2014 WIND POWER PROGRAM PEER REVIEW

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

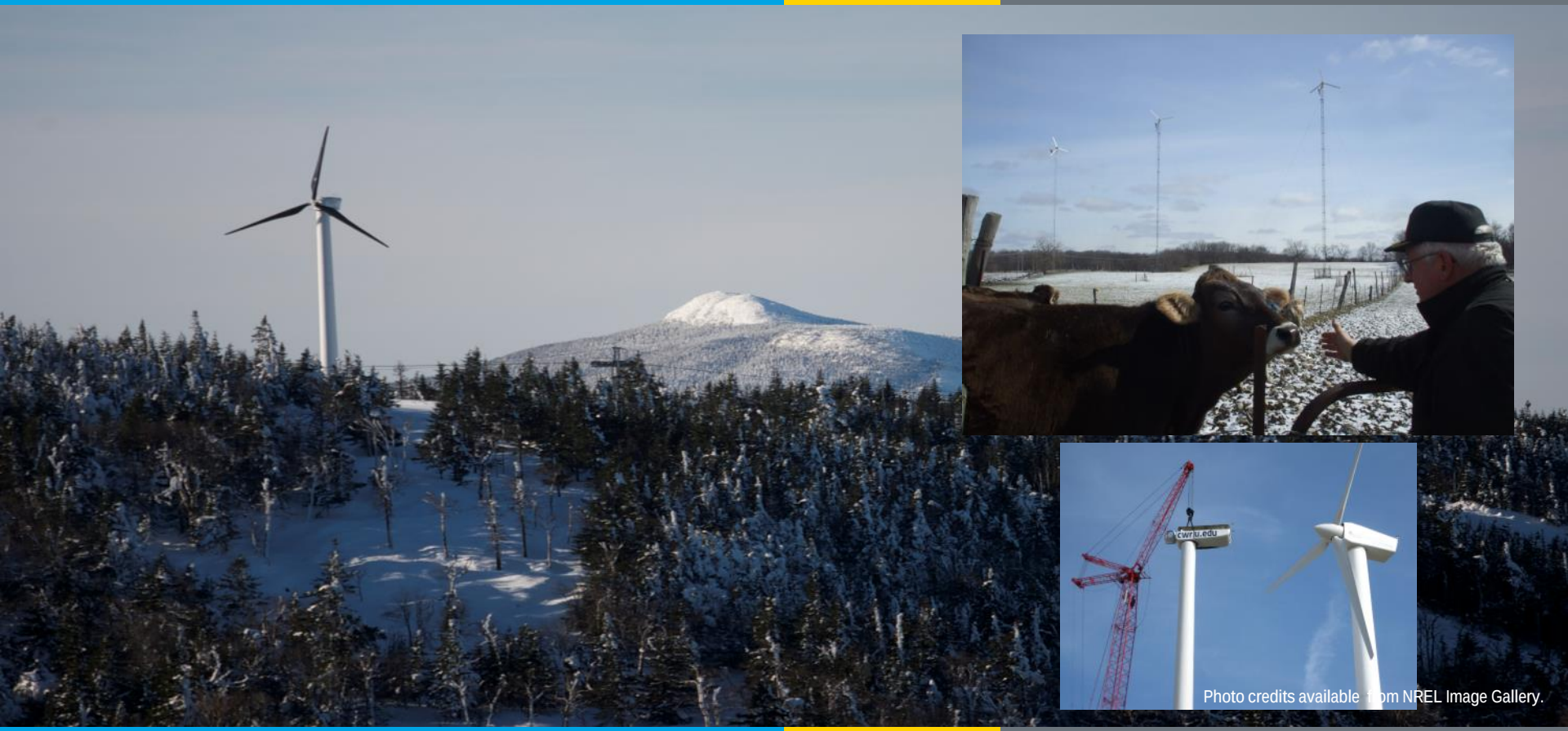
Distributed Wind

March 24-27, 2014

Wind Energy Technologies

Contents

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



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Annual Market Report on Wind Technologies in Distributed Applications & Distributed Wind Policy Comparison Tool

Alice Orrell

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March 27, 2014

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.275M

Total Cost-Share[1]:$0.000M

Problem Statement: The maturing market for wind in distributed applications is not captured by other reports. The effect of state and federal policies on distributed wind cost of energy is not well understood.

Impact of Project: Purpose of Report and Policy Tool is to quantify the distributed wind market, provide analysis of market trends and issues, and identify policy best practices.

- By highlighting successful distributed wind markets and opportunities to overcome market and technical barriers, this work will aid distributed wind in playing an increasingly significant role in supplying power.

This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Modeling & Analysis:** Conduct wind techno-economic and life-cycle assessments to help program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

Technical Approach – Data Collection

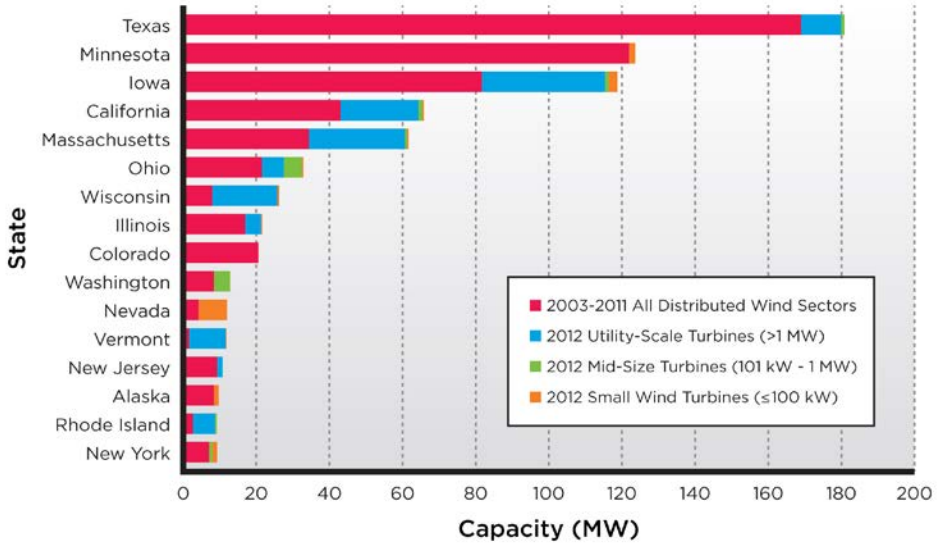
- Extensive data gathered from:
  - Turbine manufacturers
  - State and Federal agencies
  - Service providers, dealers/installers, and developers
  - American Wind Energy Association

- Data is compiled, cross-referenced, verified, and estimated (where needed)
  - Typically not all data sources are publically available, so checking multiple sources and cross-referencing facilitate quality assurance of data
- Building reputation within this industry; leveraging strong relationship and good history with subcontractor

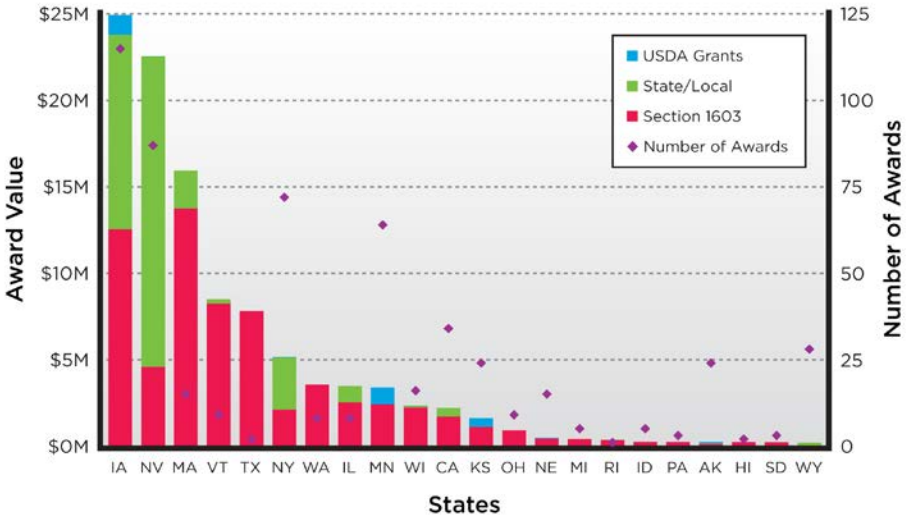
Technical Approach – Data Analysis

- What is the data saying?
  - Report content follows data
    - Example: refurbished turbines
    - More performance and maintenance information, as available
  - Shorter, more approachable report with data-driven stories and conclusions

2003-2012 Distributed Wind Capacity for Top States

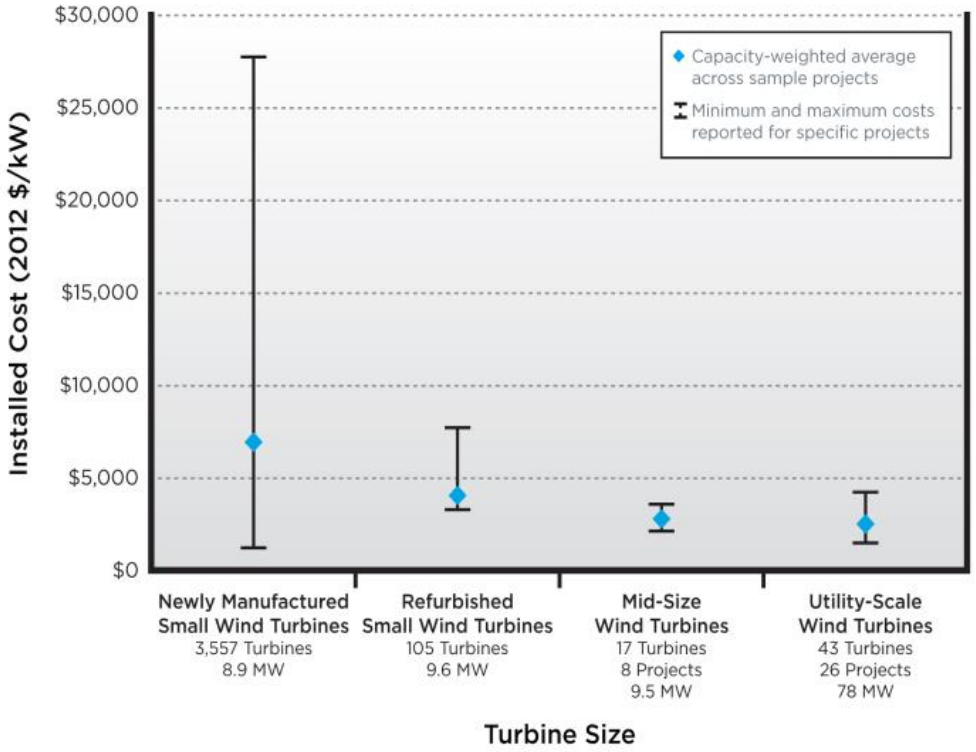


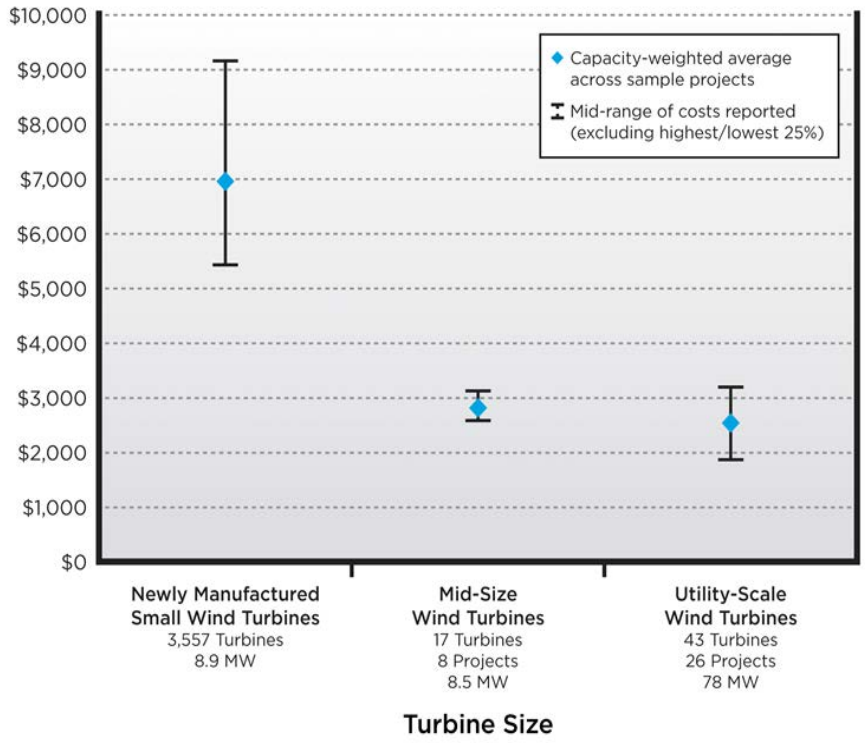
2012 Funding Awards for Distributed Wind



Technical Approach – Data Analysis

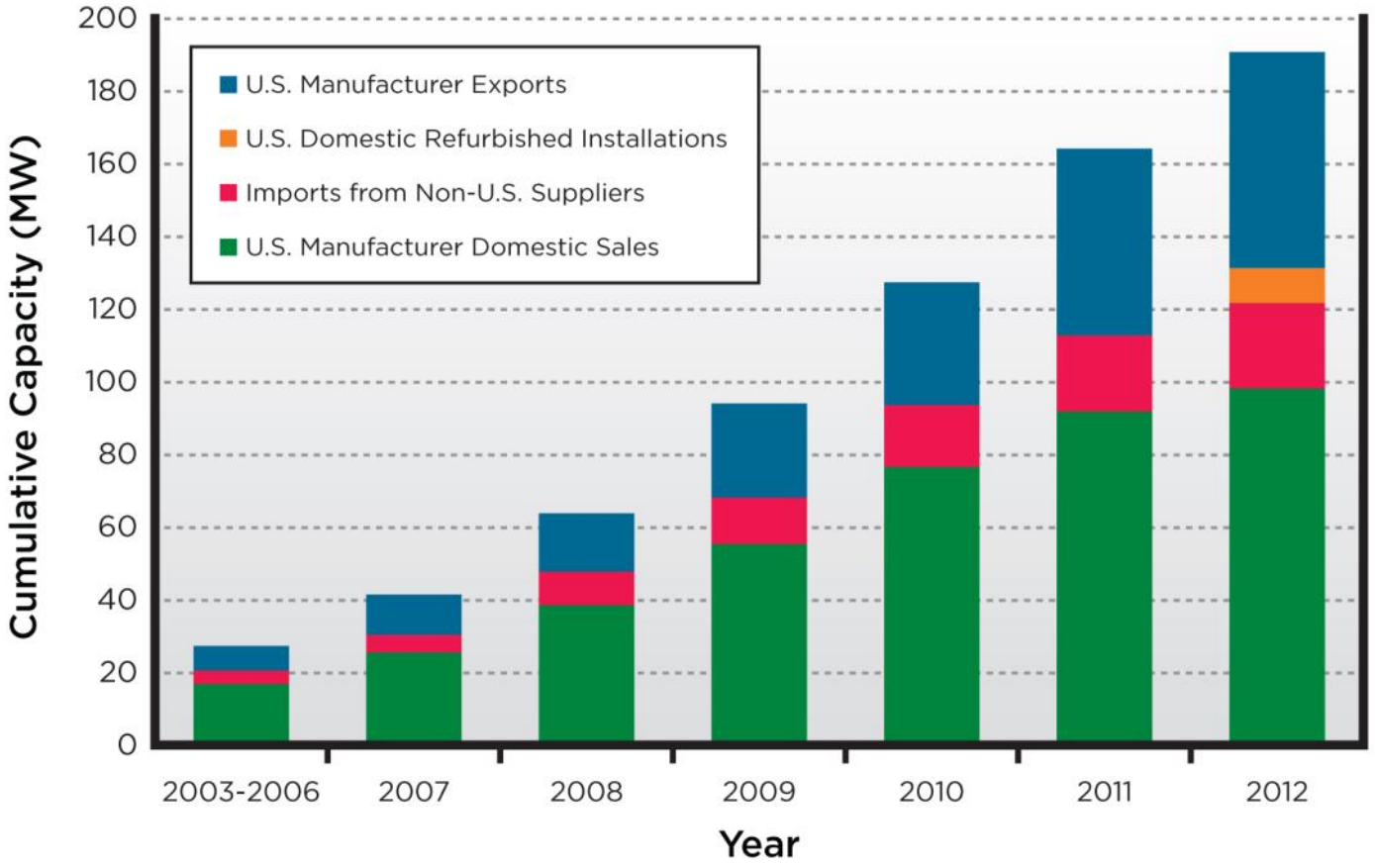
Average Installed Costs for All Turbine Types





