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Center for Energy Competitiveness

Energy Trends

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Executive Summary

The stage for action on energy policy is shifting from the federal level to the states. Significant de-regulation has occurred under President Trump. The EPA is no longer driving closure of coal-fired power plants, federal lands have been opened for exploration and production of fossil fuels, methane rules have been relaxed, it is getting easier to build pipelines and export facilities, CAFE Standards will likely be reduced, and the U.S. will be withdrawing from the Paris Accord on greenhouse gas emission reductions. President Trump and the Republican Senate will likely form a firewall against federal economy wide taxes on carbon dioxide emissions, and extending federal tax subsidies on wind, solar, and electric vehicles (EV).

Meanwhile, twenty-four states, with half the U.S. population, have joined the Climate Alliance to use state laws and regulations to meet the goals of the Paris Accord. We have seen a dozen states and the District of Columbia extend and expand their Renewable Portfolio Standards (RPS) with several setting zero emission goals. Four states are considering joining the nine state Regional Greenhouse Gas Initiative (RGGI), and eight states are considering extending a RGGI like program to gasoline and diesel fuels. State regulators are looking to expand EV charging infrastructure with government subsidies, and with regulated electric utility funds paid for by electric customers. Public utility commissions (PUC) are approving regulated utility plans to voluntarily close coal-fired power plants early to be replaced by massive increases in wind and solar power. All of this will dramatically raise electric power costs, and harm reliability.

Trends are highlighted here:

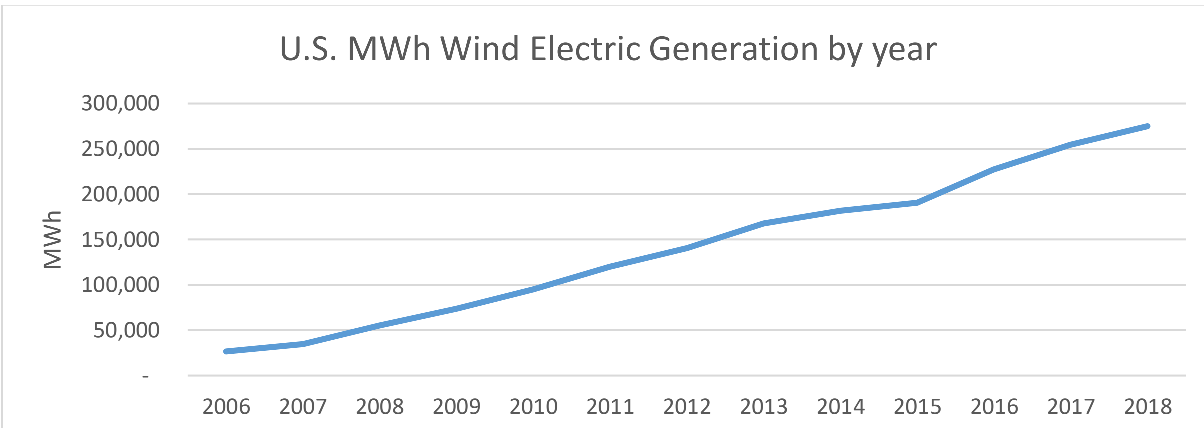
1) About 8 GW/year of new onshore wind capacity has been added for the last several years, and will accelerate to about 10 GW/year in 2019/20 to take advantage of the expiring PTC. Future new generation additions are uncertain.
2) About 4 to 5 GW of new solar capacity has been added over the last several years, and this rate is likely to continue.
3) New generation is not needed for reliability as there is existing excess capacity and electric demand is stable.
4) Wind and solar growth drivers are shifting from falling installed cost, improving efficiencies, RPS mandates, and the federal Production Tax Credit (PTC) and Investment Tax Credit (ITC), to PUC approval of voluntary regulated utility fuel shifts from coal to wind and solar over the next few decades. State legislation provides support for these changes.
5) Only 11% of national wind/solar sales were RPS driven in 2018 according to a recent Wood Mackenzie study. Thirty-seven states originally had either mandatory or voluntary RPSs. Thirteen of those states have met their goals, five more will meet their goals by 2022, and another six by 2026. By 2027 only twelve states will still have an RPS. New generation requirements will fall to about 18 GW/year.

6) To maintain reliability, regulated utilities will continue increasing reliance on new natural gas-fired generation capacity, capacity that may be closed early to meet 2050 zero emission goals sticking electric customers with the early write off costs.
7) Utilities and PUCs continue to ignore the indirect cost of wind and solar projects, such as, transmission investments, the costly operating inefficiencies of rapid cycling of coal and natural gas powered generating units, or batteries needed to back up intermittent wind and solar. These extra costs can double the direct cost of wind and solar.
8) Offshore wind generation commitments from a dozen state legislatures are driving offshore wind development from essentially zero today, to up to 34 GW by 2030, with 3 GW in the procurement process now. Up to 3 to 4 GW/year may be added if voters don't revolt against rising electric rates and the appearance of turbines off the shores of favorite tourist destinations. Offshore wind costs 2.75 times onshore wind.
9) Efficiencies of individual wind and solar projects have been improving about 4 percent a year. However, older wind turbines lose about 1.6% a year of capacity, and older solar modules lose about 0.5% a year. State legislatures are pushing for more in-state wind and solar production. This may result in lower efficiencies as more projects are built in areas with lower wind speeds, and lower insolation levels. However, states with the highest mandates tend to have the lowest generation rate of in-state wind and solar projects. Wind turbine size seems to be stabilizing as is solar module efficiency.
10) Wind cost may also rise with in-state installation requirements. For example, an onshore wind project in the Northeast can cost almost 50 percent more than the same turbine in the Midwest. The Midwest turbine may also have the advantage of double the average wind speed yielding four times the power delivery.
11) The existing RGGI states have extended the program to 2030, however, efforts to join RGGI by governors in Virginia, Pennsylvania, and North Carolina have run into stiff legislative opposition. Proposals for economy wide carbon taxes have failed in progressive states such as Vermont, Oregon, and Washington, and have been overturned in Australia, France, and in some Canadian Provinces. Eight states are considering the Transportation Climate Initiative to add emissions taxes to motor fuels with a RGGI like program that may be initiated without legislative approval.
12) Investor owned regulated utilities are aligning themselves with the growth of plug in electric vehicles by investing in public charging stations for EV owners using electric customer funds. There are at least twenty-six investor owned utilities in sixteen states, and the District of Columbia either approved or proposed to add EV charging since 2016. Public charging stations are generally unprofitable because of low utilization as EVs only constitute 0.5% of the vehicle fleet, and most charging is done at home.
13) Concerns about bird and bat fatalities, noise, and health, from wind projects, and visual blight from wind and solar have led to growing public resistance to new projects.
14) A competitive, zero CO_2 emitting natural gas generation plant just opened , and small modular nuclear reactors will begin production as soon as 2022 to 2024.

