Common evaluation methodology and tool

Open Networks
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Version History

Version	Date	Description	Prepared by	Approved by
V0.1	22 June 2020	Draft for review	Mary Treinen	Duncan Sinclair
V0.2	03 July 2020	Reviews and comments incorporated from all DNOs	Mary Treinen	Duncan Sinclair Simon Brooke (ENW)
V0.3	16 July 2020	After reviews from Steering Group	Simon Brooke	Mary Treinen
V1.0	24 December 2020	First version (reflecting consultation responses)	Chris Collins	Simon Brooke
V2.0	10 January 2022	Phase 2 update	Chris Collins and Alex Townsend	Simon Brooke
V3.0	10 September 2024	Phase 3 update	Chris Collins	Harry Taylor

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Contents

1 Introduction

1.1 Context

All the Distribution Network Operators (DNOs) in Great Britain have committed to 'market testing' potential flexibility solutions as an alternative means of releasing capacity compared to traditional asset reinforcement. Each DNO has developed its own methodology for decision making, and until recently there has been a lack of standardisation of approach.

The development of a common evaluation methodology is intended to provide transparency on how decisions are made to choose the most suitable solution to meet network needs between traditional network asset solutions (reinforcement) and procuring flexibility services from generators, storage operators or demand side response. It addresses a key action outlined in the Ofgem and BEIS Open Letter to the Energy Networks Association (ENA)[1] in July 2019.

In October 2019, a joint workshop of the Electricity Regulation Group and Open Networks members committed to developing a common evaluation methodology (CEM) for network investment decisions, to be used by all DNOs from April 2021 for the remainder of RIIO ED1 and beyond. It was agreed that this work would be progressed within the Open Networks project under Workstream 1A (Flexibility Services). The CEM would be used to decide which intervention to procure to mitigate a reinforcement need, whether that be a flexibility service, an asset reinforcement or an alternative innovative solution.

The objective of the CEM is to develop a standard approach for the DNOs and create greater transparency. In turn, this should provide greater visibility and confidence amongst flexibility providers and help stimulate volumes and competition in the market, ultimately reducing costs for network customers.

Following the release of the first version of the CEM in December 2020, Workstream 1A engaged with users of the tool and third parties, and concluded that there was a need to enhance the model in two ways:

1. Develop the treatment and articulation of option value in the tool in order to ensure that the value of flexibility could be fully recognised, particularly under conditions of load growth uncertainty
2. Expand on the calculations of carbon savings in the tool, making the inputs and calculations more explicit and standardised.

These enhancements have been implemented during a second phase of work that concluded in December 2021. The outcome of that work is the publication of the second version of the CEM tool.

A third version of the CEM tool has now been released, introducing a Simple Ceiling Price calculation, reflecting the latest Ofgem CBA, and making other minor changes to the structure and calculations within the tool.

[1] https://www.ofgem.gov.uk/publications-and-updates/open-letter-ena-open-networks-project-ofgem-and-beis

1.2 Scope of work

1.2.1 Purpose

The CEM and supporting Excel based tool (**CEM Tool v3.0**) is intended to deliver consistency in how DNOs evaluate network investment options, and supports the ENA's wider goal to facilitate visibility and accessibility and ensure network operators conduct procurement in an open and transparent manner.

1.2.2 Scope of this report

This report contains a description of the framework and key areas that make up the CEM. Table 1 below sets out how the elements of the methodology come together.

The ENA has thus far defined four standard "Flexibility Products" that can meet specific network needs as defined by the ENA[2]). The CEM tool is built to enable DNOs to make investment decisions when comparing Flexibility Products to traditional network interventions. In the next section, we describe how the methodology and tool can be used to evaluate these Flexibility Products, as well as options for alleviating export constraints where curtailment of renewables is occurring.

[2] http://www.energynetworks.org/assets/files/ON-WS1A-Product%20Definitions%20Updated-PUBLISHED.pdf

Table 1 - Key areas of the CEM

Key area	Description
Options the model is set to consider	
Outlines the purpose of the methodology and the key use cases for DNOs to put the methodology and tool to use.	
Defining the service requirement	
Load growth scenarios	As DNOs are assessing their network needs, they will utilise a scenario or a set of scenarios to determine what their needs would be. These scenarios are key to determine the volume of flexibility required into the future.
Flexibility requirements	One of the main uses cases for the CEM is the evaluation of flexibility as a network option. There is specific functionality within the tool for DNOs to input their flexibility requirements into the evaluation of options. This can be tied to the load growth scenarios, or can be input manually.
Point of view of economic assessment	
Ofgem CBA	The tool is built on the basis of the Ofgem CBA tool for network investment decisions[3], and as such there is consistency between the tool built and used by DNOs today. There are a number of inputs and values that will remain consistent with the Ofgem CBA, and some areas of the methodology that have been updated as a part of the scope of this project.
Time horizon	The methodology sets out to analyse the discounted cash flow of each solution over the life time of an asset, or 45 years. The discounted cash flow starts at the beginning of the deferral period (given that an alternative solution would be used for the duration of the deferral period), and the discounted cash flow extends for 45 years from the end of the deferral period (given that the asset would be utilised fully from that point in time).
Totex treatment	The CEM is designed as a tool to help DNOs evaluate the costs and benefits of different strategies. As such, costs and benefits are represented from the DNO's perspective, which means applying the Totex treatment, consistent with Ofgem's CBA template.
Assessment of network intervention options	
Costs	DNOs will input the appropriate costs across the baseline intervention and all alternative network intervention options for all scenarios.
Value of reinforcement deferral	A key element of value within the alternative assessment is the value of deferring network reinforcement into the future. When comparing two

[3] https://www.ofgem.gov.uk/publications/riio-ed2-data-templates-and-associated-instructions-and-guidance

Key area	Description
	potential solutions (a baseline and an alternative network intervention), in many cases the alternative solution will involve the option to defer the decision to reinforce the network to some point in the future, and use flexibility in the meantime. Through demonstrating the potential future value across a range of load growth scenarios, this methodology allows DNOs to explore the potential option value that is created in the future by decisions that they would make today. There is a facility within the tool to explore this option value further.
Wider network and societal impacts	The methodology considers some of the wider network and societal impacts of the different network interventions. This includes the impact of network losses, potential asset condition driven changes in CIs and CMLs, carbon emissions, and a range of other impacts measured in the original Ofgem CBA tool.
Outputs	
The outputs from CEM tool include: • Table and charts showing, for each scenario and for a range of years, the benefit of flexibility at a specified price • Additional insights and reporting: Least Worst Regret and Weighted Average analysis • A table showing the maximum ('ceiling') flexibility price that could be justified given the benefits of deferral • Results with and without uncertainty ('extrinsic' and 'intrinsic' value), demonstrating the potential option value of flexibility services • Detailed CBA results for a given number of deferral years for a given scenario	

2 Options the model considers

Consistent with the Ofgem CBA, DNOs must clearly identify the range of solution options that were considered to meet the specific network need. For each investment decision, the DNO should clearly explain in supporting commentary boxes and worksheets in the CEM tool, what assumptions have been used and which regulations the minimum level of intervention relates to, as well as any calculations that have been done external to the tool.

