VECTOR

powering
decision confidence

# SIMULATION

Adding a probabilistic overlay to investment metrics

# PAYING IT FORWARD

We encourage you to share with your colleagues.

Please keep the document whole to preserve the structure, intent and spirit.

While there is no single right way in Financial Modelling, we have refined our method over 30 years to deliver confidence: championing Clarity, User Experience and Integrity – prioritising certainty and minimising errors.

You can learn the core Excel skills needed for financial modelling in a single day; or you could ask AI to explain a formula; however, robust financial model design and effective structuring skills evolve over hundreds of transactions.

We dedicate our time to a select number of client transactions, in-house training and our own project investments – so there is only so much we solve(!); however, by sharing this insight into how we work we aim to give you a boost - or a Red Bull F1 pit-stop experience if you're already racing.

Wherever you are on your journey, we're here to help you work smarter, not harder - spending less time tinkering with spreadsheets, more time confidently closing deals and powering ahead.

Enjoy our thoughts and approach, we hope it helps. If you like what we do check out [vectorHQ.co](vectorHQ.co)

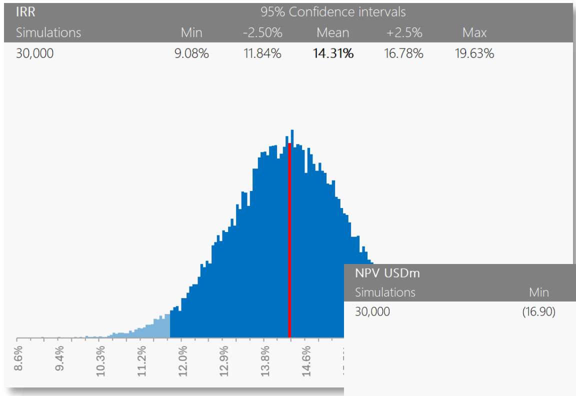
Nick + Ben

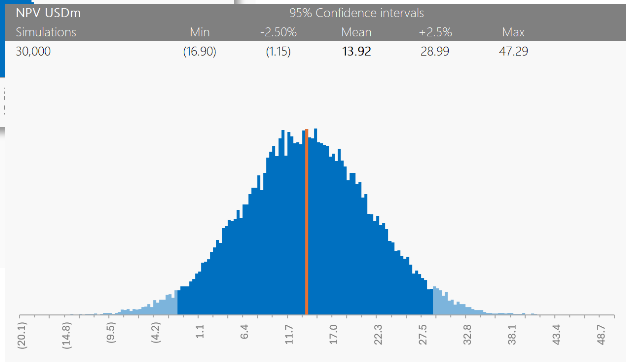
# SIMUL ATION

The intent of this section is to introduce the concept of (Monte Carlo) Simulation as a more powerful method for analysing investment returns compared to sensitivity analysis, and to demonstrate how it can be readily incorporated into a model without add-ins. It is accompanied by an Excel file.

# LET'S GET REAL

You are making an investment decision and are presented with the investment criteria that the IRR = 14.34%. This IRR is the ultimate outcome of many "best guesses" of assumptions. Compare receiving that information to the below, which allows you to understand the range of values you can have 95% confidence the IRR falls within.




Whilst there are good packages to generate this analysis, they are expensive and take some time to learn effectively. Whilst we do use this for advanced cases our clients won't have a license, and an effective outcome can be achieved with simply knowing how to "copy and paste" results in a table. This document has an associated [Excel file ](Excel file) with the basic code so you can see how to set it up.

