

Technology Development – Distributed Wind

2019 Wind Program Peer Review

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Wind Office Strategic Priorities

Clean, low-cost wind energy options nationwide

	Land-Based Wind	Offshore Wind	Distributed Wind
Technology Development & Scientific Research	Atmospheric Science & Wind Plant Systems Engineering	Atmospheric Science & Wind Plant Systems Engineering	Atmospheric Science
	Standards and Certification	Standards and Certification	Standards and Certification
	Technology Innovation	Technology Innovation	Technology Innovation
	World Class Testing Facilities	World Class Testing Facilities	
	Tech to Market Commercialization	Tech to Market Commercialization	
	Integrated Systems Design	Integrated Systems Design	
		Offshore Specific R&D Advanced Technology Demo Projects	
Market Acceleration & Deployment	Advanced Grid Integration	Advanced Grid Integration	Advanced Grid Integration
	Workforce and Education Development	Workforce and Education Development	Workforce and Education Development
	Stakeholder Engagement	Stakeholder Engagement	Stakeholder Engagement
	Environmental Research	Environmental Research	
	Siting & Wind Radar Mitigation	Siting & Wind Radar Mitigation	
Analysis & Modeling	Evaluate and Prioritize R&D	Evaluate and Prioritize R&D	Evaluate and Prioritize R&D
	Model Development and Maintenance	Model Development and Maintenance	Model Development and Maintenance
	Techno-economic Analysis	Techno-economic Analysis	Techno-economic Analysis
	Electricity Sector Modeling	Electricity Sector Modeling	Electricity Sector Modeling

Distributed Wind – Background

Enable wind technology as a key player in a growing market for Distributed Energy Resources (DER), by reducing LCOE and increasing reliability.

Programmatic goals include:

- Reducing the unsubsidized LCOE of distributed wind to be 4–7 cents/kWh or below by 2030
- Increasing the market share (by units sold) of certified small and medium sized (<1MW) wind turbines installed in U.S. to 90% by 2030, from a baseline of 69% in 2018



Wind turbine technologies of all sizes deployed as a distributed energy asset, connected directly to the electric distribution grid or at an off-grid location to support local loads and grid operations.

