Maintenance strategies for offshore wind farms

Industry Meets science 2015

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MainTech AS wind services

Advanced investment models

Consultants on technology selection

- Turbine technology
- Service agreements - Maintenance
- Coatings and corrosion protection
- Reliability studies

Maintenance & operations planning and optimisation

- Maintenance strategy development
- Benchmark audits
- Selection/specification of Computerised Maintenance Systems
- Reliability centered maintenance studies (RCM)
- Codification – systemising technical hierarchy for maintenance and spare parts
- Spare parts optimisation
- Establish maintenance and operational procedures
- Maintenance organisation
- Maintenance system implementation

O&M cost offshore wind

73% of Offshore O&M costs are vessel costs!

O&M cost for offshore wind is in the range of 2 to 6 times the costs for onshore!

Dalgic et al. 2014
Photo: H Pettersen Statoil

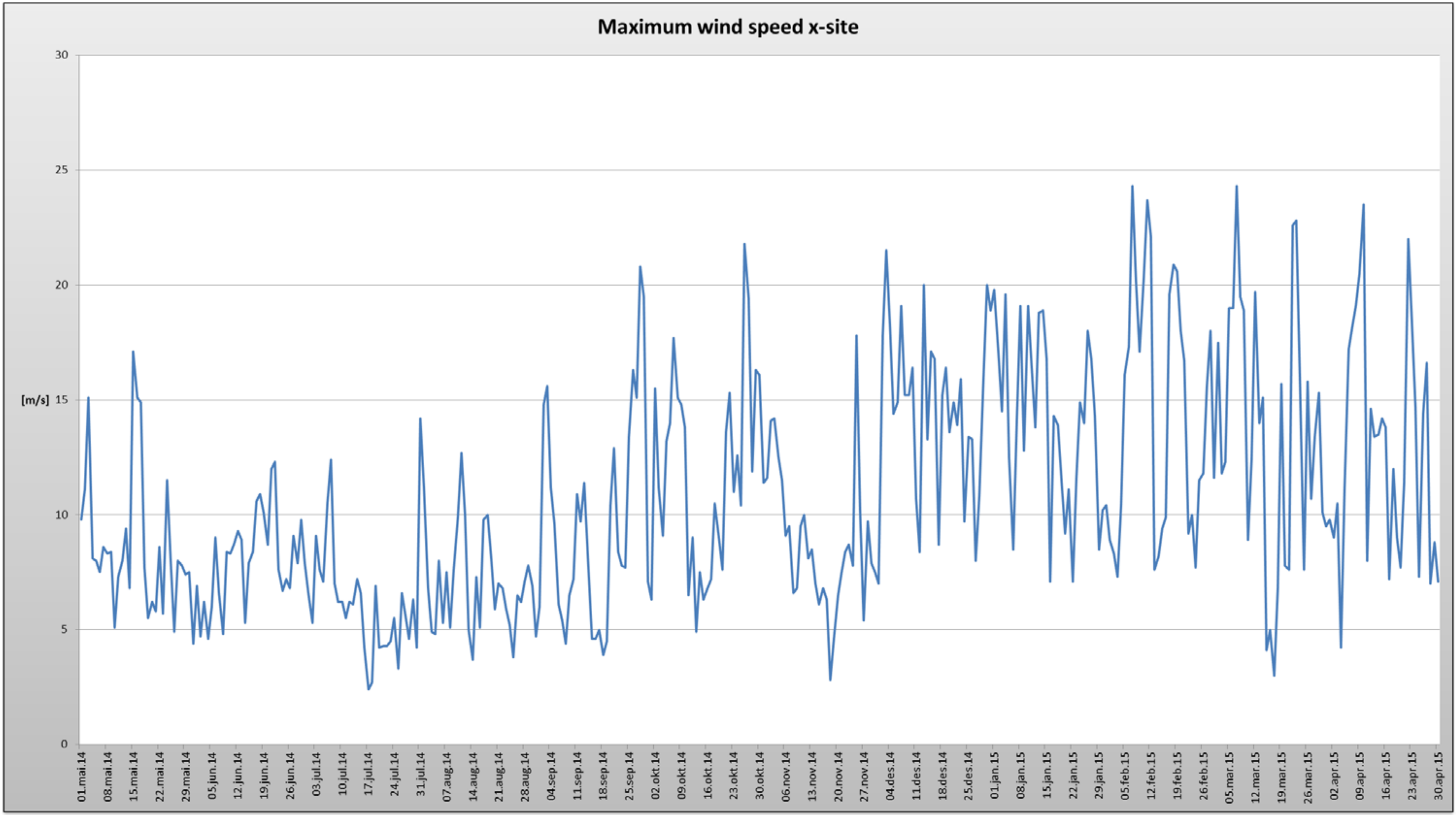
Constraints

Wind

Waves

Vessel availability

Offshore wind



Small

Medium

www.renewableuk.com

Large

LENGTH
132m

HULL BREADTH MID
39m

PROPULSION
Transit speed of 12 knots, DP2

WATER DEPTH RANGE
7.5 to 45m

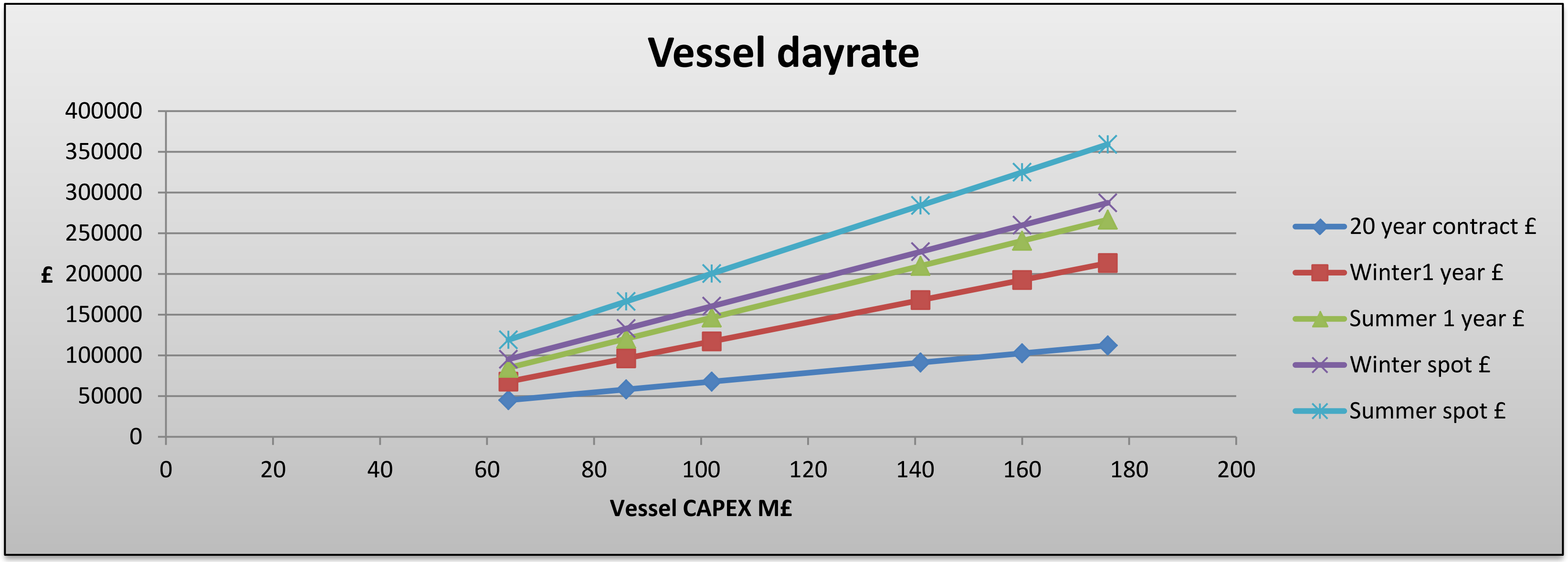
CRANE
800 tonnes at 24m outreach, 102m over deck

TYPICAL PAYLOAD
6600 tonnes

Largest

O&M Vessel cost

33 jack up vessels per June 2014



Survival of the fittest!

