

NSW Powerfuel Value Chain Tool

Documentation and tool navigation

Introductions:

The NSW Powerfuel Value Chain Tool is developed to investigate pathways to deploy Power-to-X technologies in NSW. Targeting a wide range of stakeholders, the tool can be used to evaluate the opportunity and potential costs of generating hydrogen and several key powerfuels (including ammonia) using renewable power sources across NSW. The key function of the tool is to calculate the levelised cost for hydrogen and other powerfuels, which users can then evaluate the feasibility and determine the potential for developing their own Power-to-X projects in various locations across NSW.

The tool consists of 4 main interfaces that users will interact with to build and assess projects, select location, select model, specify input parameters, and view modelled results. A walkthrough of these steps and additional information can be found in the sections that follow.



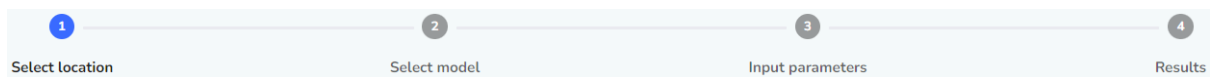
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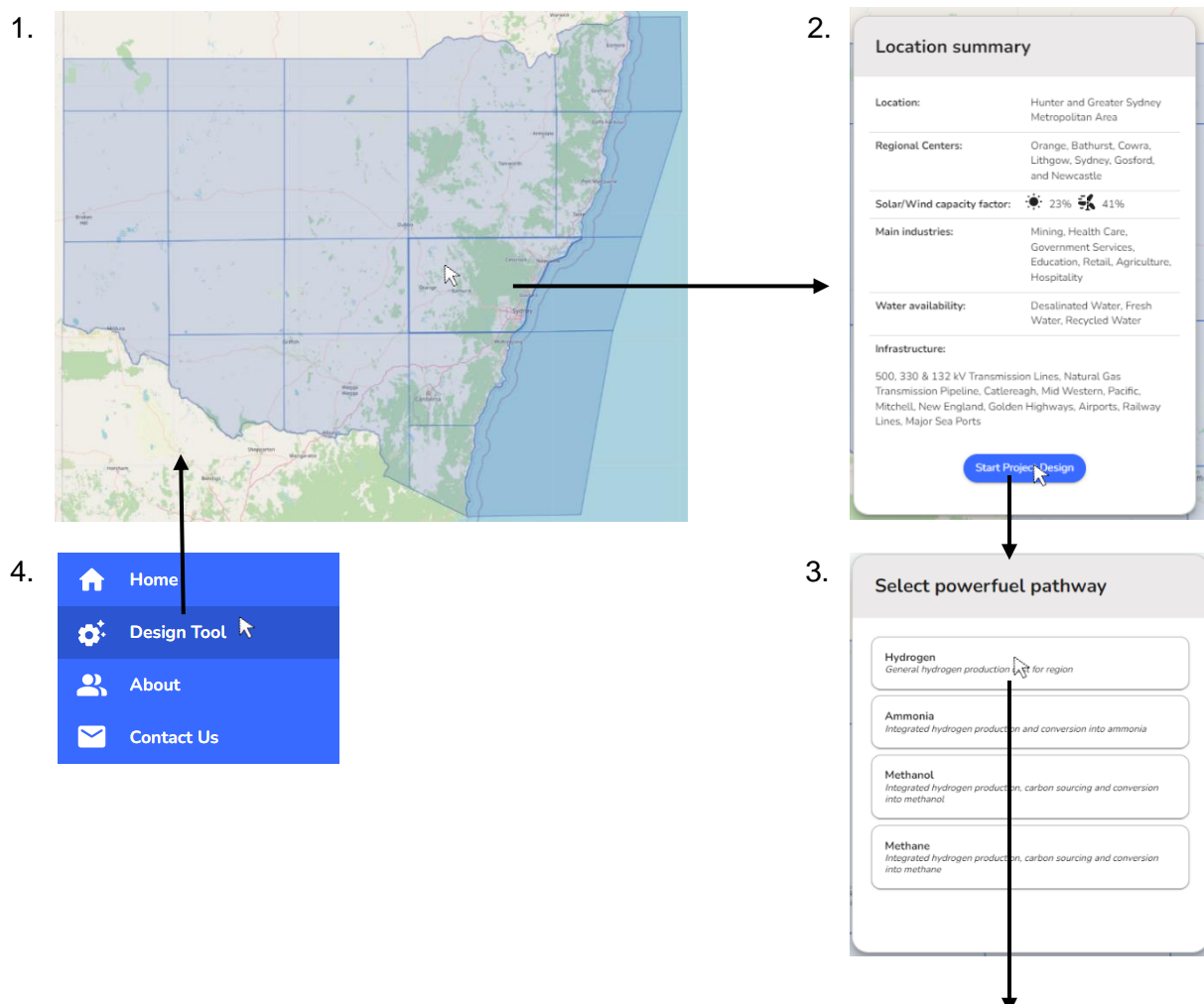
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1. Location and Model

- Select location:** The first interface that users will interact with after the landing page will be to select from the 22 available onshore and offshore zones corresponding to the desired site location within NSW. Each zone corresponds to unique set of annual solar and wind generation profiles which will be used to model project performance. These data sets are preloaded into the tool and will be updated from time to time. (Note: Offshore zones correspond to offshore wind power generation and transmission to an onshore powerfuel facility.)
- Start Project Design:** Once a zone has been selected a location summary will appear with key information about the locations in the zone as well as the average solar and wind power generation capacity factors. If desired the user can click away from the location summary to select a different location. Once satisfied, select 'Start Project Design' to choose the selected location and move to the next step.
- Select Powerfuel Pathway:** The next step is to choose from the list of powerfuels available (currently hydrogen, ammonia, methanol, or methane) to specify the pathway that will be modelled.
- Design tool ribbon:** Navigate back to this map at any time by clicking on the design tool ribbon on the left side of the tool interface.



2. Input Parameters

The model building interface will allow the user to define and customize project operating and costing parameters.

1. On this interface there is a choice between basic and advanced model inputs.
2. Both Basic and advanced pages contain collapsible menus the different groups of parameters and selections that can be specified. Default values are predefined for key inputs. However, we strongly recommend for users to review all parameters and to input their own to obtain relevant and tailored results.
3. Once all inputs have been defined, the 'Calculate' button can be selected to generate results.

2.1. Hydrogen

2.1.1. Basic Inputs

The basic model input page has been designed using simple inputs and sliders to build and evaluate a project easily and quickly.

Project scale: Specify the hydrogen production rate in thousand ton/yr (kTPA). Renewable energy and electrolyser units will be scaled automatically to match this nameplate production rate.

Electrolyser Efficiency: A slider to specify electrolyser energy efficiency relative to the theoretical minimum of 39.4 kWh/kg of H₂ produced.

Power Plant Oversize Ratio: A slider to adjust the ratio of powerplant capacity oversizing relative to the electrolyser capacity in MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the electrolyser and powerplant sizing required to meet the specified hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.

Solar to Wind Ratio: Split of solar and wind farm share in the power capacity from solar only at 100% to wind only at 0%.

Electrolyser Capital Cost: Capital cost of electrolyser per kW including the equipment and installation costs.

Power Supply option: Select 'Self Build' for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

- Self Build selected:

Solar Farm Build Cost: Capital cost of solar farm per kW including the equipment and installation costs.

Wind Farm Build Cost: Capital cost of wind farm per kW including the equipment and installation costs.

Power Supply Option (Select one option from below) ?

Self Build

Solar Farm Build Cost (\$/kW)

Range: 100 - 5,000

1200

Wind Farm Build Cost (\$/kW)

Range: 100 - 5,000

2000

Power Purchase Agreement (PPA)

- Power Purchase Agreement (PPA) selected:

PPA Cost: Cost of PPA per MWh including electricity consumption and transmission/grid usage charges.

Power Supply Option (Select one option from below) ?

Self Build

Power Purchase Agreement (PPA)

PPA Cost (\$/MWh)

Range: 0 - 200

0

Water Supply Cost: Wholesale cost of water supply per kL.

Discount rate: Required rate of return based on similar investments.

Project timeline: Length of time that project is operational in years.

2.1.2. Advanced Inputs

The advanced version of the inputs page allows for more detailed specification of operational and economic parameters.

The screenshot displays the 'Advanced Inputs' interface, organized into three primary columns:

- Electrolyser Parameters:** Includes 'Electrolyser System Capacity' (10 MW), 'Electrolyser System Efficiency', 'Electrolyser Load Range', 'Stack Replacement Type' (Cumulative Hours), 'Maximum Degradation Level', and 'Electrolyser Capital and Operating Costs'.
- Power Plant Parameters:** Includes 'Power Plant Type' (Wind, Solar, Hybrid), 'Power Plant Configuration' (Standalone, Grid Connected), and 'Power Supply Option' (Self Build, Power Purchase Agreement (PPA)).
- Battery Parameters:** Includes 'Battery Capacity', 'Battery Performance', and 'Battery Capital and Operating Costs'.

Additional sections include 'Additional Costs' (Additional Upfront/Operating Costs) and 'Financing Parameters'.

Electrolyser parameters:

Electrolyser System Capacity: Specify the electrolyser system rated capacity in MW.

Electrolyser System Efficiency:

- **Specific Energy Consumption at Nominal Load:** Specify the specific energy consumption of the electrolyser unit kWh of electricity per kg of hydrogen product.
- **Water Requirement of Electrolyser:** Water consumed per kg of hydrogen produced - independent of load.

This section shows the input for 'Specific Energy Consumption at Nominal Load' (50 kWh_e/kg_{H2}) and 'Water Requirement of Electrolyser' (15 L/kg).

Electrolyser Load Range:

- **Electrolyser Maximum Load:** Maximum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.
- **Electrolyser Minimum Load:** Minimum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.
- **Maximum Load When Overloading:** Maximum operating electrolyser loading as a percentage of the rated electrolyser capacity during overloading. Overloading is a temporary boost in production rate past the rated capacity.
- **Time between overloading:** Minimum required cooldown time between overloading events.

This section shows the input for 'Electrolyser Load Range' parameters: Maximum Load (100%), Minimum Load (10%), Maximum Load When Overloading (100%), and Time Between Overloading (0 hrs).

Stack Replacement Type: Select between electrolyser stack replacement methods. Select “Cumulative Hours” to replace the stack when it exceeds a threshold lifetime operational hours. Select “Maximum Degradation Level” to replace the stack once it degrades past a threshold percentage of the original production rate.

- **Cumulative Hours Selected:**
Cumulative Operating Hours: Cumulative hours of operation before stack replacement is due.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.
- **Maximum Degradation Level selected:**
Maximum degradation rate: Maximum allowable cumulative degradation as a percentage of original production rate before the stack must be replaced.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.

Stack Replacement Type (Select one option from below) ?

Cumulative Hours ?

Cumulative Operation Hours
 hrs
Range: 60,000 - 150,000

Stack Degradation
 %/yr

Maximum Degradation Level

Stack Replacement Type (Select one option from below) ?

Cumulative Hours

Maximum Degradation Level ?

Maximum Degradation Rate
 %
Range: 1 - 15

Stack Degradation
 %/yr

Electrolyser Capital and Operating Costs:

- **Reference Electrolyser Scale:** Scale in kW of reference electrolyser system for economies of scale.
- **Electrolyser System Purchase Cost:** Cost of reference electrolyser system per kW of capacity.
- **Electrolyser Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Electrolyser:** Costs for engineering, procurement and installation of the electrolyser as a percentage of electrolyser CAPEX.
- **Land Procurement Cost of Electrolyser:** Land Procurement Cost of Electrolyser as a percentage of electrolyser CAPEX.
- **Electrolyser O&M:** Annual electrolyser operating and maintenance costs as a percentage of CAPEX, excluding energy consumption.
- **Electrolyser Stack Replacement:** Cost of electrolyser stack replacement as a percentage of electrolyser CAPEX.
- **Water Consumption Cost:** Wholesale cost of water supply per kL.

Electrolyser Capital and Operating Costs ?

Reference Electrolyser Scale
 kW
Range: 1,000 - ∞

Electrolyser System Purchase Cost
 \$/kW
Range: 250 - ∞

Electrolyser Cost Reduction with Scale
 %
Range: 0 - ∞

Reference Fold Increase

Range: 0 - ∞

EPC/Installation Costs of Electrolyser
 %
Range: 0 - 50

Land Procurement Cost of Electrolyser
 %
Range: 0 - 50

Electrolyser O&M
 %/yr
Range: 2.5 - 10

Electrolyser Stack Replacement
 %
Range: 10 - 50

Water Consumption Cost
 \$/kL
Range: 1 - 20

Power plant Parameters:

Power Plant Type: Select between Wind only, solar only or hybrid wind and solar power generation.

- **Power Plant Capacity:** Select Power Plant capacity in MW or as a ratio of electrolyser capacity.
 - **Nominal Capacity:** Specify the wind farm and/or solar farm capacity in MW.
 - **Oversize Ratio:** Specify the ratio of powerplant capacity relative to the electrolyser capacity in MW/MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the achieved hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.
- **Wind Degradation rate:** Decrease in wind farm productivity per year as a percentage of the original power generation capacity.
- **Solar Degradation rate:** Decrease in solar farm productivity per year as a percentage of the original power generation capacity.

Power Plant Configuration: Select between standalone power plant configuration without a grid connection, or a grid/network connected configuration.

- **Grid Connected selected:**
 - Grid Connection Costs:** Capital cost for transmission connection.
 - Grid Usage Charges:** Any additional charges for using grid services, e.g. Transmission Use of System (TUOS) Charges.

Power Supply Option: Select 'Self Build' for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

Self-Build Selected:

- **Solar/Wind Farm Build Cost:** Cost of reference solar/wind farm per kW of capacity.
- **Reference Solar/Wind Farm Capacity:** Scale in kW of reference electrolyser system for economies of scale.
- **Solar Farm Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Solar/Wind Farm:** Costs for engineering, procurement and installation of the solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Solar/Wind Farm:** Land Procurement Cost of solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Solar/Wind Farm O&M Costs:** Annual Solar/Wind farm operating and maintenance costs per MW of installed capacity.

