**Key Performance Indicators for Wind Farm Operation and Maintenance**

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**INTRODUCTION**

- The wind industry is now facing a challenging scenario with more offshore presence and without incentives for both development and operations. The current growing interest in optimising operations makes wind farm (WF) operation and maintenance (O&M) a new challenging field of study.
- The use of key performance indicators (KPIs) is one of the most widespread tools to get a comprehensive overview of a business and to measure the progress towards its stated goals. WF O&M would benefit from having a suitable, well defined and standard set of KPIs as many other industries and sectors. KPIs should inform about the general status of an operating asset, influence the decision-making process and reflect changes in the O&M strategy.
- During a joint industry workshop (JIW) organised by the Advanced Wind Energy System Operation and Maintenance Expertise (AWESOME) project, the definition of KPIs arose as one of the main needs for WF O&M.
- We present a review of the major existing indicators used in the O&M of WFs, not available in the literature so far. A final list of KPIs is suggested and verified against necessary properties, together with an analysis of the stakeholders involved in O&M and their interests.

**DISCUSSION**

- **We suggest a list of KPIs verified against the necessary properties.**
- **A check-mark (✓) indicates it fulfils it; a cross-mark (✗) it does not fulfil it; an asterisk (∗) indicates that with some modifications it would fulfil the property.**

<table>
<thead>
<tr>
<th>Performance</th>
<th>Relevant</th>
<th>Specific</th>
<th>Measurable</th>
<th>Comparable</th>
<th>Traceable in time</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-based availability (%)</td>
<td>✓</td>
<td></td>
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</tbody>
</table>
| Energy-based availability (%) | | | | | | ✗

<table>
<thead>
<tr>
<th>Maintenance</th>
<th>Relevant</th>
<th>Specific</th>
<th>Measurable</th>
<th>Comparable</th>
<th>Traceable in time</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interventions per WT</td>
<td>✓</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
| Reactive maintenance (%) | | | | | | ✓
| Schedule compliance (%) | | | | | | ✓
| Overtime jobs (%) | | | | | | ✓
| Labour costs vs. TMC (%) | | | | | | ✓
| TMC vs. AMB (%) | | | | | | ✓

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Relevant</th>
<th>Specific</th>
<th>Measurable</th>
<th>Comparable</th>
<th>Traceable in time</th>
<th>Standard</th>
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</thead>
</table>
| MTBF & Failure rate (%) | | | | | | ✓
| MTTR & Repair rate (%) | | | | | | ✓
| MTTF | | | | | | ✗

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<thead>
<tr>
<th>Finance</th>
<th>Relevant</th>
<th>Specific</th>
<th>Measurable</th>
<th>Comparable</th>
<th>Traceable in time</th>
<th>Standard</th>
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</thead>
</table>
| OPEX (€/MW) | | | | | | ✓
| EBITDA margin (%) | | | | | | ✓
| LLCR (%) | | | | | | ✓
| DSCR (%) | | | | | | ✓
| LCOE (€/MW) | | | | | | ✗

**CONCLUSION & OUTLOOK**

- This paper constitutes a good first contact to WF O&M aspects for those wind professionals and researchers that have not yet approached the field.
- After analysing the stakeholders involved, defining the properties for KPIs and a thorough review of the existing ones, we propose and discuss a suitable list.
- Further numerical validation is highly recommended to make quantitative evaluation for both onshore and offshore cases.

**SELECTED REFERENCES**

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[33] T. Wireman, Developing performance indicators for managing maintenance

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