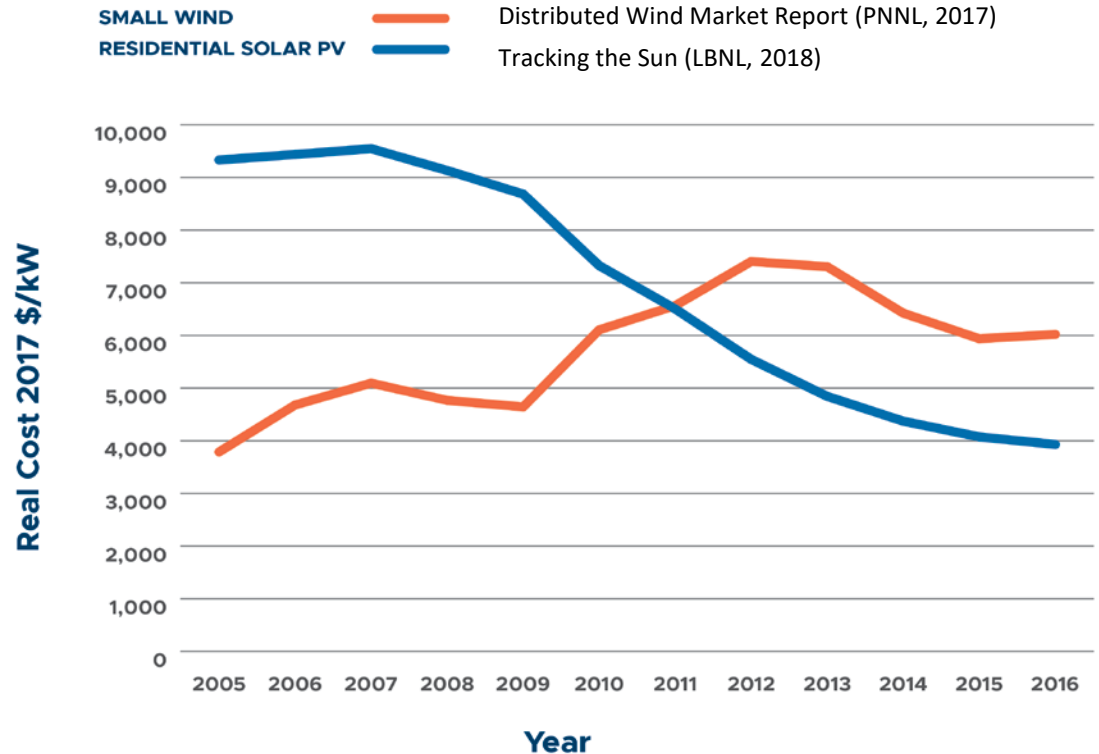
2017- 2018 Objectives

- Support innovative R&D and testing of wind technologies designed for distributed energy applications through the Competitiveness Improvement Project request for proposals
- Research, analysis, and stakeholder engagement to develop a fundamental understanding of the installed costs, market potential, and R&D challenges limiting market development

Distributed Wind: Strategic Approach

Strategic Area	Challenges	Goals	Approach
Competitiveness Improvement Project	Small and medium wind turbine technology struggle to produce cost competitive power and require expensive certification testing for commercialization	Reduce LCOE from and certify small and medium wind turbine designs	<ul style="list-style-type: none"> System performance optimization and cost reduction Turbine testing for certification

Small Wind and Residential Solar PV Installed Costs

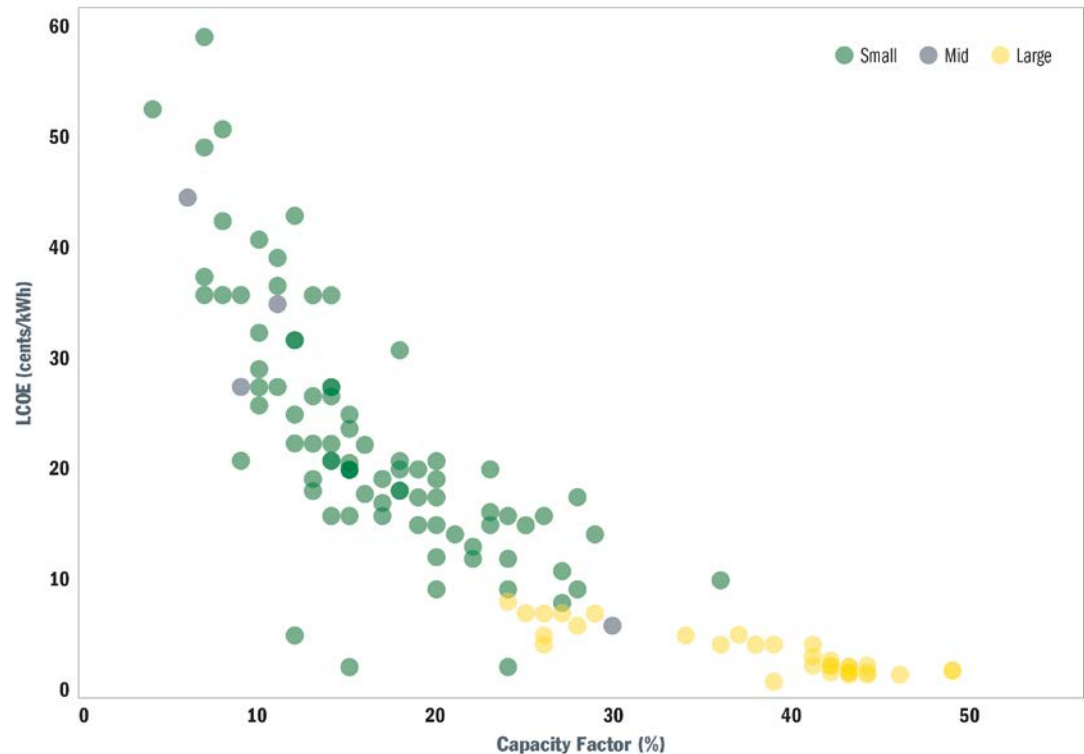


Distributed Wind: Strategic Approach

Strategic Area	Challenges	Goals	Approach
Distributed Wind Resource Assessment	Utility-scale resource assessment, is too costly and time consuming for distributed wind project development	Reduce performance assessment error and improve siting	<ul style="list-style-type: none"> Evaluate wind resource parameters impacting power performance