Wind

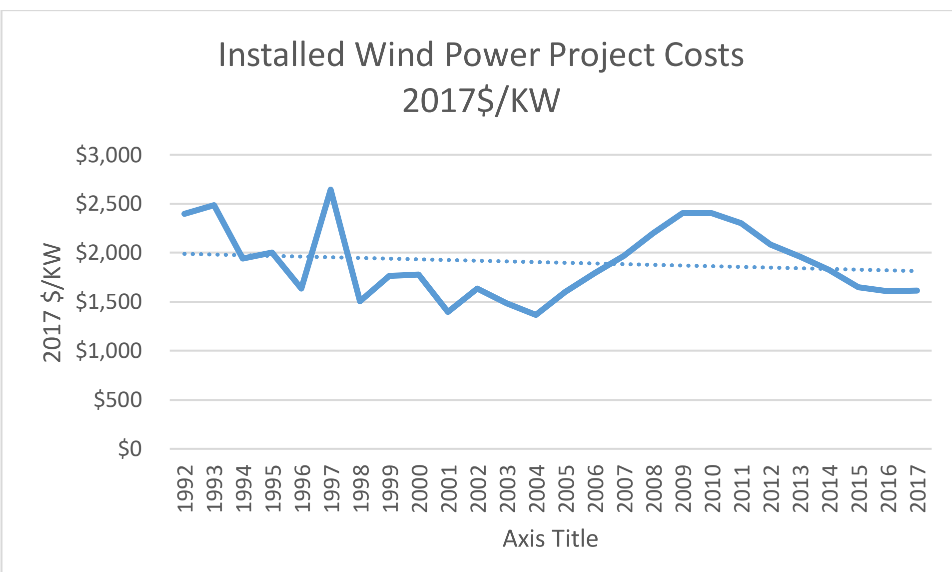
According to the U. S. Energy Information Agency (EIA), "Annual Detailed State Data"[1], between 2006 and 2018 wind power generation has grown at a compounded rate of 21.5% a year (Chart 1). In 2018 wind generation only met 7.2 percent of total U.S. demand. Rapid growth is tied to the a slightly lower cost of wind power (Chart 2), a 3.5 percent a year improvement in efficiency as size and design improved (Chart3), and the availability of the federal Production Tax Credit (PTC), according to the U.S. Department of Energy, "2017 Wind Technologies Market Report"[2]. Individual systems can vary in generation output by up to 9 percent a year, but by spreading systems across the country national annual generation output is dampened to about half that amount.

Chart 1



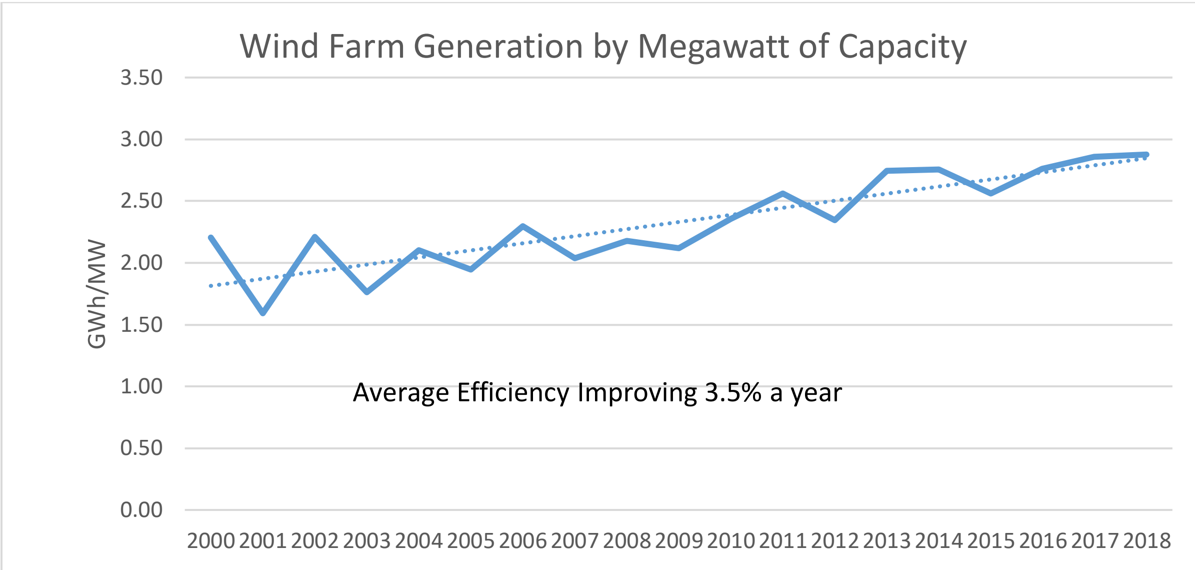
Source: U.S. Energy Information Agency Annual Detailed State Data

Chart 2



Source: U.S. Department of Energy, "2017 Wind Technologies Market Report"

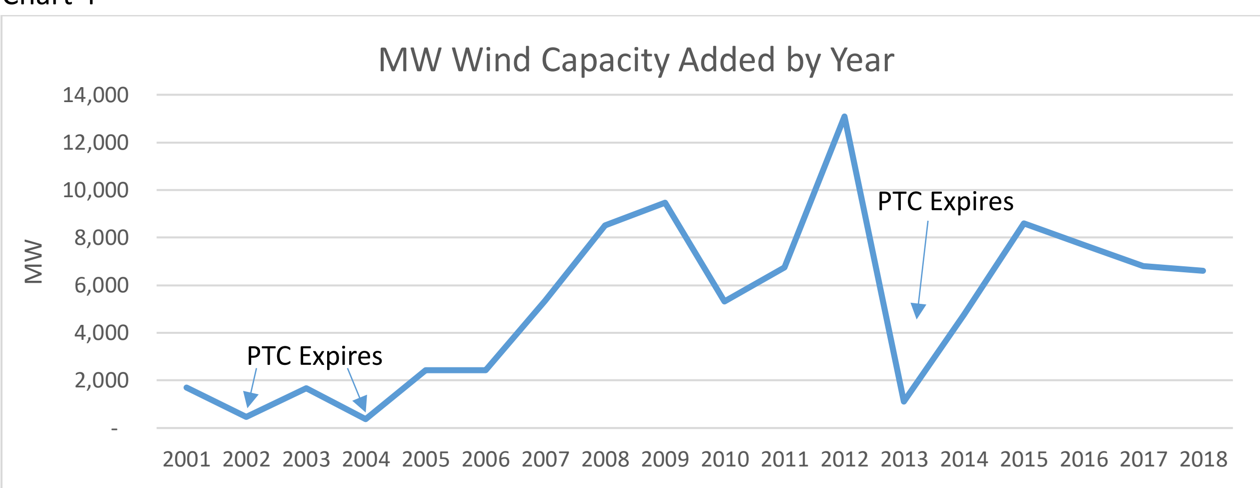
Chart 3



Source: author calculation from EIA Annual Detailed State Data

Net cost reductions were a precondition to make wind power competitive with conventional power plants. Capacity additions took off in 2006, and costs have not come down significantly since then. It appears the PTC was the primary driver of growth. Every time the PTC was allowed to expire growth of new generation fell an average of 85 percent (Chart 4). The PTC will expire at the end of 2019, but projects started in 2019 and completed in 2020 will receive the credit. After 2019 wind projects can still qualify for the federal Investment Tax Credit. Based on the EIA Electric power Monthly for April, 2019, there will be 9,800 MW of capacity added in 2019, and 10,900 MW added in 2020, with possible further additions.

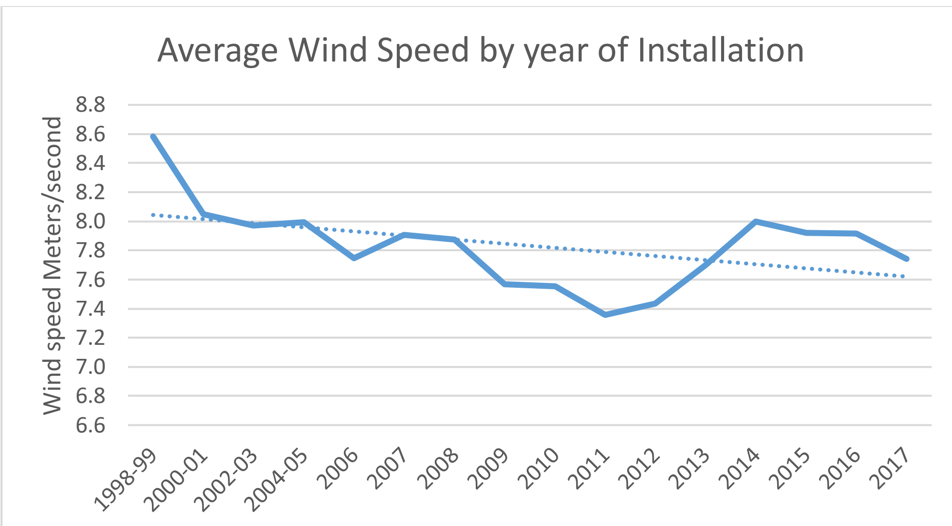
Chart 4



Source: Author calculation from EIA Annual Detailed State Data

Besides the loss of the PTC, the wind industry may be facing limited future improvements in efficiency. Increased turbine size has been important as generation increases by the square of the turbine size. The problem is transportation limitations of moving large turbine blades, and the cost of larger blades may have reached a limit. New wind farms averaged 2.3 MW in size in 2017 up from 0.7 MW in 1999, and 1.6 MW in 2006 according to the U. S. Department of Energy, "2017 Wind Technologies Market Report"[2], but average wind speed index for new deployments have dropped 15.5 percent (Chart 5) as installations spread to lower wind speed zones. Also, existing wind turbines lose operating efficiency by about 1.6 percent +/- 0.2 % a year according to a study from the Imperial College of London, "How does wind farm performance decline with age"[3].

