ENERGY

Wind farm benchmarking for improved financial performance

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26 April 2017

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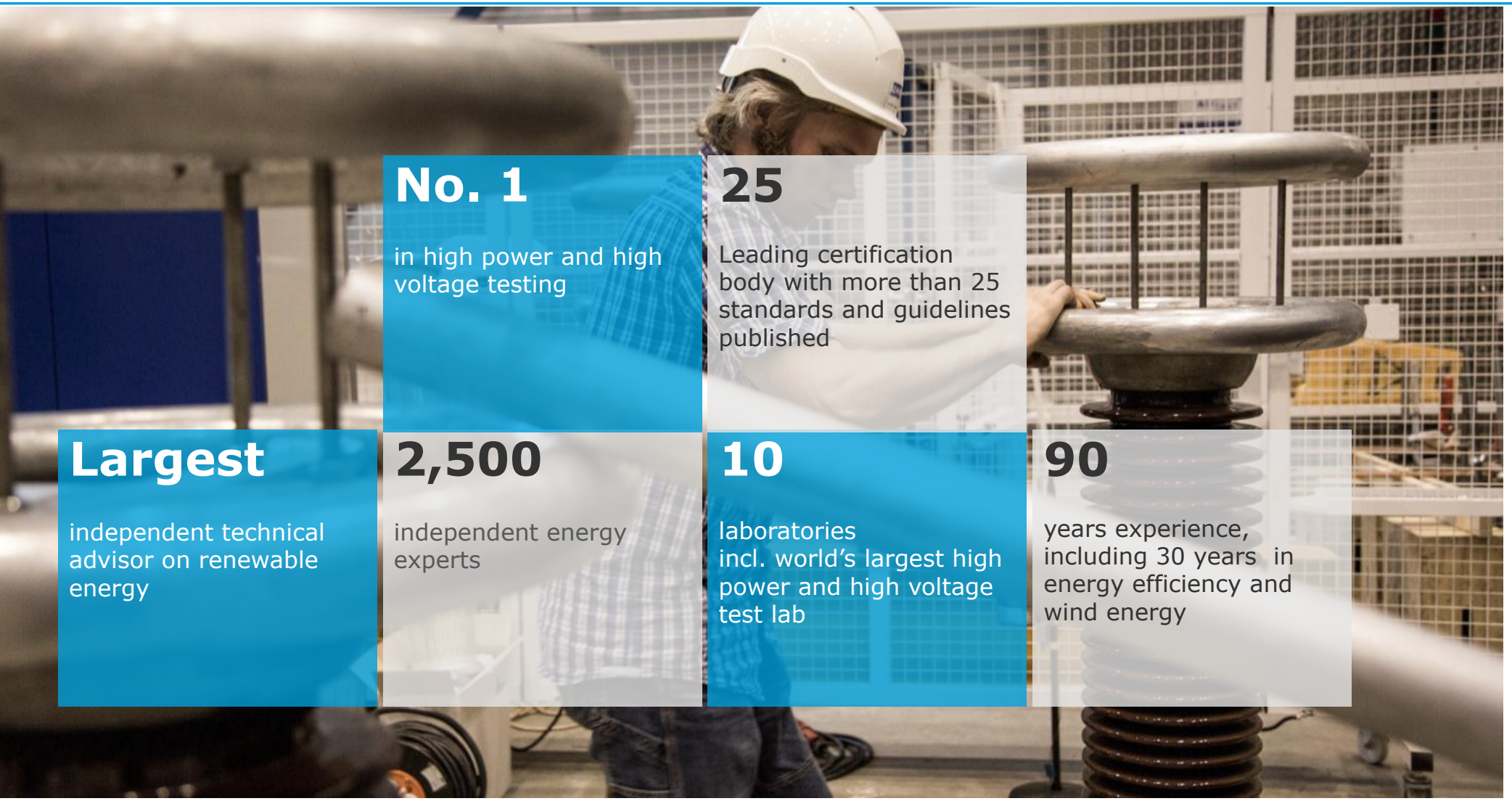
About DNV GL



No. 1

in high power and high voltage testing

25

Leading certification body with more than 25 standards and guidelines published

Largest

independent technical advisor on renewable energy

2,500

independent energy experts

10

laboratories
incl. world's largest high power and high voltage test lab

90

years experience, including 30 years in energy efficiency and wind energy

Motivation

- To increase financial value from existing wind farms, operational performance must improve.
  - Benchmarking against a reliable data set can help by identifying gaps in performance.
- To reduce financial risk on future assets, need to define realistic and accurate budgets.
  - Benchmarking against a reliable data set can help to define realistic targets for the region / project size / etc.

