CATEGORIZING DOWNTIMES AND CALCULATING DOWNTIME AND PRODUCTION LOSSES. BEST PRACTICE AND COST-BENEFIT

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CONTENTS OF PRESENTATION

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1. EREDA
2. GENERAL RESULTS OF DOWNTIMES PER COMPONENT
3. PERFORMANCE ANALYSIS
4. WEAK POINTS OF WIND FARMS
5. CONCLUSION

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1. EREDA

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RESOURCE ASSESSMENT

- Site identification
- Measurement
- Measurement management
- Resource assessment
- Site characterisation
- Micrositing and verification
- Technology selection

MESOESCALE AND REGIONAL MAPS

- Elaboration of regional maps
- Virtual masts / Virtual series
- Wind and solar radiation assessment

PROJECT ENGINEERING

- Project definition
- Grid studies
- Support to licensing
- Project engineering

CONSTRUCTION

- Technical specifications
- Tender documentation
- Management of supply
- Construction supervision
- Construction Management
- Inspection and acceptance of works

OPERATION AND MAINTENANCE

- Operation monitoring and support
- Performance verification
- Electric studies
- Adapt to new requirements
- Inspections of turbines and components
- Maintenance programming
- Supervision of maintenance

EXPERT REPORTS

- Claims
- Loss of profit
- Root cause reports
- Damage report

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1. EREDA – O&M

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Exploitation and Support to O&M of Wind Farms

Different technologies:

- Gamesa
- Acciona
- Vestas

Activities include:

- Management of assets
- Verification of activities in the assets
- Monitoring and assessment of Production, Power Curve, Availability, Alarms, Performance verification (Producibility, Reactive Power Regulation)
- Analysis of production losses

Several Countries

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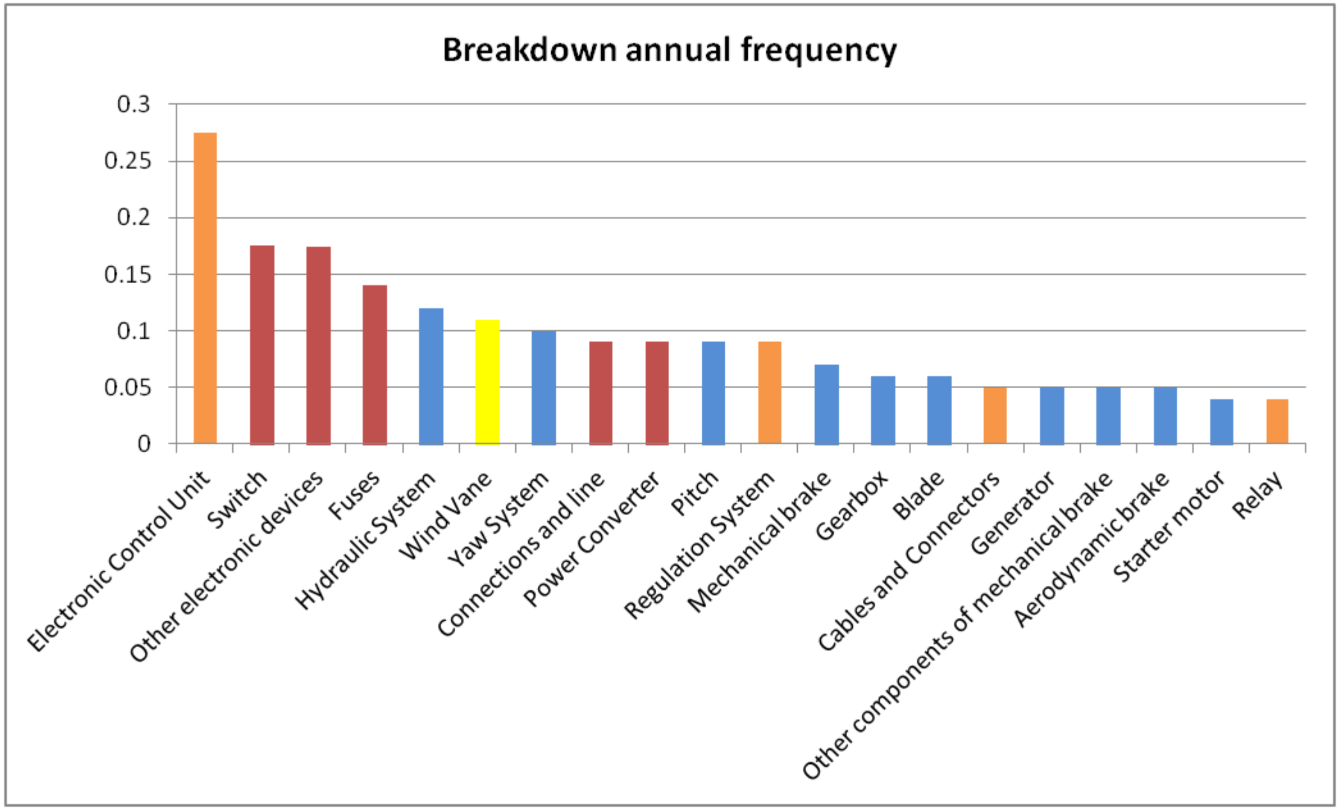
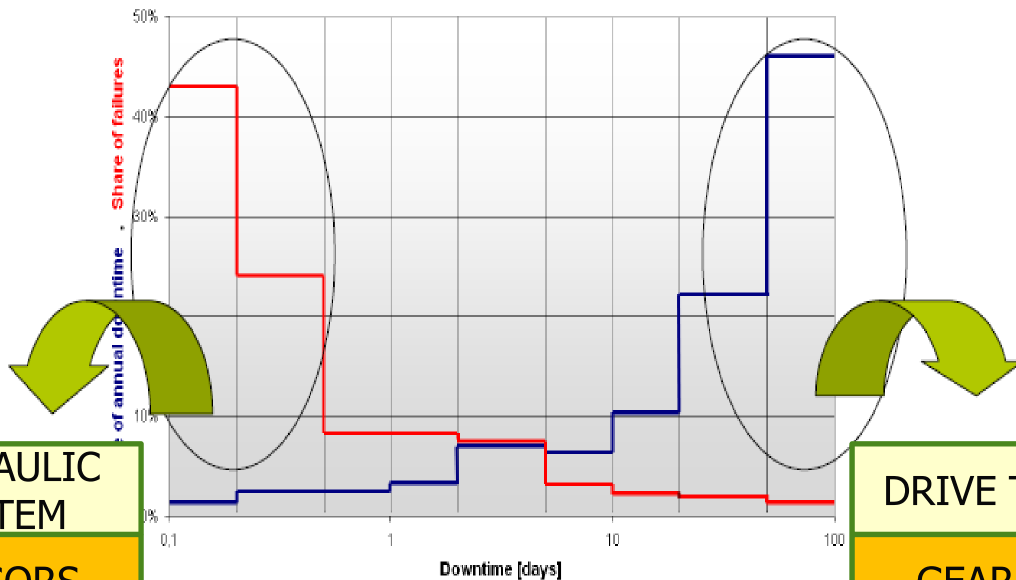
2. GENERAL RESULTS OF DOWNTIMES PER COMPONENT



