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(access authentication)

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# Value of Integrated Operations

- Cost factors for offshore wind

- equipment
- installation

- Operation costs ("normal")  
- offshore maintenance

- increased production

offshore wind  
unit cost

xyz  $\frac{\text{€}}{\text{hwh}}$

(costs / 17 years)  
5 years  
10 years

} 30%

Maintenance ~ 30% of op. costs. 0.4 MWh/h

how much build up

$30\% \times 0.4 \frac{\text{MWh}}{\text{h}} \cdot 2000 \text{ PWh}$

$0.24 \text{ P NOx}$   
 $240. \text{ E12 NOx}$   
 $240.000 \text{ Billion NOx}$

	now	2020	2050
Norway 1 TWh			1000 TWh
Europe 5 PWh 700			2000 PWh
Worldwide			

Integrated Operations

75% Maintenance

25% Operational

Transition  
 # of meters

Proactive 20-40%

48000 - 85000 BNOx  
 Europe by 2050

Norway 2020 (2050)

best practice 10-20%

20...35%

offshore wind, prod costs.

0.4  $\frac{\text{hr}}{\text{kWh}}$

Assumption:

400 MWh / (1 prototype)  
lifetime & maintenance  
+ expected production/year

∴ lifetime  
maintenance costs

3dB + 100%  
- 50%  
100M 200M... -  
50

# Proactive Maintenance

- oil replacement
- dirt (cleaning)

- inspection time
- replacement time

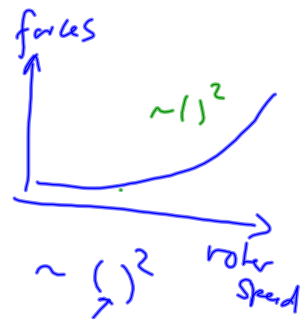
Estimation:

Easy example

- (Wind speed) → generator blade speed
- dimensioned Max RPM
- 50-80% of  $\frac{1}{2}$  lifetime
- 80-90%  $\frac{1}{90}$  hours
- 91-99%  $\frac{1}{100}$  hours

Rotor speed

dirt



Proactive maintenance

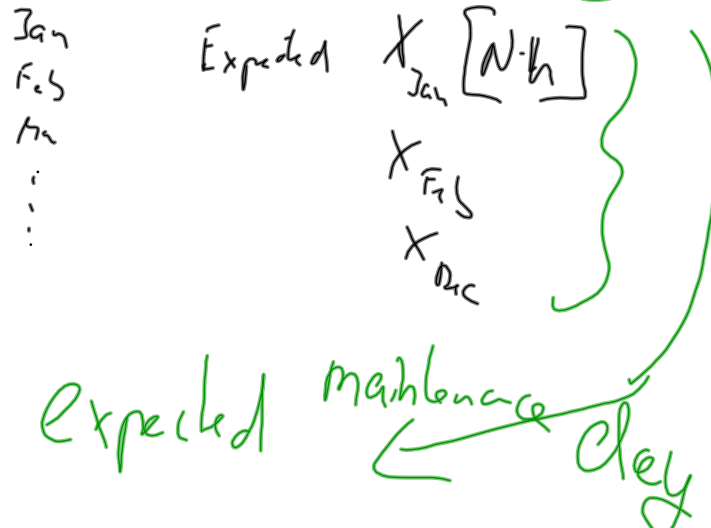
air force  $\sim (v)^2$   
und speed

$\Sigma$  Force based

- cleaning according to usage

- measure rotor speed  $\rightarrow$  derive force  $\cdot$  hours  
clean after  $X$  [Newton  $\cdot$  hours]

- Estimation tools



how to calculate  $\mu$ ?

