



Norwegian University of
Science and Technology

Cost-benefit evaluation of remote inspection of offshore wind farms by simulating the operation and maintenance phase

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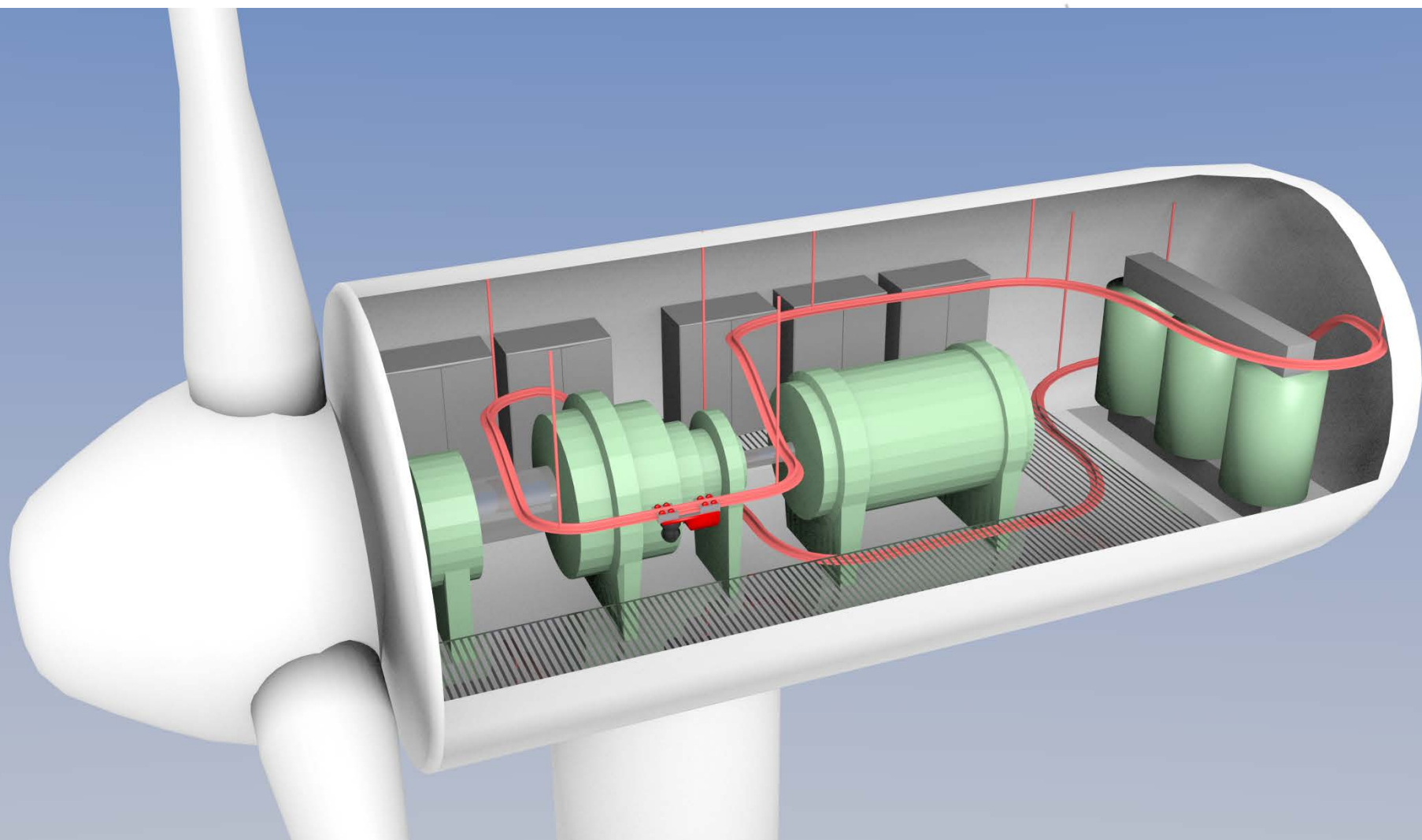
Outline

- O&M of Offshore Wind Turbines
- Remote Inspection
- Simulations
- Results
- Conclusions