We have included a section in the CEM tool for DNOs to identify and clearly list the options they have considered for each investment decision. This list of options should include those that have been considered and rejected before full costing, and the shortlist of those options that have been considered and costed, with a clear rationale for including/excluding them, which is to be summarised (i.e. a few lines or bullets) in the comment box.

One of the primary use cases for this tool is to evaluate investment in flexibility services. When utilising the methodology for flexibility, the model aligns with the standard definitions for flexibility products as defined by the ENA[4] and shown in Table 2 below. The methodology assumes that the flexibility products are compared to the baseline scenario of network investment.

The model is built as a cost and benefit comparison tool for all DNOs to utilise when making network investment decisions on an asset by asset level basis. Given that some network interventions will meet more than one network need, there may be a need to utilise multiple instances of the CEM tool to complete analysis across multiple network needs.

[4] http://www.energynetworks.org/assets/files/ON-WS1A-Product%20Definitions%20Updated-PUBLISHED.pdf

3 Defining the service requirements

3.1 Load growth scenarios

As a part of network planning processes, DNOs will have individual approaches to define load growth scenarios, and assess network needs against alternative scenarios.

For all flexibility products that have network reinforcement as their baseline[5], these scenarios provide DNOs with a view of what the annual exceedance of the particular asset that is under assessment (i.e. the amount by which electricity flows will exceed capacity), will be for a particular asset across a range of potential outcomes. There are a number of inputs that are required to determine the timeframe and windows for the decision being made. The "current year" is the year in which the decision to reinforce needs to be taken. Within the input section of the tool, DNOs will manually input the current maximum capacity for the asset (e.g. 30 MVA) and the forward-looking peak network load across the range of scenarios that are being considered within the tool. Peak load is then compared to the current asset capacity to determine the exceedance per year per scenario.

If the use case does not include reinforcement deferral (e.g. using flexibility to reduce CI/CML risk), the user can disable the model logic relating to network exceedance. The user then inputs the flexibility requirements, Incentives and Penalties, and Carbon impacts manually.

3.2 Flexibility requirements

For all use cases where DNOs will be evaluating flexibility as a network intervention option, they will be required to input the annual flexibility requirements per year per scenario. The user should ensure that enough flexibility is procured to cover both the exceedance and any over-procurement required. The user can either specify the annual availability and utilisation volume directly, or can specify the days-per-year, hours-per-day and average hourly availability and utilisation requirement.

There is an empty **Workings** worksheet within the model for DNOs to include any justification and/or assumptions around the external calculations for availability and utilisation that are used within the model.

[5] The differences for other flexibility use cases have been explained in Table 3.

4 Basis of economic assessment

4.1 Standard inputs

The tool that has been developed to replicate how costs and benefits are realised by DNOs through the price control framework. As such, it is largely based on the Ofgem CBA tool, and as this framework evolves, the CEM tool should evolve as well.

There are a number of inputs and values that will remain consistent with the original Ofgem CBA, and a few key areas of the methodology that have been updated as a part of the scope of this project.

The standard inputs from the Ofgem CBA that this methodology uses are listed in Table 2. The non-standard inputs (e.g. costs, wider and societal impacts) are explained in detail in Section 5.

Table 2 - Standard inputs from Ofgem CBA

Input	Description
Customer Interruptions (CIs)	In order to evaluate certain asset condition related impacts of network interventions and also to evaluate the 'Restore' flexibility product there is a need to quantify and value CIs. The CEM tool utilises the Ofgem standardised value of £s per interruption. DNOs are able to manually insert the number of interruptions into the tool.
Customer Minutes Lost (CMLs)	In order to evaluate certain asset condition related impacts on network interventions, there is a need to quantify and value CMLs. The CEM tool utilises the Ofgem standardised value of £s per minute lost. DNOs are able to manually insert the number of minutes lost into the tool.
Weighted Average Cost of Capital (WACC)	This value will be unique to each DNO, and is used to convert capital costs into annual costs using each individual DNO's cost of capital.
Discount rates	As defined by the Treasury's Green Book[6], this model uses the Social Time Preference Rate (STPR) of 3.5% (less than or equal to 30 years); 3% (greater than 30 years) to discount all costs and benefits, except safety where the Health Discount Rate (HDR) of 1.5% (less than or equal to 30 years); 1.2857% (greater than 30 years) should be used.
Losses value	Where expenditures are justified using the reduction of electricity lost, we have utilised the standardised value for £/MWh lost used within the Ofgem CBA.

[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

Input	Description
Carbon prices	In order to calculate the cost of carbon associated with losses, the CEM tool utilises the BEIS traded carbon price[7] (in line with the Ofgem CBA). The CEM tool remains consistent with the Ofgem CBA to quantify carbon emissions that result from network losses.
Cost per injury/fatality	In some use cases, DNOs may need to quantify benefits associated with reducing or preventing fatalities and injuries. The treatment in the CEM is consistent with the Ofgem CBA and requires DNOs to draw on guidance set out in HM Treasury Green Book[8] and the HSE[9]. However, for the purpose of evaluating flexibility solutions there is no expectation that these sort of inputs would be required for the analysis.

4.2 Time horizon

The methodology sets out to analyse the discounted cash flow of each solution over the life time of an asset, or 45 years. The discounted cash flow starts at the beginning of the deferral period (given that an alternative solution would be used for the duration of the deferral period), and the discounted cash flow extends for 45 years from the end of the deferral period (given that the asset would be utilised fully from that point in time).

4.3 Totex treatment

Within the Ofgem CBA, the Totex Incentive Mechanism (TIM) is applied to all costs. The CEM tool follows the Ofgem CBA template, applying the same Totex treatment.

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48184/3136-guide-carbon-valuation-methodology.pdf

[8] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[9] https://www.hse.gov.uk/economics/eauappraisal.htm

5 Assessment of options

5.1 Costs

5.1.1 Baseline costs

In order to evaluate the costs and benefits of different network options, the model requires DNOs to input the costs of the baseline [network] intervention. It is assumed that the baseline will usually involve asset reinforcement, but the user can specify other costs (e.g. those associated with losses, CI/CMLs or carbon emissions), provided they can be deferred (or avoided) through the use of flexibility.

