Estimating the major replacement rates in next-generation offshore wind turbines using structured expert elicitation

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Introduction and research questions

Offshore turbines are developing rapidly:

- They're getting bigger, much bigger…

- The generator and drive-train configurations have changed…

- And they're now beginning to float…

But how does this affect their reliability?

How often will large components need to be replaced?

First-generation
2-4MW rated power,
100-120m rotor diameter,
induction generators and
high-speed gearboxes

Current-generation
6-10MW rated power,
150-170m rotor diameter,
direct-drive and medium-
speed drive-trains and PM
synchronous generators

Next-generation
12-15MW+ rated power,
>200m rotor diameter,
potentially up to 10.7GW
of floating turbines by
2030 [2]

Very limited publicly available failure rate data.

Currently no publicly available failure rate data.

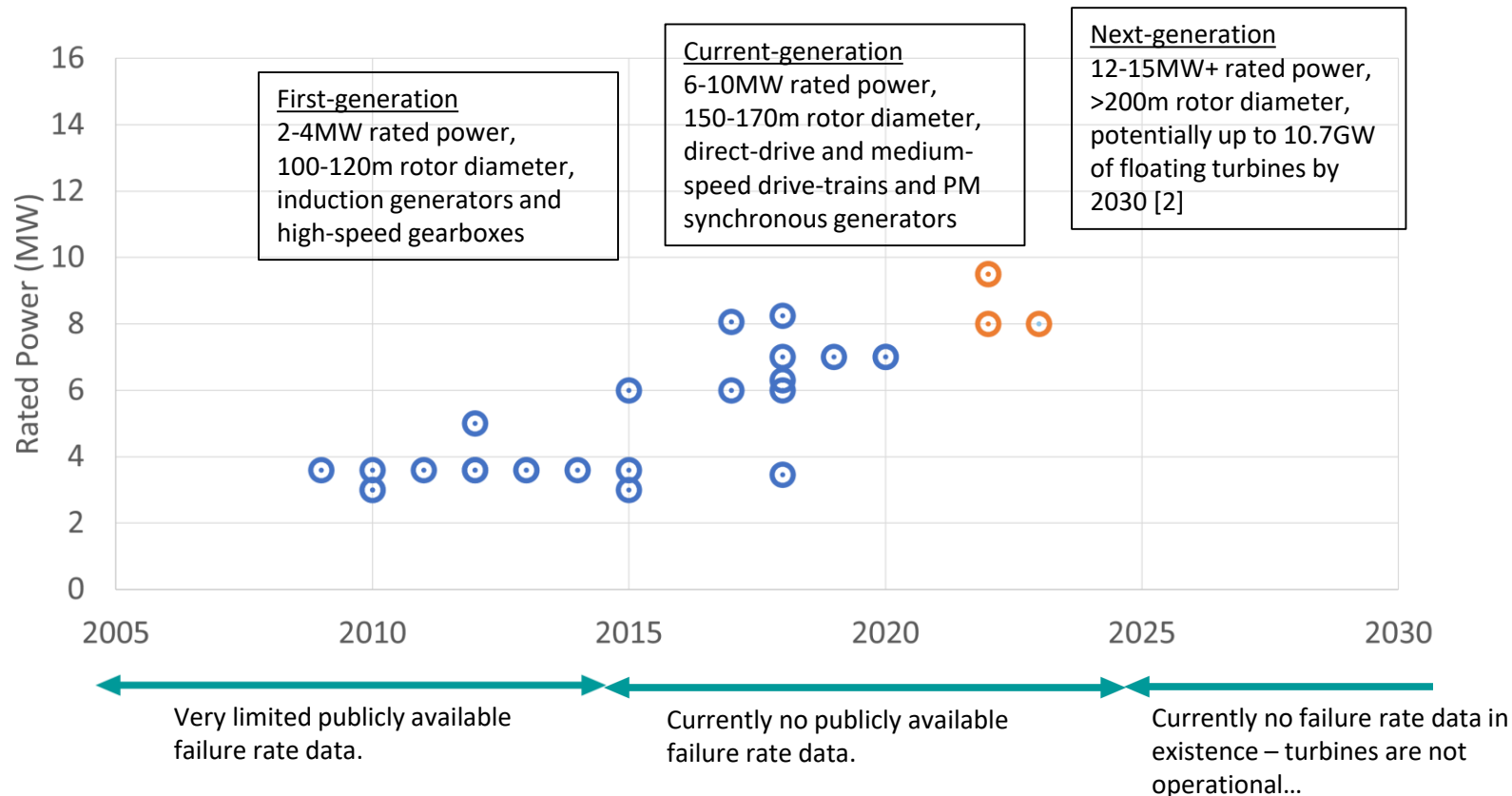Currently no failure rate data in existence – turbines are not operational…

