Report 2023

Task 43

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Wind Energy Digitalisation

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Digitalisation is one of the key barriers to increasing the value of wind energy [1].

A recent publication from Task 43 [2] defined the following grand challenges of digitalisation in wind energy:

1. Data: creating FAIR (findable, accessible, interoperable, and reusable) data frameworks.
2. Culture: connecting people and data to foster innovation
3. Coopetition: enabling collaboration and competition between organisations.

These grand challenges include a mix of technical, cultural, and business aspects that requires collaboration across industry, academia, and

governments to solve. This is the focus of the second phase of Task 43, which was approved in October 2023 following a Task extension proposal. The main objectives of Task 43 in this second phase, firstly include learning about data, data services, knowledge graphs and knowledge engineering, and ultimately publishing recommendations for improving data sharing in the sector. Existing and new ontologies will be developed and published collaboratively, and a data maturity roadmap to help the sector plan collaborative activities to increase data maturity will be published. In addition to this, methods for improving organisational culture and coopetition between organisations in the sector to foster digitalisation will be investigated. The results will be converted into recommendations and success stories. Finally, deep-dive use case workshops are planned and guidelines for best practices will be developed, outlining how priority use cases can be solved in practice.

The countries currently participating in Task 43 are listed in Table 1. Observing countries and organisations include Spain (Vortex, Creadis, EGP), France (Vaisala, France Energies Marines), and Norway (NTNU, University of Oslo, Microsoft, TGS).

Table 1. Countries Participating in Task 43.

COUNTRY/SPONSOR	INSTITUTION(S)
Switzerland	Eastern Switzerland University of Applied Sciences; EPFL: Berner Fachhochschule
United States	NREL; EPRI; Georgia Tech; Apex Clean Energy; Wood; DNV; UL; Shell; NIST; BSEE
Ireland	ServusNet; Brightwind; University College Dublin; Atlantic Technological University Sligo
Sweden	RISE
Canada	University of Windsor; UL Solutions; Southern Alberta Institute of Technology; University of Victoria
Denmark	DTU Wind and Energy Systems; Aalborg University
The Netherlands	TU Delft, Twindo, Suzlon, Wageningen University
United Kingdom	Octue; Natural Power; Bitbloom; Carbon Trust; BayWa r.e.; Ramboll; The Crown Estate; Oldbaum Services; University College London
Germany	Fraunhofer IWES; enviconnect; Ramboll; University Stuttgart

Progress and Achievements

Research activities:

- In-depth research into knowledge engineering basics and applications for wind energy.
- Further development of the WRA Data Model to include floating lidars.
- End-to-end implementation of the blade leading edge erosion decision framework using synthetic data.
- Further development of a damage growth model for leading edge erosion incorporating inspection data.
- Detailed definition of "key enablers" and "swim lanes" for the data maturity roadmap.
- Further development of the data standards gap analysis framework.
- Research into solutions for metadata and knowledge engineering from other sectors.
- Development of a use-case-driven approach for demonstrating the added value of digitalisation.
- Improving data sharing via WeDoWind, a framework for creating mutually beneficial collaborations.
- Development of a new concept for the Task extension proposal, and re-organising the Task management.
- Forming and launching new working groups for the Task extension (Figure 1).

Publications and deliverables:

- Journal paper "Knowledge Engineering for Wind Energy" submitted for publication in the Wind Energy Science journal [1].

