

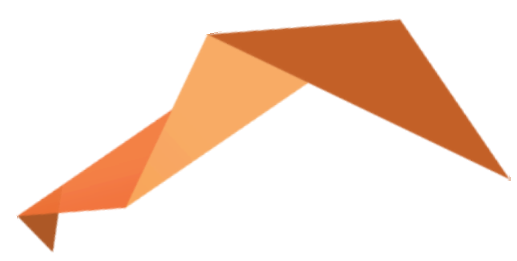


Analysis of Operating Wind Farms 2018

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



$$\textit{Availability} = \frac{\textit{Time the turbine is available, optimal operation}}{\textit{Total Operation time}}$$

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

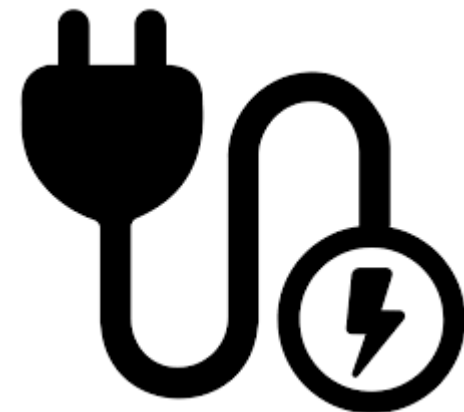
But this number does not give information on energy losses!



The Focus in the Present

Energy-based availability accounts for production

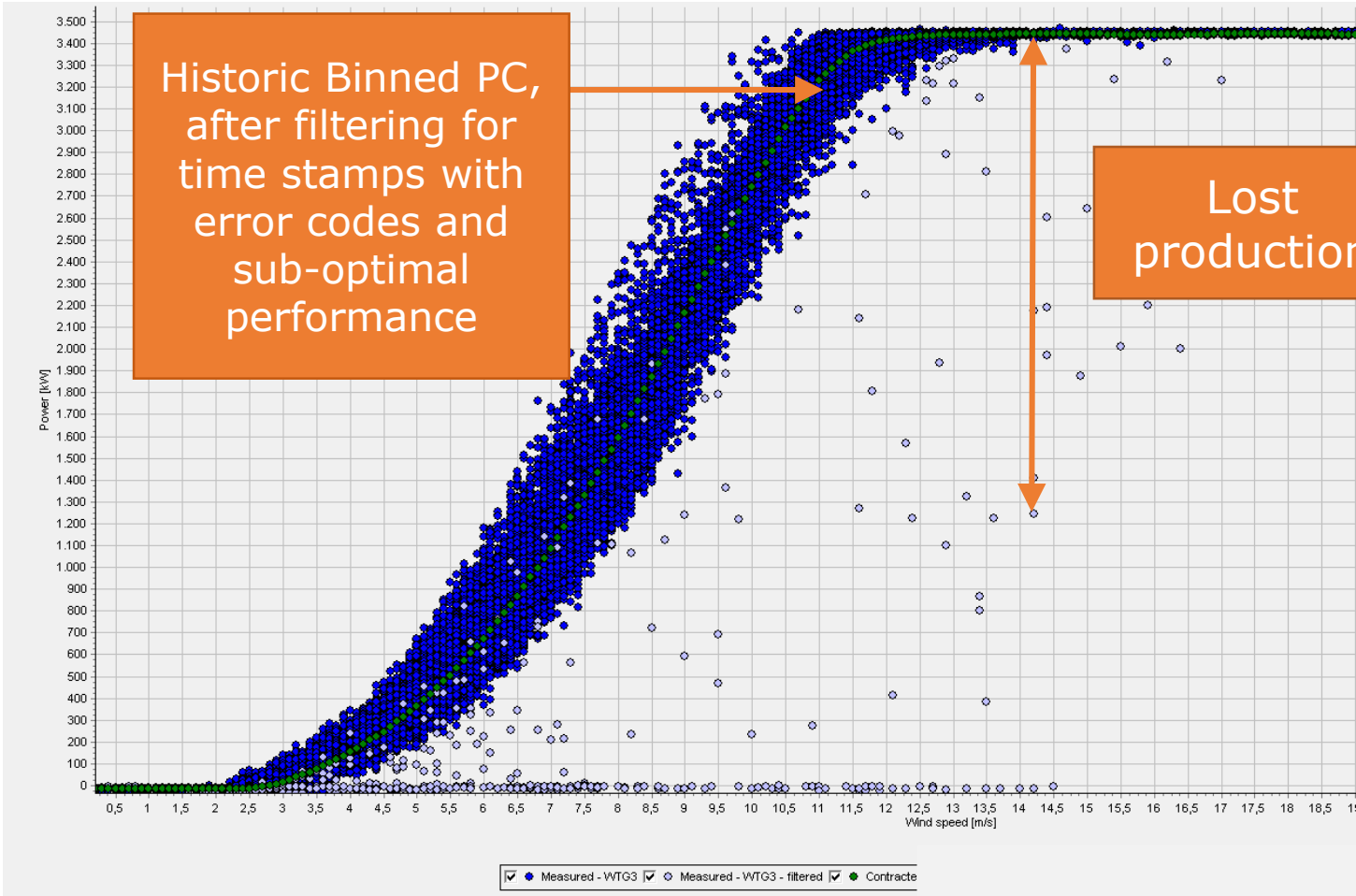
$$\text{Energy – based Availability} = \frac{\text{Realised production}}{\text{Potential production}}$$



Establish Potential Production:

- Follow process of post-construction assessment
 - SCADA incl error logs
 - Nacelle anemometer (hopefully reliable)

Methodology Potential Production



But this does not give information on revenue losses!

