Utilising SCADA data to enhance performance monitoring of operating assets:

“The move to real-time performance management”

Keir Harman
EWEA Workshop Malmo, December 2014
Asset Operations & Management

Services:
- Asset management
- Operational analysis and optimisation
- Short-term forecasting
- SCADA solutions
- Turbine inspections
- Operational energy assessment

Experience:
- Operational analysis for >50GW
- Forecasting for >40 GW
- Inspections for >700 turbines per year
- SCADA systems installed on over 7GW
Overview

- ‘The benchmark performance’
- Detection of sub-optimal performance
  - Case study: non-optimal controller settings
  - Automated detection using change point analysis
- Detection of component failure
  - SCADA-based condition monitoring technique
  - Case study: main bearing failure
- The move to real-time performance management
### The benchmark performance

<table>
<thead>
<tr>
<th>Key Performance Indicator</th>
<th>Benchmark</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data quality</td>
<td>100% data retrieval</td>
<td>Higher frequency data from a wider range of sensors</td>
</tr>
<tr>
<td>Availability</td>
<td>98% and higher</td>
<td>Predictive maintenance techniques more widely adopted</td>
</tr>
<tr>
<td>Operating Performance (efficiency)</td>
<td>100% (operating as designed)</td>
<td>More complex control means that the wind farms are more susceptible to sub-optimal performance</td>
</tr>
<tr>
<td>Production</td>
<td>Maximized</td>
<td>Intelligent management of maintenance using accurate forecasts can minimise production losses (i.e. % production loss &lt;&lt; % downtime)</td>
</tr>
</tbody>
</table>
### Sub-optimal performance: Common causes

<table>
<thead>
<tr>
<th>1) De-rating or constrained operation</th>
<th>2) Component misalignment / sensor error</th>
<th>3) Non-optimal controller settings</th>
</tr>
</thead>
</table>

#### 1) De-rating or constrained operation

![Graph showing wind speed vs. power output]

#### 2) Component misalignment / sensor error

![Image of a wind turbine]

#### 3) Non-optimal controller settings

![Image of a control panel]
Sub-optimal performance detection:
Case Study: Non-optimal controller settings

- 3 years of 10 minute average data for a commercial MW scale turbine

**Charts:**
- Power vs wind speed
- Pitch vs wind speed
- Rotational speed vs torque
Sub-optimal performance detection: Case Study: Non-optimal controller settings

- 3 years of 10 minute average data for a commercial MW scale turbine

<table>
<thead>
<tr>
<th>Power</th>
<th>Pitch</th>
<th>Rotational speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vs wind speed</td>
<td>Vs wind speed</td>
<td>Vs torque</td>
</tr>
</tbody>
</table>
Sub-optimal performance detection:
Case Study: Non-optimal controller settings

- 3 years of 10 minute average data for a commercial MW scale turbine

- Last year of operation ~1.5% more efficient than first year
- Avoidable €100k loss of generation revenue on the whole wind farm
Sub-optimal performance:
Automated detection using multi-channel change point analysis

Step 1
Establish key performance relationship (e.g. rotational speed vs torque).

Step 2
Establish the average relationship between the two channels over the analysis period.

Step 3
Calculate the residuals ("Δ") of the actual values, relative to the expected values, given the relationship (2).

Step 4
Calculate the cumulative sum of Δ ("Σ(Δ)") and for several ("i") random permutations (bootstraps) of Δ ("Σ(Δ_r)_i").

Step 5
Determine the extreme range of Σ(Δ) and Σ(Δ_r)_I. Calculate the probability of a change having occurred at the extreme point.

Source: Analytical techniques for performance monitoring of modern turbines (Lindahl, Harman, EWEC 2012)
Sub-optimal performance: Automated detection using multi-channel change point analysis.
Component Failure: Detection through SCADA-Based Condition Monitoring (SCM)

Step 1
Use SCADA data to model the relationship between turbine operating conditions and a component temperature (e.g. gearbox temperature)

Step 2
Tune model using data from ‘normal operation’

Step 3
Monitor turbines by applying model to new SCADA data

Step 4
Compare actual temperature with modelled temperature – any deviations could indicate a problem

Source: Comparison of Methods for Wind Turbine Condition Monitoring with SCADA Data (Wilkinson, EWEC 2013)
Component Failure: Case study of main bearing failure

- Traditionally managed wind farm: ‘Run to failure’ coupled with time-based maintenance.
- SCM applied but without intervention
- July 2012
  - Start of deviation in model
- June 2013
  - Main bearing failure and subsequent replacement
  - Occurred 11 months after initial deviation
  - 7 week outage to replace main bearing

- Avoidable €80k loss of generation revenue due to 7 week outage
A sophisticated control room will detect faults near real-time and schedule activities to minimise production loss.
Concluding comments

Challenge:

• Performance benchmarks are very high in the mature market, therefore sub-optimal performance and prolonged downtime are unacceptable

Solution:

• Periodic off-line fault detection is replaced by real-time performance management facilitated by increasingly sophisticated SCADA-based tools and techniques run from the wind farm control room
• ‘Run to failure’ is replaced by intelligent ‘predictive maintenance’
Thank you

Keir Harman
Keir.harman@dnvgl.com
+44 1179 729 951

www.dnvgl.com

SAFER, SMARTER, GREENER