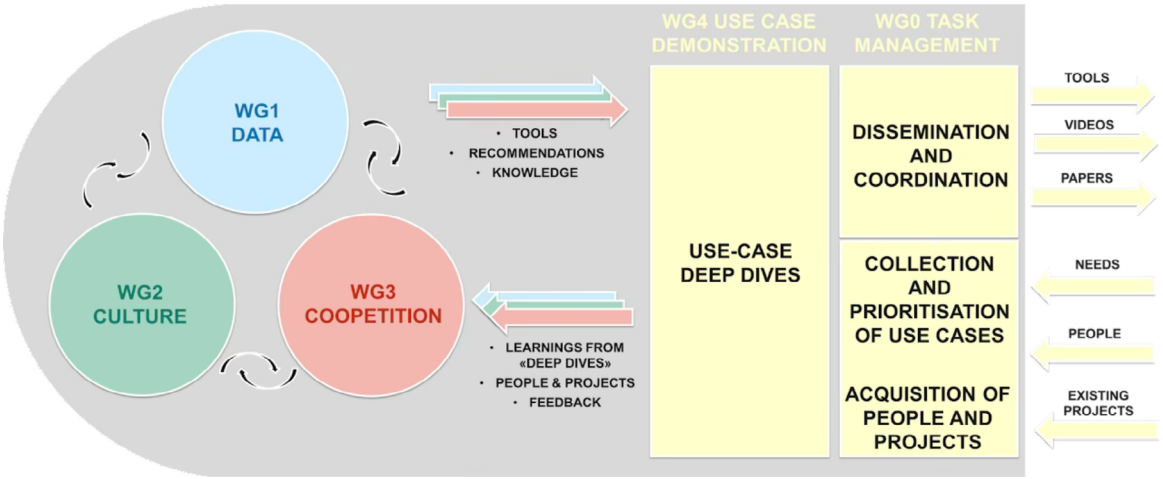

Figure 1. Overview of the working groups in phase two of the project. *Source: Sarah Barber.*

- New release of the WRA Data Model in January 2023 to include floating lidars [2].
- WindEurope Annual Event 2023 conference paper "A Use-Case-Driven Approach for Demonstrating the Added Value of Digitalisation in Wind Energy" [3].
- WindEurope Annual Event 2023 conference paper "Can Data Sharing Really Provide Added Value? Practical Data Sharing Recommendations for the Wind Energy Sector" [4].
- WindEurope Annual Event 2023 conference poster "International Energy Agency Wind Task 43 Digitalization: Data Standards Gap Analysis" [5].
- Wind Energy Science Conference 2023 presentation "Utilizing Digitalization Through Heuristic Risk-based Blade Maintenance for Leading Edge Erosion" [6].
- 4th International Symposium 2023 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" [7].
- NREL Drivetrain Reliability Collaborative Workshop 2023 "Leveraging Digitalization to Reduce Blade O&M Costs from IEA Task 43" [8].

Other communication activities:

- WRA Data Model User Workshops [9], [10].
- Six public webinars as part of the Metadata Challenge Webinar Series [11].
- Hosting of the Wind Energy Digitalisation Week at NREL in Boulder, CO, USA in June.
- Three-month research visit of the Co-Task Manager, Sarah Barber, to the other Co-Task Manager, Shawn Sheng, in Boulder, CO, USA (NREL).
- Video interview with Andy Clifton about "Grand Challenges in the Digitalisation of Wind Energy" paper [12].

Highlight(s)

Publication snapshot

The paper "Knowledge Engineering for Wind Energy" [1] discusses the obstacles encountered by wind energy experts when translating data into domain-specific knowledge, integrating it with other knowledge sources, and making it usable for advanced artificial intelligence systems. An analysis of semantic artefact adoption levels in wind energy is shown in Figure 2. Ultimately, recommendations for further advancement and enhancement are offered.

Success story

Task 43 is working towards a holistic human-centred open innovation ecosystem that includes many of the different aspects within the Task. This includes knowledge engineering, open-source and knowledge sharing communities. So far, the knowledge sharing community, which is being built up around the WeDoWind framework [13] and developed at the Eastern Switzerland University of Applied Sciences, has shown significant adoption, engaging more than 500 people from research and industry in more than 30 countries. WeDoWind is a framework for bringing asset owners, researchers, and model

developers together in a mutually beneficial collaboration, whereby asset owners get easy access to state-of-the-art data analytics and model developers get access to relevant asset data to train and validate their models.

Cross-cutting activities

In the Metadata Challenge Webinar Series [11], Task 43 has been encouraging collaboration with other sectors. In the second phase of the Task, external parties are not only invited to present inspiring and relevant work at the monthly working group meetings, but also participate in the monthly Q&A workshops run by the Task, alongside other IEA Tasks and external collaborations such as EU projects.

