Industry Benchmarking of Production Based Availability

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Contents

1. ORE Catapult
2. SPARTA
3. Production Based Availability
4. Ideal Workflow and ORE Experience
5. Conclusions
ORE Catapult

The Offshore Renewable Energy (ORE) Catapult is the UK’s flagship technology innovation and research centre for **offshore wind**, **wave** and **tidal** energy.

<table>
<thead>
<tr>
<th>Glasgow Office</th>
<th>Blyth Testing Facilities</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Glasgow Office Image" /></td>
<td><img src="image2" alt="Blyth Testing Facilities Images" /></td>
<td>- Core research</td>
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<tr>
<td></td>
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<td>- <strong>Joint industry programmes</strong></td>
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<td>- Component testing</td>
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<td>- Innovation challenges</td>
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</table>

ORE Catapult vision:

*Abundant, affordable energy from offshore wind, wave and tide.*
**SPARTA**

**System Performance, Availability and Reliability Trend Analysis**

A performance benchmarking tool for the UK Offshore Wind Industry with participation from all owner operators.

Owner/operators involved

- Statoil
- RWE
- e-on
- SSE
- DONG energy
- EDF
- Vattenfall
- ScottishPower
- Statkraft
- Centrica

Project sponsors

- Catapult
- The Crown Estate

Collaborative project

- Fraunhofer IWES

Technical advisers

- DNV-GL
Representative dataset:

<table>
<thead>
<tr>
<th>Sparta Wind Farm Details</th>
<th>– Name, Location, Rated Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sparta Wind Farm Details</td>
<td>– Manufacturer, Model</td>
</tr>
<tr>
<td>Sparta Balance of Plant</td>
<td>– Foundation types, Substations, Cabling</td>
</tr>
<tr>
<td>Sparta Site Conditions</td>
<td>– Meteorological devices, Long term mean wind speed</td>
</tr>
</tbody>
</table>

Metrics stored in the database:

- **Fixed General Metrics**
  - Wind Farm Details – Name, Location, Rated Capacity
  - Turbine Details – Manufacturer, Model
  - Balance of Plant – Foundation types, Substations, Cabling
  - Site Conditions – Meteorological devices, Long term mean wind speed

- **Variable Monthly Metrics**
  - Power Performance
  - Availability
  - Curtailment
  - Itemised System Repairs
  - Weather Measurements

74.3% Proportion of UK Offshore Fleet
3.73GW Installed Capacity

Representative dataset:

- Metrics stored in the database:

74.3% Proportion of UK Offshore Fleet
3.73GW Installed Capacity
Production Based Availability

Availability measurements are concerned with fractions of time and energy a unit is capable of providing generation.

Production-based availability = 1 – \(\frac{\text{Lost production}}{\text{Actual energy production} + \text{Lost production}}\)

Lost production = Potential energy production – Actual energy production

Rearranging, \(PBA = \frac{\text{Actual Energy Production}}{\text{Potential Energy Production}}\)

(Normally quoted as a percentage)
Production Based Availability

Wind farm Power Output

How does an operator know the operative state of the turbines?

How should an operator calculate potential production?
- Average power
- Modelled reference wind speed

Actual Production
Potential Production
Partial Performance (Curtailment)

$PBA = \frac{Actual}{Potential}$

Measured Production in a month = 19,299 MWh
Lost Production during curtailment = 888 MWh

Therefore, Potential Energy Production = 20,187 MWh
PBA = 19,299/20,187 = 0.956

PBA 95.6%
### IEC TS 61400-26-2 Information Model

- Defines Operational States
- Partitions the building blocks of a PBA calculation

**PBA = 1 – \( \frac{\text{Lost}}{\text{Actual} + \text{Lost}} \)**
Ideal Workflow

Assign operational states

Calculate production: actual and lost

Apply an availability algorithm

PBA 95.6%

SCADA

SPARTA
ORE Catapult Experience

- OEMs do not provide reliable indication of operative states
- Alarm logs generate large volumes of unclear data and there is no current consensus on how to use alarm logs to identify operative state.
- This aspect has raised significant inconsistencies for SPARTA
- No SPARTA users can currently do this for all operative states

