NATIONAL RENEWABLE ENERGY LABORATORY

A Successful Small Wind Future: There Is Great Potential

13th Annual Small Wind Conference
Bloomington, Minnesota

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April 11, 2017

NREL/PR-5000-68350

Examples of Small Wind Products, Testing, and Support

- **The U.S. Department of Energy's National Wind Technology Center facility: small wind support, research and development, and testing**
- **Competitive solicitations, such as the Competitiveness Improvement Project**
  http://www.nrel.gov/docs/fy16osti/66183.pdf
- **Webinars and slideshows (e.g., WINDExchange Slideshow on Distributed Wind Ordinances**
  http://apps2.eere.energy.gov/wind/windexchange/slideshows/distributed-wind-ordinances/#/**)**
- **Partners and stakeholder engagement: Wind for Schools, Collegiate Wind Competition, Regional Resource Centers –** see Wind Permit Toolkit: http://nwwindcenter.org/content/permitting-zoning-resources

Reports and research:

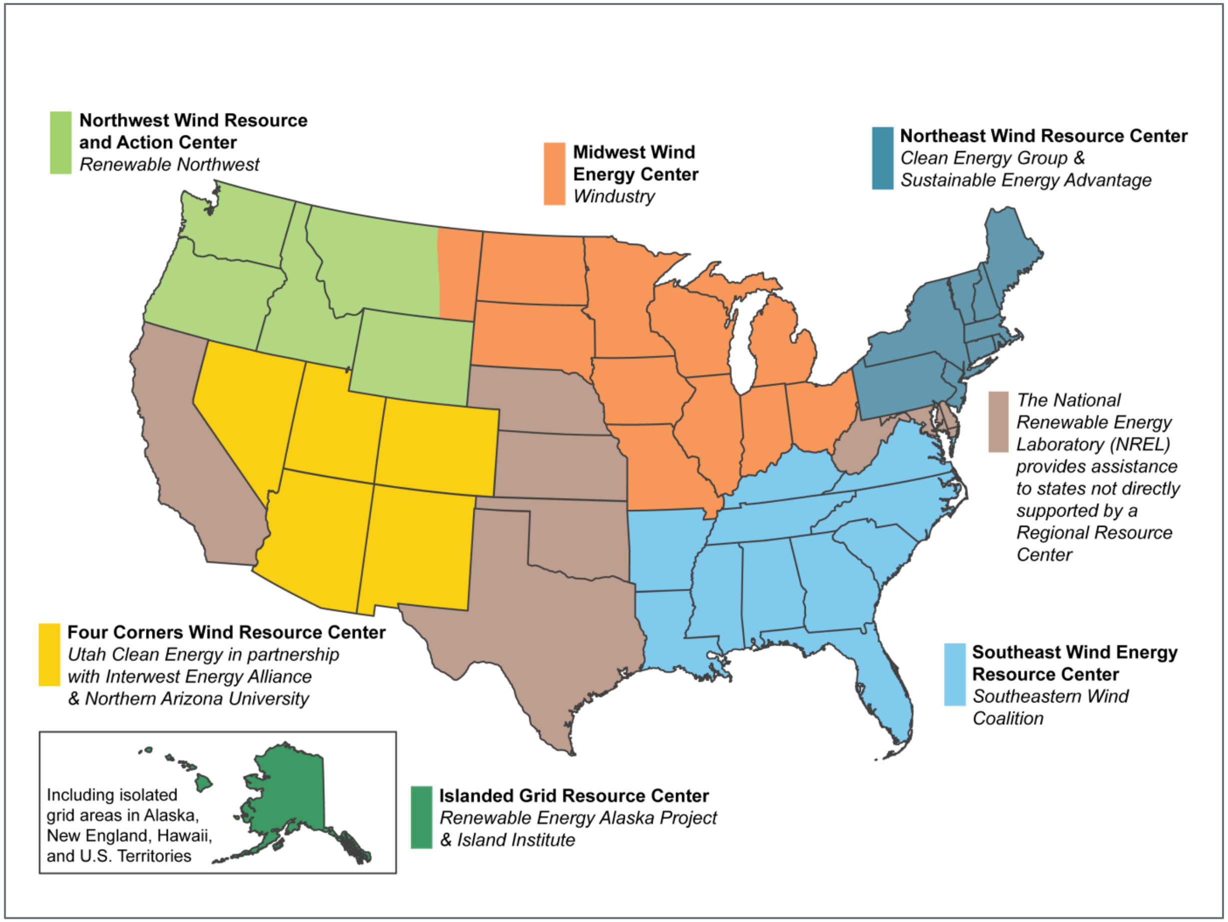
- **Market heat maps** (forthcoming)
- **The Distributed Wind Cost Taxonomy: a standardized way to evaluate costs involved with installation and operation**
  http://www.nrel.gov/docs/fy17osti/67992.pdf
- **Assessing the Future of Distributed Wind (dWind)**
  https://energy.gov/sites/prod/files/2016/11/f34/assessing-future-distributed-wind.pdf
- **Distributed Wind Resource Assessment: State of the Industry**
  http://www.nrel.gov/docs/fy16osti/66419.pdf

Deployment of Wind Turbines in the Built Environment
http://www.nrel.gov/docs/fy16osti/65622.pdf

- **Small Wind Site Assessment Guidelines**
  http://www.nrel.gov/docs/fy15osti/63696.pdf

Photo by Dennis Schroeder, NREL 37975

Regional Resource Center (RRC) Defends Distributed Wind



Efforts were underway in Oregon to restrict distributed wind PURPA* contractual requirements based on project size and power purchase agreement contract period.

The Northwest RRC provided technical information in official comments to the Oregon PUC.

