Planning Permission is Optional

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Overview

Preparatory Works

- Site Selection
- Grid Application
- Planning Application
- Financing
- Leasing Negotiations
- Wind Measurements
- Selection of Turbine Manufacturer
- Design and Layout
- Grid Connection Construction
- Contractor Selection

Variable Time Line of Preparatory Work

For Example: Scart Mountain Windfarm Website

- Design 12 - 18 months
- Planning Decision 6 - 24 months
- Pre-Construction 18 - 40 months
- Construction 18 - 24 months

First Life of the Wind Farm

Income from Electricity Production is subject to:

- Wind Speed Variability, Failures, Regulatory Changes
- Operations and Maintenance

Followed by

- End-of-Life $\leq$ End of planning permission
- Planning for Second Life

Options

- **Planning and Preparation is like a European Call Option**
- The holder may buy an asset at a pre-determined price at a specified date in the future. For example, you may have an option to buy one litre of diesel for €1.80 on 1st August 2024. How much is that option worth?
- The Asset = 1 litre of diesel
- The Expiry = 1st August 2024
- The Strike Price = €1.80
- The Distribution of the Asset's Future Value?
- Risk increases the option's value.

The Value of the Call Option

The value of the call option when it is written, c, is

$$c = \mathbb{E}\left[max\{S - X, 0\}\right] \tag{1}$$

where S is the value of one litre of diesel on 1st August, X is €1.80, the strike price, and $\mathbb{E}\left[.\right]$ is the expectation at the time the option is written.

The Risky Asset

The Cash Flows from a wind farm over its lifetime

- + Electricity Price
- + Electricity Produced
- - Failures and Repairs - can be controlled by extended warranties
- ? Regulatory Changes

In current modelling we ignore capacity payments and system services as these are small relative to the value of the electricity sold as energy. Regulatory changes are left to a future iteration of the model.

The Expiry and Strike Price

- Preparatory work starts at time $t = \alpha = -5$, i.e. 5 years before the planned start of construction of the wind farm (Final Investment Decision).
- The decision to exercise or not exercise the option is the Final Investment Decision at time $t = 0$. (This is a simplification as large wind farms are usually built in stages, and here we also assume the farm is built instantaneously.)
- The expected price of construction of the wind farm, when the option is written at time $t = -5$. The capital expenditure for the wind farm is about 75% - 80% of all expenditure during the lifespan of the wind farm. The rest is OPEX and decommissioning expenses.

The Distribution of the Asset's Future Value

- Electricity Production
- Electricity Price
- Repair Costs
- Changes in Construction Cost

Decommission, Repower or Extend Life?

At the end of the planning permission period choose one of:

- **Decommission** Remove the structure and foundations, return the land to its original state.
- **Extend Life** Replace parts of the turbines so that they can keep producing electricity for another few years. Perhaps 10?
- **Repower** Replace the towers, turbines and possibly increase the capacity of the grid connection. New turbines are usally fewer in number, taller and more powerful.

Option Terms

- **Decommission**
  If the other two choices are not viable
- **Extend Life**
  Underlying Asset Cash flows for a further 10 years
  (with embedded option for ten more years?)
  Expiry Written at $t = 15$ expiry at $t = 20$
- **Repower**
  Underlying Asset: Cash flows for a further 20 years
  Expiry Written at $t = 15$ expiry at $t = 20$

