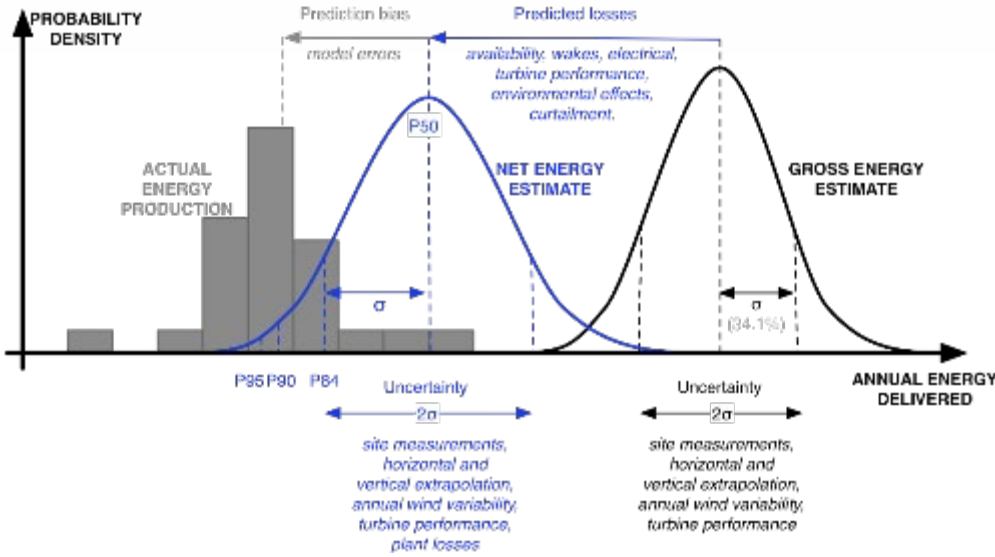
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE



A07 – PRUF – Wind Plant Performance Benchmarking

Modeling & Analysis – Modeling & Analysis

Jason Fields

National Renewable Energy Laboratory (NREL)

August 2, 2021

FY21 Peer Review - Project Overview

Project Summary:
PRUF identifies and reduces risk and uncertainty factors that impact long-term operation and profitability of wind power plants. Improving the predictability and reliability of wind power generation and operations increases investor confidence and boosts returns for wind plant owners, both of which are critical for robust and organic industry growth.

- EDPR,RES,EDF-RE, Avagrid,Pattern,E-ON/RWE, Enel, Siemens Gamesa RE, Vestas, Nordex/Acciona, GE, UL, DNV-GL, ArcVera, Natural Power, Mott Macdonald, K2, Luminate, WSP, Wood, EMD, EAPC

Overall Project Objectives (life of project):

- Market Impacts
  - Improved project selection & business outcomes
  - Increase investor confidence
- Unleash innovations
  - Improve data access
  - Validate new methods that can be deployed quickly
- LCOE Impacts (quick impact; 1-3 year uptake)
  - Up to 5% LCOE reduction from risk reduction

Project Objective(s) 2019-2020:

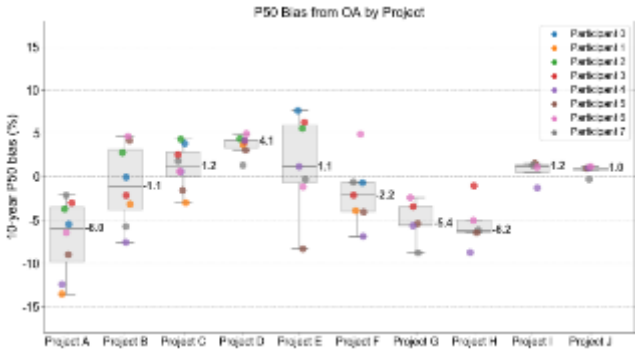
- Execute WP3 Benchmark Phase 1
- Publish OpenOA as an open source project
- Explore Wind Energy Digitalization as an innovation opportunity

