Distributed Wind 2017

Thank you to our sponsors!

Capitol Hill Sponsors

Bergey WindPower

United Wind

Gold Sponsors

Intertek
Valued Quality. Delivered.

Northern Power Systems

Enwind International Corp.

Silver Sponsors

Ambor Structures

eocycle

EWT Direct Drive Wind Turbines

Nixon Peabody

xzeres

Distributed Wind 2017

Keynote Address
Julia Hamm
President & CEO of the Smart Electric Power Alliance (SEPA)

Sustainable Markets for Distributed Energy Resources

Julia Hamm

President & CEO

Smart Electric Power Alliance

About SEPA

SEPA's mission is to facilitate the utility industry's smart transition to a clean energy future through education, research, and collaboration.

COMMUNITY

Members, Events, USC, Fact Finding Missions, Partnership Opportunities, Power Player Awards

DATA

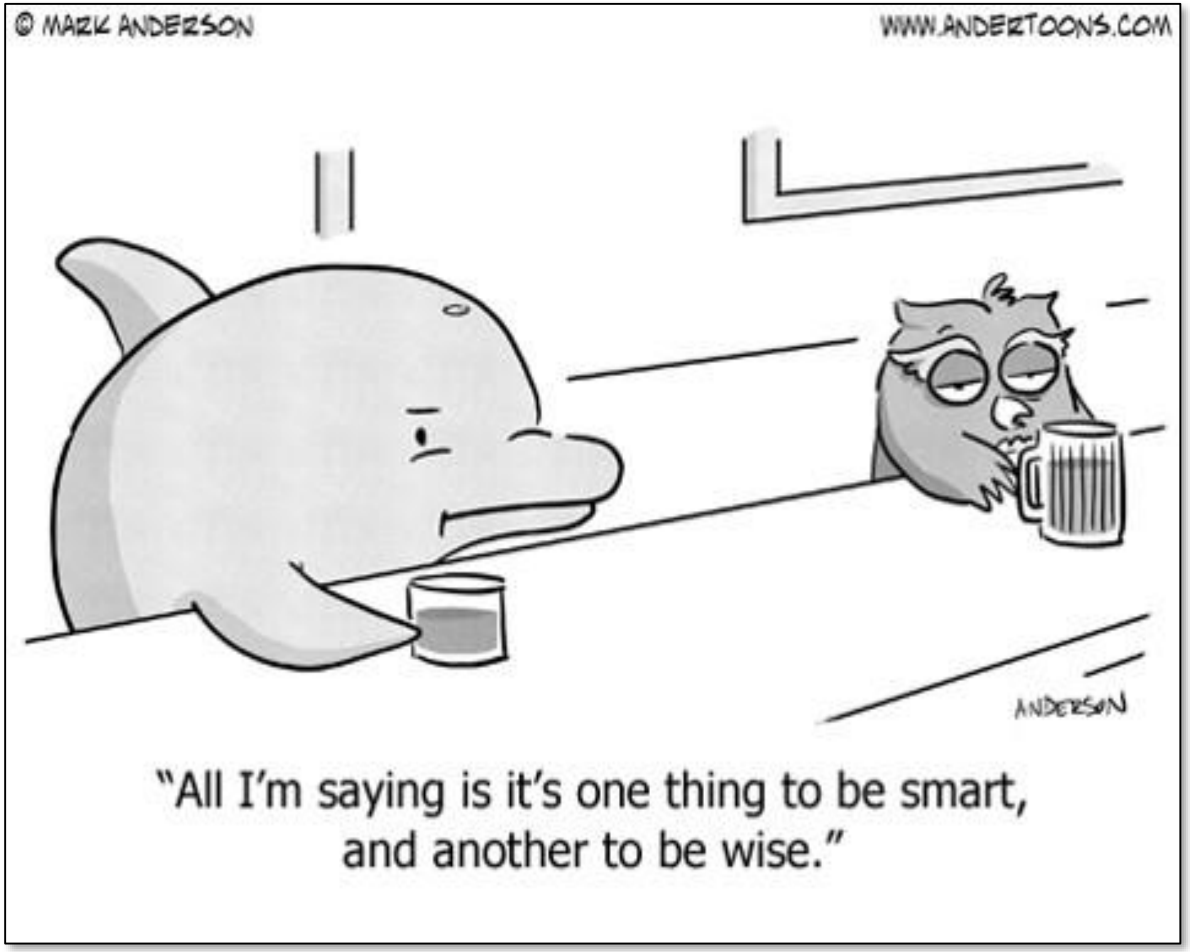
USD, Solar Calculators, Mapping Tools, Research Reports, Project and RFP News, Custom Research Solutions

INSIGHTS

Advisory Services, Webinars, Workshops, Case Studies, SEPA Publications, Blog, Expert Commentary

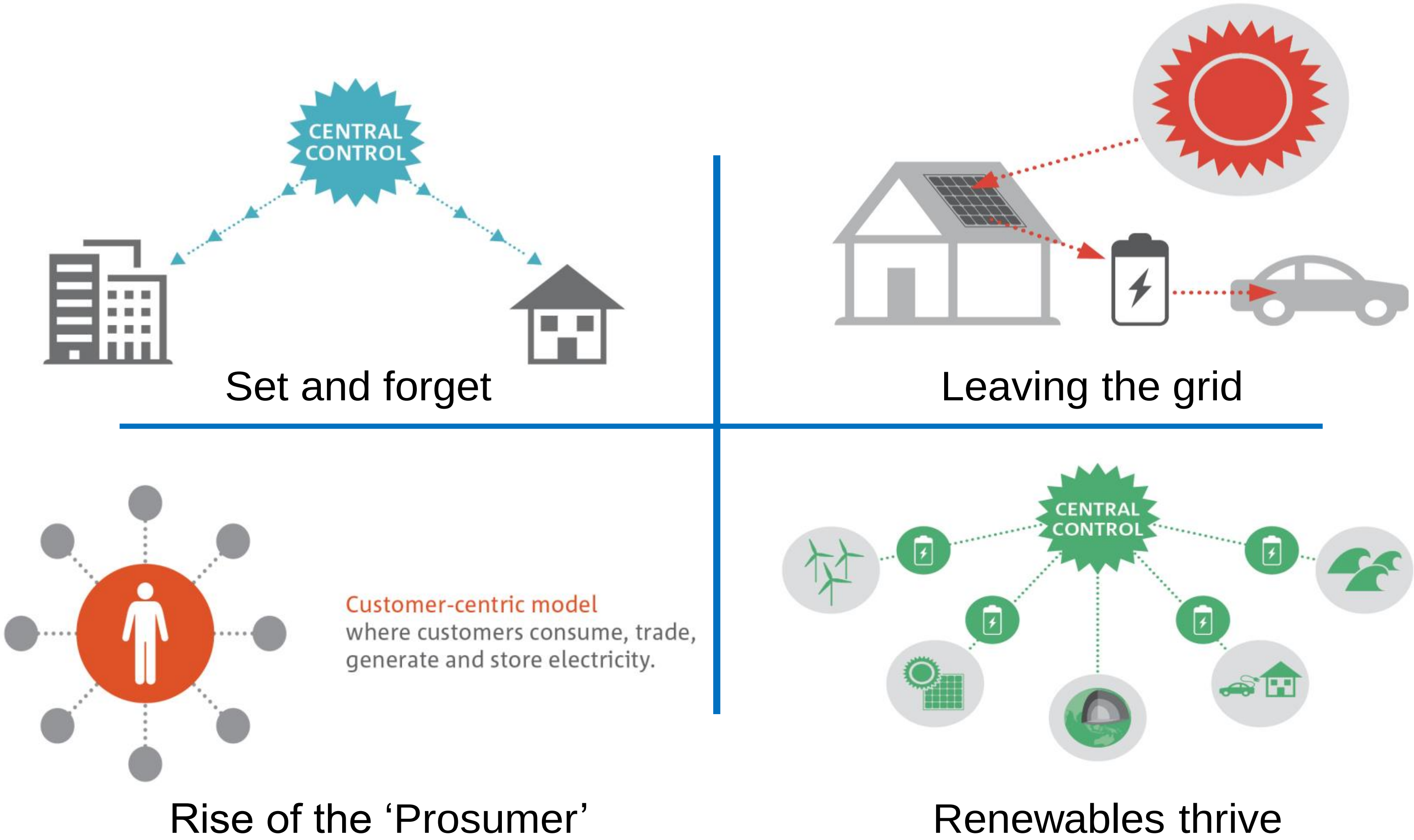
Figuring this all out…

Smart Electric Power Alliance



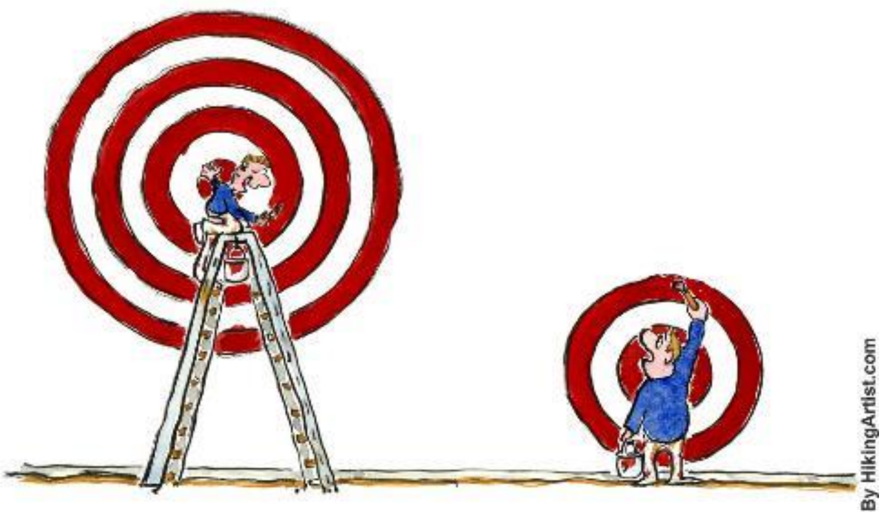
Multiple Potential Future Scenarios

Smart Electric Power Alliance



Source: Energy Networks Australia & CSIRO

Competing & Complex Policy Goals



- **Political Dynamics**
  Cost, Choice, Environment, Jobs
- **Base Expectations**
  Safety, Reliability, Affordability
- **Existing Statute & Regulations**
  State & Federal Compliance
- **Economic Development**
  Rates, X-subsidies, Jobs
- **Definitions of "Fairness"**
  Inherent Conflicts
- **The "Regulatory Compact"**
  How to and to Whom to Apply It?

Smart Electric Power Alliance

Utilities' Practical Considerations

Policy & Regulatory Uncertainty
(Environmental, Markets, Rates)

Cost Dynamics
(Fuel, Capital)

Demand Growth
(Organic Growth, DER, EE, New Sources of Load)

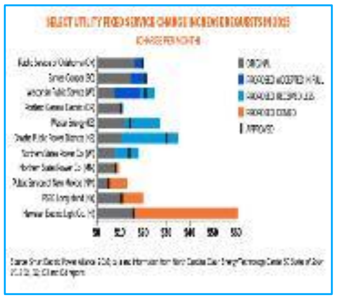
Technology Advances
(Generation, DER, Hardware, Software, Data Analytics)

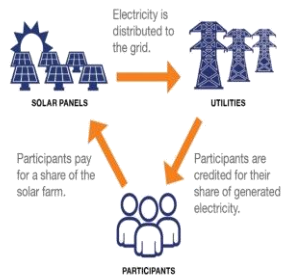
Customer Expectations
(Control, Options, Cost)

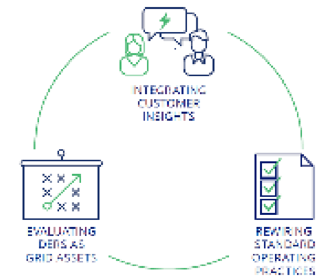
Reliability & Resiliency
(Threats, Resource Adequacy, System Coordination)

Grid-Centric Solutions

Smart Electric Power Alliance







Rate Reform

- Volumetric vs Fixed/Demand
- Time-Varying
- Market-Based / Transactive

New Customer Offerings

- Community Solar
- Rooftop Solar & Storage
- Holistic DER Solutions

Grid Modernization

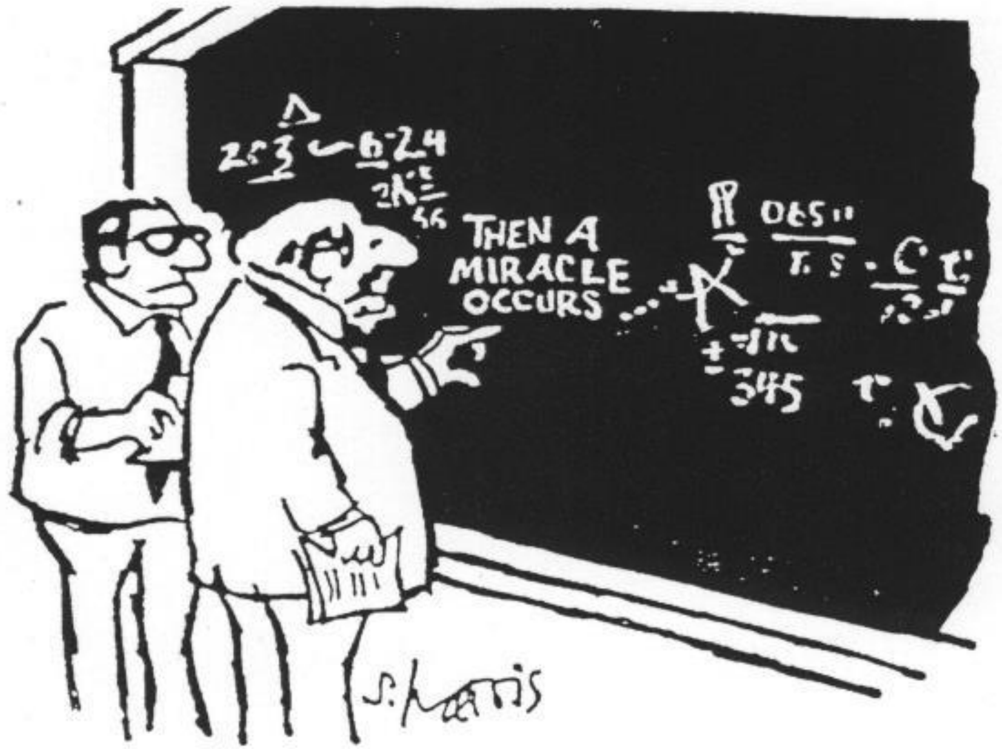
- Communications Networks
- Advanced Metering
- Data & Analytics

DER Integration

- Grid Services
- Resource Planning
- Program Design

Putting it Together

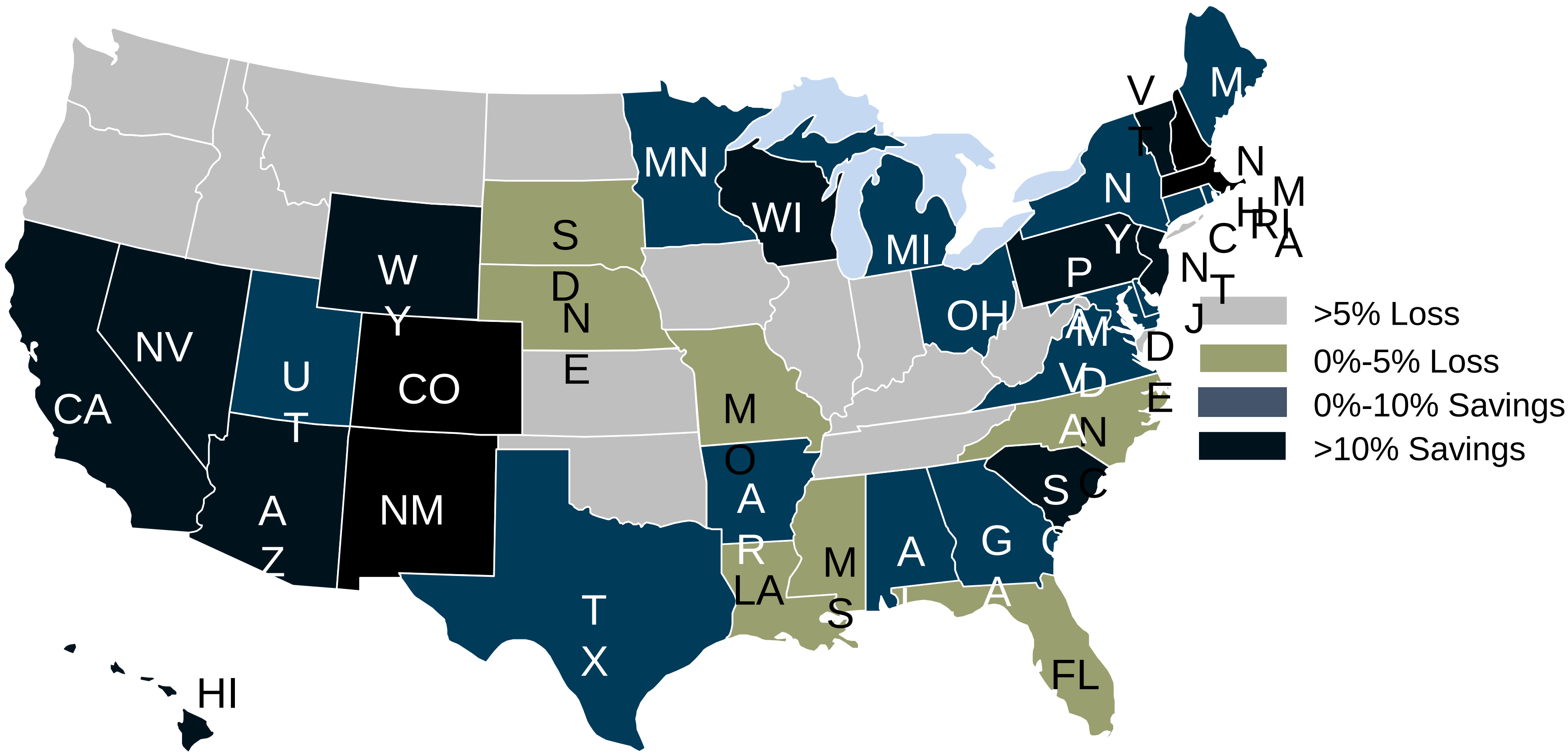
Smart Electric Power Alliance



I think you should be a little more specific, here in Step 2

Smart Electric Power Alliance

Rooftop PV as an Illustrative Example



Source: GTM Research

The Wrong Way to Simplify

Smart Electric Power Alliance

The Wrong Way to Simplify

Smart Electric Power Alliance

Grid (i.e. Utility) Perspective:

System = Value
DGPV = Cost

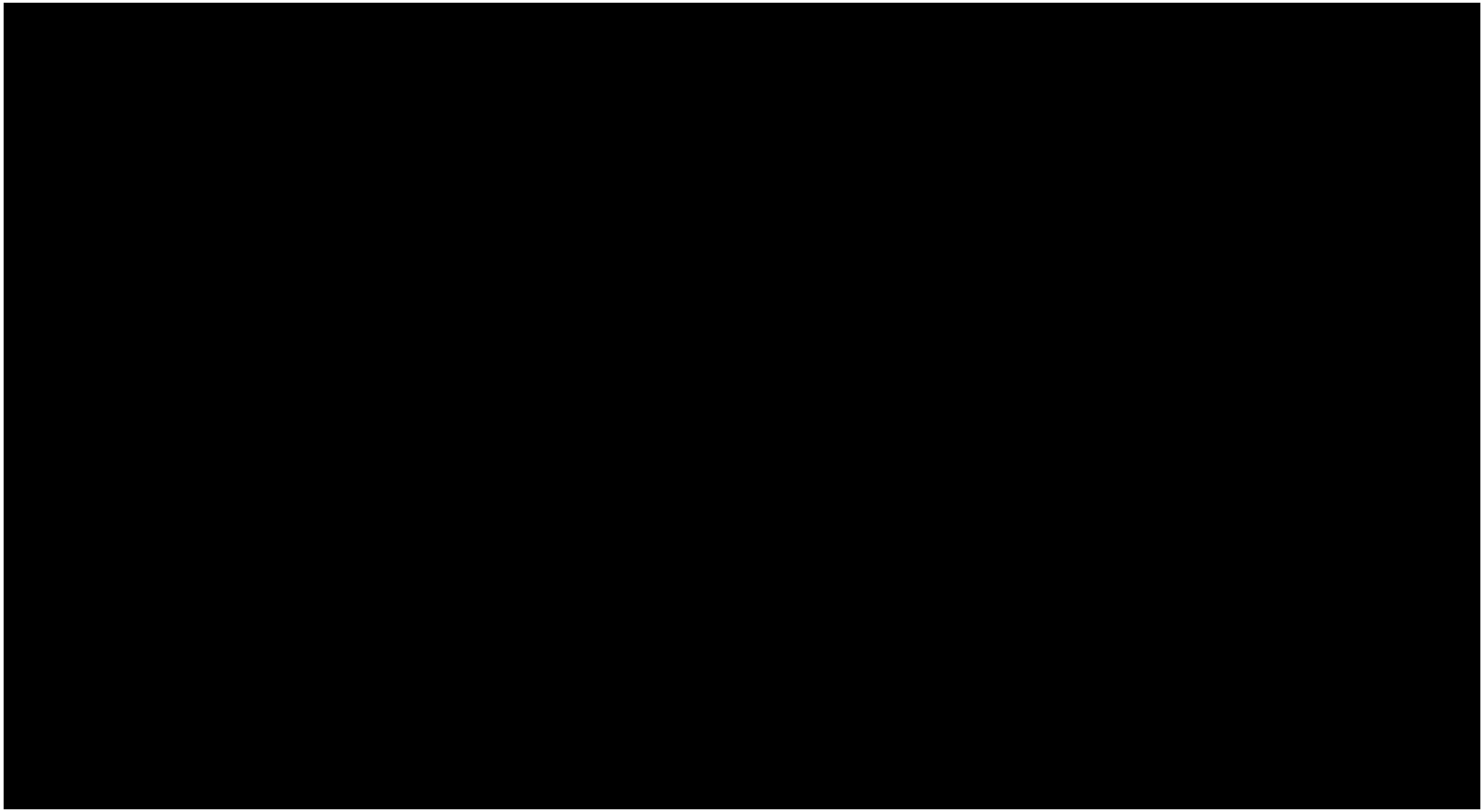
Measured Expectation of Change

Consumer (or 3rd Party) Perspective:

System = Cost
DGPV = Value

Rapid Expectation for Change

When It Gets Ugly



SEPA's Alternative Approach

Smart Electric Power Alliance

THE 51ST STATE

Smart Electric Power Alliance

51st State Community

THE 51ST STATE

- "SEPA has really taken the reigns on an evolving conversation about evolving the power grid."