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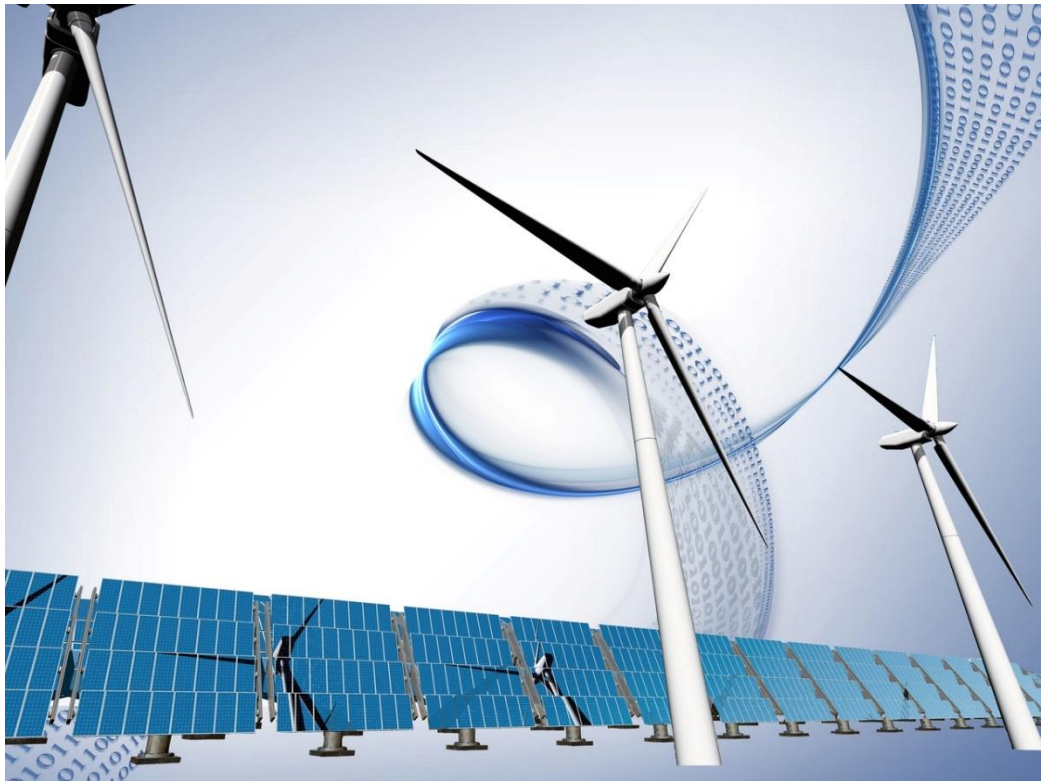
About benchmarking

- Benchmark: (verb) to evaluate (something) by comparison with a standard
  - The conclusions you draw depend on the ‘standard’ you choose to compare against

- Wind farm benchmarking metrics:
  - Availability
  - Reliability
  - Power Performance
  - Costs



