Typical damages at wind turbines – and their prevention

Presentation at the COWEC 2013
18.06.2013

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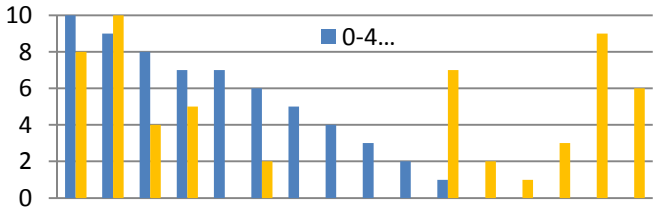
What is it about

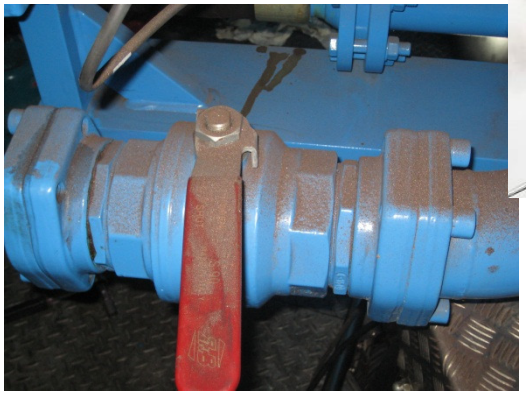
1 - Introduction

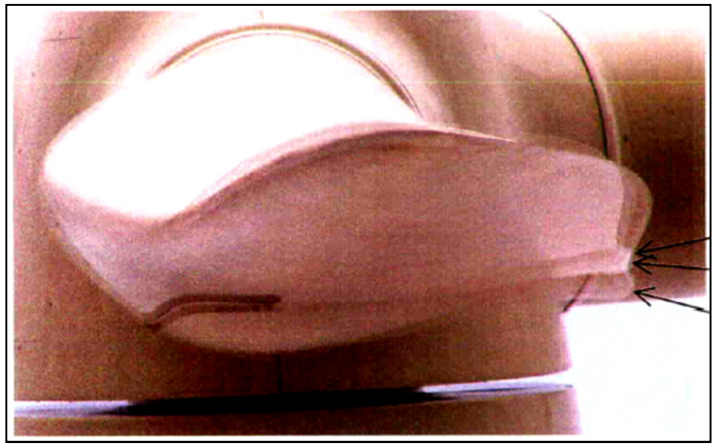
2 - What has happened and why – some cases

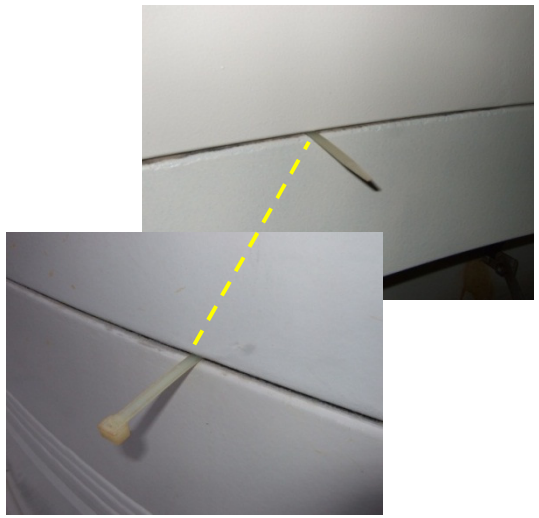
3 - Why are we here

4 - Conclusion

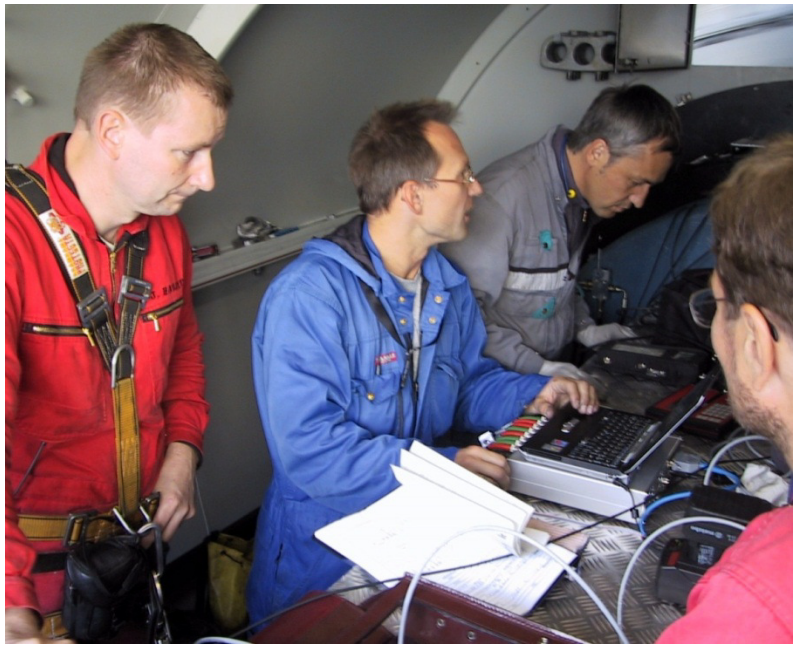








About 8.2



- Since 1995 > 15.000 Inspections of WEC
- 8.2 Consulting AG
  - Wind Energy (On-/Offshore)
  - Due Diligence / Site Assessment
  - Consultancy
  - Biogas / Biomass / Photovoltaic
  - CMS Monitoring
  - 8.2 Academy
- Independent 8.2 offices
- International 8.2 companies

Wind since 1996
8.2 Since 2004
- QM-Auditor, supervisor
- Consultancy, DD
- On- & Offshore
- Inspections
- Root cause analyses / FMEA / risk analyses

Wind since 1989
8.2 Since 1998
- Design approvals
- Consultancy, DD
- Inspections (> 2000)
- Damage analyses
- Value judgment
- QM-Audits

8.2 Die Sachverständigen für Erneuerbare Energien
The Experts in Renewable Energies

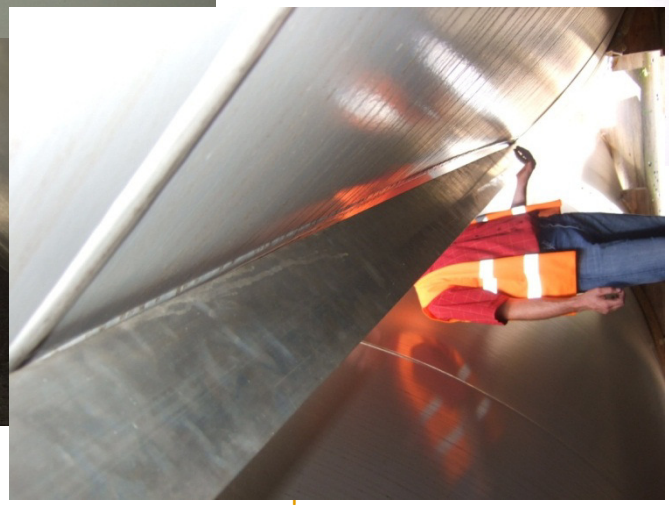
1) What has happened and why – some cases

1) fabrication of towers – serial manual fabrication

1.) fabrication of towers – serial manual fabrication

Findings:

- tilting gaps between top flange and yaw bearing
- Buckles in tower shell plates
- Notches in weldings



1.) welding defects, rolling defects

Root cause:

- quality control: poor / no measurements of flange flatness
- no consistent overall quality system (no performance figures)
- remarks in the drawing („grind notch free“) have been ignored / overseen
- steel cone has not been „calibrated“ after rolling;
- wrong interpretation of “green stamped” drawings
- missing supervision of the fabrication / workshop inspections

>> Weak Q-system / lack in the procedures / lack in qualification

Why typical:

new steel constructors “perform” the same mistakes although problems are known

„Healing“:

- shimming with plates; Regular exchange of bolts; weld repairs (offshore!)

