Common Evaluation Methodology (CEM)

Cost Benefit Analysis User Guide (Version: 3.0)

Contents

1 Introduction

This document is a User Guide for the Common Evaluation Methodology (CEM) Cost Benefit Analysis (CBA) tool, and should be read in conjunction with version 3 of that tool (**CEM Tool v3.0**).

The primary purpose of the tool is to allow the user to assess the merits of deferring reinforcement (or similar capex solutions) by employing flexibility solutions (e.g. Demand Side Response) for one or more years, although it can be used for evaluating a range of intervention options. The model allows the user to test different flexibility strategies under different load growth scenarios. It also provides insights that should help the user to make strategic decisions when uncertain about which network load growth scenarios will outturn. This document provides guidance on how to populate and interpret each worksheet within the model, as described in each of the sub-sections below.

2 Quick start guide

The CEM can be used to assess the relative costs and benefits of a range of network planning and operational solutions. However, if the user is investigating the most 'standard' use case, they can follow the Quick start guide laid out in this section. The 'standard' use case involves:

- A baseline that involves **reinforcement** of a network asset in **Year 1** of the model
- The use of **flexibility** (e.g. demand turn-down or generation turn-up) to defer that reinforcement
- **Five load growth scenarios**, with a view on the expected volume of availability and utilisation of flexibility services that would be required in the next 12 years.

If those conditions are met, the user can import the input values from the ***default_inputs*** worksheet, before changing the specific values to align to their particular case. The process the user should follow is as follows:

1. Type 'default_inputs' into cell ***Control*** !I12 and make sure that J12 is green (verifying that the named import worksheet exists. Click the **Import input parameters** button. The tool will warn you that this will overwrite any existing inputs. If you are sure you want to proceed, click **'OK'**

2. Replace the reinforcement cost (set by default to £1,000,000) in '**Baseline Reinforcement'!D48**, using the actual reinforcement cost for your specific intervention.

BASELINE REINFORCEMENT AND UPFRONT CAPEX (TO BE DEFERRED)		2024	2025
Cost 1	£	1,000,000	
Cost 2			
Cost 3			
Total	**£**	**1,000,000**	

3. In the **Flex Volume and Cost inputs** worksheet, cells D7 and D8, enter the Availability Price (default: £5/MW/h) and Utilisation Price (default: £10/MWh) you want to test.

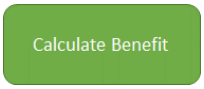
Initial flexibility price assumptions	
Availability Price (£/MW/h)	£5.00
Utilisation Price (£/MWh)	£10.00

4. For each scenario, replace the default availability and utilisation volumes (**Flex Volume and Cost Inputs** worksheet, rows 119 to 139) that you expect to be required in each year to defer the reinforcement (i.e. enough to offset the extent that the expected peak demand exceeds the firm capacity of the asset).

Total capacity of availability procured each year (MW.h/y)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Flexibility under Best view	1,500.0	1,700.0	1,800.0	2,000.0	2,200.0	2,400.0	2,600.0	2,800.0	3,000.0	3,200.0	3,400.0	3,600.0
Flexibility under Consumer Transformation	1,400.0	1,570.0	1,950.0	2,400.0	2,960.0	3,350.0	4,030.0	5,460.0	7,140.0	8,720.0	10,760.0	12,980.0
Flexibility under Falling Short	500.0	510.0	630.0	750.0	890.0	1,050.0	1,250.0	1,620.0	1,970.0	2,390.0	2,640.0	2,920.0
Flexibility under Leading the Way	1,800.0	2,310.0	2,680.0	3,110.0	3,590.0	4,280.0	5,440.0	6,950.0	8,810.0	10,750.0	12,950.0	15,180.0
Flexibility under System Transformation	1,200.0	1,340.0	1,500.0	1,680.0	1,870.0	2,160.0	2,380.0	2,680.0	3,000.0	3,300.0	4,650.0	5,400.0

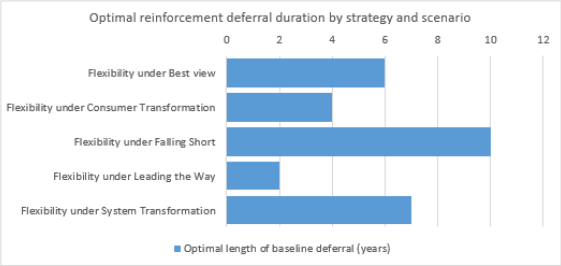
Expected annual volume of utilisation dispatched (MWh/y)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Flexibility under Best view	1,200.0	1,360.0	1,440.0	1,600.0	1,760.0	1,920.0	2,080.0	2,240.0	2,400.0	2,560.0	2,720.0	2,880.0
Flexibility under Consumer Transformation	1,120.0	1,256.0	1,560.0	1,920.0	2,368.0	2,368.0	3,224.0	4,368.0	5,712.0	6,976.0	8,608.0	10,384.0
Flexibility under Falling Short	400.0	408.0	504.0	600.0	712.0	840.0	1,000.0	1,296.0	1,576.0	1,912.0	2,112.0	2,336.0
Flexibility under Leading the Way	1,440.0	1,848.0	2,144.0	2,488.0	2,872.0	3,424.0	4,352.0	5,560.0	7,048.0	8,600.0	10,360.0	12,144.0
Flexibility under System Transformation	960.0	1,072.0	1,200.0	1,344.0	1,496.0	1,728.0	1,904.0	2,144.0	2,400.0	2,640.0	3,720.0	4,320.0

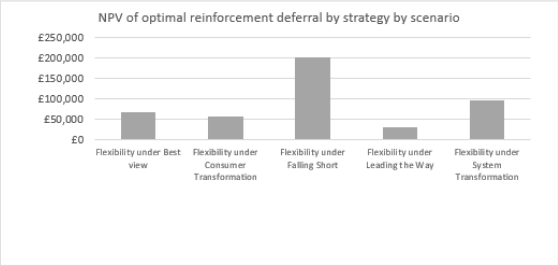
5. Go to the **Additional inputs and control** worksheet and click the **Calculate Benefit** button



6. Review the **Benefit by Strategy** worksheet to see a range of metrics relating to the case for using flexibility vs reinforcement. In particular, the ***Optimal reinforcement deferral duration by strategy and scenario*** chart shows for each scenario the number of years that flexibility is lower cost than reinforcement (in Net Present Value (NPV) terms), and the ***NPV of optimal***

reinforcement deferral by strategy and scenario chart, which shows the relative NPV of pursuing flexibility for those optimal numbers of years.