Power Supply Option (Select one option from below)

Self Build

Solar Farm Build Cost

1200 \$/kW

Range: 250 - ∞

Reference Capacity of Solar Farm

1000 kW

Range: 1,000 - ∞

Solar Farm Cost Reduction with Scale

10 %

Range: 0 - ∞

Solar Farm Reference Fold Increase

10

Range: 0 - ∞

Wind Farm Build Cost

2000 \$/kW

Range: 250 - ∞

Reference Capacity of Wind Farm

1000 kW

Range: 1,000 - ∞

Wind Farm Cost Reduction with Scale

10 %

Range: 0 - ∞

Wind Farm Reference Fold Increase

10

Range: 0 - ∞

EPC/Installation Costs of Solar Farm

30 %

Range: 0 - 50

Land Procurement Cost of Solar Farm

6 %

Range: 0 - 50

EPC/Installation Costs of Wind Farm

30 %

Range: 0 - 50

Land Procurement Cost of Wind Farm

6 %

Range: 0 - 50

Solar Farm O&M Cost

17000 \$/MW/yr

Range: 5,000 - ∞

Wind Farm O&M Cost

25000 \$/MW/yr

Range: 5,000 - ∞

Power Purchase Agreement (PPA)

Power Purchase Agreement PPA: Fixed price for electricity bought from the grid per MWh.

Power Supply Option (Select one option from below)

Self Build

Power Purchase Agreement (PPA)

Principal PPA Cost

0 \$/MWh

Range: 0 - 1,000

Battery Parameters

Battery Capacity:

- **Battery Rated Power:** Rated power capacity of the battery. Sets a limit on how much the battery can charge/ discharge instantaneously.
- **Battery Storage Duration:** Battery storage capacity in terms of hours at rated power discharge.

Battery Capacity

Battery Rated Power

0 MW

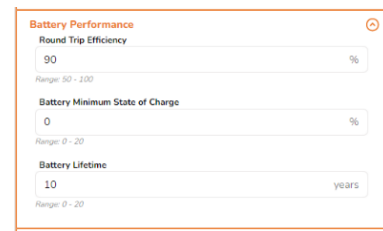
Range: 0 - ∞

Battery Storage Duration

0

Battery Performance:

- **Round Trip Efficiency:** Overall Energy efficiency of battery charge discharge cycle.
- **Battery Minimum State of Charge:** Minimum battery charge level.
- **Battery Lifetime:** Time until battery is due for replacement.



Battery Performance

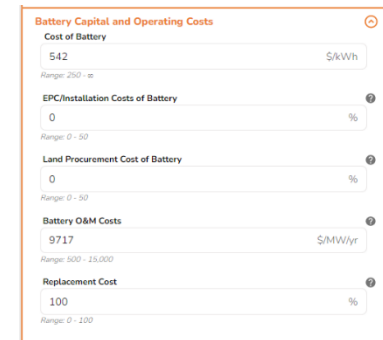
Round Trip Efficiency: 90 %
Range: 50 - 100

Battery Minimum State of Charge: 0 %
Range: 0 - 20

Battery Lifetime: 10 years
Range: 0 - 20

Battery Capital and operating Costs:

- **Cost of Battery:** Battery capital cost per kWh of storage capacity.
- **EPC/Installation Costs of Battery:** Costs for engineering, procurement and installation of the battery as a percentage of battery CAPEX.
- **Land Procurement Cost of Battery:** Land procurement cost of battery as a percentage of battery CAPEX.
- **Battery O&M Costs:** Annual battery operating and maintenance costs per MW of installed capacity.
- **Replacement Cost:** Percentage of CAPEX. Cost of battery replacement is incurred as additional operating cost in each year the battery lifetime is reached.



Battery Capital and Operating Costs

Cost of Battery: 542 \$/kWh
Range: 250 - 80

EPC/Installation Costs of Battery: 0 %
Range: 0 - 50

Land Procurement Cost of Battery: 0 %
Range: 0 - 50

Battery O&M Costs: 9717 \$/MW/yr
Range: 500 - 15,000

Replacement Cost: 100 %
Range: 0 - 100

Additional Costs:

Additional upfront/Operating Costs:

- **Additional Upfront Costs:** Any other additional costs to include as a once off in the Levelized cost of hydrogen LC_{H_2} calculation.
- **Additional Annual Costs:** Any other additional costs to include as an annual cost in the LC_{H_2} calculation.



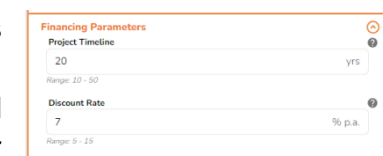
Additional Upfront/Operating Costs

Additional Upfront Costs: 0 \$
Range: 0 - 10

Additional Annual Costs: 0 \$/yr
Range: 0 - 10

Financing Parameters:

- **Project Timeline:** Length of time that project is operational. Same for both power plant and electrolyser.
- **Discount rate:** Discount rate for NPV analysis and LC_{H_2} . Required rate of return based on similar investments.



Financing Parameters

Project Timeline: 20 yrs
Range: 10 - 50

Discount Rate: 7 % p.a.
Range: 0 - 15

2.2. Ammonia

2.2.1. Basic Inputs

The basic model input page has been designed using simple inputs and sliders to build and evaluate a project easily and quickly.

The screenshot displays a user interface for configuring project parameters, organized into three main sections:

- Project Scale:** Includes a slider for 'Ammonia Plant Capacity (kTPA)' with a range of 50 to 1,000, currently set at 50.
- Electrolyser Parameters:** Contains three sliders: 'Electrolyser Efficiency (%)' (range 50-100, set at 50), 'Electrolyser System Oversizing' (range 0-100, set at 45), and 'Hydrogen Storage Capacity' (range 0-500,000, set at 50,000).
- Power Plant Capacity:** Includes two sliders: 'Power Plant Oversize Ratio' (range 1-3, set at 2) and 'Solar to Wind Capacity Ratio (%)' (range 0-100, set at 50).
- Capital & Operating Cost:** Features sliders for 'Electrolyser Capital Cost (\$/kW)' (range 100-5,000, set at 1,000), 'Ammonia Plant Capital Cost (\$/Ton)' (range 900-14,000, set at 900), and 'Water Supply Cost (\$/kL)' (range 0-10, set at 5). It also includes a 'Power Supply Option' dropdown menu with 'Self Build' selected and 'Power Purchase Agreement (PPA)' as an alternative.
- Cost Analysis:** Includes a slider for 'Discount Rate (%)' (range 1-15, set at 7) and a slider for 'Project Timeline (years)' (range 10-50, set at 20).

Ammonia Plant Capacity: Specify the Ammonia production rate in thousand tons/yr (kTPA). Ammonia plant, renewable energy and electrolyser units will be scaled automatically to match this nameplate production rate.

Electrolyser Efficiency: A slider to specify electrolyser energy efficiency relative to the theoretical maximum of 39.4 kWh/kg of H₂ produced.

Electrolyser System Oversizing: Oversize the electrolyser to optimize hydrogen supply stability to match with storage and downstream demand profile.

Hydrogen Storage Capacity: Add hydrogen storage to improve ammonia production flexibility and reduce the strain of frequent ammonia plant start up and shutdown.

Power Plant Oversize Ratio: A slider to adjust the ratio of powerplant capacity oversizing relative to the electrolyser capacity in MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the electrolyser and powerplant sizing required to meet the specified hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.

Solar to Wind Ratio: Split of solar and wind farm share in the power capacity from solar only at 100% to wind only at 0%.

Electrolyser Capital Cost: Capital cost of electrolyser per kW including the equipment and installation costs.

Ammonia Plant Capital Cost: Capital cost of Ammonia plant per ton of nameplate production capacity. Includes Ammonia Synthesis Unit, Air Separation Unit and Ammonia Storage Unit Costs.

Power Supply option: Select ‘Self Build’ for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

- **Self Build selected:**
Solar Farm Build Cost: Capital cost of solar farm per kW including the equipment and installation costs.
Wind Farm Build Cost: Capital cost of wind farm per kW including the equipment and installation costs.
- **Power Purchase Agreement (PPA) selected:**
PPA Cost: Cost of PPA per MWh including electricity consumption and transmission/grid usage charges.

Power Supply Option (Select one option from below) ?

Self Build ?

Solar Farm Build Cost (\$/kW)

Range: 100 - 5,000

1200

Wind Farm Build Cost (\$/kW)

Range: 100 - 5,000

2000

Power Purchase Agreement (PPA)

Power Supply Option (Select one option from below) ?

Self Build

Power Purchase Agreement (PPA) ?

PPA Cost (\$/MWh)

Range: 0 - 200

0

Water Supply Cost: Wholesale cost of water supply per kL.

Discount rate: Required rate of return based on similar investments.

Project timeline: Length of time that project is operational in years.

2.2.2. Advanced Inputs

The advanced version of the inputs page allows for more detailed specification of operational and economic parameters.

| | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Ammonia Parameters</p> <p>Ammonia Plant Capacity</p> <p>Ammonia Plant SEC</p> <p>Ammonia Capital and Operating Costs</p> | <p>Power Plant Parameters</p> <p>Power Plant Type (Select one option from below)</p> <p>Wind</p> <p>Solar</p> <p>Hybrid</p> <p>Power Plant Configuration (Select one option from below)</p> <p>Standalone</p> <p>Grid Connected</p> <p>Power Supply Option (Select one option from below)</p> <p>Self Build</p> <p>Power Purchase Agreement (PPA)</p> | <p>Battery Parameters</p> <p>Battery Capacity</p> <p>Battery Performance</p> <p>Battery Capital and Operating Costs</p> <p>Additional Costs</p> <p>Additional Upfront/Operating Costs</p> <p>Financing Parameters</p> |
| <p>Electrolyser & Hydrogen Parameters</p> <p>Electrolyser System Oversizing</p> <p>45 %</p> <p>Electrolyser System Efficiency</p> <p>Electrolyser Load Range</p> <p>Stack Replacement Type (Select one option from below)</p> <p>Cumulative Hours</p> <p>Maximum Degradation Level</p> <p>Hydrogen Storage</p> <p>Electrolyser Capital and Operating Costs</p> | | |

Ammonia Parameters:

Ammonia Plant Capacity:

- **Ammonia Plant Capacity:** Specify the Ammonia production rate in thousand tons/yr (kTPA).
- **Ammonia Storage Capacity:** Onsite ammonia storage capacity in number of days' worth of production volume.
- **Ammonia Plant Minimum Turndown:** The degree to which the ammonia plant loading can be reduced as a percentage of nameplate plant capacity, e.g., 50% turndown means that the ammonia plant can operate within the range of 50% to 100% of the specified plant capacity.

Ammonia Plant Capacity

Ammonia Plant Capacity

50 kTPA

Ammonia Storage Capacity

30 days

Ammonia Plant Minimum Turndown

50 %

Ammonia Plant SEC:

- **Ammonia Plant Specific Energy Consumption:** Specify the specific energy consumption of the ammonia plant kWh of electricity per kg of ammonia product.
- **Air Separation Unit Specific Energy Consumption:** Specify the specific energy consumption of the ammonia plant kWh of electricity per kg of nitrogen produced.

Ammonia Plant SEC

Ammonia Plant Specific Energy Consumption

0.6 kWh_e/kg_{NH3}

Air Separation Unit Specific Energy Consumption

0.22 kWh_e/kg_{N2}

Ammonia Plant Capital and Operating Costs:

- **Ammonia Synthesis Unit Cost:** Specify the ammonia synthesis unit capital cost per ton of ammonia plant capacity.
- **Ammonia Storage Cost:** Specify cost of onsite ammonia storage per ton of storage capacity.
- **Air Separation Unit Cost:** Specify the ASU capital cost per ton of nitrogen plant capacity.
- **EPC Costs:** Engineering and procurement costs as a percentage of Ammonia CAPEX.
- **Land Procurement Cost:** Land procurement cost of battery as a percentage of Ammonia CAPEX.
- **Ammonia Plant O&M:** Annual Ammonia operating and maintenance costs as a percentage of ammonia plant CAPEX.
- **Ammonia Storage O&M:** Annual Ammonia operating and maintenance costs as a percentage of ammonia storage CAPEX.
- **ASU Plant O&M:** Annual Ammonia operating and maintenance costs as a percentage of ASU CAPEX.

Ammonia Capital and Operating Costs

Ammonia Synthesis Unit Cost

0 AS/T_{NH3}

Ammonia Storage Cost

0 AS/T_{NH3}

Air Separation Unit Cost

0 AS/T_{N2}

EPC Costs

0 % of CAPEX

Land Procurement Cost

0 % of CAPEX

Ammonia Plant O&M

2 % of CAPEX

Ammonia Storage O&M

0 % of CAPEX

ASU Plant O&M

0 % of CAPEX

Electrolyser parameters:

Electrolysis System Oversizing: Oversize the electrolyser to optimize hydrogen supply stability to match with storage and downstream demand profile.

Electrolyser System Efficiency:

- **Specific Energy Consumption at Nominal Load:** Specify the specific energy consumption of the electrolyser unit kWh of electricity per kg of hydrogen product.
- **Water Requirement of Electrolyser:** Water consumed per kg of hydrogen produced - independent of load.

Electrolyser System Efficiency

Specific Energy Consumption at Nominal Load

50 kWh_e/kg_{H2}

Range: 33.33 - 100

Water Requirement of Electrolyser

15 L/kg

Range: 9 - 50

Electrolyser Load Range:

- **Electrolyser Maximum Load:** Maximum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.
- **Electrolyser Minimum Load:** Minimum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.
- **Maximum Load When Overloading:** Maximum operating electrolyser loading as a percentage of the rated electrolyser capacity during overloading. Overloading is a temporary boost in production rate past the rated capacity.
- **Time between overloading:** Minimum required cooldown time between overloading events.

Electrolyser Load Range

Electrolyser Maximum Load
 %
Range: 90 - 100

Electrolyser Minimum Load
 %
Range: 0 - 15

Maximum Load When Overloading
 %
Range: 100 - 150

Time Between Overloading
 hrs
Range: 0 - 24

Stack Replacement Type: Select between electrolyser stack replacement methods. Select “Cumulative Hours” to replace the stack when it exceeds a threshold lifetime operational hours. Select “Maximum Degradation Level” to replace the stack once it degrades past a threshold percentage of the original production rate.

- Cumulative Hours Selected:
Cumulative Operating Hours: Cumulative hours of operation before stack replacement is due.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.
- Maximum Degradation Level selected:
Maximum degradation rate: Maximum allowable cumulative degradation as a percentage of original production rate before the stack must be replaced.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.