Source: Fraunhofer IWES Institute

2. GENERAL RESULTS OF DOWNTIMES PER COMPONENT

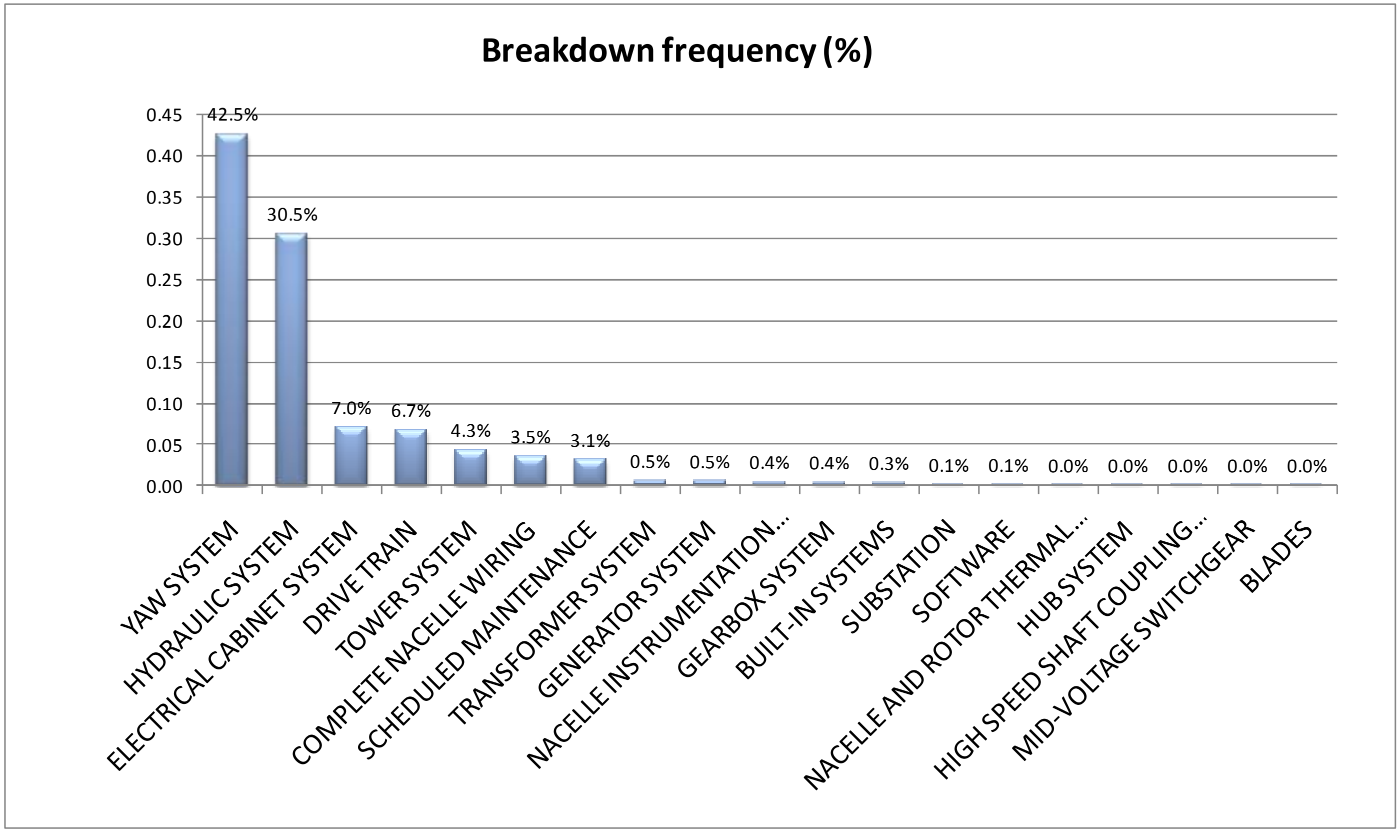


HYDRAULIC SYSTEM
SENSORS
REGULATION SYSTEM
ELECTRICAL SYSTEM

DRIVE TRAIN
GEARBOX
GENERATOR
BLADES

Source: Fraunhofer IWES Institute

2. GENERAL RESULTS OF DOWNTIMES PER COMPONENT



Source: EREDA

Rated Power of WTG: 1.5 MW ÷ 2.1 MW

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3. PERFORMANCE ANALYSIS

What is it?

Set of techniques for data analysis that allows:

- Understanding the operation of the wind farm in detail (PC, Q, availability, alarms, etc.)
- Detecting malfunctions and determining causes
- Estimating amount of not produced energy
- To implement continuous monitoring of the wind farm
- To complement predictive analysis