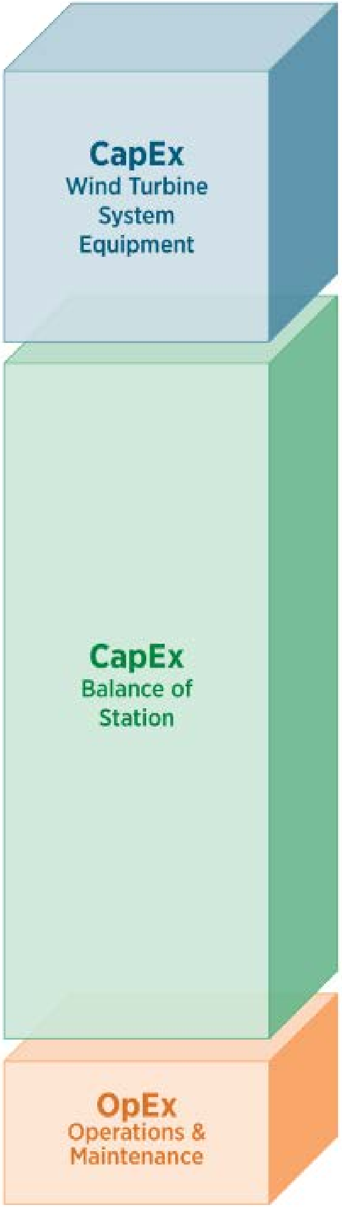
In large part due to the RRC's efforts, the final PUC ruling maintained existing PURPA interpretation.

http://www.sanger-law.com/oregon-commission-maintains-20-year-purpa-contracts/

*Public Utility Regulatory Policy Act

Standard Categories for Distributed Wind Costs:
The Distributed Wind Cost Taxonomy

The Distributed Wind Cost Taxonomy



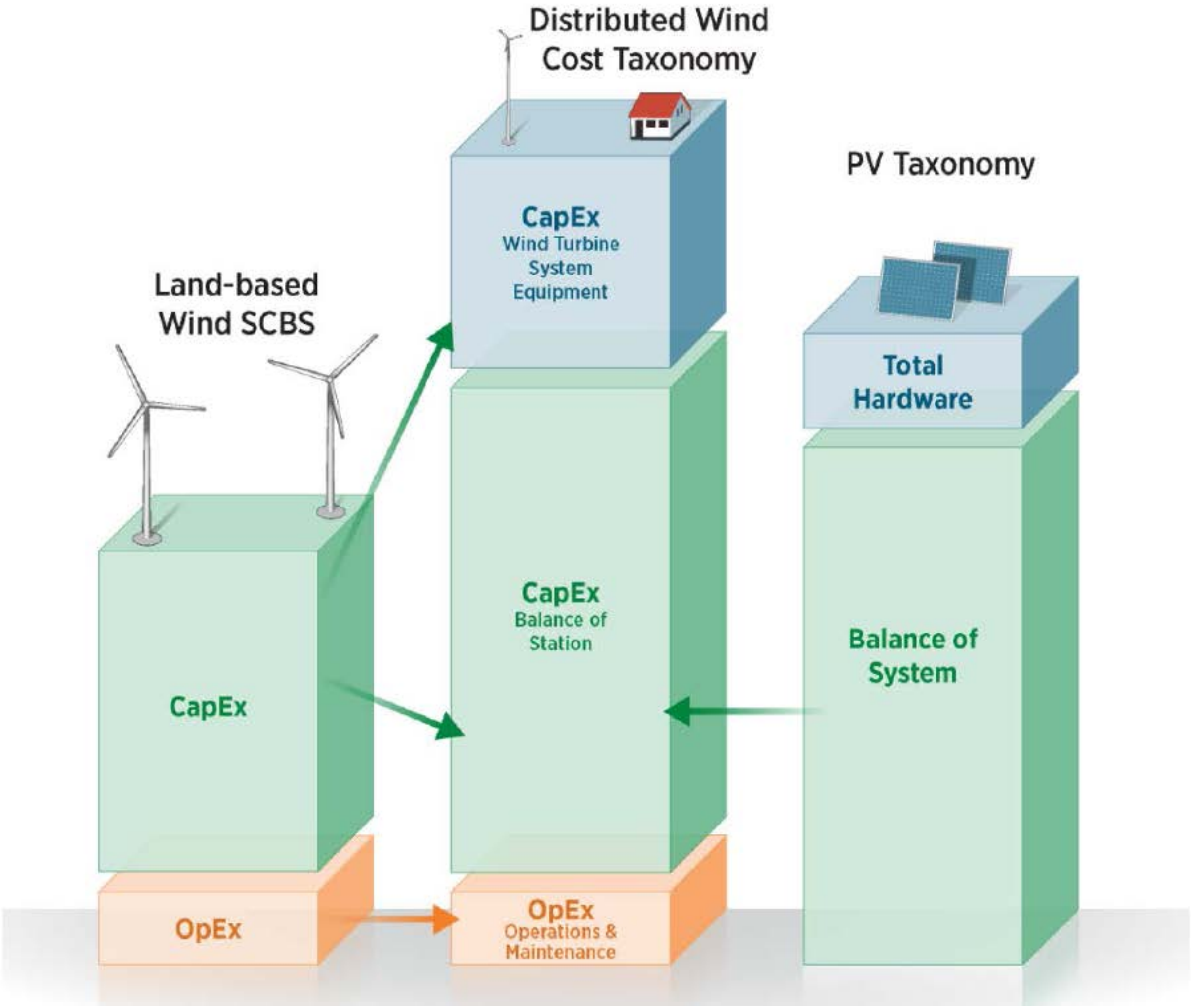
Standardizes the distributed wind cost categories to help with:

- Conversations about installation, equipment, and operational costs
- Cost comparisons within small wind and between technologies
- Comparison of your company to others (when populated with data)
- Data collection and analysis, including a forthcoming distributed wind benchmark report with costs included.

