Accessing USDA REAP funding for Your Distributed Wind Energy Project

U.S. Department of Agriculture (USDA)
National Renewable Energy Laboratory (NREL)

Edward Baring-Gould
June 17, 2024
1. Welcome and Intro to USDA REAP – Ron Omann, USDA
2. Distributed Wind 101 (25 mins) – Ian Baring-Gould, NREL
3. Distributed Wind Applications for REAP (20 mins) – Ron Omann, USDA
4. Relevant Resources and Q&A (30 mins) - USDA/NREL
Welcome
USDA REAP and RAISE
Rural and Agricultural Income & Savings from Renewable Energy (RAISE) initiative will provide savings and additional revenue sources for small agricultural businesses in rural America:

• Since 1981, the nation has lost nearly 545,000 farms and 155 million acres of former farmland.

• The nation has enjoyed record farm income in recent years, but the income has been concentrated among 7% of farms that cumulatively account for 89% of income.

• In the face of increased costs, competition for land use, and consolidation, small family farmers shouldn’t have to work twice as hard; we should find ways additional ways for them to generate revenue from the land.

Based on collaboration between the U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA), this effort will:

• Advance opportunities for small and mid-sized farmers to earn savings and income from underutilized renewable energy projects.

• Pilot new and innovative business models for farmers, rural electric cooperatives, and developers that utilize distributed energy resources (DERs) to generate revenue for farmers.

• Lead to 400 individual farmers deploying small-scale wind projects within 5 years using Rural Energy for America Program (REAP).
Distributed Wind 101
• Distributed energy resources are technologies used to generate, store, and manage energy consumption for nearby energy customers.
• Examples include:
  – Rooftop solar photovoltaics
  – Wind turbines
  – Battery storage.
• A wind turbine used as a distributed energy resource — also called **distributed wind** — is connected at the distribution level of an electricity delivery system, in off-grid applications to serve on-site energy demand, or to serve local loads on the same distribution system.
Three small wind turbines offset between 66% and 90% of the Central Maui Landfill Refuse and Recycling Center’s annual energy consumption, saving the municipal Hawaiian facility approximately $18,000 annually.

**What**
Three 10-kW Bergey Excel 10 wind turbines

**When**
2015

**Where**
Puunene, Hawaii

**How**
Installed by a local company that also performs annual maintenance at a cost of $1,000 a year

**Why**
The municipal-owned wind turbines help power the facility’s offices, leachate pumps, and gas flare. Excess electricity from the wind turbines goes to the local utility grid for which the facility is compensated.
Method Soap Manufacturing Facility

The Method Soap facility was built on a former brownfield.

<table>
<thead>
<tr>
<th>What</th>
<th>One refurbished 600-kW NEG Micon NM48 wind turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>When</td>
<td>2015</td>
</tr>
<tr>
<td>Where</td>
<td>Chicago, Illinois</td>
</tr>
<tr>
<td>How</td>
<td>Installed by a local developer</td>
</tr>
<tr>
<td>Why</td>
<td>To become an eco-friendly facility</td>
</tr>
</tbody>
</table>
Heritage Dairy Farm

The two Northern Power Systems wind turbines each produce nearly 240,000 kWh per year.

<table>
<thead>
<tr>
<th>What</th>
<th>Two 100-kW Northern Power Systems wind turbines</th>
</tr>
</thead>
<tbody>
<tr>
<td>When</td>
<td>2016</td>
</tr>
<tr>
<td>Where</td>
<td>Yuma, Colorado</td>
</tr>
<tr>
<td>How</td>
<td>Installed by a local developer</td>
</tr>
<tr>
<td>Why</td>
<td>To offset electricity use (50%-60% electricity offset)</td>
</tr>
</tbody>
</table>

Photo from Charles Newcomb
The wind turbine reduces the feed yard’s greenhouse gas footprint by producing over 90,000 kWh of clean energy per year.

<table>
<thead>
<tr>
<th>What</th>
<th>One 25-kW Eocycle wind turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>When</td>
<td>2019</td>
</tr>
<tr>
<td>Where</td>
<td>Yuma, Colorado</td>
</tr>
<tr>
<td>How</td>
<td>Designed and installed by Eocycle</td>
</tr>
<tr>
<td>Why</td>
<td>To reduce electricity cost and increase sustainability</td>
</tr>
</tbody>
</table>
After leasing some of his land for large wind farms, this farmer decided he wanted a wind turbine of his own.