5.1.2 Alternative intervention costs

In the assessment of the alternative interventions, input values should reflect the cost to the DNO of the alternative solution that is being assessed. In the case of flexibility, the user can either specify the volume and unit cost of flexibility being assumed, or can input the volume of flexibility required and allow the model to find the maximum price of the flexibility solution, beyond which it is no longer cost effective to defer the reinforcement (i.e. a net cost benefit of zero).

5.2 Value of reinforcement deferral

The value of the flexibility products is primarily derived from the time value of money from deferring large capex expenditure associated with network reinforcement. The CEM tool compares the Net Present Value (NPV) of discounted cash flows of the baseline (reinforcement scenario) with the alternative (flexibility solution) scenario. The CEM tool provides a view of the potential outcomes in terms of NPV for each set of forward-looking load growth scenarios. The outcomes of this analysis are demonstrated below in Figures 1 and 2.

Figure 1 - Discounted cash flow charts - baseline vs best view

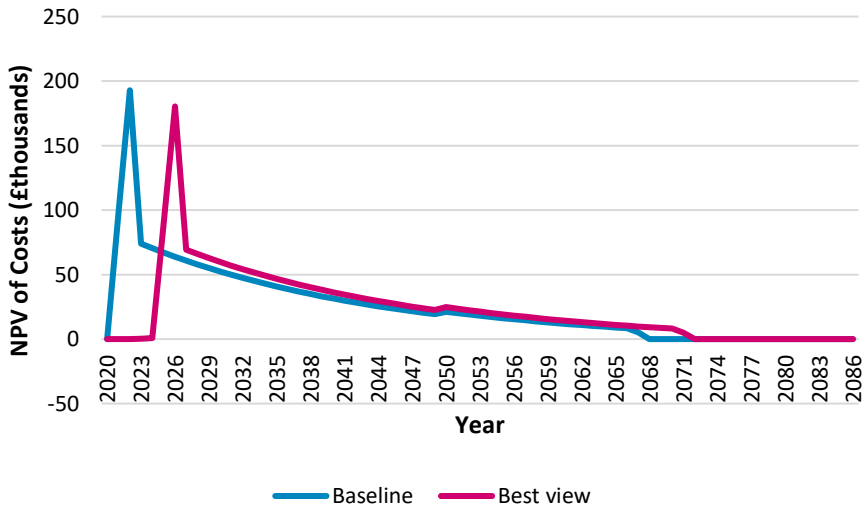
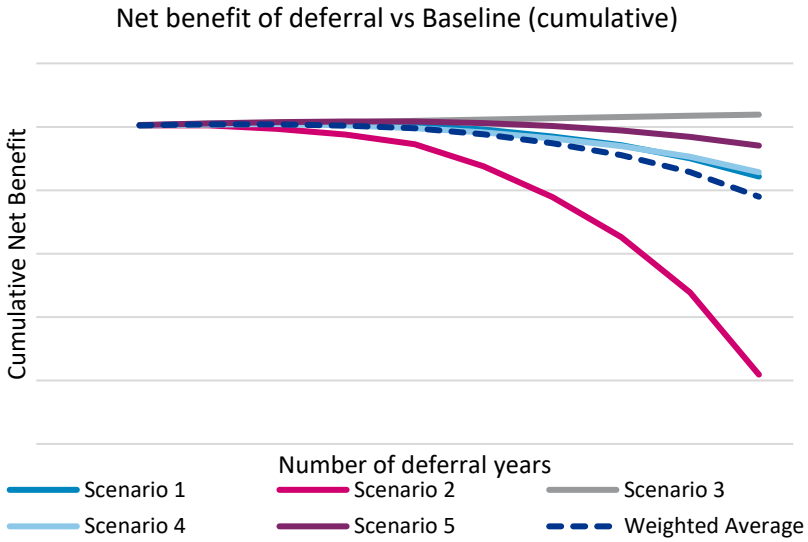


Figure 2 - Net benefit of reinforcement deferral vs the baseline (cumulative)



Through demonstrating the potential outcomes across a range of scenarios, this methodology allows DNOs to explore the potential option value that is created in the future by decisions that they would make today. There is functionality within the CEM tool that enables DNOs to further explore this option value in two ways:

- **Least Worst Regret:** Identifying the strategy that minimises the worst regret outcome across the modelled load growth scenarios
- **Weighted Average:** by assigning probabilities to the each of the load growth scenarios, the user can identify the strategy that maximise the expected net benefit.

This analysis allows DNOs to test different flexibility procurement strategies, as well as understanding the option value (i.e. the value under load growth uncertainty) associated with flexibility.

5.3 Wider network and societal impacts

5.3.1 Impact on losses

Different network interventions will have an impact on the amount of electricity lost whilst transporting through the network. The tool accounts for this by utilising the value that is standardised and set by Ofgem in £/MWh, and allowing for DNOs to manually input the volume of losses that they would face with the specific network intervention that is being assessed. The Ofgem input for the £/MWh losses is included in the fixed inputs worksheet.

DNOs are required to input the expected reduction in losses for the baseline scenario as well as all alternative scenarios. The change in expected losses is therefore factored into the assessment of alternative flexibility solutions.

5.3.2 Carbon emissions

The CEM tool remains consistent with the Ofgem CBA to quantify carbon emissions that result from network losses.

The option for DNOs to explicitly include the carbon value of different network solutions is also included in the tool. This includes the option to value the emissions associated with the energy used to release capacity under each option and embedded emissions in the baseline (reinforcement) option.

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.

In some use cases, there may be additional carbon emissions from alternative network interventions which can be incorporated in an 'other emissions' section of the model.

5.3.3 Other societal impacts

There is a range of other societal impacts that are included in the Ofgem CBA template, and captured in the CEM tool. These are unlikely to be affected by the choice of network solution, and hence are not expected to be used. However, there is an empty **Workings** worksheet within the model for DNOs to include any justification and/or assumptions around the external calculations for all societal impacts where appropriate.

5.4 Key differences in assessment of options

Through discussions with DNOs, there is an understanding that the primary use case for this methodology and tool is for DNOs to compare traditional network investment to the use of Flexibility Products where network reinforcement would be the baseline scenario. As such, the methodology and report have been developed with this in mind. However, this methodology and tool can also be used to test alternative investment use cases, such as the Restore Flexibility Product, and alternatives for managing export constraints/curtailment. The differences in the ways that these examples would be applied to the methodology have been explained in Table 5 below.