Technical Approach – Data Analysis

U.S. Small Wind Domestic, Imports, and Export Sales, 2003-2012



Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary
WBS Number: 2.2.0.1
Project Name: Distributed Wind Research Market Report
Agreement Number: 25626

Legend
Work completed
Active Task
Milestones & Deliverables (Original Plan)
Milestones & Deliverables (Actual)

Task / Event	FY2013 Q1 (Octt-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Octt-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Distributed Wind Research Market Report								
Q1 Milestone: Complete table of contents, outline, and data collection methodology.								
Q2 Milestone: Publish 2-page Market Fact Sheet.								
Q3 Milestone: Publish the full 2012 Market Report.								
Q3 Milestone: Disseminate results of Market Report and Policy Tool.								
Q4 Milesonte: Complete annual update of Distributed Wind Policy Comparison Tool.								
Q4 Milestone: Conduct 1 webinar for communications outreach on Report and Tool.								
Q1 Milestone: Complete detailed outline of report and data collection methodology								
Q2 Milestone: Complete a preview presentation of the report								
Q3 Milestone: Complete full report for DOE publication								
Q4 Milestone: Complete annual update of Distributed Wind Policy Comparison Tool								
Q4 Milestone: Conduct 1 webinar for communications outreach								
Q4 Milestone: Present market report at DOE office								

Comments:

- Project started October 2013, on schedule for completion September 2014

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Subcontractor:

- eFormative Options
  - American Wind Energy Association
  - Distributed Wind Energy Association

Collaborators:

- LBNL
- NREL
- Small Wind Certification Council
- Interstate Turbine Advisory Council

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Past and Planned Communications and Technology Transfer:

- Multiple radio interviews and print stories
- 2,260 views of “Top 8 Things You Didn’t Know About Distributed Wind” blog post on energy.gov
- 305 views of Market Report from energy.gov link
- Over 300 uses of Policy Tool since mid-July 2012
- Data provided to EIA for re-publishing on EIA website
- AWEA WINDPOWER 2014 Poster: *2013 Distributed Wind Market Report Preview*
- Presentation at Small Wind Conference 2014

Next Steps and Future Research

FY14/Current Research & Activities:

- Collecting key data.
- Compiling, cross-referencing, and verifying data.

FY14 Future Plans:

- Compiled data will be used to create preview presentation in March 2014.
- Full report will be completed by end of June for DOE publication.
- Update to Policy Tool and dissemination of Market Report will be done in July, August, and September.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Government, Industry, International Partnerships

Distributed Wind

Karin Sinclair

NREL

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March 27, 2014

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.275M

Total Cost-Share[1]:$0.000M

Problem Statement: A wide range of stakeholders in the distributed wind sector are fundamental to the success of the industry, but more resources and expertise are needed to complete the necessary activities. NREL provides technical support and enhanced credibility to various activities through partnerships.

Impact of Project: Soft-cost reductions will contribute to reduced levelized cost of energy (LCOE) and accelerated deployment of distributed wind projects. NREL partners in a number of areas. The expected endpoint is a robust distributed wind sector that is competitive in the global market.

This project aligns with the following DOE Program objectives and priorities

Mitigate Market Barriers: Reduce market barriers to preserve or expand access to quality wind resources

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

Technical Approach

The technical approach includes:

- Leadership in key organizations
- Support of non-NREL experts to attend critical meetings
- Research on key topics
- Tools development
- Conference sponsorships

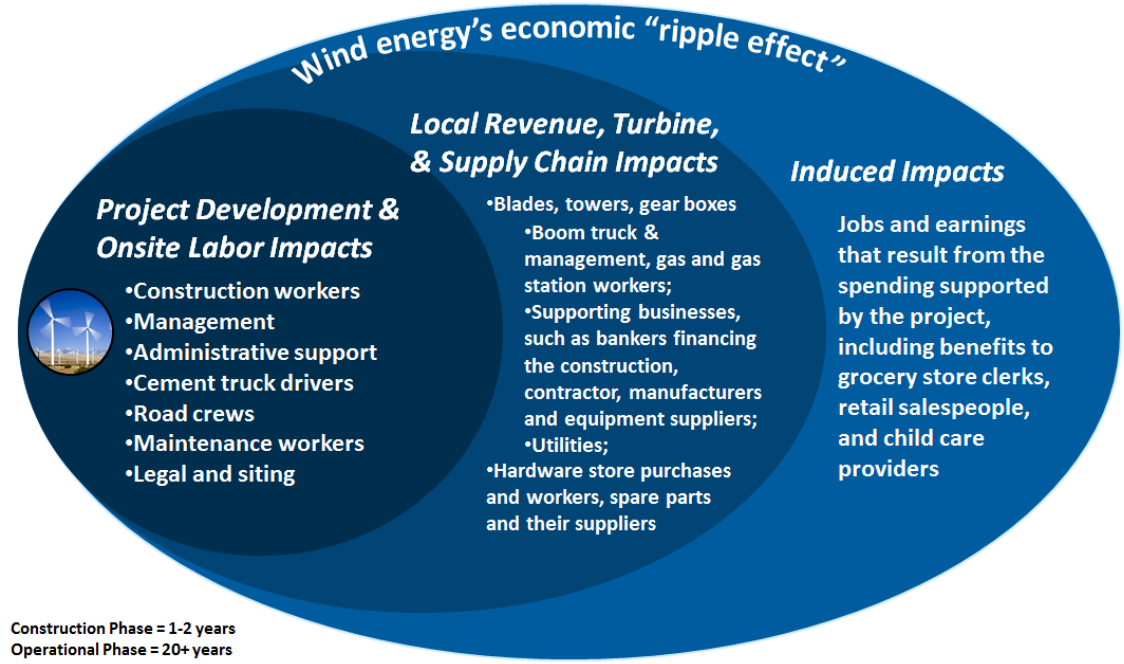
2013 Small Wind Installers Conference

Technical Approach

Key issues currently being addressed include:

- Development of small wind site assessor manual at request of small wind sector (absent small wind site assessor credential program)
- American Solar Energy Society (ASES) Wind Division (development of 5-year plan)
- Small Wind Certification Council (SWCC) board (expansion from small wind certification to include midsize turbines)

Technical Approach



JEDI Model Version W1.09.03e

Key issues currently being addressed include:

- Jobs and Economic Development Impact (JEDI) expansion at request of distributed wind sector (from small wind only to distributed wind)
- Distributed wind integration with Utility Variable-Generation Integration Group (UVIG) and IEEE

FY12/13 Accomplishments

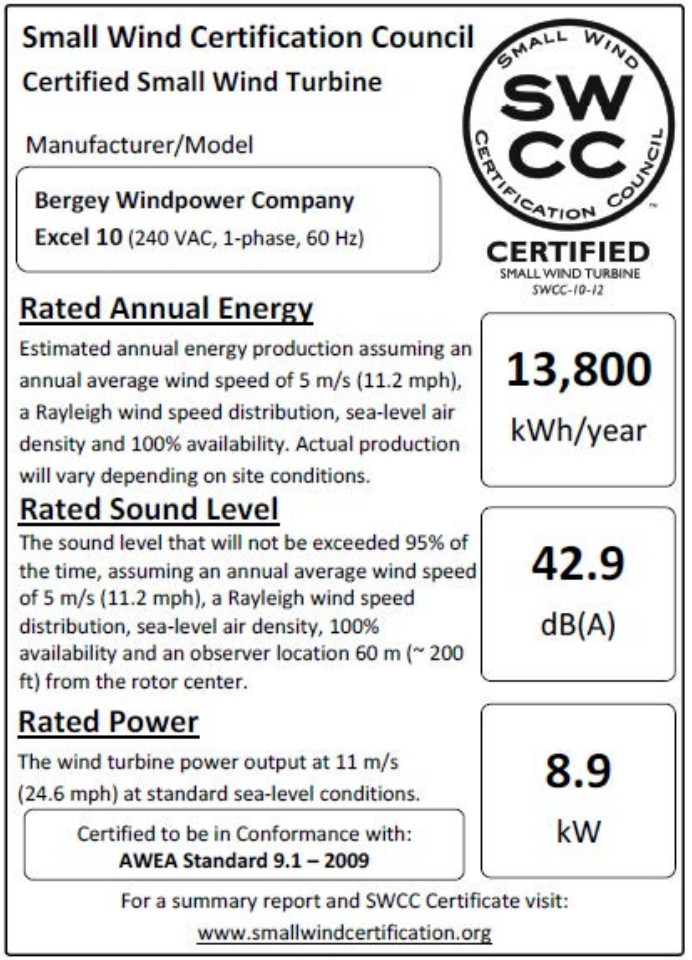
- Analysis of SW installer and site assessor credential programs—led to development of SW SA manual
- ASES Technical Wind Division expanded from SW focus to DW—led to development of 5-year plan and bi-monthly DW topic webinar series
- Supported Windustry (FOA awardee) conference
- SWCC certifying SW turbines—expanding program to also certify midsize turbines. Will provide larger pool of U.S.-certified DW turbines.

Applicant	Turbine	Power^3 @ 11m/s	
Bergey Windpower Co.	Excel 10	8.9 kW	
Bergey Windpower Co	Excel 6	5.5 kW	
Endurance Wind Power	EWP S-343	5.4 kW	
Evance Wind Turbines	Evance R9000	4.7 kW	
Eveready Diversified Products	Kestrel e400nb	2.5 kW	
Kingspan Environmental	KW6	5.2 kW	
Xzeres Wind	Skystream 3.7	2.1 kW	

Accomplishments and Progress

FY12/13 Accomplishments

- Completed JEDI SW module—led to request to expand to DW
- IEA Wind Task 27 developed consumer labels for SW turbines—currently used by SWCC
- Supported activities and moving IEC 61400-2 standard through a 4-yr process, including Committee Draft, Committee Draft for Vote, Final Draft International Standard, and International Standard
- Supported expert input to National Electrical Code modification cycle



SWCC consumer label, adapted from IEA Wind Task 27

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	2.1.2
Project Number	WE110210
Agreement Number	22501

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012 Q1 (Oct-Dec)	FY2012 Q2 (Jan-Mar)	FY2012 Q3 (Apr-Jun)	FY2012 Q4 (Jul-Sep)	FY2013 Q1 (Oct-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Oct-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Gov't, Industry, International Partnerships												
Q1 Milestone: Support DOE FOA recipient Windustry with at least one conference												
Q2 Milestone: Assess viability for a site assessor credential for small												
Q3 Milestone: Submit abstract for presentation at the ASES/WREF												
Q4 Milestone: JEDI workshop at the Small Wind Conference in June 2012												
Q1 Milestone: Develop SOW for SW SA BP document												
Q2 Milestone: JEDI SW module enhanced to include 3 turbine sizes												
Q3 Milestone: SWC sponsorship, presentations on JEDI SW and SW SA BP												
Q4 Milestone: Distributed draft SW SA BP manual to expert group for review												
Q1 Milestone: SW SA BP document submitted to DOE for review												
Q2 Milestone: ASES WD 5-year plan submitted to ASES for review and adoption												
Q3 Milestone: SWC sponsorship, presentations at conference												
Q4 Milestone: ASES WD webinar on DW topic												
Current work and future research												
Complete SW SA BP document												
Submit DW abstracts to SOLAR 2014 and 10th SWC												
Develop bi-monthly ASES WD webinar topics/speakers												
Begin effort to enhance JEDI DW module												

- 2.1.2 began in FY12. Several activities are in progress. Planned completion date dependent on decision to expand several activities or not.
- The level of effort to develop SW SA BP greater than expected—subcontractor is about 3 months behind. Planned publication is end of FY14 Q3.

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators

- Advanced Energy Systems leading SW SA manual development
- Marshall Goldberg, developer of JEDI modules
- Collaborators include:
  - Representatives from eFormative Options, the Wind Advisors Team, ConservFirst, Cape & Islands Self-Reliance Corp, Advanced Renewable Technology, Endurance Wind Power, Primus Windpower, Interstate Turbine Advisory Council, New York State Energy Research and Development Authority, Distributed Wind Energy Association, American Wind Energy Association, the Texas Renewable Energy Industries Association, TetraTech, Talco, Lisa DiFrancisco, Mick Sagrillo, and others

Communications and Technology Transfer

- Certification for Small Wind Turbine Installers: What's the Hang Up?
  2012 World Renewable Energy Forum (WREF)

- Jobs and Economic Development Impacts from Small Wind:
  JEDI Model in the Works
  AWEA Windpower 2012

- JEDI Forum
  2012 WREF

- How Many Jobs are there in the Domestic Small Wind Industry?
  Poster at 2013 Small Wind Conference (SWC)

- Building Toward a Small Wind Turbine Site Assessor Credential
  SWC 2013

- SW site assessor workshop
  SWC 2013

Next Steps and Future Research

FY14/Current research

- Complete SW SA document
- Identify next steps for SW installer and/or site assessor credential program
- Work with ASES WD to identify key research gaps and focus areas for next 5 years
- Participate on SWCC board
- Support UVIG and IEEE in distributed generation-related activities.

