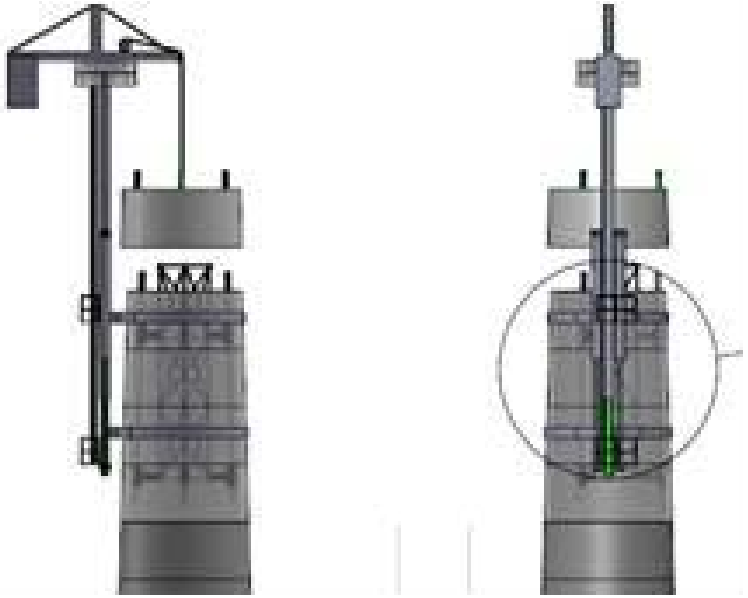
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Small Business Vouchers - Tower Technology

Project ID #T21



Paul Veers

NREL

FY17-FY18 Wind Office Project Organization

"Enabling Wind Energy Options Nationwide"

Technology Development	Market Acceleration & Deployment
Atmosphere to Electrons	Stakeholder Engagement, Workforce Development, and Human Use Considerations
Offshore Wind	Environmental Research
Distributed Wind	Grid Integration
Testing Infrastructure	Regulatory and Siting
Standards Support and International Engagement	
Advanced Components, Reliability, and Manufacturing	

Analysis and Modeling (cross-cutting)

Project Overview

T21: Small Business Vouchers - Tower Technology

Project Summary

- As part of the DOE's Small Business Vouchers Pilot, leverage and develop NREL's expertise in the evaluation of system impacts of technology innovations to support a new wind energy technology developed by Wind Tower Technologies (WTT).
- NREL provided WTT with a techno-economic evaluation of how their innovative self-erecting concrete tower (SECT) system compares to traditional technology.
- SECT will address challenges for tall wind that are associated with traditional cranes and their limitations in terms of both logistics and costs for installing turbines with hub heights of 140 m and greater.

Project Objective & Impact

- The objective of this project is to conduct an economic analysis of wind farm construction under traditional technology and self-erecting concrete tower technology.
- This work will inform WTT about the competitiveness of their technology under different scenarios and significantly enhance the ability for DOE and NREL to analyze a wide variety of innovations enabling tall wind installations.