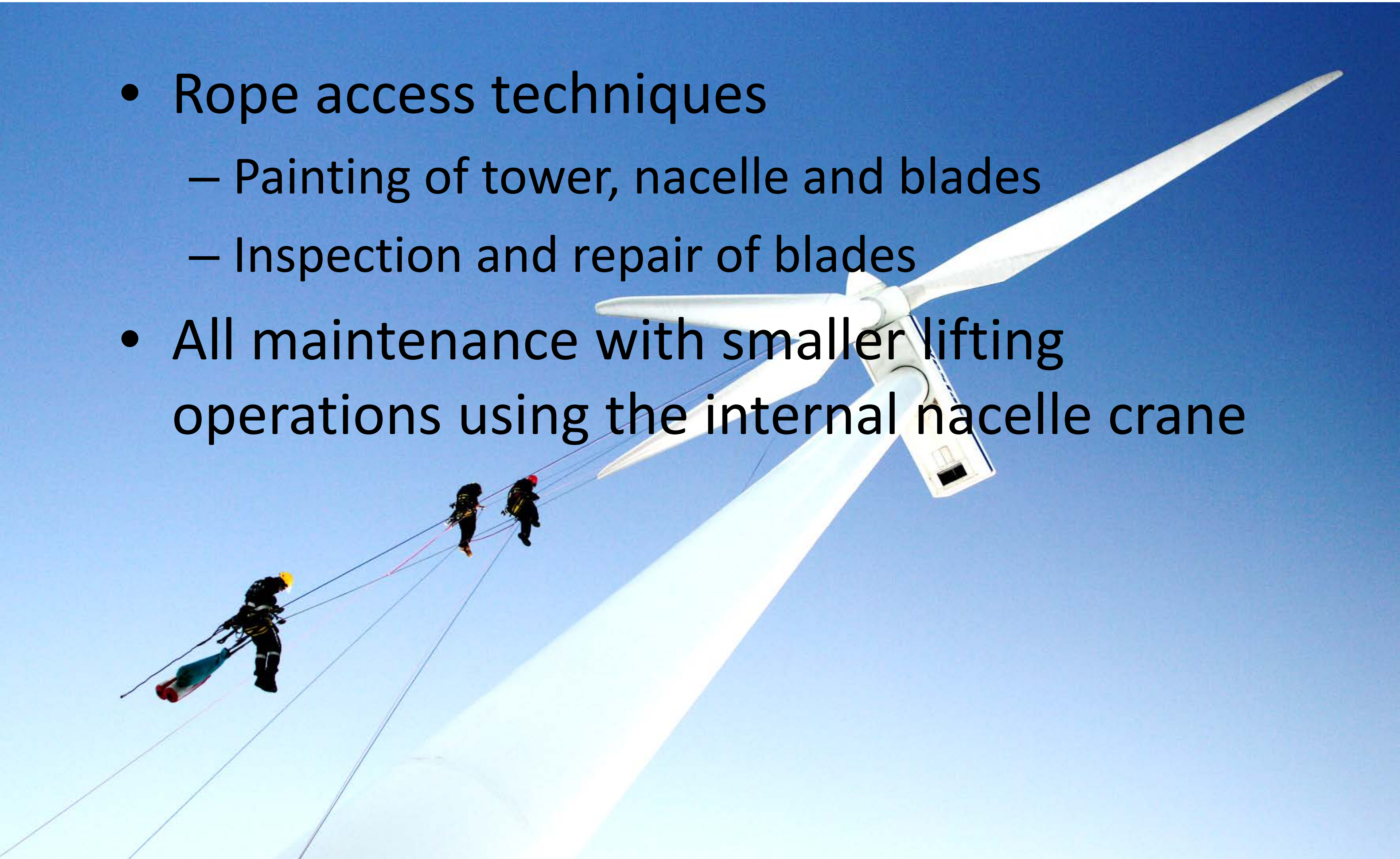
8MW current (Vestas V164)

Maintenance requiring JU vessel

- Nacelle
- Blades and hub
- Drivetrain
  - Shaft, main bearing and gearbox
- Generator
- In-turbine transformer

Maintenance not requiring JU vessel

- Rope access techniques
  - Painting of tower, nacelle and blades
  - Inspection and repair of blades
- All maintenance with smaller lifting operations using the internal nacelle crane