- To carry out specific analysis

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3. PERFORMANCE ANALYSIS

How does it work?

Required info:

- 10 – min data from WTGs and WF meterological mast
- Alarms
- Service Reports
- Production data
- O&M Contract and Error / Alarm Allocation List
- Orders by grid manager
- Log Event of grid and substation

3. PERFORMANCE ANALYSIS

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Most important parameters:

- Time based availability, a_t

$$a_t = \frac{T_{Base} - T_{Unavailable}}{T_{Base}}$$

T_{base}, $T_{unavailable}$ depending on the contract…

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Most important parameters:

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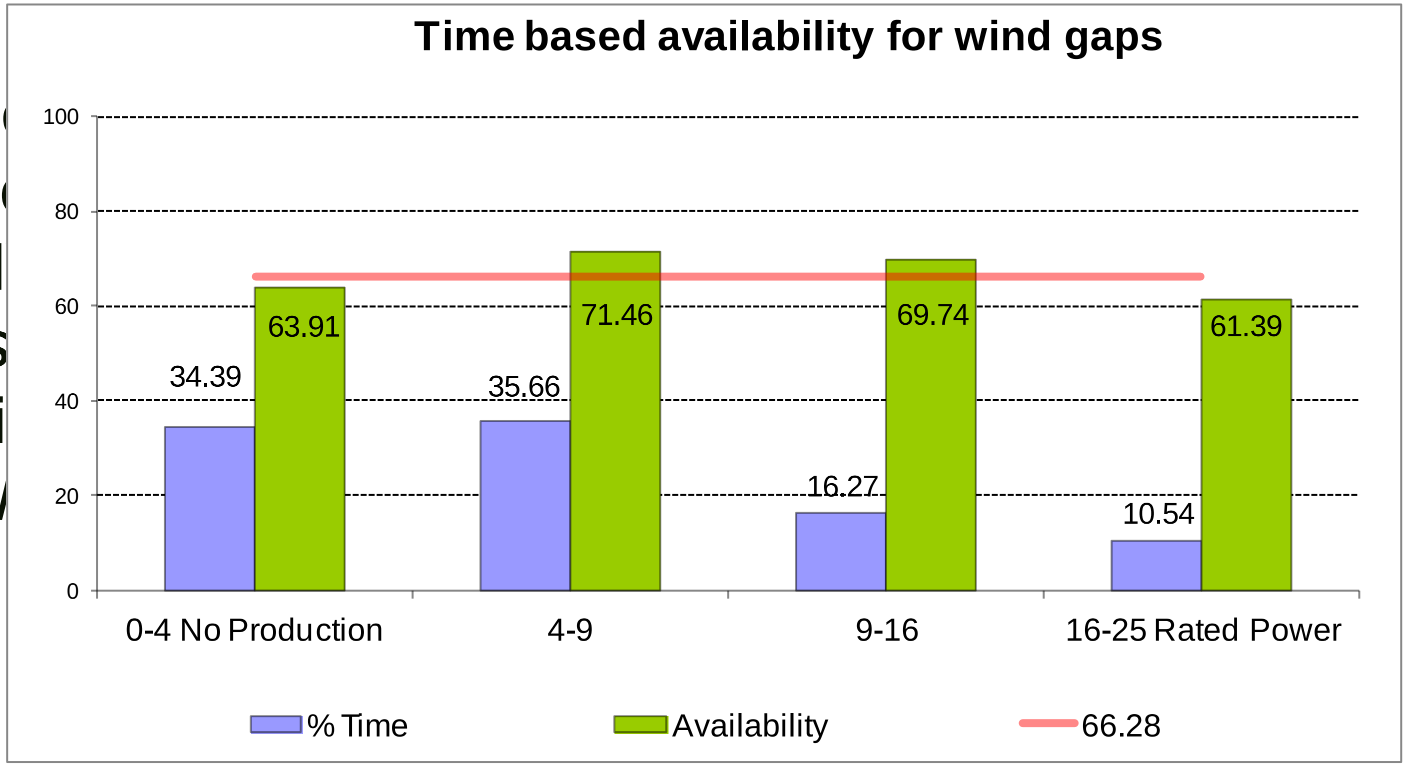