In the default example, flexibility is the preferred approach (rather than reinforcement) for all scenarios. In the 'Best view' this would be true for 6 years of flexibility. Other scenarios have different volumes (and hence costs) of flexibility, so have different optimal lengths of flexibility contracts. The user can conclude that 2 years of flexibility is NPV positive across all scenarios.

7. Review the **Simple Ceiling Price** worksheet, which shows the maximum ceiling price and availability price that would deliver a positive NPV for a 1-year flexibility contract.

Maximum justified availability price and annual cost of a 1 year flexibility contract

Configuration	Ceiling availability price (£/MW/h)	Ceiling utilisation price (£/MWh)	Average annual contract cost ceiling (£)
Flexibility under Best view	11.5	23.0	£44,770
Flexibility under Consumer Transformation	12.3	24.6	£44,770
Flexibility under Falling Short	34.4	68.9	£44,770
Flexibility under Leading the Way	9.6	19.1	£44,770
Flexibility under System Transformation	14.3	28.7	£44,770

By default, the ratio between availability and utilisation prices will be consistent with the ratio of prices set on the **Flex Volumes and Cost inputs**. Note that the **Simple Ceiling Price** weighs the cost of 1 year of flexibility (by default, but can be change in **Flex Volume and Cost Inputs** worksheet, cell D17) against the immediate benefit of a 1-year reinforcement deferral. It does not account for any further upside that may be released by opting not to commit to reinforcement (i.e. the option value of flexibility).

For any single scenario, there will be no further upside provided that the flexibility volume requirement increases year on year (i.e. gradual exceedance growth). However, the cross-scenario approaches (Least Worst Regret and Weighted Average) can exhibit additional upside. If the user wants the ceiling price to include ongoing deferral benefits, they may want to move to Step 7a:

7a. Go to the **Additional inputs and control** worksheet. Set the Maximum price for goal seek (K21) to the highest price you want the tool to test (this should be at least the value shown in K20). Set the Goal seek increment change the granularity of the resulting price (n.b. the tool takes 1-2 seconds per increment to run). Click the Calculate Ceiling Price button, and look at the **Ceiling Price** worksheet for the results.

Calculate Ceiling Price

3 Guidance by worksheet

Intro worksheet: Guidance

Intro

- **Purpose of CBA:** Describes the aim of the investment decision

Inputs

- **Control:** Defines modelling parameters and run analysis.
- **Baseline Reinforcement:** Reinforcement costs and site capacity (current, projections by scenario). The Baseline strategy is the reinforcement option in this tool.
- Flex cost inputs (2 variants depending on Control settings):
  a. **Flex Cost Inputs:** Flexibility cost estimates are input directly.
  b. **Flex Volume and Cost Inputs:** Flexibility volume requirements and price assumptions are input.
- **Flex Costs Summary:** Summary flexibility cost data given selected inputs, including option to add in multi-year flexibility procurement discounts.
- **Incentives, Penalties & Societal Impacts:** Impacts related to incentives and penalties for each scenario i.e. losses, CIs, CMLs.
- **Fixed Inputs:** Financial assumptions and prices applicable to your business.
- **Embedded emissions inputs:** GHG emissions per asset installed in the baseline reinforcement option.
- **Carbon impacts:** GHG emissions associated with changes in losses, embedded carbon, the flexibility service procured and other sources defined by the user.
- **Workings:** (Optional input) Calculations used to derive flexibility requirements and/or incentive-related impacts.
- **Additional inputs and control:** Additional inputs on selected scenario, maximum flex availability, and scenario probabilities.

Analysis and Insights

- **Benefit by strategy:** CBA results showing the Net Present Value (NPV) by scenario, strategy and deferral duration.
- **Insights and Reporting:** Insights on optimal deferral years and maximum flexibility value for specific strategies and scenarios, and across scenarios on a Least Worst Regret and Weighted Average basis.
- **Simple Ceiling Price:** Calculates the availability ceiling price (or indifference price) above which flexibility of any duration is sub-optimal, excluding any residual benefit beyond the initial contract duration.
- **Ceiling Price:** Calculates the availability ceiling price (or indifference price) above which flexibility of any duration is sub-optimal.

- **Option value:** Presents results with and without the consideration of uncertainty in load growth scenarios.

Background calculations

- **Comparison, Baseline & Config1-10:** Worksheets with no user input required. The NPV of each option (Baseline, and up to ten combinations of scenarios and strategies) is calculated, following the standard Ofgem CBA methodology. The NPV results are linked through and presented in the Analysis and Insights worksheets.
- **Ofgem CBA tabs>>>Fixed data:** Holds the fixed data from the Ofgem CBA template. Only to be updated when the Ofgem template changes.
- **compiled_inputs:** Summarises the input parameters in the current instance of the model, structured in 'long' format. Not to be used or edited directly by the user, as this is used for saving and importing input parameters
- **default_inputs, saved_inputs, Use_case_[n]:** Worksheets structured in the same way as the compiled_inputs worksheet, but with hardcoded values. Can be used for importing new values (e.g. from the default_inputs worksheet) or saving the current instance of the model, by using the buttons on the **Control** worksheet.

Intro worksheet: Purpose of CBA

The user documents the network need, and the options that the CBA is being used to evaluate. This has no impact on any calculations in the model, but allows a future user to understand the intent of the particular model setup.

Inputs worksheet: Control

In this worksheet, the user sets the parameters for the modelling run, including the model start year. All prices in the model should be input in real terms aligned to this year. NPVs are calculated by discounting future costs and benefits back to the Reference year.

The user chooses whether to input the baseline exceedance directly or to derive it from network load and rated capacity. This choice will hide redundant rows in the **Baseline Reinforcement** worksheet.