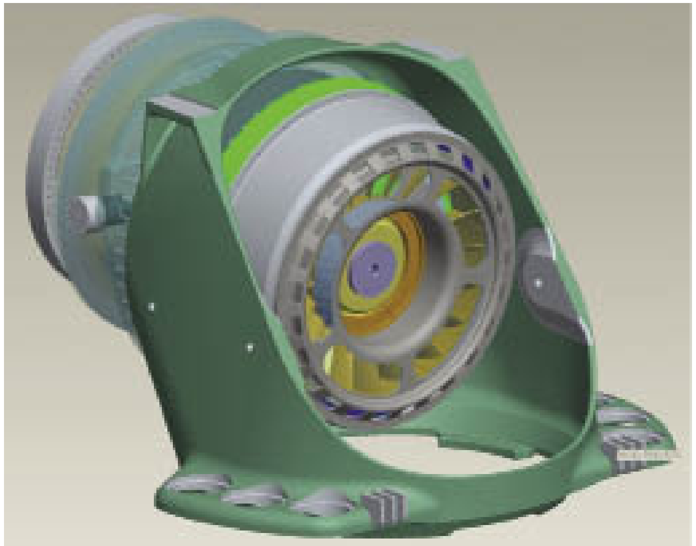


Light maintenance vessel

Wave craft – Surface Effect Ship Innovation supported by Carbon trust, Forskningsrådet, RFFAgder and Innovasjon Norge

Maintainability and redundancy

Maintainability and redundancy



The Clipper wind medium speed, 10,6MW permanent-magnet generator.

98.3% efficient 2 to 4% over conventional induction generators.

Multiple independent output windings per generator provide quad redundancy in the electrical system.