Next Steps and Future Research

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Proposed future research

Activities include development of tools and technical support for DW sector, including:

- JEDI module
- SW installer and site assessor credential programs
- Distributed wind integration with UVIG and IEEE
- National Electric Code
- DW sector partners (SWCC, SWC, ASES WD, DWEA, AWEA, and others)

Certifying Distributed Wind Turbines

Brent Summerville

Small Wind Certification Council

brent@smallwindcertification.org, 518-213-9438

27 March 2014

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.550M

Total Cost-Share[1]:$0.000M

Problem Statement:

- Consumers cannot make apples-to-apples comparisons between distributed wind turbines
- Incentive program managers cannot objectively determine eligibility and predict performance for incentive program funds
- Distributed wind market suffers when there are problems with non-certified turbines

[1] *Budget/Cost-Share for Period of Performance FY2012 – FY2013*

Purpose & Objectives

Impact of Project:

- Certify small and medium wind turbine models
- Standardize reporting of power, energy, acoustic ratings
- Help distributed wind technology gain widespread acceptance

This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Testing Infrastructure:** Enhance and sustain the world-class wind testing facilities at Universities and national laboratories to support mission-critical activities

Technical Approach

Manufacturer
(turbine design)

IEC Standards

AWEA AMERICAN WIND ENERGY ASSOCIATION

Independent,
accredited,
certification body

SMALL WIND
SWCC
CERTIFICATION COUNCIL

Test
Organization
(field testing)

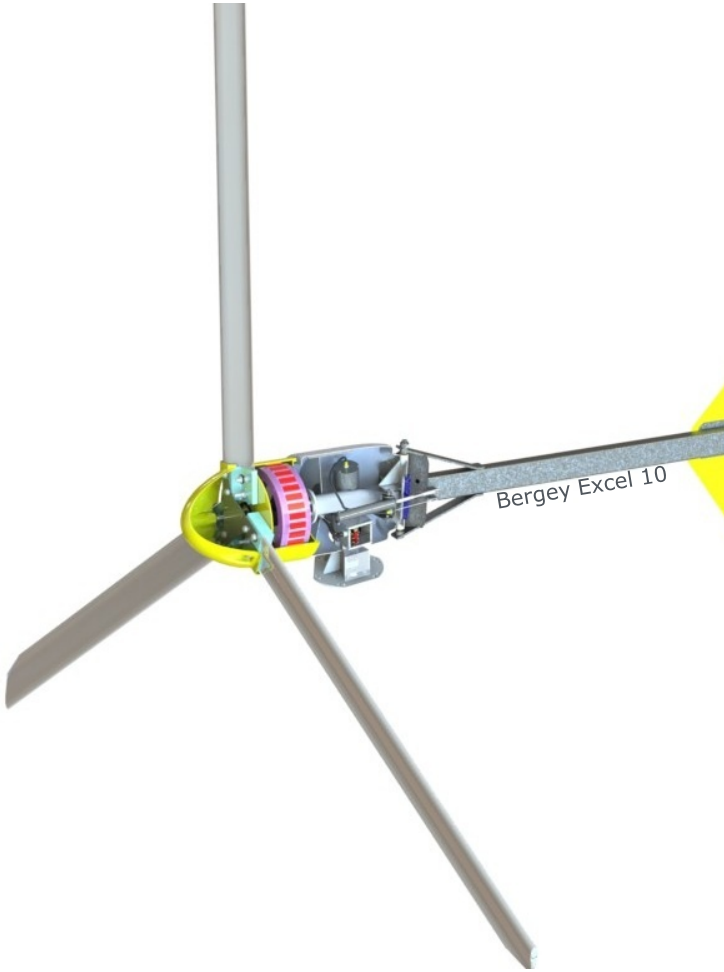
Certifies
Conformity

Technical Approach

Small Wind Turbines

- *up to 200 m^2 swept area*
- *AWEA Small Wind Turbine Performance and Safety Standard*

- Certify field testing
  - Power performance
  - Acoustics
  - Safety & Function
  - Duration
- Certify turbine design
  - Load calculations and modeling
  - Mechanical strength calculations



Technical Approach

New in 2013: Medium Wind Turbine Performance Certification (for turbine with >200 m^2 swept area)

Power Performance Certification per IEC 61400-12-1

Acoustic Performance Certification per IEC 61400-11

Public Deliverables

SWT Consumer Label

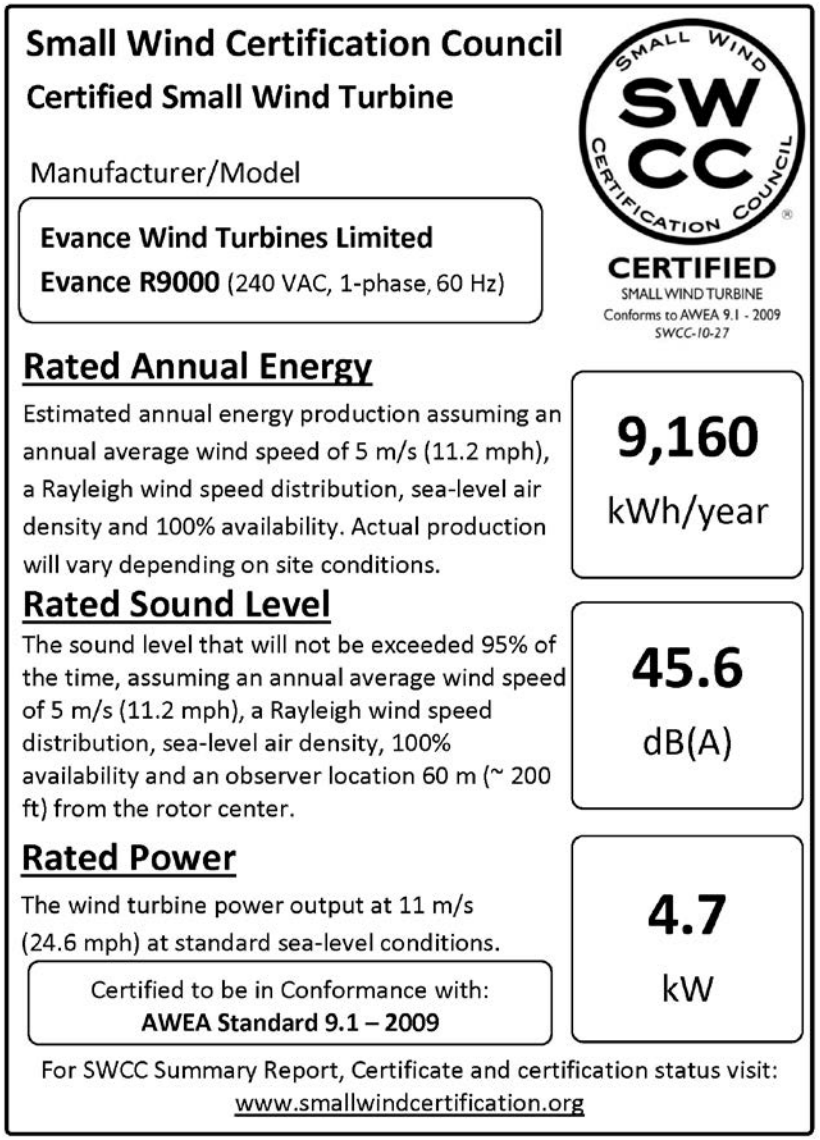
- Single-number ratings

Certificate

- Available online to confirm validity

Summary Report

- Summary of testing
- Power curve
- Annual energy curve
- Tabulated data



Small Wind Certification Council

Certified Small Wind Turbine

SMALL WIND CERTIFICATION COUNCIL SWCC

CERTIFIED
SMALL WIND TURBINE
Conforms to AWEA 9.1 - 2009
SWCC-10-27

Manufacturer/Model

Evance Wind Turbines Limited
Evance R9000 (240 VAC, 1-phase, 60 Hz)

Rated Annual Energy

Estimated annual energy production assuming an annual average wind speed of 5 m/s (11.2 mph), a Rayleigh wind speed distribution, sea-level air density and 100% availability. Actual production will vary depending on site conditions.

9,160
kWh/year

Rated Sound Level

The sound level that will not be exceeded 95% of the time, assuming an annual average wind speed of 5 m/s (11.2 mph), a Rayleigh wind speed distribution, sea-level air density, 100% availability and an observer location 60 m (~ 200 ft) from the rotor center.

45.6
dB(A)

Rated Power

The wind turbine power output at 11 m/s (24.6 mph) at standard sea-level conditions.

4.7
kW

Certified to be in Conformance with:
AWEA Standard 9.1 – 2009

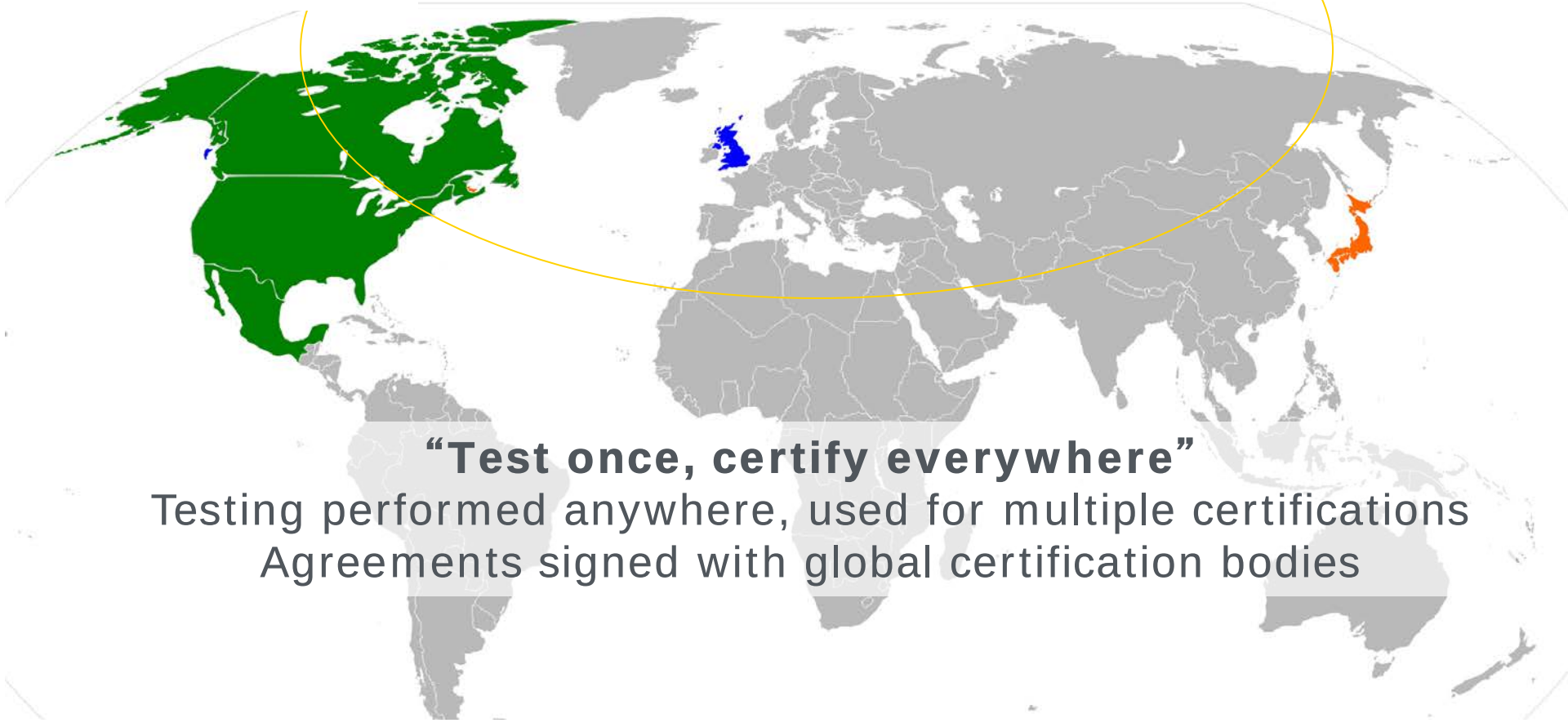
For SWCC Summary Report, Certificate and certification status visit:
www.smallwindcertification.org

Technical Approach

NEL, BBA & **BRE** in UK

SWCC in North America

ClassNK in Japan



"Test once, certify everywhere"

Testing performed anywhere, used for multiple certifications

Agreements signed with global certification bodies

Accomplishments and Progress

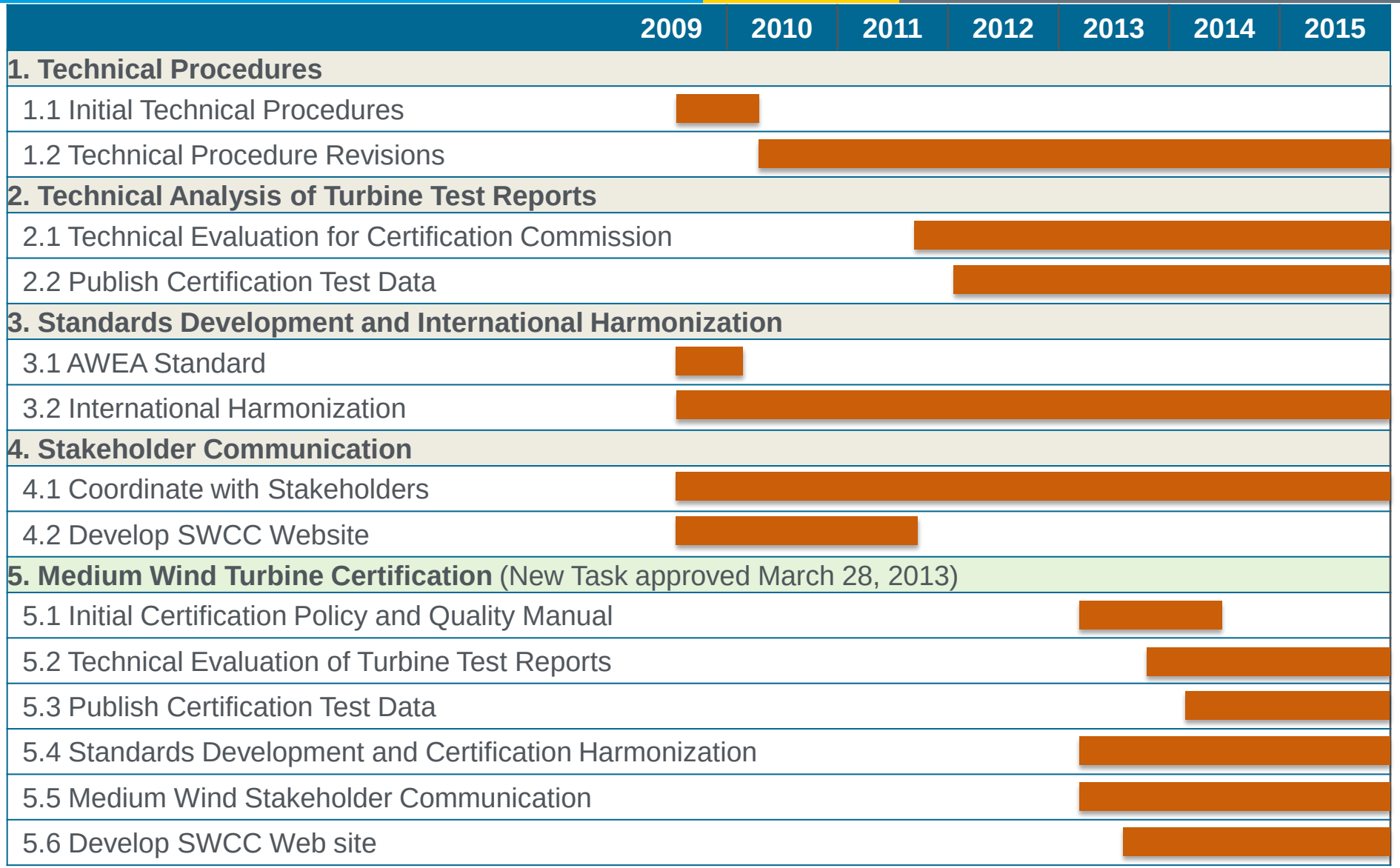
- Certification program launched in 2010
- During FY12 and FY13
  - Obtained accreditation by A2LA
  - Conducted 4 Test Site Evaluations
  - Granted full certification to 7 models
  - Added new medium wind program
- DOE goal: 12 certified models by end of FY13
  - Goal met: 7 from SWCC, 5 from Intertek
- Total of 8 certifications currently granted
  - 7 small, 1 medium (power)
- 11 models in process

