



U.S. Department of Energy Regional Resource Centers Report: State of the Wind Industry in the Regions

Ruth Baranowski, Frank Oteri,
Ian Baring-Gould, and Suzanne Tegen
National Renewable Energy Laboratory

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Technical Report
NREL/TP-5000-62942
March 2016

Contract No. DE-AC36-08GO28308



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Prepared under Task No. WE14.BB01

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Acknowledgments

The authors wish to thank the U.S. Department of Energy Wind and Water Power Technologies Office for funding the Regional Resource Centers, this report, and broader stakeholder engagement and education efforts, including the WINDEXchange initiative. Thanks also to Patrick Gilman, Maggie Yancey, and Amber Passmore for their leadership and support.

Thanks to the Regional Resource Centers for their work and contributions to this document:

- **Four Corners Wind Resource Center:** Sarah Cottrell Propst, Meghan Dutton, Rebecca Nelson, Amanda Ormond, Karin Wadsack, Sarah Wright
- **Islanded Grid Resource Center:** Suzanne MacDonald, Stephanie Nowers, Chris Rose, Brooks Winner
- **Midwest Wind Energy Center:** Lisa Daniels, Karen Majewicz, Tom Wind
- **Northeast Wind Resource Center:** Maria Blais Costello, Deborah Donovan, Warren Leon, Val Stori, Anthony Vargo, Paul Williamson
- **Northwest Wind Resource and Action Center:** Mia Devine, Jennifer Grove, Julie Peacock, Rachel Shimshak, David Wolf
- **Southeast Wind Energy Resource Center:** Jen Banks, Mary Hallisey Hunt, Katharine Kollins, Jon Miles.

Thanks to individuals from the National Renewable Energy Laboratory who reviewed the report (Dave Corbus and Brian Smith), provided input (Robi Robichaud), and work behind the scenes to support the Regional Resource Centers project and its many aspects (Corrie Christol and Julie Jones).

The authors also wish to thank the following individuals and organizations for their contributions to this report: Bruce Burcat, Mid-Atlantic Renewable Energy Coalition; Mike Kostrzewa, Colorado State University; Kylah McNabb, Oklahoma Department of Commerce; Ruth Douglas Miller, Kansas State University; Dan McGuire, McGuire Consulting; Nancy Rader, CalWEA; Remy Pangle, James Madison University; Susan Stewart, Pennsylvania State University; Rich Stromberg, Alaska Energy Authority; Brent Summerville, Appalachian State University; Heather Thomson, Mid-Atlantic Renewable Energy Coalition; and Michael Twedt, South Dakota State University.

List of Abbreviations and Acronyms

4CWRC	Four Corners Wind Resource Center
BOEM	Bureau of Ocean Energy Management
CNMI	Commonwealth of the Northern Mariana Islands
CREP	Community Renewable Energy Project
DOE	U.S. Department of Energy
MW	megawatt
MWEC	Midwest Wind Energy Center
NREL	National Renewable Energy Laboratory
NWRC	Northeast Wind Resource Center
PURPA	Public Utility Regulatory Policies Act
RPS	renewable portfolio standard
RRC	Regional Resource Center
SWERC	Southeast Wind Energy Resource Center

Executive Summary

Significant expansion of wind energy deployment will be required to achieve the President's goal of doubling renewable energy production in the United States by 2020. Wind energy currently provides more than 4% of the nation's electricity but has the potential to provide much more. In 2014, the U.S. Department of Energy (DOE) established six wind Regional Resource Centers (RRCs) to provide information about wind energy, focusing on regional qualities.

The wind industry and DOE are addressing technical challenges to increasing wind energy's contribution to the national grid (such as reducing turbine costs and increasing energy production and reliability), and they recognize that public acceptance issues can be challenges for wind energy deployment. Wind project development decisions are best made using unbiased information about the benefits and impacts of wind energy. Well-informed decision-makers and communities are better prepared to navigate the sometimes contentious development process, maximizing the benefits experienced while reducing potentially negative impacts when deploying wind in their regions. Expanding the nation's wind energy portfolio requires high-impact, regionally specific strategies to inform the policy and permitting processes and improve public discourse, thereby reducing conflict around deployment decisions and ultimately increasing the annual rate of wind deployment.

This document summarizes the status and drivers for U.S. wind energy development on regional and state levels. It is intended to be a companion to DOE's *2014 Distributed Wind Market Report* (U.S. DOE 2015a), *2014 Wind Technologies Market Report* (U.S. DOE 2015b), and *2014 Offshore Wind Market and Economic Analysis* (Navigant 2014) that provide assessments of the national wind markets for each of these technologies. Figure ES.1 shows the installed capacity of wind energy in the United States as of December 2015.

The RRCs have identified a wide array of market challenges that continue to hinder wider-scale deployments of wind technologies. Highlighted by region in the following sections, these issues include:

- Insufficient transmission capacity and the need for transmission improvements
- Energy market modifications (such as more liquid bilateral markets for integration resources, 15-minute scheduling, and development of regional energy imbalance markets)
- Lack of local wind siting or zoning ordinances; ordinances that do not reflect best practices or do not allow the flexibility in wind development to address small, distributed, community, or utility-scale wind projects
- Integration challenges and costs
- Lack of clear federal policy
- Need for public education and engagement of wind siting issues, exacerbated by misinformation and negative public opinion regarding wind energy

- Poor understanding of wind energy’s economic impacts, including local tax benefits, jobs and economic development, and turbine manufacturing
- State and regional competition
- Challenges with development on federal and native lands
- Need to advance the state-of-the-art in power sector resource planning processes, ensuring that accurate wind information is utilized in utility integrated resource and state-based clean energy planning
- Need for science-based resource planning in siting guidelines, especially for development in sage grouse and other environmentally sensitive areas
- Restricted access to capital; limited financing, funding, and technical assistance for small/community/distributed wind development

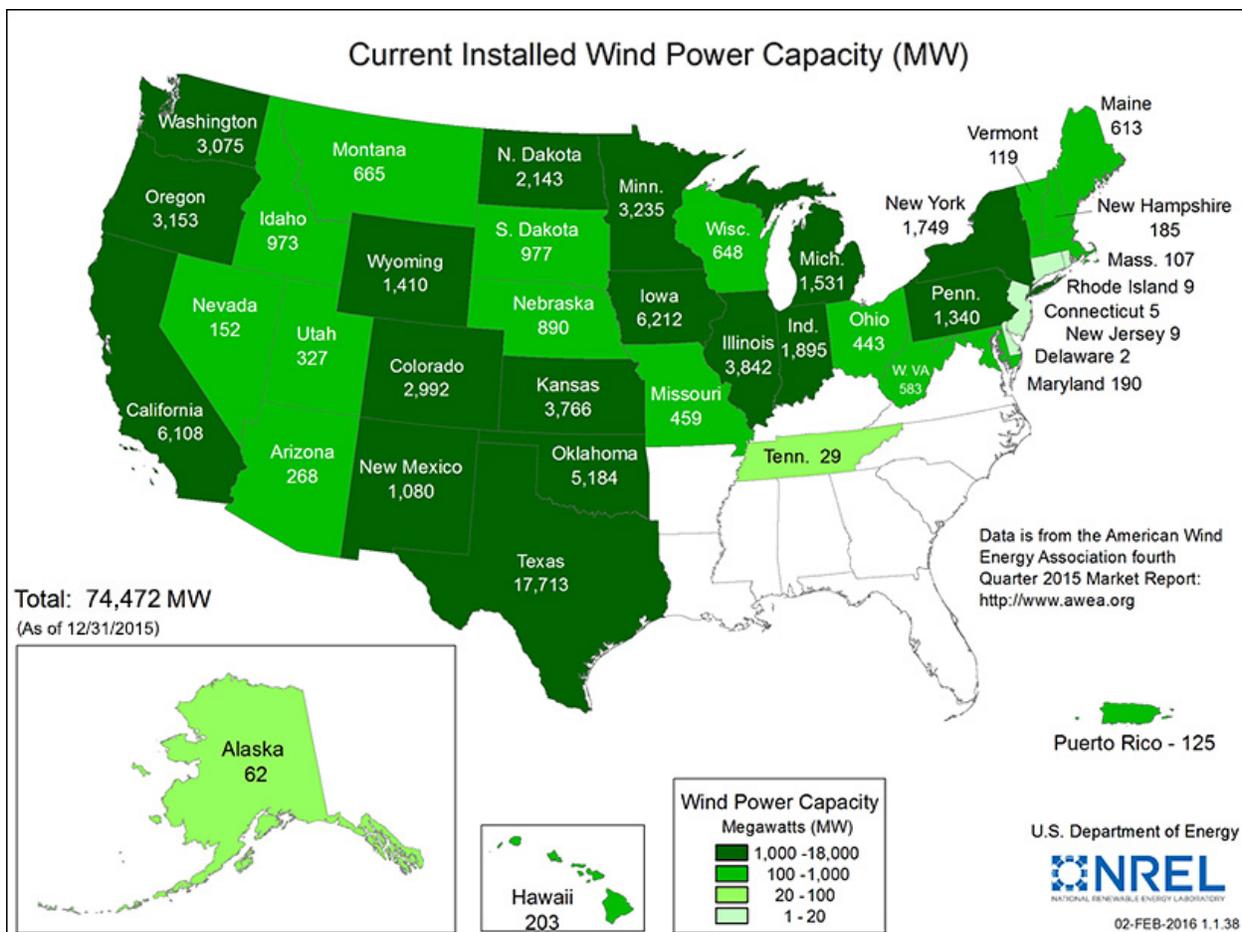


Figure ES-1. Installed wind capacity in the United States as of December 2015

- The high costs of offshore wind energy, lack of independent information and outreach geared toward innovative regional procurement targets, attracting financing, alternative financing mechanisms, and regional supply chain development

- Complexity of the offshore wind regulatory process; addressing technical issues related to installation, interconnection, and operation; researching and mitigating environmental impacts; interacting with other human uses; and public acceptance of offshore wind
- The fact that there are no full-scale offshore wind turbines currently deployed in the United States, leading to an inability to build credibility around the market opportunity.

Focused primarily on isolated, islanded power systems in Alaska, coastal New England, and the Territories of the United States, the Islanded Grid Resource Center identified additional distinct challenges unique to their situation. The primary development challenge in their region: the up-front cost of deploying a sophisticated wind-diesel system in an isolated, remote, or islanded area with relatively low technical and human capacity. Since most of these islanded power grids are located a distance away from the road system, transportation and mobilization costs are much higher than they are for communities in other regions on the road system. Besides transportation and mobilization, another challenging cost driver is scale.

There are several wind energy development challenges for large islanded grids in the Railbelt transmission system¹ in Alaska. They include the region's heavy dependence on natural gas-fired power; the risk-adverse nature of the six utilities serving the region, which prevents them from accepting wind energy; a relatively weak, inflexible grid that makes it more difficult to integrate wind power; lack of clear regulatory policy that defines the rules of engagement between those utilities and independent power producers that wish to develop wind; lack of a universal transmission tariff; lack of any regional generation and transmission planning; and lack of any regional transmission organization or independent system operator.

In general the goal of the RRCs is to make it easier for stakeholders and decision-makers to decide whether responsible and appropriate wind project development is right for their communities by producing relevant, actionable, and fact-based information and to deliver that information in useful forms to those who need it when they need it.

In their first year, the DOE's RRCs have had a tremendous impact on key stakeholders, engaging them in wind power issues in their communities and regions. The RRCs reported more than 22,000 touches with key stakeholders and have positively "engaged" more than 12,600 people, moving them toward wind power acceptance as a viable option to address the nation's long-term energy needs. Engagements were typically made through events such as meetings with identified stakeholders, interactive webinars, workshops, tours, and presentations at topical regional conferences. Additional efforts were undertaken through outreach products such as handouts, meeting materials, and newsletters, while direct engagement with regional media organizations was also supported. In total, more than 1.2 million people were identified as being reached by RRC outreach efforts. More targeted efforts ensured that key stakeholders received information that allowed them to include wind technology in plans or policies that had either not included wind or that included outdated wind information.

In addition to outreach activities to provide science-based information to key stakeholders, several RRC projects are underway that may help support expanded wind development. These include:

¹ A small, isolated transmission system in Alaska that covers the state's population centers along the main railroad line, including the Seward, the Kenai, Anchorage, Wasilla, and north to Fairbanks.

- The Northeast Wind Resource Center developed web-based information resources and a set of evaluation criteria that can be applied to information resources so that stakeholders can discern their suitability for decision-making or journalistic coverage.
- The Northwest Wind Resource and Action Center developed a Distributed Wind Siting Toolkit that provides guidance to local decision makers about developing smart siting and zoning regulations.
- The Island Institute, as part of the Islanded Grid Resource Center, produced a community engagement handbook for offshore wind development.

The overall wind industry experienced record growth in 2015, rivaling the highest deployment levels of previous years. Congress recently approved 5-year extensions of the Production Tax Credit and Investment Tax Credit, which will undoubtedly spur further wind project developments. However, uncertainty lingers around the lack of stable policy for distributed wind technologies, as well as consistent approaches around the implementation of the federal Clean Power Plan, the wider role of energy in addressing climate change impacts, state renewable portfolio standards, net metering, and other state-based incentives. These uncertain policies are among other challenges that the RRCs continue to address.

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1 Introduction

Significant expansion of wind energy deployment will be required to achieve the Obama Administration’s goal of doubling renewable energy production in the United States by 2020. Additionally, the 5-year extension of the federal Production Tax Credit (PTC) and potential early impacts of the state-based responses to the Clean Power Plan also point to robust wind development through the rest of the decade. Wind energy currently provides more than 4% of the nation's electricity but has the potential to provide much more (U.S. DOE 2015d). Increasing the country's electricity percentage from wind power means cleaner energy, leading to cleaner air and water for the nation, lower energy costs over the long term, and reduced water usage in the power sector.

The wind industry and the U.S. Department of Energy (DOE) Wind and Water Power Technologies Office are addressing technical challenges to increasing wind energy's contribution to the national grid (such as reducing turbine costs and increasing energy production and reliability), and they recognize that public acceptance issues (i.e., wind farm opposition) are barriers to wind energy deployment. Wind energy is a rapidly evolving technology that can play an important role in the U.S. energy generation mix, and credible information about it and the diversity of its possible applications should be communicated to a variety of stakeholders. In 2014, DOE established six Regional Resource Centers (RRCs) to fill this role, providing information to familiarize the public with wind energy, raising awareness about potential benefits and issues, and disseminating data on siting considerations such as turbine sound and wildlife habitat protection.

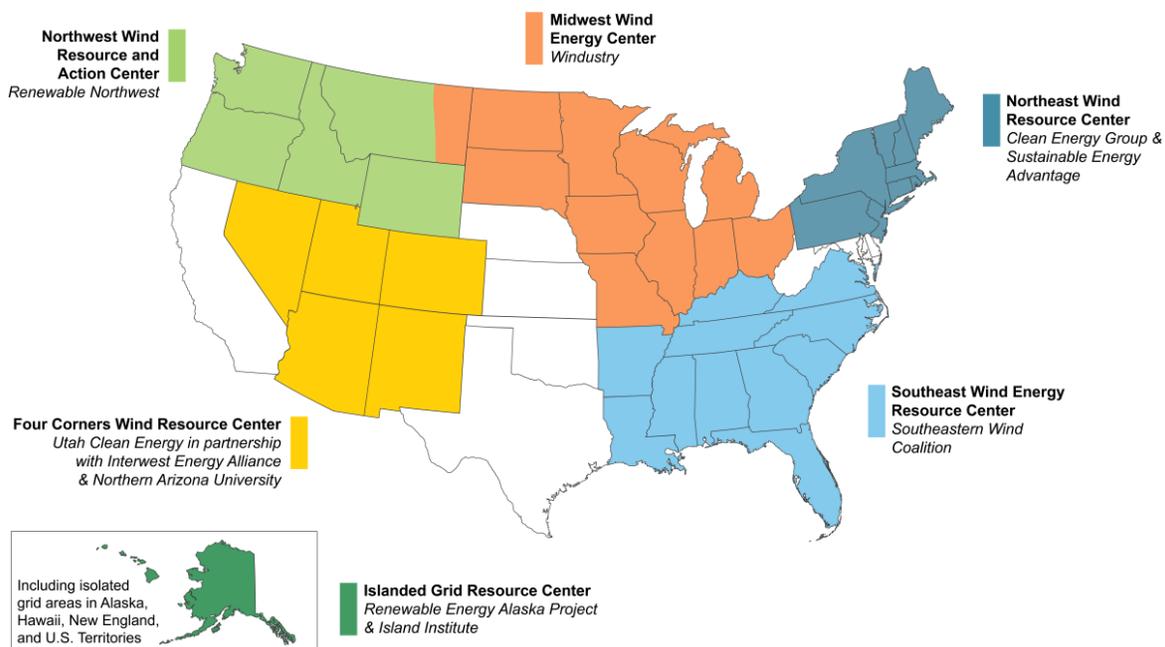


Figure 1. Map of Regional Resource Centers

The goal of the DOE RRC project is to make it easier for stakeholders and decision-makers to decide whether responsible and appropriate wind project development is right for their communities by:

- Producing relevant, actionable, and fact-based information
- Delivering that information in useful forms to those who need it when they need it.

The RRCs are as follows (in alphabetical order here and in the report sections):

- **Four Corners Wind Resource Center**, serving Arizona, Colorado, New Mexico, Utah, Nevada, and part of Wyoming
- **Islanded Grid Resource Center**, serving Alaska, Maine, Massachusetts, Rhode Island, Hawaii, Guam, American Samoa, Commonwealth of Northern Marianas, and U.S. Virgin Islands
- **Midwest Wind Energy Center**, serving eastern Montana and Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, North Dakota, Ohio, South Dakota, and Wisconsin
- **Northeast Wind Resource Center**, serving New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) and New York for land-based wind, and that same region plus New Jersey for offshore wind
- **Northwest Wind Resource and Action Center**, serving Washington, Oregon, Idaho, western Montana, and part of Wyoming
- **Southeast Wind Energy Resource Center**, serving North Carolina, Florida, Louisiana, South Carolina, Georgia, Alabama, Mississippi, Virginia, Kentucky, Tennessee, and Arkansas.

Each RRC applies a unique regional context to identify key stakeholders in the area. Stakeholders may include, for example, county commissioners, state legislators, landowners, tribal authorities, and organizations such as utilities, schools, and non-profit agencies. During their first year of operations, the RRCs reached more than 22,000 key stakeholders and documented that 12,600 of these stakeholders took actions, demonstrating a wider acceptance of wind technology deployment.

This “state of the regions” report provides an overview of each RRC region, describing the regional and state markets for wind development, impact of the current policy environment, and updates on the progress to inject credible information into regional discussions and activities to mitigate the use of biased or misleading information, allowing fair consideration of projects in areas where wind projects could be built.

The role of this document is to summarize the status and drivers for U.S. wind energy development on regional and state levels. This document is intended to be a companion to the Energy Department’s *2014 Distributed Wind Market Report* (U.S. DOE 2015a), *2014 Wind Technologies Market Report* (U.S. DOE 2015b), and *2014 Offshore Wind Market and Economic Analysis* (Navigant 2014) that provide assessments of the national wind markets for each of these technologies.

2 Four Corners Wind Resource Center

The Four Corners Wind Resource Center worked with National Renewable Energy Laboratory (NREL) researchers to provide the following assessment of the state of the wind industry in this region.

The Four Corners Wind Resource Center (4CWRC)² is managed by Utah Clean Energy in partnership with Interwest Energy Alliance and Northern Arizona University. The RRC targets wind energy stakeholders in Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming. Collaborating in this region allows the 4CWRC to leverage the experience of states with more historic wind deployment experience, like Colorado, Wyoming, and New Mexico, to inform stakeholders and expand markets in Utah, Nevada, and Arizona, including tribal lands. Additionally, the commonalities among the states enable a centralized approach to addressing wind barriers that further leverages resources and efforts within the region. For example, as the region experiences increasing droughts and water shortages, both of which are exacerbated by changes in climate, these arid Southwest states share an interest in water conservation and water-wise energy resources.

Similarly, air quality and haze issues relating to the region's fossil fuel-intensive energy mix is an increasingly critical issue for the states in the region. In light of emerging federal regulations on greenhouse gas emissions from power plants, reducing the carbon intensity of the Western generation mix is increasingly pertinent. As such, the RRC's collaborative efforts focus on promoting the water-saving, air quality, and emissions mitigation benefits of wind energy along with the ripe opportunities this resource provides to meet the West's growing energy needs. Furthermore, coordination and engagement on relevant Western regional transmission, integration, and interconnection issues, including the implementation of an energy imbalance market,³ support regional and national efforts to address key barriers to expanding wind power in the Western market.

The following section provides an overview of the wind industry in the 4CWRC region.

2.1 Renewable Portfolio Standards

Two of the states in the 4CWRC region have a renewable portfolio standard (RPS) targeting 2020 (Colorado and New Mexico), two have an RPS targeting 2025 (Arizona and Nevada), and Utah has a renewable portfolio goal instead of a standard (Table 1). Wyoming does not currently have an RPS.

Several pieces of legislation to reduce or otherwise roll back the Colorado and New Mexico RPSs were introduced during the 2015 legislative sessions but did not pass. In New Mexico, the state's House of Representatives voted in favor of reducing the 20% by 2020 renewable energy requirement (Montoya Bryan 2015). The effort stalled as the Senate's Conservation Committee voted to keep the bill from advancing to a full Senate vote (KOB4 2015).