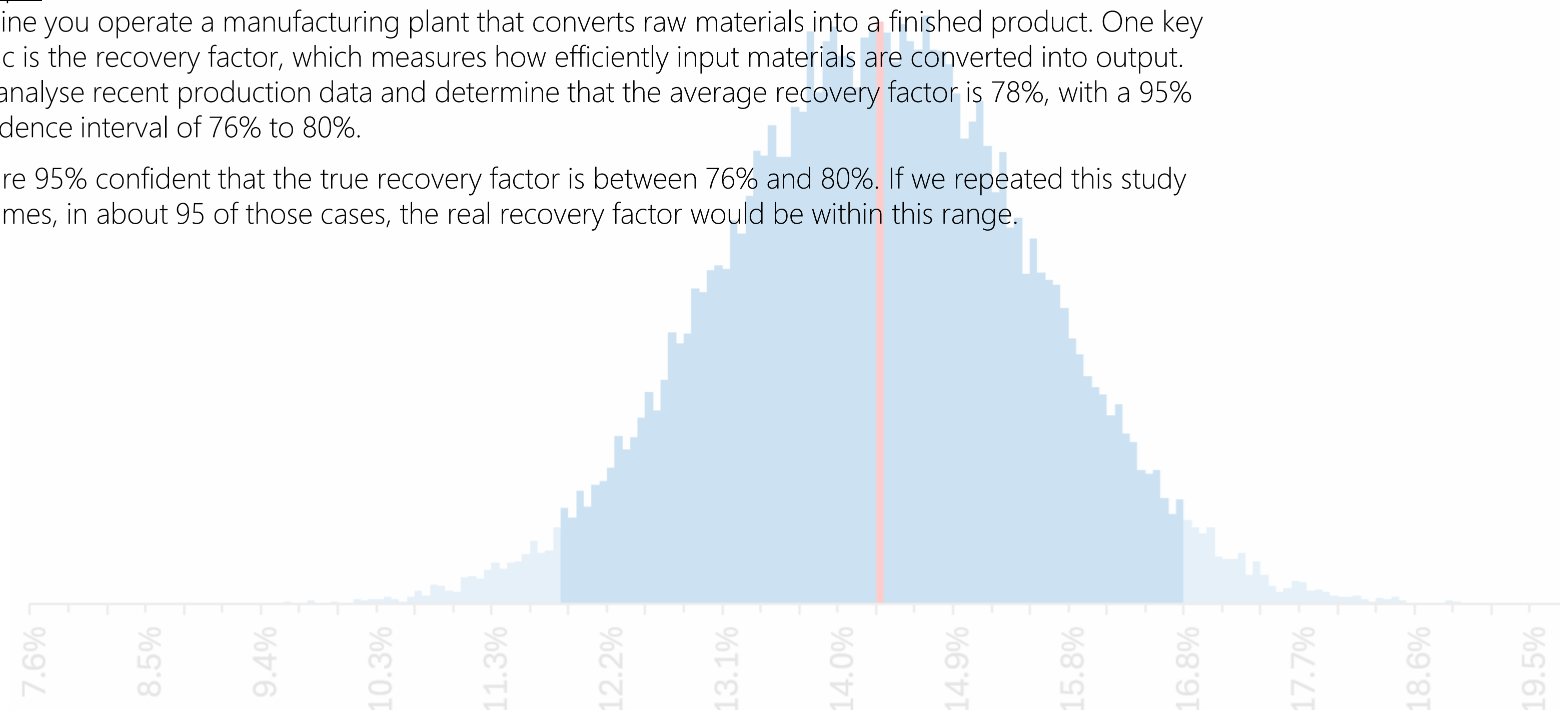
# CONFIDENCE

A 95% confidence interval is a way to express uncertainty in a result – think of it is a considered +/- error range. It gives a range where we expect the true value to be, with 95% confidence. This does not mean there's a 95% probability the true value is in the range, but rather that if we repeated the analysis many times, 95 out of 100 times the interval would contain the true value – this is a common misconception and relates to the outcome being a fixed / true value. Once the simulation has happened, we know which frequency bucket it falls within and once we have performed enough simulations, we then know the distribution of these frequencies.

Example

Imagine you operate a manufacturing plant that converts raw materials into a finished product. One key metric is the recovery factor, which measures how efficiently input materials are converted into output. You analyse recent production data and determine that the average recovery factor is 78%, with a 95% confidence interval of 76% to 80%.

We are 95% confident that the true recovery factor is between 76% and 80%. If we repeated this study 100 times, in about 95 of those cases, the real recovery factor would be within this range.



# HOW IT WORKS

There are two primary dimensions to investment risk – time and uncertainty. Typically, 'time effects' are well analysed but uncertainty attracts maybe 1% of the attention it should – so let's address that. The mission we are on is to provide a decision maker with the range they can have confidence the investment metrics fall within.

We are not presenting this demonstration as 100% statistically precise, that can be achieved, but in this intro, we want to share the 80:20 approach or "something is better than nothing". The associated Excel file does not consider, distributions other than Normal (Gaussian), Skew (Kurtosis) or Correlation between variables, which we do achieve in production models but let's get the basics working first.

The steps to integrating this within an existing Financial Model are:

**STEP 1 – BUILD FUNCTIONALITY**

Build in the Excel functionality to replace a static input with a value that is random according to a probabilistic weighting.

**STEP 2 – GENERATE DATA**

Generate a block of un-ordered results of the key output metrics you are focussing on for your investment analysis.

**STEP 3 - ANALYSE**

Extract the Mean and Standard Deviation of each metric and produce a histogram if you want to produce plots.

If you only want the confidence intervals you don't need to create plots but it helps understand the shape of the likely outputs and also spot if anything looks odd.

This is an excellent tool to investigate if your model is functioning as you expect.

