Policy Topics

07-18-24

CliSciPol

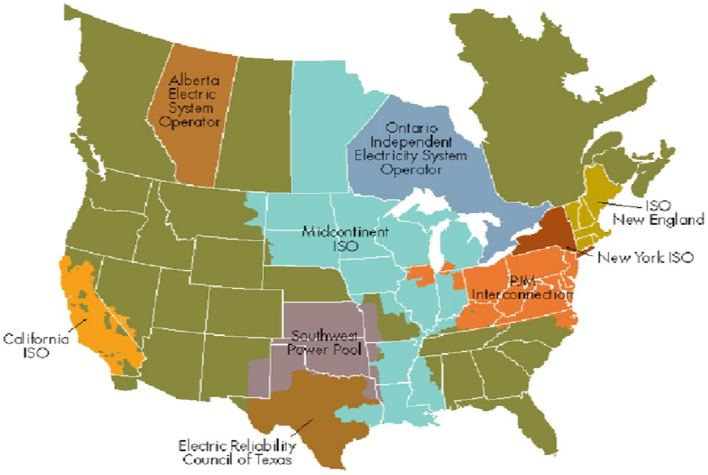
Climate Science and Policy for Nonscientists

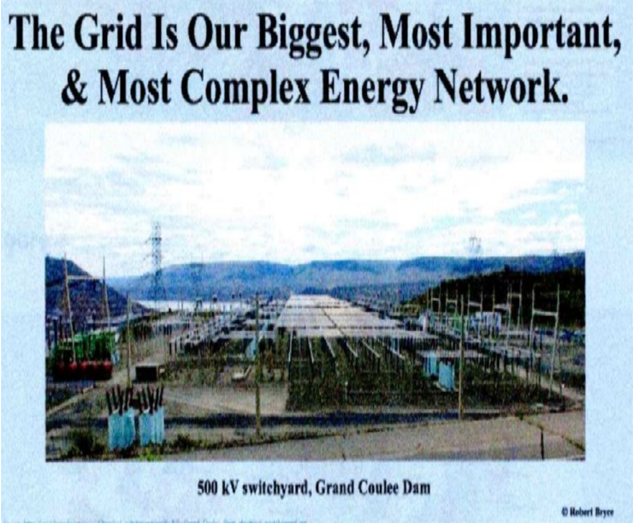
One picture is worth a thousand words.

WIND AND SOLAR - UNRELIABLE? EXPENSIVE?

Wind and solar are strongly advocated as sources of electric power by many, including Massachusetts government officials. But has this put Massachusetts on the path: (1) to blackouts due to wind and solar unreliability, and (2) to very expensive electricity?

In the late 1990s the Federal Energy Regulatory Commission authorized the formation of Regional Transmission Organizations ("RTOs"). There are now 7 RTOs in the US, covering about 60% of the continental US, including New England. Each RTO is managed by an Independent Service Operator ("ISO"), which in New England is named ISO New England ("ISO-NE" at iso-ne.com). An ISO does not own electrical generators, as do traditional utility companies. Rather an ISO buys electricity for resale to consumers. Unfortunately an ISO can not guarantee that it will be offered enough supply to satisfy demand at any particular time.