Project Start Year: [2015]
Expected Completion Year: FY [24]
Total expected duration: [9] years

FY19 - FY20 Budget: $2,377,232

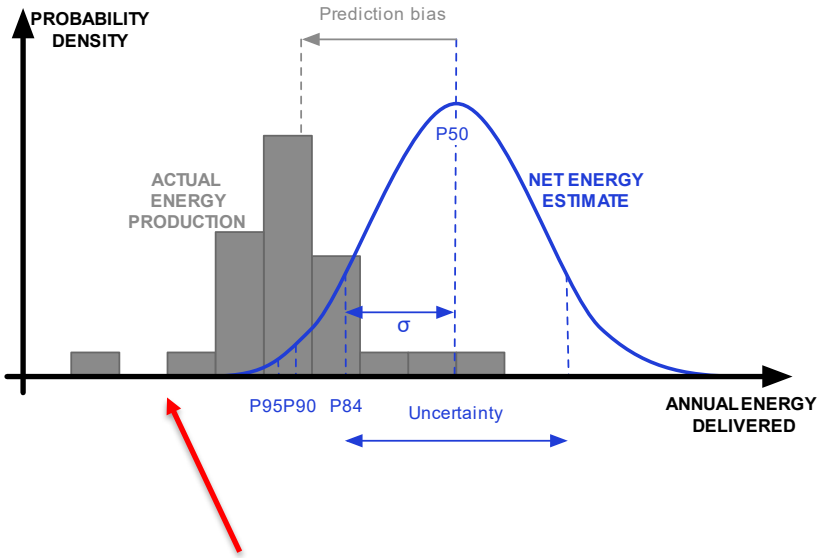
Key Project Personnel: Jason Fields (PI), Eric Simley, Jordan Perr-Sauer

Key DOE Personnel: Patrick Gilman



Project Impact

What's My Wind Farm Going To Produce?



Data is a huge challenge for validation

Why it matters

- Drives profits and investment
- Drives LCOE & Finance Cost
- A2e/Industry alignment

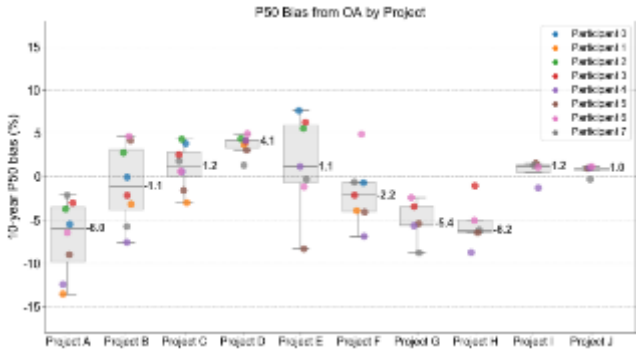
Current State

- Performance bias exists
- Poor sub models

PRUF Major Activities-Scope

WP3 Benchmark

- Phase 1: 10 projects



OpenOA

- Open source operational assessment project

Wind Energy Digitalization

- New data frontiers

Met all milestones on time (except 1)

Wind Plant Performance Prediction

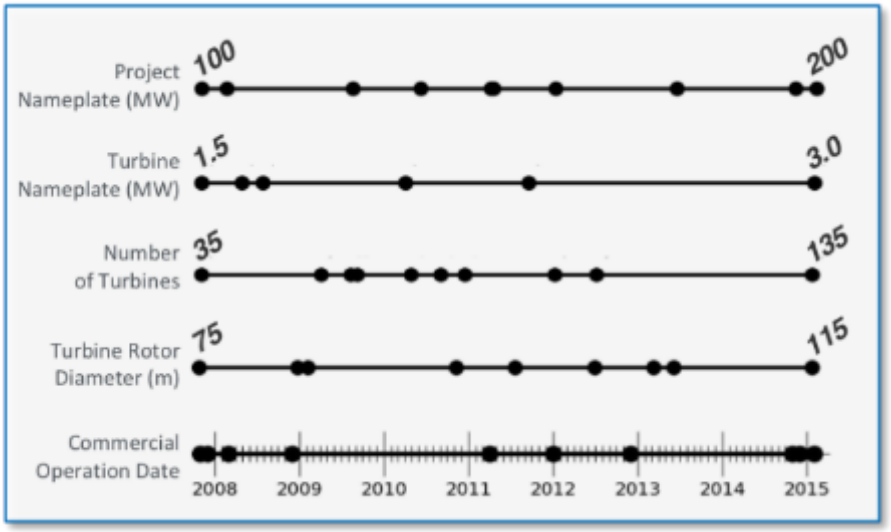
WP3 is industry collaboration.

