KPIS FOR WIND PLANT PERFORMANCE AND RELIABILITY

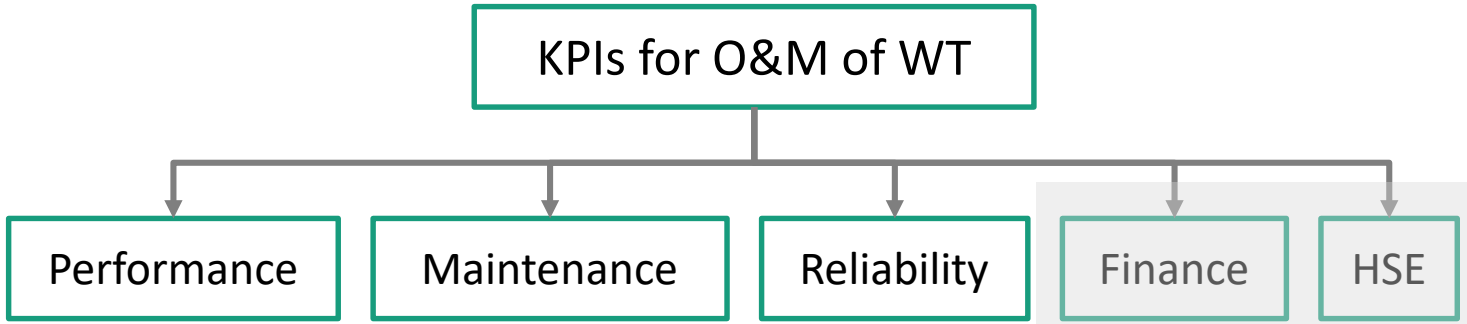
20.02.2019 Drivetrain Reliability Collaborative Workshop 2019, Golden

Sebastian Pfaffel, M.Sc. - Sebastian.Pfaffel@iee.fraunhofer.de - +49 561 7294 441

KPIs: What are we talking about?

Key Performance Indicator(s)

- Objectively describe the performance of an observed unit
- Provide information as a decision support
- Are repeatedly evaluated (monthly, quarterly, yearly …)
- Should be SMART
  - Specific
  - Measurable
  - Achievable
  - Relevant
  - Time-bound



Motivation and Scope

Situation in the wind industry (O&M)

- Various standards are available (e.g. IEC 61400-26)
- KPIs are commonly used
- Used KPI systematics and definitions vary heavily

Drawbacks

- Additional effort (design, implementation, …)
- Cross-company benchmarks aren't possible
- Hinders communication and knowledge building
- Makes contracts more complicated

Scope of this work

- Identify and prioritize commonly used KPIs
- Collect and review various definitions
- Propose a set of recommended KPIs including unified definitions

Wind Energy-Information-Data-Pool (WInD-Pool)

- Detailed maintenance data is the next “BIG STEP”
- Application of standards is very important for comparability
- Further Operators are welcome to join the initiative

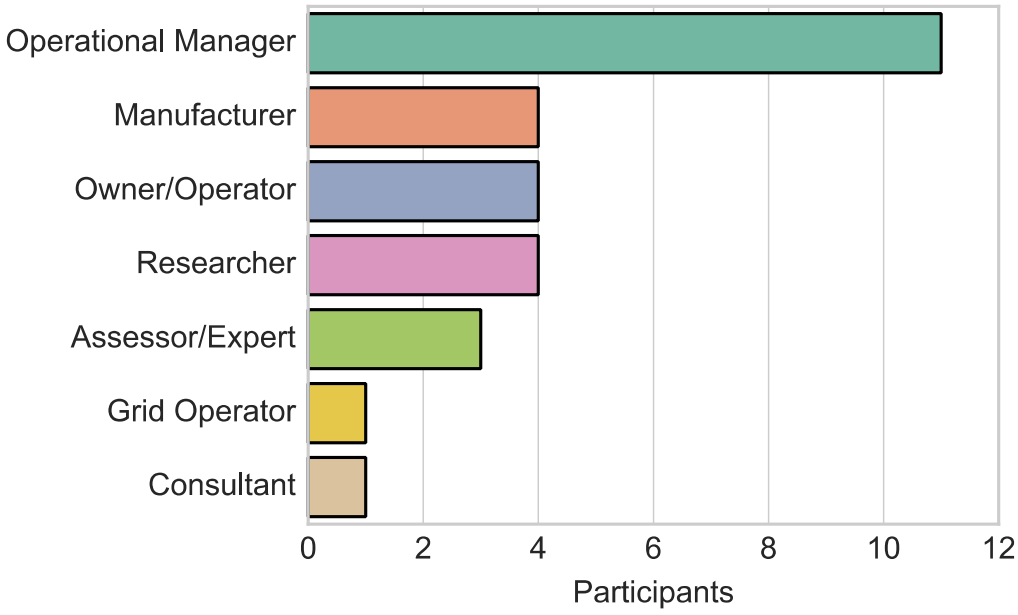

Survey on KPIs

- Survey is part of a standardization task within the FGW e.V.
- 34 different KPIs were considered in the survey
- Survey was open 4th October 2017 till 1st November 2017

What did we ask?

