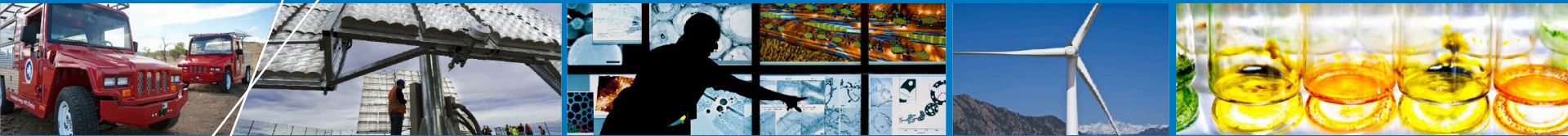


Distributed Wind Cost Reduction: Learning from Solar



Suzanne Tegen, NREL

Distributed Wind Energy Association

**Distributed Wind 2016 Business Conference & Lobby Day
Washington, D.C.
February 23, 2016**

Overview

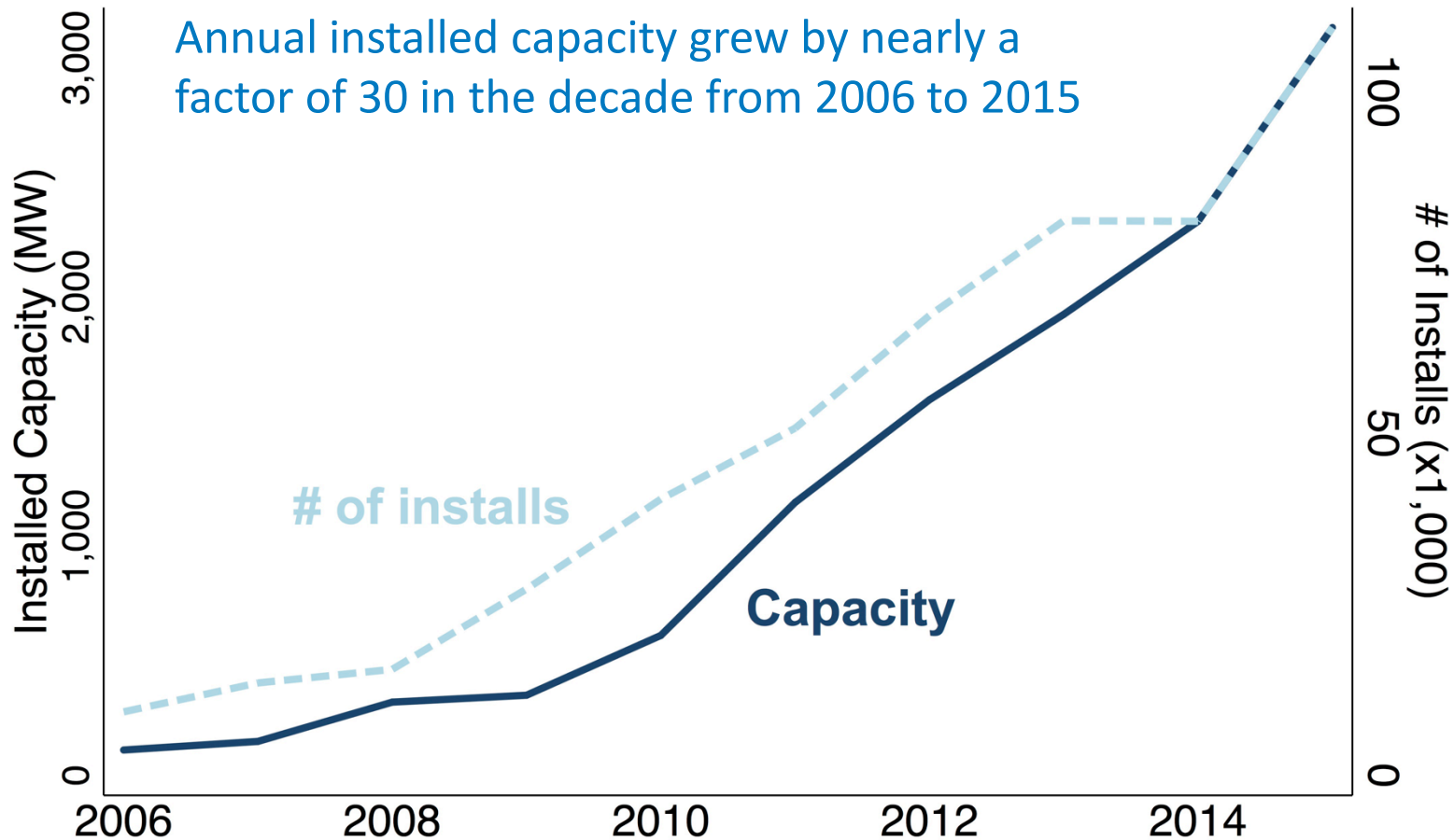
- Solar industry successes and lessons
- Recommendations from the distributed wind (DW) industry: how to reduce costs
- DW taxonomy
 - Equipment
 - Installation
 - Supply chain, transportation, and logistics
 - Site engineering and design
 - Regulatory requirements
 - Operations and maintenance (O&M).
- Next steps in U.S. Department of Energy (DOE) DW soft costs reduction work
- Potential 2016 products for the DW industry.