- Compare **pre-construction estimates to operational data**
- 100+ projects, representing **~25GW** of installed capacity
- **First of its kind collaboration** between gov't, owner/operators, consultants, independent engineers, and OEMs
- **GOAL: Improve methods for conducting pre-construction energy assessments** using data from operating projects

WP3 Stakeholder Engagement

Unprecedented Data Sharing & Collaboration among Wind Plant Owners, Resource Assessment Consultants, and Manufacturers

WP3 Results-Phase 1 participation



In kind contributions: ~$2,000,000

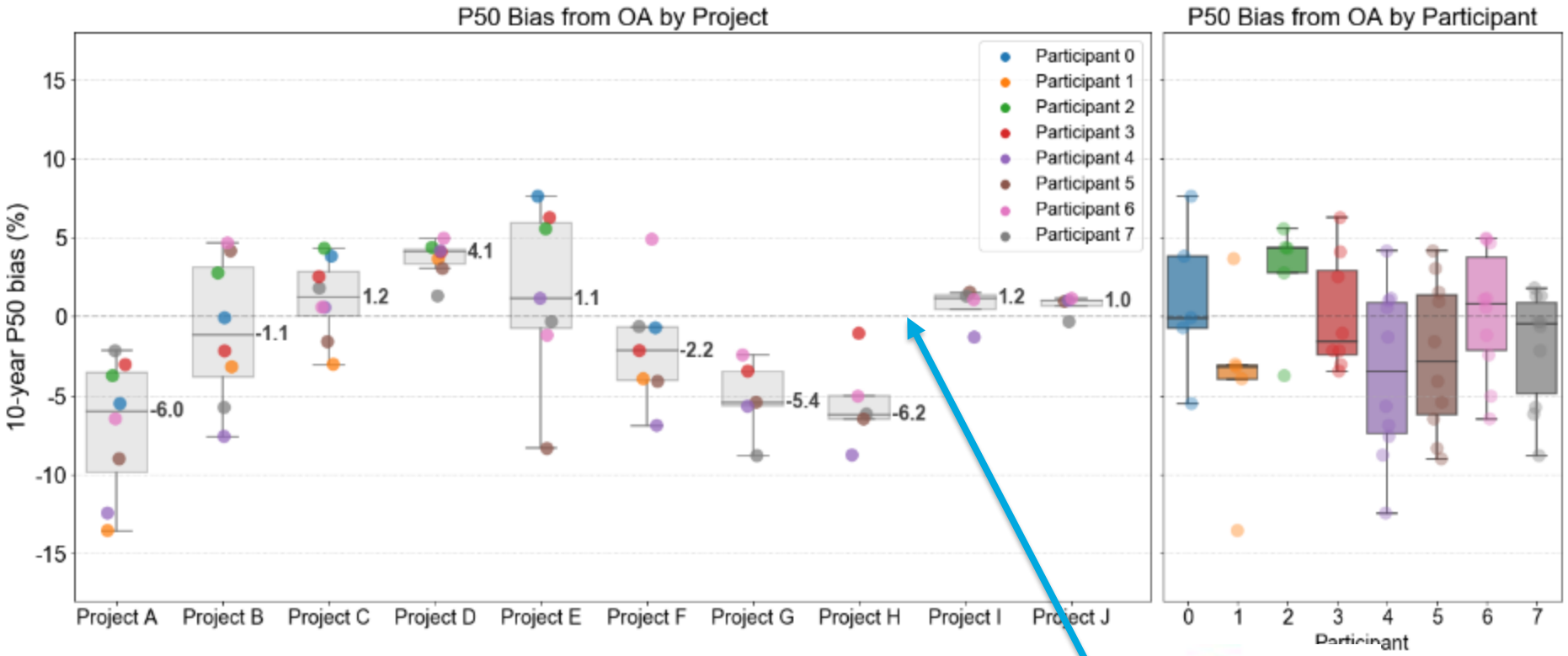
Project

Participant	A	B	C	D	E	F	G	H	I	J	TOTAL
0	✓	✓	✓	✓	✘	✓	✘	✘	✘	✘	5
1	✓	✓	✓	✓	✓	✘	✘	✘	✘	✘	5
2	✓	✓	✓	✓	✓	✓	✓	✓	✘	✘	8
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
TOTAL	8	8	8	8	7	7	6	6	5	5	68

*85% completion for 10 projects/8 consultants