**Mapping from alarm logs to operative states is required**
Actual production is read from SCADA and causes no issues.
The potential production methods in the IEC Standard are simply “informative”
A quantitative analysis has been carried out by DNV-GL on the prescribed methods for the SPARTA project.
**A cost benefit analysis led to the decision to adopt the average power based method (A.3.2 Average production of wind farm)**
Accuracy was unexpectedly high and the simplicity of the method lends itself to the needs of an industry wide methodology.
An external reference method is required for period when there are no turbines in FULL PERFORMANCE.
ORE Catapult Experience

- Technical availability (manufacturer’s view) versus system availability (wind farm user’s view)
- **There is more confidence in the system availability values within SPARTA**
  - Operators are driving SPARTA and this is of higher value for them
  - Limited ability to assign operative states has driven the uptake of the unambiguous algorithm
- With more accurate assigning of operative states, credible industry-wide benchmarking of technical availability can be achieved.
System operational production-based availability algorithm based on mandatory information categories only

<table>
<thead>
<tr>
<th>Information categories – Layer 1</th>
<th>Layer 2</th>
<th>Layer 3</th>
<th>Layer 2 subtracted from Layer 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandatory level 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandatory level 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandatory level 3</td>
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<td></td>
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<tr>
<td>Mandatory level 4</td>
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</tr>
<tr>
<td><strong>FULL PERFORMANCE (IAOGFP)</strong></td>
<td>IAOGFPP$_p$</td>
<td>IAOGFPP$_p$</td>
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</tr>
<tr>
<td><strong>PARTIAL PERFORMANCE (IAOGPPP)</strong></td>
<td>IAOGPPP$_p$</td>
<td>IAOGPPP$_p$</td>
<td>IAOGPPP$_p$ - IAOGPPP$_p$</td>
</tr>
<tr>
<td><strong>TECHNICAL STANDBY (IAONGT)</strong></td>
<td>0</td>
<td>IAOGTP$_p$</td>
<td>IAOGTP$_p$</td>
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<tr>
<td><strong>OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)</strong></td>
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<td>IAOGENP$_p$</td>
<td>IAOGENP$_p$</td>
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<tr>
<td><strong>REQUESTED SHUTDOWN (IAONGRS)</strong></td>
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<tr>
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<td><strong>FORCE MAJEURE (IAFMP)</strong></td>
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<td>IAFMP$_p$</td>
</tr>
<tr>
<td>INFORMATION UNAVAILABLE (IU)</td>
<td>*</td>
<td>*</td>
<td>?</td>
</tr>
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</table>

Prod. Av. = 1 - \[ \frac{\text{Lost}}{\text{Actual + Lost}} \]
Production Based Availability

Wind farm Power Output

Actual Production

Potential Production

Lost Energy Due to:
- Information unavailable
- Partial Performance
- Downtime

Input Values:
- Measured Production
- Lost Production
  - Partial Performance
  - Downtime

Output Benchmark:

\[
PBA = \frac{\text{actual}}{\text{actual} + \text{lost} + \text{lost}}
\]
Conclusions

• SPARTA is a performance benchmarking tool for the UK Offshore Wind Industry. All UK offshore wind operators are involved in the project and the data coverage includes 74.3% of the UK offshore wind fleet.

• Data quality and consistency in methodologies are primary design principles.

• To enhance industry-wide availability benchmarking, mapping from alarm logs to operative states is required.

• Following a quantitative analysis by DNV-GL, SPARTA has adopted the average power based method (A.3.2 Average production of wind farm) for calculating potential energy production.

• SPARTA does benchmark both technical and system availability, however the unambiguous definition of system availability has driven much more confidence in this benchmark.