Certification now required for many programs

- Interstate Turbine Advisory Council
- Energy Trust of Oregon
- Illinois Department of Commerce & Economic Opportunity
- Massachusetts Clean Energy Center (MassCEC)
- New York State Energy Research and Development Authority (NYSERDA)
- NVEnergy
- Vermont Clean Energy Development Fund

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Research Integration & Collaboration

Partners, Subcontractors, and Collaborators:

- National Renewable Energy Laboratory
- NREL/DOE funded Regional Test Centers
  - Windward Engineering
  - West Texas A&M University (now partnering with UL)
  - Kansas State University/Colby Community College
  - Intertek

Communications and Technology Transfer:

- Quarterly Stakeholder Newsletter
- Presentations at 31 conferences and meetings
- Articles in more than 18 publications
- Website includes sortable tables of certified model ratings and status of applicant, certified turbine summary reports, and other resources for consumers and stakeholders

Next Steps and Future Research

FY14/Current research:

- Promulgation of AWEA SWT Standard as ANSI standard, with AWEA Standards Development Board
- Participate in IEC Certification Advisory Committee, Small Wind Turbine subcommittee; global harmonization of SWT testing and certification
- Certify additional small and medium wind turbines
- Communicate certification results and benefits

Proposed future research:

- Continue involvement in international standards development and harmonization efforts
- Provide program for prototype testing

Loads Analysis and Standards Development for Distributed Wind

— CAE tools development for DW —

Presenter: Robert Preus

PI: Rick Damiani, PhD, PE

NREL

Robert.preus@nrel.gov, 303 384-7284

3/24-27/2014

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.380M

Total Cost-Share[1]:$0.000M

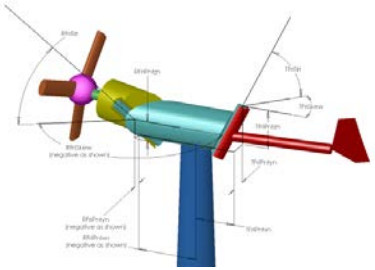
Problem Statement

- **Modest product reliability**
  - Aeroelastic effects underestimated – common myth is "small = stiff"
  - Large tower-top oscillations observed with monopole towers
    - Monopoles are steadily replacing guyed towers
    - 50% IC associated with monopole towers
- **Dynamic interaction of tower-turbine and tail/furling dynamics**
  - Aeroelastic issues observed with upwind and downwind turbines (Skystream, Whisper, Proven, Bergey, Pika, etc. experienced problems with different tower configurations, especially monopoles)
- **Resolving these problems is critical to building a mainstream distributed wind market**
  - "Beefing up" the structure solves the problem at high LCOE price
- **Recent failures → ominous shadow on the entire industry**
- **Refined modeling shows promising results**

[1] *Budget/Cost-Share for Period of Performance FY2012 – FY2013*

Problem Statement, *continued*

- **Lack of affordable CAE tools and training**
  - Aeroelastic models of SWTs are time-consuming and expensive for DW manufacturers ➔ Resort to IEC loads (mostly SLA)
- **Uncertainty in accuracy of model results ➔**
  - Overconservative (e.g, PSF = 5-7.5 Skystream/Pika on new monopoles) ➔ high costs
  - Underestimate ➔ possible fatigue failures
  - Innovations are hampered
- **Standards shortcomings (fatigue design, SLA, tower design, no VAWT SLA, limited guidance)**
  - IEC 61400-2 has limited fatigue treatment
  - TIA-222-G-DS1 developed by non-wind-turbine experts—this standard will be **the** ANSI standard for DW towers
- **VAWT certification ~ $10^6 and 10^4 hours**



Budget, Purpose, & Objectives

Problem Statement (summary)

- Modest product reliability
- Standards shortcomings (fatigue design, SLA, tower design)
- Lack of affordable CAE tools
- VAWT certification is hampered and extremely expensive

Impact of Project

- Provide the industry with:
  - Comparison data from aeroelastic models and field tests
  - Recommendations for design and certification standards improvements for HAWTS and VAWTs


INTERNATIONAL STANDARD

IEC 61400-2

Second edition 2006-03

Wind turbines –

Part 2: Design requirements for small wind turbines

This English-language version is derived from the original bilingual publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.

IEC

Reference number IEC 61400-2:2006(E)

This project aligns with the following DOE Program objectives and priorities

- **Optimize Wind Plant Performance:** Reduce Wind Plant Levelized Cost of Energy (LCOE)
- **Accelerate Technology Transfer:** Lead the way for new, high-tech U.S. industries
- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Modeling and Analysis:** Conduct wind techno-economic and lifecycle assessments to help the Program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization

Technical Approach

Multipronged Approach

- Development of aero-elastic models
  - Provide flexibility to encompass the variety of turbine configurations used in small-wind applications, including vertical-axis wind turbines (VAWTs)
- Field testing of a commercially available HAWT and VAWT at the NWTC to refine and validate models
  - Provide dataset to expand, validate, and support existing and new design and certification standards, including tower design standards and VAWT simplified loads equation development
  - Model validation dataset for both HAWT and VAWT will reduce uncertainty in the model output
- Development of a reverse-engineering blade model
  - This subtask was not funded in FY14

- **Initial focus on fatigue loads for HAWTs and, specifically, tower loads, which are relatively easy to measure, give a good idea of the overall level of the SWT loads and are important drivers for the tower base design which is often fatigue-critical.**
- **Continue with VAWT testing and modeling to support certification standards for VAWTs.**

Accomplishments and Progress

- Met all milestones on time and on budget.
- Submitted R&D plans and received approval by DOE.
- Completed field campaign with HAWT tower loads measurements—preliminary results to be shown at the SWC.
- Commenced VAWT aeroelastic model and included 2 efficient aerodynamics modules into the FAST modularization framework.
- Produced a CAE tool development plan in collaboration with Sandia National Laboratories for VAWT aeroelastic model work.
- Selected a commercially available VAWT after a survey was conducted on potential candidates.
- Procured and ordered a VAWT unit
  - Selected a foundation
  - Designed an adapter plate for installation of the unit

This task has achieved all planned accomplishments, although DOE is revisiting whether to continue its support. Thus, its future is not certain at this point.

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	
Project Number	2.0.1.10
Agreement Number	2

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012 Q1 (Oct	FY2012 Q2 (Jan	FY2012 Q3 (Apr	FY2012 Q4 (Jul-	FY2013 Q1 (Oct	FY2013 Q2 (Jan	FY2013 Q3 (Apr	FY2013 Q4 (Jul-	FY2014 Q1 (Oct	FY2014 Q2 (Jan	FY2014 Q3 (Apr	FY2014 Q4 (Jul-
Project Name: Loads Analysis and Standards Support for DW												
Q1 Milestone: R&D Plan to be submitted to DOE												
Q2 Milestone: VAWT Research Work Development Plan submitted to DOE												
Q3 Milestone: Instrument 1 small HAWT at the NWTC, with strai-gauges/accel.s, RPM												
Q4 Milestone:Complete survey of commercially available VAWTs in order to select a												
Q1 Milestone: Memorandum of HAWT testing activities and measurement summary												
Q2 Milestone: VAWT installation at the NWTC												
Q3 Milestone: Draft Paper on VAWT R&D activities to be submitted at the SWC												
Q4 Milestone: Draft Conference Paper on HAWT data analysis and SLA comparison fo												
Current work and future research												
Disseminate results on Aeroelastic modeling vs. field measurements vs. SLA for IEC-2												
Instrument VAWTs and start data collection campaign												
Continue Development of VAWT aeroelastic tool												
Validate VAWT tool and start SLA equations development for VAWTs												

Funds in FY12 were redirected to Built Environment and MidSize FOA Tech Support- Also Preparation for Strategic Planning Meeting started and stakeholders consultation was conducted.

Comments

- Project is a multi-year project to support development of new CAE tools and certification as well as design standards. Started in 2012 with planning phase. Five-year plan was delivered to DOE in Q1 of FY13.
- This task was split into 2 tasks per DOE's request: (1) Loads Analysis and Standards Support; (2) CAE tools development. As such, this task is intimately connected to the CAE tools development and aeroelastic modeling efforts.
- DOE is deciding whether to halt support to the CAE tools development task and parts of this task.

Research Integration & Collaboration

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Partners, Subcontractors, and Collaborators

- This project has benefited from a collaboration with Anemorgonics, LLC (tower provider) and was HAWT turbine tested at the NWTC.
- NREL contractors were employed to instrument and collect data from the existing turbine.
- The University of Colorado at Boulder was subcontracted to help develop the CAE tools.
- Urban Green Energy has agreed to participate in the VAWT project, sharing under an NDA, technical and proprietary data of the turbine that will be installed at the NWTC.

Communications and Technology Transfer

This R&D effort will disseminate results via:

- NWTC design codes website: http://wind.nrel.gov/designcodes/ (Results: more than 20,000 downloads since 1998).
- Dedicated workshops (e.g., SNL blade workshop, VAWT Aeroelastic Model School, DW stakeholder's meeting).
- Conferences:
  - Small Wind Conference (2014, 2015)
  - AWEA (2015)

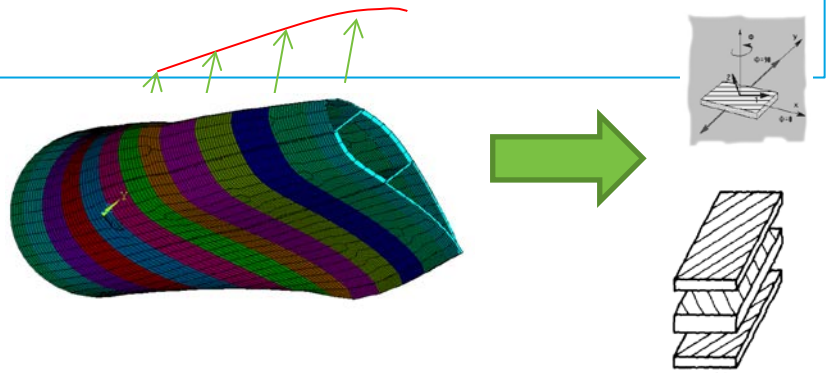
Next Steps and Future Research

FY14/Current research

- Multi-year project nature
- Small HAWT and VAWT focus: SLA/IEC validation, tower design standards
- VAWT unit installation
- Preliminary results dissemination

Proposed future research

- Blade reverse engineering tool
- Foundation modeling — reduce costs of tower/foundation
- Synergy with built-environment task



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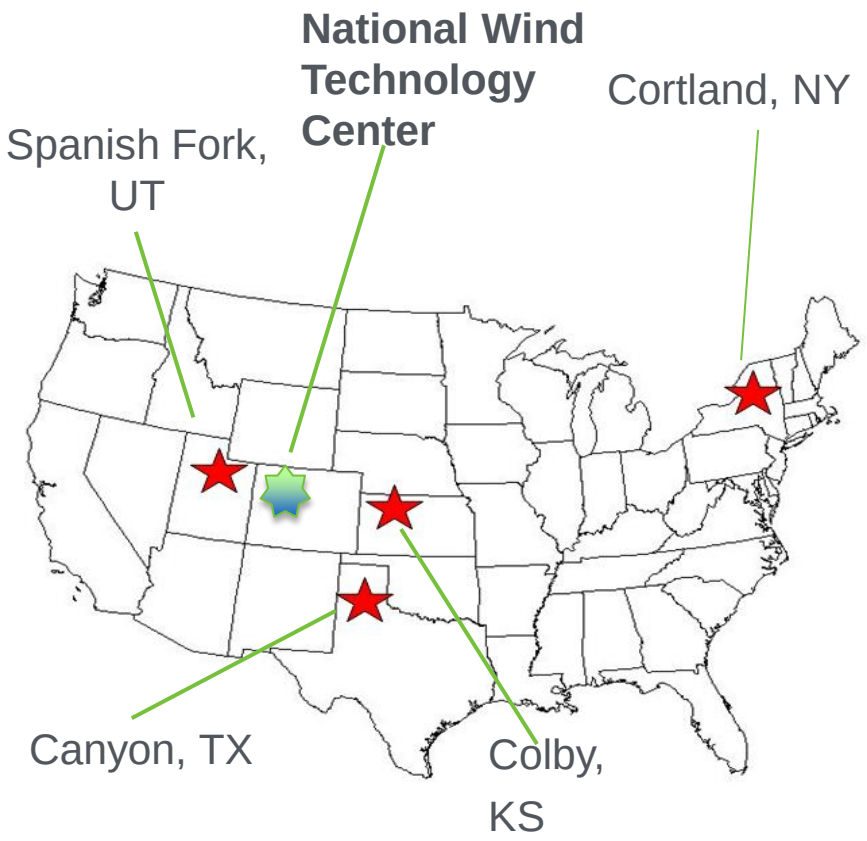


Small Wind Turbine Testing (SWTT) & Regional Test Center Technical Support (RTC)

Robert Preus

National Renewable Energy Laboratory

Robert.preus@nrel.gov (303) 384-7284

March 27, 2014

Budget, Purpose, & Objectives

Problem Statement:

Small Wind Turbine Testing (SWTT): Formerly known as Independent Testing (IT). No process existed for consumers to distinguish viable SWTs.

Regional Test Center (RTC): NWTC was the only testing facility for small wind generators.

Impact of Project: SWTT: As recently as 2009, no third party measured turbine performance (power and noise) data were available, now it is the norm. This project raised the expectation that small wind turbine manufacturers provide third-party test data. RTC: Testing availability was expanded in both volume and location. Established a body of experienced testers.

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.480M

Total Cost-Share[1]:$0.150M

This project aligns with the following DOE Program objectives and priorities

SWTT:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Testing Infrastructure:** Enhance and sustain the world-class wind testing facilities at universities and national laboratories to support mission-critical activities

RTC:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Testing Infrastructure:** Enhance and sustain the world-class wind testing facilities at universities and national laboratories to support mission-critical activities

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

Technical Approach

SWTT:

- Turbines selected via competitive solicitation. Selected small wind turbines were tested to a suite of IEC testing standards, including power performance, duration, safety and function, acoustic noise, and power quality.
- NREL led the development of the IEC SWT testing procedures and used the SWTT experience in the standards development process to fine-tune these and educate others using this public data.
- Provided a body of testing reports that were made public.