- Is the KPI used in your company?
- Which definition is used?
- Which data serves as a basis?
- How important is the KPI?

Who participated?



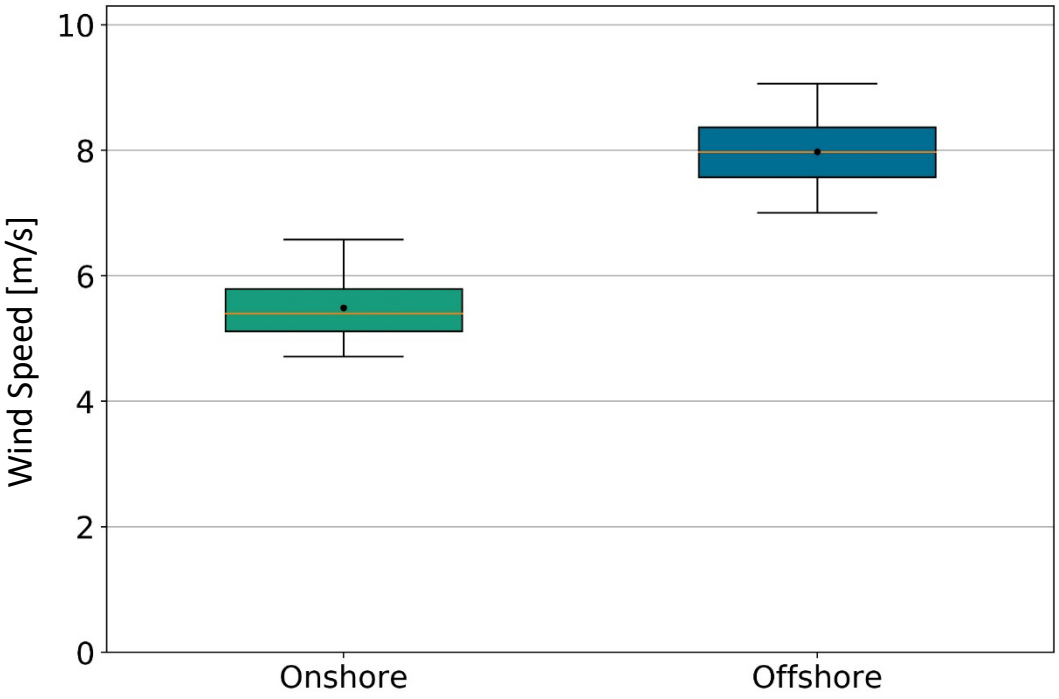
Fraunhofer IEE

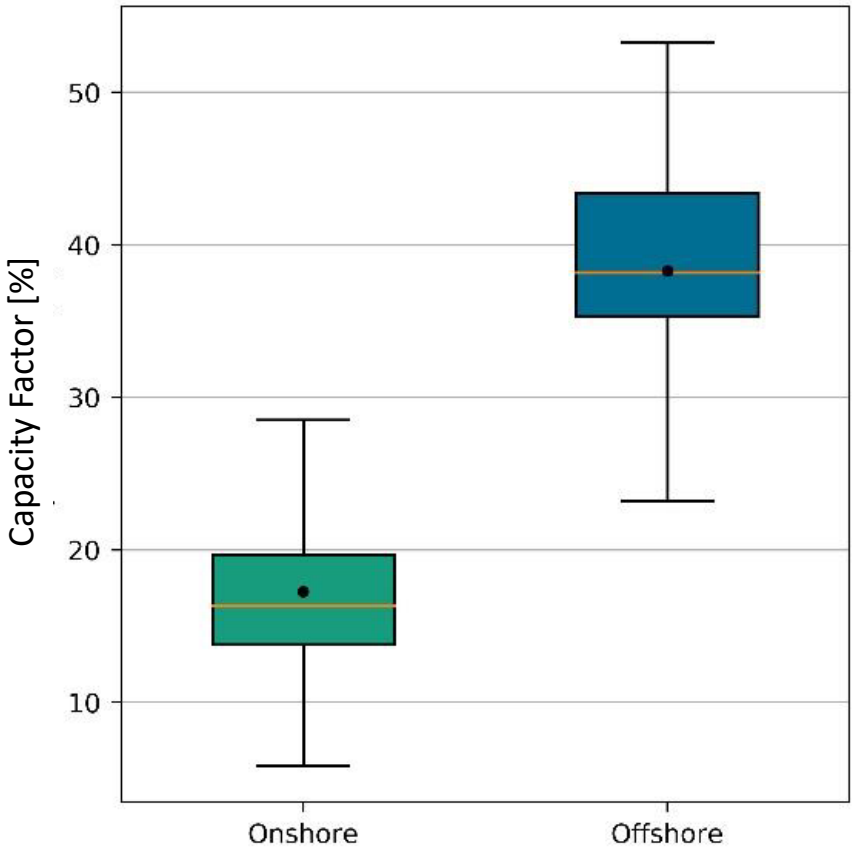
Performance KPIs

KPI	Answers	Use	Importance (1–5)	Abs. Importance
Power curve	20/20	19/20	4.5	85.5
Wind conditions	20/20	16/20	4.5	72
Average wind speed				
Wind speed distribution				
Wind direction distribution				
Average wind speed/site assessment				
Full-load hours	20/20	18/20	3.5	63
Energy consumption	20/20	16/20	3.1	49.6
Capacity factor	20/20	13/20	3.7	48.1
Data availability	20/20	11/20	4.1	45.1
Remote-resets	20/20	5/20	3.2	16
Site quality				
No. of telecommunication interruptions				
Forecast fulfillment				
Operating hours				
Specific yield				
Market value factor				

- Power Curves are the most important tool for performance assessment
- Operators use various metrics to describe the wind conditions
- Many more performance KPIs were suggested