Table 3 - Additional use cases for CEM methodology

Use Case	Key differences in application of methodology

Flexibility – Peak Reduction, Scheduled Utilisation, Operational Utilisation + Scheduled Availability, Operational Utilisation + Variable Availability[10]
Using flexibility to defer network reinforcement
	• Base case is reinforcement, triggered by, for example:
	  ○ Expected demand growth in an import-constrained area
	  ○ Expected net export growth (e.g. fall-off in local I&C demand) in an export-constrained area.
	• Model allows up to 10 network load growth scenarios to be tested
	• Model shows the benefit of deferring that reinforcement by procuring flexibility for 1 or more years, along with associated benefits (e.g. losses, carbon, CI/CML)
	• User specifies the flexibility that would need to be procured to achieve each year of deferral
	• Output shown in two ways:
	  ○ ***Net benefit of deferral*** by n years given a pre-specified flexibility price (availability and utilisation). User can see both the benefit of deferring **by n years** and the benefit of deferring by **each additional year**
	  ○ ***Maximum flexibility price*** that can be justified by reinforcement and associated costs/benefits. Again, this can be seen as the maximum price for, say, a 3-year contract, or the maximum price that can be justified in the 3rd year of deferral.

Flexibility – Operational Utilisation *Using flexibility to manage the re-energisation of the network, reducing the number and duration of customer interruptions*	• The key difference for this product is that the counterfactual/baseline scenario is the cost of CIs/CMLs and/or the cost of stand-by generation, rather than the cost of network reinforcement • Because this product does not relate to network reinforcement, there is no input required into the load growth scenarios • Manual inputs would be required to determine the flexibility requirements, because the flexibility requirements are not driven by the network asset exceedance • There would be zero capex for the baseline approach • For CIs/CMLs inputs – there are two approaches the user could take 1) input zero for the baseline and the incremental change in CIs/CMLs in the alternative, or 2) input the absolute number of CIs and CMLs in the baseline and alternative

[10] on-flexibility-products-alignment-(feb-2024).pdf (energynetworks.org)

Use Case	Key differences in application of methodology
Flexible connections – *The DNO incurs some or all of the costs associated with new connections, including flexible connections. The assumption is that this would be facilitated through ANM, where ANM curtails export at network peak loads, allowing faster and cheaper connections*	• The CEM tool should only be used to evaluate options against the DNO's share of reinforcement costs, and their expected contribution to the cost of curtailment. • The baseline is network reinforcement, driven by an export constraint and the connection of exporting assets (e.g. Distributed Generation or batteries) • The user will need to enter the revised DNO-attributable reinforcement cost profile under the ANM scenario(s) • All other inputs within the model would remain the same, assuming that the TIM would be applied in the same way.
Future technology (e.g. dynamic network reconfiguration)	• The CEM tool is able to accommodate any consideration of future technology applications, and provides options for users to input the appropriate costs into the CEM tool.

6 Outputs

6.1 Results

The CEM tool displays results in five ways:

1. **Benefit by strategy:** For a given set of baseline costs, and a user-specified cost of flexibly (availability, utilisation and annual fixed cost), the model shows the net benefit of the flexibility solution over the baseline.
2. **Insights and Reporting**: As well as providing a summary tables relating to the ***Benefit by strategy*** results, additional analysis is also provided to allow comparisons of strategies across different scenarios. Two types of analysis are carried out: ***Least Worst Regret*** and ***Weighted Average Benefit***.
3. **Ceiling price:** For a given set of baseline costs, the model shows the maximum cost of the flexibility solution before it becomes less economic than the traditional asset solution.
4. **Option value:** For a given set of scenario probabilities, the model separates the results into the *intrinsic value* (Best view) and *uncertainty value* (or *extrinsic value*) of the flexibility solution over the baseline.
5. **Summary CBA:** Although not a key output, the user can inspect the detailed CBA calculations being carried out by the tool.

Appendix A CEM key logic and functions

This appendix provides a more detailed explanation of some of the key logical steps and functions being used in the model. Note that this is not an exhaustive list, but should help the user to understand the steps being taken. The following is written from the perspective of the primary use case, namely the use of flexibility to defer conventional reinforcement.

A.1 Primary benefit calculation formula

A.1.1 Single instance net benefit calculation

Without the use of any macros, the CEM calculates the costs and benefits associated with deferring reinforcement by a number of years equal to the *deferral_years* parameter, which is specified in **Comparison!D3**. By default, this is set to be equal to the *initial_contract_length* speficied by the user in **'Flex Volume and Cost Inputs'!D17**.

Each configuration has a separate worksheet for performing the calculations. For example, the costs and benefits associated with Configuration 1 are performed in the **Config1** worksheet. These worksheets mirror the logic of the Ofgem CBA template. The worksheet pulls in the appropriate information that the user has provided, most of which is simply referencing the input cells directly, but filtering to ensure only costs and benefits are shown that correspond to the specified number of *deferral_years*. Specifically:

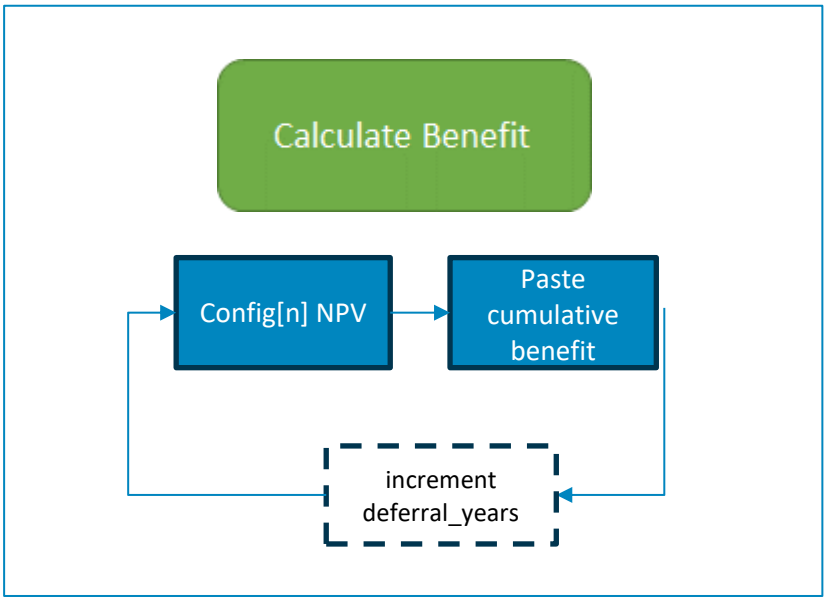
- ***Deferred Reinforcement Costs*** are the same as the baseline, but are deferred (or offset) by the number of *deferral_years*. The same is true for the embedded/embodied carbon emissions relating to the conventional reinforcement, although in that case this deferral/offsetting takes place on the **Carbon impacts** worksheet (e.g. row 34).
- **Upfront flexibility costs** are not filtered, so will be incurred regardless of the *deferral_years*. This could relate to the one-off cost of establishing a flexibility market in a specific area.
- **Fixed flexibility costs** are filtered, so will only be shown for as long as the *deferral_years* being tested by the model. These might be used for any annual flexibility costs that are not variable (in the sense that they do not change based on the volumes of flexibility procured). One such example might be the annual cost of running a flexibility tended.
- **Availability and utilisation costs** are filtered, and are only shown within the specified *deferral_years*. Otherwise, they are pulled straight from the input worksheets.
- **Incentives and penalties** are filtered, being shown only within the specified *deferral_years*.