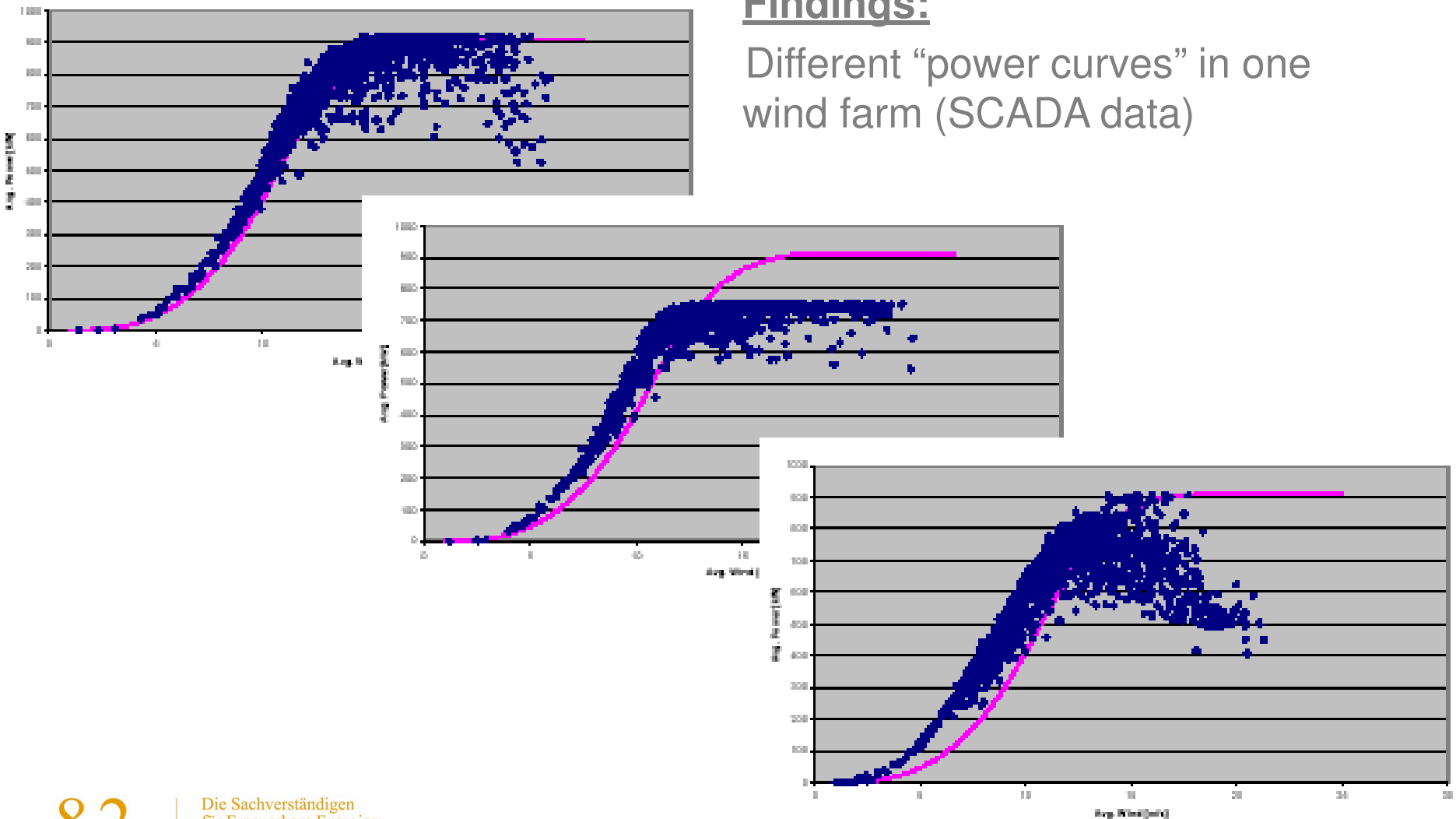
  >> extended O&M costs

- cutting an replacing of one steel cone; Cutting and replacing of secondary items

  >> Delay in shipment of several weeks, no healing after installation

2) Installation of turbines – “Mega” meets “milli”

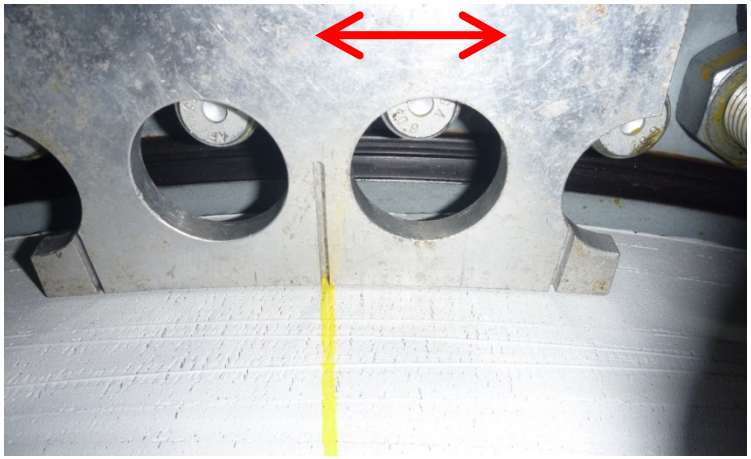
2.) small mistake – big damage



Findings:

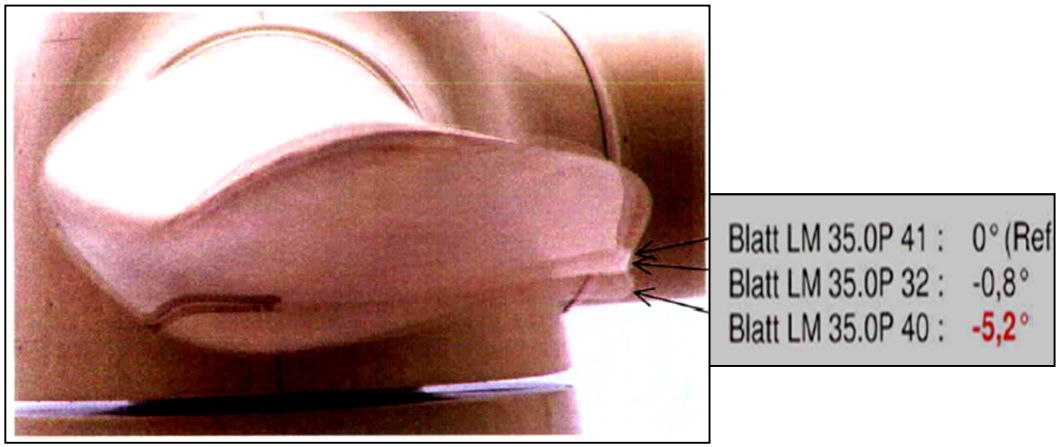
Different “power curves” in one wind farm (SCADA data)

2.) misalignment of rotor blades – aerodynamic imbalance



Root cause:

- misalignment of rotor blades cause aerodynamic imbalance
- displacement of one blade for one bolt during installation

