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## Renewable Energy Debate

### Can alternative sources replace fossil fuels?

By Matt Mossman



Michael Brochstein/SOPA Images/LightRocket via Getty Images

Demonstrators march outside the Brooklyn office of U.S. Rep. Hakeem Jeffries, D-N.Y., to urge him to support the Green New Deal pushed by liberal Democrats in Congress. The proposal in part calls for increasing the country's reliance on renewable energy, with the goal of reducing net greenhouse gas emissions to zero within 10 years.

Babcock Ranch, a planned community in Florida, is just a few years old and still growing. But when it comes to renewable energy, the town is thinking big.<sup>1</sup>

Located about 15 miles northeast of Fort Myers, Babcock Ranch bills itself as the country's first community powered completely by the sun. Most of its electricity comes from an array of 343,000 solar panels operated by Florida Power & Light. Five solar "trees" scattered around the town's center supply additional power and serve as charging stations for mobile devices, and solar panels are installed atop commercial buildings.

Babcock Ranch also boasts one of the largest battery systems in the country for storing solar power. The town taps that stored electricity at night, on cloudy days and when demand is particularly high. Once its energy needs have been met, the community shares any extra power with homes outside Babcock Ranch.<sup>2</sup>

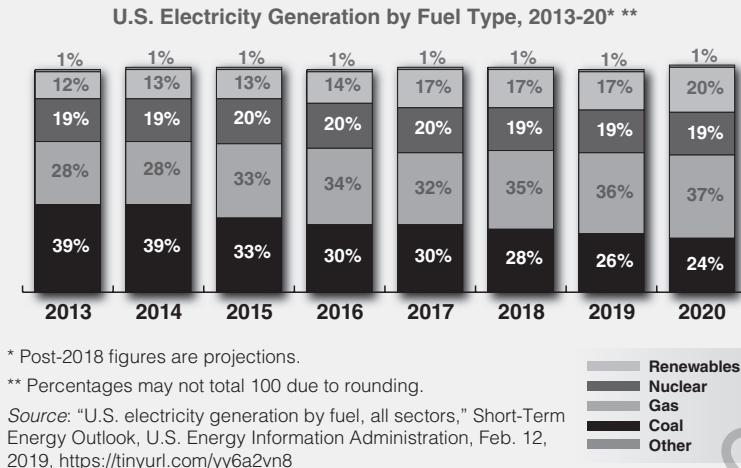
"Solar power comes to us first, and the excess goes into the grid," said Syd Kitson, a former pro football player whose real estate company, Kitson & Partners, created Babcock Ranch. "I can't see how that's not a huge win for everybody."<sup>3</sup>

Babcock Ranch is not the only U.S. community staking its future on renewable energy. At least six others—Aspen, Colo., Burlington, Vt., Georgetown, Texas, Greensburg, Kan., Kodiak Island, Alaska,

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### Electricity Increasingly Generated by Renewables

Renewable energy sources are expected to generate 20 percent of the nation's electrical power by 2020, up from 12 percent in 2013. Meanwhile, coal continues to shrink as a fuel for generating electricity.



and Rock Port, Mo.—rely completely on renewable sources for electricity.<sup>4</sup>

"The last decade has seen solar power sweep across the country," Environment America, a federation of state-based environmental advocacy groups based in Denver, said in a report last year. "Tens of thousands of wind turbines have popped up on the plains, mountains and coasts of the United States . . . It is now possible to envision an energy future for America [that] relies almost entirely on clean, renewable sources."<sup>5</sup>

Globally, many climate experts say a rapid transition to renewable energy is crucial to prevent a rise in global temperatures and more-frequent extreme weather events, including increasingly severe droughts and storms.

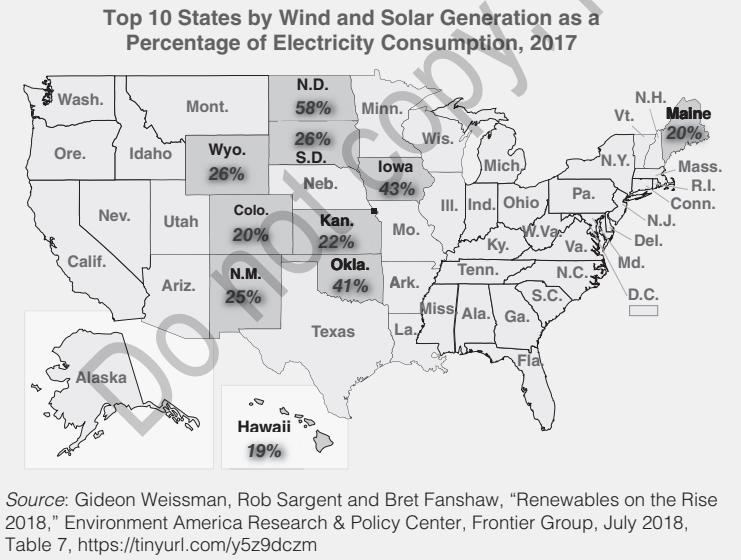
But some experts say the United States and other nations will continue to depend on fossil fuels for years to come, largely because wind and solar power are unpredictable and power grids are not designed to accommodate renewable energy sources.

"While intermittent renewables like wind and solar can make good supplements, they cannot provide for the energy needs of modern society alone," wrote Ryan Yonk, research director at Utah State University's Institute of Political Economy, and Arthur Wardle, a research fellow at the Center for Growth and Opportunity at Utah State.<sup>6</sup>

Renewable energy comes not only from sunlight and wind but also from tidal and wave action (hydrokinetic power); water flowing in rivers and through dams (hydroelectric power); heat tapped deep underground (geothermal power); and combustion of

### Midwest Leads in Solar and Wind Power

Midwestern states lead the nation in the share of electricity generated by wind and solar power, with North Dakota and Iowa topping the list.



wood, crop material or other biomass, or fuels made from biomass, such as ethanol.

Led by wind and solar power, the country's renewable energy capacity doubled between 2008 and 2017, according to Bloomberg New Energy Finance, a research firm in New York City, and the Business Council for Sustainable Energy, a coalition of renewable energy companies and associations in Washington.

Renewable sources now provide almost 18 percent of the country's power, up from 9 percent in 2008, the two groups said. They noted that renewable energy is becoming increasingly competitive on price with coal, natural gas and other conventional energy sources.<sup>7</sup>

The renewable energy industry, however, still faces major hurdles as it works to claim a larger share of the country's power supply.

Unlike decades-old fossil fuel plants located close to the areas they serve, wind and solar farms are scattered across large, often remote, areas. Linking wind and solar installations to cities often requires building long, expensive transmission lines, and the installations themselves typically require a higher initial investment than plants using fossil fuel.

"Both the financing and the siting can be significant barriers for developers and customers, even when they're eager for more renewables," according to the Union of Concerned Scientists, a science advocacy group in Cambridge, Mass., that supports increased use of renewable energy.<sup>8</sup>

Scientists also note that renewable energy sources have their own environmental impacts. Manufacturing solar panels, for example, produce highly toxic gases and substances that must be collected and contained, and wind turbines kill hundreds of thousands of birds and mosquito-eating bats each year.<sup>9</sup>

Such findings underscore that although most forms of renewable energy are inexhaustible, they are not always clean. Burning wood, for example, emits carbon dioxide, and some types of geothermal plants emit hydrogen sulfide, carbon dioxide, ammonia and other toxic gases. Developers of wind and solar farms also must deal with critics who call the projects eyesores.<sup>10</sup>

Renewable energy advocates face political and policy headwinds as well. Federal tax credits that have helped

drive the rapid expansion of residential and commercial wind and solar installations are being phased out over the next several years. To help coal and other fossil fuel producers, President Trump has rolled back Obama-era environmental protections, saying he wants to preserve jobs in those industries.

The proposed fiscal 2020 budget that the White House released on March 11, 2019, would cut renewable energy programs at the Energy Department by 70 percent, from \$2.3 billion to about \$700 million. But the proposal stands little chance of winning approval in Congress, which has rebuffed Trump's previous requests to drastically cut renewable energy programs.<sup>11</sup>

In January 2018, Trump imposed a 30 percent tariff on imported solar panels, dealing a major blow to the \$28 billion U.S. solar power industry. Energy experts say the tariff will make solar power more expensive and will do little to benefit domestic companies because most U.S. solar workers are involved in installing and maintaining solar panels, not manufacturing them.<sup>12</sup>

In addition, some experts say the nation's electrical grid cannot yet accommodate wind and solar farms because the power they produce fluctuates according to weather conditions. When weather conditions are optimal—with strong wind or blazing sunshine—renewables can supply so much power that conventional grids cannot handle it.

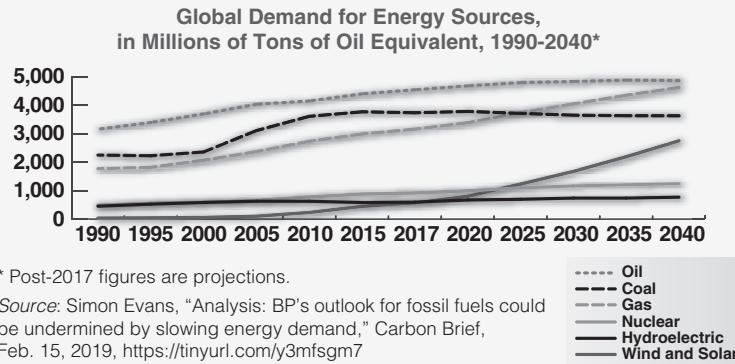
"You can't spontaneously increase wind or sunshine," said Robert Blohm, who serves on the operating and standards committees of the North American Electric Reliability Corp., an industry trade group based in Atlanta.<sup>13</sup>

Renewable energy advocates counter that recent developments prove the renewable energy industry is rapidly overcoming the obstacles cited by Blohm and other skeptics:

- The costs of building and operating solar and wind installations have plunged 88 percent and 69 percent, respectively, since 2009, according to an analysis by New York investment firm Lazard. In several regions of the country, renewable energy facilities are cheaper to build than coal and natural gas plants.<sup>14</sup> "The [cost] fight is over and renewables won," says Recep Kendircioglu, who invests in renewable energy for funds managed by John

### Wind, Solar Demand to Soar Worldwide

Global demand for wind and solar power is expected to surge over the next two decades, while use of coal is forecast to decline. Demand for oil likely will begin to plateau around 2030.



Hancock Financial Services in Boston. "Breakthroughs in technology and mass production made them cheap."

- Corporations across the country, including Facebook, Google and Walmart, are investing heavily in renewable energy. Utility companies are making similar commitments. Xcel Energy in Minneapolis, which supplies electricity to millions of people in eight Western and Midwestern states, for example, said it would deliver only carbon-free power by 2050.<sup>15</sup>

- Advances in battery technology are rapidly making it easier to balance fluctuating wind and solar energy on electrical grids, and the cost of those batteries is falling quickly. "Batteries are the optimal means of balancing renewables-dominant grids because they can inject power into grids rapidly and in the precise amounts needed," said John Campion, CEO of APR Energy, a company in Jacksonville, Fla., that helps governments and industries solve energy problems.<sup>16</sup>

- Most additions to the nation's energy capacity this year will come from renewable sources, according to federal energy officials.<sup>17</sup>

- State and local governments are accelerating their efforts to generate power using renewable sources. As of December, the mayors of more than 200 U.S. cities and towns had committed to switching to 100 percent renewable energy by 2035. In September 2018, then-California Gov. Jerry Brown signed legislation that speeds up the

state's timetable—to 2045—for eliminating greenhouse gas emissions in the state, largely through the use of renewable energy. Hawaii is pursuing a goal of using only renewable energy sources for electricity by the same date.<sup>18</sup>

"States continued to act as a counterweight to federal policy, raising clean-energy goals at the same time that the federal government sought to roll back environmental regulations," said the February 2019 report from Bloomberg New Energy Finance and the Business Council for Sustainable Energy.<sup>19</sup>

Polls show most Americans support development of renewables. A survey by the Pew Research Center in Washington, for example, found 71 percent of American adults support greater reliance on renewable energy sources. "Robust support for expanding solar and wind power represents a rare point of bipartisan consensus in how the U.S. views energy policies," Pew said.<sup>20</sup>

Additional support comes from liberal congressional Democrats. Among the most aggressive proposals is the Green New Deal introduced in February by Rep. Alexandria Ocasio-Cortez, D-N.Y., and Sen. Ed Markey, D-Mass. The plan, which faces skepticism among some Democrats, calls for increasing the country's reliance on renewable energy with the goal of eliminating greenhouse gas emissions within 10 years "as much as technologically feasible."<sup>21</sup>

Republicans have sharply criticized the idea of relying completely on renewable energy as unrealistic. Senate Majority Leader Mitch McConnell, R-Ky., called the Green New Deal "a socialist fantasy to wreck our economy."<sup>22</sup>

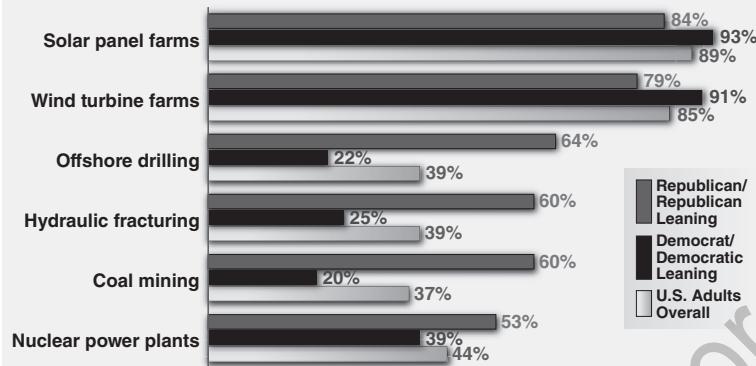
Another debate focuses on whether countries around the world can increase their reliance on renewable energy quickly enough to avoid the worst effects of climate change.