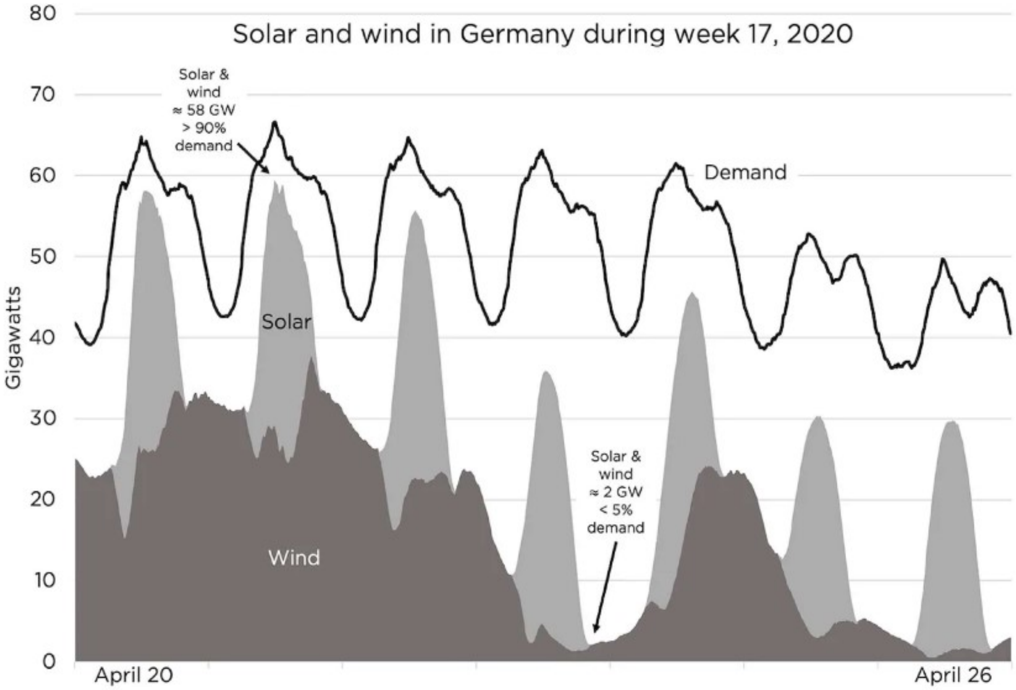




Each regional grid is an extremely complicated system. (Image from Robert Bryce, whose Substack newsletter is highly recommended). For New England ISO-NE plans the transmission system, administers the region's wholesale markets, and operates the power system to ensure reliable and competitively priced wholesale electricity. One of ISO-NE's key functions is to balance electricity supply and demand every minute of the day. If supply and demand are out of balance, this can result in rolling blackouts, and, if the imbalance increases, the grid can crash, resulting in blackouts that can be long and catastrophic. Unfortunately in a RTO the ISO does not have the ability to ensure system reliability. The ISO can only purchase the power that is offered to it.

In Texas in February 2021 the ISO was unable to prevent a supply shortfall leading to a major power crisis. Severe winter storms triggered a major shortage of supply (not under the ISO's control), which led to a massive blackout, which, in turn, caused major shortages of water, food, and heat for grid customers. More than 4.5 million homes and businesses were left without power, some for several days. At least 246 people were killed directly or indirectly, with some estimates as high as 702

Snow covering grounds of the Texas Capitol on February 15, 2021



Solar and wind in Germany during week 17, 2020

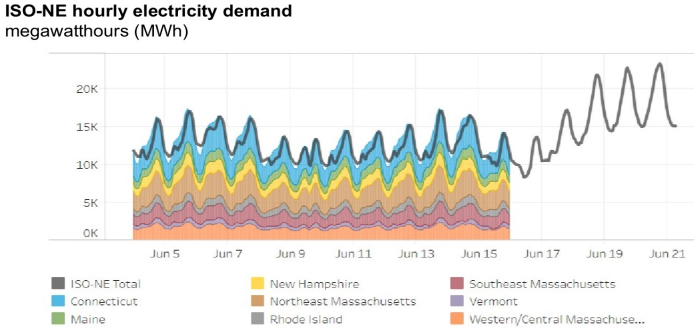
Balancing electricity supply and demand on a grid is complicated, particularly for grids with large amounts of wind and solar, e.g. Germany. The image above shows a typical spring week in Germany. This is typical of many weeks in systems that rely heavily on wind and solar. The top line shows the actual electricity demand. Below that is the available electricity from wind and solar throughout the week. Demand cycles up and down significantly each day, and the availability of wind and solar varies even more. The system operator can not control the amount of electricity produced by wind or solar at a particular time. Given Germany's latitude, solar power is only available in quantity from about 9 AM to 4 PM. Solar productivity varies significantly with latitude and season.

Wind power is available only when the wind blows, which can be very "spiky." To avoid a grid crash: (1) back-up power has to be provided rapidly whenever wind and solar power decline rapidly, and (2) various other sources of power have to be shut down rapidly whenever wind and solar spike upward. There were a number of hours in the middle of the week when wind and solar together were producing virtually no electricity, so over 90% of demand had to be met by back-up power. It has been estimated that for each MW of wind and solar capacity on a grid there has to be more than one MW of backup capacity (usually gas-fired) to assure reliability.

Wind tends to vary seasonally with maximum wind in the spring and fall. Unfortunately demand for electricity tends to reach it maximums in the winter heating season and in the summer air conditioning season. Wind patterns vary greatly from one location to another. Even during the seasonal maximums, wind can have periods of “lull” or “drought” that can last for a week or more. Sun has a seasonal maximum in the summer, which is good for the summer demand maximum, but it has a minimum in the winter heating season when demand is at its other seasonal maximum.

Monthly wind (utility-scale) generation.
Source: U.S. Energy Information Administration (EIA)

Electricity demand surged in New England amid heat wave

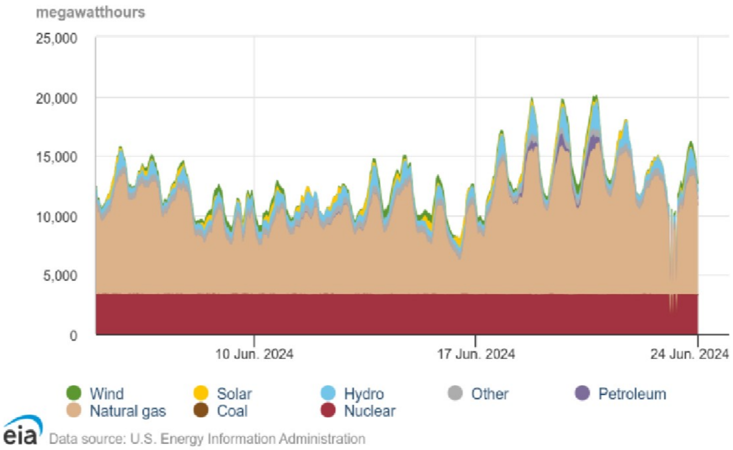


Data source: *U.S. Energy Information Administration, Wholesale Electricity Market Portal*

