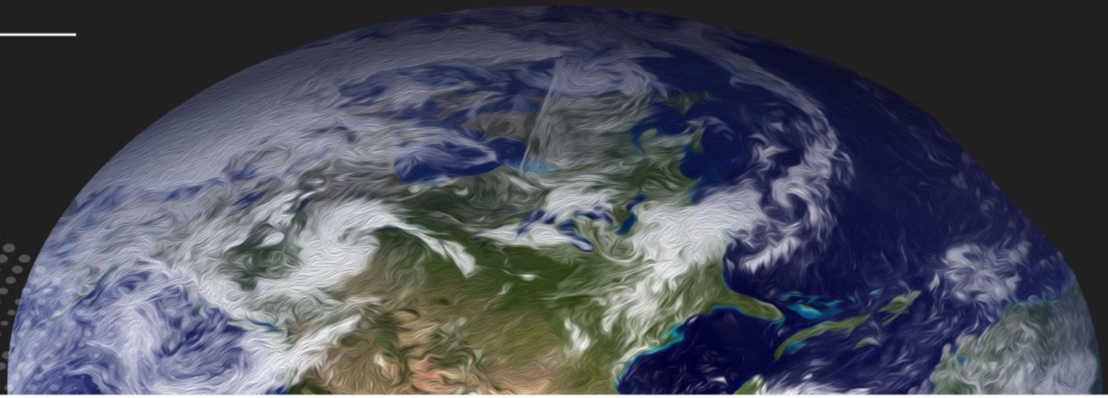


UCC

SUSTAINABILITY RESEARCH SEMINAR

SHOWCASING UCC'S SUSTAINABILITY RESEARCH

2pm
30th May 2023
The Shtepps, The Hub, UCC Main Campus

UCCGREENCAMPUS

Environmental Research Institute

Wind Value

An Opportunity for Climate Action and for Energy Communities

Dorcas Mikindani[1,2]

Supervisors: Peter Deeney [2], Paul Leahy [2,3], John O'Brien[1]

[1] Cork University Business School, University College Cork

[2] Environmental Research Institute, University College Cork

[3] School of Engineering and Architecture, University College Cork

Background

Wind farms have an average operational life of 20 to 25 years (Ziegler et al., 2018). As wind farms age their value gradually reduces to the point where they can become a liability rather than an asset. The operation and maintenance costs increase due to wear and tear and the operating permit ends. Planning for this situation means that wind farm operators must decide whether to carry out repowering, life extension or decommissioning. This decision needs careful assessment of the financial implication of the three alternatives.

The Wind Value project will produce a **decision support tool** which wind farm operators can use to estimate the financial outcomes from these three alternatives and assess their risk profiles. The project will also investigate on the opportunities of co-investment between local communities and wind farm operators.

