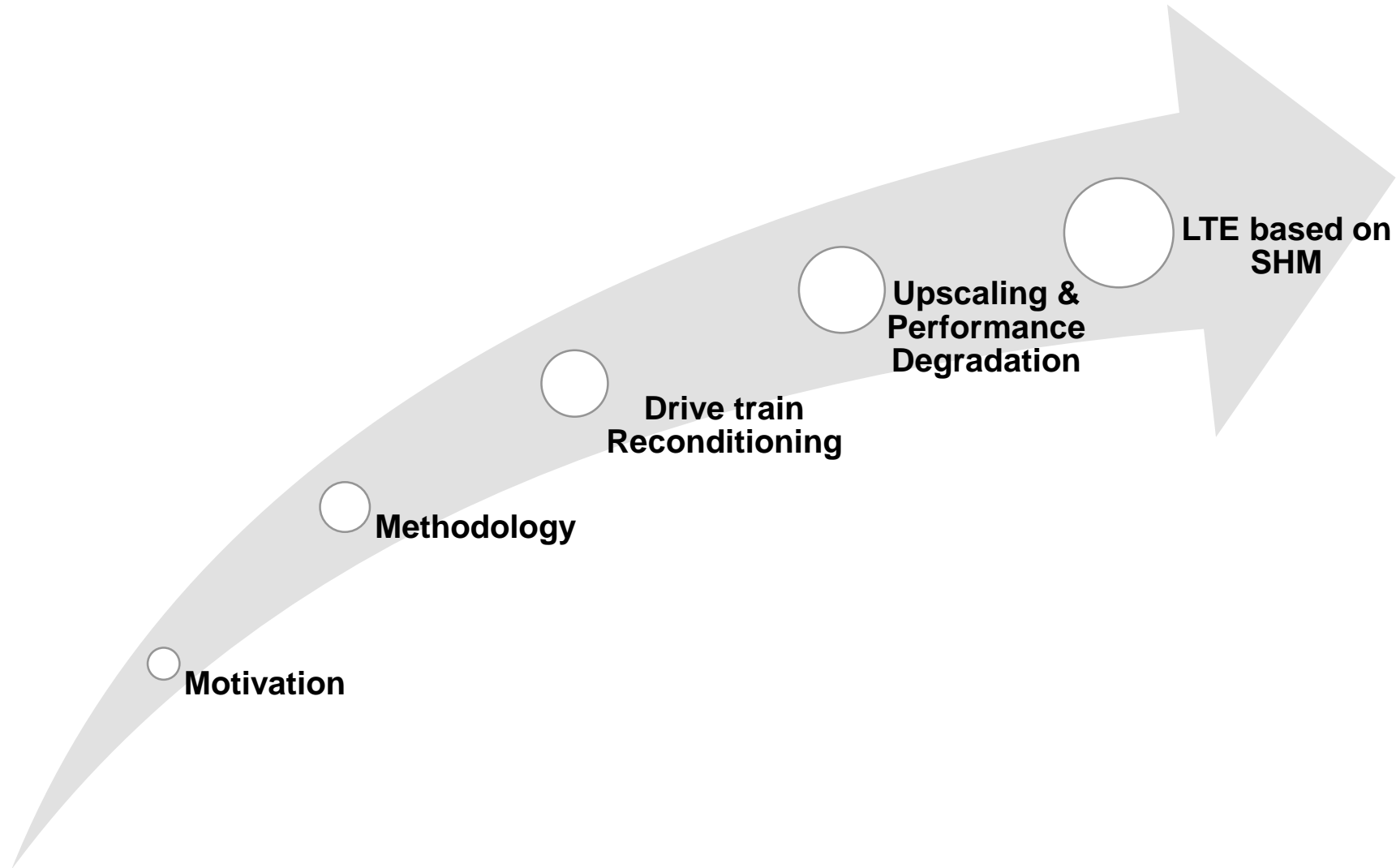


Lifetime Extension of Wind Turbines

Tim Rubert, David McMillan, Pawel Niewczas et al.