The International Renewable Energy Agency (IRENA), an organization based in the United Arab Emirates that helps countries switch to sustainable energy, said last year that avoiding disastrous climate-change

### Renewables Attract Bipartisan Support

Large majorities of Republicans and Democrats support increased use of solar panels and wind turbines to generate power, but Democrats are far less likely than Republicans to support coal mining, offshore oil drilling, hydraulic fracking or nuclear power plants as sources of energy.

Percentage of U.S. Adults Favoring Increased Use of Energy Sources, by Party Affiliation, 2018



Source: "Majorities See Government Efforts to Protect the Environment as Insufficient," Pew Research Center, May 14, 2018, <https://tinyurl.com/y5a3m72g>

consequences is possible—assuming at least a sixfold increase in the planned growth of renewable energy and rapid reductions in energy use overall.<sup>23</sup>

Skeptics, including some advocates for renewable energy, say such scenarios are unrealistic. They cite, among other obstacles, continued heavy reliance on fossil fuels and a shortage of available land for wind and solar farms.

"Simply switching to renewables alone will not solve the climate change problem," said Steffen Böhm, a professor of sustainability at the University of Exeter Business School in England.<sup>24</sup>

As climate change experts, environmentalists and policymakers look to the future of renewable energy, here are some of the questions they are asking:

#### Can renewables meet global energy needs?

Advocates of abandoning fossil fuels say wind turbines, solar farms, hydropower plants and other sources of renewable energy can eventually meet global energy demand—and they are counting on Hawaii to prove their point.

Sixty renewable energy projects send power into Hawaii's electrical grids, and the islands are on track to

reduce their dependence on fossil fuels by 60 percent over the next three years by using wind and solar power as well as biomass energy from burning municipal solid waste.<sup>25</sup>

"If this can be done in Hawaii, it can be replicated anywhere else," said Martha Symko-Davies, program manager for the Energy Systems Integration Facility at the U.S. Department of Energy's National Renewable Energy Laboratory, which focuses on renewable energy research.<sup>26</sup>

Worldwide, renewable energy is expected to meet almost 30 percent of demand for electricity by 2023, according to the International Energy Agency (IEA), an autonomous, intergovernmental organization based in Paris that works to maintain energy security for its 30 member countries. Today, renewables meet about 25 percent of the world's electricity demand.<sup>27</sup>

Electricity generation is the metric most frequently used to assess renewable energy's usefulness because electricity potentially can be used to power virtually everything, either directly or through batteries. Meeting global energy demands with renewables alone would require electrifying almost everything, experts say.

But around the world, natural gas and other fossil fuels are used much more often than electricity to heat buildings and to power cars, trucks and planes, which means renewables are contributing very little to meeting those demands.<sup>28</sup>

"The global energy transition [to renewables] is only fully underway for the power sector," REN21, a global network of renewable energy stakeholders, said in a 2018 report. "For other sectors it has barely begun."<sup>29</sup>

Last year, oil, gas and coal met most of the increase in global energy demand. In 2023, renewables will meet 12.4 percent of global energy demand, up from about 10 percent now, according to the IEA.<sup>30</sup>

Some experts say the world will always need to supplement renewable energy with nonrenewable sources.



A utility company customer examines a Tesla energy storage battery inside a home in Monkton, Vt. Such batteries help homeowners store energy from rooftop solar panels for use at night and on cloudy days.

“While many . . . scenarios have been published claiming to show that a 100 percent renewable electricity system is achievable, there is no empirical or historical evidence that demonstrates that such systems are in fact feasible,” Ben Heard, a scientist at the University of Adelaide in Australia, said in a study that he and other Australian researchers published in September 2017.<sup>31</sup>

Other experts say renewables present a variety of problems that greatly lessen their potential to replace fossil fuels. They say inland wind farms, for example, require too much land to address energy needs on a large scale, and it is unclear whether wind turbines located offshore can withstand increasingly powerful hurricanes.<sup>32</sup>

Experts also disagree on whether battery technology can solve the most obvious problem linked to wind and solar farms—that sometimes they generate no power at all while at other times they generate too much, threatening to overload electrical grids. Many energy researchers say batteries still cannot store enough electricity to make them cost-effective in balancing out fluctuations in power from renewable sources.

“Many implausible technological changes would have to happen before batteries will be capable of doing what clean-energy visionaries hope,” said Ross Marchand, policy director at the Taxpayers Protection Alliance, a conservative think tank in Washington.<sup>33</sup>

But some utility companies see a bright future in battery technology.

In January 2019, Hawaiian Electric Co. requested regulatory approval for seven battery projects to store solar power. And last year, California regulators approved a proposal from Pacific Gas and Electric (PG&E) to build the two largest battery systems in the world to store renewable energy. The future of that project, however, may be complicated by PG&E’s decision in January 2019 to file for bankruptcy because of billions of dollars of claims linked to deadly wildfires.<sup>34</sup>

A team of researchers from Germany, South Africa, the Netherlands and Denmark took issue last year with experts who say renewables will never meet global energy demands, specifically targeting the assertions made by Heard and his colleagues in Australia.

“There are technical solutions to all the points they raised, using today’s technology,” said Tom Brown, a researcher at the Karlsruhe Institute of Technology, a public research university in Germany.<sup>35</sup>

Countries could use electricity produced by renewable sources, for example, to produce hydrogen—through a process called electrolysis that splits water into hydrogen and oxygen—and store that hydrogen for use as a power source when wind power and solar energy are in short supply, Brown and his colleagues said. “One-hundred percent renewable energy scenarios . . . are not just feasible, but also viable,” they said.<sup>36</sup>

Mark Jacobson, a professor of civil and environmental engineering at Stanford University, was similarly optimistic about prospects for renewable energy in his 2018 online book, *100 Percent Clean, Renewable Energy and Storage for Everything*.

“The main obstacles appear to be social and political,” Jacobson said.<sup>37</sup>

In 2017, Jacobson and other Stanford researchers published guidelines showing how 139 countries could transition completely to renewable power sources by 2050. “The solution is to electrify all energy sectors . . . and provide all electricity with 100 percent wind, water, and solar power,” the researchers said.<sup>38</sup>

### **Can the world transition to renewable energy quickly enough to avoid the worst effects of climate change?**

Under the 2015 Paris Agreement on Climate Change, countries around the world have committed to sharply reducing greenhouse gas emissions as part of a global action plan to avoid worst-case sea-level increases and

severe storms, droughts and other extreme weather events linked to global warming. Of the 195 countries that have signed the agreement, 185 have ratified it.<sup>39</sup>

So far, the plan does not seem likely to succeed, many climate experts say. They note that emissions of planet-warming carbon dioxide rose an estimated 2.7 percent last year, to a record 37 billion tons.<sup>40</sup>

“If we’re trying to avoid the absolute worst and scariest impacts of climate change, we should be transforming the energy system far faster than we are,” said John Larsen, director of power sector and energy systems research at the Rhodium Group, a New York City firm that advises policymakers on energy and other issues.<sup>41</sup>

In India and China, which continue to depend heavily on coal as a source of electricity, emissions increased more than 6 percent and 5 percent, respectively, last year. “Coal’s getting pushed out in some countries and it’s not coming back, but at the same time there’s still new coal plants being built in the world,” says David Livingston, a climate change and energy expert at the Atlantic Council, a think tank in Washington.

Emissions declined by just under 1 percent in Europe and rose 2.5 percent in the United States, where President Trump has announced plans to withdraw from the Paris Agreement.<sup>42</sup>

To limit global warming to 1.5 degrees Celsius (2.7 degrees Fahrenheit) above preindustrial levels and avoid disastrous weather-related events linked to climate change, renewables must supply about half of the world’s electricity by 2030 and at least 70 percent by 2050, according to an October 2018 report from the Intergovernmental Panel on Climate Change (IPCC), a United Nations organization in Geneva that researches global warming.<sup>43</sup>

“The report shows that we only have the slimmest of opportunities remaining to avoid unthinkable damage to the climate system that supports life as we know it,” said Amjad Abdulla, an IPCC board member.<sup>44</sup>

But Nathan Hultman, a nonresident senior fellow at the Brookings Institution, a think tank in Washington, said the IPCC report leaves room for optimism. “Renewable energy deployment has shown remarkable progress, surpassing expectations and surprising analysts,” Hultman wrote in October. “So, progress is already happening. . . . [I]t’s just that we need to go faster and do more.”<sup>45</sup>

In the United States, renewable energy generation is expanding rapidly. In February 2019, the Energy

Information Administration, part of the U.S. Department of Energy, reported that electricity generated by solar and wind farms jumped 24.4 percent and 8.1 percent, respectively, between 2017 and 2018. Electricity generated by coal, meanwhile, dropped 4.9 percent.<sup>46</sup>

Mara Prentiss, a Harvard University physicist and author of the 2015 book *Energy Revolution*, believes the United States is on track to replace fossil fuels with renewables within 25 years. “Things may not be able to be done cheaply, but we can get to 100 percent renewables with technologies we already have now,” she says.

Dan Kammen, an energy professor at the University of California, Berkeley, envisions an even faster timetable. “The U.S. could make the transition to 90 percent to 100 percent renewables in just a bit over a decade,” he says.

International surveys show strong public support for renewable energy—support that experts say will be crucial in meeting global emissions goals. For example, a 2017 survey of more than 26,000 people in 13 countries, including the United States, found 82 percent backed the idea that creating a world fully powered by renewable energy is important.

“The support is regardless of age, education level or political ideology,” Ørsted, the largest energy company in Denmark, said in releasing the survey.<sup>47</sup>

In the United States, the strongest support for renewable energy comes from people between ages 18 and 34. “The expectation that climate change, toxics and pollution are simply the price of modern life and can’t be changed makes no sense to people whose life experience has been constant change,” said Steven Cohen, director of the Research Program on Sustainability Policy and Management at Columbia University.<sup>48</sup>

But the Trump administration does not share such enthusiasm for renewable energy. The United States is among five countries that have not committed to meeting the goals of the Paris agreement, according to the Climate Action Tracker, an analysis of progress on climate action conducted by research organizations in Europe and Australia. In announcing his decision to withdraw from the Paris Agreement, President Trump said the pact would lead to “lost jobs, lower wages, shuttered factories, and vastly diminished economic production.”<sup>49</sup>

The United States ranks second behind China in greenhouse gas emissions, so U.S. action to control

emissions is crucial in the global effort to avoid the consequences of climate change, said Louise Jeffery, an emissions expert with the Potsdam Institute for Climate Impact Research, a research organization in Germany. “I would be surprised if it’s possible [for the world] to meet [a] 1.5- to 2-degree Celsius target without the U.S. meeting their commitment,” she said.<sup>50</sup>

### **Can the U.S. electrical grid handle mass adoption of renewables?**

Nancy Traweek understands better than most people just how tricky it can be making renewable energy work on an electrical system originally built for nonrenewable sources.

Traweek directs day-to-day operations at the California Independent System Operator, which oversees the state’s power grid. She and her co-workers might find themselves rushing one minute to tap extra energy from natural gas to compensate for a drop in solar power when the sun stops shining, and scrambling the next minute to keep too much solar or wind power from overloading transmission lines.

“Within an hour, you could have a cloud come over a solar field and then a few minutes later move away and then come back over,” Traweek said.<sup>51</sup>

Utilities around the country are dealing with similar peak-and-valley challenges as more solar and wind farms connect to electrical grids.

Without nonrenewable energy sources such as natural gas, nuclear power and coal, “there simply is not enough energy to sufficiently supply the grid at all times of day, no matter how many solar or wind facilities get tacked on,” according to Yonk and Wardle.<sup>52</sup>

But other experts say power systems are adapting rapidly to renewables, thanks to improvements in battery-storage technology, weather forecasting and computer software that helps the grids balance wind and solar power with nonrenewable energy sources.

The nation’s electrical grid was originally designed to accommodate large power plants that were built close to cities and produced a predictable amount of electricity moving in a single direction—from the plants to consumers. The amount of power going into the grid must equal the amount of power coming out. Otherwise, power stations and transmission lines will break down.

Wind and solar farms do not fit neatly into that model, and not just because their power is unpredictable. Homes with rooftop solar panels, for example, take power from the grid at night and when the sky is overcast, but they also might send excess solar power into the grid during the day. And renewable energy sources are widely scattered, often far from cities, requiring long-distance transmission lines.

“Making the electricity grid cleaner with wind and solar is an evolving process that requires significant changes to how the power grid is currently run—but one that offers large opportunities, if we as a country can become more flexible when we use electricity,” scientists at the Lawrence Berkeley National Laboratory, a Department of Energy research center managed by the University of California and located in Berkeley, Calif.<sup>53</sup>

As an example of that flexibility, the scientists said, areas of the country that use lots of solar energy might want to locate chargers for electric cars at stores and office buildings to encourage charging during the day when the sun is out. “But in a region with strong winds at night and many wind turbines, power may be cheapest and cleanest when electric vehicles are parked at the owner’s residence,” they said.<sup>54</sup>

Other experts, however, question whether the nation’s electrical grid is equipped to operate without help from fossil fuels, especially natural gas, which can be tapped more quickly than other nonrenewable sources when wind or solar power dips. Those experts note that energy storage batteries are far from ready to replace natural gas “peaker” plants—which operate only at times of high demand—in compensating for the variability of renewable energy. Most energy storage batteries used by utilities hold about four hours’ worth of electricity.<sup>55</sup>

“We think [batteries] can do some, but not all,” said Seb Henbest, head of Europe, the Middle East and Africa at Bloomberg New Energy Finance. He said peaker plants will remain crucial in meeting global electricity demands far into the future, especially in the United States.<sup>56</sup>

The Energy Innovation Reform Project (EIRP), an organization in Arlington, Va., that works to make energy more affordable and reliable, said nonrenewable energy sources such as nuclear power will be “indispensable” in working with renewables to reduce greenhouse emissions linked to the electrical grid.