3. PERFORMANCE ANALYSIS

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Most important parameters:

Reflections on Time based availability, a_t:

- Time based availability, differences from WTG counters and calculated values

WTG	SERVICE REPORTS			WTG COUNTERS		ALARMS INFO		
	N of SR	Duration of SR	a_t by SR	Duration of Failures	a_t	N of Stops	Duration of Failures	a_t
1	0	0:00:00	100.00%	0:06:00	99.99%	1	0:12:27	99.97%
2	6	9:40:00	98.66%	2:18:00	99.68%	19	11:42:45	98.37%
3	0	0:00:00	100.00%	0:06:00	99.99%	0	0:00:00	100.00%
4	0	0:00:00	100.00%	0:00:00	100.00%	0	0:00:00	100.00%
5	0	0:00:00	100.00%	0:06:00	99.99%	0	0:00:00	100.00%
6	1	0:34:00	99.92%	0:42:00	99.90%	1	0:50:54	99.88%
7	0	0:00:00	100.00%	0:00:00	100.00%	0	0:00:00	100.00%
8	1	0:34:00	99.92%	0:18:00	99.96%	1	1:34:56	99.78%
9	0	0:00:00	100.00%	0:18:00	99.96%	1	0:21:13	99.95%
10	1	4:15:00	99.41%	2:18:00	99.68%	3	5:19:47	99.26%
Total/Average	**9**	**15:03:00**	**99.79%**	**6:12:00**	**99.91%**	**26**	**20:02:02**	**99.72%**

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Most important parameters:

- Energy based availability, a_e

$$a_e = \frac{P}{P + LossP}$$

LossP depending on the contract

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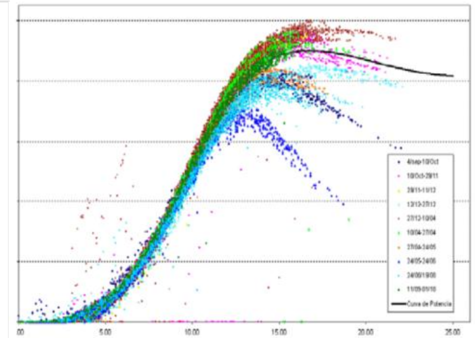
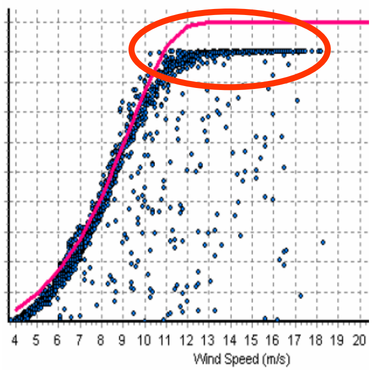
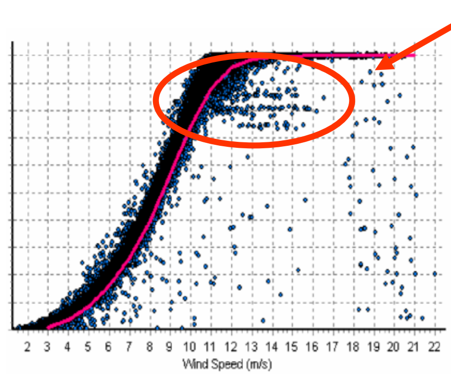
3. PERFORMANCE ANALYSIS

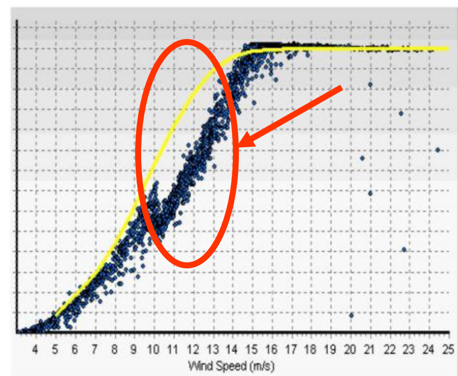
Most important parameters:

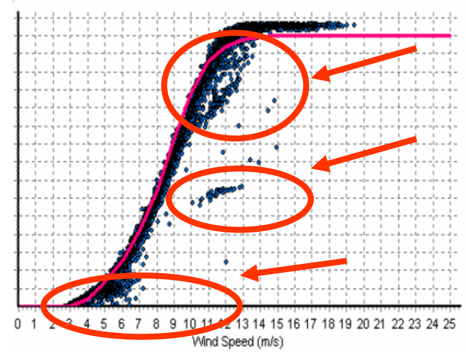
- Energy losses due to power curve limitations or anomalies











$$P_{the} - P_{act}$$

Which was the cause?