Industrial Partner: SSE & SPR

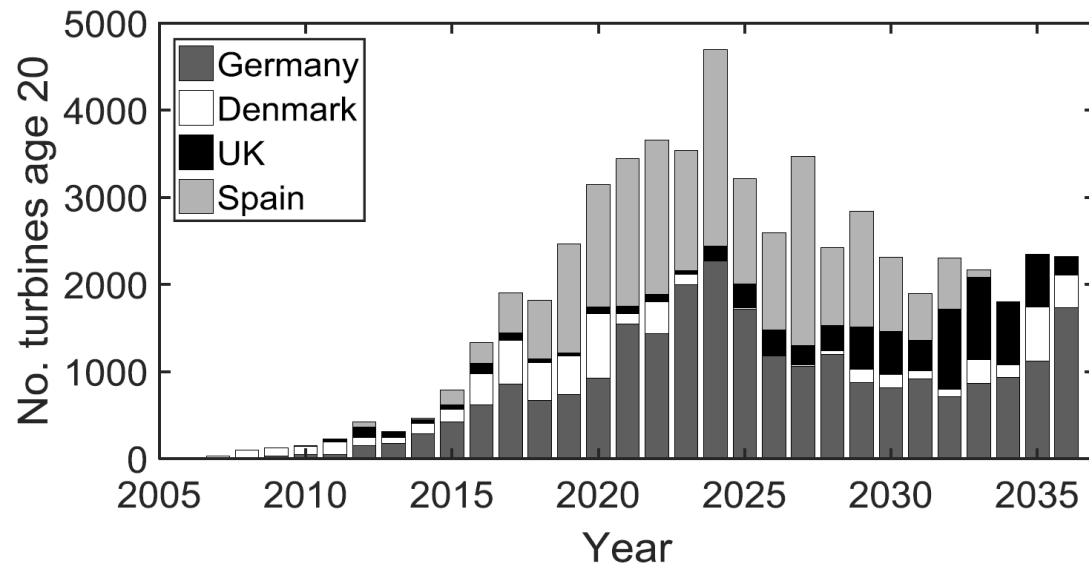
Agenda



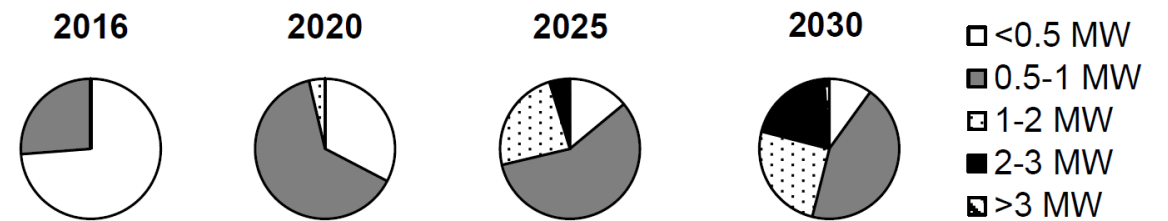
Motivation

Marked Development

LTE Market

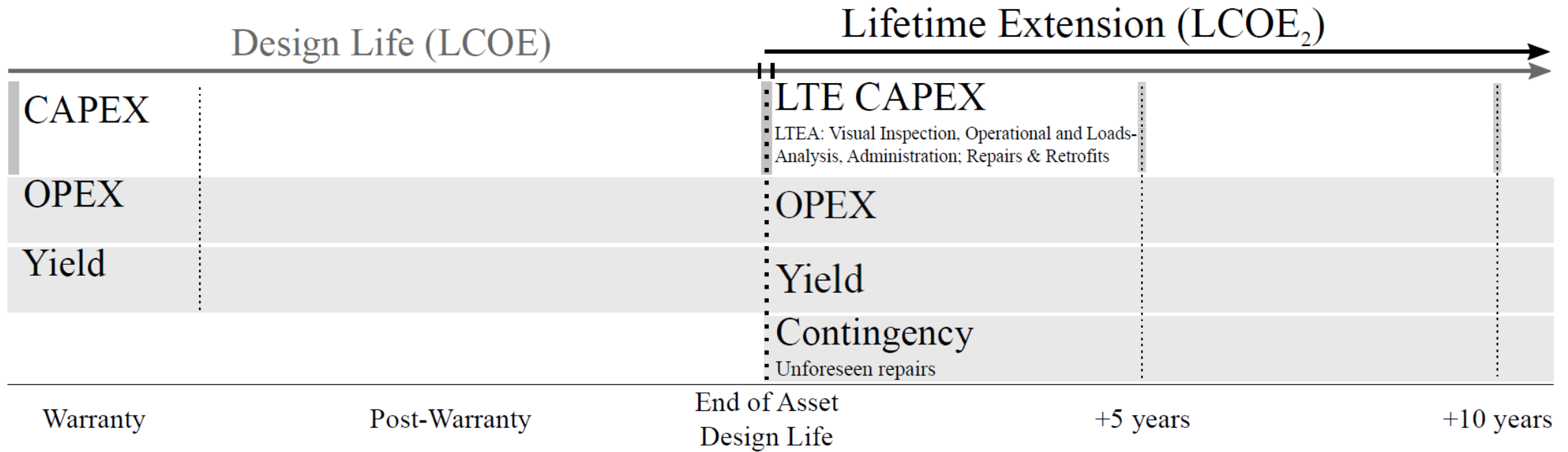


Future Capacity Distribution



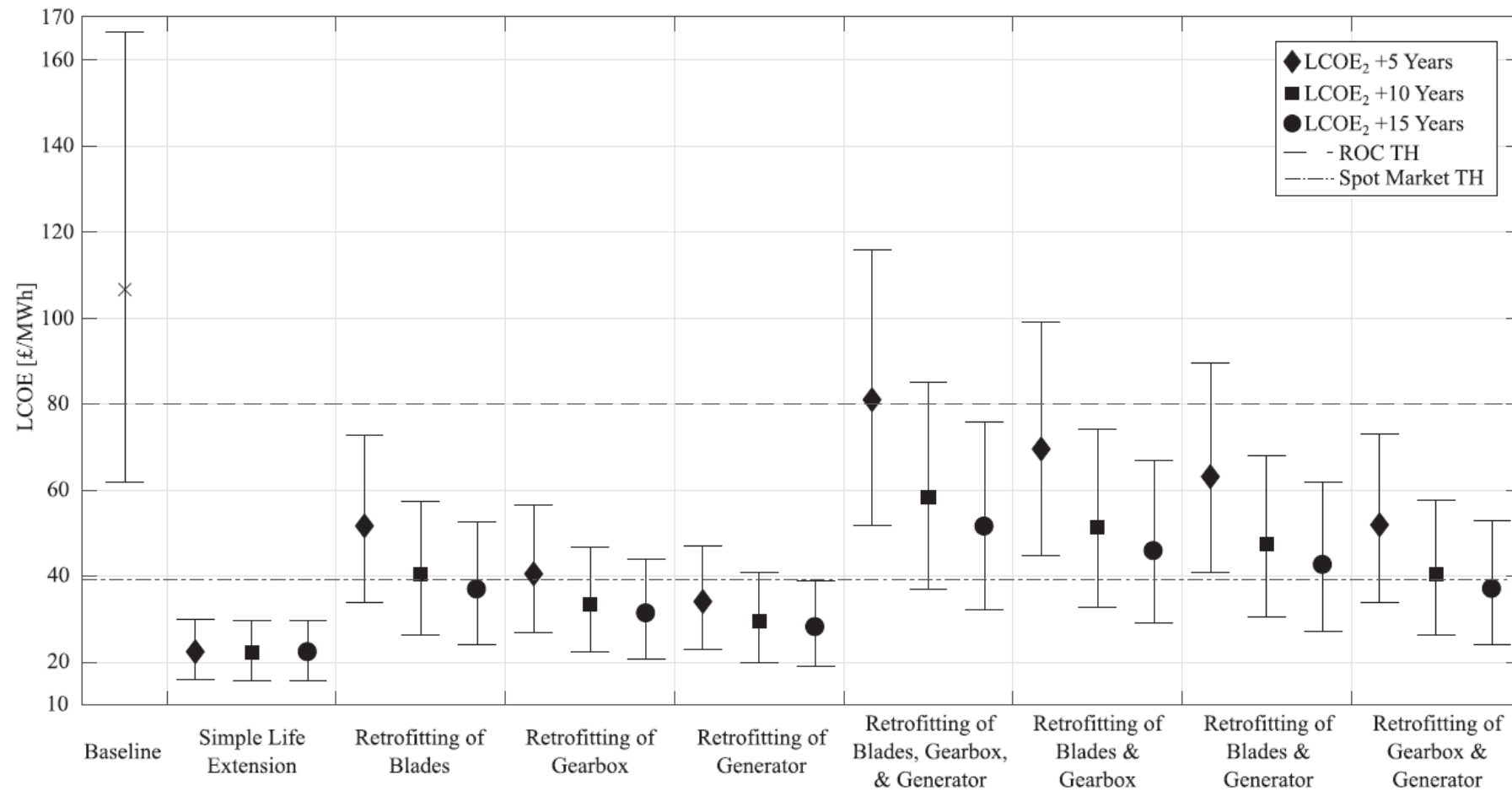
