IER INSTITUTE FOR ENERGY RESEARCH

POLICY BRIEF

The 100 Percent Renewable Energy Myth

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Advocates for wind and solar energy are trying to convince Americans that the economy can thrive on 100 percent renewable energy. However, wind and solar energy are intermittent sources that currently need back up power from reliable energy sources like coal, nuclear, and natural gas to keep the lights on, keep our homes heated, and keep our factories running. The truth is, the physics of wind and solar energy render 100 percent renewable energy nothing more than a myth. These technologies can only operate if the sun shines or the wind blows, requiring large amounts of storage for back up. Additionally, their land area requirements are immense, they have much lower capacity factors compared to traditional sources, and the cost of transition would be enormous. Bottom line: setting a national goal of relying upon 100 percent renewable energy within a decade would lead to catastrophe.

Intermittency

Wind and solar power's intermittency means they are not available 24/7. In fact, the Germans have a term lamenting wind and solar's intermittency, "Dunkelflaute" (dark doldrums). Because we require power around the clock, there must be a back-up system at all times that is either battery-based, which is extremely costly and unproven on a large scale, or provided by traditional generating units, which would also be expensive since those technologies would not be operating to their maximum potential, having to spread costs over a lower amount of electricity production than they are capable of producing.

Land Requirements

Both wind and solar require significant amounts of land. Based on Harvard engineering data published in the Environmental Impact Letters, for the U.S. to reach 100 percent of its electricity through solar and wind power projects, it could require one-third of the country[1] to be covered by solar and wind facilities.

The Suncyclopedia estimates two and a half acres are required per one megawatt of solar panels and four acres if the outbuildings associated with industrial solar power projects are included in the estimate.[2] That estimate is dependent upon whether the solar arrays have trackers that move with the sun. If they do not, the estimate increases to six acres per one megawatt.

For wind turbines, the land required per megawatt of power produced varies based on their optimal position to capture the winds in the terrain that they are to occupy. Besides topography, setback regulations, which regulate the amount of distance that an industrial wind turbine must be placed away

[1] Deever, D. A. (21 December 2018). Nevada May Be Too Small to Produce 50 percent of its Own Renewable Energy as Mandated by Question 6. *Nevada Capital News*. https://nevadacapitalnews.org/2018/12/21/nevada-may-be-too-small-to-produce-50-of-its-own-renewable-energy-as-mandated-by-question-6/

[2] Suncyclopedia. http://www.suncyclopedia.com/en/area-required-for-solar-pv-power-plants/. Accessed (7 February 2019)

from homes so that noise pollution remains within legal limits, also affect the land area needed. Setback regulations vary from state to state from twice the height of a turbine to two kilometers. Setbacks for ports and military-controlled lands are typically larger. Some researchers, however, find that on average, wind turbines should be spaced two-thirds of a mile from each other for optimal efficiency and others find that one to three acres are needed per turbine.

In *The Footprint of Energy: Land Use of U.S. Electricity Production*, Strata Policy found that wind power requires 70.64 acres per megawatt and solar power requires 43.50 acres per megawatt. In contrast, natural gas-fired power plants require 12.41 acres per megawatt. This means, solar power requires more than three and a half times more land per megawatt and wind requires more than five and a half times the amount of land per megawatt.[3]

Capacity Factors

Winds do not blow at optimal speeds 24/7, 365 days of the year. At certain times, wind turbines may not produce electricity even when winds do blow. The speed at which most wind turbine blades start turning, known as the cut-in speed, typically ranges between seven to ten miles per hour.[4] Most turbines can produce their maximum rated power around 30 miles per hour, but that design speed is contingent upon the blades being new, clean, and without nicks or fractures from bird or bat impacts. When wind speeds are too high, turbine blades can lock into a stationary position to avoid damage—a condition that can occur between 35 and 55 miles per hour, known in the industry as the cut-out speed. According to the Energy Information Administration, wind turbines in the United States perform at 34.6 percent of their nameplate rating or the intended full-load output capacity.[5]

Similarly, solar units in the U.S. perform at 25.7 percent[6] of their nameplate rating. This is in contrast to natural gas and coal units that can perform at 85 percent[7] or more of their nameplate ratings and nuclear units that can perform at over 90 percent[8] of their nameplate rating.