Technical Approach

RTC:

- Partner Regional Test Centers selected via competitive solicitation. Funding provided to support field testing of two turbines each of four Test Centers. NREL provides technical expertise for testing, data analysis, and test report writing.
- Limited experience and capability in testing small wind generators. Workshops and support provided for site calibration, instrument and data validation, resolving acoustic testing challenges, data processing and analysis.
- Workshops allowed dissemination of knowledge from NREL and sharing of lessons learned among test centers.

Accomplishments and Progress

SWTT: Enhanced NREL testing expertise, published examples of testing reports, and provided certification testing for seven small wind generators. Public test reports now expected for small wind turbines in the market.

RTC: Several wind turbines originally selected became unavailable. Selecting alternatives delayed the program. The test center groups have been supported in developing the technical expertise to conduct certification testing. Three have completed, and a fourth group is still in the process.

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	
2.3.0.3	

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012				FY2013				FY2014			
	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Project Name: Small Wind Turbine Testing												
Q1 Milestone: Install & commission the Viryd CS8												
Q2 Milestone: Complete data collection on 1st DOE Independent Testing small turbine												
Q3 Milestone: Complete data collection on 2nd DOE Independent small turbine												
Q4 Milestone: Complete all test reports for 1st DOE Independent Testing small turbine												
Q1 Milestone: Complete acoustic testing to IEC on the Viryd turbine												
Q2 Milestone: Complete and publish IEC power performance test report, Viryd turbine												
Q3 Milestone: Complete and publish IEC duration test report, Viryd turbine												
Q4 Milestone: Report on all IEC testing (above + safety & function), Viryd turbine												
Current work and future research												
None												

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	
WE110215	
2.2.0.3	

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012 Q1 (Oct-Dec)	FY2012 Q2 (Jan-Mar)	FY2012 Q3 (Apr-Jun)	FY2012 Q4 (Jul-Sep)	FY2013 Q1 (Oct-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Oct-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Regional Test Center Technical Support												
Q1 Milestone: 6 small wind turbines installed across 4 RTCs												
Q2 Milestone: Testing & reports completed for 1 SWT at 1 RTC												
Q3 Milestone: 7 of 8 SWTs installed across the 4 RTCs												
Q4 Milestone: Testing completed & reports posted for 3 SWTs												
Q1 Milestone: Complete & post Jacobs 31-20 test reports												
Q2 Milestone: Complete testing on Endurance & Nikko SWTs												
Q3 Milestone: Complete & post test reports on Endurance & Nikko												
Q4 Milestone: Complete testing of Windspire SWT												
Current work and future research												
Q1 Milestone: Test plans completed for 3 turbines												
Jan. Go/No-Go for 3 turbines												
Q3 Milestone: Site Varification visit												
Q4 Milestone: no milestone, waiting for KSU testing to complete												

Project Plan & Schedule

Comments Small Wind Testing

- SWTT project initiation FY07 and completed Q3 FY13

Comments Regional Test Centers

- RTC project initiation FY11and planned completion FY15
- Drop in sales and venture funding resulted in several subject test turbines manufacturers going out of business. This caused delays in the start of RTC testing, especially at KSU. Impact on budget small.
- There were a series of go/no-go decision points in January 2014. Hummingbird turbine was dropped at that time. Dakota turbine has go/no-go decision coming in April.
- Testing at KSU to continue into FY15, little NREL effort until test report preparation

SWTT

Partners, Subcontractors, and Collaborators:
SWTT: NREL partnered with Abundant Renewable Energy, Entegrity Wind, Gaia, Mariah, Ventera, Viryd Technologies, Cascade Engineering. They all had turbines tested.

Communications and Technology Transfer:
SWTT: Published turbine test reports at http://www.nrel.gov/wind/smallwind/independent_testing.html. Presentations on project made at Small Wind Installers Conference, Small Wind Testers Workshops, AWEA conference, and several others.

RTC

Partners, Subcontractors, and Collaborators: RTC: Contracts with Intertek, Windward Engineering, West Texas A&M, Kansas State University.

Communications and Technology Transfer:
RTC:NREL created webinars on certification testing http://www.nrel.gov/wind/smallwind/workshops_webinars.html. NREL organized six workshops on small wind certification testing and provided extensive technical support to the RTCs for testing, data analysis, and report writing. Partner test reports at: http://www.intertek.com/wind/small/RTC/ http://windwardengineering.com/our-work/projects/nrel-rtc/ http://www.windenergy.org/windtestcenter/wtc2013/nikko1kw.html

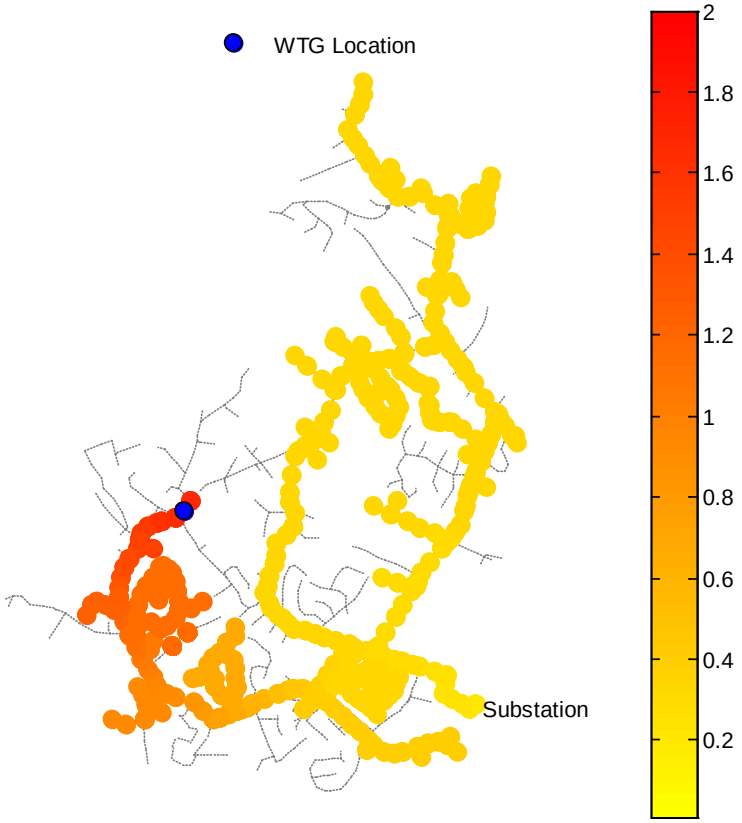
Next Steps and Future Research

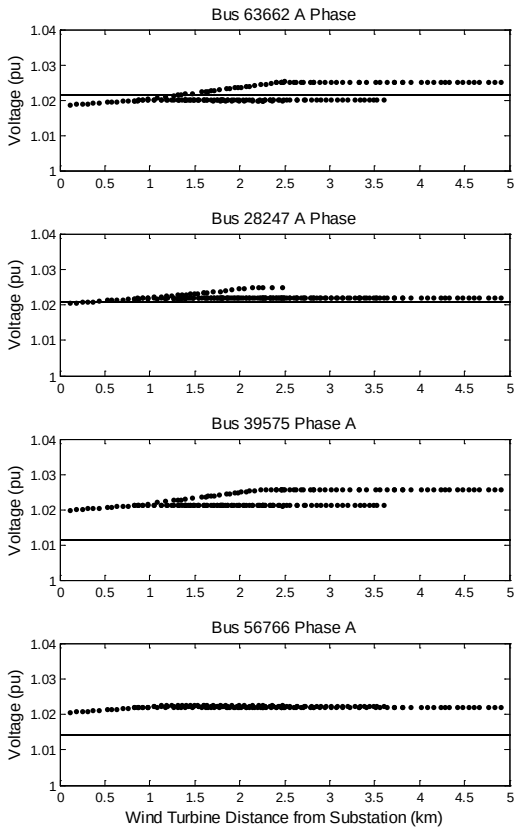
FY14/Current research:

SWTT is complete. RTC has one turbine being installed and commissioned by April, one turbine is still in testing, and five are done testing.

Proposed future research:

The RTC project has resulted in the development of sufficient testing capability to meet current and expected future needs for small wind turbine certification testing. However, further testing at NWTC to develop datasets for model validation and to gain experience in what level of testing (duration and conditions) is required to determine infant mortality issues would be extremely valuable.





Grid/Transmission Issues for Distributed Generation

Barbara O'Neill
PI: Bri-Mathias Hodge

NREL
Barbara.oneill@nrel.gov, 303 384-7025
March 27, 2014

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.450M

Total Cost-Share[1]:$0.000M

Problem Statement: Determining the limitations of utility-scale wind turbines on the distribution system and the impacts that large amounts would have on the transmission system.

Impact of Project: This work could allow for higher penetrations of distributed wind, reducing the need for building transmission to reach good wind resources.

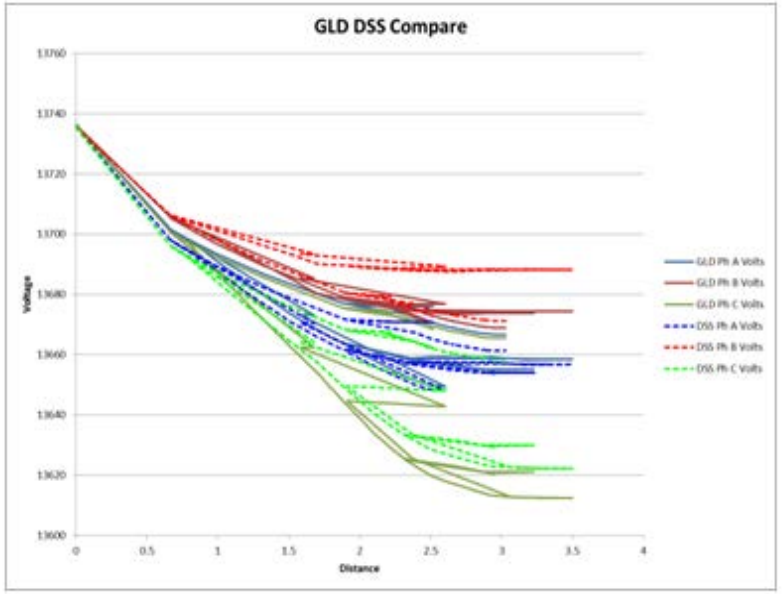
This project aligns with the following DOE Program objectives and priorities:

- **Mitigate Market Barriers:** Reduce market barriers to preserve or expand access to quality wind resources
- **Advanced Grid Integration:** Provide access to high wind resource areas, and provide cost effective dispatch of wind energy onto the grid
- **Modeling & Analysis:** Conduct wind techno-economic and life-cycle assessments to help program focus its technology development priorities and identify key drivers and hurdles for wind energy technology commercialization

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

Distribution Side

Utilize distribution modeling software such as OpenDSS to discover generalized conditions where large-scale wind turbines may be sited on the distribution grid without significant power quality implications



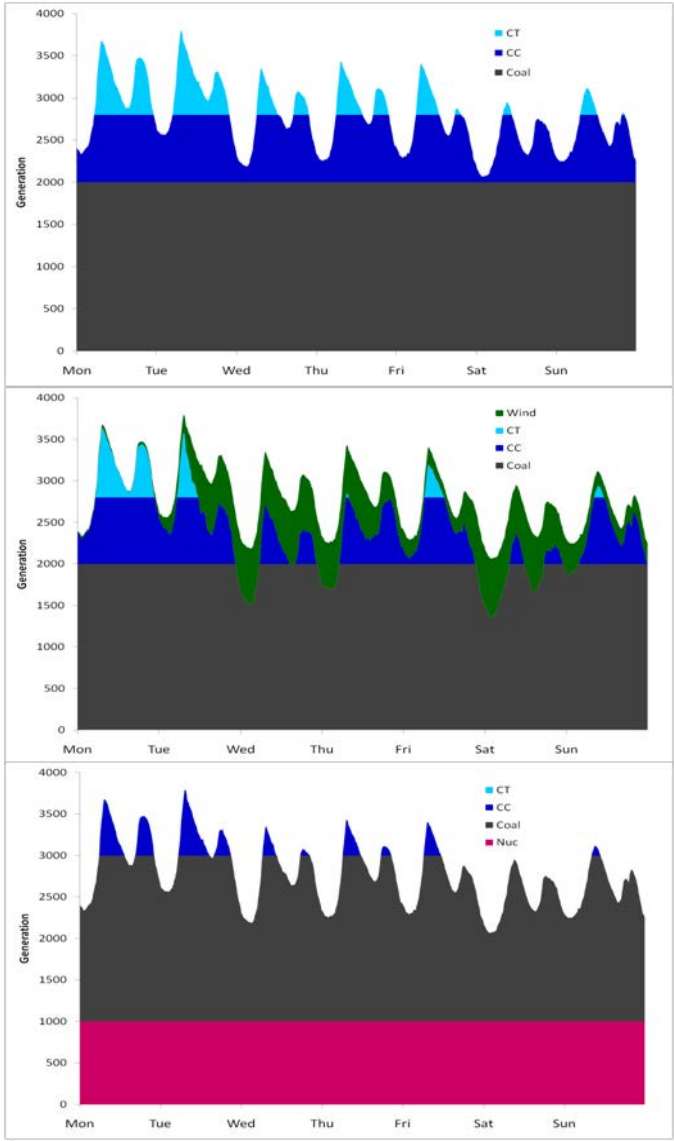
Comparison of GridLAB-D and OpenDSS bus voltages for taxonomy feeder R2-25.00-1