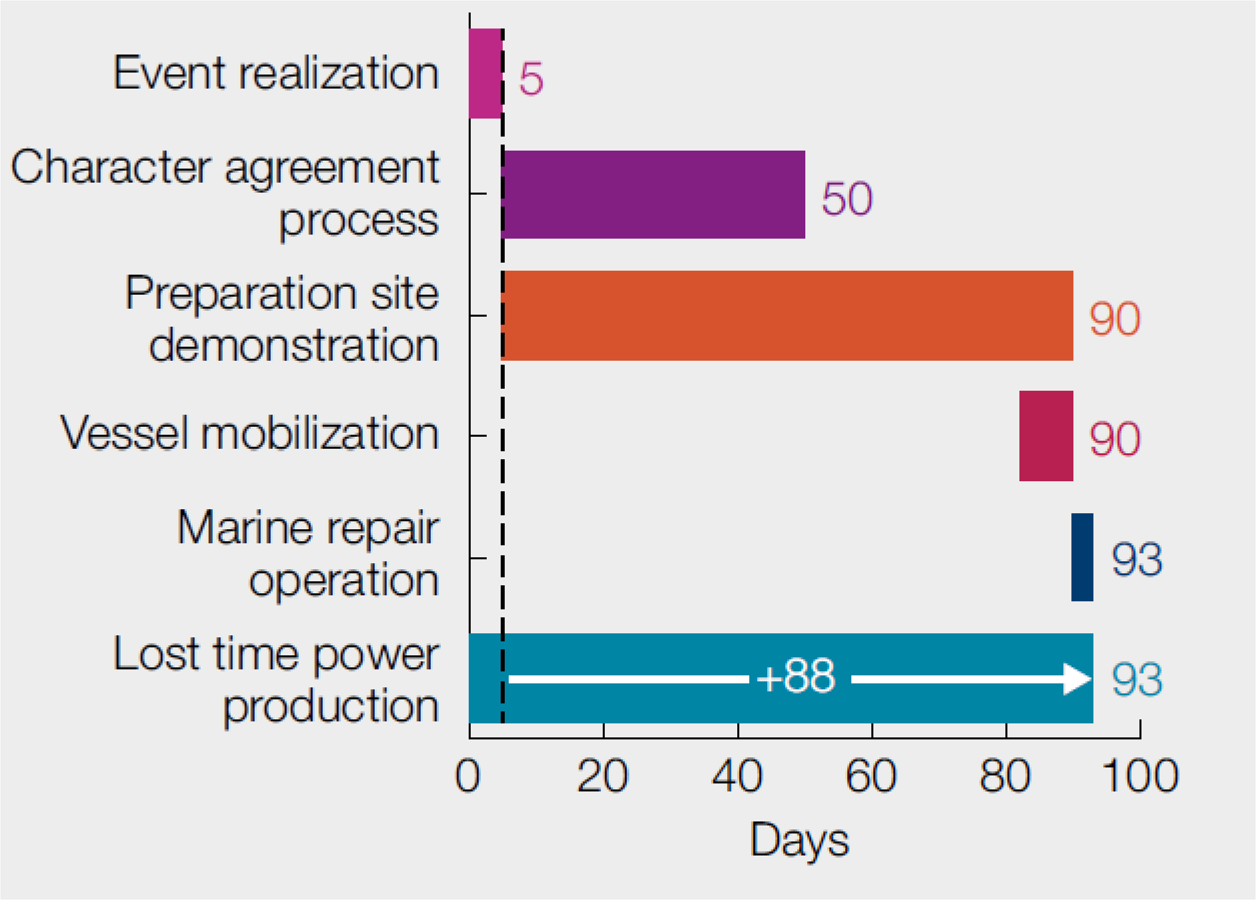
Maintainability and redundancy

Number of turbines which could be stopped for 12 months and still meet 95% contractual availability guarantee given an assumed "background" contractual availability	"Background" availability (contractual availability excluding main component downtime)		
	96%	97%	98%
50 turbine site	0	1	2
100 turbine site	1	2	4
