Energy Exchange

Federal Sustainability for the Next Decade

U.S. Department of Energy

Emerging Wind Energy Opportunities in the Federal Sector

Robi Robichaud

National Renewable Energy Laboratory

August 8, 2016

NREL/PR-5000-66899

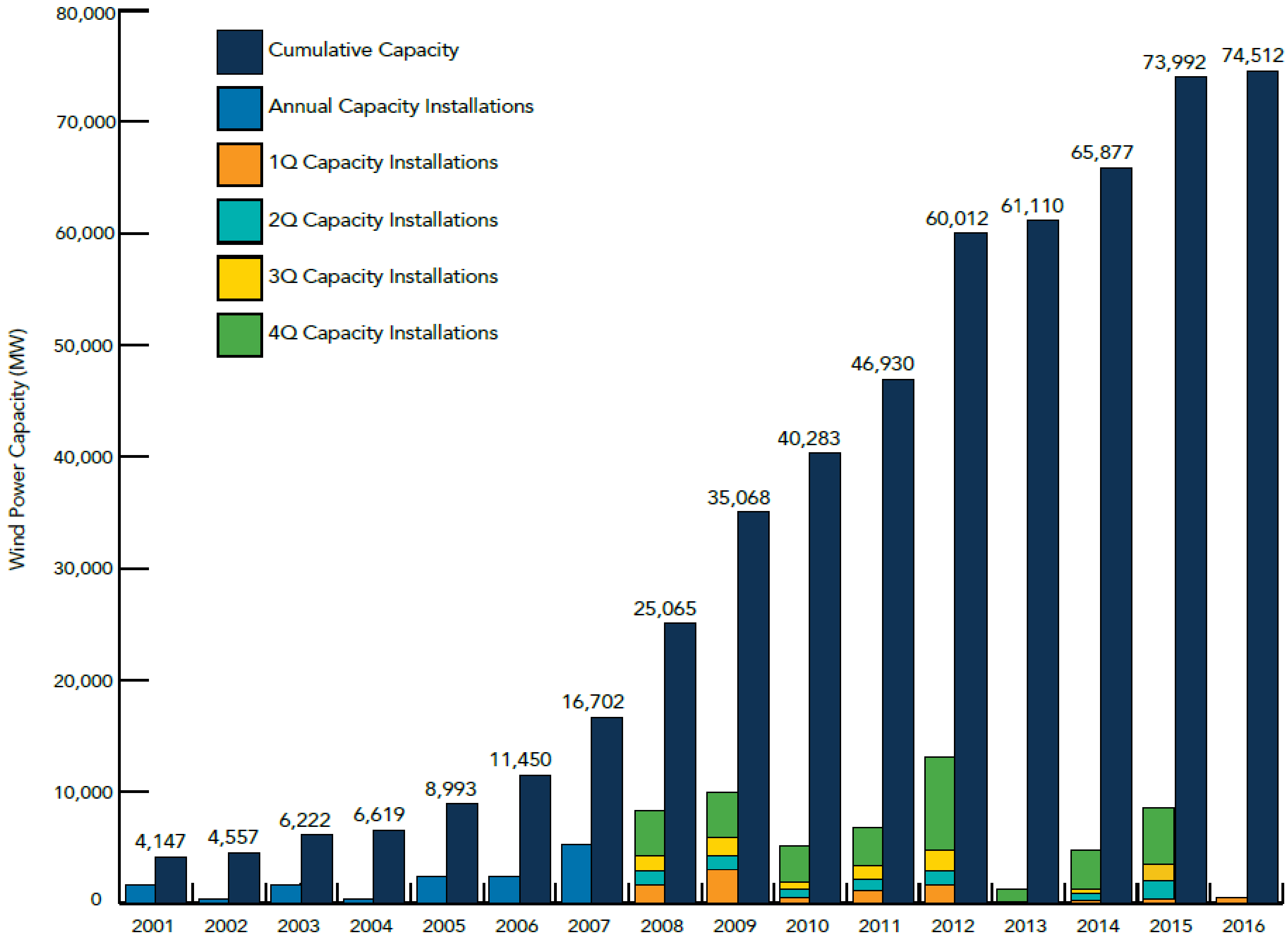
Emerging Opportunities for Federal Wind

Photo by Dennis Schroeder, NREL 25915

Emerging Opportunities for Federal Wind

- Wind Energy Update
  - Background and Trends
- Technology Trends that Increase Opportunities
- Financing Options at Federal Facilities
- How to Develop a Successful Federal Wind Project
  - Creative Approaches