Stack Replacement Type (Select one option from below)

Cumulative Hours

Cumulative Operation Hours
 hrs
Range: 60,000 - 150,000

Stack Degradation
 %/yr

Stack Replacement Type (Select one option from below)

Maximum Degradation Level

Maximum Degradation Rate
 %
Range: 1 - 15

Stack Degradation
 %/yr

Hydrogen Storage:

- **Hydrogen Storage Capacity:** Add hydrogen storage to improve ammonia production flexibility and reduce the strain of frequent ammonia plant start up and shutdown.
- **Minimum Hydrogen Storage:** Minimum hydrogen storage capacity as a percentage of total storage capacity. This determines the usable volume of the specified hydrogen storage capacity.

Hydrogen Storage

Hydrogen Storage Capacity
 kg

Minimum Hydrogen Storage
 %

Electrolyser Capital and Operating Costs:

- **Reference Electrolyser Scale:** Scale in kW of reference electrolyser system for economies of scale.
- **Electrolyser System Purchase Cost:** Cost of reference electrolyser system per kW of capacity.
- **Electrolyser Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Electrolyser:** Costs for engineering, procurement and installation of the electrolyser as a percentage of electrolyser CAPEX.
- **Land Procurement Cost of Electrolyser:** Land Procurement Cost of Electrolyser as a percentage of electrolyser CAPEX.
- **Electrolyser O&M:** Annual electrolyser operating and maintenance costs as a percentage of CAPEX, excluding energy consumption.
- **Electrolyser Stack Replacement:** Cost of electrolyser stack replacement as a percentage of electrolyser CAPEX.
- **Water Consumption Cost:** Wholesale cost of water supply per kL.

Electrolyser Capital and Operating Costs

Reference Electrolyser Scale: 1000 kW
Range: 1,000 - ∞

Electrolyser System Purchase Cost: 1000 \$/kW
Range: 250 - ∞

Electrolyser Cost Reduction with Scale: 10 %
Range: 0 - ∞

Reference Fold Increase: 10
Range: 0 - ∞

EPC/Installation Costs of Electrolyser: 30 %
Range: 0 - 50

Land Procurement Cost of Electrolyser: 6 %
Range: 0 - 50

Electrolyser O&M: 2.5 %/yr
Range: 2.5 - 10

Electrolyser Stack Replacement: 40 %
Range: 10 - 50

Water Consumption Cost: 5 \$/kL
Range: 1 - 20

Power plant Parameters:

Power Plant Type: Select between Wind only, solar only or hybrid wind and solar power generation.

- **Power Plant Capacity:** Select power plant capacity as a ratio of electrolyser capacity.
 - **Oversize Ratio:** Specify the ratio of powerplant capacity relative to the electrolyser capacity in MW/MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the achieved hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.
- **Wind Degradation rate:** Decrease in wind farm productivity per year as a percentage of the original power generation capacity.
- **Solar Degradation rate:** Decrease in solar farm productivity per year as a percentage of the original power generation capacity.

Power Plant Configuration: Select between standalone power plant configuration without a grid connection, or a grid connected configuration. Grid connected configurations make use of private or shared transmission networks to transmit power from an offsite renewable energy farm to the site of the project. With no offtake from fossil fuel power generation.

- Grid Connected selected:
Grid Connection Costs: Capital cost for transmission connection.
Grid Usage Charges: Any additional charges for using grid services, e.g. Transmission Use of System (TUOS) Charges.

Power Supply Option: Select 'Self Build' for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

Self-Build Selected:

- **Solar/Wind Farm Build Cost:** Cost of reference solar/wind farm per kW of capacity.
- **Reference Solar/Wind Farm Capacity:** Scale in kW of reference electrolyser system for economies of scale.
- **Solar Farm Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Solar/Wind Farm:** Costs for engineering, procurement and installation of the solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Solar/Wind Farm:** Land Procurement Cost of solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Solar/Wind Farm O&M Costs:** Annual Solar/Wind farm operating and maintenance costs per MW of installed capacity.

Power Supply Option (Select one option from below)

Self Build

Solar Farm Build Cost
 1200 \$/kW
 Range: 250 - ∞

Reference Capacity of Solar Farm
 1000 kW
 Range: 1,000 - ∞

Solar Farm Cost Reduction with Scale
 10 %
 Range: 0 - ∞

Solar Farm Reference Fold Increase
 10
 Range: 0 - ∞

Wind Farm Build Cost
 2000 \$/kW
 Range: 250 - ∞

Reference Capacity of Wind Farm
 1000 kW
 Range: 1,000 - ∞

Wind Farm Cost Reduction with Scale
 10 %
 Range: 0 - ∞

Wind Farm Reference Fold Increase
 10
 Range: 0 - ∞

EPC/Installation Costs of Solar Farm
 Land Procurement Cost of Solar Farm
 6 %
 Range: 0 - 50

EPC/Installation Costs of Wind Farm
 Land Procurement Cost of Wind Farm
 6 %
 Range: 0 - 50

Solar Farm O&M Cost
 17000 \$/MW/yr
 Range: 5,000 - ∞

Wind Farm O&M Cost
 25000 \$/MW/yr
 Range: 5,000 - ∞

Power Purchase Agreement (PPA)

Power Purchase Agreement PPA: Fixed price for electricity bought from the grid per MWh.

Power Supply Option (Select one option from below)

Self Build

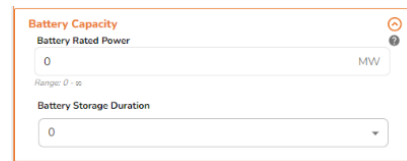
Power Purchase Agreement (PPA)

Principal PPA Cost
 0 \$/MWh
 Range: 0 - 1,000

Battery Parameters

Battery Capacity:

- **Battery Rated Power:** Rated power capacity of the battery. Sets a limit on how much the battery can charge/ discharge instantaneously.
- **Battery Storage Duration:** Battery storage capacity in terms of hours at rated power discharge.



The screenshot shows two input fields for Battery Capacity. The first field is 'Battery Rated Power' with a value of 0 and a unit of MW. The second field is 'Battery Storage Duration' with a value of 0 and a dropdown arrow. Both fields have a range of 0 to infinity.

Battery Performance:

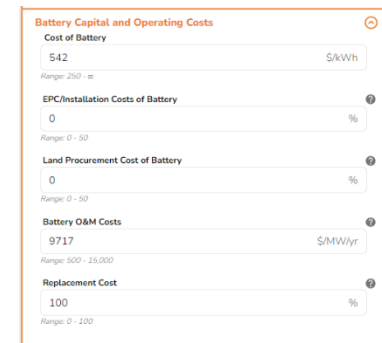
- **Round Trip Efficiency:** Overall Energy efficiency of battery charge discharge cycle.
- **Battery Minimum State of Charge:** Minimum battery charge level.
- **Battery Lifetime:** Time until battery is due for replacement.



The screenshot shows three input fields for Battery Performance. The first field is 'Round Trip Efficiency' with a value of 90 and a unit of %. The second field is 'Battery Minimum State of Charge' with a value of 0 and a unit of %. The third field is 'Battery Lifetime' with a value of 10 and a unit of years. All fields have a range of 0 to 100.

Battery Capital and operating Costs:

- **Cost of Battery:** Battery capital cost per kWh of storage capacity.
- **EPC/Installation Costs of Battery:** Costs for engineering, procurement and installation of the battery as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Battery:** Land procurement cost of battery as a percentage of solar/wind farm CAPEX.
- **Battery O&M Costs:** Annual battery operating and maintenance costs per MW of installed capacity.
- **Replacement Cost:** Percentage of CAPEX. Cost of battery replacement is incurred as additional operating cost in each year the battery lifetime is reached.



The screenshot shows five input fields for Battery Capital and Operating Costs. The first field is 'Cost of Battery' with a value of 542 and a unit of \$/kWh. The second field is 'EPC/Installation Costs of Battery' with a value of 0 and a unit of %. The third field is 'Land Procurement Cost of Battery' with a value of 0 and a unit of %. The fourth field is 'Battery O&M Costs' with a value of 9717 and a unit of \$/MW/yr. The fifth field is 'Replacement Cost' with a value of 100 and a unit of %. All fields have a range of 0 to 100.

Additional Costs:

Additional upfront/Operating Costs:

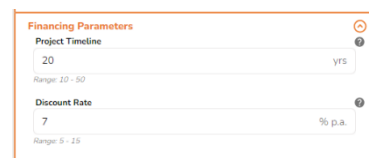
- **Additional Upfront Costs:** Any other additional costs to include as a once off in the Levelized cost of hydrogen LC_{H_2} calculation.
- **Additional Annual Costs:** Any other additional costs to include as an annual cost in the LC_{H_2} calculation.



The screenshot shows two input fields for Additional Upfront/Operating Costs. The first field is 'Additional Upfront Costs' with a value of 0 and a unit of \$. The second field is 'Additional Annual Costs' with a value of 0 and a unit of \$/yr. Both fields have a range of 0 to infinity.

Financing Parameters:

- **Project Timeline:** Length of time that project is operational. Same for both power plant and electrolyser.
- **Discount rate:** Discount rate for NPV analysis and LC_{H_2} . Required rate of return based on similar investments.



The screenshot shows two input fields for Financing Parameters. The first field is 'Project Timeline' with a value of 20 and a unit of yrs. The second field is 'Discount Rate' with a value of 7 and a unit of % p.a. Both fields have a range of 0 to 15.

2.3. Methanol

2.3.1. Basic Inputs

The basic model input page has been designed using simple inputs and sliders to build and evaluate a project easily and quickly.

The screenshot displays a user interface for configuring a methanol production model. It is organized into several panels, each with a title and a set of controls:

- Project Scale:** A slider for 'Methanol Plant Capacity (kTPA)' ranging from 50 to 1,000, with a value of 400 entered.
- Electrolyser Parameters:** Three sliders: 'Electrolyser Efficiency (%)' (50-100, value 70), 'Electrolyser System Oversizing (%)' (0-500, value 45), and 'Hydrogen Storage Capacity (kg)' (0-500,000, value 500,000).
- Power Plant Capacity:** Two sliders: 'Power Plant Oversize Ratio' (1-5, value 1.5) and 'Power Plant Capacity Mix - Share of Solar Input' (0-100, value 50).
- Capital & Operating Cost:** Three sliders: 'Electrolyser Capital Cost (\$/kW)' (100-5,000, value 1500), 'Methanol Plant Capital Cost (\$/Ton)' (100-1,000, value 300), and 'Water Supply Cost (\$/kL)' (0-10, value 2.5). It also includes a dropdown for 'Carbon Capture Source' (set to 'Cement Plant') and a section for 'Power Supply Option' with 'Self Build' and 'Power Purchase Agreement (PPA)' buttons.
- Cost Analysis:** Two sliders: 'Discount Rate (%)' (1-15, value 7) and 'Project Timeline (years)' (10-50, value 25).

Methanol Plant Capacity: Specify the Methanol production rate in thousand tons/yr (kTPA). Methanol plant, Carbon capture plant, renewable energy, electrolyser and battery units will be scaled automatically to match this nameplate production rate.

Electrolyser Efficiency: A slider to specify electrolyser energy efficiency relative to the theoretical maximum of 39.4 kWh/kg of H₂ produced.

Electrolyser System Oversizing: Oversize the electrolyser to optimize hydrogen supply stability to match with storage and downstream demand profile.

Hydrogen Storage Capacity: Add hydrogen storage to improve Methanol production flexibility and reduce the strain of frequent Methanol plant start up and shutdown.

Power Plant Oversize Ratio: A slider to adjust the ratio of powerplant capacity oversizing relative to the electrolyser capacity in MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the electrolyser and powerplant sizing required to meet the specified hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.

Solar to Wind Ratio: Split of solar and wind farm share in the power capacity from solar only at 100% to wind only at 0%.

Electrolyser Capital Cost: Capital cost of electrolyser per kW including the equipment and installation costs.

Methanol Plant Capital Cost: Capital cost of Methanol plant per ton of nameplate production capacity. Includes Methanol Synthesis process, Methanol Storage Unit Costs.

Carbon Capture Source: Select from a list of pre-set carbon capture sources including DAC – Direct Air capture, and flue gas from industrial sources including cement, steel, CO₂ by-product of fermentation, Coal fired power generation, and SMR – Steam methane reforming. Corresponding default specific energy consumption and capital cost, values will be assigned based on selection.

Power Supply option: Select ‘Self Build’ for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

- **Self Build selected:**
Solar Farm Build Cost: Capital cost of solar farm per kW including the equipment and installation costs.
Wind Farm Build Cost: Capital cost of wind farm per kW including the equipment and installation costs.
- **Power Purchase Agreement (PPA) selected:**
PPA Cost: Cost of PPA per MWh including electricity consumption and transmission/grid usage charges.

Water Supply Cost: Wholesale cost of water supply per kL.

Discount rate: Required rate of return based on similar investments.

Project timeline: Length of time that project is operational in years.

2.3.2. Advanced Inputs

The advanced version of the inputs page allows for more detailed specification of operational and economic parameters.

| | | |
|---------------------------|------------------------------------|--------------------|
| Methanol Parameters | Electrolyser & Hydrogen Parameters | Battery Parameters |
| Carbon Capture Parameters | Power Plant Parameters | Additional Costs |

Methanol Parameters:

Methanol Plant Capacity:

- **Methanol Plant Capacity:** Specify the Methanol production rate in thousand tons/yr (kTPA).
- **Methanol Storage Capacity:** Onsite Methanol storage capacity in number of days' worth of production volume.
- **Methanol Plant Minimum Turndown:** The degree to which the Methanol plant loading can be reduced as a percentage of nameplate plant capacity, e.g., 50% turndown means that the Methanol plant can operate within the range of 50% to 100% of the specified plant capacity.

Methanol Parameters

Methanol Plant Capacity

Methanol Plant Capacity

400kTPA

Methanol Storage Capacity

30days

Methanol Plant Minimum Turndown

100%

Methanol Plant SEC:

- **Methanol Plant Specific Energy Consumption:** Specify the specific energy consumption of the Methanol plant kWh of electricity per kg of Methanol product.

Methanol Plant SEC

Methanol Plant Specific Energy Consumption

0.36kWh/kg_{MeOH}

Methanol Plant Capital and Operating Costs:

- **Methanol Synthesis Plant Cost:** Specify the Methanol synthesis unit capital cost per ton of Methanol plant capacity.
- **Methanol Storage Cost:** Specify cost of onsite Methanol storage per ton of storage capacity.
- **EPC Costs:** Engineering and procurement costs as a percentage of Methanol CAPEX.
- **Land Procurement Cost:** Land procurement cost of battery as a percentage of Methanol CAPEX.
- **Methanol Plant O&M:** Annual Methanol operating and maintenance costs as a percentage of Methanol plant CAPEX. Excluding energy costs which are accounted for by costing of the renewable energy plant.
- **Methanol Storage O&M:** Annual Methanol operating and maintenance costs as a percentage of Methanol storage CAPEX. Excluding energy costs which are accounted for by costing of the renewable energy plant.