150 turbine site	1	3	6
200 turbine site	2	4	8

How many turbines that can be allowed to not produce depends on:

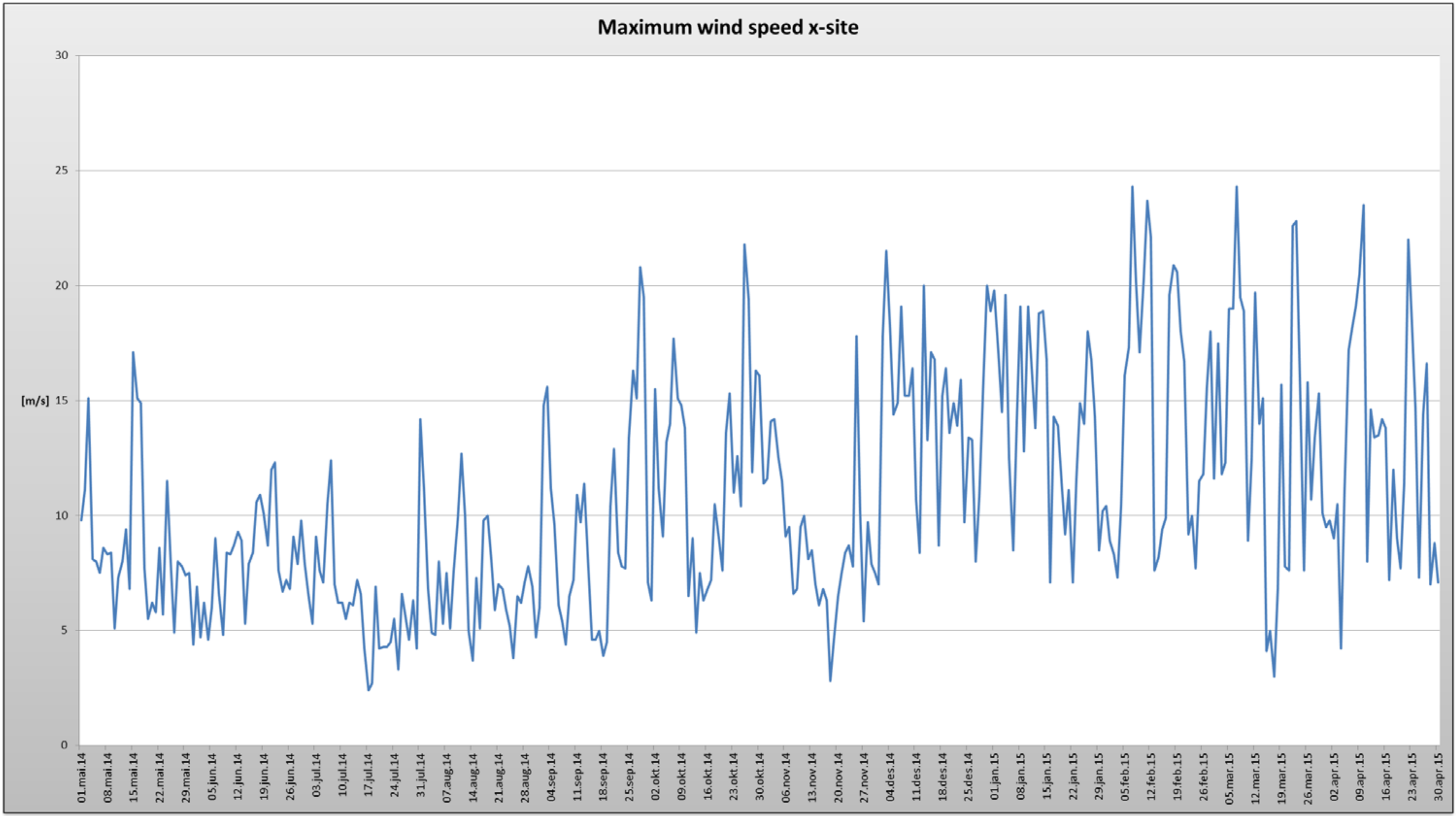
- The contractual availability
- The size of the wind farm
- The number of turbines
- The turbine size
- The turbine individual realibility (background availability)
- The calculated revenue loss vs. Estimated repair cost