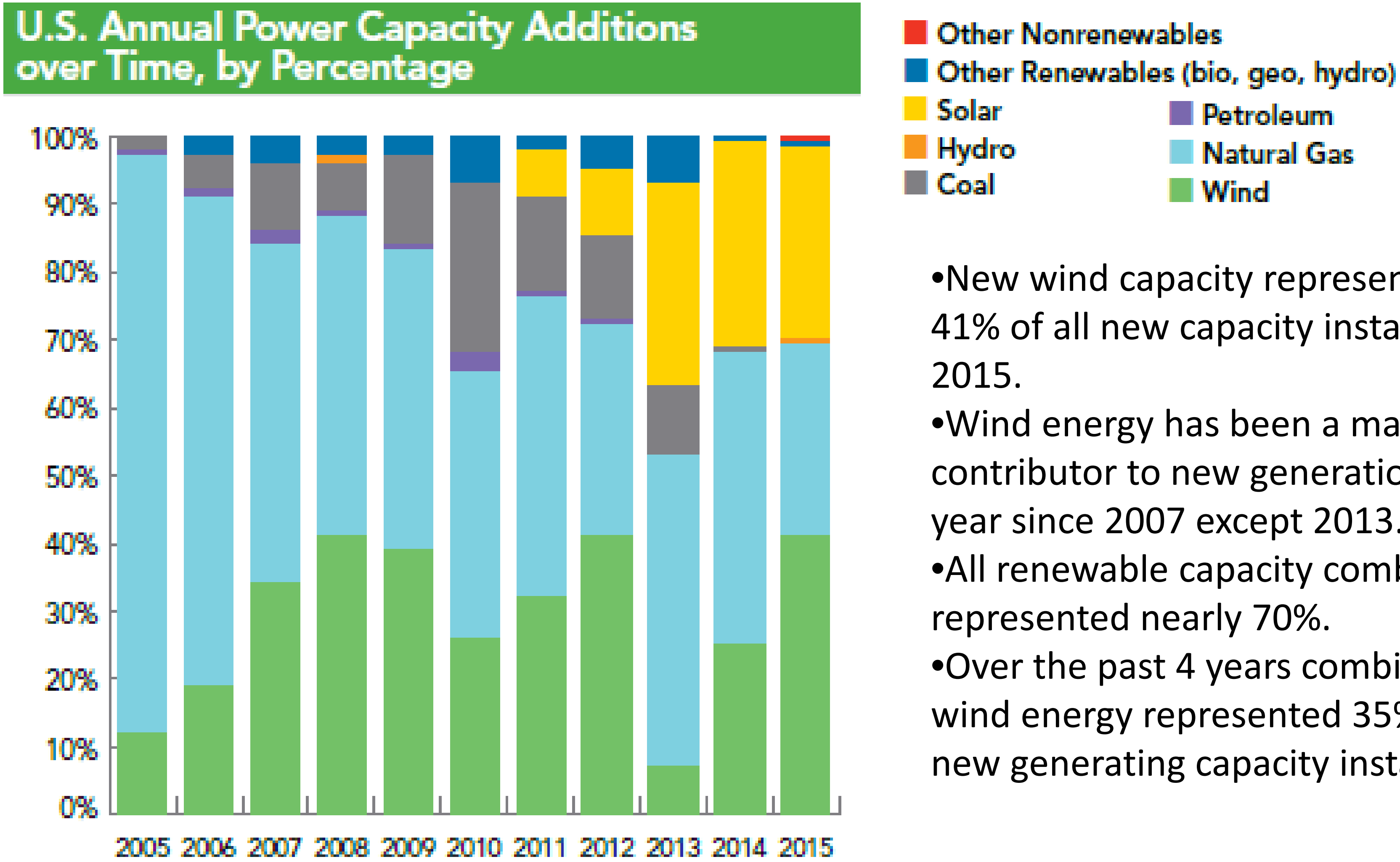
U.S. Annual Wind Capacity & Cumulative Wind Capacity



Note: Utility-scale wind capacity includes installations of wind turbines larger than 100-kW for the purpose of the AWEA U.S. Wind Industry Quarterly Market Reports. Annual capacity additions and cumulative capacity may not always add up due to decommissioned, uprated and repowered wind turbines. Wind capacity data for each year is continuously updated as information changes.

American Wind Energy Association | **U.S. Wind Industry First Quarter 2016 Market Report** | AWEA Member Version 4

Annual U.S. Electricity-Generating Capacity Additions



- New wind capacity represented 41% of all new capacity installed in 2015.
- Wind energy has been a major contributor to new generation every year since 2007 except 2013.
- All renewable capacity combined represented nearly 70%.
- Over the past 4 years combined, wind energy represented 35% of all new generating capacity installed.