Alarms provide us with this info

3. PERFORMANCE ANALYSIS

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Overall values:

How wind farm is working, but…

WTG	Mean v (m/s)	Time based availability (%)	Production (kWh)	Loss Production (kWh)
1	5.75	96.80	4,001,465	287,488
2	5.54	96.14	3,737,209	252,480
3	5.71	94.58	4,013,419	365,069
4	6.03	93.53	4,094,068	657,844
5	5.89	96.75	4,311,293	366,019
WIND FARM	**5.78**	**95.56**	**20,157,453**	**1,928,899**

Where to start to work on???

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4. WEAK POINTS OF WIND FARMS

More important parameters:

- Availability losses per alarm

  What is the contribution of each alarm to the total loss of availability?

- Energy losses per alarm

  What is the contribution of each alarm to the total loss of energy?

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4. WEAK POINTS OF WIND FARMS

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Alarm	Repetition number	Time (hours)	Average duration (hours)	Unavailability associated to the alarm (%)	Lost MWh	Economic Loss (80 €/MWh) (€)
Mech TowerVib Stop	2,674	1,284.70	0.48	0.2993%	2,554.5	204,358.68
Pitch CAN ComFail	2,660	388.68	0.15	0.0905%	217.7	17,415.30
Mech Cable Autowind	2,104	1,485.62	0.71	0.1823%	1,059.9	84,795.78
PID PowerLowerThanWindSpeed	1,863	123.65	0.07	0.0288%	231.7	18,538.51
Pitch SafetyTestActiv	1,826	58.37	0.03	0.0013%	34.3	2,743.13
Elec ParkControlStop	1,454	1,873.93	1.29	0.0015%	832.8	66,621.61
Pitch Akku Voltage LowStop	1,107	361.52	0.33	0.0842%	261.6	20,930.47
Mech Rpm DiffStop	1,091	257.44	0.24	0.0597%	43.7	3,495.03
FSS Fault	949	708.79	0.75	0.1651%	500.4	40,031.06

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4. WEAK POINTS OF WIND FARMS

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WTG	Alarm	Repetition number	Time (hours)	Average duration (hours)	Unavailability associated to the alarm (%)	Lost MWh	Economic Loss (80euros/MWh) (€)
1	Extreme tilt moment: xxx kNm	205	121.10	0.59	0.1243%	281.9	22,549.67
1	High voltage Li: xx V	1	28.92	28.92	0.0297%	50.9	4,073.65
1	Low flow to tank blockA: xx bar	12	53.22	4.43	0.0546%	46.6	3,725.63
1	Error azimuth angle	18	29.45	1.64	0.0302%	38.8	3,100.48
1	Extreme yaw moment: xxx kNm	13	10.22	0.79	0.0105%	27.3	2,185.80
1	Extr. high volt. Li: xx V	13	11.00	0.85	0.0113%	22.9	1,830.85
1	Blade i could not be released	5	23.08	4.62	0.0237%	14.0	1,117.41
2	Extreme tilt moment: xxx kNm	57	25.22	0.44	0.026%	48.977	3,918
2	Lubrication error & res. empty	2	25.00	12.50	0.026%	37.182	2,975
2	Extreme yaw moment: xxx kNm	7	14.37	2.05	0.015%	26.721	2,138
3	Extreme yaw moment: xxx kNm	15	29.27	1.95	0.0300%	57.4	4,595.66
3	Low oil-level, pitch hydraulic	1	18.85	18.85	0.0193%	56.6	4,524.00
3	Trip Q8 Feedback fejl	2	18.53	9.27	0.0190%	54.8	4,384.43
3	Extreme tilt moment: xxx kNm	69	12.57	0.18	0.0129%	36.6	2,926.25