- Decommission
- Repower
- Life-extension

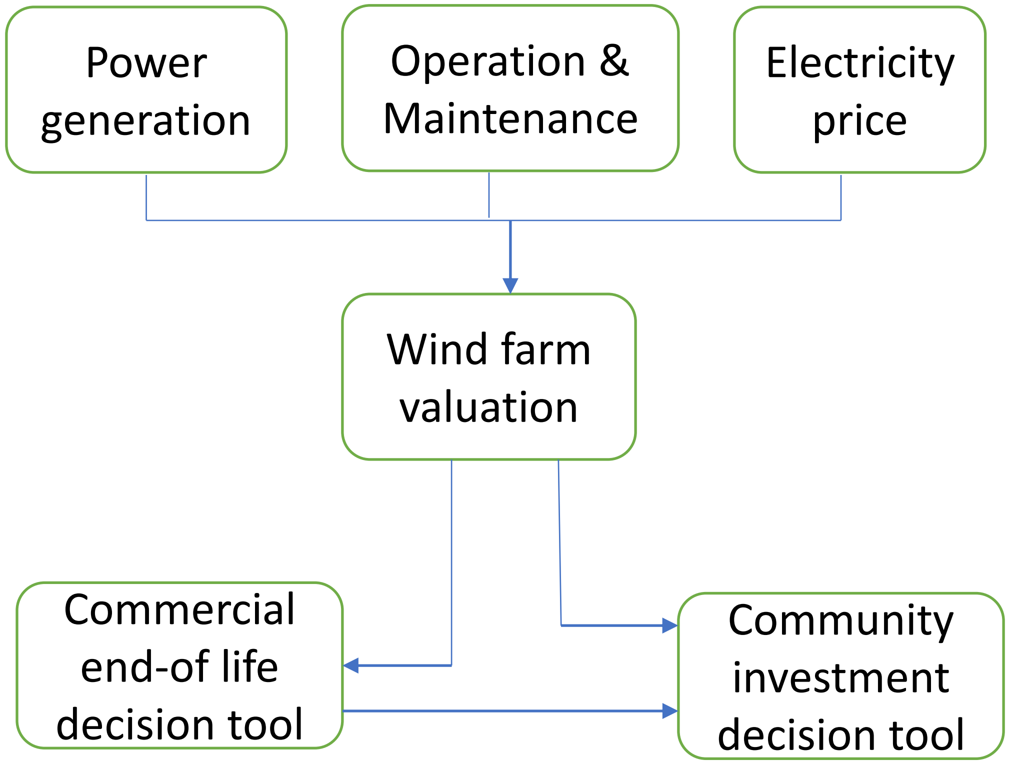
Wind industry to operate sustainably and contribute to the ongoing energy transition

Opportunities at the end of life

- ECONOMIC CONSIDERATION: ASSESSMENT OF RISK-RETURN SPECTRUM WITH PRIOR KNOWLEDGE ON KPI$_S$ (CASHFLOWS, WIND SPEED, TRANSMISSION, CUSTOMERS, PPAS)
- ENVIRONMENTAL IMPACT: PROPER END-OF-LIFE MANAGEMENT HELP MITIGATE ENVIRONMENT RISKS, A CHANCE TO MAKE GREEN CHOICES
- RISK MANAGEMENT: AS WIND TURBINES AGE, MAINTENANCE COSTS CAN RISE, AND SAFETY RISKS MAY INCREASE.
- ENERGY TRANSITION AND UPGRADE: REPOWERING THE SITE WITH NEWER AND MORE EFFICIENT TURBINES
- BUILDING ENERGY COMMUNITIES (CO-INVESTMENT)

PhD Design

The model



1. Power generation- existing models of power generation from wind farms matched to existing wind farms historical data.

2. Assessing financial risk from operation and maintenance

3. Electricity price modelling, development of the new price model which will give an indication of the mean price and includes also the variability in the electricity prices

4. Investigating investment risk profiles for the wind farms local communities

5. Decision support tool for end-of-life options

Results

1ST paper: Understanding financial risk from operating failures in wind turbines: A riskmetric approach.

The costs of running a wind farm over its lifetime are dominated by the initial capital investment, however the costs associated with wind turbine failures have a significant impact on profitability. We model these failures as random events over the lifetime of a windfarm based on industry data and the existing literature. The model includes both the direct cost of repairs and the opportunity cost due to loss of power generation when these repairs are taking place.

Methodology

- We use Weibull distributions to model failures profile, like engineering failures in (Hribar and Duka, 2010) power systems in (dos Santos and de Barros,2015) and spacecraft (Imken et al., 2018)
- We use Monte Carlo simulation to estimate failures of wind turbines over their operation life
- We use NPV techniques to quantify the costs and risk distributions