Methanol Capital and Operating Costs

Methanol Plant Unit Cost

300A\$/T_{MeOH}

Methanol Storage Cost

227A\$/T_{MeOH}

Methanol EPC Costs

10% of CAPEX

Methanol Land Procurement Cost

0% of CAPEX

Methanol Plant O&M

5% of CAPEX

Methanol Storage O&M

0% of CAPEX

Carbon Capture Parameters:

Carbon Capture Parameters

Carbon Capture Plant Cost and SEC

Carbon Capture Installation and Operating Costs

Carbon Capture Plant Cost and SEC:

- **Pre-Set vs Self-Configured:** Select between pre-set options or providing custom carbon capture costing and energy consumption values.
- **Pre-Set Carbon Capture Source:** Select from a list of pre-set carbon capture sources including DAC – Direct Air capture, and flue gas from industrial sources including cement, steel, CO₂ by-product of fermentation, Coal fired power generation, and SMR – Steam methane reforming. Corresponding default specific energy consumption and capital cost, values will be assigned based on selection.
- **Self-Configured Carbon Capture Plant Cost:** Specify capital cost of carbon capture plant per ton of annual carbon capture capacity.
- **Self-Configured Carbon Capture SEC:** Specify the specific energy consumption of the carbon capture plant in kWh of electricity per kg of CO₂ captured.

The screenshot shows a configuration window titled "Carbon Capture Plant Cost and SEC". It has two main sections. The first section, "Source Configuration (Select one option from below)", has a dropdown menu with "Preset Source" selected. The second section, "Self Configured", contains two input fields: "Carbon Capture Plant Cost" with a value of 1610 and unit "A\$/T_{CO2}", and "Carbon Capture Unit Specific Energy Consumption" with a value of 0.86 and unit "kWh_e/kg_{CO2}".

Carbon Capture Plant Cost and SEC

Source Configuration (Select one option from below)

Preset Source

Self Configured

Preset Source

Carbon Capture Source

Cement Plant

Fermentation Plant

Coal Power Plant

Steel Plant

Direct Air Capture

Steam Methane Reforming

Self Configured

Carbon Capture Plant Cost

1610 A\$/T_{CO2}

Carbon Capture Unit Specific Energy Consumption

0.86 kWh_e/kg_{CO2}

Carbon Capture Installation and Operating Costs:

- **Carbon Capture EPC Costs:** Engineering and procurement costs as a percentage of Carbon Capture CAPEX.
- **Land Procurement Cost:** Land procurement cost of battery as a percentage of Carbon Capture CAPEX.
- **Carbon Capture Plant O&M:** Annual Carbon Capture Plant operating and maintenance costs as a percentage of Carbon Capture plant CAPEX. Excluding energy costs which are accounted for by costing of the renewable energy plant.

The screenshot shows a configuration window titled "Carbon Capture Installation and Operating Costs". It contains three input fields, all with units of "% of CAPEX": "Carbon Capture EPC Costs" with a value of 0, "Carbon Capture Land Procurement Cost" with a value of 0, and "Carbon Capture Plant O&M" with a value of 5.

Carbon Capture Installation and Operating Costs

Carbon Capture EPC Costs

0 % of CAPEX

Carbon Capture Land Procurement Cost

0 % of CAPEX

Carbon Capture Plant O&M

5 % of CAPEX

Electrolyser parameters:

Electrolysis System Oversizing: Oversize the electrolyser to optimize hydrogen supply stability to match with storage and downstream demand profile.

Electrolyser System Efficiency:

- **Specific Energy Consumption at Nominal Load:** Specify the specific energy consumption of the electrolyser unit kWh of electricity per kg of hydrogen product.
- **Water Requirement of Electrolyser:** Water consumed per kg of hydrogen produced - independent of load.

The screenshot shows a configuration window titled "Electrolyser System Efficiency". It contains two input fields: "Specific Energy Consumption at Nominal Load" with a value of 50 and unit "kWh_e/kg_{H2}", and "Water Requirement of Electrolyser" with a value of 15 and unit "L/kg". Ranges are provided for both: "Range: 33.33 - 100" for the first field and "Range: 9 - 50" for the second.

Electrolyser System Efficiency

Specific Energy Consumption at Nominal Load

50 kWh_e/kg_{H2}

Range: 33.33 - 100

Water Requirement of Electrolyser

15 L/kg

Range: 9 - 50

Electrolyser Load Range:

- **Electrolyser Maximum Load:** Maximum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.
- **Electrolyser Minimum Load:** Minimum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.

The screenshot shows a form titled "Electrolyser Load Range" with a close button. It contains two input fields: "Electrolyser Maximum Load" with a value of 100 and a range of 90 - 100, and "Electrolyser Minimum Load" with a value of 10 and a range of 0 - 15. Both fields are marked with a percentage sign.

Stack Replacement Type: Select between electrolyser stack replacement methods. Select "Cumulative Hours" to replace the stack when it exceeds a threshold lifetime operational hours. Select "Maximum Degradation Level" to replace the stack once it degrades past a threshold percentage of the original production rate.

- Cumulative Hours Selected:
Cumulative Operating Hours: Cumulative hours of operation before stack replacement is due.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.
- Maximum Degradation Level selected:
Maximum degradation rate: Maximum allowable cumulative degradation as a percentage of original production rate before the stack must be replaced.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.

The first screenshot shows the "Stack Replacement Type" dropdown set to "Cumulative Hours". Below it, the "Cumulative Operating Hours" field is set to 80000 (range 60,000 - 150,000) and the "Stack Degradation" field is set to 0 %/yr. The second screenshot shows the dropdown set to "Maximum Degradation Level". Below it, the "Maximum Degradation Rate" field is set to 0 (range 1 - 15) and the "Stack Degradation" field is set to 0 %/yr.

Hydrogen Storage:

- **Hydrogen Storage Capacity:** Add hydrogen storage to improve methanol production flexibility and reduce the strain of frequent Methanol plant start up and shutdown.
- **Minimum Hydrogen Storage:** Minimum hydrogen storage capacity as a percentage of total storage capacity. This determines the usable volume of the specified hydrogen storage capacity.

The screenshot shows a form titled "Hydrogen Storage" with a close button. It contains two input fields: "Hydrogen Storage Capacity" with a value of 50000 and a unit of kg, and "Minimum Hydrogen Storage" with a value of 10 and a unit of %.

Electrolyser Capital and Operating Costs:

- **Reference Electrolyser Scale:** Scale in kW of reference electrolyser system for economies of scale.
- **Electrolyser System Purchase Cost:** Cost of reference electrolyser system per kW of capacity.
- **Electrolyser Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Electrolyser:** Costs for engineering, procurement and installation of the electrolyser as a percentage of electrolyser CAPEX.
- **Land Procurement Cost of Electrolyser:** Land Procurement Cost of Electrolyser as a percentage of electrolyser CAPEX.
- **Electrolyser O&M:** Annual electrolyser operating and maintenance costs as a percentage of CAPEX, excluding energy consumption.
- **Electrolyser Stack Replacement:** Cost of electrolyser stack replacement as a percentage of electrolyser CAPEX.
- **Water Consumption Cost:** Wholesale cost of water supply per kL.

| Parameter | Value | Unit | Range |
|----------------------------------------|-------|-------|-----------|
| Reference Electrolyser Scale | 1000 | kW | 1,000 - ∞ |
| Electrolyser System Purchase Cost | 1000 | \$/kW | 250 - ∞ |
| Electrolyser Cost Reduction with Scale | 10 | % | 0 - ∞ |
| Reference Fold Increase | 10 | | 0 - ∞ |
| EPC/Installation Costs of Electrolyser | 30 | % | 0 - 50 |
| Land Procurement Cost of Electrolyser | 6 | % | 0 - 50 |
| Electrolyser O&M | 2.5 | %/yr | 2.5 - 10 |
| Electrolyser Stack Replacement | 40 | % | 10 - 50 |
| Water Consumption Cost | 5 | \$/kL | 1 - 20 |

Power plant Parameters:

Power Plant Type: Select between Wind only, solar only or hybrid wind and solar power generation.

- **Power Plant Capacity:** Select power plant capacity as a ratio of electrolyser capacity.
 - **Oversize Ratio:** Specify the ratio of powerplant capacity relative to the electrolyser capacity in MW/MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the achieved hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.
- **Wind Degradation rate:** Decrease in wind farm productivity per year as a percentage of the original power generation capacity.
- **Solar Degradation rate:** Decrease in solar farm productivity per year as a percentage of the original power generation capacity.
- **Power Plant Capacity Mix – Share of Solar Input:** Hybrid type only. Select the percentage of Solar in the total power plant installed capacity. Wind will make up the balance of the total installed capacity. E.g., Input 100% for solar only and 0% for wind only.

Power Plant Configuration: Select between standalone power plant configuration without a grid connection, or a grid connected configuration. Grid connected configurations make use of private or shared transmission networks to transmit power from an offsite renewable energy farm to the site of the project. With no offtake from fossil fuel power generation.

- Grid Connected selected:
Grid Connection Costs: Capital cost for transmission connection.
Grid Usage Charges: Any additional charges for using grid services, e.g. Transmission Use of System (TUOS) Charges.

Power Supply Option: Select 'Self Build' for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

Self-Build Selected:

- **Solar/Wind Farm Build Cost:** Cost of reference solar/wind farm per kW of capacity.
- **Reference Solar/Wind Farm Capacity:** Scale in kW of reference electrolyser system for economies of scale.
- **Solar Farm Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Solar/Wind Farm:** Costs for engineering, procurement and installation of the solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Solar/Wind Farm:** Land Procurement Cost of solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Solar/Wind Farm O&M Costs:** Annual Solar/Wind farm operating and maintenance costs per MW of installed capacity.

Power Supply Option (Select one option from below)

Self Build

Solar Farm Build Cost
1200 \$/kW
Range: 250 - ∞

Reference Capacity of Solar Farm
1000 kW
Range: 1,000 - ∞

Solar Farm Cost Reduction with Scale
10 %
Range: 0 - ∞

Solar Farm Reference Fold Increase
10
Range: 0 - ∞

Wind Farm Build Cost
2000 \$/kW
Range: 250 - ∞

Reference Capacity of Wind Farm
1000 kW
Range: 1,000 - ∞

Wind Farm Cost Reduction with Scale
10 %
Range: 0 - ∞

Wind Farm Reference Fold Increase
10
Range: 0 - ∞

EPC/Installation Costs of Solar Farm
Land Procurement Cost of Solar Farm
6 %
Range: 0 - 50

EPC/Installation Costs of Wind Farm
Land Procurement Cost of Wind Farm
6 %
Range: 0 - 50

Solar Farm O&M Cost
17000 \$/MW/yr
Range: 5,000 - ∞

Wind Farm O&M Cost
25000 \$/MW/yr
Range: 5,000 - ∞

Power Purchase Agreement (PPA)

Power Purchase Agreement PPA: Fixed price for electricity bought from the grid per MWh.

Power Supply Option (Select one option from below)

Self Build

Power Purchase Agreement (PPA)

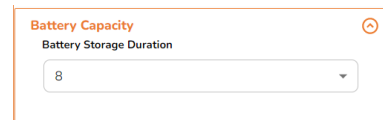
Principal PPA Cost
0 \$/MWh
Range: 0 - 1,000

Battery Parameters

Battery Capacity:

Battery storage was deemed to be an integral part of the Power to methanol pathway to provide backup utilities to the methanol and carbon capture facilities during periods of low power generation. Therefore, the battery storage capacity is automatically matched to the designed power demand of methanol and carbon capture plants. Depending on power generation profile, this can dramatically improve the modelled methanol plant capacity factor. To exclude battery storage from the plant design, select 0 hours for battery storage duration.


- **Battery Storage Duration:** Battery storage capacity in terms of hours at rated power discharge.



The screenshot shows a form titled "Battery Capacity" with a sub-label "Battery Storage Duration". Below it is a dropdown menu with the value "8" selected.

Battery Performance:

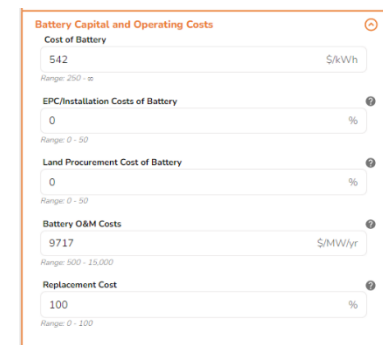
- **Round Trip Efficiency:** Overall Energy efficiency of battery charge discharge cycle.
- **Battery Minimum State of Charge:** Minimum battery charge level.
- **Battery Lifetime:** Time until battery is due for replacement.



The screenshot shows a form titled "Battery Performance" with three input fields: "Round Trip Efficiency" (90%), "Battery Minimum State of Charge" (0%), and "Battery Lifetime" (10 years). Each field has a range indicator below it.

Battery Capital and operating Costs:

- **Cost of Battery:** Battery capital cost per kWh of storage capacity.
- **EPC/Installation Costs of Battery:** Costs for engineering, procurement and installation of the battery as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Battery:** Land procurement cost of battery as a percentage of solar/wind farm CAPEX.
- **Battery O&M Costs:** Annual battery operating and maintenance costs per MW of installed capacity.
- **Replacement Cost:** Percentage of CAPEX. Cost of battery replacement is incurred as additional operating cost in each year the battery lifetime is reached.



The screenshot shows a form titled "Battery Capital and Operating Costs" with five input fields: "Cost of Battery" (542 \$/kWh), "EPC/Installation Costs of Battery" (0%), "Land Procurement Cost of Battery" (0%), "Battery O&M Costs" (9717 \$/MW/yr), and "Replacement Cost" (100%). Each field has a range indicator below it.

Additional Costs:

Additional upfront/Operating Costs:

- **Additional Upfront Costs:** Any other additional costs to include as a once off in the Levelized cost of hydrogen LC_{H_2} calculation.
- **Additional Annual Costs:** Any other additional costs to include as an annual cost in the LC_{H_2} calculation.



The screenshot shows a form titled "Additional Upfront/Operating Costs" with two input fields: "Additional Upfront Costs" (0 \$) and "Additional Annual Costs" (0 \$/yr). Each field has a range indicator below it.