Methodology

LCOE-Based Analysis & Contingency Approach



Results

Under varying reconditioning



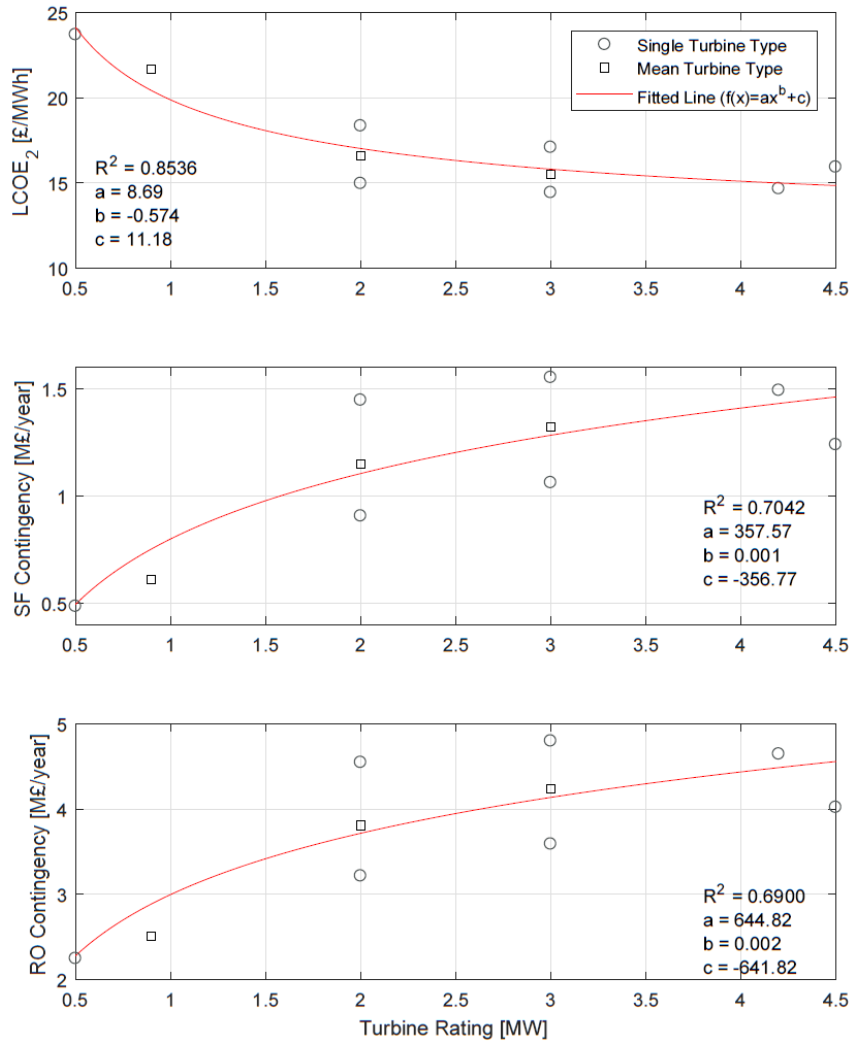
Methodology

Sensitivity Analysis

Case [-10%]	Gearbox retrofit [+10 years]		No retrofit [+10 years]	
	LCOE ₂ [£]	Δ Baseline [%]	LCOE ₂ [£]	Δ Baseline [%]
