CLIMATE CENTRAL SOLUTIONS BRIEF: WIND ENERGY

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Research brief by
Climate Central

CLIMATE CENTRAL

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Part of the *Climate Solutions* series

INTRODUCTION

Wind energy is among the crucial tools needed to combat climate change. If aggressively coupled with other clean energy technologies, including solar, smart grids, battery storage, nuclear power, carbon capture on power plants and factories, and the use of electricity to power everything from cars to heating systems, experts say the U.S. could effectively eliminate its emissions of heat-trapping greenhouse gas pollution within a generation. In effect, this would enable the U.S. to meet the goals of domestic net-zero emissions by 2050.

Used for thousands of years to propel ships, crush grain and pump water, wind energy sputtered toward mainstream adoption in Europe and the U.S. in the 1970s, spurred by oil shortages and hikes in energy prices. But since the start of this century, wind energy growth in the U.S. has increased dramatically, and now accounts for 8.4% of utility-scale electricity. With advanced technology and lower costs, wind energy farms are now generating copious amounts of clean energy across the U.S. and providing farmers, ranchers, and local governments with substantial new sources of revenue while employing a growing army of workers, some of whom previously worked in fossil fuel jobs. While the U.S. has lagged behind Europe and parts of Asia in developing offshore wind, a number of projects are currently in the works, with expectations for at least 20 gigawatts (GW) operating off the East Coast by 2030 — similar to the output of ten large nuclear power plants.

This brief provides wind energy data, resources, and story and interview suggestions to help reporters find and tell compelling stories on wind energy within their own communities. Check the Climate Central website for other solutions briefs, including battery storage, getting to net zero, and solar energy.

TURBINE SHAPES AND SIZES

TYPE

Horizontal-axis wind turbine
- Most common style
- Three long blades resemble airplane propellers
- Blades face toward the wind to rotate and generate power

Vertical-axis wind turbine
- Does not need to face the wind to generate power
- Blades are more curved, shaped like beaters on a mixer
- Less common and also less effective at generating power

Utility scale, onshore wind
- Collection of turbines placed in a pattern on land ("wind farm")
- Wind farm generating capacities range from tens to hundreds of megawatts
- Connected to main electrical grid

Offshore wind
- Similar to utility scale wind farms, but sited in large bodies of water
- Individual turbines tend to be larger than onshore turbines

Distributed wind
- Wind turbines smaller than 100 kilowatts in capacity
- Directly powers a home or business; not connected to grid
- Very rare

SIZE

The taller the tower that holds the turbine, the longer the blades can be, meaning more energy gets generated and electricity prices decline.

With blades longer than football fields, research has also found that the larger the turbine, the greener the energy.