Financing Parameters:

- **Project Timeline:** Length of time that project is operational. Same for both power plant and electrolyser.
- **Discount rate:** Discount rate for NPV analysis and LC_{H_2} . Required rate of return based on similar investments.



The screenshot shows a form titled "Financing Parameters" with two input fields: "Project Timeline" (20 yrs) and "Discount Rate" (7% p.a.). Each field has a range indicator below it.

2.4. Methane

2.4.1. Basic Inputs

The basic model input page has been designed using simple inputs and sliders to build and evaluate a project easily and quickly.

The screenshot displays a user interface for configuring a methane production model. It is organized into four main sections, each with a title and a set of controls:

- Project Scale:** Includes a slider for 'Methane Plant Capacity (kTPA)' ranging from 50 to 1,000, with a current value of 400.
- Electrolyser Parameters:** Contains three sliders: 'Electrolyser Efficiency (%)' (50-100, value 70), 'Electrolyser System Oversizing (%)' (0-500, value 45), and 'Hydrogen Storage Capacity (kg)' (0-500,000, value 50,000).
- Power Plant Capacity:** Includes two sliders: 'Power Plant Oversize Ratio' (1-5, value 1.5) and 'Power Plant Capacity Mix - Share of Solar Input' (0-100, value 50).
- Capital & Operating Cost:** Features sliders for 'Electrolyser Capital Cost (\$/kW)' (100-5,000, value 1,500) and 'Methane Plant Capital Cost (\$/Ton)' (100-1,000, value 400). It also includes a dropdown for 'Carbon Capture Source' (set to 'Cement Plant'), a radio button for 'Power Supply Option' (selected 'Self Build'), and a slider for 'Water Supply Cost (\$/kL)' (0-10, value 2.5).
- Cost Analysis:** Includes a slider for 'Discount Rate (%)' (1-15, value 7) and a slider for 'Project Timeline (years)' (10-50, value 25).

Methane Plant Capacity: Specify the Methane production rate in thousand tons/yr (kTPA). Methane plant, Carbon capture plant, renewable energy, electrolyser and battery units will be scaled automatically to match this nameplate production rate.

Electrolyser Efficiency: A slider to specify electrolyser energy efficiency relative to the theoretical maximum of 39.4 kWh/kg of H₂ produced.

Electrolyser System Oversizing: Oversize the electrolyser to optimize hydrogen supply stability to match with storage and downstream demand profile.

Hydrogen Storage Capacity: Add hydrogen storage to improve Methane production flexibility and reduce the strain of frequent Methane plant start up and shutdown.

Power Plant Oversize Ratio: A slider to adjust the ratio of powerplant capacity oversizing relative to the electrolyser capacity in MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the electrolyser and powerplant sizing required to meet the specified hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.

Solar to Wind Ratio: Split of solar and wind farm share in the power capacity from solar only at 100% to wind only at 0%.

Electrolyser Capital Cost: Capital cost of electrolyser per kW including the equipment and installation costs.

Methane Plant Capital Cost: Capital cost of Methane plant per ton of nameplate production capacity. Includes Methane Synthesis process, Methane Storage Unit Costs.

Carbon Capture Source: Select from a list of pre-set carbon capture sources including DAC – Direct Air capture, and flue gas from industrial sources including cement, steel, CO₂ by-product of fermentation, Coal fired power generation, and SMR – Steam methane reforming. Corresponding default specific energy consumption and capital cost, values will be assigned based on selection.

Power Supply option: Select ‘Self Build’ for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

- **Self-Build selected:**
Solar Farm Build Cost: Capital cost of solar farm per kW including the equipment and installation costs.
Wind Farm Build Cost: Capital cost of wind farm per kW including the equipment and installation costs.
- **Power Purchase Agreement (PPA) selected:**
PPA Cost: Cost of PPA per MWh including electricity consumption and transmission/grid usage charges.

Water Supply Cost: Wholesale cost of water supply per kL.

Discount rate: Required rate of return based on similar investments.

Project timeline: Length of time that project is operational in years.

2.4.2. Advanced Inputs

The advanced version of the inputs page allows for more detailed specification of operational and economic parameters.

| | | |
|---------------------------|------------------------------------|--------------------|
| Methane Parameters | Electrolyser & Hydrogen Parameters | Battery Parameters |
| Carbon Capture Parameters | Power Plant Parameters | Additional Costs |

Methane Parameters:

Methane Plant Capacity:

- **Methane Plant Capacity:** Specify the Methane production rate in thousand tons/yr (kTPA).
- **Methane Storage Capacity:** Onsite Methane storage capacity in number of days' worth of production volume.
- **Methane Plant Minimum Turndown:** The degree to which the Methane plant loading can be reduced as a percentage of nameplate plant capacity, e.g., 50% turndown means that the Methane plant can operate within the range of 50% to 100% of the specified plant capacity.

Methane Parameters

Methane Plant Capacity

Methane Plant Capacity

400kTPA

Methane Storage Capacity

30days

Methane Plant Minimum Turndown

100%

Methane Plant SEC:

- **Methane Plant Specific Energy Consumption:** Specify the specific energy consumption of the Methane plant kWh of electricity per kg of Methane product.

Methane Plant SEC

Methane Plant Specific Energy Consumption

0.51kWh/kg_{SNG}

Methane Plant Capital and Operating Costs:

- **Methane Synthesis Plant Cost:** Specify the Methane synthesis unit capital cost per ton of Methane plant capacity.
- **Methane Storage Cost:** Specify cost of onsite Methane storage per ton of storage capacity.
- **EPC Costs:** Engineering and procurement costs as a percentage of Methane CAPEX.
- **Land Procurement Cost:** Land procurement cost of battery as a percentage of Methane CAPEX.
- **Methane Plant O&M:** Annual Methane operating and maintenance costs as a percentage of Methane plant CAPEX. Excluding energy costs which are accounted for by costing of the renewable energy plant.
- **Methane Storage O&M:** Annual Methane operating and maintenance costs as a percentage of Methane storage CAPEX. Excluding energy costs which are accounted for by costing of the renewable energy plant.

Methane Capital and Operating Costs

Methane Plant Unit Cost

400A\$/T_{SNG}

Methane Storage Cost

227A\$/T_{SNG}

Methane EPC Costs

0% of CAPEX

Methane Land Procurement Cost

0% of CAPEX

Methane Plant O&M

5% of CAPEX

Methane Storage O&M

5% of CAPEX

Carbon Capture Parameters:

Carbon Capture Parameters

Carbon Capture Plant Cost and SEC

Carbon Capture Installation and Operating Costs

Carbon Capture Plant Cost and SEC:

- **Pre-Set vs Self-Configured:** Select between pre-set options or providing custom carbon capture costing and energy consumption values.
- **Pre-Set Carbon Capture Source:** Select from a list of pre-set carbon capture sources including DAC – Direct Air capture, and flue gas from industrial sources including cement, steel, CO₂ by-product of fermentation, Coal fired power generation, and SMR – Steam methane reforming. Corresponding default specific energy consumption and capital cost, values will be assigned based on selection.
- **Self-Configured Carbon Capture Plant Cost:** Specify capital cost of carbon capture plant per ton of annual carbon capture capacity.
- **Self-Configured Carbon Capture SEC:** Specify the specific energy consumption of the carbon capture plant in kWh of electricity per kg of CO₂ captured.

The screenshot shows the 'Carbon Capture Plant Cost and SEC' configuration window. It has two main sections: 'Preset Source' and 'Self Configured'.

Carbon Capture Plant Cost and SEC

Source Configuration (Select one option from below)

Preset Source

Carbon Capture Source

- Cement Plant
- Fermentation Plant
- Coal Power Plant
- Steel Plant
- Direct Air Capture
- Steam Methane Reforming

Self Configured

Carbon Capture Plant Cost: 1610 A\$/T_{CO2}

Carbon Capture Unit Specific Energy Consumption: 0.86 kWh_e/kg_{CO2}

Carbon Capture Installation and Operating Costs:

- **Carbon Capture EPC Costs:** Engineering and procurement costs as a percentage of Carbon Capture CAPEX.
- **Land Procurement Cost:** Land procurement cost of battery as a percentage of Carbon Capture CAPEX.
- **Carbon Capture Plant O&M:** Annual Carbon Capture Plant operating and maintenance costs as a percentage of Carbon Capture plant CAPEX. Excluding energy costs which are accounted for by costing of the renewable energy plant.

The screenshot shows the 'Carbon Capture Installation and Operating Costs' configuration window.

Carbon Capture Installation and Operating Costs

Carbon Capture EPC Costs: 0 % of CAPEX

Carbon Capture Land Procurement Cost: 0 % of CAPEX

Carbon Capture Plant O&M: 5 % of CAPEX

Electrolyser parameters:

Electrolysis System Oversizing: Oversize the electrolyser to optimize hydrogen supply stability to match with storage and downstream demand profile.

Electrolyser System Efficiency:

- **Specific Energy Consumption at Nominal Load:** Specify the specific energy consumption of the electrolyser unit kWh of electricity per kg of hydrogen product.
- **Water Requirement of Electrolyser:** Water consumed per kg of hydrogen produced - independent of load.

The screenshot shows the 'Electrolyser System Efficiency' configuration window.

Electrolyser System Efficiency

Specific Energy Consumption at Nominal Load: 50 kWh_e/kg_{H2}

Range: 33.33 - 100

Water Requirement of Electrolyser: 15 L/kg

Range: 9 - 50

Electrolyser Load Range:

- **Electrolyser Maximum Load:** Maximum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.
- **Electrolyser Minimum Load:** Minimum normal operating electrolyser loading as a percentage of the rated electrolyser capacity.

The screenshot shows a configuration panel titled "Electrolyser Load Range". It contains two input fields: "Electrolyser Maximum Load" with a value of 100 and a range of 90 - 100, and "Electrolyser Minimum Load" with a value of 10 and a range of 0 - 15. Both fields are followed by a percentage symbol (%).

Stack Replacement Type: Select between electrolyser stack replacement methods. Select "Cumulative Hours" to replace the stack when it exceeds a threshold lifetime operational hours. Select "Maximum Degradation Level" to replace the stack once it degrades past a threshold percentage of the original production rate.

- Cumulative Hours Selected:
Cumulative Operating Hours: Cumulative hours of operation before stack replacement is due.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.
- Maximum Degradation Level selected:
Maximum degradation rate: Maximum allowable cumulative degradation as a percentage of original production rate before the stack must be replaced.
Stack Degradation: Decrease in stack productivity per year as a percentage of the original production rate.

The screenshots show two configuration panels for "Stack Replacement Type". The first panel, titled "Cumulative Hours", shows "Cumulative Operation Hours" set to 80000 (range 60,000 - 150,000) and "Stack Degradation" set to 0 (%/yr). The second panel, titled "Maximum Degradation Level", shows "Maximum Degradation Rate" set to 0 (%) (range 1 - 15) and "Stack Degradation" set to 0 (%/yr). Both panels have a "Maximum Degradation Level" button below them.

Hydrogen Storage:

- **Hydrogen Storage Capacity:** Add hydrogen storage to improve Methane production flexibility and reduce the strain of frequent Methane plant start up and shutdown.
- **Minimum Hydrogen Storage:** Minimum hydrogen storage capacity as a percentage of total storage capacity. This determines the usable volume of the specified hydrogen storage capacity.

The screenshot shows a configuration panel titled "Hydrogen Storage". It contains two input fields: "Hydrogen Storage Capacity" with a value of 50000 and a unit of kg, and "Minimum Hydrogen Storage" with a value of 10 and a unit of %.

Electrolyser Capital and Operating Costs:

- **Reference Electrolyser Scale:** Scale in kW of reference electrolyser system for economies of scale.
- **Electrolyser System Purchase Cost:** Cost of reference electrolyser system per kW of capacity.
- **Electrolyser Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Electrolyser:** Costs for engineering, procurement and installation of the electrolyser as a percentage of electrolyser CAPEX.
- **Land Procurement Cost of Electrolyser:** Land Procurement Cost of Electrolyser as a percentage of electrolyser CAPEX.
- **Electrolyser O&M:** Annual electrolyser operating and maintenance costs as a percentage of CAPEX, excluding energy consumption.
- **Electrolyser Stack Replacement:** Cost of electrolyser stack replacement as a percentage of electrolyser CAPEX.
- **Water Consumption Cost:** Wholesale cost of water supply per kL.

| Parameter | Value | Unit | Range |
|----------------------------------------|-------|-------|-----------|
| Reference Electrolyser Scale | 1000 | kW | 1,000 - ∞ |
| Electrolyser System Purchase Cost | 1000 | \$/kW | 250 - ∞ |
| Electrolyser Cost Reduction with Scale | 10 | % | 0 - ∞ |
| Reference Fold Increase | 10 | | 0 - ∞ |
| EPC/Installation Costs of Electrolyser | 30 | % | 0 - 50 |
| Land Procurement Cost of Electrolyser | 6 | % | 0 - 50 |
| Electrolyser O&M | 2.5 | %/yr | 2.5 - 10 |
| Electrolyser Stack Replacement | 40 | % | 10 - 50 |
| Water Consumption Cost | 5 | \$/kL | 1 - 20 |

Power plant Parameters:

Power Plant Type: Select between Wind only, solar only or hybrid wind and solar power generation.

- **Power Plant Capacity:** Select power plant capacity as a ratio of electrolyser capacity.
 - **Oversize Ratio:** Specify the ratio of powerplant capacity relative to the electrolyser capacity in MW/MW, e.g., choosing 3 results in the powerplant full load capacity (MW) being 3 times that of the electrolyser full load capacity (MW). This is an important configurational choice, which affects the achieved electrolyser capacity factor and thus the achieved hydrogen production rate. Note: Higher powerplant oversizing will lower the required electrolyser capacity to meet the same hydrogen production rate.
- **Wind Degradation rate:** Decrease in wind farm productivity per year as a percentage of the original power generation capacity.
- **Solar Degradation rate:** Decrease in solar farm productivity per year as a percentage of the original power generation capacity.
- **Power Plant Capacity Mix – Share of Solar Input:** Hybrid type only. Select the percentage of Solar in the total power plant installed capacity. Wind will make up the balance of the total installed capacity. E.g., Input 100% for solar only and 0% for wind only.

Power Plant Configuration: Select between standalone power plant configuration without a grid connection, or a grid connected configuration. Grid connected configurations make use of private or shared transmission networks to transmit power from an offsite renewable energy farm to the site of the project. With no offtake from fossil fuel power generation.