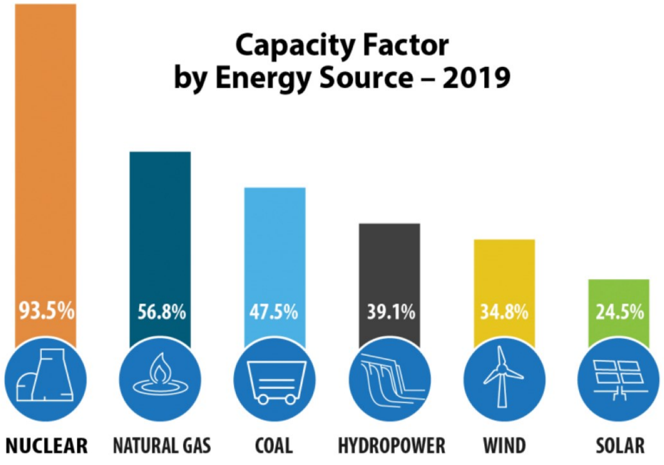
When there is a heat wave, like in New England in June 2024, demand surges as air conditioner use surges. ISO-NE has to hope there is back-up power ready to come online to avoid a blackout. Air conditioner use typically peaks in the evening when there is virtually no sun and when there may or may not be wind.

Virtually all of the electricity that kept New England going during June 2024 came from nuclear and natural gas together with a small amount of hydro. Wind and solar contributed negligible amounts. Australia has a good operational history of wind farm performance, and the data shows that about 50 times a year Australian wind farm generation falls by 500 MW (megawatts) or more within one hour or less.

ISO New England (ISNE) electricity generation by energy source
6/5/2024 – 6/24/2024, Eastern Time



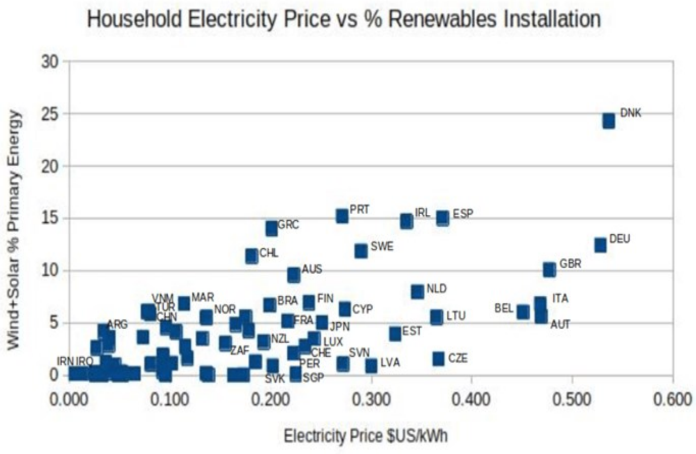
Data source: U.S. Energy Information Administration

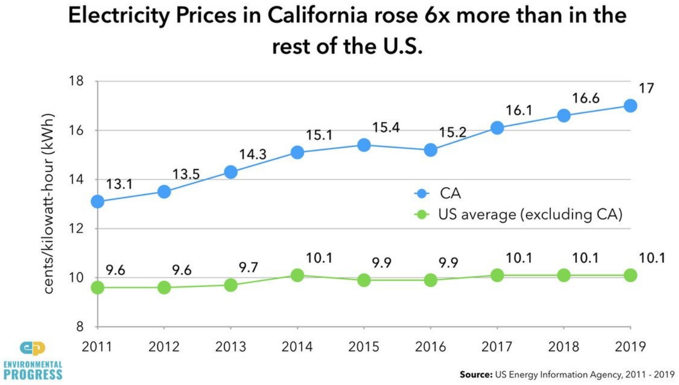


Energy source capacity factor comparison. (Credit: U.S. Energy Information Administration)

Various sources of electricity have rated capacity factors, which is a measure of the source’s actual output versus its maximum theoretical output. One of the strong points of nuclear power is that its capacity factor is >90%, whereas wind on average has a capacity factor of only around 35% and solar around 25%. A problem with nuclear power is that such plants can not generally cycle up and down on short notice. One great advantage of gas-fired plants is that they can cycle up or down rapidly as sun or wind vary, so they are good for backup.

Wind and solar are cheap on a marginal cost basis when they are producing power, because they have zero fuel cost. But they are very expensive on a fully distributed cost basis, because the costs of backing them up is so great, and because they receive such large government direct and indirect subsidies, which wind and solar companies demand even though wind and solar is supposed to be cheap. The more a country uses wind and solar, the higher the price for electricity.

