Categorisation, systematisation and presentation of anomalies in the operation of wind turbines on the basis of analysed SCADA data

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TÜV SÜD at a glance

- **150+** years of safety, security & sustainability
- **1,000+** locations worldwide
- **€2.6** billion in annual revenue
- **25,000+** employees*
- **574,000** certificates
- **100%** independent & impartial
- **41%** of revenue outside Germany^**

*As of 2019-12-31.
^Based on clients' locations.
Note: Figures have been rounded off.

TÜV SÜD Business Line Green Energy
Categorisation, systematisation and presentation of anomalies in the operation of wind energy turbines on the basis of analysed SCADA data.
What is the problem?
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Definition of the problem

Problem:

Wind farm operator says my turbine is not doing well.

What does it mean? Tell me

Possible answers:

The production is too low

Something is no ok with power curve

The turbine is wrong
Definition of the problem

Current status of operational analysis in literature:

- No standard for failures or error description
- No common rules for data treatment
- No classification of errors
- No differentiation between errors and anomalies
Development of categories

1. Energy Yield
2. Permit
3. Life time /Loads
Analysis of Operational problems

Trigger → Abnormality → Variables → Potential Error identification

Variables

Known Error

Trigger
Analysis of Operational problems

- Wind speed,
- Wind direction,
- Pitch-angle,
- ...

signals

combination
- Wind speed+
- Power out

power curve
- Time series

definition

search
- Patterns
- Deviations

classification
- Error
- Non-error

category
- Yield
- Permit
- Life time

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Yield category

1. Signal selection:
   - Power out
   - Wind speed
2. Combination
3. Definition
   - Standard power curve
4. Search
   - patterns
   - deviation
5. Classification
   - Error
   - Non-Error
6. Category
   - yield
Yield category

- **Speed-torque curves**
  - Wind independent evidence for turbine mal function

- **Pitch-angle**

- **Power curve degradation**
  - Blade ageing
  - Dirt on blade
  - Damages

- **Idling above cut-in**
  - Power curtailment
  - Reduced grid capacity
Permit category

Deviation wind roses

Problem: Offset between Roses
Permit risk: Violating of permitted sector management
Signal: wind direction of two turbines
Permit category

- Wrong temperature violates the bat shot down requirements
- Failing the grid requirements
- Exceeding of permitted feed production
Life time

**Problem:**
Exceedance of design torque

**Life time risk:**
High torque destroys the azimuth drives

**Signal:** torque of azimuth drives
Life time

High temperatures
- Temperature signal high above normal
- Signal: Temperature in Generator Stator, Power
- Risk: Isolation melting

Rotor overspeed
- Rotor speed above design speed
- Signal: Rotor Rpm, Power
- Risk: Mechanical loads above design loads => Turbine break down

Pitch-angles
- Pitch-angles outside operational area
- Signal: Pitch-angel over time
- Risk: failure pitch system => worst case turbine break down
Mixed case

**Deviation wind measurements**

**Problem:**
Wind speed wrongly estimated

**Signal:** wind speed signal compare with the Cp-curves

**Risks:**
- Yield: wrong power curve
- Permit: wrong bat signal
- Life time: Wrong cut off wind speed

![Cp-curve measured vs. warranted](image-url)
Outlook

Ongoing:
- Development of more case per category

Steps in Progress:
- Taking the analysis from a qualitative assessment to a quantitate one

Future
- Achieving acceptance of SCADA-data findings in warranty discussions without inspections
- Applying the results for probabilistic failure identification
- Applying the review on real time data assessment
Summary

- SCADA signals used to identify problems
- Categorisation and classification of problems
- Yield category
- Permit category
- Life time category

Questions?