  \- 51st State Summit Participant 2016

- "51st State is my favorite industry initiative"

  \- Regulatory Support Executive

Bruce Nordma

The future belongs to those who prepare for it today.

--Malcolm X

Thank you

Julia Hamm
President and CEO
jhamm@sepapower.org
202-559-2025

Distributed Wind 2017

Leaders Panel: State of the Industry

Moderator

Larry Flowers, G4 Wind

Speakers

Mike Bergey, Bergey Windpower

Ciel Caldwell, Northern Power Systems

Mark Jones, EWT

Jason Kaplan, United Wind

Kevin Schulte, SunCommon NY

Federal Agency Opportunities & Updates

Moderator
Chris Diaz, Seminole Financial Services

Speakers
Patrick Gilman, U.S. Department of Energy, Wind Energy Technology Office
Doug MacCourt, U.S. Department of Energy, Office of Indian Energy
Blake Marshall, U.S. Department of Energy, Advanced Manufacturing Office
Aaron Morris, USDA Rural Business-Cooperative Service

Distributed Wind 2017

Federal Agency Opportunities & Updates

Patrick Gilman
U.S. Department of Energy,
Wind Energy Technology Office

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

Distributed Wind Engagement Opportunities

Patrick Gilman
Distributed Wind Team Lead

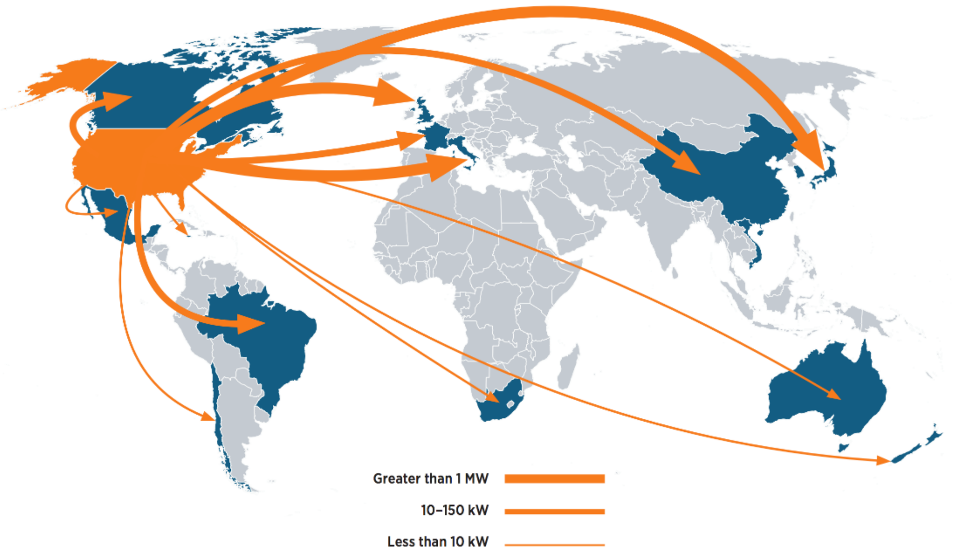
February 28, 2017

Why Distributed Wind (DW) Matters

Major Untapped Market Potential in Rural America

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

Used to provide power to remote "off-grid" communities and to offset all or a portion of energy costs for retail power customers.



US Small Wind Exports, 2015

Significant Market Potential

Technically feasible for approximately 49.5 million residential, commercial, and industrial sites nationwide.

Market potential on nearly 4 GW by 2030 and 20 GW by 2050.

Presently over 75,000 wind turbines, totaling 934 MW in cumulative capacity, deployed across all 50 states.

Made in America

U.S. small wind (≤ 100kW) turbine manufacturers report domestic content levels ranging from 66% to 100%

U.S. distributed wind businesses support jobs in 23 states

U.S. small wind turbine manufacturers accounted for nearly **100%** of domestic sales in 2015

Global Leadership

U.S. manufacturers accounted for nearly 75% of 2015 global small wind turbine sales.

U.S. small wind manufacturers doubled exports to international markets from 2014 to 2015.

Since 2011 exports have accounted for more than half of U.S. small wind manufacturers sales

DOE Programmatic Focus Areas

Challenges, goals, and approaches

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

Focus Area	Challenges	Goals	Approaches
Market Assessment and Analysis	**Consistent access to trustworthy data to inform future investment decisions. Inability to confidently quantify U.S. Distributed Wind market potential.**	Report annually on distributed market trends and confidently quantify market growth potential.	• **Collect, store and analyze market data** • **Diffusion model development and scenario analysis.**
Soft Costs	**Non-hardware or "soft" costs are not document for distributed wind systems and cost reduction opportunities are not well understood.**	Establish a baseline for distributed wind soft costs and identify cost reduction opportunities.	• **Establish DW Cost taxonomy** • **Interview installers to collect detailed project cost data.**
Wind Resource and Performance Assessment	**Utility-scale site assessment, specifically resource assessment, is too costly and time consuming for distributed wind project development leading performance assessments that are not bankable.**	Facilitate business models that access low cost capital by accurately predicting distributed wind system performance.	• **Convene industry experts to document state of the art** • **Reduce performance assessment error.**
Turbine Technology	**Small and medium wind turbine technology is not optimized distributed applications, outdated, and struggles to be cost competitive with other distributed generation technologies.**	Develop and certify low wind speed optimized, lower cost small and medium wind turbine designs.	• **Support design optimization** • **Facilitate utilization of advanced manufacturing.**
Consumer Confidence	**Adoption of distributed wind systems has been hindered by untested technologies, unverified claims about turbine performance, and equipment failures.**	Increase confidence in and appeal of distributed wind system to consumers beyond "early adopters".	• **Support turbine certification testing** • **Educate stakeholders.**

Competitiveness Improvement Program

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

Increased Energy Production

CIP *system optimization* awardee Northern Power Systems of Barre, Vermont, achieved a 15% energy production increase for the NPS-100 100-kilowatt turbine by increasing blade length and improving blade aerodynamics.

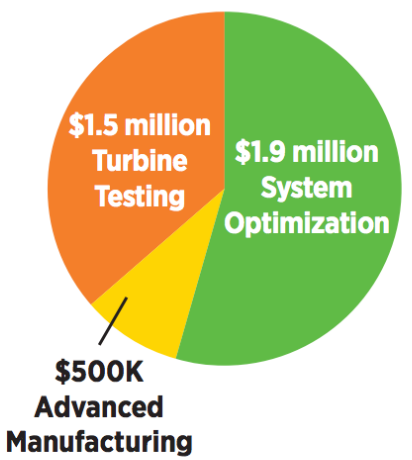
Reduced Hardware Costs

CIP *advanced manufacturing* awardee Pika Energy of Westbrook, Maine, reduced blade costs by approximately 90% by developing an innovative tooling and cooling strategy to produce blades using injection-molded plastic.

Certified Turbine Performance & Safety

Four CIP *turbine certification* awardees are testing their turbine designs to national standards. Turbine certification requires third-party verified testing for safety, function, performance, and durability to national standards.

As of May 2016, DOE and NREL awarded 16 subcontracts to nine manufacturers, totaling $3.9 million of investment across three topic areas



Endurance Windpower (Seattle, WA)

Northern Power Systems (Barre, VT)

Bergey Windpower (Norman, OK)

Pika Energy (Westbrook, ME)

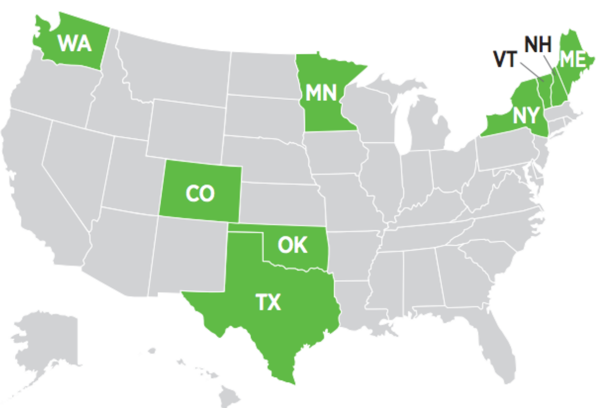
Primus Windpower (Lakewood, CO)

Ventera Wind (Duluth, MN)

Urban Green Energy (NYC)

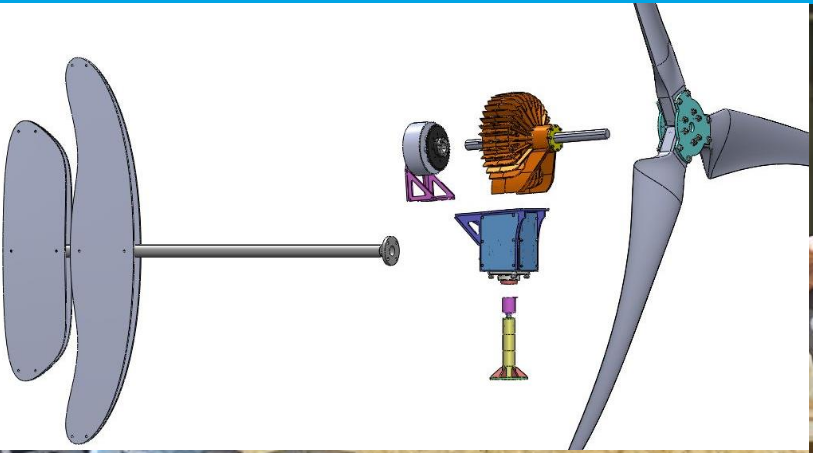
Intergrid (Temple, NH)

Wetzel Engineering (Round Rock, TX)



Courtesy of NREL

Competitiveness Improvement Program
Round 5 launching this year!





CIP Round 5 to be issued by April 30

- Notice of Intent issued by NREL on 1/24/2017
- CIP forum held 2/27/2017

Pending feedback from CIP forum, topics likely to include at least Advanced Manufacturing, System Optimization, and Turbine Testing

Engagement with and tools to support Installers

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

NREL to establish new DW Installers Collaborative to:

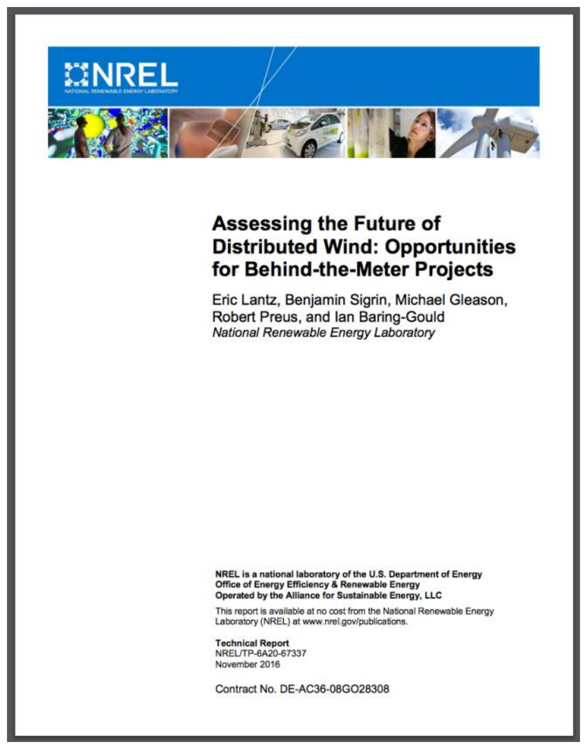
- **Reduce soft costs and address zoning, permitting and interconnection challenges**
- **Improve site and resource assessment**
- **Identify pathways to new markets**

First meeting to be held at Small Wind Installers Conference, contact suzanne.tegen@nrel.com for details

DW Market & Cost Benchmarking

- Publicly available, anonymized cost and performance data necessary to raise awareness of the sector and support future investment decisions

We need your help (and your data)!



NREL

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

Planned 2017 Publications

- Distributed Wind Market Report
- Distributed Wind Costs Taxonomy
- Distributed Wind Costs Benchmark & Cost Reduction Opportunities

Other Potential Opportunities

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

WINDExchange and Regional Resource Centers:
- Provide direct technical support and information across the country on zoning and permitting issues (http://apps2.eere.energy.gov/wind/windexchange/regional.asp).
- Developed a permitting and zoning toolkit (http://nwwindcenter.org/content/permitting-zoning-resources)
- Wind Energy Ordinance database which includes 430 ordinances from across the country (http://apps2.eere.energy.gov/wind/windexchange/policy/ordinances.asp)
- Small wind Guidebook Wiki (http://en.openei.org/wiki/Small_Wind_Guidebook)

Collegiate Wind Competition:
- Teams from universities around the country design and build a small wind turbine to address an off grid energy need. DW industry can engage with teams throughout the competition as team funders, mentors, and educators. (https://energy.gov/eere/collegiatewindcompetition)

Wind for Schools:
- Active educational programs at 12 universities, working to install small turbines at host schools. DW industry can engage state programs to provide technical support, hardware, and education opportunities. (http://apps2.eere.energy.gov/wind/windexchange/schools_wfs_project.asp)

Small Business Vouchers Program:
- Provides laboratory based technical assistance across a wide array of potential issues. (https://www.sbv.org/)

How can we help?

Distributed Wind 2017

Federal Agency Opportunities & Updates

Doug MacCourt
U.S. Department of Energy, Office of Indian Energy

DOE OFFICE OF INDIAN ENERGY

Distributed Generation in Indian Country

February 28, 2017

Douglas C. MacCourt, Senior Policy Advisor

U.S. DEPARTMENT OF ENERGY | Office of Indian Energy

Reality of 567 Federally Recognized Tribes

Staggering gaps between Indian Country and the rest of the U.S.

American Indian and Alaska Native households in large tribal areas are more than **3 times as likely to live in overcrowded housing** and more than **11 times as likely to live in housing without adequate plumbing**

Poverty and unemployment rates among American Indian and Alaska Natives living in tribal areas in 2006–2010 were at least **twice as high** as those among non-Indians nationally

Ready access to electricity is still considered a luxury in many tribal communities … as many as **15,000 Navajo homes — about 30% — still lack electricity**

More than **175 remote Alaska village populations** rely almost exclusively on diesel fuel for electricity generation and heating oil for heat. In some rural Alaska communities, electricity costs exceed **$1.00/kilowatt-hour** (kWh) — more than **8 times the national average of $0.12/kWh**

Office of Indian Energy Policy & Programs

Our Mission

To maximize the development and deployment of energy solutions for the benefit of American Indians and Alaska Natives

Our Vision

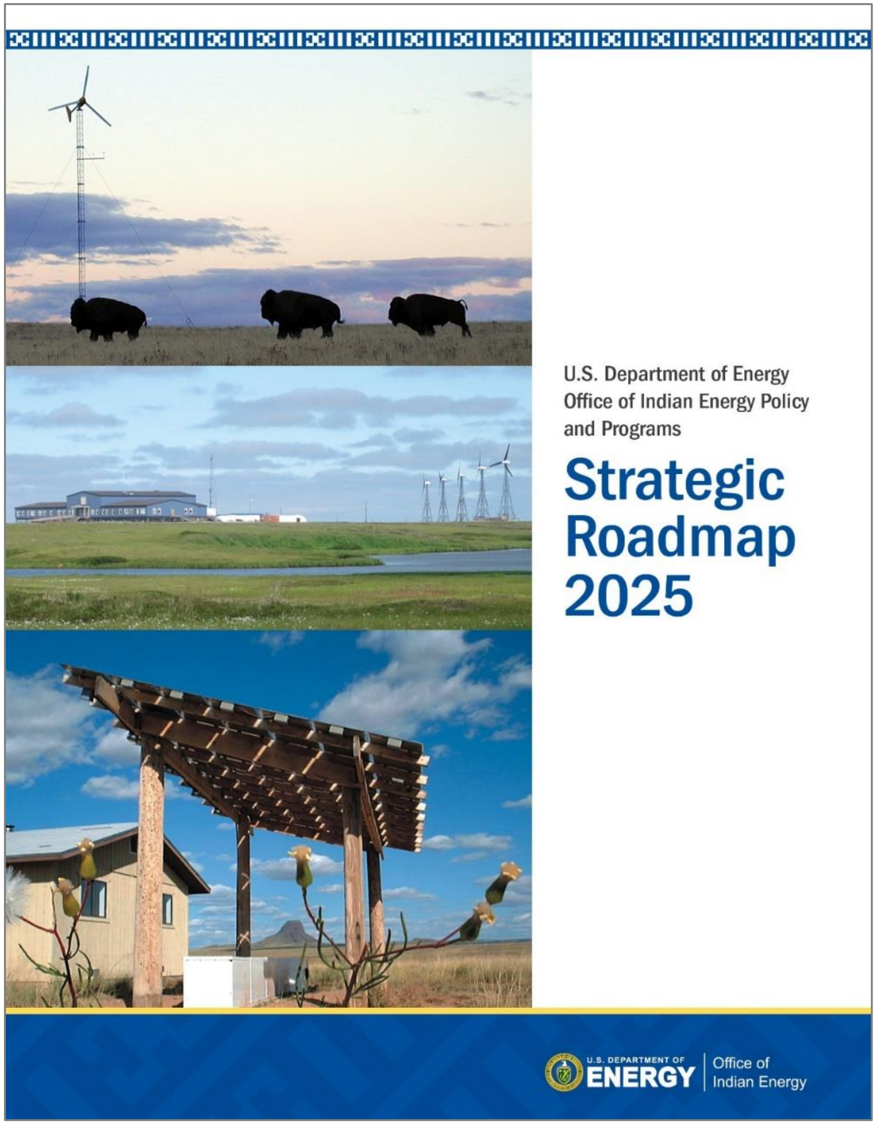
To be the premier federal office for providing tribal communities and Alaska Native villages with the knowledge, skills and resources needed to implement successful strategic energy solutions

Energy Policy Act Of 2005

Authorizes and directs DOE's Office of Indian Energy to provide, direct, foster, coordinate, and implement energy planning, education, management, and conservation, including:

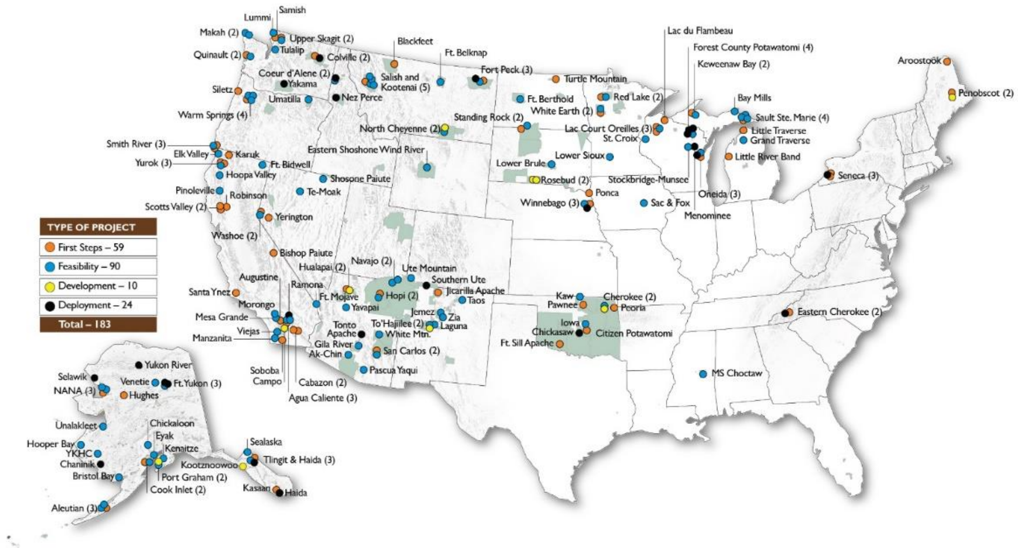
- Promote Indian tribal energy development, efficiency, and use
- Reduce or stabilize energy costs
- Enhance and strengthen Indian tribal energy and economic infrastructure relating to natural resource development and electrification
- Bring electrical power and service to Indian land and the homes of tribal members.