- Grid Connected selected:
Grid Connection Costs: Capital cost for transmission connection.
Grid Usage Charges: Any additional charges for using grid services, e.g. Transmission Use of System (TUOS) Charges.

Power Supply Option: Select 'Self Build' for cases in which a new power plant is built in conjunction with electrolyser. Select PPA if there is a grid connection to a power supplier.

Self-Build Selected:

- **Solar/Wind Farm Build Cost:** Cost of reference solar/wind farm per kW of capacity.
- **Reference Solar/Wind Farm Capacity:** Scale in kW of reference electrolyser system for economies of scale.
- **Solar Farm Cost Reduction with Scale:** Cost reduction due to economies of scale per specified fold increase.
- **Reference Fold Increase:** Cost reduction occurs for every specified fold increase in capacity vs. reference scale.
- **EPC/Installation Costs of Solar/Wind Farm:** Costs for engineering, procurement and installation of the solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Solar/Wind Farm:** Land Procurement Cost of solar/wind farm as a percentage of solar/wind farm CAPEX.
- **Solar/Wind Farm O&M Costs:** Annual Solar/Wind farm operating and maintenance costs per MW of installed capacity.

Power Supply Option (Select one option from below)

Self Build

Solar Farm Build Cost
1200 \$/kW
Range: 250 - ∞

Reference Capacity of Solar Farm
1000 kW
Range: 1,000 - ∞

Solar Farm Cost Reduction with Scale
10 %
Range: 0 - ∞

Solar Farm Reference Fold Increase
10
Range: 0 - ∞

Wind Farm Build Cost
2000 \$/kW
Range: 250 - ∞

Reference Capacity of Wind Farm
1000 kW
Range: 1,000 - ∞

Wind Farm Cost Reduction with Scale
10 %
Range: 0 - ∞

Wind Farm Reference Fold Increase
10
Range: 0 - ∞

EPC/Installation Costs of Solar Farm
Land Procurement Cost of Solar Farm
6 %
Range: 0 - 50

EPC/Installation Costs of Wind Farm
Land Procurement Cost of Wind Farm
6 %
Range: 0 - 50

Solar Farm O&M Cost
17000 \$/MW/yr
Range: 5,000 - ∞

Wind Farm O&M Cost
25000 \$/MW/yr
Range: 5,000 - ∞

Power Purchase Agreement (PPA)

Power Purchase Agreement PPA: Fixed price for electricity bought from the grid per MWh.

Power Supply Option (Select one option from below)

Self Build

Power Purchase Agreement (PPA)

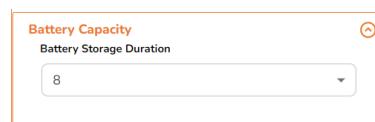
Principal PPA Cost
0 \$/MWh
Range: 0 - 1,000

Battery Parameters

Battery Capacity:

Battery storage was deemed to be an integral part of the Power to Methane pathway to provide backup utilities to the Methane and carbon capture facilities during periods of low power generation. Therefore, the battery storage capacity is automatically matched to the designed power demand of Methane and carbon capture plants. Depending on power generation profile, this can dramatically improve the modelled Methane plant capacity factor. To exclude battery storage from the plant design, select 0 hours for battery storage duration.


- **Battery Storage Duration:** Battery storage capacity in terms of hours at rated power discharge.



The screenshot shows a form titled "Battery Capacity" with a sub-label "Battery Storage Duration". Below it is a dropdown menu with the value "8" selected.

Battery Performance:

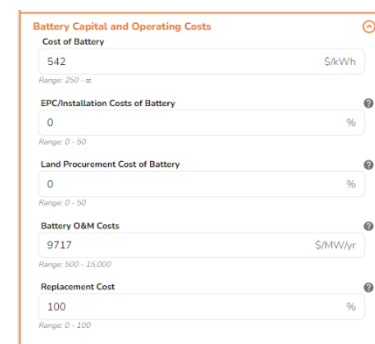
- **Round Trip Efficiency:** Overall Energy efficiency of battery charge discharge cycle.
- **Battery Minimum State of Charge:** Minimum battery charge level.
- **Battery Lifetime:** Time until battery is due for replacement.



The screenshot shows a form titled "Battery Performance" with three input fields: "Round Trip Efficiency" (90%), "Battery Minimum State of Charge" (0%), and "Battery Lifetime" (10 years). Each field has a range indicator below it.

Battery Capital and operating Costs:

- **Cost of Battery:** Battery capital cost per kWh of storage capacity.
- **EPC/Installation Costs of Battery:** Costs for engineering, procurement and installation of the battery as a percentage of solar/wind farm CAPEX.
- **Land Procurement Cost of Battery:** Land procurement cost of battery as a percentage of solar/wind farm CAPEX.
- **Battery O&M Costs:** Annual battery operating and maintenance costs per MW of installed capacity.
- **Replacement Cost:** Percentage of CAPEX. Cost of battery replacement is incurred as additional operating cost in each year the battery lifetime is reached.



The screenshot shows a form titled "Battery Capital and Operating Costs" with five input fields: "Cost of Battery" (542 \$/kWh), "EPC/Installation Costs of Battery" (0%), "Land Procurement Cost of Battery" (0%), "Battery O&M Costs" (9717 \$/MW/yr), and "Replacement Cost" (100%). Each field has a range indicator below it.

Additional Costs:

Additional upfront/Operating Costs:

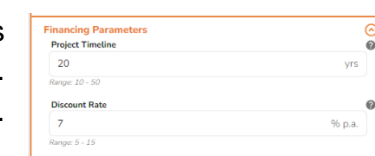
- **Additional Upfront Costs:** Any other additional costs to include as a once off in the Levelized cost of hydrogen LC_{H_2} calculation.
- **Additional Annual Costs:** Any other additional costs to include as an annual cost in the LC_{H_2} calculation.



The screenshot shows a form titled "Additional Upfront/Operating Costs" with two input fields: "Additional Upfront Costs" (0 \$) and "Additional Annual Costs" (0 \$/yr). Each field has a range indicator below it.

Financing Parameters:

- **Project Timeline:** Length of time that project is operational. Same for both power plant and electrolyser.
- **Discount rate:** Discount rate for NPV analysis and LC_{H_2} . Required rate of return based on similar investments.

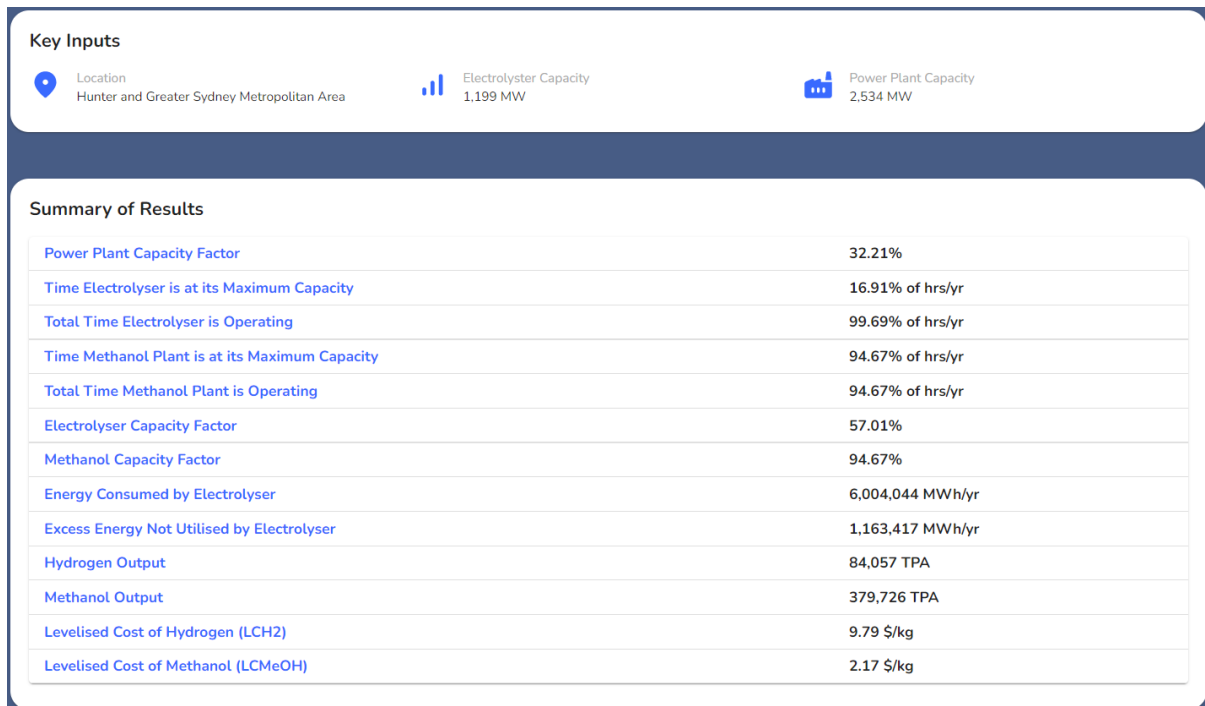


The screenshot shows a form titled "Financing Parameters" with two input fields: "Project Timeline" (20 yrs) and "Discount Rate" (7% p.a.). Each field has a range indicator below it.

3. Results

The results interface features a summary of key results for the modelled project, key inputs, and various charts of the project costs and performance.

3.1. Results Page



Key inputs:

- **Location:** Selected project location zone.
- **Electrolyser Capacity:** Scale of project electrolyser unit based on model inputs.
- **Power Plant Capacity:** Scale of project renewable energy farm capacity based on model inputs

Summary of Results:

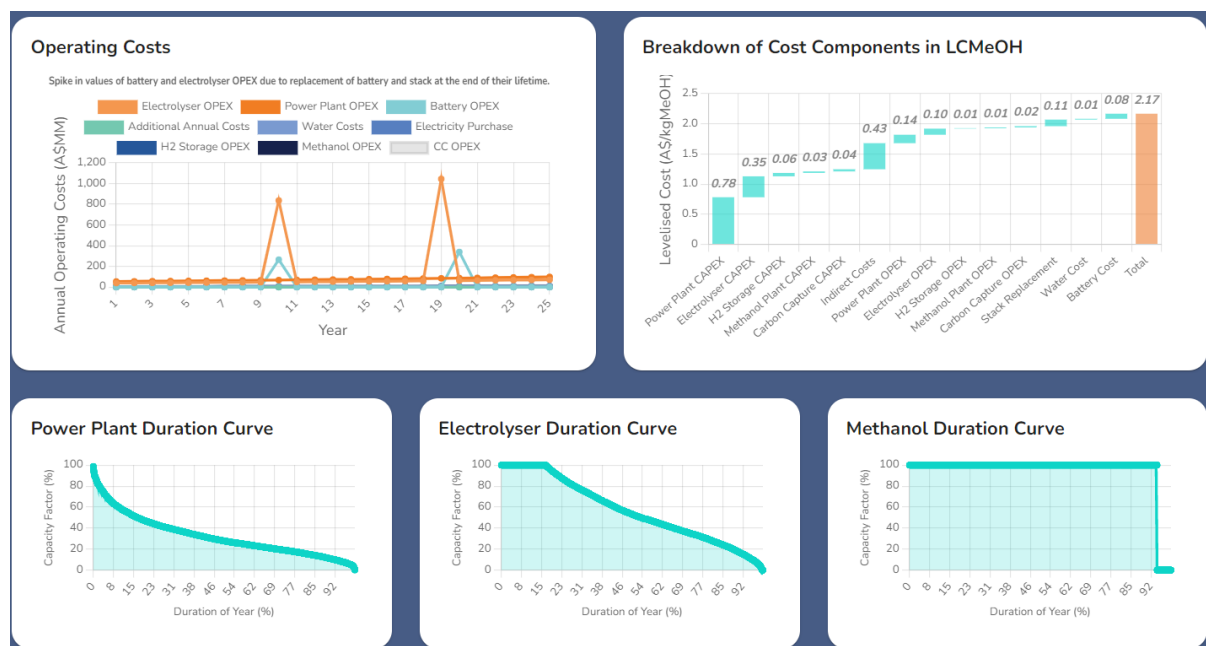
- **Power Plant Capacity Factor:** Average annual power plant capacity factor based on selected renewable energy zone profile and mix of solar and wind power generation. Capacity factor refers to the actual output as a percentage of the maximum possible output at constant full load operation.
- **Time Electrolyser is at its Maximum Capacity:** The modelled percentage of time that the electrolyser unit operates at maximum capacity. This is dependant on the selected zone, and sizing parameters of both the electrolyser and the power plant.
- **Total Time Electrolyser is Operating:** The modelled percentage of time that the electrolyser unit is operational. The electrolyser is not operational at times when the power supplied to the electrolyser unit is below the minimum electrolyser operating load.
- **Electrolyser capacity factor:** Average annual electrolyser capacity factor. Based on the chosen sizing parameters for the electrolyser, and powerplant units as well as the