Check out our Simulation Demo to see how these five steps are put into practice:

1. In Excel set up a randomised probability weighted version of key inputs such that every time you calculate (F9) a new value is generated driven from a Mean, Standard Deviation, Minimum and Maximum. This is easier than it sounds!
2. Allow the version of the input that flows through to the calculations to be managed with a Switch.
3. Collate the key investment metrics
4. For [x] simulations copy the investment metrics into one block
5. Produce a frequency histogram to show the confidence intervals.

# THE SETUP

Firstly, let's make sure the identified key variables are set-up for probabilistically weighted randomness. We are going to use a Normal Distribution for key parameters, these are good when you have general uncertainty and the situation is non-binary and not an unlikely event, in these situations we would consider Uniform, Digital, Beta or Poisson distributions.

To generate a Normal Distribution, we use NORMINVS() which is a pretty good starting point for simulating uncertainty around:

- Long Term equilibrium macroeconomic factors
- Capital Expenditure totals
- Capacity Factors / Solar Irradiance
- Loss Factors / Efficiency
- Non-Contracted prices
- Operating costs
- Processing / Recovery yields

**NEW VALUE GENERATION**

Simulation harnesses that NORMIVS() is a volatile function which means that every time the model "calculates" a new value is generated.

We embrace probability but for the purposes of the demonstration we've kept a Normal Distribution but have not constrained allowed minimums and maximums which is useful for when values simply will not be negative such as a recovery factor at a mine or wind speed where a negative outcome is not meaningful.

| | | | |
|---|---|---|---|
| Monte Carlo | On | | |
| Simulations | 2,000 | | |

| | | | | Probabilistic value | | | |
|---|---|---|---|---|---|---|---|
| | | Input | Simulate? | Mean | 1 StDev | Generated | Applied |
| Construction | Months | 12 | Off | 12 | 1 | 10 | 12 |
| Project | Years | 20 | Off | 20 | 1 | 19 | 20 |
| Capacity | MW | 100 | On | 100 | 2 | 102 | 102 |
| Capex | USD/MW | 1,000,000 | On | 1,000,000 | 10,000 | 1,014,060 | 1,014,060 |
| Irradiance | kWh/kW/Year | 1,400 | On | 1,400 | 100 | 1,358 | 1,358 |
| Price | USD/MWh | 110 | Off | 110 | 10 | 103 | 110 |
| WACC | | 12% | Off | 12% | 2% | 12.93% | 12.00% |

**STATIC INPUTS**

These are typical inputs which scenarios and sensitivity analysis are driven from. This can still be applied however we can override with a probability generated value.

**GENERATED VALUES**

We can set the most likely 'best guess' value, and it's spread. In this example we've used a Normal Distribution, but this can also be selectable.

# FACTORING IN RISK

Decisions can only be properly made with an insight into the risks involved.

Now we have inputs set up with a new probabilistically weighted variables we can start to look at how to generate output.

# PSEUDO CODE

As per our Guide to Leveraging VBA we always start with Pseudo Code before writing the code, which distills the VBA development to a largely administrative, syntax exercise. In this case our Pseudo Code would be:

1. Give the user an option to run it or cancel because once started it's best not to interrupt.
2. Allow the statistically generated values to flow through instead of the static inputs. (Turn the Monte Carlo switch "On".)
3. Turn screen updating "Off" – to minimise the time to complete
4. Clear any previously stored data

[LOOP]

5. Copy the investment metrics (and associated inputs) into the first row of data
   Calculate a new batch of dynamic inputs
   Copy the investment metrics (and associated inputs) into the second row of data
   Repeat this sub block for the defined number of iterations informing Status Bar of progress.

[ENDLOOP]