Rosebud Sioux's (SD) Little Soldier Turbine (First 750-kW turbine on tribal lands in contiguous United States)



1. Promote Energy Development
2. Reduce or Stabilize Energy Costs
3. Enhance Energy and Economic Infrastructure
4. Foster Electrification
5. Support Energy Initiatives

DOE's Investment in Tribal Energy Projects



DOE has invested **$66.5 million** in **217** tribal clean energy projects valued at **more than $126 million** (2002–2016). DOE's investments were leveraged by **$59.7 million** in tribal cost-share. Tangible results of those shared investments include:

- Retrofitting **70 tribal buildings** saving tribes more than **10 million kilowatt-hours** of energy and **$2.5 million** per year
- Completing energy audits on more than **250** tribal buildings
- Moving more than **580 MW** of potential new renewable energy generation into development
- Supporting tribes and Alaska Native villages in assessing the potential for more than **4 gigawatts** of new renewable energy generation
- Providing training to more than **170** tribal project participants

Indian Country Energy and Infrastructure Working Group (ICEIWG)

MEMBERS

Association of Village Council Presidents
- Brent Latham, Director, AVCP Economic and Energy Department
- Myron Naneng, Sr., President

Blue Lake Rancheria
- Jana Ganion, Energy Director
- Jason Ramos, Gaming Commission Chairman
- Arla Ramsey, Vice Chairperson

Cherokee Nation
- Bill John Baker, Principal Chief
- Sara Hill, Secretary of Natural Resources
- Kim Teehee, Director of Government Relations

Confederated Tribes of the Warm Springs Reservation of Oregon
- Delvis Heath, Sr., Chief
- Jim Manion, General Manager, Warm Springs Power

Ewiiaapaayp Band of Kumeyaay Indians
- William Micklin, CEO

Gila River Indian Community
- Robert Stone, Councilman

Ho-Chunk Nation
- David Greendeer, Representative

Mandan, Hidatsa & Arikara (MHA) Nation
- Mark Fox, Chairman

Mississippi Band of Choctaw Indians
- John Hendrix, Director of Economic Development

Osage Nation
- Jill S. Jones, Board Chair, Osage Nation Energy Services, LLC
- Geoffrey Standing Bear, Principal Chief

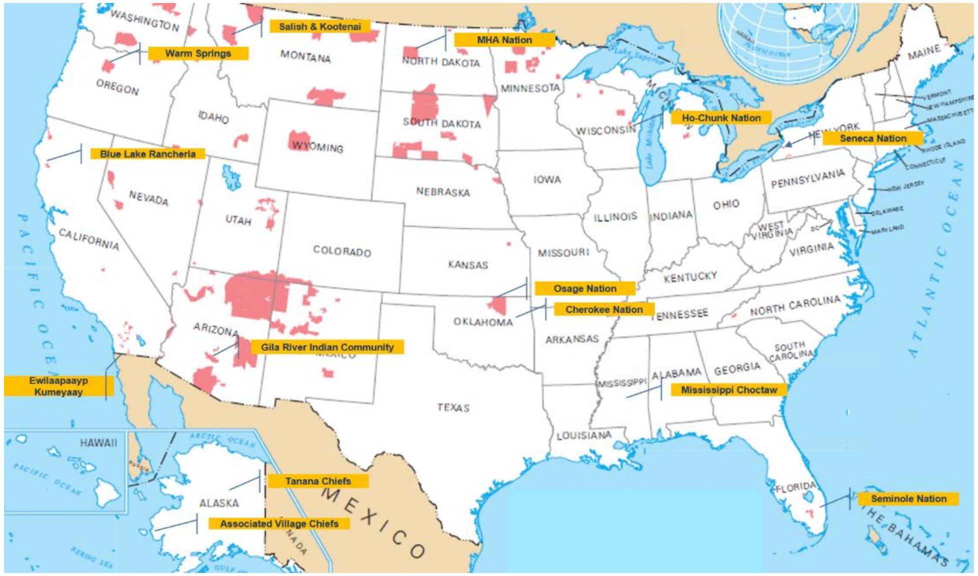
Seminole Tribe of Florida
- Joe Frank, Big Cypress Board Representative, STOF, Inc.
- Steve Osceola, Hollywood Board Representative, STOF, Inc.

Seneca Nation of Indians
- Anthony J. Giacobbe, General Manager, Seneca Energy, LLC
- Michael Kimelberg, Chief Operating Officer

Tanana Chiefs Conference
- Will Mayo, Executive Director of Tribal Services

The Confederated Salish and Kootenai Tribes of the Flathead Nation
- Vernon Finley, Tribal Council Chairman
- Brian Lipscomb, Chief Executive Officer, Energy Keepers, Inc.

U.S. Department of Energy
- Christopher Deschene, Director of Indian Energy Policy and Programs



FY 2016 ICEIWG Priorities

1. Increase Access to Capital
2. Secure Energy Costs and Reliability
3. Improve and Modernize Regulatory System and Agency Nexus
4. Capacity Development

National Tribal Energy Summit

- The bi-annual summit focuses on energy policy priorities important to American Indian tribes and brings together representatives from tribal and state governments, federal agencies, tribal corporations, private industry, utilities, and academia to explore energy development and security issues identified by tribes and the U.S. Department of Energy's (DOE's) **Indian Country Energy and Infrastructure Working Group.**

- **The next Summit is scheduled for May 1-3 2017, Washington, D.C.**

Electrification in Indian Country

- American Indian reservations are known to have much lower levels of electrification than the non-reservation U.S. population, but recent data on electrification is difficult to obtain.
- In 2000, the U.S. Energy Information Administration found that on the nation's largest reservation, the Navajo, 37% of Indian households were without electricity.
- The same study found that one in seven Indian households living on reservations was without electricity service. In 2010, 1.1 million American Indian or Alaska Native people lived on reservations and Alaska Native Village Areas. If the electrification rates found by EIA in 2000 are still applicable, that implies an additional 160,000 people without electricity. U.S. Energy Information Administration. Energy Consumption and Renewable Energy Development Potential on Indian Lands. SR/CNEAF/2000-01. April 2000. Table ES-3.

References for Indian Country Electrification

- U.S. Energy Information Administration. Energy Consumption and Renewable Energy Development Potential on Indian Lands. SR/CNEAF/2000-01. April 2000. Page 3.
- U.S. Census Bureau. *The American Indian and Alaska Native Population: 2010*. C2010BR-10. January 2012. http://www.census.gov/prod/cen2010/briefs/c2010br-10.pdf. Accessed 12 July 2016.

Quadrennial Energy Review (QER) 1.2

- Chapter VII: A 21st Century Electricity System: Conclusions and Recommendations
  - Ensure Electricity Access for Low-Income and Under-Served Americans
    - Increase Electricity Access and Improve Electricity-Related Economic Development for Tribal Lands
- www.energy.gov/QER

Alaska/Arctic Indian Energy Highlights

Chaninik Wind Group – Lower Kuskokwin Delta, AK

- This project enhances a community high-penetration wind-diesel construction project by adding a Renewable Energy Network Controller, thermal stoves and meters. The overall system consists of:
  – An integrated renewable energy network, or "Smart Grid" Controller
  – A Web-server based Smart Meter Management and Accounting System
  – Self-regulating controller for Electric Thermal Storage (ETS) devices that will enable ETS devices to autonomously absorb excess wind energy and stabilize the local power grid
  – Smart electrical metering systems in 500 homes
  – Installation of electric thermal energy storage units in 90 homes to capture excess wind energy as heat.

Goals of Chaninik Wind Project

- Reduce the consumption of fossil fuel by 40% in four Lower Kuskokwim Alaska villages and use wind energy to displace 200,000 gallons of diesel fuel, 70,000 of which is now being used to generate power, and 130,000 of which will be captured and stored for use as heat.
- The project will benefit the tribal communities with fuel savings, increased revenues to each local utility, and reduced heating cost, as well as enable utilities and customers to control costs. Culturally and socially, the project will create jobs and increase local employment

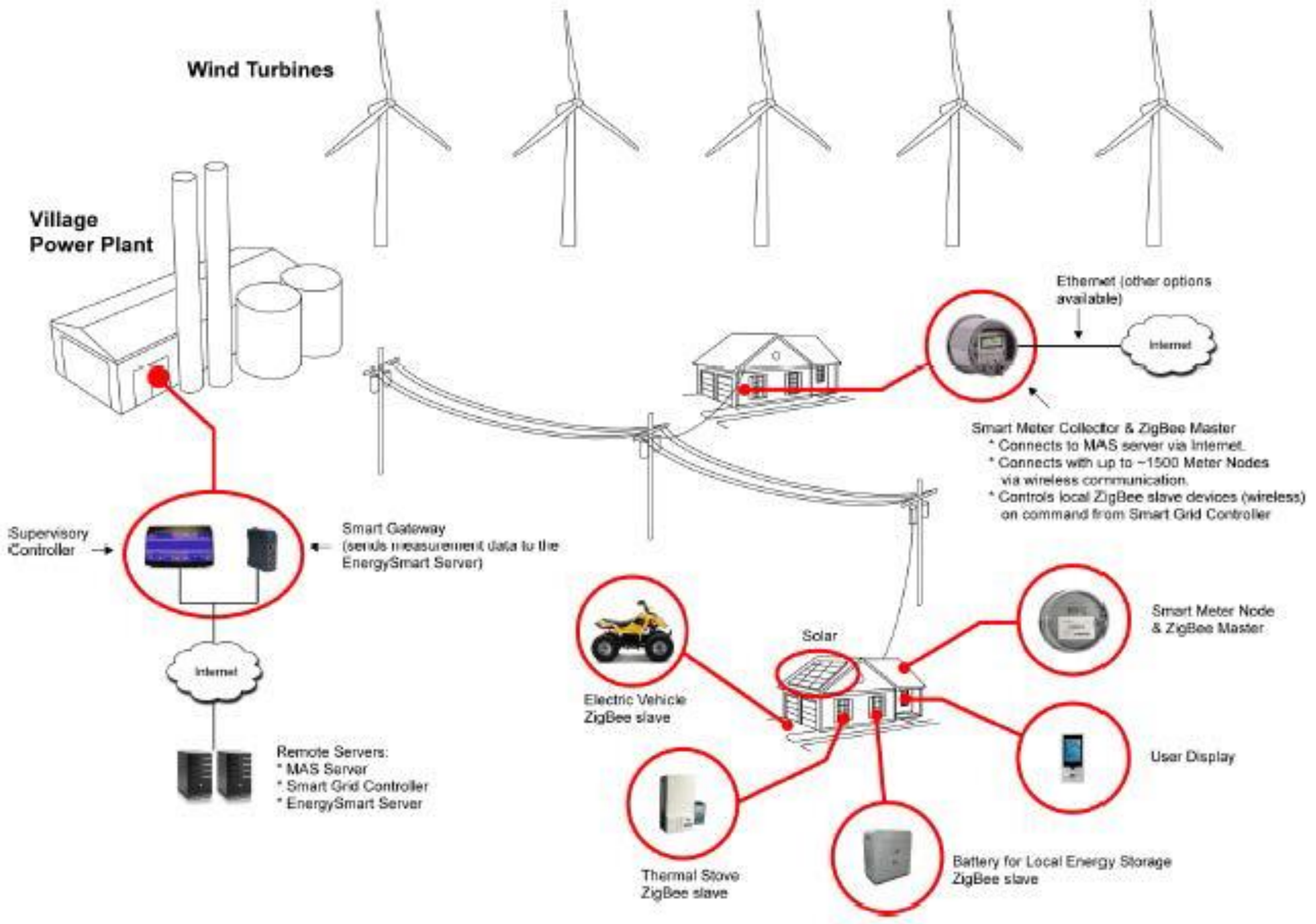
Chaninik Wind Group - System Components

- Five 90 kW Windmatic S-17 wind turbines
- Wind-diesel control integration upgrades
- Heat recovery boiler for community heating
- ETS devices in 21–30 homes
- A smart metering system

Final project report available online at:

https://energy.gov/sites/prod/files/2015/12/f27/chaninik_final_report_ee00002497_july_2013.pdf

Chaninik Wind Group – System Components



Kumeyaay Wind – San Diego County, CA

Thank You!

Douglas MacCourt
Senior Policy Advisor
Office of Indian Energy Policy & Programs
Department of Energy
(202) 586-7866
(301) 820-2749 (cell)
Email: douglas.maccourt@hq.doe.gov

Website: www.energy.gov/indianenergy

Distributed Wind 2017

Federal Agency Opportunities & Updates

Blake Marshall
U.S. Department of Energy,
Advanced Manufacturing Office

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

Federal Agency Opportunities & Updates: Advanced Manufacturing Office

February 27, 2017

Blake Marshall

Additive Manufacturing Technology Manager

Advanced Manufacturing Office

www.manufacturing.energy.gov

AMO RD&D Areas

Diagram Showing Connections between the Fourteen Advanced Manufacturing Technology Areas (which coincide with the 2015 QTR Manufacturing Technology Assessment Topics), Energy Systems Influenced by Manufacturing, and Emerging and Crosscutting Areas.

Achieved through public input, open engagement, Public-Private and National Lab Partnerships, and focused execution.

http://energy.gov/quadrennial-technology-review-2015

AMO's R&D Facilities: Public-Private consortia model

CMI Accelerating Energy Innovations

Critical Materials Institute

AN ENERGY INNOVATION HUB

MDF

Manufacturing Demonstration Facility

PowerAmerica

Clean Energy Smart Manufacturing Innovation Institute

RAPID

Manufacturing USA

The Composites iacmi Institute

REMADE Institute

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

Manufacturing Demonstration Facility at ORNL

Core Research and Development

- R&D in materials, systems, and computational applications to develop broad of additive manufacturing

Industry Collaborations

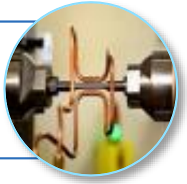
- Cooperative research to develop and demonstrate advanced manufacturing to industry in energy related fields

Education and Training

- Internships, academic collaborations, workshops, training programs, and course curriculum for universities and community colleges.

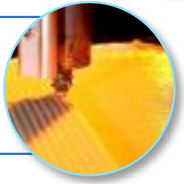
Neutron scattering: SNS and HFIR

- World's most intense pulsed neutron beams
- World's highest flux reactor-based neutron source



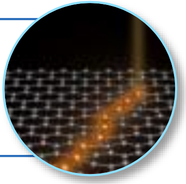
Advanced Materials

- DOE lead lab for basic to applied materials R&D
- Technology transfer: Billion dollar impacts



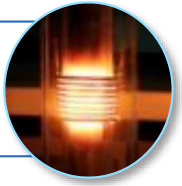
Leadership-class computing: Titan

- Nation's most powerful open science supercomputer



Advanced Manufacturing

- Novel materials
- Advanced processing



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

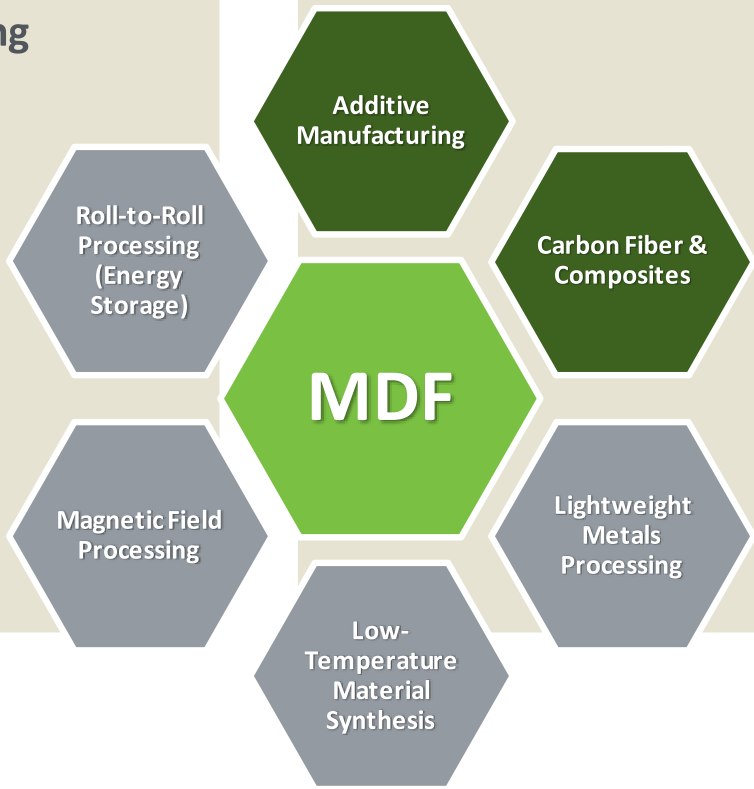
Technology Collaborations at MDF

Explore

- Opportunity for industry to discover and apply new manufacturing technologies

Engage

- Work with MDF staff to develop scope of work



Execute

- Simplified on-line application
- Phase 1 $40K, Phase 2 $200K
- 1:1 Cost Match
- Non-Negotiable CRADA
- ~90-day cycle time from review to a signed agreement

Technology Collaborations at MDF

Materials Suppliers

- Techmer PM Polymer Modifiers
- ATI
- nanocomp Technologies, Inc.
- American Process
- Imerys
- FMC Technologies
- Metal Powder Products (MPP)
- Erasteel
- Stratasys for a 3D World
- PolyOne
- Sandvik
- TLS Technik Spezialpulver
- Carpenter
- sabic
- Cristal
- TIMET
- Chomarat
- Raymor Industries Inc.
- AvCarb
- Continental Structural Plastics
- Alcoa

Equipment Suppliers

- CAD to Metal Arcam AB
- Fabrisonic
- ExOne Digital Part Materialization
- Stratasys for a 3D World
- Cincinnati – Cincinnati Incorporated
- Impossible Objects
- Ajax Tocco Magnethermic
- DM3D
- Quintus Technologies
- POM
- ECM Technologies
- MakerBot
- Grid Logic
- Renishaw
- HotEnd Works
- Solidoodle
- Afinia
- MVP Magnum Venus Products
- Objet
- Cubify
- AO Applied Optimization

End Users

- LM Local Motors
- Cummins
- S-RAM Dynamics
- PPG
- Lockheed Martin
- EPRI Electric Power Research Institute
- Solar Turbines – A Caterpillar Company
- faurecia
- GE
- Hendrickson – The World Rides On Us
- Brayton Energy LLC
- π
- Eaton
- Whirlpool Corporation
- United Technologies Research Center
- Praxair
- Arnold Magnetic Technologies
- Piedmont Propulsion Systems, LLC
- Honeywell
- Aerovalve
- Radio Systems Corporation
- Composite Application Group
- Tru Design
- Planetary Systems Corporation
- Northrop Grumman
- CK Technologies
- Boeing

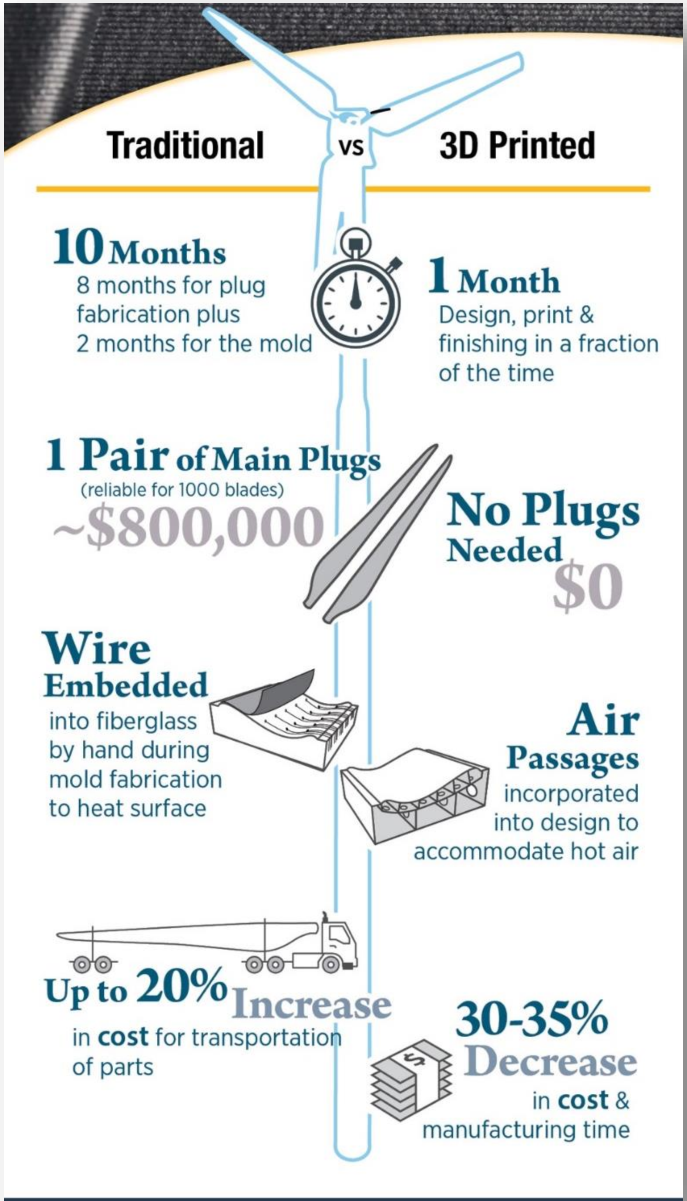
Big Area Additive Manufacturing (BAAM)

- **Obstacle:** Most additive processes are slow (1-4 in^3/hr), use higher cost feedstocks, and have small build chambers.
- **Solution:** ORNL has worked with equipment manufacturers and the supply chain to develop large scale additive processes that are bigger, faster, cheaper, and increase the materials used.