CapEx: Capital Expenditure OpEx: Operational Expenditure
SCBS: System Cost Breakdown Structure PV: Photovoltaic

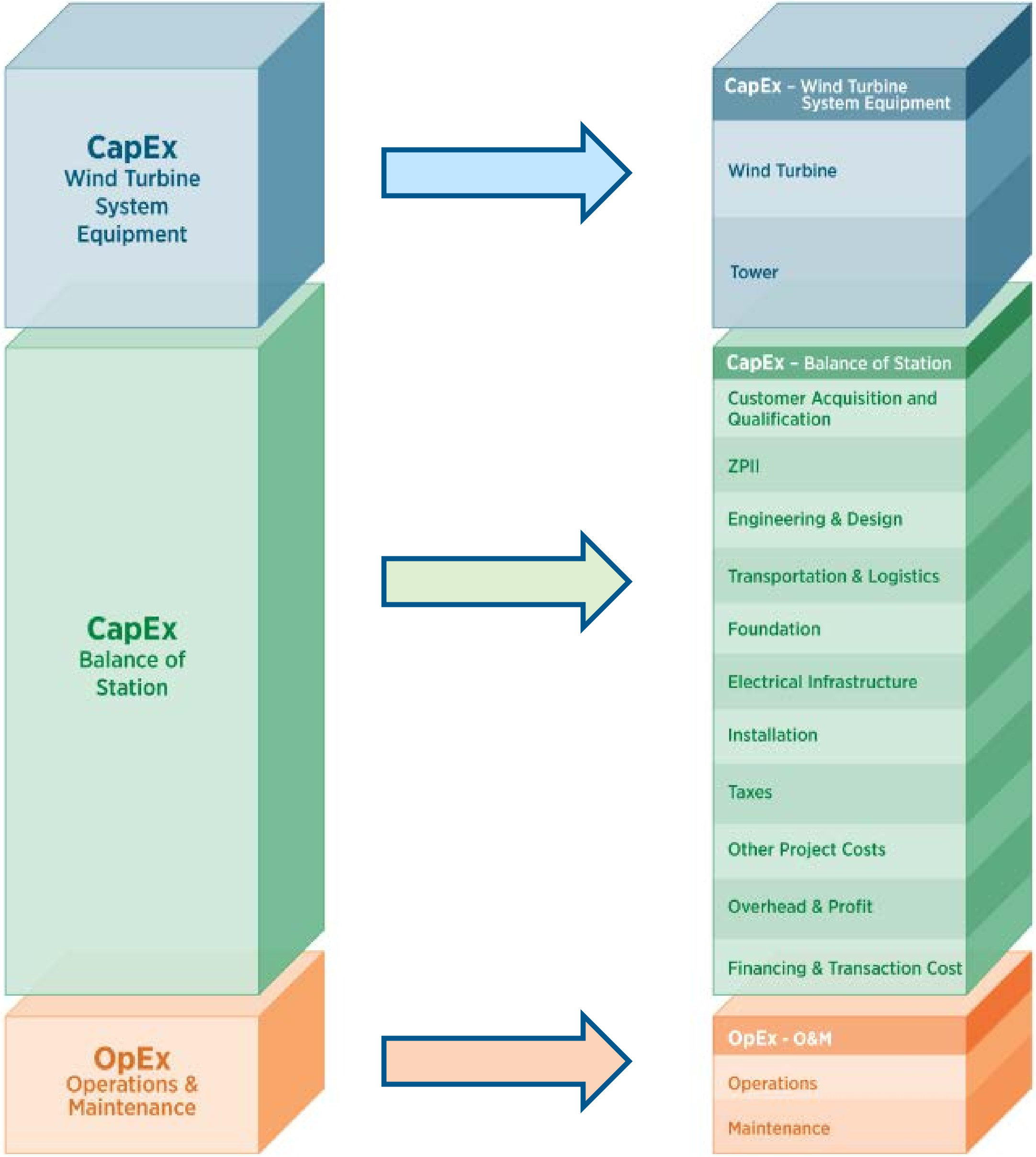
Distributed Wind Cost Taxonomy Origins

To define the categories, we started with published sources and then collected feedback from industry.