The Config[n] worksheet then calculate the Net Present Value of these costs and benefits, in line with the Fixed Cost inputs and the overall Ofgem CBA logic. Note that the primary benefit tends to derive from the deferral of reinforcement costs, and the reduction in NPV that this implies.

A.2 VBA macros

A.2.1 Calculate Benefit

Figure 3 Calculate Benefit simple schematic



The Calculate Benefit button on the **Additional inputs and control** worksheet calculates the benefit based on the specified inputs including the ***Availability Price*** and **Utilisation Price** on the **Flex Volume and Cost Inputs** worksheet.

The only difference from the **Single instance net benefit calculation** described in A.1.1 above is that the model tests the NPV for a range of *deferral_years*. The model runs VBA code to override the *deferral_years* parameter so that it no longer equals the initial_contract_length. Instead, it tests the NPV of each configuration for a range of contract lengths as specified by the user in **'Additional inputs and control'!C22:C34**.

For each *deferral_years*, the VBA then calculates the relative NPV of each configuration compared to the baseline, and puts the result into the **Benefit by strategy** worksheet. For example, the relative NPV of configuration 1 compared to the baseline is put in **'Benefit by strategy'!E51** for a 1-year deferral, and into **'Benefit by strategy'!F51** for a 2-year deferral.

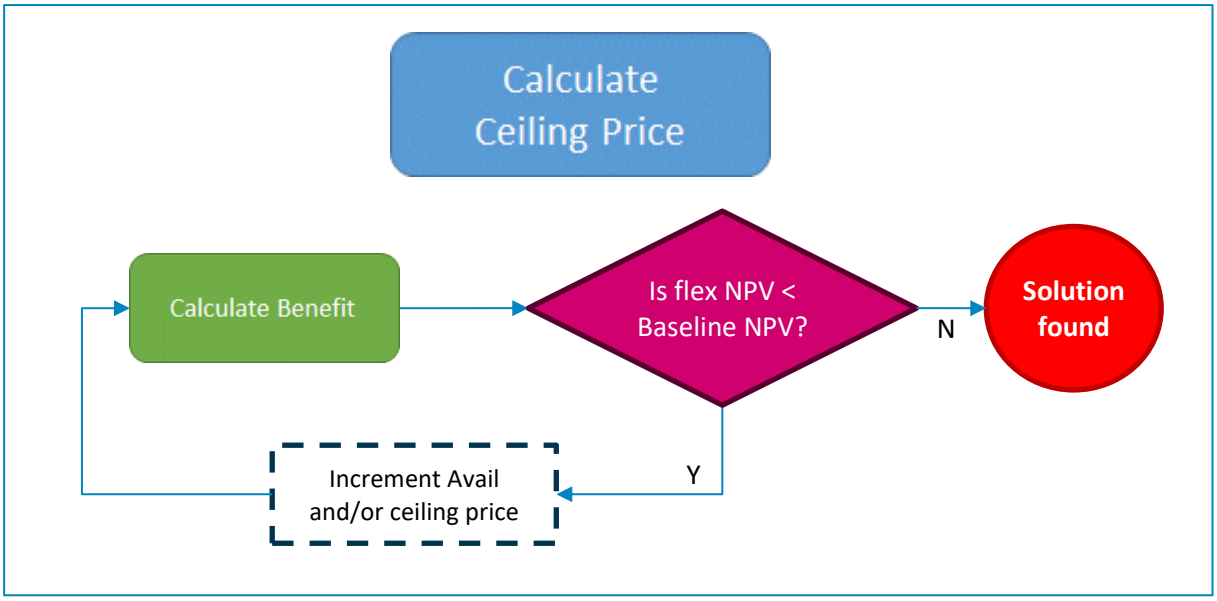
In this way, the user can see not only the benefit of deferring reinforcement by the *initial_contract_length*, but also for additional deferral after that initial deferral. The **Benefit by strategy** worksheet then uses these pasted values to calculate four things:

- The **cumulative benefit of deferral** just refers to the pasted values themselves. This is the NPV of deferring by the *deferral_years*.
- The **marginal benefit of deferral**, which is the additional NPV locked in by moving from one deferral length to the next (e.g. 2-yr vs 1-yr)

- The **residual benefit of deferral**, which is any further upside that can be secured after the tested *deferral_years*. This reflects the option value associated with flexibility, i.e. the fact that by deferring reinforcement by 1 year, this gives you the opportunity to secure additional value in years 2 and beyond
- The **overall benefit of deferral**, which for any specified *deferral_years* is the sum of the cumulative and residual benefit, i.e. the benefit of deferring by *deferral_years* plus any future residual benefit that this deferral enables.

A.2.2 Ceiling price

Figure 4 Ceiling price simple schematic



The Ceiling Price logic also uses a VBA macro. In this case, it cycles through different Availability and/or Utilisation prices, and for each it runs the **Calculate Benefit** macro, looking to find the price(s) at which using flexibility for the *initial_contract_length* becomes more expensive (has a worse NPV) than reinforcing (i.e. the baseline). Below that price, the value of deferral (plus the associated incentives, minus the associated penalties) has a better NPV than reinforcing the asset in Year 1.