² <http://www.fourcornerswind.org/>

³ An energy imbalance market is a means of supplying and dispatching electricity to balance fluctuations in generation and load. It aggregates the variability of generation and load over multiple balancing authority areas.

Colorado’s Senate Bill 44 intended to halve the state’s 30% by 2020 renewable requirement for large utilities while reducing the standard for rural electricity associations from 20% to 15% starting in 2020. The state’s House of Representatives voted down the effort (Bunch 2015). The constitutionality of the state’s RPS was also upheld in the Tenth Circuit Court of Appeals, ending litigation that began in 2011 (Proctor 2015).

Table 1. Key Statistics for the Four Corners Wind Resource Center Region

	AZ	CO	NM	NV	UT	WY
Installed Wind, 2015 (MW) ⁴	268	2,992	1,080	152	327	1,410
Percentage of Energy Supplied by Wind Projects (2014) ⁵	0.4%	13.6%	7.0%	0.8%	1.5%	8.9%
Projected Potential Capacity (MW), 80 m, 30% CF	10,904	387,220	492,083	7,247	13,103	552,072
Projected Potential Capacity (MW), 100 m, 30% CF	25,791	429,456	568,112	12,034	26,237	593,769
Contribution from Distributed Wind Projects, 2014 (MW) ⁶	3.33	28.8	36.6	12.3	1	5.9

Table 2. RPS Overview for Four Corners Wind Resource Center States

RPS	
Arizona	15% by 2025 30% by 2020 (investor-owned utilities) 20% by 2020 (co-ops serving 100,000 or more meters) 10% by 2020 (co-ops serving fewer than 100,000 meters and municipal utilities serving 40,000 or more customers)
Colorado	
Nevada	25% by 2025 20% x 2020 (investor-owned utilities)
New Mexico	10% x 2020 (electric co-ops)
Utah	Goal of 20% by 2025
Wyoming	None

2.2 Workforce Development

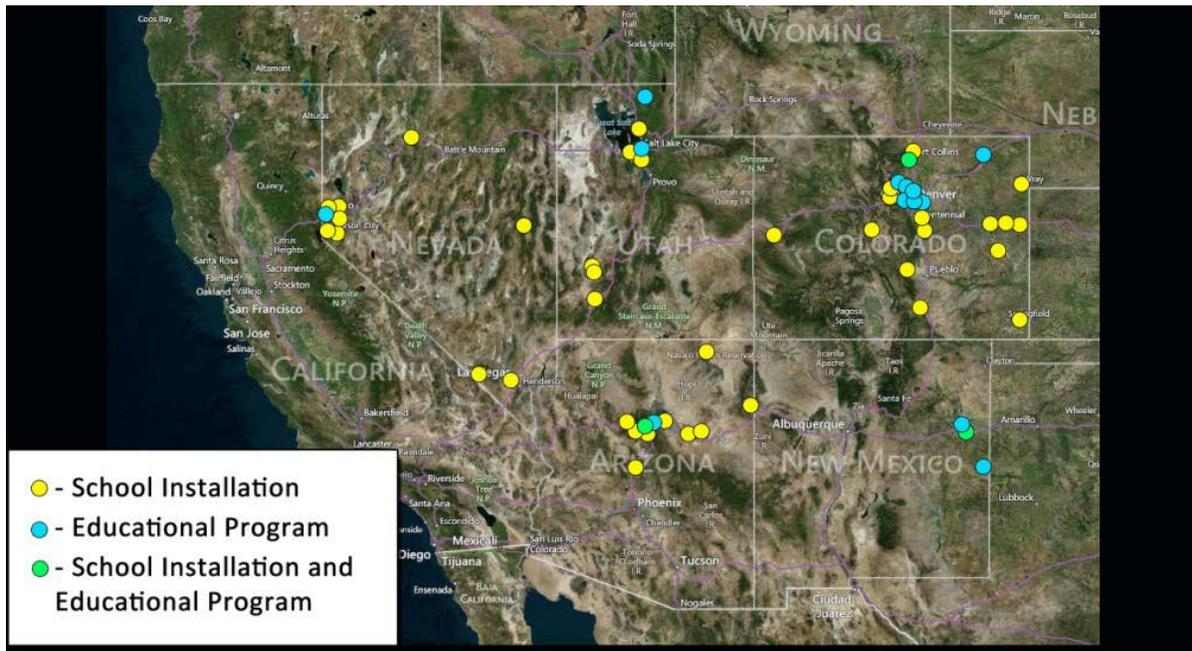
The 4CWRC region has a strong and well developed wind energy educational infrastructure with colleges or universities active in all six states in the region; see each state section for specifics. The WINDEXchange website also offers information and interactive maps regarding workforce development, the DOE’s Collegiate Wind Competition, the DOE’s Wind for Schools project,

⁴ 2015 Year End Wind Power Capacity Map. Available at http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp

⁵ U.S. Energy Information Administration Electricity Data Browser. Available at <http://www.eia.gov/electricity/data/browser/#/topic/0?agg=1,0,2&fuel=008&geo=0000000001jo&sec=o3g&freq=A&start=2001&end=2014&ctype=linechart<ype=pin&rtype=s&maptype=0&rse=0&pin=>

⁶ Distributed wind project installed capacity is defined as 2003-2014 cumulative capacity (DOE 2015a).

school wind project locations, and locations of education and training programs in the 4CWRC region and other states.⁷



Four Corners Wind Resource Center (NV, UT, CO, AZ, NM)

Figure 2. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs within the Four Corners Wind Resource Center’s area

2.3 Manufacturing

NREL researchers compiled the following wind energy manufacturing data for this region as part of DOE’s annual wind market report effort (DOE 2015c). Nevada, New Mexico, Utah, and Wyoming do not have any manufacturing facilities supporting the wind industry. In Table 3, Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

Table 3. Wind-Related Manufacturing Overview for Four Corners Wind Resource Center States

Name	City	State	Component	Tier
Power-One	Phoenix	AZ	Power converters	II
Cobham Slip Rings	Prescott	AZ	Slip rings	II
Primus Windpower	Lakewood	CO	Distributed wind	I
Vestas	Windsor	CO	Blades	I
Vestas	Brighton	CO	Blades	I
Woodward Governor	Fort Collins	CO	Inverters	II
SGB USA	Wheat Ridge	CO	Electrical	II

⁷ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

Name	City	State	Component	Tier
PMC Technology	Golden	CO	Hydraulics	II
O'Neal Steel	Pueblo	CO	Tower internals	II
Aluwind	Castle Rock	CO	Tower internals	II
Vestas	Pueblo	CO	Towers	I
Vestas	Brighton	CO	Turbine (nacelle assembly)	I

2.4 Key Stakeholder Groups and Deployment Challenges

The 4CWRC targets three stakeholder groups:

- Utility regulators, commissioners, utility representatives, and staff
- State, local, and tribal decision makers and staff
- Interested members of the public.

The information provided to these stakeholder groups addresses the following wind energy deployment market barriers that are prevalent in this region:

- Insufficient transmission capacity that has historically hindered growth in the region
- Lack of local wind siting ordinances or ordinances that do not reflect best practices
- Wind technology costs and outputs
- Integration challenges and costs
- Lack of clear policy direction supporting wind
- Misinformation and negative public opinion regarding wind energy
- Wildlife issues
- Challenges with development on federal land.

2.5 Collaborating Organizations

Organizations that have collaborated with the 4CWRC include:

- Advanced Energy Economy
- American Wind Energy Association
- Arizona Governor's Office of Energy Policy
- Beaver County, Utah
- Coconino County, Arizona
- Colorado Energy Office
- Colorado State University Center for the New Energy Economy
- Distributed Wind Energy Association
- Hopi Tribe Renewable Energy Office
- Hualapai Tribe Planning Office
- Lincoln County, Colorado
- New Mexico Renewable Energy Transmission Authority

- State of New Mexico Energy, Minerals and Natural Resources Department
- State of Utah Office of Energy Development
- Summit County Council
- Western Area Power Administration.

2.6 State Updates

Although the 4CWRC contributes to engagement activities in Wyoming, in this report the state's activities are listed in the Northwest Wind Resource and Action Center's section.

2.6.1 Arizona

By the end of 2015, Arizona had 268 megawatts (MW) of installed wind capacity (WINDEXchange 2016). The wind industry in Arizona supplied \$710,000 in annual land lease payments to farmers, ranchers, and other landowners (AWEA 2015a).

Wind energy development in Arizona slowed down with the fulfillment of state utility RPS goals; the instability of the federal Production Tax Credit; BP's exit from renewable energy development; and the preference of the Hualapai Tribe, Navajo Nation, and Hopi Tribe for solar development over wind. Development ceased on a number of projects that were well underway with feasibility or pre-construction studies. These include BP's wind project (up to 500 MW), Gray Mountain (500 MW) and Big Boquillas (180 MW) on the Navajo Nation, and Hualapai (170 MW) and Hopi (100 MW) proposed projects. In addition, developers of the Sunshine Wind Project permitted for 40 MW for Foresight Renewables elected not to renew the county permit. Resource assessment is taking place in a number of counties, but there is no indication that projects will be built in the near term.

The 4CWRC is working with the Hopi Tribe on resource assessment activities and tribal council education on wind development steps and is supporting the Hualapai Tribe in pursuing additional wind resource assessment.

Arizona is also participating in the DOE Wind for Schools project; Northern Arizona University has led the effort and the installation of 18 school systems in the state. Northern Arizona University also participated in the 2014 Collegiate Wind Competition and is an entrant for the 2016 Competition.

2.6.2 Colorado

The wind industry is a thriving market in Colorado, with wind power providing nearly 14% of the electricity generated in the state by the end of 2014. By the end of 2015, Colorado had 2,992 MW of installed wind capacity (WINDEXchange 2016). The wind industry in Colorado provided a total capital investment of \$4.8 billion across 24 projects and more than \$7.8 million in annual land lease payments to farmers, ranchers, and other landowners (AWEA 2015c). Communities benefit from a broader tax base, which helps to pay for roads, schools, and other critical public projects.

Colorado's RPS has helped to spur wind development in the state. The original RPS was established when Colorado voters approved Amendment 37 in 2004, and the legislature has

made several adjustments over the years. Investor-owned utilities must meet a 30% by 2020 renewable standard. Legislation passed during the 2013 session increased the standard for electric co-ops serving 100,000 or more electric meters to 20% by 2020 and left the standard at 10% by 2020 for smaller co-ops and municipal utilities.

Recent low prices for wind power have spurred procurement over and above state RPS requirements. The Colorado Public Utilities Commission approved a 2011 Public Service Company of Colorado's request to add 450 MW of new wind resources acquired at unprecedented low bid prices, finding that the wind energy would save ratepayers \$231 million from the displacement of fuel and variable operating costs required by facilities powered by fossil fuels (Xcel Energy 2015). Diversifying Colorado's energy supply with wind provides long-term price stability, protecting consumers when natural gas prices suddenly increase.

Like many states, barriers to increased wind development in Colorado include instability of the federal Production Tax Credit and transmission constraints. Public Service Company of Colorado is exploring the possibility of joining a regional transmission energy imbalance market, which could provide additional opportunities for Colorado wind. Continued low costs of wind, compliance with the Environmental Protection Agency's Clean Power Plan, and Public Service Company of Colorado's ongoing improvements in integration and forecasting technology present opportunities for more Colorado wind power.

Colorado has been heavily engaged in wind energy education, with university programs at Colorado State University, University of Colorado at Boulder, and the Colorado School of Mines. These three educational organizations have teamed with NREL to develop the Center for Research and Education in Wind,⁸ a research center under the Colorado Renewable Energy Collaboratory. The Colorado School of Mines also participated in the 2014 Collegiate Wind Competition. Colorado also participates in the DOE's Wind for Schools project; Colorado State University leads the effort with 12 school systems currently installed in the state. The Ecotech Institute in Aurora, Colorado, hosts an extensive wind technician training program.

2.6.3 New Mexico

At the end of 2015, New Mexico was home to 1,080 MW of installed wind capacity (WINDEXchange 2016) with 330 MW under construction (AWEA 2015h). State utilities are on track to meet a 20% by 2020 RPS for investor-owned utilities and 10% by 2020 for rural electric co-ops. In addition to the RPS, the state's renewable energy production tax credit (available for wind, solar, and biomass) has contributed to wind project development in the state. The New Mexico Energy, Minerals & Natural Resources Department recently commissioned an economic analysis of the state renewable energy production tax credit, which was published in February 2015. The study indicated that between 2003 and 2012, the state expended \$61.6 million on the production tax credit (of which \$54.2 million was for wind projects). For these same projects and time period, the study estimates the total labor income impacts to New Mexico's economy were \$434 million and more than 9,000 jobs, with more than 80% of the impact coming from wind facilities. The study estimates an additional value of more than \$400 million of avoided emissions in the state (New Mexico Energy, Minerals and Natural Resources Department 2015).

⁸ <http://crew.colorado.edu/>

New Mexico's relatively slow economic recovery from the global recession combined with a small, rural population presents challenges for finding in-state markets for new wind development. In addition, utilities serving New Mexico customers have frequently chosen solar PV in relatively small megawatt procurements for RPS compliance. New Mexico's state utilities and the Public Regulation Commission have not demonstrated a willingness to consider beyond-RPS renewable energy purchases.

The most significant opportunities for New Mexico wind are likely in western markets beyond its borders. While there are transmission constraints for exports, several major projects are underway, including SunZia, Southline, and Western Spirit.

The Southwest Technology Development Institute based at New Mexico State University has a long history of outreach and development work focusing on distributed wind technologies.

2.6.4 Nevada

Nevada's first (and only) utility-scale wind project, Spring Valley, came online in 2012 near Ely. Spring Valley is a 152-MW project with total capital investment of approximately \$280 million (AWEA 2015g). While wind developers remain interested in Nevada, wind energy developers face competition from the state's strong solar and geothermal resources. However, NV Energy's recent announcement that it plans to join the regional energy imbalance market could help to create additional opportunities for Nevada wind power throughout the region.

The state still faces many hurdles regarding the wildlife impacts or perceived potential impacts associated with wind energy. Concerns include golden eagles (Brean 2015), Mexican free-tailed bats, and desert tortoises. These hurdles have resulted in project delays and increased measures to reduce impacts from Spring Valley. An additional challenge related to the expansion of wind energy in Nevada pertains to siting issues on or near federal lands (Emmerich 2015) (which comprise 81.1% of Nevada's total acreage) (Congressional Research Service 2014). Figure 3 shows the U.S. wind resource at 80 meters overlaid with federal land.

2.6.5 Utah

Utah has four wind projects online with a total of 327 MW of installed capacity and 144 MW under construction. The industry supplies nearly \$1 million in annual land lease payments to farmers, ranchers, and other landowners (AWEA 2015o). Two of the four wind projects are located in Beaver County, where these projects increased the tax base from \$680 to more than \$3 million, paying for a new hospital, a new elementary school, and improved road infrastructure.

Challenges to wind development in Utah include the state's use of a voluntary renewable energy goal of 20% by 2025 instead of a mandatory standard, a lack of available transmission capacity, issues siting on or near federal lands that comprise 66.5% of Utah's total acreage (Congressional Research Service 2014), lack of wind siting ordinances, developer efforts focused on solar prior to the scheduled reduction of the federal investment tax credit for solar, and integration challenges including costs. The 4CWRC is working to address many of these challenges.

PacifiCorp's recent announcements that it plans to join the regional energy imbalance market and explore the possibility of joining the California ISO could help to create additional opportunities for Utah wind power throughout the region.

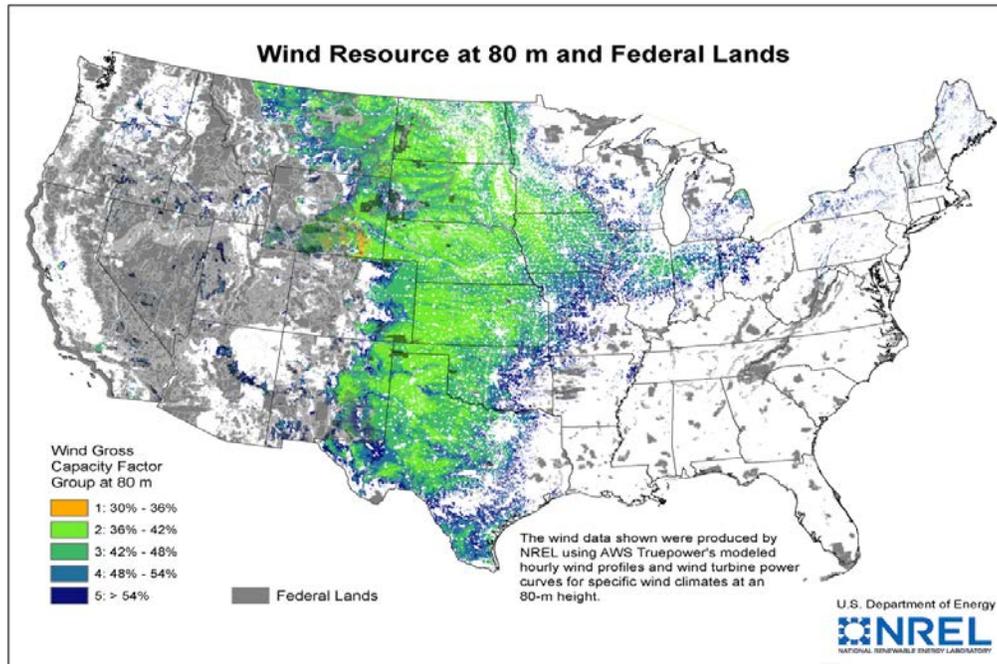


Figure 3. Wind resource at 80 meters overlaid with federal lands

3 Islanded Grid Resource Center

The Islanded Grid Resource Center worked with NREL researchers to provide the following assessment of the state of the wind industry in this region.

Interested parties of the Islanded Grid Resource Center⁹ are located in Alaska, Maine, Massachusetts, Rhode Island,¹⁰ Hawaii, Guam, American Samoa, Commonwealth of the Northern Mariana Islands (CNMI), and U.S. Virgin Islands. The three main focus areas of the RRC are wind-diesel systems, megawatt-scale systems on islanded grids, and support for island communities in close proximity to proposed commercial-scale offshore wind and other ocean energy projects. Any interested party may join the group.

Although not linked geographically, islanded grid communities share common challenges and opportunities for wind development. Most have small populations with limited human capacity and sub-optimal infrastructure. Transportation and distribution costs tend to be higher than in other parts of the country, exacerbating financing challenges. Many of these communities have severe climates and/or are being impacted by climate change and rising sea levels. Most rely on expensive diesel fuel (subject to volatile price swings) to generate electricity and therefore share technical difficulties associated with wind integration. Reliance on diesel fuel comes with a host of environmental concerns, including meeting emissions standards, the need for bulk fuel storage, and the potential for diesel spills. However, many of the islanded grid communities have excellent wind resources, with some in close proximity to proposed offshore wind projects.

Because islanded communities are remote and geographically distant, many of these jurisdictions have not traditionally communicated with each other about progress related to wind energy implementation. Currently, islands and islanded regions have few places to turn for help. These regions rarely can look to wind development on large-scale grid systems as models, and, with sparse funding and resources, they have limited ability to do testing and development work on their own.

The following section provides an overview of the wind industry in the Islanded Grid Resource Center region.

Table 4. Key Statistics for the Islanded Grid Resource Center Region

	Alaska	Guam	Hawaii	NE Islands
Installed Wind, 2015 (MW)	66	.005	203	4.5
Percentage of Energy Supplied by Wind Projects	2%	<1%	5%	
Projected Potential Capacity (MW), 80 m, 30% CF	2,902		3,265	

⁹ <http://islandedgrid.org/>

¹⁰ Maine, Massachusetts, and Rhode Island are also part of the Northeast Wind Resource Center region.

	Alaska	Guam	Hawaii	NE Islands
Projected Potential Capacity (MW), 100 m, 30% CF	3,765 ¹¹		3,564	
Contribution from Distributed Wind Projects, 2014 (MW) ¹²	12.9		.7	4.5

3.1 Renewable Portfolio Standards

Alaska does not have an RPS but has a renewable energy goal to be 50% powered by renewables by 2025. Hawaii enacted an RPS in 2001 and includes wind as an eligible technology in its standard. Applicable sectors are investor-owned utilities and rural electric cooperatives. Each of the U.S. Territories covered by this RRC has an RPS with the exception of American Samoa, which does not yet have one, and the U.S. Virgin Islands, which has renewable targets.

Table 5. RPS Overview for Isolated Grid Resource Center States and Territories

	RPS
Alaska	Target: 50% of electrical generation by 2050
American Samoa	None
Guam	5% of net electricity sales from renewables by 2015 and 25% of sales by 2035
Hawaii	30% of net electricity sales by 2020/100% of sales by 2045
CNMI	20% of net electricity sales by 2016.
Maine	40% of net electricity sales by 2017
U.S. Virgin Islands	Targets: 20% by 2015; 25% by 2020; 30% by 2025; increasing until 51% of generating capacity is derived from renewable or alternative energy

3.2 Workforce Development

The Power Systems Integration Lab (formerly the Alaska Wind-Diesel Wind Application Center) is located at the University of Alaska-Fairbanks and supports educational programs through the Alaska Center for Energy and Power. The University of Alaska Fairbanks has also participated in the Collegiate Wind Competition and, in collaboration with the Renewable Energy Alaska Project, supported a state Wind for Schools effort. The Alaska Institute for Technology has also supported technical curricula associated with the operation and maintenance of wind energy as part of its remote power system technician training curricula, supporting wind deployment in remote and isolated communities. See the map below for the locations of other school projects. The WINDEXchange website also offers information and interactive maps regarding workforce development, the DOE's Collegiate Wind Competition, the DOE's Wind

¹¹ Estimates provided by Alaska Energy Authority Wind Program Manager Rich Stromberg, based on developable land likely being limited to private land

¹² Distributed wind project installed capacity is defined as 2003-2014 cumulative capacity (DOE 2015a).

for Schools project, school wind project locations, and locations of education and training programs in the Islanded Grid region and other states.¹³



Figure 4. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs within the Islanded Grid Resource Center's area

3.3 Manufacturing

There is no wind-related manufacturing in the region.

