U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

NREL
Transforming ENERGY

A03 - Wind Plant Technology Characterization

Modeling & Analysis - Modeling & Analysis
Matt Shields
National Renewable Energy Laboratory (NREL)

August 2, 2021

FY21 Peer Review - Project Overview

Project Summary:

- This project develops open-source models and conducts analyses to evaluate various innovation pathways
- The project also characterizes the state of the domestic and global industry through benchmark data and reporting
- Project partners include International Energy Agency Wind Task 26, developers, original equipment manufacturers, regulatory agencies, and universities

Project Objective(s) 2019-2020:

- Produce and deliver open-source land-based and offshore cost models
- Produce and deliver open-source 15 MW reference wind turbine design
- Compile and report on domestic and global market data, statistics, and technology trends for land-based and offshore wind
- Conduct cost evaluations for various individual and system-level innovations for land-based and offshore wind

Overall Project Objectives (life of project):

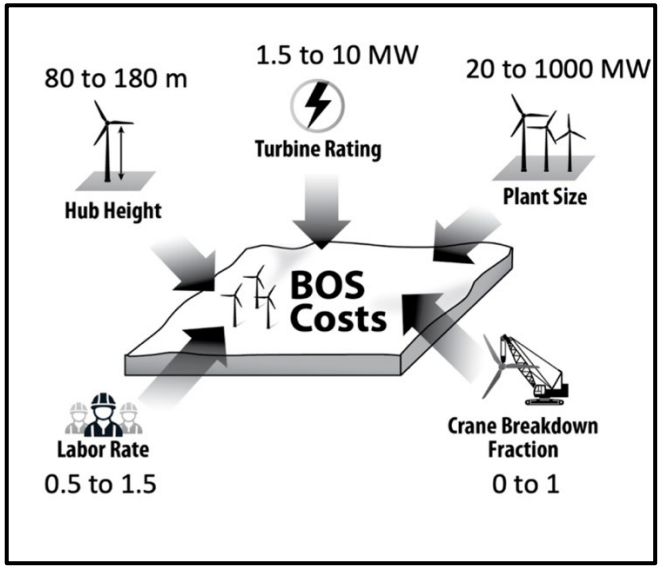
- Develop and apply capabilities to assess the value of innovation opportunities for land-based and offshore wind
- Track historical trends and evaluate future trajectories for land-based and offshore wind cost, performance, and technology
- Provide cost data to DOE to meet reporting requirements under the Government Performance and Results Act
- Inform research and development strategy

Project Start Year: FY 2019
Expected Completion Year: FY 2023
Total expected duration: 5 years

FY19 - FY20 Budget: $3,789,002

Key Project Personnel:
Matt Shields (PI)
Annika Eberle
Tyler Stehly

Key DOE Personnel:
Patrick Gilman (PM)