- **Large Scale Printers**
  – Cincinnati System 8’x20’x6’ build volume
- **Fast Deposition Rates**
  – Up to 100 lbs/hr (or 1,000 ci/hr)
- **Cheaper Feedstocks: Pellet-to-Part**
  – Pelletized feed replaces filament with up to 50x reduction in material cost
- **Better Materials**
  – Higher temperature materials
  – Bio-derived materials
  – Composites Hybrids

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

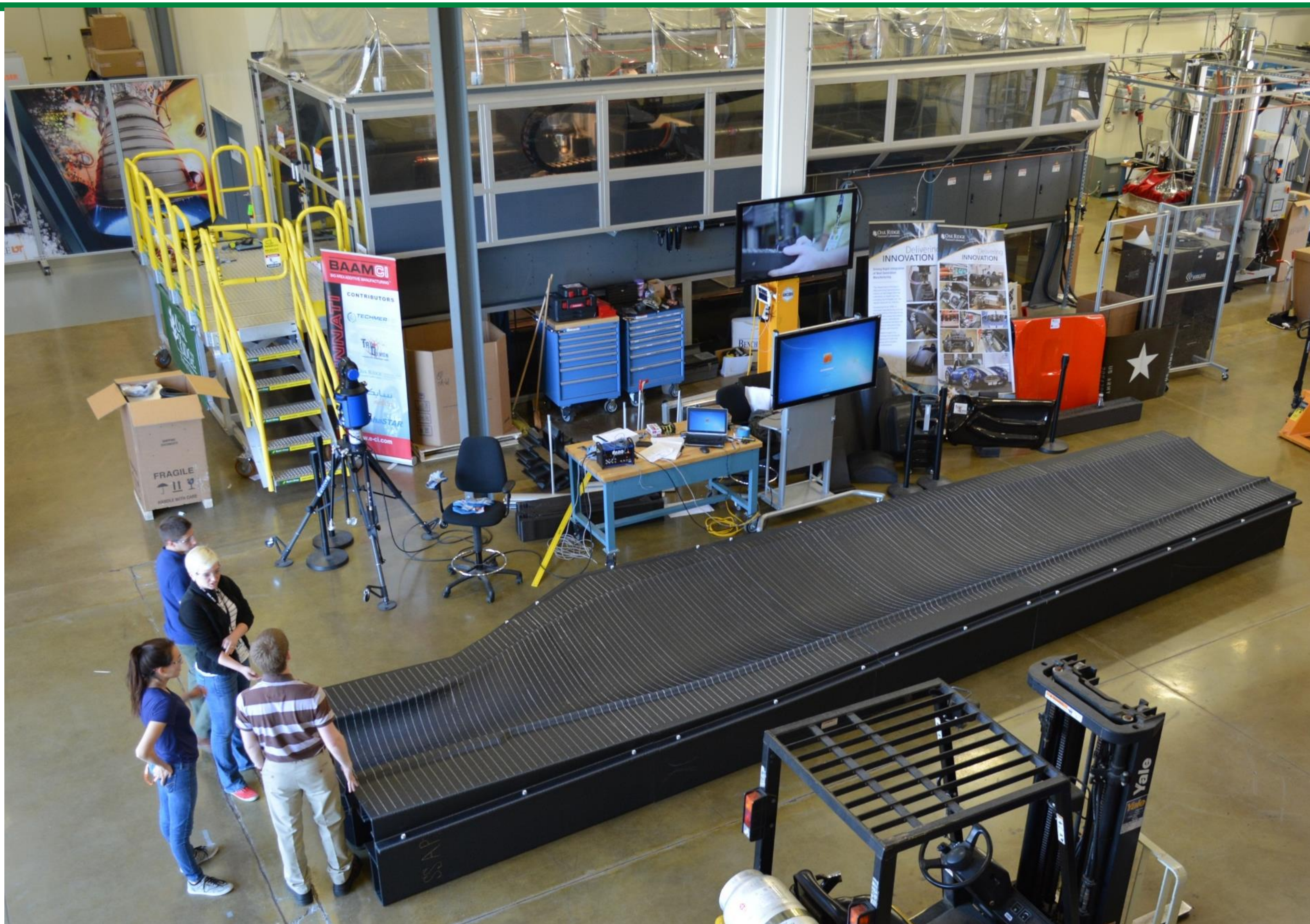
Technical Collaboration project highlight



- **Obstacle:** Although wind energy is among the fastest growing clean energy technologies, there are still critical challenges in achieving our national clean energy goals
- **Solution:** By utilizing large-scale additive manufacturing, ORNL researchers were able to redesign the traditional mold, eliminating unnecessary parts and procedures. Creating unique opportunities in this traditionally time consuming process.

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

Technical Collaboration project highlight



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

Thank you!

Blake Marshall

Blake.marshall@ee.doe.gov

Advanced Manufacturing Office home:
https://energy.gov/eere/amo/advanced-manufacturing-office

Oak Ridge National Laboratory MDF home:
http://web.ornl.gov/sci/manufacturing/mdf/

ORNL MDF Technical Collaborations:
http://web.ornl.gov/sci/manufacturing/industry/

Distributed Wind 2017

Federal Agency Opportunities & Updates

Aaron Morris
USDA Rural Business-Cooperative Service

Distributed Wind 2017

Technical Panel

Moderator
Eileen Prado, ICC-SRCC

Speakers
Paul Dawson, Eocycle
Paul Gipe, wind-works.org
Wes Slaymaker, WES Engineering

Distributed Wind 2017

Technical Panel

Paul Dawson, Eocycle

02.28.2017

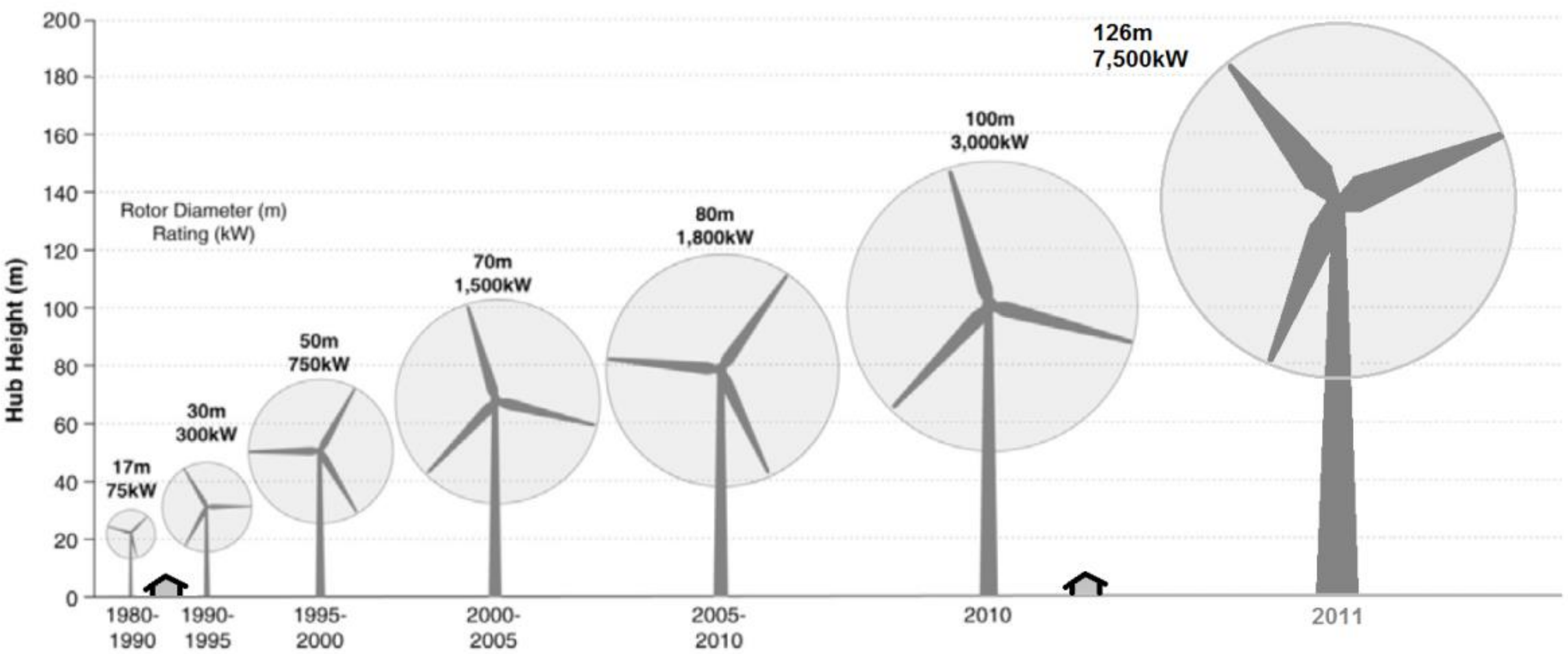
eocycle.com

Is Taller Always Better?

Case study: the economics of tall towers with an EO25 wind turbine

eocycle

Evolution of Tower Height: "Big Wind"

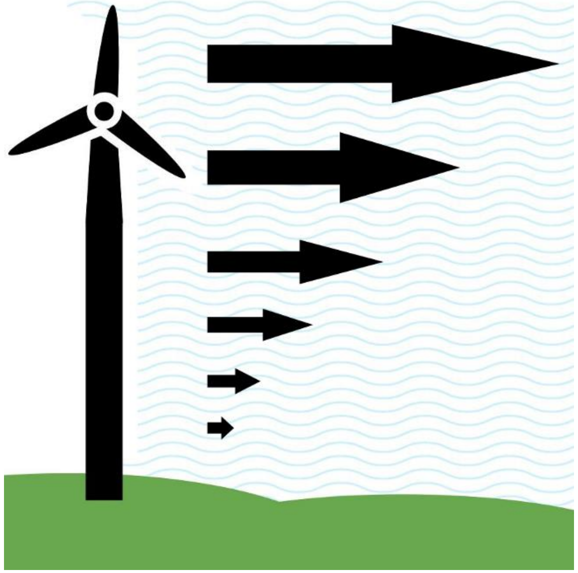


What About Small Wind Turbines?

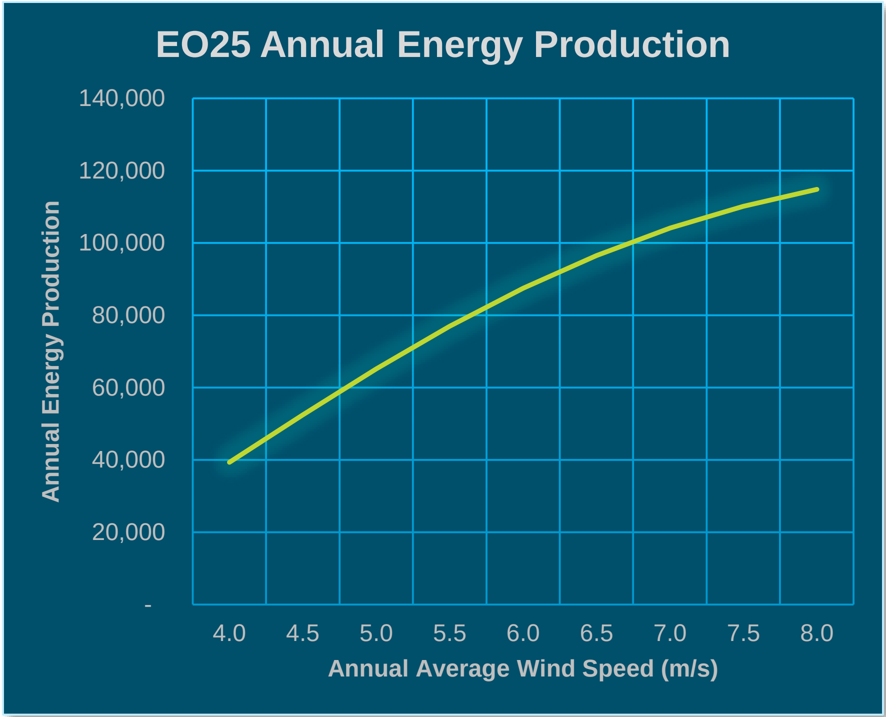
What is Wind Shear?

Wind shear is the change in the magnitude of wind with height.

α	Description of terrain
0.95	Coastal waters of inland sea
0.121	Flat shore of ocean small islands
0.130 – 0.135	Open grasslands without trees
0.143	Open slightly rolling farm land
0.128 – 0.170	Open level agricultural land with isolated trees
0.170	Open fields divided by los stone walls
0.200	Rough coast
0.220	Gently rolling country with bushes and small trees
0.230	Relatively level meadow land with hedges and trees
0.250 – 0.303	Level country uniformly covered with scrub oak and pine
0.357	Wooded and treed farm land



The Fundamental Question



VS

How to Measure The Economics?

Levelized Cost of Energy =

$$\frac{\text{NPV of Lifetime Costs}}{\text{Lifetime kWh}}$$

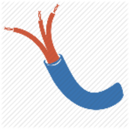
What are the Cost Drivers?

Tower

Labor (installation)

Foundation

Boom truck / lift



Cabling

Crane

What’s Missing in LCOE?

Uncertainty

- Power law
- Wind shear

Cost of unexpected maintenance

- Crane vs tilt-down

Cost Estimates

- General variability of estimates

The Inputs

- Tower: $16,000 - $54,000
- Foundation: $12,000 - $26,000
- Crane: $8,000
- Boom truck: $1,500
- Cabling: $500 - $1,500
- Labor: $1,900 - $3,000

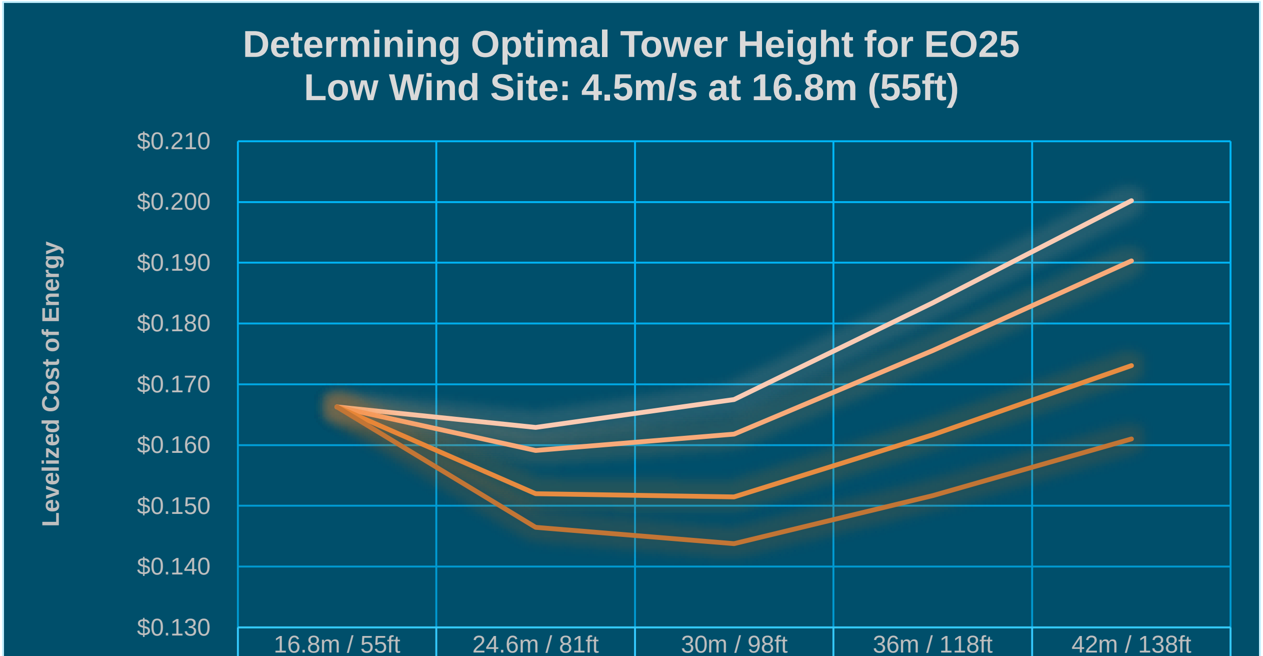
The Results

Low Wind Shear: 0.11					
Annual Average Wind speed	Tower Height				
	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
4.0 m/s (9 mph)	$ 0.221	$ 0.213	$ 0.217	$ 0.236	$ 0.256
4.5 m/s (10.1 mph)	$ 0.166	$ 0.163	$ 0.167	$ 0.183	$ 0.200
5.0 m/s (11.2 mph)	$ 0.135	$ 0.133	$ 0.138	$ 0.152	$ 0.167
5.5 m/s (12.3 mph)	$ 0.114	$ 0.114	$ 0.119	$ 0.132	$ 0.145
6.0 m/s (13.5 mph)	$ 0.100	$ 0.102	$ 0.106	$ 0.119	$ 0.131
6.5 m/s (14.5 mph)	$ 0.091	$ 0.093	$ 0.098	$ 0.109	$ 0.121
7.0 m/s (15.6 mph)	$ 0.084	$ 0.087	$ 0.092		
7.5 m/s (16.8 mph)	$ 0.080				