Technical Approach

Transmission Side

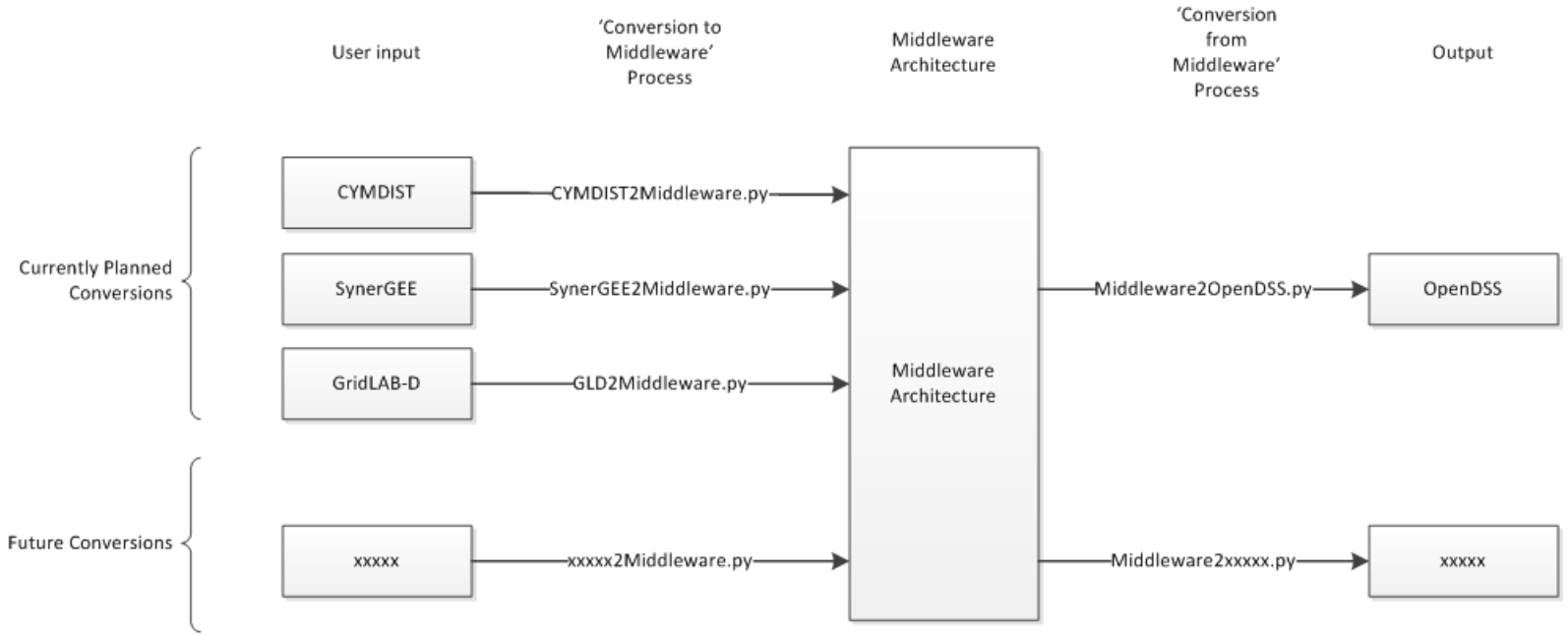
Use production cost modeling software (PLEXOS) to determine the maximum distributed wind penetration levels possible under varying scenarios of system operations (forecasting, visibility, reserves)

Currently putting the finishing touches on a PLEXOS model of the ISO-NE system that will allow the examination of transmission constraints below 69 kV and designing distributed wind penetration scenarios



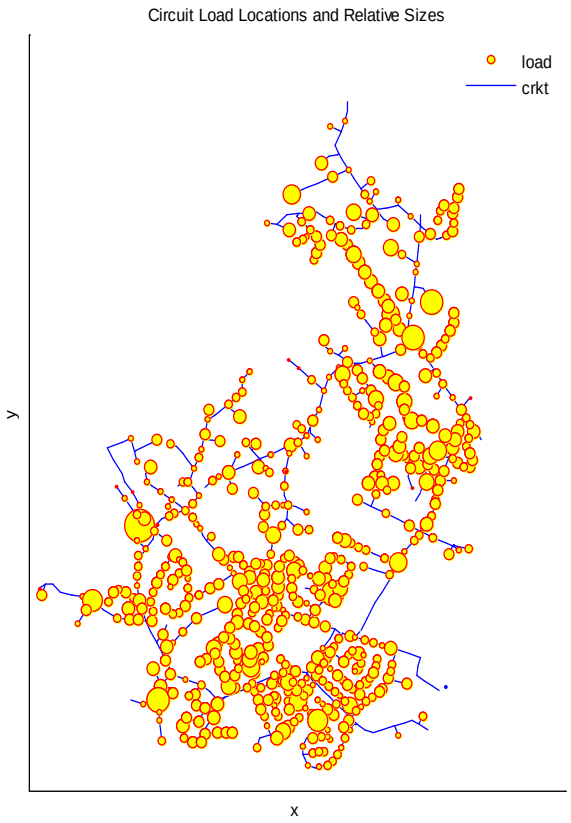
Accomplishments and Progress

- Creation of the open source software "GLD2OCT," which will be made publically available shortly
  - *This software converts from distribution software format GridLab-D to OpenDSS format and will convert other formats in FY14 (see below).*
  - *This allows the study of the GridLab-D taxonomy feeders for generalizing distribution system conditions conducive to utility-scale wind turbines.*



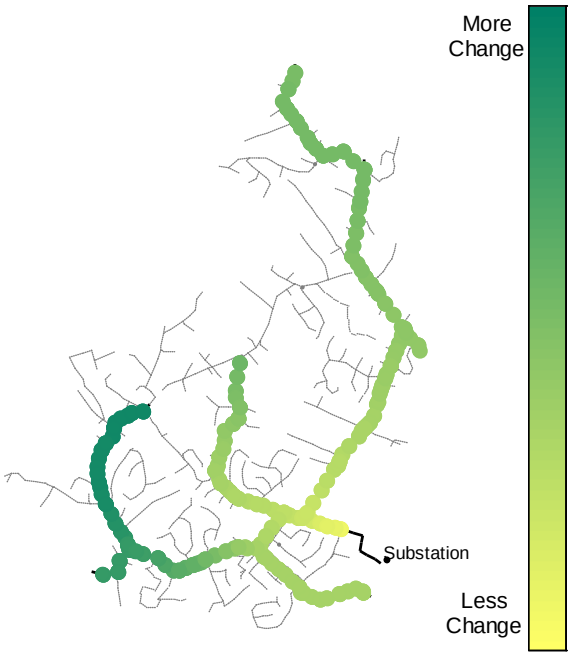
Accomplishments and Progress

Examination of the voltage profiles on rural distribution feeders from adding varying numbers of wind turbines and the impact of turbine location



The preliminary work toward classifying when a full interconnection study is advisable based on a generalization of the findings.

→ No study; No WTG
→ No study; Yes WTG
→ Yes study; ? WTG



Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	8.1.6
Project Number	
Agreement Number	

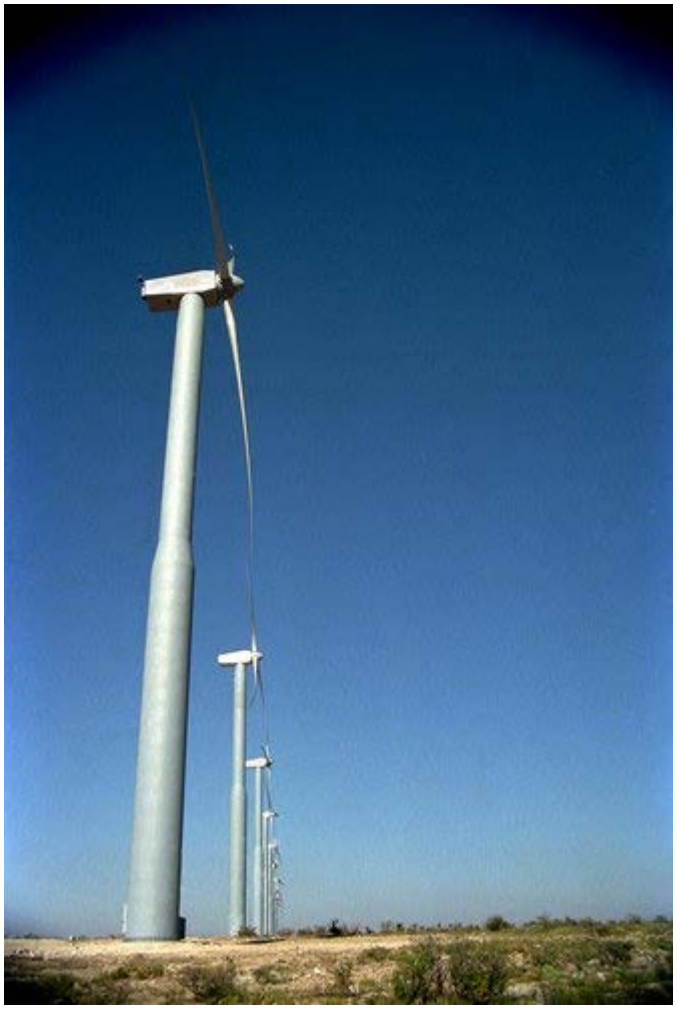
Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Task / Event	FY2012 Q1 (Octt-Dec)	FY2012 Q2 (Jan-Mar)	FY2012 Q3 (Apr-Jun)	FY2012 Q4 (Jul-Sep)	FY2013 Q1 (Octt-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Octt-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Grid/Transmission Issues for Distributed Generation												
Q1: Perform distribution system simulations detailed in an NREL technical report												
Q2: Complete final list of locations within the case study area												
Q3: Complete the data collection necessary in the study area												
Q4: Complete the study final report												
Q1: Identify the distribution and transmission system platforms to be integrated												
Q2: Complete an interim technical report on the transient and dynamic limitation factors												
Current work and future research												
Q3: Working platform for the simultaneous simulation of distribution and transmission												
Q4: Complete the study final report detailing the transient and dynamic limitations												

Comments

- Project initiated in October 2013 and planned for completion in FY15
- Data issues due to software incompatibility and delays in hiring process of distribution system expertise resulted in delays
- FY14 milestones on schedule, FY13 milestones scheduled for completion in FY14 (not consecutive milestones)

Research Integration & Collaboration



Partners, Subcontractors, and Collaborators:

We are collaborating with ISO-NE, the system operator for the case study area, as well as with one of the distribution system operators in the region, National Grid. ISO-NE has been actively involved in scoping the project and providing data and feedback on technical progress. National Grid has provided distribution feeder data.

Communications and Technology Transfer:

Publications:

Alicia Allen, Yingchen Zhang, Bri-Mathias Hodge: "Impact of Increasing Distributed Wind Power and Wind Turbine Siting on Rural Distribution Feeder Voltage Profiles," 12th International Workshop on Large-Scale Integration of Wind Power into Power Systems, October 22-24, 2013, London, UK.

Yingchen Zhang, Alicia Allen, Bri-Mathias Hodge: "Impact of Distribution-Connected Large-Scale Wind Turbines on Transmission System Stability during Large Disturbances," Accepted for the Proceedings of the IEEE Power & Energy Society General Meeting, July 27-31, 2014, National Harbor, MD, USA.

Open Source Software "GLD2OCT" will be made publically available shortly. This software converts from distribution software format GridLab-D to OpenDSS format.

Next Steps and Future Research

FY14 / Current Research

- Previous work focused on steady-state issues
- FY 14 work concerned primarily with transient and stability research on interconnecting large amounts of distributed wind
- Includes linking transmission and distribution models from different software platforms
- Studying the impact of transient events (and the distributed generation response) on transmission
- Groundwork for the Distributed Wind Vision

Next Steps and Future Research

Proposed Future Research

The software combinations are somewhat *ad hoc* currently. The formalization of these tools through software development would lead to important tools for industry to examine distributed generation issues.

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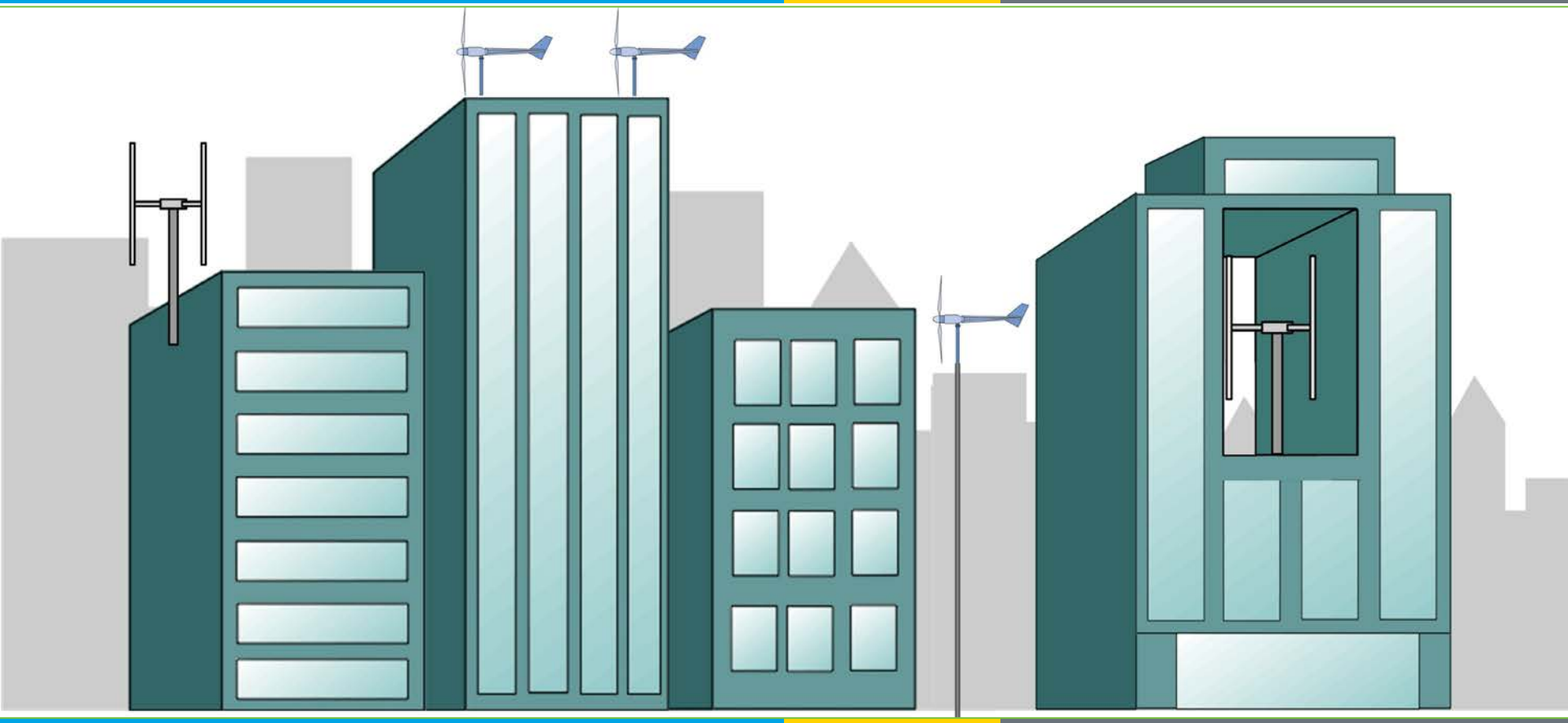

Built Environment Research Update

Jason Fields

NREL

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March 27, 2014

Budget, Purpose, & Objectives
What is Built Environment?

- Wind Turbines installed in the urban environment
  - Building Mounted
  - Building Integrated
  - Surface Mounted near Buildings
- Unique Considerations
  - Existing design standards not intended for urban environment
  - Existing test protocols not intended for urban environment

Budget, Purpose, & Objectives

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Total DOE Budget[1]: $0.400M

Total Cost-Share[1]:$0.120M

Problem Statement: Urban wind turbines are proximal to people in dense numbers, raising the issue of safety and reliability for potential stakeholders. Robust science is needed to inform consumers, policy makers, regulators and standards development on the most appropriate use of this technology advancement.