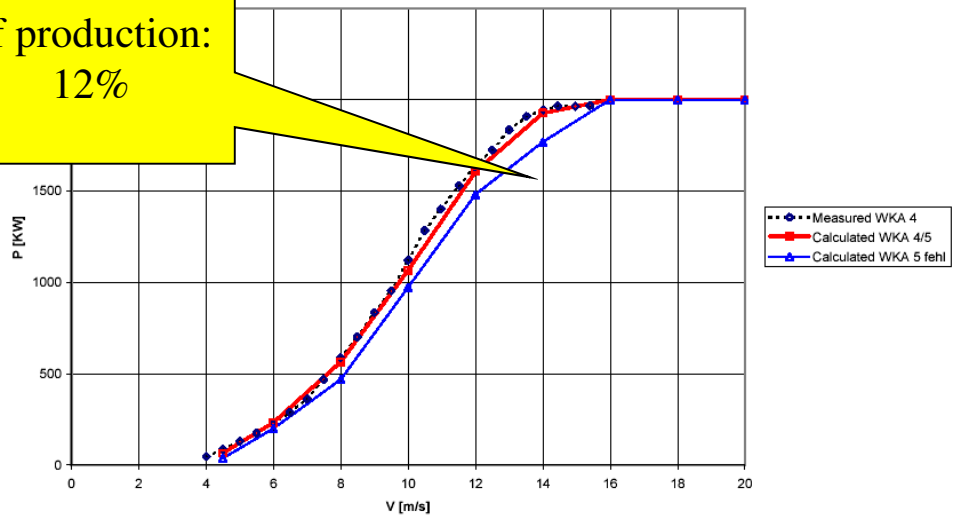


„Healing“:

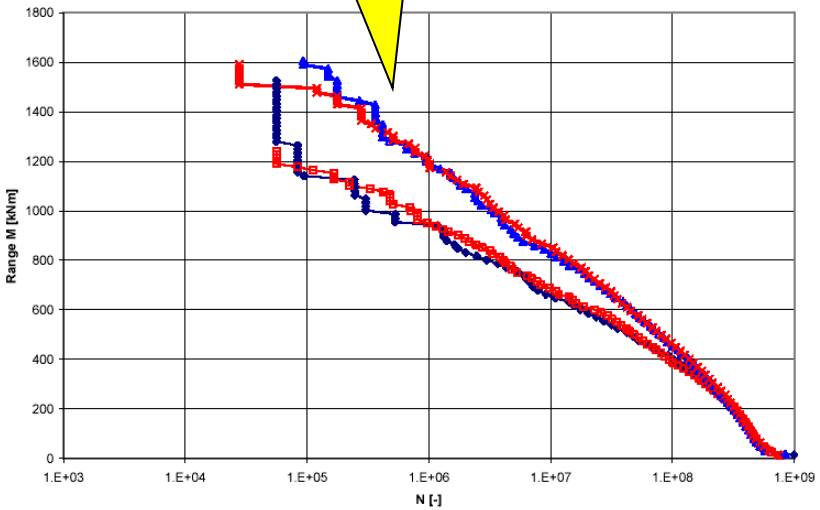
- correction of blade position
- re-calculation of life time

2.) misalignment of rotor blades – financial damage

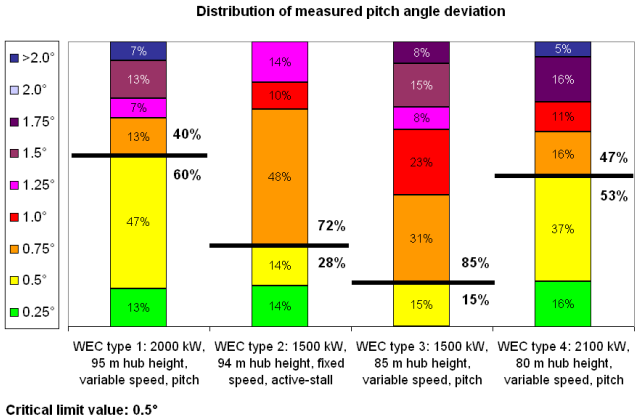
Annual loss of production: 12%



Reduced life time of the rotor hub: 70% (14 years)



Why typical: Statistics show that such cases are quite often. (figure below: Berlin wind)



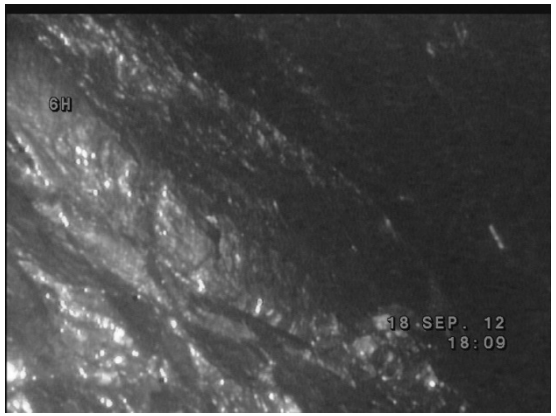
3) Condition Monitoring – what do you know about your WEC?

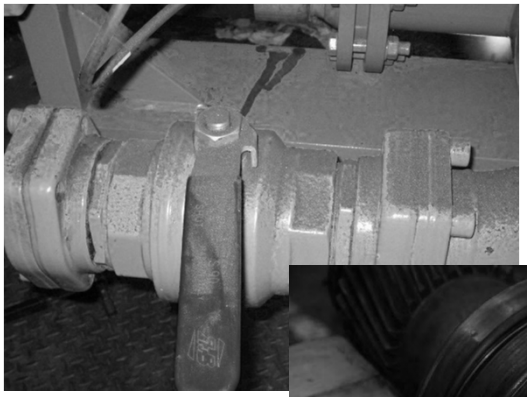
What do you see…

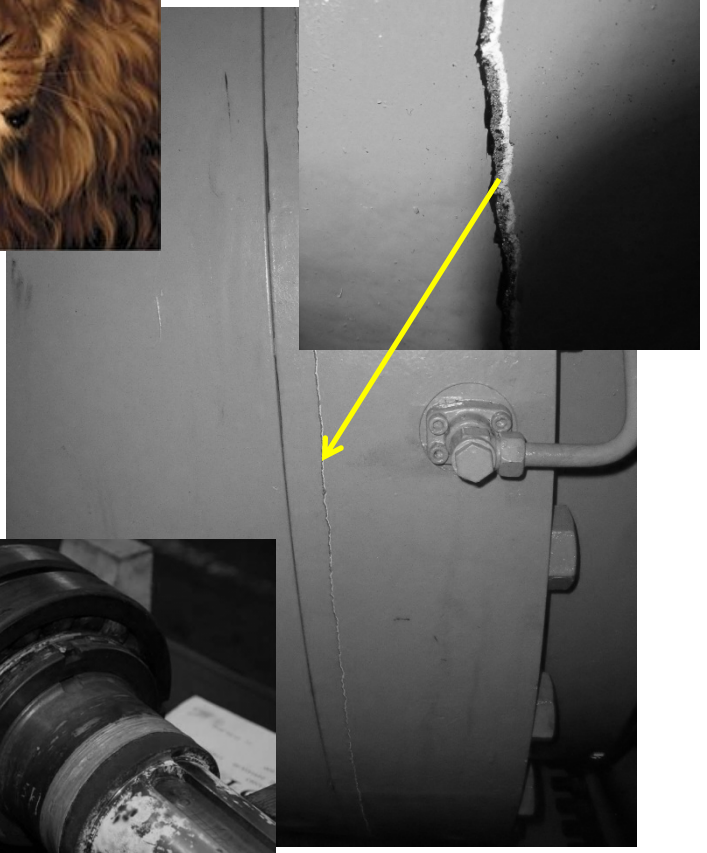
3.) What do these have in common?

Findings:

- Sudden rise of oil filter pressure
- Alarm of the fire-detector
- Alarm of the particle-sensor
- Alarm of the temp sensor
- “Shock” in the control room
- Sudden “death” of the WEC







3.) in all cases a CMS was installed – signs have been ignored

Root cause:

besides the technical reasons behind which caused the damages, the installed CMS was not able to give an early alarm due to:

- systems were not cross linked
- systems were not connected to the WEC-Control system
- systems have not been monitored (manual data transfer)
- supervisors could not read the signs

Why typical:

in some cases, there is still no holistic view of “condition monitoring”, people rely on “S” but have no overall “CM”

A holistic **C**ondition **M**onitoring can help to avoid collateral damages
A holistic drive train CMS can help to detect damages early enough.