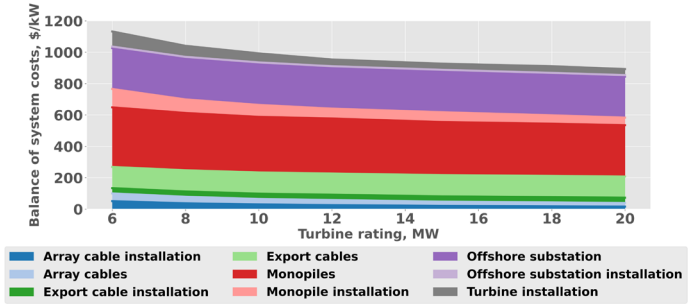


Project Impact

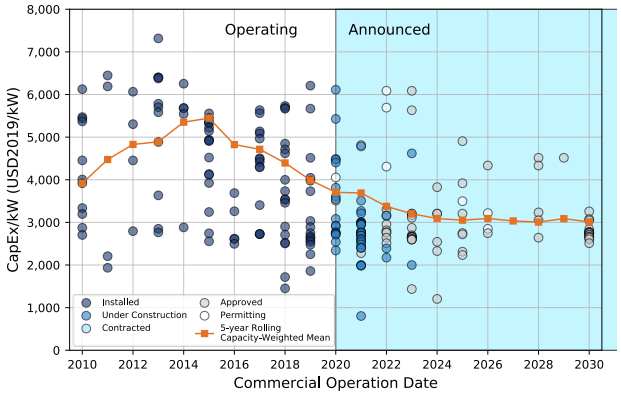
Products/outputs

Techno-economic models

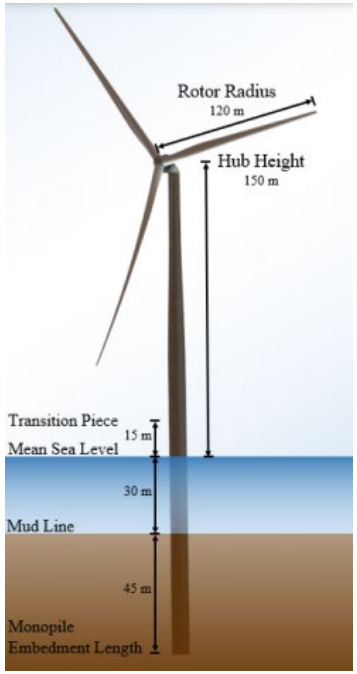
Market data



Cost impacts of increasing turbine rating



Global trends in offshore wind project capital costs



15 MW reference turbine design

Products/outputs	Outcomes
Evaluate innovations quantitatively	Prioritize funding and deployment decisions Publish high impact studies
Produce open-source models	Enable industry-wide research standardization
Report cost and technology benchmarks	Provide baseline evaluation metrics

Program Performance – Scope, Schedule, Execution

Approach and methodology:

Data collection	Analysis	Review and report
Public literature	Innovation evaluation	Benchmarking
Industry partners	Future technology trends	Industry review
Collaborative analysis groups	Global benchmarks	Journal peer review
Collaboration within NREL	Sensitivity analyses	DOE reporting requirements
	Novel methodologies	

Outputs and outcomes (all project milestones delivered on time):

- 7 journal articles
- 7 technical reports
- 3 open-source models/designs
- Conference/workshop participation

- Industry engagement: Collaborative analysis, model adoption, report reviews, data collection
- Capability development: Basis for analysis work, proposal development, industry partnerships
- High impact publications: Reports with over 10K citations, provide benchmark data

Program Performance – Accomplishments & Progress

The 15 MW Offshore Reference Wind Turbine

Project Summary:

- Developed open-source design and models
- Led international design team
- Created baseline for industry and research community