- **What**: One 25-kW Eocycle wind turbine
- **When**: 2020
- **Where**: Cosmos, Minnesota
- **How**: Designed and installed by Eocycle
- **Why**: To save on electricity bills (30%-50% bill savings)
Wind Turbine Technology – The Basics
Many different designs are available, but all use aerodynamic lift on the blades or drag on a capture device, causing them to rotate, turning a generator where potential energy is converted into electricity.
Wind Turbine Power Basics

- Wind speed is critical for wind power production
  - Power generation is based on wind speed cubed
    - If wind speed doubles, power output increases by a factor of eight
  - Wind speeds increase with higher elevations
  - While higher wind speeds mean more power production, gusts of high-speed wind or highly turbulent winds are not ideal

Wind Turbine Power \( P = \frac{1}{2} \rho A V^3 \)

- \( P \) = power (Watts)
- \( \rho \) = air density (kg/m³)
- \( A \) = rotor swept area (m²)
- \( V \) = wind speed (meters per second)

\( Wind \ speed \ is \ important! \)

However! All turbines can only extract 59.3% of the power available in wind. This is known as the Betz Limit – though some methods may augment the wind flow to increase energy capture.
Distributed wind turbines can provide electricity for all types of customers.

**Wind Turbine Sizes**

### Small (<100 kW)
- Homes
- Farms
- Remote applications (e.g., water pumping, telecom sites, ice making)

### Mid-scale (100–1,000 kW)
- Village and hybrid power
- Community and distributed power
- Small commercial and industrial applications

### Large, land-based (1–3 MW)
- Large commercial and industrial deployments
- Large distributed power
- Utility-scale wind farms

### Large, offshore (3–7 MW)
- Utility-scale wind farms, shallow coastal waters with transition to deep water
Types of Wind Turbine Technology

**Horizontal Axis Wind Turbines (HAWTs)**
- Axis of rotation is parallel to the wind stream
- The dominant configuration in the marketplace

**Vertical Axis Wind Turbines (VAWTs)**
- Axis of rotation is perpendicular to ground
- More challenged in terms of efficiency, performance, and achieving certification to industry standards
Distributed Wind Markets
Wind Speed Recommendations at Hub Heights

General rules of thumb:

• For large wind turbines, an annual average wind speed of at least 6.5 m/s at an 80 m height is recommended.
• For small wind turbines, an annual average wind speed of at least 4 m/s at a 30 m height is recommended.
NREL-based modeling shows strong potential for wind development.

Areas with good wind resource outside of developed areas show very strong potential for behind-the-meter development.

Wind turbines are not typically deployed in areas with the best wind resource! Potential behind-the-meter installations (upper left) are driven by wind resource (upper right), electricity costs (lower left), and lot size of potential users (lower right).

How much distributed wind development is viable?

The United States currently has the potential to profitably deploy hundreds of gigawatts (GW) of distributed wind energy capacity.

*This amount equates to more than half of the nation’s current annual electricity consumption.*
In the NREL Distributed Wind Energy Futures Study, a metric of economic potential is Threshold Capital Expenditure (Threshold CapEx).

Threshold CapEx ($/kW) is the highest cost at which a project can be installed and still achieve a positive rate of return. The higher the threshold CapEx, the higher the favorability for distributed wind energy.

In the U.S. heat map of results on the right, the darker the color, the higher the Threshold CapEx.
29.5 MW of distributed wind capacity was deployed in the United States in 2022.

Cumulative distributed wind capacity reached 1,104 MW in 2022 from over 90,000 wind turbines across all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and Guam.
Three states led the United States in new distributed wind capacity: Iowa, California, and Nebraska

In 2022, new distributed wind projects were documented in 13 states:

<table>
<thead>
<tr>
<th>California</th>
<th>New York</th>
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<tbody>
<tr>
<td>Iowa</td>
<td>Ohio</td>
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<tr>
<td>Kansas</td>
<td>Illinois</td>
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<tr>
<td>Michigan</td>
<td>Virginia</td>
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<tr>
<td>Minnesota</td>
<td>Vermont</td>
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<tr>
<td>Montana</td>
<td>Wisconsin</td>
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<tr>
<td>Nebraska</td>
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</table>
Small Wind Turbine Certification
Turbine Certification

• What is Certification?
  – The formal process through which an independent organization performs conformity assessment of a turbine to established criteria in industry standards

• Why Is It Important?
  – Provides consumer protection; helps prevent unethical marketing and false claims
  – Allows turbine manufacturers to demonstrate that the turbine model meets performance, durability, and quality standards
  – Allows for apples-to-apples comparisons for consumers
  – Funding agencies and utilities have greater confidence that wind turbines installed with public funds have been tested for safety, function, performance, and durability
  – Some incentive programs may only fund certified turbines.
• Small wind turbine models are certified to standards at test facilities by third-party, independent certification bodies.