3.4 Key Stakeholder Groups and Deployment Challenges

The Islanded Grid Resource Center targets these stakeholder groups:

- Utilities and wind operators
- Researchers and technical experts
- Trade associations and non-profits
- Military
- Policymakers, elected and non-elected
- Manufacturers and supply chain businesses
- General public.

The information provided to these stakeholder groups addresses the following wind energy deployment market barriers that are prevalent in this region:

¹³ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

- The primary development challenge facing wind-diesel development is the upfront cost of deploying a sophisticated system in a remote area with relatively low technical and human capacity. Since most of these grids are off the road system, transportation and mobilization costs are much higher than they are for communities in other regions on the road system. Besides transportation and mobilization, another challenging cost driver is scale.
- There are several wind energy development challenges for large islanded grids in the Railbelt transmission system¹⁴ in Alaska. They include the region's heavy dependence on natural gas-fired power; the risk-adverse nature of the six utilities serving the region, which prevents them from accepting wind energy; a relatively weak, inflexible grid that makes it more difficult to integrate wind power; lack of clear regulatory policy that defines the rules of engagement between those utilities and independent power producers that wish to develop wind; lack of a universal transmission tariff; lack of any regional generation and transmission planning; and lack of any regional transmission organization or independent system operator.



Figure 5. Island Institute team members met with Maine island residents to discuss energy development options for islanded communities. Photo courtesy of Islanded Grid Resource Center

¹⁴ A small, isolated transmission system in Alaska that covers the main population centers of the state along the main railroad line including the Seward, the Kenai, Anchorage, Wasilla, and north to Fairbanks

3.5 Collaborating Organizations

Organizations that have collaborated with the Islanded Grid Resource Center include:

- Alaska Center for Energy and Power
- Alaska Congressional Delegation
- Alaska Energy Authority
- Alaska Federation of Natives
- Alaska Power and Telephone Company
- Alaska Village Electric Cooperative
- American Samoa Power Authority
- American Wind Energy Association
- Bergey Windpower Company
- Chugach Electric Association
- College of the Atlantic
- Commonwealth Utilities Corporation (CNMI)
- Cook Inlet Region Inc.
- Cuttyhunk Electric
- Distributed Wind Energy Association
- Endurance Wind Power
- Fox Islands Electric Cooperative
- Guam Power Authority
- Hawaii Natural Energy Institute
- Kodiak Electric Association
- Maine Congressional Delegation
- Maine PUC
- Marsh Creek LLC
- Martinicus Isle Plantation
- Monhegan Plantation Power District
- Naushon Trust
- Ocean Renewable Power Company
- Sgurr Energy
- Solar Electric Light Fund
- Star Island Corporation
- State of Alaska
- Swan's Island Electric Cooperative
- Town of Nantucket
- Town of New Shoreham
- University of Alaska Anchorage Institute of Social & Economic Research
- University of Maine
- U.S. Virgin Islands Energy Office
- U.S. Department of Agriculture Rural Development
- Utility Variable-Generation Integration Group.

3.6 State and Territory Updates

3.6.1 Alaska

Alaska has two distinct markets for wind development: larger communities that are connected by the Railbelt and rural communities that are completely isolated from the state's grid. At the end of 2015, Alaska had 62 MW of installed wind capacity, including 41 MW of capacity added since 2012 on the Railbelt grid that serves Anchorage, the main population center. One notable

success is the 9-MW system located on Kodiak Island.¹⁵ Coupled with hydro and a battery and flywheel system, this system made the island 99.7% powered by renewables.

Barriers to wind development in Alaska continue to be cost and the fact that high-contribution wind systems are technically complicated. The Islanded Grid Resource Center shares information on technical barriers, including control systems, secondary load control, and the use of energy storage. Other barriers include limited technical training, support, and human capacity-building for remote communities; limited financing; misalignment of the state's power cost equalization fuel subsidy and incentives to decrease diesel usage; complicated foundation technology (due to areas of permafrost); high mobilization, construction, and logistics costs; and lack of understanding of the long-term benefits and applicability of wind technology to reduce usage of imported fuel options.

In the past year, the state experienced a severe fiscal shock as the price of oil dropped precipitously and drastically reduced the state's revenues. As a result, the Alaska Renewable Energy Fund, the state's primary renewable energy driver, has experienced and could continue to experience major funding cuts by the state legislature into the near future. Several entities are working to make private, alternative financing available and to increase the percentage of state funds that are available for resource assessments and feasibility studies. Energy stakeholders are also working to reform the power cost equalization program to provide incentives for communities to use less diesel through renewables and efficiency. In the Railbelt, there has been significant progress toward establishing an independent system operator that would set a universal transmission tariff and help level the playing field for new wind developments. Progress has also been made in creating a private transmission company to finance needed transmission upgrades to further facilitate economic dispatch of the grid by the independent system operator.

Alaska participates in the Wind for Schools project. The University of Alaska Fairbanks worked to help install seven school systems in the state, participated in the 2014 Collegiate Wind Competition, and is an entrant for the 2016 Competition.

3.6.2 American Samoa

American Samoa, an unincorporated territory of the United States, is a group of five islands about halfway between Hawaii and New Zealand in the South Pacific Ocean. The territory's only utility, the American Samoa Power Authority, provides electric, water, wastewater, and solid waste utility services for its 12,300 customers. American Samoa is almost completely dependent on fossil fuels for meeting its energy generation needs. In 2014, the peak load averaged about 22 MW with annual diesel generation totaling 154 million kilowatt-hours. To date, American Samoa Power Authority has installed 2 MW of photovoltaic solar panels near the Pago Pago International Airport, which generates about 2% of the utility's power. American Samoa currently has no wind projects installed. In 2013, the governor established the American Samoa Renewable Energy Committee, which developed a strategic energy plan and energy action plan. The plan includes a goal for Manu'a Islands, American Samoa's easternmost group, to be 100% powered by renewables by 2016.

¹⁵ Learn more at <http://islandedgrid.org/100-renewably-powered-alaskas-kodiak-island-goes-all-in-with-wind-and-hydro/>

3.6.3 Hawaii

Hawaii's governor signed a law requiring 100% of Hawaii's electricity to be generated by renewable sources by 2045, increasing the state's former renewable energy goal of 40% clean energy by 2040 (Hawaii Clean Energy Initiative 2015). Hawaii had 203 MW of installed wind capacity as of the end of 2015 (WINDExchange 2016), providing 5% of the state's electricity. The state has substantial renewable resources throughout the island chain and has a robust wind regime with wind farms' capacity factors exceeding those commonly found elsewhere. Utility-scale wind potential is found onshore and offshore, with the state's six commercial wind farms on Oahu, Maui, and the "big island" of Hawaii. There are two proposals for offshore wind development off Hawaii's coasts. The 408-MW Alpha Wind Energy floating offshore wind farm, which would transmit electricity to Oahu through an undersea cable, has submitted a license proposal with the Bureau of Ocean Energy Management (BOEM).

Hurdles to wind development in Hawaii include endangered avian and plant species that can complicate the siting and development of wind projects in Hawaii's unique environments. Visual impacts can also be of concern, given the height of wind turbines and limited sites suitable for wind development in Hawaii.

3.6.4 Guam

Guam, the largest island in Micronesia, is located in the Pacific Ocean about three-fourths of the way from Hawaii to the Philippines. Surrounded by coral reef, Guam sits on the edge of the Mariana Trench and its Challenger Deep, the deepest known place on earth. Guam has no renewable resources and meets nearly all of its energy needs, including electricity, with petroleum products shipped in by tanker. The island's population is estimated to be about 161,000, plus 12,000 to 14,000 military personnel and their dependents.

Guam has substantial wind potential but also unique siting issues. It is seismically active and is in the Pacific's Typhoon Alley, so wind turbines must be engineered to resist earthquakes and typhoon-force winds. Other barriers to wind deployment on Guam include limited land, potential windy sites on privately owned land, concerns over aesthetics of wind turbines, a large amount of military land that may create issues with zoning variances, no local tax incentive, bat concerns, and other potential environmental impacts. Both the Navy and Guam Power Authority have conducted wind resource mapping and assessments, and the Guam Power Authority installed a 275-kW turbine in 2015 as a pilot project (Dumat-ol Daleno 2016). Guam currently has a renewable energy portfolio goal that calls for 5% of net electricity sales to come from renewable energy resources by 2015, increasing to 25% by 2035.

3.6.5 Commonwealth of the Northern Mariana Islands

The CNMI is a chain of 14 islands in the Pacific Ocean, located between Hawaii and the Philippines. Only three islands on the southern end of the island chain are currently inhabited: Saipan, Tinian, and Rota. About 9 in 10 residents live on Saipan, the largest island. The population has been shrinking and totaled about 54,000 in the 2010 U.S. Census. The islands meet nearly all of their energy demand through imported petroleum products, including 22 million to 24 million gallons of diesel fuel annually to run the islands' five electricity-generating plants. The CNMI's electric system is owned and operated by the Commonwealth Utilities Corporation, a public corporation of the CNMI government. The CNMI has three small electric

grids, one on each of the inhabited islands. Generating capability is about 70 MW on Saipan, 20 MW on Tinian, and 4.5 MW on Rota.

Saipan, Tinian, and Rota are believed to have prevailing wind resources suitable for commercial turbines. However, potential sites are limited because the islands are mountainous, land is scarce, and turbines may interfere with airstrip and military facilities. There are also concerns about turbine impacts on several threatened bird species. Turbines must also be designed to withstand typhoons.

3.6.6 *Maine and Other Northeast Island Communities*

Several New England island communities have investigated community-scale wind as a cost-effective option for reducing high, primarily diesel-based energy costs, but none of the islands has installed wind power generation since the 4.5-MW Fox Islands Wind Project was constructed in 2009. The Deepwater Wind project off Block Island, Rhode Island, is also in development but does not represent island projects because of its interconnection to the main grid. The Islanded Grid Resource Center has worked with the Block Island community and other island communities that face the potential development of large-scale offshore wind projects.

3.6.7 *U.S. Virgin Islands*

The U.S. Virgin Islands is a U.S. territory located in the Caribbean, about 600 miles from Miami, Florida. The U.S. Virgin Islands has two separate electricity grids, each with its own generation, managed by the Water and Power Authority, an independent government agency. Generating units include combustion, steam turbines, and backup diesel, all fueled by imported petroleum. The 199-MW St. Thomas system supplies nearby St. John and Water Island by underwater cable. The 122-MW St. Croix system, separated from St. Thomas by 40 miles of ocean, has its own grid. The USVI government's goal of reducing fossil fuel use 60% by 2025 has led to working with U.S. federal agencies and industry to find other energy sources. More than half of reductions are planned to come from energy efficiency, particularly in generation, transmission, street lighting, and desalination, with the balance coming from wind, solar, and biomass technologies, including waste-to-energy and landfill gas.

The U.S. Virgin Islands has potential commercial wind energy resources, but finding the large sites needed for utility-scale projects on the islands has been a challenge. The most promising locations for utility-scale wind projects are on high ridges and exposed capes. Wind data collected in 2012 and 2013 at potential sites around Longford on St. Croix and the Bovoni Peninsula on St. Thomas found wind speeds suitable for large turbines that could play a meaningful part in helping the U.S. Virgin Islands meet its 60% by 2025 goal. The Virgin Islands Water and Power Authority, in conjunction with the Virgin Islands Energy Office, completed wind studies to determine the economic feasibility of wind power development in the territory. As of July 2015, the Water and Power Authority is negotiating with several qualified facilities proposing wind projects that were approved by the Public Services Commission pursuant to the Cogeneration and Small Power Production Act. The size of the proposed wind farm is 7 to 10.5 MW.

4 Midwest Wind Energy Center

The Midwest Wind Energy Center (MWEC) worked with NREL researchers to provide the following assessment of the state of the wind industry in this region.

The MWEC¹⁶ serves the following states: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, eastern Montana, North Dakota, Ohio, South Dakota, and Wisconsin. The MWEC's main organizer is Windustry. Other key players are the Iowa Wind Energy Association and Tom Wind of Wind Utility Consulting. The following section provides an overview of the wind industry in the region.

The MWEC states have different levels of wind resources (Figure 6). The states in the western portion of the region (Montana, the Dakotas, Iowa, and western Minnesota) have strong, world-class winds and vast rural areas. The states in the eastern portion of the region (Ohio, Missouri, Indiana, and Michigan) have moderate and low wind resources. Additionally, some states (Illinois, Ohio) have dense populations in some of their windiest areas and are limited in the extent of their land-based development (assuming 80-m hub heights).

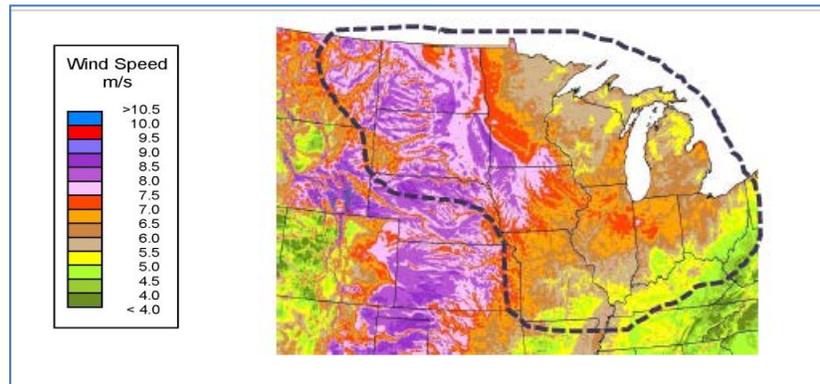


Figure 6. MWEC footprint and average wind speeds at 80 meters

Eight of the states in the MWEC region are in the top 20 nationally in installed wind capacity, and four MWEC states have 15% or higher in-state wind generation. The MWEC region is a strong national leader in distributed wind, defined as wind turbines of any size serving local loads, on either side of the meter, the retail customer side for on-site load or the wholesale side for large loads nearby.

Overall, the states in this region have vastly different energy demands, with many existing energy plants in transition. This region has historically relied heavily on central station coal and nuclear plants for most of its electricity generation. These plants are aging, and other energy sources such as wind and solar are abundant locally.

The energy demand of the most populous state, Illinois, is spurring development of dedicated transmission for renewable energy. Two large transmission projects dedicated to addressing wind generation in the MWEC region are currently in the planning process. One project is the Rock

¹⁶ <http://www.midwestwindenergycenter.org/>

Island Clean Line, a 500-mile overhead direct current transmission line that will deliver 3,500 MW from northwest Iowa and the surrounding region to communities in Illinois and other states to the east. Another planned project is the Grain Belt Express Clean Line, a 750-mile direct current transmission line that will connect the rich wind resources of Kansas to Missouri, Illinois, Indiana, and markets farther east.

Table 6. Key Statistics for the Midwest Wind Energy Center Region

	IL	IN	IA	MI	MN	MO	MT ¹⁷	ND	OH	SD	WI
Installed Wind, 2015 (MW) ¹⁸	3,842	1,895	6,212	1,531	3,235	459	665	2,143	443	977	648
Percentage of Energy Supplied by Wind Projects, 2014	5%	3%	29%	2%	16%	1%	6.5%	16%	.8%	21%	2%
Projected Potential Capacity (MW), 80 m, 30% CF	249,882	148,228	570,714	59,042	489,271	274,355	944,004	770,196	54,920	882,412	103,757
Projected Potential Capacity (MW), 100 m, 30% CF	329,618	183,832	601,957	179,056	603,427	399,635	1,012,355	771,791	123,328	890,626	215,447
Contribution from Distributed Wind Projects, 2014 (MW) ¹⁹	21.7	8.5	121.2	4	125.4	7.6	4.9	8.1	37.3	3.2	26.4
Proposed Offshore Wind Projects (MW)	0	0	0	0	0	0	0	0	27 ²⁰	0	0

4.1 Renewable Portfolio Standards

In the MWEC region, eight states have an RPS (Illinois, Iowa, Michigan, Minnesota, Missouri, Montana, Ohio, and Wisconsin) and three states have a renewable energy goal (Indiana, North Dakota, and South Dakota).

¹⁷ Montana is divided between two RRCs: Northwest Wind Resource and Action Center (western Montana) and Midwest Wind Energy Center (eastern Montana). For this report, each RRC provided data for the entire state.

¹⁸ 2015 Year End Wind Power Capacity Map. Available at http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp

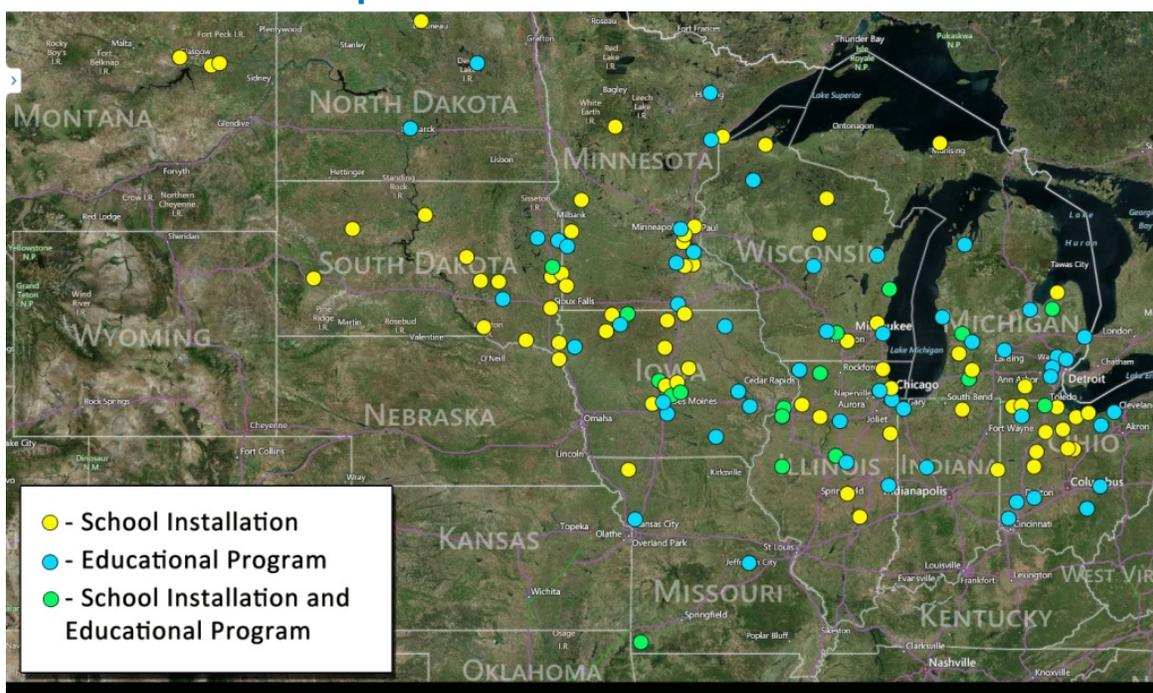
¹⁹ Distributed wind project installed capacity is defined as 2003-2014 cumulative capacity (DOE 2015a).