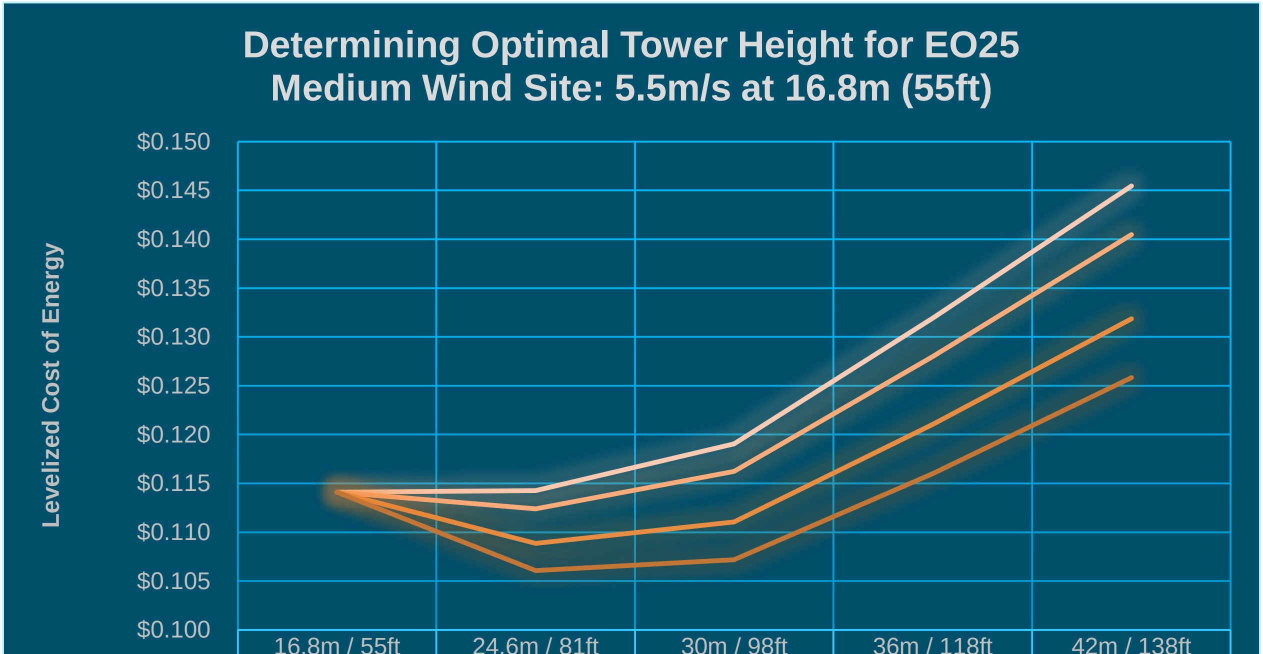
High Wind Shear: 0.20					
Annual Average Wind speed	Tower Height				
	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
4.0 m/s (9 mph)	$ 0.221	$ 0.196	$ 0.192	$ 0.203	$ 0.214
4.5 m/s (10.1 mph)	$ 0.166	$ 0.152	$ 0.151	$ 0.162	$ 0.173
5.0 m/s (11.2 mph)	$ 0.135	$ 0.126	$ 0.127	$ 0.137	$ 0.148
5.5 m/s (12.3 mph)	$ 0.114	$ 0.109	$ 0.111	$ 0.121	$ 0.132
6.0 m/s (13.5 mph)	$ 0.100	$ 0.098	$ 0.101	$ 0.110	$ 0.121
6.5 m/s (14.5 mph)	$ 0.091	$ 0.090	$ 0.093		
7.0 m/s (15.6 mph)	$ 0.084				
7.5 m/s (16.8 mph)	$ 0.080				

Medium Wind Shear: 0.14					
Annual Average Wind speed	Tower Height				
	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
4.0 m/s (9 mph)	$ 0.221	$ 0.207	$ 0.208	$ 0.224	$ 0.241
4.5 m/s (10.1 mph)	$ 0.166	$ 0.159	$ 0.162	$ 0.176	$ 0.190
5.0 m/s (11.2 mph)	$ 0.135	$ 0.131	$ 0.134	$ 0.147	$ 0.160
5.5 m/s (12.3 mph)	$ 0.114	$ 0.112	$ 0.116	$ 0.128	$ 0.140
6.0 m/s (13.5 mph)	$ 0.100	$ 0.100	$ 0.104	$ 0.116	$ 0.128
6.5 m/s (14.5 mph)	$ 0.091	$ 0.092	$ 0.096	$ 0.107	$ 0.119
7.0 m/s (15.6 mph)	$ 0.084	$ 0.086			
7.5 m/s (16.8 mph)	$ 0.080				

Very High Wind Shear: 0.25					
Annual Average Wind speed	Tower Height				
	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
4.0 m/s (9 mph)	$ 0.221	$ 0.187	$ 0.181	$ 0.187	$ 0.196
4.5 m/s (10.1 mph)	$ 0.166	$ 0.146	$ 0.144	$ 0.152	$ 0.161
5.0 m/s (11.2 mph)	$ 0.135	$ 0.122	$ 0.121	$ 0.130	$ 0.140
5.5 m/s (12.3 mph)	$ 0.114	$ 0.106	$ 0.107	$ 0.116	$ 0.126
6.0 m/s (13.5 mph)	$ 0.100	$ 0.096	$ 0.098	$ 0.107	$ 0.117
6.5 m/s (14.5 mph)	$ 0.091	$ 0.088	$ 0.091		
7.0 m/s (15.6 mph)	$ 0.084				
7.5 m/s (16.8 mph)	$ 0.080				

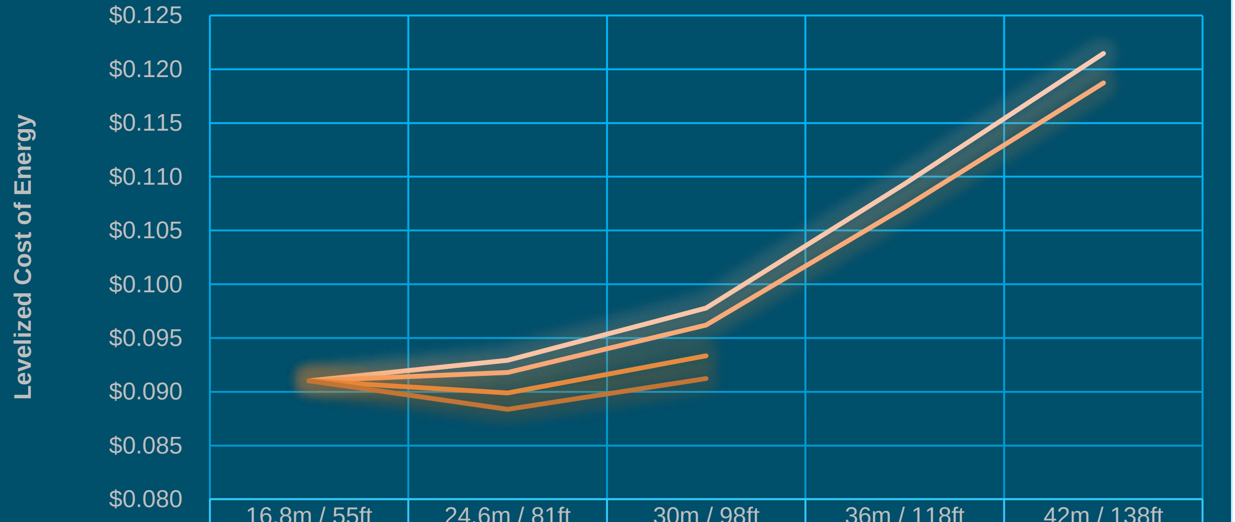


	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
Shear 0.11	$0.166	$0.163	$0.167	$0.183	$0.200
Shear 0.14	$0.166	$0.159	$0.162	$0.176	$0.190
Shear 0.20	$0.166	$0.152	$0.151	$0.162	$0.173
Shear 0.25	$0.166	$0.146	$0.144	$0.152	$0.161



	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
Shear 0.11	$0.114	$0.114	$0.119	$0.132	$0.145
Shear 0.14	$0.114	$0.112	$0.116	$0.128	$0.140
Shear 0.20	$0.114	$0.109	$0.111	$0.121	$0.132
Shear 0.25	$0.114	$0.106	$0.107	$0.116	$0.126

Determining Optimal Tower Height for EO25
High Wind Site: 6.5m/s at 16.8m (55ft)



	16.8m / 55ft	24.6m / 81ft	30m / 98ft	36m / 118ft	42m / 138ft
Shear 0.11	$0.091	$0.093	$0.098	$0.109	$0.121
Shear 0.14	$0.091	$0.092	$0.096	$0.107	$0.119
Shear 0.20	$0.091	$0.090	$0.093		
Shear 0.25	$0.091	$0.088	$0.091		

Conclusions

EO25

- Taller towers generally are NOT the best choice for achieving lowest LCOE
  - Low and medium wind sites: 24.6m (81ft) tilt-up is best
  - High wind sites: 16.8m (55ft) or 24.6m (81ft) tilt-up is best

- Taller towers appear attractive in a few cases (especially, low-wind, high shear sites), but if the risk of additional crane costs is factored into the equation, shorter towers remain the optimal choice. Tilt-up towers provide very predictable costs.

Conclusions

General

- The optimal tower height will vary by turbine
- Class III wind turbines will trend towards shorter towers. Class II wind turbines will trend towards taller towers
  - The difference in LCOE between Class III and Class II wind turbines at <7.5m/s (16.8mph) wind sites is compounded because of this
- The larger the rated power of the turbine, the more it is likely to benefit from a taller tower
  - Actual AEP differences are larger and relative tower costs are lower
- Low wind sites are more likely to benefit from a taller tower
- High shear sites are more likely to benefit from a taller tower
- There can be exceptional situations where a taller tower is the right choice
  - The presence of particularly large or tall obstacles near a turbine
  - The extra AEP from a taller tower is more important than the slight price premium and added cost risk

Conclusions

<u>Areas for further study</u>

- Sensitivity analysis for EO25 case study
- Examine results from input of other small wind turbines into the model
- Opportunity to make a public tool?

Thank you

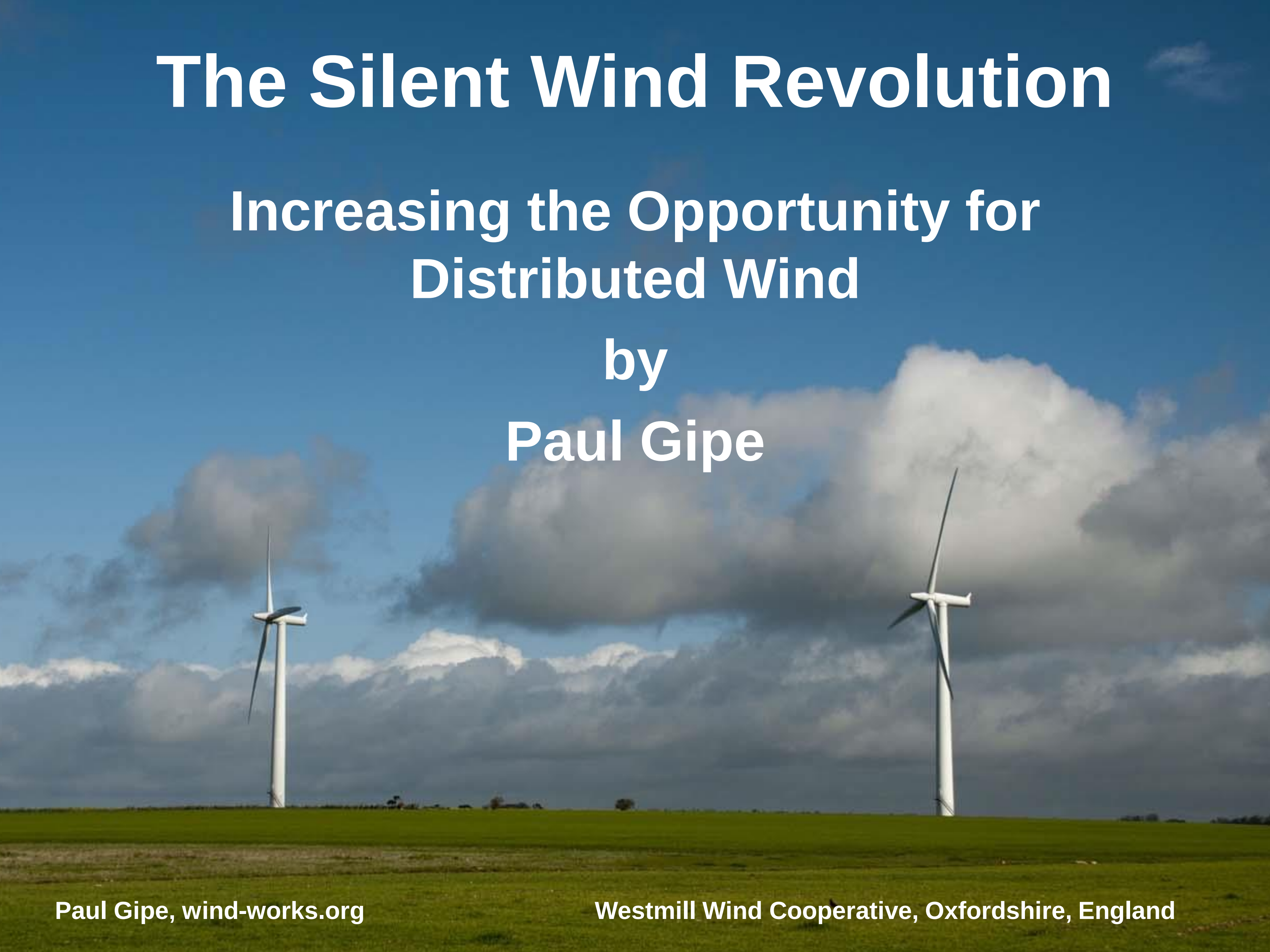
eocycle

7665 rue Larrey, Suite 201
Montréal (Québec)
H1J 2T7

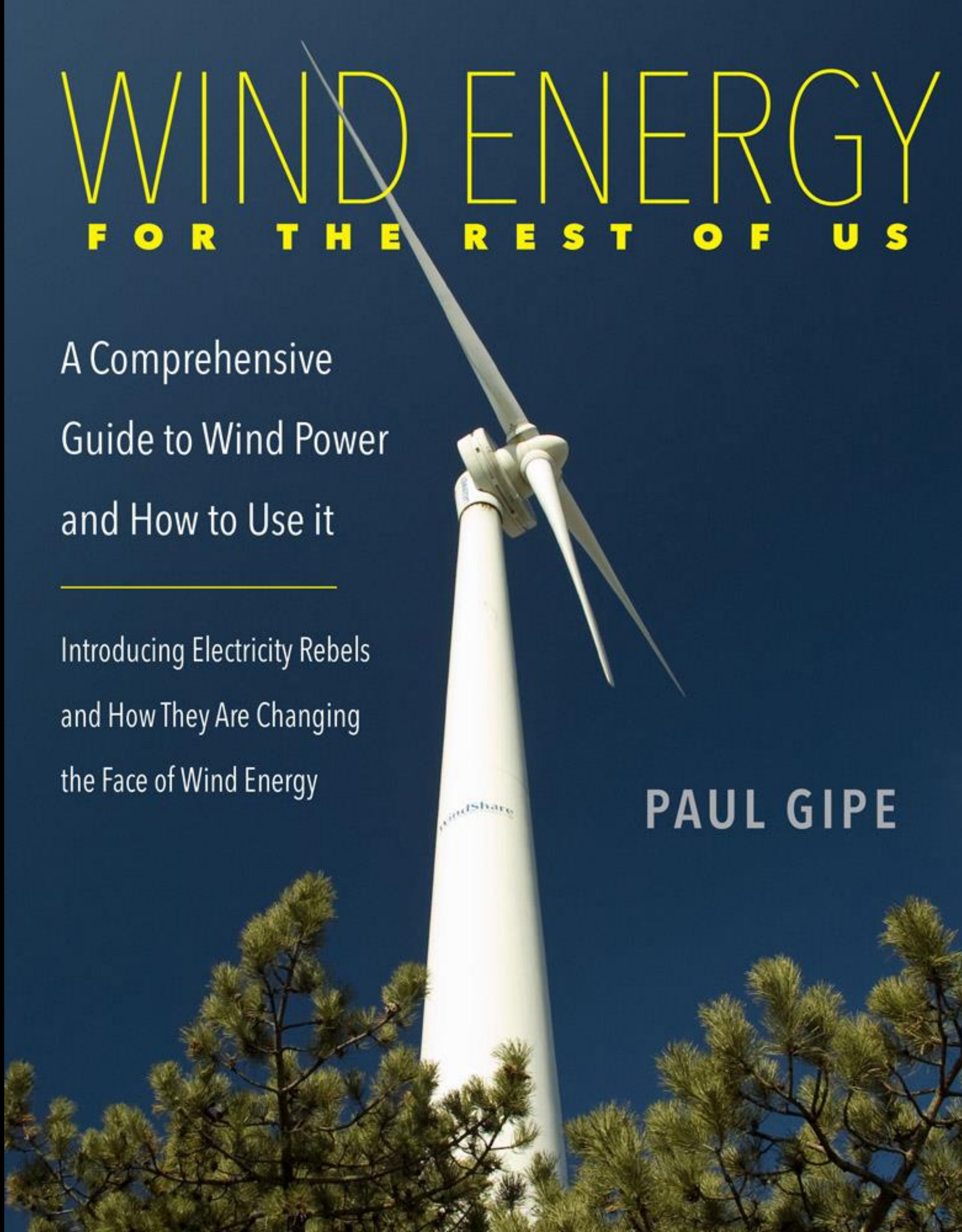
Distributed Wind 2017

Technical Panel

Paul Gipe, wind-works.org


The Silent Wind Revolution
Increasing the Opportunity for Distributed Wind
by
Paul Gipe
Paul Gipe, wind-works.org
Westmill Wind Cooperative, Oxfordshire, England