Renewable Subsidies

Despite the declining cost of wind and solar technologies, they depend on government subsidies and are not feasible without them. As Warren Buffet stated, "…we get a tax credit if we build a lot of wind farms. That's the only reason to build them. They don't make sense without the tax credit."[9] The subsidies are paid by either electricity users or taxpayers or, many times, both. In the United States, the federal government subsidizes wind with the production tax credit and solar power with the investment tax credit. U.S. states subsidize solar and wind power with mandates for their production, forcing utilities to invest in them or purchase their power, regardless of the cost or impact on grid stability. In Germany, ratepayers

[3] Stevens, L., Strata Policy. (June 2017) The Footprint of Energy: Land Use of U.S. Electricity Production. https://www.strata.org/pdf/2017/footprints-full.pdf

[4] Deever, D. A. (2018, December 21). Nevada May Be Too Small to Produce 50 percent of its Own Renewable Energy as Mandated by Question 6. *Nevada Capital News*. https://nevadacapitalnews.org/2018/12/21/nevada-may-be-too-small-to-produce-50-of-its-own-renewable-energy-as-mandated-by-question-6/

[5] U.S. Energy Information Administration . Electric Power Monthly. https://www.eia.gov/electricity/monthly/epm_table_grapher.php

[6] Ibid.

[7] U.S. Energy Information Administration. (March 2018) Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2018 https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

[8] U.S. Energy Information Administration. Electric Power Monthly. https://www.eia.gov/electricity/monthly/epm_table_grapher.php

[9] The Wall Street Journal. https://www.wsj.com/articles/the-real-buffett-rule-1399244204

subsidize the renewable industry, which has resulted in residential electricity prices three times those in the U.S.

Furthermore, the subsidies for intermittent wind and solar discourage other innovation because they lead to low wholesale prices for innovators to compete against. In essence, the subsidies force intermittent power into the system regardless of need. Doing so drives down the efficiency and economics of the other sources of electricity, which consumers are required to pay for anyway in order to ensure the system does not break down and fail to deliver electricity to homes and businesses.

Electricity Prices

Germany and Denmark have been world leaders in wind and solar investment. From 2006 to 2016, prices of electricity in Germany increased 51 percent[10] and since 1995, electricity prices in Denmark have doubled as a result of wind and solar installation.

In the United States, electricity prices increased 7 percent from 2009 to 2017,[11] while electricity from solar and wind increased from two to eight percent of generation.[12] In 2017, California generated 23 percent of its electricity from wind and solar sources and its residential electricity rates were 18.24 cents per kilowatt-hour, [13] at least 40 percent higher than any other western U.S. state. Other states that have increased their use of solar and wind generation have also seen large increases in their electricity prices.

The U.S. Energy Information Administration reports:[14]

- North Dakota's electricity prices increased 40 percent while electricity from solar and wind increased from nine to 27 percent.
- South Dakota's electricity prices increased 34 percent while electricity from solar and wind increased from five to 30 percent.
- Kansas's electricity prices increased 33 percent while electricity from solar and wind increased from six to 36 percent.
- Iowa's electricity prices increased 21 percent while electricity from solar and wind increased from 14 to 37 percent.
- Oklahoma's electricity prices increased 18 percent while electricity from solar and wind increased from four to 32 percent.
- Hawaii's electricity prices increased 23 percent while electricity from solar and wind increased from three to 18 percent.
- California's electricity prices increased 22 percent while electricity from solar and wind increased from three to 23 percent.

A UK analysis of 3,000 onshore wind turbines found that they generate electricity efficiently for only 12-15 years—generating more than twice as much electricity in their first year than when they are 15 years old.[15] Even when faced with the data, the wind industry and the government base their calculations on turbines having a lifespan of 30 years. Therefore, the cost of wind is being underestimated, particularly when their costs are compared to other technologies.

[10] Deever, D. A. (2018, December 21). Nevada May Be Too Small to Produce 50 percent of its Own Renewable Energy as Mandated by Question 6. *Nevada Capital News*. https://nevadacapitalnews.org/2018/12/21/nevada-may-be-too-small-to-produce-50-of-its-own-renewable-energy-as-mandated-by-question-6/
[11] U.S. Energy Information Administration. https://www.eia.gov/totalenergy/data/monthly/pdf/sec9_11.pdf
[12] U.S. Energy Information Administration. https://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf
[13] U.S. Energy Information Administration. https://www.eia.gov/electricity/monthly/archive/february2018.pdf
[14] Ibid.
[15] Mendick, R. (30 December 2012). The Telegraph. https://www.telegraph.co.uk/news/earth/energy/windpower/9770837/Wind-farm-turbines-wear-sooner-than-expected-says-study.html

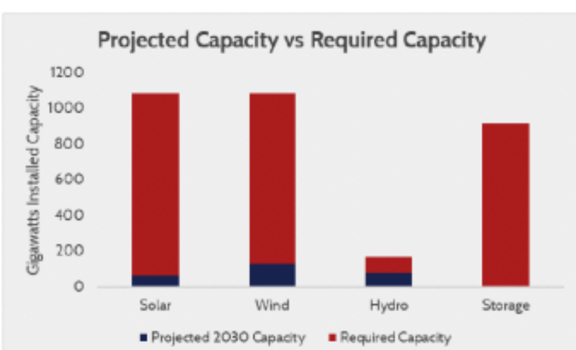
Cost to Transition to 100-Percent Renewables

According to an analysis by the American Action Forum, the proposal to transition 100 percent of U.S. electricity production to renewable sources by 2030 would require at least $5.7 trillion of investment in renewable energy and storage.[16] This is a ballpark estimate and not an in-depth projection, and may not include all the contingencies necessary to make the system work. The group also notes that it is likely to be a significant underestimation, as it reflects the lowest possible cost.