Error code	Description	Category
900	Pause pressed on keyboard	Manufacturer
20001	Power curtailment	AUTO error code
220	New SERVICE state: __, ____	Unscheduled maintenance
2950	GenHighPhaseTemp: Min __ Max __ $\tilde{\Delta}, \hat{\Delta}^{\circ}\text{C}$	Manufacturer
3172	PowerStopHighTemp	Manufacturer
100	Too many auto-restarts: ____	Manufacturer
3164	PwrStopActive, Par1 ____ Par2 ____	Manufacturer
3475	SafetySys Converter Stopped	Manufacturer
2863	ConvWaterCoolPressLow ____ bar	Manufacturer
3656	Conv Charge Failed	Utility
3253	HighTempPwrStopRes: Mod __, __ $\tilde{\Delta}, \hat{\Delta}^{\circ}\text{C}$	Manufacturer
144	High windspeed: __. __ m/s	Environment
3222	HighTempMSC.IGBT: Mod __; __ $\tilde{\Delta}, \hat{\Delta}^{\circ}\text{C}$	Manufacturer
3472	SafetySystem Reset Required	Manufacturer
3633	Yaw System Stopped	Manufacturer
356	Extreme yawerror __. __ m/s __. __ $\tilde{\Delta}, \hat{\Delta}^{\circ}$	Environment
3298	Yaw To Cable Twist Reset	Manufacturer
3272	YawUntwistCW: Code __, __ $\tilde{\Delta}, \hat{\Delta}^{\circ}$	Manufacturer



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

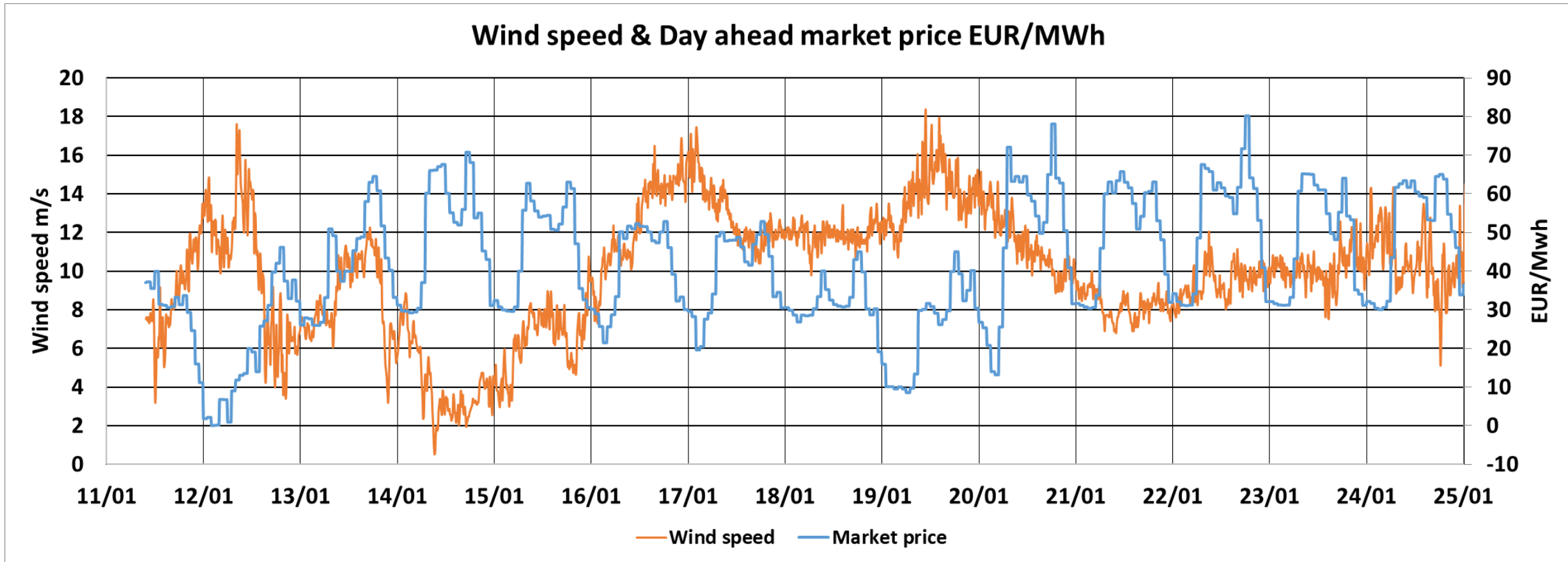


$$\text{Revenue Availability} = \frac{\text{Sum of realised revenue}}{\text{Potential revenue}}$$

- Impact the way you evaluate your asset:
Lost hours \neq Lost production \neq Lost revenue
- Quest for finding the most expensive losses...