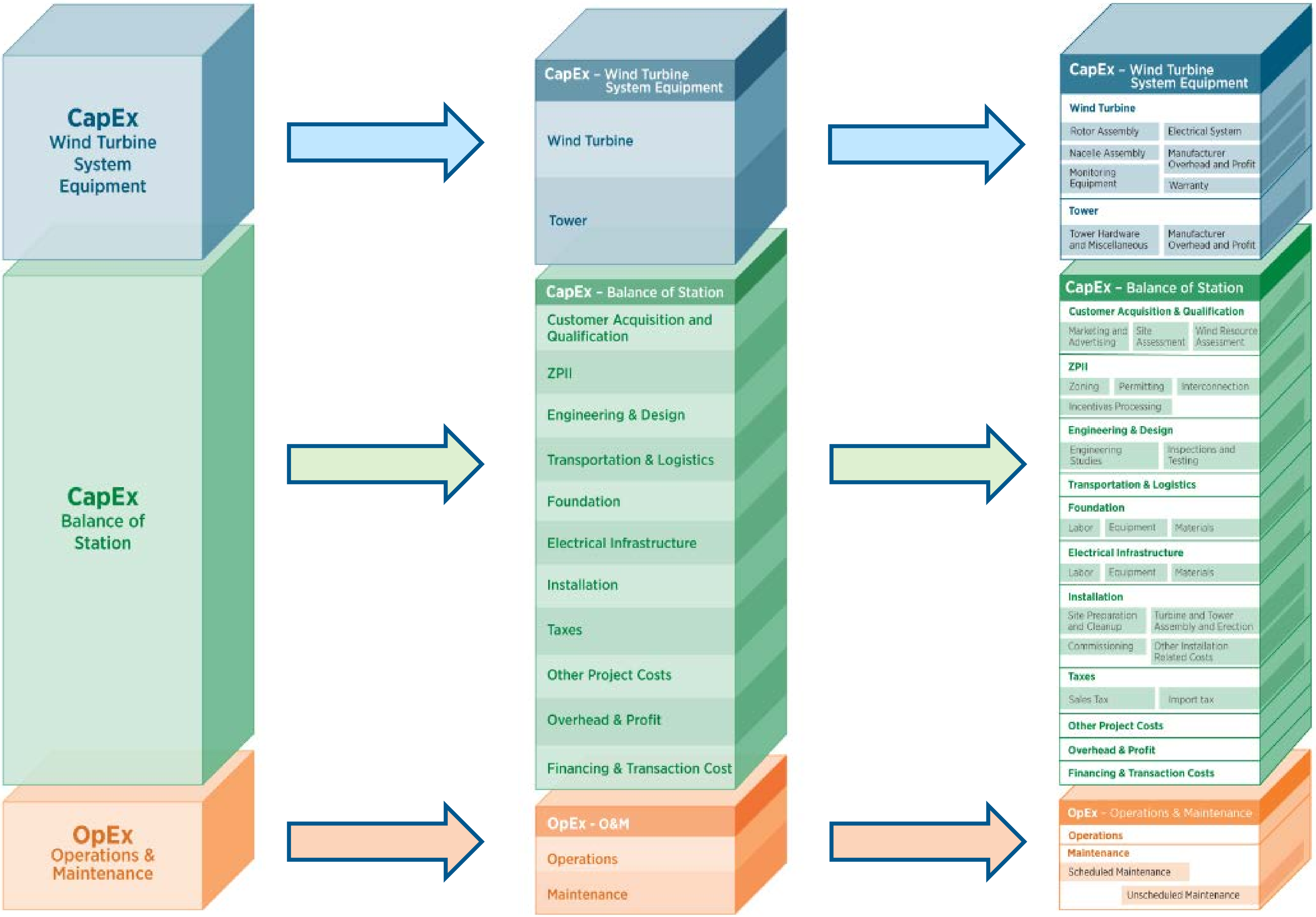


CapEx: Capital Expenditure
SCBS: System Cost Breakdown Structure
OpEx: Operational Expenditure
PV: Photovoltaic

Taxonomy Tiers 1 and 2



Taxonomy Tiers 1, 2, and 3



There Is Great Potential: The dWind Model and Results

NREL dWind Team and Report Authors:
Eric Lantz
Ben Sigrin
Michael Gleason
Robert Preus
Ian Baring-Gould

Distributed Wind Generation Market Model (dWind)

dWind is a simulation model that allows assessment of the distributed wind market based on technical and economic conditions. dWind:

- Simulates consumer purchase decisions based on economics and consumer behavior
- Models large populations of consumers on a statistical basis applied to high-resolution wind data
- Is not a siting tool and covers *only distributed wind associated with a customer load*
  - Community wind and wind gardens are not covered.
  - Out of 842 MW of distributed wind, ~45% is behind the meter.
- Does not directly model permitting and zoning barriers
  - Population density is used as a proxy for siting exclusions and height restrictions.

Distributed Wind Technology Classes

- dWind represents variations in *turbine performance* using four discrete technology size classes defined by DOE:
  - Residential
  - Commercial
  - Midsize
  - Large.

- Each size class is represented in dWind by multiple turbine sizes used to:
  - Capture variations in capital costs and tower heights
  - Offer multiple technology options for end users
  - Provide the ability to adapt future technology characterization (at the turbine resolution).

- Note: Multiple large turbines may be installed for sites with sufficient electricity demand.