DW soft costs work is based on successful work from

Solar Industry Successes & Lessons

Solar PV Market Growth



Installed Capacity (MW) and # of Installs for Residential and Non-Residential PV Systems from 2006-2015

Sources: GTM/SEIA 2015; LBNL *Tracking the Sun* data

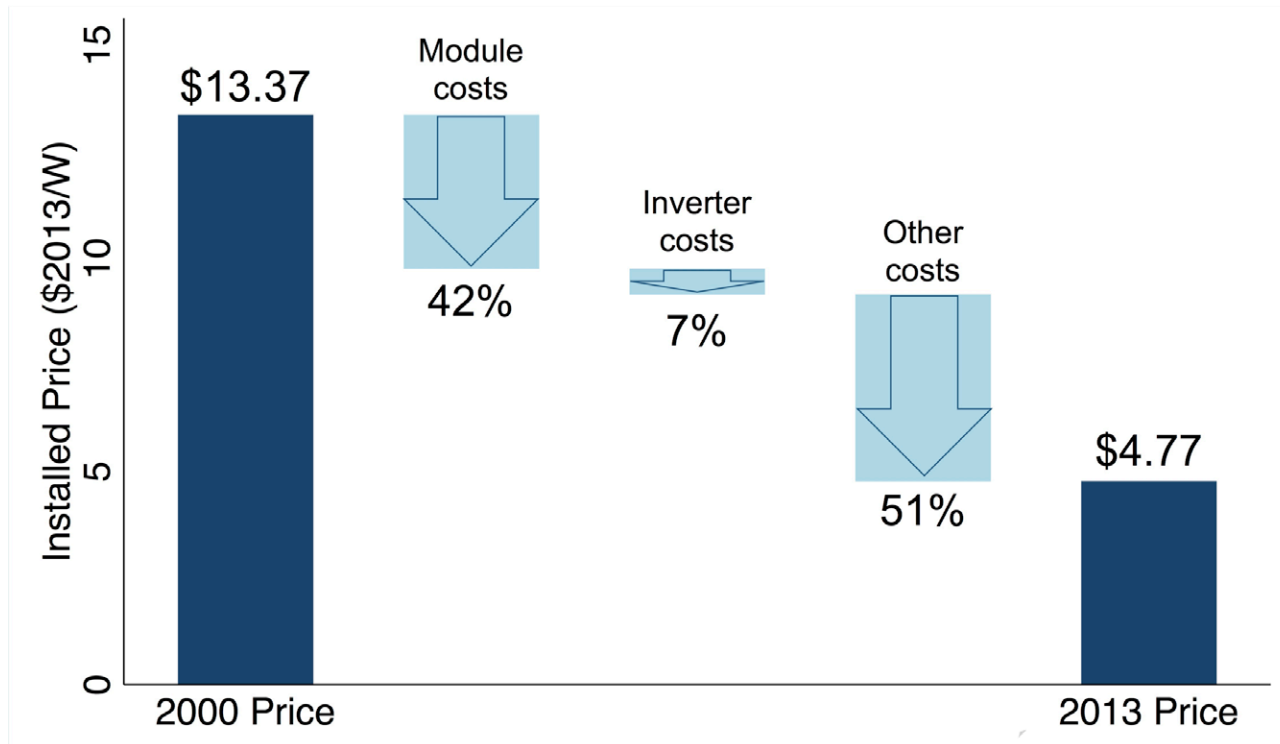
Solar Market Update

- **System prices continue to drop.**
- **Inverter prices have fallen by more than 50% from 2010.**
- **Global PV module costs fell 6% in 2015.**
- **Hardware cost reductions have been historically important, but future cost reductions may come mostly from soft costs.**
- **Permitting, inspection, and interconnection costs may see continued reductions due to expediting permitting reforms at the state level.**
- **Some soft costs (e.g., customer acquisition) may increase in coming years.**

Sources: Chung et al. 2015; Feldman et al. 2016; Nemet et al. 2016

Drivers in Solar Cost Reductions