Chart 5

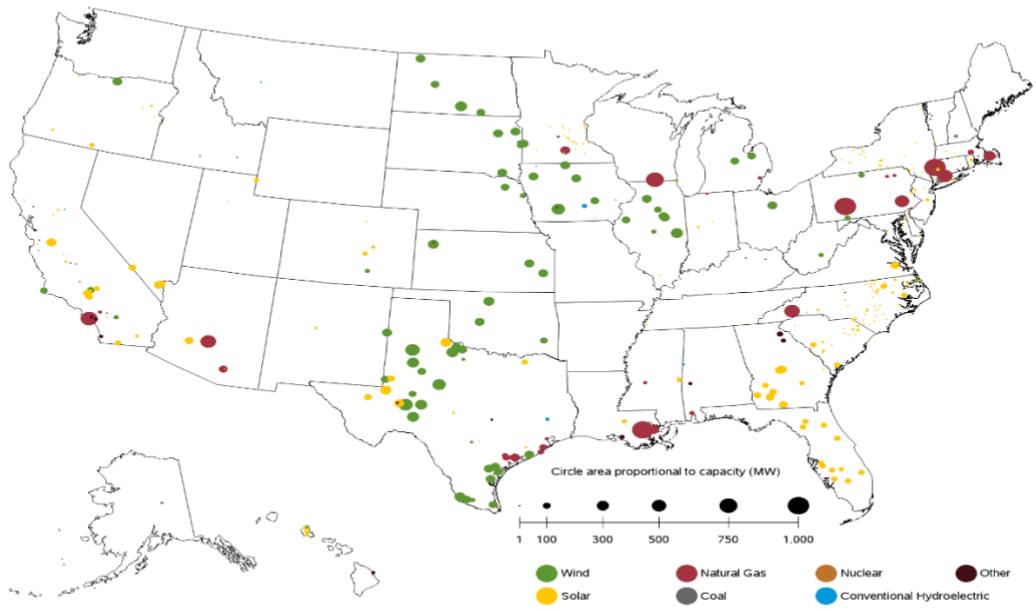


Source: U.S. DOE 2017 Wind Technologies Market Report

Compare proposed new national wind and solar project locations (Map 1) from the U.S. EIA, "Electric Power Monthly"[4] to the National Renewable Energy Laboratory (NREL), Wind Resource Map[5] (Map 2) and see how new projects have been primarily placed in high resource areas by investors adding capacity beyond state mandated levels. That could change soon. State regulatory programs, and regulated utility choices may encourage building wind and solar projects in state. For example Consumers Energy and DTE Energy in Michigan have voluntarily proposed early closure of coal-fired power plants to be replaced by wind and solar generation in-state. The best wind resource sites left in Michigan are only rated as fair, and the NREL Solar Resource Map[6] (Map 3) shows Michigan as one of the poorest solar resource states in the country. Construction costs vary by region. Currently most wind projects are being built in the highest wind speed, lowest cost regions, but requirements for in-state construction could raise average costs almost 50 percent (Table 1). The best turbine locations also have the advantage of double the average wind speed yielding four times the power delivery.

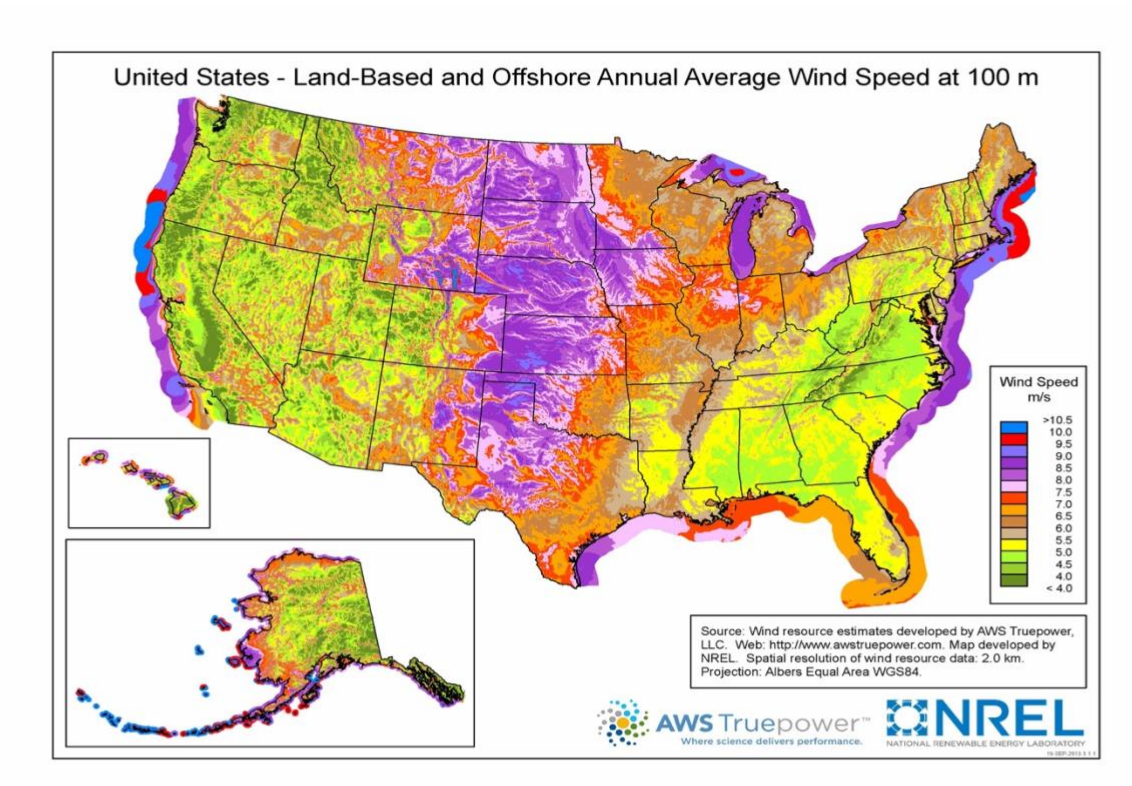
Map 1: New Wind (green dots) & Solar Generation (yellow dots) projects for 2019-20

Figure 6.1.C. Utility-Scale Generating Units Planned to Come Online from April 2019 to March 2020



Sources: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report' and Form EIA-860M, 'Monthly Update to the Annual Electric Generator Report.'