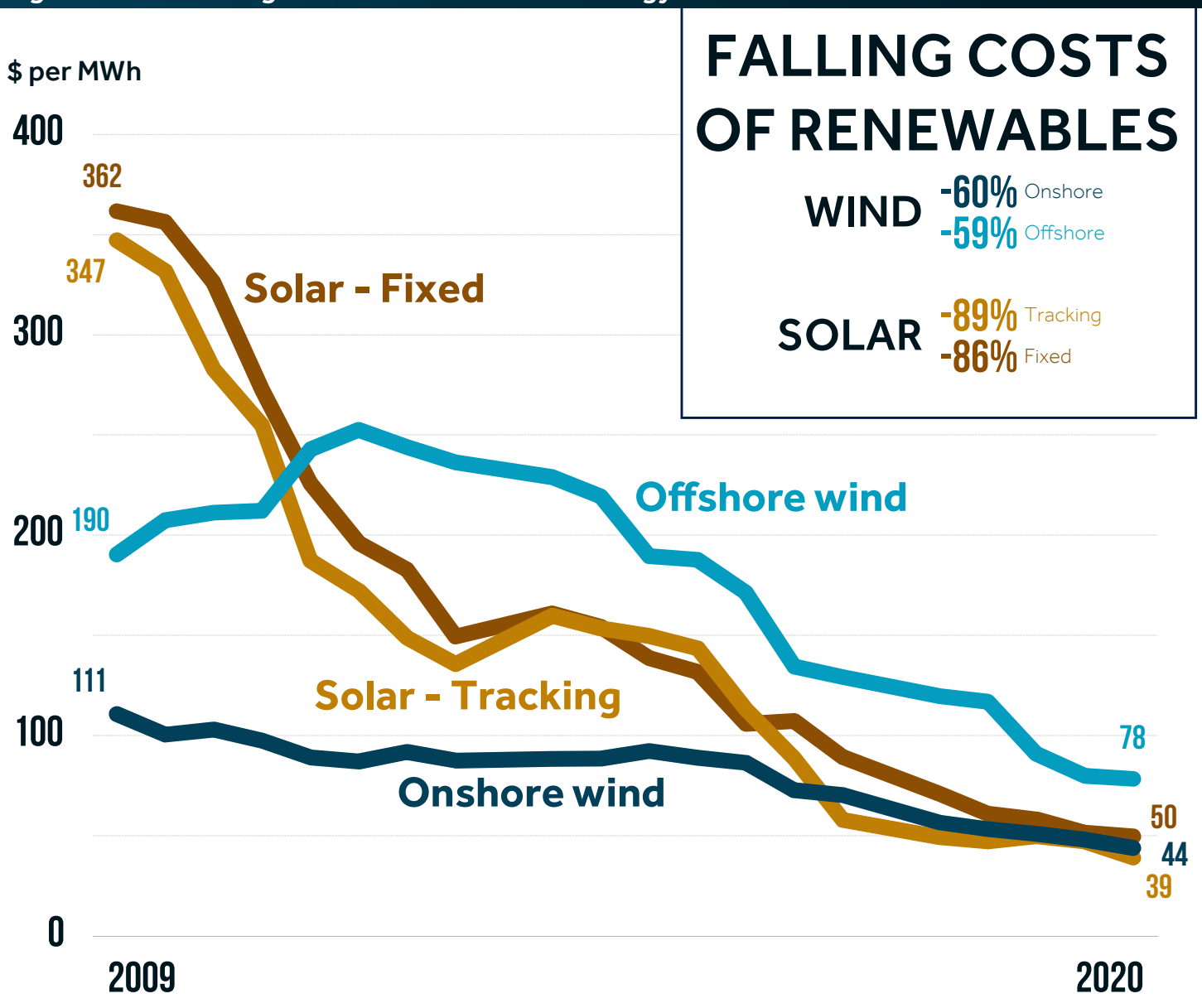
THE BASICS OF WIND ENERGY

Benefits of wind energy include its effectiveness in slowing climate change by producing electricity without releasing heat-trapping pollution associated with fossil fuels. Wind energy's replacement of coal and natural gas plants can protect human health against the effects of pollution and bring resilience to the nation's electrical grid. Finally, onshore wind farms are already bringing money to rural areas, and the entire wind industry is a growing source of jobs.

The U.S. Office of Energy Efficiency and Renewable Energy's Wind Energy Basics page describes how wind turbines convert kinetic energy from wind into electricity. Like solar energy, wind energy is variable — when breezes die down, so does energy production. But wind is a strong complement to solar, as it tends to generate more power at night. When combined with utility-scale battery storage, wind and solar are increasingly able to meet the power demands of the U.S. energy grid.

Wind generators are often far from where the electricity they generate is needed. Moving the power to neighborhoods and factories requires transmission lines. Because transmission lines are costly to build, and power is lost during transmission, it makes sense to locate wind farms closer to population centers and large industrial electricity customers. But because of their size, wind turbines are relatively rare inside dense urban environments. The sweet spot for a wind farm is in a windy environment on relatively flat land just outside a city.

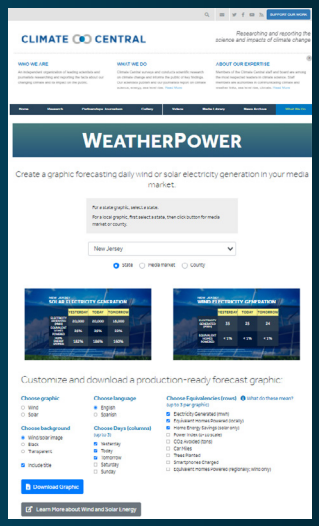
Figure 1. BloombergNEF Levelized Cost of Energy



ONSHORE WIND

Even during the pandemic, the wind energy sector continued its U.S. expansion in 2020. According to American Clean Power, an advocacy group representing renewable energy companies, the industry added 90 wind farm projects across 26 states with capacity totaling nearly 17 gigawatts.