The user chooses whether to input flexibility cost assumptions directly, or to input flexibility volume and price assumptions in order to derive flexibility costs. Each input method has its own input worksheet, so this choice will hide the worksheet not used. Also, by inputting flexibility costs directly, the **Ceiling Price** and **Option value** logic is non-functional, so these worksheets becomes hidden if this option is selected.

The user then chooses a list of scenarios and strategies, up to a total of 10 "configurations". We define these as follows:

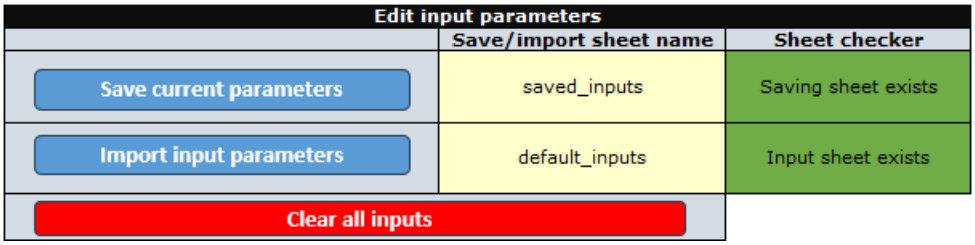
- **Scenario:** A scenario that defines the load growth for the network, e.g. "Steady Progression"
- **Strategy:** What the DNO will do to mitigate the exceedance that arises from the scenario, e.g. "Flexibility"

- **Configuration:** The combination of strategy and scenario that will be tested by the model, e.g. Flexibility under Steady Progression

The user can input a long list of scenarios and strategies, then select from this list using the drop-down. Configurations must be listed from Config1 down (i.e. you can populate Config1-4 then leave the rest blank, but do not populate only Configs 1, 3, 5 and 7).

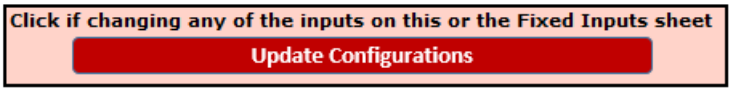
For each configuration, the model specifies the last year at which a strategy can be effective. This is based on the volume of flexibility (in MVA) required to accommodate the load growth, and the maximum flex availability specified by the user on the **Additional inputs and control** worksheet.

The user can save down all inputs into a specified worksheet, or can import all inputs from a specified worksheet, such as a pre-populated **default_inputs** worksheet. This is done by specifying the relevant worksheet names in the Save/import worksheet name cells, and clicking the **Save current parameters** or **Import input parameters** buttons. The user can also choose to **Clear all inputs**, which will empty **all** yellow input cells. This is generally not advised, as some of the inputs do not typically need to be changed for each use of the model.



It is advised whenever clearing inputs or importing new inputs to first save down the existing inputs. The best way to do this is to find the **default_inputs** worksheet, right click on it, choose 'Move or copy…', tick the 'Create a copy' box, then give the created worksheet your preferred name (e.g. saved _[asset_id]_[date]). Then insert that new name into Control!I9, and click the Save current parameters button.

Once the parameters are chosen, in order to set up the model correctly the user must click:



This will hide redundant worksheets and rows.

Inputs worksheet: Baseline Reinforcement

This worksheet calculates the exceedance of the network under each scenario, and the Baseline reinforcement expenditure profile (n.b. only one Baseline can be defined for any given instance of the model, which then applies to all scenarios). Depending on the parameter chosen in the **Control** worksheet, the user can either input the exceedance profile directly for each scenario, or can input the network load growth and the assumed network capacity.

The important outputs of this worksheet are:

- the **baseline expenditure profile**

BASELINE REINFORCEMENT AND UPFRONT CAPEX (TO BE DEFERRED)		2024	2025
Cost 1	€	1,000,000	
Cost 2			
Cost 3			
Total	€	1,000,000	

- the **intervention start year**, which is the first year that exceedance occurs in the selected control scenario.

In cell ***D4*** the user can choose one of two ways to determine at which year an intervention is first required:

1. **Manual input:** The user states in which year some form of intervention is needed, in which case the model will use the value chosen in cell ***D5***
2. **Determined by scenario:** The user chooses a load growth scenario (in cell ***D6***), which the model then uses to calculate the first year in which an intervention is required.

The subsequent years of exceedance should correspond to the flexibility requirements in the **Flex Costs Summary** worksheet.

Inputs worksheet: Flex input a) Flex Costs Inputs

Note: Worksheet only visible and used if flex_cost_input_type (in Control worksheet) is set to "Input all flex costs directly"

The user specifies their projection of the costs associated with flexibility procurement. Where there are upfront or fixed costs that could be shared between schemes (e.g. central dispatch control), it is up to the user to decide how to apportion those costs to the particular scheme being tested in the CBA. As a general rule, when deciding whether to use flexibility in this particular scheme, costs that have already been incurred (e.g. central dispatch control systems) should not be included in this CBA since they are 'sunk' and cannot be avoided by choosing not to do flexibility in this particular instance.

Upfront costs are incurred regardless of how long the flexibility strategy is pursued. However, the other costs (annual fixed costs, availability costs and utilisation costs) are only incurred if the flexibility strategy is active. ***For example, even if availability costs are specified over a 10-year horizon, if the model is considering the value of a 2-year baseline deferral, it will only consider 2 years of availability costs.*** Therefore, the user can populate the model with a full horizon of cost projections, then use the model to test the Net Present Value (NPV) of different deferral periods.

Inputs worksheet: Flex input b) Flex Volume and Cost Inputs

Note: Worksheet only visible and used if flex_cost_input_type (in Control worksheet) is set to "Flex Costs from Volumes"

The user sets the initial price assumed for availability and utilisation, along with a trajectory for availability prices over time to account for possible price trends in the market.