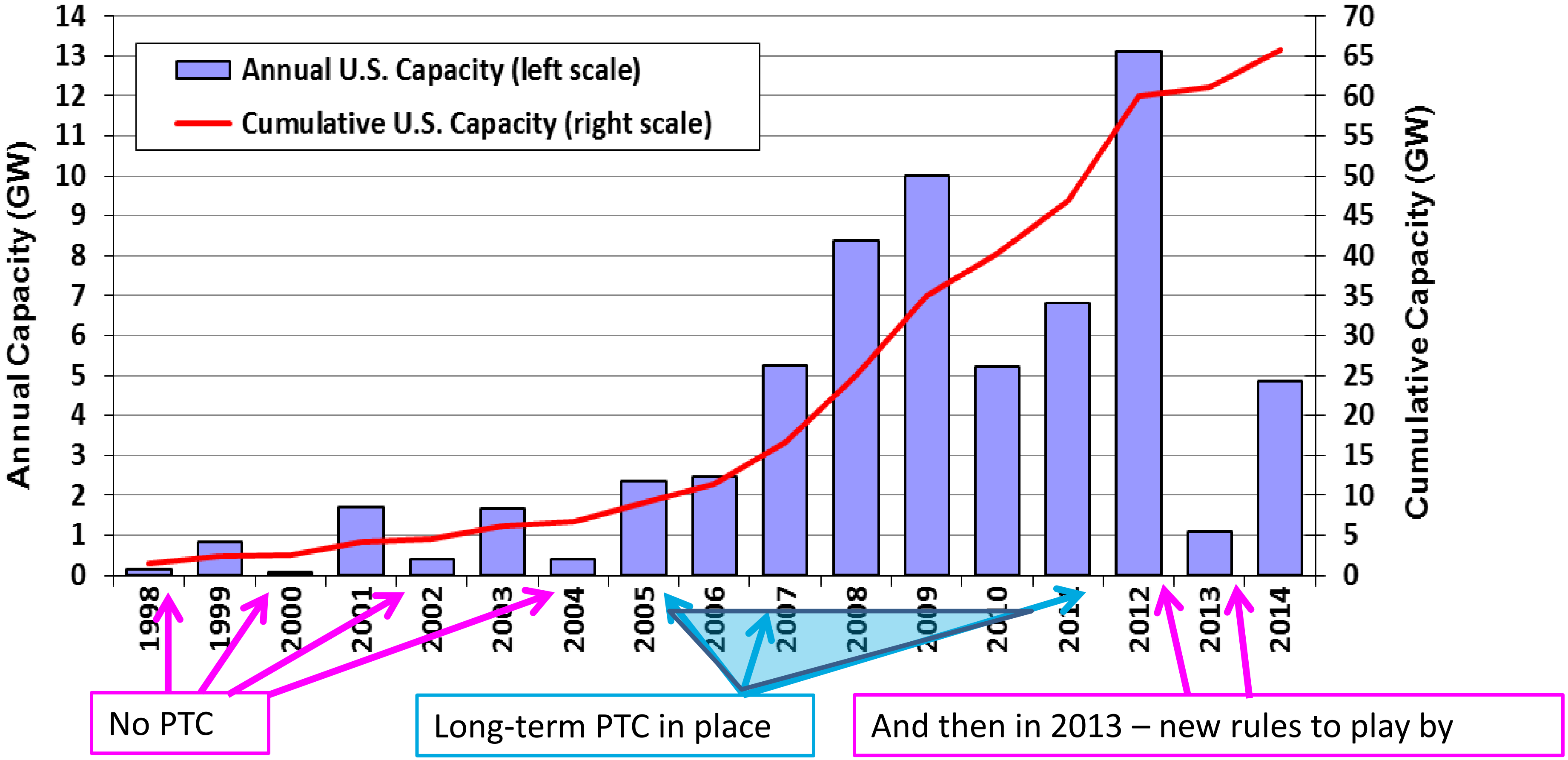
Source: *2014 Wind Technologies Market Report*. Wiser, R.; Bolinger, M. (August 2015). http://www.nrel.gov/docs/fy15osti/64522.pdf

Wind Capacity Additions

2014: 4,854 MW 2015: 8,598 MW

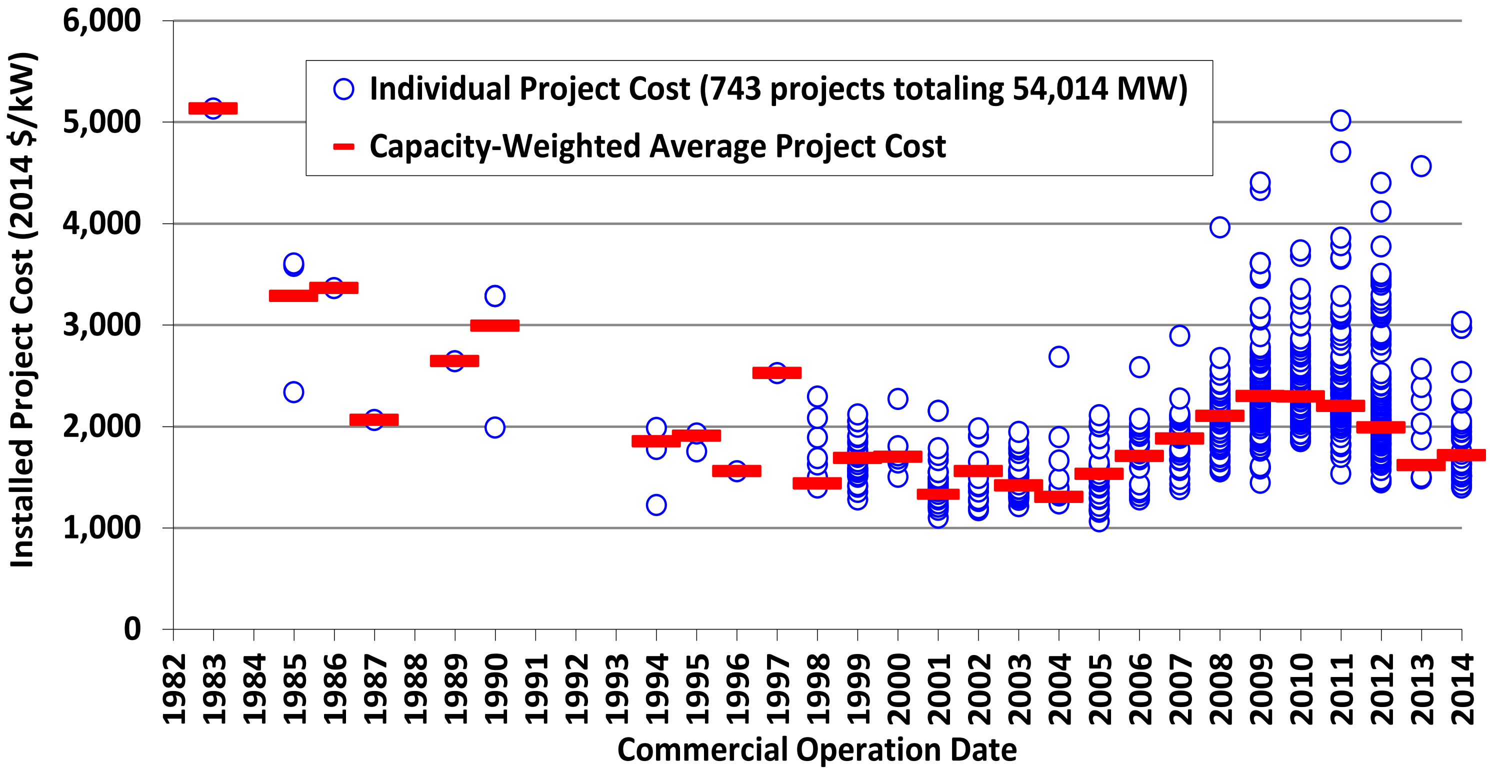
Does policy make a difference?

