Analysis of Operating Wind Farms 2018

Towards Revenue Assessment

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Understanding your Assets

What are we going to present?

• From PPA to spot market
• How do we assess our assets: from past to future focus
• Three sites investigated:
  • Time-based [hours]
  • Energy-based [kWh]
  • Revenue-based [Euro]
  “availability”
• Impact of different loss categories on 3 different forms of availability
• Conclusion
The Focus in the Past

**Time-based availability** accounts for downtime

Different definitions used in industry

\[
\text{Availability} = \frac{\text{Time the turbine is available, optimal operation}}{\text{Total Operation time}}
\]

Here: “available” means not only “ready”, but optimal operation

But this number does not give information on energy losses!
The Focus in the Present

Energy-based availability accounts for production

\[
\text{Energy-based Availability} = \frac{\text{Realised production}}{\text{Potential production}}
\]

Establish Potential Production:
- Follow process of post-construction assessment
  - SCADA incl error logs
  - Nacelle anemometer (hopefully reliable)
Methodology Potential Production

Lost production

But this does not give information on revenue losses!

<table>
<thead>
<tr>
<th>Error code</th>
<th>Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>Pause pressed on keyboard</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>20001</td>
<td>Power curtailment</td>
<td>AUTO error code</td>
</tr>
<tr>
<td>220</td>
<td>New SERVICE state: _____, _____</td>
<td>Unscheduled</td>
</tr>
<tr>
<td>2950</td>
<td>GenHighPhaseTemp: Min__Max__°C</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3172</td>
<td>PowerStopHighTemp</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>100</td>
<td>Too many auto-restarts: _____</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3164</td>
<td>PwrStopActive, Par1____Par2____</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3475</td>
<td>SafetySys Converter Stopped</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>2863</td>
<td>ConvWaterCoolPressLow____bar</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3656</td>
<td>Conv Charge Failed</td>
<td>Utility</td>
</tr>
<tr>
<td>3253</td>
<td>HighTempPwrStopRes: Mod__,___°C</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>144</td>
<td>High windspeed: ____ m/s</td>
<td>Environment</td>
</tr>
<tr>
<td>3222</td>
<td>HighTempMSC.IGBT: Mod__,____°C</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3472</td>
<td>SafetySystem Reset Required</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3633</td>
<td>Yaw System Stopped</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>356</td>
<td>Extreme yawerror ____.m/s ___.°</td>
<td>Environment</td>
</tr>
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<td>3298</td>
<td>Yaw To Cable Twist Reset</td>
<td>Manufacturer</td>
</tr>
<tr>
<td>3272</td>
<td>YawUntwistCW: Code__,_______°</td>
<td>Manufacturer</td>
</tr>
</tbody>
</table>
The focus in the Future

**Revenue-based availability** accounts for money

- PPA might become a rarity as support schemes connect to the spot market prices

\[
Revenue \text{ Availability} = \frac{\text{Sum of realised revenue}}{\text{Potential revenue}}
\]

- Impact the way you evaluate your asset:
  - Lost hours ≠ Lost production ≠ Lost revenue
- Quest for finding the most expensive losses...
Spot Market Prices

Example: Two week wind speed and electricity price
Spot Market Prices

Low seasonal influence but strong daily variation

Seasonal variation

Daily variation

- Wind speed
- Market price
Spot Market Prices

A new factor in the matrix of understanding you asset’s performance

Service at midnight during high wind speeds?

3MW/h yield but income = 30EUR/h

1.5MW/h yield but income = 90EUR/h
Spot Market Prices

Hot times for Hybrids?

Wind speed & Market price & revenue from production EUR/MWh 10min steps

See Poster: PO.044 Hybrid solutions for how to capitalize on low wind and high day-ahead spot market prices.

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Methodology

Three different sites investigated

From each wind farm one individual WTG is presented:

- Project No1: Vestas V117 3.3 MW turbine, losses very small
- Project No2: Vestas V112 3.075 MW turbine, medium losses
- Project No3: Enercon E115 3.0MW turbine, curtailment and icing

Data:

- 1 full year of 10min SCADA data: wind speed, production, status
- List of turbine error code
- Concurrent hourly spot market prices

Results:

- Time-, energy- and revenue-based availability are established
- Compared per loss category
Site 1: low losses

V117 3.45MW

Hours lost

Sum of Losses MWh

Sum of Lost income EUR

Absolute loss

Time based  Energetic loss  Revenue
Site 1: low losses

Comparison of normalised time-, energy- and revenue-based availability

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Site 2: medium losses

V112 3.075MW turbine

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Site 2: medium losses

Comparison of normalized time-, energy- and revenue-based availability

![Graph showing comparison of normalized availability]
Site 3: high losses

Enercon E115 3.0MW

- Site 3: high losses
- Enercon E115 3.0MW
- Utility: Site 3
- Hours lost
- Sum of Lost production MWh
- Sum of Lost revenue EUR

Graphs showing:
- Hours lost vs. various factors
- Sum of Lost production MWh vs. various factors
- Sum of Lost revenue EUR vs. various factors
- Turbine combined losses

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Site 3: high losses

Comparison of normalized time-, energy- and revenue-based availability
More information to be gained: Pareto Analysis

Enables more focused analysis:
- What causes lost revenue?
- Is it worth it to replace the "generator heating: Hygrostat rectifier" Cost annually 5800.EUR
Conclusion

Revenue-based availability is important

• In future more and more wind farms will be selling electricity on the spot market.
• Revenue-based availability gives you the relevant overview of your asset’s performance
• Increase understanding of the relevant faults
• Optimization of service/maintenance strategies
Thank you for your attention

Contact Detail

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