Map 2: Wind Resource Map



Map 3: Solar Resource Map

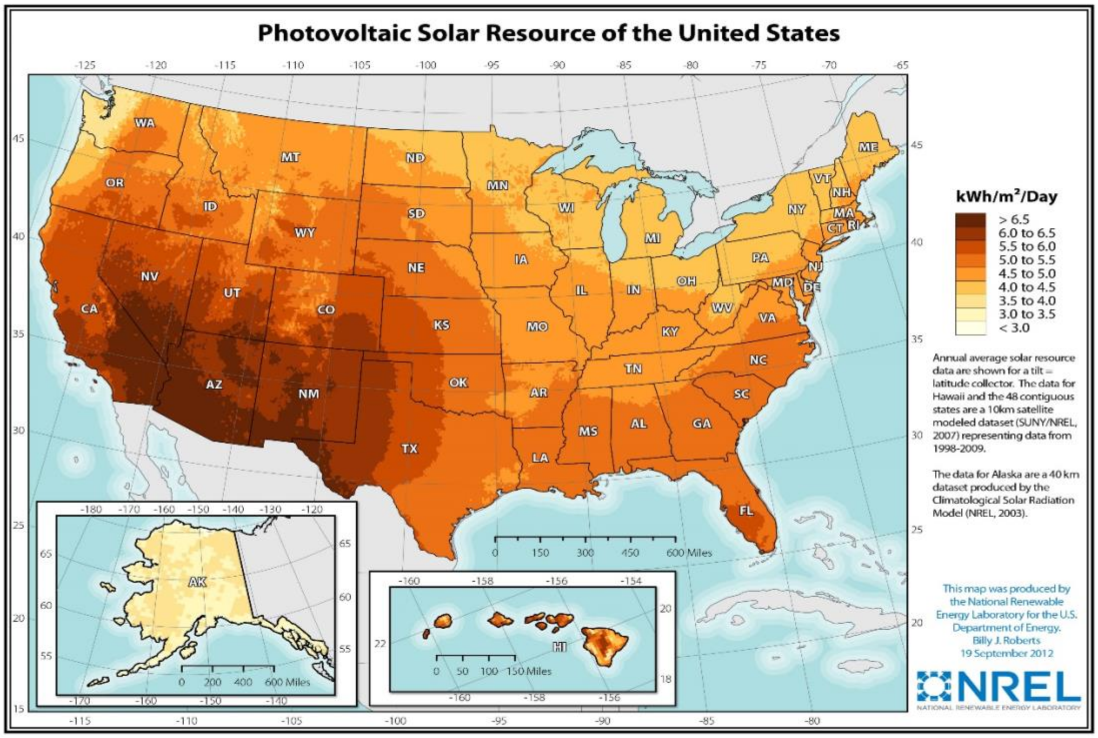


Table 1: Wind Farm Construction Cost by Region 2016-2017, $2017

Location	$/KW
Interior	$1,552
Great Lakes	$1,776
Southeast	$1,882
West	$2,157
Northeast	$2,272
Total	$1,610

Source: U. S. Department of Energy, “2017 Wind Technologies Market Report”[2]

Utility scale wind power projects are facing a number of obstacles. The extreme cases are in European countries that have been leaders in such projects, but resistance is also growing in the US. Concerns revolve around bird and bat fatalities, noise, health, and visual blight. For more details see Robert Bryce’s article in Real Clear Energy titled, “Big Wind’s Headwinds”[7].

Below is a list of specific examples of halted or delayed projects:

- Denmark has stopped all onshore projects because of a combination of health and visual concerns.
- German installations of new wind turbines fell 82 percent in the first half of 2019 from the same prior year period because of concerns about bird and bat fatalities, and noise. Wind power provides about 20 percent of electrical power in Germany.

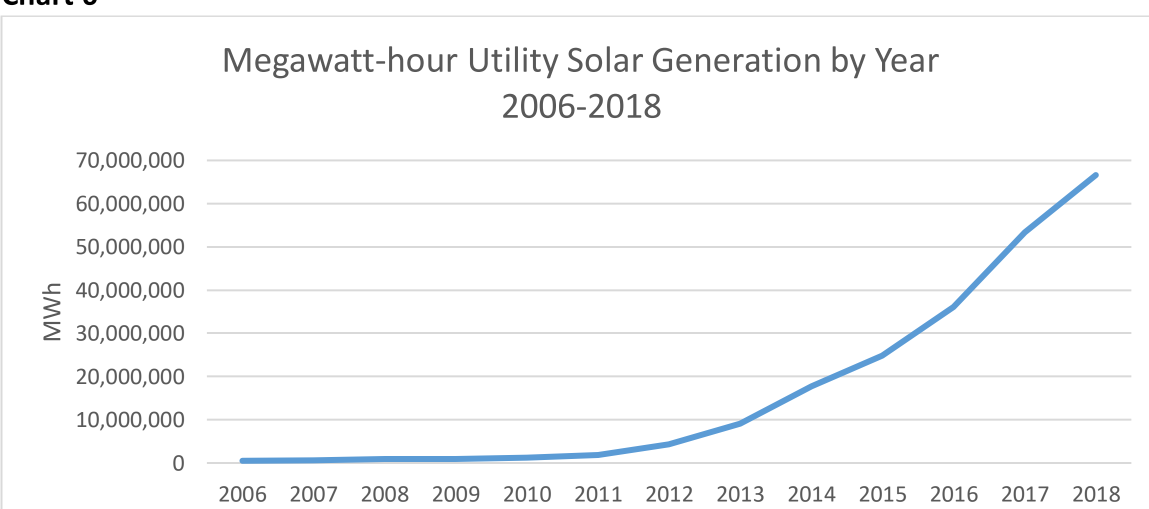
- A $2.8 billion project off Martha's Vineyard has been delayed because of concerns about bird and bat fatalities, marine life, and overall environmental impact.
- The Oregon Supreme Court has halted a large project because of potential bird and bat fatalities.
- The North Dakota Public Service Commission stopped a project because of concerns about Bald and Golden Eagle fatalities.
- New York State stopped a project because of concerns about Bald Eagles.
- In Indiana, Tippecanoe County commissioners voted to prohibit wind turbines taller than 140 feet, about half the typical tower height of new projects. The commissioners decided the wind projects were crowding out other economic developments by using too much land. A typical turbine is placed on an average of about 130 acres.

The Wildlife Society, "estimated 888,000 bat and 573,000 bird fatalities/year (including 83,000 raptor fatalities) at 51,630 megawatt (MW) of installed wind-energy capacity in the United States in 2012"[8]. Generation has roughly doubled since then.

Solar

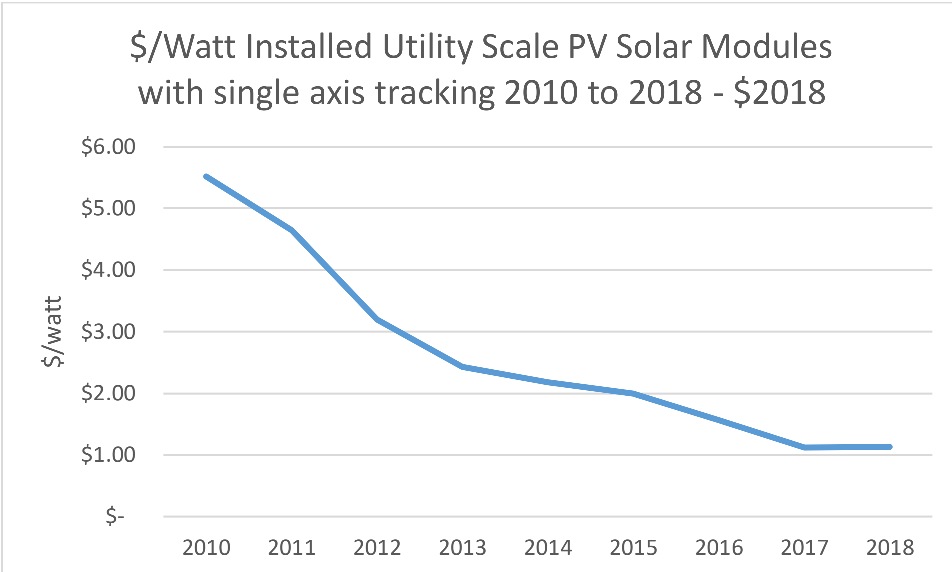
According to EIA "Annual Detailed State Data"[1], between 2006 and 2018 solar power generation has grown at a compounded rate of 50% a year (Chart 6). Rapid growth is tied to the falling cost of solar power (Chart 7), a 4.2 percent a year improvement in efficiency (Chart 8), and the availability of the federal Investment Tax Credit (ITC) that became law in 2005, according to the NREL "Solar Photovoltaic System Cost Q1 2018"[9]. 2018 solar generation only met 1.8 percent of total US demand including less than 0.1 percent met by distributed solar. Individual systems can vary in generation output by up to 9 percent a year, but by spreading systems across the country national annual generation output is dampened to about half that amount.