Figure 1. Rated power of wind turbines in UK offshore wind farms greater than 100MW [1]

[1] Renewable UK, *Wind Energy Projects*. [Online] Available: https://www.renewableuk.com/page/UKWEDSearch
[2] Carbon Trust 2020 Floating Wind Joint Industry Project: Phase II summary report

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Method: Structured expert elicitation

Structured expert elicitation:

When no representative data is available, the knowledge of subject matter experts is often the best available alternative.

This work is based on the Classical Model of structured expert elicitation, and is implemented using steps outlined in the EFSA guidance on practically applying expert knowledge elicitation methods [3].

This provides a structured framework which captures expert reasoning and uncertainty, and reduces the impacts of cognitive biases and heuristics on values provided.
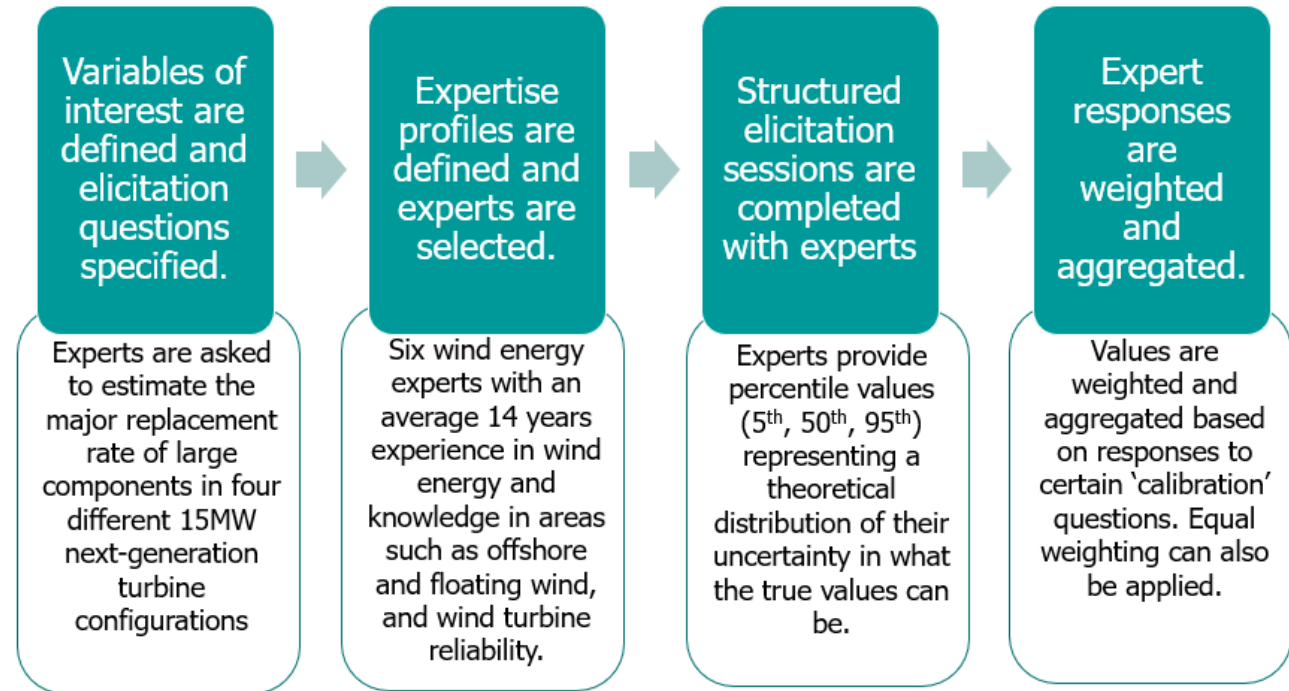
Variables of interest are defined and elicitation questions specified.

Experts are asked to estimate the major replacement rate of large components in four different 15MW next-generation turbine configurations

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Expertise profiles are defined and experts are selected.

Six wind energy experts with an average 14 years experience in wind energy and knowledge in areas such as offshore and floating wind, and wind turbine reliability.