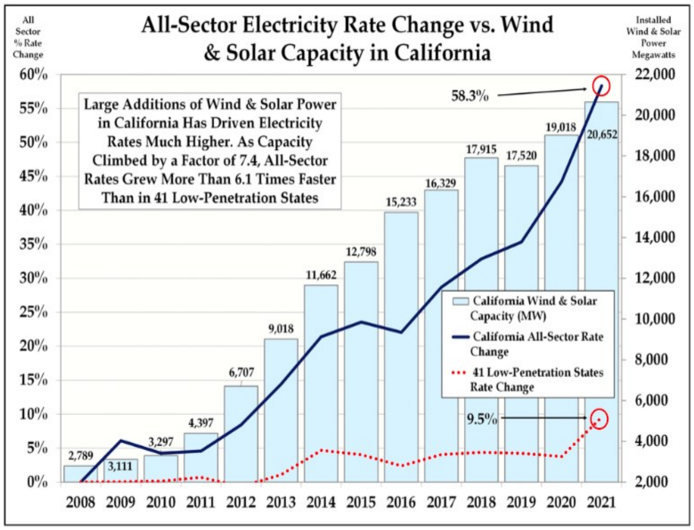

Household Electricity Price vs % Renewables Installation

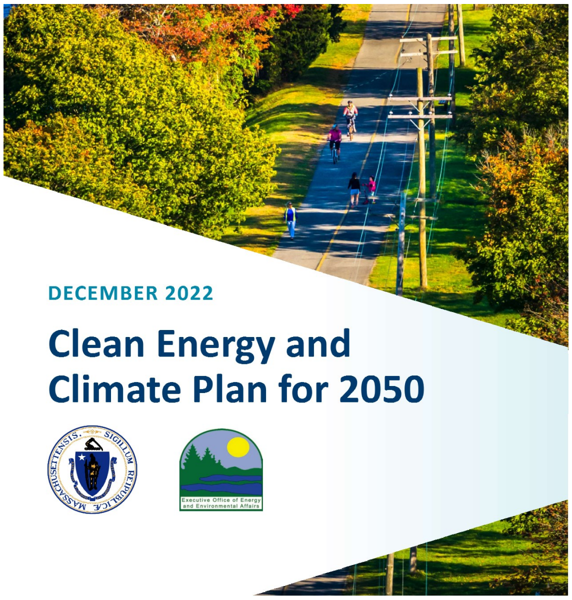

Electricity Prices in California rose 6x more than in the rest of the U.S.

Source: US Energy Information Agency, 2011 - 2019

Actual operational data now shows that, the more wind and solar on a grid, the higher the retail electricity price. In the US California has been a leader in installing wind and solar with the result that its electricity prices have risen much faster than the US average.

There is a significant correlation between California's rising electricity rate and the increase of wind and solar on the California grid. But in 41 states, where there is much less use of wind and solar, the rate of rise has been much smaller.


All-Sector Electricity Rate Change vs. Wind & Solar Capacity in California


DECEMBER 2022

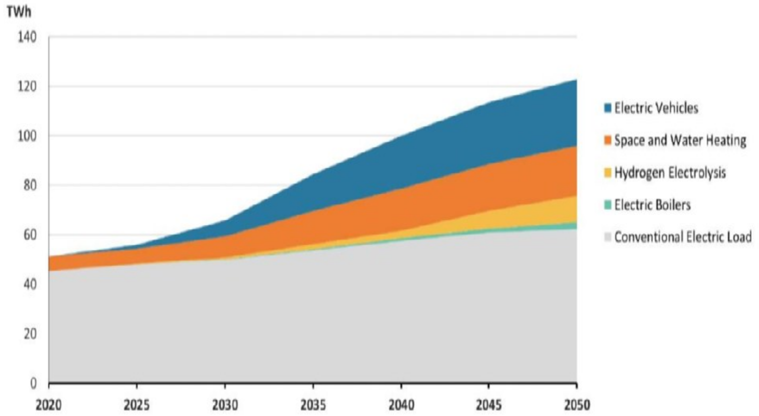
Clean Energy and Climate Plan for 2050

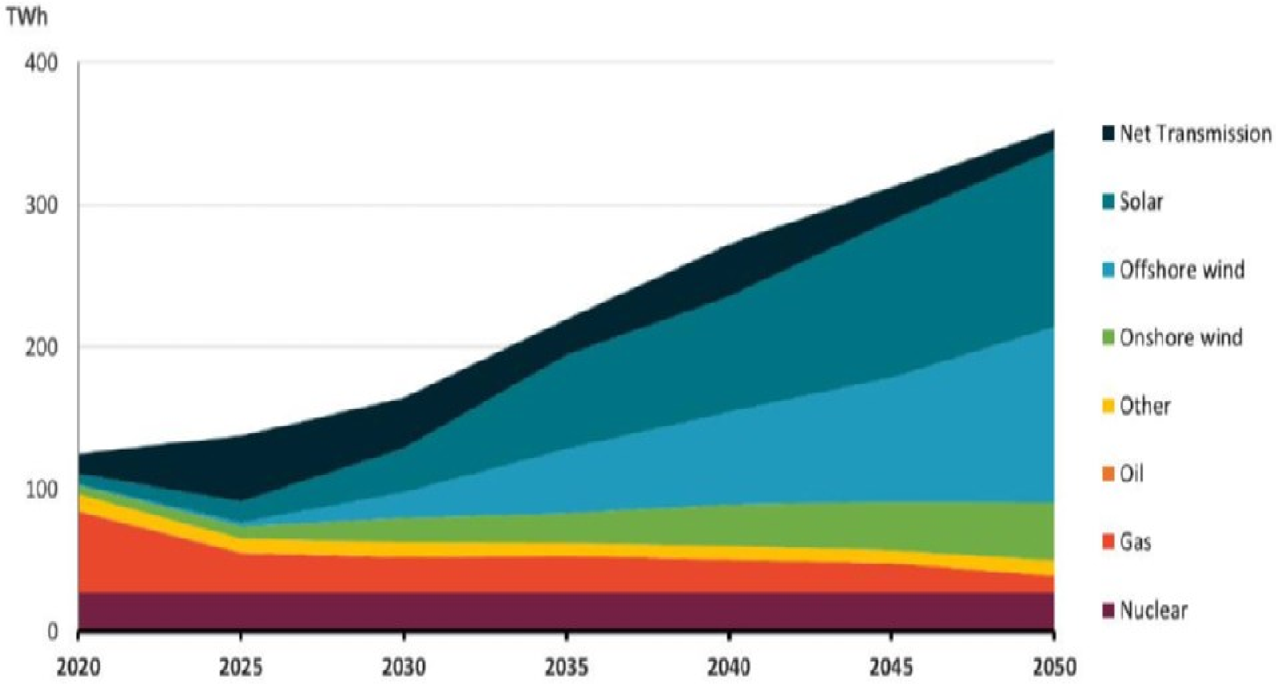
Executive Office of Energy and Environmental Affairs