“While it is theoretically possible to rely primarily (or even entirely) on variable renewable energy resources such

as wind and solar, it would be significantly more challenging and costly than pathways that employ a diverse portfolio of resources,” the EIRP said in a 2017 report.<sup>57</sup>

Steve Hauser, CEO of Gridwise Alliance, an organization in Washington that works to improve electricity energy policies, says that while the country may not need to build nuclear plants, it will continue to rely on the ones already operating. “It is still necessary, and it is clean,” he says of nuclear power.

## BACKGROUND

### Early Electricity Research

Before the Industrial Revolution, which began in Great Britain in the mid-1700s and spread to the United States in the 1800s, people cooked over wood or coal fires, used animals to transport heavy loads, and ground grain into flour using wheels powered by river currents. Some of the world’s poorest countries still use such methods of generating energy.

The transformation of agrarian societies into economies that used machines for manufacturing was possible because of discoveries that made coal efficient for powering steam engines. Those discoveries, notably by Scottish inventor and engineer James Watt, led to steam-powered trains and factories.<sup>58</sup>

Experimentation continued throughout the industrial era, with scientists and inventors in the United States and elsewhere working simultaneously on similar ideas.

One of the most famous experiments was Benjamin Franklin’s attempt to fly a kite in a lightning storm in a Philadelphia field in 1752 to demonstrate that lightning was electrical in nature, something scientists had long suspected was true but had never proved. Franklin’s kite was not actually struck by lightning, which likely would have killed him. But a bolt did come close enough to transmit an ambient electrical charge to a Leyden jar (an early device used to store high-voltage electricity), proving it was possible to capture the energy in lightning.<sup>59</sup>

Hans Christian Ørsted, a Danish physicist and chemist, discovered in 1820 that an electrical current flowing through a wire produced a magnetic field. Building on that work the following year, English scientist Michael Faraday used a small mercury bath to transform electrical energy into mechanical energy, producing the first electric motor.

In 1831, Faraday discovered that changing a magnetic field produces an electric field. That breakthrough led him to construct a dynamo, which used magnetism to convert mechanical energy into electricity. Faraday’s work paved the way for making electricity practical for everyday use.<sup>60</sup>

In 1839, French scientist Edmond Becquerel discovered that submerging silver chloride in an acidic solution and exposing it to sunlight while it was connected to platinum electrodes created an electric current, a phenomenon later known as the photovoltaic effect. The discovery made possible today’s technology that uses silicon crystals to create electricity in solar cells.<sup>61</sup>

Inventors had come up with light bulbs before Thomas Edison demonstrated his bulb in public in 1879, but Edison’s was the first version practical enough for widespread use in homes, and the bulbs offered a cost-competitive, cleaner alternative to gas lighting. His invention spurred demand for electric power and led to the construction in 1882 of the first commercial power plant, on Pearl Street in New York City. The plant, initially powered by steam, provided electricity to paying customers in a one-square-mile area.<sup>62</sup>

The first electricity-generating wind turbine was invented in 1888 in Cleveland by Charles Brush, an engineer. It produced about 12 kilowatts of electricity, far less than the approximately 3,000 kilowatts that the average wind turbine produces today. For 20 years, Brush used the turbine and 12 batteries to supply clean, renewable energy to his mansion in Cleveland.<sup>63</sup>

### Battery-Powered Cars

H.J. Rogers, who owned paper mills in Appleton, Wis., opened the world’s first hydroelectric power plant in 1882 on the Fox River in Appleton. The plant used a water wheel connected to a generator to supply enough power—12.5 kilowatts—to light Rogers’ home and two mills. But it experienced a number of technical problems early on. When water flow was high, for example, voltage spiked and burned out the lights, an early harbinger of the problems that affect modern electricity grids adapting to increased use of renewable energy sources.<sup>64</sup>

In 1896, a hydroelectric plant powered by Niagara Falls began sending power to Buffalo, N.Y., about 20 miles away. Instead of direct current, in which electrons flow steadily in one direction, the new plant used alternating current, in which electrons switch directions periodically. Alternating

current, developed for practical use by Nikola Tesla, a Serbian engineer who had moved to the United States, was far superior in transmitting electricity over long distances and laid the groundwork for the modern electrical grid.

Exhibits at the 1900 world's fair in Paris included the first public demonstration of an engine powered by vegetable oil-based diesel fuel. But the design of diesel engines gradually changed to accommodate diesel fuel based on petroleum, which was increasingly available at low prices.<sup>65</sup>

Auto technology, meanwhile, was advancing rapidly. Battery-powered cars were popular in the early 1900s partly because they were not prone to exploding, as gasoline-powered cars sometimes did, and because they were easier to drive.

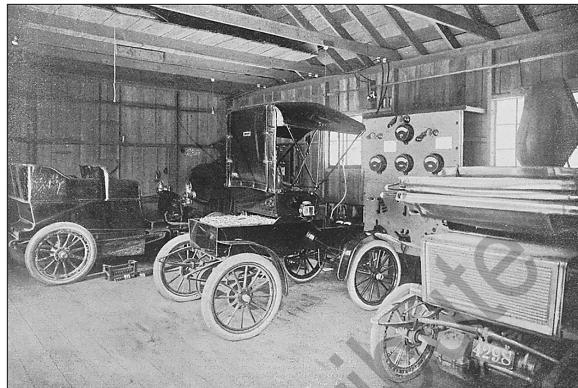
"Electricity is the thing," Edison, who developed nickel-iron storage batteries for cars and other uses, said in 1903. "There are no whirring and grinding gears with their numerous levers to confuse. There is not that almost terrifying uncertain throb and whirl of the powerful combustion engine. There is no water circulating system to get out of order—no dangerous and evil-smelling gasoline."<sup>66</sup>

But mass production of the Model T, which debuted in 1908, eventually doomed the electric car industry. Henry Ford's car could travel farther than an electric car and was more affordable, selling in 1912 for about \$650 (approximately \$16,800 in today's currency), less than half the price of an electric car.<sup>67</sup>

By that time, coal had overtaken wood as the country's energy source. Coal-fired power plants equipped with steam generators could produce up to 10 megawatts of electricity, enough to power thousands of homes.<sup>68</sup>

Construction of Hoover Dam on the Colorado River between Nevada and Arizona began in 1931. The project, described by President Franklin D. Roosevelt as "an engineering victory of the first order," began generating hydroelectric power in 1936. Turbines continued to be added until 1961.<sup>69</sup>

Roosevelt's slate of New Deal programs aimed at helping the country recover from the Great Depression included the Tennessee Valley Authority, created in 1933 in part to initiate a massive program of hydropower construction. The hydroelectric industry thrived from the 1930s through the 1960s as the federal government invested heavily in major dam projects. Hydropower provided much of the electricity needed for factories, aiding the country's participation in World War II.<sup>70</sup>



De Agostini Editorial/Getty Images

Electric cars made by inventor Thomas Edison sit in a garage in 1907. The debut of Henry Ford's gas-powered Model T in 1908 helped move the country away from electric vehicles.

After the war, with the country's energy consumption doubling every 10 years, federal officials made plans to build more than 200 nuclear plants throughout the country to generate electricity. The first full-scale nuclear power plant in the United States began operating in 1957 in Shippingport, Pa.<sup>71</sup>

As the number of cars increased, so did demand for petroleum. By 1950, petroleum had surged ahead of coal as the nation's most consumed source of energy.<sup>72</sup>

Solar energy research began to accelerate during the postwar era with the discovery that silicon was a much more efficient semiconductor than selenium, the chemical element originally used to make solar cells. The first solar panel made from silicon was built in 1954 and converted 6 percent of the sunlight it was exposed to into electricity. That compares to about 15-17 percent for most solar panels made today.<sup>73</sup>

U.S. officials viewed the space race with the Soviet Union as a compelling reason to advance solar technology. *Vanguard 1*, the first solar-powered satellite, was launched in March 1958 from Cape Canaveral, Fla., with the goal of testing the launch capabilities of a three-state rocket. Sixty-one years later, it is still circling the Earth, but only because it was launched into such a high orbit that it will be many years before that orbit decays to the point that *Vanguard 1* re-enters the atmosphere. Its solar-powered batteries died long ago.<sup>74</sup>

## C H R O N O L O G Y

**1830s-1950s** *Scientists tap the energy-producing potential of water, sunlight and wind.*

**1839** French scientist Edmond Becquerel discovers that exposing certain materials to sunlight can create electricity.

**1882** A dam on the Fox River in Appleton, Wis., becomes the world's first source of hydroelectric power.

**1887** Scottish electrical engineer James Blyth builds the first electricity-generating wind turbine. . . . U.S. inventor Charles Brush builds a wind turbine that he uses to power his home in Cleveland. . . . Coal is the dominant energy source in the U.S.

**1908** Henry Ford's Model T makes gas-powered cars popular and hastens the decline of electric cars.

**1936** Hoover Dam on the Colorado River begins generating hydroelectric power.

**1954** Scientists at Bell Labs in New Jersey demonstrate a solar panel made of silicon that is six times more efficient than earlier designs, making the technology useful for satellites.

**1960s-1980s** *New reasons to explore renewable technologies emerge as U.S. energy use surges.*

**1962** Author Rachel Carson publishes *Silent Spring*, a critique of pesticide use that helps start the environmental movement in the U.S.

**1973** Arab oil embargo revives interest in alternative energy sources in the U.S.

**1978** The Public Utility Regulatory Policy Act ends utility companies' exclusive rights to generate electricity in the U.S., leading to sharp increases in renewable energy production.

**1979** President Jimmy Carter holds a press conference on the roof of the White House to display solar panels installed there and announce new subsidies and tax credits for alternative fuels; his successor, Ronald Reagan, removes the panels.

**1988** NASA scientist James Hansen tells a U.S. Senate committee that the burning of fossil fuels is causing global warming.

**1990s-Present** *Use of renewable energy rises before encountering political headwinds.*

**2000** U.S. Green Building Council introduces its first Leadership in Energy and Environmental Design (LEED) certification for buildings that meet the group's energy-efficiency standards.

**2008** Texas oil billionaire T. Boone Pickens plans a massive wind farm between Texas and Canada, but the plan fails due to lack of political will in Congress and the high cost of building transmission lines.

**2015** Nearly 200 countries sign the Paris Agreement on Climate Change, which calls for major investments in renewable energy. . . . The Obama administration's Clean Power Plan encourages renewable energy development to limit carbon emissions from power plants.

**2017** Renewable sources, led by wind and solar power, produce almost 18 percent of U.S. electricity, up from 9 percent in 2008. . . . President Trump announces U.S. will exit the Paris Agreement.

**2018** Trump imposes a 30 percent tariff on imported solar-power equipment (January). . . . Trump proposes revamping Clean Power Plan to let states decide whether and how to limit greenhouse gas emissions (August). . . . A lease auction for wind power off the Massachusetts coast draws a record \$405 million in winning bids (December).

**2019** Federal energy officials predict that 64 percent of new U.S. energy production in 2019 will come from wind and solar power (January). . . . Congressional Democrats propose a Green New Deal to eliminate greenhouse gas emissions within 10 years by drastically increasing reliance on renewable power (February).

# “Carbon Dividends” Plan Puts New Spin on Climate Debate

*“Americans would pay more for food, health care—you name it.”*

In October 2018, ExxonMobil announced plans to donate to a cause that, at first glance, seems completely at odds with the company’s interests.

The money—\$1 million over the next two years—will go to Americans for Carbon Dividends, created last year to lobby Congress for what the group calls a “carbon dividends plan.” The plan would tax ExxonMobil and other fossil fuel companies for the carbon-based fuel they produce—starting at \$40 a ton—as a way to lower greenhouse gas emissions and fight climate change.

Proceeds would go to consumers in the form of dividend checks, with a family of four receiving about \$2,000 the first year, the group says. Proceeds from the tax would not be available for spending by the government.<sup>1</sup>

“Economists are nearly unanimous in their belief that a carbon fee is the most efficient and effective way to reduce carbon emissions,” the group says on its website. “The more the climate is protected, the greater the individual dividend payments to all Americans.”<sup>2</sup>

But the idea faces opposition from critics who say it would raise prices for goods and services well beyond the energy sector, weighing down the entire economy.

“Americans would pay more for food, health care, education, clothes, cleaning supplies—you name it,” said Bryan Cosby and Katie Tubb of the Heritage Foundation, a conservative think tank in Washington. Low-income Americans would be hurt the most, they and other critics say, because

the dividends they would receive under the plan would not make up for their higher bills.<sup>3</sup>

The proposal faces an uphill battle in Congress, where most Republicans oppose any form of a carbon tax plan. Last year, Republicans then in control of the House won approval of a nonbinding measure denouncing a carbon tax.<sup>4</sup>

The tax-and-dividend plan is one of a number of approaches designed to give carbon-intensive businesses an incentive to lower emissions and give consumers a reason to use energy more efficiently. “Putting a price on carbon helps to incorporate climate risks into the cost of doing business,” said the Union of Concerned Scientists, an advocacy organization in Massachusetts that focuses on climate change and other issues.<sup>5</sup>

California uses a cap-and-trade system in which companies purchase emission “allowances” from the state, with the number of allowances gradually declining as a way to cap emissions. Companies can increase their emissions by buying allowances from other companies that pollute less. Nine New England and mid-Atlantic states have formed a Regional Greenhouse Gas Initiative that takes a similar approach. Other clean-energy advocates prefer lowering emissions through regulations.<sup>6</sup>

Energy industry experts say ExxonMobil and other oil companies—including ConocoPhillips, BP and Shell Oil—support the tax-and-dividend plan partly because it calls for shielding companies from federal and state lawsuits

The Clean Air Act, passed by Congress in 1963, consisted of a comprehensive strategy to control air pollution and encouraged development of alternative fuels, including renewable fuels such as ethanol, methanol and biodiesel. Seven years later, the country celebrated the first Earth Day, which focused attention on the need to protect the environment.<sup>75</sup>

## Oil Crisis

U.S. oil production rose sharply during the 1960s, rising to 9.6 million barrels per day in 1970. But Americans suddenly had a new reason to worry about gas supplies

in 1973, when Arab countries decided not to sell oil to the United States and other countries that had supported Israel during the Yom Kippur War that year.