Cost Considerations

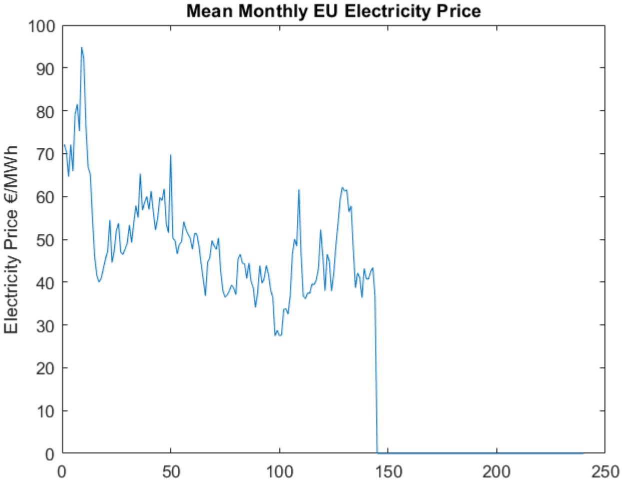
- **Decommission**
  At present (2024) this is an expense
- **Extend Life**
  Wind Information for 20 years is available
  Maintenance expectations are accurate
  Existing grid connection will be sufficient
  Repair/replacement costs are critical
- **Repower and Extend Life**
  Wind Information for 20 years is available
  Maintenance expectations are accurate
  Possible cost of larger grid connection
  Price of new turbines is critical

Data Sources

- Wind Data from Met Eireann - Malin Head 1955 to 2024
- Electricity Prices from Mean Reversion Model using monthly mean wholesale prices for Europe
- Failure data from Mikindani et al. (under review)

EU Monthly Prices 2008 to 2019

Monthly prices used to mimic Power Purchase Agreements (PPAs) which are common in the wind industry.



Electricity Price Model

Brennan-Schwartz Mean Reversion Model
EU average Monthly prices in €/MWh, twelve years 2008 - 2019

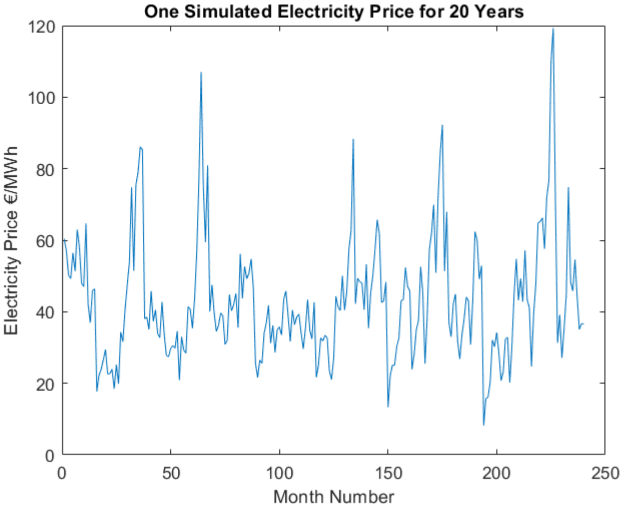
$$dX_t = \alpha(\mu - X_t)dt + \sigma X_t dB_t$$

where the parameters

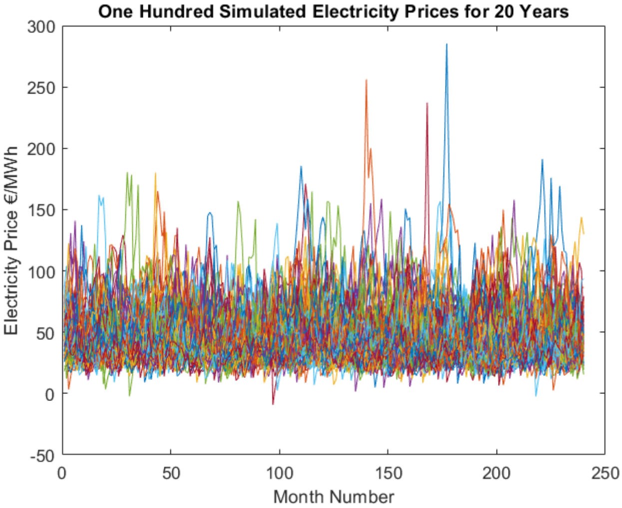
$$\alpha = 0.25; \mu = 46.9; \sigma = 0.26;$$

are calculated using Marin, Sanchez and Palacio (2013)