6. Set Monte Carlo Simulation back to "Off"
7. Turn Screen Updating back on
8. Tell the User it's finished.

# PSEUDO TO REAL CODE

The code you need is contained within our associated download. However, it is only an exercise in "Copying and Pasting". The graphs are generated simply with only basic Excel to produce histograms.

```
Sub MonteCarlo()

    'Declare variables
    Dim AreaToClear As Range
    Dim AreatoCopy As Range
    Dim Anchor As Range
    Dim Switch As Range
    Dim MaxSimulations As Range
    Dim Index As Long
    Dim Response As Integer
    Dim Message As String
    Dim UpdateScreen As Integer

    'Set Ranges
    Set AreaToClear = Range("MC.AreaToClear")
    Set AreatoCopy = Range("MC.AreaToCopy")
    Set Anchor = Range("MC.Anchor")
    Set Switch = Range("MC.Switch")
    Set MaxSimulations = Range("MC.MaxSimulations")

    'Confirm to run or cancel
    Message = "This action will make changes to the worksheet." & vbCrLf & vbCrLf & _
              "Are you sure you want to proceed?" & vbCrLf & _
              "Progress will be displayed in status bar" & vbCrLf & _
              "Click OK to continue or Cancel to abort."

    ' Display the OK/Cancel message box
    Response = MsgBox(Message, vbOKCancel + vbQuestion, "Vector | Basic Simulation Example")

    If Response = vbOK Then
        GoTo 10
    Else
        MsgBox "Operation Cancelled.", vbInformation, "Vector | Base Simulation Example"
        GoTo 20
    End If

10

    'Initialise environment
    Switch = "On"
    AreaToClear.ClearContents DoEvents
    Application.ScreenUpdating = False
    UpdateScreen = 100

    'Run simulation
    For Index = 1 To MaxSimulations

        Anchor.Offset(Index - 1, 0).Value = AreatoCopy.Value

        'UpdateScreen
        If (Index Mod UpdateScreen) = 0 Then
            Application.ScreenUpdating = True
            DoEvents
            Application.ScreenUpdating = False
        End If

        Application.StatusBar = "Running simulation | " & Index & " of " & MaxSimulations
        DoEvents

    Next
20
    'Restore environment
    Switch = "Off"
    Application.ScreenUpdating = True
    Application.StatusBar = False

End Sub
```

**THE MAIN PART**

Once the ranges have been established to the spreadsheet this part is all the code that is needed at a basic level.

This code becomes more sophisticated when we need to handle a Pause or a Stop command, but this gets you 80-90% of the way there and functionally it's complete to get you going.

# FROM CODE TO DATA

The VBA required to generate the Data is surprisingly minimal, knowing how to copy one row into a block is all that is needed to get you started. In this example we've provided for 30,000 simulations but that is not always practical, but 5,000 runs will generate a meaningful block of data for analysis.

| | Inputs | | | | | | | Outputs | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Construction | Project | Capacity | Capex | Irradiance | Price | WACC | IRR | NPV | Payback |
| Sim run | 12 | 20 | 100 | 1,000,000 | 1,400 | 110 | 12.00% | 14.34% | 14.08 | 7.42 |
| 1 | 12 | 20 | 97 | 997,684 | 1,566 | 110.00 | 12.00% | 16.43% | 26.26 | 6.75 |
| 2 | 12 | 20 | 100 | 993,059 | 1,214 | 110.00 | 12.00% | 12.06% | 0.35 | 8.42 |
| 3 | 12 | 20 | 97 | 1,006,106 | 1,264 | 110.00 | 12.00% | 12.50% | 2.89 | 8.17 |
| 4 | 12 | 20 | 98 | 997,823 | 1,414 | 110.00 | 12.00% | 14.54% | 15.08 | 7.42 |
| 5 | 12 | 20 | 97 | 981,472 | 1,521 | 110.00 | 12.00% | 16.19% | 24.44 | 6.83 |
| 6 | 12 | 20 | 101 | 984,855 | 1,306 | 110.00 | 12.00% | 13.40% | 8.32 | 7.83 |
| 7 | 12 | 20 | 100 | 980,554 | 1,327 | 110.00 | 12.00% | 13.74% | 10.25 | 7.67 |
| 8 | 12 | 20 | 99 | 1,011,392 | 1,459 | 110.00 | 12.00% | 14.87% | 17.38 | 7.25 |
| 9 | 12 | 20 | 100 | 998,845 | 1,298 | 110.00 | 12.00% | 13.06% | 6.33 | 7.92 |
| 10 | 12 | 20 | 97 | 1,000,671 | 1,423 | 110.00 | 12.00% | 14.61% | 15.37 | 7.33 |
| 11 | 12 | 20 | 98 | 1,001,186 | 1,329 | 110.00 | 12.00% | 13.41% | 8.33 | 7.83 |
| 12 | 12 | 20 | 101 | 1,007,707 | 1,386 | 110.00 | 12.00% | 14.02% | 12.37 | 7.58 |
| 13 | 12 | 20 | 102 | 1,006,633 | 1,522 | 110.00 | 12.00% | 15.72% | 23.34 | 7.00 |
| 14 | 12 | 20 | 103 | 1,017,316 | 1,350 | 110.00 | 12.00% | 13.41% | 8.85 | 7.83 |
| 15 | 12 | 20 | 100 | 1,007,203 | 1,422 | 110.00 | 12.00% | 14.49% | 15.20 | 7.42 |
| 16 | 12 | 20 | 98 | 1,006,971 | 1,327 | 110.00 | 12.00% | 13.29% | 7.60 | 7.83 |
| 17 | 12 | 20 | 102 | 1,005,296 | 1,492 | 110.00 | 12.00% | 15.39% | 21.15 | 7.08 |
| 18 | 12 | 20 | 99 | 1,016,748 | 1,320 | 110.00 | 12.00% | 13.04% | 6.25 | 8.00 |
| 19 | 12 | 20 | 97 | 993,750 | 1,451 | 110.00 | 12.00% | 15.08% | 18.07 | 7.17 |
| 20 | 12 | 20 | 101 | 1,000,307 | 1,302 | 110.00 | 12.00% | 13.08% | 6.53 | 7.92 |
| 29997 | 12 | 20 | 100 | 1,003,040 | 1,405 | 110.00 | 12.00% | 14.35% | 14.17 | 7.42 |
| 29998 | 12 | 20 | 100 | 1,001,799 | 1,258 | 110.00 | 12.00% | 12.50% | 2.95 | 8.17 |
| 29999 | 12 | 20 | 99 | 1,010,100 | 1,417 | 110.00 | 12.00% | 14.37% | 14.26 | 7.42 |
| 30000 | 12 | 20 | 100 | 1,023,154 | 1,556 | 110.00 | 12.00% | 15.84% | 24.09 | 6.92 |