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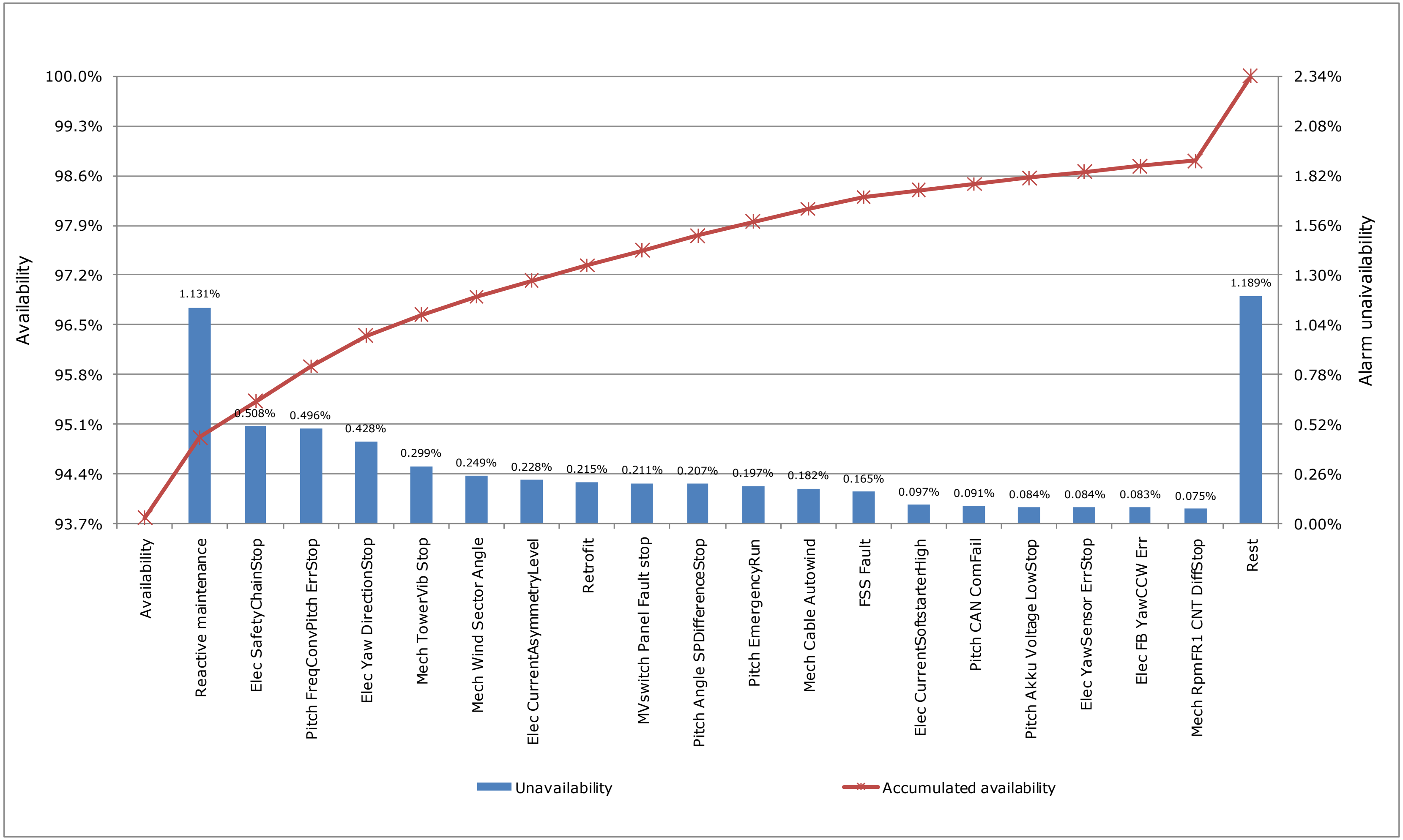
4. WEAK POINTS OF WIND FARMS



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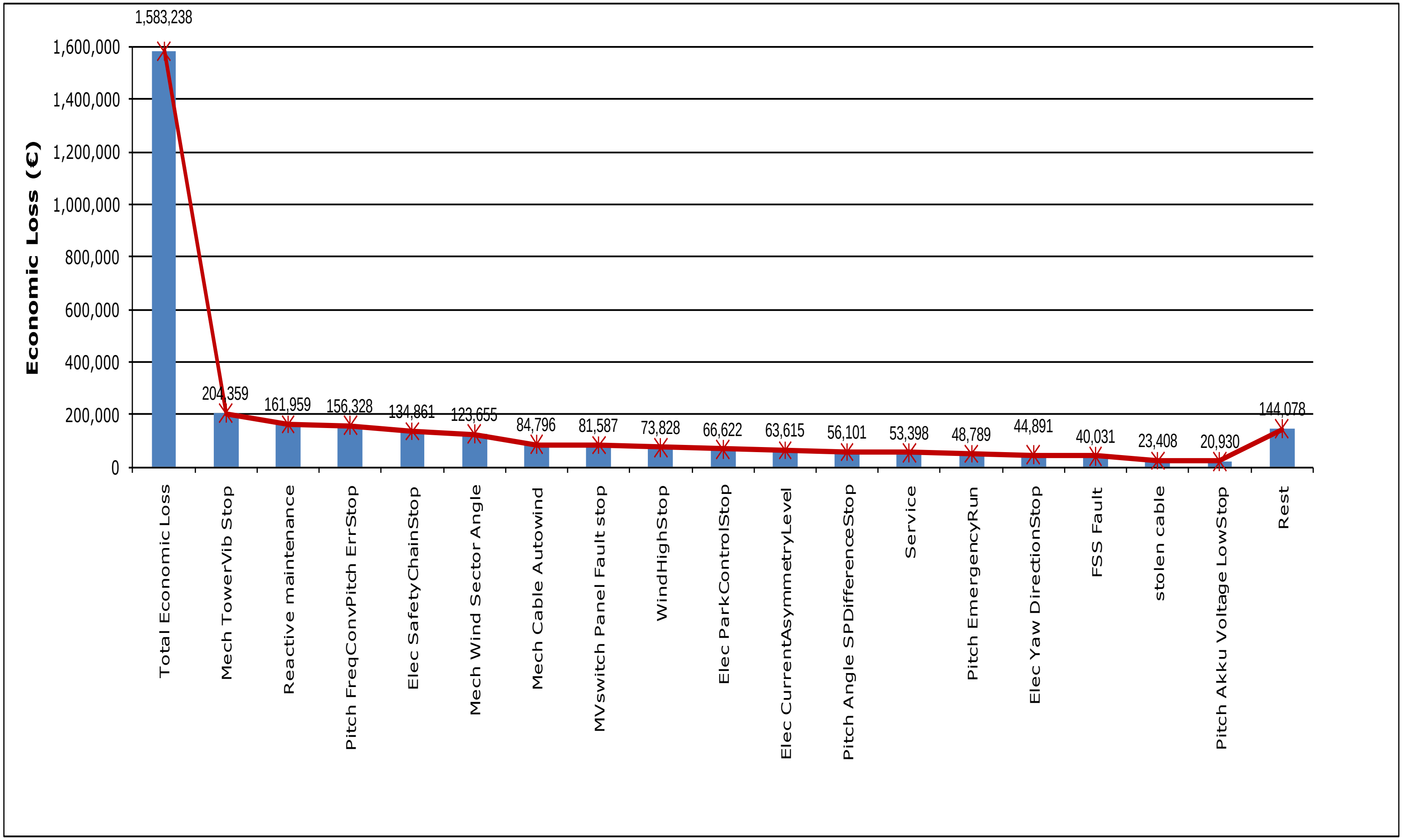
4. WEAK POINTS OF WIND FARMS