3.) detecting damages at gearboxes

Inspection method	Visual inspection & Stethos.				Endoscopy				Vibration analysis			
category	Obs.	Warn.	Alarm	Σ	Obs.	Warn.	Alarm	Σ	Obs.	Warn.	Alarm	Σ
Gearbox mainly	9%	5%	0%	14%	1%	1%	3%	5%	1%	0%	0%	1%
Planetary stage	1%	0%	0%	1%					6%	3%	0%	9%
Plan. stage bearing					31%	9%	7%	47%	6%	2%	1%	9%
Plan. stage gear					28%	21%	11%	60%	32%	14%	1%	47%
LSS bearing	1%	0%	0%	1%	33%	8%	5%	46%	5%	1%	1%	7%
LSS gear	25%	3%	0%	28%	23%	7%	3%	33%	6%	1%	0%	7%
MSS bearing	0%	0%	0%	0%	22%	7%	4%	33%	20%	7%	2%	29%
MSS gear	21%	3%	0%	24%	27%	8%	4%	39%	16%	1%	0%	17%
HSS bearing	8%	7%	0%	15%	38%	9%	13%	60%	30%	12%	8%	50%
HSS gear	29%	3%	0%	32%	22%	3%	4%	29%	23%	5%	1%	29%

Data Base of table: 417 reports of 8.2 / P ≥ 1.000 kW / 3-stage gear box (1 planetary / 2 spur gear) / since 1998

4) Fire in the turbine

4.) Fire – several reasons

Why typical:

- Reason for most losses of complete turbines (newspaper research; 5-10/a)
- Some cases caused by lightning
- Several cases caused by electrical defects

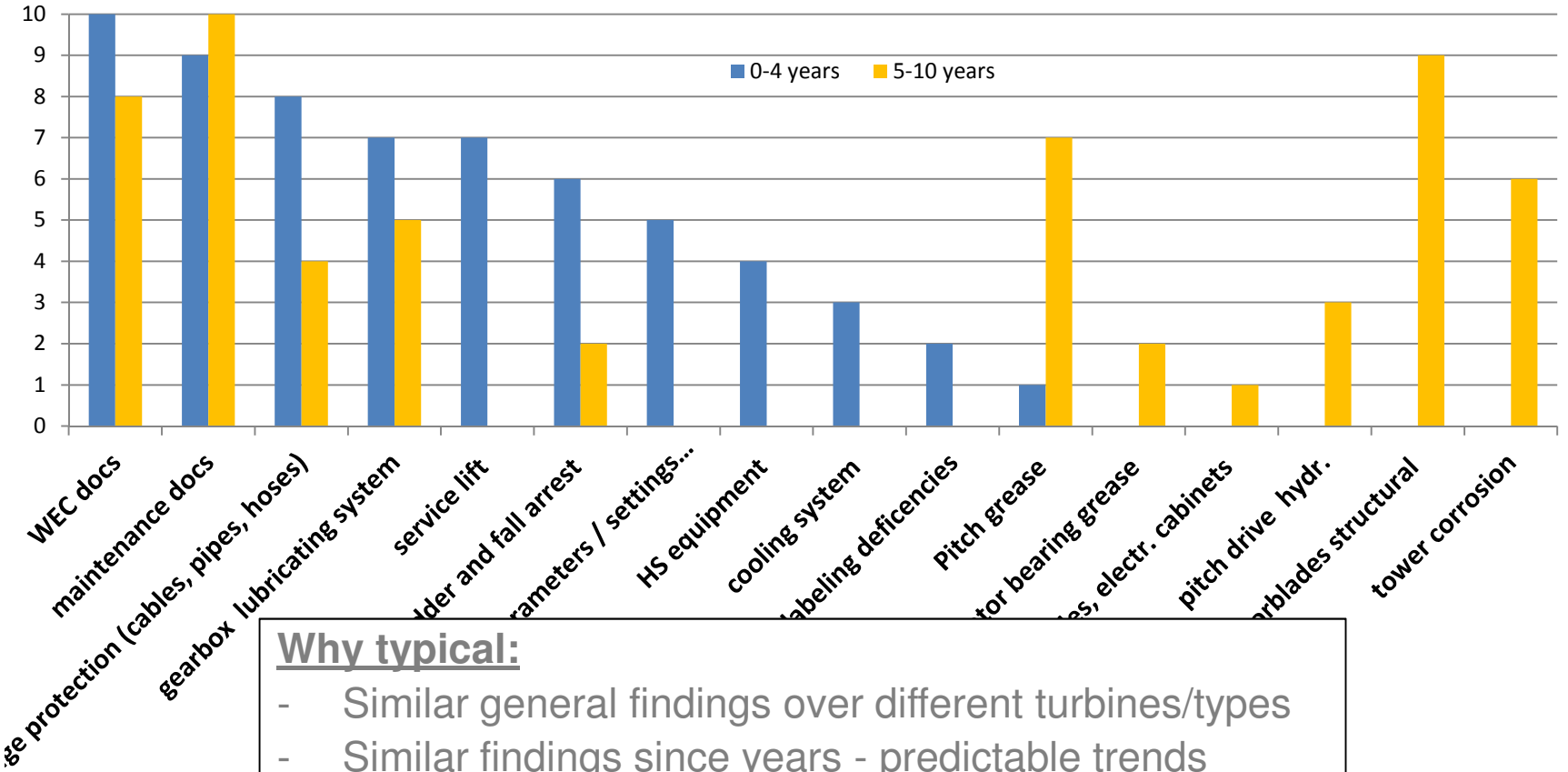
Background (only mechanical reasons):

- Electrical installation / cabinets contain many bolts
- Bolt torque can hardly be checked (very low values necessary)
- torque control may need a complete disconnection from the grid
- Cabinets are vibrating due to turbine operation, ventilators, etc.