1. Copy generated results
2. Paste values into a table
3. Convert to a frequency histogram for each parameter you want to monitor.

| Bucket | | |
|---|---|---|
| From | To | Count |
| 7.5860% | 7.6471% | - |
| 7.6471% | 7.7082% | - |
| 7.7082% | 7.7693% | - |
| 7.7693% | 7.8304% | - |
| 7.8304% | 7.8915% | - |
| 7.8915% | 7.9526% | - |
| 7.9526% | 8.0137% | - |
| 8.0137% | 8.0748% | - |
| 8.0748% | 8.1359% | - |
| 8.1359% | 8.1970% | 1 |
| 8.1970% | 8.2581% | - |
| 8.2581% | 8.3192% | - |
| 8.3192% | 8.3803% | - |
| 8.3803% | 8.4414% | 1 |
| 8.4414% | 8.5025% | - |
| 8.5025% | 8.5636% | - |
| 8.5636% | 8.6247% | - |
| 8.6247% | 8.6858% | - |
| 8.6858% | 8.7469% | - |
| 8.7469% | 8.8080% | - |
| 8.8080% | 8.8691% | - |
| 8.8691% | 8.9302% | - |
| 8.9302% | 8.9913% | 1 |
| 8.9913% | 9.0524% | 1 |
| 9.0524% | 9.1135% | - |
| 9.1135% | 9.1746% | - |
| 9.1746% | 9.2357% | - |
| 9.2357% | 9.2968% | - |
| 9.2968% | 9.3579% | 1 |
| 9.3579% | 9.4190% | - |

# FROM DATA TO ANALYSIS

Now we have a large block of randomly generated, unsorted output for each investment metric we can create order and insight. You will see in the associated file the raw data for each metric is picked up by a histogram which then drives the plots and shows the +/-95% confidence intervals.

A 95% confidence interval provides a range within which the true value is likely to fall, based on sample data. It means that if we repeated the analysis multiple times, 95% of the time, the calculated range would contain the actual value. This helps quantify uncertainty while making informed business decisions.

For executives, this is useful in evaluating risks and forecasts. For example, if customer retention is estimated between 70% and 80% with 95% confidence, it means the true rate likely falls within that range. It doesn't guarantee exactness but offers a reliable basis for decision-making while accounting for variability.

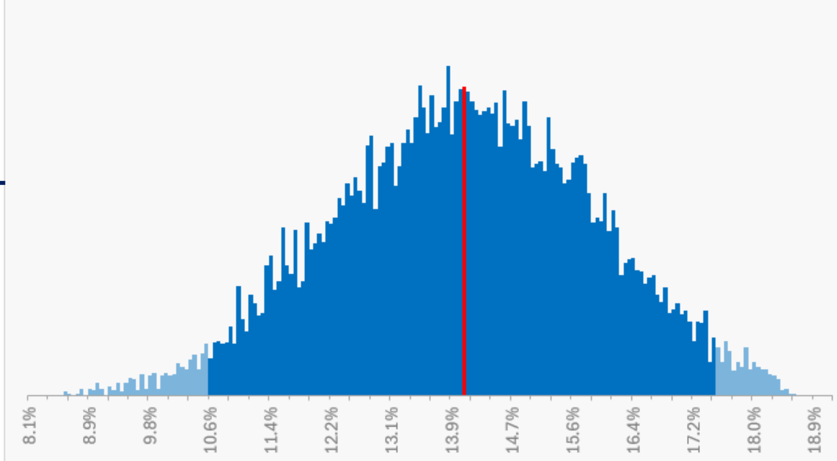
**CONFIDENCE INTERVALS**

In this plot after 30,000 simulations the mean is 14.09% with a 95% probability that it will fall within the range 10.62% and 17.56%.