The U.S. Wind Turbine Database, updated monthly, shows nearly 70,000 individual turbines now in operation nationwide. The turbines are producing clean energy and adding capacity to the grid, helping to reduce risks of blackouts. Although some initially blamed wind turbines for deadly outages in Texas during a cold storm this year, the main causes of the blackouts were failures of natural gas energy infrastructure.



WeatherPower

Climate Central's WeatherPower tool uses forecast weather conditions to project how much daily wind and solar electricity will be generated anywhere within the U.S. It generates easy-to-read graphics in English and Spanish.

Jobs

Job growth in the industry is strong. The wind energy sector needs people to manufacture wind turbine components and install wind turbines. Once the turbines are in place, technicians are needed to maintain them, and other professionals manage the systems that operate and draw power from the turbines.

Environmental Entrepreneurs (E2) most recent report concluded that the wind energy sector employs 117,000 of the nearly half million Americans working in renewable energy. That figure will be dwarfed if wind power continues to scale up. According to estimates from the Net-Zero America project, the wind sector could employ nearly 1.1 million Americans by 2050 with an effort that achieves net-zero greenhouse gas emissions by that year.

The U.S. Bureau of Labor Statistics says wind energy technicians and solar panel installers are America's fastest-growing job categories, with most wind energy technicians making $40,000 to $80,000 a year.

As employment opportunities for wind energy workers grow, community colleges and other organizations are setting up programs to help train them. The Energy Department publishes a database of nearly 200 such organizations nationwide on its searchable WINDExchange website and has a long list of careers within the sector.

Who works on wind?

The technicians that service turbines often work hundreds of feet from the ground. The trade attracts mechanically-minded people "who like working with their hands and the autonomy of being up there," said Neal Gyngard, a former wind energy technician.

"Most people that we see join the industry are mechanically sound, they grew up on a farm possibly, they just have a can-do attitude and sort out any issue. They're just trouble-shooters," Gyngard said.

Gyngard makes his living now organizing a national community of wind energy technicians. Funded by sponsors that sell hand tools and other specialist products needed by these workers, he hosts barbecues and other get-togethers nationwide. "I've got a truck and a trailer and we wrap it up in all these logos and make it a big to-do, and we head out to wind farms and specific regions."

From wind project development through to component manufacturing, construction and maintenance, the wind sector employs a diverse array of workers. More than 500 manufacturing facilities across the U.S. produce components for wind turbines and wind farms. In December, New Jersey announced plans for a $250 million facility in the state to build the steel structures that support offshore wind turbines, called monopiles.

How wind projects get developed: Lease payments, local taxes and state and federal policies

Two major drivers of wind energy growth are policy-related—federal tax incentives for wind generation and state mandates known as renewable portfolio standards. These state standards require utilities to include particular amounts of wind, solar, or other clean energy in their electricity sales. Other drivers include technological improvements and construction of larger turbines and projects, both of which drive down costs.

At the federal level, the Production Tax Credit provides financial incentives for developers of wind farms. These incentives have been inconsistent since the program began in 1992, causing slumps and spikes in construction activity. The tax credit will expire at the end of 2021 unless Congress votes to extend it again.

Researchers at Lawrence Berkeley National Laboratory found about half of the renewable energy capacity built across the U.S. since 2000 was associated with efforts to meet state-level renewable portfolio standards (RPSs). That figure declined to about a quarter in 2019, partly due to renewable energy growth now being driven by lower prices in places like Texas and the Midwest. Since the start of 2019, eight states have increased their renewable electricity targets to make up at least 50% of sales to residential and commercial consumers.

Although wind turbines have sparked opposition from those who fear for impacts on views or on the local ecosystem, individual farmers and rural communities have been welcoming. The wind farms bring monthly lease payments to property owners, while allowing farmers and ranchers to continue to use the vast majority of their land. And the ongoing projects provide tax revenues to local governments in addition to growing local employment opportunities.

According to estimates from the Rocky Mountain Institute's Seeds of Opportunity report, an aggressive rollout of clean energy in the U.S. could eventually lead to wind developer lease payments to farmers totaling $23 billion for projects that begin construction from 2020 to 2030. In addition to lease payments, the group estimated that over the lives of these wind farms, the turbine owners would pay $28 billion in local taxes, $10 billion in construction wages, and $47 billion in operating and maintenance wages.