WP3 Results-P50

P50 Net Energy Estimate



WP3 Benchmark Data Challenges

Data Type	Number of plants
Metered Energy Data	
- Monthly	1
- Hourly or better	9
Availability and Curtailment Losses	
- Monthly	3
- Hourly or better	7
- Single availability metric	7
- Detailed breakdown of avail. Losses	3
- Turbine level	3
- Plant level	7
Status Codes / Event logs	
- No data provided	2
- High level categories provided	2
- Detailed (i.e. raw) data provided	6

80% of the effort is just wrangling disparate or bad or unstandardized data

Example 1: No upgrade information

Example 2: Operations started in 2011 but no information before 2015

Industry interviews

"Basic data management and reporting takes all of our time" - Wind Plant Operator

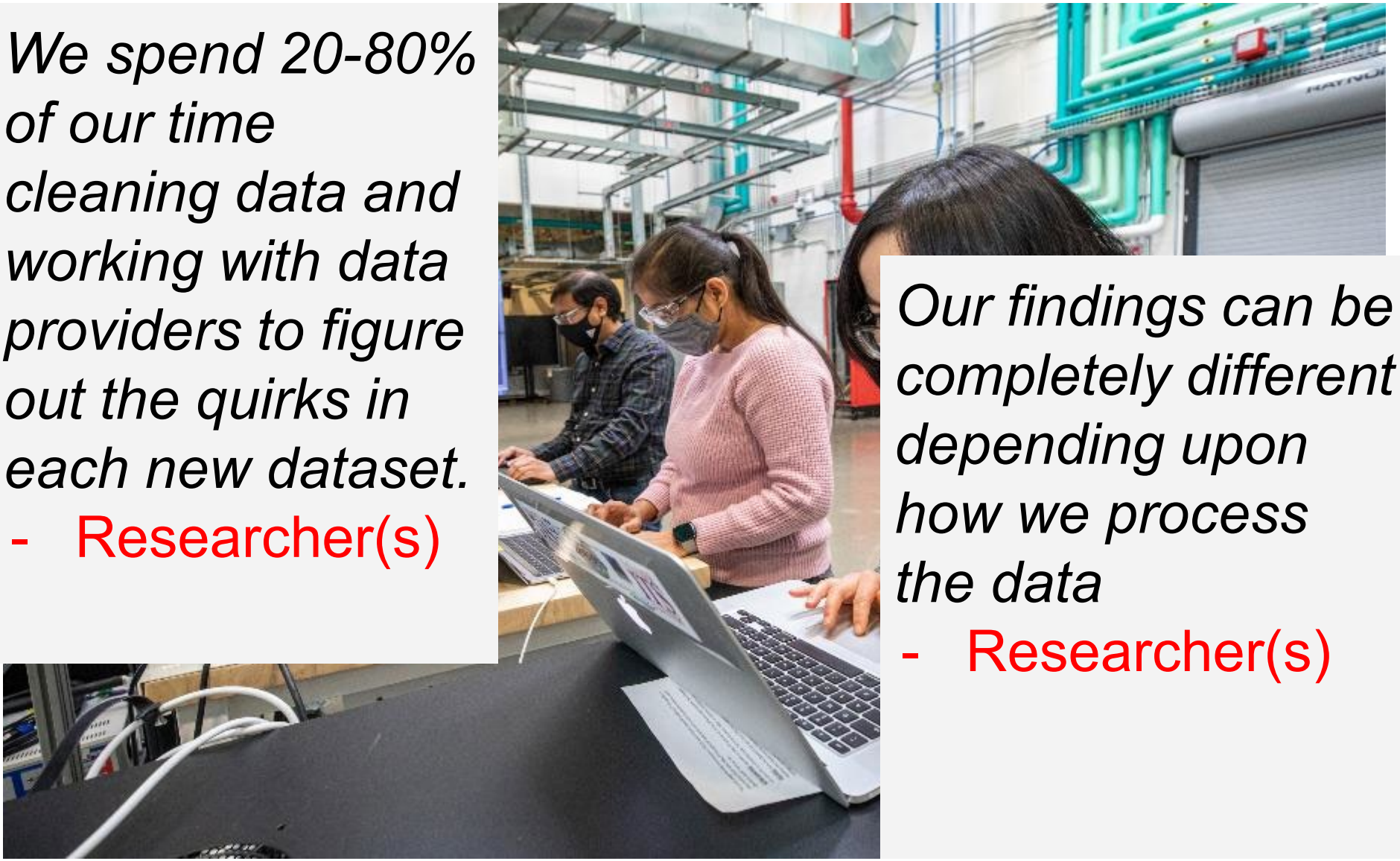
"We have no time or ability to engage third parties with 4 month trials" -Wind Plant Operator