²⁰ On Lake Erie

Table 7. RPS Overview for Midwest Wind Energy Center States

	RPS
Illinois	25% x 2026
Indiana	Clean Energy Portfolio Goal of 15% x 2025
Iowa	IOUs must contract for a total of 105 MW of renewables
Michigan	10% x 2015
Minnesota	26.5% x 2025 (investor-owned utilities) 31.5% x 2020 (Xcel) 25% x 2025 (other utilities)
Missouri	15% x 2021
Montana	15% x 2015
North Dakota	Goal of 10% x 2015
Ohio	12.5% x 2026, but frozen at 2014 level of 2.5% until 2017
South Dakota	Goal of 10% x 2015
Wisconsin	10% x 2015

4.2 Workforce Development



Midwest Wind Energy Center (Eastern MT, ND, SD, MN, IA, MO, WI, IL, IN, MI, OH)

Figure 7. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs within the Midwest Wind Energy Center’s area

Educating the future generations of wind energy technicians, engineers, and stakeholders plays a key role in developing the domestic wind workforce. Iowa Lakes Community College was one of the first in the country to offer a wind technician training program and has been providing wind energy education since 2003. Now several community colleges and universities in the

Midwest offer wind energy training and education. Figure 7 shows the school installations and educational programs for wind energy in the MWEC area. Educational activities are described in more detail in the state sections below. The WINDEXchange website also offers information and interactive maps regarding workforce development, the DOE’s Collegiate Wind Competition, the DOE’s Wind for Schools project, school wind project locations, and locations of education and training programs in the MWEC region and other states.²¹

4.3 Manufacturing

NREL researchers compiled the following wind energy manufacturing data for this region as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

Table 8. Wind-Related Manufacturing Overview for Midwest Wind Energy Center States

Name	City	State	Component	Tier
Winergy Drive Systems	Elgin	IL	Gear drive	I
Siemens/Winergy	Elgin	IL	Gear drive	I
Brad Foote Gear Works	Cicero	IL	Power transmission gears	II
HYDAC	Glendale Heights	IL	Hydraulics, brake systems	II
Finkl and Sons	Chicago	IL	Components	II
Centa Corp.	Aurora	IL	Couplings	II
Deublin Company	Waukegan	IL	Slip rings, hydraulic components	II
R&W America	Bensenville	IL	Couplings	II
Stanley Machining & Tool Corp.	Carpentersville	IL	Gear cases, torque arms, planetary carriers	II
Randack Fasteners America	Lake Zurich	IL	Bolts	II
SMF	Minonk	IL	Embed rings, template rings	II
Chicago Industrial Fasteners	West Chicago	IL	Blade studs	II
Trinity Structural Towers	Clinton	IL	Towers	I
Carlisle Industrial Brakes and Friction	Bloomington	IN	Brakes	II
Oerlikon Fairfield	Lafayette	IN	Gears	II
Brevini	Yorktown	IN	Gearbox	II
ATI Casting	LaPorte	IN	Component castings	II
Bedford Machine and Tool	Bedford	IN	Rotor hubs and plates	II
Siemens	Fort Madison	IA	Blades	I
Goian North America	Ankeny	IA	Elevation systems	II
D.A.D. Manufacturing	Hiawatha	IA	Walkways, doors, components	II
D.A.D. Manufacturing	Lisbon	IA	Walkways, doors, components	II
Trinity Structural Towers	Newton	IA	Towers	I
Acciona	West Branch	IA	Turbines	I
Energetx	Holland	MI	Blades	I

²¹ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

Name	City	State	Component	Tier
Genzink Steel	Holland	MI	Generator frames	II
Ventura Wund	Duluth	MI	Distributed wind	I
Wind Turbine Industries Corp.	Prior Lake	MI	Distributed wind	I
Citation Corporation	Novi	MI	Gearbox covers and housings	II
Three M Tool and Machine	Commerce	MI	Gearbox housings and forward housings	II
Akebono Corp	Farmington Hills	MI	Brakes	II
K&M Machine Fabricating	Cassopolis	MI	Hub and gearbox housings	II
Great Lakes Gear Technology	Canton	MI	Gears	II
ATI Castings	Alpena	MI	Castings	II
Dowding Industries	Eaton Rapids	MI	Transmission housings, components	II
Ideal Fabricators	Livonia	MI	Components	II
Dokka	Auburn Hills	MI	Fasteners	II
Ventower	Monroe	MI	Towers	I
Columbia Gear Corporation	Avon	MN	Gears	II
Zero-Max	Plymouth	MN	Couplings	II
Millwood Metal Works	Freeport	MN	Embed rings, template rings, forms	II
Remelle Engineering	Big Lake	MN	Machine castings	II
Continental Disc Corporation	Liberty	MO	Brakes	II
Gasket Engineering	Kansas City	MO	Blade components	II
FAG Bearings	Joplin	MO	Bearings	II
Vest-Fiber	Moberly	MO	Components	II
LM Wind Power	Grand Forks	ND	Blades	I
Trinity Structural Towers	West Fargo	ND	Towers	I
Federal Gear	Willoughby	OH	Gears	II
Advanced Manufacturing	Cleveland	OH	Gearboxes	II
Horsburgh and Scott	Cleveland	OH	Gears	II
Swiger Coil Systems	Cleveland	OH	Generators	II
Parker Hannifin Corp.	Mayfield Heights	OH	Hydraulic components, brakes	II
HPM America	Mount Gilead	OH	Hubs, bases, generator frames	II
Minster Wind	Minster	OH	Machine castings, components	II
Hamby Young	Aurora	OH	Substations	II
Rotek Inc.	Aurora	OH	Slew bearings	II
Kaydon Bearing	Avon	OH	Bearings	II
Kalt Manufacturing	North Ridgeville	OH	Large components	II
Magna Machine	Forest Park	OH	Rotor hubs, support bases	II
Cast Fab	Cincinnati	OH	Ductile iron component castings	II
Canton Drop Forge	Canton	OH	Gear blanks	II
Byrne Manufacturing	Mansfield	OH	Speed increasers	II
Dyson Corp.	Painseville	OH	Fasteners	II

Name	City	State	Component	Tier
Eaton Corp.	Cleveland	OH	Electrical	II
CMC/BMC Utility Products	Hamilton	OH	Power transmission components	II
EGC Enterprises	Chardon	OH	Fasteners	II
Tuf-Tug Products	Moraine	OH	Fall protection gear	II
The Benjamin Company	Put-In-Bay	OH	Power transmission components	II
Milacron Inc	Mount Orab	OH	Component	II
The American Tank and Fabricating Company	Cleveland	OH	Power transmission components	II
Elyria Foundry	Elyria	OH	Component castings	II
Edco Inc.	Toledo	OH	Power transmission machining	II
Molded Fiber Glass	Aberdeen	SD	Blades	I
Marmen	Brandon	SD	Towers	I
Merit Gear	Antigo	WI	Gears	II
Milwaukee Gear Company	Milwaukee	WI	Gears	II
MAG Giddings and Lewis	Fond du Lac	WI	Turbine housing, gearbox, bearings	II
Ingeteam	Milwaukee	WI	Generators	II
Lindquist Machine	Green Bay	WI	Gearbox, pitch linkage, main shafts, gearbox rebuilds	II
Avanti Wind Systems	New Berlin	WI	Fall protection	II
Plexus	Neeah	WI	Electronic components	II
Bassett Mechanical	Kaukauna	WI	Embed rings, template rings, forms	II
Broadwind	Manitowoc	WI	Towers	I

4.4 Key Stakeholder Groups and Deployment Challenges

The MWEC targets these stakeholder groups:

- Engaged citizens, including those impacted by existing or planned wind power projects, members of local energy committees, and community organizations either supportive of or concerned about wind energy impacts
- Other stakeholders: educators, students, media, and members of the general public interested in learning more about wind energy
- Policy makers, including regulators, legislators, and administrators
- Policy implementers, including state, regional, and local regulatory/planning authorities, health department, municipal officials (e.g., planning board, economic development, etc.), siting and permitting officials and staff
- Utility representatives: municipal and investor-owned utilities
- Wind development community: developers, manufacturers, scientists.

The information provided to these stakeholder groups addresses the following wind energy deployment market barriers that are prevalent in this region:

- Transmission issues
- Permitting
- Zoning and legislative issues
- Public acceptance and siting issues
- Poor understanding of wind energy's economic impacts
- Limited understanding of and support for manufacturing
- State and regional competition
- Need for education and engagement of rural populations
- Limited financing and funding for small/community/distributed wind
- Issues with developing on Native lands
- Environmental issues and limitations.

4.5 Collaborating Organizations

Organizations that have collaborated with the MWEC include:

- American Wind Energy Association
- Distributed Wind Energy Association
- eFormative Options
- Energy and Environmental Research Center
- Great Lakes Wind Collaborative / Great Lakes Commission
- Green Energy Ohio
- Illinois Institute for Rural Affairs at Western Illinois University
- Illinois State University
- IndianaDG
- Intertribal Council on Utility Policy
- Iowa Economic Development Authority
- Iowa Energy Center
- Iowa Environmental Council
- Iowa Lakes Community College
- Iowa State University
- Iowa Wind Energy Association
- Juhl Energy
- Lawrence Berkeley National Laboratory
- Midwest Renewable Energy Association
- Missouri Energy Initiative
- Montana Department of Commerce
- Navigant
- North Dakota Alliance for Renewable Energy
- Ohio Environmental Council
- RENEW Wisconsin
- Sand Creek Winds
- Small Wind Certification Council
- South Dakota Renewable Energy Association
- South Dakota Wind Energy Association
- Wind on the Wires.

4.6 State Updates

Due to the location of the East-West grid intertie, wind energy engagement in eastern Montana is covered by the MWEC while the Northwest Wind Resource and Action Center addresses engagement in the western part of the state. Since more of the state is covered under the western market, discussion of the Montana market is included in Section 6 of this document.

4.6.1 Illinois

Illinois has 3,842 MW of wind installed at the end of 2015 (WINDEXchange 2016) with some new projects planned. A notable development is the Kankakee Wind Farm, a 175-MW project developed to supply Microsoft with electricity.

Illinois has several geographic advantages for wind. It has a strong wind resource located near urban centers and can take advantage of exporting energy to eastern markets through PJM Interconnection. However, wind also faces competition from a powerful nuclear sector.

The state has an ambitious RPS of 25% renewables by 2025. Nevertheless, there are financial complexities in the utility market in Illinois that have caused the state to be at high risk to not meet this standard. An unintended consequence of the deregulation of electric utilities in Illinois rendered the current RPS “toothless.” Therefore, fixing the RPS continues to be a top priority for the wind industry. Although the Illinois General Assembly has not taken up any major energy legislation this year, an energy bill is possible in the near future because Exelon has a large nuclear plant in Illinois and has asked for state financial support.

Illinois is also participating in the Wind for Schools project, through the engagement of Western Illinois University, with seven school systems installed in the state.

4.6.2 Indiana

Indiana has 1,895 MW of wind installed at the end of 2015 (WINDEXchange 2016), which reflects 200 MW brought online in 2014 by the Headwaters Wind Farm in Randolph County. A major new development for 2015 is the Amazon Wind Farm (Fowler Ridge), a 150-MW project developed to supply Amazon Web Services data centers.

A positive policy development for small wind occurred in Indiana this past legislative session. NIPSCO, an investor-owned utility, agreed to extend its successful voluntary feed-in tariff program, which will facilitate more small wind in northern Indiana.

Indiana is one of three states in the MWEC region with a modest renewable energy goal (10% by 2015) that is voluntary.

4.6.3 Iowa

Iowa has 6,212 MW of wind installed at the end of 2015 (WINDEXchange 2016). Iowa ranks second in the nation for installed capacity (American Wind Energy Association 2015n). One of the primary reasons for this high ranking is that Iowa is the headquarters of Mid-American Energy Utility, an investor-owned utility primarily owned by Warren Buffet, a vocal supporter of wind energy. While state policy in Iowa has played a role in supporting wind development, Mid-

American's investment literally changed the farming landscape as well as the state's energy landscape.

In addition to the strong industry players, Iowa has an exceptionally strong wind resource and is in a good location along the electrical grid to export electricity to eastern markets. It also enjoys high public acceptance and support from government leaders.

Iowa is already producing more electricity than the state needs. The recent and future huge growth in wind capacity means that Iowa will eventually need increased transmission lines to continue exporting its power. Experts predict that nearby states will rely on Iowa to help them meet new federal carbon emissions regulations; they will purchase Iowa's clean energy exports to use as credits to reach their own Clean Power Plan targets.

Iowa is home to several wind education programs, including those at Iowa State University and the University of Iowa. Iowa Lakes Community College was one of the first colleges in the country to offer a wind technician training program.

4.6.4 Michigan

Michigan has 1,531 MW of wind installed (WINDEXchange 2016). If offshore policy and technology advance, Michigan has good potential for offshore wind development. An important development in 2015 was the completion of a new high-voltage transmission line to serve the wind turbines in Michigan's thumb region. ITC Transmission built this line to enable growth in the renewable energy market.

However, wind developers face obstacles in Michigan. One barrier is the uncertainty of dealing with unreceptive local governments because most zoning is decided at the township level. A second barrier is that the state's RPS was challenged; although the challenge was not successful, it resulted in uncertainty in the market.

A recent statewide change is the new agency created by Governor Snyder via executive order: Michigan Agency for Energy. This agency will be housed under the Department of Licensing and Regulatory Affairs and will absorb the current Michigan Energy Office. A key task of the Michigan Agency for Energy will be to focus on coordinating efforts to replace the state's coal power plants with cleaner energy sources.

4.6.5 Minnesota

Minnesota has 3,235 MW of wind installed at the end of 2015 (WINDEXchange 2016). It also has just more than 125 MW of distributed wind installed, which is the highest in the MWEC region. Minnesota began the 21st century as a leader in Midwestern wind, but even with several new projects planned, Minnesota's wind development has slowed in recent years.

Minnesota has a strong wind resource in the southwestern part of the state and enjoys relatively high public acceptance. Although the state historically has had receptive leadership and policies conducive to wind development, all new energy policy updates were stalled during the most recent legislative session.

The ongoing CapX2020 transmission line project may increase renewable energy in the near future. Two CapX2020 high-voltage transmission lines, the Brookings County-Hampton and Fargo-St. Cloud-Monticello lines, were energized in early 2015.

4.6.6 Missouri

Missouri has 459 MW of wind installed at the end of 2015 (WINDEXchange 2016). No new wind projects are planned, and the installed capacity has remained the same for several years. Missouri has a strong but underutilized wind resource in the northwestern part of the state.

Missouri gets most of its energy by importing coal. Eighty-two percent of Missouri's electricity comes from coal, nearly all of it shipped from Wyoming. However, Missouri has the potential to increase its energy independence and could even create its own renewable energy export industry. The 2015 Wind Vision Report suggests that Missouri could vastly increase its installed wind capacity in the coming decades and could produce as much wind energy as Minnesota and the Dakotas.

New solar initiatives moving forward in Missouri may lead the way to more in-state renewable energy development.

4.6.7 North Dakota

North Dakota has 2,143 MW of wind capacity installed at the end of 2015 (WINDEXchange 2016). North Dakota has been involved in several multi-state transmission projects in recent years, including one that was completed in 2014 (American Wind Energy Association 2015m). New projects have been aided by 2015 legislation that extended wind tax credits. North Dakota has a very strong wind resource, but the state's leaders have been primarily focused on the economic benefits of traditional sources of energy. The state's renewable energy goal (10% by 2015) is voluntary. Wildlife impacts pertaining to sage grouse, bats, and a variety of avian species remain a concern in the state.

4.6.8 Ohio

Ohio has 443 MW of wind installed at the end of 2015 (WINDEXchange 2016), which is the lowest in the MWECC region. However, it also has more than 37 MW of distributed wind installed in 2014, which is the third highest in the region. Wind energy development continues to move forward in the state with the 250-MW Northwest Ohio wind project. DOE continues to provide support for the six-turbine, 18-MW Icebreaker pilot project on Lake Erie. The installation will likely be the nation's first freshwater offshore wind farm. The Lake Erie Energy Development Corporation began taking core samples in September 2015 and has performed extensive resource assessment and engineering analysis work for the project (Funk 2015).

Ohio has a strong manufacturing sector, which can produce many renewable energy jobs, and it could host offshore wind projects if current technology improves. However, the state's leadership has discouraged new wind developments through public policy. In 2014, Ohio became the first state in the nation to freeze its RPS and energy efficiency standards. It also drastically increased setback requirements for large wind turbines. While these changes are in effect, they make it nearly impossible for developers to build any new wind farms in Ohio.

Case Western Reserve University in Cleveland has developed a strong offshore wind education collaborative with the Lake Erie Energy Development Corporation offshore wind project.

4.6.9 South Dakota

Although South Dakota has only 977 MW of wind installed at the end of 2015 (WINDEXchange 2016), the state has a very strong wind resource that has been developed without extensive state policy legislation: it is the only state in the region without a net metering policy, and its renewable energy goal (10% by 2015) is voluntary. South Dakota has an uncompetitive tax rate on wind compared to surrounding states, but tax rates were adjusted in a new bill passed in 2015. This bill reduced state taxes on wind to the levels of neighbors North Dakota and Minnesota to be more competitive.

A significant project is underway in South Dakota involving a partnership of Native American tribes. Eight Sioux tribes plan to jointly develop their wind resources. The resulting enterprise has the potential to build one of the largest utility-grade wind installations in the country, generating more than a gigawatt of power, and will provide economic self-sufficiency and political self-determination for the tribes, which occupy the poorest counties in the United States.

South Dakota participates in the DOE's Wind for Schools project, with South Dakota State University helping to install six school systems in the state.

4.6.10 Wisconsin

Wisconsin has 648 MW of wind installed at the end of 2015 (WINDEXchange 2016) with no new projects under construction. Coal is the state's main source of energy, and there are plans to increase it.

Although the state has strong laws on wind siting and is well positioned for transmission to load centers, it suffers from weak public acceptance. Individual counties have even defied state regulations on siting. In 2014, Brown County declared wind turbines a health hazard. The state has dedicated public funding for a study of health issues related to wind turbines and plans to include documentation from sources that have not been peer reviewed. Concerns regarding bats and other wildlife also continue to impact development in the state. Wisconsin had a healthy small and distributed wind sector through 2012, but both markets have slowed down considerably in recent years (U.S. Department of Energy 2015a).

University of Wisconsin-Madison is participating in the DOE 2016 Collegiate Wind Competition.

5 Northeast Wind Resource Center

The Northeast Wind Resource Center (NWRC) worked with NREL researchers to provide the following assessment of the state of the wind industry in this region.

The NWRC²² encompasses the following states: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.²³ The NWRC spans offshore and land-based wind energy development at the commercial and community scale through interstate cooperation, information sharing, education, stakeholder engagement, knowledge transfer, and community dialogue. Clean Energy Group leads the offshore wind work; Sustainable Energy Advantage, LLC leads the land-based wind work; and the Maine Ocean and Wind Industry Initiative serves as a key liaison between the project and the wind industry. The NWRC is built on the foundation of previous stakeholder engagement and educational activities, including the New England Wind Energy Education Project, the New England Wind Forum, and current projects such as the Offshore Wind Accelerator Project.²⁴

The challenges and opportunities for wind energy development in the region vary from state to state. In addition, land-based wind and offshore wind face different challenges. Land-based wind's biggest challenges across the region are public acceptance and project siting, while offshore wind's major challenges include cost, infrastructure, regulatory barriers, and public acceptance.

Because of the Northeast's demographics, population density, and land-use and ownership patterns, community-scale and larger installations face unique challenges to development. An increasing number of communities across the region are adopting strict zoning regulations or outright bans on land-based commercial wind installations. When doubt and uncertainty enter the debate, decision-makers usually revert to the status quo (no wind project). Many factors are contributing to land-based wind project delays or terminations, including systematically deployed opposition efforts that often derail projects in preliminary stages. Projects that progress beyond initial proposals are all subject to significant hurdles due to permitting appeals and lawsuits. Other factors contributing to declines in wind development include transmission constraints, lack of power purchase agreements, and federal tax policy. The factors make siting projects, even appropriately located ones, progressively more challenging. Developers, some with long-term power purchase agreements, are stepping away from some proposed projects. Development in Maine and Pennsylvania is the exception to this northeast land-based wind development story. Maine has a good amount of wind development potential in the northern, lower population areas of the state where wind development remains strong with more than 1,500 MW in development. Pennsylvania has less near-term development underway but also has many areas of good wind resource and lower population density.

The high cost of offshore wind energy is a major barrier to its development. Offshore wind projects face high costs due to construction, installation, and operation at sea, as well as the modifications to turbines and foundations for life at sea. Infrastructure barriers include

²² <http://www.northeastwindcenter.org/>

²³ Island communities in coastal Maine, Massachusetts, and Rhode Island are also part of the Islanded Grid Resource Center region.

²⁴ <http://www.cesa.org/projects/accelerating-offshore-wind-owap/>

transmission challenges, lack of deep-water ports, lack of specialized installation vessels, a workforce with limited experience, and a nascent supply chain. Complex permitting, lengthy site selection and leasing processes, and uncoordinated planning (jurisdiction by jurisdiction) pose regulatory challenges. Public acceptance issues and lengthy litigation battles mainly have been an issue in Massachusetts, the proposed site of the Cape Wind Project. The Block Island Wind Farm in Rhode Island initiated offshore construction in the summer of 2015 and will be America’s first offshore wind farm. This five-turbine, 30-MW project being developed by Deepwater Wind is expected to go online in 2016.

The following section provides an overview of the wind industry in the region.

Table 9. Key Statistics for the Northeast Wind Resource Center Region

	CT	ME	MA	NH	NJ	NY	PA	RI	VT
Land-Based Wind Projects									
Installed Wind, 2015 (MW)	5	613	107	185	9	1,749	1,340	9	119
Proposed Offshore Wind Projects (MW)		12 ²⁵	1,000 w/ RI (Deepwater One)		25			1,000 w/ MA (Deepwater One) ²⁶	
Offshore Wind Projects Under Construction/ Permitted (MW)								30	
Percentage of Energy Supplied by Wind Projects, 2014	0%	7%	.6%	2%	0%	3%	2%	0%	3%
Projected Potential Capacity (MW), 80 m, 30% CF	27	11,251	1,028	2,135	132	25,781	3,307	47	2,949
Projected Potential Capacity (MW), 100 m, 30% CF	186	30,847	1,913	3,919	349	57,639	7,222	84	5,637
Contribution from Distributed Wind Projects (MW) ²⁷	.5	7.7	65.5	1.7	10.9	10.4	5.9	9.3	12

5.1 Renewable Portfolio Standards

In the NWRC's region, eight states have an RPS, while Vermont has a Sustainably Priced Energy Enterprise Development Program created to promote renewable energy development. The program is not a renewable portfolio goal or standard. However, the Vermont Legislature recently passed a renewable energy bill that would create a renewable energy standard, requiring utilities to buy and sell renewable electricity beginning in 2017. It is expected that the Governor will sign the legislation into law. In other states, legislative proposals to modify the RPS programs are pending, although it is unclear whether they will be acted on or passed.

²⁵ University of Maine

²⁶ Block Island

²⁷ Distributed wind project installed capacity is defined as 2003-2014 cumulative capacity (U.S. Department of Energy 2015a).