Spotlight on Lincoln County, CO

- All of Colorado's installed wind capacity is located on its sparsely populated Eastern Plains.
- Much of the state's wind power is produced in a four-county region an hour or two from Denver that includes Lincoln, Elbert, Kit Carson and Cheyenne counties.
- There are five wind farms in the four-county region, with more coming.
- Lincoln County contains portions of all the four-county area's five wind projects, with taxes on those projects of $1.8 million a year representing 42% of the county's tax base.
- Also in Lincoln County, which has a population of fewer than 6,000 people, wind farms employ an estimated 45 to 50 people.
- "The increase in tax revenues coupled with payments to landowners is a significant addition to our local economy. Wind generation really is keeping many farming and ranching families solvent, and in business long term," said Lincoln County Economic Development Corporation Executive Director Troy McCue.

Source: Rocky Mountain Institute 2021 report Seeds of Opportunity

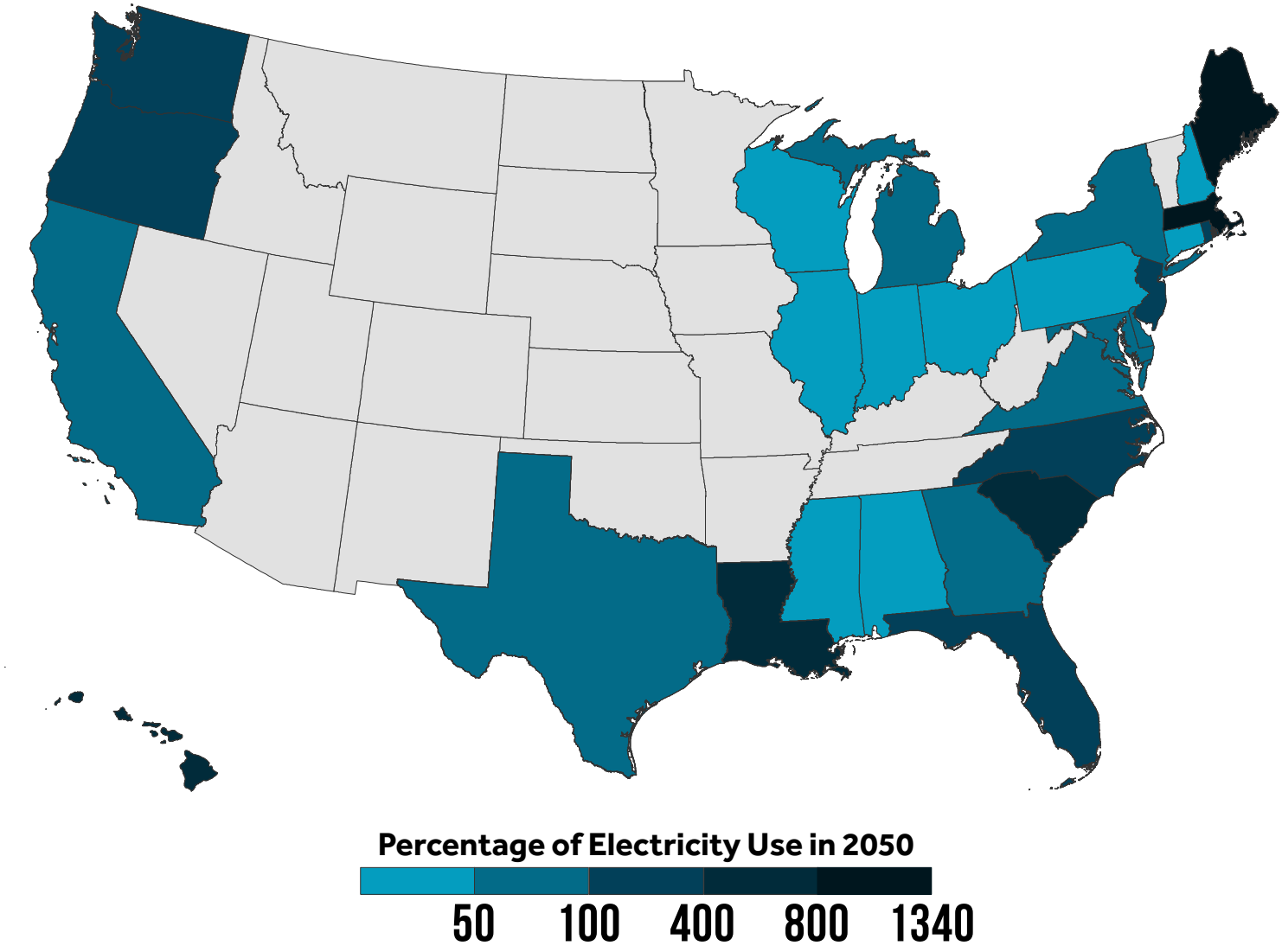
OFFSHORE WIND

The potential to generate clean power from offshore wind turbines along the East, West and Gulf coasts and in the waters of the Great Lakes is both vast and virtually untapped. While enormous wind farms now provide power to millions throughout Asia and Europe, just a handful of turbines have so far been installed in American waters.