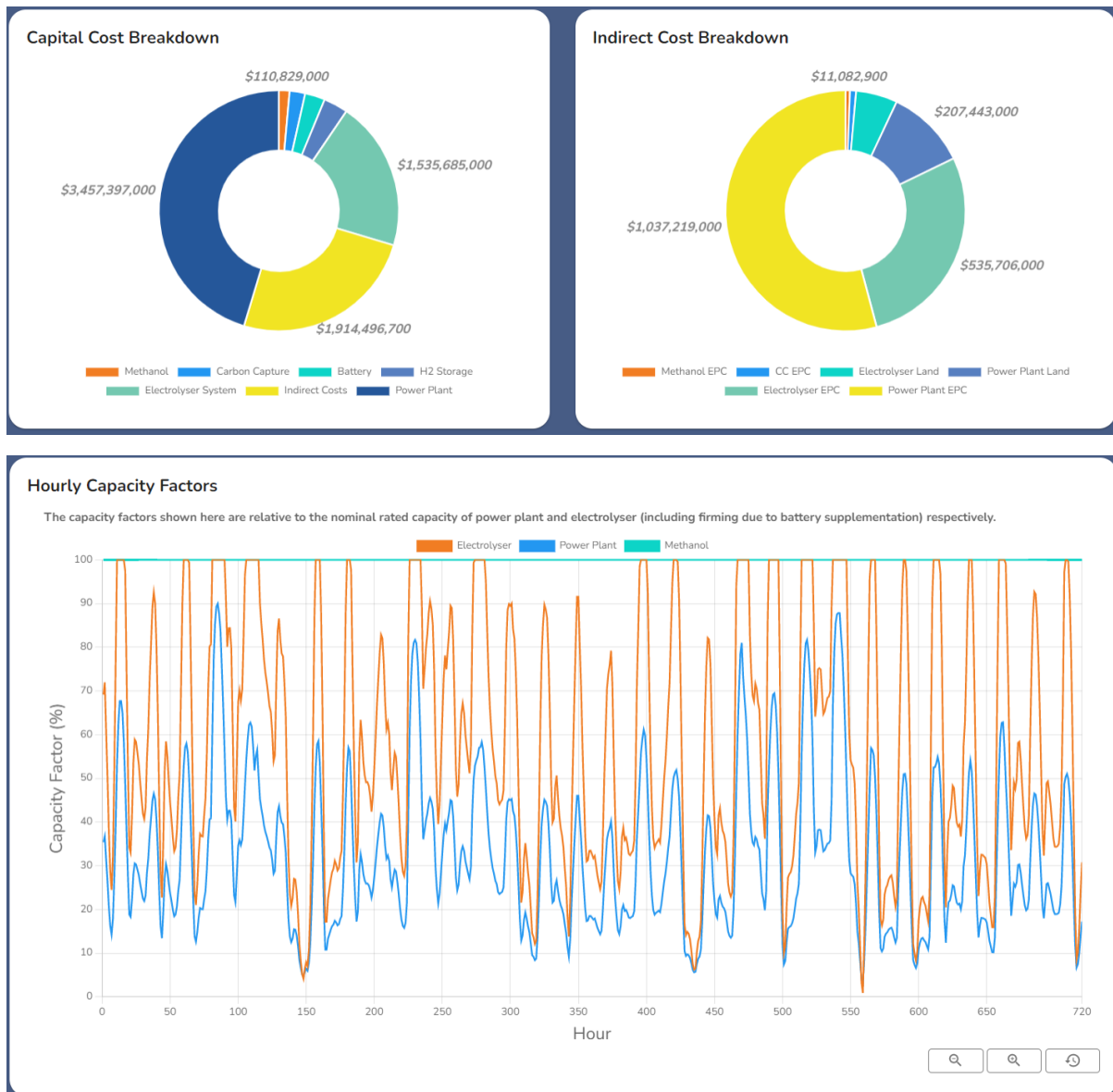
power generation profile corresponding to the chosen renewable energy zone. Capacity factor refers to the actual output as a percentage of the maximum possible output at constant full load operation.

- **Energy Consumed by Electrolyser:** Modelled annual power consumption of the electrolyser unit.
- **Excess energy not utilized by electrolyser:** Curtailed or excess power generation that could not be utilized by the electrolyser unit during peaks due to oversizing of the power plant.
- **Hydrogen generation output:** The modelled annual hydrogen production in ton per year.
- **Powerfuel Output (Ammonia, Methanol, Methane):** The modelled annual powerfuel production in metric ton per year.
- **Levelised cost of product (Hydrogen, Ammonia, Methanol, Methane):** Levelised cost of product. This is the discounted cost of product over the project lifetime in A\$ per kg.

Graphical Results:

- **Operating Costs:** Annual operating costs over the project lifetime. Spikes correlate to replacement costs of key units in a given year (Electrolyser stack, battery etc.).
- **Breakdown of cost Components in LCH₂:** Waterfall breakdown of the levelized cost of hydrogen into key cost categories.
- **Duration Curves:** Ordered annual capacity factor data for each major section (Powerplant, electrolyser, powerfuel plant). This illustrates the proportion of time at different operating loads throughout the year (from 0 to 100% capacity factor).
- **Capital Cost Breakdown:** Pie chart of major capital costs.
- **Indirect Cost Breakdown:** Pie chart of indirect costs. (Engineering and procurement costs EPC, and Land costs of different plant sections)
- **Hourly Capacity Factors:** Simulated hourly plant capacity factors (Powerplant, Electrolyser, Powerfuels plant), scroll right to see different portions of the year. Use to inspect impact of configuration choices on plant operation.





4. Default Values

4.1. Hydrogen – Basic

| Input Parameter | Default Value |
|---------------------------|---------------|
| Project Scale | 15 KTPA |
| Electrolyser Efficiency | 70% |
| Powerplant Oversize Ratio | 1.5 |
| Solar and Wind Mix | 50% |
| Electrolyser Capital Cost | A\$2000 |
| Powerplant Build option | Self-Build |
| Solar Farm Build Cost | A\$1200 |
| Wind Farm Build Cost | A\$2000 |
| PPA Cost | A\$60/MWh |
| Water Supply Cost | A\$5/kL |
| Discount Rate | 0.07 |
| Project Timeline | 15 Years |

4.2. Hydrogen – Advanced

| Input Category | Defaults |
|-----------------------------------------------------------------------------------|------------|
| Electrolyser System Capacity | 100 MW |
| <i>Electrolyser Efficiency</i> | |
| Electrolyser System Electricity Consumption at Nominal load (SEC at Nominal load) | 50 kWh/kg |
| Water Requirement | 15 |
| <i>Electrolyser Load Range</i> | |
| Electrolyser Operation Range | 100% |
| Electrolyser Overloading | 10% |
| Maximum Load when overloading | 100% |
| Time Between overloading | 0 |
| <i>Electrolyser Stack Replacement</i> | |
| Replacement Type | Cumulative |
| Cumulative Operation Hours | 80000 |
| Maximum Degradation Rate | 10% |
| Stack Degradation | 1% |
| <i>Electrolyser Capital and Operating Cost</i> | |
| Electrolyser System Purchase Cost | 1500 \$/kW |
| Reference Electrolyser Scale | 1000 kW |
| Electrolyser cost reduction with scale | 5% |
| Reference fold increase for economies of scale to occur | 10 |
| <i>Electrolyser System Installation Costs</i> | |
| EPC Costs | 30% |
| Land Cost | 6% |
| <i>Electrolyser Operating Costs</i> | |
| Electrolyser O&M | 3% |
| Electrolyser Stack Replacement | 40% |
| Water Consumption Cost | 5 \$/kL |
| Powerplant Configuration | Standalone |
| Powerplant Type | Hybrid |
| Oversize Ratio | 1.5 |
| Solar to Wind Capacity | 50% |
| <i>Powerplant Efficiency</i> | |
| Powerplant Degradation Rate | 1% |
| <i>Powerplant Capital and Operating Costs</i> | |
| Power supply option | Self-Build |
| Powerplant Equipment Costs | |
| Solar Farm Purchase Cost | A\$1200/kW |
| Reference Solar Farm Scale | 1000 kW |
| Solar Farm cost reduction with scale | 5% |
| Reference fold increase for economies of scale to occur | 10 |

| | |
|---------------------------------------------------------|-----------------|
| Wind Farm Purchase Cost | A\$2000/kW |
| Reference Wind Farm Scale | 1000 kW |
| Wind Farm cost reduction with scale | 5% |
| Reference fold increase for economies of scale to occur | 10 |
| Powerplant Installation Costs | |
| EPC/Installation Costs of Solar Farm | 30% |
| Land Development Cost of Solar Farm | 6% |
| EPC/Installation Costs of Wind Farm | 30% |
| Land Development Cost of Wind Farm | 6% |
| Powerplant Operating Costs | |
| Solar Farm O&M | 17000 \$/MWh/y |
| Wind Farm O&M | 25000 \$/MWh/y |
| PPA Costs | |
| PPA Costs | A\$50/MWh |
| Grid Connection Costs | |
| Grid Connection Costs | A\$1,000,000 |
| Grid Usage Charges | A\$10/MWh |
| Battery Capacity | |
| Battery Rated Power Capacity | 0% |
| Battery Storage Duration | 0% |
| Battery Performance | |
| Round Trip Efficiency | 85% |
| Battery Minimum State of Charge | 10% |
| Battery Maximum State of Charge | 100% |
| Battery Lifetime | 10 |
| Battery Capital Costs | |
| Battery System Purchase Costs | A\$1000/kWh |
| Battery System Installation Costs | 0% |
| Battery System Land Costs | 0% |
| Battery Operating Costs | |
| Battery O&M Costs | 10,000 \$/MWh/y |
| Battery Replacement Costs | 100% |
| Additional Costs | |
| Additional Upfront Costs | 0% |
| Additional Annual Costs | 0% |
| Financing Parameters | |
| Project Timeline | 15 |
| Discount Rate | 7% |

4.3. Ammonia – Basic

| Input Category | Default Values |
|-------------------------------------|----------------|
| Project Scale | 50 KTPA |
| Electrolyser Parameter | |
| Electrolyser Efficiency | 75% |
| Electrolyser Oversizing | 45% |
| Hydrogen Storage | 50000 kg |
| Powerplant Capacity | |
| Powerplant Oversizing | 1.5 |
| Solar and Wind Mix | 50% |
| Capital and Operating Costs | |
| Ammonia Plant Capital Cost | A\$900/Ton |
| Electrolyser Capital Cost | A\$1500/kW |
| Powerplant Build option | |
| Build Powerplant | |
| Solar Farm Build Cost | A\$1200/kW |
| Wind Farm Build Cost | A\$1800/kW |
| Purchase Electricity via PPA | |
| PPA Cost | A\$50/MWh |
| Water Supply Cost | A\$5/kL |
| Cost Analysis | |
| Discount Rate | 7% |
| Project Timeline | 25 Years |

4.4. Ammonia – Advanced

| Input Category | Defaults |
|--------------------------------------------------|------------|
| Ammonia Plant Capacity | 50 KTPA |
| Ammonia Plant Specific Energy Consumption | |
| Ammonia Unit Specific Energy Consumption | 0.4 kWh/kg |
| Air Separation Unit Specific Energy Consumption | 0.2 kWh/kg |
| Ammonia Plant Load Range and Storage | |
| Minimum Turndown | 33% |
| Duration of Ammonia Storage | 30 Days |
| Ammonia Plant Capital and Operating Costs | |
| Capital Costs | |
| Ammonia Synthesis Unit Cost | A\$400/t/a |
| Ammonia Storage Cost | A\$100/t/a |
| Air Separation Unit Cost | A\$200/t |
| Ammonia Plant Installation Costs | |
| EPC Costs | 10% |
| Land Cost | 0% |
| Operating Costs | |
| Ammonia Synthesis Unit Cost | 2% |
| Ammonia Storage Cost | 2% |
| Air Separation Unit Cost | 2% |
| Electrolyser System Oversizing | 45% |

| | |
|-----------------------------------------------------------------------------------|-------------|
| Minimum Hydrogen Storage | 10% |
| <i>Electrolyser Efficiency</i> | |
| Electrolyser System Electricity Consumption at Nominal load (SEC at Nominal load) | 50 kWh/kg |
| Water Requirement | 15 L/kg |
| <i>Electrolyser Load Range</i> | |
| Electrolyser Operation Range | 10 – 100% |
| <i>Electrolyser Stack Replacement</i> | |
| Replacement Type | Cumulative |
| Cumulative Operation Hours | 80000 |
| Maximum Degradation Rate | 10% |
| <i>Electrolyser Capital and Operating Cost</i> | |
| <i>Electrolyser Equipment Costs</i> | |
| Electrolyser System Purchase Cost | 1500 \$/kW |
| Reference Electrolyser Scale | 1000 kW |
| Electrolyser cost reduction with scale | 10 % |
| Reference fold increase for economies of scale to occur | 10 |
| Hydrogen Storage Purchase Cost | A\$500 / kg |
| <i>Electrolyser System Installation Costs</i> | |
| EPC Costs | 30% |
| Land Cost | 6% |
| <i>Electrolyser Operating Costs</i> | |
| Electrolyser O&M | 2.5% |
| Hydrogen Storage O&M | 2.00% |
| Electrolyser Stack Replacement | 40% |
| Water Consumption Cost | 5 \$/kL |
| <i>Powerplant Capacity</i> | |
| Powerplant Configuration | Standalone |
| Powerplant Type | Hybrid |
| Powerplant Oversizing | 1.5 |
| Hybrid Mix | 50% |
| <i>Powerplant Efficiency</i> | |
| Powerplant Degradation Rate | 0% |
| <i>Powerplant Capital and Operating Costs</i> | |
| Power supply option | Self Build |
| <i>Powerplant Equipment Costs</i> | |
| Solar Farm Purchase Cost | 1200 \$/kW |
| Reference Solar Farm Scale | 1000 kW |
| Solar Farm cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| Wind Farm Purchase Cost | 2000 \$/kW |
| Reference Wind Farm Scale | 1000 kW |
| Wind Farm cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| <i>Powerplant Installation Costs</i> | |
| EPC/Installation Costs of Solar Farm | 30% |
| Land Development Cost of Solar Farm | 6% |

| | |
|--------------------------------------------|----------------|
| EPC/Installation Costs of Wind Farm | 30% |
| Land Development Cost of Wind Farm | 6% |
| Powerplant Operating Costs | |
| Solar Farm O&M | 17000 \$/MW/yr |
| Wind Farm O&M | 25000 \$/MW/yr |
| PPA Costs | |
| PPA Costs | 50 \$/MWh |
| Grid Connection Costs | |
| Grid Connection Costs | \$ 1000000 |
| Grid Usage Charges | 10 \$/MWh |
| Battery Capacity | |
| Battery Rated Power Capacity | 0 |
| Battery Storage Duration | 0 |
| Battery Performance | |
| Round Trip Efficiency | 85% |
| Battery Minimum State of Charge | 10% |
| Battery Lifetime | 10 yrs |
| Battery Capital and Operating Costs | |
| Battery System Equipment Costs | |
| Battery System Purchase Costs | 380 \$/kWh |
| Battery Systems Installation Costs | |
| Battery System Installation Costs EPC | 0 |
| Battery System Land Costs | 0 |
| Battery Operating Costs | |
| Battery O&M Costs | 10000 \$/MW/yr |
| Battery Replacement Costs | 100% |