On the **Additional inputs and control** worksheet, the user specifies how it wants to goal seek the solution. The key input parameters here are:

- **Price varied for goal seek** can take one of four settings:
  - **Availability:** Keeps the Utilisation price unchanged from its user-defined value on **Flex Volume and Cost Inputs**, sets the Availability price to zero then tests Availability prices in increments (specified by the user) up to a maximum test value (specified by the user)
  - **Utilisation:** Keeps the Availability price unchanged from its user-defined value on **Flex Volume and Cost Inputs**, sets the Utilisation price to zero then tests Utilisation prices in increments (specified by the user) up to a maximum test value (specified by the user)

- **Availability (lock ratio):** Keeps the ratio between Availability and Utilisation prices consistent with the user-defined value on **Flex Volume and Cost Inputs** worksheet. Both are first set to zero, then the Availability price is increased in increments (user-specified) and Utilisation price is increased by increments equal to the Utilisation:Availability price ratio. This continues until the maximum Availability goal seek value (user-defined) is reached.
- **Utilisation (lock ratio):** Keeps the ratio between Availability and Utilisation prices consistent with the user-defined value on **Flex Volume and Cost Inputs** worksheet. Both are first set to zero, then the Utilisation price is increased in increments (user-specified) and Availability price is increased by increments equal to the Availability:Utilisation price ratio. This continues until the maximum Utilisation goal seek value (user-defined) is reached.

- **Goal seek increment** and **Maximum price** for goal seek are user defined, setting the steps by which the VBA macro increases the prices and the maximum value tested. Depending on the **Price varied for goal seek** these parameters correspond to either the Availability price or Utilisation price.

A.3 Other key calculations

A.3.1 Least Worst Regret (LWR)

LWR is a method that identifies the strategy that delivers the lowest 'worst regret' across all modelled scenarios. For context, it is one of the methods that NGESO uses for its Network Options Assessment (NOA) planning process.

'Regret' for a given strategy is defined for each scenario as the difference between the benefit (NPV) that was achieved vs the maximum benefit that could have been achieved by choosing a different strategy (e.g. Flexibility vs Baseline reinforcement).

The steps for this calculation are as follows:

1. For each Configuration, take the ***Overall benefit of strategy vs baseline*** from the **Benefit by strategy** worksheet for the Baseline (no flexibility) and each of the deferral lengths
2. For each Configuration, on the **Insights and reporting** worksheet calculate the Regret for the Baseline (no flexibility) and each of the deferral lengths
3. For each Strategy (e.g. Flexibility) find the Worst Regret (comparing the Baseline and each flexibility duration to each other.
4. For each Strategy, find the Least Worst Regret NPV outcome (which may be Baseline of one of the flexibility contract lengths) and return the name of that strategy (e.g. Flexibility for 1 year). Note that if more than one flexibility contract length gives the same minimum worst regret (e.g. £0 for Flex of 1, 2 or 3 years) the model will choose the shortest contract length.

A.3.2 Weighted Average

This is similar to the LWR in that it looks across scenarios and strategies. It shows the expected benefit of each strategy (Baseline, Flex for 1 year, Flex for 2 years, etc.) and finds the strategy that maximises that benefit. The calculation steps are as follows:

1. The user specifies the probability of each scenario on the **Additional inputs and control** worksheet.
2. On the **Insights and reporting** worksheet, in rows 116-125 each configuration is mapped to a Strategy, and the appropriate probability is referenced.
3. **Insights and reporting** rows 85-94 calculate the expected benefit of each strategy based on those scenario weightings
4. **Insights and reporting** rows 100-109 then calculate, for each strategy, the flexibility contract length that maximises the expected benefit. **Insights and reporting** row 110 shows the strategy that maximises the expected benefit across all strategies considered.

A.3.3 Simple Ceiling Price

The **Simple Ceiling Price** worksheet is intended to replicate the **Ceiling Price** logic for most situations, without the need to run a VBA macro. Different formulae are used for each of the selected ***'Price varied for ceiling price goal seek'*** options on the **Additional inputs and control** worksheet.

For each configuration, the components for these calculations are as follows:

- **Flex_cost_calc** worksheet: Calculates the effective cost of a unit of flexibility in each year it is spent, taking account of capitalisation, depreciation and discounting. This worksheet is calculated when the user runs the Update Configurations VBA macro, and should be updated if and when there is a change to ***Capitalisation rate***, ***Asset Lifetime*** or the ***Discount Rate*** on the **Fixed Inputs** worksheet.
- **'Budget' (Simple Ceiling Price** worksheet **column M):** Calculates the NPV headroom that is available once the cost of Availability and Utilisation payments are removed from the current configurations. It does this by taking the NPV of the Baseline configuration and subtracting the NPV of the relevant configuration. It then then adds back in the cost of Availability and Flexibility, after weighting these in line with the weightings in **Flex_cost_calc** row 121.
- **Utilisation discounted spend (Simple Ceiling Price column P) and Availability discounted spend (Simple Ceiling Price column Q):** Calculates the cost of utilisation and availability, respectively, at the user-defined input prices (on the **Flex Volume and Cost Inputs** worksheet).
- **Utilisation volume (weighted) and Availability volume (weighted):** Calculates the volume of Utilisation and Availability, respectively, that needs to be procured for the ***Initial contract length*** weighted by the **Flex_cost_calc** calculations.

These components are then combined in different ways depending on the selected ***'Price varied for ceiling price goal seek'*** options on the **Additional inputs and control** worksheet:

- **Availability simple ceiling price:** Calculated as the ***Budget*** minus the ***Utilisation discounted spend***, all divided by the ***Availability volume (weighted)***.
- **Utilisation simple ceiling price:** Calculated as the ***Budget*** minus the ***Availability discounted spend***, all divided by the ***Utilisation volume (weighted)***.
- **Availability simple ceiling price (lock ratio):** Calculated as the Budget divided by the sum of the ***Availability volume (weighted)*** and the ***Utilisation volume (weighted)*** x ***Current Utilisation Price ÷ Current Availability Price***. The Current Availability Price is given a negligible but non-zero floor to avoid #DIV/0! errors.

- **Utilisation simple ceiling price (lock ratio):** Calculated as the Budget divided by the sum of the ***Utilisation volume (weighted)*** and the ***Availability volume (weighted)*** x ***Current Availability Price ÷ Current Utilisation Price***. The Current Utilisation Price is given a negligible but non-zero floor to avoid #DIV/0! errors.

Each of these calculations is intended to find the price at which the cost of the flexibility strategy (for the initial contract length) equals the cost of Baseline reinforcement.

Note that the Simple Ceiling Price should give the same result as the Ceiling Price, provided that the cost of flexibility increases over time. This will apply to scenarios where the load grows consistently, and does not either fall away – as in the case of a temporary exceedance – or becomes significantly cheaper in future years. This is because the Simple Ceiling Price does not take into account the Residual value of a flexibility procurement decision, only the initial value of that contract.