Mean wind speed	40.89	22.03	26.83	20.05
OPEX	31.36	-6.42	20.19	-9.62
C _{p,max}	35.40	5.66	23.50	5.16
CAPEX (spares)	32.42	-3.24	N/A	N/A
Weibull shape factor	33.14	-1.08	22.12	-0.98
CAPEX LTE	33.42	-0.25	22.26	-0.38

Results

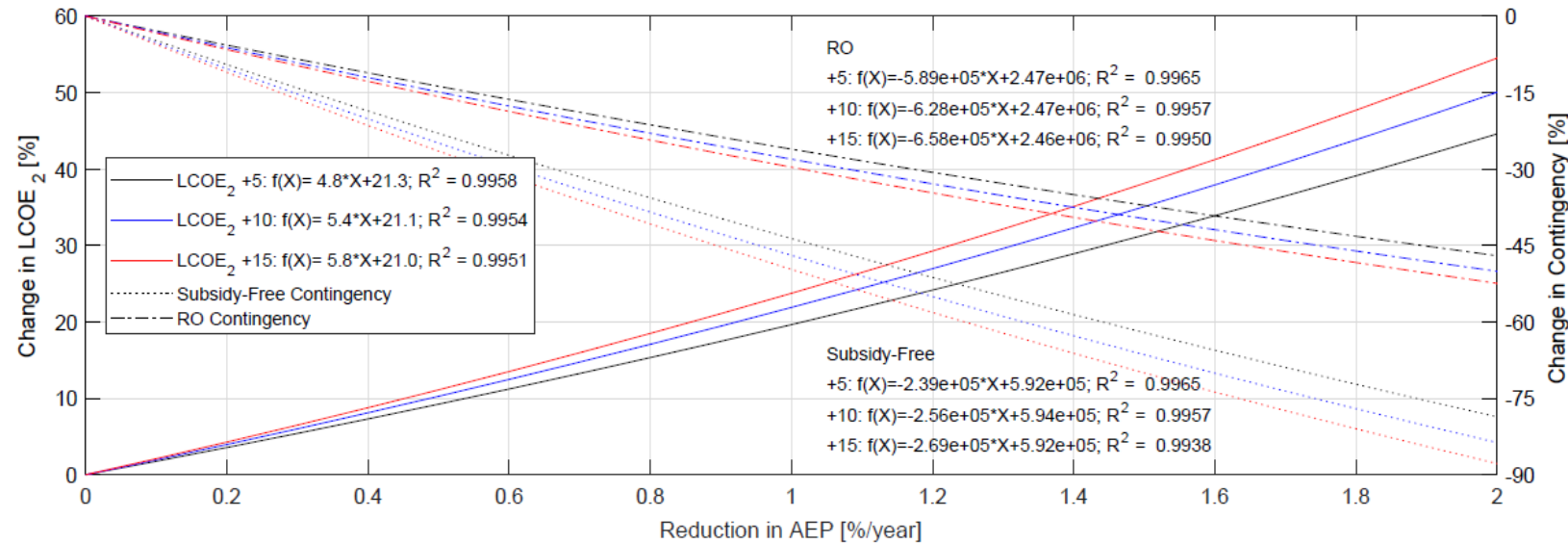
Upscaling



- Goodness of fit indicators illustrate the great variance within turbine classes (some turbines have comparatively upscaled rotors, presumably for low wind speed regimes).
- Reductions in costs are most prominent sub 2MW installations.
- Size matters