4.5. Methanol – Basic

| Input Category | Default Values |
|------------------------------------|-------------------|
| Project Scale | 400 KTPA |
| Electrolyser Parameters | |
| Electrolyser Efficiency | 70% |
| Electrolyser Oversizing | 85% |
| Hydrogen Storage | 500,000kg |
| Powerplant Capacity | |
| Powerplant Oversizing | 100% |
| Solar and Wind Mix | 50% solar |
| Backup power source | Battery |
| Capital and Operating Costs | |
| Methanol Plant Capital Cost | A\$265/Ton |
| Carbon Capture Plant Cost | |
| DAC | A\$ 1610 /t CO2/a |
| Cement | A\$ 275 /t CO2/a |
| Steel | A\$ 460 /t CO2/a |
| Coal | A\$ 420 /t CO2/a |
| Fermentation CO ₂ | A\$ 0 /t CO2/a |
| SMR | A\$ 420 /t CO2/a |

| | |
|---------------------------------------------|------------|
| Electrolyser Capital Cost | A\$1500/kW |
| Power plant Configuration Parameters | |
| Build Powerplant | Self Build |
| Solar Farm Build Cost | A\$1200/kW |
| Wind Farm Build Cost | A\$2000/kW |
| Battery Build Cost | A\$380/kW |
| Purchase Electricity via PPA | |
| PPA Cost | A\$65/MWh |
| Water Supply Cost | A\$2.5/kL |
| Cost Analysis | |
| Discount Rate | 7% |
| Project Timeline | 25 years |

4.6. Methanol – Advanced

| Input Category | Defaults |
|---------------------------------------------------------|--------------------------------|
| Methanol Plant Parameters | |
| Methanol Plant Capacity | 400 kTPA |
| Methanol Plant Specific Energy Consumption | |
| Methanol Unit Specific Energy Consumption | 0.36 kWh/kg |
| Methanol Plant Load Range and Storage | |
| Minimum Turndown | 100% |
| Duration of Methanol Storage | 30 Days |
| Methanol Plant Capital and Operating Costs | |
| Capital Costs | |
| Methanol Synthesis Unit Cost | A\$265 /t MeOH/a |
| Methanol Storage Cost | A\$227 /t MeOH |
| Methanol Plant Installation Costs | |
| EPC Costs | 0 |
| Land Cost | 0 |
| Operating Costs | |
| Methanol Synthesis Unit Cost | 5% |
| Methanol Storage Cost | 0% |
| Carbon Capture Plant Parameters | |
| Carbon Capture Plant Source Type | Cement |
| Carbon Capture Plant Specific Energy Consumption | |
| Carbon capture plant Specific Energy Consumption | |
| DAC | 1.535 kW/kg CO ₂ |
| Cement | 0.78 kW/kg CO ₂ |
| Steel | 0.78 kW/kg CO ₂ |
| Coal | 0.86 kW/kg CO ₂ |
| Fermentation CO ₂ | 0 kW/kg CO ₂ |
| SMR | 0.78 kW/kg CO ₂ |
| Carbon Capture Plant Capital and Operating Costs | |
| Capital Costs | |
| Carbon Capture Plant Cost | |
| DAC | A\$ 1610 /t CO ₂ /a |

| | |
|-----------------------------------------------------------------------------------|-------------------------|
| <i>Cement</i> | A\$ 275 /t CO2/a |
| <i>Steel</i> | A\$ 460 /t CO2/a |
| <i>Coal</i> | A\$ 420 /t CO2/a |
| <i>Fermentation CO₂</i> | A\$ 0 /t CO2/a |
| <i>SMR</i> | A\$ 420 /t CO2/a |
| <i>Methanol Plant Installation Costs</i> | |
| EPC Costs | 0% |
| Land Cost | 0% |
| <i>Operating Costs</i> | |
| Carbon Capture Plant Cost | 5% |
| <i>Electrolyser and Hydrogen Storage Parameter</i> | |
| Electrolyser System Oversizing | 85% |
| Minimum Hydrogen Storage | 10% |
| <i>Electrolyser Efficiency</i> | |
| Electrolyser System Electricity Consumption at Nominal load (SEC at Nominal load) | 50 kWh/kgH ₂ |
| Water Requirement | 25 L/kg h ₂ |
| <i>Electrolyser Load Range</i> | |
| Electrolyser Operation Range | 10% - 100% |
| <i>Electrolyser Stack Replacement</i> | |
| Replacement Type | Cumulative |
| Cumulative Operation Hours | 80,000 |
| Maximum Degradation Rate | 10% |
| <i>Electrolyser Capital and Operating Cost</i> | |
| <i>Electrolyser Equipment Costs</i> | |
| Electrolyser System Purchase Cost | A\$1500 /kW |
| Reference Electrolyser Scale | 1000 kW |
| Electrolyser cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| Hydrogen Storage Purchase Cost | A\$500/kg |
| <i>Electrolyser System Installation Costs</i> | |
| EPC Costs | 30% of CAPEX |
| Land Cost | 6% of Capex |
| <i>Electrolyser Operating Costs</i> | |
| Electrolyser O&M | 2.5% of CAPEX |
| hydrogen Storage O&M | 1.00% |
| Electrolyser Stack Replacement | 40% of Capex |
| Water Consumption Cost | A\$2.7/kL |
| <i>Powerplant Parameters</i> | |
| <i>Powerplant Capacity</i> | |
| Powerplant Configuration | Standalone |
| Powerplant Type | Hybrid |
| Powerplant Oversizing ratio | 2 |
| Hybrid Mix | 50%:50% |
| <i>Powerplant Efficiency</i> | |
| Powerplant Degradation Rate | 0% |
| <i>Powerplant Capital and Operating Costs</i> | |
| Power supply option | Self Build |
| <i>Powerplant Equipment Costs</i> | |

| | |
|---------------------------------------------------------|-----------------------------------------------------------------------------|
| Solar Farm Purchase Cost | 1200 \$/kW |
| Reference Solar Farm Scale | 1000 kW |
| Solar Farm cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| Wind Farm Purchase Cost | 2000 \$/kW |
| Reference Wind Farm Scale | 1000 kW |
| Wind Farm cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| Powerplant Installation Costs | |
| EPC/Installation Costs of Solar Farm | 30% |
| Land Development Cost of Solar Farm | 6% |
| EPC/Installation Costs of Wind Farm | 30% |
| Land Development Cost of Wind Farm | 6% |
| Powerplant Operating Costs | |
| Solar Farm O&M | 17000 \$/MW/yr |
| Wind Farm O&M | 25000 \$/MW/yr |
| PPA Costs | |
| PPA Costs | 65 \$/MWh |
| Grid Connection Costs | |
| Grid Connection Costs | \$ 1000000 |
| Grid Usage Charges | 10 \$/MWh |
| Battery Parameters | |
| Battery Capacity | |
| Battery Rated Power Capacity | "set to equal methanol and carbon capture plant instantaneous power demand" |
| Battery Storage Duration | 8 hr |
| Battery Performance | |
| Round Trip Efficiency | 85% |
| Battery Minimum State of Charge | 0% |
| Battery Lifetime | 10 yrs |
| Battery Capital and Operating Costs | |
| Battery System Equipment Costs | |
| Battery System Purchase Costs | A\$380/kW |
| Battery Systems Installation Costs | |
| Battery System Installation Costs EPC | 0 |
| Battery System Land Costs | 0 |
| Battery Operating Costs | |
| Battery O&M Costs | 10000 \$/MW/yr |
| Battery Replacement Costs | 100% |
| Cost Analysis | |
| Discount Rate | 7% |
| Project Timeline | 25 years |

4.7. Methane – Basic

| Input Category | Default Values |
|---------------------------------------------|--------------------------------|
| Project Scale | 400 KTPA |
| Electrolyser Parameters | |
| Electrolyser Efficiency | 70% |
| Electrolyser Oversizing | 85% |
| Hydrogen Storage | 500,000kg |
| Powerplant Capacity | |
| Powerplant Oversizing | 100% |
| Solar and Wind Mix | 50% solar |
| Backup power source | Battery |
| Capital and Operating Costs | |
| Methane Plant Capital Cost | A\$400/Ton |
| Carbon Capture Capital Cost | |
| DAC | A\$ 1610 /t CO ₂ /a |
| Cement | A\$ 275 /t CO ₂ /a |
| Steel | A\$ 460 /t CO ₂ /a |
| Coal | A\$ 420 /t CO ₂ /a |
| Fermentation CO ₂ | A\$ 0 /t CO ₂ /a |
| SMR | A\$ 420 /t CO ₂ /a |
| Electrolyser Capital Cost | A\$1500/kW |
| Power plant Configuration Parameters | |
| Build Powerplant | Self Build |
| Solar Farm Build Cost | A\$1200/kW |
| Wind Farm Build Cost | A\$2000/kW |
| Battery Build Cost | A\$380/kW |
| Purchase Electricity via PPA | |
| PPA Cost | A\$65/MWh |
| Water Supply Cost | A\$2.5/kL |
| Cost Analysis | |
| Discount Rate | 7% |
| Project Timeline | 25 years |

4.8. Methane – Advanced

| Input Category | Defaults |
|--------------------------------------------------|-----------------|
| Methane Plant Parameters | |
| Methane Plant Capacity | 400 kTPA |
| Methane Plant Specific Energy Consumption | |
| Methane Unit Specific Energy Consumption | 0.36 kWh/kg |
| Methane Plant Load Range and Storage | |
| Minimum Turndown | 100% |
| Methane Plant Capital and Operating Costs | |
| Capital Costs | |
| Methane Synthesis Unit Cost | A\$400/t MeOH/a |
| Methane Plant Installation Costs | |
| EPC Costs | 0 |

| | |
|-----------------------------------------------------------------------------------|--------------------------------|
| Land Cost | 0 |
| Operating Costs | |
| Methane Synthesis Unit Cost | 5% |
| Methane Storage Cost | 0% |
| Carbon Capture Plant Parameters | |
| Carbon Capture Plant Source Type | Cement |
| Carbon Capture Plant Specific Energy Consumption | |
| Carbon capture plant Specific Energy Consumption | |
| DAC | 1.535 kW/kg CO ₂ |
| Cement | 0.78 kW/kg CO ₂ |
| Steel | 0.78 kW/kg CO ₂ |
| Coal | 0.86 kW/kg CO ₂ |
| Fermentation CO ₂ | 0 kW/kg CO ₂ |
| SMR | 0.78 kW/kg CO ₂ |
| Carbon Capture Plant Capital and Operating Costs | |
| Capital Costs | |
| Carbon Capture Plant Cost | |
| DAC | A\$ 1610 /t CO ₂ /a |
| Cement | A\$ 275 /t CO ₂ /a |
| Steel | A\$ 460 /t CO ₂ /a |
| Coal | A\$ 420 /t CO ₂ /a |
| Fermentation CO ₂ | A\$ 0 /t CO ₂ /a |
| SMR | A\$ 420 /t CO ₂ /a |
| Methane Plant Installation Costs | |
| EPC Costs | 0% |
| Land Cost | 0% |
| Operating Costs | |
| Carbon Capture Plant Cost | 5% |
| Electrolyser and Hydrogen Storage Parameter | |
| Electrolyser System Oversizing | 85% |
| Minimum Hydrogen Storage | 10% |
| Electrolyser Efficiency | |
| Electrolyser System Electricity Consumption at Nominal load (SEC at Nominal load) | 50 kWh/kgH ₂ |
| Water Requirement | 25 L/kg h ₂ |
| Electrolyser Load Range | |
| Electrolyser Operation Range | 10% - 100% |
| Electrolyser Stack Replacement | |
| Replacement Type | Cumulative |
| Cumulative Operation Hours | 80,000 |
| Maximum Degradation Rate | 10% |
| Electrolyser Capital and Operating Cost | |
| Electrolyser Equipment Costs | |
| Electrolyser System Purchase Cost | A\$1500 /kW |
| Reference Electrolyser Scale | 1000 kW |
| Electrolyser cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| Hydrogen Storage Purchase Cost | A\$500/kg |

| | |
|---------------------------------------------------------|----------------------------------------------------------------------------|
| <i>Electrolyser System Installation Costs</i> | |
| EPC Costs | 30% of CAPEX |
| Land Cost | 6% of Capex |
| <i>Electrolyser Operating Costs</i> | |
| Electrolyser O&M | 2.5% of CAPEX |
| hydrogen Storage O&M | 1.00% |
| Electrolyser Stack Replacement | 40% of Capex |
| Water Consumption Cost | A\$2.7/kL |
| <i>Powerplant Parameters</i> | |
| <i>Powerplant Capacity</i> | |
| Powerplant Configuration | Standalone |
| Powerplant Type | Hybrid |
| Powerplant Oversizing ratio | 2 |
| Hybrid Mix | 50%:50% |
| <i>Powerplant Efficiency</i> | |
| Powerplant Degradation Rate | 0% |
| <i>Powerplant Capital and Operating Costs</i> | |
| Power supply option | Self Build |
| <i>Powerplant Equipment Costs</i> | |
| Solar Farm Purchase Cost | 1200 \$/kW |
| Reference Solar Farm Scale | 1000 kW |
| Solar Farm cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| Wind Farm Purchase Cost | 2000 \$/kW |
| Reference Wind Farm Scale | 1000 kW |
| Wind Farm cost reduction with scale | 10% |
| Reference fold increase for economies of scale to occur | 10 |
| <i>Powerplant Installation Costs</i> | |
| EPC/Installation Costs of Solar Farm | 30% |
| Land Development Cost of Solar Farm | 6% |
| EPC/Installation Costs of Wind Farm | 30% |
| Land Development Cost of Wind Farm | 6% |
| <i>Powerplant Operating Costs</i> | |
| Solar Farm O&M | 17000 \$/MW/yr |
| Wind Farm O&M | 25000 \$/MW/yr |
| <i>PPA Costs</i> | |
| PPA Costs | 65 \$/MWh |
| <i>Grid Connection Costs</i> | |
| Grid Connection Costs | \$ 1000000 |
| Grid Usage Charges | 10 \$/MWh |
| <i>Battery Parameters</i> | |
| <i>Battery Capacity</i> | |
| Battery Rated Power Capacity | "set to equal Methane and carbon capture plant instantaneous power demand" |
| Battery Storage Duration | 8 hr |
| <i>Battery Performance</i> | |
| Round Trip Efficiency | 85% |
| Battery Minimum State of Charge | 0% |

| | |
|--------------------------------------------|----------------|
| Battery Lifetime | 10 yrs |
| Battery Capital and Operating Costs | |
| Battery System Equipment Costs | |
| Battery System Purchase Costs | A\$380/kW |
| Battery Systems Installation Costs | |
| Battery System Installation Costs EPC | 0 |
| Battery System Land Costs | 0 |
| Battery Operating Costs | |
| Battery O&M Costs | 10000 \$/MW/yr |
| Battery Replacement Costs | 100% |
| Cost Analysis | |
| Discount Rate | 7% |
| Project Timeline | 25 years |