Researchers at Environment America examined a variety of data published by the National Renewable Energy Laboratory and concluded that the U.S. could produce more than 7,200 terawatt-hours per year of electricity from offshore wind. (A terawatt-hour, or TWh, is one billion kilowatt-hours). This is nearly twice the amount of electricity the U.S. consumed in 2019, and it is about the amount that Environment America expects the U.S. to use in 2050—if we transition away from fossil fuels and electrify transportation, industry, and our buildings.

While the coming boom in wind energy off America's coasts is good news for the climate and economy, it has some commercial fishermen worried. They're concerned about disruption to fishing seasons during the construction of offshore wind turbines and about losing fishing grounds to the enormous turbines. Wind developers are working with fishing fleets to try to reduce these impacts and ease their fears.

Figure 2. Offshore Wind Potential



Source: Environment America, National Renewable Energy Laboratory

Spotlight on Massachusetts

In New England, after the success of a modest 30-megawatt wind farm offshore from Rhode Island, a larger project is coming to fruition. Construction of the Vineyard Wind Project off Massachusetts coast is further along than any other large-scale off-shore wind-farm in the U.S.

- Location: 15 miles off of Massachusetts
- First large-scale off-shore wind farm in the U.S.
- 800 megawatt peak generating capacity
- Features world's largest turbine design, capable of producing 13 megawatts apiece
- Will generate enough power to run 400,000+ homes and businesses
- Expected to reduce heat-trapping carbon dioxide emissions from fossil fuel plants by over 1.6 million tons per year

Source: Vineyard Wind

WILDLIFE IMPACTS AND SAFETY IMPROVEMENTS

Wind turbines are frequently criticized for their impacts on wildlife. Those impacts have fallen dramatically since the first-generation onshore wind farms were built on California's Altamont Pass in the 1970s, and steps are being taken to protect marine species from impacts of offshore wind farms, particularly during the construction phases.

Birds and bats

- According to U.S. Fish & Wildlife Service estimates between 140,000 and 500,000 birds are killed each year by crashing into wind turbines. (Bats are also killed.) While that number is expected to grow, it is about 200 times less than the estimated 100 million to 1 billion birds killed in the U.S. each year following collisions with buildings and windows. The deaths due to turbines are also much lower than the additional 60 million or more birds killed each year by cars. Other causes of bird mortality include cats, power lines, oil spills and the devastating effects of climate change.

- The Audubon Society says it "strongly supports wind energy that is sited and operated properly to avoid, minimize, and mitigate effectively for the impacts on birds, other wildlife, and the places they need now and in the future. To that end, we support the development of wind energy to achieve 100% clean electricity."

- The careful placement of onshore wind turbines and wind farms is one of the important ways the onshore wind industry is protecting wildlife from its turbines, alongside advances in turbine design. The U.S. Energy Department has published facts about these impacts and improvements on its website.

Whales and other marine wildlife

- Risks from offshore wind farms to whales, dolphins and other marine mammals are concentrated during the planning and construction phases. That's when seismic air gun surveying and pile driving cause loud underwater noises that can disorientate and even kill marine mammals. To protect marine life, particularly migratory species off the East Coast, federal protections include the imposition of restrictions on times of year when seismic surveying and piledriving may occur.