Results

Performance Degradation

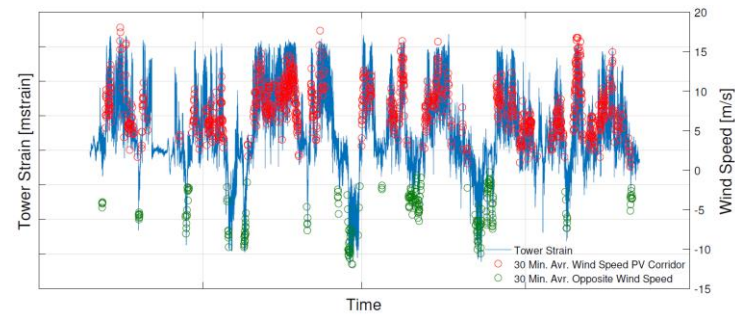


- **Methodology:** a reduction in AEP reduces yield and variable OPEX. Greater impact on yield, increasing the cost of energy.
- **Design life:** results indicate that an annual PD of 1.6% (0.2%) increases LCOE by 11.8% (1.4%).
- **LCOE₂:** results indicate that an annual PD of 1.6% (0.2%) elevates LCOE₂ by 34-41% (3.6-4.3%).

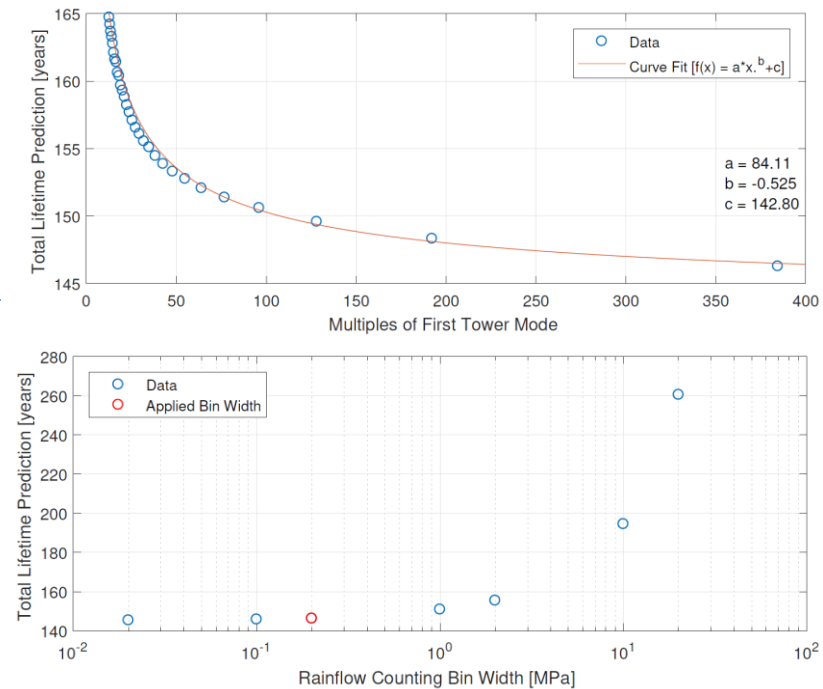
Results

LTE based on SHM

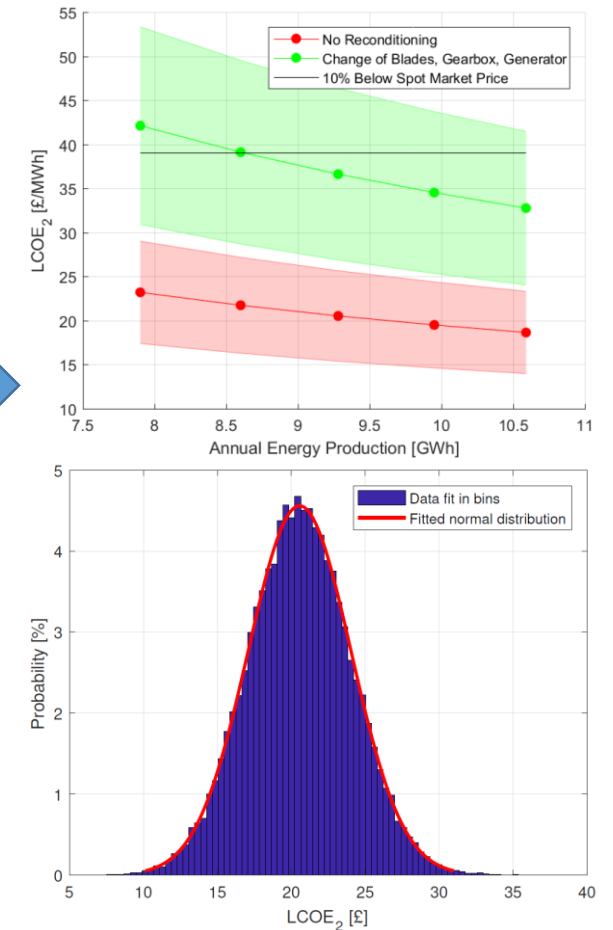
Strain Data



Component RUL



Commercial Strategy



