Report 2023

# Task 53

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# Wind Energy Economics

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**Wind power serves as a key source of low cost, clean energy in markets around the world. The wind sector's future depends on a sophisticated understanding of cost reduction opportunities and how society can maximize the value of wind energy in the energy sector.**

The work within Task 53 aims to inform the analysis, policy, and regulatory communities of the current and future cost of wind energy for land-based and offshore wind technologies, and the technology's value proposition. The Task is focused on new wind applications, insights on evolving economic metrics and procurement instruments, as well as analysis and outcomes that examine a future where wind energy is tailored towards a fundamentally different power system. Specifically, one where wind provides more than half of the total electricity supply in several markets globally. By providing high-quality data that supports analyses related to the cost and value of wind energy, the Task enhances the broader energy community's efforts to plan for the future. The Task also develops novel methods that are often applied by key stakeholder groups and industry. Organisations such as IEA and the International Renewable Energy Agency (IRENA) have benefitted from Task 53 wind project cost and performance statistics, and participants of the Task regularly use this data for internal and external purposes.

## Introduction

In service of a better understanding of cost reduction opportunities and how society can maximize the value of wind energy, Task 53 was formed in 2022 to generate data and insights that inform the potential role of wind power in the future energy system. The Task is focused on new wind applications, new insights on evolving economic metrics and procurement instruments, as well as analysis and outcomes examining a future where wind energy is tailored towards a fundamentally different power system.

The Task has ten IEA Wind TCP Members, representing 18 distinct organisations with participation from about 22 individuals (Table 1). In its work programme, the Task considers the full array of land-based and offshore wind power applications but focuses primarily on utility-scale technologies and plants. The work scope extends through calendar year 2025. In the end of January 2023, the first in-person meeting was hosted by TNO in Amsterdam, Netherlands (Figure 1), which was followed by another in-person meeting in November in Kassel, Germany, hosted by Fraunhofer IEE. Industry stakeholders and external research entities regularly collaborate on work products and participate in the Task's in-person meetings.

### Table 1. Countries Participating in Task 53.

| COUNTRY/SPONSOR | INSTITUTION(S) |
|---|---|
| **Denmark** | DTU Wind and Energy Systems; EA Energy Analysis |
| **European Commission** | Joint Research Centre (JRC) |
| **Germany** | Deutsche WindGuard; Fraunhofer IEE; Fraunhofer ISI |
| **Ireland** | Sustainable Energy Authority of Ireland (SEAI); University College Cork |
| **Japan** | University of Tokyo; Osaka Sangyo University |
| **Norway** | Norwegian Water Resources and Energy Directorate (NVE) |
| **Sweden** | Swedish Energy Agency (SEA) |
| **The United Kingdom** | Offshore Renewable Energy (ORE) Catapult ; University of Sussex |
| **The United States** | Lawrence Berkeley National Laboratory (LBNL) ;National Renewable Energy Laboratory (NREL) |
| **The Netherlands** | Netherlands Organisation for Applied Scientific Research (TNO); Eneco |

Collaborators observing the work of the Task in the past year include IRENA and wind energy finance professionals.

## Progress and Achievements

Task 53 is now in its second year and results of the work have started to come to fruition. A summary of the collaboration, dissemination, and publications accomplished in 2023 include:

- 'The enduring role of contracts for difference in risk management and market creation for renewables' published in Nature Energy, 5th of December 2023.
- Assessment of capital expenditure for fixed-bottom offshore wind farms using probabilistic engineering cost model' published in Applied Energy, 1st of July 2023.
- 'Wind Technology, Cost, and Performance Trends for Denmark, Germany, Ireland, Japan, Norway, Sweden, the European Union, and the United States 2016-2019' published as a technical report on the IEA Wind TCP website in February 2023.

In addition to monthly web meetings, an in-person Task meeting took place


**Figure 1:** Experts Participating in IEA Wind Task 53. *Photo Credit: Fraunhofer IEE*.

of areas with a few highlights from select Work Packages (WPs):