Initial flexibility price assumptions	
Availability Price (£/MW/h)	£125.00
Utilisation Price (£/MWh)	£175.00

Availability price trend assumption	2024	2025
Price trend	100%	100%
Effective availability price (£/MW/h)	125.00	125.00
Effective utilisation price (£/MWh)	175.00	175.00

The user also indicates the first year of flexibility (which will typically be when reinforcement is otherwise required), and the length of the initial contract (1 year by default). If a longer contract is specified (e.g. 3 years), the user can specify two further parameters:

1. **Contract shaping logic:** If this is set to ***'Ramping'***, the model will assume that the flexibility required aligns with the annual flexibility requirement specified further down on this worksheet (e.g. growing year on year as the exceedance increases). This may be appropriate if the DNO thinks it can increase the volume of flexibility procured over the three-year period, for example. If, instead, this parameter is set to ***'Flat'*** the model will assume that the flexibility contract will need to be sized to the maximum level needed to cover the entire contract period (e.g. procuring enough availability across all three years to ensure there is sufficient capacity in year 3). This may be appropriate if, for example, flexibility is to be provided by a single large asset (e.g. a battery) sized to meet the Year-3 need, but that needs that full contract from Year 1 onwards.
2. **Apply discount for longer contracts:** Set to ***'No discount'*** by default, the user can change this to ***'Discount'*** and set values for the ***Multi-year discount (input)***. This will apply an additional discount to the flexibility contracts depending on the contract length. This may be useful if the DNO believes that longer contracts – while committing the DNO for more time – can be secured at lower cost than shorter contracts.

The user then specifies, for each configuration:

- **Upfront fixed costs:** These are incurred regardless of how long a flexibility strategy is in place (i.e. even if reinforcement is only deferred by 1 or 2 years)
- **Annual fixed costs:** These costs are only incurred whilst the flexibility strategy is in place (i.e. if reinforcement is only deferred for 2 years, these costs will only be incurred for 2 years, even if there are costs in this input from year 3 onwards)

Finally, the user inputs the volumes of availability and utilisation they expect to be required in each year in order to defer the reinforcement (or for any other use case being considered). The user first chooses the **Flex input method.**

Flex input method
MWh/MW.h

- If they choose to set this as *MWh/MW.h*, they specify the expected volumes directly.

	Total capacity of availability procured each year (MW.h/y)	2024	2025
1	Flexibility under Best view	1,500.0	1,700.0
2	Flexibility under Consumer Transformation	1,400.0	1,570.0
3	Flexibility under Falling Short	500.0	510.0
4	Flexibility under Leading the Way	1,800.0	2,310.0
5	Flexibility under System Transformation	1,200.0	1,340.0

	Expected annual volume of utilisation dispatched (MWh/y)	2024	2025
1	Flexibility under Best view	1,200.0	1,360.0
2	Flexibility under Consumer Transformation	1,120.0	1,256.0
3	Flexibility under Falling Short	400.0	408.0
4	Flexibility under Leading the Way	1,440.0	1,848.0
5	Flexibility under System Transformation	960.0	1,072.0

- If instead they set this to *Hours-days-average* they will need to specify the *hours per day* and *days per year* that flexibility is required, along with the *average availability and utilisation* volumes required in the average hour.

Inputs worksheet: Flex Costs Summary

Summarises the flexibility costs based on the user inputs, either from the Flex Cost Inputs worksheet or the Flex Volume and Cost Inputs worksheet, depending on the chosen state of the ***flex_cost_input_type*** parameter (Control!B13).

Inputs worksheet: Fixed Inputs

This worksheet contains all fixed parameters as per the Ofgem CBA template. The values are consistent with the CBA template published by Ofgem for RIIO ED2 and should be updated accordingly for future changes in the template.

The user should enter the capitalisation rate and pre-tax WACC that are specific to their DNO.

Capitalisation rates	75%
pre-tax WACC	5.0%

Inputs worksheet: Incentives and Penalties

The user can populate this worksheet with other benefits or adverse impacts associated with either the Baseline or one of the selected strategies. This includes losses, Customer Interruptions (CIs), Customer Minutes Lost (CMLs), and other environmental and safety metrics.

Strictly, this should only include metrics against which a DNO is incentivised, with the cost or benefit relating to the appropriate rate set in the Final Determinations. However, the tool does have functionality to consider other societal benefits such as CO_2 emissions (see below). If populated, these wider societal benefits will be included in the overall NPV of a strategy, even if the cost or benefit does not strictly accrue to the DNO (i.e. these may be customer or wider societal benefits).

The unit cost or value associated with these is set in the **Fixed Inputs** worksheet. The purpose of this worksheet is to allow the user to reflect that a strategy may have different outcomes compared to the Baseline (e.g. using flex may incur higher or lower losses than conventional reinforcement). So whilst non-zero values can be entered into the Baseline, the model only considers the delta between the Baseline and each strategy. For this reason, it may be clearer to leave the Baseline values in the Incentives, Penalties and Societal Impacts worksheet as zero, and assess all strategies relative to this Baseline.

As with the flexibility costs (excluding upfront costs), any incentives or penalties will only be taken into account whilst the flexibility strategy is being enacted, even if the user inputs costs and benefits over a longer horizon. For example, if flexibility is used for 2 years, the net societal costs and benefits from years 3 onwards will be zero.

Inputs worksheet: Embedded Emissions Inputs

This worksheet calculates the embedded GHG emissions (tCO_2e) in the baseline reinforcement option. It allows the user to insert information on the number of assets installed and the embedded GHG emissions in each asset. The worksheet is populated with preliminary estimates of the embedded carbon which the user should review and update accordingly.

As with the baseline reinforcement costs, any embedded carbon associated with the reinforcement will be deferred through the use of flexibility.

Inputs worksheet: Carbon Impacts

This worksheet collates and calculates the GHG emissions (tCO_2e) associated with each configuration and the monetary value of changes in emissions based on the carbon prices specified in the **Fixed Inputs** worksheet.

The worksheet is separated into four areas:

- Emissions associated with losses
- Embedded emissions in the reinforcement option
- Emissions associated with the energy used to meet capacity requirement (i.e. the flex option)
- Other emissions impacts

The emissions associated with losses and the embedded emissions[1] in the reinforcement option are calculated automatically based on the inputs provided by the user in the **Incentives and Penalties** worksheet and **Embedded Emissions Inputs** worksheet.

The emissions associated with the energy used to release additional capacity at the site captures the emissions intensity of the energy used for the flexibility solution relative to the baseline reinforcement option. The user should enter the emissions factor of each option over time, factoring in changes in the generation mix and efficiency of solutions where appropriate. The table below provides examples for the potential source for these assumptions based on the type of intervention in each option.