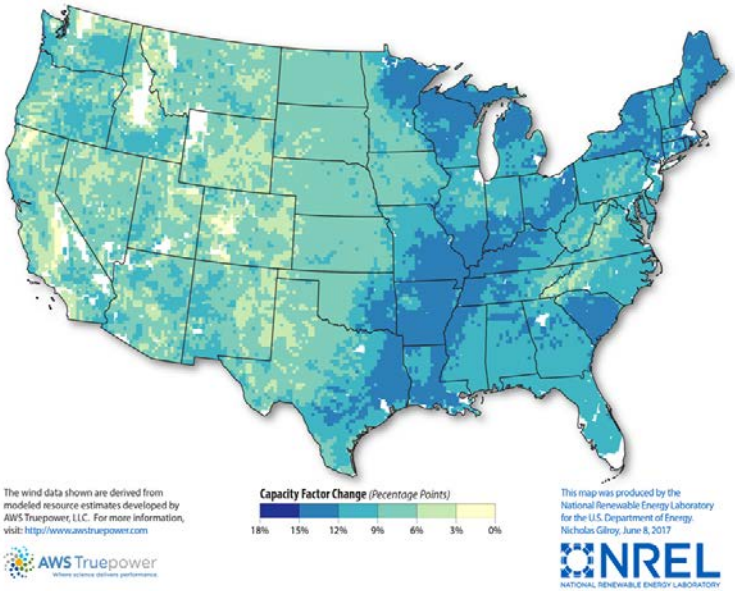
Project Attributes

Project Principal Investigator(s)
Katherine Dykes
DOE Lead
Alex Lemke
Project Partners/Subs
Wind Turbine Technology (WTT)
Project Duration
FY18 Q1 – Q3

Technical Merit and Relevance

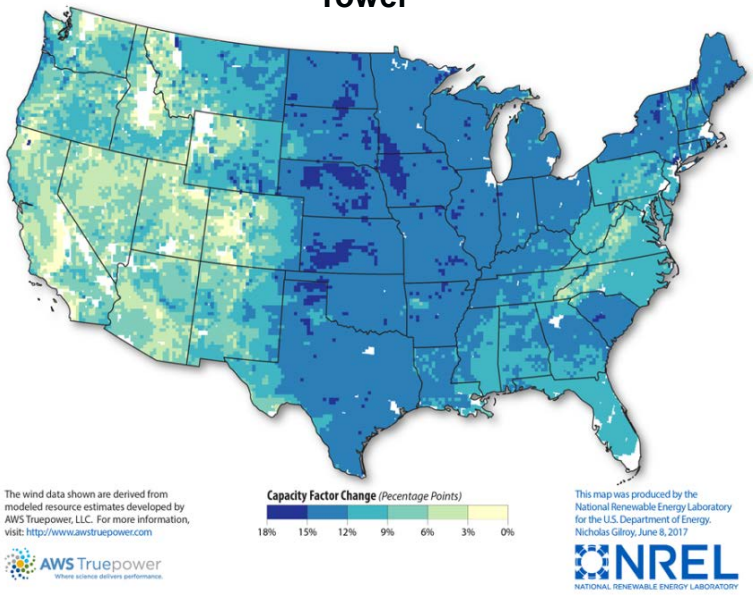
- **Enabling tall tower technology will increase deployment opportunities for wind energy nationwide:**
  - Higher hub heights (approaching 140 m or more) increase access to higher wind speeds with significantly higher energy capture

Change in Net Capacity Factor for Modern 3-Megawatt (MW) Turbines on a 110-m Tower



Source: Lantz et al. 2018

Change in Net Capacity Factor for Future (2030) Generation 3-MW Turbines and Plants on a 135-m Tower