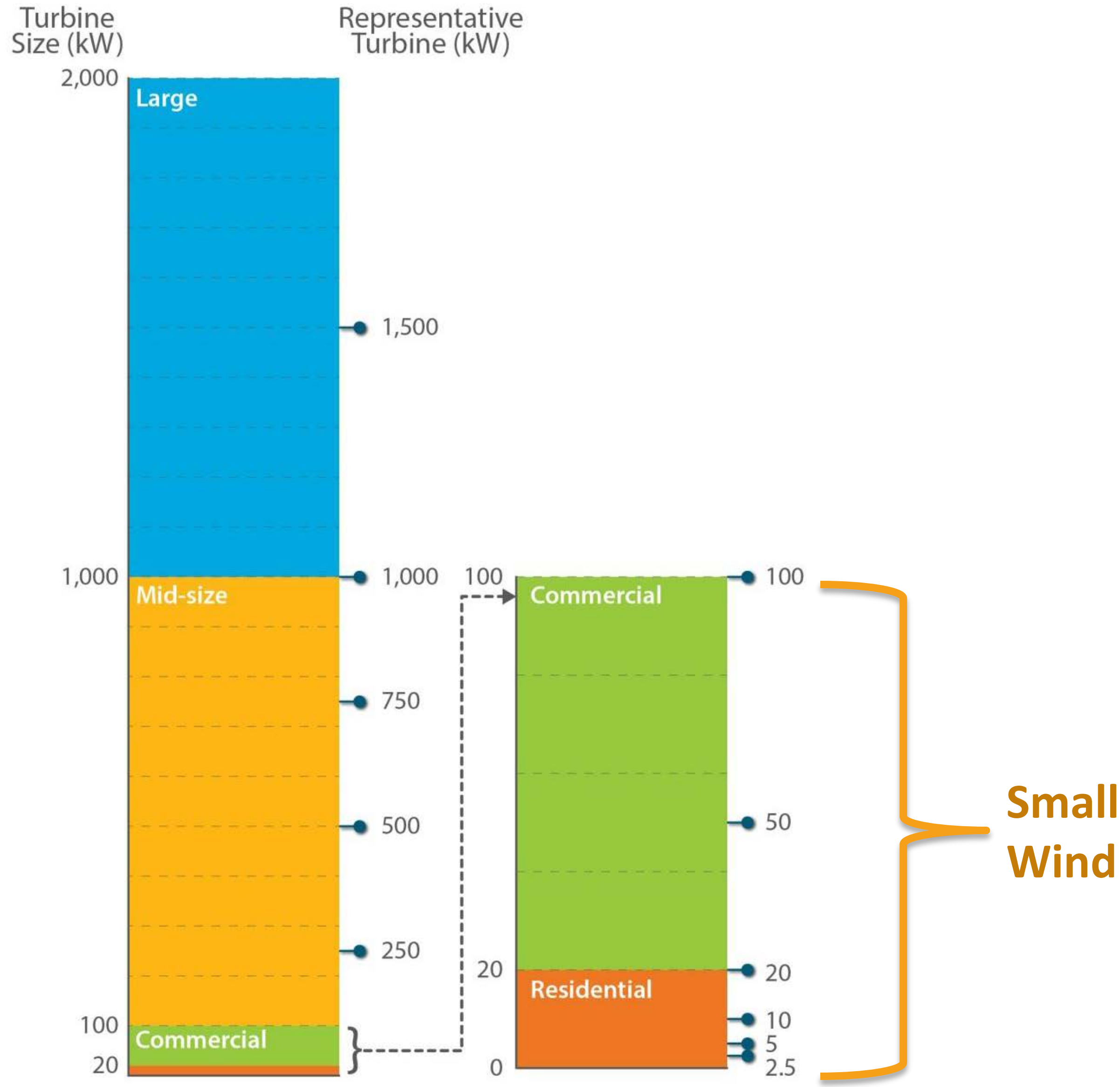
Distributed Wind Sizes and Classes

Industrial/Large:
> 1 MW
(in a distributed application)

Midsize:
> 100 kW up to 1 MW

Commercial:
20 kW to 100 kW

Residential:
up to 20 kW



Basic dWind Model Mechanics

1) Generate Model Agents

- Generates representative customers (“agents”) for each region and assigns them attributes based on underlying geospatial data (e.g., location, load, wind resource quality, electricity rates)

2) Apply Siting Criteria

- Identifies applicable distributed wind system sizes for agents based on siting criteria (e.g., parcel size, tree canopy, extent of land development)

3) Estimate Electricity Generation

- Estimates electricity production from applicable distributed wind technologies and compares to agents’ electricity needs

4) Calculate Maximum Market Share

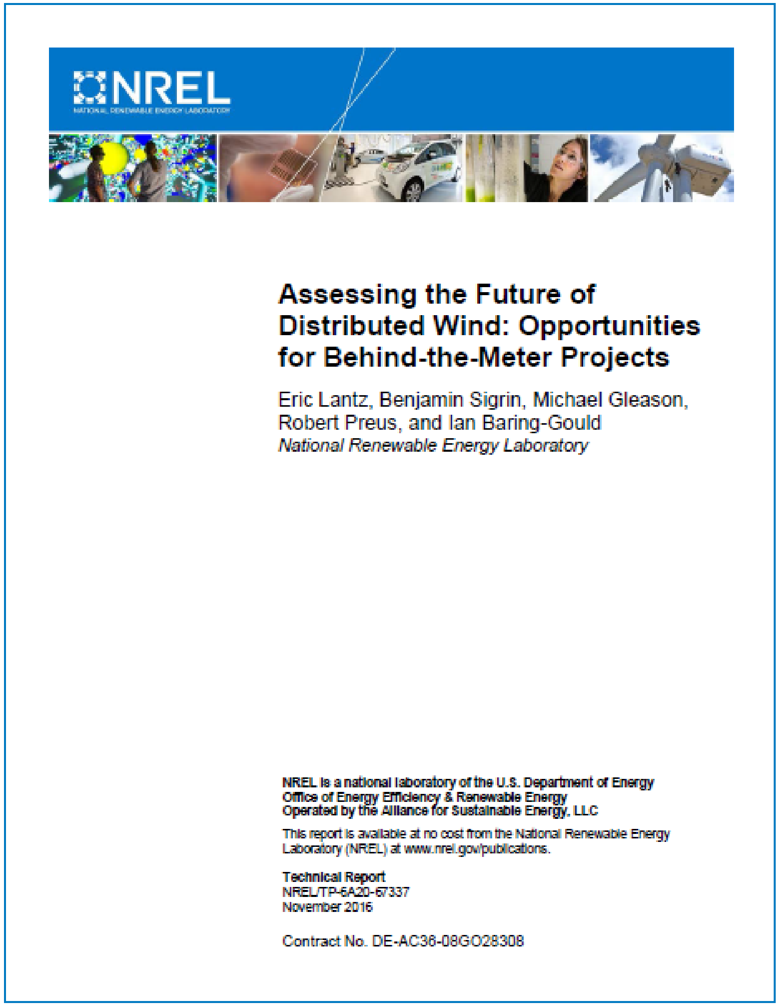
- Estimates maximum market penetration into population of agents based on calculated financials (e.g., payback, monthly bill savings)

5) Simulate Market Deployment

- Allows technology to penetrate the market with a “Bass diffusion model” (S-Curve) based on expected time to saturation for a given payback period.

DW Futures Study ("dWind study")

- Models market growth through 2050
- Explores market impacts of:
  - Price changes
  - R&D improvements
  - Available incentives and net energy metering policies
  - Electricity rates and rate structure
  - Customer behavior.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Assessing the Future of Distributed Wind: Opportunities for Behind-the-Meter Projects

Eric Lantz, Benjamin Sigrin, Michael Gleason, Robert Preus, and Ian Baring-Gould
National Renewable Energy Laboratory

