Report 2022

Task 43

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Wind Energy Digitalization

Author *Sarah Barber, Eastern Switzerland University of Applied Sciences, Switzerland.*

The purpose of phase 1 of IEA Wind Task 43 (December 2019 to March 2023) was to coordinate research and development activities, from data and analytics to connectivity, across the global wind industry and to recommend best practices and maximize realization of benefits from digitalization while minimizing duplicate effort.

This was achieved by convening an international expert body aiming to:

- Define what is meant by wind energy digitalization.
- Describe the current state of digitalization capability and practice within the wind energy sector.
- Identify and prioritize value-added opportunities enabled by further digitalization.
- Learn from and build upon similar work in other sectors to develop recommended digitalization practices for the wind energy sector.

The main results from 2022 are:

- WRA Data Model developed and released.
- Decision-making framework, an end-to-end decision-support

methodology around inspection and repair of blade leading edge erosion, developed.

- Industrial Advisory Board founded.
- "Grand Challenges" paper published.
- Draft digitalization roadmap completed.
- Data standards gap analysis draft completed and presented at a conference.
- Metadata Challenge Webinar Series launched and seven webinars organized.
- Review paper "Knowledge Engineering for Wind Energy" submitted.
- "Digitalization use cases" survey designed, run, analyzed and presented at a conference.

We have managed to secure a large interest from the industry. Our participants include people from Vestas, Siemens Gamesa, Suzlon, DNV, Vattenfall, Apex Clean Energy, Natural Power, NASH Renewables, Wood plc, Vortex fdc, Mott McDonald, as well as many small innovative companies. Our recently formed Industrial Advisory Board includes people from BP, Vestas, Siemens Gamesa, Orsted, Microsoft and Envision. In particular, the continued dissemination of our two recent publications, "Grand Challenges of Digitalization in Wind Energy" and "Knowledge Engineering in Wind Energy" is attracting more and more interest in the industry as our position as catalyzers of digital transformation becomes established.

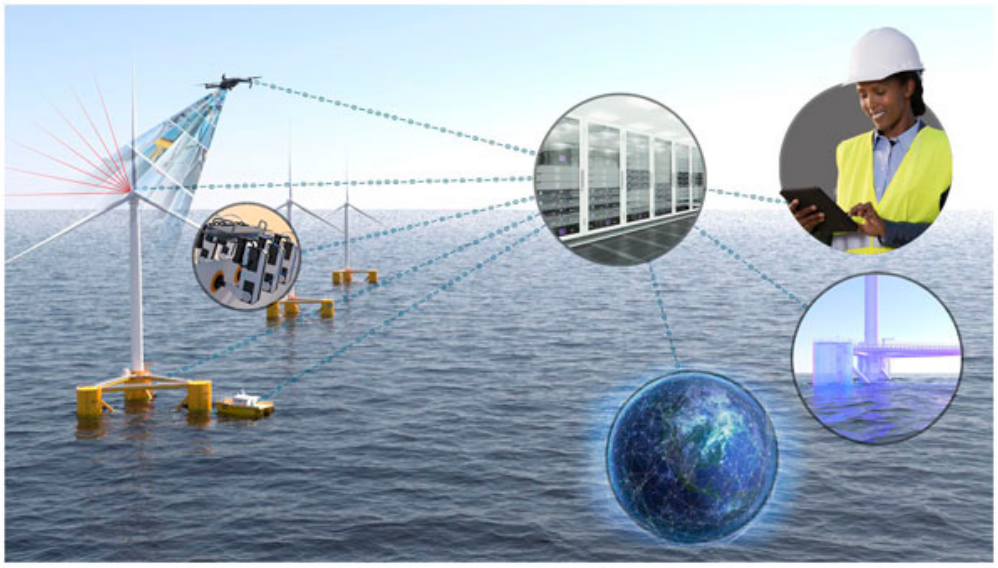

Figure 1: Digitalization in action. In this future floating wind energy plant, digitalization enables a plant manager to take data-based decisions in real-time, increasing safety and reducing the cost of energy.
Image credit: NREL graphics team [1].

