Preparation is Optional:

Using Real Options to Estimate the Value of Preparatory Works Before Installation, Repowering and Life Extension of Wind Farms

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Research Question

About 75% - 80% of the money spent on a wind farm is spent before it begins to generate electricity (NREL, 2023), of this about 15% is spent on preparatory works before the final investment decision to install the turbines. Due to this huge front-loading of investment, the decisions about whether to build a wind farm, and later, whether to decommission, repower or extend its life, are difficult as they face a great deal of uncertainty. If we consider the preparatory work done before the final investment decision as being like a financial option, we can use real options analysis to estimate the value of this work based on the electricity markets, construction prices, the likelihood of planning consent and expected electricity production levels. If the value of the preparatory work exceeds the cost, then it is a good investment.

Method

If the cost of the preparatory work (planning application, environmental impact assessment, grid connection, site works etc.) is less than the value of the preparatory work, then it is a bad investment. The research presented here estimates the value of the preparatory work using real options. Put simply, this is the expected value of the discounted cashflows coming from the wind farm during its life, less the borrowing cost for construction with an adjustment made to allow the project to be abandoned before the construction begins. Sixty eight years of real wind data is taken from Met Eireann and random sampling is used to mimic failures and hence repair costs and downtime.

Input	Value
Preparation Time	5 yrs
Construction Time	2 yrs
Lifespan	20 yrs
Turbine Power	2 MW
Planning Prob	75%
Construction Price	€1.4m/MW
Mean O&M (not repairs)	€3,680 /Month /MW
Wind Speeds	Malin Head, Met Eireann

In addition to calculating the value of the preparatory works the probability of a default is also calculated and the size of the unpaid debt can be estimated.

Failure Data from NREL	Repair Cost €	Downtime hours	Fail Rate per year	Life Span Yrs
Structure	682,386	97	0.09	11.1
Gearbox	528,253	260.5	0.1	10.0
Blades	305,873	146.53	0.17	5.9
Main Shaft	199,170	181.77	0.05	20.0
Generator	189,908	126.13	0.1	10.0
Yaw Sys.	199,990	67.93	0.18	5.6
Convertor	81,272	90	0.24	4.2
Electrics	33,980	72.93	0.55	1.8
Control Sys.	28,388	55.2	0.41	2.4
Hydraulics	23,300	41.47	0.23	4.3
Brake	8,560	65.6	0.13	7.7
Others	5,000	105.6	0.11	9.1

Results

Based on work by Love et al. (2013) and Deeney et al. (2021), electricity prices and interest rates are found to have a huge effect on the value of the initial preparatory work calculated by real options analysis. Lower interest rates and higher electricity prices will increase the value of the wind farm, and hence the value of the preparation work. Figure 1 shows the boundaries where the cost of the preparatory work per MW installed, equals the value of the preparatory work as calculated by real options analysis. This is done for preparatory works costing €33,000/MW, €67,000/MW and €100,000/MW, for initial installation of an Irish 2MW onshore wind turbine. Adjusted models can run for repowering, life extension or decommissioning. Using this model, bankruptcy probability and the likely size of losses is also available.

The region to the upper left of each boundary, comprising of higher interest rates and lower electricity prices, is the "No Go" region where the cost of the preparatory work exceeds its value, and the region to the bottom right indicates the region where the value exceeds the cost, indicating a good investment.