• Industry standards are the following:
  – AWEA 9.1-2009 Small Wind Turbine Standard: For small wind turbines up to about 65 kW
  – ACP 101.1-2021 Small Wind Turbine Standard: For small wind turbines having a peak power of 150 kW or less; can replace AWEA 9.1-2009
  – IEC 61400 -1 (design), -2 (small wind turbines) -11 (sound), and -12 (power performance)
## Certified Small Wind Turbines

<table>
<thead>
<tr>
<th>Applicant</th>
<th>Turbine Model</th>
<th>Year of Initial Certification</th>
<th>Certified Power Rating @ 11 m/s (kW)</th>
<th>Certification Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bergey Windpower Company</td>
<td>Excel 10</td>
<td>2011</td>
<td>8.9</td>
<td>AWEA 9.1</td>
</tr>
<tr>
<td>Bergey Windpower Company</td>
<td>Excel 15</td>
<td>2021</td>
<td>15.6</td>
<td>AWEA 9.1</td>
</tr>
<tr>
<td>Eveready Diversified Products (Pty) Ltd.</td>
<td>Kestrel e400nb</td>
<td>2013</td>
<td>2.5</td>
<td>AWEA 9.1</td>
</tr>
<tr>
<td>Eocycle Technologies, Inc.</td>
<td>EOX S-16 (formerly EO20/E025)</td>
<td>2017</td>
<td>22.5/28.9</td>
<td>AWEA 9.1</td>
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<tr>
<td>HI-VAWT Technology Corporation / Colite Technologies</td>
<td>DS3000</td>
<td>2019</td>
<td>1.4</td>
<td>AWEA 9.1</td>
</tr>
<tr>
<td>Primus Wind Power</td>
<td>AIR 30/AIR X</td>
<td>2019</td>
<td>0.16</td>
<td>IEC 61400</td>
</tr>
<tr>
<td>Primus Wind Power</td>
<td>AIR 40/Air Breeze</td>
<td>2018</td>
<td>0.16</td>
<td>IEC 61400</td>
</tr>
<tr>
<td>SD Wind Energy, Ltd.</td>
<td>SD6</td>
<td>2019</td>
<td>5.2</td>
<td>AWEA 9.1</td>
</tr>
<tr>
<td>Wind Resource, LLC</td>
<td>Skystream 3.7</td>
<td>2023</td>
<td>2.1</td>
<td>AWEA 9.1</td>
</tr>
</tbody>
</table>

Source: [https://www.pnnl.gov/distributed-wind](https://www.pnnl.gov/distributed-wind)
Siting Considerations
Land Use for Large-Scale Distributed Wind

Large-scale installations with multiple turbines may occupy a large land footprint due to spacing requirements, but physically disturb little land.

General rule of thumb for spacing:
- ~8 rotor diameters apart in prevailing wind direction
- ~4 rotor diameters apart in perpendicular direction

Permanent land requirement:
- ~1 acre/MW
  - Includes direct impacts, such as wind turbine pads, access roads, substations, etc., that physically occupy land area and create impermeable surfaces.

Total land requirement: 25 - 124 acres/MW
(for multi-MW large wind projects)
Land Use for Small-Scale Distributed Wind

- Land use impacts may be non-existent or marginal for small wind
  - General rule of thumb for spacing: A minimum of 1 acre is typically required to allow for setbacks from neighbors and property lines and from obstacles that could cause turbulence.

- Turbulence can be a major issue for small turbines because of their lower tower heights and location near homes and other buildings.
  - Turbines need to be sited upwind of buildings and trees.
  - A rule of thumb is for the tower to be 30 ft. above anything within a 500-ft. horizontal radius.
  - For tilt-up towers, enough space is needed to raise and lower the tower for maintenance; for guyed towers, space is needed to secure the guy wires.
How tall do distributed wind turbine towers need to be?