The Least Worst Regret and Weighted Average calculations are simplified compared to their equivalents on the Ceiling Price worksheet.

- The LWR ceiling price and cost is simply taken as the minimum price and cost from the configurations being considered. As such, it is better seen as a conservative price that ensures that flexibility is preferred under all scenarios, rather than being a true LWR strategy.
- The Weighted Average ceiling price is calculated by taking the scenario probabilities on **Additional inputs and control**, then calculating the expected volume of procurement under each scenario, and calculating the price (for Availability, Utilisation, or both) that makes the cost of that procurement equal to the value of reinforcement deferral.

A.4 VBA Macros

This section includes the key extracts from the VBA macros (which can be seen in full within the model by pressing ALT-F11).

A.4.1 Sub Benefit_at_Flex_Price()

```
'set the minimum contract length
min_contract_length = Range("initial_contract_length")

Set Output_years = Range("Output_years")
' Loop through the list of deferral years, calculate the NPV in 'NPV_range' and
paste in 'NPV_output'
For i = 1 To 13

    If Output_years(i) < min_contract_length Then

        Range("NPV_output").Offset(rowOffset:=0, columnOffset:=i).Value =
vbNullString

    Else
        Range("Deferral_years") = Output_years(i)
        Calculate
        Range("NPV_output").Offset(rowOffset:=0, columnOffset:=i).Value =
Range("NPV_range").Value
    End If

Next i
```

```
' Return deferal_years to the default value
Range("deferral_years").Formula = "=initial_contract_length"
```

A.4.2 Sub Ceiling_price()

```
'Pick up required parameters
Goal_seek_price_basis = Range("Goal_seek_price_basis")
Avail_price0 = Range("Avail_price")
Util_price0 = Range("Util_price")
Util_avail_ratio = Util_price0 / Application.WorksheetFunction.Max(Avail_price0,
1E-17)
Increment = Range("Price_increment")
Max_price = Range("Ceiling_max_price")
config_count = Range("config_count")
strategy_count = Range("strategy_count")
scenario_count = Range("scenario_count")

Max_incremental_steps = Application.WorksheetFunction.RoundUp(Max_price /
Increment, 0)

' Clear output ranges
For j = 1 To 10

    Range("ceiling_config_output" & j) = vbNullString
    Range("ceiling_config_output" & j).Offset(0, 1) = vbNullString

Next

Range("ceiling_overall_LWR_output") = vbNullString
Range("ceiling_overall_average_output") = vbNullString
Range("ceiling_overall_LWR_output").Offset(0, 1) = vbNullString
Range("ceiling_overall_average_output").Offset(0, 1) = vbNullString

'-------------------------------------------------------------------------------
---

'Start iteration

For j = 1 To config_count
    Range("ceiling_config_output" & j).Offset(0, 1) = "Outside range"
    Range("ceiling_config_output" & j) = "Outside range"
    Range("ceiling_overall_LWR_output") = "Outside range"
    Range("ceiling_overall_average_output") = "Outside range"
Next


If Goal_seek_price_basis = "Availability" Then

    Range("Avail_price") = 0
    Avail_price = 0

    Range("ceiling_config_output" & j).Offset(0, 1) = Util_price0
    Range("ceiling_overall_LWR_output").Offset(0, 1) = Util_price0
    Range("ceiling_overall_average_output").Offset(0, 1) = Util_price0

End If

If Goal_seek_price_basis = "Utilisation" Then

    Range("Util_price") = 0
    Util_price = 0
```

```
    Range("ceiling_config_output" & j) = Avail_price0
    Range("ceiling_overall_LWR_output").Offset(0, 1) = Avail_price0
    Range("ceiling_overall_average_output").Offset(0, 1) = Avail_price0
End If


If Goal_seek_price_basis = "Availability (lock ratio)" Or Goal_seek_price_basis =
"Utilisation (lock ratio)" Then

    Range("Util_price") = 0
    Util_price = 0
    Range("Avail_price") = 0
    Avail_price = 0

    Range("ceiling_config_output" & j) = 0
    Range("ceiling_overall_LWR_output").Offset(0, 1) = 0
    Range("ceiling_overall_average_output").Offset(0, 1) = 0
End If

ReDim ceiling_config(1 To config_count)
ReDim ceiling_config_solution_found(1 To config_count)
ReDim ceiling_config_output(1 To config_count)


'Set solution found count to zero
For j = 1 To config_count
    ceiling_config_solution_found(j) = 0
Next

ceiling_overall_LWR_solution_found = 0
ceiling_overall_average_solution_found = 0

'Calculate benefits at each increment

For i = 1 To Max_incremental_steps + 1

    Call Benefit_at_Flex_Price
    Application.Calculation = xlCalculationManual

    For j = 1 To config_count

        ceiling_config(j) = Range("ceiling_config" & j).Value

            If ceiling_config(j) = 1 Then
                If ceiling_config_solution_found(j) = 0 Then


                    If Goal_seek_price_basis = "Availability" Then
                        Range("ceiling_config_output" & j) =
Application.WorksheetFunction.Max(Avail_price - Increment, 0)
                        Range("ceiling_config_output" & j).Offset(0, 1) =
Util_price0
                    End If

                    If Goal_seek_price_basis = "Utilisation" Then
                        Range("ceiling_config_output" & j) = Avail_price0
                        Range("ceiling_config_output" & j).Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment, 0)
                    End If

                    If Goal_seek_price_basis = "Availability (lock ratio)" Then
                        Range("ceiling_config_output" & j) =
Application.WorksheetFunction.Max(Avail_price - Increment, 0)
```

```
                        Range("ceiling_config_output" & j).Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment * Util_avail_ratio, 0)
                    End If

                    If Goal_seek_price_basis = "Utilisation (lock ratio)" Then
                        Range("ceiling_config_output" & j) =
Application.WorksheetFunction.Max(Avail_price - Increment * (1 / Util_avail_ratio),
0)
                        Range("ceiling_config_output" & j).Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment, 0)
                    End If


                    ceiling_config_solution_found(j) = 1
                End If
            End If

    Next


    ceiling_overall_LWR = Range("ceiling_overall_LWR").Value
    If ceiling_overall_LWR = 1 Then
        If ceiling_overall_LWR_solution_found = 0 Then

                    If Goal_seek_price_basis = "Availability" Then
                        Range("ceiling_overall_LWR_output") =
Application.WorksheetFunction.Max(Avail_price - Increment, 0)
                        Range("ceiling_overall_LWR_output").Offset(0, 1) =
Util_price0
                    End If

                    If Goal_seek_price_basis = "Utilisation" Then
                        Range("ceiling_overall_LWR_output") = Avail_price0
                        Range("ceiling_overall_LWR_output").Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment, 0)
                    End If

                    If Goal_seek_price_basis = "Availability (lock ratio)" Then
                        Range("ceiling_overall_LWR_output") =
Application.WorksheetFunction.Max(Avail_price - Increment, 0)
                        Range("ceiling_overall_LWR_output").Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment * Util_avail_ratio, 0)
                    End If

                    If Goal_seek_price_basis = "Utilisation (lock ratio)" Then
                        Range("ceiling_overall_LWR_output") =
Application.WorksheetFunction.Max(Avail_price - Increment * (1 / Util_avail_ratio),
0)
                        Range("ceiling_overall_LWR_output").Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment, 0)
                    End If

              ceiling_overall_LWR_solution_found = 1
        End If
    End If


    ceiling_overall_average = Range("ceiling_overall_average").Value
    If ceiling_overall_average = 1 Then
        If ceiling_overall_average_solution_found = 0 Then

                    If Goal_seek_price_basis = "Availability" Then
                        Range("ceiling_overall_average_output") =
Application.WorksheetFunction.Max(Avail_price - Increment, 0)
```

```
                        Range("ceiling_overall_average_output").Offset(0, 1) =
Util_price0
                    End If

                    If Goal_seek_price_basis = "Utilisation" Then
                        Range("ceiling_overall_average_output") = Avail_price0
                        Range("ceiling_overall_average_output").Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment, 0)
                    End If

                    If Goal_seek_price_basis = "Availability (lock ratio)" Then
                        Range("ceiling_overall_average_output") =
Application.WorksheetFunction.Max(Avail_price - Increment, 0)
                        Range("ceiling_overall_average_output").Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment * Util_avail_ratio, 0)
                    End If

                    If Goal_seek_price_basis = "Utilisation (lock ratio)" Then
                        Range("ceiling_overall_average_output") =
Application.WorksheetFunction.Max(Avail_price - Increment * (1 / Util_avail_ratio),
0)
                        Range("ceiling_overall_average_output").Offset(0, 1) =
Application.WorksheetFunction.Max(Util_price - Increment, 0)
                    End If


            ceiling_overall_average_solution_found = 1
        End If
    End If

 '-------------------------------------------------------------------------------
----

    'Price = Price + Increment

    If Goal_seek_price_basis = "Availability" Then
        Avail_price = Avail_price + Increment
        Range("Avail_price") = Avail_price
        Application.StatusBar = "Testing availability price of £" & Avail_price &
"/MW/h (with utilisation price of £" & Util_price0 & "/MWh)"
    End If

    If Goal_seek_price_basis = "Utilisation" Then
        Util_price = Util_price + Increment
        Range("Util_price") = Util_price
        Application.StatusBar = "Testing utilisation price of £" & Util_price &
"/MWh (with availability price of £" & Avail_price0 & "/MW/h)"
    End If

    If Goal_seek_price_basis = "Availability (lock ratio)" Then
        Avail_price = Avail_price + Increment
        Util_price = Util_price + Increment * Util_avail_ratio
        Range("Avail_price") = Avail_price
        Range("Util_price") = Util_price
        Application.StatusBar = "Testing availability price of £" & Avail_price &
"/MW/h (with utilisation price of £" & Util_price & "/MWh)"
    End If

    If Goal_seek_price_basis = "Utilisation (lock ratio)" Then
        Util_price = Util_price + Increment
        Avail_price = Avail_price + Increment * (1 / Util_avail_ratio)
        Range("Avail_price") = Avail_price
        Range("Util_price") = Util_price
```

```
        Application.StatusBar = "Testing utilisation price of £" & Util_price &
"/MWh (with availability price of £" & Avail_price & "/MW/h)"
    End If


'-------------------------------------------------------------------------------
---


Next

'If outside range, reflect in the outputs
For j = 1 To config_count

    If Range("ceiling_config" & j).Offset(0, 1).Value = 0 Then
        Range("ceiling_config_output" & j) = "Flex not used"
    End If

Next

If Range("ceiling_overall_LWR").Offset(0, 1).Value = 0 Then
    Range("ceiling_overall_LWR_output") = "Flex not used"
End If


If Range("ceiling_overall_average").Offset(0, 1).Value = 0 Then
    Range("ceiling_overall_average_output") = "Flex not used"
End If

'-------------------------------------------------------------------------------
---
'Return prices to original values
Range("Avail_price") = Avail_price0
Range("Util_price") = Util_price0

'-------------------------------------------------------------------------------
---

Call Benefit_at_Flex_Price
```