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4. WEAK POINTS OF WIND FARMS

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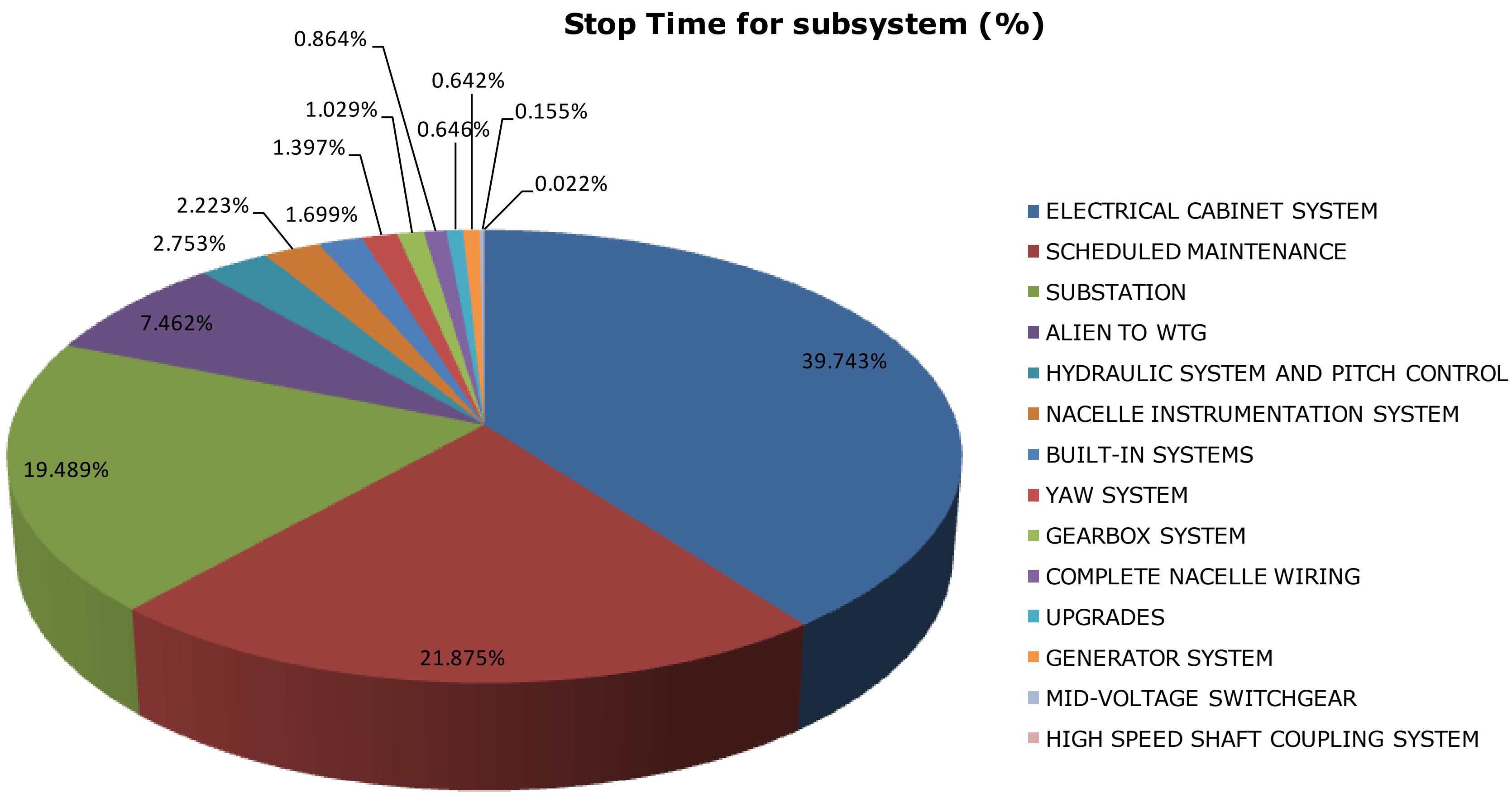