- (install date
  - last cleaned date
- } +  $\sum$  actual forces

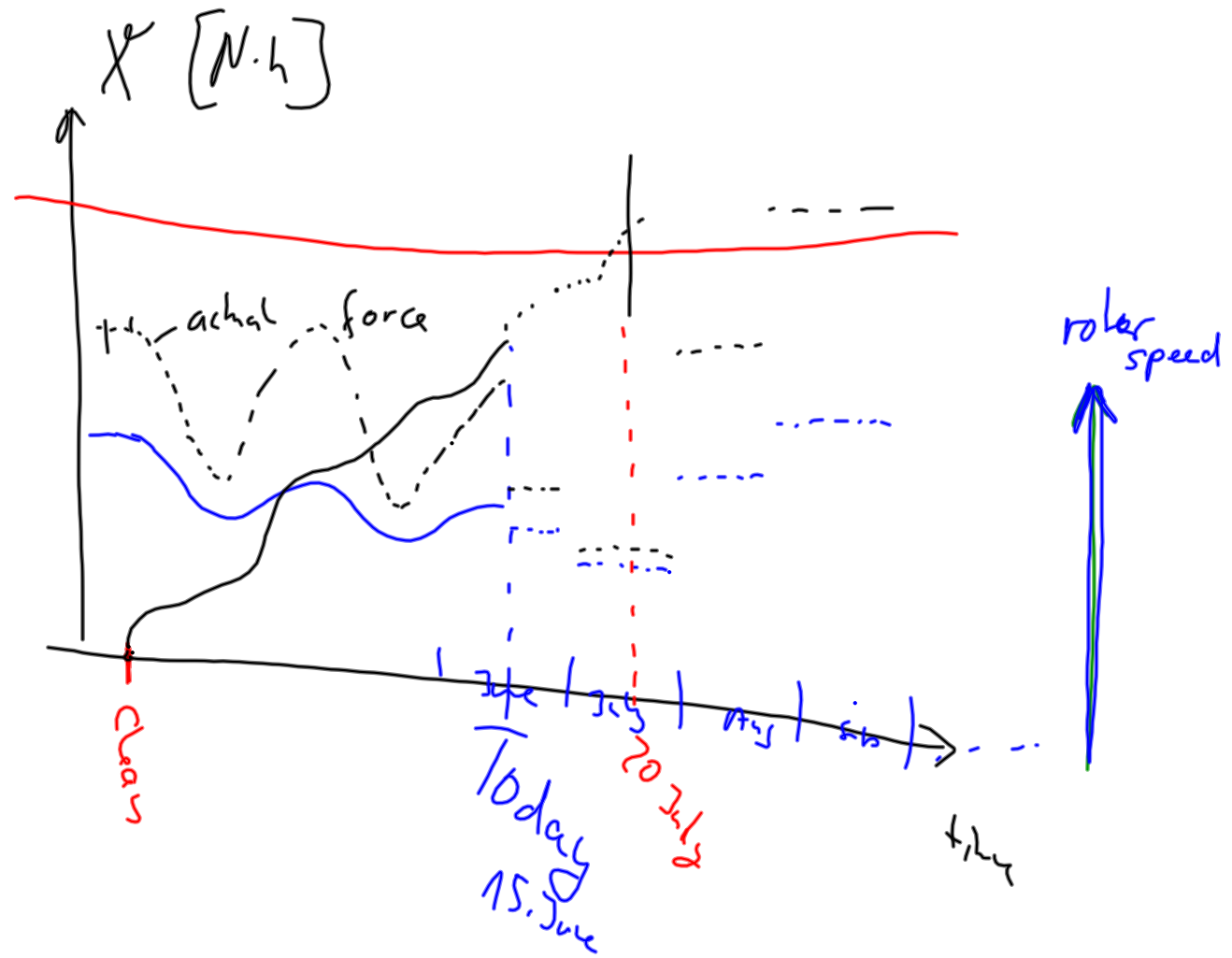
↑  
measured  
rotor speed  $\frac{b}{h}$  }

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Open issues

- dirt due to point impact
- slow increase?

# Example





Wind speed

achieved power

rotor speed / generator speed