NREL PIX 04178

Researcher interviews

We spend 20-80% of our time cleaning data and working with data providers to figure out the quirks in each new dataset.

- Researcher(s)



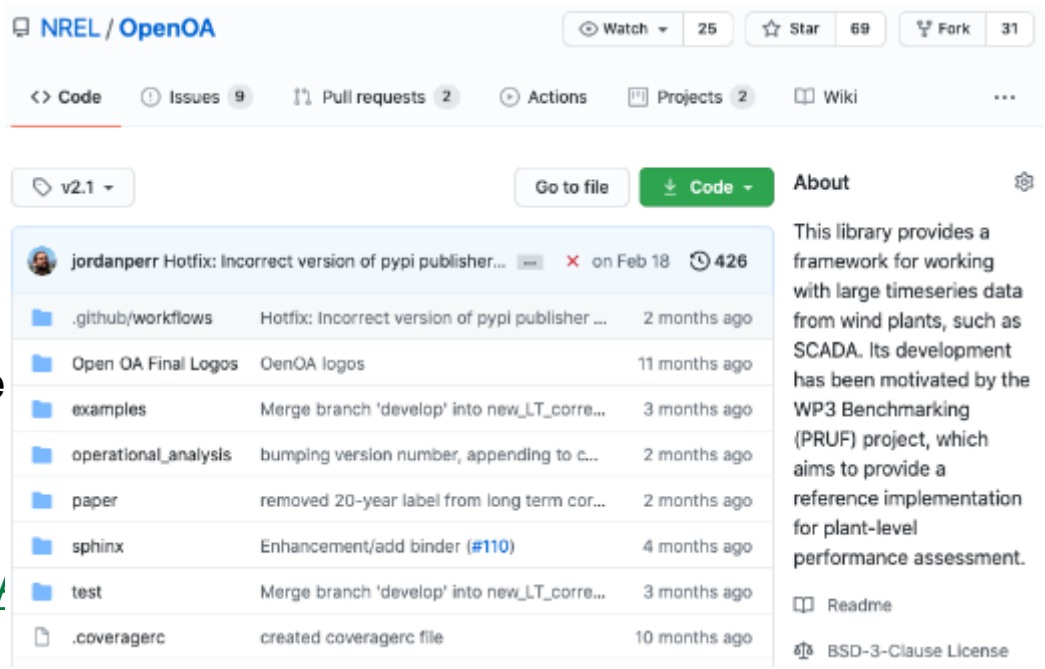
Our findings can be completely different depending upon how we process the data

- Researcher(s)

NREL PIX 62793

What is OpenOA ?