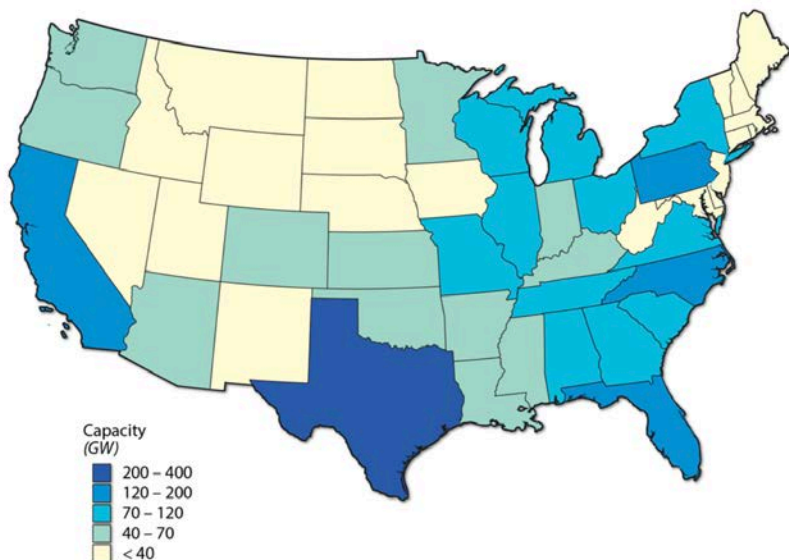
Projects show significant LCOE spread, particularly for small (<100kW) and mid-size (>100kW, <1 MW) turbines

Distributed Wind Market Report (PNNL, 2017)

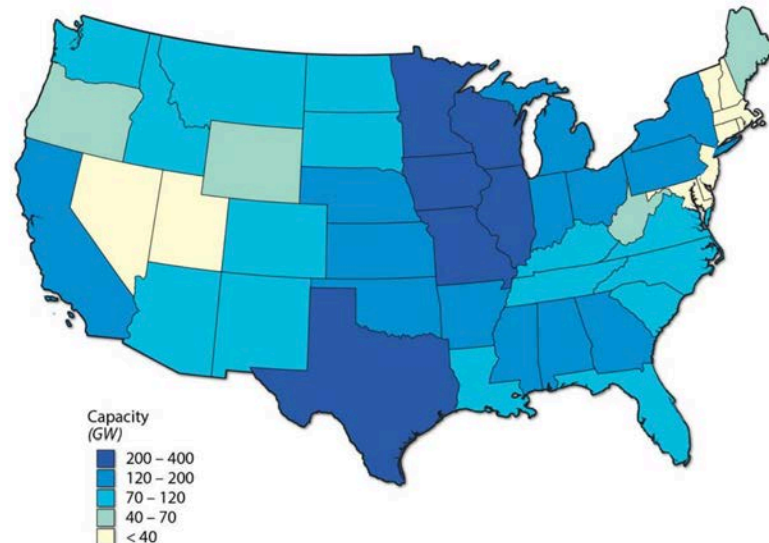


Distributed Wind: Strategic Approach

Strategic Area	Challenges	Goals	Approach
Market Potential Assessment	Market intelligence, growth opportunities and barriers are not well documented or understood	Improve understanding of market potential and barriers	<ul style="list-style-type: none"> • Develop geospatial modeling tools • Collect market data
Cost Analysis	Soft costs and cost reduction opportunities are not document for distributed wind	Establish a soft cost baseline and identify cost reduction opportunities	<ul style="list-style-type: none"> • Establish DW Cost taxonomy and collect data



Addressable resource of submegawatt-scale turbines by state



Addressable resource of megawatt-scale turbines by state

Assessing the Future of Distributed Wind: Opportunities for Behind-the-Meter Projects (NREL, 2016)

Projects Under Review

Distributed Wind

Distributed Wind Research Development & Testing (5:20 PM, May1, 2019) Ian Baring-Gould



Distributed Wind: Key Projects Over Time

Small Wind Turbine Certification

Reduce Cost of Energy

2009

2010

2011

2012

2013

2014

2015

2016

2017

2018

2019

Establish 4 Regional Small Wind Turbine Test Facilities

Small Wind Turbine Independent Testing at NWT

Assessing the Future of Distributed Wind: Opportunities for Behind-the-Meter Projects

Assessment of the Economic Potential of Distributed Wind in Colorado, Minnesota, New York, and California

First Small Wind Turbine Certified in U.S.