→

Structured elicitation sessions are completed with experts

Experts provide percentile values (5th, 50th, 95th) representing a theoretical distribution of their uncertainty in what the true values can be.

→

Expert responses are weighted and aggregated.

Values are weighted and aggregated based on responses to certain 'calibration' questions. Equal weighting can also be applied.

Figure 2. Overview of the key steps applied.

[3] European Food Safety Authority 2014 *Guidance on Expert Knowledge Elicitation in Food and Feed Safety Risk Assessment*
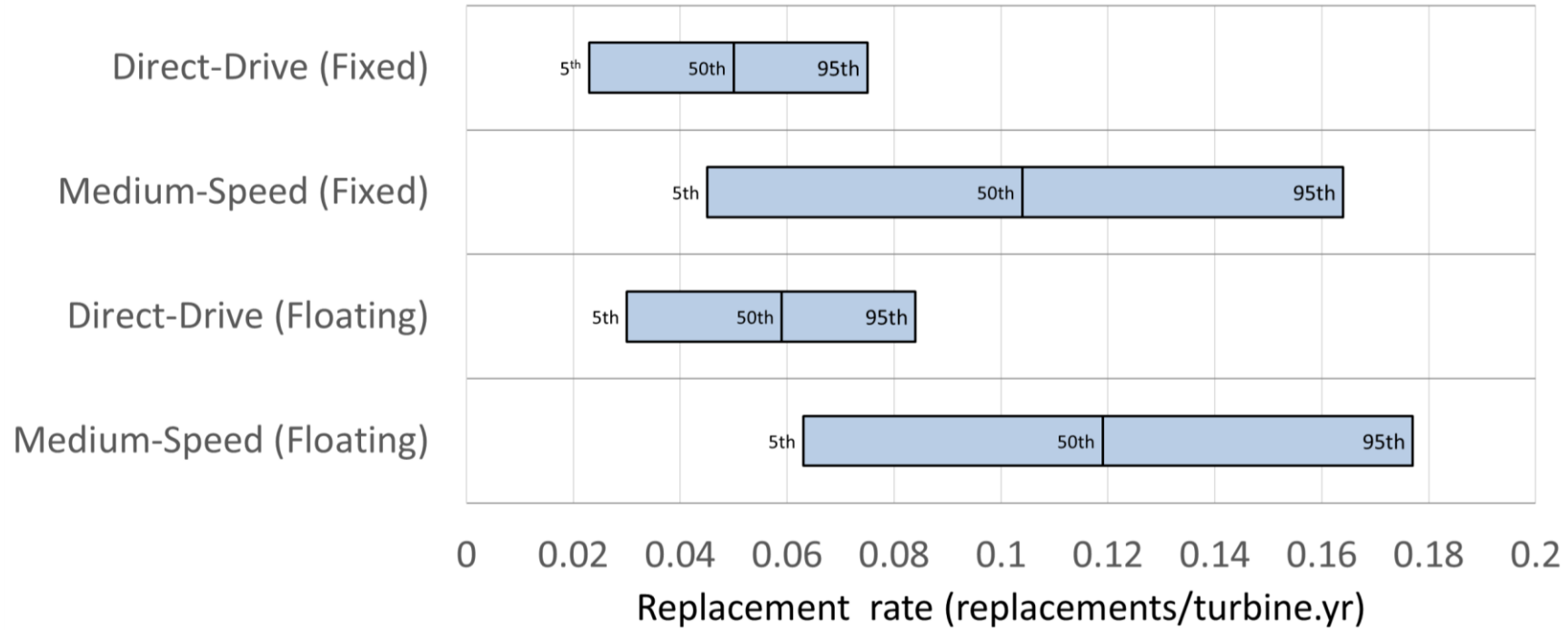
Results: Equal weighting aggregation

Figure 3. Equally weighted aggregation of estimated 15MW next-generation turbine major replacement rate values (generator + gearbox + rotor). Figure shows the aggregated 5th, 50th, and 95th percentile values.

Conclusions and next steps

- Still a large uncertainty range in what these values are likely to be, however:

  - Lower rate of large component major replacement operations expected in next-generation turbines compared to first-generation offshore turbines.

  - Lower rate of major replacement operations expected in direct-drive turbines compared to medium-speed, and in fixed-foundation turbines compared to floating turbines.

- Next steps include applying the Classical Model's global weighting aggregation method as an alternative to equal weighting.