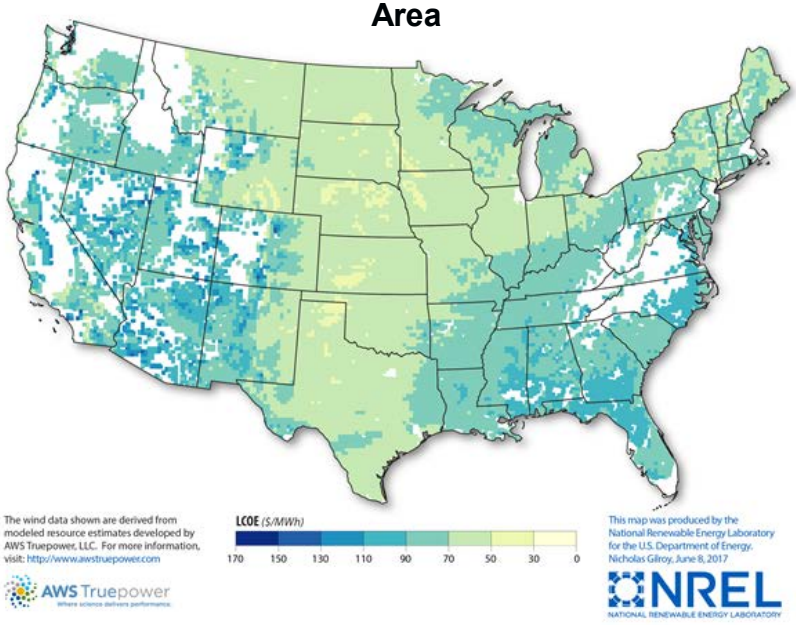


Note: Impacts include advanced, low specific power technology and reduced losses from improved plant design and operation

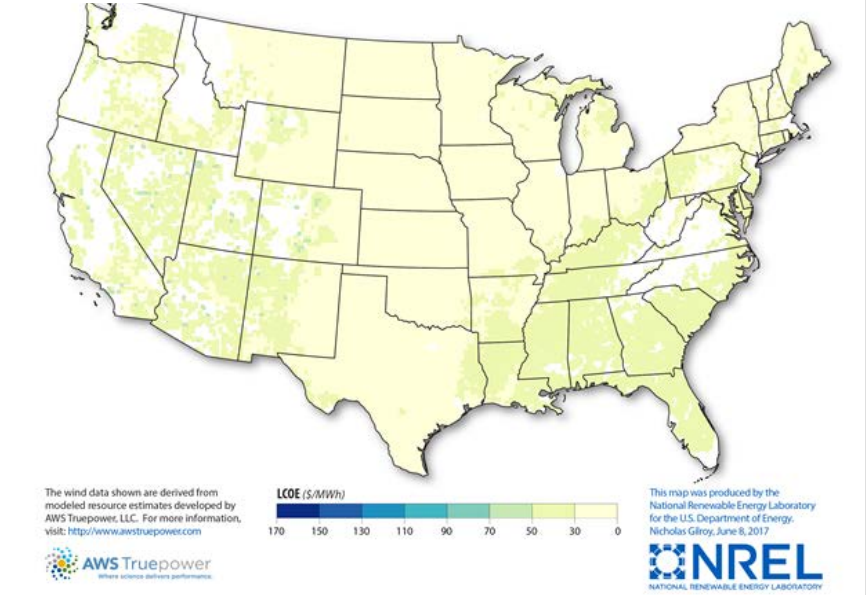
Technical Merit and Relevance

- **Creating the business case for tall tower technology, such as Wind Tower Technologies' self-erecting concrete tower (SECT), requires rigorous evaluation of the value proposition compared to traditional technologies:**
  - Need engineering and cost models that represent both traditional and novel tower concepts in order to perform comprehensive & comparative analysis

Estimated LCOE for Modern 3-MW Turbines on a 110-m Tower Focusing on the Best Sites in Each Area



Estimated Advanced Research and Development LCOE for 2030 Generation 3-MW Turbines and Plants on a 135-m Tower



Note: LCOE above based on the top 20% of land area for a given grid cell and excludes local grid spur line costs as well as regional economic cost multipliers.

Approach and Methodology

Technical Approach:

1. Scenario development and model gap analysis

- Identify appropriate analysis scenarios (85 m (baseline), 120 m, 140 m and 160 m)
- Perform gap analysis of current modeling capability with respect to baseline and Wind Tower Technology's self-erecting concrete tower (SECT) concept

2. Develop tower models (metal and concrete) for each scenario

- Adapt traditional metal tower model for concrete application
- Perform high-level design of metal and concrete towers for each scenario