A combination of hardware and soft cost reductions is driving down installed system prices.



Components of Solar PV System Price Reductions from 2000 to 2013

Source: Nemet et al. 2016

Solar PV Soft Costs Work – DOE SunShot

Overview

Through industry surveys, interviews, and cost modeling, the National Renewable Energy Laboratory's (NREL's) PV soft costs benchmarking helped to establish a standard set of cost definitions and quantify previously unknown costs. In support of the DOE SunShot Initiative, this work was completed in two phases:

Phase 1: Benchmark 2010 Installed Costs

Conducted industry surveys and interviews to create taxonomy and gather data on the following soft cost categories for residential and commercial PV:

- Customer acquisition
- Permitting, inspection, interconnection
- Installation labor
- Labor re: third-party financing.

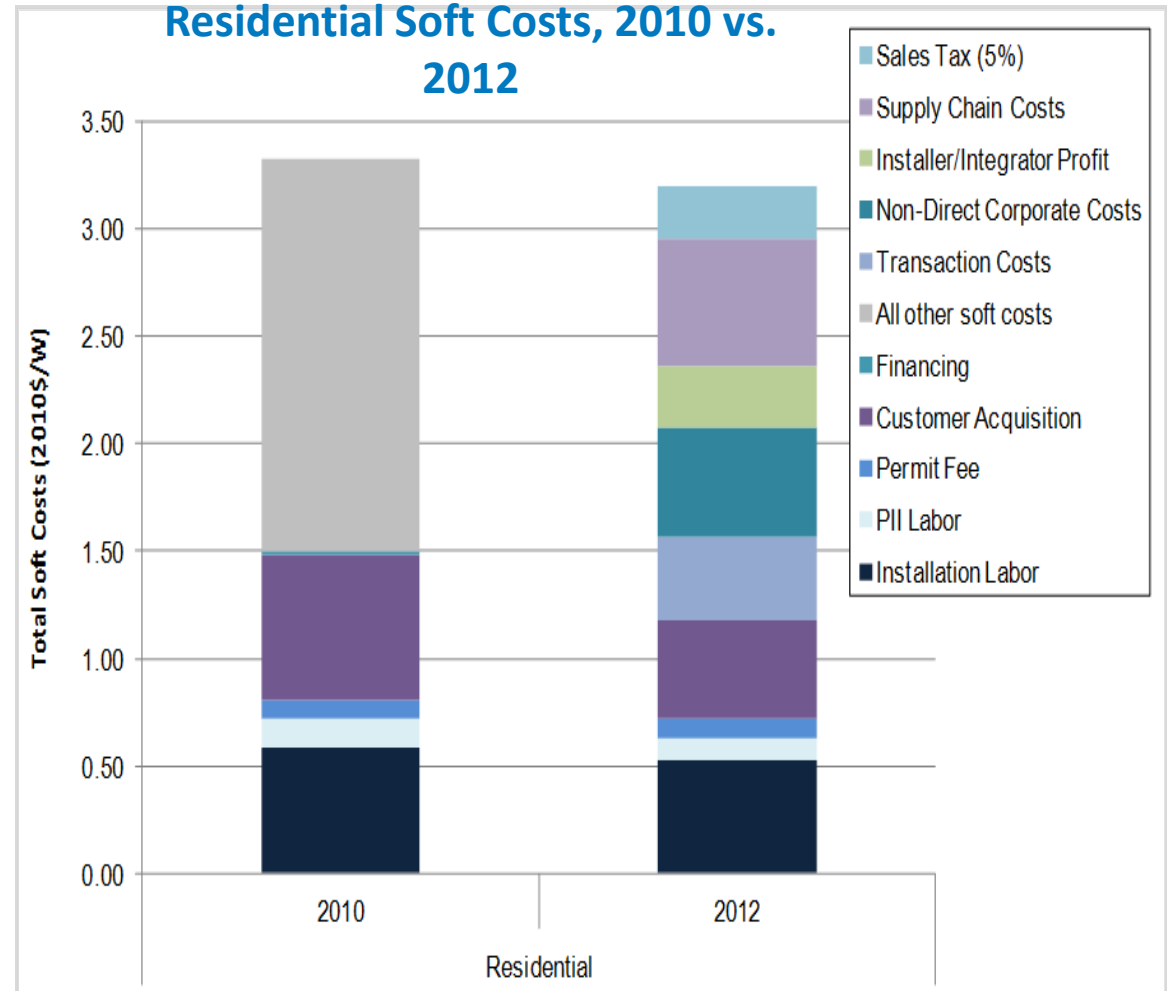
Phase 2: Benchmark 2012 Installed Costs and Disaggregate “Other Soft Costs”