The remaining 5% is split across both sides of the plot shown here in light blue.

The red line is the mean and you could also consider the mode as the most likely to occur, however the mean factors in the asymmetrical parameters of the data distribution so is usually the most useful.

| IRR | 95% Confidence intervals | | | | |
|---|---|---|---|---|---|
| Simulations | Min | -2.50% | Mean | +2.5% | Max |
| 30,000 | 8.60% | 10.62% | **14.09%** | 17.56% | 18.65% |



# INSPIR ATION

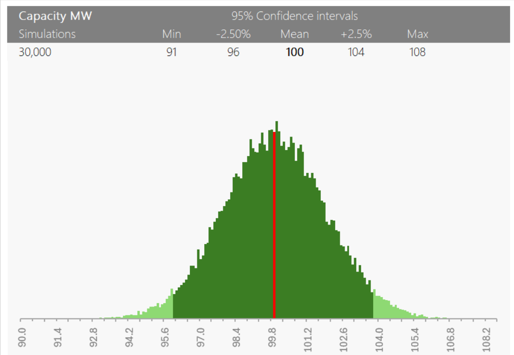
In this section, let’s have a look at some of the ways we harness simulation to solve a wide range of investment and techno-economic decisions

# SINGLE PROJECT ANALYSIS

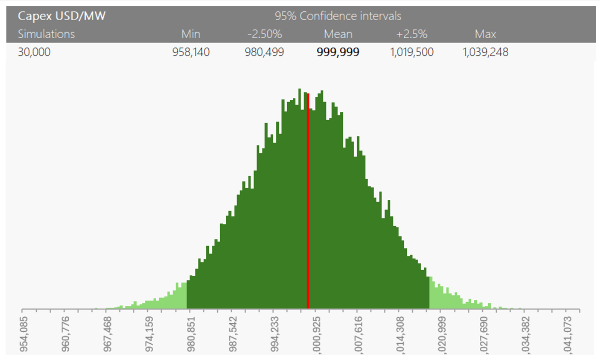
Understanding the spread of key investment metrics provides greater insight into what can be expected given a considered spread of input variables. In these examples we have only considered normally distributed input variables with no skews or constraints.

Sample key inputs:

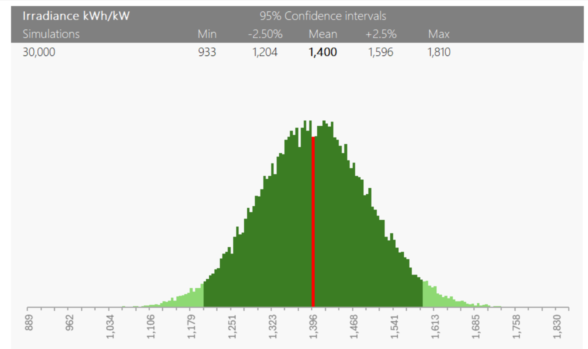
Capacity Installed (MW)




Capex (USD/MW)

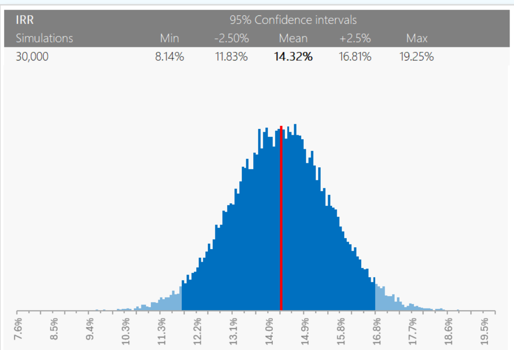



Solar Irradiance (kWh/kW)

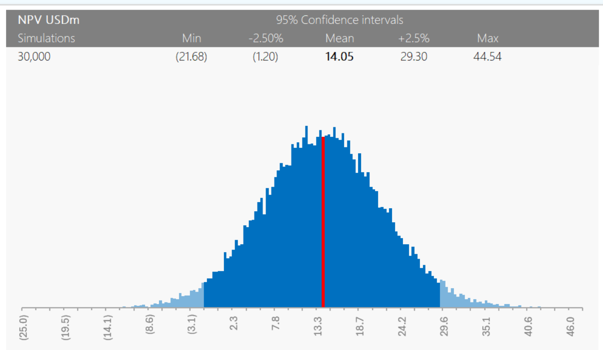



Sample investment metrics:

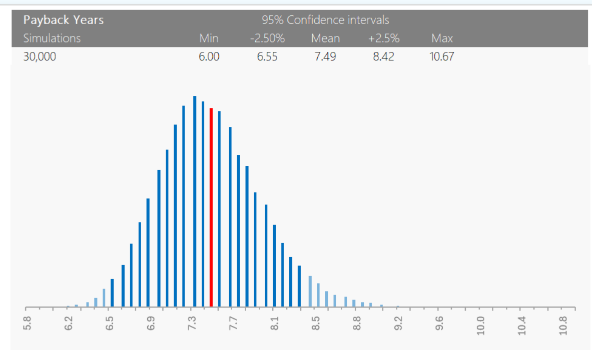
IRR




NPV (USDm)



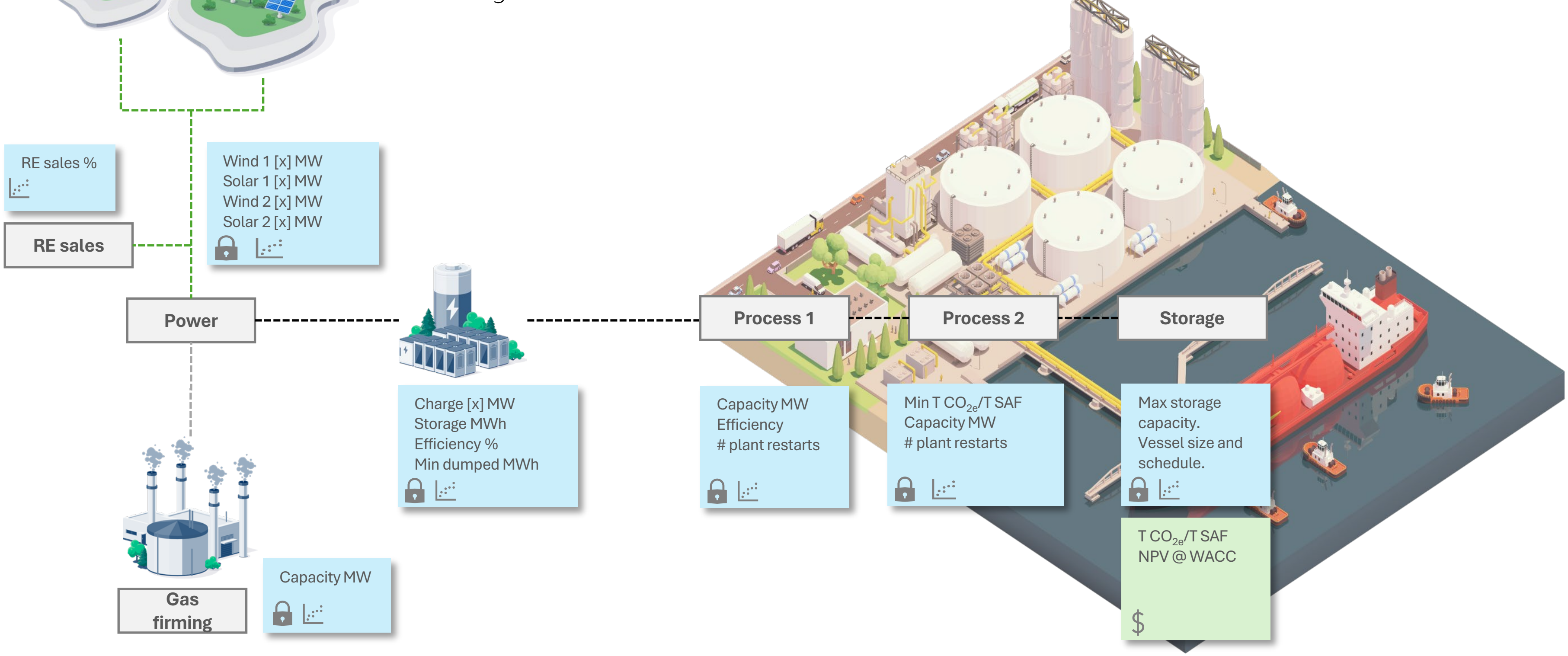

Payback period (Years)



# INTEGRATED INVESTMENT

This large-scale Green Sustainable Aviation Fuel (SAF) production project example illustrates just some of the key inputs required to analyse a sophisticated large scale multi-asset project. This case required a simulation and optimisation model using non-linear metaheuristic search algorithms to maximise investment return, minimise carbon intensity of product working within the constraints of power generation possibilities, technology efficiency, bottlenecks, re-starts and shipping schedules.

Simulation was essential to 'solve' the best combinations of power production that would ensure 'green fuel' status was achieved whilst still clearing investment metric hurdles.