Historical context: Production Tax Credit was in place in 1999, 2001, 2003, and 2005 - 2008, then extended to 2012.



Source: *2014 Wind Technologies Market Report*. Wiser, R.; Bolinger, M. (August 2015). http://www.nrel.gov/docs/fy15osti/64522.pdf

Installed Cost Range for Wind Turbines

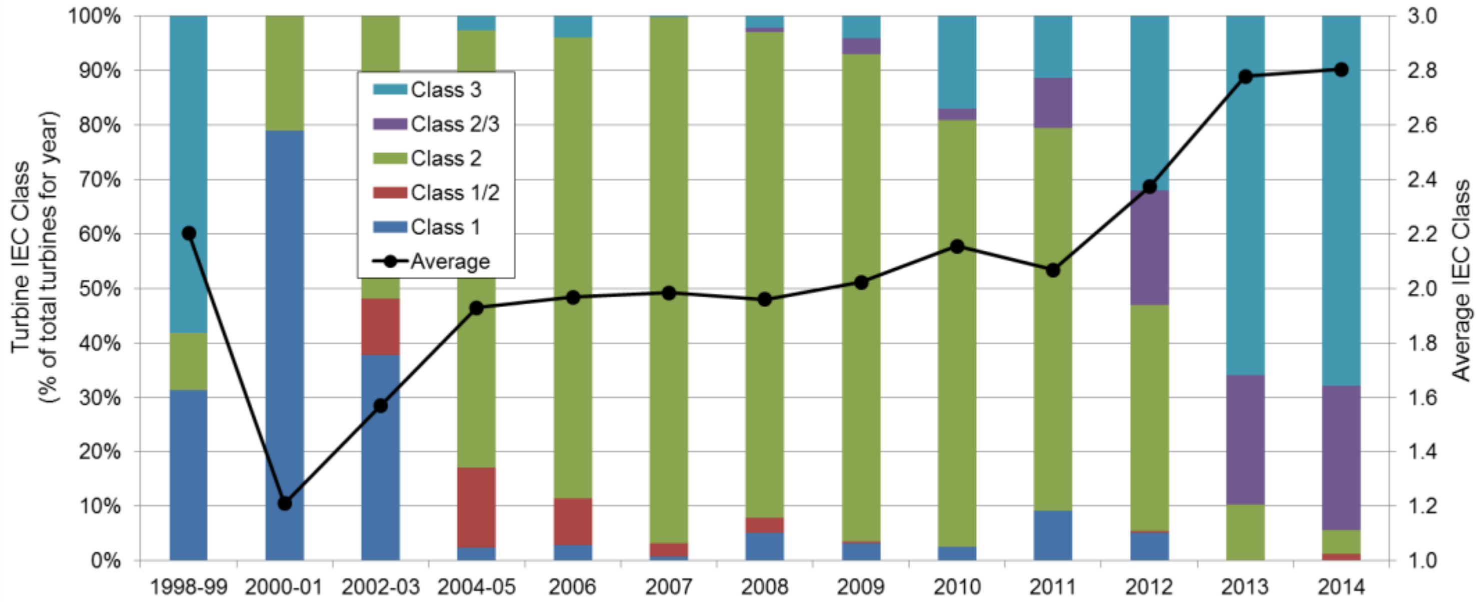


- 2014 projects had an average cost of $1,710/kW, down $580/kW since 2009 and 2010 (up slightly from small sample of 2013 projects)
- Limited sample of under-construction projects slated for completion in 2015 suggest no material change in costs

Source: *2014 Wind Technologies Market Report*. Wiser, R.; Bolinger, M. (August 2015). http://www.nrel.gov/docs/fy15osti/64522.pdf

Turbines Originally Designed for Lower-Wind-Speed Sites Have Rapidly Gained Market Share