Starting with the Global Warming Solutions Act of 2008, the Massachusetts legislature has mandated Net Zero by 2050. To implement this requirement the Massachusetts Office of Energy and Environmental Affairs adopted in 2022 a Clean Energy and Climate Plan for 2050 (the "Plan"), which presents the "overall policies and strategies to achieve Net Zero in 2050." (Plan p.x)

The Plan projects that the demand (load) for electricity in Massachusetts will increase from about 50 terrawatt hours in 2020 to over 120 TWH in 2050, an increase of over 240%. (Plan p.66)

FIGURE 4-1. PROJECTION OF MASSACHUSETTS ELECTRICITY LOAD





The Plan then proposes (at p.66) how this demand (load) will be met while transitioning to Net Zero by 2050. There will be major reliance on solar and offshore wind while oil and gas are almost totally phased out. Hence the grid will become significantly vulnerable to the vagaries of sun and wind and to the operational capacity factors of the solar and wind farms that will need to be built. But there is no explanation about how backup power will be provided when the sun does not shine and the wind does not blow, so it is impossible to assess the cost and risks involved in providing the needed backup.

In the Plan there is no evaluation of: (1) the overall costs of such as transition, (2) the effect on retail electricity rates, or (3) the impact on per capita GDP in Massachusetts. The Plan's discussion of economics (Plan p.133-140) is limited to the increase in jobs created by the new construction, as opposed to the net effect on jobs that takes into account not only jobs gained but also jobs lost in the transition. The Plan announces without any support, "Efficiency gains of electrification will result in lower household energy expenditures through 2050 (monthly bills for electricity and fuels)." (Plan p.141). But this proposition is contradicted by all the actual data, presented previously, that shows the increased use of wind and solar drives up electricity costs.

In 2022 ISO-NE, the New England grid manager, issued "2021 Economic Study: Future Grid Reliability Study Phase 1." (The "Study"). Despite the use of the word "economic" in the name, the Study performed no analysis of costs or rates. Rather the study analyzed whether a grid that complied with the Massachusetts requirement of Net Zero by 2050 would be reliable. The study's modeling showed that "by large margins available resources were repeatedly unable to match their aggregate output to system demand." (Study p.2). The "Deep Decarbonization" scenario that matched Massachusetts' Net Zero requirement "did not meet required reliability criteria." (Study p.2)


ISO new england 25 years

2021 Economic Study:
Future Grid Reliability Study
Phase 1

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JULY 29, 2022

ISO-NE PUBLIC

The Study's Deep Decarbonization scenario (Net Zero by 2050) was based on sources of electricity through 2050 being as projected in the Plan at p.66. (see prior image). This projection shows energy source goals for 2050 of about -

36% offshore wind
34% solar
11% onshore wind

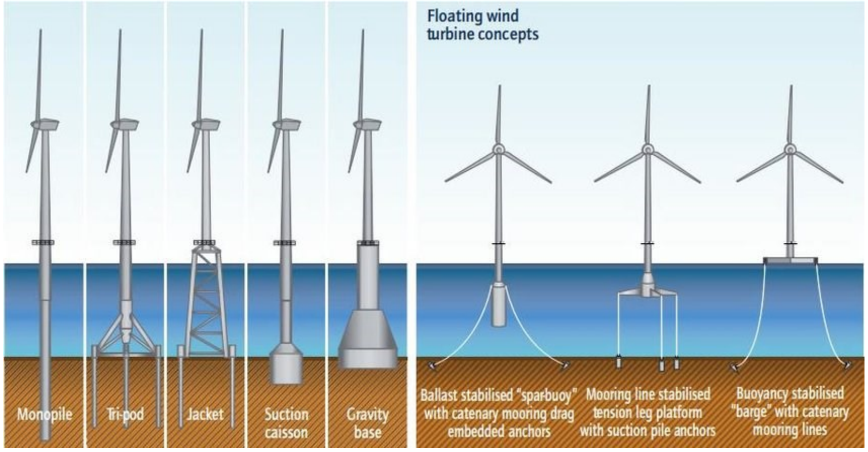
8% nuclear
6% oil and gas
5% net transmission.

The Plan admits that offshore wind will be a "cornerstone" of energy supply for coming decades. (Plan p.68)

Offshore wind in the US has very little actual operating history, but it is much further advanced in Europe where data is becoming available on actual operating costs of both onshore and offshore wind. There are 2 basic types of offshore wind, fixed-base and floating. While there remain major uncertainties, the emerging trends for both types of wind show: (1) costs have *risen* steadily for the last decade, (2) costs of onshore wind are about twice the cost of gas, (3) costs of *fixed-base* offshore wind are 3-4 times the cost of gas, and (4) costs of *floating* wind are probably (very little actual data) 5-6 times the cost of gas.