Type of intervention	Source of energy to meet capacity requirement	Relevant emissions factor

[1] Note that where embedded emissions are deferred through the use of flexibility (e.g. delaying the date at which transformer reinforcement is required), the value of carbon (£/tonne) is kept aligned to the Baseline year, rather than reflecting the price in the year in which the deferred reinforcement occurs. The alternative would be to reflect the carbon price in the year in which reinforcement actually occurs. However, because the carbon price increases over time, this would mean that deferring the installation of carbon-intensive equipment would be seen as a negative. We do not believe that this approach would be appropriate in this context. However, whilst we believe that our proposed approach leads to sensible model behaviour, we recognise that there may be alternative approaches that we have not considered. This area may, therefore, require further consideration in the future.

Reinforcement	Electricity from the grid	Marginal electricity GHG conversion factor in Fixed Inputs worksheet
Diesel, gas or other fuel generators	Diesel, gas or other fuel	Emissions factors from Defra guidance on GHG reporting
Battery storage with renewables as the source	Electricity from renewables	Zero
Energy efficiency	Demand reduction	Zero
Demand side response	Electricity from the grid	Depends on where load is being shifted from and to in the day (i.e. peak or off peak)

The model combines the difference in emissions factors with the utilisation data to calculate the change in emissions associated with the energy used to meet the capacity requirement. All other differences in emissions can be recorded in the other emissions impacts section.

Inputs worksheet: Workings

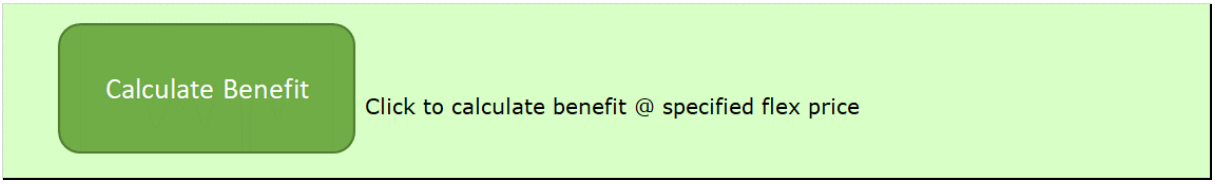
This worksheet allows the user to insert background workings to some of the manual entry inputs in the "Flexibility Requirements" and "Societal Impacts" worksheets (or other inputs) as appropriate. Note, this worksheet has no effect on the calculations within the model.

Inputs worksheet: Additional Inputs and Control

This worksheet allows to set additional constraints and inputs that influence the calculations in the model. This includes:

- **Scenario for intrinsic value calculation:** In order to calculate the 'intrinsic value' of flexibility (i.e. its value when there is no load growth uncertainty) the user needs to specify which scenario is acting as the central view. This influences the representation of option value on the **Option value** worksheet
- The **maximum amount of flexibility available** across all scenarios in MWh/y or MW.h/y (i.e. the maximum volume of flexibility that the user believes can be procured to address the constraint
- The probability assigned to each scenario (used for the Weighted Average approach) represented on the **Insights and Reporting** and **Option value** worksheets.

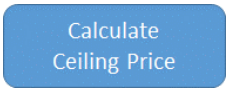
This worksheet also allows the user to run the model. In order to calculate the benefit at the specified flexibility input price, the user clicks:



In order to calculate the ceiling price, the user first specifies the search parameters:

- **Price varied for ceiling price goal seek:** The user can vary the *Availability* price only (using the input utilisation price), the *Utilisation* price only (using the input availability price) or one of the *lock ratio* settings, which will keep the ratio between the utilisation price and availability price consistent with the input values (incrementing either on the availability or utilisation price in the goal seek).
- **Goal seek increment:** The steps by which the price (MWh/y for utilisation or MW.h/y for availability) will be incremented as the tool searches for the ceiling price.
- **Maximum price for goal seek:** The highest utilisation or availability price that the tool will test in the goal seek (n.b. the maximum of the Simple Ceiling Price calculation is shown in cell K20 as an indicative value, which is typically equal to or lower than the value that will be calculated for the Ceiling Price).

Once these settings have been specified, the user clicks the Calculate Ceiling Price button.



Note: Unless these buttons are clicked, the Analysis and Insights worksheets will not update and will not correspond to the input values.

Analysis and Insights worksheet: Benefit by strategy

This is the first output worksheet, and shows the benefit of each strategy under each scenario. These representations are also shown graphically within the tool in four charts:

- **Optimal reinforcement deferral duration by strategy and scenario:** Shows the length of deferral that gives the highest NPV
- **NPV of optimal reinforcement deferral by strategy by scenario:** Shows the NPV of the optimal deferral length, i.e. the maximum NPV that can be achieved
- **Cumulative NPV of deferring by a number of years vs the baseline strategy:** Shows the NPV of deferring the baseline expenditure by a certain number of years, i.e. the cumulative benefit of each year of deferral to the specified duration (e.g. “Defer by 3 years to 2027”)
- **Marginal NPV of deferring from one period to the next:** Shows the benefit of deferring by an additional year (or, where the modelled years are non-consecutive, from one snapshot to the next) i.e. the marginal benefit (e.g. “Defer from 2026 to 2027”).

Detailed results tables are given below the charts. In order to understand what is described in each of these tables, it is important to remember the two separate questions that this tool is addressing:

1. **Total strategy duration and value:** For a given strategy (e.g. flexibility) under a given scenario (e.g. Steady Progression), for how long does it make sense to defer the Baseline (reinforcement) costs, and what is the value of doing so?
2. **Initial contract duration and value:** For a given strategy and scenario, how long should the initial flexibility contract (or similar) be, and what is the value of deferring the baseline costs for that period?

The model recognises that even if it makes sense, knowing what we know today, to defer reinforcement for, say, 4 years, the DNO does not necessarily need to sign up to a 4-year flexibility contract on day 1. It can instead secure, say, an initial 3-year flexibility contract, then procure an additional year of flexibility once that initial contract expires, if the CBA for doing so is still positive at this stage. Where a minimum contract length is specified, the model automatically adjusts the results to show the NPVs for the contract duration, and for each additional year thereafter.