The price of crude oil quadrupled to more than \$12 a barrel, contributing to a severe global economic recession. President Richard Nixon responded by announcing Project Independence, which was designed to conserve oil and rely more on coal and nuclear power, with the objective of ending reliance on imported oil by 1980.<sup>76</sup>

In 1975, Congress passed the Energy Policy and Conservation Act, which established fuel economy

over carbon emissions. The plan also would eliminate most Environmental Protection Agency rules limiting carbon emissions, based on the theory that adopting the plan would make such regulations redundant by giving companies a reason to voluntarily lower emissions.

Carbon imports from countries without a comparable arrangement would be subject to the tax, with that money included in the dividends paid to U.S. consumers.<sup>7</sup>

Some environmental groups, including Conservation International and The Nature Conservancy, also support the proposal.

The tax-and-dividend idea was proposed in February 2017 by former Secretaries of State James Baker and George Shultz in collaboration with other former Republican officials. They published their idea in a report titled “The Conservative Case for Carbon Dividends” and simultaneously formed a group called the Climate Leadership Council based on the proposal. Americans for Carbon Dividends is the council’s lobbying arm.<sup>8</sup>

Supporters of the proposal say it would reduce U.S. carbon emissions by about 32 percent by 2025. That is a much deeper cut than the country had pledged to achieve under the 2015 Paris Agreement on Climate Change before President Trump announced in 2017 that the United States would withdraw from the accord.<sup>9</sup>

“The plan’s effectiveness in reducing emissions substantially raises the environmental bar, while its reliance on a market-based carbon tax makes it—according to economists of all stripes—the most cost-effective climate solution,” the Climate Leadership Council said in a September 2018 report.<sup>10</sup>

But Benjamin Zycher, a resident scholar at the American Enterprise Institute, a conservative think tank in Washington, said virtually all of the Climate Leadership Council’s claims about the tax plan’s benefits “are incorrect

or implausible,” including its assertion that a carbon tax is a more efficient method of reducing emissions than regulations.<sup>11</sup>

— Matt Mossman

<sup>1</sup> Steven Mufson, “ExxonMobil gives \$1 million to promote a carbon tax-and-dividend plan,” *The Washington Post*, Oct. 9, 2018, <https://tinyurl.com/yyg8a5oy>; “The Solution,” Americans for Carbon Dividends, undated, <https://tinyurl.com/y4gzwlqc>.

<sup>2</sup> “The Solution,” *ibid.*

<sup>3</sup> Bryan Cosby and Katie Tubb, “Why the ‘Conservative’ Carbon Tax Is Still a Non-Starter,” The Heritage Foundation, July 17, 2018, <http://tinyurl.com/y6cxueh2>.

<sup>4</sup> Timothy Cama and Miranda Green, “Bipartisan group of lawmakers propose landmark carbon tax,” *The Hill*, Nov. 27, 2018, <https://tinyurl.com/ybs9yt58>; Timothy Cama and Juliegrace Brufke, “House votes to disavow carbon tax,” *The Hill*, July 19, 2018, <https://tinyurl.com/yywq9sje>.

<sup>5</sup> “What is carbon pricing?” Union of Concerned Scientists, undated, <http://tinyurl.com/y2gjoykv>.

<sup>6</sup> Amel Ahmed, “California cap-and-trade is working—for other states,” PBS, July 15, 2018, <https://tinyurl.com/yd5murjv>; “Welcome,” The Regional Greenhouse Gas Initiative, undated, <https://tinyurl.com/y6k94zbd>.

<sup>7</sup> “The Solution,” *op. cit.*

<sup>8</sup> “Mission,” Climate Leadership Council, undated, <https://tinyurl.com/yxc54wpj>.

<sup>9</sup> “Exceeding Paris: How The Baker-Shultz Carbon Dividends Plan Would Significantly Exceed the U.S. Paris Commitment,” Climate Leadership Council, September 2018, <https://tinyurl.com/ybhgq7xk>.

<sup>10</sup> *Ibid.*

<sup>11</sup> Benjamin Zycher, “The deeply flawed conservative case for a carbon tax,” American Enterprise Institute, March 7, 2017, <https://tinyurl.com/y5emsf76>.

requirements and emissions restrictions for new cars and trucks.<sup>77</sup>

Federal officials also began looking to solar energy as a potential alternative to oil. The 1974 Solar Energy Research, Development and Demonstration Act made it official U.S. policy “to pursue . . . the objective of utilizing solar energy as a major source for our national energy needs.” The act also created a new federal office, the Solar Energy Research Institute—later renamed the National Renewable Energy Laboratory—to advance the industrial use of solar power.<sup>78</sup>

Another 1974 bill, the Solar Heating and Cooling Demonstration Act, ordered solar heating and cooling

units installed in federal buildings by 1977. “Essentially, Congress was attempting to turn federal buildings into billboards for solar energy,” according to the Institute for Energy Research, an organization in Washington that studies government regulation of global energy markets.<sup>79</sup>

More shocks to the U.S. energy sector came in 1979, after political upheaval in Iran, combined with strong global economic growth and fuel hoarding based on fears of future oil shortages, caused oil prices to more than double between April 1979 and April 1980.<sup>80</sup>

In March 1979, a reactor at the Three Mile Island nuclear power plant near Middletown, Pa., experienced a

# Use of Renewables Varies Widely Across World

*Overall, wind and solar power are growing at an “unprecedented” rate.*

Across the globe, local conditions and needs are shaping nations’ efforts to find alternatives to fossil fuels. Technologically advanced countries such as Denmark and Germany are focusing on wind power and energy efficiency, while Brazil is using its agricultural bounty to become a leader in cleaner fuels made from sugarcane. China, the world leader in greenhouse-gas emissions, also is the largest manufacturer and buyer of solar panels.<sup>1</sup>

Such efforts helped renewable energy sources achieve the fastest growth rate among all energy sources in 2017, according to the International Energy Agency (IEA), a non-governmental organization in Paris that promotes energy reliability and security among its 30 member countries. The group said renewables now account for about 25 percent of global electricity generation.<sup>2</sup>

“The growth of wind power and solar . . . in 2017 was unprecedented,” the IEA said. Wind power accounted for 36 percent of the growth in renewable sources that year and solar power accounted for 27 percent.<sup>3</sup>

Despite that trend, the world as a whole is not meeting its goals for limiting carbon emissions in line with the objectives of the 2015 Paris Agreement on Climate Change, which aims to keep global temperatures from rising more than 1.5 degrees Celsius above preindustrial levels.

“We need to aggressively reduce carbon emissions as soon as possible, which is not impossible, but challenging,” said Luis Mundaca, a professor of industrial environmental economics at Lund University in Sweden. He was a lead author on a United Nations report released in October that said achieving the Paris Agreement’s goals will require drastic action by countries throughout the world.<sup>4</sup>

Individual countries are charting very different courses in pursuit of those goals.

Denmark, a world leader in renewable energy technology and policy, set a national record for wind power in 2017, with wind turbines generating the equivalent of 44 percent of the country’s total electricity consumption. Danish officials say the country is on track to generate all of its electricity from renewable sources by 2030 and to give up fossil fuels entirely by 2050.<sup>5</sup>

Germany, the largest economy in Europe, once shared Denmark’s reputation as a climate action standout. Recently, however, Germany has failed to meet its targets



Chris Ratzliff/Bloomberg via Getty Images

The sun sets behind wind turbines near Fjerritslev, Denmark. The country aims to use wind power and other renewable sources to generate all its electricity by 2030.

for reducing greenhouse gas emissions. Coal still accounts for nearly 40 percent of the country’s electricity generation.

Despite that, Germany has achieved some remarkable milestones in using renewable energy. For brief periods on two different days in 2018, January 1 and May 1, it relied completely on wind energy or a combination of wind and solar energy to meet total demand for electricity. Both days were public holidays in Germany, so lower energy demand was a factor.<sup>6</sup>

In 2018, for the first time, combined power from solar arrays, wind turbines, hydroelectric plants and other renewable sources overtook coal as Germany’s top source of energy. German officials said in January 2019 the country will close all 84 of its coal-fired power plants by 2038 to get its emissions plan back on track.<sup>7</sup>

RWE, the largest operator of coal-fired power plants in Germany, warned that the move will cost thousands of jobs. About 20,000 people work in the German coal industry. The closure plan includes a recommendation that the country spend about \$45 billion to aid industry workers.<sup>8</sup>

Indonesia is headed in the opposite direction. Thirty-nine coal plants were under construction in February 2019, with plans for another 68, and an Indonesian energy official said last year the country was tapping only 2 percent of its renewable energy potential. The country ranks as one of the world’s biggest polluters, with farmers burning or cutting down massive swaths of carbon-rich rain forests that would otherwise absorb greenhouse gases.<sup>9</sup>

"It certainly makes it a lot harder to meet international climate goals if you have such a big emitter that [has] continued its big emissions," said Jonah Busch, now chief economist at Earth Innovation Institute, an organization in San Francisco that works to reduce deforestation.<sup>10</sup>

Overall, however, Asia accounted for two-thirds of the global increase in renewable energy generating capacity in 2017, with China and India leading the way.<sup>11</sup>

China is a study in contrasts. The country burns half the world's coal but also owns half the world's electric vehicles and is adding solar capacity at a faster rate than any other major country. Choking air pollution in some cities, which has led to rising civil unrest, is one motivating factor.<sup>12</sup>

In September 2018, the country announced plans to use renewables to meet at least 35 percent of its energy demands by 2030. An earlier plan had called for using "non-fossil fuels" to meet 20 percent of demand within the same period. China also is gradually implementing a program that essentially puts a price on carbon emissions, giving the power sector an incentive to use more energy from renewables.<sup>13</sup>

In India, new solar installations are expected to increase solar power capacity 50 percent this year, a national record. Coal still accounts for 60 percent of energy consumption, but India is adding renewable energy capacity faster than it is adding capacity from coal.<sup>14</sup>

"India is running one of the largest and most ambitious renewable capacity expansion programs in the world," Deloitte, a global professional services firm based in London, reported last year.<sup>15</sup>

Historically, Brazil also has had ambitious plans to replace fossil fuels. The country depends more on renewable energy, including hydroelectric plants and biofuels made from sugarcane, than any other large energy consumer in the world, and it has made significant strides in curbing deforestation.

But it is not clear that renewables will be a priority for the country's newly elected right-wing president, Jair Bolsonaro, who has threatened to withdraw from the 2015 Paris Agreement on Climate Change.<sup>16</sup>

— Matt Mossman

<sup>1</sup> Jesper Berggreen, "44% Wind—Denmark Set New Wind Energy Record In 2017," *Clean Technica*, Jan. 6, 2018, <http://tinyurl.com/y6qpt4sr>; Paul Hockenos, "Can Germany revive its stalled transition to clean energy?" *WETA*, Dec. 20, 2018, <http://tinyurl.com/y2unffsw>; Tim Albrecht, "All Eyes On Ethanol," *Ethanol Producer Magazine*, May 30, 2018, <http://tinyurl.com/y2htracg>; Chris Martin and Brian Eckhouse, "Solar Power Buyers Loved 2018, But Panel Makers Loathed It," *Bloomberg*, Dec. 18, 2018, <http://tinyurl.com/yc8zow5u>.

<sup>2</sup> "Global Energy & CO<sub>2</sub> Status Report: Latest trends in renewables," International Energy Agency, March 2018, <http://tinyurl.com/y3nvoq8u>.

<sup>3</sup> *Ibid.*

<sup>4</sup> "Can we limit global warming to 1.5 degrees C?" *Phys.org*, Oct. 25, 2018, <https://tinyurl.com/y4sakt4z>; "Summary for Policymakers of IPCC Special Report on Global Warming or 1.5° approved by governments," International Panel on Climate Change, United Nations, Oct. 8, 2018, <https://tinyurl.com/y9jxdc39>.

<sup>5</sup> "New Danish energy agreement secured: 50 per cent of Denmark's energy needs to be met by renewable energy in 2030," *State of Green*, July 2, 2018, <http://tinyurl.com/y3l6qpjd>.

<sup>6</sup> Benjamin Wehrmann, "Renewables briefly cover 100% of Germany's power demand for 2nd time," *Clean Energy Wire*, May 2, 2018, <http://tinyurl.com/y3clouvo>; Giles Parkinson, "Germany reaches 100% renewables for a few hours, 42% so far this year," *Renew Economy*, May 4, 2018, <http://tinyurl.com/y6pmaf9m>.

<sup>7</sup> Erik Kirschbaum, "Germany to close All 84 of its coal-fired power plants, will rely primarily on renewable energy," *Los Angeles Times*, Jan. 26, 2019, <http://tinyurl.com/yyc4dl2c>; "Renewables overtake coal as Germany's main energy source," *Reuters*, Jan. 3, 2019, <http://tinyurl.com/y8yg56p4>.

<sup>8</sup> "Energy giant warns of 'significant' job losses over Germany's coal phase out," *The Local*, Jan. 28, 2019, <http://tinyurl.com/yd5z9w5f>; Kirschbaum, *ibid.*

<sup>9</sup> Hans Nicholas Jong, "For Indonesian presidential hopefuls, burning coal is business as usual," *Mongabay*, Feb. 15, 2019, <https://tinyurl.com/y4ynd8fh>; Nithin Coca, "The Other Country Crucial to Global Climate Goals: Indonesia," *The Diplomat*, March 28, 2018, <http://tinyurl.com/y5vyntae>; "Exploitation of renewable energy only 2 percent of potential capacity," *AntaraNews.com*, Aug. 1, 2018, <http://tinyurl.com/y2a9dfxw>.