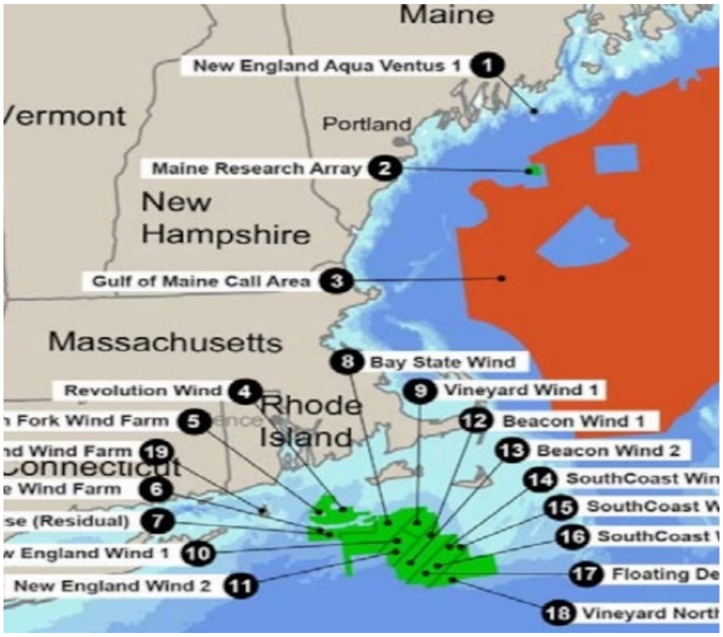
US OFFSHORE WIND HISTORY

2016	Block Island Wind Farm completed. Small scale 30 MW.
2017	Cape Wind off Massachusetts canceled. The first large-scale offshore wind project in the US. It had been pending for 16 years
2020	12 MW pilot project came online off Virginia. First project in federally controlled waters.
2024	South Fork Wind Farm off NY began producing (132 MW). Vineyard Wind started producing 68 MW out of 805 MW planned.

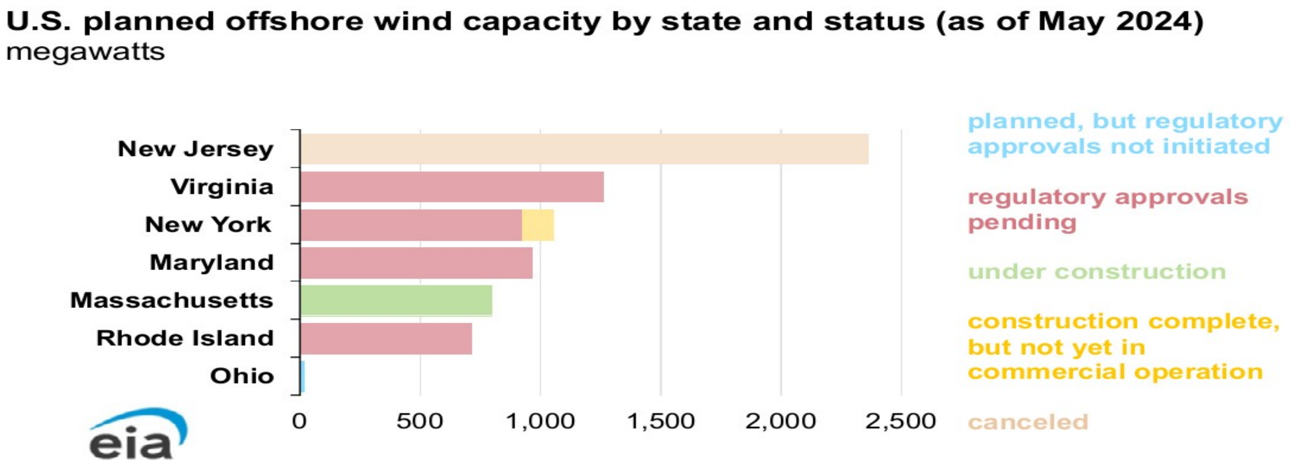


There are a number of different proposed designs for both fixed-base and floating offshore wind. There is not enough operational history to judge a best design in either category, or to judge whether any of the designs will provide an operational lifetime that results in economic feasibility.

Construction of offshore wind farms is significantly limited by the shortage of the wind-turbine-installation vessels (WTIVs) needed, and also by the shortage of the trained crews needed to do the installing.