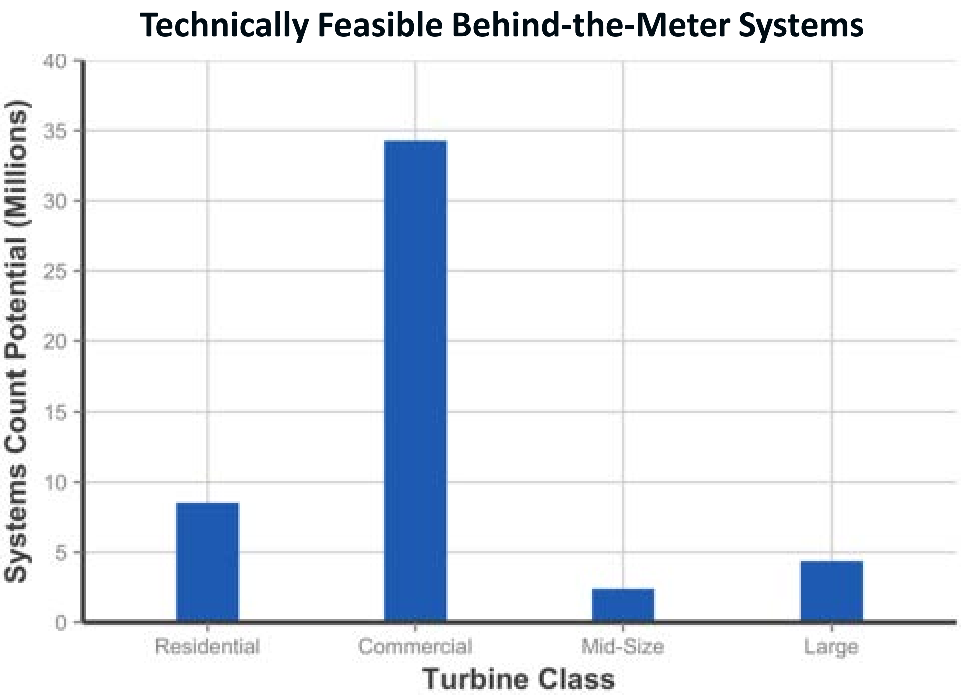
NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
Operated by the Alliance for Sustainable Energy, LLC

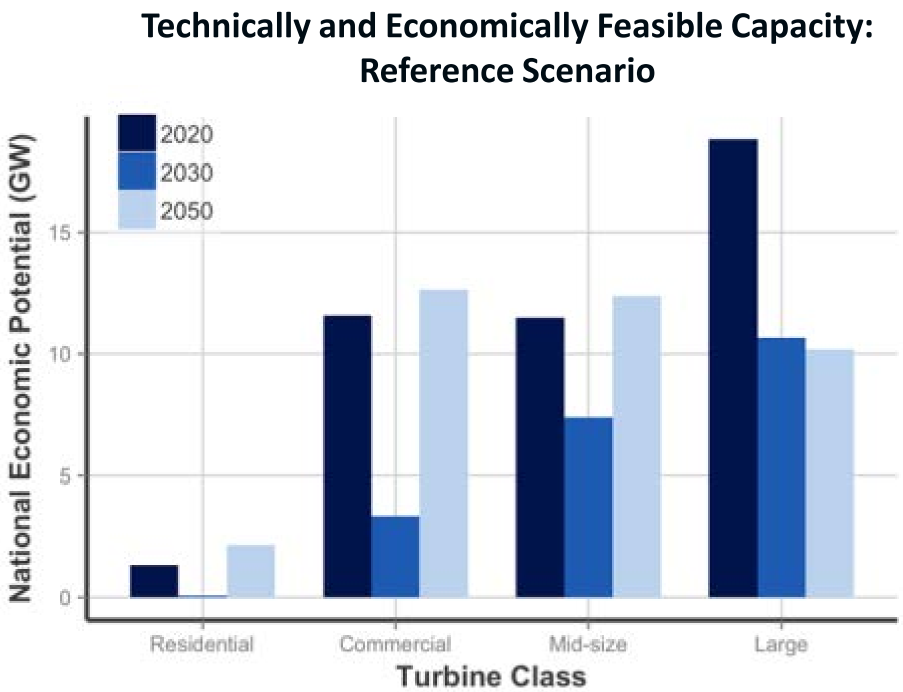
This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Technical Report
NREL/TP-6A20-67337
November 2016

Contract No. DE-AC36-08GO28308

Sample Results: Addressable Resource and Economic Potential



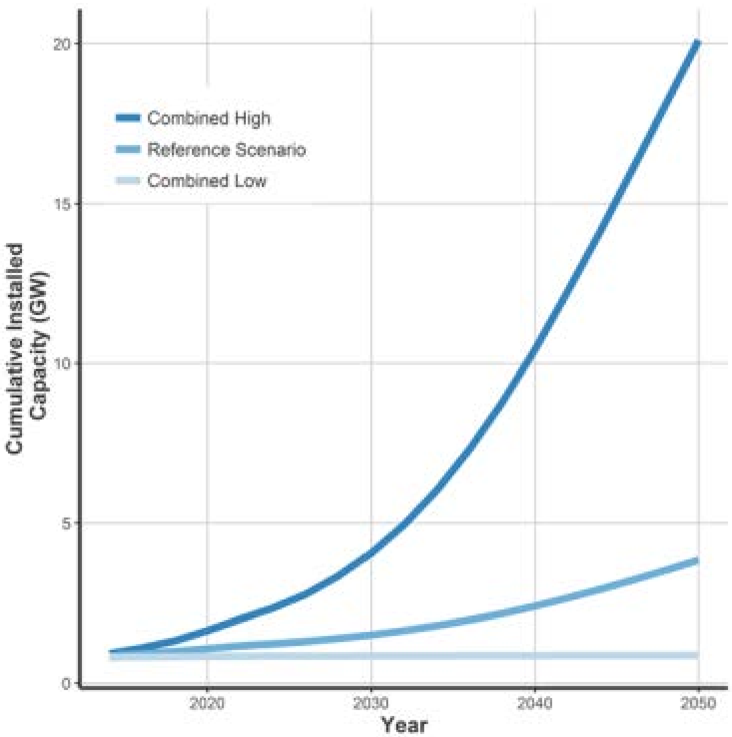


- Addressable resource potential is estimated to be approximately 3 TW when focusing on systems less than 1 MW. Including systems greater than 1 MW results in an additional 5 TW.