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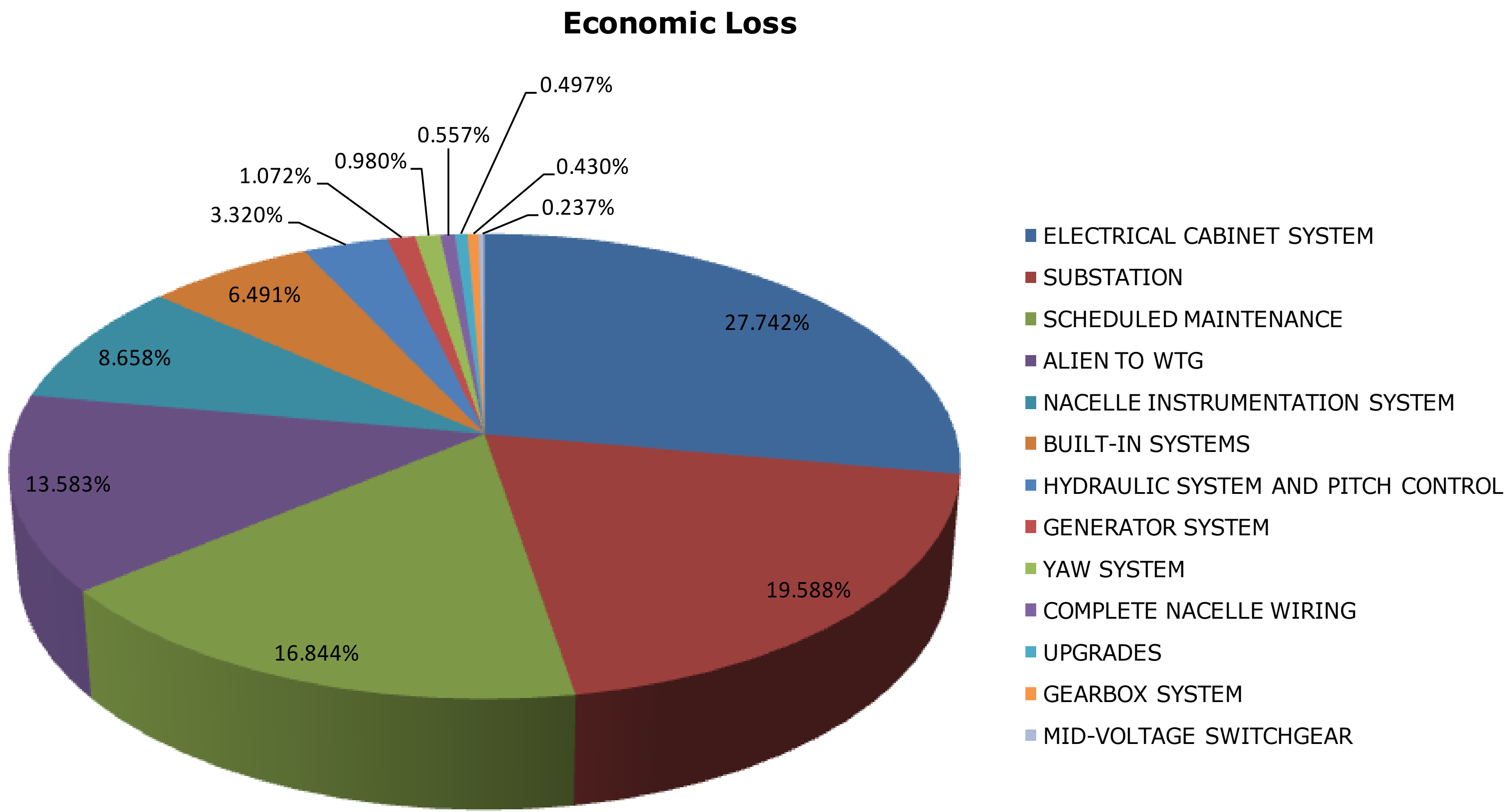
4. WEAK POINTS OF WIND FARMS



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CONCLUSIONS

Experience shows that detailed analysis of performance of the wind farm require an effort which is widely compensate by benefits.

Performance tests can detect 1-5% losses

EREDA owns computational algorithms and dedicated software for systematical analysis.

Categorizing production and availability losses by alarms provides the ground to address efforts to the most critical aspects of wind farm exploitation.

Thank you for your attention

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