix).
43. Major problems with this plan are the sheer number of new transmission lines needed, battery storage needed, as well as large amounts of new gas capacity. I don't think an energy-only market can fund and operate this "renewables" plan.

The Nuclear Plus Renewables Plan

44. A 5% fossil fuel energy at 120 GW peak demand plan needs 47 GW new nuclear, 40 GW wind, 50 GW solar, 100 GWh batteries, and 47 GW gas peaking generation.
45. Major problems are NRC licensing, funding of the nuclear plants, making the investments low risk, and public acceptance of nuclear plants near load centers.

What Needs To Happen

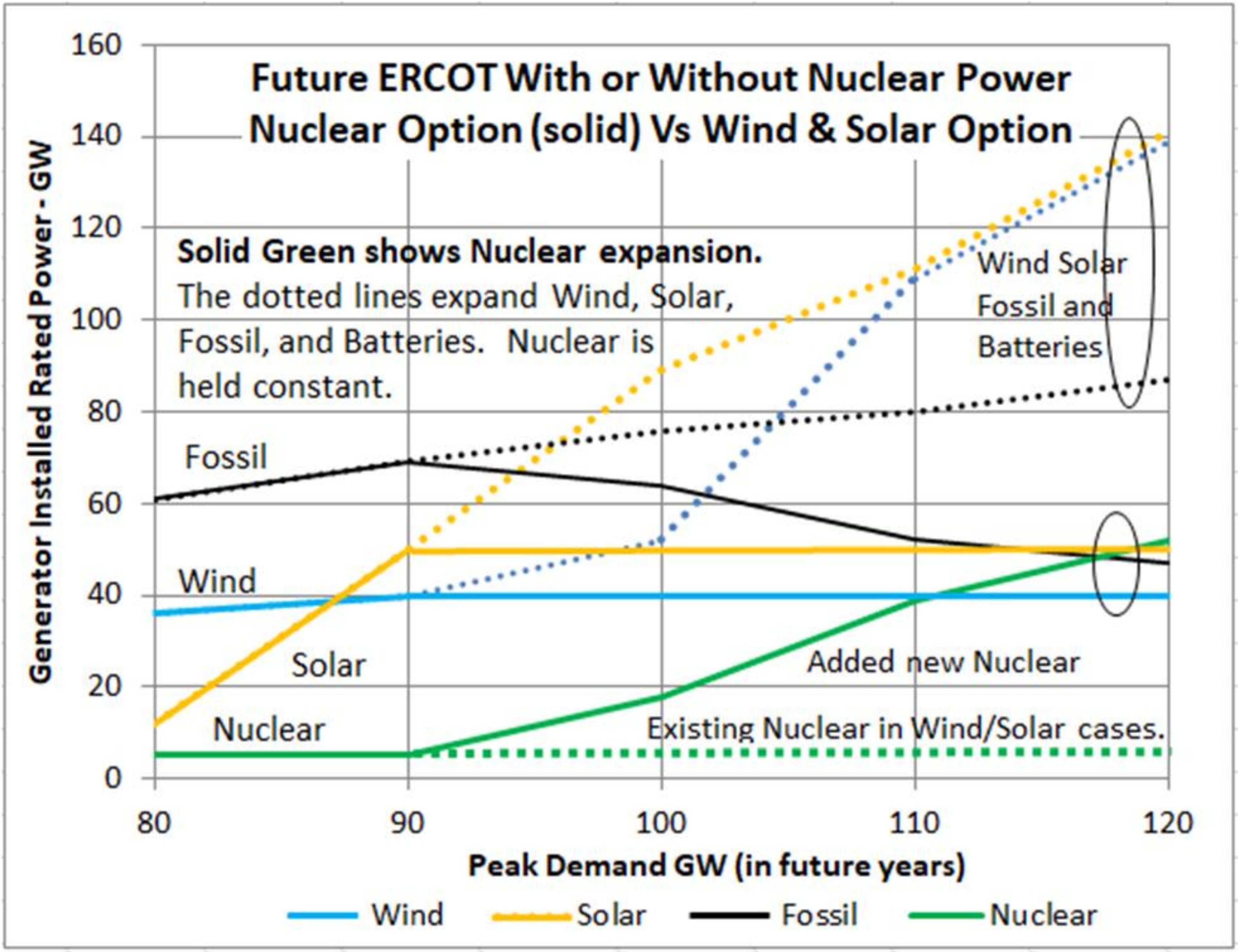
46. Manmade climate change and CO_2 emission reduction must be a priority.
47. ERCOT must get involved in generation planning and coordinated long range transmission planning.
48. Capacity markets should only be for the capacity needed for new gas plants. Note that all other resources supplying capacity do not compete in this capacity market.
49. Large but economic capital costs such as nuclear plants and storage must be uplifted and made reliable investments as long as they are functional.
50. Some operating costs can be operated in the present energy market, but not all the costs, just the variable ones.
51. Competition for large plants such as nuclear plants can be held as an auction with a bidder selected through a process of selection. Once a base loaded resource is in service such as nuclear, it operates as dictated by ERCOT, not by the lowest hourly energy bid price.
52. Generation, transmission, and sales long range planning must be cooperative.
53. The NRC needs to be closed and an Atomic Energy Agency with new rules needs to be formed at the federal level to get the US out of its nuclear gridlock situation.