Adapted from



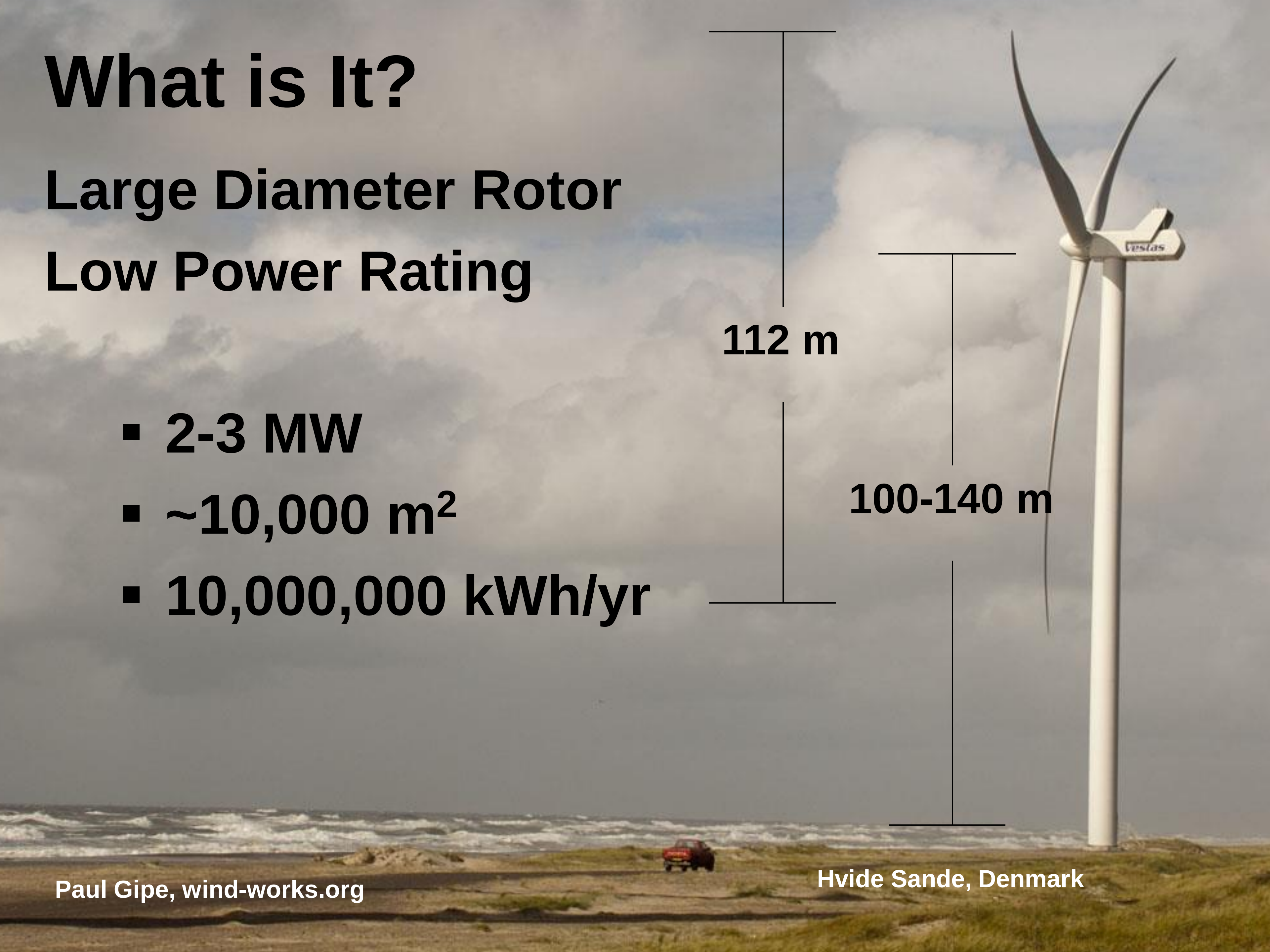
Paul Gipe, wind-works.org

Wind's Technological Revolution

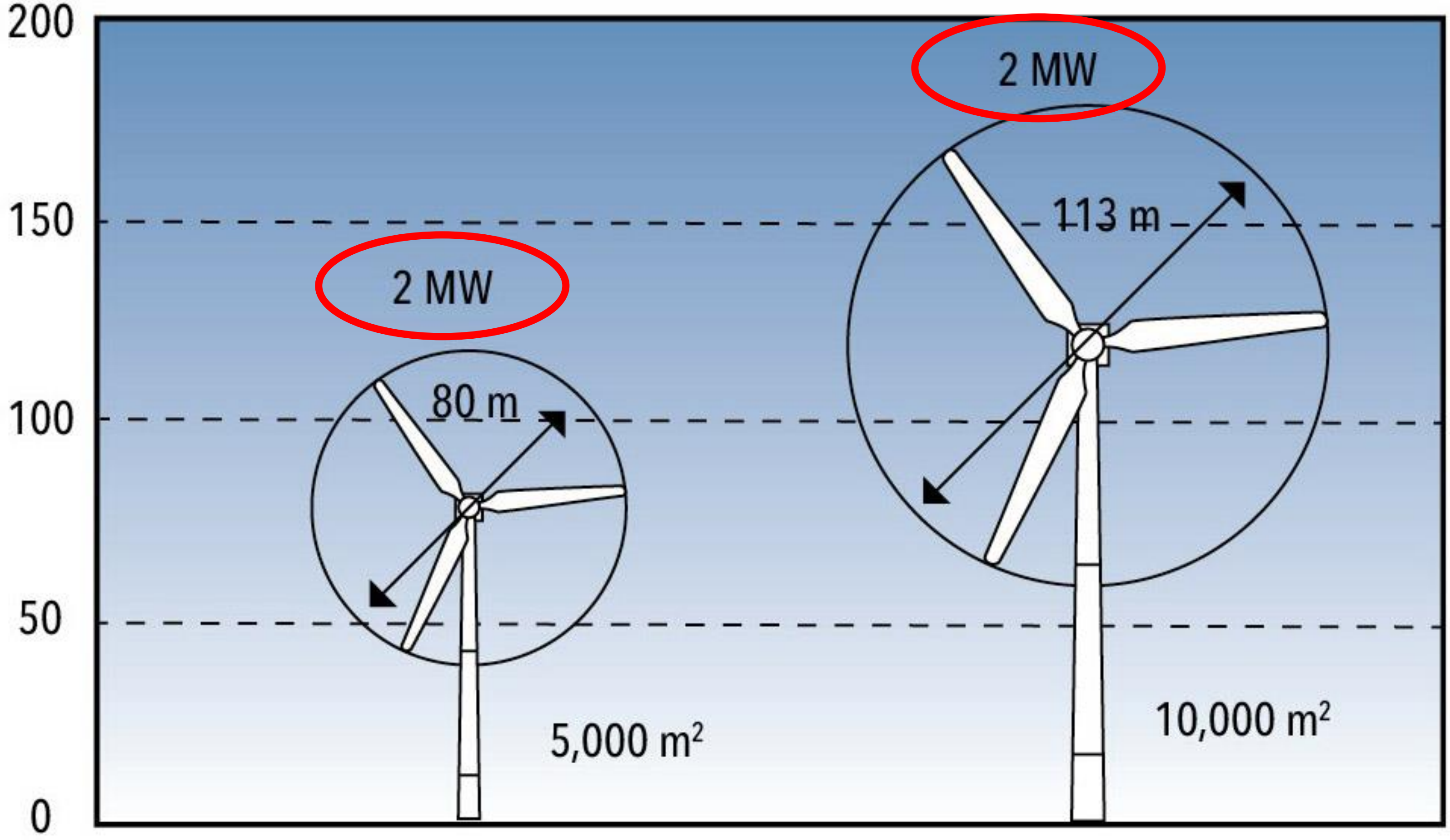
- **Not VAWTs**
- **Not DAWTs**
- **Not Flashy**
- **Not Sexy**
- **"It is a Silent Revolution"**

--Bernard Chabot

Paul Gipe, wind-works.org


What is It?
Large Diameter Rotor
Low Power Rating
▪ 2-3 MW
▪ ~10,000 m²
▪ 10,000,000 kWh/yr
112 m
100-140 m
Paul Gipe, wind-works.org
Hvide Sande, Denmark

Silent Wind Power Revolution



Paul Gipe, wind-works.org

Adapted from *Wind Energy for the Rest of Us*

Silent Wind Power Revolution

Year		2000	2014
Diameter	m	80	113
Swept Area	m2	5,000	10,000
Hub height	m	80	130
Capacity	MW	2	2
Specific power	W/m2	400	200
Specific area	m2/kW	2.5	5
Diameter/height		1	1.2

Doubled Specific Area!

Paul Gipe, wind-works.org

High Specific Area
Low Specific Power

- **Specific Area**

  Area/kW = 1-10 m^2/kW

- **Specific Power**

  kW/Area= 100-1,000 W/m^2

Paul Gipe, wind-works.org

Endurance, Upland, Indiana

Is This Good? Yes!

- **Higher Wind Penetration**
- **More Generation per MW**
- **Expands Resource Base**
  - More Land Available
- **Less Demand on Windy Sites**
  - Less Opposition Likely
- **Easier Grid Integration**
  - We Can Put Wind Where the People Are
- **Long Overdue**

Endurance, Upland, Indiana

Paul Gipe, wind-works.org

Why This Is Good
Jens Peter Molly, DEWI

- **100 m diameter, 1 kW**
  - **100% Capacity Factor = Easier to Integrate**
  - **Few kWh = Costly/kWh**
- **100 m diameter, 10 MW**
  - **Interconnection Costly**
    - **Must Be Over Dimensioned for Peak Power**
  - **@ Rated Power only Few Hours per Year: Low CF**
- **Optimum**
  - **Goldilocks: Not Too Big, Not Too Small, Just Right for the Wind Resource**

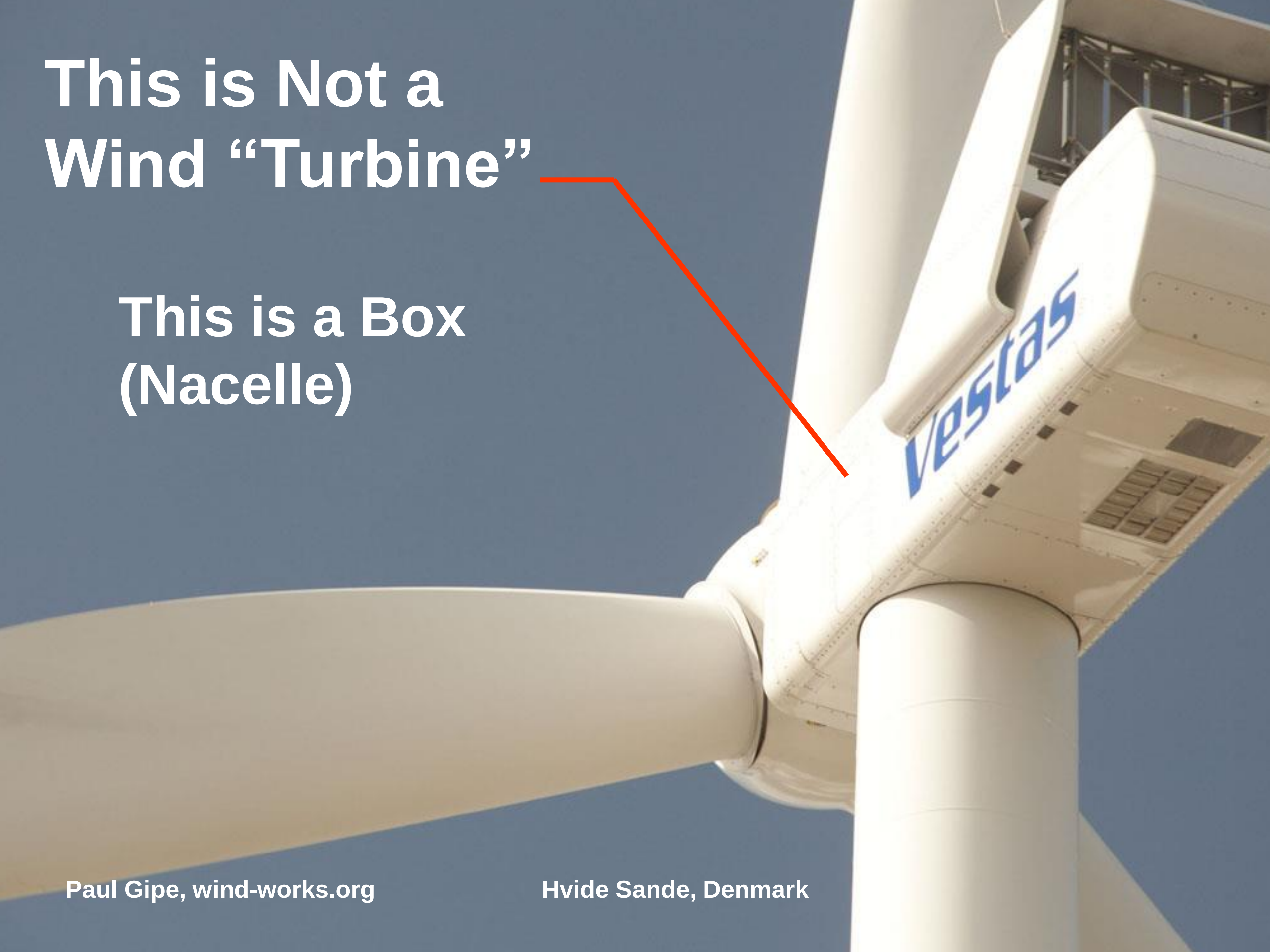
What is a Wind Turbine?

Ponnequin, Colorado

Paul Gipe, wind-works.org

This is Not a Wind “Turbine”

This is a Box (Nacelle)

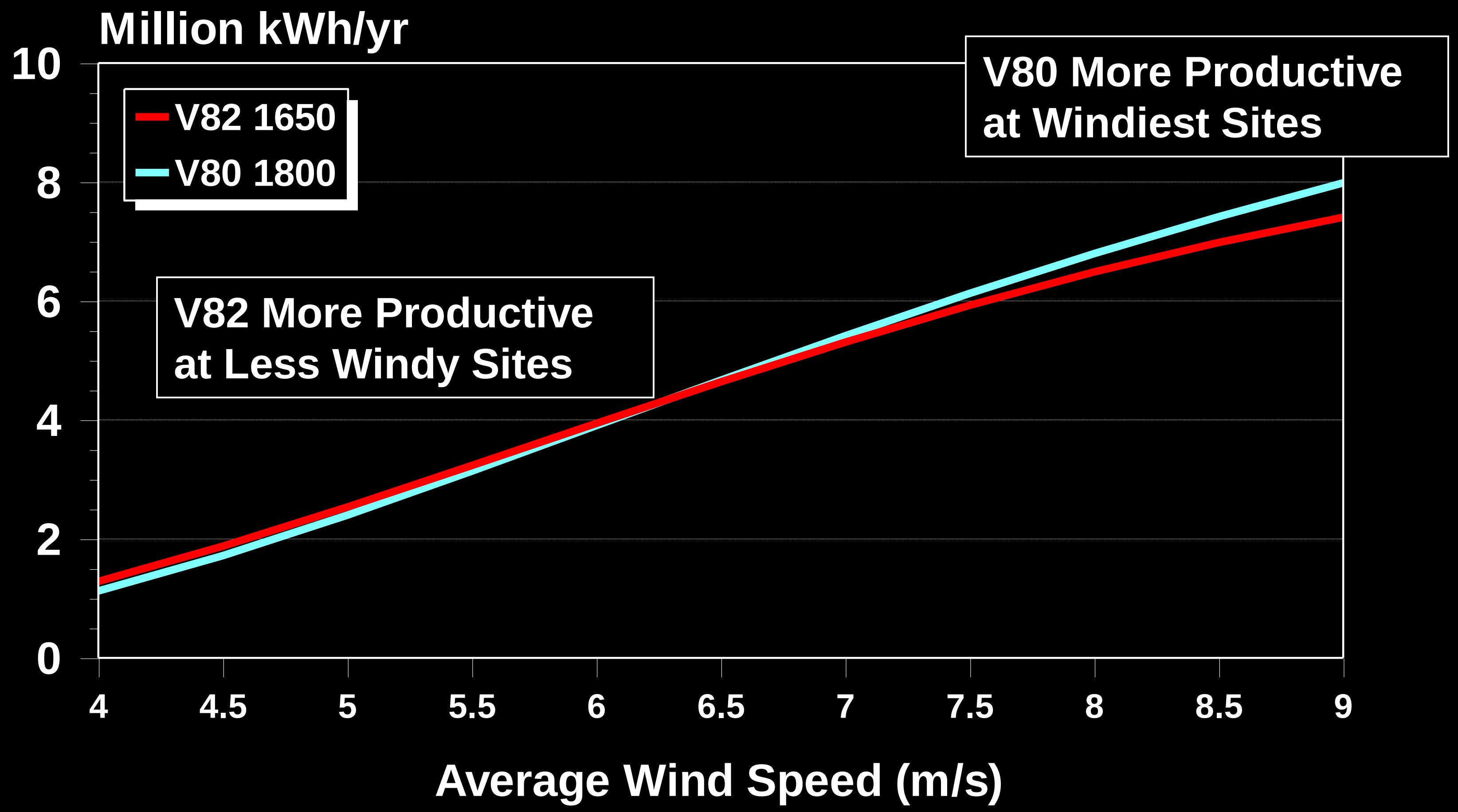


Paul Gipe, wind-works.org

Hvide Sande, Denmark

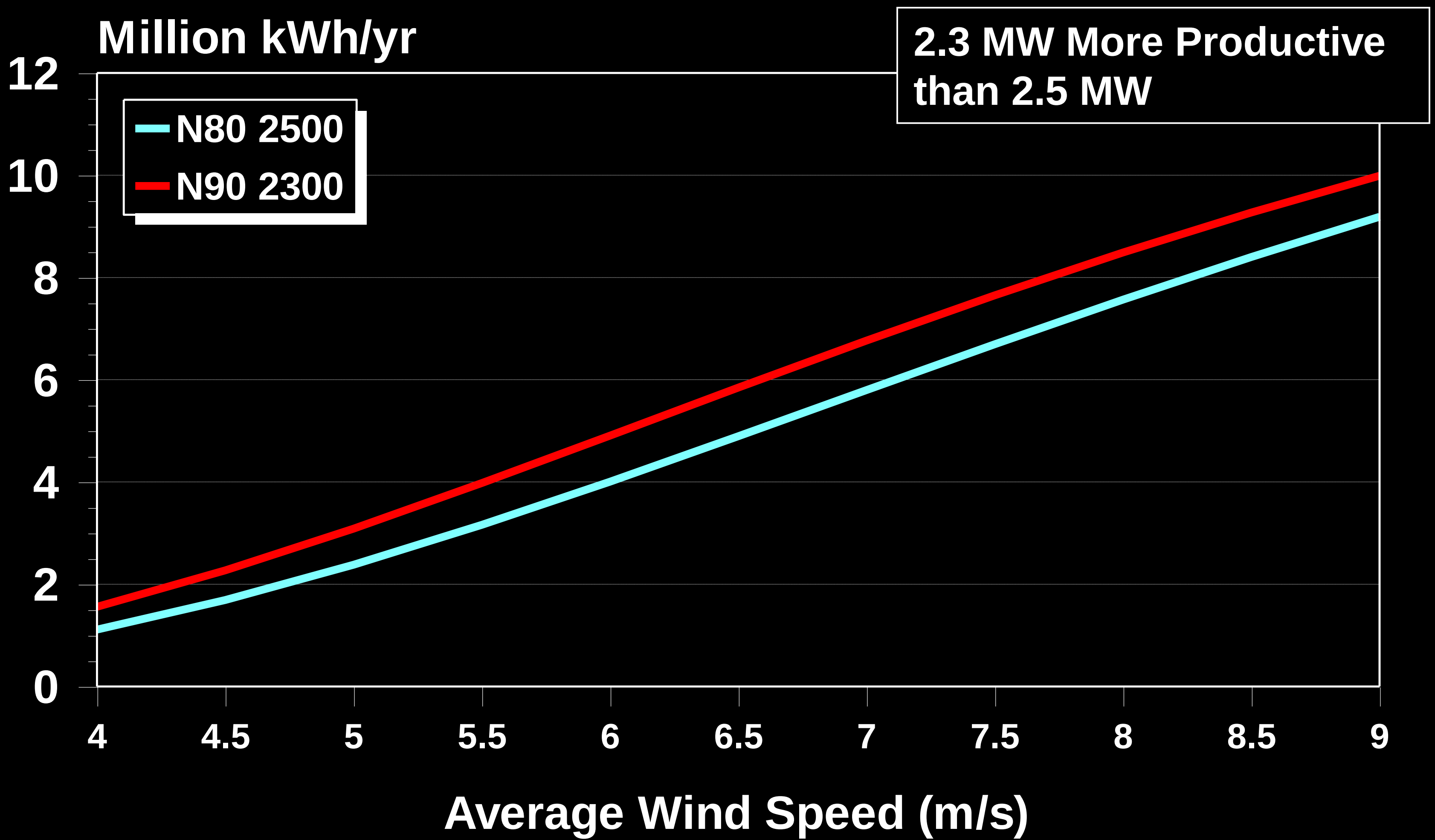

This is the "Turbine" of a Wind Turbine
Tehachapi Pass, 2013
Paul Gipe, wind-works.org