Performance KPIs - WInD-Pool results



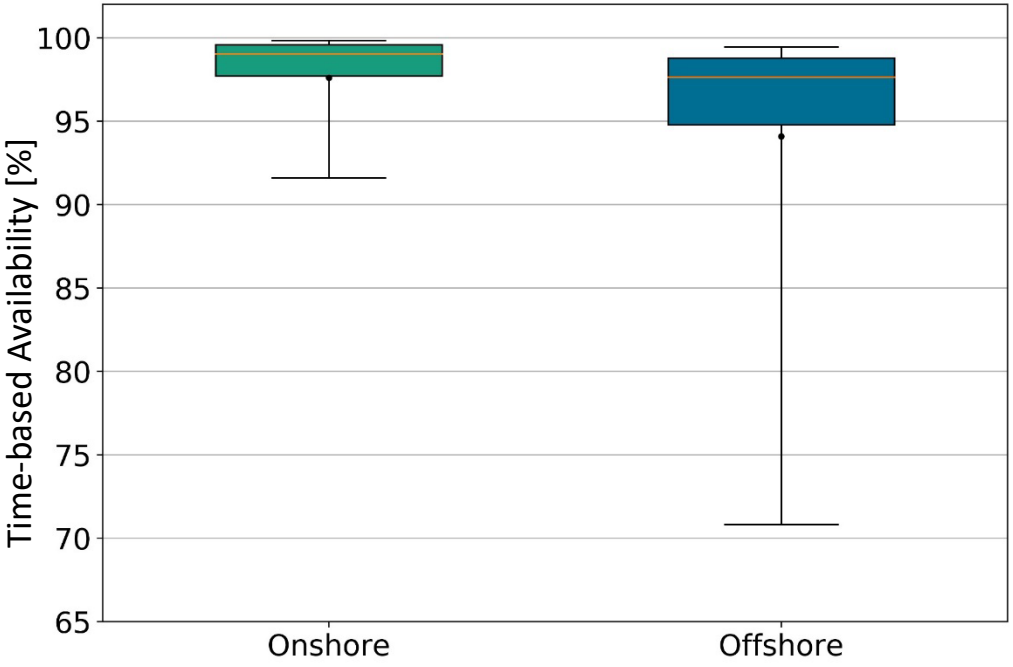


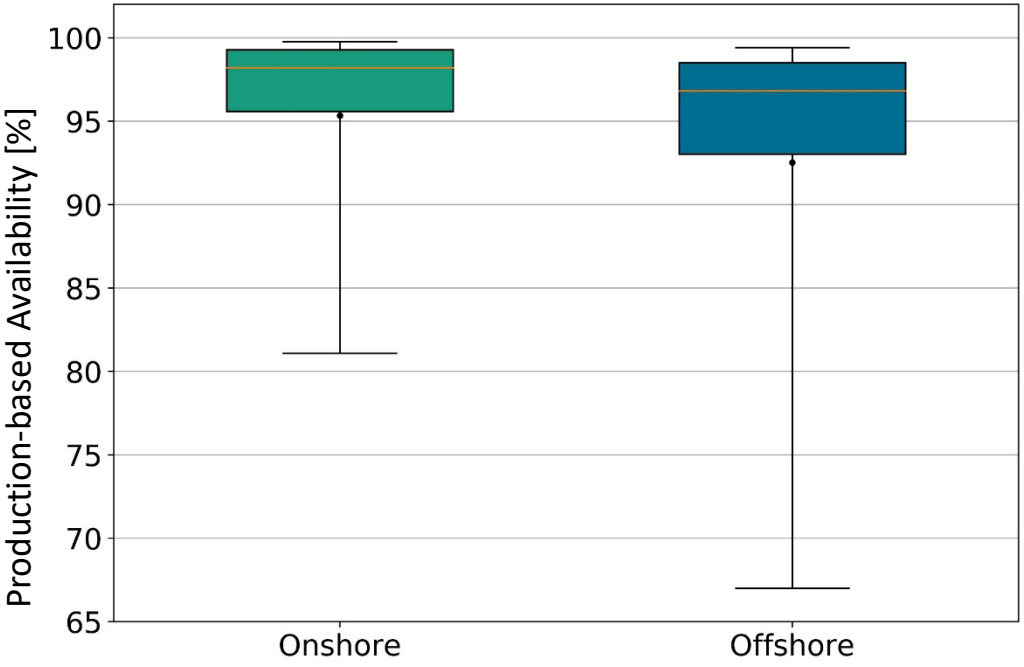
Maintenance KPIs

KPI	Answers	Use	Importance (1–5)	Abs. Importance
Time-based availability	16/16	16/16	4.7	75.2
Production-based availability	16/16	12/16	4.1	49.2
Production ratio				
Yield losses by cause				
Monetary-based availability				
Maintenance tasks	16/16	7/16	4	28
Preventive maintenance tasks	16/16	7/16	3.3	23.1
Number of routine maintenance tasks				
Number of inspections/visual inspections				
Number of repairs				
Reactive maintenance tasks	16/16	7/16	3.3	23.1
Risk priority number (RPN)	16/16	1/16	5	5

- KPIs are defined in IEC 61400-26
- A new availability definition will be introduced
- Further categorization for maintenance tasks required