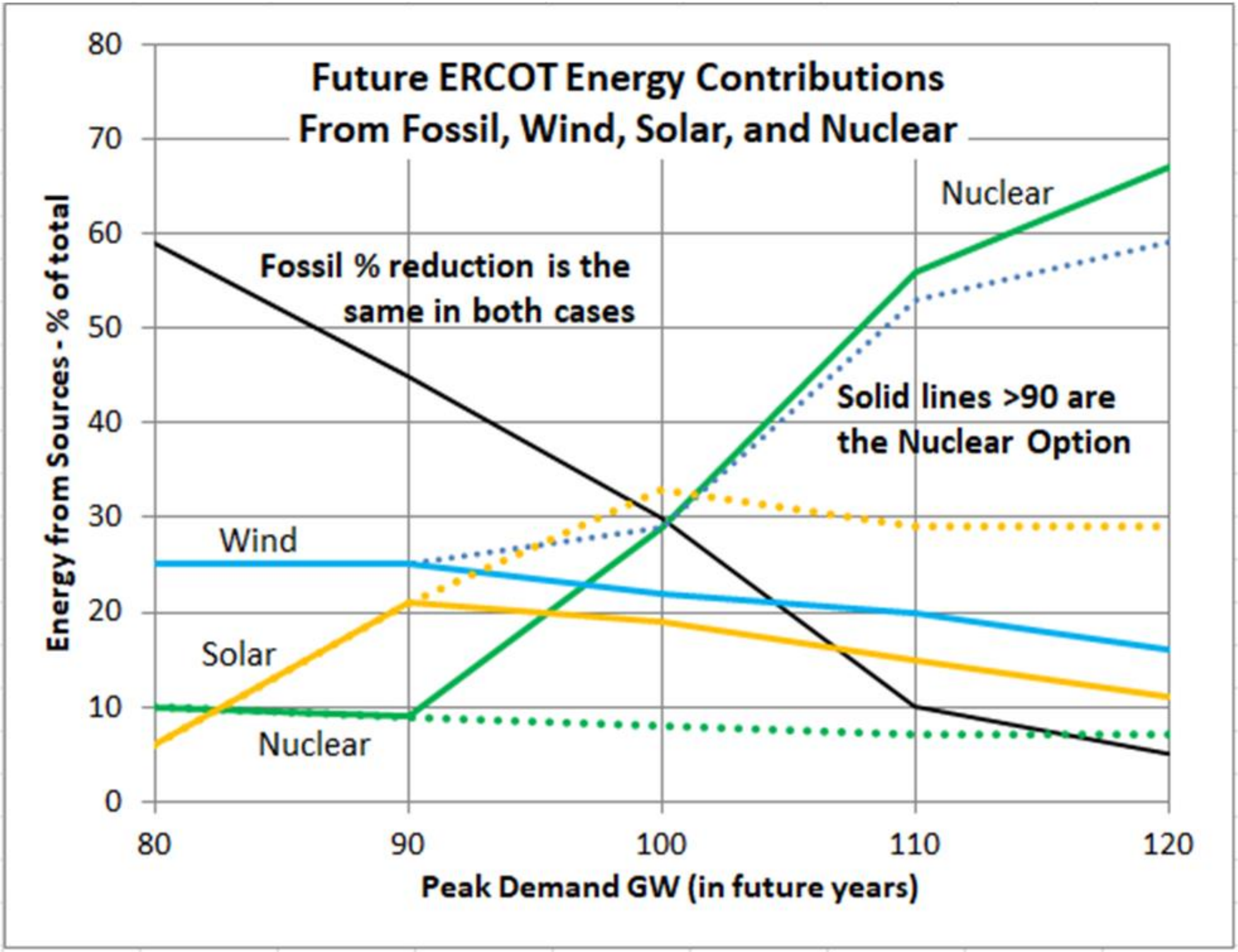
What happens if these things do not happen?