Table 10. RPS Overview for Northeast Wind Resource Center States

	RPS
Connecticut	27% x 2020 30% x 2000
Maine	New RE: 10% x 2017 22.1% x 2020
Massachusetts	(+1% annually thereafter)
New Hampshire	24.8% x 2025
New Jersey	20.38% RE x 2021 + 4.1% solar x 2028
New York	29% x 2015
Pennsylvania	18% x 2021 (include non-renewable alternative resources)
Rhode Island	16% x 2020
Vermont	55% by 2017 and 75% by 2032

5.2 Workforce Development

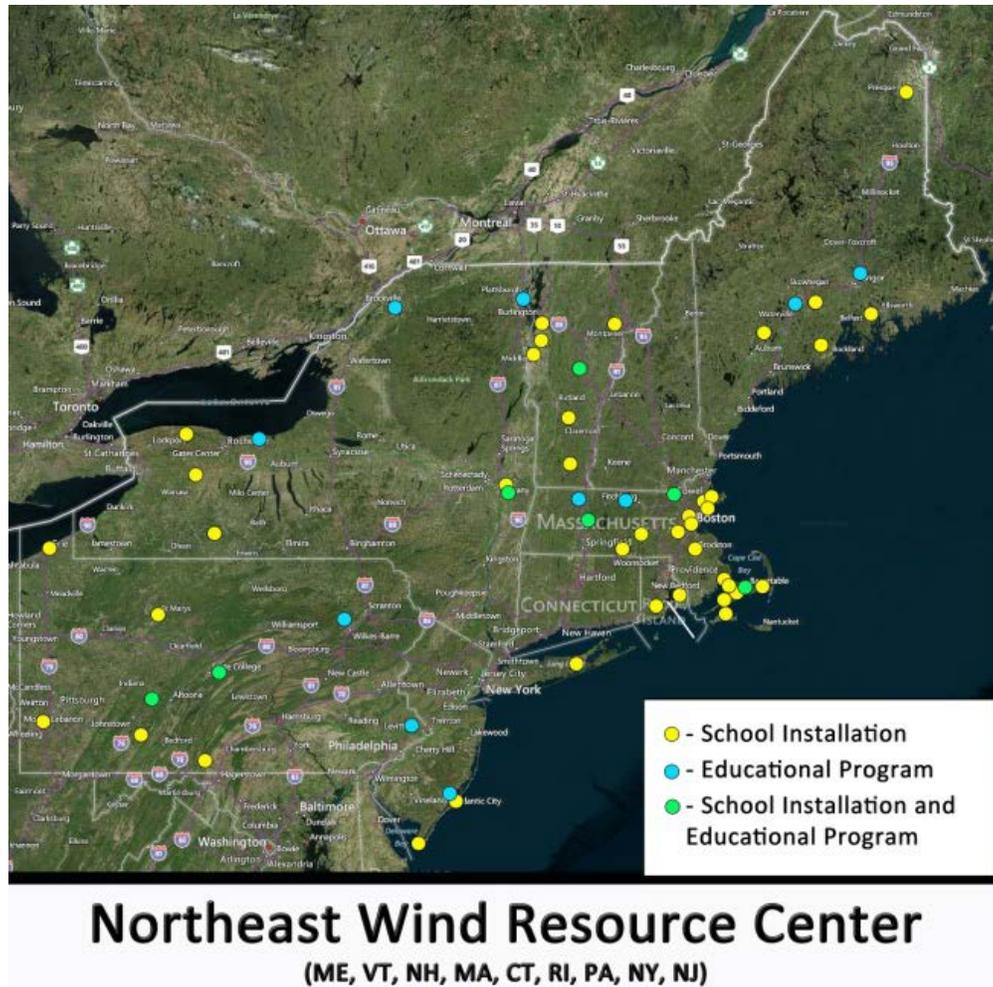


Figure 8. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs within the Northeast Wind Resource Center’s area

Several institutions provide wind energy education in the region, including Pennsylvania State University, University of Massachusetts Amherst and Lowell, University of Delaware, University of Maine, Massachusetts Institute of Technology, Cornell University, and Cape Cod Community College. Educational activities are described in more detail in the state sections below. The WINDEXchange website also offers information and interactive maps regarding workforce development, the DOE’s Collegiate Wind Competition, the DOE’s Wind for Schools project, school wind project locations, and locations of education and training programs in the NWRC region and other states.²⁸

5.3 Manufacturing

NREL researchers compiled the following wind energy manufacturing data for this region as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

Table 11. Wind-Related Manufacturing Overview for Northeast Wind Resource Center States

Name	City	State	Component	Tier
Second Wind	Somerville	MA	Anemometers, controllers, sensors	II
BJA Magnetics	Rutland	MA	Magnetics	II
Pika Energy	Westbrook	ME	Distributed wind	I
Hendrix Wire and Cable	Milford	NH	Cable systems	II
Weaver Wind Energy	Freeville	NY	Distributed wind	I
UGE International	New York	NY	Distributed wind	I
Ioxus	Oneonta	NY	Ultracapacitors	II
Vacon Inc.	Chambersburg	PA	A/C drives	II
Ellwood Group	Irvine	PA	Main shaft bearings	II
Eickhoff Corporation	Pittsburgh	PA	Gearbox	I
Hodge Foundry	Greenville	PA	Component castings	II
Windurance	Seneca	PA	Pitch control systems	II
Northern Power Systems	Barre	VT	Distributed wind	I

5.4 Key Stakeholder Groups and Deployment Challenges

The NWRC targets these stakeholder groups:

- For offshore wind, the NWRC is focused on state clean energy funds and the public utility commission as its primary stakeholders.
- For land-based wind, the NWRC is focused on state and local policy-makers, media, and members of the public.
- Through its industry partner the Maine Ocean Wind Industry Initiative, some offshore wind outreach is provided to industry stakeholders and the general Maine public.

Information provided to these stakeholder groups addresses wind energy deployment market barriers that are prevalent in this region.

²⁸ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

- The high costs of offshore wind energy are addressed on a regional basis. Information and outreach is geared toward innovative regional procurement targets, regional financing, alternative financing through green banks and bonds, and regional supply chain development. The Islanded Grid Resource Center reported that island communities in coastal New England choosing to pursue offshore wind projects face challenges including attracting financial investment; lowering the cost of energy produced; navigating the regulatory process; addressing technical issues related to installation, interconnection, and operation; researching and mitigating environmental impacts; interacting with other human uses; and public acceptance. The fact that there are no full-scale offshore wind turbines currently deployed in the United States further complicates many of these challenges, as there are no domestic projects that can serve as examples to inform these topics.
- Information on financing and cost reductions in Europe is shared with stakeholders.
- Information and outreach to the land-based wind stakeholder groups include publications, guidelines, and other materials that can aid sound decision-making when considering new policies or wind project proposals.
- The NWRC is compiling information resources on its website as well as convening a working group that is developing a set of evaluation criteria that can be applied to individual information resources so that stakeholders can discern their suitability for decision-making or journalistic coverage.
- The topics covered in the resource library include wind physiological and environmental impacts, along with technical, economic, financial, and operational issues.

5.5 Collaborating Organizations

Organizations that have collaborated with the Northeast Wind Resource Center include:

- Appalachian Mountain Club
- Cape & Islands Self Reliance
- Consensus Building Institute
- Conservation Law Foundation
- Distributed Wind Energy Association
- Fishermen’s Energy
- Great Lakes Wind Collaborative
- Lawrence Berkeley National Laboratory
- Maine Renewable Energy Association
- Massachusetts Clean Energy Center
- Meister Consultants Group
- Metcalf Institute-University of Rhode Island
- Mid-Atlantic Reg. Resource Center
- Natural Resources Council of Maine
- New York State Energy Research and Development Authority
- Renewable Energy Long Island
- Rhode Island Office of Energy Resources
- Small Wind Certification Council
- Southeast Coastal Wind Coalition
- Southern Alliance for Clean Energy
- UMass Wind Energy Center
- Union of Concerned Scientists
- University of Maine

- Utility Variable-Generation Integration Group
- U.S. Offshore Wind Collaborative
- Vermont Public Service Department.

5.6 State Updates

5.6.1 Connecticut

At the end of 2015, Connecticut had 5 MW of installed wind capacity (WINDEXchange 2016). The state is moving toward initiatives on regional procurement of clean energy resources in collaboration with other states. Connecticut, Massachusetts, and Rhode Island have drafted a request for proposals that utility-scale wind resources would be eligible to respond to. The three states hope to complete the joint procurement process by the end of 2016. In 2014, the approval of wind siting guidelines ended an effective moratorium on wind development.

After a long legal battle, construction began on Connecticut's first commercial wind turbines in the summer of 2015. BNE Energy is developing the Colebrook South Project, which consists of three turbines (Boughton 2015).

5.6.2 Maine

With 613 MW of installed wind capacity at the end of 2015 (WINDEXchange 2016), Maine is the regional leader in wind power deployment for New England. Wind power provides 8% of the state's total electricity supply and development of large-scale, onshore projects continues to expand with 276 MW of additional capacity under construction. However, the development of community-scale and offshore wind projects has slowed in recent years due to an unstable political climate and public acceptance issues surrounding sound and aesthetic impacts.

The University of Maine received a \$3 million DOE grant in May 2014 for its proposed 12-MW floating offshore wind farm. Earlier in 2014, the Maine Public Utilities Commission approved a term sheet for the Aqua Ventus project, calling on the offshore pilot project to sell electricity to Central Maine Power for 23 cents per kilowatt-hour. The University of Maine received additional funding from DOE in 2015 to continue developing its offshore wind project.

5.6.3 Massachusetts

At the end of 2015, Massachusetts had 107 MW of installed wind capacity (American Wind Energy Association 2015e). The single project constructed in 2014 was the Lynn Water & Sewer Commission's 660-kW turbine (American Wind Energy Association 2015m). The project was partially funded through the Massachusetts Clean Energy Center, which continues to support installations in the state through its Commonwealth Wind Program.²⁹ Several projects were initiated in 2015 with expected commissioning in 2016, including the 8-MW Future Generation Wind project in Plymouth, Massachusetts (Mass Energy Consumers Alliance 2016).

The Massachusetts Clean Energy Center also approved up to \$1.8 million in relief assistance for the Town of Falmouth to financially assist the municipality as it attempts to navigate the impacts associated with reduced operations of the town's wind project. Community concerns surrounding

²⁹ <http://www.masscec.com/programs/commonwealth-wind-program>

sound impacts led to curtailment and unanticipated costs (Massachusetts Clean Energy Center 2014).

The proposed Cape Wind project in Massachusetts was dealt a major blow when the two utilities with power purchase agreements pulled their agreements after Cape Wind failed to obtain financing by the deadline. Without these power purchase agreements, the project cannot be built. Cape Wind brought the utilities' action to court. Most recently, a federal appellate court overturned a lower court's earlier ruling defending Cape Wind's power purchase agreement, representing another potentially lethal setback for the project.

Two federal lease sales in a second Massachusetts Wind Energy Area occurred in January 2015; the leases went to RES Americas and Offshore MW. Both leases were sold much cheaper than other lease areas, possibly due to the deeper water at the site. RES Americas paid \$281,285 for the lease, which covers 760 square kilometers and has the potential to generate more than 1 gigawatt of capacity. DONG Energy, a Danish developer and utility—and the largest offshore wind developer in the world—acquired RES Americas' lease. This is encouraging news for the U.S. offshore wind sector, although DONG is awaiting BOEM approval of the lease transfer.

Massachusetts is part of the three-state initiative for clean energy procurement described in the section on Connecticut.

Massachusetts has a number of wind energy education programs. The University of Massachusetts at Amherst has had an active wind energy program for more than 40 years. The University of Massachusetts at Lowell has also participated in the 2014 Collegiate Wind Competition and is an entrant for the 2016 Competition. University of Massachusetts at Amherst is also an entrant for the 2016 Competition.

5.6.4 New Hampshire

New Hampshire had 185 MW installed wind capacity at the end of 2015 (WINDEXchange 2016). Projects in the state have faced high levels of opposition, leading to some efforts being abandoned prior to construction. In 2014, Iberdrola announced that it would abandon its Wild Meadows Wind Farm plans, citing the company's recent experience with the Groton Wind Farm and the state's current political and regulatory environments (Morris 2014). Installed in 2012, the Groton Wind Farm has faced continued opposition and hearings due to alleged changes that were made to the project without consent or review by the state's permitting authority (Seufert 2014).

The New Hampshire Legislature passed a bill creating an offshore wind study committee that presented its recommendations to the legislature and Governor. Included in the recommendations to the legislature was a multi-state approach to developing offshore wind and the designation of a BOEM multi-state task force to further explore the offshore wind potential in New Hampshire.

The New Hampshire Site Evaluation Committee developed and released draft siting guidelines, but meanwhile towns continue to pass restrictive wind siting bylaws and moratoria.

5.6.5 New Jersey

Onshore and offshore developments have moved slowly in New Jersey, which had 9 MW of land-based installed wind energy at the end of 2014 (American Wind Energy Association 2015m), with that number remaining the same at the end of 2015 (WINDEXchange 2016).

Fishermen's Energy, a proposed five-turbine offshore project that is one of DOE's Offshore Wind Advanced Technology Demonstration Projects, has not received approval from the New Jersey Board of Public Utilities to move forward. In a recent appellate court decision, the court backed the board's rejection of the demonstration project, affirming that Fishermen's Energy had not established the project's financial viability. Fishermen's Energy has been seeking approval to move forward with the project since 2008.

5.6.6 New York

With 1,749 MW of installed wind, New York leads the Northeast in overall wind energy capacity. This amount of development equates to a \$3.4 billion capital investment for the state. It also provides approximately \$5.2 million in annual land lease payments (American Wind Energy Association 2015i).

The small and distributed wind markets continue to be active in New York. While the main driver of this has historically been an incentive program provided through the New York State Energy Research and Development Authority, third-party leasing is a new model that is expected to further advance this type of installation. United Wind, a leader in this area, reported that it had five New York projects financed through third-party leasing in 2014. Though this was a slower-than-expected beginning for the company, 2015 has seen an increase in total projects utilizing this model. As of May 2015, 27 projects had been commissioned using this financing mechanism (U.S. Department of Energy 2015a).

Currently the state is re-designing its overall energy strategy. New York has adopted an aggressive goal of obtaining electricity from renewable sources, with RPS targets aimed at three groups: large-scale generators that sell power to the wholesale grid or in some cases generate power for onsite use; small-scale generators such as a wind turbine at a residence; and other market activities, such as individuals and businesses that choose to pay a premium on their electricity bill to support renewable energy (New York State Energy Research and Development Authority 2015).

New York is also reviewing the planning process for its transmission system, which currently is constrained and is affecting wind development and operation. BOEM hosted public open houses in June 2015 to share visual simulations of potential offshore wind development.

5.6.7 Pennsylvania

At the end of 2015, Pennsylvania had 1,340 MW of installed wind capacity. A vast majority of this clean generation comes from 24 wind projects that have been installed across the state. This amount of development equates to a \$2.7 billion capital investment and provides approximately \$4 million in annual land lease payments (American Wind Energy Association 2015k). There have been no utility-scale wind farms installed in the state since 2012. Wildlife issues, including wind energy's impact on bats in the state, have hampered development, as have concerns related to sound, health, and property values. Another significant issue for the state is that many of the windiest, undeveloped locations are on state game lands, which thus far are not available for wind project development (S. Stewart, personal interview, December 2015).

The proposed 2015-2016 budget for the state's Department of Environmental Protection contains bonds that will provide \$20 million to "increase the state's fleet of wind energy plants" (Pennsylvania Department of Environmental Protection 2015).

In 2004, Pennsylvania established its Alternative Energy Portfolio Standards Act, which requires 18% of the state's energy to be generated by clean, efficient sources by 2021 (Pennsylvania Public Utility Commission 2016).

Pennsylvania is also participating in the Wind for Schools project through the engagement of Pennsylvania State University and the installation of five school systems. Pennsylvania State University was the winner of the 2014 Collegiate Wind Competition and is an entrant for the 2016 Competition.

5.6.8 Rhode Island

Rhode Island finished 2015 with 9 MW of wind energy installed (American Wind Energy Association 2015m). Development on the Block Island 30-MW offshore wind farm continues; construction began in the summer of 2015. Contracts have been secured for turbines, foundations, blades, and more. The project is scheduled to go online in the summer of 2016. The \$225 million project will provide electricity to Block Island and Rhode Island customers. Although project construction has begun, opponents continue to pursue litigation, filing a complaint in August 2015 in the U.S. District Court in an attempt to overturn the project's August 2010 power purchase agreement (Kuffner 2015).

Rhode Island is part of the three-state initiative for clean energy procurement described in the section on Connecticut.

5.6.9 Vermont

Vermont's total wind energy capacity was 119 MW at the end of 2014 (American Wind Energy Association 2015o), and that number remains the same at the end of 2015. Issues concerning aesthetics, wildlife (Ring 2015), and property value impacts (Preedom 2015) still prevail in the state, slowing development and leading to community resistance to hosting wind turbines.

The Vermont legislature passed a very aggressive RPS starting at 55% by 2017 and then increasing by 4% every 3 years until reaching 75% by 2032 (DSIRE 2015). Specifics are provided for distributed generation, retail electricity providers, and municipal utilities. While the targets for the program are high, the previously mentioned development challenges will likely limit the opportunities for utility-scale wind to participate.

6 Northwest Wind Resource and Action Center

The Northwest Wind Resource and Action Center worked with NREL researchers to provide the following assessment of the state of the wind industry in this region.

The Northwest Wind Resource and Action Center³⁰ encompasses the following states: Idaho, western Montana, Oregon, Washington, and Wyoming. Renewable Northwest Project is the principal investigator. Northwest Sustainable Energy for Economic Development (Northwest SEED) facilitates committee activities related to distributed and community wind. The Oregon Department of Energy leads the offshore wind work. The Commerce Departments of Washington and Montana, along with Boise State University, serve on the steering committee.

All states in the region face barriers related to wildlife and project siting; depressed electric market prices; low natural gas costs; little load growth; and a combination of transmission constraints, a need for balancing area coordination, and better integration services markets. In addition, those states with renewable portfolio standards (Montana, Oregon, and Washington) are seeing decreased market potential as utilities fulfill their near-term target requirements. These factors have slowed the pace for new project development, although a pipeline of approved projects exists once markets improve.

The following section provides an overview of the wind industry in the region.

Table 12. Key Statistics for the Northwest Wind Resource and Action Center Region

	ID	MT ³¹	OR	WA	WY
Installed Wind, 2015 (MW) ³²	973	665	3,153	3,075	1,410
Percentage of Energy Supplied by Wind Projects, 2014	16%	6%	12%	6%	8%
Projected Potential Capacity (MW), 80 m, 30% CF	18,076	944,004	27,100	18,479	552,073
Projected Potential Capacity (MW), 100 m, 30% CF	44,770	1,012,355	50,566	32,606	593,769
Contribution from Distributed Wind Projects, 2014 (MW) ³³	2.4	4.9	4.9	12.7	5.9
Proposed Offshore Wind Projects (MW)			30 ³⁴		

6.1 Renewable Portfolio Standards

In the Northwest Wind Resource and Action Center's region, Oregon, Washington, and Montana each have an RPS in place.

³⁰ <http://nwwindcenter.org/>

³¹ Montana is divided between two RRCs: Northwest Wind Resource and Action Center (western Montana) and Midwest Wind Energy Center (eastern Montana). For reporting purposes, each RRC provides data for the entire state.

³² 2015 Year End Wind Power Capacity Map. Available at http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp

³³ Distributed wind project installed capacity is defined as 2003-2014 cumulative capacity (U.S. DOE 2015a).

³⁴ Principle Power

- In 2005, Montana passed an RPS requiring large investor-owned utilities to acquire 15% of their energy from new renewable resources by 2015. Montana utilities will meet the overall 2015 target but will need to add renewable resources in the future to maintain compliance. Montana also has a Community Renewable Energy Project (CREP) provision in the state’s RPS that requires utilities to procure a certain amount of nameplate capacity of smaller (less than 25 MW) locally owned renewable energy projects, either wholly utility-owned or at least 50% owned by Montana investors. NorthWestern Energy is the only utility with CREP obligation left in Montana and must procure roughly 45 MW. Satisfying the CREP requirement has resulted in regulatory and project development challenges in recent years but remains a near-term driver for renewable energy projects in the state. NorthWestern Energy is currently out of compliance with the CREP requirement and is requesting a waiver from the Public Service Commission for the 2014 compliance year.
- The Oregon Renewable Energy Act (SB 838) was signed into law on June 6, 2007. The Act establishes a Renewable Energy Standard that requires Oregon’s largest utilities to acquire 25% of their electricity from renewable energy sources by 2025. Smaller Oregon utilities must meet targets of 5% or 10% by 2025. Oregon utilities have met the 2015 targets but will need to acquire new resources to meet the final 2025 targets.
- In November 2006, Washington voters passed Initiative 937, the Clean Energy Initiative. I-937 enacts a renewable energy standard that requires Washington’s 17 largest utilities to get 15% of their electricity from new, homegrown, renewable energy sources by 2020. Utilities will also be required to pursue all low-cost energy efficiency and conservation opportunities. Washington utilities met their interim 2012 targets. Many utilities will need to acquire additional resources to meet the 2020 target.

Two of the states in the region, Idaho and Wyoming, have no RPS.