3. Adapt balance-of-system (BOS) model for new technology

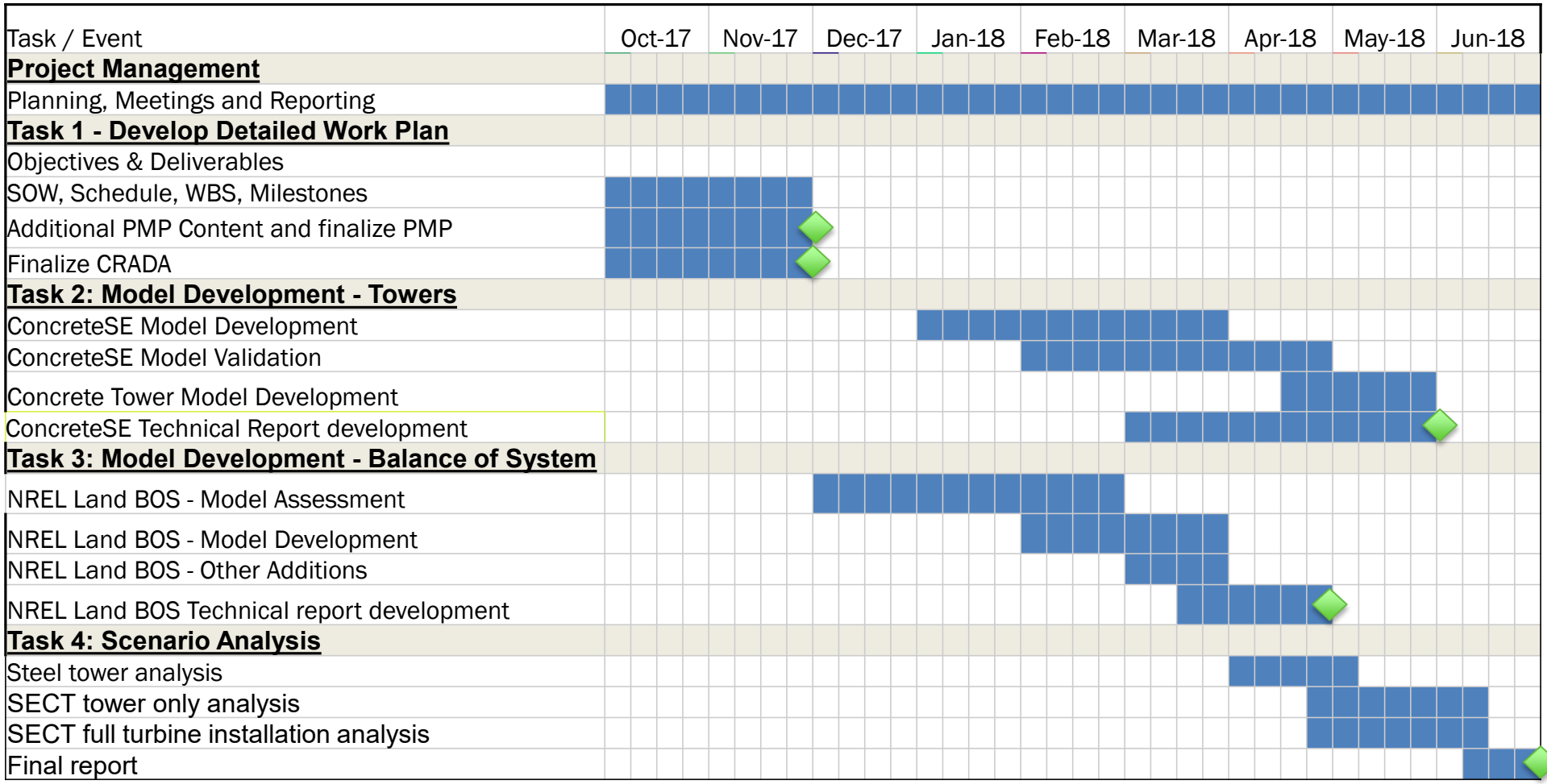
- Completely restructure model to develop process-based BOS cost assessment tool for land-based wind
- Collaboration with industry partners to refine and calibrate model based on industry data (through multiple non-disclosure agreements)

4. Levelized cost of energy (LCOE) assessment for SECT compared to traditional technology for each scenario

- Cost analysis of towers and balance-of-system in each scenario combined with site-specific energy assessment and operational expenditures for full LCOE analysis