4.) Fire – several reasons

5) Findings at inspections – possible damages

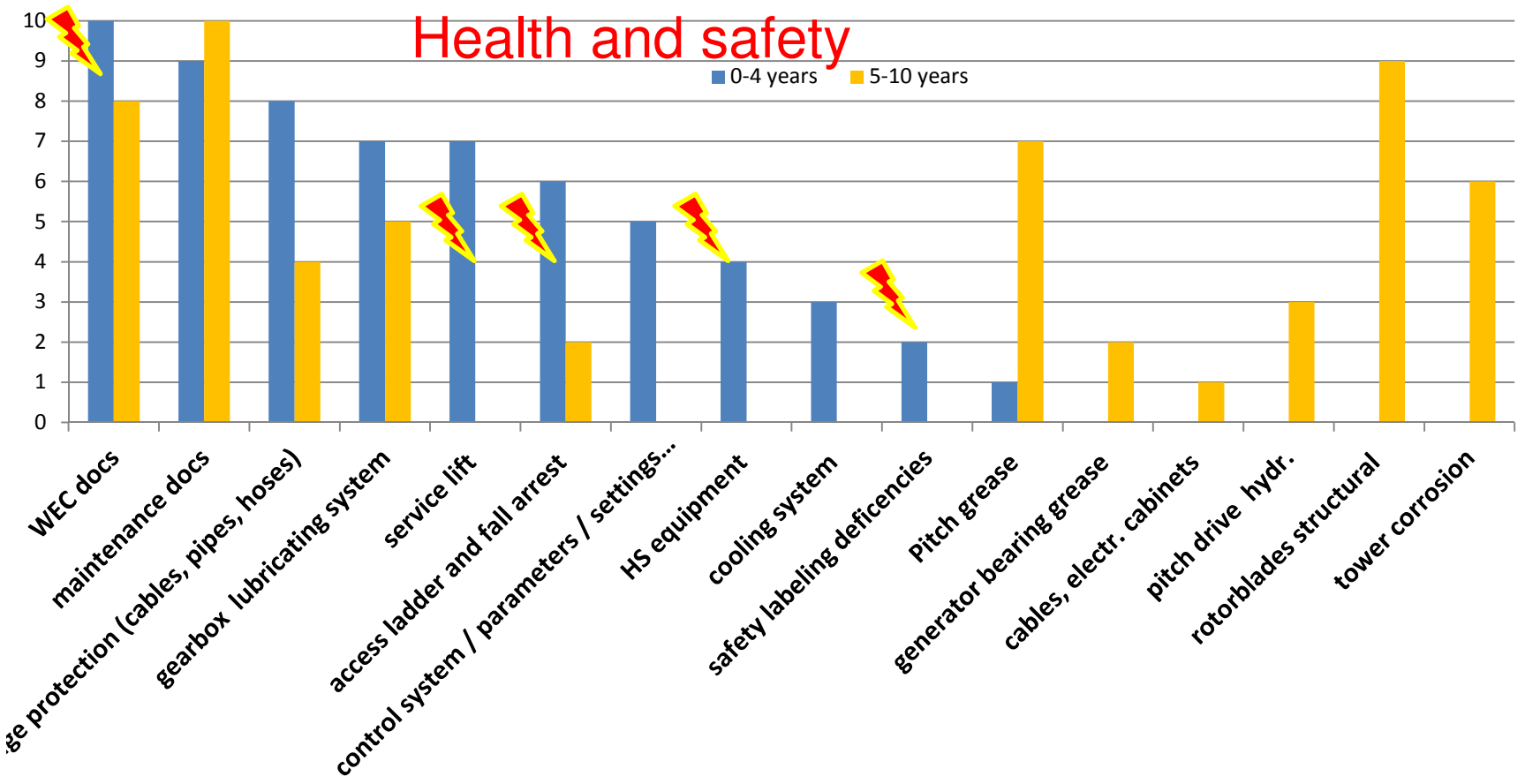
Top 10 - findings 8.2 inspections (deficiencies)



Why typical:

- Similar general findings over different turbines/types
- Similar findings since years - predictable trends
- The operator / owner is surprised!!!

Top 10 - findings 8.2 inspections (deficiencies)



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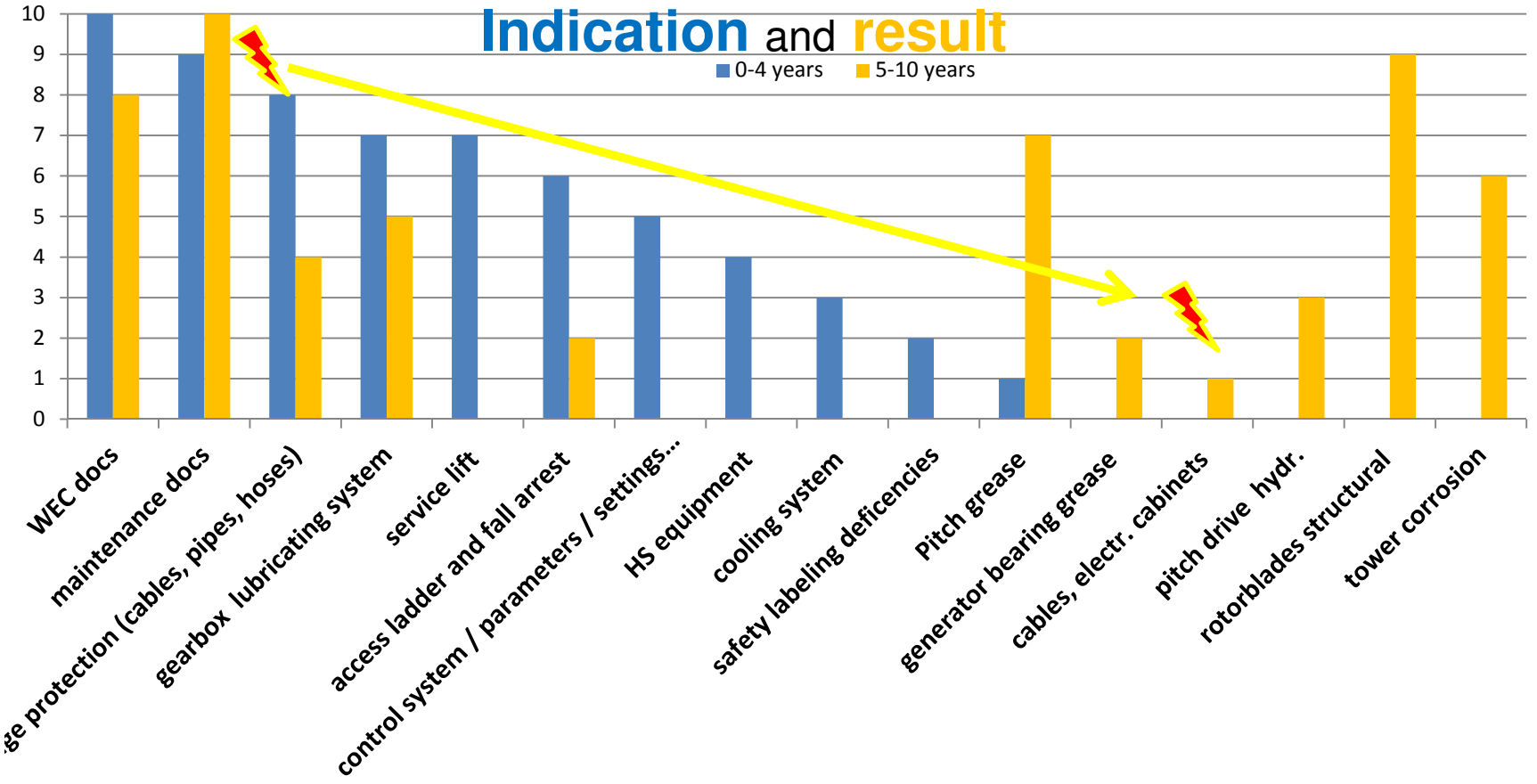