Typical single down time event



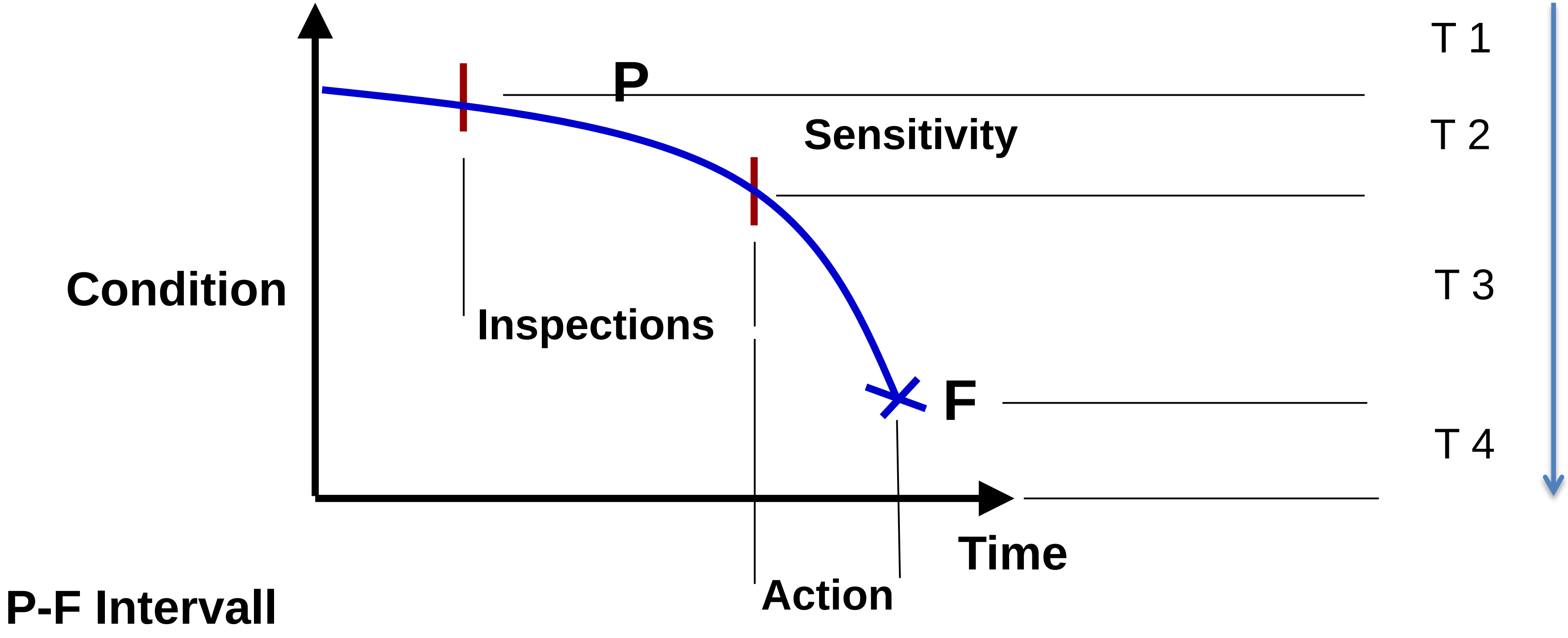
Experience of planning jack-up vessel operations – duration of pre-operational stages.
The Crown estate - July 2014 (reproduced with permission of DBB Jack-up Services Ltd)

CM necessary prediction time



PF-Interval -response on maintenance

- Selection of condition monitoring
  - **Depends on the component having a measurable failure development that enables action before failure:**