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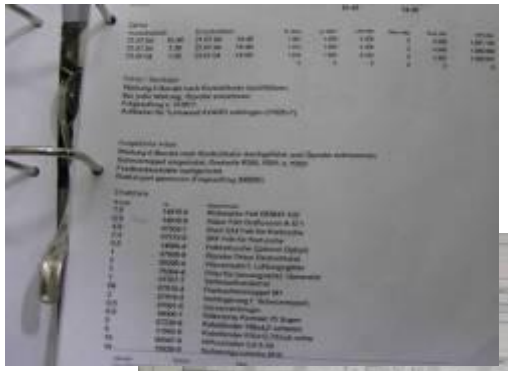
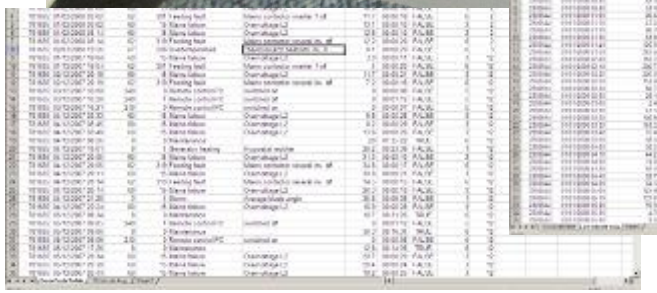
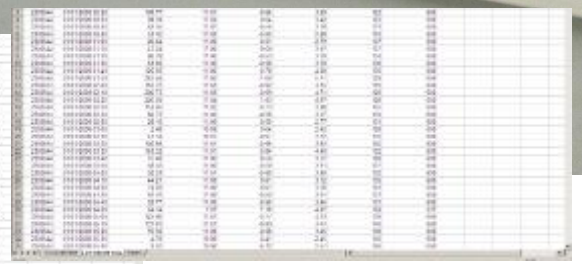
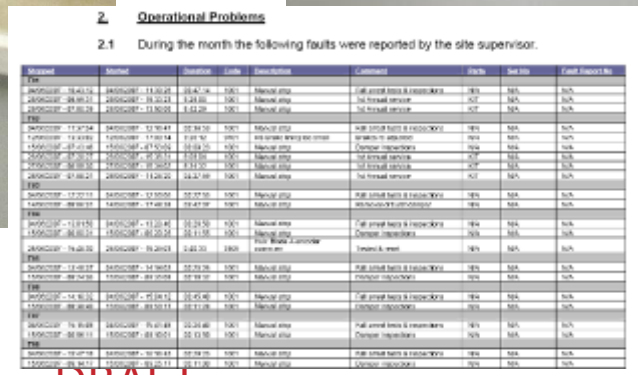
Common pitfalls in defining an appropriate benchmark









Real-world data are:

messy,

incomplete,

in different formats,

inconsistent over time,

etc.

Defining an appropriate benchmark

Best Practice	Example
(1) Choose a measurable quantity (metric)	e.g. Wind farm system availability
(2) For each metric, choose definition	Time-based or energy-based, including all wind-farm downtime (turbine, balance of plant, grid-related, environmental); or use IEC61400-26
(3) Gather as many data points as possible (a) Include metadata, or information about the data points (b) Include a quality metric for each data point	Wind farm location, age, turbine type and quantity, … High / medium / low confidence level
(4) Check the data set for bias and statistical significance	Minimum of 20 independent data points for each sub sample
(5) Be cautious about zeros: does 0 indicate a value (e.g. 0% available or 0 failures), or missing data?	Zeros are important to include with failure statistics, as "no failures" is as significant as "1 failure"