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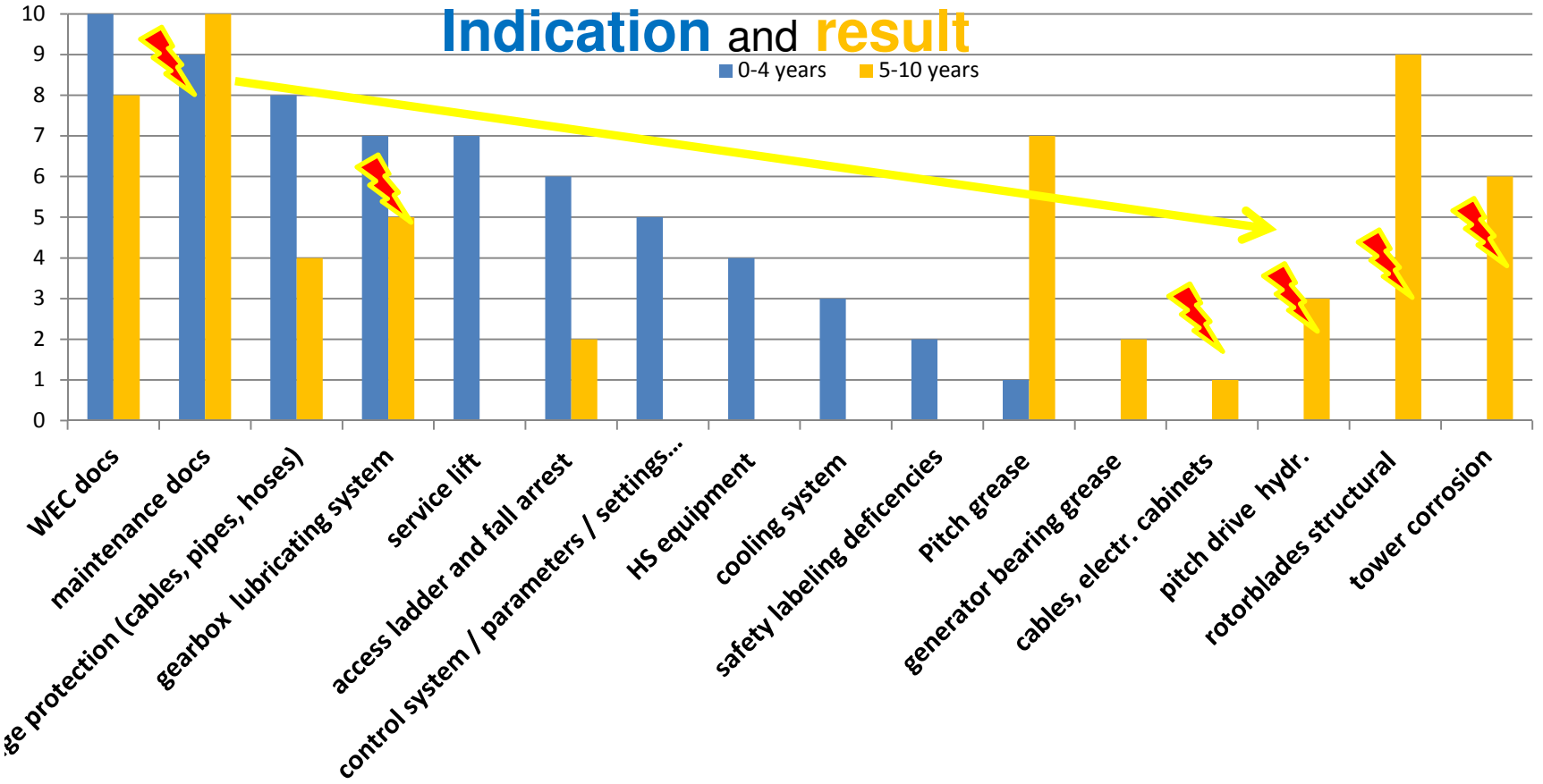


Why are we here – some background

We know the statistics…

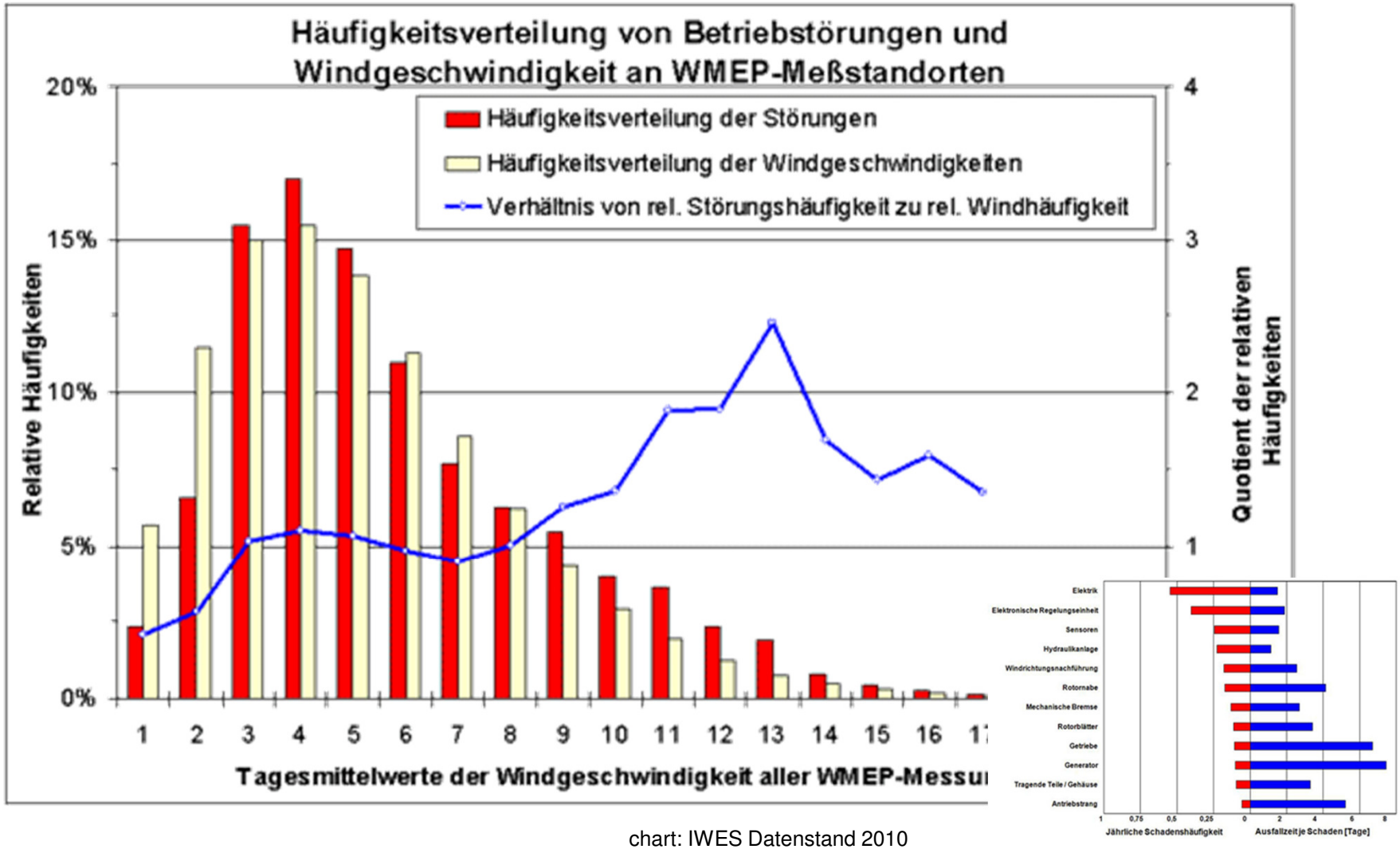


chart: IWES Datenstand 2010

How do we react?

And if you think Offshore

when does „operation“ start?