Chart 6



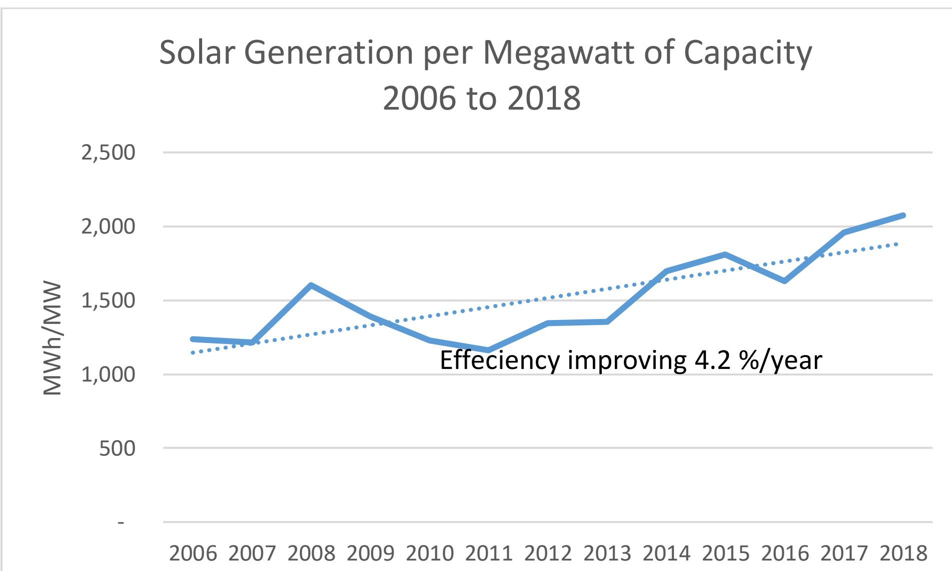
Source: U.S. EIA Annual Detailed State Data[1]

Chart 7



Source: National Renewable Energy Laboratory, "Solar Photovoltaic System Cost Q1 2018"

Chart 8



Source: Author calculation from EIA Annual State Data

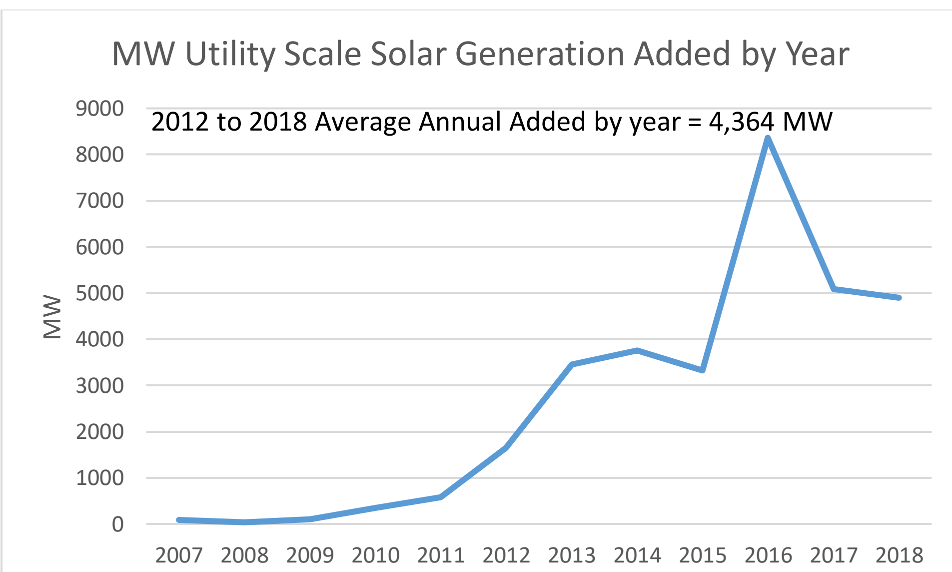
Capacity additions for both utility scale solar, and distributed solar took off in 2010 (Chart 9 and 10). Based on the EIA "Electric Power Monthly" for February, 2019[10], there was 4,900 MW of utility scale capacity added in 2018. The Solar Energy Industry Association is projecting about 9,000 MW a year of utility scale solar will be added over the next few years as the ITC winds down in its "Solar Market Insight Report 2018 Year in Review"[11], and expects 4,000 to 5,000 MW may be added each year beginning in 2021.

Installed cost reductions were a precondition to make solar power competitive with conventional power plants. National and local governments around the world began offering subsidies in the mid aughts to offset the high cost of solar compared to other generation sources. The most important change, however, was the investment by Chinese companies in large scale manufacturing facilities. The price of solar photovoltaic (PV) modules began to fall quickly starting in 2008, and other installation components followed suit, and the PV market took off (Chart 11). In inflation adjusted dollars, module prices fell from $4/watt to $0.33 in 2018, or 92 percent.

Further cost reductions will have minimal impact on additional levels of installation. By 2018 the 30 percent U.S. ITC was only worth the equivalent of $0.10/watt on module cost, or about a 3 percent module cost reduction compared to the benefit in 2007. The ITC will begin falling from its current level of 30 percent of the system cost to 26 percent in 2020, 22 percent in 2021, and 10 percent in 2022 and thereafter for commercial projects, and to zero for residential projects. The ITC will have a minimal impact on PV sales after 2021.

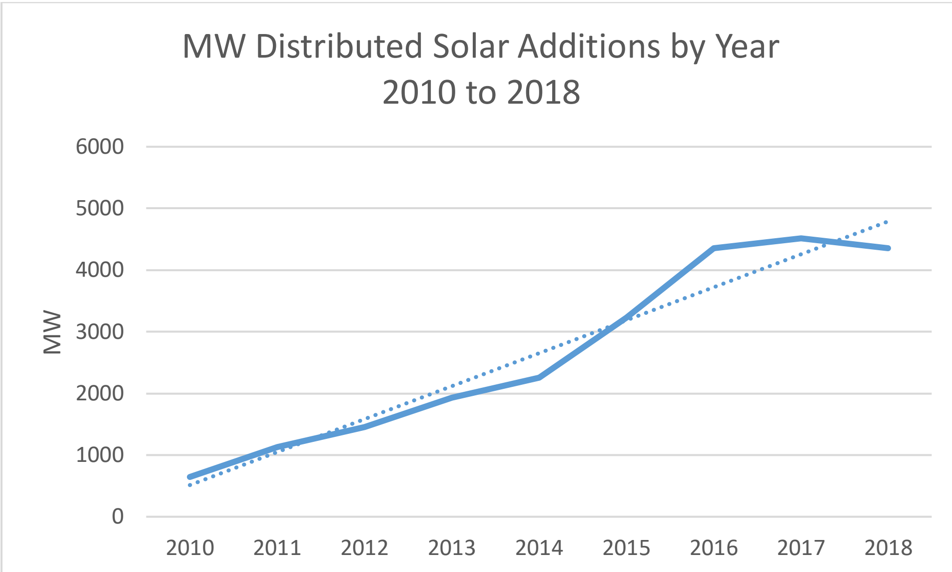
System efficiency has improved about 65 percent since 2007 with about half of the improvement coming from the addition of single axis tracking, and about half from improved panel efficiency in converting sunlight to power. There may be some additional improvements in efficiency, however, so far efficiency improvements have come with a commensurate higher price. The most commonly used panels, now forty year old technology, convert only about 16 to 17 percent of solar energy to electricity. Further significant cost reductions will require the invention of solar panels that can convert significantly more sunlight to power.