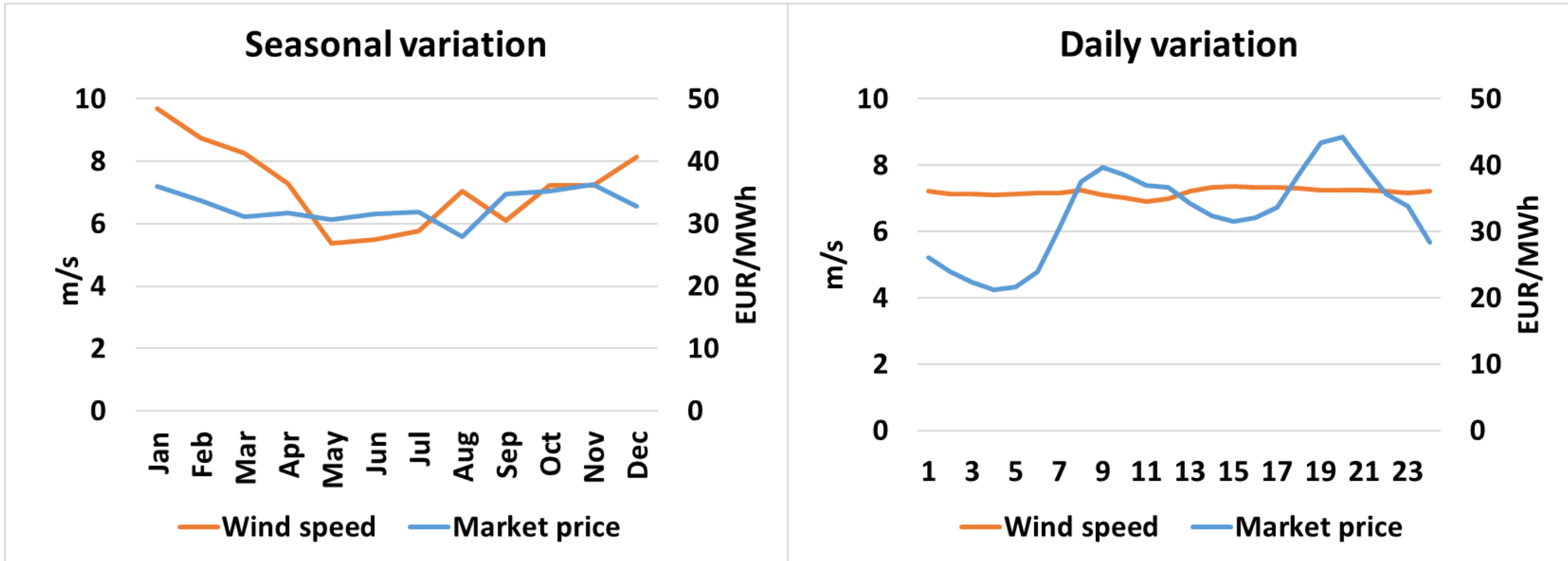
Spot Market Prices

Example: Two week wind speed and electricity price



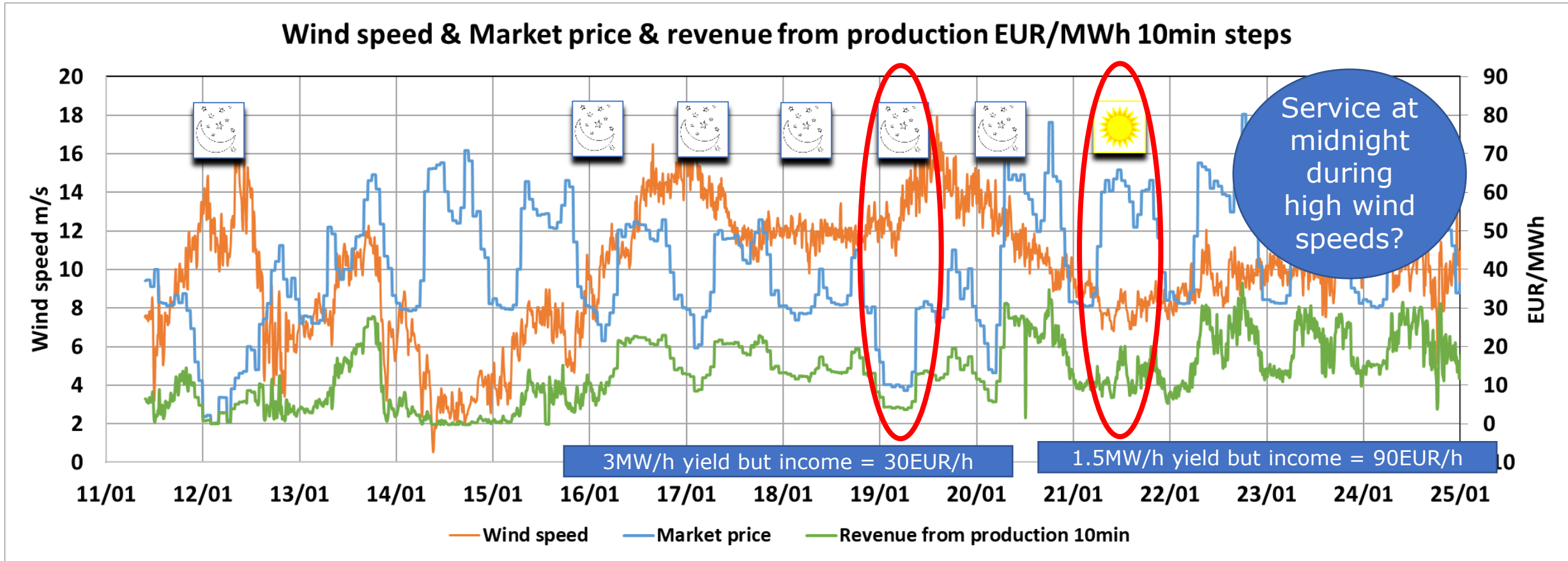
Spot Market Prices

Low seasonal influence but strong daily variation



Spot Market Prices

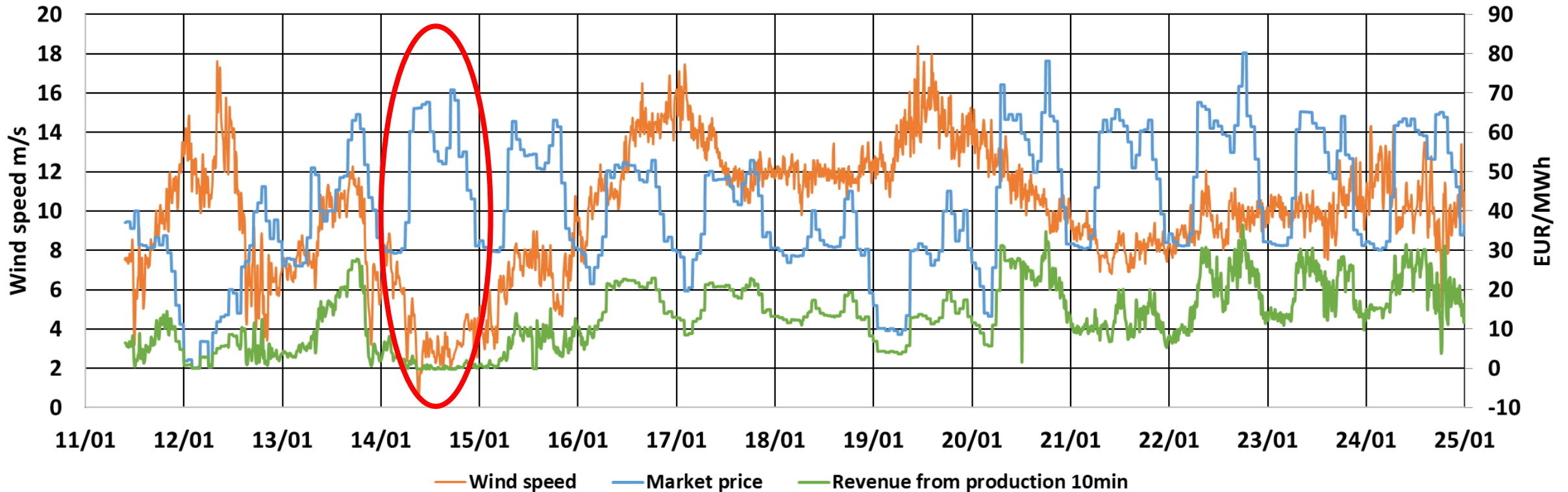
A new factor in the matrix of understanding you asset's performance



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.