Table 13. RPS Overview for Northwest Wind Resource and Action Center States

RPS	
Idaho	None
Montana	15% by 2015
Oregon	Large utilities: 25% by 2025 Small utilities: 10% by 2025 Smallest utilities: 5% by 2025
Washington	15% renewables by 2020
Wyoming	None

6.2 Workforce Development

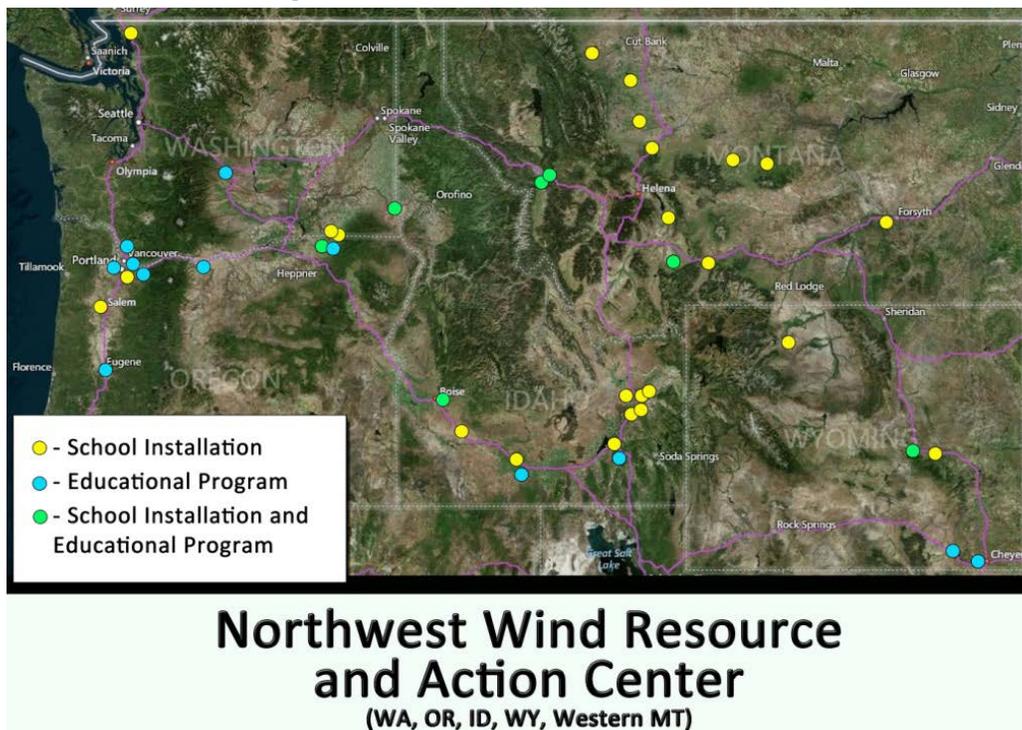


Figure 9. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs within the Northwest Wind Resource and Action Center's area

Wind energy educational programs across the Northwest have been limited. Educational activities are described in more detail in the state sections below. The WINDEXchange website also offers information and interactive maps regarding workforce development, the DOE's Collegiate Wind Competition, the DOE's Wind for Schools project, school wind project locations, and locations of education and training programs in the Northwest Wind Resource and Action Center's region and other states.³⁵

6.3 Manufacturing

NREL researchers compiled the following wind energy manufacturing data for this region as part of DOE's annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

Table 14. Wind-Related Manufacturing Overview for Northwest Wind Resource and Action Center States

Name	City	State	Component	Tier
XZERES Wind	Wilsonville	OR	Distributed wind	I
Moventas	Portland	OR	Gearbox	I
PowerClimber Wind	Seattle	WA	Hoist, rigging equipment	II

³⁵ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

6.4 Key Stakeholder Groups and Deployment Challenges

The Northwest Wind Resource and Action Center targets these stakeholder groups:

- Bonneville Power Administration
- County commissioners
- Developers
- Educational institutions (academia)
- Experts (researchers, technical)
- Federal agencies
- Federal government (decision makers, elected officials, policy makers)
- Public interest groups (advisory, advocacy, affiliates, boards, committees, community, consumer, councils, NGOs, partner network, working group)
- Industry (manufacturers, supply chain, associated businesses)
- Industry trade groups
- Media
- Merchant energy suppliers
- Non-elected government officials
- Public (engaged citizens, interested and general public)
- Regulatory (public utility commissioners, decision makers, staff, interveners)
- State agencies
- State government (decision makers, elected officials, governor staff, policy makers)
- Tribal
- Utilities (power authorities, publics, munis, co-ops, decision makers, staff)
- Utility trade groups.

The information provided to these stakeholder groups addresses the following wind energy deployment market barriers that are prevalent in this region:

- Need to advance the state-of-the art in resource planning processes and ensure accurate wind information is utilized in utility integrated resource planning
- Need for transmission and energy market advances, including a liquid bilateral market for integration resources, 15-minute scheduling, and development of a regional energy imbalance market
- Need for science-based resource planning in siting guidelines, especially for development in sage grouse areas

- Need for improved zoning and permitting practices in jurisdictions with high distributed/community wind potential
- Restricted access to capital for distributed/community wind development
- Lack of technical assistance available for potential community wind projects
- Lack of strong baseline of technical information about offshore wind and the need to build credibility around the resource opportunity.

6.5 Collaborating Organizations

Organizations that have collaborated with the Northwest Wind Resource and Action Center include:

- American Wind Energy Association
- Beneficial State Bank
- Boise State University
- Columbia Gorge Community College
- Community Renewable Energy Association
- Distributed Wind Energy Association
- DNV GL
- EDP Renewables North America
- eFormative Options
- Endurance Wind Power
- EWT Americas
- Iberdrola Renewables
- Idaho National Laboratory
- McKinstry
- Montana Department of Environmental Quality
- Montana Renewable Energy Association
- Northwest National Marine Renewable Energy Center
- Oregon State University
- Oregon Wave Energy Trust
- Pacific Northwest National Laboratory
- Puget Sound Energy
- Oregon Wave Energy Trust
- Vaisala 3Tier.

6.6 State Updates

6.6.1 Idaho

As of the end of 2014, Idaho has 33 wind projects with a total installed capacity of 973 MW, and that number remained the same at the end of 2015 (WINDEXchange 2016). Idaho has a larger percentage of smaller projects compared to neighboring states as many of the wind projects were developed under the Public Utility Regulatory Policies Act (PURPA) limits. The major utility in the state, Idaho Power, has leveraged this to influence policy changes at the Public Utilities Commission that limit project size and make changes to rates for standard PURPA contracts that increase costs for developers. Opponents of wind development have also been very active, including billboard messaging on the I-84 corridor, focusing on areas with high concentrations of wind projects. The political climate has limited the effectiveness of messaging by wind

proponents in a variety of venues. Idaho has 2.4 MW of distributed wind capacity installed and no community wind projects.

Idaho participates in the Energy Department's Wind for Schools project through the engagement of Boise State University, with the installation of seven school systems in the state. Boise State University also participated in the 2014 Collegiate Wind Competition and is an entrant for the 2016 Competition.

6.6.2 Montana

As of the end of 2015, Montana had 17 wind projects with a total installed capacity of 665 MW. The state has a large wind resource, ranking third nationally in total wind energy potential, but the lack of transmission capacity to other states inhibits Montana from capturing it. This is especially problematic in eastern Montana, which has the lowest population and the highest wind resource. A growing local opportunity could be the industrial boom in the Bakken region. Ironically, this boom has created a new market of local demand for electricity, which could be supplied by wind. Governor Steve Bullock supports energy development in general, including wind, and holds a fairly conservative stance on carbon regulation, which would benefit wind but also impact Montana's coal industry. Public support is overwhelmingly in favor of wind energy development but at the same time supportive of existing coal generation.

The Montana Public Service Commission currently has a mixed track record on wind energy development. Recently the commission approved a 25 MW negotiated Qualifying Facilities/PURPA wind contract on NorthWestern Energy's system. At the same time, the commission has reduced the standard offer contract terms for new Qualifying Facilities/PURPA wind projects from 10 MW of maximum capacity to 3 MW. The Public Service Commission has also complicated proposals for CREPs, though perhaps not primarily because the projects were wind or renewable energy.

Transmission issues make it challenging for Montana to export its power to population centers in other states. The two biggest electric grids in the United States are the Western Connection and the Eastern Connection, and they meet in eastern Montana. However, policy and financial issues make it impractical for eastern Montana to export energy across the grid divide into Washington State. As a result, the strong wind resource potential in eastern Montana is effectively cut off from exporting energy to the West.

While opposition to new transmission lines still exists, improvements to the siting process and some legislative changes have created a more favorable climate over the past few years. In the case of the Mountain States Transmission Intertie line, creating a citizens-based study group helped the average person's voice be heard in the siting process. Unfortunately, market forces have delayed development of the line and other major projects in the region, such as Bonneville Power Administration's Montana-to-Washington project. Planned and potential coal plant retirements may also affect transmission capacity available for wind energy export to certain markets.

Montana has a 15% by 2015 RPS. Northwestern Energy, the largest utility in the state, will meet the 2015 RPS target mostly through generation from seven wind projects with a total installed capacity of 213.4 MW, plus three small hydro projects totaling 15.5 MW.

As in other Western states, impact on sage grouse populations is an issue in terms of siting wind projects. Montana's Sage Grouse Conservation Strategy, adopted in anticipation of Endangered Species Act listing decision by the U.S. Fish and Wildlife Service, could affect wind energy development in Montana. The strategy calls for wind energy development to be avoided in all sage grouse core areas.

Montana has 4.9 MW of distributed wind capacity installed, primarily consisting of turbines rated at 100 kW or less. Gordon Butte, the only community wind project, has an interconnection and power purchase agreement with NorthWestern Energy. Several other community wind projects are in the development phase; however, low power purchase agreement prices and lack of the 1603 Treasury program grant in lieu of tax credit have limited the financial viability of these projects. During the 2015 legislative session, several bills were proposed that would help open the market for distributed wind projects, including aggregate net metering, neighborhood net metering, and increasing the net metering cap; however, these bills did not move forward.

Montana participates in the Energy Department's Wind for Schools project³⁶ through the engagement of Montana State University, with 11 school systems installed in the state. The University of Montana also provides wind energy curricula.

Note that Eastern Montana is also supported by the Midwest Regional Resource Center.

6.6.3 Oregon

As of the end of 2015, Oregon has a total installed capacity of 3,153 MW (WINDExchange 2016). Despite this incredible progress, new project development has stalled due to a number of factors including depressed demand for power, low natural gas prices, uncertainty about the persistence of federal policy, and utilities fulfilling their near-term RPS compliance targets. Because of this delay in construction activity, some projects that have already been approved through state and county processes need to either apply for permit extensions or let their existing permits expire. Twelve projects totaling 1,519 MW have approved permits, and another 1,628 MW of wind are in the permitting process, so the pipeline is primed for activity once the market turns around.

Inaccurate wind energy information also undermines long-term planning for new renewable resources in utility integrated resource planning. This is being addressed through active participation in the planning processes at the Oregon Public Utility Commission.

Transmission and market issues in the region further suppress wind development in the state. Improvements are needed in liquid bi-lateral markets for integration resources, a transition to 15-minute scheduling, and development of a regional energy imbalance market. Regional advances are being made in certain areas, such as 15-minute scheduling and bilateral markets. Work on a regional energy imbalance market is more divided with many utilities and Bonneville Power Administration exploring a Northwest energy imbalance market option, while some larger

³⁶ http://apps2.eere.energy.gov/wind/windexchange/schools_wfs_project.asp

utilities are considering joining CAISO³⁷ as an alternative. One positive development is that Senator Ron Wyden has become a strong supporter of a regional energy imbalance market.

As in other Western states, impact on sage grouse populations is an issue in terms of siting wind projects. Oregon is developing a state plan for sage grouse conservation that will affect the potential for wind energy development in the southeastern quadrant of the state. Oregon is attempting to avoid the core area exclusion approach used in other states by formulating a new regulatory approach and enhancing the compensatory mitigation system.

Oregon has 4.8 MW of distributed wind capacity installed, primarily located in territory covered by the Energy Trust of Oregon's incentive program. Oregon has a single 9-MW community wind project, PaTu Wind, which sells power through a power purchase agreement with Portland General Electric and a long-term transmission contract with Bonneville Power. Like other states in the region, additional distributed wind projects are limited by high installed costs and community wind projects are challenged by low power purchase agreement prices and lack of the investment tax credit cash grant.

Oregon also has one proposed offshore wind project, the 30-MW Principle Power WindFloat Pacific project, one of DOE's Offshore Wind Advanced Technology Demonstration Projects. Interest in offshore wind on the West Coast has been limited because the depth of the water is too great for typical offshore turbine installations. This demonstration project would use floating turbine platforms to address this issue. If successful, this approach could open up new areas for offshore development.

Columbia Gorge Community College was one of the original colleges offering wind technician training programs and continues to offer degree and certificate programs in renewable energy.

6.6.4 Washington

As of the end of 2015, Washington has a total installed capacity of 3,075 MW (WINDExchange 2016). Similar to other states in the Northwest, new project development has slowed due to factors such as depressed demand for power, low natural gas prices, uncertainty about the persistence of federal policy, and utilities fulfilling their near-term RPS compliance targets. Despite this dynamic, six projects totaling 1,307 MW have approved permits, and another 601 MW of wind are in the permitting process, so projects are ready to move forward once the market turns around.

Inaccurate wind energy information also undermines long-term planning for new renewable resources in utility integrated resource planning. This is being addressed through active participation in the planning processes at the Washington Utilities and Transportation Commission.

Transmission and market issues in the region further suppress wind development in the state. Improvements are needed in liquid bi-lateral markets for integration resources, a transition to 15-minute scheduling, and development of a regional energy imbalance market. Regional advances are being made in certain areas, such as 15-minute scheduling and bi-lateral markets. Work on a regional energy imbalance market is more divided with many Washington public utilities and

³⁷ An independent, non-profit Independent System Operator (ISO) serving California

Bonneville Power Administration exploring a Northwest energy imbalance market option, while Puget Sound Energy has signaled it would like to join the CAISO energy imbalance market as an alternative.

Washington has 12.7 MW of distributed wind capacity installed, of which 10.4 MW are also community wind projects (Coastal Energy Project and Swauk Wind). Washington State offers a production-based incentive of \$0.12 per kilowatt-hour for net-metered wind systems up to 100 kW; however, the high installed cost of these systems remains a barrier. The incentive expires in June 2020, and efforts are underway to renew and expand this program.

6.6.5 Wyoming

By the end of 2015, Wyoming had 1,410 MW of installed wind capacity, representing total capital investment of \$2.6 billion across 21 projects. The wind industry in the state supplies more than \$4 million in annual land lease payments to farmers, ranchers, and other landowners potential (American Wind Energy Association 2015r). Wyoming has 5.8 MW of distributed wind capacity installed and no community wind projects.

As with other states in the region, transmission constraints limit development, although three large transmission projects have been proposed to deliver power to larger markets (American Wind Energy Association 2015r). Several large wind projects have been proposed for Wyoming to utilize that transmission capacity if the new lines move forward. Other siting considerations for wind development in Wyoming include a state tax on wind energy generated in the state and wildlife concerns relating to sage grouse and eagles. Wind education programs in Wyoming include programs at the University of Wyoming and Larimer County Community College, one of the original colleges offering certificate programs for wind turbine technicians.

Note that the Four Corners Wind Resource Center also supports activities in Wyoming.

7 Southeast Wind Energy Resource Center

The Southeast Wind Energy Resource Center (SWERC) worked with NREL researchers to provide the following assessment of the state of the wind industry in this region.

The SWERC³⁸ encompasses the following states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The RRC works to advance the wind industry in the Southeast by providing fact-based information to stakeholders, engaging electric utilities, engaging on wind energy permitting processes, and preserving access to quality wind resources, both onshore and offshore. The RRC is a joint effort of The Southeastern Wind Coalition and several partners, including the North Carolina Clean Energy Technology Center at North Carolina State University, Clemson University, Coastal Carolina University, Georgia Institute of Technology, the Florida Energy Systems Consortium, James Madison University, Navigant Consulting, and a network of more than 80 affiliate organizations. These partners have long been reliable sources of unbiased information on wind energy and have a long history of stakeholder engagement in the region.

The following section provides an overview of the wind industry in the region. It should be noted that improved technology and accessing the wind resource at higher above-ground heights allow for geographic expansion of wind development into areas such as the Southeast, which historically was categorized as having a poor wind resource and little potential for wind development (DOE 2015b). New potential wind capacity maps are available for a 2014 industry standard wind turbine installed on a 110-m tower, which represents plausible current technology options, and a wind turbine on a 140-m tower, which represents near-future technology options (WINDEXchange 2015).

Table 15. Key Statistics for the Southeast Wind Energy Resource Center Region

	AL	AR	FL	GA	KY	LA	MS	NC	SC	TN	VA
Installed Wind, 2015 (MW) ³⁹	.07	.68	.39	.11	.20	.11	.03	.29	.03	.29	.95
Projected Potential Capacity (MW), 80 m, 30% CF	118	9,200	.4	130	61	410	0	808	185	309	1,793
Projected Potential Capacity (MW), 100 m, 30% CF	568	49,962	.4	294	699	2,840	0	1,500	1,215	817	3,466
Contribution from Distributed Wind Projects, 2014 (MW) ⁴⁰	.1	.7	.39	.11	.20	.11	0.03	.29	.03	.14	.95
Proposed Offshore Wind Projects (MW)											2,012 ⁴¹

³⁸ <http://www.sewind.org/>

³⁹ 2015 Year End Wind Power Capacity Map. Available at http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp

⁴⁰ Distributed wind project installed capacity is defined as 2003-2013 cumulative capacity (U.S. DOE 2015a).

⁴¹ Virginia Offshore Wind Technology Advancement Project 12 MW, Dominion Virginia Power 2,000 MW

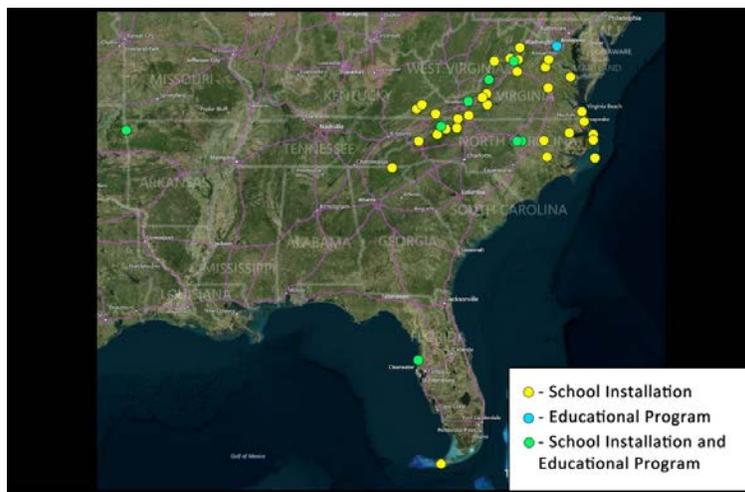
7.1 Renewable Portfolio Standards

Of the states located in the SWERC's area, only North Carolina has an RPS. South Carolina and Virginia have goals, and the remaining eight states have neither in place.

Table 16. RPS Overview for Southeast Wind Resource Center States

	RPS
AL	None
AR	None
FL	None
GA	None
KY	None
LA	None
MS	None
NC	12.5% x 2021 (investor-owned utilities)
SC	10% x 2018 (co-ops & munis)
TN	Goal of 2% by 2021
VA	None
	Goal of 15% x 2025

7.2 Workforce Development



Southeast Wind Energy Resource Center
(VA, KY, TN, NC, SC, GA, AL, MS, AR, LA, FL)

Figure 10. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs within the Southeast Wind Energy Resource Center's area

University-based wind energy programs in the Southeast are more limited than in other regions; however, robust programs at James Madison University, land-based wind programs at Virginia Technical University, offshore wind programs at Clemson University and Georgia Technical University, and distributed wind programs at Appalachian State University provide diversity. Educational activities are described in more detail in the state sections below. The WINDEXchange website also offers information and interactive maps regarding workforce

development, the DOE’s Collegiate Wind Competition, the DOE’s Wind for Schools project, school wind project locations, and locations of education and training programs in the SWERC region and other states.⁴²

7.3 Manufacturing

NREL researchers compiled the following wind energy manufacturing data for this region as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

Table 17. Wind-Related Manufacturing Overview for Southeast Wind Energy Resource Center States

Name	City	State	Component	Tier
Molded Fiber Glass	Opp	AL	Enclosures	II
LM Wind Power	Little Rock	AR	Blades	I
GE Energy	Pensacola	FL	Turbine (nacelle assembly)	I
ZF Group	Gainesville	GA	Gearbox	I
Hailo LLC	Elberton	GA	Climbing devices	II
Blade Dynamics	New Orleans	LA	Blades	I
Comer Industries	Charlotte	NC	Yaw, pitch control systems	II
ABB Inc.	Huntersville	NC	Electrical	II
IMO Group	Charleston	SC	Slew rings and drives	II
Ahlstrom Specialty Reinforcements	Bishopville	SC	Composites	II
Timken	Union	SC	Bearings	II
Thomas and Betts Corporation	Memphis	TN	Fasteners	II
BGB Technology	Chesterfield County	VA	Slipring assembly	II

7.4 Key Stakeholder Groups and Deployment Challenges

The SWERC targets these stakeholder groups:

- Utilities: Electric utilities are a critical stakeholder for all market sectors of wind energy, especially in the Southeast. The large, vertically integrated, regulated utilities are major economic drivers and have connections at the highest levels of state leadership. As a result, they have tremendous influence in energy policy and permitting, and that affects land-based, offshore, and distributed wind energy. SWERC engages utilities through its Utility Advisory Group, which provides a forum for the utilities to discuss wind energy issues in the Southeast.
- Federal and state decision makers: State policies have been the largest driver for renewable energy demand creation in the United States. So far in the Southeast, only North Carolina passed an RPS. However, the RRC sees broader interest from other states creating possible demand signals for wind energy. The RPS may not be the policy of choice in every state, but whatever the mechanisms end up being, it is likely that state policy makers will play a

⁴² <http://apps2.eere.energy.gov/wind/windexchange/schools/>

leading role in advancing or holding back wind deployment in the region. The value and need for unbiased, relevant, and actionable information provided to state policy makers will prove critical in helping to insure the appropriate development of the region's wind resources.