Competitiveness Improvement Projects

Small Wind Site Assessment Guidelines

Distributed Wind Resource Assessment: State of the Industry

Distributed Wind Resource Assessment Framework: Functional Requirements and Metrics for Performance and Reliability Modeling

Establish the Small Wind Certification Council

Request for Information

Distributed Wind Costs Taxonomy

U.S. Small Wind Costs Benchmark

Annual Distributed Wind Market Report

Distributed Wind: Activities & Accomplishments (FY17-18)

Strategic Area

Accomplishments

Collaborators

Competitiveness Improvement Project (CIP)

- Awarded nearly \$3M across 12 subcontracts
- 4 small wind turbines certified to national or international standards

- NREL
- OEMs



Prior to CIP

Bergey Excel
10 kW – 30
year old design
no longer cost
competitive

2013

Complete
aerodynamic
redesigned into
Excel 15 kW

2014

Advanced controls and
functionality of the turbine
power electronics to couple
with storage provide grid
support

2015

Excel 15 kW testing
for certification to
national standards

2017

Excel 15 kW tower
and foundation
redesign to reduce
balance of system
cost

Stepwise CIP awards to develop the Excel 15 kW enabled BWP to increase power output by 110% with a >50% LCOE reduction to \$0.09/kWh over the Excel 10 kW while adding functionality to support grid operations

Distributed Wind: Activities & Accomplishments (FY17-18)

Strategic Area

Accomplishments

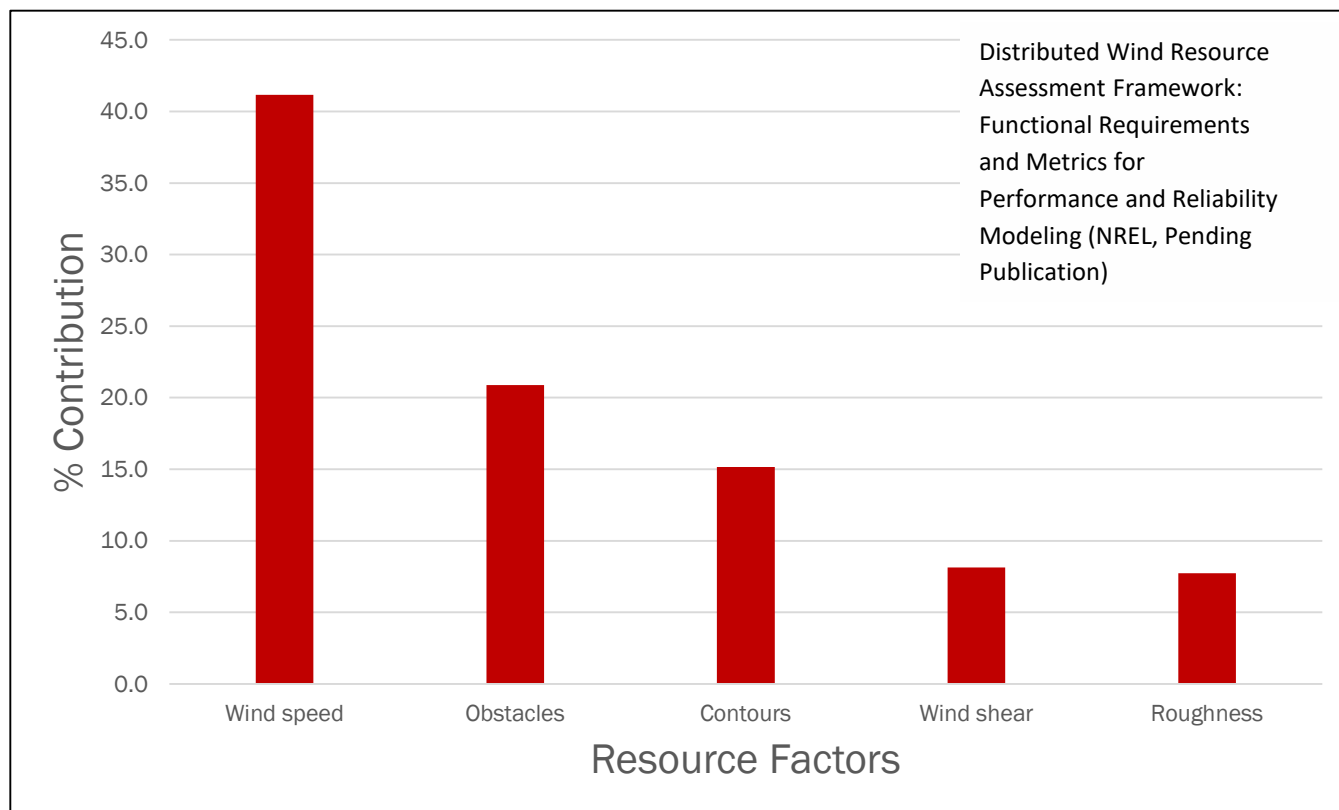
Collaborators

**Distributed
Wind
Resource
Assessment**

- Submitted for publication Distributed Wind Resource Assessment Framework: Functional Requirements and Metrics for Performance and Reliability Modeling