AEP Relative to Power & Rotor Area



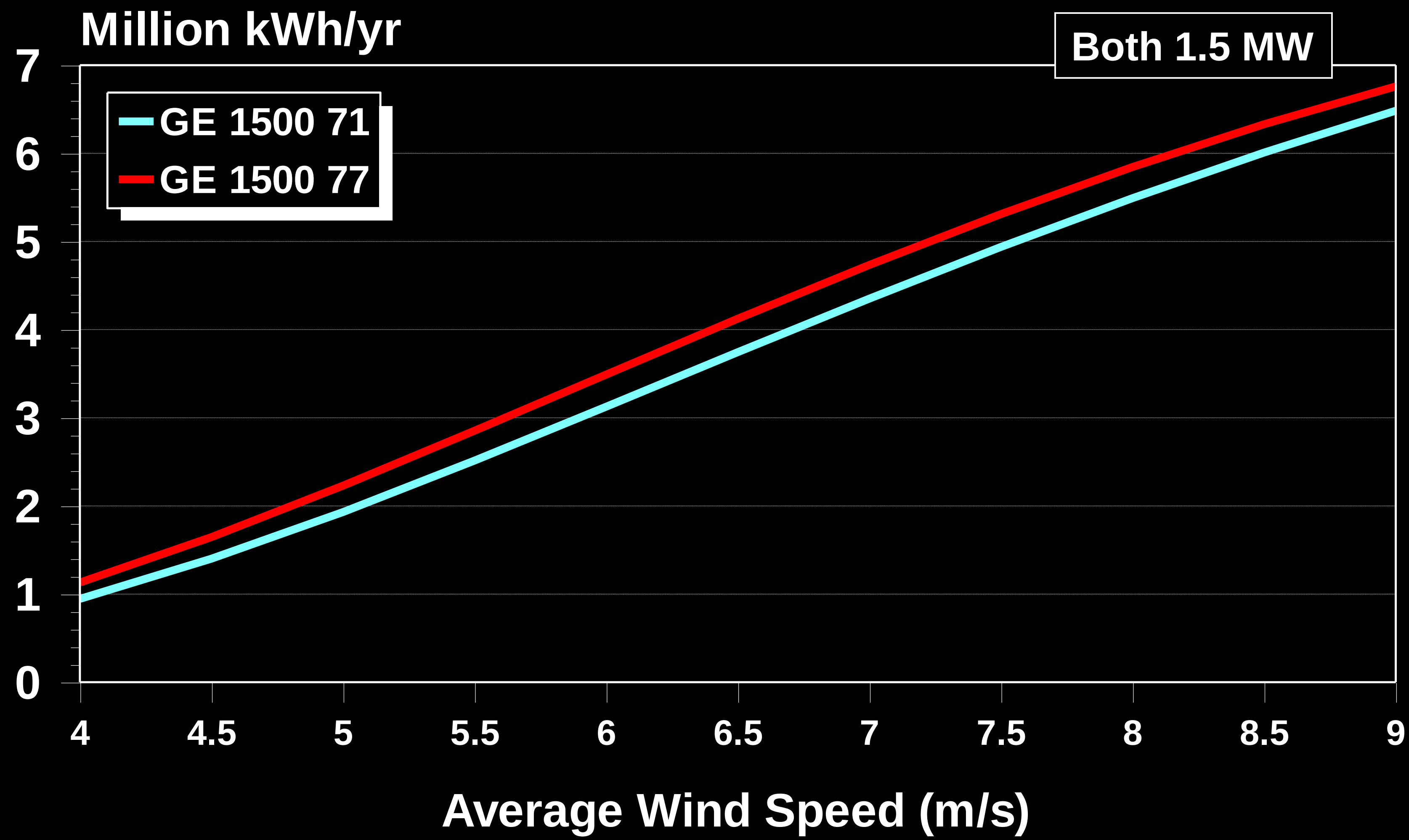
Paul Gipe, wind-works.org

AEP Relative to Power & Rotor Area



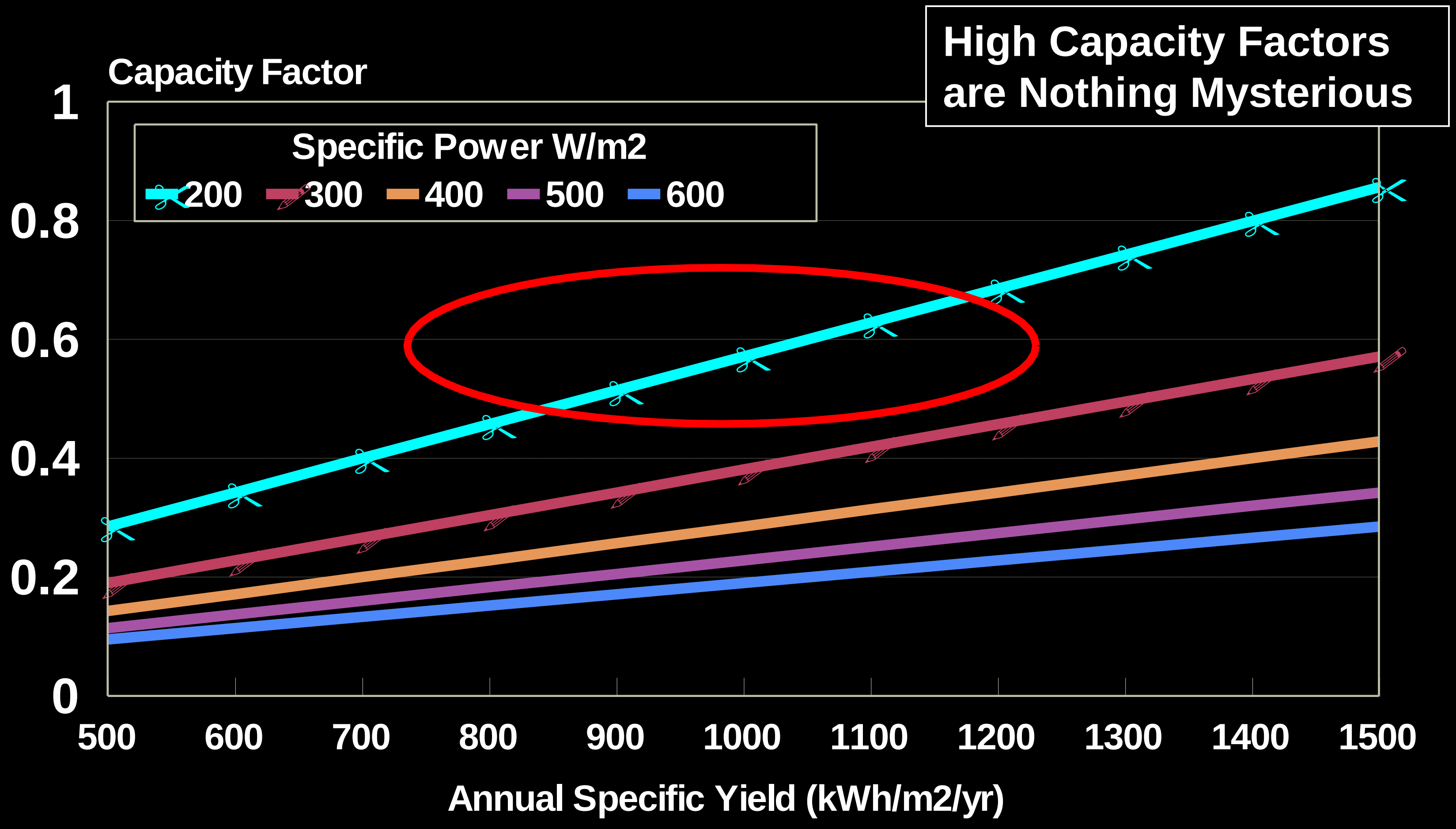
Paul Gipe, wind-works.org

AEP Relative to Power & Rotor Area

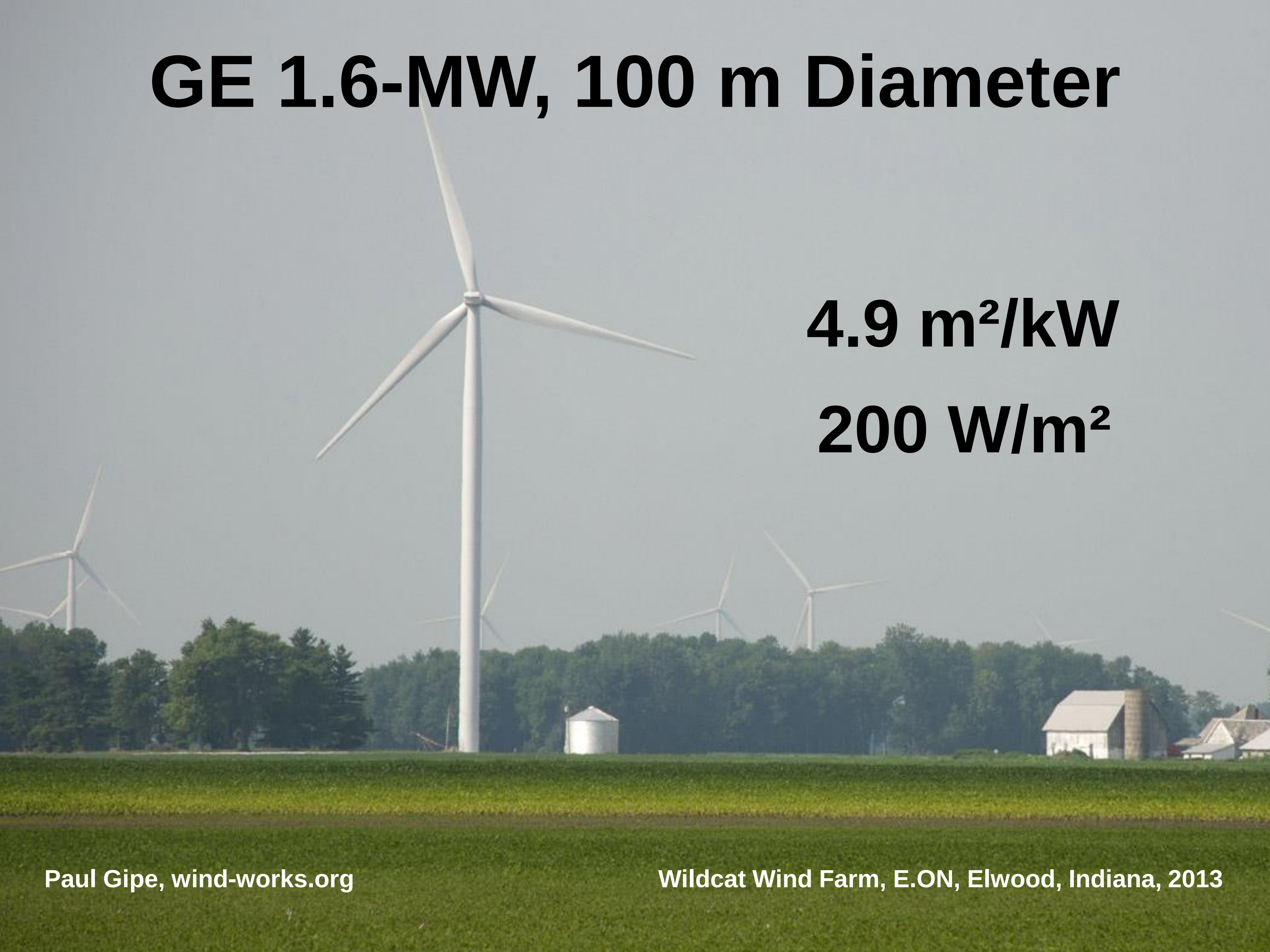


Paul Gipe, wind-works.org

Capacity Factor for Specific Power



Paul Gipe, wind-works.org


GE 1.6-MW, 100 m Diameter
4.9 m²/kW
200 W/m²
Paul Gipe, wind-works.org
Wildcat Wind Farm, E.ON, Elwood, Indiana, 2013

Sample Specific Power & Specific Area

Sample Specific Power & Specific Area						
		Rotor	Swept	Rated	Specific	Specific
		Dia.	Area	Power	Power	Area
Manufacturer	Model	m	m^2	kW	W/m^2	m^2/kW
Nordex	N80	80	5,027	2,500	497	2.0
GE	1500	71	3,959	1,500	379	2.6
Nordex	N90	90	6,362	2,300	362	2.8
Vestas	V80	80	5,027	1,800	358	2.8
GE	1500SL	77	4,657	1,500	322	3.1
Vestas	V82	82	5,281	1,650	312	3.2
GE	100-1.6	100	7,854	1,600	204	4.9

Paul Gipe, wind-works.org

It Wasn't Always So!

Specific Power of Selected Wind Turbines in the 1980s

	kW	m2	W/m2	m2/kW
Fayette	95	95	1,000	1
Carter	300	332	904	1.1
Windmaster	200	373	536	1.9

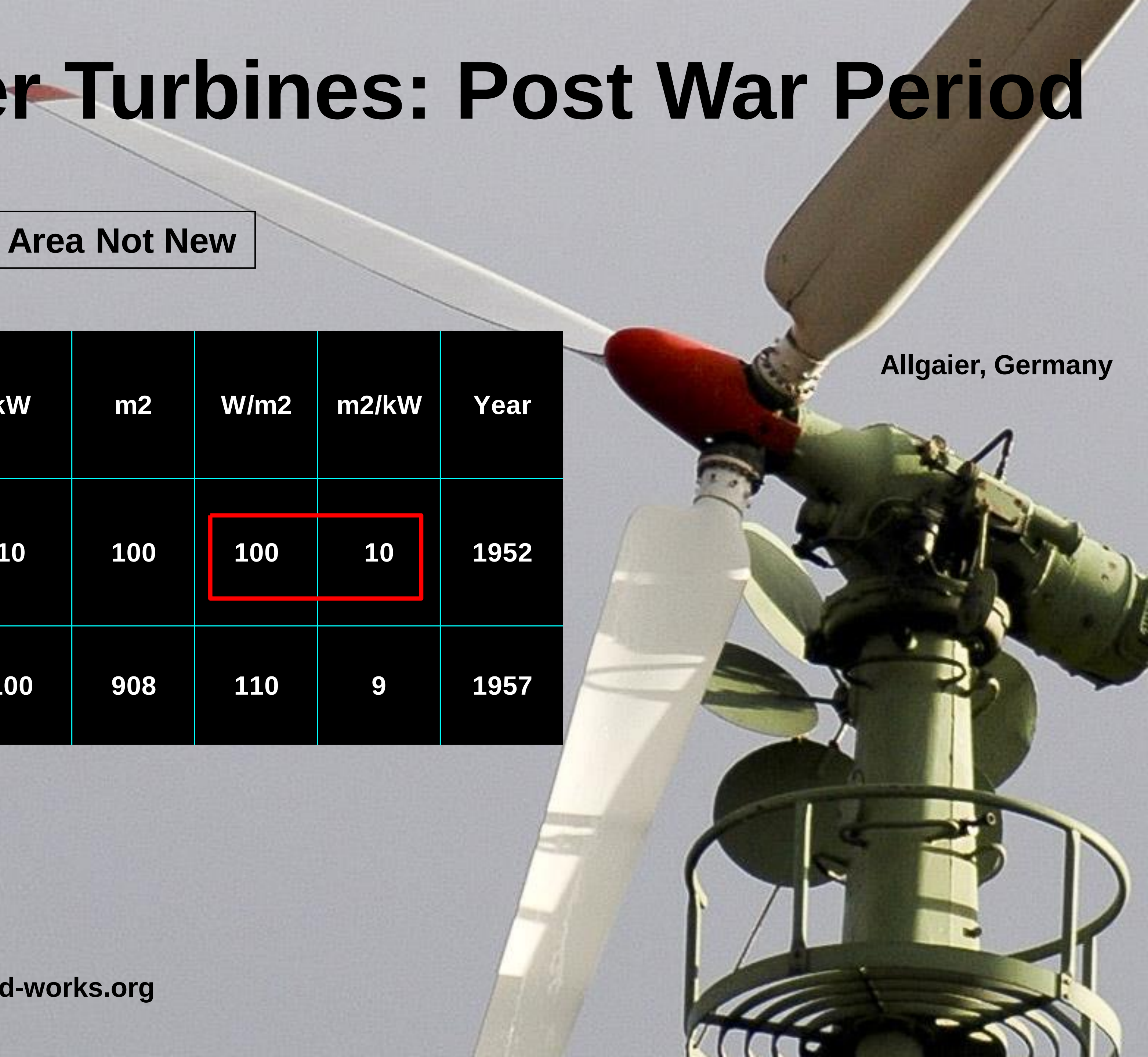
Widespread Hype Oversold Wind

Paul Gipe, wind-works.org

Hütter Turbines: Post War Period

High Specific Area Not New

	kW	m2	W/m2	m2/kW	Year
Allgaier	10	100	100	10	1952
Hütter	100	908	110	9	1957



Allgaier, Germany

Paul Gipe, wind-works.org

Revolutionary? Yes--New? No

“The specific power . . . was kept to a low level in order to assure an almost uniform energy output in places with relatively low wind speeds. Therefore, contrary to teams in France, Denmark, England, United States, etc., we intentionally chose a design of only 110 W/m^2 swept area instead of the usual 300 to 400 W/m^2.”

--Sepp Armbrust, United Nations, 1961*

***A colleague of Ulrich Hütter.**

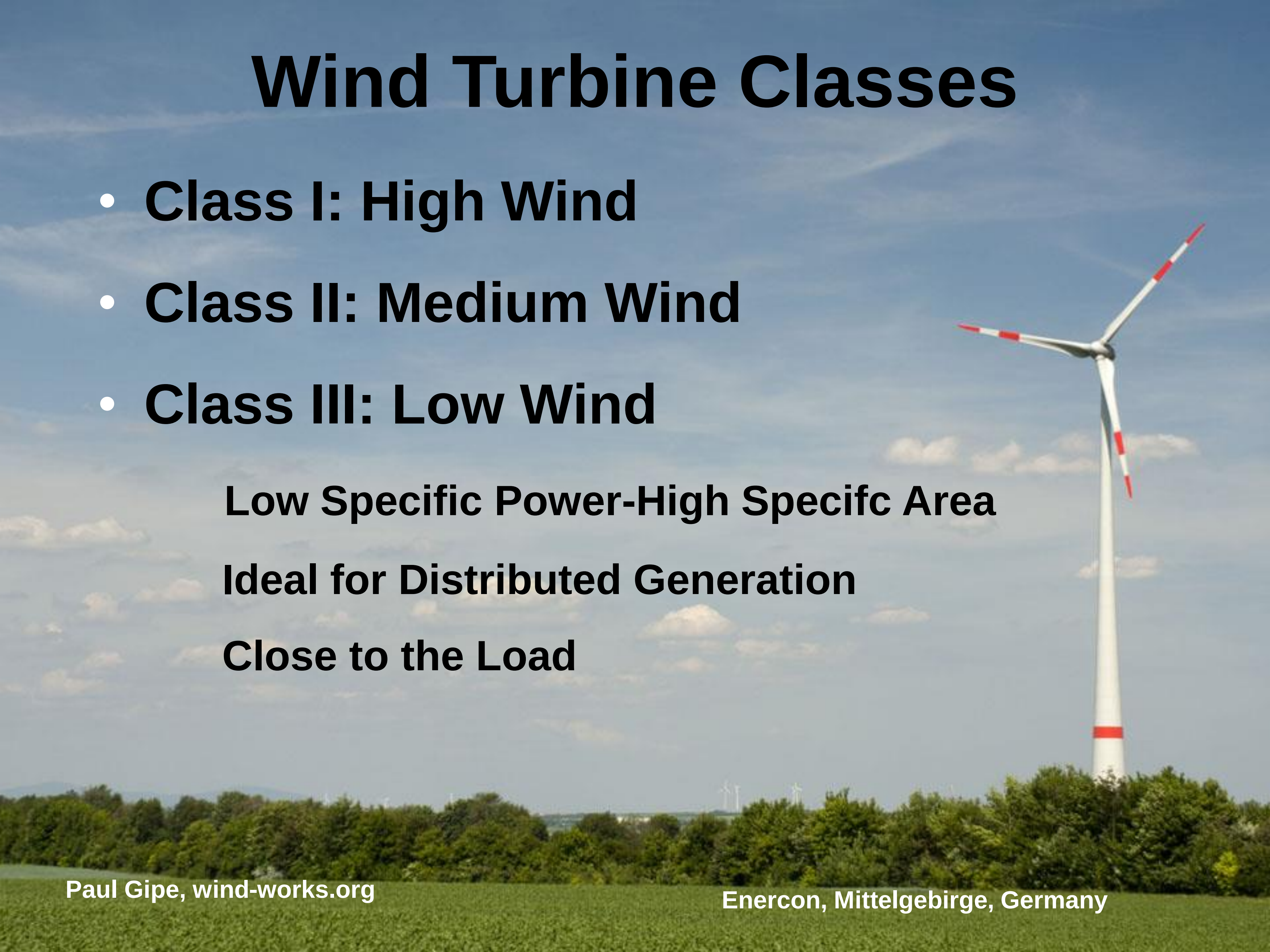
Wind Turbine Classes

- **Class I: High Wind**
- **Class II: Medium Wind**
- **Class III: Low Wind**

Low Specific Power-High Specifc Area

Ideal for Distributed Generation

Close to the Load



Paul Gipe, wind-works.org

Enercon, Mittelgebirge, Germany

Specific Power-Specific Area
Small & Medium-Size Turbines

	kW	m2	W/m2	m2/kW	Class
NPS	100	346	289	3.5	IIA
Bergey	8.9	38	231	4.3	II
NPS	95	452	210	4.8	III/S
Evance	4.7	24	198	5.1	II
Endurance	50	290	173	5.8	IIIA
Eocycle	25	196	128	7.8	IIIA
Gaia	11	133	83	12.1	IIIB

Paul Gipe, wind-works.org

Doubling the Resource: Germany

- **Wind Studies: 2010, 2013**
- **2013 Study**

  High Specific Area (only 3.2 m^2/kW)
- **Doubled the Land Area**

  With Same Exclusions
- **3,000 TWh/yr**

  5 X Current Demand

Paul Gipe, wind-works.org

Ihlow, Niedersacshsen, Germany

More Cost Effective

Hypothetical Relative Costs for GE 1.6 MW Platform			
Adapted from Ryan Wiser LBNL 2012			
		Standard	Low Wind
Platform	MW	1.62	1.62
Diameter	m	82.5	100
Swept Area	m^2	5,346	7,854
Relative Installed Cost	$/kW	$1,600	$1,850
Installed Cost	$	2,600,000	3,000,000
Specific Area	m^2/kW	3.30	4.85
~Yield at 7.5 m/s	kWh/m^2/yr	1,000	850
~AEP	kWh/yr	5,300,000	6,700,000
Relative Cost	$/kWh	0.49	0.45

Higher Installed Cost But Cheaper Energy

Paul Gipe, wind-works.org

War on Centralized Generation?