Disaggregated soft costs further by breaking down “other soft costs” into following categories:

- Sales tax
- Supply chain costs
- Installer/developer profit
- Non-direct corporate costs
- Transaction costs.

PV Phase 2: Disaggregate “Other Soft Costs”

- Provided detail on “other soft costs” by breaking out sales tax, supply chain costs, installer/integrator profit, non-direct corporate costs, and transaction costs
- Multiple methods would be required to further elicit soft costs, including in-depth interviews and cost modeling.



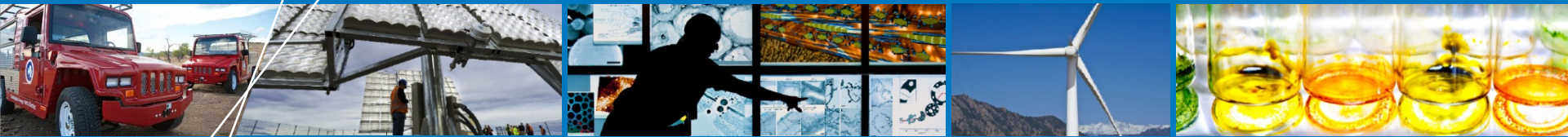
What Have We Learned from Solar?

We've learned a lot. For this project:

- **First, benchmark where we are today.**
- **When the DOE Solar Program knew what to work on, the benchmarking data provided justification to allocate funding to soft costs.**
- **Listen to industry members. They know how to reduce costs.**



Photo from Roy Rakobitsch / Windsine Inc., NREL 26789



We're Listening: Industry Suggestions for Reducing Soft Costs

Sample Installation Cost Reduction Opportunities

- **Investigate possible lessons learned** for large wind met tower installations that could apply to small wind turbines
- **Simplify tower design requirements** by further researching most-constraining design loads
- **Research/develop improved lower-cost, free-standing tower designs** for taller towers
- **Develop more modular turbine designs** that allow the use of smaller cranes
- **Develop crane-free or tilt-up turbine installation designs** for commercial and mid-sized turbines
- **Develop a cantilevered, cross-based approach** for concrete-free small wind towers
- Others?



Photo from Nathan Broaddus, NREL 30095

Sample Zoning Permitting Inspection Interconnection (ZPII) Cost Reduction Opportunities

- **Publish much-needed handbooks, factsheets, and reference materials** on DW issues to educate stakeholders; this may require conducting new research on specific topics
- **Establish DW Permitting Resource Center**
- **Fund regional experts to attend local meetings**
- **Summarize state permitting policies**
- **Establish credentialing process/programs for people and turbines** beyond what is currently available
- **Others?**

Sample Financing & Contracting Cost Reduction Ideas

- **Support the development of turbine reliability tracking** to improve financing terms
- **Develop and implement models** that have worked for the solar industry: wind gardens, privately owned community wind, community net metering, etc.
- **Develop and implement lower-cost/higher-reliability resource assessment** (higher reliability production estimates)
- Others?