- **Local decision makers:** County commissioners, city managers, town managers, and other local leaders can have a tremendous influence on the ability to deploy wind energy in appropriately sited locations. They are often a “make or break” party for development projects. For example, a land-based project by Apex Wind in Alabama was effectively shut down by opposition from the county commission. This is a critical audience for delivering unbiased and fact-based information so that they are able to make informed decisions about wind energy projects and related policies in their jurisdiction.
- **Industry:** Wind industry developers, consultants, service, and supply chain companies are a powerful and historically underutilized ally in efforts to advance responsible wind energy deployment. As the voice of jobs and economic development, they have considerable influence with decision-makers and leaders. They are also a valuable source of technical information.
- **Affiliate network:** Many organizations are engaged in supporting wind energy efforts in the Southeast, from state energy offices to environmental organizations to academic groups. The SWERC will connect these diverse groups that are able to reach a wide range of stakeholders. The affiliate network is SWERC's “eyes, ears, and boots on the ground” to help identify issues that need to be considered and then to disseminate RRC information to address those issues. The affiliate network is open to any group with an interest in learning more about wind energy in the Southeast and is targeted toward those groups interested in engaging with SWERC's key stakeholders.

The information provided to these stakeholder groups addresses the following wind energy deployment market barriers that are prevalent in this region:

- Policy makers are not aware of the wind industry jobs and assets in their jurisdictions. This lack of information makes it difficult for them to support expanded wind development, especially in the face of vocal opposition to a project. SWERC activities include outreach to state and local decision makers to address this issue.
- Stakeholders in the region need credible, fact-based information to counter organized misinformation campaigns in the region.
- A lack of state RPS policies in the region (except for North Carolina) and low average electricity prices contribute to the lack of demand for wind energy and additional hurdles for wind deployment compared to some other regions.
- Navigating the potential conflicts with existing offshore activities is a challenge and requires significant engagement with many stakeholders. The SWERC is working to navigate these issues in North Carolina and South Carolina.
- The military is a very large economic driver in many states in the Southeast. Any conflicts with military operations—whether real, perceived, or just unknown—create uncertainty for development, especially in discussions between base commanders and local government officials.

- Some level of utility support will be necessary for offshore wind to move forward in the Southeast. Because Southeast utilities are conservative by nature and they have no first-hand operating experience with offshore wind, the unknowns are often extrapolated to “worst-case” perceived risks. That includes all of the typical questions that are still unanswered for Southeast development, such as diurnal wind patterns, ramp rates, seasonality, demand coincidence, transmission needs, O&M issues, etc.

7.5 Collaborating Organizations

Organizations that have collaborated with the SWERC include:

- ABB Inc.
- Alabama Rivers Alliance
- Alliance for Affordable Energy
- American Council on Renewable Energy
- American Planning Association
- American Wind Energy Association
- Apex Wind
- Arkansas Advanced Energy
- Arkansas Energy Office
- AWS Truepower
- AXYS Technologies
- Blue Green Alliance Foundation
- Cape Fear Community College
- Chesapeake Climate Action Network
- City of North Myrtle Beach
- City of Tybee Island
- Clean Line Energy
- Coastal Carolina University
- Consumer Energy Alliance
- COWI
- Distributed Wind Energy Association
- Dominion Power
- Duke Energy
- Duke University
- E4 Carolinas
- eFormative Options
- Electric Power Research Institute
- Energy Foundation
- Enterprise Florida
- Environment America
- Fishermen's Energy
- Florida Energy Systems Consortium
- Florida Sea Grant
- Georgia Department of Natural Resources, Coastal Resources Division
- Georgia Energy Center of Innovation

- Georgia Energy Office
- Georgia Tech Strategic Energy Institute
- Green Law
- Gulf States Renewable Energy Association
- Iberdrola Renewables
- International Council for Local Energy Initiatives, Local Governments for Sustainability
- K&L Gates
- Kentucky Energy Office
- Marsh
- Mississippi & Alabama Sea Grant
- Mountain Association for Community Economic Development
- National Wildlife Federation
- Natural Resources Defense Council
- Navigant
- Nicholas Institute
- Normandeau Associates
- North Carolina Conservation Network
- North Carolina Energy Office
- North Carolina Ports Authority
- North Carolina Sea Grant
- North Carolina Sustainable Energy Association
- North Myrtle Beach Chamber of Commerce
- Nucor Corporation
- Ocean Isle Fishing Center
- Parker Poe
- REAP
- Research Triangle Cleantech Cluster
- Saertex
- Santee Cooper
- Savannah River National Laboratory
- SCANA Corporation
- ScottMadden
- Siemens
- Sierra Club
- Signal Energy
- South Carolina Clean Energy Business Alliance
- South Carolina Coastal Conservation League
- South Carolina Sea Grant
- South Carolina State Ports Authority
- Southeast Energy Efficiency Alliance
- Southern Company
- Tennessee Energy Office
- Tetra Tech

- U.S. Offshore Wind Collaborative
- University of North Carolina Chapel Hill
- University of North Carolina Charlotte (EPIC Center)
- Virginia Conservation Network
- Virginia Offshore Wind Coalition
- Wake Forest University.

7.6 State Updates

7.6.1 Alabama

Although Alabama has no utility-scale wind installed, the state is home to 16 companies and 18 facilities that are involved in the full value chain of the wind energy industry (including headquarters), according to AWEA. Alabama Power has contracts in place to purchase 404 MW of wind energy from projects located in Kansas and Oklahoma. These contracts, put in place in 2011 and 2012, can provide power for up to 100,000 homes.

7.6.2 Arkansas

Arkansas does not have wind development, but it is home to 12 wind manufacturing facilities, according to AWEA, and the Arkansas Electric Cooperative Corporation has three power purchase agreements for wind energy totaling 309 MW from projects in Oklahoma and Kansas. All three agreements have been signed over the past few years: a 2012 agreement to purchase 51 MW from the Flat Ridge 2 South Wind Farm in Kansas, a 2013 agreement to purchase 150 MW from the Origin Wind Farm in Oklahoma, and a 2015 agreement to purchase 108 MW from the Drift Sand Wind Farm in Oklahoma.

7.6.3 Florida

Although no wind projects have been installed in the state, Gulf Power signed a power purchase agreement to bring wind power into Florida from Oklahoma's Kingfisher Wind Project. The Florida Public Service Commission approved the power purchase agreement for 178 MW in May 2015. Resource assessment and early development work for several sites in northern Florida have been undertaken, but there are no projects under development.

Florida is the headquarters to several major players in the wind energy industry, with 50 facilities involved in the full value chain of the wind energy industry. NextEra Energy Resources, headquartered in Juno Beach, is the largest owner of wind power capacity in the United States, and Siemens, a major wind turbine manufacturer, is headquartered in Orlando. Florida has been successful in attracting manufacturing investment for the wind industry. Market leader General Electric has a wind turbine assembly facility in Pensacola, several other wind energy manufacturers have Florida facilities, and Siemens Energy opened a Wind Service Training Center in Orlando in September 2013.

7.6.4 Georgia

Georgia Power signed a power purchase agreement to bring 250 MW of wind energy into its service territory from Oklahoma wind projects starting in 2016. Additionally, Southern Company submitted an application to BOEM for an interim policy lease that would allow for meteorological measurement activities offshore from Tybee Island.

Georgia is home to more than 32 companies and nearly 50 facilities that are involved in the full value chain of the wind energy industry. The Georgia Wind Working Group continues to advance the wind industry in the state by creating educational opportunities for all stakeholders. Close coordination with the Georgia Public Service Commission resulted in several opportunities for commissioners to speak in support of wind energy activities within the state. The second annual Georgia Tech Energy Expo in April 2015 brought together state and national energy experts for a comprehensive and interactive event with an enthusiastic public audience. The Georgia Wind Working Group utilized its network of professional affiliates to populate the discussion panels for this event. Georgia Public Service Commissioner Chuck Eaton broached the importance of energy diversity and employing a long-term outlook when planning the energy utility future of the state, while Commissioner Tim Echols moderated a panel on the infrastructure and workforce of state energy development while advocating the importance of renewables.

7.6.5 Kentucky

Kentucky is already home to 15 companies and 16 facilities (according to AWEA) that are involved in the full value chain of the wind energy industry, even though no wind farms exist in the state. Some notable examples include companies like Rotek and Muehlhan Wind Power.

Recently, turbine manufacturers have designed taller towers and longer blades, improving energy output, especially at lower-wind-speed sites. In Kentucky, the wind potential with future turbine technology is estimated to be more than 524.5 terrawatt-hours per year.

7.6.6 Louisiana

Louisiana has nine companies and 10 facilities that are involved in the full value chain of the wind energy industry, even though no wind farms exist in the state. Blade Dynamics manufactures wind turbine blades at their facility in New Orleans. The AEP Southwestern Electric Power Company has power purchase agreements for 469 MW of wind energy. These contracts bring wind from several projects in Texas, Oklahoma, and Kansas.

7.6.7 Mississippi

According to AWEA, Mississippi is home to seven companies and eight facilities that are involved in the full value chain of the wind energy industry. Though the state has no utility-scale wind installed, the potential areas for wind development in the state are increasing due to technological advancements for taller turbines and longer blades.

7.6.8 North Carolina

North Carolina will be home to the first large utility-scale wind farm in the Southeast. The Amazon Wind Farm U.S. East project by Iberdrola Renewables will include an initial phase of 208 MW of wind energy in Pasquotank County and Perquimans County in the northeastern part of the state. During the project's groundbreaking ceremony in July, North Carolina Governor Pat

McCrorry expressed support for the project's economic development benefits. The turbines will be located on private land leased by Iberdrola and will result in millions in tax and landowner revenue over the 20- to 30-year lifetime of the project.

The jobs and economic development generated by this project will build on the wind industry jobs already present in the state through the supply chain. There are more than 25 facilities in North Carolina that supply component parts for the wind industry, according to AWEA, and building wind projects in the state can help to strengthen and build the local supply chain. The Amazon project will provide an opportunity for communities in the Southeast to see first-hand the benefits of utility-scale wind. Coastal North Carolina has several kilowatts of distributed wind, some of which are Wind for Schools project turbines.

Despite these advancements, barriers to developing wind in North Carolina remain. The state has a weak RPS of 12.5% by 2021, and opponents have organized misinformation campaigns. In April 2015, the North Carolina Clean Energy Technology Center at North Carolina State University, as a part of SWERC, published fact sheets⁴³ to address some of the key wind energy myths being spread regarding health impacts, economic impacts, environmental/wildlife impacts, and grid/military impacts.

North Carolina is also participating in the Wind for Schools project, through the engagement of Appalachian State University, with the installation of 11 school systems within the state.

7.6.9 South Carolina

South Carolina has a few kilowatts of wind power capacity installed as a result of Wind for Schools projects deployed in North Carolina, as well as ongoing efforts for offshore wind in the state. The state's BOEM task force is refining the areas offshore from Horry County and Georgetown County that will be included in a Call for Information and potentially offered for lease. In 2014, the South Carolina General Assembly passed a resolution in support of wind energy in the state. The resolution acknowledges the state's wind manufacturing assets, offshore wind resource potential, supportive local governments and Clemson University's large-scale wind turbine drivetrain testing facility in Charleston. Several local governments in the state (Charleston, North Charleston, and North Myrtle Beach) have also expressed support for wind energy.

Coastal Carolina University hosted a wind energy forum in late 2014 to engage industry experts, academics, and state and local leaders in a discussion about advancing offshore wind energy opportunities in South Carolina and the Southeast. The event included remarks from a number of state and local leaders, with Senator Greg Hembree outlining a bill that he introduced in 2015 to enable the investor-owned utilities in the state to recover the costs of a small-scale demonstration project through their rates.

Clemson University's South Carolina Electric & Gas Energy Innovation Center⁴⁴ is a wind turbine drivetrain testing and grid simulator facility that completed construction in 2013. Testing performed at the Center benefits the industry as a whole while also drawing attention to the Southeast. In addition to technical testing, the facility provides tours, offers education on the

⁴³ Available at <http://nccleantech.ncsu.edu/technology/renewable-energy/wind-energy/>

⁴⁴ <http://clemsonenergy.com/>

technical characteristics of wind turbines, and creates opportunities for stakeholders to meet and learn.

7.6.10 Tennessee

Tennessee is home to the Southeast's only utility-scale wind farm, the 29-MW Buffalo Mountain project completed in 2004. According to AWEA, the state also has 27 companies and more than 30 facilities that are involved in the full value chain of the wind energy industry. The Tennessee Valley Authority has contracts for more than 1,500 MW of wind energy from Kansas, Illinois, and Iowa (American Wind Energy Association 2015m). The Eastern Clean Line transmission line is a proposed project that could facilitate the import of additional wind energy from the Oklahoma Panhandle region (Monies 2015b).

7.6.11 Virginia

The state's proposed land-based wind projects are making progress in the planning stages and the state has expanded net metering, but much of the focus remains on solar energy. Virginia's offshore wind activities are moving forward with progress in the BOEM leasing process.

Virginia Electric and Power Company was awarded a lease for the Virginia Wind Energy Area, and Virginia's Department of Mines Minerals and Energy was awarded a research lease for the two-turbine Virginia Offshore Wind Technology Advancement Project. This project, led by Dominion Virginia Power, is one of DOE's Offshore Wind Advanced Technology Demonstration Project and will deploy two direct-drive Alstom wind turbines 26 miles off the coast of Virginia Beach. The project, designed to reduce costs and uncertainty for a future large-scale project, is undertaking a stakeholder process to find a path forward for the project after initial cost estimates exceeded the conceptual estimate.

In addition, the Virginia Offshore Wind Coalition is an industry group comprised of developers, supply chain companies, localities, and utilities. The group's objectives are to develop Hampton Roads as a logistical hub of the offshore wind supply chain, to promote industry and employment opportunities in the commonwealth, and to cultivate wind projects off the Virginia shore (Virginia Offshore Wind Coalition 2014).

Installation of small wind projects has slowed.⁴⁵ Some small wind projects are installed as part of the Wind for Schools project⁴⁶ through the engagement of James Madison University, with nine school systems installed in the state. James Madison University also participated in the 2014 Collegiate Wind Competition. Virginia Technical University has also been active in wind energy programs, including hosting of the 2015 North American Wind Energy Academy symposium.⁴⁷

⁴⁵ James Madison University offers a time-lapse illustrating small wind energy system installations in Virginia from 2000 to 2015: <http://ecodefend.t15.org/>

⁴⁶ http://apps2.eere.energy.gov/wind/windexchange/schools_wfs_project.asp

⁴⁷ <http://www.nawea.org/>

8 Updates for States Outside of RRC Regions

The WINDEXchange team based at NREL researched the current state of wind energy in states outside of RRCs and compiled the following brief summaries. The states not included as part of an RRC are California, Delaware, Kansas, Maryland, Nebraska, Oklahoma, Texas, and West Virginia.

Note that Delaware, Nebraska, and West Virginia do not have any manufacturing facilities serving the wind industry.

8.1 California

As of the end of 2015, California's installed wind capacity was 6,108 MW (WINDEXchange 2016). A vast majority of this clean generation comes from the 124 wind projects installed across the state. This amount of development equates to an \$11.7 billion capital investment and provides approximately \$17.8 million in annual land lease payments (American Wind Energy Association 2015b). California generated 12,998 gigawatt-hours from wind in 2014, equivalent to approximately 6.57% of the state's gross system power (California Energy Commission 2016). The state saw 107 MW of wind energy come online through the third quarter of 2015 (American Wind Energy Association 2015n).

Although the state adopted a 20% by 2020 RPS in 2002 that was increased to 33% in 2011, Governor Jerry Brown proposed a new goal of 50% renewable energy by 2030 in early 2015 (Siders 2015). The state has been working to build the necessary transmission to achieve its targets. Two transmission projects will play an integral role in the state meeting its RPS goal. The nearly \$1.9 billion Sunrise Powerlink Project, a 117-mile transmission project that came online in 2012, has allowed San Diego Gas and Electric to increase the amount of clean generation it can provide its customers (San Diego Gas & Electric 2012). The \$2.1 billion Tehachapi Renewable Transmission Project (Edison International) is a 173-mile project that is expected to be fully completed by late 2016 and have the ability to transmit 4,500 MW of wind energy to the state (Southern California Edison 2014).

Siting challenges in California include impacts to wildlife (particularly raptors), desert tortoises, and other species. The state is developing its Desert Renewable Energy Conservation Plan to help address this issue, but the impact of this plan on wind energy's ability to move forward in the state has raised concerns regarding future development (Roth 2014).

Although the state has a strong potential for offshore wind, there are many challenges to overcome prior to any project development. These include establishing a more streamlined regulatory process, working with BOEM to establish an offshore wind task force, and establishing an environmental baseline for potential project locations to understand impacts on avian and marine wildlife. The high cost of offshore wind compared to onshore wind and solar has also been a challenge. It should be noted that California's deep waters will require floating platforms for offshore wind projects, and these platforms are still in the prototype stage (van Dam 2014).

California ranks third among the top five states for wind energy generation (the other top five states are Texas, Iowa, Oklahoma, and Kansas). California is home to more than 2,000 jobs

related to the wind energy industry (American Wind Energy Association 2015b), and it ranked among the top three states in 2014 in terms of adding distributed wind capacity (U.S. Department of Energy 2015a).

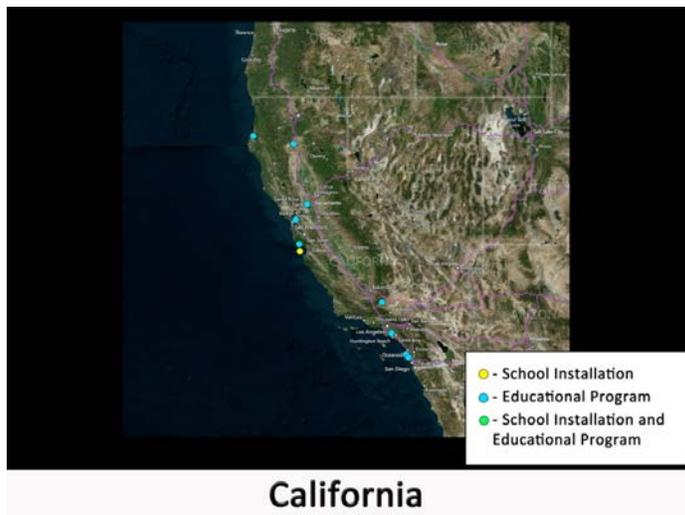


Figure 11. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs in California

Two California schools have participated in the DOE Collegiate Wind Competition, with the California Maritime Academy participating in the 2014 Collegiate Wind Competition and as an entrant in the 2016 Competition. California State University Chico is also an entrant for the 2016 Competition. Several universities in the state (such as the University of California, Davis and University of California, Berkeley) have been at the forefront of wind energy research. Visit the WINDEXchange website for information about school wind projects and educational programs in California and other states.⁴⁸

NREL researchers compiled the following California wind energy manufacturing data as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

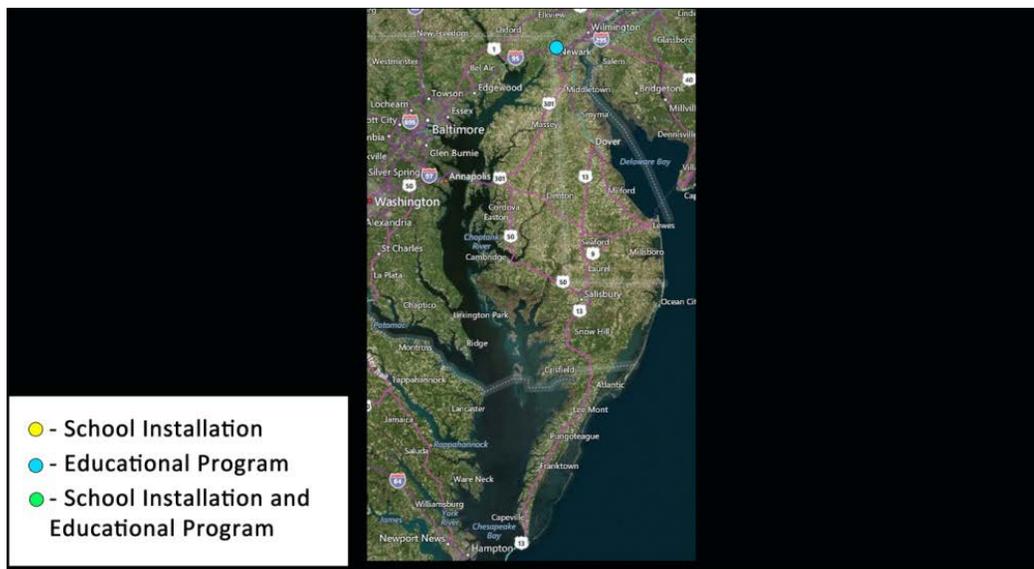
Table 18. California Wind-Related Manufacturing Overview

Name	City	State	Component	Tier
PowerWorks	Tracy	CA	Distributed wind	I
Molded Fiber Glass	Adelanto	CA	Nacelle components	II
Halus Power Systems	San Leandro	CA	Turbine Refurbishing	I

⁴⁸ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

8.2 Delaware

Delaware has 2 MW of wind capacity installed (at the University of Delaware’s Lewes campus), with no wind projects under construction and no manufacturing facilities in the state supporting the wind industry. Delaware has implemented an aggressive RPS that requires all retail electricity suppliers to purchase 25% of the electricity sold in the state from renewable sources by the end of the 2026 state fiscal year. However, the RPS requirements leading to wind energy projects are effectively reduced by a determination that provides a two times REC multiplier for the energy output of certain natural gas powered fuel cells (State of Delaware Public Service Commission 2011).