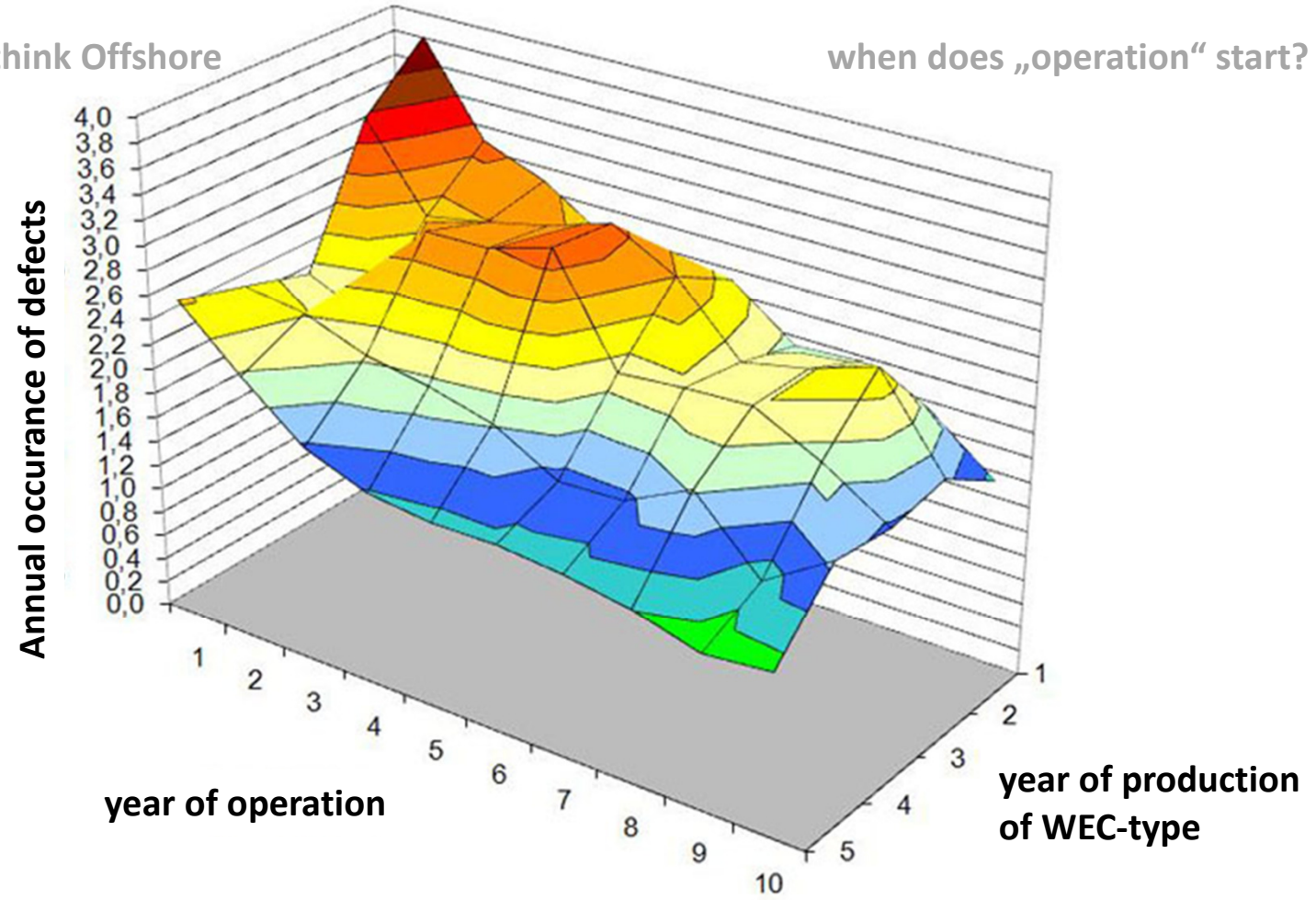


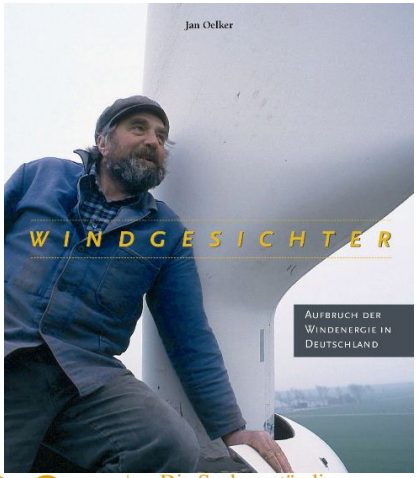
chart: IWES Datenstand 2010

Proven technology – and long experience

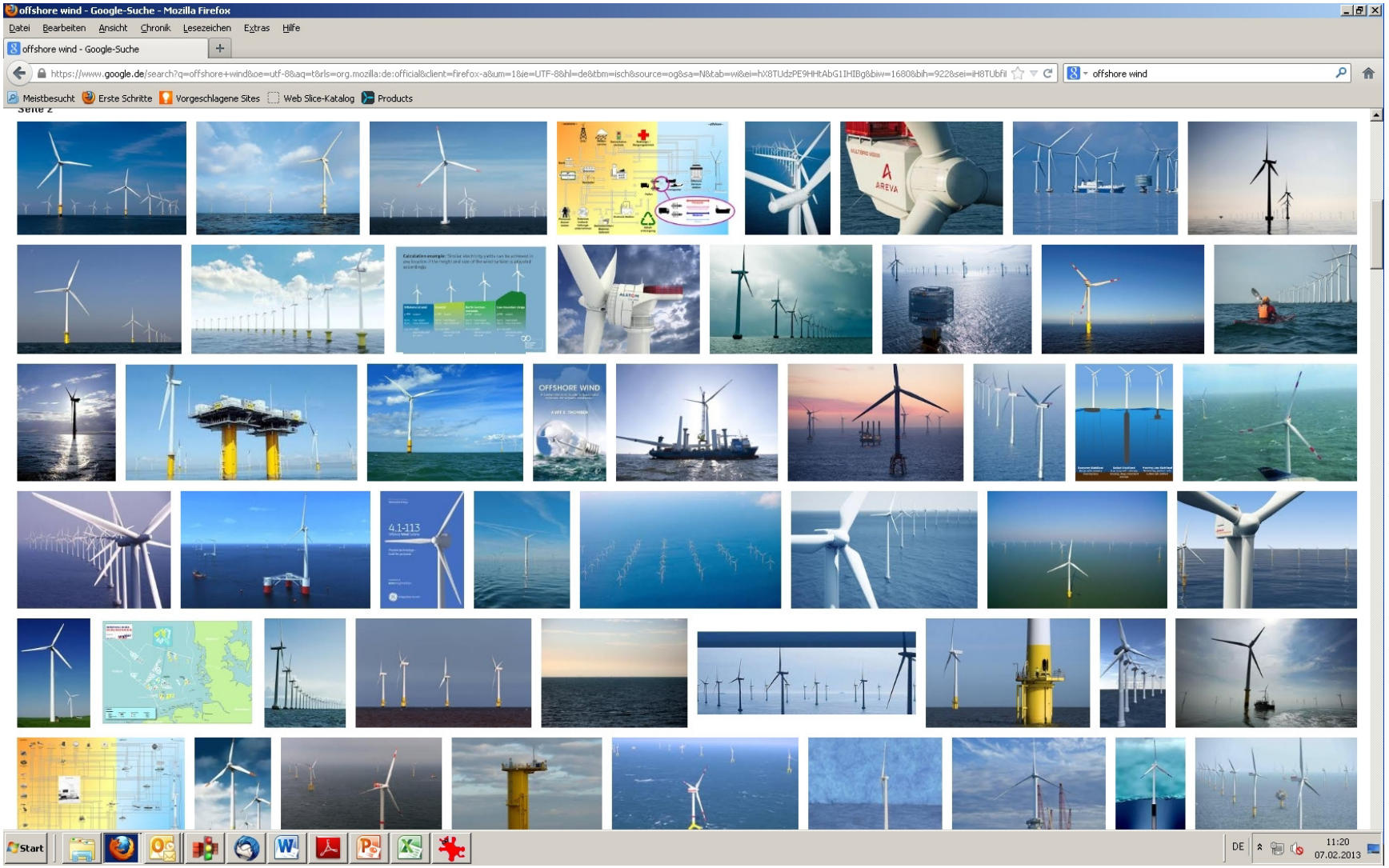
Matured over years – and yet new

Same product, bigger projects, new customers,,different worlds, stronger requirements

50kW 200 500 1MW 2 5 6 7



Is it so easy – what do we expect?



Is there any analogy to your project?

Conclusions

Interesting facts about damages at wind turbines

- Methods of calculation, tools etc. are proven; load assumptions acc. to the actual rules and guidelines are “safe”.

>> Few damages of modern turbines are based on wrong calculations or load assumptions. If so, this happens mainly when stepping into the next „MW-class“

- Mistakes in manufacturing, testing, handling, installation, service and operation are predictable. Conferences (like the COWEC) teach a lot.

>> After 30 years most typical damages in the wind industry are still caused by these mistakes.

- Most hardware-damages could be detected early enough to avoid unplanned standstill of the turbine
- State of the art Quality-Management-Tools are known and easily available. They are very effective to avoid mistakes or solve problems.