- WP 1: A core team led by NREL with support from LBNL has developed a survey instrument to elicit perspectives on how wind plant siting, layout, and operations might be different in a highly decarbonised energy future by 2040.
- WP 2: Published an article in Applied Energy, focused on the capital expenditures for fixed-bottom offshore wind farms through a probabilistic assessment. The author team from the University of Tokyo have developed an offshore wind cost model for Japan and tested the impact of technology innovations onto CapEx by comparing their extent to those reported by U.K. projects.
- WP 3: Published a perspective article in Nature Energy on "The enduring role of contracts for difference in risk management and market creation for renewables". The author team challenges the notion of contracts-for-difference (CFDs) as subsidies and highlights the risk management qualities the contract vehicle provides to renewables and wind energy specifically.
- WP 4: Integrated country-specific cost and performance data into a view in Tableau on the IEA Wind TCP website, allowing an improved visual experience and utilisation of the data by global users.
- WP 5: Starting with a literature review of the cost and value implications of transmission and hydrogen options for offshore wind energy coupling, the project team from EA Energy Analyses have laid out potential synergies conceptually and has been exploring potential trade-offs quantitatively in the power system model, Balmoral.
- WP 6: The EU JRC has completed a supply chain database of Tier 1 through Tier 5 wind energy turbine suppliers.

## Highlight(s)

In the article published in Applied Energy, the capital expenditure (CAPEX) for a fixed-bottom offshore wind farm was assessed using a probabilistic engineering cost model to analyse potential cost reduction scenarios in Japan. A new export cable length model was introduced, which considers the landing point distance. Further, a vessel size model has been developed that takes turbine rated power into consideration. The proposed engineering cost model has successfully been able to explain the increase and decrease of CAPEX experienced by select offshore wind projects in the United Kingdom. The uncertainties of model parameters were identified from the data reported by the United Kingdom and modelled by a normal distribution function. The workability was predicted using the discrete event simulation. The predicted CAPEX was then compared with records from 30 existing fixed-bottom offshore wind farms in the United Kingdom. The predicted mean and standard deviation values of CAPEX showed good agreement with the reported ones, while the conventional parametric model underestimated the mean value and was not able to predict the standard deviation (Figure 2). Finally, the cost reduction scenarios and their uncertainties for offshore wind farms in Japan were analysed using the proposed probabilistic engineering cost model. The levelised cost of wind energy was found to reduce from 20.0 JPY/kWh to 17.0 JPY/kWh from a reduction of installation days using the specific installation vessel, to 13.6 JPY/kWh from the turbine enlargement, and 10.1 JPY/kWh from the improvement of operation and maintenance efficiency. The predicted supply prices for each cost reduction scenario agree well with those reported at the first auction conducted in 2021 in Japan [1].

## Outcomes and Significance

Task 53's work aims to inform the analysis, policy, and regulatory communities of the current and future cost of wind energy for land-based and offshore wind technologies, and the technology's value proposition within an evolving power system.