Introduction

Digitalization has been recognized as one of the key barriers to increasing the value of wind energy, as well as in the efficient implementation of the energy transition. In wind energy, much remains to be done to develop a holistic view and identify wider opportunities to reduce lifecycle costs, enhance the performance of assets and effectively integrate wind energy into evolving energy grids and markets. Therefore, the purpose of this IEA Wind Task 43 is to coordinate research and development activities, from data and analytics to connectivity, across the global wind industry and to recommend best practices and maximize realization of benefits from digitalization. The objectives are to:

- Define what is meant by wind energy digitalization.
- Describe the current state of digitalization capability and practice within the wind energy sector.'
- Identify and prioritize value-added opportunities enabled by further digitalization.
- Learn from and build upon similar work in other sectors to develop recommended digitalization practices for the wind energy sector.

The expected results include webinars, recommendations and conference presentations related to wind energy digitalization, as well as new data models and frameworks for the industry to use.

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Progress and Achievements

Technical work carried out:

- We have launched a data model (WRA Data Model) to capture the metadata which describes how a wind resource measurement device has been configured and how this configuration changes over time.
- We have developed a decision-making framework, which can be used as an end-to-end decision-support methodology around inspection and repair of blade leading edge erosion. A draft was presented at the WindEurope Annual Event, and we are working on its final release.
- A new Industrial Advisory Board was founded in order to improve collaboration with the industry.

Table 1. Countries Participating in Task.

COUNTRY	ORGANIZATIONS
Australia	WakeWatch P/L
Belgium	KU Leuven
Brazil	DNV
Canada	Southern Alberta Institute of Technology (SAIT); University of Victoria; Institute for Integrated Energy Systems, University of Victoria
Denmark	Technical University of Denmark; Aalborg University; DTU Wind and Energy Systems; Sewpg European Innovation Center
France	VAISALA
Germany	Fraunhofer IWES; Vattenfall; Natural Power; NASH Renewables; Dhara Consulting Services/Vaisala; University of Stuttgart; enviConnect; Pavana GmbH; badenova AG & Co.KG
Ireland	Brightwind; ServusNet Analytics
India	Wind Pioneers
Netherlands	RTDT Laboratories AG; Wageningen University and Research; TU Delft; Suzlon
Portugal	Vestas
Singapore	DNV
Spain	DNV; Vortex f.d.c.
Sweden	RISE Research Institutes of Sweden
Switzerland	Eastern Switzerland University of Applied Sciences
Thailand	Mott MacDonald
Turkey	Ege University
UK	Dulas Ltd; Carbon Trust; Octue; Renewable Dynamics
United States	NREL; Wood; Sandia National Laboratories; EPRI; DNV; Idaho National Laboratory; Skyview Renewables LLC; SparkCognition Inc; Georgia Tech; Apex

- A collaborative review paper "Grand Challenges in the Digitalisation of Wind Energy" paper was published in the Wind Energy Science Journal. This paper formed the inspiration for our recent task extension proposal, which focuses on addressing the three "Grand Challenges".
- We completed a draft version of our digitalisation roadmap, which aims to align the industry on what data practices, policies and technologies will be needed for a mature wind industry.
- A draft "Data standards gap analysis" was completed and presented at the WindEurope Annual Event, in which a framework for assessing the coverage of standards and guidelines was presented.
- Metadata Challenge Webinar Series launched and seven webinars organised.
- Review paper "Knowledge Engineering for Wind Energy" submitted (Figure 2).
- "Digitalisation use cases" survey designed, run, analysed and presented at a conference.

Recent publications and deliverables:

- Wind Energy Science Journal paper "Grand challenges in the digitalisation of wind energy" [1].
- Submitted Journal paper "Knowledge Engineering for Wind Energy" [2].
- WindEurope Technology Workshop 2022 presentation "IEA Wind Task 43: grand challenges in the digitalisation of wind energy" [3].
- WindEurope Annual Event 2023 conference paper "A use-case-driven approach for demonstrating the added value of digitalisation in wind energy" [4].
- WindEurope Annual Event 2023 conference poster "International Energy Agency Wind Task 43 Digitalization: Data Standards Gap Analysis" [5].
- GitHub repository "Wind Resource Assessment Data Model and Standard" [6].
- Workshop recording "WRA Data Model User Workshop - Part 1" [7].
- Workshop recording "WRA Data Model User Workshop - Part 2" [8].
- Wind Energy Science Conference 2023 presentation "Utilizing digitalization through heuristic risk-based blade maintenance for leading-edge erosion" [9].
- 4th International Symposium on Leading Edge Erosion and Protection of Wind Turbine Blades presentation "Progress in the Development of a Damage Growth Model for Leading Edge Erosion Incorporating Inspection Data" [10].
- NREL Drivetrain Reliability Collaborative Workshop 2023 "Leveraging Digitalization to Reduce Blade O&M Costs from IEA Task 43" [11].

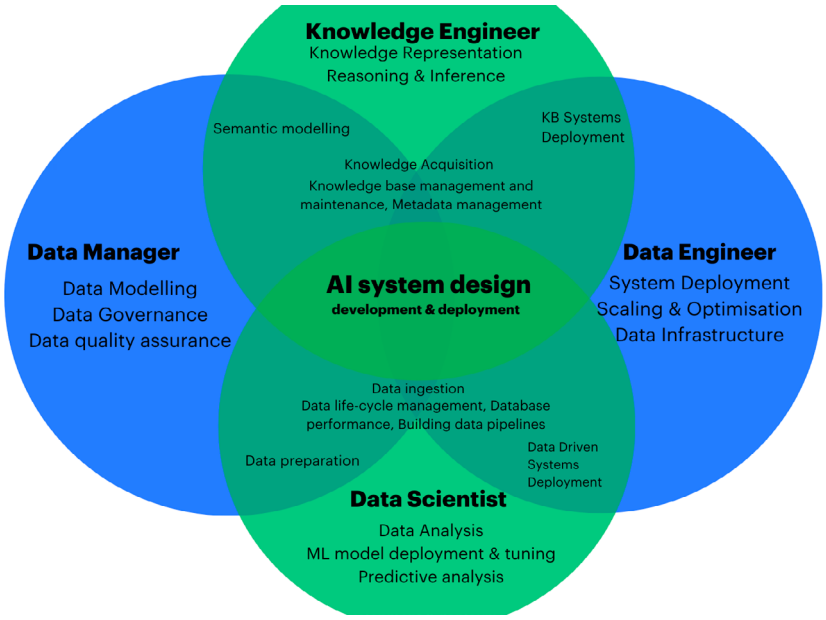

Figure 2: The knowledge engineering roles defined in our recent review paper "Knowledge Engineering in Wind Energy" [2].

Highlight(s)

Publication Snapshot

A review paper "Grand Challenges in the Digitalization of Wind Energy" was published in the Wind Energy Science Journal. It formed inspiration for a recent task extension proposal, which focuses on addressing the three "Grand Challenges" and were defined to be:

- Data: creating FAIR data frameworks.
- Culture: connecting people and data to foster innovation.
- Coopetition: enabling collaboration and competition between organizations.

They include a mix of technical, cultural, and business aspects that will require collaboration between businesses, academia, and government. Working to mitigate them is the beginning of a dynamic process that will position wind energy as an essential part of a global clean energy future.

Success Story: Adoption of WRA Data Model

Recently, we carried out a User Workshop with more than 30 attendees from the sector. In the first part, we shed some light on how different organizations are implementing or using the WRA Data Model in the "Industry Success Stories" session. This was followed by tutorials on how to create a WRA Data Model formatted JSON file and a demonstration of how it can be used in a floating lidar context. The recordings are available here.

Cross-cutting Activities

During the last year, we have built up a collaboration with the Research Data Alliance (RDA). In October 2023 we will launch an RDA working group on wind energy standards, which will be used to accelerate the learning and adoption of data standards and concepts related to metadata and knowledge engineering in the wind energy sector.

Outcomes and Significance

The results are beneficial to the participants in several ways:

- There is a strong learning effect. By working together on publications, guidelines and frameworks, the participants learn from each other and build up their own understanding of specific topics, which can then be transferred to their colleagues outside of the Task.
- The participants strengthen their network. By interacting with people from different areas of the sector, from both academia and industry, the participants get to know each other and develop ideas together.
- The participants benefit from early adoption of recommendations and tools. Through our internal dissemination activities (website, Slack channel, webinars, yearly meetings, topical meetings, etc.), the participants are well-connected to all the activities within the Task and can test and adopt the results more quickly and effectively than non-participants.