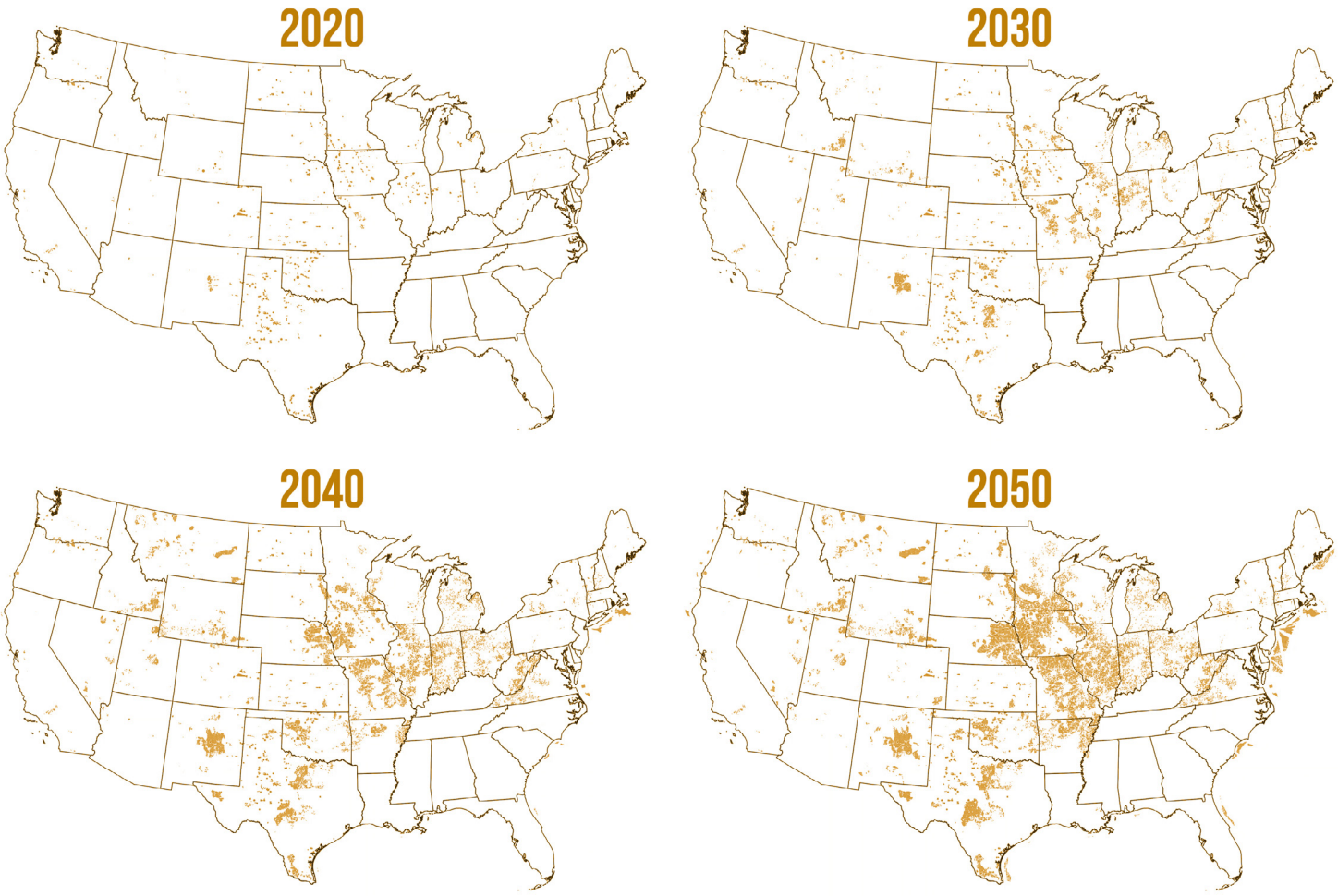
- To protect North Atlantic right whales, which is one of the world's most endangered species of whales, the Vineyard Wind project limits boating speeds, surveying activities, and turbine construction to times of year when the species is unlikely to be in the area.

REACHING NET ZERO

On Earth Day this year, the Biden administration pledged to cut U.S. greenhouse gas emissions to 50% of 2005 levels by the year 2030. This would set the country on a path toward reaching net zero emissions by 2050, in accordance with the Paris Climate Agreement goal to limit the increase in global temperatures to well below 2.0°C (3.6°F) above pre-industrial levels.

Net Zero America (NZA), a research initiative led by scientists and engineers at Princeton University, identified five pathways which would get the U.S. to net-zero emissions by 2050. In this section, we explore their "middle-of-the-road" scenario, the high electrification, or E+ scenario, and what it could mean for wind capacity and jobs over the next 30 years.