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:

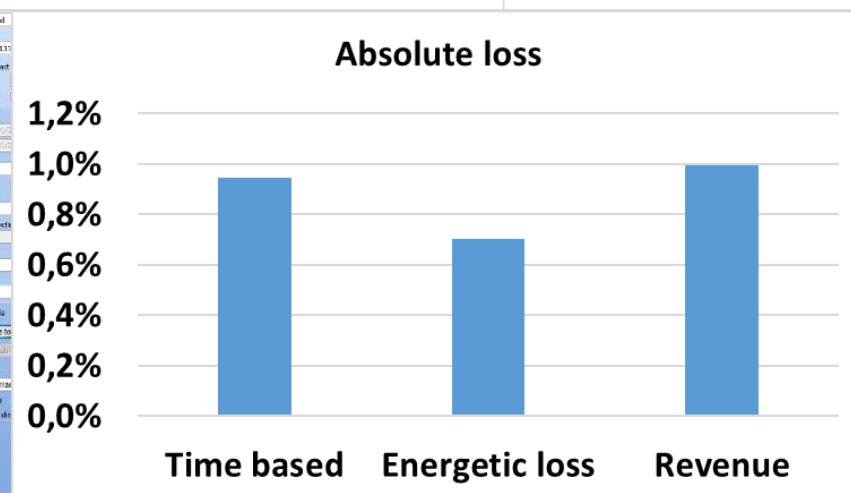
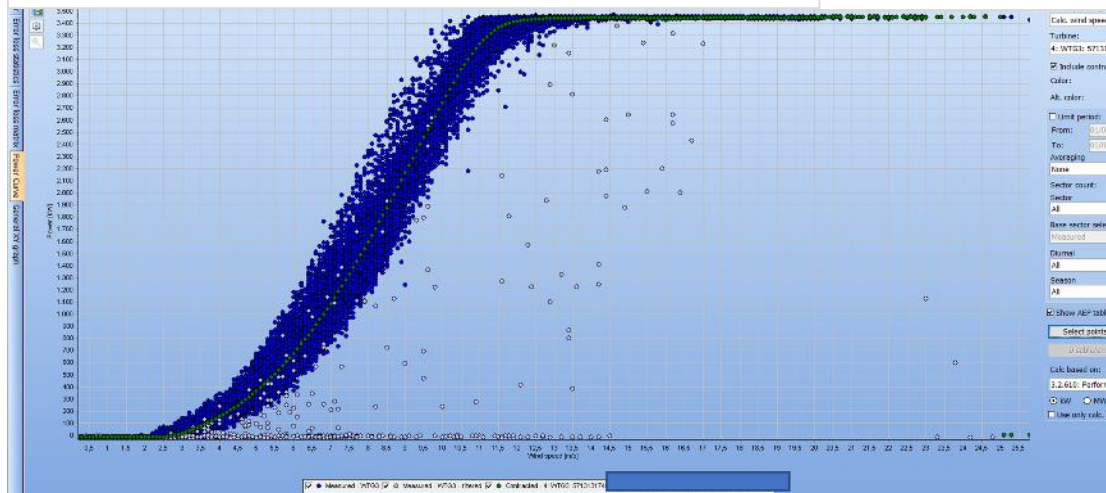
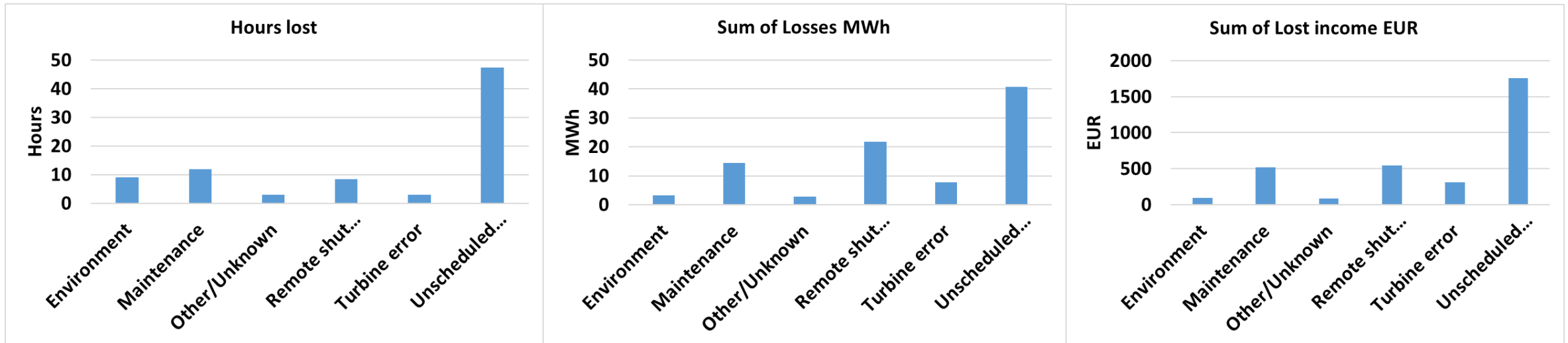
- 1 full year of 10min SCADA data: wind speed, production, status
- List of turbine error code
- Concurrent hourly spot market prices

Results:

- Time-, energy- and revenue-based availability are established
- Compared per loss category