Impact of Project: This project will lay the foundation for understanding the guidelines and standards which will inform safe and effective deployment of wind turbines in the built environment

This project aligns with the following DOE Program objectives and priorities:

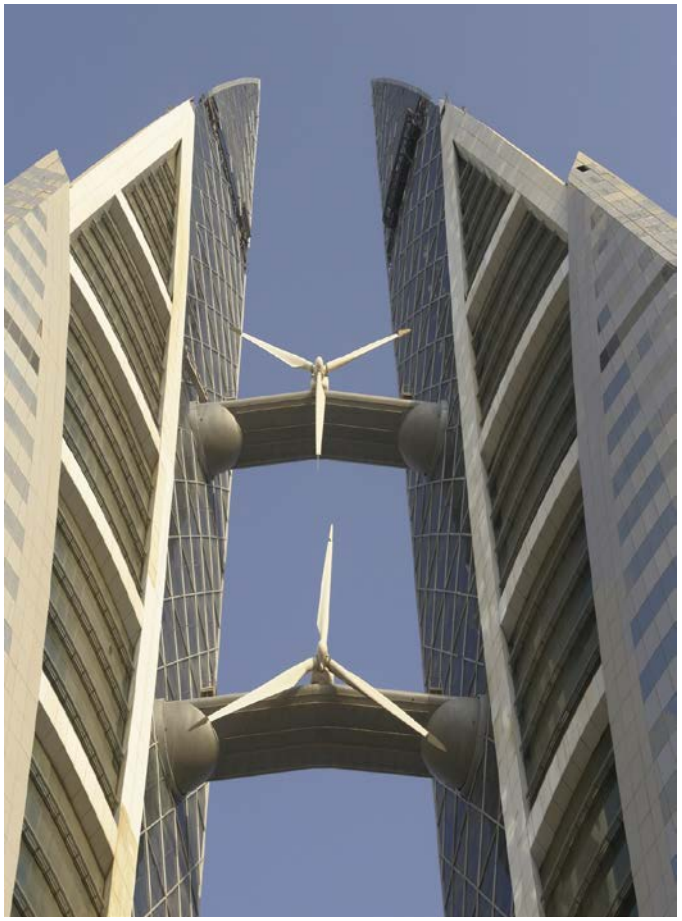
Accelerate Technology Transfer: Lead the way for new high-tech U.S. industries

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

Purpose & Objectives
BEWT overview

- Benefits
  - Clean & Renewable
  - Visible
  - Distributed Generation
- Challenges
  - Safety
  - Reliability
  - Performance & Economics

Lack of reliable information on characteristics of wind in urban environment!



Bahrain World Trade Center
Photo from iStock/6924031

What, Where, and How?

The What

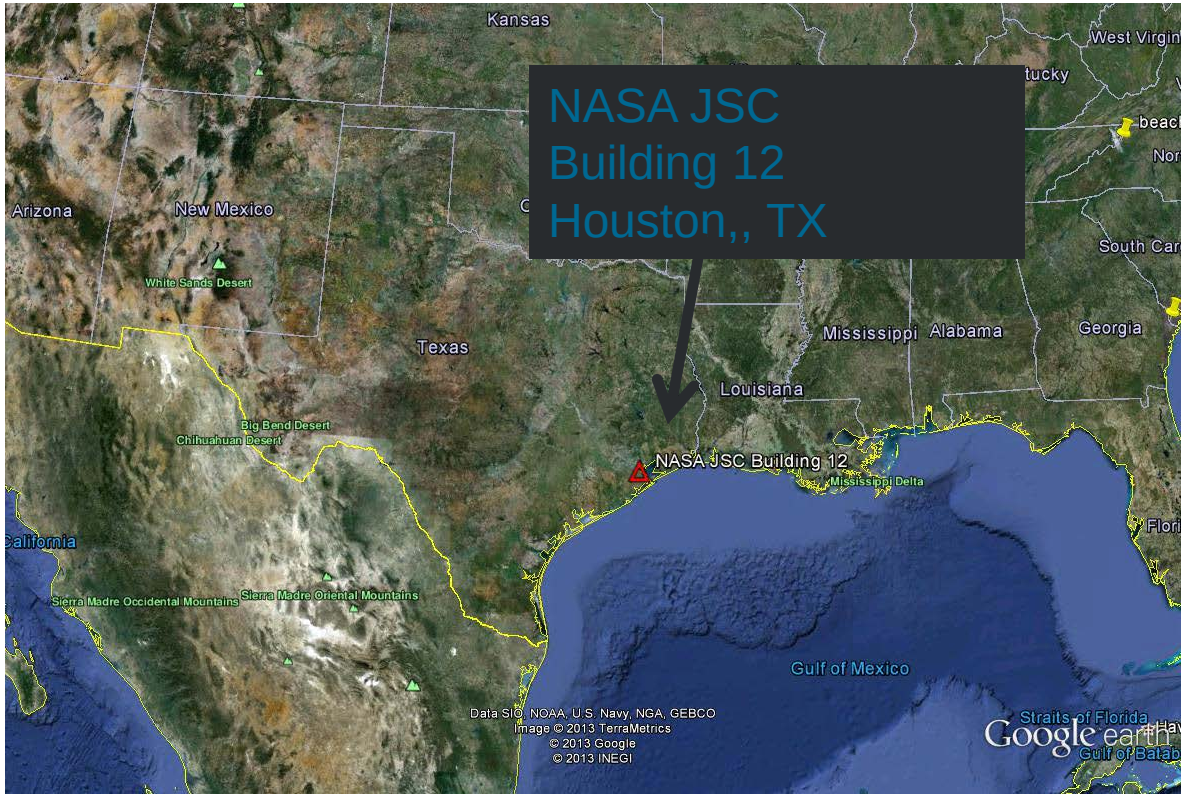
- Resource Characterization
  - Inflow Angle
  - Turbulence
  - 3D Wind
- Turbine Response
  - Yaw rates
  - Vibration
  - Power production

Index	Topic
3.56	Wind profile, wind shear law
3.6	Wind speed distribution
6.2	SWT classes
6.3.1	Inclination flow
6.3.2.1	Wind speed distribution
6.3.2.2	Normal Wind profile model (NWP)
6.3.2.3	Normal Turbulence Model (NTM)
6.3.3.2	Extreme Wind Speed Model (EWM)
6.3.3.3	Extreme Operating Gust (EOG)
6.3.3.4	Extreme direction Change (EDC)
6.3.3.5	Extreme Coherent Gust (ECG)
6.3.3.6	Extreme Coherent gust with Direction Change(ECD)

Technical Approach
BEWT-Measure

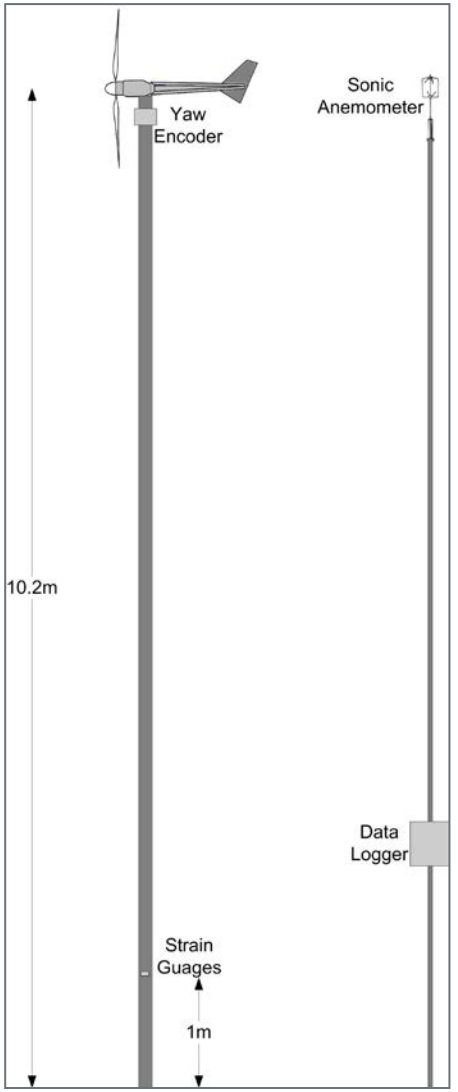
Where

- Urban environment or simulated urban environment
- Existing or planned wind energy deployments
- Open access/scientific ethos
- Supporting data



How

Instrument Suite
3-axis Sonic Anemometer
Yaw Encoder
Acceleratormeter
Strain Gages
Temperature
Barometric Pressure
Wetness Sensor (Ice Detection)
Power transducer
Datalogger & Communications



Technical Approach
NASA Building 12

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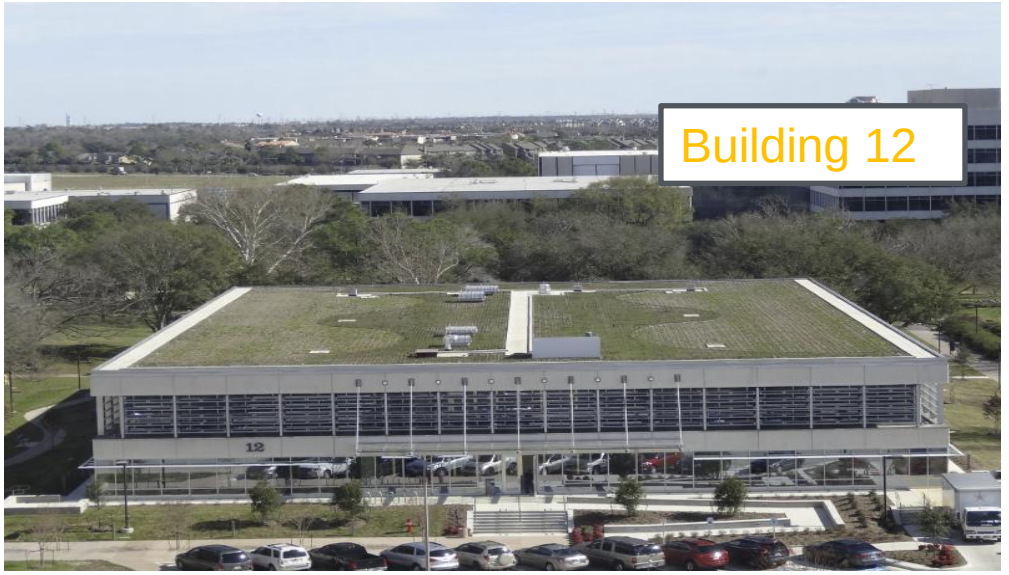
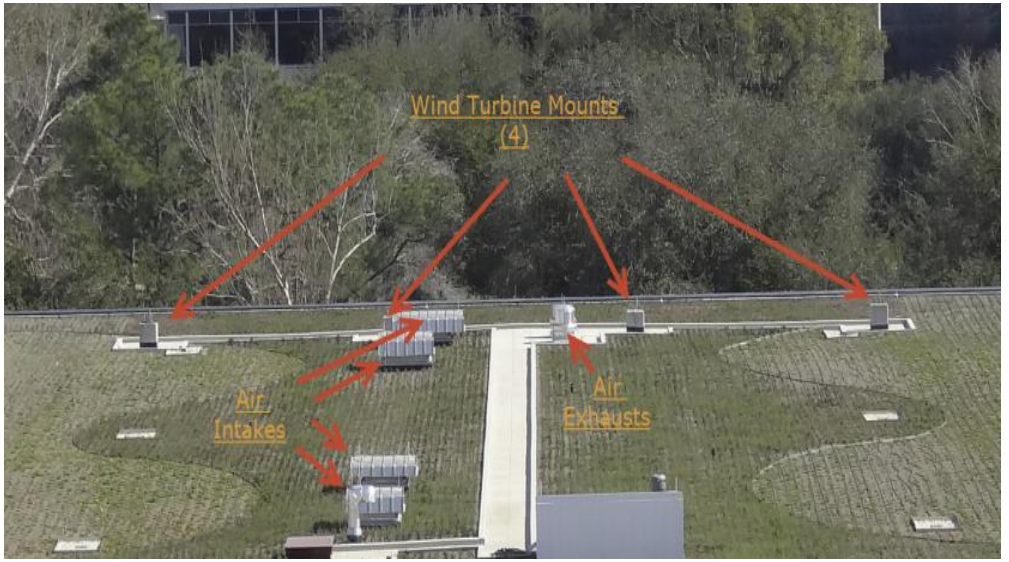
Background
NASA installing 4 x 1 kW Urban Green Energy VAWTs on Building 12 at Johnson Space Center (JSC).

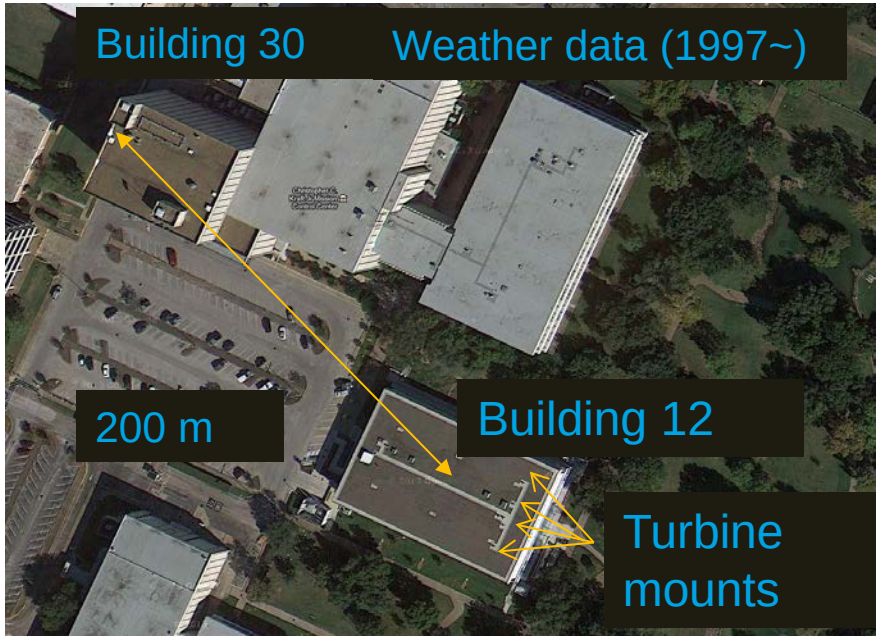
Purpose
- Perform an end to end wind resource assessment
- Includes preconstruction and post construction data
- Long-term AEP estimates
- Provide data monitoring and visualization online and in building

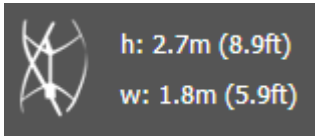
Collaborative Efforts
NREL/DOE partnering with NASA to generate high quality data set for current and future study





Technical Approach
NASA Building 12





Work Plan

Near term (1 year)

Pre construction measurements
- -wind velocity and turbulence intensity
- -wind direction
- -temperature
- -heat flux
- -barometric pressure

Long term (1-3 years)

Post construction measurements
- -turbine power
- -turbine operation status
- -turbine structural response

Dataset for DWT WRA case study
- -nearby long term dataset (since 1997)
- -reanalysis long term data (MERRA, ERA-I)
- -downscaled NWP model (~5 km, WRF)
- -turbine power and availability