Figure 3. Evolution of Wind Projects, NZA High Electrification Scenario



Source: Net-Zero America

More clean power

Texas, which is already the largest producer of wind energy in the U.S., could continue to lead the country, with more than 180 gigawatts potentially installed by 2050, according to the NZA analysis. Missouri, Iowa, Illinois and Nebraska each could become home to more than 100 gigawatts. Regarding the potential of offshore wind generation only, New Jersey, New York, Maine and Massachusetts in the Northeast could be the biggest producers by 2050.

Figure 4. Potential for Wind Capacity under NZA High Electrification Scenario

Largest Total Wind Capacity in 2050 *(Total MWs)*	
Texas	183,925
Missouri	155,043
Iowa	143,702
Illinois	135,080
Nebraska	113,660
Minnesota	84,661
New Mexico	79,939
Montana	62,633
Oklahoma	57,483
Arkansas	57,370

Largest Total Offshore Wind Capacity in 2050 *(Total MWs)*	
New Jersey	39,330
New York	28,731
Maine	28,516
Massachusetts	26,167
Maryland	15,370
South Carolina	11,769
Oregon	9,476
Florida	9,078
Texas	8,930
Delaware	8,319

Source: Net-Zero America

More clean jobs

According to the NZA analysis, these advances in wind power would need a large workforce that installs and maintains the turbines, many of which are secured atop towers that are hundreds of feet tall. While the NZA analysis indicates that solar jobs would multiply rapidly from now until 2050, the biggest jumps in wind jobs would begin in the latter half of the 2020s and into the 2030s, when offshore generation starts ramping up. This means states like West Virginia, which has a lot of potential for wind generation, are at risk of seeing time lags between losses of fossil fuel jobs early in the transition and gains in wind energy jobs that might replace them.

By 2050, more than 130,000 people could be working in the wind industry in Texas, and more than 50,000 each in Midwestern states like Missouri, Illinois, Iowa and Nebraska. Looking at jobs by population, the rural states of Wyoming, Nebraska, Montana and Iowa could expect more than 200 jobs for every 10,000 residents.

Figure 5. Potential for Wind Jobs under NZA High Electrification Scenario

Largest Total Number of Wind Jobs in 2050 *(Total # of Jobs)*		Largest Per Capita Wind Jobs in 2050 *(Jobs per 10k people)*		Change in Per Capita Wind Jobs 2030-2050 *(Additional Jobs per 10k people)*	
Texas	137,867	Wyoming	325	Nebraska	234
Missouri	75,034	Nebraska	287	Montana	231
Illinois	71,532	Montana	280	Iowa	169
Iowa	69,200	Iowa	222	Maine	147
Nebraska	54,454	New Mexico	182	Wyoming	126
Minnesota	43,043	South Dakota	172	South Dakota	115
New York	40,607	Maine	154	Missouri	72
New Mexico	37,946	North Dakota	145	New Mexico	71
Oklahoma	34,543	Missouri	123	Arkansas	70
New Jersey	30,016	Arkansas	97	North Dakota	67

Source: Net-Zero America

Transmission

Miles of new transmission lines are expected to be built to deliver electricity from the new wind farms to the cities where they are needed, as well as new distribution lines to get it into the homes and businesses where the power is used — to charge electric cars, trucks and tractors. The high costs of building and maintaining these lines is the main influence when locating rural wind farms as close as possible to cities.

Figure 6. Potential for Transmission Expansion, NZA High Electrification Scenario

Year	Cumulative new builds	Total trans. capacity	Increase from 2020 *(%)*
2025	98,500	418,500	31
2030	196,000	516,000	61
2035	331,500	651,500	104
2040	448,500	768,500	140
2045	667,200	987,200	209
2050	691,700	1,011,700	216

Source: Net-Zero America

GLOSSARY

Capacity - The maximum output of electricity that a generator can produce under ideal conditions, typically determined as a result of performance tests. Capacity is generally measured in megawatts or kilowatts.

Generation - The amount of electricity that is actually produced over a specific period of time, measured in megawatt-hours or kilowatt-hours.

Power Grid (or transmission system) - the interconnected group of power lines and associated equipment for moving electric energy at high voltage between points of supply and points at which it is delivered to other electric systems or transformed to a lower voltage for delivery to customers.

Tower - Supports the structure of a wind turbine and is made of tubular steel, concrete, or steel lattice.

Wind Turbine - a machine that converts the kinetic energy in the wind into mechanical power (electricity).

Source: Energy.gov