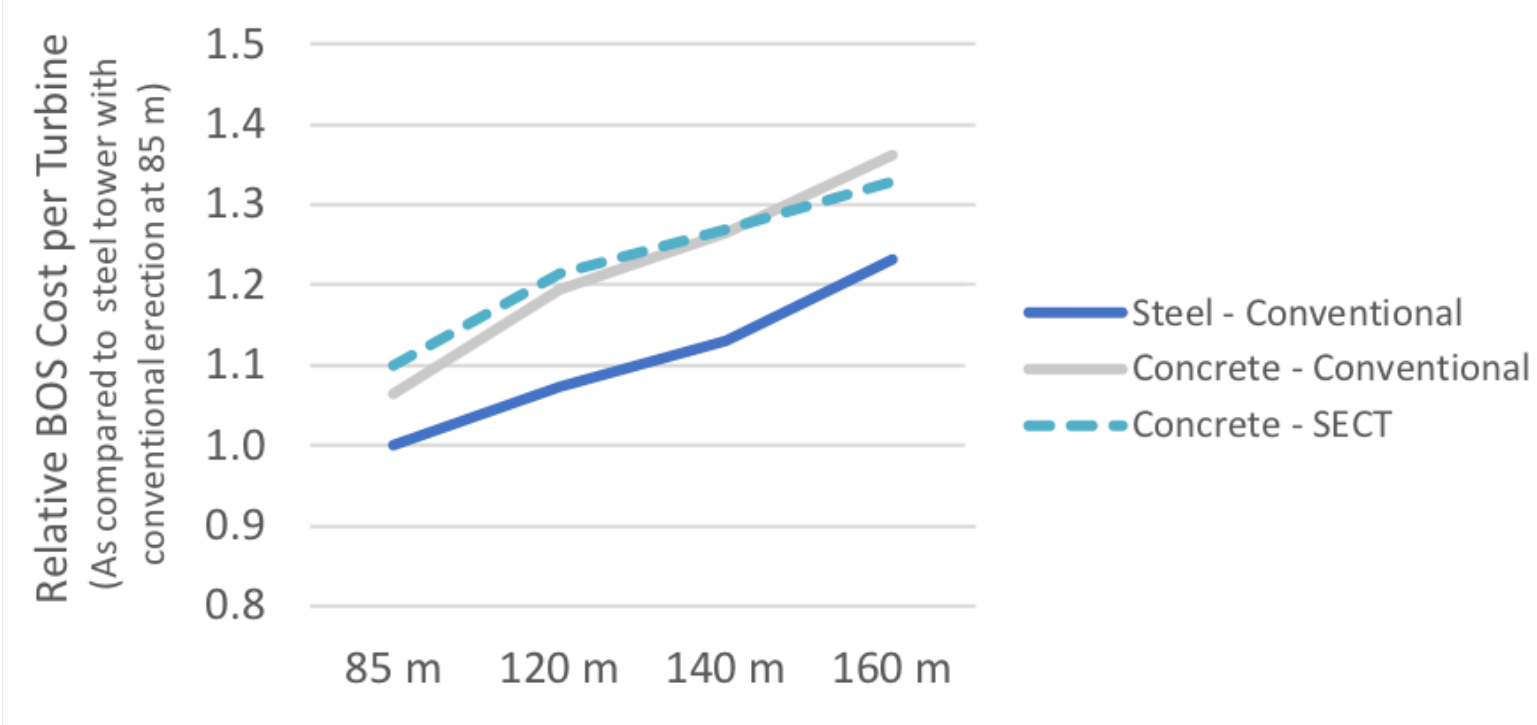
Accomplishments and Progress

- **Project Schedule and Milestones (diamonds):**



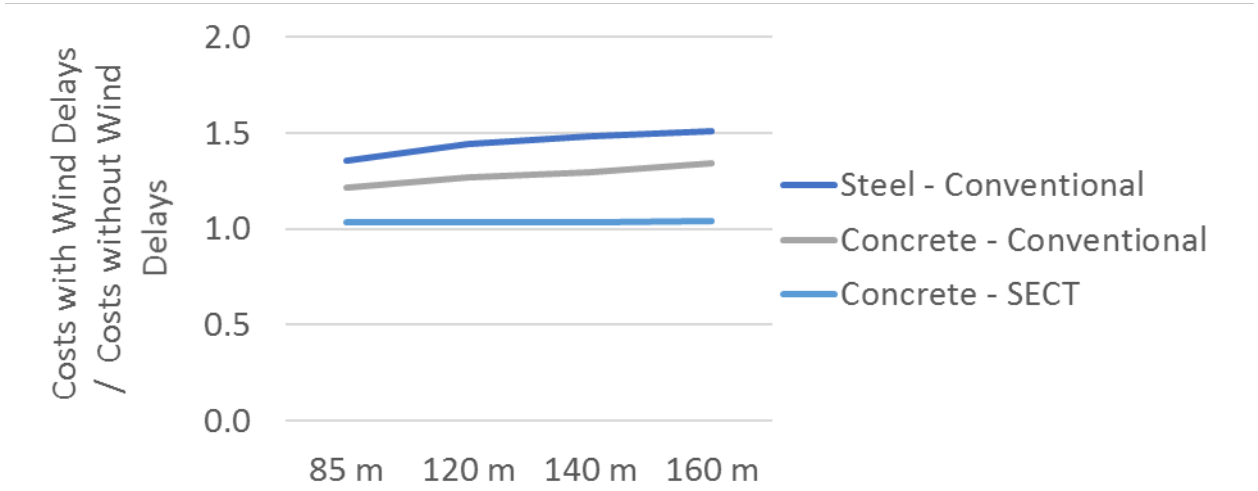
Accomplishments and Progress

- **Detailed analysis results are protected under a cooperative research and development agreement (CRADA) with Wind Tower Technologies**
- **Here we provide an illustration of the relative comparison of the balance-of-system costs for steel and concrete towers at 85, 120, 140 and 160 m hub heights using conventional erection and a self-erecting concrete tower (SECT)**
  - Results show that BOS costs are lowest for steel towers constructed using conventional erection technology; concrete towers did not have a BOS cost advantage any height, which was largely driven by the costs of turbine erection being higher for concrete tower sections



Accomplishments and Progress

- **Balance-of-system (BOS) costs for steel and concrete towers are strongly dependent on weather delays associated with the installation of tower sections**
  - BOS costs associated Wind Tower Technologies' self-erecting concrete tower (SECT) technology are less impacted by wind delays as compared to conventional concrete and steel tower construction
  - As tower heights increase, the impact of weather delays on BOS costs increases for steel and concrete towers erected using conventional technology while SECT costs remain constant
  - The study concluded that additional analysis for site-specific conditions would be needed to truly understand whether SECT technology would have an advantage because if the weather profile of the construction site becomes more severe than the case considered here, wind delays could differ



Communication, Coordination, and Commercialization

- **Project results were communicated internally to DOE, but the LCOE analysis results are protected under a cooperative research and development agreement (CRADA) with WTT and were not widely communicated**

- **Follow-on activity has led to the development of a technical report on the new land-based Balance of System Model which will be published in FY19 and a version of the code for the LandBOSSE model was released publicly in Q1 of FY19**
  - The project team plans to coordinate with the NREL communications team to develop a news article about the model's capabilities
  - The model is being incorporated into NREL's Wind-Plant Integrated System Design and Engineering Model (WISDEM) and has been used already in multiple DOE studies to look at balance-of-system impacts from new technologies; publications on these projects are forthcoming.

- **WTT has expanded their business line in China, where the results from this analysis indicate that the balance between labor and hardware costs are in their favor**