Products

Technical report and conference paper

Model on GitHub

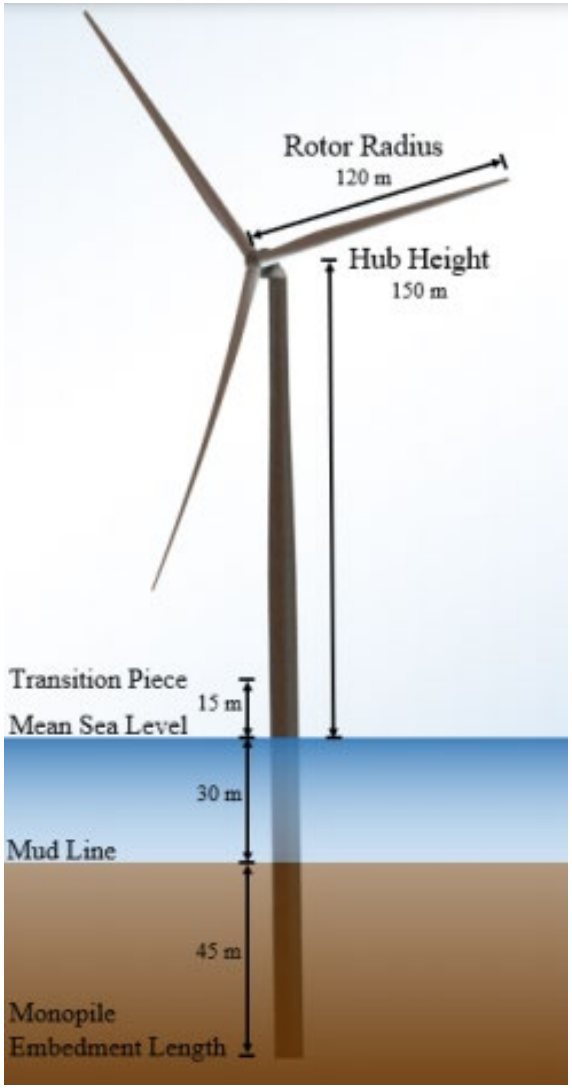
Outcomes

12K report downloads

10 new code users and over 100 unique visitors per week

Prescribed for National Offshore Wind Research and Development Consortium proposals

Analysis basis for collaboration with industry partners



Schematic of the 15 MW offshore reference wind turbine (Gaertner, et al., 2020)

Program Performance – Accomplishments & Progress

Development and release of open-source cost models

Project Summary:

- Developed open source, process-based balance-of-system models
- Addressed gap in available tools
- Can model impacts of innovations
- Collaborated with industry reviewers

ORBIT:
Offshore Renewables Balance-of-system Installation Tool

LandBOSSE:
Land-based Balance-of-System Systems Engineering

Products

Technical reports and conference paper

Model on GitHub

Outcomes

Core analysis capability

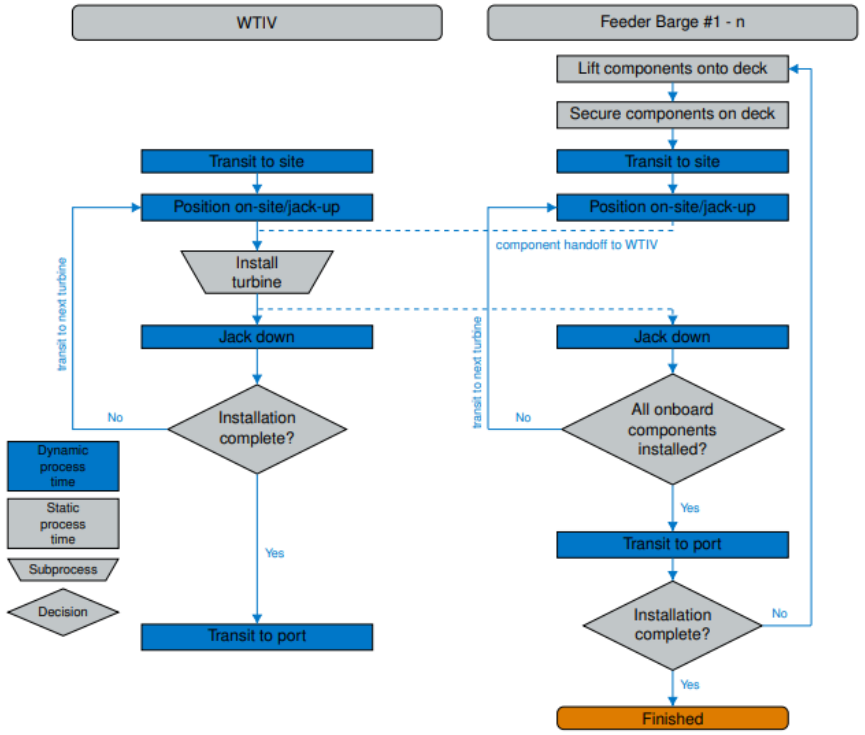
Partnerships with 6 industry groups

Basis of 7 awarded proposals

1.5K report downloads

5 new code users and 50 unique visitors per week

University outreach



Process diagram showing the turbine installation process used in ORBIT (Nunemaker, et al., 2020)

Program Performance – Accomplishments & Progress

Cost impact analysis of turbine and plant upsizing

Project Summary:

- Addressed knowledge gap for system-level cost impacts of larger turbines and plants
- Conducted bottom-up cost and performance modeling for land-based and offshore scenarios