>> Why do we still face so many „typical“ problems?

Condition Monitoring >> the holistic view

◄ Watch

- Scada
- Webcams,
- Inspections (regular, Service)

◄ Listen

- Vibration diagnostics
- Wear scans (particle, oil pressure, …)
- Web-microphones

◄ See details

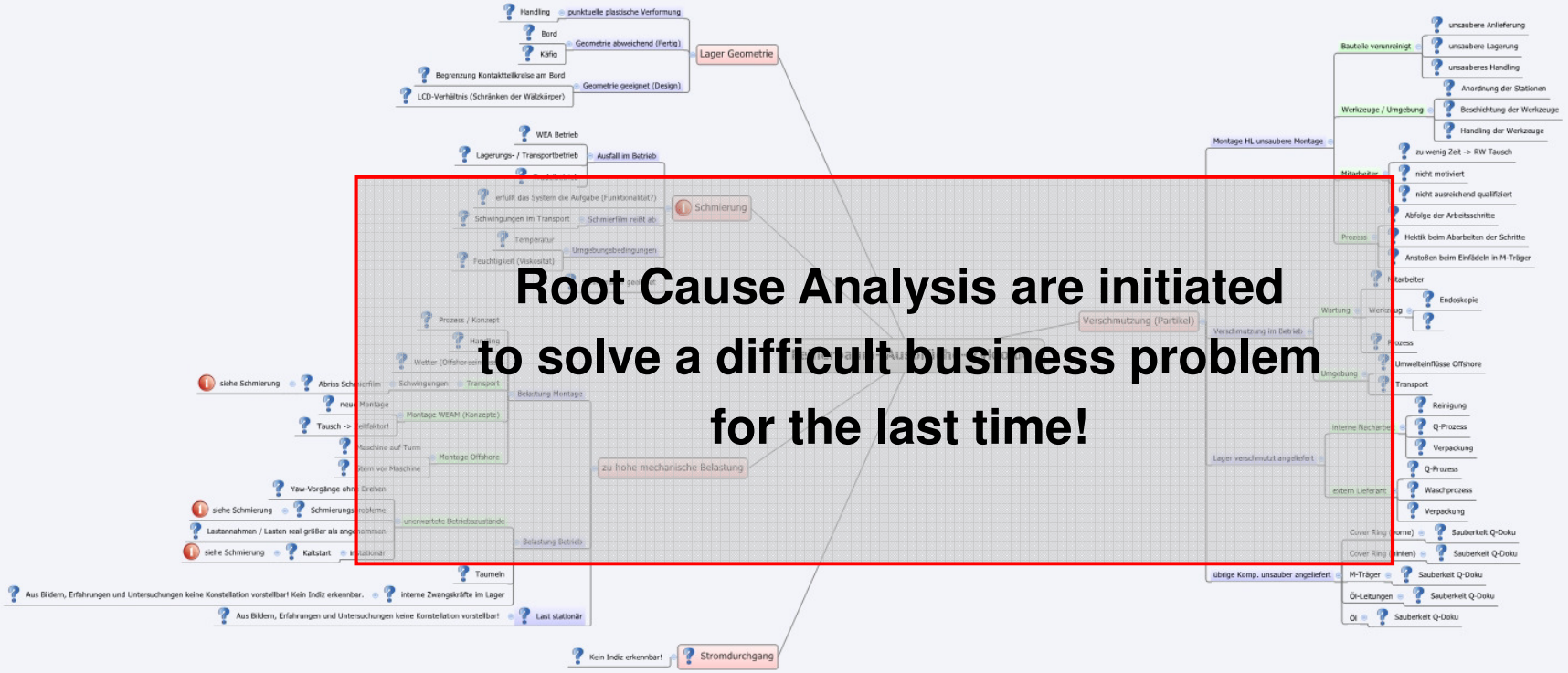
- Video endoscopy

◄ Measure

- Vibration diagnostics
- Wear scans
- Oil samples
- Drive train alignment

Bring it all together and read the signs !

What about a failure-tree-analyses ?



What about root cause analyses?

RCA #	RCA Title	Root Cause Contributed To	Closed 2007	2007 Cycle Time to Identify Root Cause (in weeks)	Closed 2008	2008 Cycle Time to Identify Root Cause (in weeks)	Closed 2009	2009 Cycle Time to Identify Root Cause (in weeks)
Yaw and Pitch System								
8	Pitch Drive Couplers	Design						
10	Pitch Motor Burnout	Design	x	6				
24	Yaw Brake Failure	Design			x			
26	Pitch Position Failures	Design			x			
30	Digital Vibration Monitor	Design			x	7		
55	DC Bus Overvoltage, Limit Switch & Motor Quivering	Design					x	8
57	Yaw Drive Broken Teeth	Design			x	6		
61	Yaw Twist System Failures	Design					x	6
66	Yaw Gearbox Oil Leaks	Design			x	4		
69	Pitch Drive Failures: Training and Troubleshooting	Process Improvement					x	5
70	Pitch System Failures – Design Upgrades	Design					x	5

RCA #	RCA Title	Root Cause Contributed To	Closed 2007	2007 Cycle Time to Identify Root Cause (in weeks)	Closed 2008	2008 Cycle Time to Identify Root Cause (in weeks)	Closed 2009	2009 Cycle Time to Identify Root Cause (in weeks)
Composites								
33	Nacelle Quality Defects	Design			x	5		
51	Blade T-bolt Alignment	Supplier			x	4		
58	Leading Edge Cracks	Supplier			x	8		
59	Loose Blade Balancing Mass	Supplier			x	5		
73	Blade Skin Imperfections	Supplier				6	x	
Mechanical								
38	Jib Cranes	Design			x	10		
72	Jib Crane Hoist Failure	Design			x	2		

Root Cause Analysis are initiated to solve a difficult business problem for the last time!

Ever done a FMEA?

No.	System	Subsystem	Bauteil	Fehler	Fehlerursache	B	A	E	RPZ
Line 64	WEC	controller	optical fibre	no production	damage optical fibre	7	4	8	224
Line 59	WEC	grid connection	grid cable	no production / grid loss	failure beneath water level	7	3	8	168
Line 25	WEC	drive train	generator	no production	winding failure	9	3	6	162
Line 04	WEC	Rotor	rotor blade	lower efficiency	nonconformity airfoils	8	2	10	160
Line 75	Support	foundation	grouting	total loss WEC	damage grouting	9	4	4	144
Line 17	WEC	drive train	gear box	no production	damage bearing	9	4	4	144
Line 12	WEC	drive train	main bearing	no production	damage / defect	9	4	4	144
Line 07	WEC	Rotor	rotor blade	lower corrosion protection	break down coating leading edge	6	4	6	144
Line 15	WEC	drive train	main bearing	failure lubrication	grid loss and accu empty	7	4	5	140
Line 74	Support	foundation	grouting	lower structural safety	cracks grouting	8	4	4	128
Line 13	WEC	drive train	main bearing	lower efficiency	extraordinary wear	8	4	4	128
Line 06	WEC	Rotor	rotor blade	lower corrosion protection	break down coating	6	3	6	108

Example of an FMEA
for an Offshore-Turbine.
You need a good team for that.

What is possible to do

1. **More may be Less**
   - 10x rule, Offshore: 100x rule
   - „Lessons Learned“

2. **…for they know not what they do**
   - FMEA / Risc-Assessments
   - specifications / contracts
   - „Brain-Pool“ instead of „top secret“
   - Apply industry business standards (docs, procedures)

3. **Trust ist good, control is better…**
   - Fabrication / installation / service >> have it supervised
   - Condition Monitoring (holistic and from scratch)

4. **Go out – and go mad**
   - make a difference

Thank you …

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