- Wind speed increases with height in the atmosphere.
- Small increases in wind speed can result in large increases in wind power.
- Tall towers are often needed to provide clearance above obstacles (buildings, trees).

Considerations:

- Potential power production increases with the height of the wind turbine tower.
- However, cost and permitting challenges also increase with the height of the wind turbine tower.
- Depending on height and location, the Federal Aviation Administration may require the turbine to have nighttime lighting.

Note: Tower heights are typically measured as the distance from the ground to the turbine rotor, which is also known as the “hub height.”
Building-Integrated & Rooftop Installations

Most turbines deployed on buildings and rooftops perform below expectations and well below what they would in a more traditional location.

Not recommended due to:
- Turbulent wind flow around buildings
  - Makes installation & maintenance difficult
  - Causes underperformance and degrades turbine reliability
- Vibration and sound issues in buildings
- Higher cost resulting from complexities with installation and maintenance
- Potential liability and safety issues.

Of six built-environment projects assessed by NREL in a report, **NONE** met their energy production estimates!
For grid connected energy systems:

- State and local provider (power company) policies drive the conditions in which small-turbine consumers can connect distributed energy resources (DER) to the grid.

- Need to work with local service providers to understand interconnection requirements, even for projects installed on the customer side of the utility meter.

- Hosting capacity is the amount of DERs that can be added to a distribution feeder or circuit without affecting power quality or reliability.

- To safely and reliably integrate additional DERs beyond the hosting capacity limit, control or system upgrades would be required.
Siting is important to minimize impacts to birds, bats, and other migratory species.

- Impacts to animals are primarily through collision and habitat disruption, and to a lesser extent, changes in air pressure caused by the spinning turbines.

Studies have concluded that these impacts are relatively low, especially for smaller projects.

- Impacts are species- and habitat-specific.
- Micro-siting is key to reducing impacts, and some locations may not be suitable for development.
  - Micro-siting refers to the process of identifying where an individual turbine will be located within a larger area.

Potential impacts at a large wind farm will be different than for a single, small wind turbine.
Wildlife & Habitat

Small wind turbines are less likely to cause wildlife impacts.

• Findings suggest that small residential turbines have limited impacts on avian mortality and behavior.

• No turbine-related avian fatalities were recorded during a 2007-2012 study on small wind turbines in Maine (*Morris and Stumpe 2015*).

• Distributed wind projects are more likely to be sited in already disturbed areas, such as a manufacturing complex or an agricultural field.

• The *U.S. Fish & Wildlife Service Land-Based Wind Energy Guidelines* provides a tiered approach for assessing potential wildlife impacts and does not expect distributed wind projects to need to go beyond preliminary site evaluations.

Although wind-wildlife impacts are more common for large-scale wind projects, regardless of project size, micro-siting is critical to mitigating potential impacts.
Reported Health Effects

Fact: Studies have consistently found that wind turbines do not cause adverse health impacts. While some studies have found a correlation between exposure and annoyance (e.g., sleep disturbance, negative emotions), this is largely influenced by one’s perception of the project.

Reported health effects by residents near large-scale wind turbines include:

- Decreased Quality of Life
- Annoyance
- Stress
- Sleep Disturbance
- Headache
- Anxiety
- Depression
- Cognitive Dysfunction
- Ringing in the Ears
- Mood and Memory Problems
- Equilibrium Issues
- Nausea
Sound Emissions

• Modern turbines do not produce sound at levels that can cause hearing impairment.

• There is evidence to suggest wind turbine sound annoyance is mostly a function of individual perception and experience.
  – There have been reports of increased annoyance, stress, irritation, and sleep disturbance, especially at wind turbine sound pressure levels greater than 40 dB(A).

• Modern turbines have features capable of controlling sound emissions, such as:
  – Insulation of the nacelle* and gearbox
  – Blade serrations

• Sound concerns can also be mitigated with proper distances between turbines and nearby residences.

*The nacelle houses all the generating components in a turbine (the generator, gearbox, drive train, and brake assembly).
Shadow Flicker

• Occurs when rotating wind turbine blades cast shadows on the ground or on nearby structures, usually at sunrise and sunset.