O&M of Offshore Wind Farms

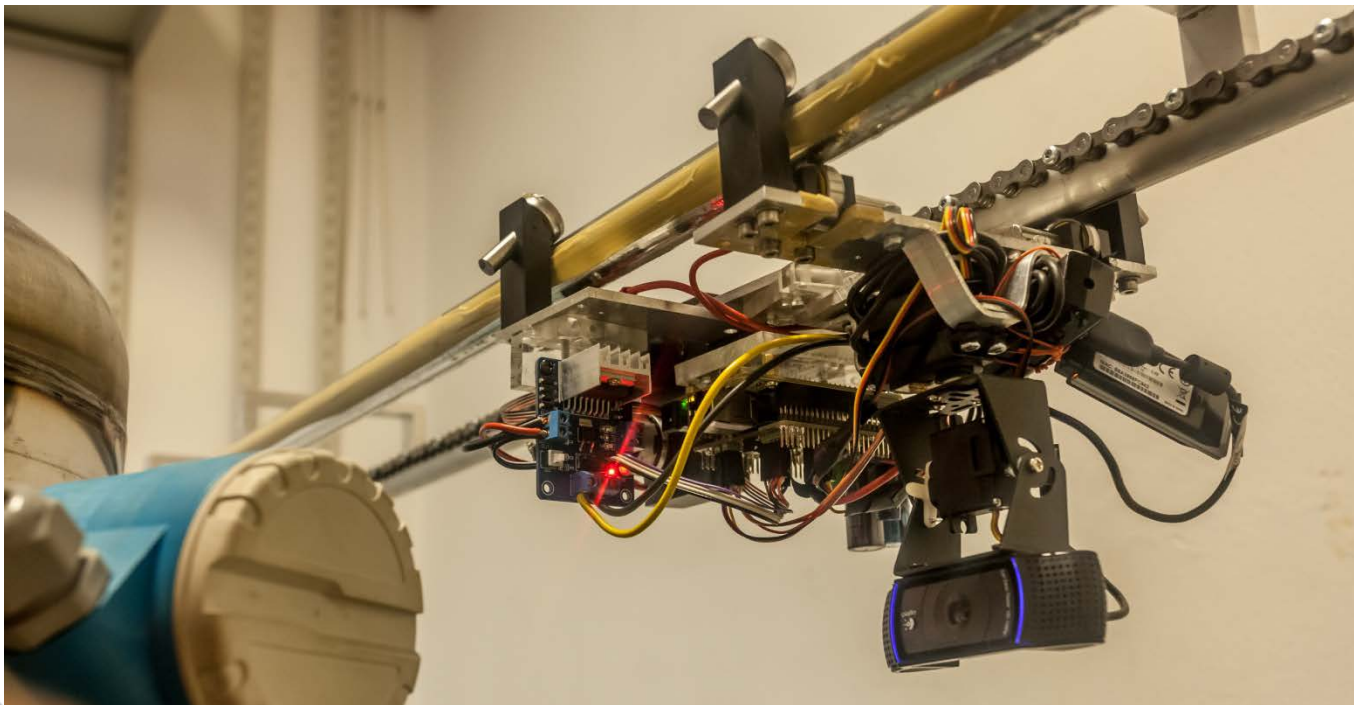
- High cost compared to on land.
- Access to the turbines are:
 - Expensive.
 - Time consuming.
 - Not possible in harsh weather.
- Reduction in «offshore work» can reduce the cost.

Remote Inspection Concept



Remote Inspection Prototype

- A prototype has been developed.
- Have been tested in a series of experiments that compare remote and manned inspections.
- Results have shown that with this early prototype, remote inspections have performed almost as good as manned inspections.