Validate and tune computational models

Representative dataset to inform BEWT design standards

Technical Approach
Met Tower and WT Layout

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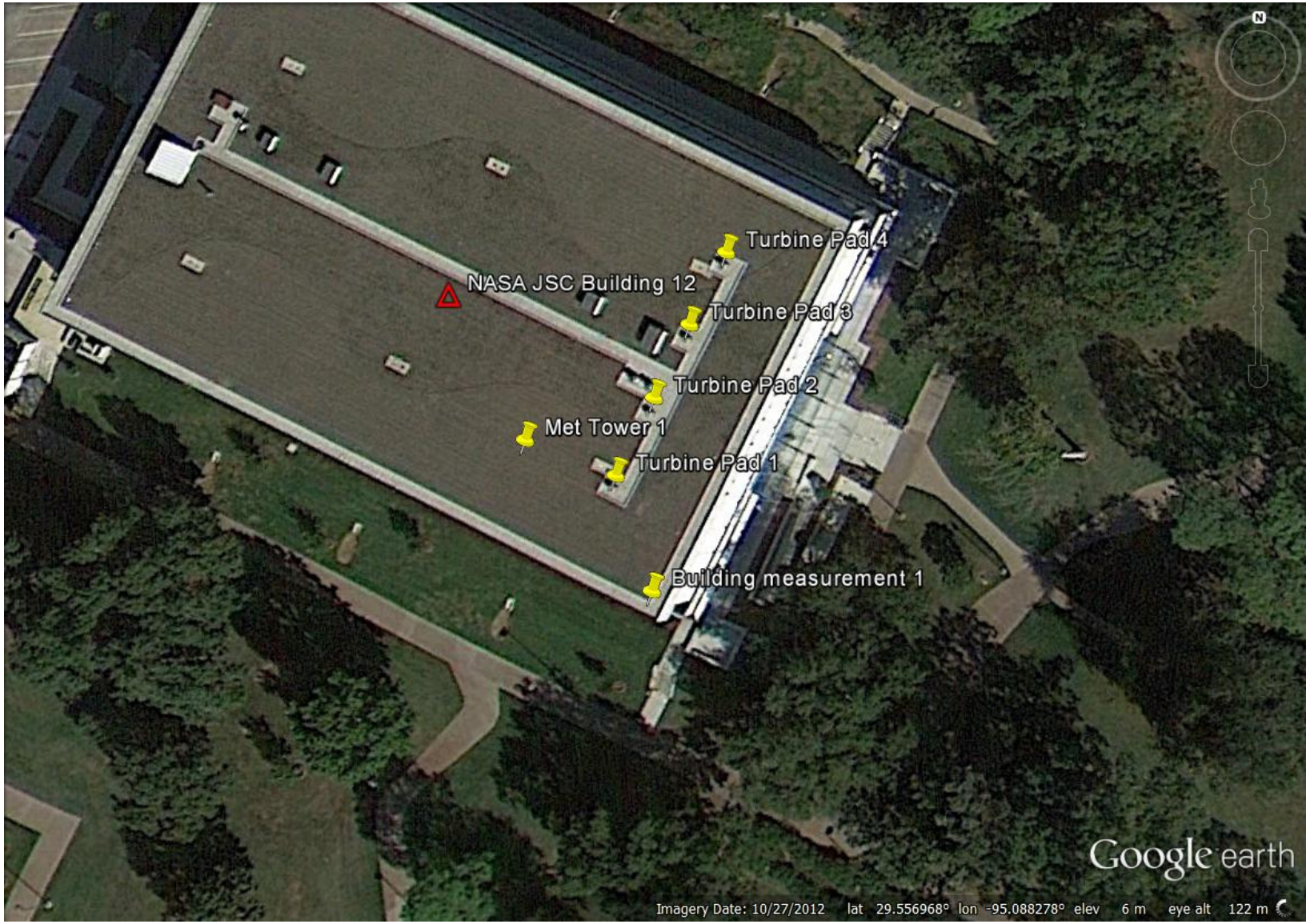

Datalogger
Campbell Scientific CR3000
Campbell Scientific CR1000
Cellular telemetry-LTE

Anemometers
8-Gill WindMaster @ 20Hz
3D Windspeed and Direction, Sonic Temperature

Met Pak Weather Station(Gill)
Wind Speed & Direction, Temperature, Humidity, Barometric Pressure & Dew Point

Miscellaneous
Pyranomemter
Rain Gauge

Technical Approach
NASA Building 12 Process Flow

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Instrumentation

DataLogger w/ 4G LTE modem

LoggerNet on server

Data Analysis Code-R

Website Publication

Nrel.gov

Accomplishments and Progress

- FY13 (Oct 2012-Sep 2013)
  - Location identified
  - Access negotiations started
  - Detailed instrument specification
  - Subcontractor identified
    - instruments procured
  - Engineering review started
  - Instrument calibrations completed

NASA Building 12 Instruments
Photo courtesy Dynamax

Project Plan & Schedule

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Summary	
WBS Number or Agreement Number	
Project Number	
Agreement Number :	2.1.6

Legend	
	Work completed
	Active Task
	Milestones & Deliverables (Original Plan)
	Milestones & Deliverables (Actual)

Built Environment Wind Reasearch	FY2012				FY2013				FY2014			
Task / Event	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Octt-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Project Name: Wind Energy Forecasting Methods and Validation for Tall Turbine Resource Assessment												
Q1 Milestone: NA												
Q2 Milestone: NA												
Q3 Milestone: Draft NASA Building 12 Deployment Plan							◆					
Q4 Milestone: Deploy instrumnet suite at NASA Building 12										◆		
Current work and future research												
Q1 Milestone: Present preliminary results to IEA Task 27 Fall Meeting									◆	◇		
Q2 Milestone: Complete documentation of NASA Building 12 Instrument Deployment										◇		
Q3 Milestone: Develop data QC algorithms and documentation											◇	
Q4-1 Milestone: Finalize instrumentation plan for phase II (Turbine Deployment)												◇
Q4-2 Milestone:Proposal for NASA Building 12 wind resource assessment analysis plan												◇

Comments

- Extensive project scoping and debate during Q1 & Q2 FY13
- NWTC based test site Vs real world location
- Instrument deployment delayed due to permitting and contractual issues

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators:

NASA Headquarters
NASA Johnson Space Center (Houston, TX)
Dynamax, Inc (Installation Subcontractor)
Urban Green Energy (Turbine Vendor)

Communications and Technology Transfer:

Presentations:
IEA Task 27 Meeting Q2-2012
IEA Task 27 Meeting Q4-2012
IEA Task 27 Meeting Q2-2013
IEA Task 27 Meeting Q1-2014
iSWAT Meeting 2012
Poster:
Windpower 2012

NASA Building 12 Current Progress

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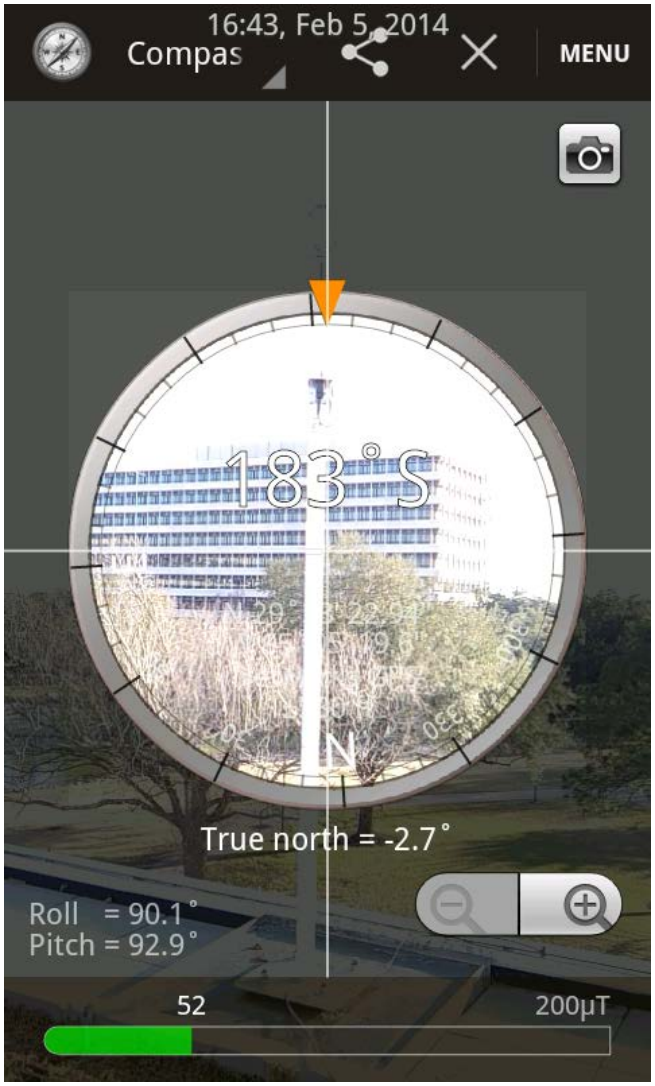
NASA Building 12 Current Progress

- 

Next Steps and Future Research

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FY14 Milestones

FY14 Q1: Present preliminary results of the NASA Building 12 pre-construction wind resource measurement program at IEA Wind Task 27 Fall Meeting by December 31, 2013.-Complete

Q2: Complete documentation of the NASA Building 12 pre-construction wind resource measurement program in support of a full data package publication in FY 2015 by March 31, 2014.

Q3: Develop quality control algorithms and documentation for incoming NASA Building 12 data instrumentation program in support of full data package publication in FY 2015 by June 30, 2014.

Q4-1: Finalize the instrumentation plan for Phase II of the NASA Building 12 wind turbine response test program by September 30, 2014.

Q4-2: Completion of proposal for NASA building 12 WRA data analysis by 9/30/14.

Next Steps and Future Research

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FY14/Current Research

- Community Involvement & Data Sharing
  - NREL website
  - IEA Task 27
  - NAU
- Current DOE R&D scope
  - Installation & maintenance
  - Dataset management
    - Storage and dissemination logistics
    - Quality control algorithms
  - Documentation
  - Planning for Phase 2: turbine instrumentation
  - Proposal for WRA Data Analysis

Proposed Future Research

- Exploring 3D Volumetric measurements
  - Sonic tomography
- Lessons learned document or case study
  - Compare Building 12 resource/performance with ground mounted installations
  - Best practice guidance
- Data Analysis
  - IEC Classification
  - Temporal trends
- WRA Benchmarking
  - Re-analysis
  - Mesoscale modeling
  - Microscale models
  - Site Assessor methods
  - Statistical/Empirical approaches

Contact Information

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Competitiveness Improvement Project

Distributed Wind

Karin Sinclair

NREL

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March 27, 2014

Budget, Purpose, & Objectives

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Total DOE Budget[1]: $0.870M

Total Cost-Share[1]:$0.364M

Problem Statement: U.S. distributed wind manufacturers need to increase their competitiveness in the global market through technological advances that focus on reducing levelized cost of energy.

Impact of Project: This project directly contributes to the DOE objective to increase the number of certified small and midsize wind systems in the United States (goal of 40 SWTs certified by 2020) and reduce levelized cost of energy of turbines in distributed wind applications. The current focus is on turbines with a rotor-swept area of 1000 m^2 or less (approximately 250 kW).

This project aligns with the following DOE Program objectives and priorities:

- **Optimize Wind Plant Performance:** Reduce Wind Plant Levelized Cost of Energy (LCOE)
- **Accelerate Technology Transfer:** Lead the way for new high-tech U.S. industries

[1] ***Budget/Cost-Share for Period of Performance FY2012 – FY2013***

Technical Approach

Technical Approach: Provide cost-shared support to the U.S. distributed wind industry for component and manufacturing process improvements, and turbine testing. NREL will also provide technical support, to the extent it is needed and the budget allows.

Key Issue: Identifying areas where U.S. distributed wind turbine system designers, manufacturers and component suppliers can develop systems that are globally competitive and can be certified for the U.S. market. The overall objective is to assist the U.S. distributed wind industry in reclaiming its leadership in this sector, help grow the distributed wind sector, and contribute to overall wind deployment.

Accomplishments and Progress

Through a competitive solicitation (released in late FY12), two awardees were selected – one focused on component improvements (Bergey Windpower Company), the other on manufacturing process improvements (Pika Energy).

A second solicitation was released in late FY13. Contract negotiations are in progress.

Field testing of Pika T701 in North Gorham, Maine

Accomplishments and Progress

Each CIP awardee was also provided technical support:

- Pika - blade fatigue testing
- BWC – development of modeling capabilities to characterize twist coupling of blades. However, BWC's focus has changed to stall-regulated approach with enhanced rotors.

Rotor Fatigue Test for Pika at NWTC

Project Plan & Schedule

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Summary	
WBS Number or Agreement Number	2.1.8
Project Number	WE110280
Agreement Number	22501

Legend

- Work completed
- Active Task
- Milestones & Deliverables (Original Plan)
- Milestones & Deliverables (Actual)

Task / Event	FY2012 Q1 (Octt-Dec)	FY2012 Q2 (Jan-Mar)	FY2012 Q3 (Apr-Jun)	FY2012 Q4 (Jul-Sep)	FY2013 Q1 (Octt-Dec)	FY2013 Q2 (Jan-Mar)	FY2013 Q3 (Apr-Jun)	FY2013 Q4 (Jul-Sep)	FY2014 Q1 (Octt-Dec)	FY2014 Q2 (Jan-Mar)	FY2014 Q3 (Apr-Jun)	FY2014 Q4 (Jul-Sep)
Project Name: Competitiveness Improvement Project												
Q3 Milestone: Develop preliminary CIP solicitation materials												
Q4 Milestone: Select CIP awardees												
Q1 Milestone: Execute subcontracts with awardees												
Q2 Milestone: Submit SOW and project description to HQ for each awardee												
Q3 Milestone: Submit progress report for each project to HQ												
Q4 Milestone: Submit progress report for each project to HQ												
Q4 Milestone: Release 2nd CIP solicitation												
Q1 Milestone: Complete blade fatigue test for Pika Energy												
Q2 Milestone: Execute subcontracts with awardees												
Q3 Milestone: Finalize technical support commitments for awardees												
Q4 Milestone: Final Pika Energy report												
Current work and future research												
Technical support for Pika Energy												
Execute subcontracts												
Determine technical support needed for new awardees												

Comments: Project original initiation date was August 2012; planned completion date is TBD. Blade fatigue test for Pika Energy is not complete for the following reasons: original blades damaged in shipping; new approach to adhere strain gages to blades was developed due to blade material; bolts in hub broke (twice) during testing and a new design was developed.

Research Integration & Collaboration

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators:

- Pika Energy
- Bergey Windpower Company
- Additional awardees TBD

Communications and Technology Transfer:

- Pika Energy has given numerous presentations on their turbine development activities.
- Abstracts have been submitted to conferences.

Next Steps and Future Research

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FY14/Current research:

Technical support being provided to Pika Energy (blade fatigue testing). Once new awardees are under contract, NREL will evaluate what, if any, technical support can be provided. Each Offeror was asked to include requests for technical support in the proposal. Details will be negotiated after contracts are executed and there is more certainty about the remaining budget.

Upcoming milestones/deliverables: Pika Energy to complete final report; BWC to submit next QR; NREL to execute new subcontracts and determine technical support for awardees; conference presentations made if abstract is accepted.

Next Steps and Future Research

Proposed Future Research:

It is anticipated that a third solicitation will be released in FY15 should funding become available.

Research needs are expected to be revealed throughout this project, which will allow for small and midsize R&D needs to be identified and prioritized.

Examples are:

- Blade fatigue testing
- Tower dynamics modeling
- Power electronics reliability.