The tables in this worksheet show three sets of results:

1. **Benefit of initial deferral (cumulative and marginal):** These show the NPV of deferring the Baseline (reinforcement) costs by n years (where n is the number of years in the header row), taking account of any discount associated with multi-year contracts. Data appear from the final year of the minimum contract length, where specified. Note that these results are shown both on a cumulative and a marginal basis. For the cumulative view, the optimal number of deferral years should correspond to the maximum NPV, which will be highlighted in green. Although subsequent deferral years may still show a net positive NPV overall, the fact that the cumulative NPV is below this optimal level means that value is being eroded. This will be reflected in the Marginal benefit table.
2. **Residual benefit after initial deferral:** This shows the additional NPV that can still be secured by signing additional flexibility contracts after the initial n-year contract. The model assumes that no multi-year discounts apply to these subsequent contracts.
3. **Overall benefit:** Shows the total NPV (initial + subsequent) associated with flexibility contract(s) of n years' duration. The optimal deferral length (or deferral lengths) is highlighted in green. Note that the model may show a number of years with the same optimal NPV outcome. This will be because the cost of rolling 1-year flexibility contracts has the same cost as procuring the full optimal deferral length in one go.

Analysis and Insights worksheet: Insights and Reporting

This worksheet summarises the results from the **Benefit by strategy** worksheet. It also provides additional analysis to identify which strategy would be optimal, and over how many years, given the uncertainty associated with having multiple possible future scenarios.

This first section simply summarises the **Benefit by strategy** findings. It shows for how many years Baseline (reinforcement) deferral has a positive NPV, and what that NPV is. It also breaks this NPV into the initial value (associated with the initial flexibility contract) and the subsequent value (any further deferral that can be achieved after the initial contract has expired).

Up to this point, each scenario and strategy has been treated individually. However, the DNO needs to make a decision regarding the procurement of flexibility (or some other strategy) without knowing which scenario will outturn. This worksheet provides two methods for making this assessment:

- **Analysis: Least Worst Regret method** - This section presents the results of a Least Worst Regret approach.[2] In the case of flexibility, this analysis reveals the initial flexibility contract length that gives you the "least worst" regret across all the modelled scenarios. This is typically a short contract length, since this allows you to lock in the benefit under most or all scenarios, whilst avoiding procuring flexibility in those scenario years where

[2] Regret is defined as the maximum benefit that you could have achieved under a given scenario minus the benefit that you actually achieved.

the NPV may subsequently go negative (i.e. where the cost of flexibility is higher than the benefit of deferral and associated incentive-related benefits).

- **Analysis: Weighted Average method** – This section allows the user to apply probabilities to each scenario, then to calculate the weighted average NPV by strategy. This tells the user what NPV they should expect to secure by procuring, say, a flexibility contract of n years. The analysis then identifies the optimal value for n (i.e. how long the contract should be) and what the expected NPV would be (again noting that even if the contract is short, there is still subsequent value that is taken into account).

Analysis and Insights worksheet: Simple Ceiling Price

Note: This worksheet is only usable if flex_cost_input_type (on the Control worksheet) is set to "Flex Costs from Volumes", i.e. the user calculates the cost of flexibility on the basis of explicit flexibility volumes and flexibility prices.

This worksheet calculates the availability price at which the user should be indifferent to a Baseline or a flexibility-type strategy. Below that price, flexibility has a positive NPV for the initial flexibility contract length.

Note that this worksheet delivers much of the same functionality as the Ceiling Price worksheet (see below), but calculates the results directly without the user needing to click a button. However, the key difference is that this worksheet does not take into account any **residual benefit after initial deferral** (as described in the ***Analysis and Insights worksheet: Benefit by strategy*** section above). In other words, it only considers the cost of the initial flexibility contract (of duration specified by the user) and the value of deferring reinforcement by that specified duration.

In the case of any single configuration, provided that flexibility costs increase over time (e.g. increasing volume requirements, with no cost reductions occurring at future dates), the result should align with the Ceiling Price (and indeed will give a more accurate result since the ceiling price is calculated algebraically, rather than using a goal seek logic). However, if the need for flexibility is only temporary, or of costs are expected to fall over time, the user may wish to use the Ceiling Price logic in full to check whether there is additional upside.

Note also that for the cross-scenario analyses (Least Worst Regret and Weighted Average) there may be divergence with the full Ceiling Price calculation, even if flexibility requirements are always increasing. If the user is relying on the LWR or WA for decision-making, they should consider running the full Ceiling Price goal seek to check whether any residual value beyond the initial contract needs to be considered.

Analysis and Insights worksheet: Ceiling Price

Note: This worksheet is only usable if flex_cost_input_type (on the Control worksheet) is set to "Flex Costs from Volumes", i.e. the user calculates the cost of flexibility on the basis of explicit flexibility volumes and flexibility prices.

This worksheet calculates the availability price at which the user should be indifferent to a Baseline or a flexibility-type strategy. Below that price, flexibility has a positive NPV for at least the minimum flexibility contract length, whereas above that price the NPV of flexibility will be negative.

The user specifies an initial Availability and Utilisation price on the **Flex Volume and Cost Inputs** worksheet, along with the availability price trend, availability and utilisation volumes, fixed costs, any incentives or penalties, and any assumed discount associated with multi-year flexibility contracts.

The model will search based on the settings in the **Additional inputs and control** worksheet in the specified increments from a zero availability or utilisation price up to the maximum price.

The worksheet reports, for each strategy under each scenario, the availability and utilisation ceiling price, i.e. the price above which the strategy does not give a positive NPV for any flexibility contract length. It also shows the maximum average annual cost (including fixed, availability and utilisation fees) above which flexibility is not justified.

This worksheet also shows the ceiling price for the initial contract when applying the Least Worst Regret and Weighted Average valuation methodology. As well as the ceiling availability price, it shows the ceiling flexibility cost, although it should be noted that the tool uses the flexibility volume associated with the 'best view' scenario in order to make this calculation.

Analysis and Insights worksheet: Option Value

This worksheet separates the results from the **Benefit by strategy** worksheet and **Insights and Reporting** worksheet into the intrinsic value and extrinsic value under each strategy.