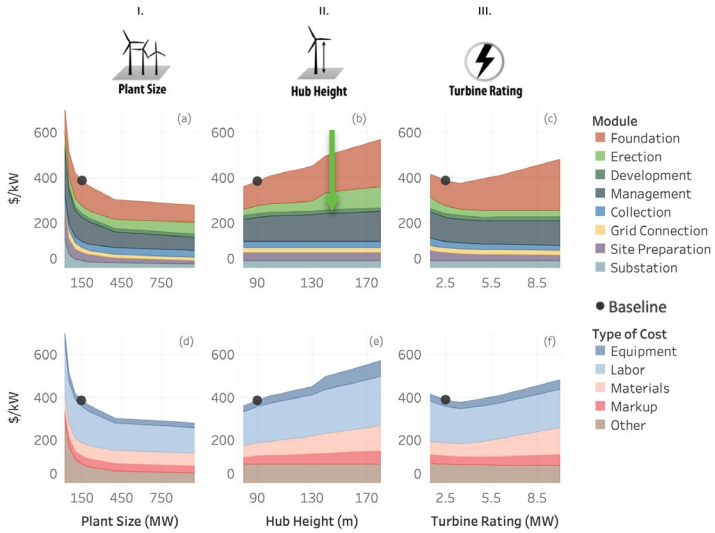
Products

Journal articles (1 published, 1 under review)

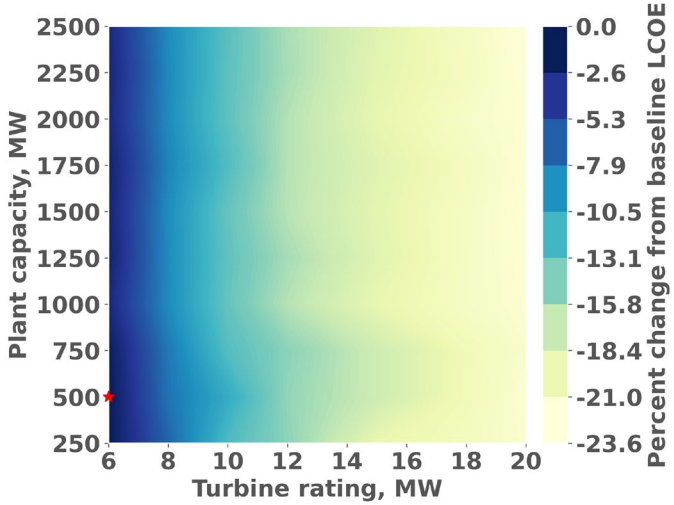
Outcomes

Capabilities used for land-based spatial innovation analysis

Informs strategic planning with port and vessel developers



Impacts of plant size, hub height, and turbine rating on capital costs of land-based projects (Key, et al, under review at *Wind Engineering*)



Impacts of plant size, and turbine rating on the levelized cost of energy of offshore projects (Shields, et al, (2021), *Applied Energy*)

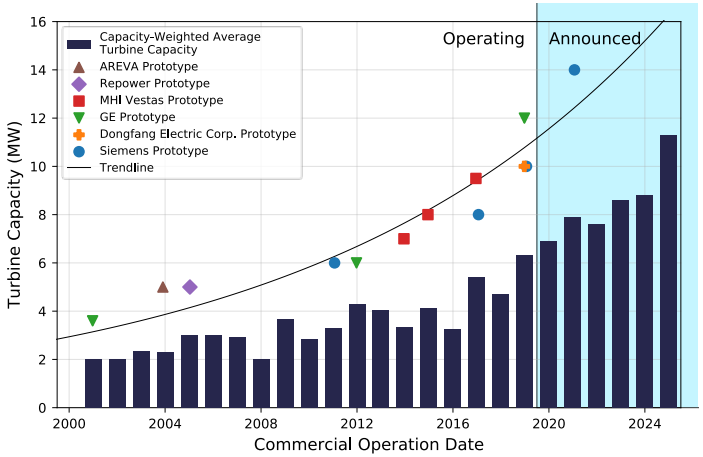
Program Performance – Accomplishments & Progress