<sup>10</sup> Coca, *ibid.*

<sup>11</sup> "Renewable Energy Market: 2019 Global Industry Size, Growth, Share, Trends, Value, Emerging Technologies, Growth, and Regional Outlook to 2023," *Market Watch*, March 4, 2019, <https://tinyurl.com/y59h46w8>.

<sup>12</sup> Eric Niiler, "China Is Both the Best and Worst Hope for Clean Energy," *Wired*, Dec. 4, 2018, <http://tinyurl.com/y4r3spl5>; Robert Rapier, "Why Did China Tap the Brakes on Its Solar Program?" *Forbes*, June 8, 2018, <http://tinyurl.com/ybz459aq>; Zhuoshi Liu, "The People vs. Pollution: Empowering NGOs to Combat Pollution with Environmental Law," *New Security Beat*, Aug. 23, 2018, <https://tinyurl.com/y37za4cr>.

<sup>13</sup> "China Sets New Renewables Target of 35 Percent by 2030," *Renewable Energy World*, Sept. 26, 2018, <http://tinyurl.com/y3wnmepq>; James Temple, "China is creating a huge carbon market—but not a particularly aggressive one," *MIT Technology Review*, June 18, 2018, <http://tinyurl.com/y9kgtc9k>.

<sup>14</sup> Kuwar Singh, "India will add a record level of solar power capacity in 2019," *Quartz*, Jan. 10, 2019, <http://tinyurl.com/yy997grc>.

<sup>15</sup> "The Evolving Energy Landscape in India: Opportunities for investments," *Deloitte*, April 2018, <https://tinyurl.com/y4c9whcr>.

<sup>16</sup> Lisa Viscidi and Nate Graham, "Brazil Was a Global Leader on Climate Change. Now It's a Threat," *Foreign Policy*, Jan. 4, 2019, <http://tinyurl.com/y5elg6jx>.

partial meltdown. There were no direct casualties, but the episode badly shook the nation's faith in nuclear power as a safe form of energy.<sup>81</sup>

Government tax credits for wind energy projects, a response to the oil shocks of the 1970s, triggered a "wind rush" during the following decade. The country's first wind farm was built in 1980 at Crotched Mountain, N.H. Larger projects followed in 1981 at Altamont Pass and Tehachapi in California.<sup>82</sup>

### Global Warming Debates

Climate change emerged as a new focus of national concern after NASA scientist James Hansen told a Senate committee in 1988 that a buildup of carbon in the atmosphere from the burning of fossil fuels was causing the planet to warm. "It is time to stop waffling so much and say that the evidence is pretty strong that the greenhouse effect is here," Hansen said. He had issued similar warnings before, but this time his words had a stronger impact.<sup>83</sup>

At that time, renewable energy accounted for 8.8 percent of the country's electricity generation, with fossil fuels accounting for 71.7 percent and nuclear plants 19.5 percent.<sup>84</sup>

Four years later, Congress passed the Energy Policy Act, which provided loan guarantees for companies developing zero-emissions technologies and increased the amount of biofuel—such as ethanol, made with corn—that previous laws had stipulated must be mixed into gasoline to reduce emissions. That same year, the United Nations Framework Convention on Climate Change identified greenhouse gases as the main contributors to global warming.<sup>85</sup>

Congress, meanwhile, was continuing to take steps to reduce air pollution, passing amendments to the Clean Air Act in 1990 that recognized acid rain as a problem.<sup>86</sup>

Debates over the role of human activity in climate change continued in the early 2000s. People installed solar panels on their rooftops and bought gas-electric hybrid cars such as the Toyota Prius, introduced in 1997.<sup>87</sup>

Wind power found an unlikely champion in T. Boone Pickens, a Texas oil billionaire, in 2007. Pickens spent \$2 billion to buy 687 General Electric wind turbines for a massive wind farm he planned to build in the Texas Panhandle. But the plan collapsed in 2009. Pickens said he faced technical problems building transmission lines to link the turbines to a power distribution system.<sup>88</sup>

The bankruptcy of solar panel company Solyndra in 2011—and its default on a \$535 million loan guaranteed by the Department of Energy—focused new attention on federal subsidies for renewable energy. The department's inspector general later concluded that, when applying for the loan guarantee, the company had made misleading and inaccurate statements about its sales contracts.<sup>89</sup>

The Paris Agreement on Climate Change, concluded in 2015, took effect the next year. The agreement's goal is to reduce the consequences of climate change by limiting the rise in global temperatures to "well below" 2 degrees Celsius above preindustrial levels, and preferably no more than 1.5 degrees Celsius above those levels.<sup>90</sup>

In 2017, President Trump, who has long denied that human activity contributes to climate change, announced that he would withdraw from the agreement, saying it "disadvantages the United States to the exclusive benefit of other countries."<sup>91</sup>

But use of renewable energy is soaring in the country, with solar power accounting for about 62 percent of new utility-scale electricity generation in 2016. By 2017, solar, wind and hydroelectric power supplied 17.7 percent of the country's electricity, double the share they had claimed only nine years earlier. Between 2006 and 2017, renewable sources accounted for more than half of cumulative additions to U.S. energy capacity.<sup>92</sup>

Prices for wind and solar energy in the United States continued to plunge in 2017 and 2018. Average wind-power prices dropped to \$20 per megawatt hour in 2017, down from \$70 in 2009, according to federal energy officials. The cost of coal-fired electricity, by comparison, ranges from \$60 to \$143 per megawatt hour.<sup>93</sup>

In June last year, NV Energy, a public utility in Nevada, filed for state regulatory approval of a contract that would provide solar power at the record low price of \$23.76 per megawatt hour at Eagle Shadow Mountain Solar Farm, being developed by 8minutenergy Renewables, a renewable energy company based in San Francisco.<sup>94</sup>

Prices for energy storage batteries also have plunged, falling 79 percent since 2010. "The economic case for building new coal and gas capacity is crumbling, as batteries start to encroach on the flexibility and [peak demand] revenues enjoyed by fossil fuel plants," said Elena Giannakopoulou, head of energy economics at Bloomberg New Energy Finance.<sup>95</sup>

## CURRENT SITUATION

### Green New Deal

Demand for renewable energy among consumers and businesses continues to grow, according to polling by Deloitte, a global professional services network based in London. Seventy percent of businesses surveyed by the firm last year said their customers are demanding that they obtain a certain percentage of their electricity from renewable sources—up 9 percentage points from 2017. And 48 percent of businesses said they are working to rely more on renewable sources for electricity.<sup>96</sup>

Deloitte noted that significant shares of consumers are not yet making lifestyle changes that reflect their increasing support for renewable energy, but the firm said young adults may change that.

“Millennials, who are largely greener and ‘techie’ than previous generations, could soon tip this scale,” the firm said. “As Millennials make up a larger proportion of the workforce and wield greater purchasing power, they are demanding environmentally responsible products and services from companies, and those demands are echoing throughout the supply chain. As a result, more and more businesses are finding that energy efficiency and expanded use of renewables are no longer optional; they have become essential to satisfying a wide range of stakeholders.”<sup>97</sup>

Growing demand for renewables is reflected in the Green New Deal pending in Congress. The sweeping proposal combines calls for action on climate change—including dramatically increased reliance on renewable energy sources—with a promise that such action will provide jobs and economic security for Americans on the low-income side of the country’s widening wealth gap.<sup>98</sup>

The plan calls for “meeting 100 percent of the power demand in the United States through clean, renewable and zero-emission energy sources” by 2030, and for building new renewable energy power plants and a national “smart” power grid.<sup>99</sup>

“Such a national grid would enable companies at various locations to buy and sell electricity to each other across long distances to take advantage of different weather patterns across the country,” said William Holahan, an economics professor emeritus at the University of Wisconsin, Milwaukee, and Charles Kroncke, retired dean of the university’s business college.

They also said a smart grid might charge customers higher prices for using electricity during high-demand periods. If customers responded by, for example, charging their electric cars at night rather than during the day, total energy capacity needed to meet demand would drop.<sup>100</sup>

The Green New Deal also proposes:

- Investing federal research and development money in renewable energy technologies and industries.
- Making all buildings in the country energy efficient.
- Working with farmers to eliminate greenhouse gas emissions from agricultural operations.<sup>101</sup>

“Climate change and our environmental challenges are one of the biggest existential threats to our way of life, not just as a nation, but as a world,” said Ocasio-Cortez, the liberal Democrat who introduced the Green New Deal resolution in the House in February. “In order for us to combat that threat we must be as ambitious and innovative in our solution as possible.”<sup>102</sup>

But the resolution does not mention a funding source, leading conservatives and other skeptics an opening to bash it as financially reckless. Critics also have attacked the plan for going beyond issues directly related to climate change to address “systemic injustices,” including “anti-labor policies,” income inequality and “historic oppression” of minorities and others.<sup>103</sup>

“This Green New Deal . . . would be a raw deal for American families as the cost of energy skyrockets under their leftist plan,” said Sen. John Barrasso, R-Wyo., chairman of the Senate Environment and Public Works Committee.<sup>104</sup>

Some Democrats also have criticized the plan as too ambitious. “I believe that setting a 10-year goal to go totally carbon-free . . . does not set us up for success—particularly given the range of energy sources that communities and industries rely on,” said Rep. Elissa Slotkin, D-Mich.<sup>105</sup>

As a nonbinding resolution, the proposal does not have the force of law, and it stands little chance of passing as long as Republicans control the Senate.

### Storage Challenges

Experts also say the Green New Deal’s renewable energy goals will remain unachievable without major advances in storage battery technology.

## A T I S S U E

## Is meeting U.S. electricity demand with renewables by 2030 the right goal?

**YES****Steve Clemmer***Director of Energy Research and Analysis,  
Union of Concerned Scientists**Written for CQ Researcher, March 2019*

The United States can rely on renewable sources for most of its electricity on that timetable. It won't be easy, but it must be done if we are to virtually eliminate heat-trapping emissions by mid-century, which is what scientists say is needed to limit the worst effects of climate change.

The Union of Concerned Scientists analyzed various scenarios for how the U.S. power sector might achieve deep cuts in emissions over the next decade. Our research makes it clear that we need to significantly reduce our reliance on fossil fuels—which currently provide more than 60 percent of U.S. electricity—by ramping up renewable energy and other low-carbon sources and increasing overall energy efficiency.

In most of the scenarios we modeled, renewables, including hydropower, could jump from 18 percent of U.S. electricity generation today to 55 percent by 2030. And if most nuclear plants continue to operate, low-carbon energy could provide at least 72 percent of the country's electricity by that date.

Turning this goal into reality is a hefty challenge. To achieve it, federal and state legislators and regulators need to enact strong climate and clean energy policies. These policies should include putting a price on carbon, increasing renewable electricity and energy efficiency standards, providing tax incentives for installing wind and solar systems, and increasing investments in improving electrical infrastructure and in research and development targeting a suite of carbon-free energy solutions.

The entire energy sector must work together to modernize the electricity grid—including increasing transmission capacity and energy storage—so a high amount of renewable generation can be incorporated. Grid operators must embrace renewables, too, using advanced tools and grid planning to maintain reliability.

The good news is we already have the tools to build on recent progress and continue ramping up renewable energy. The cost of wind and solar has fallen by more than 70 percent over the past decade, and continued cost reductions are expected. Several states already have committed to obtaining more than 50 percent of their electricity from renewables by 2030 and achieving 100 percent carbon-free electricity by 2050. Many other states are actively considering such policies.

But we can't and shouldn't stop there. Renewables can provide at least 80 percent of U.S. electricity by mid-century, bringing significant climate, public and economic benefits. There is no time to lose. We must act now.

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The International Panel on Climate Change has given the world 12 years to save itself. States are passing "100% renewable" bills. The Green New Deal is a broader industrial policy vision the public supports.

State and federal support is necessary but insufficient. The goal is to reconfigure electrical grids and deploy distributed and renewable generation to eliminate fossil fuels entirely—across electricity, transportation, industry, buildings, etc.—while optimizing production and usage patterns and maximizing efficiencies. That process will vary by regional economy and city.

This requires more locally informed, nimble and competent governance than the utility industry offers. State regulatory commissions—designed a century ago to move slowly—consistently mismanage technological progress, distributed energy integration and the evolution of utility business models. Infrastructure and information technology are outdated. Strategic planning and rule-making are siloed. Markets are flawed.

How do we create the local relationships, knowledge, policies, programs and market reforms to deploy appropriate business models and technologies—in that order?

The answer is to engage municipal governments. They have inherent authorities across all sectors, are accountable, stable and business-oriented, understand their communities and plan regionally. Hundreds have "climate action plans" and "100% renewable" goals.

California's experience is encouraging. Over 170 city and county governments have launched 15 "Community Choice Energy" agencies that are self-funded and evolving rapidly while selling competitively priced electricity to 4 million customers.

These agencies are building more than 2,000 megawatts of renewable energy and storage and are creating comprehensive decarbonization plans. They are leveraging municipal authorities and collaborating with each other and with local and regional agencies, legislators, utilities, labor, developers and manufacturers to remove barriers to rooftop solar installations, electric vehicles and other innovations. One agency negotiated the siting of a new electric bus factory, creating local jobs and the nation's first all-electric bus fleet. Another submitted a lease application for California's first offshore wind project. Others are building renewable microgrids for critical facilities and business parks,

partnering with utilities and energy companies to replace natural gas power stations. Most of this has occurred since 2016.

This is what rapid, effective decarbonization looks like.

These strategies can be applied everywhere: by public and investor-owned utilities developing new “smart city” partnerships and in restructured states that have or are enabling Community Choice.

We have to act now—locally and everywhere.