IEC Class

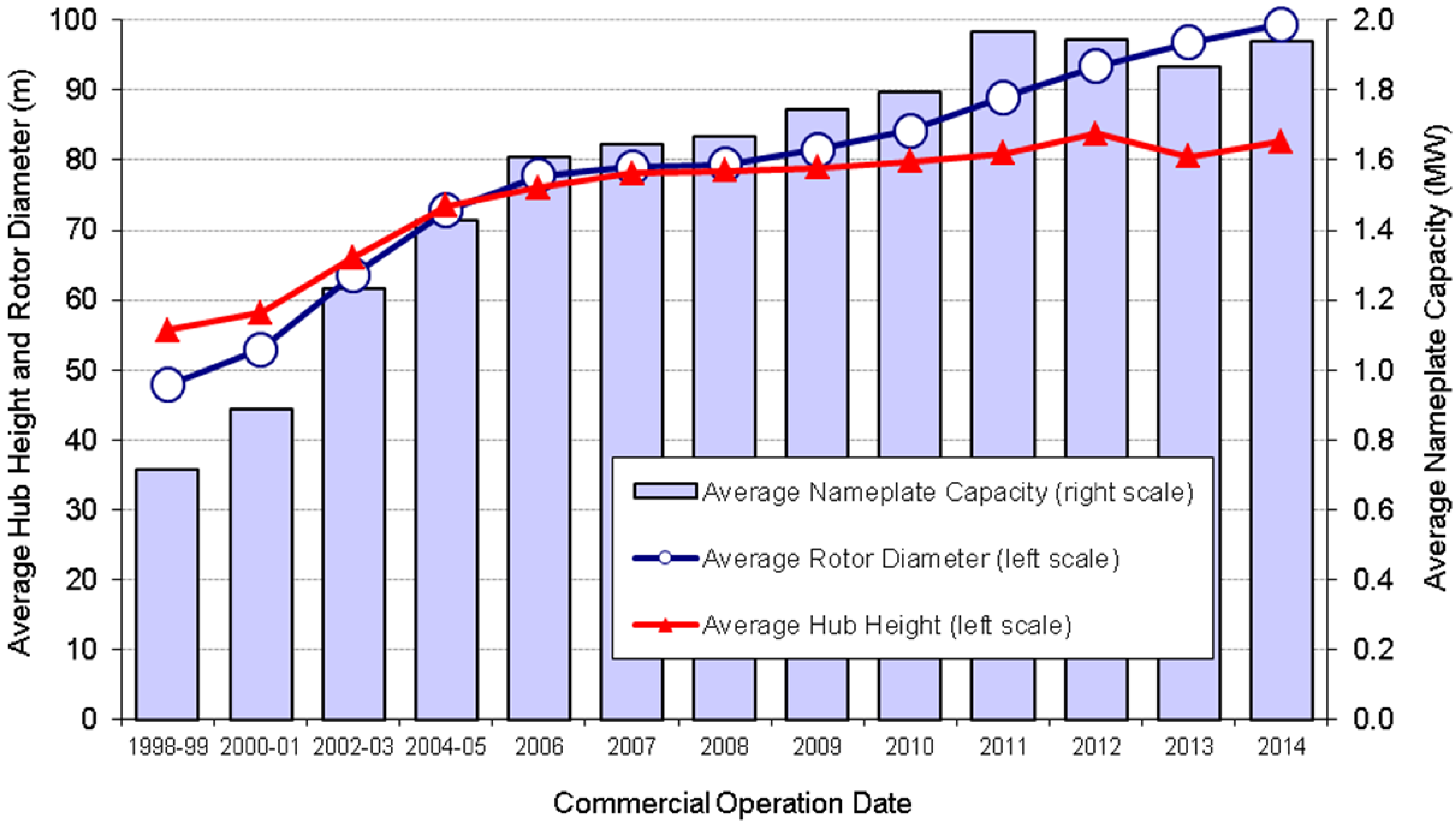


Improved controls increase the range of deployment opportunities for a given turbine type. An IEC Class III turbine designed for a mean wind speed of 7.5 m/s can be safely deployed at windier sites.

Many of the best wind sites were developed in the past 10 to 15 years. More turbines (Class III and IV) are being deployed at sites previously dismissed as not being windy enough.