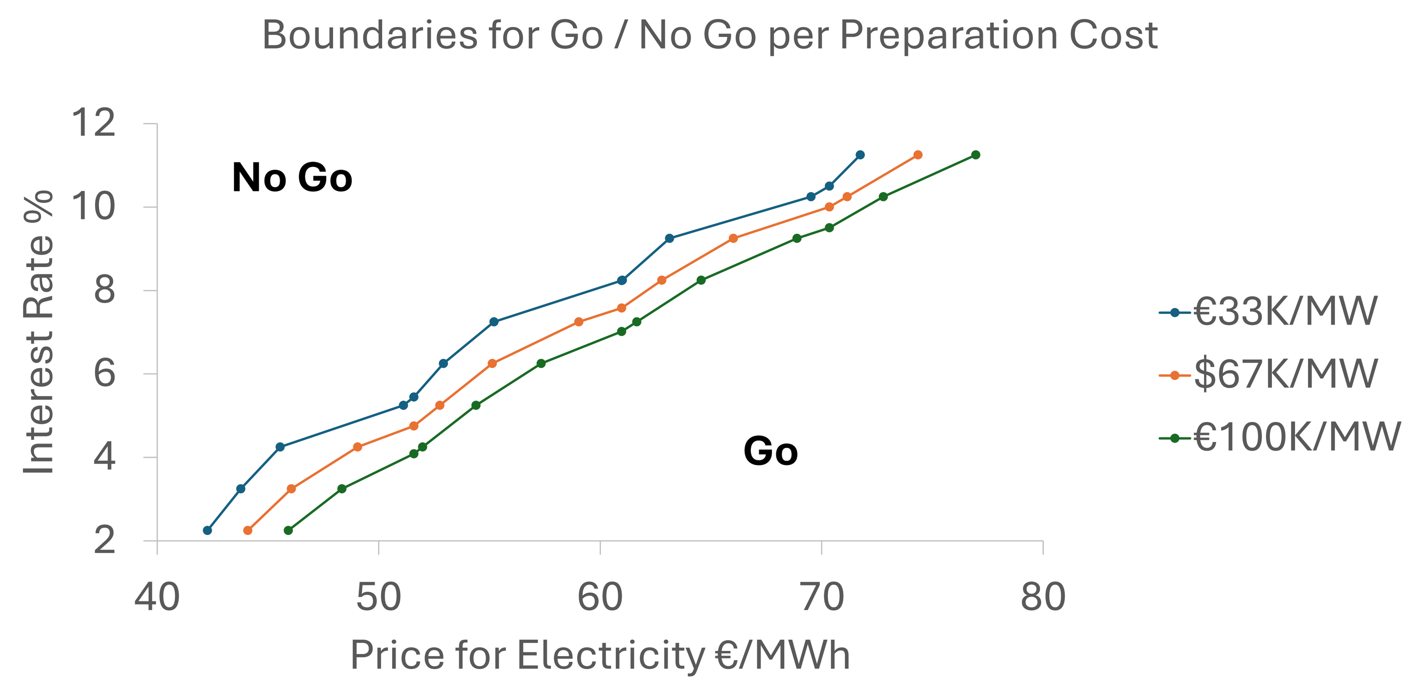

Fig 1. Given the cost of the preparatory works before the final investment decision to build a wind farm, the figure illustrates a boundary, depending on cost, between the region to the right and down where the electricity price is high enough and interest rates low enough to support the cost, and the region upwards and left where such a cost is not supported.

Table 1 shows The probability of default during the lifetime of the wind farm in %.

Interest rate % \ Electricity price €/MWh	23.45	32.83	42.21	51.59	60.97	70.35	79.73	89.11	98.49	107.87
11.25	11.322	9.482	7.672	5.869	4.073	2.326	0.963	0.261	0.038	0.003
10.25	8.998	7.386	5.800	4.220	2.647	1.224	0.360	0.054	0.004	0.001
9.25	7.142	5.726	4.332	2.944	1.580	0.538	0.093	0.006	0.002	0.001
8.25	5.661	4.413	3.185	1.962	0.826	0.181	0.013	0.002	0.002	0.001
7.25	4.479	3.376	2.291	1.213	0.358	0.038	0.003	0.002	0.002	0.001
6.25	3.536	2.559	1.597	0.668	0.119	0.005	0.003	0.002	0.002	0.001
5.25	2.785	1.916	1.061	0.310	0.025	0.003	0.003	0.002	0.002	0.001
4.25	2.187	1.412	0.652	0.115	0.005	0.003	0.002	0.002	0.002	0.001
3.25	1.711	1.018	0.355	0.031	0.004	0.003	0.002	0.002	0.002	0.001
2.25	1.358	0.710	0.166	0.008	0.004	0.003	0.002	0.002	0.002	0.001

Impact

This work will be of benefit to wind farm developers who wish to have a quantitative opinion about whether to begin the preparatory work to build a wind farm. The model underlying this work has a flexible approach and can assist with the decisions at the end-of-life when the wind farm must be decommissioned, repowered or have its life extended, and it can be used for offshore wind. The model relies on predicted cash flows from a turbine during its lifetime. The inputs to the model are electricity price history, wind speed history, failure rates for the components, prices of turbines and the probability of planning consent. The current model uses wind speed data from Met Eireann, prices from SEAI, running costs from IEA Wind Task 50 and IRENA.

Conclusions

The model presented here depends entirely on the input variables which vary considerably according to the expected costs for the preparatory works, the installation costs and the local wind speeds. These figures offer a guide so that a developer can estimate how to trade off expected electricity prices against the interest rates payable on the loan to build the wind farm. In addition, this research has produced estimated probabilities for default on the loan and estimates of the size of the default.

It is hoped that these figures could offer guidance for decision making in renewable energy, of all sorts.

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Project Website https://windvalue.ie/