- **Python package** built largely to support **Wind Plant Performance Prediction (WP3) Benchmarking** project
- Extensive input from industry during code development
- Released publicly in 2018 (v1.0)
  - v2.0 released October 2020
- Implemented using **modern software development practices** to promote community engagement
  - Code hosted on GitHub: https://github.com/NREL/OpenOA/
  - Community contributions managed using pull requests
  - Unit and integration tests
  - Documented using Sphinx



Digital Technology

what is it? why now?

compute

Large and small

Distributed

Cloud

Edge

connectivity

Internet

Mobile

5G

sensors & data

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Proliferation of data

Decreasing cost of sensors

IoT

software

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AI/Machine learning

Blockchain

Big data

Open Source

Source: DNV-GL

IEA Wind Task 43

WIND ENERGY DIGITALIZATION

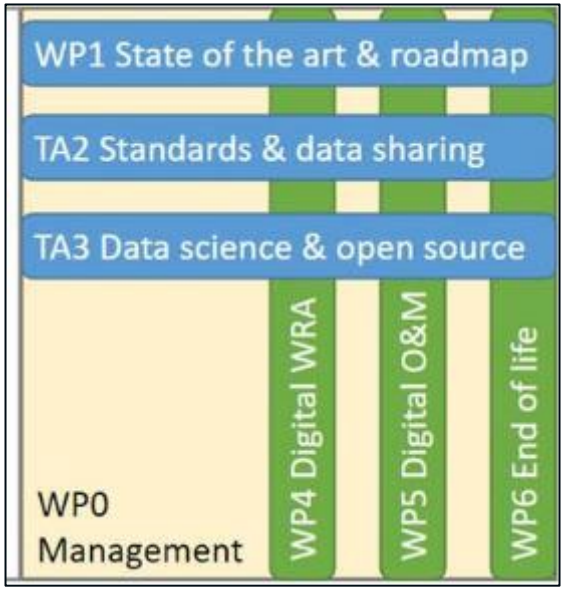
WP1-3: Cross cutting

WP4-6: Application areas

Leading the Digitalization grand challenges

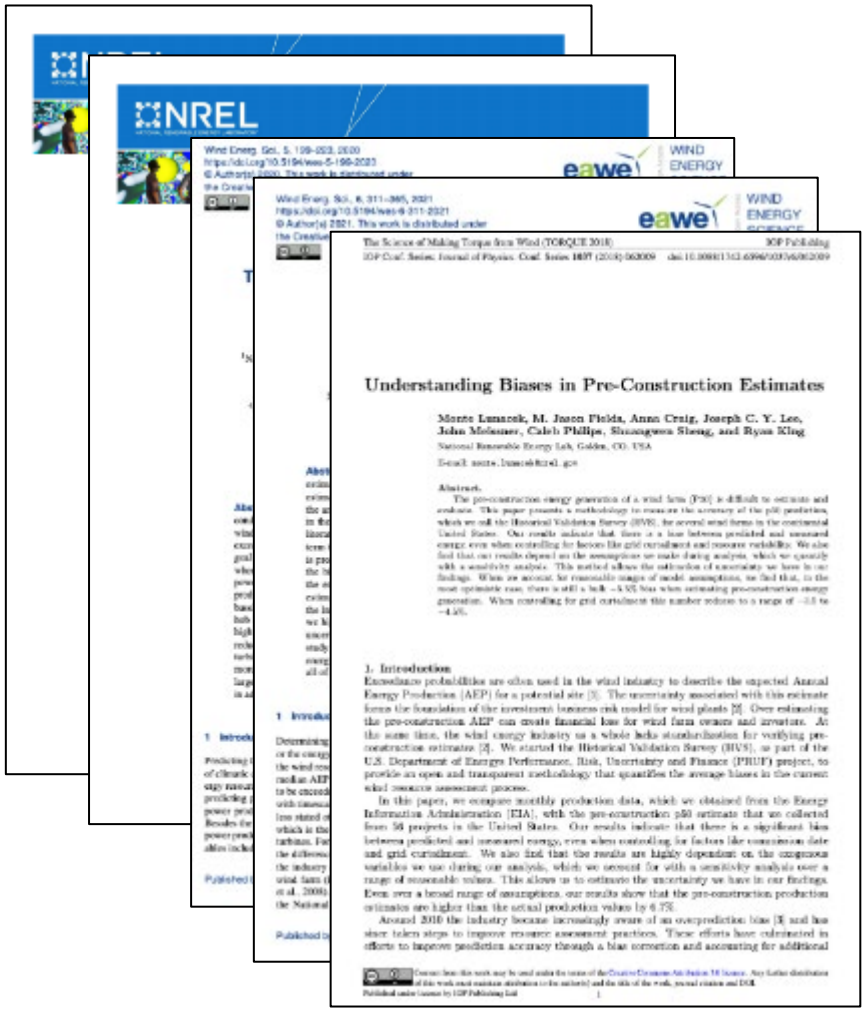
Deliverables:

- Data Standards, Best Practices, and open source tools



Participants: DNV-GL, EDF R&D, EDF Energy, NREL,NRG Systems, Fraunhofer IEE, DTU, RES, Sentient Science, GI-Engineering, OWI-lab/VUB, GE, Siemens-Gamesa

PRUF Accomplishments & Outreach



- Technical Reports
- Peer reviewed Publications
- Open Source Software
- Conferences
- Podcast
- IEA Task

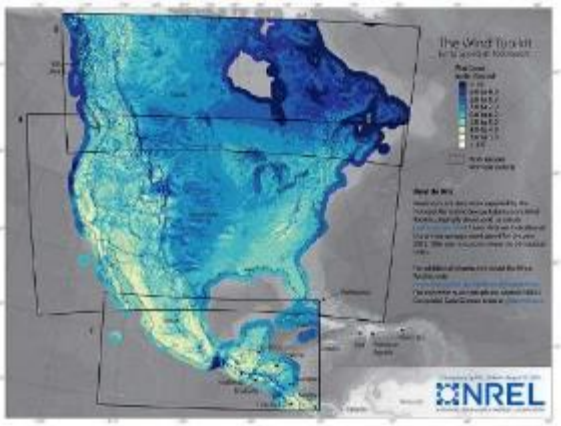
OpenOA

WIND ENERGY DIGITALIZATION

PRUF Accomplishments-Research Support

DOE Research Support

- Wind Toolkit Validation
- ML Downscaling Validation
- OpenOA



External Research Support

ARCVERA RENEWABLES

WSP

OpenOA

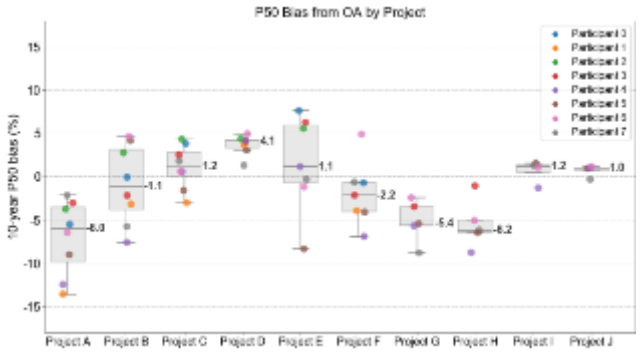
UL

K2 Management

Summary

WP3 Benchmark

- Phase 1: 10 projects



OpenOA

- Open source operational assessment project

Wind Energy Digitalization

- New data frontiers

Thank you

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