RELIABILITY-CENTERED MAINTENANCE: COST-EFFECTIVE TECHNIQUE TO MINIMIZE TURBINE FAILURE

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AGENDA

• Nordex at a glance
• RAMS concept and O&M relation
• Reliability centered maintenance
• Life-cycle management and (un)certainty
• RCM and costs management
• Summary
Currently focused on ~20 countries – onshore market position 2015 (w/o AWP)

- **UK**
  - Market share 2015: 32%
- **Ireland**
  - Market share 2015: 25%
- **Finland**
  - Market share 2015: 40%
- **Germany**
  - Market share 2015: 12%
- **Pakistan**
  - Nx installations 2015: 28 MW
  - (market data not yet disclosed)
- **UK**
  - Market share 2015: 32%
- **France**
  - Market share 2015: 14%
- **Chile**
  - Subsidiary established
- **South Africa**
  - Market share 2015: 18%
- **Uruguay**
  - Market share 2015: 17%
- **Turkey**
  - Market share 2015: 29%
  - Order intake: +67%
- **EUROPE**
  - Market share 2015: 13%
- **GLOBAL**
  - Market share 2015: 3%
- **China**
  - Sourcing only
Reliability
• Designed-in reliability

Operating environment
• Asset performance without operational errors

Maintenance plan
• Sustaining reliability of the asset
• Availability improvement

OEM
- design optimization
- reliability specifications
- maintenance optimization
- cost reduction

O&M
OPERATION AND MAINTENANCE CHALLENGES

Market
- O&M market is growing!

Challenge
- Competition
- Aging and diverse fleet requires innovative O&M approach

Opportunity
- Decrease OPEX

Tools
- Cost-effective strategies: RCM
RELIABILITY CENTERED MAINTENANCE

The goal is to reduce life-cycle costs while continuing to allow the system to function as intended with required reliability and availability.

- **Reactive**
  - non critical
  - redundant

- **Preventive**
  - known failure pattern
  - wear-out
  - consumable

- **Predictive**
  - critical
  - not wear-out
  - random failures

- **Proactive**
  - root cause analysis
  - FMEA
  - commissioning
Function and failure analysis
Failure modes analysis
Maintenances strategies selection
Preventive tasks selection

Potential 1
Prolong lifecycle

Potential 2
Exchange component

Potential 3
Do nothing

System condition

100%
SYSTEM LIFECYCLE MANAGEMENT

Decision making process

Input data
- Failure records
- Operational data
- Maintenance records

System reliability model

Component A
Component B
Component C
Component D
Component E

System

Life-time analysis

Analysis on component level
UNCERTAINTY SOURCES

All models are wrong, but some are useful. /George E. P. Box/

Note: Examples present simulated failure data
There is a 95% probability that the calculated confidence interval encompasses the true value of the population parameter.

*Sample size = N(n/m): N - total sample size, n – failed, m - healthy.

Note: Examples present simulated failure data
**Monte Carlo Simulation** performs risk analysis by generating possible results by substituting a range of values—a probability distribution—for any factor that has inherent uncertainty.

Note: Examples present simulated failure data.
Output variability

Best case scenario – 22 failed
Worst case scenario – 50 failed

€ 11M € 25M

Decision

30 gearboxes will fail in the next 2 years

80%

Money?

(€500K/gearbox)

Note: Examples present simulated failure data
RCM approach offers a high potential for smart O&M

Life cycle analysis of the system - input to verify reliability and optimize maintainance

Uncertainty and risk assessment is the basic step in RCM strategies selection

RCM plays significant role in conflict between product costs saving and maintaining reliability of the product in the field
Thank you for your attention!

Questions?

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REFERENCES