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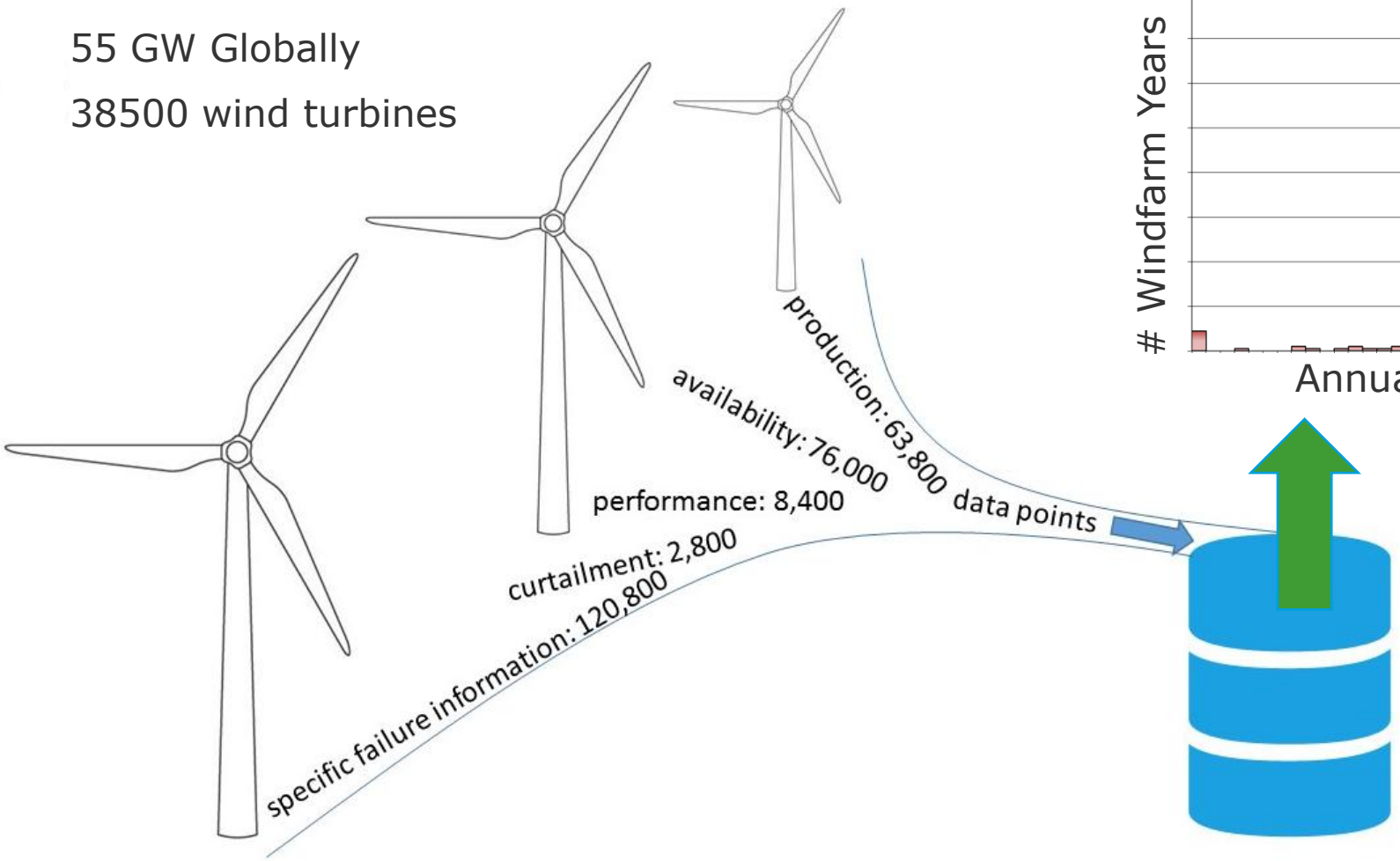
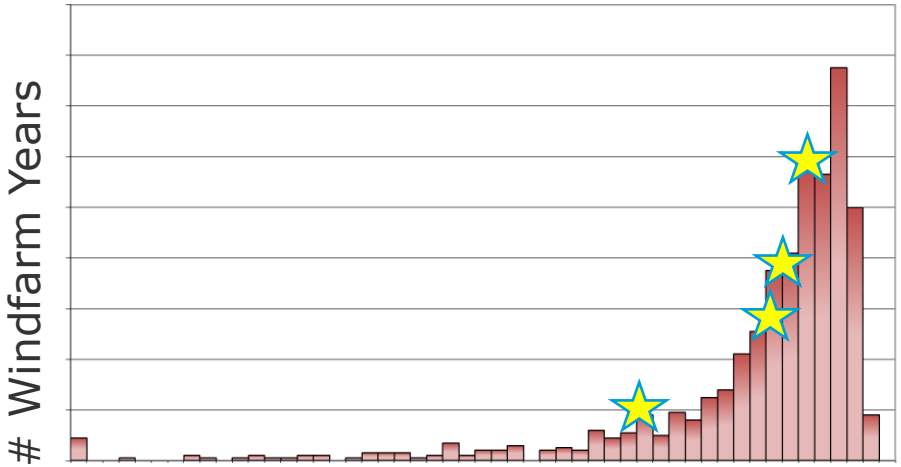
DNV GL Global Renewables Benchmark

55 GW Globally

38500 wind turbines





Customer data

Conclusions

- Project data and industry benchmark statistics can be used to improve performance of the wind farm and reduce financial risks.
- The value of the benchmark depends on whether best-practices have been used to collect the data.

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Questions?

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