One Simulated Electricity Price Series

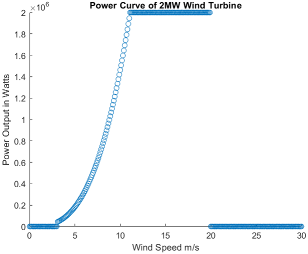


100 Simulated Electricity Price Series



Power Production

$v_{\text{cut-in}} = 3m/s$; $v_{\text{rated}} = 11.1m/s$; $R = 44m$; $v_{\text{cut-out}} = 20m/s$;$\eta$ is the efficiency; ρ is the density of air.



$$P_t = \begin{cases} v < v_{\text{cut in}}, & 0 \\ v_{\text{cut in}} \leq v \leq v_{\text{r}}, & \frac{\pi}{2}\rho\eta R^2 v_t^3 \\ v_{\text{r}} \leq v \leq v_{\text{cut out}}, & \frac{\pi}{2}\rho\eta R^2 v_{\text{r}}^3 \\ v_{\text{cut out}} < v, & 0 \end{cases}$$

Repair Costs

- Using a 2 factor Weibull distribution for time between failures, from Mikindani et al. (2024) under review
- Assumes constant availability of access to turbines (onshore)
- Repairs take 24 hours plus a random time for delivery of parts, with mean 72 hrs, and an exponential distribution

Factors For Planning Success

Van Rensburg, T.M., Kelley, H. and Jeserich, N., (2015). What influences the probability of wind farm planning approval: Evidence from Ireland. Ecological Economics

- Length of time the appeal process takes
- Decisions of local authorities and inspectors
- Identities of applicants
- Conflict with strategic development plans
- Visual impact
- Area used
- Rated Output
- Hub Height
- Wind Availability
- Proximity to dwellings, towns or protected habitats
- **Assume probability of success is 50%**

Additional Model Assumptions

- r the risk free rate is taken as 2.72% per year, the yield on 30 year German Bunds (Bloomberg)
- Investment cost is not known precisely at time $t = \alpha = -5$, approximated by $X_0 = 1.3mN(1, 0.25^2)$ per MW, 20% of that for life extension
- O&M costs €68,000 per year per MW
- Fail rate doubles during life extension

Option Pricing

Proceed with the investment if

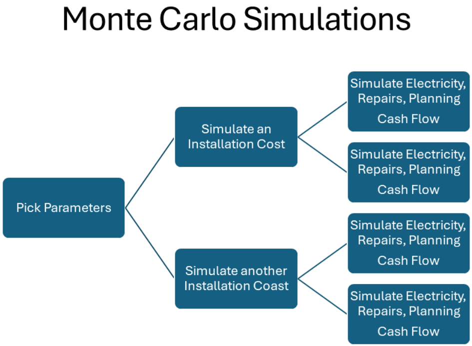
$$\mathbb{E}\left[\sum_{t=0}^{\omega}(E_t - M_t)e^{-rt}\right] - X_0 > 0$$

where, E_t is the income from electricity during time t, X_0 is the construction cost, M_t is the running and maintenance cost, r is the risk free rate, ω is the expected end of life and the expectation is taken at time $t = 0$, thus the value of the option, c, is

$$c = \mathbb{E}\left[max\left\{\mathbb{E}\left[\sum_{t=0}^{\omega}(E_t - M_t)e^{-ri}\right] - X_0,\ 0\right\}\right]$$

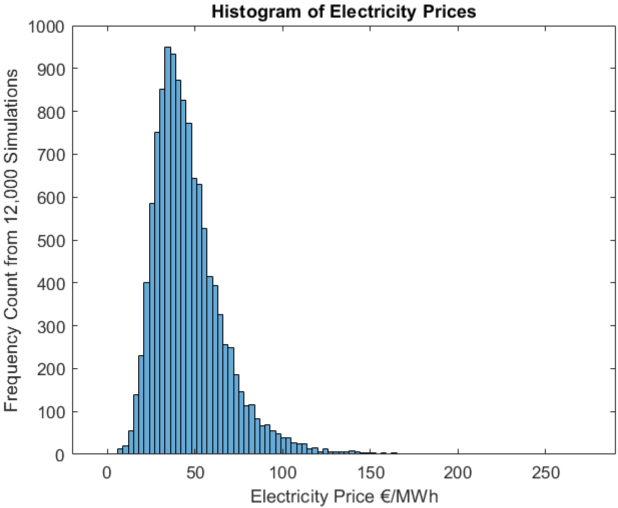
where the expectation is taken at time $t = \alpha$, typically $\alpha = -5$, note that X_0 is inside the expectation.