Assumptions of the analysis include:

- the United States would use solar power during the day, and wind power during the night;
- for the hours in the day where neither solar nor wind produce their stated capacity (due to capacity factors of these electricity sources), a mixture of hydroelectricity and storage is used;
- the U.S. builds the entirety of all potential hydroelectricity resources[17] (something which would be extremely controversial with environmentalists and time consuming well beyond 2030);
- storage costs associated with batteries is their average operation and maintenance cost, rather than the significantly higher costs of batteries that can discharge a lot of electricity quickly and repeatedly throughout the day;
- electricity demand is roughly flat (rather than demand spiking during afternoon hours); and,
- there is no increase in the price of wind, solar, hydroelectricity, or storage, despite the fact that demand for all of these sources would skyrocket due to such policy.

The current electricity generating capacity of the United States is 1,085 gigawatts, which provides enough capacity to satisfy peak electricity demands, plus reserve capacity, which acts as a safety net in the event of supply disruptions, equipment failures, or other issues that prevent generation from meeting demand. To maintain an available capacity of 1,085 gigawatts, the United States would need to have well over 1,085 gigawatts of solar, wind, hydroelectricity, and storage because of the low capacity factors for solar (25.7 percent) and wind (34.6 percent), noted previously.



The table below shows the costs assuming the Energy Information Administration's overnight capital costs and operation and maintenance costs from the 2018 Annual Energy Outlook.

All costs millions USD	Required New Capacity (GW)	Capital Expenditures	Annual O&M	Annual Costs (20-year recovery)
Solar	1022	$1,891,500	$23,892	$118,467
Wind	954	$1,579,966	$51,505	$130,503
Hydro	91	$262,765	$7,666	$20,805
Storage	912	$1,978,498	$55,225	$154,150
Total		**$5,712,729**	**$138,288**	**$423,925**

Source: American Action Forum

[16] Rossetti, P. (25 January 2019). American Action Forum. What it Costs to Go 100 Percent Renewable. https://www.americanactionforum.org/research/what-it-costs-go-100-percent-renewable/

[17] Oak Ridge National Laboratory, U.S. Department of Energy. HydroSource. https://hydrosource.ornl.gov/hydropower-potential

Construction Materials
Manufacturing wind turbines is a resource-intensive process. A typical wind turbine contains more than 8,000 different components, many of which are made from steel, cast iron, and concrete. One component is magnets made from neodymium and dysprosium—rare earth metals mined almost exclusively in China, which controls most of the world's supply. Thin-film solar panels use rare earth metals like indium and tellurium.

Converting the world's largest economy to renewable energy would vastly increase demand overnight for these materials. It would also shift the United States' self-reliance on electricity generation to a reliance on Chinese and other suppliers, unless countless new mines were started in the U.S. to develop the copper for electric motor windings and the strategic and critical rare earth metals that are essential to these technologies. The United States would be much more dependent on China for these materials than the United States was ever dependent on the Middle East for oil before the horizontal drilling and hydraulic fracturing revolution came along.

Without the use of fossil fuels, the wind and solar industries would also need to obtain substitutes for the cement and steel needed for producing and installing the turbines and solar panels. Further, it is not clear whether enough rare earth metals are available to build all the required units, particularly in the time frame of the Green New Deal.

Conclusion
Intermittent wind and solar cannot stand on their own. They must have some form of back-up power, from reliable coal, natural gas, nuclear units, storage capability from hydroelectric facilities, and/or batteries. Batteries of the size and scope needed for 100-percent renewables are unproven and not cost effective. Even if a 100 percent renewable future were feasible, the land requirements and costs of transitioning would be enormous and would require subsidies to ease the electricity price increases that would result. Germany's experience of phasing out its nuclear plants in favor of wind and solar projects should be taken as a warning against the ludicrousness of this undertaking.

Electricity is not something with which to trifle. We take it for granted in the world's richest and most advanced economy that things will work when we want them to work, but a 100 percent renewable plan would put that in jeopardy. The various pronouncements that glibly peddle reliance on wind and solar energy should be met with demands for verifiable, in-depth analysis of how to do it. No such analysis has yet been delivered.

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