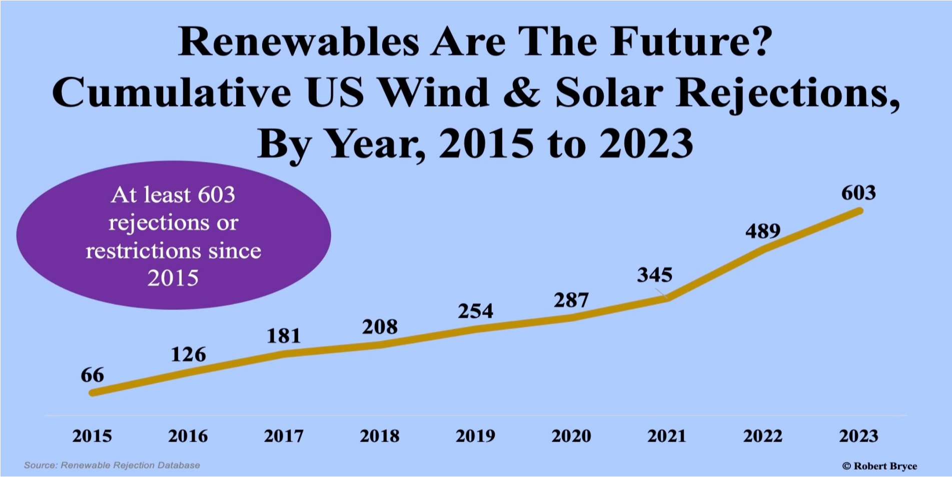


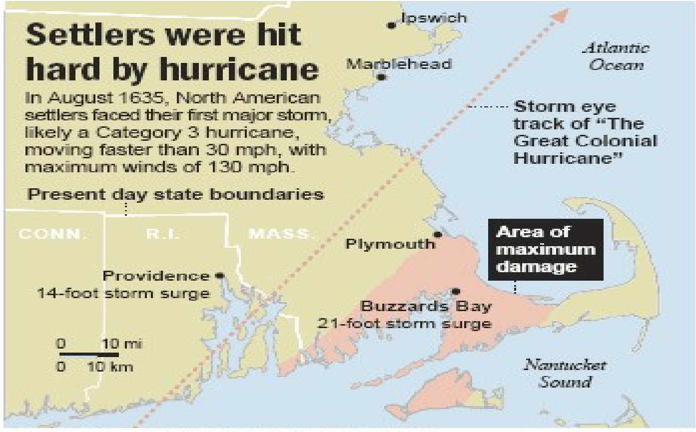
To date most of the proposed offshore wind projects have been fixed-base, but there is a very limited number of suitable sites for such projects off the US East Coast. Most of the next generation of offshore wind projects, such as in the Gulf of Maine, will have be of the hugely expensive and untested floating designs. There is very little operational history to establish: (1) actual costs of building such projects, (2) actual maintenance costs over years of operation, and (3) actual productive lifetimes that can be expected for such installations.



As of May 2024 a great majority of US planned offshore wind projects have either been canceled or are still in the regulatory approval process. As previously discussed, there are remarkably few US offshore wind projects in operation today. As of July 2024 two of Europe's biggest energy companies (Shell and BP) are cutting back, if not abandoning, offshore wind. Over the last year three projects along the US East Coast have been cancelled (Skipjack Wind, Park City Wind, and South Coast Wind, which was a Massachusetts project). Cancellations have totaled 14,700 MW while the total of capacity now in development, under construction, or operational is only 15,500 MW. The major problem has been estimated costs ballooning far above what is sustainable.

US wind and solar projects face daunting regulatory challenges to obtain the required approvals. Large numbers of proposed projects are being rejected. (Data collected by Robert Bryce).





SOURCES: Queens College; National Hurricane Center AP

No one has actual data on how much damage a hurricane will cause an offshore wind farm. New England has a long history of major hurricane strikes going back to 1635 (the "Great Colonial Hurricane"). The Hurricane of 1775 went all the way to Newfoundland, It destroyed the British fishing fleet there and killed over 4,000 people.

The image is of some damage from the Great New England Hurricane of 1938. From 1938 to 1991 New England was hit by 8 major (Cat.3+) hurricanes, on average one every 6.7 years. Despite all the warnings in the media about increasing hurricane frequency, New England has not been hit by a Cat.3+ hurricane since 1991, an unprecedented span of 33 years. We are long overdue.

This is an example of the damage done to electrical transmission lines in Houston by Hurricane Beryl, which was only Cat.1 when it came onshore on July 9, 2024. As of July 12 nearly 1.3 million homes and businesses in the Houston area were still without power. There has been no report to date on: (1) what damages Beryl caused to Houston area solar farms or onshore wind farms, or (2) how many home roof-top solar panels were blown away or badly damaged.

The ISO-NE Study concluded that, for the Net Zero scenario, there were significant periods during the winter and summer demand maximums when the New England system was unreliable, and that there were other significant periods when the system was at risk. (Study p.46)