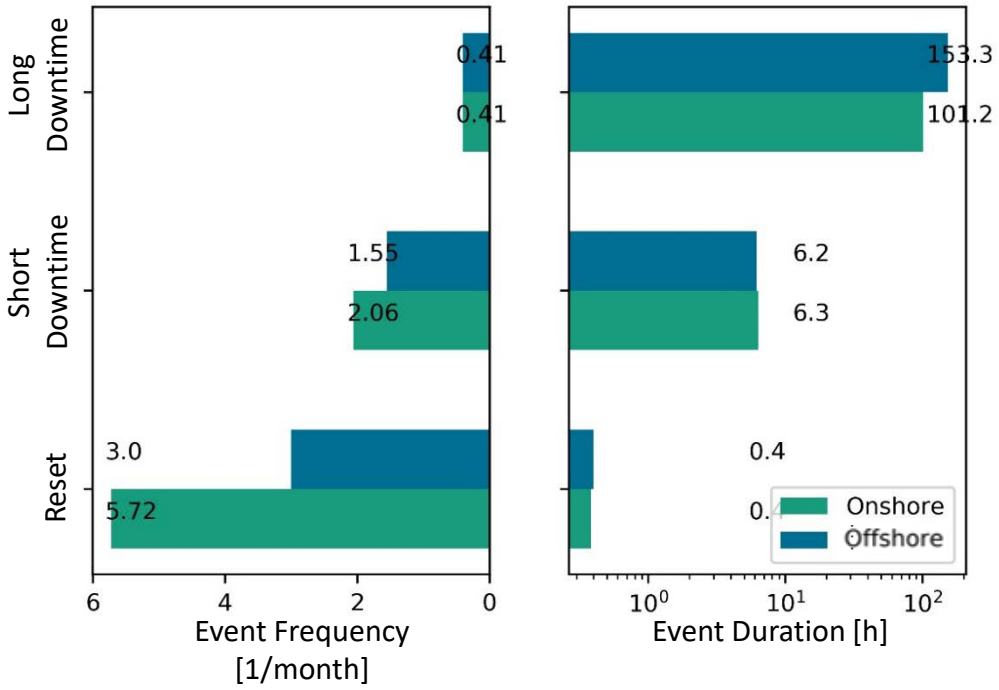
Maintenance KPIs - WInD-Pool results

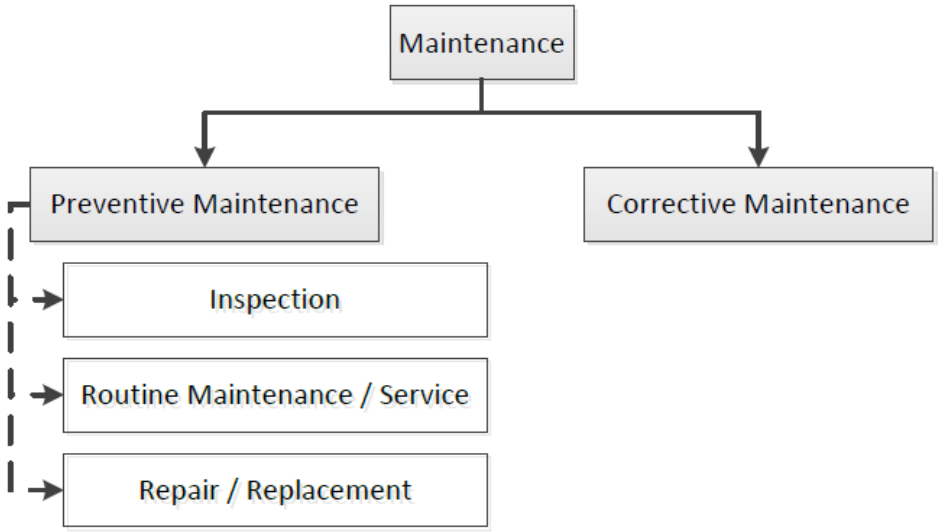




Fraunhofer IEE

Maintenance KPIs – Events / Maintenance Tasks





Structure to categorize maintenance tasks by the maintenance type and activity
according to BS EN 13306 and BS EN ISO 14224

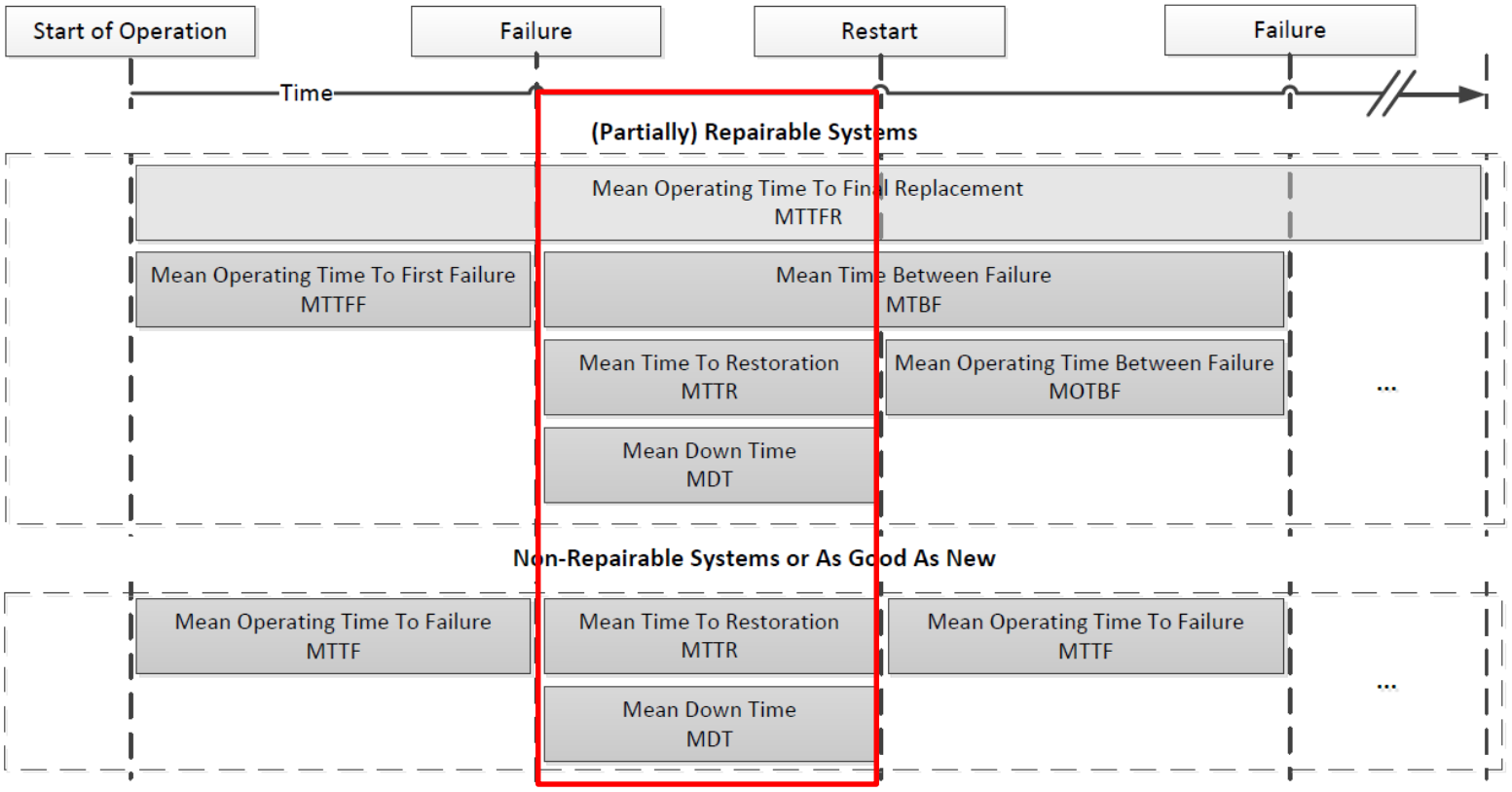
Reliability KPIs

KPI	Answers	Use	Importance (1–5)	Abs. Importance
Failure rate	10/10	8/10	3.6	28.8
Mean time between failures (MTBF)	10/10	7/10	3.6	25.2
Mean time to repair / restoration (MTTR)	10/10	7/10	3.3	23.1
Mean down time (MDT)	10/10	6/10	3	18
Mean operating time between failures (MOTBF)	10/10	5/10	3.2	16
Mean operating time to failures (MTTF)	10/10	5/10	2.8	14
Repair rate	10/10	3/10	2.3	6.9

- Reliability Mean Time Measures are sometimes tricky to differentiate
- Different standards use different naming rules
- MTTR or MTTRes? MTBF or MOTBF?