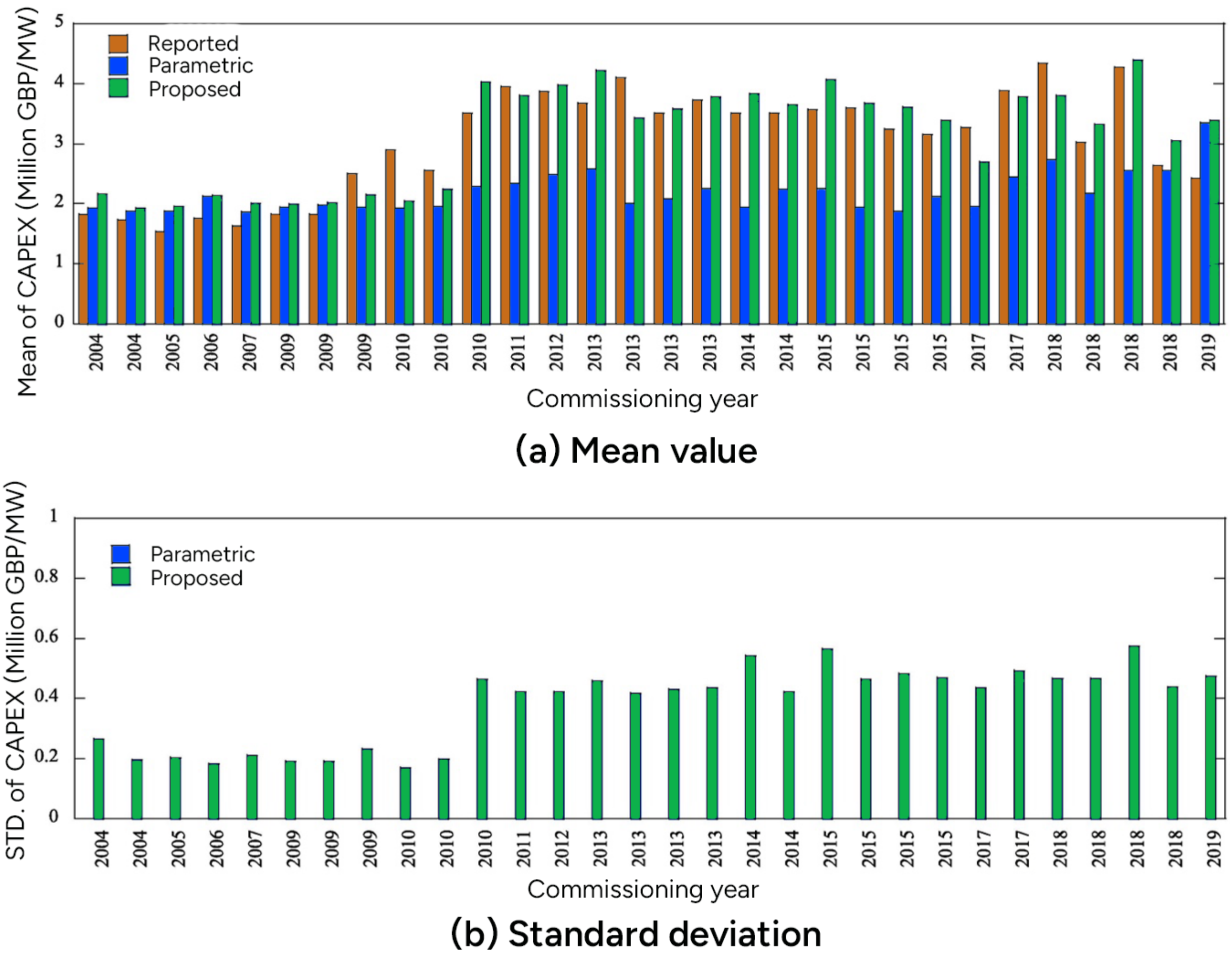


**Figure 2:** Comparison of mean and standard deviation of CAPEX reported in the UK and predicted by the proposed probabilistic engineering cost model and the parametric cost model. *Figure Source: [1].*

By providing high-quality data and published analyses that inform our understanding of the cost and value of wind energy, the Task enhances the broader energy community's efforts to plan for the future. The Task also develops novel approaches and insights that can be applied by key stakeholder groups and industry. Task 53 wind project cost and performance statistics have been used by organisations such as IEA and IRENA, and Task participants regularly use this data for internal and external purposes. Task 53 members are frequent presenters at conferences and industry leading events around the world.

## Next Steps

In 2024, the Task is expected to continue constructive dialogues during the monthly web meetings and the upcoming in-person Task meeting held in Dublin, Ireland, this Spring, hosted by the Sustainable Energy Authority of Ireland (SEAI). This meeting will be held in conjunction with the Technical Expert Meeting (TEM) #113 on 'net zero' power systems (jointly organised by Task 25 on Design and Operation of Energy Systems with Large Amounts of Variable Generation' and Task 53 on Digitalisation), as well as a joint meeting between Task 25 and Task 53. The latter joint meeting will serve the purpose of identifying joint research activities to pursue in the future. In Europe, one in-person in the Autumn, plus virtual collaborative meetings will be used to facilitate cooperation and successful completion of the remaining Task deliverables.

Major upcoming deliverables include a journal article on accounting of wind energy uncertainties and risks, dissemination activities for our planned expert survey, a technical report or journal article on cost and value considerations for offshore wind and hydrogen coupling, and an inventory of supply chain and port capabilities.

## References

[1] Beiter, Philipp, Jérôme Guillet, Malte Jansen, Elizabeth Wilson, and Lena Kitzing. 2024. "The Enduring Role of Contracts for Difference in Risk Management and Market Creation for Renewables." *Nature Energy* 9 (1): 20–26. https://doi.org/10.1038/s41560-023-01401-w

[2] Kikuchi, Y., T. Ishihara (2023) "Assessment of capital expenditure for fixed-bottom offshore wind farms using probabilistic engineering cost model". The University of Tokyo, School of Engineering, Department of Civil Engineering, Japan.

[3] Riva, Alberto, Janos Hethey, Peter Eriksen, Silke Luers, Forest Mak, Shadi Kalash, Magnus Wold, Jonas Bjarnstedt, Linus Palmblad, Thomas Telsnig, Tyler Stehly, Joe Rand, Ryan Wiser, Yuka Kikuchi. 2023. "*Wind Technology, Cost, and Performance Trends for Denmark, Germany, Ireland, Japan, Norway, Sweden, the European Union, and the United States 2016-2019*" IEA Wind TCP Report. https://www.nrel.gov/docs/fy23osti/81246.pdf

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