As digitalization is such a broad topic and we address the whole life cycle, the results are beneficial to the entire industry. We have published various guidelines, papers, tools, codes and models, which are available to everyone. Our webinar series helps people connect and understand what we do. Furthermore, the results apply to society as a whole. Our work inspires international and open collaboration and innovation.

Next Steps

We have recently submitted a task extension proposal. Our new vision is to unlock the full value of wind energy through digital transformation. Our mission is to act as a digital transformation catalyst by driving open collaboration within and beyond the wind community to deliver insights, recommendations, standards and tools in the key areas of data, culture, and coopetition. Our efforts will be focused around the three Grand Challenges of Digitalisation in Wind Energy, as well as on specific priority "use cases" brought in by the industry.

References

[1] Clifton, A., Barber, S., Bray, A., Enevoldsen, P., Fields, J., Sempreviva, A. M., Williams, L., Quick, J., Purdue, M., Totaro, P., and Ding, Y.: Grand challenges in the digitalisation of wind energy, Wind Energ. Sci., 8, 947–974, https://doi.org/10.5194/wes-8-947-2023, 2023.

[2] Marykovskiy, Y., Clark, T., Day, J., Wiens, M., Henderson, C., Quick, J., ... & Barber, S. (2023). Knowledge Engineering for Wind Energy. arXiv preprint arXiv:2310.00804. https://arxiv.org/abs/2310.00804

[3] Bray, A. (2021), IEA Wind Task 43: grand challenges in the digitalisation of wind energy, WindEurope Resource Assessment & Analysis of Operating Wind Farms 2021. https://windeurope.org/tech2021/poster-presentations/#bm

[4] S Barber, A M Sempreviva, S Sheng, D Farren and D Zappalá (2023), A use-case-driven approach for demonstrating the added value of digitalisation in wind energy, Journal of Physics: Conference Series, Volume 2507, WindEurope Annual Event 2023. https://doi.org/10.1088/1742-6596/2507/1/012002

[5] Marc-Alexander Lutz, (2023), International Energy Agency Wind Task 43 Digitalization: Data Standards Gap Analysis, WindEurope Annual Event 2023. https://windeurope.org/annual2023/conference/posters/PO030/

[6] IEA Wind Task 43 GitHub repository: https://github.com/IEA-Task-43

[7] WRA Data Model User Workshop - Part 1: https://www.youtube.com/watch?v=DxQ22SfXS58

[8] WRA Data Model User Workshop - Part 2: https://www.youtube.com/watch?v=MoKDz1FptDA

[9] Wind Energy Science Conference 2023 presentation "Utilizing digitalization through heuristic risk-based blade maintenance for leading edge erosion": Wind Energy Science Conference 2023 presentation: https://abbey.eventsair.com/AbbeyEventApp/wind-energy-science-conference-wesc-2023/wesc-info-site/Agenda/AgendaItemDetail?id=c51e4aad-497d-4380-8b0c-aa7be3cb3156

[10] 4th International Symposium on Leading Edge Erosion and Protection of Wind Turbine Blades presentation "Progress in the Development of a Damage Growth Model for Leading Edge Erosion Incorporating Inspection Data: https://www.dtu.dk/english/calender/arrangement?id=d-326b40a-0351-4f00-bd0c-a10e-d99532a7

[11] NREL Drivetrain Reliability Collaborative Workshop 2023 "Leveraging Digitalization to Reduce Blade O&M Costs from IEA Task 43": https://www.nrel.gov/wind/drivetrain-reliability-collaborative-workshop-2023.html

Task Contact

Sarah Barber,
Eastern Switzerland University of Applied Sciences, Switzerland.
Shawn Sheng,
National Renewable Energy Laboratory, USA.

Emails
sarah.barber@ost.ch
shawn.sheng@nrel.gov

Website
https://www.ieawindtask43.org/