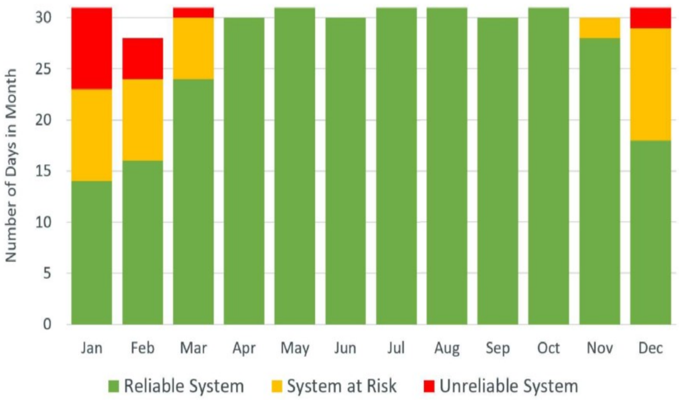
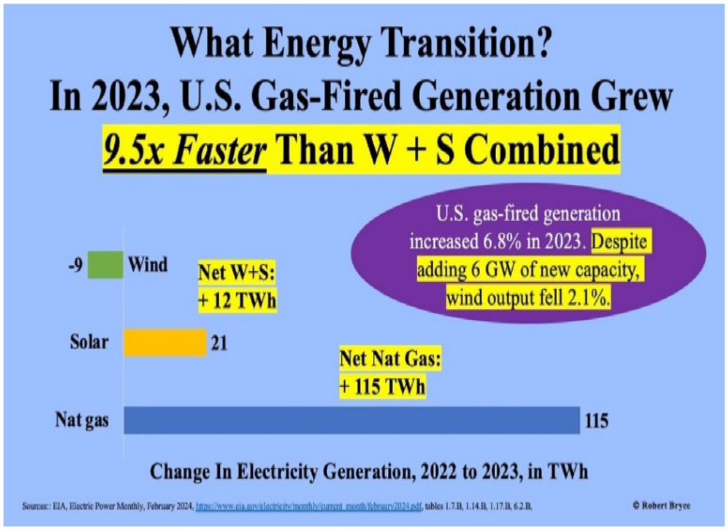


Figure 6-3: Days Per Month of Natural Gas Supply Risk Under FGRS Scenario 3



What Energy Transition?
In 2023, U.S. Gas-Fired Generation Grew
9.5x Faster Than W + S Combined

U.S. gas-fired generation increased 6.8% in 2023. Despite adding 6 GW of new capacity, wind output fell 2.1%.

Change In Electricity Generation, 2022 to 2023, in TWh

Sources:: EIA, Electric Power Monthly, February 2024, https://www.eia.gov/electricity/monthly/current_month/february2024.pdf, tables 1.7.B, 1.14.B, 1.17.B, 6.2.B.

© Robert Bryce

As shown by Robert Bryce, gas use in the US in 2023 grew over 9 times faster than wind and solar combined. Economic reality has prevailed. Gas is far cheaper than wind or solar for operation on a grid. The cheapest source of electricity is coal, which is the reason that China and India are building so many coal-fired power plants.

But gas produces only about half the amount of CO2 as coal to produce the same amount of electricity. Burning gas produces only about 10% of the pollution caused by burning coal. Gas is reliable and dispatchable, which means that it can be readily ramped up or down as needed as demand fluctuates, which makes it very important to assure system reliability as the use of wind and solar grows. These reasons account for the popularity of gas around the US. Yet the Massachusetts Plan calls for almost a total phase-out of gas by 2050 while providing only speculation about the source or the cost of necessary backup power.

There has *never* been a successful demonstration project of a Net Zero grid. There have been two serious attempts, one at El Hierro in the Canary Islands (population around 11,000) and the other at King Island off the coast of Tasmania (population under 2,000). The El Hierro plan called for pumped hydro, as shown, as a backup source of power. The King Island plan called for a variety of backup options, including batteries. Each project has been a dismal failure

CONCLUSION

The Massachusetts' Plan for Net Zero 2050 is highly dependent on wind and solar (Plan p.66) and is therefore high risk. It is particularly risky in its dependence on offshore wind projects: (1) that may never actually be built due to economic infeasibility and due to regulatory and construction problems, (2) that, if built, have unknown operational life expectancies, and (3) that, if built, may result in such high electricity prices as to be politically unsustainable.

The ISO-NE Study warns that the Plan raises such uncertainties that ISO-NE does not even have the tools adequately to model the Plan. (Study p.50-51,56). Hence ISO-NE's analysis is unable to provide any assurance that the Plan is operationally feasible. Nevertheless the Study could conclude that, by 2050, for many periods during the year, the grid will be unreliable or at risk. (Study p.46).

Neither the Plan nor the Study provide any assurance that the Plan will result in electricity prices that are acceptable to the people of Massachusetts or New England. Strong opposition to Net Zero is appearing in Europe due to the rising costs caused by the growing use of wind and solar in those countries.

It is truly shocking that Massachusetts has committed to the goal of Net Zero by 2050 without any kind of demonstration project, ever, in the world, showing that the Net Zero goal can be achieved technologically, let alone at reasonable cost. Edison had to conduct two successful demonstration projects before he was allowed to build his first commercial power plant in New York City. The Massachusetts Plan is only *conceptual*. It is so vague that it is impossible to estimate the costs of the Plan. The Plan even admits that it does not have a procurement model to obtain the capital needed to finance future renewable construction. (Plan p. 67-68). It is impossible to confirm whether or not the Plan has economic *feasibility*.

The ISO-NE Study repeatedly warns that fossil fuel plants must not be retired "prematurely" in the hope that wind and solar projects will be able to provide the electricity that New England needs to avoid dangerous blackouts. (Study p.37, 49).

There is no need to rush the energy transition, because there is no scientific basis for the goal of Net Zero by 2050. The Paris Agreement of 2015 does not require it. Rather the Paris Agreement in Art. 4, Sec. 1, only calls for the parties "to achieve a balance between...emissions, and removals...in the *second half* of this century. (see CLISCIPOL Science Topic: Tipping Points and the Paris Agreement Goals). Our first concern should be the reliability of the New England grid. Our second concern should be that electricity prices do not rise unreasonably.