Industry benchmark reporting

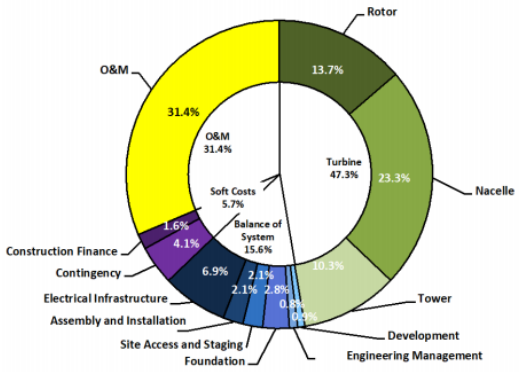
Project Summary:

- Tracked historical, current, and projected industry cost and technology trends
- Provided baseline data upon which novel innovations or strategies can be compared
- Collaborated with IEA Wind Task 26 to report on global cost trends and comparisons

Products	Outcomes
Cost of Wind Energy Review	13K downloads
Offshore Wind Technologies Market Report	Benchmark data for stakeholders and government reporting requirements
Annual Technology Baseline scenarios	Inputs to national electricity sector analysis
Technical report with IEA Wind Task 26	Close engagement with industry reviewers and international analysts



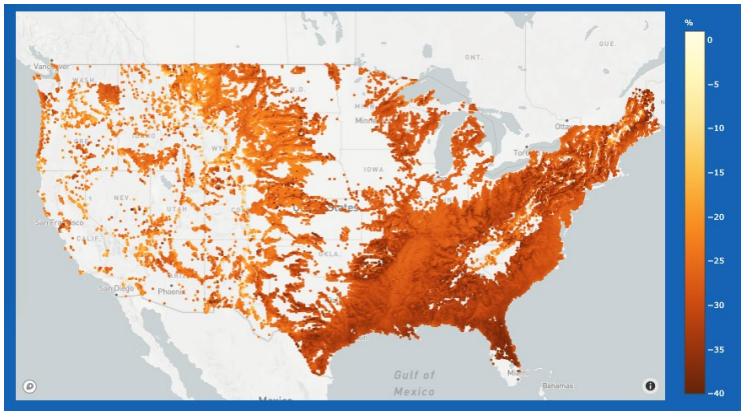
Commercial offshore turbine growth (Musial, et al, 2020)



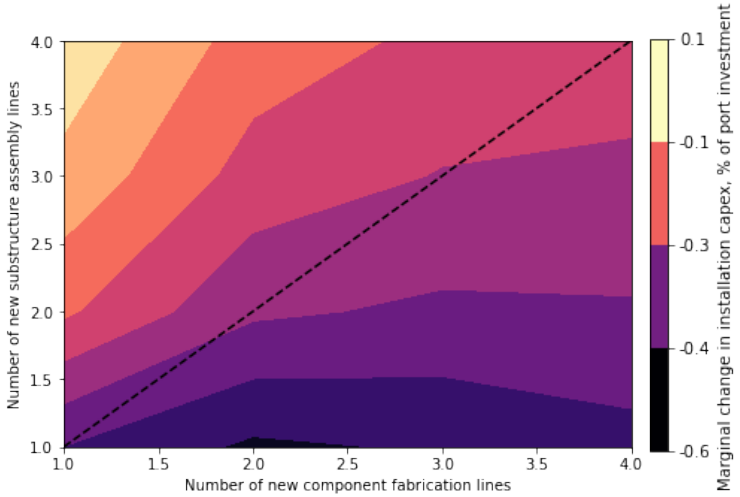
Component level levelized cost of energy breakdown for a representative land-based project (Stehly, et al., 2020)

Project Performance - Upcoming Activities

	FY21	FY22+
Capability development (open-source models)	• Operation and maintenance • Offshore cost projections • Land-based hybrid systems	• Decommissioning • Supply chain • Manufacturing • Transport logistics • Hybrid systems
Analysis work	• Couple plant-level innovation impacts with spatial models • End-of-life foundation material flows • Installation logistics for floating wind • Mapping risk to financing terms	• Spatial impact of innovations • Probabilistic lifecycle cost and risk analysis • Advanced manufacturing and supply chain logistics • System optimization • Operations and maintenance cost benefit tradeoffs
Reporting	• Ongoing reporting • Collaboration with IEA Wind Task 26 resulting in 5 journal publications • Integration of new cost models into workflow	• Ongoing reporting • Collaboration with IEA Wind Task 26, including model development activities