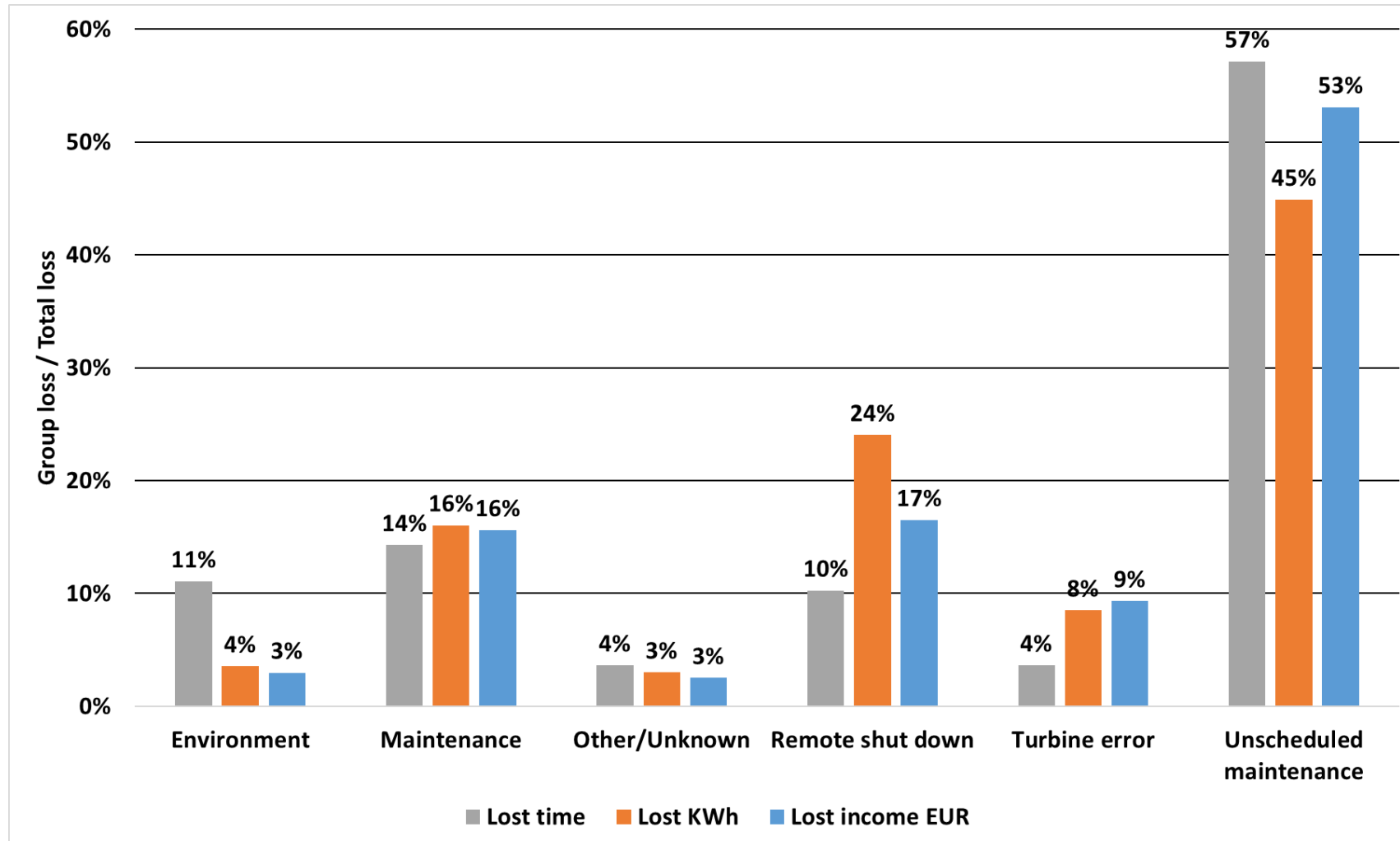
Site 1: low losses

V117 3.45MW



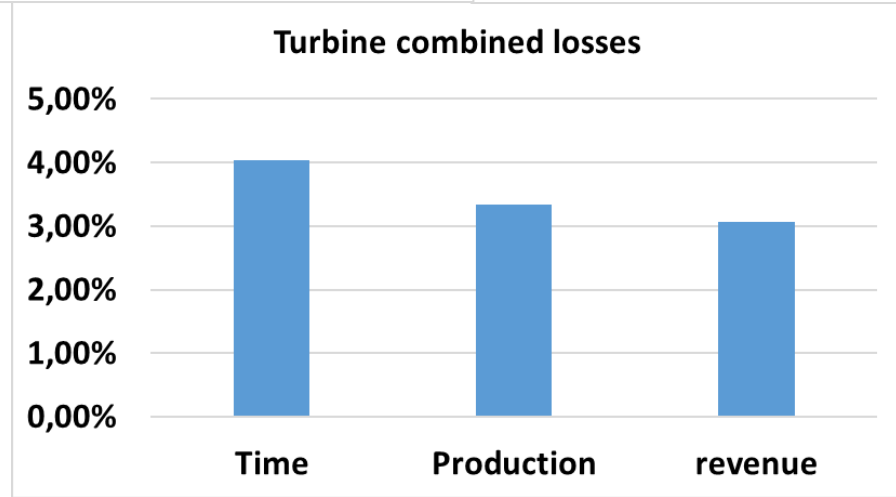
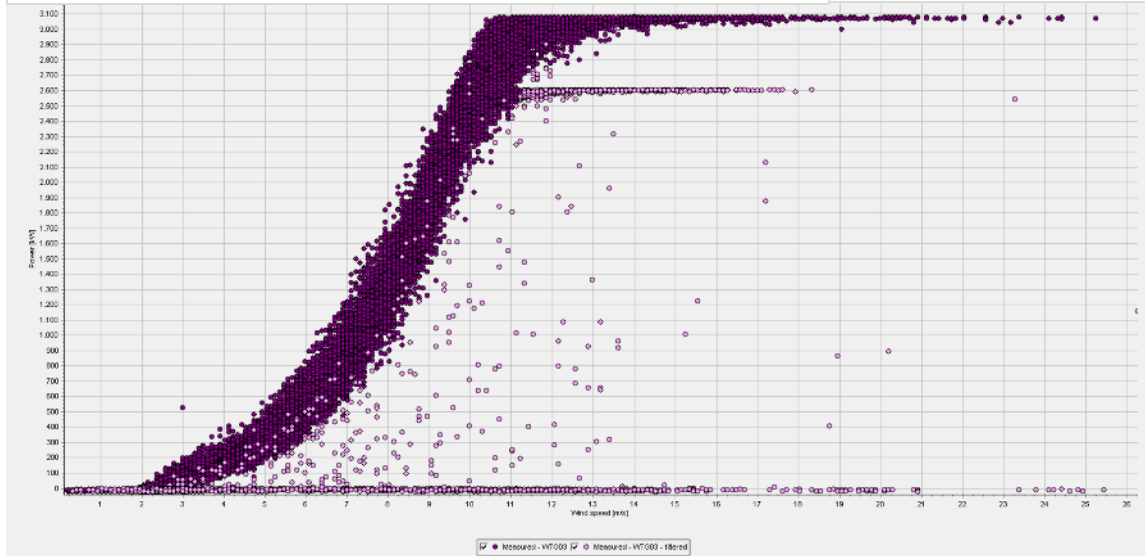
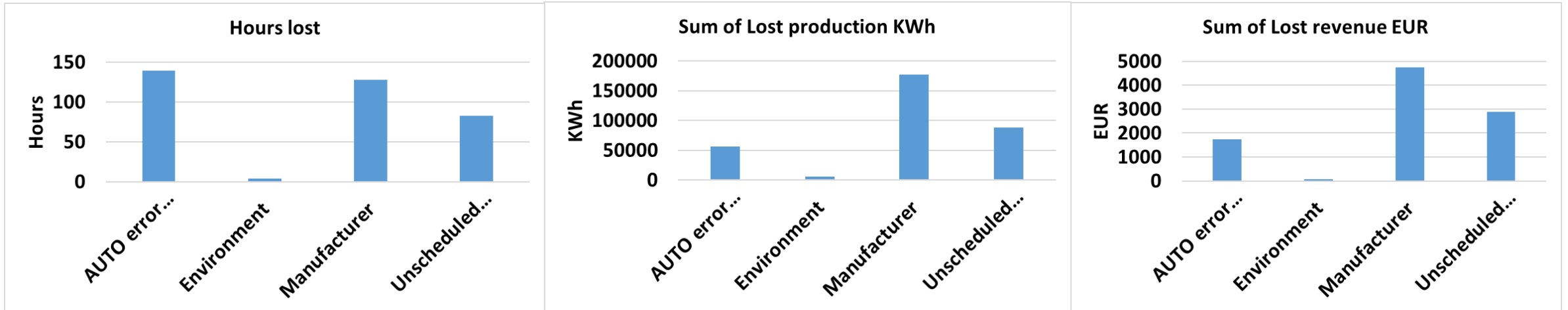
Site 1: low losses