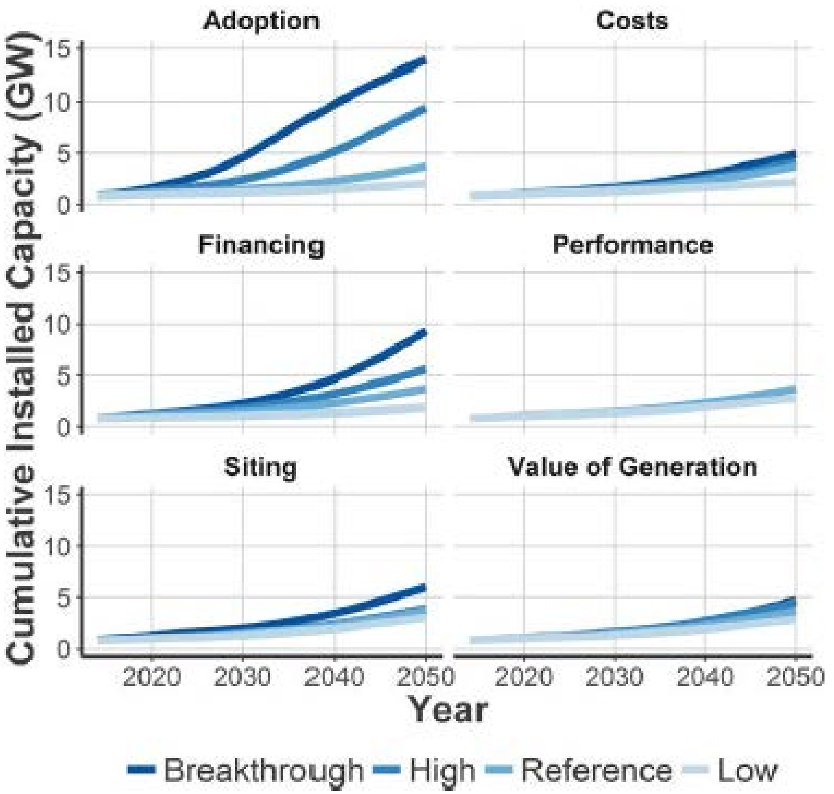
- Economic potential is also sizable (GWs); although it is significantly impacted by currently legislated policy expirations, and results suggest the importance of financing and consumer adoption patterns if we are to fundamentally change the market picture.

Sample Results: Modeled Deployment

Reference and Combined Scenarios



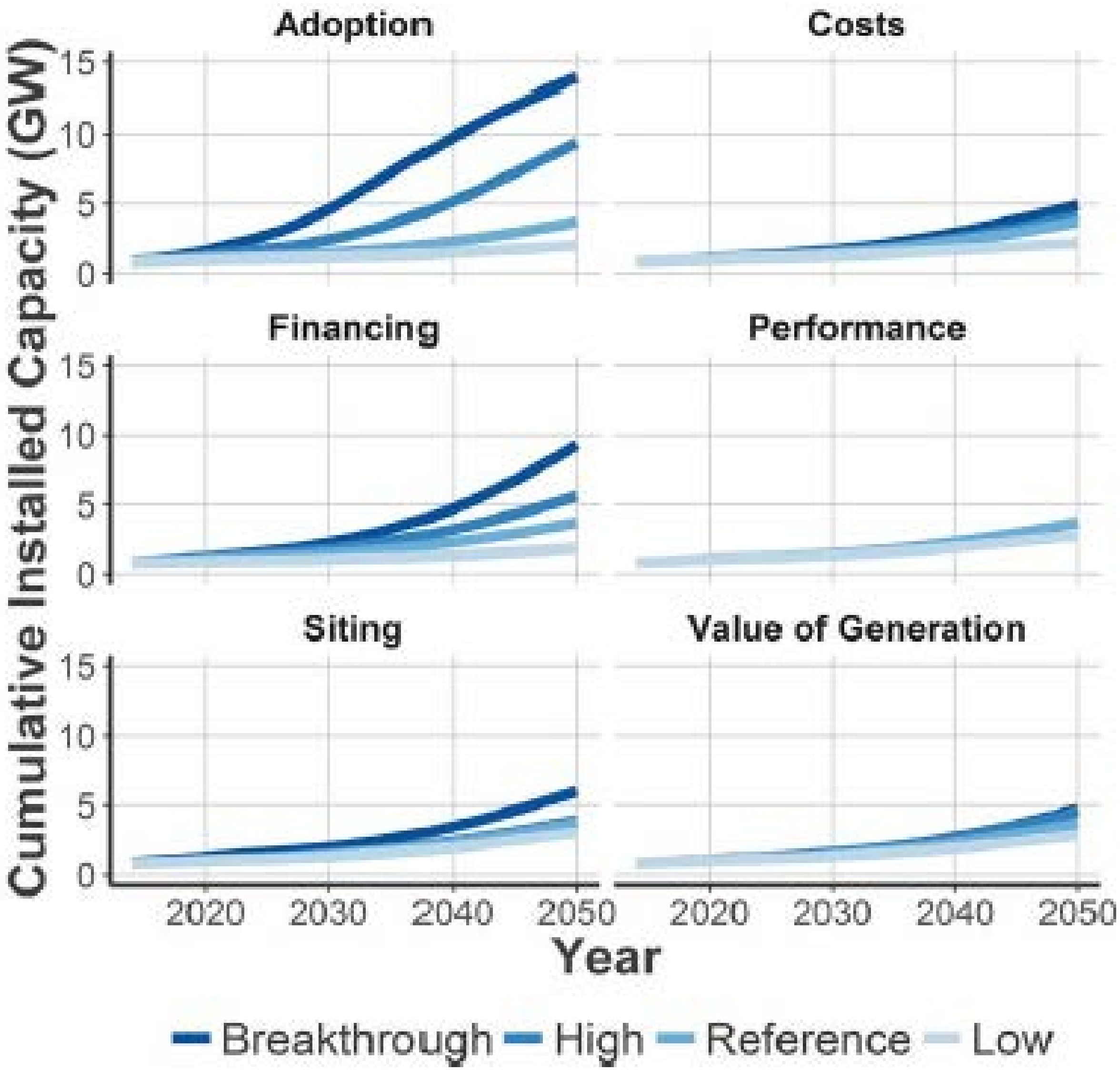
Market Potential: Single Variable Sensitivities



- Assuming behind-the-meter applications are about half of today's total installed distributed wind capacity, the reference scenario results represent a ~300% increase in the market by 2030 and approximately three doublings of cumulative behind-the-meter capacity by 2050.