"The new IEC Class III turbines are not only revolutionary because they allow deploying new wind generating capacity in lower wind speed regions but also because—whether they realize it or not—the manufacturers have declared war on the centralized generation model and the long transmission lines that are an essential part of that model."

--Bernard Saulnier, Hydro Quebec


High Specific Area-Low Specific Power
• More kWh at Lower Cost
• Closer to the Load
• Less Transmission Needed
• Better Use of Infrastructure
That was Built at Such High Public Cost
• Leads to Higher Penetration
• = Revolutionary
--Bernard Chabot
Paul Gipe, wind-works.org


Big Rotors
Small Generators
Revolutionary!
Paul Gipe, wind-works.org
Ferndale, Ontario

Distributed Wind 2017

Technical Panel

Wes Slaymaker, WES Engineering

SC Johnson Waxdale Plant
3MW wind project

behind the meter is
ahead of its time

Wes Slaymaker, P.E.
Wind Energy Systems Engineering

DWEA Annual Conference
February 28, 2017

Weselley Slaymaker, P.E.

Project Engineer

2000-Denmark

2007-Spain

- 16 years working on and developing wind projects from 0.1 to 5MW in the Midwest
- Specializing in Community Wind projects and distributed generation

Outline of Talk

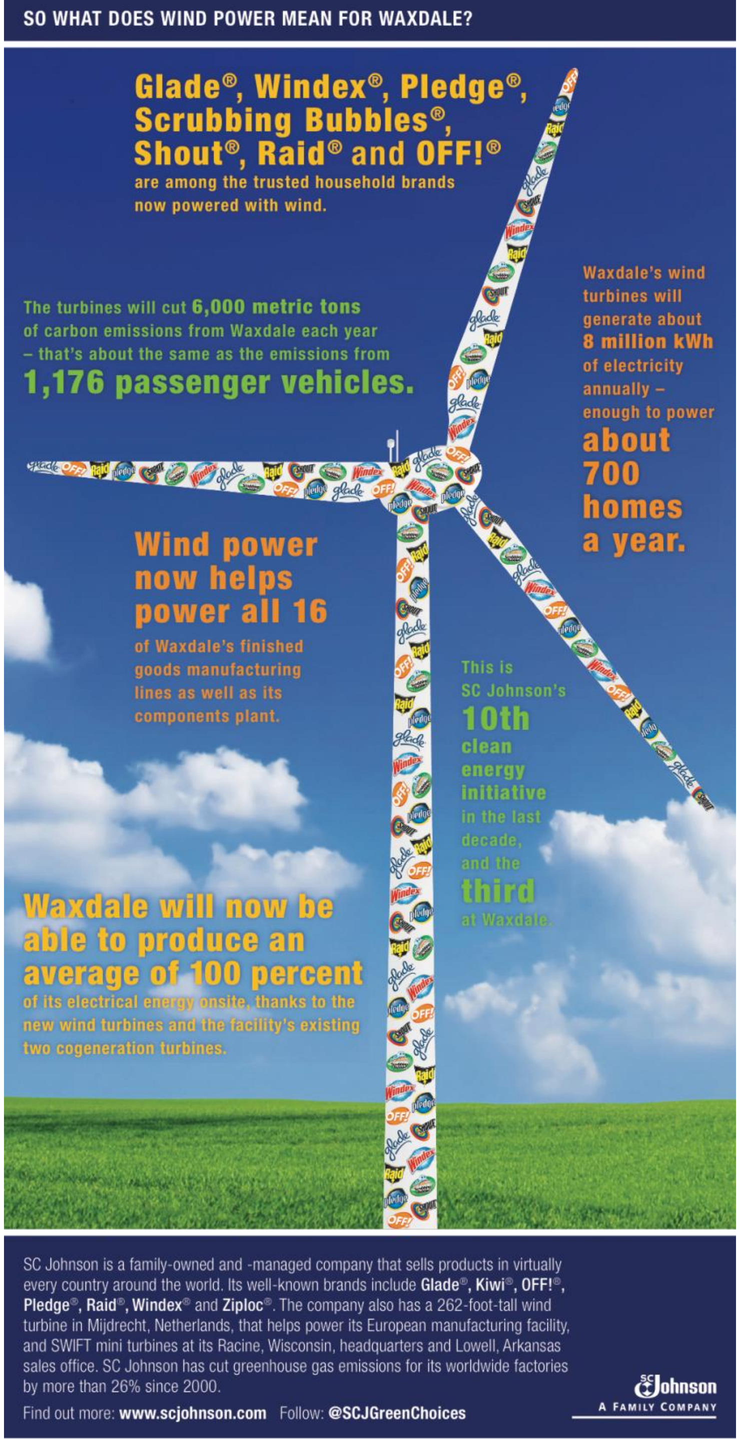
Learn how the SCJ wind project created successful 3MW project:

- FAA issues
- Community impacts
- Permitting- lots of meetings and tours
- Wildlife issues
- Financial

Project Overview

- SC Johnson has a large plant in Mount Pleasant, WI- Waxdale
- SCJ would like to generate 100% of its own power on annual basis
- SCJ Waxdale also has natural gas fired generators using landfill gas
- Motivations are to reduce carbon footprint, hedge electric costs for operations, partner with UW on research effort on foundations

- SC Johnson marketing benefits from wind turbines
- SCJ to generate 100% of its own power on annual basis
- Major brands such as: Glade, Windex, Ziploc and Pledge



SCJ wind development process

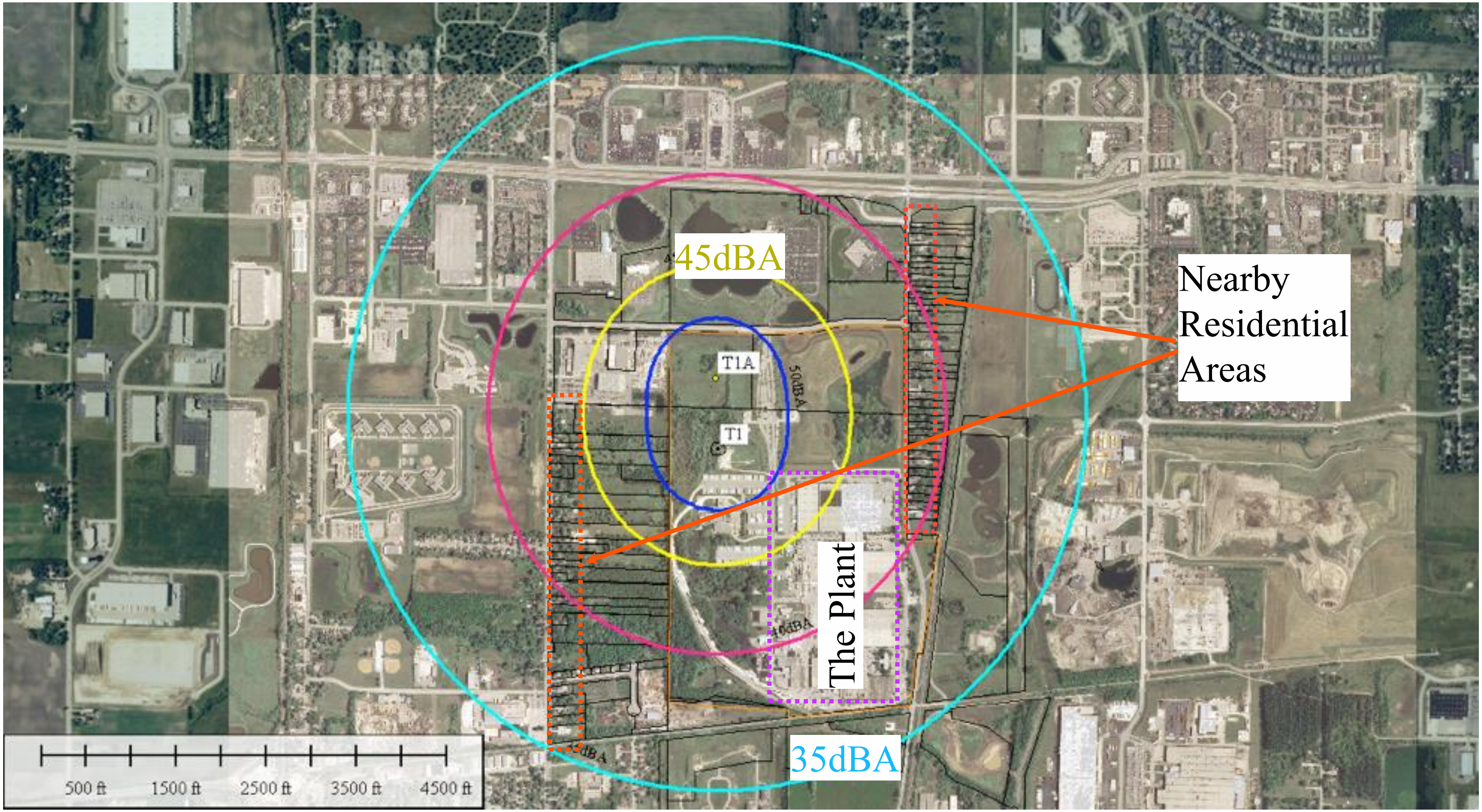
- Determine project size and location
- Identify best equipment choice
- Grants- US Treasury
- Permitting- Local and FAA
- Interconnect- distributed generation- WI PSC standard documents
- Order equipment
- Construct

Site Plan- qty 2 1.5MW Vensys

Permitting

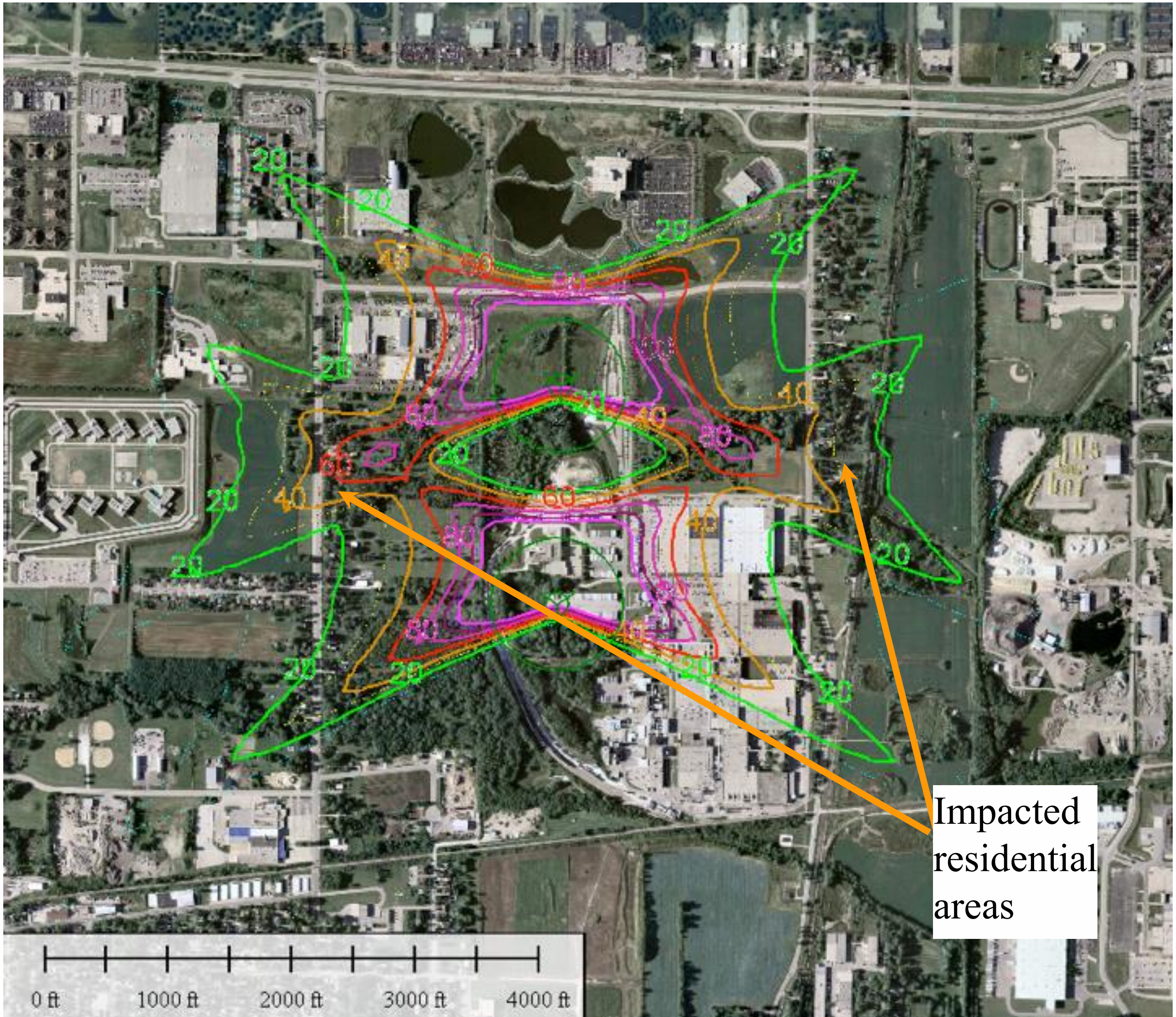
- Community meetings- at local school
- Community presentation- at Village
- Invite to tour nearby similar turbines
- Address concerns:
  - Sound- Windfarmer model
  - Shadow Flicker- Windfarmer model
  - Wildlife- DNR comments
  - TV reception- COMSearch Study

Noise Modeling



Noise Isolines, stay below 45dBA at residences

Shadow Flicker



Shadow Flicker control device installed to limit to no more than 25 hours per year at any residence

Photo Simulations

Not many places turbines were visible due to trees

Project Timeline

- Early 2011- wind analysis, turbine selection
- Summer 2011- FAA studies, microwave study
- Fall 2011- community meetings
- Spring 2012- soil borings and foundation design
- Spring 2012- negotiate TSA and contractor agreement, start foundations
- Fall 2012- erect wind turbines!
- Dec 2012- online and making $$$

Interconnection

- Distribution connection 4160V at substation transformer on site
- Interconnect Agreement with WE Energies (follows WI Public Service Commission guidelines)
- Connect North and South plant substations to allow energy to stay on site for use and not be exported (exported energy receives lower price)

Where is power used?

- SC Johnson Waxdale plant consumes approximately 100% output of both turbines, approximately 7,500,000 kWh
- Any remainder is “backfed” to the 4.16kV distribution system
- Power used on site saves Owner the “energy” cost of power, no reduction in demand from wind turbines.

Turbine Choice

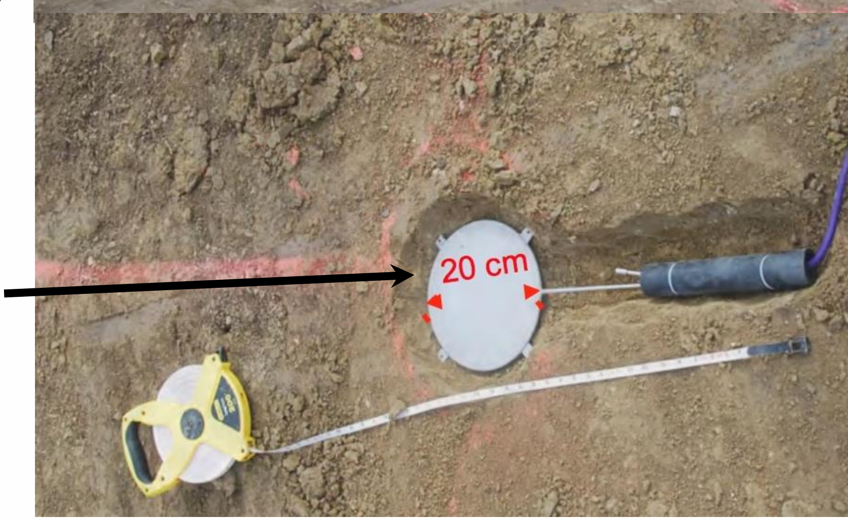
- Owner wanted turbines on property, only two locations possible.
- Large turbines desired for maximum yield from two locations.
- Height limits so 1.5MW turbines on 85m towers are largest possible (413′ height)
- Vensys direct drive variable speed turbine, 82m rotor is quietest on market
- Low maintenance costs, ability to support project far from service crews.

UW Foundation Research

- UW Civil Engineer professor Jim Tinjum, instruments under turbine with pressure sensors and inside tower wall with strain gauges to measure forces, deflection.

Strain Gauge

Pressure Sensor



▪Outline of Field Testing

Optical Strain Gauges

- Monitor Dynamic Loads Transferred to the Foundation

Accelerometers

- Monitor the Displacement of the WTG Foundation

Pressure Cells

- Monitor Pressure and Soil Response

Geotechnical Strain Gauges

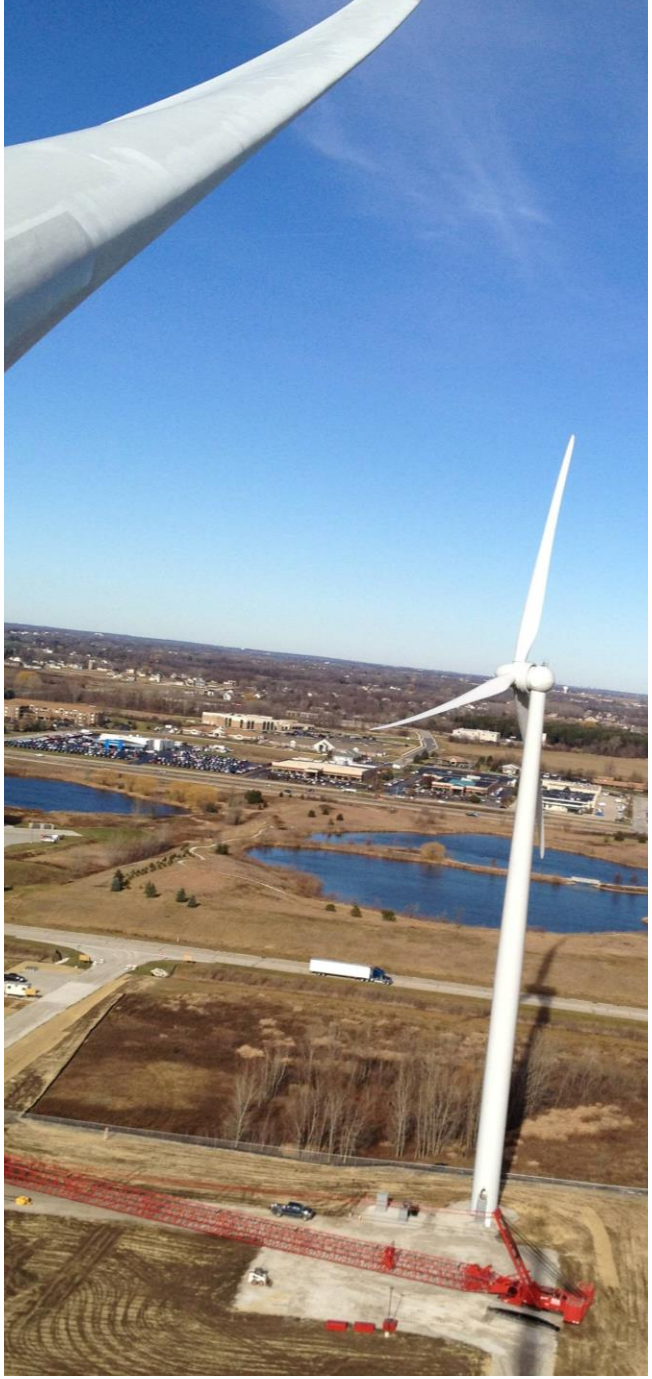
- Measure Soil Deformation
- Determine the Magnitude of Shear Strain

Financing

- SCJ entity can balance sheet finance.
- No need for expensive construction financing
- US Treasury grant simplifies tax treatment
- Handled entirely by SCJ staff.

Construction

- Foundations and cabling installed in Fall 2012
- Turbine erection starts Nov, 2012
- Two weeks per turbine from delivery
- Larger foundations and piers underneath for wet soils issues
- COD Dec 9, 2012



Project Costs- Overview

Cost Category	Amount
Development	$250,000
Engineering	$200,000
Interconnect	$750,000
Balance of Plant	$2 million
Turbines	$4.8 million
Total	Approx. $8 million dollars

Contact Information

Wes Slaymaker, P.E.

President

WES Engineering Inc.

706 S. Orchard St

Madison, WI 53715

Phone: 608-259-9304

E-mail: wes@WESengineering.com

Distributed Wind 2017