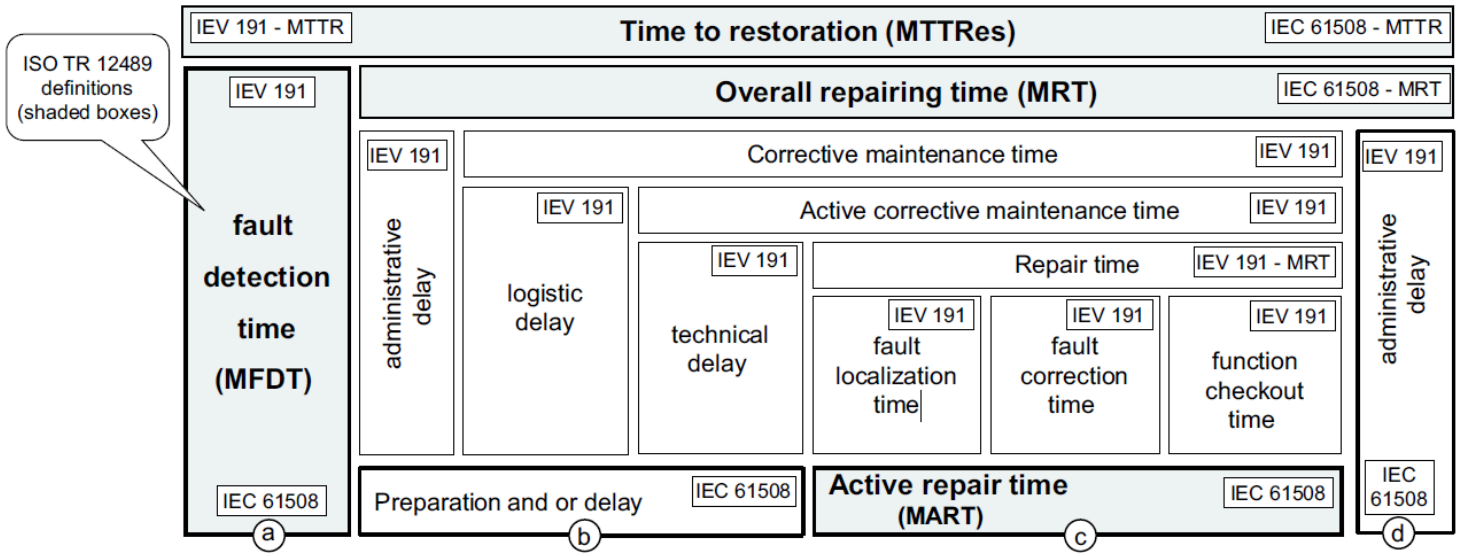
Unified definitions and naming rules are essential to avoid misunderstandings and mistakes

Reliability KPIs – Reliability Mean Time Measures



Reliability mean time measures for (partially) repairable and non-repairable systems according to ISO and IEC standards.