Lost production costs

Scenario	Value of lost production (£)[5]	
	Round 1/Round 2	Future development
A: 'unprepared' Six month wait for jack-up vessel while turbine is not producing power	£885k	£1.7m
B: 'spot market – prepared' Three month wait for jack-up vessel while turbine is not producing power	£443k	£867k
C: 'fault detection – pre-prepared' Condition monitoring predicts defect before failure and jack-up vessel arrangements in place to ensure no downtime during jack-up vessel mobilisation[6]	£53k	£100k

5 Based on typical revenue expectations and production-weighted average capacity factors of 39% (currently operational) and 44% (late Round 2 developments onwards) and assuming a typical turbine capacity of 3.6MW for Round 1/Round 2 and 6MW for Remaining Round 2 / Round 3 / Scottish Territorial Waters / Northern Ireland

6 In this scenario the only downtime experience is while the turbine is stripped down and prepared for the replacement of a main component, the time taken to undertake lifting operations and then to rebuild and recommission the wind turbine

Typical failure rates

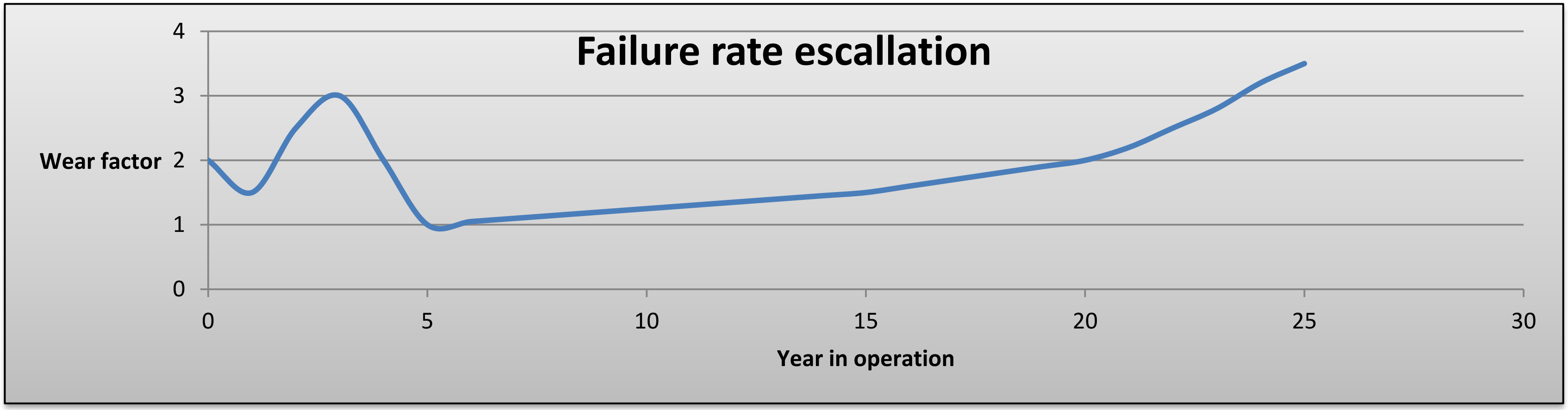
Overall stop related: In the range of 0,6 to 0,9/WTG/Year

Crane related- major repairs:

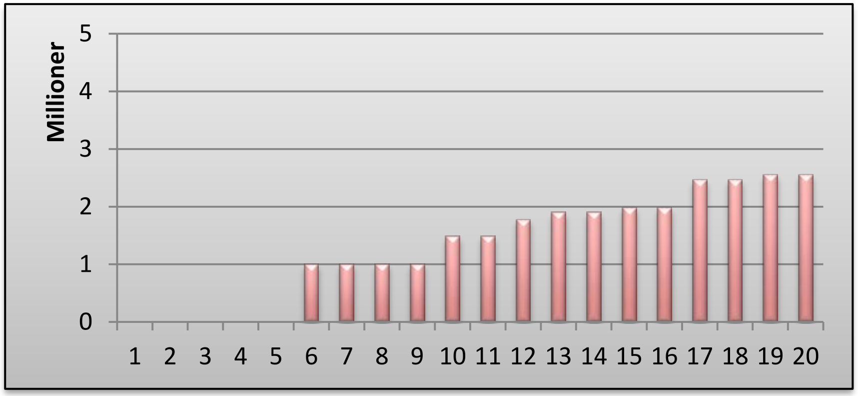
Warranty period:	0,25/WTG/y
Year 5:	0,01 to 0,10/WTG/y
Year 5 to 20:	Increasing in accordance with actual wear factor