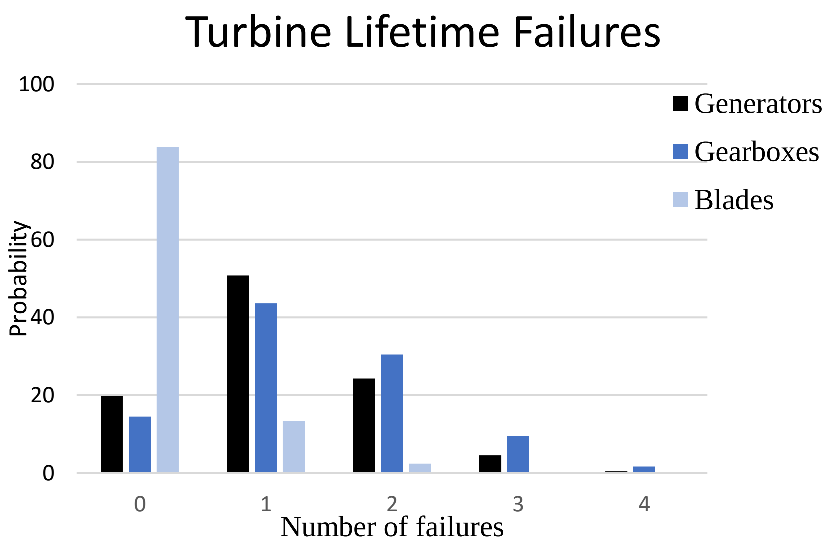
Risk Analysis

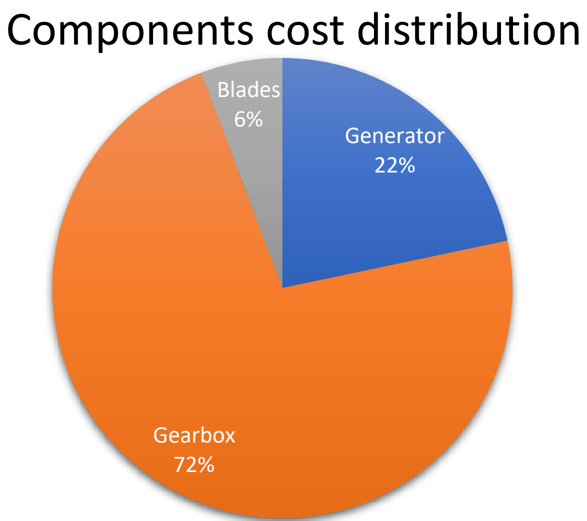
- Failure rates- refers to the frequency at which components or systems within a turbine experience malfunctions or breakdowns, leading to the turbine's inability to operate as intended.
- Expected cost (EC)- the discounted cost of repairs due to failures in wind turbines
- Value at risk (VaR)- used to estimate the maximum amount of potential loss that a portfolio of investments may incur over a given time period, at a certain level of confidence
- Conditioned value at risk (CVaR)- also known as Estimated Tail Loss (ETL), is used to estimate the potential loss of a portfolio beyond the VaR

Results cont…

1. 2.5MW Turbine analysis

- We study three components which represents most of the failures in a turbine according to insurance market statistics data (Shaun Campbell, 2015).
- Results show that gearboxes display higher failure rates than other components. Blades are more reliable which explains the pilling up of blades after the end of operational life. This aligns with the components cost distribution
- The failure cost over the lifetime of a wind turbine is 23% of the initial capital cost. The value at risk at a 95% confidence level is 59% of the initial investment.