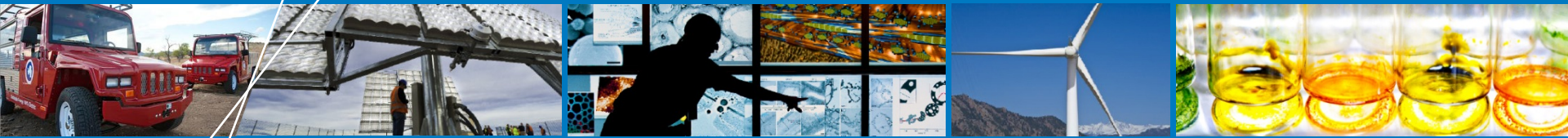
Photo from Westwind Solar Electric, Inc., NREL 18820

Sample O&M Cost Reduction Opportunities

- **Address issues surrounding the lack of on-site cranes**
- **Put crane as close to the tower base as possible**
- **Develop interactive monitoring systems to help identify scheduled and unscheduled maintenance issues**
- **Develop a DW reliability/O&M database**
- **Others?**



Photo from Town of Hempstead, NREL 28964



DOE/NREL/PNNL DW Soft Costs

DOE DW Soft Costs Overview

Key challenge: The U.S. DW industry identified high, non-hardware, balance-of-system soft costs as a barrier to DW system deployment. We do not have industry-wide cost details of installed DW turbine systems.

Key opportunity: Follow efforts undertaken by the solar industry, largely under the U.S. DOE SunShot Initiative, to understand and then reduce soft costs associated with DW technologies.



Photo from Byers and Renier Construction, NREL 18820

DOE/NREL/PNNL Soft Costs

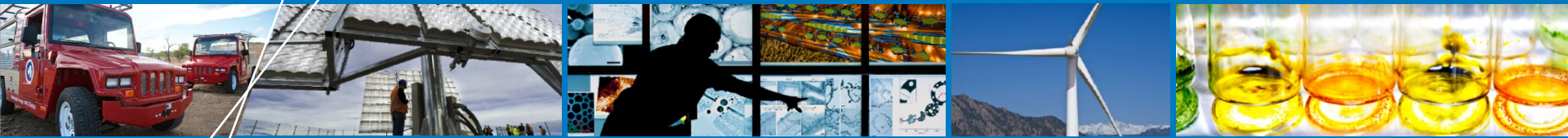
- Develop DW taxonomy based on industry input
- Use known data sets and select industry data to proof test and populate a DW soft cost draft database
- Make this compatible with Pacific Northwest National Laboratory's (PNNL) master DW database
- After 2016: Develop a technical report documenting the DW taxonomy data summarizing the direct and indirect, non-hardware, balance-of-system costs.

DW Soft Cost Taxonomy – First Tier

- Turbine system equipment
- Installation
- Supply chain, transportation, and logistics for turbine
- Sales tax (material, labor, local, state, etc.)
- ZPII/regulatory requirements
- Site engineering and design
- Financing
- Customer acquisition
- Installer overhead and profit (not otherwise covered)
- Other (installation-related) costs
- O&M.



Photo from Gwen Bassetti, NREL 26430



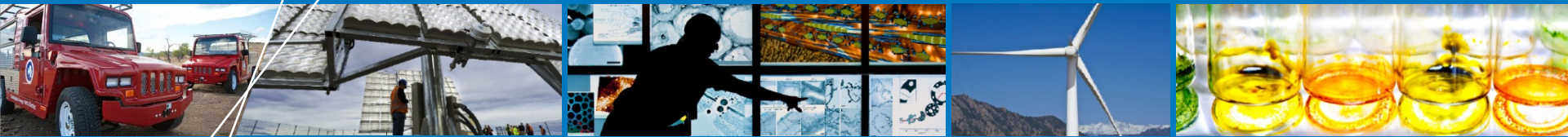
Key Findings of Early Soft Costs Efforts

Key Findings on Soft Cost Data Gathering

- **Data gathering methods must be tailored to the data type being collected.** As demonstrated by the PV assessments, different types of information may require different data collection methods. For example, surveys were used to gather data on permitting, inspection, and interconnection costs, while indirect corporate and financing costs were estimated by modeling.
- **Don't try to do it all at once.** The PV soft costs work required multiple phases over a number of years.
- **“Soft costs” mean different things to different stakeholders.** Soft costs are associated with turbine manufacturing and assembly, turbine system installation, and O&M activities. The PV soft costs effort focused on installation-related soft costs only.
- Efforts to collect data on O&M costs are also a high priority that should be considered in the near term.