Chart 9



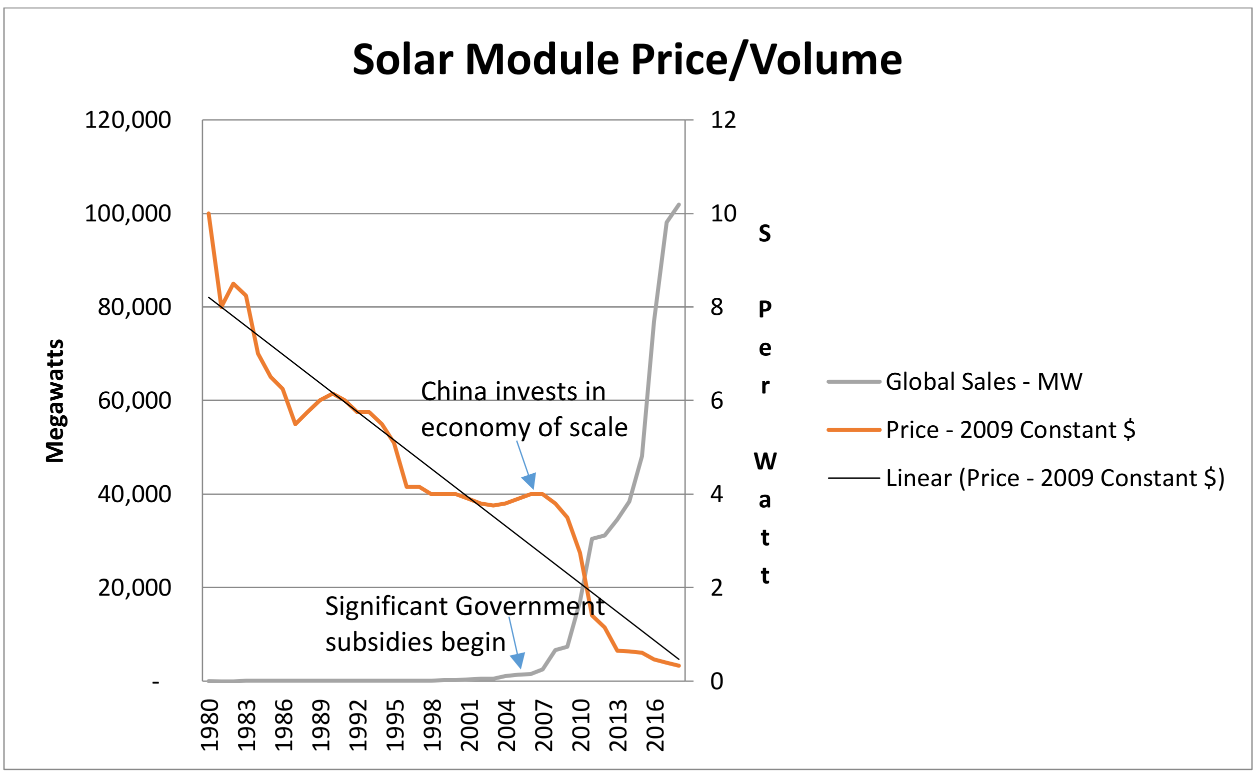
Source: Author calculation from EIA Annual Detailed State Data

Chart 10



Source: National Renewable Energy Laboratory, Solar Photovoltaic System Cost Q1 2018

Chart 11



Source: Various[12]

Offshore Wind

Offshore wind capacity is expected to grow significantly over the next decade according to the U.S. Department of Energy “2017 Offshore Wind Technologies Market Update”[13]. While only 30 MW is actually operational, another 3 GWs is moving through procurement stages, and another 31 GWs is planned in twelve states (see Table 2 below). The latest quote in the U.S. for the 800 MW Ocean Wind project off the coast of Atlantic City, NJ, was for about $135/MWh ($37/MWh in PJM wholesale price, plus $98/MWh in ORECs). In Europe, recent prices have run from $74 to $85/MWh using new floating base technology, an average capacity of 8 MW/turbine, and capacity factors of 39% to 43%. U.S. EIA estimates levelized cost[14] to average about $118/MWh, 2.75 times onshore wind. None of the cost estimates include transmission costs, or the cost for backing up intermittent power.

Table 2: Offshore Wind Targets by State

State	In Procurement or installed MW	Additional Planned MW
CA		765
CT	200	
HI		1,200
MA	800	9,532
MD	368	1,200
ME	12	
NC		3,735
NJ	1124	4,099
NY	90	8,910
OH	21	
RI	400	600
VA	12	1,371
Total	**3027**	**30,412**

Source: 2017 Offshore Wind Technologies Market Update

Expansion of state carbon taxes slowing

Efforts to join the RGGI carbon dioxide emission cap and trade program by governors in Virginia, Pennsylvania, and North Caroline have run into stiff legislative opposition. New Jersey has still not begun participating in RGGI auctions. The nine existing RGGI states have extended the program to 2030, raising the cost per ton estimates from about $6/ton in 2019 to possibly $11 to $24/ton in 2030. Proposals for economy wide carbon taxes have failed in progressive states such as Vermont, Washington, and Oregon, and have been overturned in Australia, France, and in some Canadian Provinces. Despite over two decades of efforts, the U.S Congress has failed to pass a national tax on carbon dioxide emissions.

State RPS mandates waning

We are seeing a last hurrah for expanding state RPS mandates to impractical levels in perhaps a dozen states. Some states have raised RPS mandates to forty to fifty percent of electric demand, and some to even one hundred percent. However, grid managers, such as the PJM Regional Transmission Organization, have reported an ability to incorporate only up to thirty percent intermittent wind and solar power without causing reliability issues[15]. New wind and solar capacity is really not needed to meet current electricity demand. For example, PJM has a 28.7 percent reserve capacity margin compared to only 16.1 percent required by the Federal Energy Regulatory Commission[16]. PJM has no authority to limit new wind and solar capacity additions, and simply modifies the grid, at whatever cost, to accommodate the additions.

The increase in distributed solar above five percent of flow on individual feeder lines will almost certainly overwhelm some distribution circuits, impacting the ability to control voltage. That can cause damage to customer and distribution system equipment, which can cause injury from stray current and from power feedback, and make it difficult to detect and isolate faults. Engineering solutions are possible but may be costly.

The EIA projects new wind and solar projects are competitive with new natural gas-fired power plant[17]. However, EIA does not include the costs of adding new transmission lines, load balancing costs to deal with intermittency, or the separate costs of energy credits needed to meet state RPS requirements. Also, the electricity costs from new wind and solar projects will be about 30 percent higher than from existing power plants ($46/MWh v. $35).

Large wind and solar utility scale projects are often far from existing transmission lines and sub-stations requiring significant infrastructure investment. That investment is not captured in the EIA cost estimates. Some examples are the $6 billion Texas invested in a transmission backbone from the panhandle that had good wind resources to population centers in Dallas, Houston, and Austin. Michigan spent almost $600 million on a transmission backbone to add more wind farms to the Saginaw Bay area only to have so much local resistance to more windfarms the transmission line hasn't been used. Energy credits are sold separately from power supply costs to meet RPS mandates, and add about another ten percent to direct costs.

There may likely be extra costs for inefficiencies caused by the frequent cycling of dispatchable power plants to fill in for the intermittency of wind and solar power. See the Manhattan Institute study, "The New Energy Economy an Exercise in Magical Thinking", for more information on these hidden costs[18], and the Center of the American Experiment study, "Doubling Down on Failure"[19], and a recent study from the University of Chicago, "Do Renewable Portfolio Standards Deliver"[20]. These studies show the typical reduction cost for a ton of carbon dioxide from wind and solar projects are about twenty times higher than the current average tax on carbon dioxide emissions from RGGI allowances auctions ($100 to $130/ton vs. $6/ton), and adding these effects double the estimated real costs of new wind and solar projects to about $90/MWh.