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



Site 2: medium losses

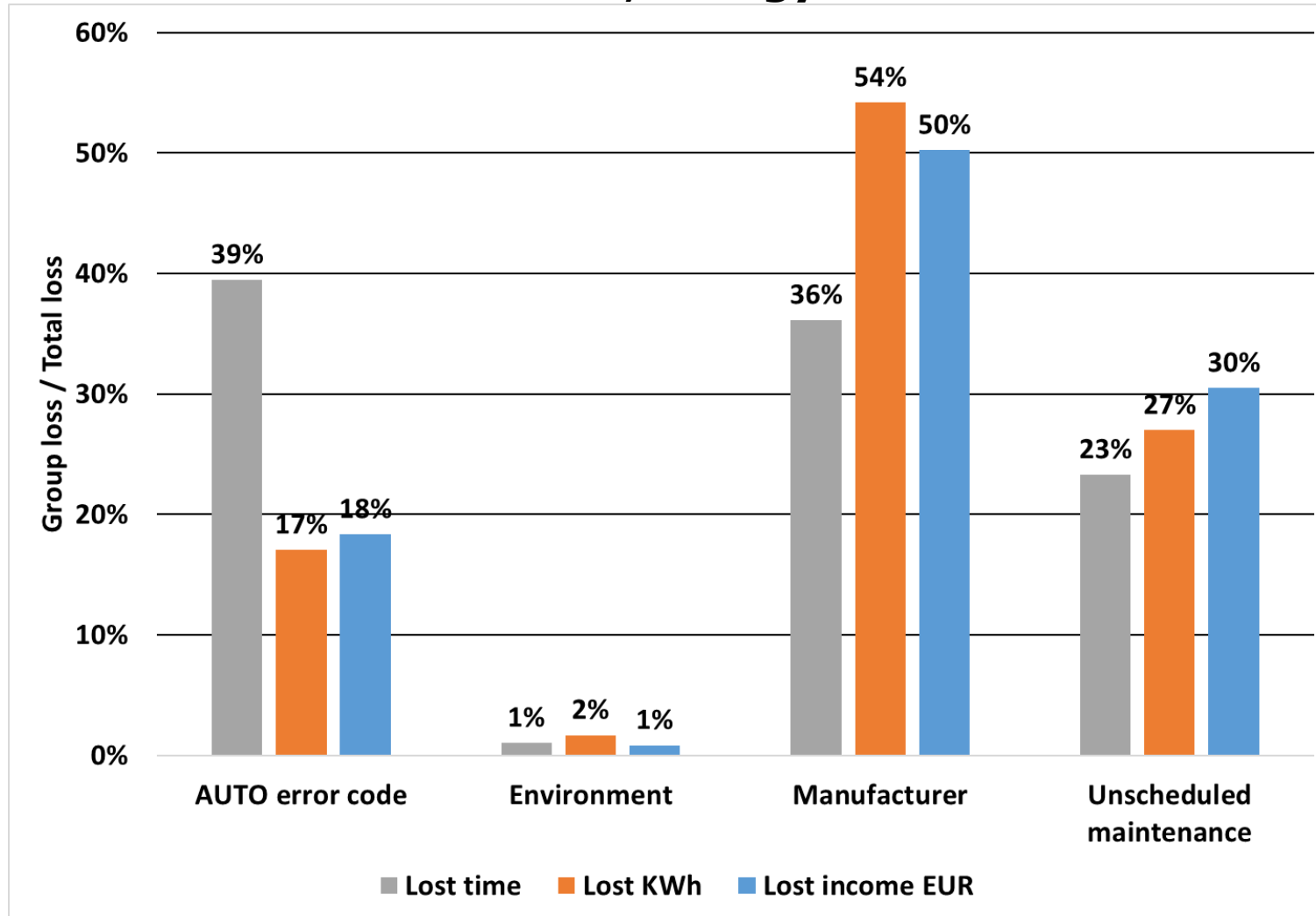
V112 3.075MW turbine



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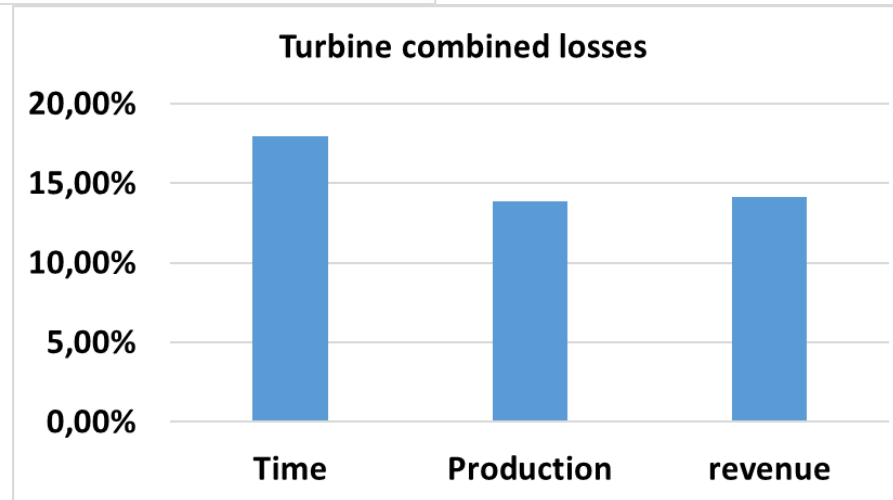