• There is no strong epidemiological evidence linking shadow flicker to serious health effects.
  – Studies revealed turbines are unlikely to induce an epileptic response. *(Knopper and Ollson 2011)*

• Computer models can accurately predict when, where, and to what degree shadow flicker will occur.
  • Wind project developers can mitigate flicker impact during site selection.

• Shadow flicker concerns can be mitigated with proper setback distances between turbines and nearby residences.
Ice Throw & Fall

- Ice throw is the projection of accumulated ice from rotating blades.
- Ice fall occurs when ice drops from a stationary turbine.
- Ice buildup on wind turbine rotor blades is influenced by combinations of:
  - Wind speeds
  - Air temperature
  - Cloud height
  - Liquid water content.
- Risk mitigation options include:
  - Siting the turbine away from people and infrastructure
  - Installing a fence around the wind turbine
  - Monitoring weather conditions to shut down the wind turbine in advance of icing
  - Having ice monitoring sensors and warning systems
  - Painting blades black to absorb heat.
In a partial decommissioning scenario, project infrastructure such as the below-ground foundation and wires may be left in place. Anchor bolts may be cut flush to the ground. Decommissioning standards at the state or local level determine the removal depth for these types of project components. Most decommissioning standards allow in-ground components below 3-5 feet to remain in place.

Although partially leaving a foundation in place can limit environmental impacts (e.g., erosion), it may have its own potential impacts (e.g., impairing drainage).
Costs
The average capacity-weighted installed cost for new small wind projects in 2022 was $7,850/kW.
The small wind average capacity factor from a sample of projects that generated energy in 2022 was 15%.

Locations with a capacity factor of less than 15 should be avoided.
Operations & Maintenance Costs

- Costs can vary yearly.
- A reasonable O&M budget estimate is $30-$40 per kilowatt per year.
- Larger turbine costs typically range closer to $30 per kilowatt per year, depending on project location and other factors.
- O&M agreements are typical, especially for turbines above ~20 kW, and can cover a range of services.
- Costs may increase as the turbine ages and needs more repairs.

O&M cost information can be found in the U.S. Department of Energy's annual Distributed Wind Market Reports and Wind Technologies Market Reports, and the National Renewable Energy's Distributed Generation Technology Operations and Maintenance Costs database.
Distributed Wind Applications for REAP
REAP Application Tips

Ron Omann
Minnesota State Energy Coordinator
Project Description

- Number of turbines
- Make/Model of Turbine(s)
- Rated Peak Power of Turbine
- Height of Tower
- Project Purpose
# Turbine Information

## Design
- Spec Sheet
- Certification
- Commercially Available
- Warranty
Project Team

• Relevant Credentials & Experience

• For Whom?
  – Site Assessor
  – Installer
  – Electrical Contractor
Permits and Agreements

- Local Permits
- Interconnection Agreement
Resource Assessment

- Site specific evaluation
  - Hub Height
  - Wind Map to determine speed (m/s)
  - Wind Rose from local airport

= Turbine Production Curve
Wind Rose Maps

Primary Wind Direction

Summary
Obs Used: 115348
Obs Without Wind: 1663
Avg Speed: 10.1 mph

Calm values are < 2.0 mph
Bar Convention: Meteorology
Flow arrows relative to plot center.
Generated: 21 Apr 2024
Ground Level Photographs

• Identify barriers to production

• Provide the State Historic Preservation Office with documentation of surrounding properties
3. **Annual Energy Production Curve**

**Estimated Annual Energy Production**
(AEP-measured) with Standard Uncertainty

**Bergey Excel 15**
Reference air density: 1.225 kg/m³
Economic Assessment

• Project financial performance
  – Total project costs
  – Revenue
    • Sales of Energy
    • Replacement of cost energy
    • Combination
Project Development Schedule

- Major Activities/Month
- Equipment Availability

TASK 1
TASK 2
TASK 3
TASK 4
Maintenance

• Plan for replacement/breakdown
  – Domestic Service
  – Availability of Spare Parts

• Service Agreement
• Applicant must own or control the site
• Control can consist of a long term lease
Complete Application = Follow the Checklist