Key Findings on Soft Cost Data Gathering

- Zoning is a big issue for DW. We added “zoning” to permitting, inspection, and interconnection (PII → ZPII). Compared to permitting, zoning is more political and personal. For example, an inspector can’t withhold an electrical permit if the work in question complies with the electrical code. A zoning board can deny a variance if enough neighbors complain about a proposed installation.
- Benchmarking for DW is more complicated than for PV due to large variance in sizes, installation, and often rural locations.



Our Next Steps

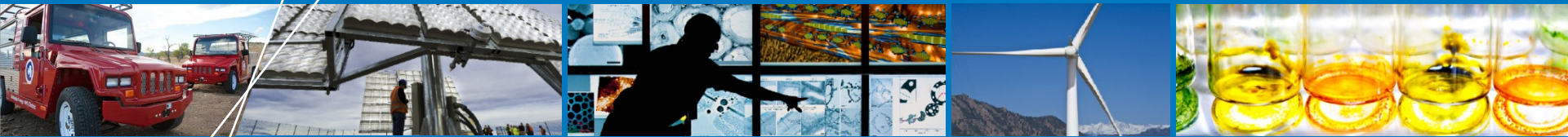
Coming Up

2016

- Build draft database based on taxonomy
- Proof-test draft database for DW soft costs taxonomy (PNNL, NREL)
- Present to industry at Small Wind Installers Conference
- *Develop soft cost informational products for industry and stakeholders.*

Potential future activities:

- Benchmark DW soft costs based on data collection
- Produce technical report soft cost benchmark
- Analyze soft cost reduction opportunities
- Perform detailed studies on soft costs data needs
- Develop soft cost reduction activities and products.



Thank you

The lab team: Suzanne Tegen, Ian Baring-Gould, Tony Jimenez, Alice Orrell, Robert Preus, Trudy Forsyth, Ruth Baranowski, Frank Oteri, Corrie Christol

Turbine System Equipment (1 of 2)

Turbine system equipment

- Turbine system: generator, gearbox, mechanical and over-speed systems, etc. (materials, labor, purchased sub-components)
- Blades: unless included in turbine system (materials, labor, purchased sub-components)
- Nacelle assembly: nacelle assembly could include blades and other (materials, labor, purchased sub-components)
- Inverter/power electronics/controls/monitoring (materials, labor, purchased sub-components)
- Tower (materials, labor, purchased sub-components)
 - Tower parts
 - Anchor bolts (includes embedment rings).
- Manufacturing overhead
 - Rental, real estate (office, factory/workshop, storage)
 - Rental/ownership, manufacturing equipment (vehicles, tools, heavy equipment)
 - Supply chain and quality assurance.



Photo from McKinstry, NREL 26778

First Tier

- Second Tier
- Third Tier

Note: Sum of the costs for items within turbine system equipment is known as “Cost of Goods Sold” (COGS)

Turbine System Equipment (2 of 2)

Turbine system equipment (continued)

• Engineering

- Engineering product development and testing
- Turbine certification
- Engineering product support
- Equipment due diligence
- Remote fleet monitoring.

• General and administrative

- Executive and administrative labor
- Customer acquisition (marketing, advertising, sales)
- Office and non-manufacturing equipment expenses
- Workforce training
- Insurance
- Warranty costs
- Profit.



Photo from Gary Harcourt, NREL 35609

First Tier

- **Second Tier**
- Third Tier

Installation (1 of 2)

Installation

- **Site preparation**
 - Site prep labor
 - Site prep equipment
 - Site prep material
- **Foundation installation**
 - Foundation labor
 - Foundation equipment
 - Foundation material
- **Electrical system installation**
 - Electrical system labor
 - Electrical system equipment
 - Electrical system material.



Photo from Gary Harcourt, NREL 35608

- First Tier**
- **Second Tier**
- Third Tier

Installation (2 of 2)



Installation (continued)

- **Turbine installation**

- Turbine installation labor
- Turbine installation equipment
- Turbine installation material

- **Commissioning**

- Commissioning labor
- Commissioning equipment
- Commissioning material

- **Other installation related (e.g., fleet control, monitoring)**

- Other labor
- Other equipment
- Other material.