Simulations

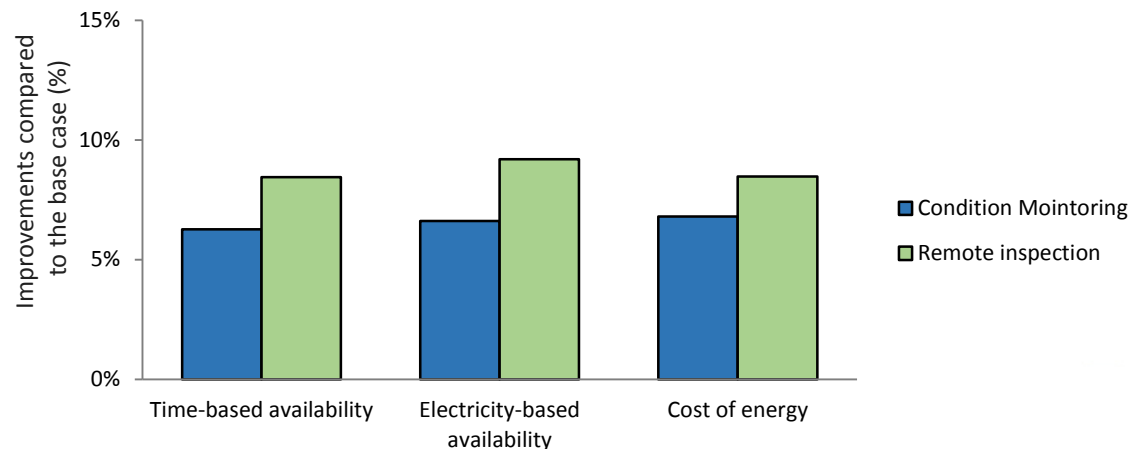
- Simulations performed with the NOWIcob tool.
- Wind farm size, possible failures, vessels and maintenance personnel were the same for all simulations.
- Three cases were defined:

	Base	Condition monitoring	Remote inspection
Corrective maintenance	Yes	Yes	Yes
Condition-based maintenance		Yes	Yes
Pre-inspecions	Manned	Manned	Remote
False alarms		Manned	Remote

- Three variants of the remote inspection case were tested:
 1. Five times higher investment cost of the system.
 2. The remote inspection system fails five times as often.
 3. Remote inspection failures cause the turbine to stop.

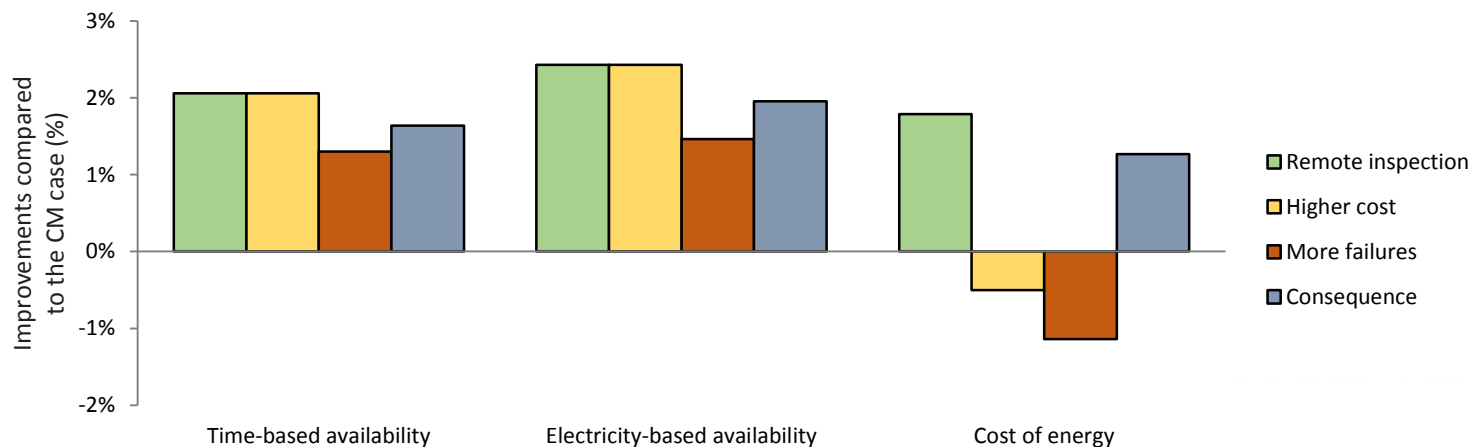
Condition Monitoring vs Remote Inspection

- To rely on corrective maintenance alone, as the base case, is not a viable strategy.
- Remote inspections had better availability than condition monitoring.
- Cost of energy is also better, but due to the additional investment cost and cost of replacement robots the improvement over condition monitoring is smaller than for availability.
- The difference between the two cases are larger for electricity-based availability than time-based.



Pessimistic Variants

- Five time increase in investment cost or failure rate are highly exaggerated values, thus a large effect is expected.
- The availability is still higher than for condition monitoring, larger effect on the cost of energy.
- It seems as keeping the remote inspection system reliable is important.



Conclusions

- The results show an economic benefit to remote inspections.
- The effect seems robust for the case variants that were tested.

Questions?



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