- 4280-App Form
- Requirements, not suggestions

<table>
<thead>
<tr>
<th>XVII. Attach the following if not already submitted:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Form SF 424, “Application for Federal Assistance”.</td>
</tr>
<tr>
<td>☐ Form SF-424C, “Budget Information-Construction Programs”.</td>
</tr>
<tr>
<td>☐ Form SF-424D, “Assurances Construction Programs”.</td>
</tr>
<tr>
<td>☐ Environmental documentation per 7 C.F.R, 1970.</td>
</tr>
<tr>
<td>☐ Renewable Energy Resource documentation.</td>
</tr>
<tr>
<td>☐ RES Replacement-Minimum of 12 months historical utility bills,</td>
</tr>
<tr>
<td>☐ RES Rate &amp; Energy Quantity documentation: PPA/Net metering or crediting policies/Letter from utility,</td>
</tr>
<tr>
<td>☐ Energy Audit with a minimum of 12 months historical utility bills (An Energy Audit is required for energy-efficiency projects over $200,000 Total Project Costs).</td>
</tr>
<tr>
<td>☐ Matching funds documentation.</td>
</tr>
<tr>
<td>☐ Financial Statements, for projects with Total Project Costs over $200,000,</td>
</tr>
<tr>
<td>☐ Feasibility Study, as necessary, for Renewable Energy System projects.</td>
</tr>
<tr>
<td>☐ Other, Describe:</td>
</tr>
</tbody>
</table>
USDA is an equal opportunity provider, employer, and lender.
Relevant Resources and Q&A
General Resources

• General information: [WINDEXchange Distributed Wind](#) overview and [Distributed Wind Energy Resource Hub](#)
• Searchable wind resource time series: [Wind resource data viewer](#)
• Searchable monthly wind speed and production: [Tools Assessing Performance](#)
• Information on distributed wind developers and manufacturers: [Distributed Wind Energy Association](#)
# Wind Energy Basics

<table>
<thead>
<tr>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WINDEExchange</strong></td>
<td>Platform that shares wind energy information with communities to make wind development decisions; understand siting, permitting, and installation processes; and weigh costs and benefits.</td>
</tr>
<tr>
<td><strong>What is Distributed Wind?</strong></td>
<td>Highlights the various research, development, and deployment programs being run by DOE's Wind Energy Technologies Office.</td>
</tr>
<tr>
<td><strong>How Distributed Wind Works</strong></td>
<td>Explains how distributed wind works.</td>
</tr>
<tr>
<td><strong>Distributed Wind Basics</strong></td>
<td>Offers information on distributed wind (community wind and residential wind) and additional inputs on market condition and data.</td>
</tr>
<tr>
<td><strong>Top Ten Things on Distributed Wind</strong></td>
<td>Provides key points and fun facts about the U.S. distributed wind market.</td>
</tr>
<tr>
<td><strong>Utility-Scale Wind Basics</strong></td>
<td>Offers relevant information on utility-scale land-based wind.</td>
</tr>
<tr>
<td><strong>Small Community Wind Handbook</strong></td>
<td>Offers guidance for the siting and development activities required to develop a wind project in a small community.</td>
</tr>
<tr>
<td><strong>Large Community Wind Handbook</strong></td>
<td>Provides guidance for the siting and development activities required to develop a wind project in a large community.</td>
</tr>
<tr>
<td>Resource</td>
<td>Description</td>
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<td>--------------------------------------------------------------------------</td>
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</tr>
<tr>
<td><strong>Zoning and Permitting for Wind</strong></td>
<td>Serves as a resource to facilitate the installation of distributed wind energy systems.</td>
</tr>
<tr>
<td><strong>Distributed Wind Installers</strong></td>
<td>Lists distributed wind installers for consumers' reference but does not represent an endorsement of any installer.</td>
</tr>
<tr>
<td><strong>Selecting, Implementing, and Funding Distributed Wind Systems in Federal Facilities</strong></td>
<td>Provides a free, on-demand training divided into modules. Only the financing module is hyper-specific to federal agencies.</td>
</tr>
<tr>
<td><strong>Distributed Wind for Federal Agencies</strong></td>
<td>Provides a free, on-demand training that reviews wind resource assessment screening tools and other distributed wind tools and resources.</td>
</tr>
<tr>
<td><strong>RADWIND</strong></td>
<td>Offers guidance from the Rural Area Distributed Wind Integration Network Development (RADWIND), which was a WETO-funded project led by the National Rural Electric Cooperative Association to address barriers to the adoption of distributed wind by rural utilities. Its resources include project development guidance.</td>
</tr>
<tr>
<td><strong>RADWIND Case Studies</strong></td>
<td>Shows case studies that highlight the experience of electric cooperatives and rural public power districts deploying or interconnecting distributed wind projects.</td>
</tr>
<tr>
<td><strong>Distributed Wind Installers Collaborative Case Studies</strong></td>
<td>Presents case studies that cover a variety of customers using distributed wind energy.</td>
</tr>
<tr>
<td><strong>REPowering Schools</strong></td>
<td>Provides programming and opportunities to engage and train a diverse and sustained renewable energy workforce.</td>
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# Data and Information