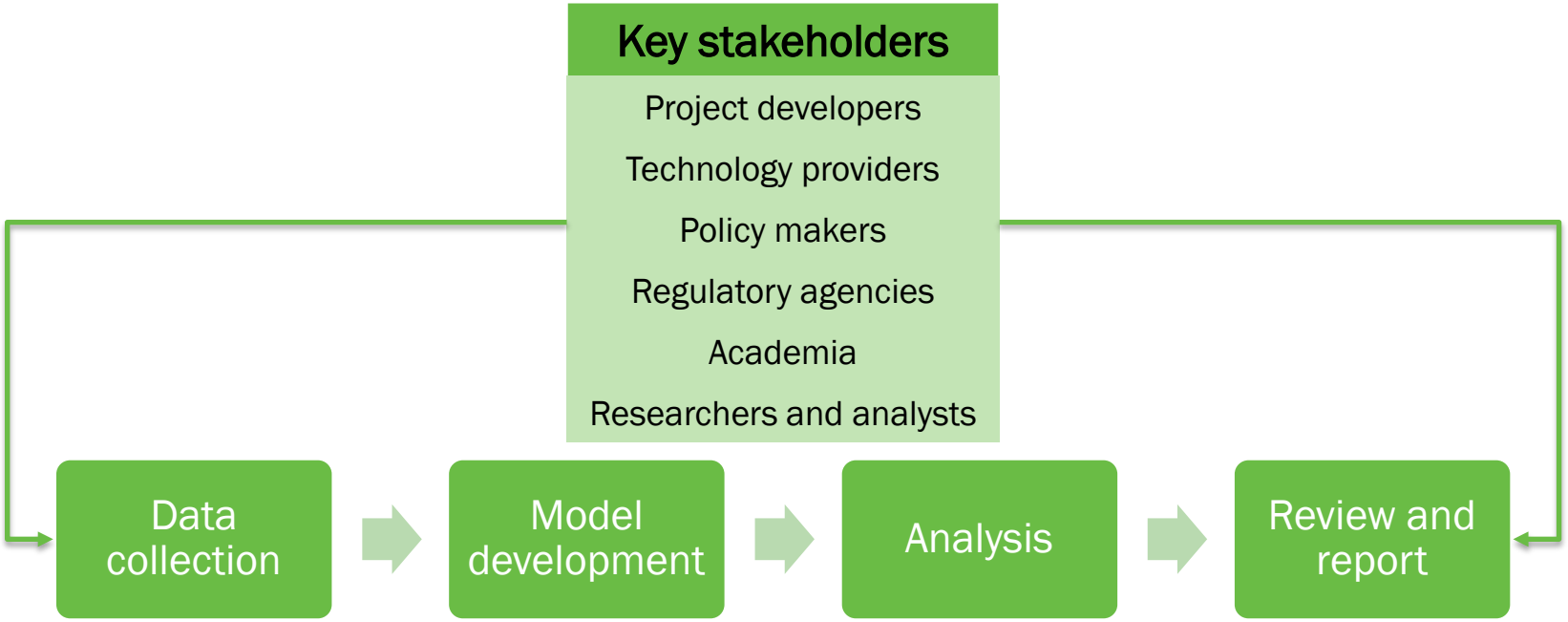


Spatial impacts of land-based wind turbine innovations on levelized cost of energy, including novel erection, tower, O&M, and control strategies



Marginal value of port infrastructure investment on floating wind installation costs

Stakeholder Engagement & Information Sharing



Information sharing

- Publications and presentations
- Open source models
- Topical expert meetings
- Webinars/panels
- Social media and news outlets
- Briefings to WETO

Impacts

- Model and design adoption by industry and academia
- Benchmark data provided to analyst community
- High impact reports downloaded over 10K times each
- Collaboration with national and international partners