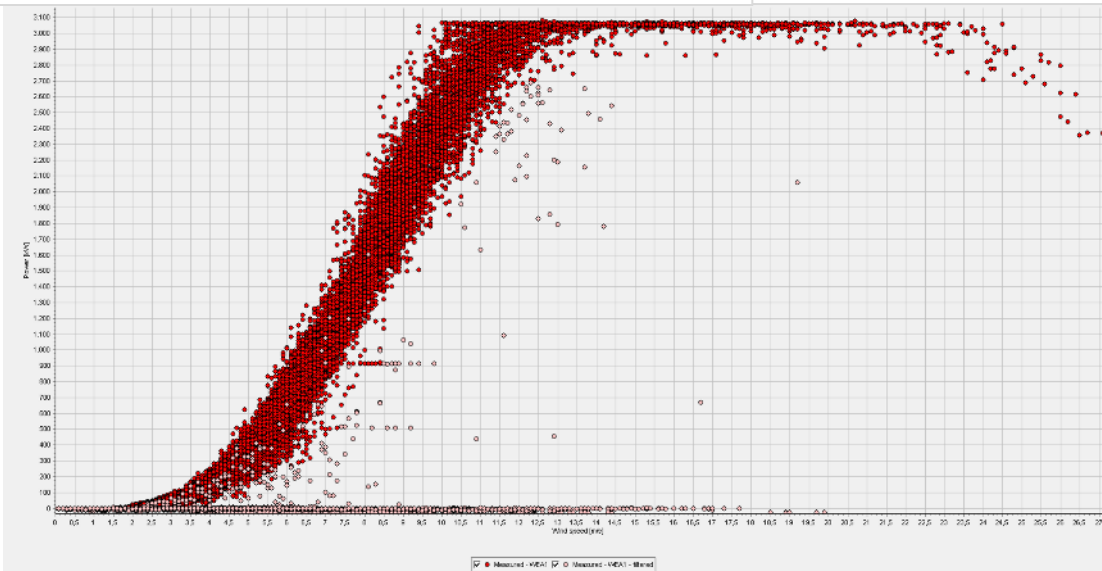
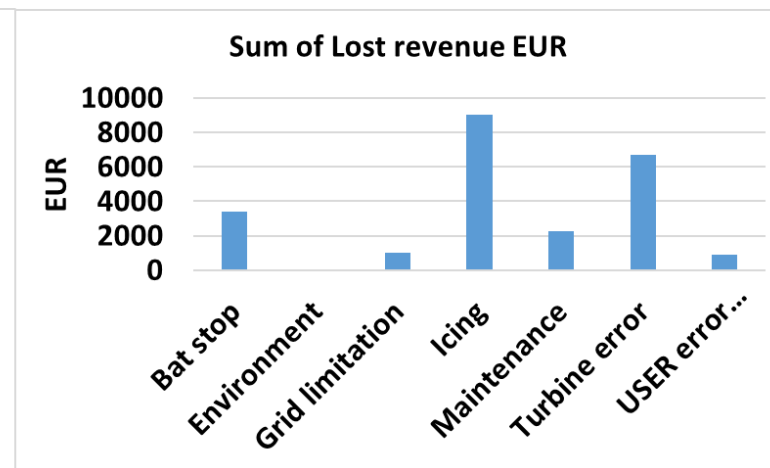
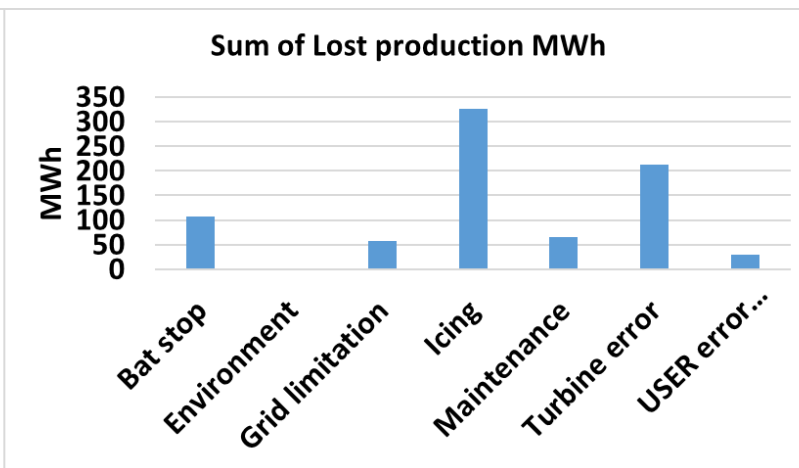
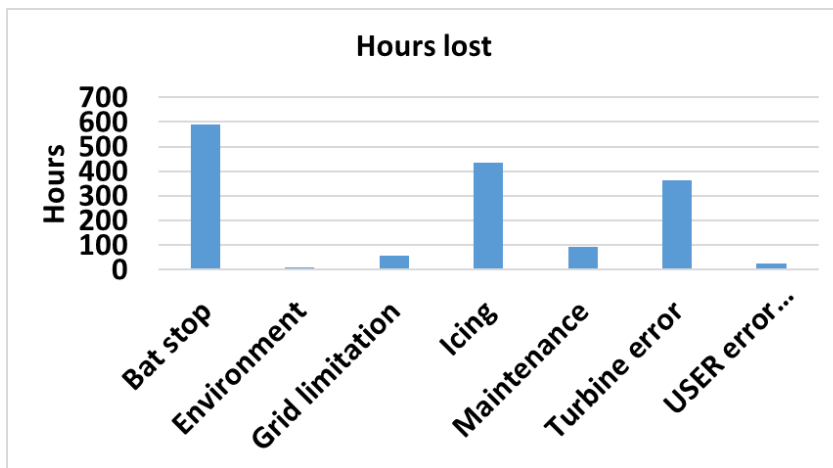
Site 2: medium losses