<table>
<thead>
<tr>
<th>Resource</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Wind Technology Resource Center</strong></td>
<td>Features technical resources from DOE on wind energy research topics through publications, data, and analysis.</td>
</tr>
<tr>
<td><strong>The U.S. Wind Turbine Database</strong></td>
<td>Offers a comprehensive dataset of U.S. wind turbine locations and characteristics that is updated quarterly.</td>
</tr>
<tr>
<td><strong>Wind Energy Technologies Office Projects Maps</strong></td>
<td>Details the Wind Energy Technologies Office's research and development portfolio.</td>
</tr>
<tr>
<td><strong>Wind Energy Maps and Data</strong></td>
<td>Shows existing wind capacity and the potential wind resources up to 140 meters above ground.</td>
</tr>
<tr>
<td><strong>Wind Energy Technologies Office Publication and Product Library</strong></td>
<td>Provides information about improving performance, lowering costs, and reducing market barriers for U.S. wind energy.</td>
</tr>
<tr>
<td><strong>Distributed Wind Photo Gallery</strong></td>
<td>Case studies to educate consumers on the many facets and opportunities within the distributed wind industry.</td>
</tr>
<tr>
<td><strong>Distributed Wind Research—NREL</strong></td>
<td>Outlines NREL's distributed and small wind research.</td>
</tr>
<tr>
<td><strong>Distributed Wind Research—PNNL</strong></td>
<td>Summarizes PNNL's distributed and small wind research.</td>
</tr>
<tr>
<td><strong>Distributed Wind Database</strong></td>
<td>Presents PNNL's distributed wind data from turbine manufacturers, operations and maintenance providers, state and federal agencies, and other stakeholders for projects installed in the United States.</td>
</tr>
</tbody>
</table>
## Wind Resource Assessment

<table>
<thead>
<tr>
<th>Resource</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>WINDEXchange</td>
<td>Features wind energy resource assessment maps, data and trends.</td>
</tr>
<tr>
<td>Wind resource data viewer</td>
<td>Identifies high-wind areas for wind power generation.</td>
</tr>
<tr>
<td>DW-TAP API</td>
<td>Offers estimates of wind direction, wind speed, and wind power.</td>
</tr>
</tbody>
</table>
# Financial Analysis

<table>
<thead>
<tr>
<th>Resource</th>
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</thead>
<tbody>
<tr>
<td><strong>Cost of Renewable Energy Spreadsheet Tool (CREST)</strong></td>
<td>Contains economic, cash-flow models designed to assess project economics, design cost-based incentives, and evaluate the impact of state and federal support structures on renewable energy.</td>
</tr>
<tr>
<td><strong>System Advisor Model (SAM)</strong></td>
<td>Free techno-economic software model that facilitates decision-making for people in the renewable energy industry.</td>
</tr>
<tr>
<td><strong>Levelized Cost of Energy (LCOE) Calculator</strong></td>
<td>Provides a simple way to calculate a metric that encompasses capital costs, operations and maintenance (O&amp;M), performance, and fuel costs of renewable energy technologies.</td>
</tr>
<tr>
<td><strong>Renewable Energy Integration and Optimization (REopt)</strong></td>
<td>Techno-economic decision support platform that helps optimize energy systems for buildings, campuses, communities, microgrids, and more.</td>
</tr>
<tr>
<td><strong>Jobs and Economic Development Impact (JEDI)</strong></td>
<td>Estimates the economic impacts of constructing and operating power generation and biofuel plants at the local and state levels.</td>
</tr>
<tr>
<td><strong>Annual Technology Baseline (ATB)</strong></td>
<td>Features consistent, freely available, technology-specific cost and performance parameters across a range of research and development advancements scenarios, resource characteristics, sites, fuel prices, and financial assumptions for electricity-generating technologies, both at present and with projections through 2050.</td>
</tr>
</tbody>
</table>