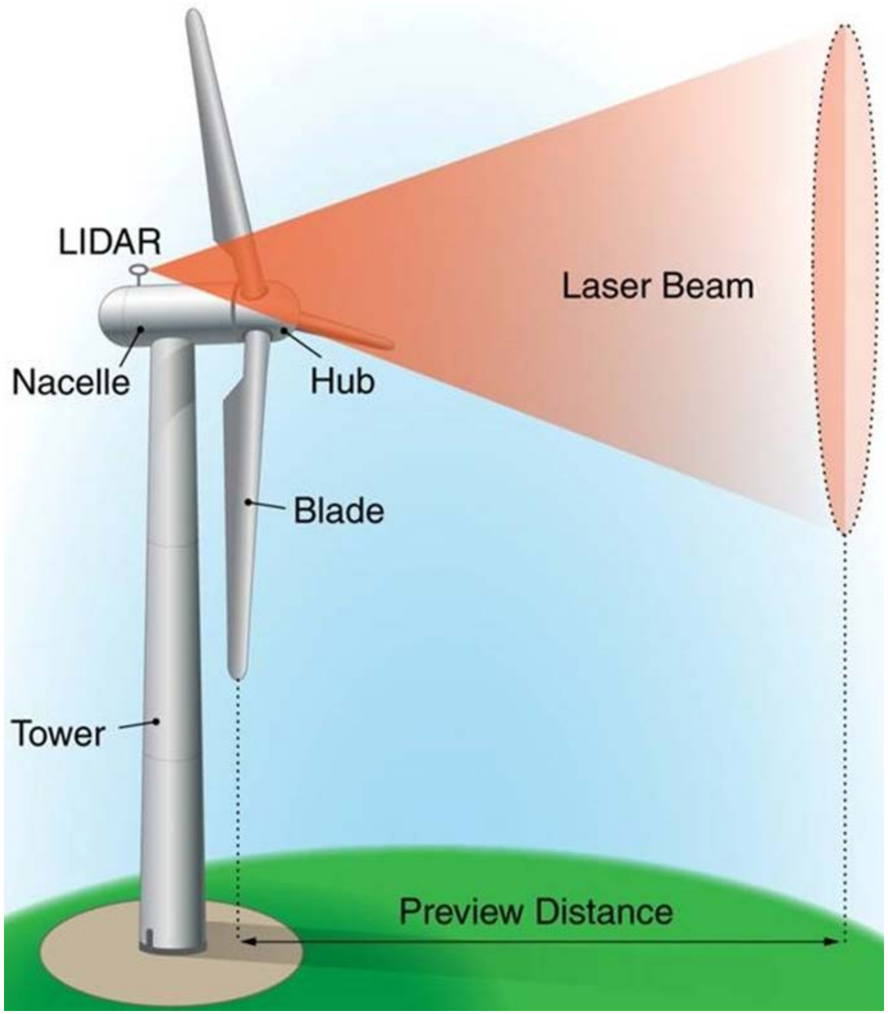
Source: *2014 Wind Technologies Market Report*. Wiser, R.; Bolinger, M. (August 2015). http://www.nrel.gov/docs/fy15osti/64522.pdf

Wind Turbine Size Trends: Where and Why



Source: *2014 Wind Technologies Market Report*. Wiser, R.; Bolinger, M. (August 2015). http://www.nrel.gov/docs/fy15osti/64522.pdf

New Approach to Increase Energy Capture



Rendering: Al Hicks, NREL

Lidar-informed control algorithms

- Use lidar oriented horizontally to inform on wind speed and turbulence into the rotor
- Individually pitch the blades to maximize energy capture
- If turbulence factors are high, adjust pitch to minimize the loads, contributing to lowering turbine wear and O&M costs.

Source: *Introduction to lidar-assisted control of wind turbines*. Scholbrock, A. (July 2016). IEA Wind Task 32 Workshop – Optimizing Lidars for Wind Turbine Control Applications

Lidar – **L**ight **d**etection **a**nd **r**anging

New Approach to Increase Energy Capture

Wake impacts:

Impact of turbine wakes on downwind turbines is greater than originally modeled

Impact on downwind turbines:

- Reduced energy capture
- Increased turbulence on turbine.

Photo from Uni-Fly A/S

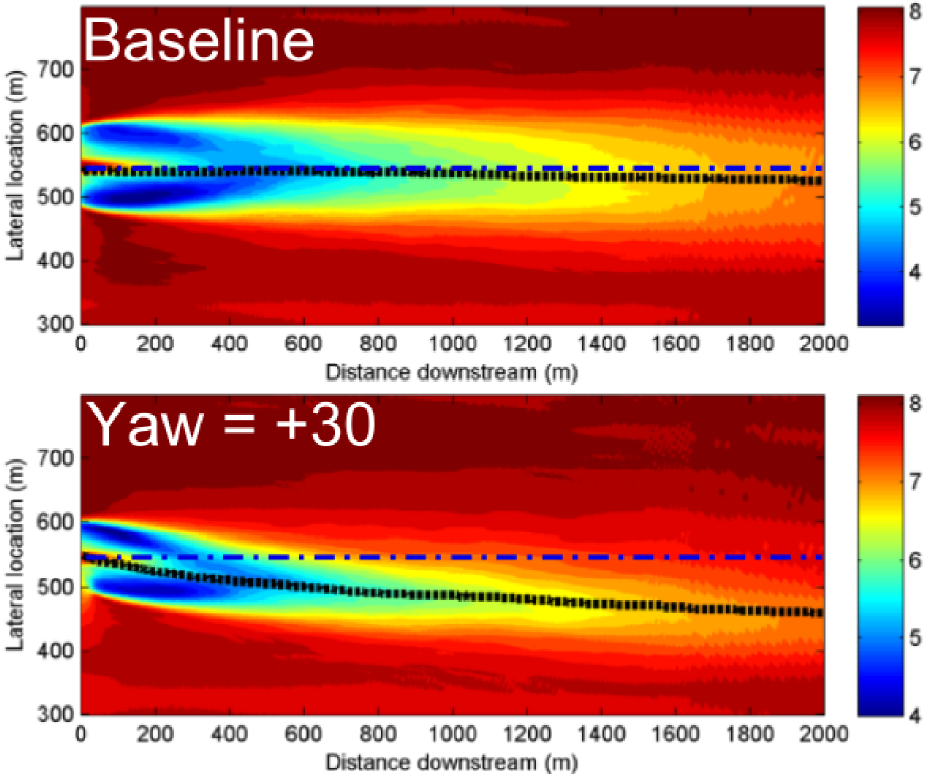
New Approach to Increase Energy Capture

Wake steering:

- **Yaw-based**
- Tilt-based wake steering
- Pitch-based wake steering

Results:

- Reduced loads on the turbine
- Increased power production
- Working to optimize throughout entire wind farm



Source: *Wind Farm Control Research*. P. Fleming (March 2016)

Financing Options at Federal Facilities

Sampling of Recent Federal Wind Projects

Site	Manufacturer	Turbine Rated Power	Rotor Dia-meter	Hub Height	# of Turbines	Installed Cost	Installed Cost/kW	Funding Source	% of Site Load Met	Annual Savings
		kW	m	m	#	$ million	$/kW		%	$ thousand
Pantex	Siemens	2300	101	77	5	$55	$4,783	ESPC + Buy-down	60%	$2,800
JBCC - AFCEC	Furhlaender	1500	77	80	1	$4.87 *	$3,247	DERA +	80-90%	$1,500
JBCC - AFCEC	GE	1600	77	80	2	$9.4 **	$5,875	DERA		
Pave Paws	GE	1680	77	80	2	$8.5	$5,060	ECIP ++	74%	$600
Tooele	CPC	1500	77	65	1	$4.3	$2,867	ECIP	60-80%	$320
Tooele	GE	1790	101	80	1	$6.5	$3,631	ECIP		
USMC Barstow	AAER	1500	62	70	1	$4.6 ***	$3,067	UESC	30%	$515
Camp Williams	NEG Micon	225	30	30	1	$0.28	$1,240	NGB Readiness & State Energy Office	~17-24%	$43
Camp Williams	Vestas	660	47	50	1	$0.80	$1,215	ECIP & State Energy Office via FEMP		

* Included 2 year O&M package

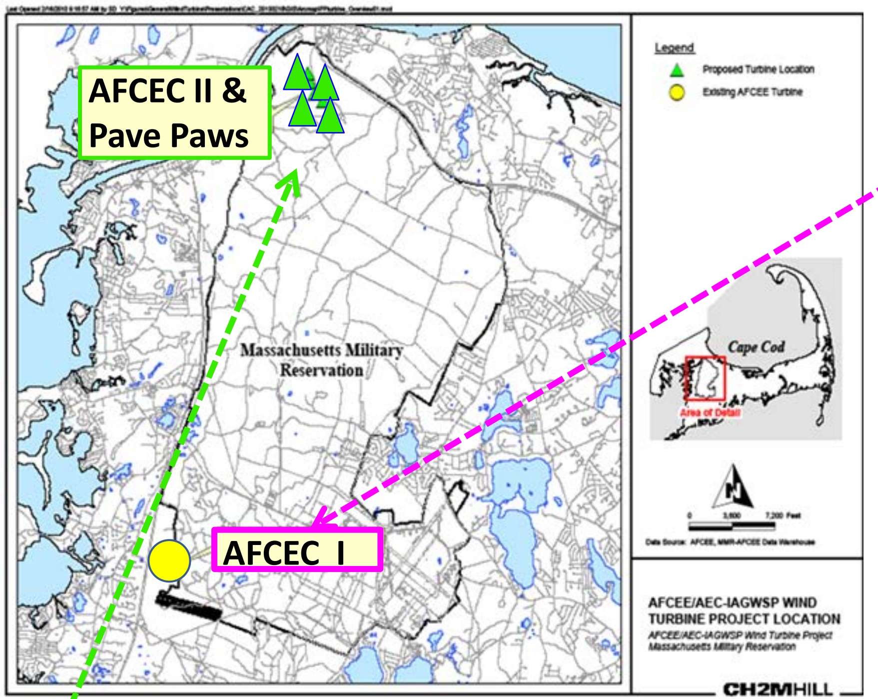
** Included 7.5MVA substation and 1 year O&M package

*** Cost was $6.1 million less $1.5 million rebate

+ DERA - Defense Environmental Restoration Account

++ ECIP - Energy Conservation Investment Program

Joint Base Cape Cod – Air Force Civil Engineering Center, MA



Source: AFCEC Wind Feasibility Study, 2009. Rose Forbes, Remediation Program Manager, Joint Base Cape Cod

JBCC Cape Cod, MA

First turbine: Furhlaender 1.5-MW turbine in 2009

Energy production: Good when working

Funding/finance: Defense Environmental Restoration Account (DERA)

Installation issues:

- Design specifications

O&M issues:

- O&M contractor & package: non-local, few U.S. turbines

Second and third turbines: GE 1.5-MW in 2011

Energy production: Very good

Funding/finance: Defense Environmental Restoration Account

AFCEC operations are now net zero (not full base)

LESSONS LEARNED – 1st Wind Project to 2nd Wind Project

Project	Timeline	Transport-ation	Installation	O&M	Energy Delivery
1st turbine	~ 5 years	Pathways & permits	Logistical errors	Ineffective contractor	Good when working
2nd & 3rd turbines	~ 2 years	As planned	As planned	Effective contractor	Exceed Expectation

Joint Base Cape Cod – Pave Paws Radar Station, MA

Installed 2 GE 1.7-MW turbines in 2011

Energy production: Exceeds expectations; intended to meet ~50% load, turbines have performed so well they meet ~75% of load

Funding/finance: Energy Conservation Investment Program (ECIP)

Capitalized on AFCEC's experience and support

Also great support from Space Command HQ

Pave Paws Radar Station and 4 GE wind turbines

Photo from Jeremiah Walsh, Massachusetts Army National Guard

LESSONS LEARNED:
Establish funding mechanism (escrow or other) for repairs ahead of time – waiting for approval, funds, contracting for repairs, etc. takes too much time.