- NREL

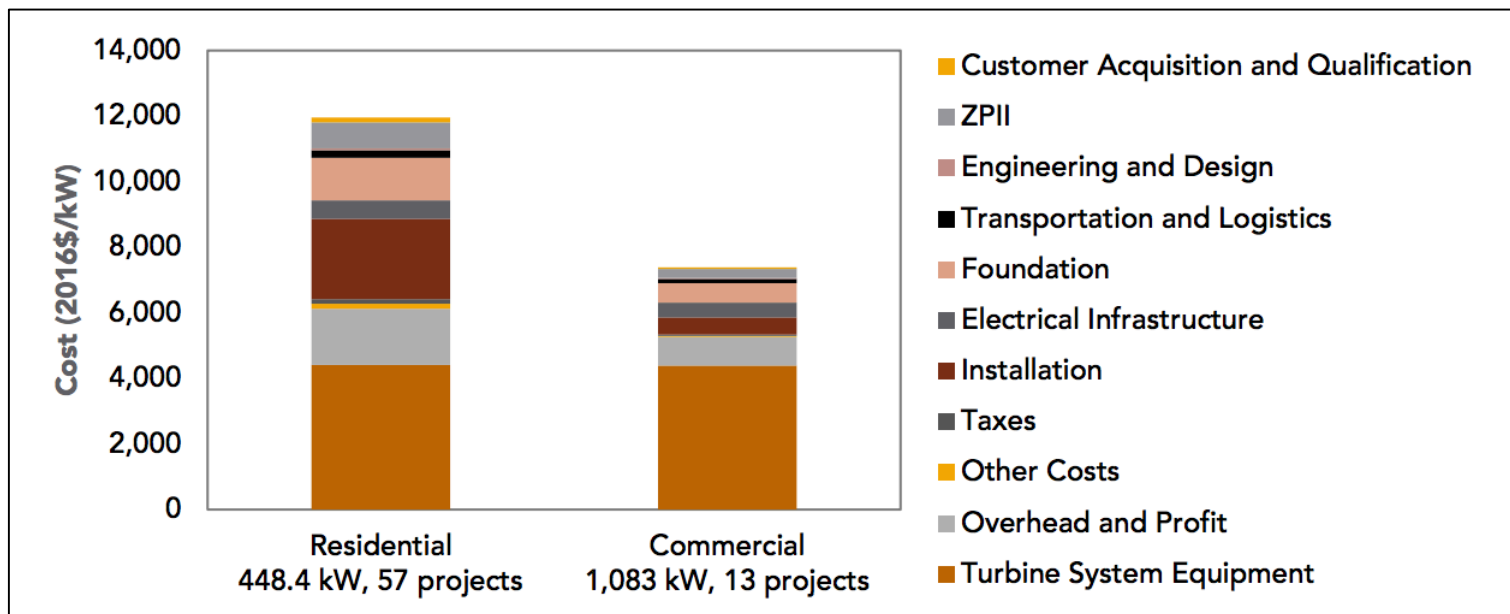
**Contribution
from top five
resource
assessment
factors
impacting
turbine power
output**



Distributed Wind: Activities & Accomplishments (FY17-18)

Strategic Area	Accomplishments	Collaborators
Market Potential Assessment	<ul style="list-style-type: none"> Published Assessment of the Economic Potential of Distributed Wind in Colorado, Minnesota, and New York Submitted for publication California TOU Transition: Effect on Distributed Wind and Solar Economic Potential 	NREL
Cost Analysis	<ul style="list-style-type: none"> Published The Distributed Wind Cost Taxonomy Published U.S. Small Wind Costs Benchmark 	NREL, PNNL

Wind Turbine System Equipment and Balance of Station Costs on a per kW Basis



Benchmarking U.S. Small Wind Costs (PNNL, 2017)

Distributed Wind: Future Priorities (FY19 and beyond)