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



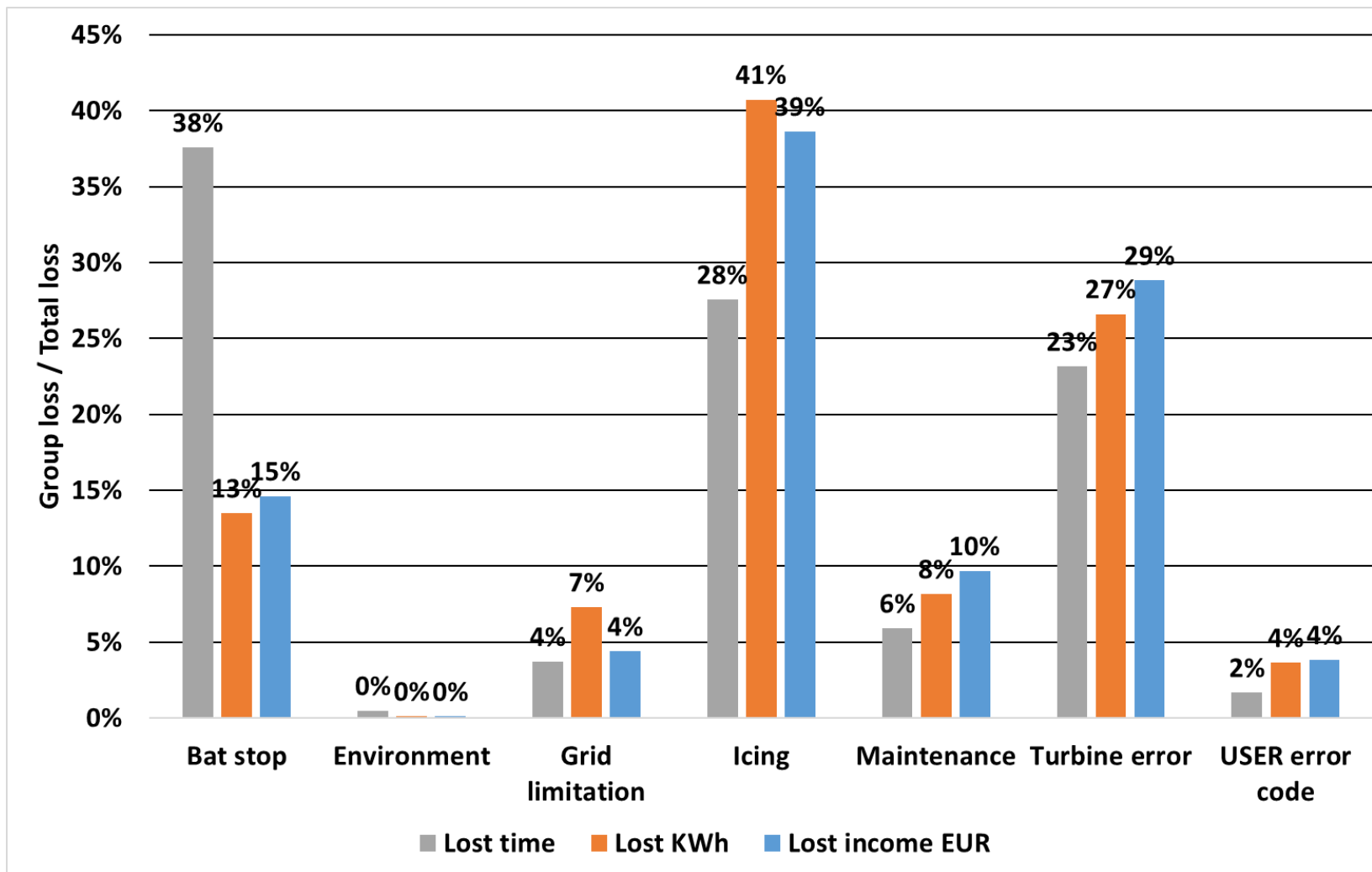
Site 3: high losses

Enercon E115 3.0MW



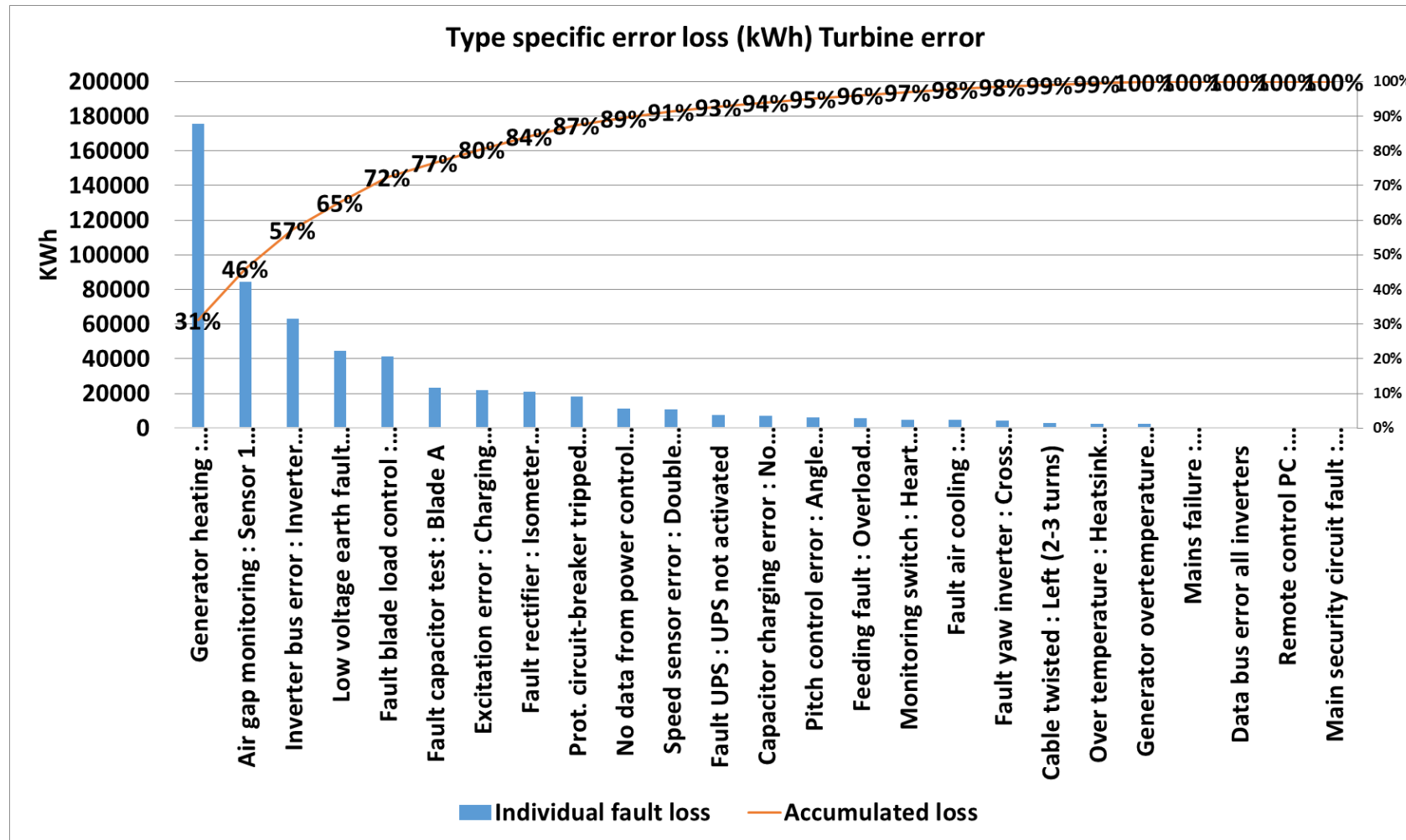
Site 3: high losses

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



Site 3

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 you 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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