Delaware

Figure 12. Map of sole educational program location in Delaware

The University of Delaware has developed extensive capabilities in offshore wind technology and research involving the social acceptance of land-based and offshore wind technologies. Visit the WINDEXchange website for information about school wind projects and educational programs in Delaware and other states.⁴⁹

8.3 Kansas

At the end of 2015, Kansas had 3,766 MW of installed wind capacity (WINDEXchange 2016). A vast majority of this clean generation comes from the 30 wind projects that have been installed across the state. This amount of development equates to a \$5.5 billion capital investment and provides approximately \$8.9 million in annual land lease payments. Wind energy provides further economic development in the state through wind turbine manufacturing. Siemens operates a \$50 million nacelle assembly facility in Hutchinson (American Wind Energy Association 2015d). Kansas generated 10,844 gigawatt-hours from wind in 2014 (American Wind Energy Association 2015m).

⁴⁹ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

The state enacted an RPS in May 2009 that requires certain utilities to generate or purchase 20% of their electricity from renewable resources by 2020 (American Wind Energy Association 2015d). The RPS was repealed in May 2015 and was replaced with a voluntary goal of 20% electricity from renewable resources by 2020.

Several barriers inhibit wind development in Kansas. According to a survey conducted by Kansas State University in 2010, environmental concerns rated the highest. People are very concerned about potential development in the Flint Hills; the proximity of wind turbines to the great wetlands of Cheyenne Bottoms and Quivera Wildlife Refuge, an extremely popular stopover point for waterfowl and cranes; and the impact on prairie chicken species that are under threat in Kansas. Other concerns about developing wind power in Kansas include health impacts and property rights. An additional barrier to wind development in the state is a lack of transmission from the wind-rich western part of the state to load centers in the eastern part of the state (National Renewable Energy Laboratory 2013).



Kansas

Figure 13. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs in Kansas

Kansas participates in the Wind for Schools project through the engagement of Kansas State University, with 28 school systems installed. According to state facilitator Ruth Douglas Miller, 24 of the 28 turbines are operational, and the state's Wind Application Center is working to get these systems collecting data and sending information to the OpenEI turbine database.⁵⁰ The disabled turbines must be repaired, dismantled and removed, or moved to other schools. A tight budget situation due to state-level policy makes it difficult for schools to maintain turbines; nevertheless, the Wind Application Center still receives occasional requests for assistance in installing a new turbine.

⁵⁰ http://en.openei.org/wiki/Wind_for_Schools_Portal

Kansas State University also participated in the 2014 Collegiate Wind Competition and is an entrant for the 2016 Competition. The University of Kansas also participated in the 2014 Collegiate Wind Competition. Visit the WINDEXchange website for information about school wind projects and educational programs in Kansas and other states.⁵¹

NREL researchers compiled the following Kansas wind energy manufacturing data as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

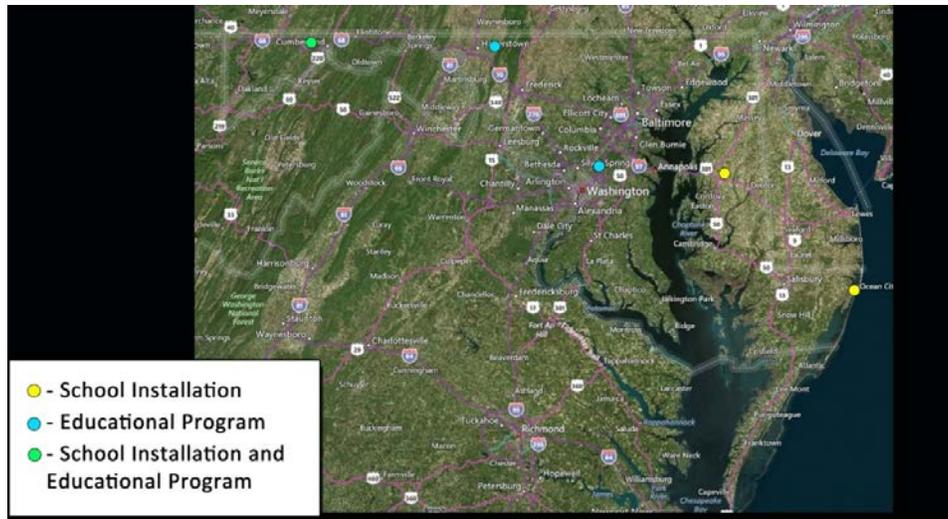
Table 19. Kansas Wind-Related Manufacturing Overview

Name	City	State	Component	Tier
Jupiter Group	Junction City	KS	Nacelle covers and spinners	II
Draka	Hutchinson	KS	Electrical	II
Siemens	Hutchinson	KS	Turbines	I

8.4 Maryland

Maryland has 190 MW of installed wind capacity at the end of 2015 (WINDEXchange 2016). With an RPS of 20% by 2022, Maryland has many additional opportunities for land-based and offshore projects, although most of the attention is focused on offshore wind. BOEM, under the U.S. Department of the Interior, has granted a competitive lease for sites in Maryland (U.S. Department of Energy 2015c). Nearly 80,000 acres of offshore federal waters were auctioned off in August 2014 with U.S. Wind Inc. attaining the rights. Preliminary project planning is underway, and a site assessment plan will be submitted to BOEM (Wheeler 2015a). Onshore development has recently been hampered due to concerns related to potential radar, wildlife, aesthetic, and property value impacts (Wheeler 2015b).

⁵¹ <http://apps2.eere.energy.gov/wind/windexchange/schools/>



Maryland

Figure 14. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs in Maryland

Although Maryland does not have many wind energy educational programs, the University of Maryland is an entrant for the 2016 Collegiate Wind Competition. Visit the WINDEXchange website for information about school wind projects and educational programs in Maryland and other states.⁵²

NREL researchers compiled the following Maryland wind energy manufacturing data as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

Table 20. Maryland Wind-Related Manufacturing Overview

Name	City	State	Component	Tier
LAI International	Westminster	MD	Bearing cages	II

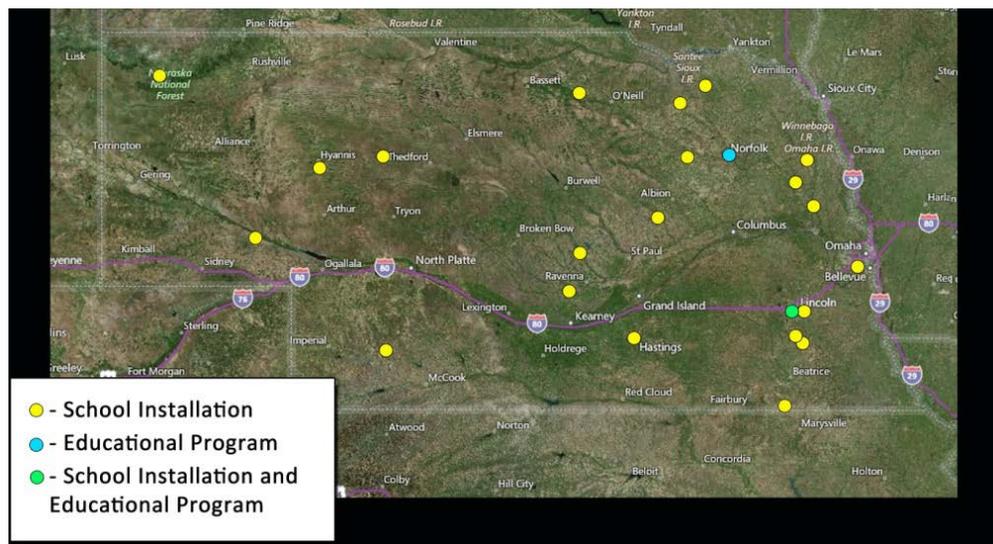
8.5 Nebraska

Nebraska had 890 MW of installed wind capacity at the end of 2015 (WINDEXchange 2016). A vast majority of this clean generation comes from the 16 wind projects that have been installed across the state. This amount of development equates to a \$1.5 billion capital investment and provides approximately \$2.4 million in annual land lease payments (American Wind Energy Association 2015f). The state has four projects with signed power purchase agreements under construction totaling more than 500 MW (Nebraska Energy Office 2016). When the last of these installations come online at the end of 2016, the state will have 1,325 MW in operation.

⁵² <http://apps2.eere.energy.gov/wind/windexchange/schools/>

Lincoln Electric System has committed to adding two wind projects, one of which will be located in-state, totaling 173 MW along with one 5-MW solar project. These developments are expected to save Lincoln Electric System customers more than \$420 million over the next 25 years (Laukaitis 2014).

Additional commitments by local utilities are beginning to shape Nebraska’s energy future. Nebraska Public Power District is working to achieve its goal of 10% energy from renewable resources by 2020. In 2015, it announced the final route for its \$361 million R-Project. The 220-plus-mile project will provide new transmission capacity to address future renewable generation (Nebraska Public Power District 2015). 2015 also saw the Omaha Public Power District board approve work to support the Midwest Transmission Project, a 180-mile transmission line that will run from Nebraska City to Sibley, Missouri. Scheduled to be in service by late 2016, the project will help advance renewable energy and increase system reliability (Omaha Public Power District 2015a). The Omaha Public Power District also confirmed its plan to have more than 30% of future retail generation provided by renewable resources (Omaha Public Power District 2015b).



Nebraska

Figure 15. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs in Nebraska

The Nebraska Farmers Union and the American Corn Growers Foundation Wealth from the Wind program have performed a lot of public outreach to communities and found that customers and landowners are very supportive of wind energy. In addition, since 2008, volunteers from farmer and rancher organizations, state agencies, public power utilities, and higher education institutions have organized the annual Nebraska Wind and Solar Conference and Exhibition to advance these industries in the state.⁵³

⁵³ <http://nebraskawindandsolarconference.com/>

Nebraska does not have an RPS or a renewable energy goal. A 2015 proposal to stimulate wind energy in the state was filibustered and removed from the 2015 legislative agenda (Walton 2015). Given the level of wind energy support from many of Nebraska's state senators, new legislation to facilitate wind development is anticipated in the 2016 legislative session (personal communication, Dan McGuire).

Nebraska participated in the original Wind for Schools project through the engagement of the University of Nebraska-Lincoln, with the installation of 25 K-12 partner school systems in the state. The University of Nebraska Wind Applications Center is actively working with those partner schools to enhance their curriculum, career development, and the overall operation of their existing small-scale wind turbines in 2016. Visit the WINDEXchange website for information about school wind projects and educational programs in Nebraska and other states.⁵⁴

Nebraska has no wind-related manufacturing.

8.6 Oklahoma

By the end of 2015, Oklahoma had installed a wind capacity of 5,184 MW (WINDEXchange 2016). A vast majority of this clean generation comes from the 34 wind projects that have been installed across the state. This amount of development equates to a \$7 billion capital investment and provides approximately \$11.4 million in annual land lease payments (American Wind Energy Association 2015j). In 2010, Oklahoma set a renewable energy target for 15% of total installed generation capacity for operating electric utilities to be renewable sources by 2015 (American Wind Energy Association 2015j).

Barriers to wind development in the state include legislation for decommissioning requirements (Justia 2010), siting requirements (setbacks from schools, hospitals, and airports), as well as notification requirements (Monies 2015a). In May 2015, Oklahoma's Governor Mary Fallin signed Senate Bill 498, which is designed to end property tax exemptions for new wind developments in 2017 (Green 2015).

Oklahoma wind energy developments export clean energy to multiple states, including Alabama, Nebraska, Arkansas, and Colorado (Teague 2015). Oklahoma also is home to a national example of the private sector working with wind projects, an Oklahoma wind project that provides power to a Google data center located in the northeastern part of the state (Google 2012).

Visit the WINDEXchange website for information about school wind projects and educational programs in Oklahoma and other states.⁵⁵

⁵⁴ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

⁵⁵ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

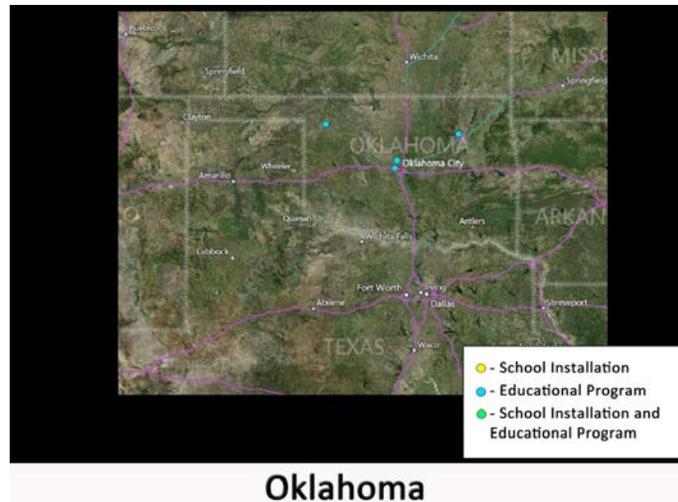


Figure 16. Map of school wind educational programs in Oklahoma

NREL researchers compiled the following Oklahoma wind energy manufacturing data as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers.

Table 21. Oklahoma Wind-Related Manufacturing Overview

Name	City	State	Component	Tier
Bergey Windpwer	Norman	OK	Distributed Turbines	I
Trinity Structural Towers	Tulsa	OK	Towers	I

8.7 Texas

By the end of 2015, Texas had an installed wind capacity of 17,713 MW, more than any other state in the nation (WINDEXchange 2016). Texas established an RPS in 1999 and amended it in 2005. The current RPS requires 5,880 MW of renewable energy by 2015. The state also has a target of 10,000 MW of renewable capacity by 2025 (which the wind energy industry met in 2010) (American Wind Energy Association 2015l). New transmission has helped spur recent wind development in the state. Completed in late 2013, the Competitive Renewable Energy Zone transmission lines have helped increase wind energy in the state while lowering curtailment for already established projects. The 1,811 MW of new capacity installed in 2014 is said to be directly tied to this transmission expansion (American Wind Energy Association 2015m).

New Mexico, Texas, and California led the United States in new distributed wind power capacity additions in 2014 across all turbine sizes (U.S. Department of Energy 2015a).

Some cities in Texas have their own renewable energy goals that stretch beyond the state RPS. For example, Georgetown, Texas announced that its municipal utility, Georgetown Utility Systems, could soon get 100% of its electricity from renewable (Gross 2015).

In 2015, Texas produced more wind power in a given amount of time than ever in history. The state reached “peak wind” at 8:48 p.m. on March 26, when the state’s wind farms produced 10,296 MW of electricity, or 29% of the total electricity load of the state’s main power grid (Magill 2014).

Texas has several educational programs that focus on wind energy: Texas Tech University; the University of Houston; and Texas State Technical College, West Texas. Visit the WINDEXchange website for information about school wind projects and educational programs in Texas and other states.⁵⁶

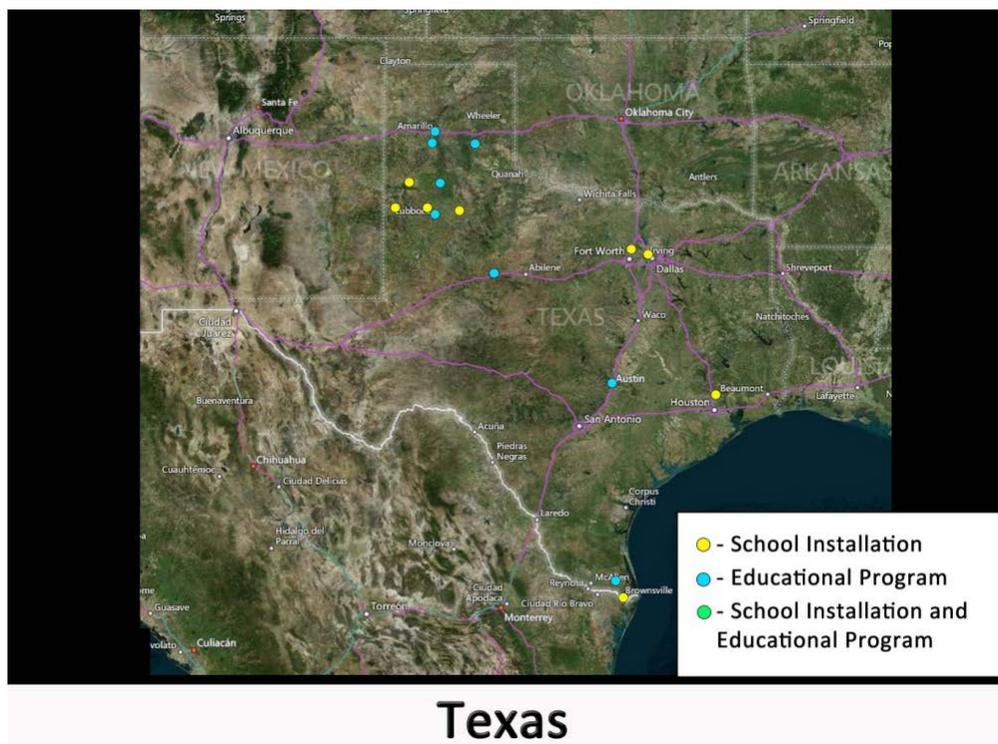


Figure 17. Map of school wind turbine projects, educational programs, and locations with both wind turbines and educational programs in Texas

NREL researchers compiled the following Texas wind energy manufacturing data as part of DOE’s annual wind market report effort (DOE 2015c). Tier I represents major components such as blades and towers, and Tier II components are sub-components, such as inverters and electrical equipment, to make the Tier I equipment.

⁵⁶ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

Table 22. Texas Wind-Related Manufacturing Overview

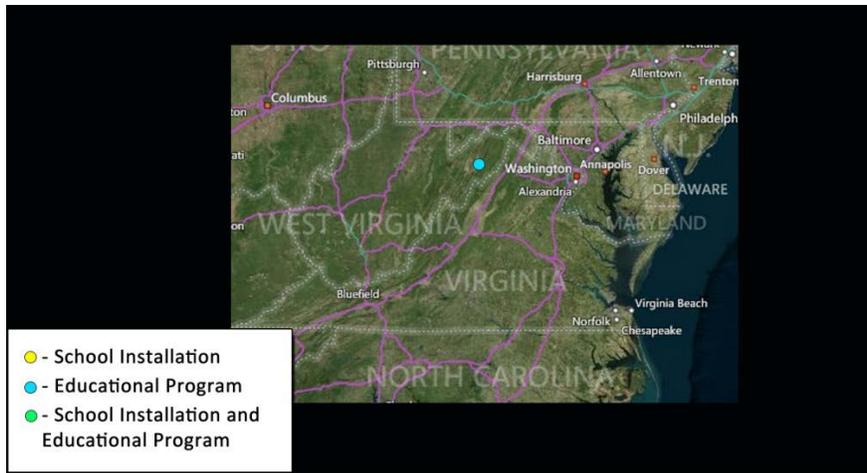
Name	City	State	Component	Tier
Molded Fiber Glass	Gainesville	TX	Blades	I
CB Gear and Machine	Houston	TX	Gears	II
CAB Inc.	Nacogdoches	TX	Flanges	II
Diab Inc.	Desoto	TX	Blade cores	II
Barr Fabrication	Brownwood	TX	Tower internals	II
All-Pro Fasteners	Arlington	TX	Bolts	II
RBC Bearings	Houston	TX	Bearings	II
EMA Electromecanica	Sweetwater	TX	Electronics	II
Broadwind	Abilene	TX	Towers	I
Alstom Power	Amarillo	TX	Turbines	I

8.8 West Virginia

At the end of 2015, West Virginia had 583 MW of installed wind capacity (WINDEXchange 2016). A vast majority of this clean generation comes from five wind projects that have been installed across the state. This amount of development equates to a \$1.2 billion capital investment and provides approximately \$1.8 million in annual land lease payments (American Wind Energy Association 2015q). A sixth wind farm, the 103-MW New Wind Creek project, is scheduled to be placed in service in December 2016 (Reuters 2015).

In 2009, West Virginia passed an Alternative and Renewable Energy Portfolio Standard that requires certain utilities to derive 25% of their sales from alternative and renewable energy resources by 2025 (American Wind Energy Association 2015q). In early 2015, West Virginia lawmakers repealed this measure (Sadasivam 2015).

Projects in the state continue to experience wildlife concerns, primarily related to bats. Land use issues regarding mountain top mining impacts in the southern part of the state have also created challenges (Dutton et al. 2014).



West Virginia

Figure 18. Map of sole school wind educational program in West Virginia

Visit the WINDEXchange website⁵⁷ for information about school wind projects and educational programs in West Virginia and other states.

⁵⁷ <http://apps2.eere.energy.gov/wind/windexchange/schools/>

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