Conclusion

- LTE period requires a technical and economic analysis
- Size matters ($P = \frac{1}{2} \rho \pi r^2 C_p v^3$) – so does **curtailment**
- For greater turbines ($x > 0.5$ MW) a more strategic LTE decision making is expected
- There is room for manoeuvre in a subsidy-free environment
- SHM can confirm the commercial LTE strategy

Thank You for your Attention



Questions?

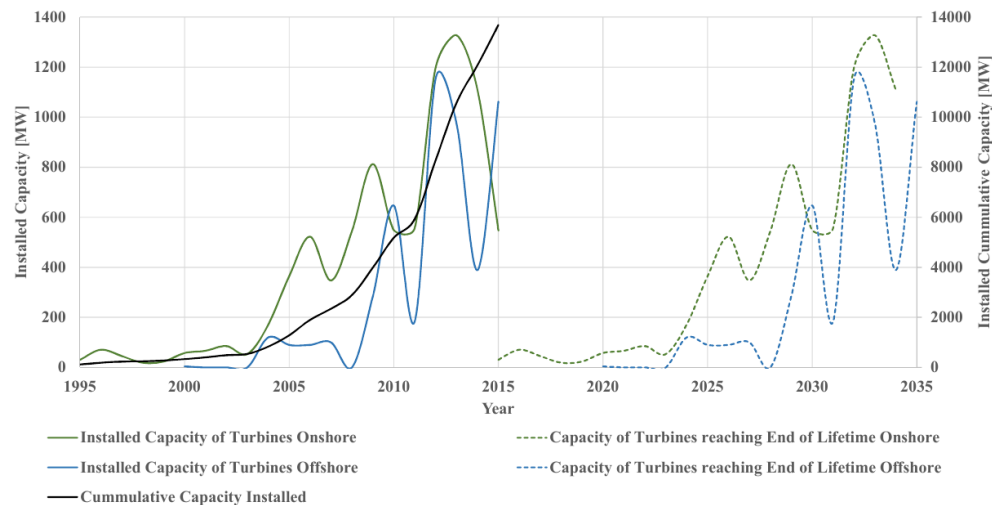
Comments?

Suggestions?

futureWind 2018 & Marine

UK Motivation Marked Development

LTE Market



Future Capacity Distribution