Reliability KPIs – Reliability Mean Time Measures

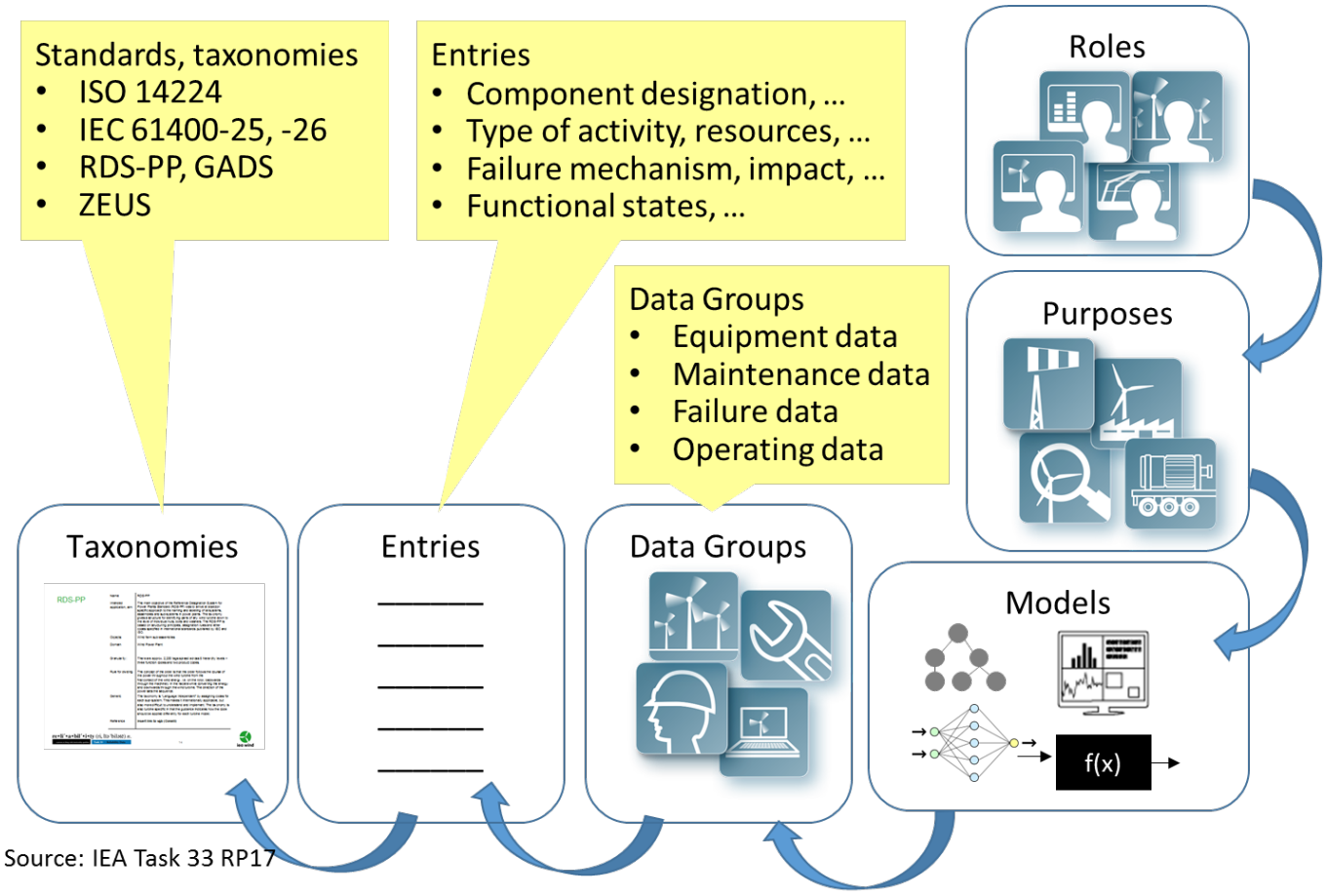


Taxonomies of MTTR subcategories from ISO/TR 12489

Fraunhofer IEE

Recommended Practices for Reliability Data

iea wind
Task 33

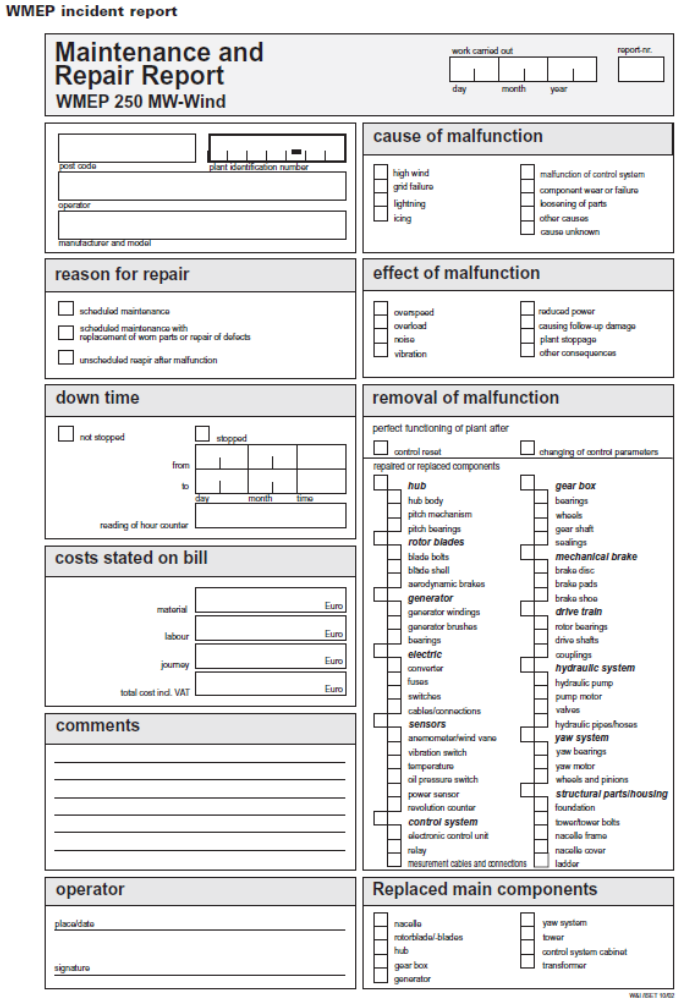


Source: IEA Task 33 RP17

- https://community.ieawind.org/tasks/new-item/task33

Fraunhofer IEE

Standardization of Maintenance Data



WMEP incident report

Maintenance and Repair Report
WMEP 250 MW-Wind

work carried out: day / month / year
report-nr.