The RPS is a transfer of wealth from lower income families to higher income families who can afford to add solar and energy efficiency investments to their homes, and can take advantage of generous tax breaks and subsidies. In real life, only about 3% of electric customers voluntarily pay any premium for wind and solar power when given a choice according to an NREL study, "Voluntary Green Power Procurement"[21], but RPS mandates force everyone to pay for the subsidies. Interestingly, states with the highest mandates send most electric customer premiums for construction to out-of-state wind and solar projects, and have very low rates of in state generation. Six eastern states and the District of Columbia, who have recently significantly raised RPS mandates, only generate about four percent renewable electricity in state (Table 3). Western states with high RPS mandates, with better wind, solar, and geothermal resources, averaged about twenty percent in state generation (Table 4).

Table 3: Eastern States with high RPS mandates

Jurisdiction	RPS Mandate	% RPS Generation in-state
DC	50% by 2032	0.4 %
MA	35% by 2030	4.2 %
MD	50% by 2030	2.3 %
NJ	50% by 2030	2.6 %
RI	39% by 2035	2.9 %
CT	40% by 2030	2.3 %
NY	50% by 2030	4.6 %
Total		3.9 %

Source: Author calculation from EIA Annual Detailed State Data

Table 4: Western States with high RPS Mandates

Jurisdiction	RPS Mandate	% RPS Generation in-state
CA	60% by 2030	21.2 %
HI	100% by 2045	14.9 %
NM	59% by 2030	25.3 %
NV	50% by 2030	21.4 %
OR	50% by 2040	13.9%
CO	30% by 2030	19.0 %
Total		20.2 %

Source: Author calculation from EIA Annual Detailed State Data

Meanwhile, only 11% of national wind and solar sales were RPS driven in 2018 according to a recent Wood Mackenzie study[22]. Much of the rest of new capacity was built by investors taking advantage of tax breaks and subsidies, and utilities voluntarily exceeding RPS mandates. My recent review determined thirty-seven states and DC originally had either mandatory or voluntary RPS standards (spread sheet available upon request). Thirteen of those states have met their goals, five more will meet their goals by 2022, and another six by 2025. By 2026 only thirteen states and DC will still have an RPS. The total new generation requirements to meet the RPS by year is shown in Table 5. For reference the total generation increase for 2017 was

44.6 million MWh, and 34.8 million MWh in 2018, with new generation required by extended RPS requirements falling to about 18 million MWh by 2027. Eight of those thirteen states are already in the top thirteen highest electricity price states. The average price for the thirteen states is 14.3 cents/KWh compared to 9.1 cents for the balance of states, or 57 percent higher[23].

Table 5: Total new requirements to meet the RPS by year

Year	MWh in millions	# of States + DC
2020	30.1	24
2021	33.6	22
2022	23.2	18
2023	23.2	18
2024	23.2	18
2025	25.4	18
2026	20.4	13
2027	18.3	12
2028	18.3	12
2029	18.3	12
2030	18.3	12

Source: Author Calculation, note RPS generation increased 44.6 in 2017, and 34.8 in 2018

Extending and expanding RPS goals beyond about 25 percent is not only a major risk for reliability, but also a very expensive prospect. Wood Mackenzie is a leading natural resource market research and brokerage company, including a focus on the power and renewables industries. They have released a new report titled, "Deep decarbonization, the multi-trillion dollar question"[24]. They estimate the cost, and barriers of moving to an electric grid powered 100 percent by wind solar, hydro, and biomass, and conclude it would take an investment of $4.7 trillion, more than doubling electric rates, if completed over the next one to two decades. The estimate excludes supply chain impacts, and the cost of stranded existing generation assets. The report also does not answer the questions of how to deal with low to zero wholesale electricity market prices that occur when renewables obtain a 10 to 50 percent market share that makes it impossible for even wind and solar projects to make a profit. They call the goal aspirational, and expect massive disruption with far-flung economic and social repercussions with a possible public backlash.

The Wood Mackenzie estimates reflect a mostly reasonable first attempt at defining the costs. The largest single cost factor is construction of a battery backup system at $2.5 trillion, or over half the investment cost. While the calculated average battery cost of $150/KWh is reasonable, the assumption only 24 hours of countrywide backup potential is needed, is questionable. The study seems to favor a twenty year transition. Given that timeline, the study does not appear to account for the need to replace wind and solar capacity that will age out over the period including all existing capacity as the life expectancy of wind and solar projects is about twenty years. A more thorough analysis might see electric prices tripling instead of rising the 120% Wood Mackenzie now estimates. Either estimate is way above customer willingness to pay surveys.

Below is a summary of the study cut and pasted from the report:

> "Wood Mackenzie estimates full decarbonization of the US power grid at US$4.5 trillion, given the current state of technology – nearly as much as what the country has spent, since 2001, on the war on terror. From a budgetary perspective, the cost is staggering at US$35,000 per household – that equates to nearly US$2,000 per year if assuming a 20-year plan.
>
> For any country to embrace a nationwide transition to 100% renewable energy (RE100) or zero carbon (ZC100) emissions constitutes a massive disruption with far-flung economic and social repercussions. Nimbyism is inevitable and forecasted increases in consumer energy costs may result in public backlash against aggressive climate change policies.
>
> Wood Mackenzie concludes that RE100 goals remain largely aspirational, but attainable given a reasonable time horizon to allow for technology development, regulatory realignment and socio-economic reforms.
>
> Today, no large and complex power system (LCPS) in the world operates with an average annual penetration of greater than 30% wind and solar (W+S). RE100 policies for an LCPS represent uncharted territory. There is little to no historical precedence for dealing with the technological and commercial disruptions that would accompany the mass deployment of variable energy resources. Current evidence shows that an LCPS tends to reach a 25% W+S market penetration with relative ease, assuming fundamental natural resource and grid infrastructure prerequisites. Beyond that point, operational and cost complexities progressively multiply, in large part due to the intermittent nature of renewables. In Western Europe and North America currently averaging between 20% and 30% W+S market share on an annual basis. Hourly W+S generation shares, however, range from a minimum of 0% to as high as 101%.
>
> These issues are further compounded when fossil fuel generators are retired prematurely from the grid due to economic pressures from low-cost renewables. In the absence of energy storage, installed capacities of W+S must increase exponentially to provide sufficient reserve margins for an LCPS, dramatically increasing system costs and introducing massive generation inefficiencies. Prices approach nil at higher levels of renewables generation, negatively impacting the profitability of fossil fuel generators and renewable generators alike. (Wholesale prices fall below current average levels at just 10% generation penetration, and to zero at about 50%).

> Levelized cost of electricity (LCOE) is the per unit cost of building and operating a new generation asset. By contrast, the total price associated with transitioning to renewables is more akin to the impact on customer rates – assuming rate payers ultimately foot the bill. (Customer rates would rise 120% at 100% renewables). The current US power grid has about 1,060 GW of nameplate capacity, including roughly 130 GW of W+S capacity. Adoption of RE100 would involve massive investments that could lead to significant transition costs and customer rate impacts, despite the falling cost of renewables. Wood Mackenzie estimates that about 1,600 GW of new W+S capacity would be needed to produce enough energy to replace all fossil fuel generation in the US.
>
> Assuming the capital costs for W+S continue to fall, this represents a cost of roughly US$1.5 trillion. Next, approximately 900 GW of storage investments would be required to ensure clean energy from W+S resources are available and reliable exactly when consumers need it. Assuming 24 hours of duration (16.8 TWh), these storage assets more than double RE100 costs to US$4.0 trillion (adding US$2.5 trillion). Transmission is central to ensuring renewable energy can be delivered to customers in areas where W+S resources are limited or areas of high population density where W+S facilities cannot be located. Assuming 200,000 miles of new HVT at an average price of US$3.5 million/mile adds US$700 billion. In summary – excluding supply chain impacts and other items, such as stranded costs – an investment of US$4.5 trillion would be required to fully transition the US power grid to renewables over the next 10 to 20 years."