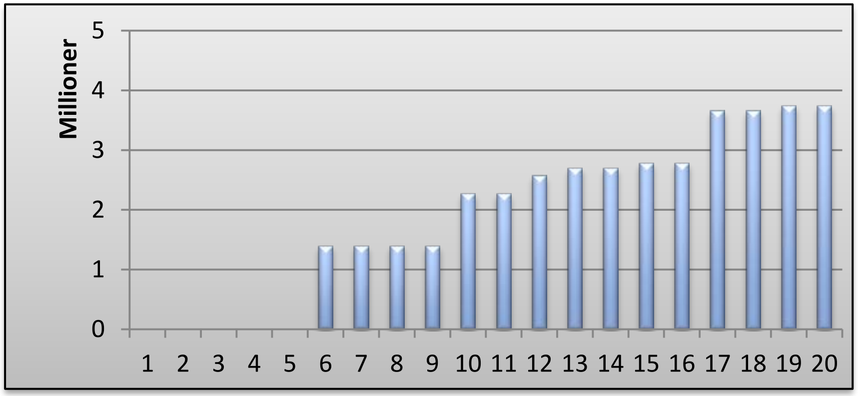
Meaning: You must expect to change main components between one or two times during the life of the turbine!

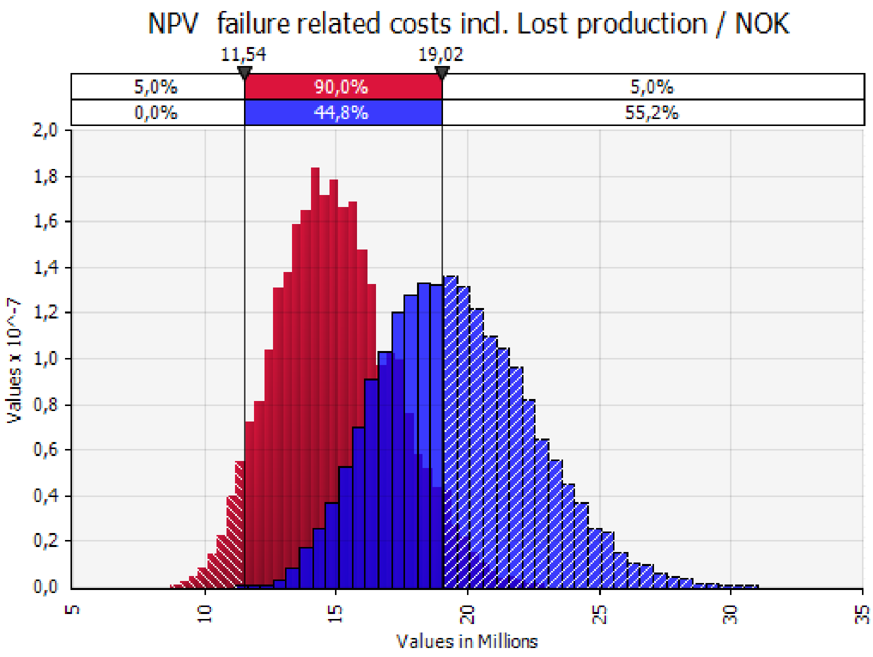
Sub-assemblies wear or sudden failure



Selecting turbine A over B







Owner mainteance strategy

Carry out maintenace management within its own organisation

With services from turbine manufacturer as:

- Spare parts management
- Condition monitoring
- Heavy maintenance

= Better control and perhaps lower cost to a higher risk

Or leave it all to the turbine manufacturer to an agreed availability = lower risk at perhaps lower income

Development needs

Management:

- Models and agreements for vessel sharing and readiness
- Pre-planned pit-stop heavy maintenance readiness

Vessel technology:

- Vessels that increase accessibility vs. Waves and wind

Turbine technology:

- Better modularisation/redundacy to avoid crane related maintenance
- More reliable turbine components
- Smarter solutions on maintainability
- Better condition monitoring systems to predict failure
- 6 months or more ahead

Tiden.
Vi reduserer effekten av den.



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