Al Drago/Bloomberg via Getty Images



Rep. Alexandria Ocasio-Cortez, D-N.Y., and Sen. Ed Markey, D-Mass., announce their Green New Deal resolution on Feb. 7, 2019, in Washington. Supporters describe the proposal as a bold action plan for keeping carbon emissions in check, but Republicans and some moderate Democrats see it as unrealistic, and some critics have attacked it as environmental socialism.

“We need to find a way to store massive amounts of solar and wind power to be distributed upon demand to make renewable energies viable,” said Ellen Wald, an energy consultant and a senior fellow at the Atlantic Council.<sup>106</sup>

The energy storage industry is dominated by lithium-ion batteries, but engineers at Massachusetts Institute of Technology (MIT) are working on a new approach. Their battery would use tanks of molten silicon to store heat generated by excess electricity from solar or wind farms. The light from the glowing silicon would then be converted into electricity when needed, using special solar cells.<sup>107</sup>

“In theory, this is the linchpin to enabling renewable energy to power the entire grid,” Asegun Henry, an associate professor of mechanical engineering at MIT, said of the molten silicon idea.<sup>108</sup>

The researchers say molten silicon would be a cheaper way to store renewable energy than the current cheapest method, in which excess hydroelectric energy is used to pump water from one reservoir to another at a higher elevation. The higher-level water is then released through turbines at times of peak electricity demand.<sup>109</sup>

Trump’s 30 percent tariff on imported solar equipment, meanwhile, is suppressing growth in the solar industry, experts say. The import tax is scheduled to last four years and decrease by 5 percent a year.

After Trump announced the tariff last year, renewable energy companies froze or canceled more than \$2.5 billion in major solar installation projects. The industry lost almost 8,000 jobs last year, and the Solar Energy Industries Association, the national trade association for the solar industry, predicted the tariff will eventually cost more than 23,000 jobs.<sup>110</sup>

### Consumer Demand

But in at least 29 states last year, the number of solar jobs increased, with Florida in the lead. Experts say the tariff, as well as Trump’s actions reversing Obama-era environmental programs, will do little to slow the country’s increased reliance on sustainable power sources.

“More and more corporations and consumers are saying, ‘We want 100 percent renewable energy,’” said Susan Nickey, managing director at Hannon Armstrong, a firm in Annapolis, Md. that invests in renewable energy projects.<sup>111</sup>

Such sentiments are especially strong in California, the world’s fifth-largest economy and a national leader in adopting policies to expand the use of renewable energy. California’s commitment to going carbon-free means it has the most ambitious clean-energy goals of any state besides Hawaii.<sup>112</sup>

Those goals do not focus exclusively on renewable energy, however. Of the 100 percent clean-energy total that California aims to reach by 2045, at least 60 percent would come from renewables, but the rest could come from nonrenewable sources, including nuclear power and even natural gas plants, as long as the gas plants capture and store their carbon emissions underground.

Critics of the new law say it will raise electricity prices. “If it’s not affordable, it’s not sustainable,” PG&E, the California utility, said in a statement. “We believe customers must be protected from unreasonable rate and bill impacts.”<sup>113</sup>

But 67 percent of likely California voters support the law, and half are willing to pay more for electricity if it comes from renewable sources, according to a survey conducted last year by the Public Policy Institute of California, a think tank in San Francisco.<sup>114</sup>

California leads the nation in solar energy growth and is home to Topaz Solar Farm in San Luis Obispo County, one of the largest solar farms in the world. The 550-megawatt farm produces enough electricity to power 160,000 homes. The largest solar farm in the world, in the Tengger Desert in China, produces almost three times that much electricity—1,547 megawatts.<sup>115</sup>

To meet its emission reduction goals, California is working with the Trump administration—a rare case of climate-related cooperation between the state and the administration—on a plan to lease about 688,000 acres off the state’s northern and central shorelines to develop wind energy. The only utility-scale offshore wind farm now operating in the United States is off Block Island in Rhode Island.<sup>116</sup>

Wind is also a major industry in Texas, which has more than 12,000 turbines. In December, Texas briefly generated 19,168 megawatts of electricity from wind power, a state record. One megawatt of electricity powers about 200 homes in the state.<sup>117</sup>

## OUTLOOK

### Continued Expansion

[Recep] Kendircioglu at John Hancock Financial Services says that within 10 years, advances in energy-storage batteries will open new frontiers in solar and wind energy. “We will still be talking about renewable energy as a major driver of change, though it might not be the biggest

part of the electricity mix,” he says. “That could take longer.”

That uncertainty hinges partly on the outlook for federal renewable energy tax credits that have helped bring the number of homes with solar panels to about 2 million. This year, homeowners and businesses can deduct up to 30 percent of the cost of installing a solar or small wind turbine system from their federal income taxes. The deduction falls to 26 percent next year and to 22 percent in 2021. After 2021, the solar tax credit drops to 10 percent indefinitely for businesses and disappears for homeowners, and the wind tax credit disappears for both homeowners and businesses.<sup>118</sup>

A separate production tax credit (PTC) for wind developers, based on the number of kilowatt hours of electricity they sell each taxable year, disappears for projects starting construction after 2019. Experts say the tax credit, the most expensive energy subsidy in the country, has been the primary driver of wind development nationwide.<sup>119</sup>

Some experts believe the momentum behind renewable energy projects will continue despite declining federal investments.

Sean O’Leary, communications director for the Northwest Energy Coalition, an alliance of environmental and civic organizations headquartered in Seattle, said wind developers, for example, are rushing to start projects this year before the PTC expires. But he added, “We’re not seeing an indication now that there’s going to be a major retreat on wind development.”<sup>120</sup>

That is partly due to policies in some states—called renewable portfolio standards—that require utilities to obtain a set share of their electricity from renewable sources. At least 29 states and Washington, D.C., have such standards in place, and more are considering it.<sup>121</sup>

Increasing interest in renewable energy among states and cities, combined with rising consumer demand for sustainable power sources and falling prices for electricity from wind and solar farms, will continue to drive expansion in renewables, government officials say.

By 2050, renewable energy sources will have overtaken both coal and nuclear power in supplying the United States with electricity and will be second only to natural gas, according to the U.S. Energy Information Administration. It predicts that renewables will account for 31 percent of the country’s electricity generation in 30

years, up from about 18 percent now, with solar power leading the way.

“Growing renewable use has driven down the costs of renewables technologies . . . further supporting their expanding adoption by the electric power and buildings sectors,” the agency said.<sup>122</sup>

## NOTES

1. Roger Williams, “The view from here: Looking back at 2018 and forward through 2019,” *Babcock Ranch Telegraph*, Feb. 13, 2019, <https://tinyurl.com/yy9qcuzy>.
2. “Partners for a Brighter Future,” Florida Power & Light, undated, <https://tinyurl.com/y2hmlfmu>; “Building a cleaner energy future for all,” Florida Power & Light, undated, <https://tinyurl.com/yy6elbsg>.
3. Richard Luscombe, “Can a New ‘Solar City’ Make Suburbia Green?” *CityLab*, May 3, 2018, <https://tinyurl.com/yyr9hw92>.
4. “100% Commitments in Cities, Counties, & States,” Sierra Club, undated, <https://tinyurl.com/yyb64tzs>.
5. Gideon Weissman, Rob Sargent and Bret Fanshaw, “Renewables on the Rise 2018,” Environment America Research & Policy Center, Frontier Group, July 2018, <https://tinyurl.com/y5z9dczm>.
6. Ryan Yonk and Arthur Wardle, “Why renewables alone cannot meet our energy needs,” *The Hill*, Aug. 19, 2016, <http://tinyurl.com/y5dfprok>.
7. “2018 Sustainable Energy in America Factbook,” Bloomberg New Energy Finance and The Business Council for Sustainable Energy, 2018, <https://tinyurl.com/yxlqdhjy>; “2019 Sustainable Energy in America Factbook,” Bloomberg New Energy Finance and The Business Council for Sustainable Energy, February 2019, <https://tinyurl.com/y22cf4jb>.
8. “Barriers to Renewable Energy Technologies,” Union of Concerned Scientists, Dec. 20, 2017, <https://tinyurl.com/y5t8qpt7>; “Advantages and Challenges of Wind Energy,” Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, undated, <https://tinyurl.com/y8e3y86v>.
9. Thomas Overton, “Weighing the Environmental Impacts of Wind and Solar,” *Power*, July 1, 2016, <https://tinyurl.com/y5dvswem>.
10. “Environmental Impacts of Hydrokinetic Energy,” Union of Concerned Scientists, undated, <https://tinyurl.com/y3on87ww>; Philip Warburg, “Large-scale U.S. solar could get ugly, at least to some,” *GreenBiz*, Oct. 13, 2015, <https://tinyurl.com/y66lr3yy>.
11. John Siciliano, “Trump’s energy budget makes coal and nuclear a priority over renewables,” *Washington Examiner*, March 11, 2019, <https://tinyurl.com/y43wrhxu>.
12. Timothy Cama, “Trump imposes 30 percent tariff on solar panel imports,” *The Hill*, Jan. 22, 2018, <https://tinyurl.com/y2bto54m>; Ana Swanson and Brad Plumer, “Trump’s Solar Tariffs Are Clouding the Industry’s Future,” *The New York Times*, Jan. 23, 2018, <https://tinyurl.com/y9yy6ahr>.
13. Robert Blohm, “The Green New Deal’s Impossible Electric Grid,” *The Wall Street Journal*, Feb. 20, 2019, <https://tinyurl.com/y468j9d6>.
14. “Levelized Cost of Energy and Levelized Cost of Storage 2018,” Lazard, Nov. 8, 2018, <https://tinyurl.com/yaqjwgso>; Robbie Orvis, “America’s Renewable Electricity Forecast Grows To 2050, Even Under Trump,” *Forbes*, May 10, 2017, <https://tinyurl.com/yxw9kk5b>.
15. “2019 Sustainable Energy in America Factbook: Executive Summary,” Bloomberg New Energy Finance and The Business Council for Sustainable Energy, February 2019, <https://tinyurl.com/y42ccerq>.
16. Herman K. Trabish, “Will batteries do for wind what they’re doing for solar?” *Utility Dive*, May 31, 2018, <https://tinyurl.com/yczjmzy9>; John Champion, “Battery technology will define the future of renewable energy,” *The Hill*, Feb. 7, 2018, <https://tinyurl.com/yy2ay8l6>.
17. “New electric generating capacity in 2019 will come from renewables and natural gas,” U.S. Energy Information Association, Jan. 10, 2019, <https://tinyurl.com/y8j73cgw>.

18. Mark Chediak, "California Governor Jerry Brown Signs Bill for Carbon-Free Power by 2045," Bloomberg, Sept. 10, 2018, <https://tinyurl.com/yc9xszezq>; Marlene Motyka, "2019 renewable energy outlook," Deloitte, undated, <https://tinyurl.com/yx9bleph>.
19. "2019 Sustainable Energy in America Factbook: Executive Summary," *op. cit.*
20. "Majorities See Government Efforts to Protect the Environment as Insufficient," Pew Research Center, May 14, 2018, <https://tinyurl.com/y5a3m72g>.
21. Tom DiChristopher, "Alexandria Ocasio-Cortez just released her massive Green New Deal—here's what's in it," CNBC, Feb. 7, 2019, <https://tinyurl.com/y8crkd5c>; "Resolution Recognizing the duty of the Federal Government to create a Green New Deal," documentcloud.org., Feb. 5, 2019, <https://tinyurl.com/y249geec6>.
22. Josh Siegel, "Senate Republicans argue that progressives' Green New Deal would be impossible and unaffordable," *Washington Examiner*, Dec. 11, 2018, <http://tinyurl.com/yy4p4yak>; Ledyard King, "Green New Deal: Why the GOP secretly likes Democrats' climate change plan," *USA Today*, Feb. 17, 2019, <https://tinyurl.com/yyoa7o6p>.
23. "Global Energy Transformation: A Roadmap to 2050," International Renewable Energy Agency, 2018, <https://tinyurl.com/y3d2d8rv>.
24. Steffen Böhm, "We can't simply bet on renewable energy to stop global warming," *The Conversation*, Nov. 4, 2016, <https://tinyurl.com/y69apdfj>.
25. Betsy Lillian, "In 2018, Hawaii Made Big Progress On Path To 100% Renewable Energy," *Solar Industry*, Jan. 3, 2019, <http://tinyurl.com/y4j4zfqb>.
26. John Fialka, "As Hawaii Aims for 100% Renewable Energy, Other States Watching Closely," *Scientific American*, April 27, 2018, <http://tinyurl.com/y2s8e76x>.
27. "Renewables," International Energy Agency, undated, <http://tinyurl.com/y5a3tv4f>.
28. "The State of the Global Renewable Energy Transition," REN21, 2018, <http://tinyurl.com/y3nz73du>.
29. *Ibid.*
30. "Renewables 2018," International Energy Agency, 2018, <http://tinyurl.com/yd4g5nbp>; "Global energy demand grew by 2.1% in 2017, and carbon emissions rose for the first time since 2014," International Energy Agency, March 22, 2018, <http://tinyurl.com/y3nxw48r>.
31. B.P. Heard *et al.*, "Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems," ScienceDirect, September 2017, <http://tinyurl.com/yyndjpsk>.
32. "Renewable energy sources can take up to 1000 times more space than fossil fuels," Phys.org, Aug. 28, 2018, <http://tinyurl.com/y67wq7zy>; Rochelle P. Worsnop *et al.*, "Gusts and shear within hurricane eyewalls can exceed offshore wind turbine design standards," AGU 100, May 30, 2017, <http://tinyurl.com/y6geablj>.
33. Ross Marchand, "Uncle Sam is all-in on expensive, impractical batteries," *Washington Examiner*, Oct. 8, 2018, <https://tinyurl.com/y9k2cw97>.
34. Emma Foehringer Merchant, "Hawaiian Electric Announces 'Mind-Blowing' Solar-Plus-Storage Contracts," Greentech Media, Jan. 4, 2019, <https://tinyurl.com/y6rlq8yo>; Julian Spector, "PG&E's Record-Breaking Battery Proposal Wins Approval From Regulators," Greentech Media, Nov. 8, 2018, <http://tinyurl.com/y2wjdst6>; Umair Irfan, "California's largest utility just declared bankruptcy. Hello, climate change," *Vox*, Jan. 29, 2019, <https://tinyurl.com/ybsxhrdy>.
35. "Can we get 100 percent of our energy from renewable sources?" ScienceDaily, May 17, 2018, <http://tinyurl.com/y8pzaev>.
36. T.W. Brown, "Response to 'Burden of proof: A comprehensive review of the feasibility of 100% renewable-electricity systems,'" ScienceDirect, September 2018, <http://tinyurl.com/yxm6r6zz>.
37. Mark Z. Jacobson, "100 percent Clean, Renewable Energy and Storage for Everything," Stanford University, Feb. 10, 2019, <https://tinyurl.com/y6zhxb7m>.
38. Mark Z. Jacobson *et al.*, "100% Clean and Renewable Wind, Water, and Sunlight All-Sector