- By examining the sensitivity of future deployment to individual factors, we found that continued cost improvement is a necessary but not sufficient condition to developing a market with tens of gigawatts. Instead, a successful strategy targets multiple areas simultaneously—for example, access to lower financing rates and simplified siting requirements.

So, What Do We Need to Do to Get There?

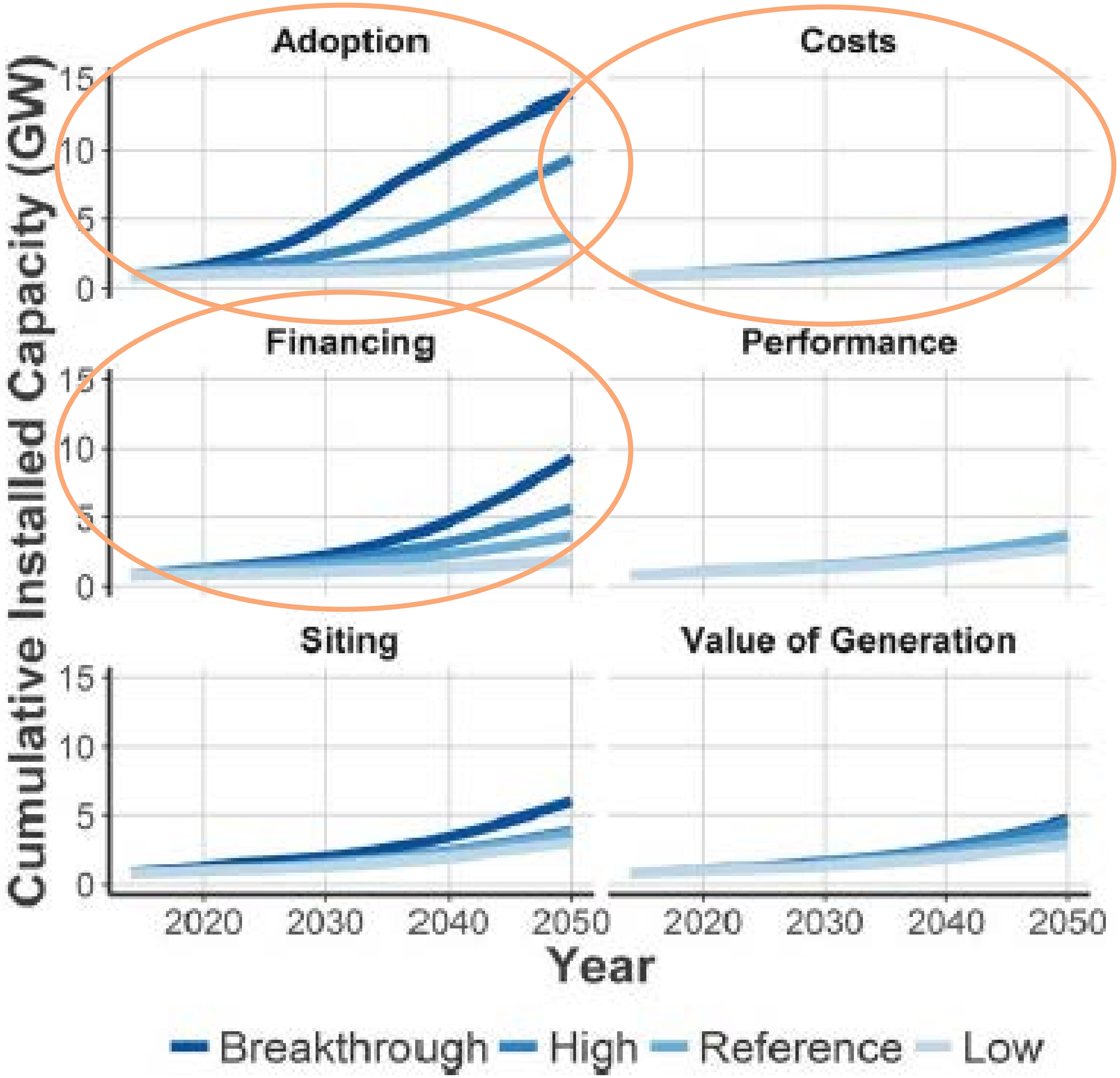


To increase technology adoption, we need more effective marketing and more successful, long-lasting deployments so people see wind turbines on their neighbors' properties.

To enable increased deployment, we need access to lower financing rates.

To increase deployment, we need simplified siting requirements, perhaps like SOLSMART: http://www.gosparc.org/

So, What Do We Need to Do to Get There?



Resource assessment (performance prediction) is one part of the solution that can help with these three modeled variables.

Resources and More Good Reads

- **DOE Distributed Wind Competitiveness Improvement Project Fact Sheet**
  http://www.nrel.gov/docs/fy16osti/66183.pdf
- **Small Wind Site Assessment Guidelines**
  http://www.nrel.gov/docs/fy15osti/63696.pdf
- **DOE Distributed Wind webpage**
  https://energy.gov/eere/wind/distributed-wind
- **DOE WINDExchange installed capacity and wind speed maps**
  http://apps2.eere.energy.gov/wind/windexchange/wind_installed_capacity.asp
- **DOE WINDExchange ordinance database**
  http://apps2.eere.energy.gov/wind/windexchange/policy/ordinances.asp
- **SOLSMART Program** funded by the DOE SunShot Initiative
  http://www.gosparc.org/

Thank you

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