Wood Mackenzie concludes that "RE100 goals remain largely aspirational, but attainable given a reasonable time horizon to allow for technology development, regulatory realignment and socio-economic reforms. Further, adoption of ZC100 or even ZC80 goals increases the likelihood of success, incentivizing the development of next-generation nuclear and carbon capture technologies."

Duke Energy, North Carolina, has shown adding solar to the grid has almost doubled nitrogen oxide emissions as natural gas power plants cycle up and down to accommodate the solar generation[25]. Nitrogen oxide is a pollutant under Clean Air Act standards, but also is a precursor for ground level ozone which can cause premature deaths, and lung issues. In 2018, the emissions problems occurred with solar and wind generation only accounting for 5.4% of total electric generation.

Regulated utilities offloading risks to electric customers

Some regulated investor owned utilities apparently view their remaining coal-fired power plants as a liability for investors. A number of states deregulated the supply portion of electric bills in the early 2000's resulting in the sale of power plants from regulated utilities to independent generating companies. The selling price was attractive for the regulated utilities. Many politicians are calling for a national tax on carbon dioxide emissions, and some additional states are considering deregulation. It is unlikely a buyer could be found for a coal-fired power plant today.

Forced early closure of these plants, either from deregulation or high carbon dioxide taxes, would be borne by investors. In response, some utilities are trying to obtain utility commission permission to voluntarily close power plants early with the power supply replaced by massive amounts of new wind and solar projects. The cost of early closings would be shifted to electric customers using the "benefit" of new renewable power as an excuse. The cost estimates of the strategy are under estimated in the Integrated Resource Plan submissions by regulated utilities to utility commissions. My limited search turned up several examples of this strategy including Xcel Energy in Colorado, New Mexico, and Minnesota, and Consumers Energy and DTE energy in Michigan. It is likely more utilities will adopt similar strategies.

Utilities forcing customers to invest in electric vehicle charging

Stymied by slow growth in electric demand, investor owned regulated utilities are aligning themselves with the growth of plug in electric vehicles (EV). In many states, out dated rules allow only regulated utilities to sell electricity to retail customers. Utilities can corner the charging market by investing in public charging stations for EV owners. Rather than use investor funds, the utilities are applying to utility commissions for permission to install electric charging capacity at the expense of all utility customers, rather than only those customers owning EVs. Non-EV owning customers also absorb the very real risk chargers will be under-utilized. Existing public charging infrastructure in most states is only used about 1 to 20 percent of the time.

My published review of a utility docket in Delaware provides a window into the EV charging strategy[26]. Between seventy and eighty percent of charging occurs at home, leaving less volume for public chargers. So far, EVs only represent half a percent of the US light duty vehicle fleet leading to low utilization rates for public chargers. Utilities are supported by environmental groups unsatisfied with the rate of charger installations. I count twenty-six investor owned utility applications in sixteen states, and the District of Columbia either approved or underway since 2016, with $1.2 billion in investments approved (Table 5). While that is only about ten percent of all investor owned utilities, others are sure to follow.

Table 6: Approved Regulated Utility EV charging Infrastructure Programs

State	Date	Utility	$ million	# of chargers
CA	Feb-16	Southern California Edison / San Diego Gas & Electric	67	5,000
CA	2017	Pacific Gas & Electric	130	7,500
CA	May-18	PG&E, SoCal, SDG&E	760	61,734
MD	Jan-19	Baltimore Gas & Electric / Potomac Edison	9	3,250
MD	Jan-19	Delmarva Power & Light / Potomac Electric Power	11	1,600
OH	18-Apr	American Electric Power	10	375
DE	Apr-19	Delmarva Power & Light	0.6	4
MI	Jan-19	Consumers Energy	10	224

PA	Dec-18	Duquesne Light Company	1.5	2
GA	Mar-15	Georgia Power	12	50
AZ	Feb-19	Tuscon Electric Power	1.2	1,312
NV	Apr-18	NV Energy	15	
OR	Mar-18	Pacific Power	4.6	
OR	Mar-18	Portland General Electric	5.3	
NY	May-18	New York Power Authority	40	
MA	Jun-17	Eversource	45	4,072
MA	Jun-18	National Grid	24	1,280
DC	Sep-18	Potomac Electric Power	15	
			1161.2	
Proposed				
NJ		Public Service Electric & Gas	364	40,000
NJ		Atlantic City Electric	14.3	
OH		Dayton Power & Light	7	50
SC		Duke Energy Carolina	6.7	
SC		Duke Progress	3	
MN		Xcel Energy	23.6	
Total			418.6	

My research shows other utilities are using a similar play book. Initially, a “pilot” program is requested so the utility can “learn” the charging habits of EV owners. As if they can’t learn from leading edge states, such as California, or even sister utilities in other jurisdictions that already have approved pilot programs. The applications come with a Benefit/Cost Analysis using exaggerated environmental gains, and exaggerated EV market penetration potential. Additionally, estimated potential long term savings for all customers are exaggerated by the assumption grid infrastructure will be more effectively used when EVs are charged at off peak times. Cost estimates for non-EV residential customers are often stated as being below about $0.50/month when in reality they will be much higher. EVs are generally purchased by higher income families, so the poorer wind up subsidizing the richer.

The initial requests for utility commission approval are usually settled with approvals of a quarter to a third of what was requested. California demonstrates the rest of the trend. That state’s three regulated utilities were approved for almost $200 million dollars in charging investments starting in 2016, for 12,500 chargers. A second round of applications led to $760 million of approvals by the end of 2018 for almost 62,000 chargers. I expect other utilities to follow this example.

Alternative low CO_2 Emission technologies

New York and Ohio, are providing subsidies to keep existing nuclear plants open, and Illinois may join them. New small modular reactors with designs similar to power plants used on submarines, and aircraft carriers are being approved by the Nuclear Regulatory Commission, and a small number may be installed by 2022-2024 according to discussions with the U.S. Department of Energy. Sizes might range from 25 MW to 150 MW with cost as low as $67/MWh, higher than new natural gas-fired plants but less than new wind and solar generation when transmission, and back up costs are included. Public acceptance is still an unknown.

A 50 MW natural gas–fired generating plant has just been completed by Net Power in La Porte, TX, to demonstrate the Allam cycle, invented by Rodney Allam[27]. Supercritical CO_2 is the working fluid allowing natural gas, or coal gas, combustion in pure oxygen. The bulk of the CO_2 is reused in the process with the rest concentrated and ready for use or sequestration. Very little water is used, and there are no air pollutants emitted. The process potentially produces power at a lower cost than conventional natural gas power plants. A 300 MW plant is planned for 2020. The foot print is smaller than conventional power plants.

Conclusion

The center of gravity of energy policy is moving away from federal policies to state government mandated green energy policies, such as carbon dioxide emission cap & trade programs, and Renewable Portfolio Standards (RPS). Regulated utilities, with public utility commission approval, are using green energy policies as cover to offload potential investor liabilities for aging coal-fired power plants, and to enter the electric vehicle charging market by having their customers finance early power plant closings, and public EV charging infrastructure. The bottom line is these trends in state mandates, and regulated utility strategies are resulting in higher electricity prices, a less reliable electric grid, potentially more air pollution, and a falling economy leading to fewer, and lower paying jobs. Popular resistance to these trends is growing. Meanwhile, the feasibility of competitive, base load, alternative zero emission technologies will be proven in the next few years. It makes sense to slow the rush into adding more expensive, intermittent wind and solar power.

Notes

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