- Energy Roadmaps for 139 Countries of the World,” *Joule*, Aug. 23, 2017, <http://tinyurl.com/y5nyyu23>.
39. “United Nations Treaty Collection,” United Nations, March 12, 2019, <https://tinyurl.com/y9e8fufg>.
  40. Brady Dennis and Chris Mooney, “‘We are in trouble.’ Global carbon emissions reached a record high in 2018,” *The Washington Post*, Dec. 5, 2018, <http://tinyurl.com/y6dt4vht>.
  41. Benjamin Storrow, “Renewable Energy Is Surging, but Not Fast Enough to Stop Warming,” *Scientific American*, Nov. 14, 2018, <http://tinyurl.com/y6w7uv7a>.
  42. Dennis and Mooney, *op. cit.*
  43. “Characteristics of four illustrative model pathways,” Intergovernmental Panel on Climate Change, October 2018, <http://tinyurl.com/y2p63j64>.
  44. Emma Foehringer Merchant, “IPCC: Renewables to Supply 70%-85% of Electricity by 2050 to Avoid Worst Impacts of Climate Change,” Greentech Media, Oct. 8, 2018, <http://tinyurl.com/y56rd7of>.
  45. Nathan Hultman, “We’re almost out of time: The alarming IPCC climate report and what to do next,” Brookings, Oct. 16, 2018, <http://tinyurl.com/y4fzaqox>.
  46. “Electric Power Monthly with Data for December 2018,” U.S. Energy Information Administration, February 2019, <https://tinyurl.com/y3v2e3za>.
  47. “Green Energy Barometer,” Ørsted, 2017, <http://tinyurl.com/yxg4rf6t>.
  48. Steven Cohen, “Why Renewable Energy Will Replace Fossil Fuels,” *Huffington Post*, July 17, 2017, <http://tinyurl.com/yawe9vx7>.
  49. “Countries,” Climate Action Tracker, January 2019, <http://tinyurl.com/ybrkmfl7>; “Statement by President Trump on the Paris Climate Accord,” The White House, June 1, 2017, <https://tinyurl.com/yazkrs3d>.
  50. Jan Burck *et al.*, “Results 2018,” Climate Change Performance Index, 2018, <http://tinyurl.com/y7kh7fdo>; Bob Berwyn, “Can the World Meet Paris Climate Goals Without the United States?” *Pacific Standard*, Nov. 14, 2016, <http://tinyurl.com/y2mgql37>.
  51. Lauren Sommer, “Why 100 Percent Clean Energy in California is Gonna Be Tricky,” KQED, Sept. 10, 2018, <http://tinyurl.com/yxnmrhzm>.
  52. Yonk and Wardle, *op. cit.*
  53. Joachim Seel, Andrew Mills and Ryan Wiser, “As more solar and wind come onto the grid, prices go down but new questions come up,” *The Conversation*, May 23, 2018, <http://tinyurl.com/y5rtu9fe>.
  54. *Ibid.*
  55. “Fact Sheet: Energy Storage (2019),” Environmental and Energy Study Institute, Feb. 22, 2019, <https://tinyurl.com/yyly4koa>.
  56. Emma Foehringer Merchant, “BNEF: Gas Still ‘Necessary’ in a 50 Percent Wind and Solar Scenario,” Greentech Media, June 22, 2018, <http://tinyurl.com/y4dzz77g>.
  57. Jesse D. Jenkins and Samuel Thernstrom, “Deep Decarbonization of the Electric Power Sector: Insights from Recent Literature,” Energy Innovation Reform Project, March 2017, <http://tinyurl.com/yb9wd4f7>.
  58. “Industrial Revolution,” *Encyclopaedia Britannica*, undated, <http://tinyurl.com/gr4es6c>; C.N. Trueman, “James Watt,” The History Learning Site, March 31, 2015, <http://tinyurl.com/y4o7bnq2>.
  59. “Benjamin Franklin and the Kite Experiment,” The Franklin Institute, June 12, 2017, <https://tinyurl.com/yxsnz2km>.
  60. “Michael Faraday’s electric magnetic rotation apparatus (motor),” The Royal Institution, undated, <https://tinyurl.com/y3wgkg8z>; Suzanne Deffree, “Faraday discovers electromagnetic induction, August 29, 1831,” EDN Network, Aug. 29, 2018, <https://tinyurl.com/yycneweh>.
  61. “Early History of Solar,” solarcentral.com, undated, <https://tinyurl.com/y3da3avb>.
  62. “Edison Biography,” U.S. National Park Service, undated, <https://tinyurl.com/y42rft22>.
  63. Jake Richardson, “America’s First Wind Turbine Generated Electricity In 1888,” *Clean Technica*, June 22, 2014, <https://tinyurl.com/y4bm8mc2>.

64. Caleb March, "On This Day: First Hydroelectric Plant Opens," *Finding Dulcinea*, Sept. 30, 2011, <https://tinyurl.com/b8p7zrd>.
65. "Historical Timeline: History of Alternative Energy and Fossil Fuels," *ProCon.org*, June 13, 2013, <https://tinyurl.com/y5osao2k>.
66. Daniel Strohl, "How Henry Ford And Thomas Edison Killed The Electric Car," *Jalopnik*, June 16, 2010, <https://tinyurl.com/y4vqxc44>.
67. Megan Barber, "Before Tesla: Why everyone wanted an electric car in 1905," *Curbed*, Sept. 22, 2017, <https://tinyurl.com/y8lnx2ru>.
68. Abby Harvey, Aaron Larson and Sonal Patel, "History of Power: The Evolution of the Electric Generation Industry," *Power*, Oct. 1, 2017, <https://tinyurl.com/yybqpmq2>.
69. "Construction of the Dam," University of Virginia, undated, <https://tinyurl.com/y34mb4gl>.
70. "Our History," Tennessee Valley Authority, undated, <https://tinyurl.com/gvqjdxs>; "Hydroelectric Power," *Dictionary of American History*, Encyclopedia.com, 2003, <https://tinyurl.com/y6n2rtce>.
71. "A Short History of Energy: The Old Days," Union of Concerned Scientists, <https://tinyurl.com/y3xv72gm>; "Historical Timeline: History of Alternative Energy and Fossil Fuels," *op. cit.*
72. "United States Energy Use by Source, 1950-2015," *ProCon.org*, Jan. 20, 2018, <https://tinyurl.com/y33gt4us>.
73. "Electricity & Alternative Energy: The Photovoltaic Effect and the Development of Solar Technology," Alberta Culture and Tourism, undated, <https://tinyurl.com/y43rj7sp>; "What are the most efficient solar panels on the market? Solar panel efficiency explained," *energysage*, undated, <https://tinyurl.com/ybj43pk5>.
74. "Electricity & Alternative Energy: The Photovoltaic Effect and the Development of Solar Technology," *ibid.*; Alice Gorman, "60 years in orbit for 'grapefruit satellite'—the oldest human object in space," *The Conversation*, March 21, 2018, <https://tinyurl.com/ybbzr6fv>.
75. "Clean Air Act," *USLegal*, undated, <https://tinyurl.com/y72tyjdw>; Alina Bradford, "Earth Day: Facts & History," *Live Science*, April 18, 2017, <https://tinyurl.com/y95xw82v>.
76. James Williams, "Oil Price History and Analysis," WTRG Economics, Montclair State University, April 9, 2008, <https://tinyurl.com/y4gzlhdo>; Robert Rapier "The Lasting Impact of the 1973 Oil Embargo," *Energy Trends Insider*, Oct. 23, 2013, <https://tinyurl.com/y5t9apjg>.
77. "Corporate Average Fuel Economy (CAFE) Standards," U.S. Department of Transportation, Aug. 27, 2014, <https://tinyurl.com/m8d4kcg>.
78. "H.R.16276 - Solar Energy Research, Development and Demonstration Act," *Congress.gov*, Aug. 6, 1974, <https://tinyurl.com/y6e3eryg>; Matthew Sabas, "History of Solar Power," Institute for Energy Research, Feb. 18, 2016, <https://tinyurl.com/y5j9lsuy>.
79. Sabas, *ibid.*
80. Laurel Graefe, "Oil Shock of 1978-79," *Federal Reserve History*, Nov. 22, 2013, <https://tinyurl.com/yysb47uw>.
81. "Backgrounder on the Three Mile Island Accident," U.S. Nuclear Regulatory Commission, June 2018, <https://tinyurl.com/lt928ce>.
82. "U.S. wind energy grows in California, then stagnates nationwide in the 1980's," *American Wind Energy Association*, undated, <https://tinyurl.com/yxh9vu4m>; Molly Lautamo, "Altamont Pass: What's the Story With Those Windmills?" *Mobile Ranger*, Aug. 9, 2016, <https://tinyurl.com/nraxg67>.
83. Philip Shabecoff, "Global Warming Has Begun, Expert Tells Senate," *The New York Times*, June 24, 1988, <https://tinyurl.com/yc4bv98g>.
84. "Mapped: How the US generates electricity," *Carbon Brief*, Oct. 10, 2017, <https://tinyurl.com/yc77ae9k>.
85. "Summary of the Energy Policy Act," U.S. Environmental Protection Agency, undated, <https://tinyurl.com/zxordbu>; "United Nations Framework Convention on Climate Change," United Nations, 1992, <https://tinyurl.com/od8tdn6>.
86. Thomas H. Moore, "Acid Rain: New Approach to Old Problem," *CQ Researcher*, March 8, 1991, pp. 129-144.

87. "History of the Toyota Prius," Toyota, Feb. 12, 2019, <https://tinyurl.com/y5lmmm9c>.
88. John Porretto, "Pickens calls off massive wind farm in Texas," The Associated Press, ABC News, July 8, 2009, <https://tinyurl.com/yy69z5jn>.
89. "Special Report: The Department of Energy's Loan Guarantee to Solyndra, Inc.," U.S. Department of Energy Office of Inspector General, Aug. 24, 2015, <https://tinyurl.com/y2t8656p>.
90. "Paris Climate Agreement to enter into force on 4 November," United Nations, Oct. 5, 2016, <https://tinyurl.com/y4cmv624>.
91. "Statement by President Trump on the Paris Climate Accord," *op. cit.*
92. Chris Meehan, "Rooftop Solar Pushes New Renewable Energy in 2017 Past Halfway Mark for all New Energy," Solar Reviews, Jan. 16, 2018, <https://tinyurl.com/y2khdmf0>; "US Renewable Electricity Production Up 14.7%, Fossil Fuels & Nuclear Drop (CleanTechnica Chart)," Clean Technica, Dec. 6, 2017, <https://tinyurl.com/yye2ds4j>.
93. Ryan Wisner and Mark Bolinger, "2017 Wind Technologies Market Report," Lawrence Berkeley National Laboratory, U.S. Department of Energy, <https://tinyurl.com/yyo8en92>; Coley Girouard, "The Numbers are In and Renewables are Winning On Price Alone," Blog, Advanced Energy Economy, Dec. 5, 2018, <https://tinyurl.com/yx8l9ons>.
94. Julian Spector, "Nevada's 2.3-Cent Bid Beats Arizona's Record-Low Solar PPA Price," Greentech Media, June 12, 2018, <https://tinyurl.com/yyzphjyw>.
95. "Tumbling Costs for Wind, Solar, Batteries Are Squeezing Fossil Fuels," Bloomberg NEF, March 28, 2018, <https://tinyurl.com/y8kelroh>.
96. "Deloitte Resources 2018 Study," Deloitte Insights, 2018, <https://tinyurl.com/y4hmdlw4>.
97. *Ibid.*
98. "Resolution Recognizing the duty of the Federal Government to create a Green New Deal," *op. cit.*
99. *Ibid.*
100. William L. Holahan and Charles O. Kroncke, "Column: The smart grid and the Green New Deal," *Tampa Bay Times*, Feb. 24, 2019, <https://tinyurl.com/y5m7r5js>.
101. "Resolution Recognizing the duty of the Federal Government to create a Green New Deal," *op. cit.*
102. Benjy Sarlin, "'Existential' threat to the planet: Ocasio-Cortez offers Green New Deal details," NBC News, Feb. 7, 2019, <https://tinyurl.com/ydch7m4m>.
103. "Resolution Recognizing the duty of the Federal Government to create a Green New Deal," *op. cit.*
104. Andrew Duehren, "'Green New Deal' Democrats Position Climate Change as Central Issue in 2020," *The Wall Street Journal*, Feb. 8, 2019, <https://tinyurl.com/yyybwsfp>.
105. "Green New Deal too ambitious for some Democrats, even those who say Congress must 'do something,'" *USA Today*, March 7, 2019, <https://tinyurl.com/y5popzjt>.
106. Ellen R. Wald, "Forget The Green New Deal, The Future Is Batteries," *Forbes*, Feb. 21, 2019, <https://tinyurl.com/y2ab3rtv>.
107. Jennifer Chu, "'Sun in a box' would store renewable energy for the grid," MIT, Dec. 5, 2018, <https://tinyurl.com/y9w3cvdn>.
108. Colm Gorey, "Amazing renewable energy battery could power an entire city around the clock," Silicon Republic, Dec. 7, 2018, <https://tinyurl.com/ya8bdz3s>.
109. "A flexible, dynamic way to store and generate energy," Duke Energy, undated, <https://tinyurl.com/yypey7r6>.
110. "Billions in US solar projects have been shelved after Trump panel tariff," Reuters, CNBC, June 7, 2018, <https://tinyurl.com/y8t8m8ut>; Kelly Pickerel, "Solar Jobs Census: U.S. solar workforce loses 8,000 jobs in 2018 due to tariffs and state policy changes," Solar Power World, Feb. 12, 2019, <https://tinyurl.com/y6s45dts>; McKenna Moore, "Trump's Solar Tariff May Cost Up to 23,000 U.S. Jobs, But Boost Domestic Manufacturing," *Fortune*, June 11, 2018, <https://tinyurl.com/y4d2952e>.
111. Tom DiChristopher, "US solar workforce shrinks for second straight year as Trump tariffs bite," CNBC, Feb. 12, 2019, <https://tinyurl.com/yxqmfohp>; Dave Gregorio, "Renewable energy seeks demand, investment to survive Trump squeeze," Reuters, June 22, 2018, <https://tinyurl.com/y3twalqo>.