The ***intrinsic value*** shows the value of deferring reinforcement in the absence of any uncertainty (i.e. under the 'Best View' scenario). The ***extrinsic value*** or ***uncertainty benefit*** captures the additional value provided by flexibility given the uncertainty associated with having multiple possible future scenarios. This uncertainty benefit is calculated using a weighted average of the probability of each scenario specified by the user in the **Additional Inputs and Control** worksheet.

Background calculations: Comparison, Baseline, Config[n] and Flex_cost_calc

These are calculation worksheets and should not be changed by the user.

Ofgem CBA worksheets: Fixed Data

This is a direct mirror of the Fixed Data worksheet from the Ofgem CBA template. It should not be edited by the user, except to be updated in line with future releases of the Ofgem CBA template. Note that if future templates present the Fixed Data in a different way (e.g. with values in different cells) the user may need to fix the references to this worksheet to ensure consistency and functionality.

compiled_inputs and subsequent worksheets

The **compiled_inputs** worksheet references all current inputs in the tool, presenting them in 'long' form. The user does not need to, and should not, change the formulae on this worksheet.

The remaining worksheets in the tool mirror the structure of the **compiled_inputs** worksheet, but are used either to save instances of inputs in the model, or to load new inputs from a saved version of the model. The user can save the current version of the tool (using the relevant button on the

Control worksheet) into the **saved_inputs** worksheet, or can duplicate this worksheet to save down different version of the inputs. Similarly, the user can load inputs from the **for_import** worksheet, or can load from any previously saved version that they have created.

4 Use Cases

This section describes some of the different ways in which the CEM CBA tool can be used. This includes the primary use case (the deferral of conventional reinforcement through the procurement of flexibility services). It also includes variants that can be examined, including an ANM use case and an energy efficiency use case.

Use Case 1: Flexibility for reinforcement deferral

The guidance in the previous section is written with the primary use case in mind: the user specifies the costs associated with a flexibility contract, and compares it to the benefit of reinforcement deferral, along with any associated incentive-related costs or benefits.

It is worth noting that 'flexibility' can take different forms. The language of the model describes availability payments and utilisation volumes, which relate to flexibility service agreements. However, if the user wants to investigate the use of, say, purchasing flexibility as a service from a temporary battery or generator they can use the same input fields to specify perhaps the 'annual service fee' and the 'annual usage cost'.

What is important for the model is that the annual cost of flexibility is calculated, and then compared with the value of reinforcement deferral and associated incentive-related benefits.

Use Case 2: Flexibility for incentive-related improvement

In some cases, the user may be considering the use of flexibility not to defer reinforcement, but to address some other issue on the network. For example, flexibility might be able to reduce customer outages, thereby improving Customer Interruptions and Customer Minutes Lost (CIs & CMLs) and other customer service metrics.

To reflect this in the tool, on the **Baseline Reinforcement** worksheet the user should set the 'Baseline reinforcement and upfront capex' to zero. This will set the 'Intervention start year' to the start of the modelling horizon. The model will then simply compare the cost of flexibility (summarised in the **Flex Costs Summary** worksheet) to the net benefit associated with the inputs on the **Incentives, Penalties and Societal Impacts** worksheet.

As with all Use Cases, the user needs to ensure that the flexibility costs specified are consistent with what can be procured, and that they are specified for the entire modelling horizon. If the user only provides flexibility costs for 5 years, for example, but shows incentive-related benefits for 45 years, the model will infer that after the first 5 years the cost of flexibility is effectively zero. If the user only wants to consider up to 5 years of NPVs they can either set both the flex costs and incentive-related benefits to zero from year 6 onwards, or can use the 'Last date at which strategy can be effective' parameter in the **Control** worksheet to a value 5 years after the model start year.

The **Analysis and Insights** worksheets can be interpreted in much the same way as in Use Case 1, although the tables will no longer refer to "deferral length". Rather, the NPV of a strategy at, say, year 5 simply means the NPV of using flexibility for 5 years and receiving 5 years of incentive-related benefits.

Use Case 3: Energy efficiency to defer reinforcement

Rather than using DSR or similar, a DNO might want to investigate using some sort of efficiency drive to reduce network peak loading, and hence defer reinforcement. In many ways, the model can be populated in exactly the same way as for a classic 'flexibility' example (Use Case 1).

For example, upfront and annual fixed costs can be included to refer to the cost of setting up the scheme and maintaining it. If the efficiency drive has some volume-related incentives (e.g. payments for peak load reduction) this can be reflected as a form of estimated availability or utilisation payment. What matters for the NPV calculation is that the total annual 'flexibility' cost is equal to the expected annual cost of delivering the energy efficiency scheme.

On the reinforcement side, the user will need to ensure that the deferral for each year is achievable with the efficiency strategy, and that the 'flexibility' cost is consistent with that. The model will then say whether the cost of efficiency in that year is justified given the deferral achieved and the incentive-related benefits.

One key difference between DSR and energy efficiency is that, potentially, efficiency has lasting benefits once the scheme is no longer active. For example, if the scheme involves replacing light bulbs with LEDs, the carbon benefits should endure even once the scheme ends. However, ***this model is not designed to reflect this case since it cannot show the incentive-related benefits enduring whilst the deferral-related benefits do not***.

Take the situation where the user wants to model implementing an efficiency scheme for 5 years, deferring reinforcement for 5 years, but getting a further 5 years of CO_2 reduction benefits. The user could enter 'flexibility' costs for 5 years, but shows emission-related benefits for 10 years. However, when reading off the 10-year benefit in the **Analysis and Insights** worksheets this will implicitly include the benefit of deferring reinforcement for 10 years. The user has two possible work-arounds:

1. **Run the model twice**, looking first at the benefit of deferral (over 5 years), then the benefit of CO_2 reduction (over 10 years). The user can then combine the NPVs outside the model, which makes it difficult to interpret the results. The user will also need to ensure that the cost of the efficiency is not double-counted; or
2. **Reflect the enduring CO_2 benefit in year 5:** The user inflates the CO2 benefit in year 5 to reflect the additional benefit that would have occurred in years 6-10. The user will then read off the NPV in year 5. Strictly, the user would need to account for the discounted value of CO2 reduction in years 6-10.