First Tier

- **Second Tier**

- Third Tier

Photo from Gary Harcourt, NREL 35607

Supply Chain, Transportation, and Logistics

Supply chain, transportation, and logistics

Transport to customer location

- Shipping (to installer warehouse or directly to customer from OEM)
 - Delivery (to customer if not shipped direct from OEM)
 - Warehousing/storage.
- Intermediary markups (difference between OEM invoice and cost to customer).



Photo from Stephanie Lively, NREL 16147

First Tier

- **Second Tier**
- Third Tier

ZPII/Regulatory Requirements (1 of 2)

ZPII/Regulatory Requirements

- **Zoning (e.g., attending zoning hearings by dealer/installer)**
 - Labor for community and approval official education
 - Labor (includes filing applications; preparing for and participating in zoning hearings)
 - Fees (for application, hearings, etc.)
 - Other (including travel expenses).
- **Permitting (environmental, Federal Aviation Administration, building, electrical, etc.)**
 - Labor (includes filing paperwork; preparing for and participating in meetings)
 - Consultants
 - Fees (for all permits or permit applications other than zoning)
 - Other (anything else including travel expenses).
- **Inspection (typically building and electrical)**
 - Labor (includes filing paperwork; preparing for and participating in meetings)
 - Fees (inspection charges)
 - Other (including travel expenses).

First Tier
• **Second Tier**
○ Third Tier

ZPII/Regulatory Requirements (2 of 2)

ZPII/regulatory requirements (continued)

- **Utility interconnection (interconnection agreement and inspection)**
 - Labor (includes filing applications; preparing for and participating in zoning hearings)
 - Fees (for interconnection agreement, inspection, interconnection analysis)
 - Interconnection studies
 - Other (any additional insurance required for interconnection, other).
- **Incentives processing**
 - Labor (includes filing applications; preparing for and participating in zoning hearings)
 - Fees (application fees)
 - Consultant/legal advisor (likely if incentive is tax based)
 - Other (any additional insurance required for incentive qualification, other).



Photo from Gary Harcourt, NREL 35606

First Tier

- **Second Tier**
- Third Tier

Site Engineering and Design

Site engineering and design

- Site assessment (wind resource; soils, roads, and trees; access and assembly evaluation; availability to utility connection)
- Site plans/layout
- Electrical design
- Geotechnical report
- Foundation design
- Stamped tower structural.



Photo from Kodiak Electric Association, NREL 16796

First Tier

- Second Tier
- Third Tier

Financing and Customer Acquisition

Financing

- Financing acquisition costs – access to financing (e.g., due diligence by developer and/or OEM)
- Transaction costs (e.g., equity fee, loan origination fee)
- Interest
- Grant applications, etc.

Customer Acquisition

- Marketing
- Advertising.



Photo from Byers and Renier Construction, NREL 18815

First Tier

- Second Tier
- Third Tier

Overhead, Sales Tax, Other

Installer overhead and profit (not otherwise covered)

- Office rental and expenses
- Administration labor
- Workforce training
- Licensing, bonding, insurance
- Other overhead
- Profit.



Photo from Bergey Wind Power, NREL 11996

Sales tax (material, labor, local, state, etc.)

Other soft costs

First Tier

- Second Tier
- Third Tier

O&M (1 of 2)

O&M

- **Scheduled maintenance**

- Labor
- Equipment rental
- Equipment mobilization
- Consumables
- Parts
- Internet connectivity
- Travel
- Subcontracted tech services
- Other.



Photo from Chris Brooks, NREL 16743

First Tier

- **Second Tier**
- Third Tier

O&M (2 of 2)

O&M (continued)

- **Unscheduled maintenance**
 - Labor
 - Equipment rental
 - Equipment mobilization
 - Consumables
 - Parts
 - Internet connectivity
 - Travel
 - Tech services
 - Other.
- **Service contract/warranty**
- **Owner insurance (liability/umbrella, bird take, etc.)**



Photo from McKinstry, NREL 26781

- | |
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| First Tier <ul style="list-style-type: none">• Second Tier○ Third Tier |
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