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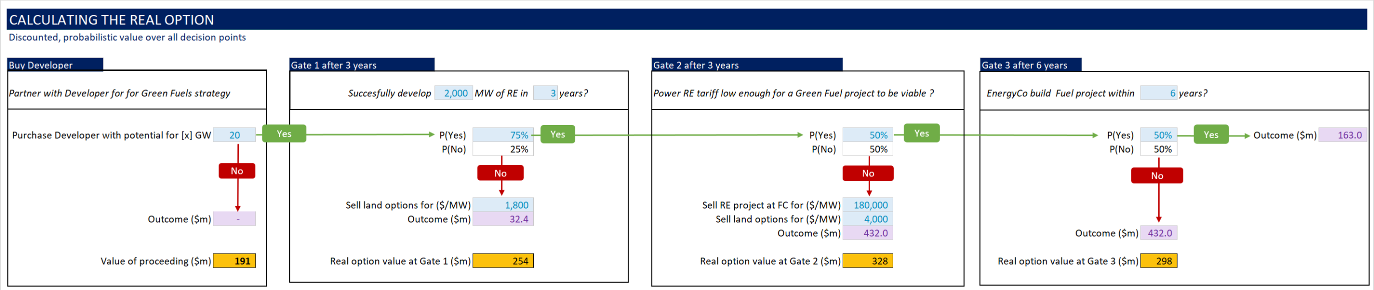
# REAL OPTIONS

Real options refer to the strategic choice's businesses have when making investment decisions under uncertainty. Unlike traditional financial options, which deal with stocks or assets, real options apply to tangible business opportunities—such as expanding a factory, delaying a project, or entering a new market. They provide flexibility, allowing companies to adjust plans as conditions change rather than committing to a fixed path. This approach helps businesses manage risk by considering opportunities as a series of decisions rather than one-time commitment.

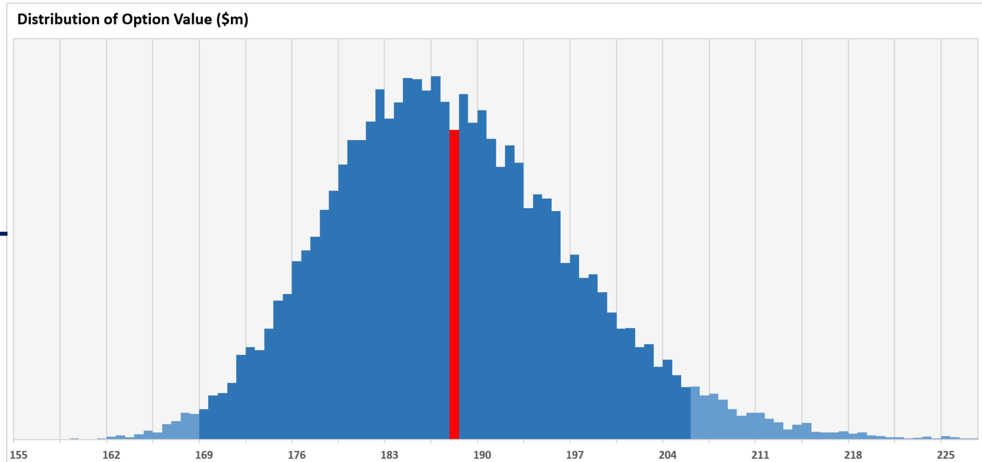
In this case we are analysing the staged values of a transaction where an Energy Company could acquire a Renewable Power Developer to have the option to build 20 GW of Wind and Solar to power a Green Fuels project. The decision gates are shown below with the probabilistic value of the proceeding steps shown as a single value $191m – we then analyse the spread due to uncertainty of key parameters to identify 95% intervals.




| Value of options at sequential gates | | $m |
|---|---|---|
| Buy Developer | If EnergyCo buys Developer who owns Solar/Wind sites | **191** |
| Gate 1 after 3 years | EnergyCo succesfully develops Wind/Solar projects | 254 |
| Gate 2 after 3 years | Is Power tariff low enough for Green Fuels to be viable? | 328 |
| Gate 3 after 6 years | EnergyCo develops a contracted Green Fuels Project | 298 |

## OPTION VALUE

Instead of relying only on a 'single' value derived from static assumptions, after 20,000 simulations we achieved deeper insight into the option value using probabilistic spreads for the 10 key variables.



# VECTOR WHEN IT MATTERS

Our purpose is to develop elegant solutions for complex situations enabling stakeholders to make confident investment decisions, build team capabilities - as trusted advisors. We can be in for the deal but usually once the deal is done our client's ask us to work with them each subsequent time and train their teams.

- Expertise – our two principals deliver decades of hands-on experience for 100% for your engagement.
- Responsiveness – here when you need us.
- Mission focused – your project is our project.
- Knowledge sharers – no restrictions, no licenses.

If you'd like us on your side in a transaction or to build your teams capabilities contact us at hello@vectorHQ.co or check us outline at vectorHQ.co

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**TRAINING**