Strategic Area

Future Priorities

Collaborators

Wind Innovations for Rural Economic Development

- Innovations to enhance resilience and reliability of rural electric utilities through integration of hybrid distributed energy systems utilizing wind
- Balance of system cost reduction through standardization in distributed energy project development and deployment

- TBD FOA Awardees

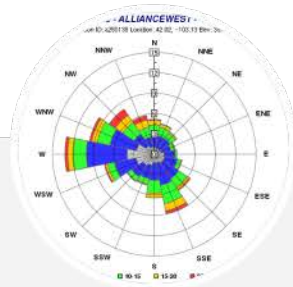


Distributed Wind: Future Priorities (FY19 and beyond)

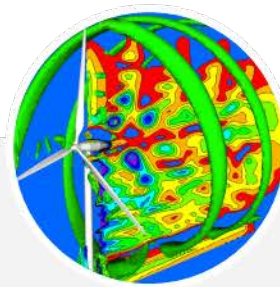
Strategic Area	Future Priorities	Collaborators
Tools Assessing Performance	<ul style="list-style-type: none"> • Develop benchmark data sets for evaluating existing tools • Identify gaps and opportunities in existing modeling tools • Prioritize R&D to advance modeling capability • Integrate backend with User-facing tools 	<ul style="list-style-type: none"> • NREL • PNNL • ANL • LANL



Stakeholder Engagement



Wind Resource Dataset



Flow Modeling



Computational Framework



User-facing Tool Design

Distributed Wind: Future Priorities (FY19 and beyond)

Strategic Area

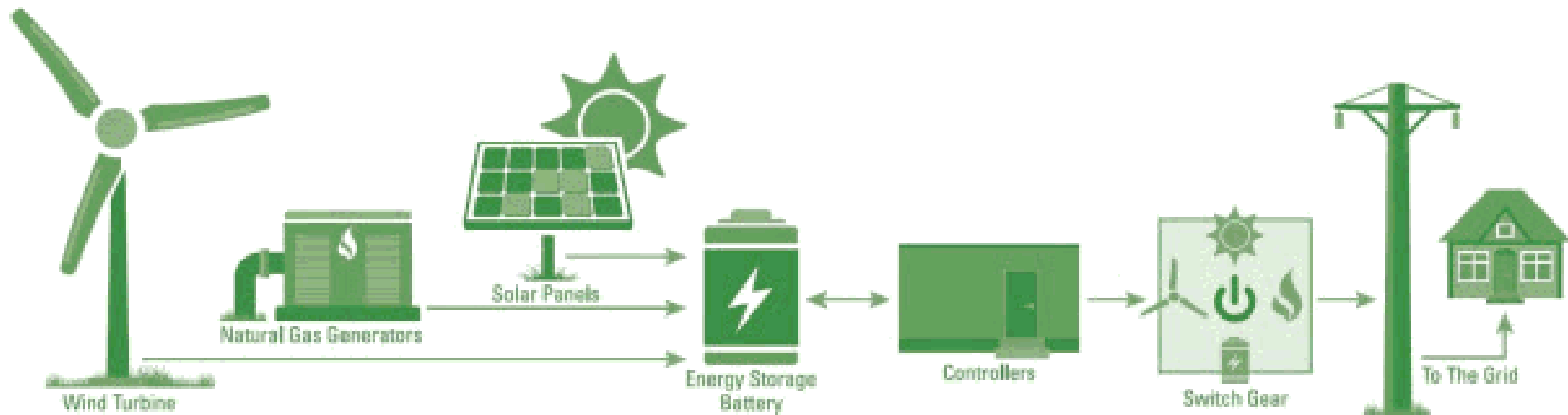
**Microgrids,
Infrastructure
Resilience and
Advanced Controls
Launchpad**

Future Priorities

- Modernize and virtually connect lab infrastructure
- Develop advance controls for transactive systems blending Distributed Energy Resources (DERs)
- Develop cyber security standards and integrate into turbine technology
- Develop approach to value integrated system services to central power system

Collaborators

- NREL
- PNNL
- SNL
- INL



Distributed Wind: Future Priorities (FY19 and beyond)

Strategic Area

Future Priorities

Collaborators

Defense and Disaster Deployable Wind Turbine

- Assess market for deployable wind turbines in operational applications
- Develop design requirements for deployable wind turbines
- Evaluate commercial technology against design requirements
- Develop new technology as needed to meet market need

- SNL
- NREL
- INL

