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(access authorization)

Value of Integrated operations

- Cost factors for offshore wind

- equipment
- installation

- Operation costs ("normal")
- offshore maintenance

- increased production

offshore wind
unitary cost

xyz per kWh

(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 PWh
240.000 Billion NOK

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

Integrated Operations

75% Maintenance

25% Operational

Transition
of meters

Proactive 20-40%

48000 - 85000 B NOK
Europe by 2050

Norway 2020 (2050)

best practice 10-20%

20-35%

offshore wind, prod costs.

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

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)

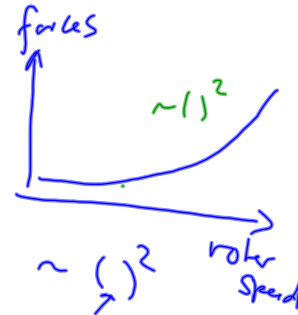
→ inspection time
→ replacement time

Estimation: Easy example

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

Rotor speed

dirt



Proactive maintenance

air force $\sim v^2$

Force based $\sim v^2$

- cleaning according to usage

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

- Estimation tools

$\begin{matrix} J_{an} \\ F_{LS} \\ M_c \\ \vdots \end{matrix}$

Expected

$X_{Jan} [N \cdot h]$

$X_{F_{LS}}$

X_{M_c}

Expected maintenance $\leftarrow$ day

how to calculate η ?

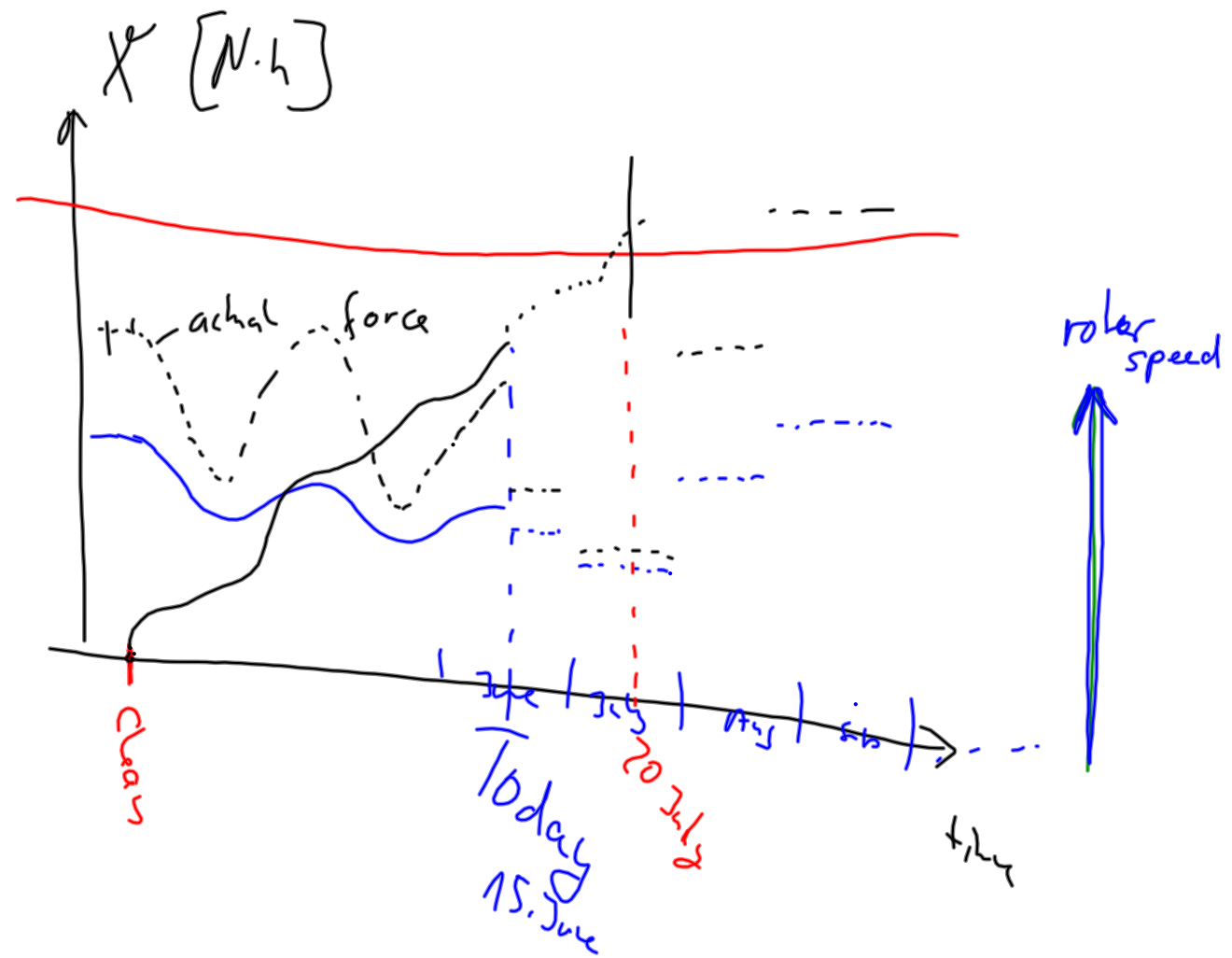
- install date
 - last cleaned date
- } + $\sum$ actual forces

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

Open issues

- dirt due to point impact
- slow increase?

Example



Wind speed

achieved power

rotor speed / generator speed