Use Case 4: Active Network Management (ANM)

It should be noted that this CBA tool is deliberately designed to give the DNO's perspective on its costs and benefits. It is not intended to account for the costs and benefits of a connecting party, for example.

If a customer wishes to connect to a DNO's network, some of the costs of connecting that customer are paid by the connecting party, and some are paid by the DNO. In additional to conventional connection offers, DNOs are increasingly offering Flexible Connections which include some ANM costs, some reinforcement costs (although smaller than for the conventional connection offer) and an obligation on the connecting party to accept curtailment when the network is constrained.

As with conventional connection, under Flexible Connections there are certain costs that are covered by the DNO rather than the connecting party. These are defined in the as per the Common Connections Charging Methodology (CCCM), and are summarised in Table 1.

Table 1 CCCM cost recovery associated with Flexible Connections

Typical connection components[1]	Type 1A - Single	Type 1B – Multiple	Type 2 – Wide Area
Extension Assets for customer	You fund	You fund	You fund
End user control unit for the customer	You fund	You fund	You fund
Local system management unit	You fund	Shared equally between participants	We fund
Scheme management unit	You fund	Shared equally between participants	We fund
Central management unit	N/A	N/A	We fund
Scheme specific ongoing costs e.g. communications	We fund	We fund	We fund

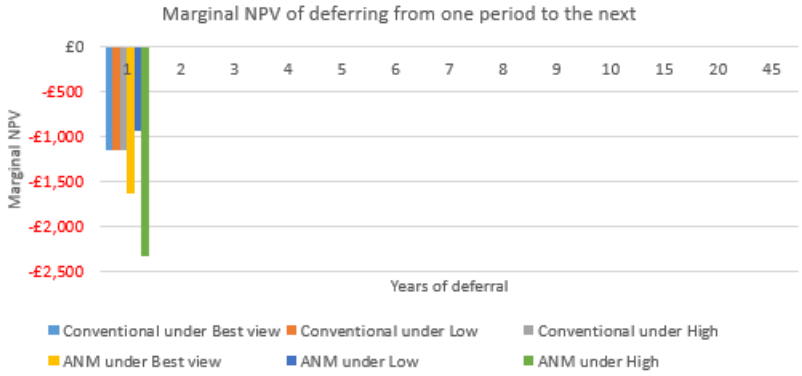
The DNO can use the CEM CBA tool in a number of ways.

DNO's costs under conventional vs ANM connections

A DNO can use the CBA tool in order to determine whether it is cheaper for it to offer a conventional connection or a flexible connection. In order to do this, the following steps should occur:

- In the **Baseline Reinforcement** worksheet, set all exceedance and reinforcement costs to zero (note, even though we may be considering reinforcement, this is not a 'deferral' use case, so these costs should not be included in this worksheet
- In the **Incentive and Penalty** worksheet, set all inputs to zero
- In the **Control** worksheet, define two strategies for each scenario, e.g. "Conventional" and "ANM"
- In either the **Flex Volume and Cost Inputs** worksheet or the **Flex Cost Inputs** worksheets (depending on the ***flex_cost_input_type*** setting on the **Control** worksheet), describe the DNO's estimates of its costs under a Conventional and a Flexible connection. This is likely to be some combination of upfront and ongoing fixed costs. Note, this may include some reinforcement costs, but these should still be included in this worksheet. It is advisable to include costs over the full (45 year) modelling horizon, even if that involves inputting zeroes.

The user can then look at the Analysis and Insights worksheets to determine which strategy (conventional or ANM) yields the highest NPV for the DNO over the whole modelling horizon. Note that most of the analysis will not be meaningful, including any reference to deferral over a particular time period. Nevertheless, the user can see the relative NPVs (all of which will be negative to a notional baseline). The user can see, however, the NPV of DNO costs under Conventional vs ANM connection under the different scenarios by looking at "1 year of deferral" in the output, or by looking directly at the *Comparison* worksheet.



Option	Discounted cost (£)	Cost reduction (£)
Baseline	£ -	
Conventional under Best view	£ 1,160	-£ 1,160
Conventional under Low	£ 1,160	-£ 1,160
Conventional under High	£ 1,160	-£ 1,160
ANM under Best view	£ 1,628	-£ 1,628
ANM under Low	£ 930	-£ 930
ANM under High	£ 2,326	-£ 2,326

Using flexibility to avoid connection-related reinforcement

This Use Case could apply for either conventional or flexible connections. When a customer connects to a DNO's network, some network reinforcement can be required. The DNO incurs some of the costs associated with that reinforcement. The DNO can use the CBA tool to determine whether it makes sense to avoid or defer that reinforcement through the use of flexibility contracts. This could equally be applicable to conventional or ANM connections, although the reinforcement cost is typically higher in conventional connections.

To reflect this Use Case, the user would take the following steps:

- Input the connection-related reinforcement cost ***attributed to the DNO*** in the **Baseline Reinforcement** worksheet
- In the **Flex Volume and Cost Inputs** worksheet, input the flexibility costs that the DNO estimates it would incur to manage that level of exceedance (and hence defer the need for reinforcement)
- If there are any incentive-related benefits, the user can input these as in the standard flexibility use case (Use Case 1).

In other words, this Use Case is no different from the normal flexibility use case except for the fact that ***only the DNO*** share of reinforcement costs is included, rather than the total cost that would be typically included for load-related reinforcement.

Other possible ANM use cases

It may be possible to use the CEM CBA tool to examine other use cases related to ANM, but a number of those being considered involve accounting for the costs associated with the connecting party. By design, this tool has a DNO lens (with accounting treatment that is specific to the DNOs). Regulations around network access and charging could change in the future, which may change the costs and risks attributable to the DNOs. This could increase the number of use cases for which this tool is suitable, for example addressing:

- Whether it is cheaper for the connecting party to face the opportunity cost of curtailment under ANM or instead to manage the constraint by procuring flexibility services or enacting a local flexibility market.
- Whether the levels of curtailment being faced by ANM customers justifies the reinforcement of a network to alleviate the constraint.