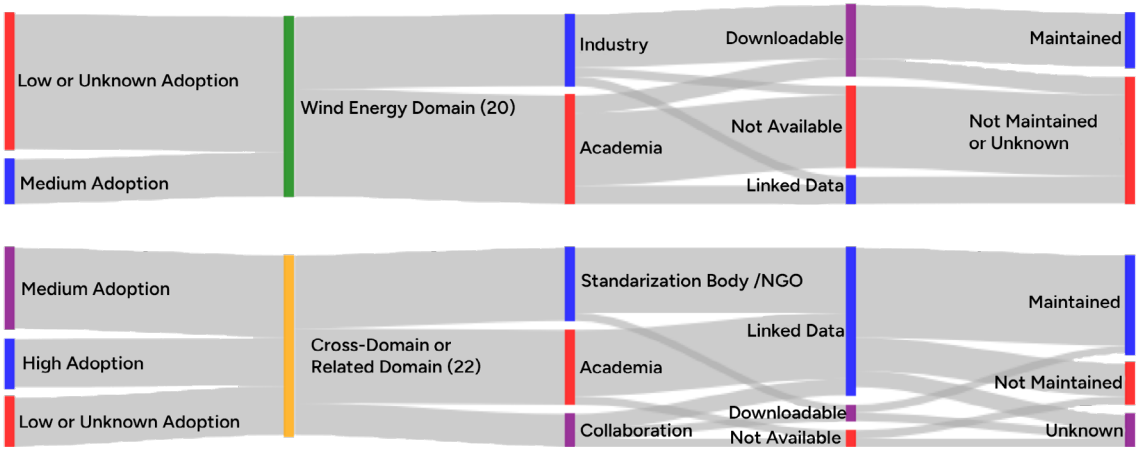

Figure 2. Analysis of semantic artefacts adoption levels. *Source: [1].*

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 on 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, webinars), the participants are well-connected to all activities within the Task, and can test and adopt the results more quickly and effectively than non-participants.

As digitalisation is such a broad topic and the whole lifecycle is addressed, the results are beneficial to the entire industry. Various guidelines, papers, tools, code and models have been published and are available to everyone. The webinar series helps people connect and understand the purpose and mission of Task 43. Furthermore, the results are applicable to society as a whole as the work provides inspiration for international and open collaboration and innovation.

Next Steps

The next steps are:

- Develop and publish a questionnaire to understand the role of culture in fostering digitalisation in wind energy.
- Carry out a literature review and develop recommendations for fostering digitalisation through culture and coopetition.
- Publish existing ontologies and develop new ones collaboratively.
- Carry out regular webinars.
- Write a recommended practice for data sharing in the wind sector.
- Write a recommended practice for knowledge graph based digital twins in practice.
- Conduct further deep-dives into selected digitalisation use cases to develop practical guidelines and recommendations.
- Publish the data maturity roadmap.

References

[1] Marykovskiy, Y., Clark, T., Day, J., Wiens, M., Henderson, C., Quick, J., Abdallah, I., Sempreviva, A. M., Calbimonte, J.-P., Chatzi, E., and Barber, S. (2024) Knowledge engineering for wind energy, Wind Energ. Sci., 9, 883–917. https://doi.org/10.5194/wes-9-883-2024

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

[3] Barber S., Sempreviva A. M., Sheng S., Farren D., and Zappalá D. (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

[4] Barber S., Hammer F., and Henderson C. (2023). Can data sharing really provide added value? Practical data sharing recommendations for the wind energy sector, Journal of Physics: Conference Series, Volume 2507, WindEurope Annual Event 2023. https://doi.org/10.1088/1742-6596/2507/1/012003

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

[6] Wind Energy Science Conference 2023 presentation: "Utilizing digitalization through heuristic risk-based blade maintenance for leading edge erosion". https://doi.org/10.5281/zenodo.13222882

[7] 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://doi.org/10.5281/zenodo.13223465

[8] NREL Drivetrain Reliability Collaborative Workshop 2023: "Leveraging Digitalization to Reduce Blade O&M Costs from IEA Task 43". https://doi.org/10.5281/zenodo.7753751

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

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

[11] Six public webinars as part of the Metadata Challenge Webinar Series: https://www.youtube.com/playlist?list=PL-FG5eR2-kX1fw2Yo-6JRNspoKi6trmN8V

[12] Video interview with Andy Clifton about "Grand Challenges in the Digitalisation of Wind Energy" paper: https://www.youtube.com/watch?v=kw0qM7njyv4

[13]Barber, S.; Lima, L.A.M., Sakagami, Y.; Quick, J.; Latiffianti, E.; Liu, Y.; Ferrari, R.; Letzgus, S.; Zhang, X.; Hammer, F. Enabling Co-Innovation for a Successful Digital Transformation in Wind Energy Using a New Digital Ecosystem and a Fault Detection Case Study. Energies 2022, 15, 5638. https://doi.org/10.3390/en15155638

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