Tooele Army Depot, UT

First turbine: CPC 1.5-MW turbine in 2010
Energy production: Good when working
Funding/finance: Energy Conservation Investment Program (ECIP)
Installation issues: Manufacturing quality control
O&M issues: Non-local O&M contractor and package

Photo by Robi Robichaud, NREL

Second turbine: GE 1.8-MW turbine in 2016
Resource assessment: Able to collect on-site wind data
Energy production: Very good
Funding/finance: ECIP

LESSONS LEARNED – 1st Wind Project to 2nd Wind Project

Project	Purchase	Manufacture	O&M	Energy Delivery
1st turbine	Funds limitation impacted choice	Quality control issues	Non- US-based	Good when working
2nd turbine	Enough funds for quality turbine	No issue	Effective contractor	Very good

Pantex Plant, TX

Photo by Robi Robichaud, NREL

Largest wind farm in federal fleet: Five 2.3-MW turbines -> 11.5-MW wind plant

Benefits: ~47 GWh/yr, 65% of electric load

Funding/finance: ESPC contract

Developed solutions to issues:

- Radar
- Ownership
- Institutional delays

O&M approach:

- 5-year O&M with warranty by Siemens
- Five additional 1-year options that can be exercised

LESSONS LEARNED:
Resolve interconnection logistics early as it can impact project development activities.
Establish escrow account for easier access to funds for "non-routine" repairs.

How to Develop a Successful Federal Wind Project

- **Identify a viable project:** wind resource, cost of electricity, suitable load, available land
- **Form a team:** energy/electricity, contracting, mission, public relations, facilities – develop allies
- **Develop strategy and timeline:** identify and meet with stakeholders, identify and discuss issues, communicate often with stakeholders
- **Keep moving forward:** be flexible, willing to compromise

How to Develop a Successful Federal Wind Project

Keys to success at JBCC: Remediation Program Manager **Rose Forbes**, an energetic champion with vision, resourcefulness, persistence, and diligence

Key meetings and activities included:

- Met with stakeholders individually and a multi-agency group to foster cross-agency communication
- Met with FAA, Air Force Space Command - Pave Paws Radar to explain project
- Met with media and conducted open public meetings to explain project parameters and intent.

Keys to success at Pantex: John Herrera, an energetic champion with vision, resourcefulness, persistence, and diligence (picked up by **Ashleigh Pope** as the project neared completion), and **contracts champion Johnnie Guelker**, who used multiple creative options to address challenges and keep the project moving.

Key meetings and activities included:

- Met with Site Operations and resolved radar issues
- Met with airport/FAA and found effective solution to height restriction
- Resolved budgeting issues when project installation moved more slowly than anticipated; reserved budget allocation for initial cost buy-down.

No one got "everything they wanted," but compromise solutions allowed these projects to move forward to successful completion.

Federal Wind – Civilian Agencies – Creative Approaches

Use Limited Funds for "Down Payments"

- Consider using agency budget for "down payment"; just like a mortgage
- After buydown, the wind project serves as a hedge against future electricity prices increases whether due to increased demand (population growth), carbon tax, or general inflation
- Instead of fully funding one turbine at $6 million
  - One 2-MW turbine –> agency net impact = 2 MW
- Provide $1 million-$2 million to three to six wind projects
  - Three to six 2-MW turbines -> agency net impact = 6 MW to 12 MW

Federal Wind – DOD – Creative Approaches

Spread the benefit of ECIP cash to more projects by limiting contribution to 10%-25% of project cost, not 100%

- ECIP funding – instead of funding the entire project (for ~$10 million)
  - Sample result: Two 1.5-MW turbines at one base –> net impact = 3 MW
- Fund 4-5 DOD bases for $2 million to $2.5 million each from ECIP, finance the balance with ESPC
  - Sample result: four to five wind projects with two 1.5-MW turbines each –> net impact = 12 MW to 15 MW

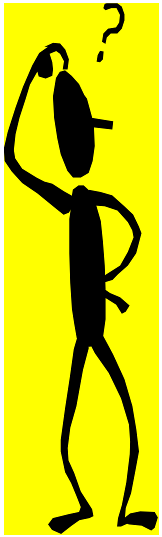
Federal Wind – DOE – Creative Approaches

- **DOE-assisted financing:**
  - Create "revolving loan fund" for federal agencies
  - Require agencies to contribute a 10% to 30% down payment to ensure positive cash flows for loan repayment
  - DOE finances the balance; low-interest, low-risk loans to federal agencies
  - Repayments are put back into the pool of funds available for other federal renewable energy projects
  - Paid for by 2% to 3% loan rate

Questions?

For more information:

- http://www.nrel.gov/wind/
- http://apps2.eere.energy.gov/wind/windexchange/
- http://www.nrel.gov/wind/market_acceleration.html
- http://www.awea.org/



Robi Robichaud
Senior Energy Engineer, Wind and Water Deployment
robi.robichaud@nrel.gov
303-384-6969
NREL, 15013 Denver West Parkway
Golden, CO 80401-3305