post code
plant identification number
operator
manufacturer and model

cause of malfunction
- high wind
- grid failure
- lightning
- icing
- malfunction of control system
- component wear or failure
- loosening of parts
- other causes
- cause unknown

reason for repair
- scheduled maintenance
- scheduled maintenance with replacement of worn parts or repair of defects
- unscheduled reapir after malfunction

effect of malfunction
- overspeed
- overload
- noise
- vibration
- reduced power
- causing follow-up damage
- plant stoppage
- other consequences

down time
- not stopped
- stopped
- from (day / month / time)
- to (day / month / time)
- reading of hour counter

removal of malfunction
perfect functioning of plant after
- control reset
- changing of control parameters

repaired or replaced components
- ***hub***
  - hub body
  - pitch mechanism
  - pitch bearings
- ***rotor blades***
  - blade bolts
  - blade shell
  - aerodynamic brakes
- ***generator***
  - generator windings
  - generator brushes
  - bearings
- ***electric***
  - convertor
  - fuses
  - switches
  - cables/connections
- ***sensors***
  - anemometer/wind vane
  - vibration switch
  - temperature
  - oil pressure switch
  - power sensor
  - revolution counter
- ***control system***
  - electronic control unit
  - relay
  - measurement cables and connections
- ***gear box***
  - bearings
  - wheels
  - gear shaft
  - sealings
- ***mechanical brake***
  - brake disc
  - brake pads
  - brake shoe
- ***drive train***
  - rotor bearings
  - drive shafts
  - couplings
- ***hydraulic system***
  - hydraulic pump
  - pump motor
  - valves
  - hydraulic pipes/hoses
- ***yaw system***
  - yaw bearings
  - yaw motor
  - wheels and pinions
- ***structural parts/housing***
  - foundation
  - towertower bolts
  - nacelle frame
  - nacelle cover
  - ladder

costs stated on bill
- material — Euro
- labour — Euro
- journey — Euro
- total cost incl. VAT — Euro

comments

operator
place/date
signature

Replaced main components
- nacelle
- rotorblade/-blades
- hub
- gear box
- generator
- yaw system
- tower
- control system cabinet
- transformer

WMEP/EET 10/02

SCADA-Data – IEC 61400-25

Naming rules for SCADA - Data

IEC 61400-25

Available ✓

Reference Designation System – RDS-PP

Designation system for power plants, systems and components

VGB-Standard-S-823-T32

Available ✓

State-Cause-Event-System – ZEUS

Unified description of the wts state, events and maintenance measures

Technical guideline TR7 D2 (FGW e.V.)

Available ✓

Global-Service-Protocol – GSP

FGW renewable energies

Unified protocol to exchange Maintenance information

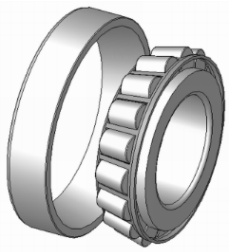
Technical guideline TR7 D3 (FGW e.V.)

Available ✓

Fraunhofer IEE

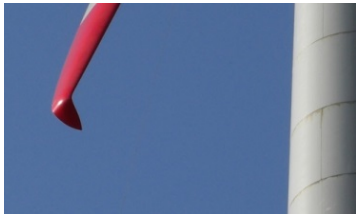
Standardization of Maintenance Data
From Information → Knowledge

Generator bearing temperatures are rising. Borescope inspections revealed pitting. The bearing should be monitored regularly.



RDS-PP Code:
=MKA12 GA001 -UP001

Some corrosion on the tower has been spotted. New protection will be added during the next visit.



RDS-PP Code:
=UMD12

Conclusion and Outlook

Conclusion

- Many KPIs and many varying KPI definitions are in use
- Performance KPIs are most important for operational managers
- Current situation can lead to confusion
- A unified set of KPIs makes life easier for everyone
- An international technical guideline would be beneficial
- Standardized maintenance data is needed to achieve comparability

→ Make use of unified KPI and Data definitions!

Outlook

- Starting point for committee work on a technical guideline (FGW e.V.)
- The current list is not complete, further KPIs will be developed
- Further topics like aggregation or uncertainties of KPIs have to be addressed.
- A detailed review of HSE- and Finance-KPIs is still required

DISCUSSION

Fraunhofer
IEE

Sebastian Pfaffel, M. Sc.

Wind turbine operations analyst
Planning and Operation of Generating Assets

Königstor 59 | 34119 Kassel / Germany

+49 561 7294-441
sebastian.pfaffel@iwes.fraunhofer.de
www.iwes.fraunhofer.de