112. Paul Rogers, "California mandates 100 percent clean energy by 2045," *The Mercury News*, Sept. 10, 2018, <https://tinyurl.com/ya4dks3t>.
113. *Ibid.*
114. "Californians & the Environment," Public Policy Institute of California, July 2018, <https://tinyurl.com/y688d85y>.
115. Anmar Frangoul, "From California to Texas, these are the US states leading the way in solar," CNBC, Sept. 19, 2018, <https://tinyurl.com/y76jl958>; "Topaz Solar Farm," First Solar, undated, <https://tinyurl.com/y37f84mm>; Kelly Hodgkins, "These are the largest solar farms in the world," Digital Trends, Oct. 27, 2018, <https://tinyurl.com/y22yal67>.
116. Dino Grandoni, "The Energy 202: California and the Trump administration rarely agree on energy policy. Here's an exception," *The Washington Post*, Oct. 22, 2018, <https://tinyurl.com/y3vqoqkf>.
117. Patrick Sisson, "A mighty wind: How Texas's pro-energy, anti-regulation philosophy conspired to create a regional wind boom," *Curbed*, Oct. 24, 2018, <https://tinyurl.com/yy5bduot>; Erin Douglas, "Texas wind generation breaks record, ERCOT reports," *Houston Chronicle*, Dec. 20, 2018, <https://tinyurl.com/yxhx5h28>.
118. Angela Chen, "Why solar is likely to power the Home of the Future," *The Verge*, Aug. 13, 2018, <https://tinyurl.com/y7tgwtk6>; "The Energy Credit: An Investment Tax Credit for Renewable Energy," Congressional Research Service, Nov. 2, 2018, <https://tinyurl.com/y2ufmmz4>.
119. Lisa Linowes, "Wind Growth after PTC Expiration," MasterResource, Sept. 24, 2018, <https://tinyurl.com/y7vw9xdf>.
120. Samantha Wohlfeil, "With a major tax incentive about to sunset, experts say the time to buy into wind projects is now," *Inlander*, Dec. 27, 2018, <https://tinyurl.com/yyg9kucp>.
121. "Updated renewable portfolio standards will lead to more renewable electricity generation," U.S. Energy Information Administration, Feb. 27, 2019, <https://tinyurl.com/y3out362>.
122. "Annual Energy Outlook 2019 with projections to 2050," U.S. Energy Information Administration, January 2019, <https://tinyurl.com/y2dl0o5o>.

## BIBLIOGRAPHY

### Books

**Prentiss, Mara**, *Energy Revolution: The Physics and the Promise of Efficient Technology*, Belknap Press, 2015.

A Harvard University physics professor explains how current renewable technologies can meet global energy demand.

**Sivaram, Varun**, *Taming the Sun: Innovations to Harness Solar Energy and Power the Planet*, The MIT Press, 2019.

The chief technology officer at India's largest renewable energy company describes the state of the solar energy industry and its role in the global transition from fossil fuels to renewable energy.

**Usher, Bruce**, *Renewable Energy: A Primer for the Twenty-First Century*, Columbia University Press, 2019.

A Columbia University business professor analyzes economic and other forces that have produced rapid growth in the use of wind and solar energy.

### Articles

**Bade, Gavin**, "10 trends shaping the electric power sector in 2019," *Utility Dive*, Jan. 2, 2019, <https://tinyurl.com/ya7p3s4k>.

State and local governments will increasingly adopt policies promoting the use of renewable energy this year, even as the Trump administration rolls back environmental protections and works to prop up the coal industry, according to a reporter who covers the utility industry.

**Coren, Michael J.**, "Electricity from renewables topped coal in Germany for first time in 2018," *Quartz*, Jan. 5, 2018, <https://tinyurl.com/yyqlxwkt>.

A science reporter says solar, wind and biomass sources accounted for 40 percent of the electric power used in Germany last year.

**Gerdes, Justin**, "Record-Breaking Massachusetts Offshore Wind Auction Reaps \$405 Million in Winning Bids," *Greentech Media*, Dec. 17, 2018, <https://tinyurl.com/y459zqzh>.

Unexpectedly high bids at a state auction of offshore wind-development rights may signal more attempts to build wind turbines off the country's coastline.

**Hill, Joshua S.**, "Trump Imposes 30% Imported Solar Tariff, Threatens 23,000 Jobs In 2018," *Clean Technica*, Jan. 23, 2018, <https://tinyurl.com/y4kff7u6>.

President Trump's decision to impose levies on imported solar panels and modules will have a devastating impact on the U.S. renewable energy industry, according to industry representatives.

**Pierre-Louis, Kendra, "Greenhouse Gas Emissions Accelerate Like a 'Speeding Freight Train' in 2018,"** *The New York Times*, Dec. 5, 2018, <https://tinyurl.com/y7h5y4l4>.

Climate scientists say that, despite the rapidly increasing use of renewable energy, planet-warming emissions likely rose to record levels last year.

**Roberts, David, "There's now an official Green New Deal. Here's what's in it,"** *Vox*, Feb. 7, 2019, <https://tinyurl.com/y92zcubf>.

An energy writer analyzes the environmental and social policy goals included in the federal climate-change action plan introduced by newly elected Rep. Alexandria Ocasio-Cortez, D-N.Y.

**Storrow, Benjamin, "Renewable Energy Is Surging, but Not Fast Enough to Stop Warming,"** *Scientific American*, Nov. 14, 2018, <https://tinyurl.com/y6w7uv7a>.

The costs of wind and solar power will have to fall even more quickly than they are now to avoid the most catastrophic consequences of climate change, some experts say.

## Reports and Studies

**"The Danish Energy Model: Innovative, Efficient and Sustainable,"** Danish Energy Agency, undated, <https://tinyurl.com/y5tjdxr4>.

Energy officials in Denmark explain their country's long-term approach to using renewable energy and increasing energy efficiency.

**"Energy Storage Gains Ground,"** Norton Rose Fulbright, Aug. 9, 2018, <https://tinyurl.com/y29qqg2g>.

Executives at companies working to advance battery technology for storing renewable energy discuss the opportunities and challenges their industry faces, as well as regulatory reforms they would like to see.

**"Renewables 2018 Global Status Report,"** REN21, 2018, <https://tinyurl.com/ycjlszoh>.

Countries are increasingly relying on renewable power sources, but that progress has been uneven across sectors, with slow adoption of renewables for heating, cooling and transportation, according to a global network of renewable energy policy stakeholders.

**Motyka, Marlene, Andrew Slaughter and Carolyn Amon, "Global renewable energy trends: Solar and wind move from mainstream to preferred,"** Deloitte Insights, Sept. 13, 2018, <https://tinyurl.com/y60aoo8>.

A global professional services firm says a combination of supply and demand trends is helping solar and wind power compete successfully with conventional energy sources.

## THE NEXT STEP

### Climate Change

**Becker, Rachel, "Even in a warmer Europe, wind and solar could still keep the lights on,"** *The Verge*, March 6, 2019, <https://tinyurl.com/yxz5mn94>.

European researchers say power grids that rely on renewable energy in the future should be able to withstand less extreme weather shifts related to climate change.

**Elbein, Saul, "Europe's renewable energy policy is built on burning American trees,"** *Vox*, March 4, 2019, <https://tinyurl.com/y54s45x3>.

Europe burns wood as a "biomass" fuel, which technically qualifies as a renewable energy source, but some scientists say the practice adds more carbon into the atmosphere and worsens the effects of climate change.

### Company Efforts

**Frangoul, Anmar, "Facebook just made a huge commitment on renewable energy,"** CNBC, Aug. 29, 2018, <https://tinyurl.com/yd7klfeh>.

Facebook has pledged to cut its greenhouse gas emissions by 75 percent and use 100 percent renewable energy to power its global operations by the end of 2020.

**Kelleher, Kevin, "Apple Is Leading a Plan to Develop Wind and Solar Power With Akamai, Etsy and Other Companies,"** *Fortune*, Aug. 6, 2018, <https://tinyurl.com/yy7zz5ma>.

Apple has developed wind and solar energy farms in Illinois and Virginia to help power thousands of homes and provide renewable energy to other companies.

**Russo, Donovan, "Google is building a solar power project above fishing ponds in Taiwan, its first in Asia,"** CNBC, Feb. 17, 2019, <https://tinyurl.com/yxem4sfe>.

A solar-panel "canopy" project in Taiwan is the latest of more than 30 other solar and wind energy projects to which Google has committed since 2010.

## State Actions

**Jones, Natalie**, “Maryland legislators push for increase in renewable energy, jobs,” *The Baltimore Sun*, March 5, 2019, <https://tinyurl.com/y5obxlqq>.

Maryland is considering legislation that would commit the state to obtaining at least half its energy from renewables by 2030 and a plan to increase that to 100 percent by 2040.

**Magill, Bobby**, “Hawaii ‘Postcard From the Future’ for Renewables,” *Bloomberg*, Feb. 19, 2019, <https://tinyurl.com/y45qeu7r>.

Hawaii’s endeavors in renewable energy make it a prime example for other states on how to successfully integrate wind, solar and other renewable sources into existing power grids, a business reporter says.

**Pyper, Julia**, “New Illinois Bill Targets 100% Renewable—Not Just Clean—Electricity by 2050,” *Green Tech Media*, March 4, 2019, <https://tinyurl.com/y49tfyup>.

Illinois state lawmakers are considering legislation that would end the state’s reliance on nuclear power and make it second only to Hawaii in pursuing a plan to obtain all energy from renewables.

## Trump Administration

**Cama, Timothy**, “Trump administration opens door for California offshore wind farms,” *The Hill*, Oct. 18, 2018, <https://tinyurl.com/y7jkaorg>.

The Interior Department took initial steps last year to explore the viability of building wind energy farms in waters off California.

**Ellsmoor, James**, “Under Trump’s Tariffs, The US Lost 20,000 Solar Energy Jobs,” *Forbes*, Feb. 24, 2019, <https://tinyurl.com/y5bfpk32>.

President Trump’s 30 percent tariff on imported solar panels has dealt the U.S. solar industry a serious blow in the past year, says a solar energy entrepreneur.

**Natter, Ari**, “Trump Again Seeks Deep Cuts in Renewable Energy Funding,” *Bloomberg*, March 7, 2019, <https://tinyurl.com/y2verhca>.

A U.S. Energy Department official says President Trump’s fiscal 2020 budget will propose a 70 percent cut in the department’s spending on renewable energy programs.

## For More Information

**American Public Power Association**, 2451 Crystal Drive, Suite 1000, Arlington, VA 22202; 202-467-2900; [www.publicpower.org](http://www.publicpower.org). Represents the interests of the approximately 2,000 community-owned utilities in the United States.

**American Wind Energy Association**, 1501 M St., N.W., Suite 900, Washington, DC 20005; 202-383-2500; [www.awea.org](http://www.awea.org). Represents the interests of wind-power developers, equipment manufacturers and services providers.

**Carbon Tracker Initiative**, Second Floor, 40 Bermondsey St., London, United Kingdom, SE1 3UD; [www.carbon-tracker.org](http://www.carbon-tracker.org). Think tank that helps businesses and investors understand climate change risks.

**International Energy Agency**, 31-35 rue de la Fédération, 75739 Paris, Cedex 15, France; +33 (0)1 40 57 65 00; [www.iea.org](http://www.iea.org). Intergovernmental organization that promotes energy reliability, affordability and cleanliness for 30 member states.

**International Renewable Energy Agency**, Masdar City, P.O. Box 236, Abu Dhabi, United Arab Emirates; +971 24179000; [www.irena.org](http://www.irena.org). International organization created to study and promote the use of renewable energy.

**N.C. Clean Energy Technology Center**, 1575 Varsity Drive, Raleigh, NC 27606; 919-515-3480; [www.nccleantech.ncsu.edu](http://www.nccleantech.ncsu.edu). Clean-energy organization housed at North Carolina State University that maintains the Database of State Incentives for Renewables & Efficiency ([www.dsireusa.org](http://www.dsireusa.org)), which tracks government incentives for renewable energy.

**U.S. Energy Information Administration**, 1000 Independence Ave., S.W., Washington, DC 20585; 202-586-8800; [www.eia.gov](http://www.eia.gov). Branch of the U.S. Department of Energy that collects and publishes statistics and other information about energy use worldwide.