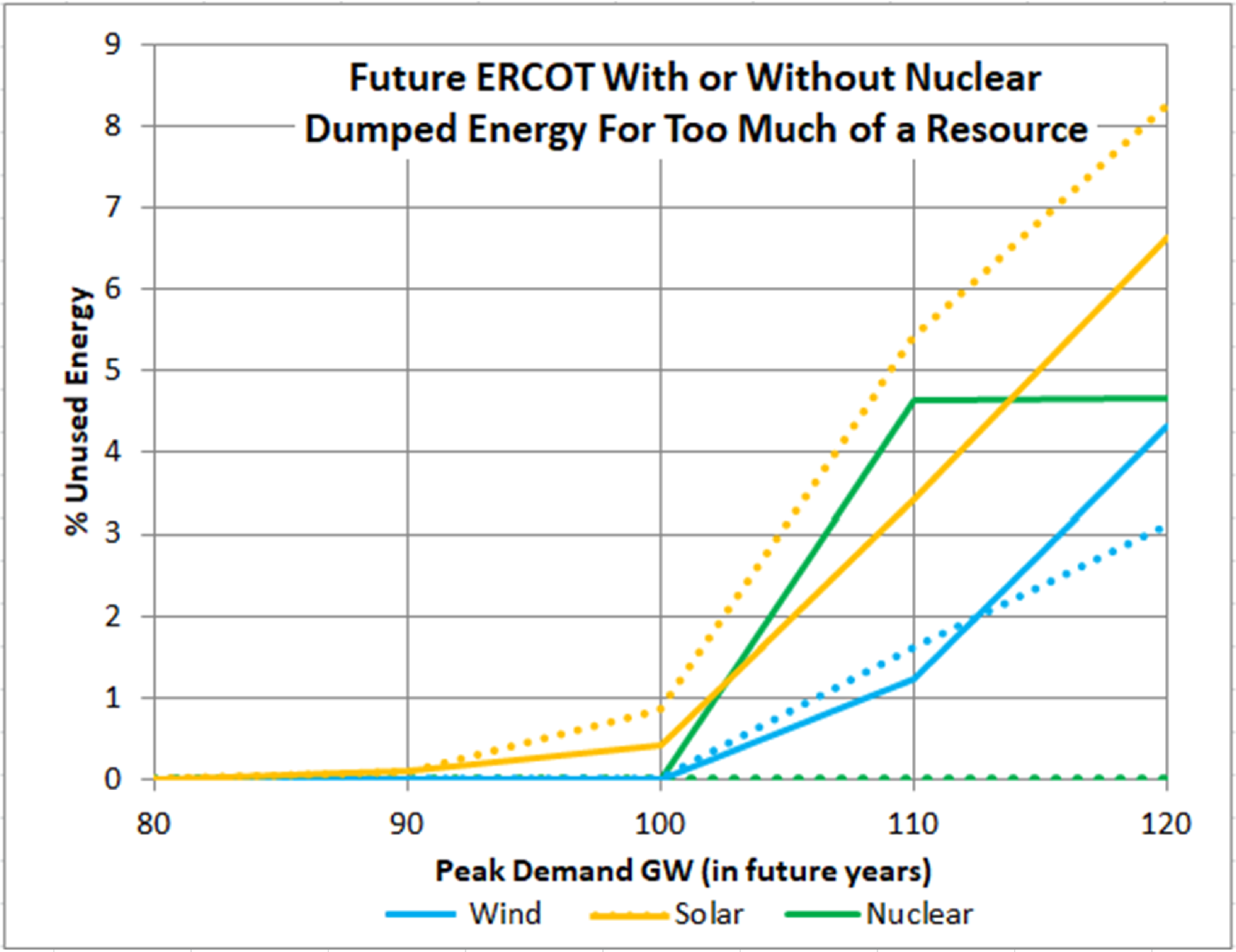
The lights will go out at some point in the future - or worse.

We could have both power outages and insufficient water.

More graphs follow if there are questions that need them.


Future ERCOT With or Without Nuclear Power
Nuclear Option (solid) Vs Wind & Solar Option
Solid Green shows Nuclear expansion.
The dotted lines expand Wind, Solar, Fossil, and Batteries. Nuclear is held constant.
Wind Solar Fossil and Batteries
Fossil
Wind
Solar
Nuclear
Added new Nuclear
Existing Nuclear in Wind/Solar cases.
Generator Installed Rated Power - GW
160
140
120
100
80
60
40
20
0
80
90
100
110
120
Peak Demand GW (in future years)
Wind
Solar
Fossil
Nuclear


Future ERCOT Energy Contributions
From Fossil, Wind, Solar, and Nuclear
Nuclear
Fossil % reduction is the
same in both cases
Solid lines >90 are
the Nuclear Option
Wind
Solar
Nuclear
Energy from Sources - % of total
Peak Demand GW (in future years)
0
10
20
30
40
50
60
70
80
80
90
100
110
120



Future ERCOT With or Without Nuclear
Dumped Energy For Too Much of a Resource
% Unused Energy
9
8
7
6
5
4
3
2
1
0
80
90
100
110
120
Peak Demand GW (in future years)
Wind
Solar
Nuclear