Monte Carlo Arrangement

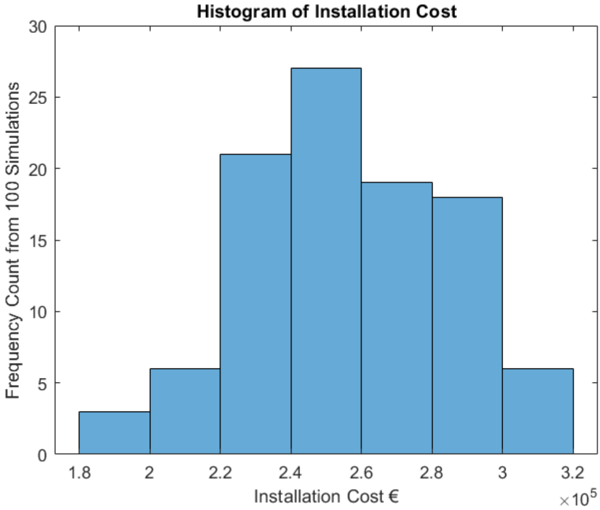


Instead of 2 x 2, the model does 100 x 100

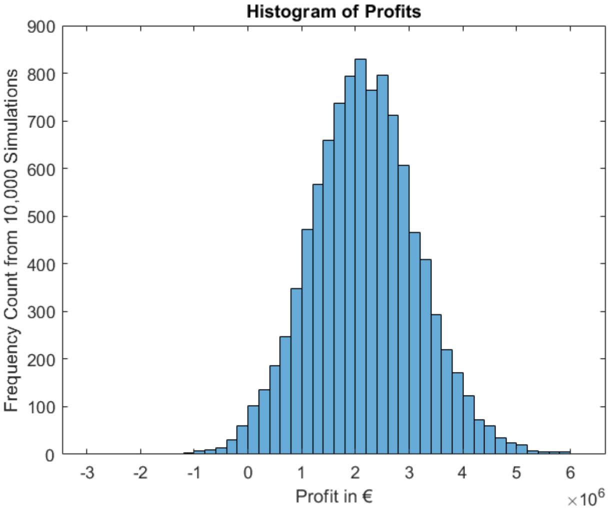
Distribution of Electricity Prices



Distribution of Installation Cost



Distribution of Profit



Value of the Option to Construct

Figures are upper and lower values for samples of wind speeds over 60 years

- €0.40m - €0.59m per 2MW Turbine Construction
- €0.90m - €1.08m per 2MW Turbine Extend Life
- €0.59m - €0.83m per 2.5MW Turbine Repowering
- €0.80m - €1.07m per 3MW Turbine Repowering
- This is the most you should pay for preparatory works
- These numbers are indicative
- **Since repowering and life extension preparation will cost less than the initial preparatory work, it is best to repower or extend life. Look at the actual costs and make your mind up.**

Professional Help, Just Like R&D

Offside is only an offence if the player is interfering with play.

Is professional help worth the money?

- **No Professional Assistance** A minimal, (if irrational), approach to wind farm planning where only regulatory obligations are carried out.
- **Professional Assistance** The work improves the income and reduces the expenditures from the wind farm. This is achieved by making better than average choices for location, size of farm, leasing agreements, OEM selection, layout of wind farm, financial planning,... etc.

Next

- How much is professional help worth?
- This is a theoretical exercise, for now....

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The End

Thank You,

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