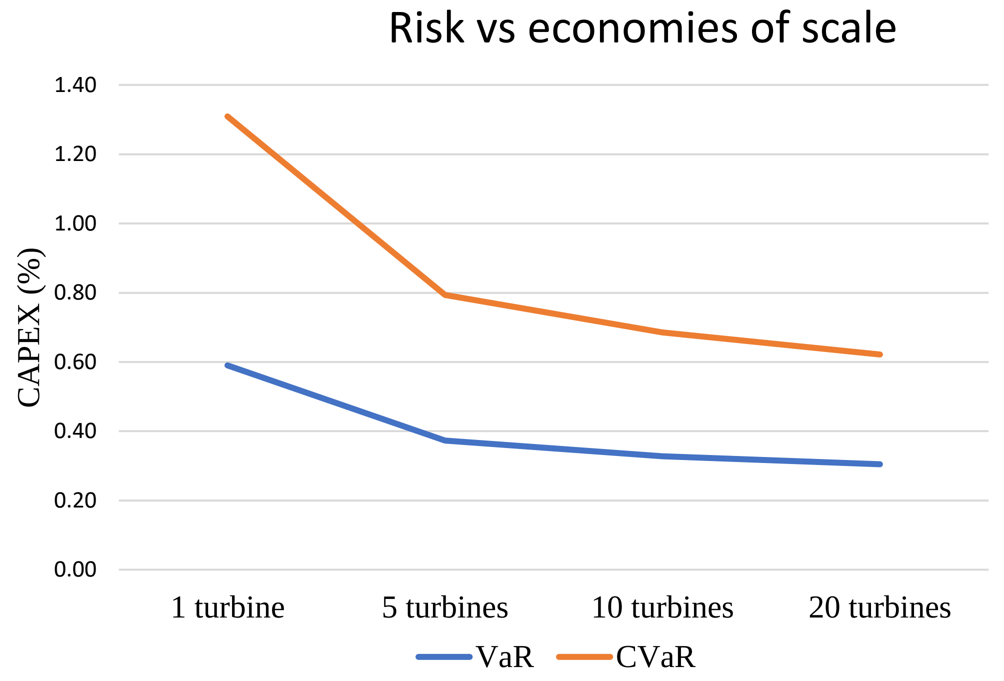
Turbine risk analysis

	Generator	Gearbox	Blades	Total	CAPEX (%)
EC	152,285	510,563	40,440	703,289	23
VaR	367,219	1,187,253	289,544	1,844,016	59
CVaR	436,802	1,400,136	410,889	2,247,828	72

Results cont...

2. Wind Farm Analysis

- The mean failure rate and deviation in failures are results of the size of the farm.
- There is a decreasing trend in the percentage of capital expenditure required to cover potential losses (% CAPEX) from 59% to 37% to 32% and 30% as we move from a single turbine wind farm to a 20 turbines farm
- Diminishing return effect



Wind farms failure rates

year	1 turbine	5 turbines	10 turbines	20 turbines
mean	0.13763	0.68814	1.37628	2.75300
std	0.00058	0.00292	0.00584	0.01200

Wind farms risk analysis

No of Turbines	1	5	10	20
VaR	1,844,016	5,834,469	10,242,562	19,057,475
CVaR	2,247,828	6,561,884	11,190,809	19,784,938

Conclusion

Highlights

- The results section shows that operation and maintenance in wind turbines have significant contribution to the CAPEX in wind projects
- For generators spend more on quality, gearboxes spend more on maintenance and a good guarantee from operation and maintenance companies and for blades ensure they are installed correctly.
- Scheduled maintenance is important.
- Owning one turbine has more risk profiles than having several turbines in a farm
- If the viable end of life option will be life extension or repowering, an increase in the size of the farm should be given a priority.

Limitation

- Data limitation
- Constant electricity price (opportunity cost represent no more than 6% of failure cost), need to change for future research
- Scope of failures

PhD Next Phase

ELECTRICITY PRICE LONG TERM FORECASTING

ENERGY COMMUNITY RISK ANALYSIS

References

dos Santos, A., de Barros, M.C., 2015. Stochastic modeling of power system faults. Electr. Power Syst. Res. 126, 29–37.

Hribar, L., Duka, D., 2010b. Weibull distribution in modeling component failures. Presented at the Proceedings ELMAR-2010, IEEE, pp. 183–186.

Imken, T., Randolph, T., DiNicola, M., Nicholas, A., 2018. Modeling spacecraft safe mode events. Presented at the 2018 IEEE Aerospace Conference, IEEE, pp. 1–13

Shaun Campbell, 2015. Annual blade failures estimated at around 3,800. Wind Power Mon. URL https://www.windpowermonthly.com/article/1347145/annual-blade-failures-estimated-around-3800 (accessed 3.7.23).

Ziegler, L., Gonzalez, E., Rubert, T., Smolka, U., Melero, J.J., 2018. Lifetime extension of onshore wind turbines: A review covering Germany, Spain, Denmark, and the UK. Renew. Sustain. Energy Rev. 82, 1261–1271.