Appendix B Stakeholder feedback and use of the CEM Tool

B.1 Purpose and use case for the CEM

The focus of the product is to standardise the approach that DNOs follow when assessing network options and make it transparent to stakeholders. The DNOs are the users of the tool, and may use the CEM to analyse various network options (e.g. flexibility, ANM).

B.2 Consideration of option value within the CEM

It was noted in a number of the responses to the Flexibility consultation in July 2020 that the CEM tool did not calculate the "option value" associated with flexibility solutions. There were concerns that, as a result, the value of flexibility would not be adequately reflected by DNOs. One of the advantages of using flexibility as opposed to conventional reinforcement is that, after the initial flexibility contract has expired, the DNO has the option to procure further flexibility, to reinforce, or to pursue some other strategy. By contrast, if a DNO initially reinforces the network, these subsequent options are no longer available.

The CEM tool has been updated to make the option value of uncertainty more explicit. The intrinsic value of flexibility is the value that corresponds to a single 'best view' scenario, whereas the total option value (including the uncertainty value) relates to the value when looking across all scenarios, either through the use of the Least Worst Regret or Weighted Average analytical approach.

B.3 Applying the CEM to 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 may 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 4 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.

B.3.1 DNO's costs under conventional vs ANM connections

A DNO can use the CBA tool in order to determine the costs and benefits of offering a conventional connection or a flexible connection. Using the CEM CBA tool, the user can determine which strategy (conventional or ANM) yields the highest NPV for the DNO over the whole modelling horizon. Further details for implementing this Use Case can be found within the User Guide embedded in the CEM CBA tool itself.

B.3.2 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.

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 general reinforcement. Again, the User Guide embedded in the CEM CBA tool includes further details on how to implement this Use Case.

B.3.3 Using energy efficiency to defer reinforcement

A DNO can test the effect of running an efficiency programme as a means to drive down peak demand. The CEM would need to be parameterised in the same way as in the Flexibility for Deferral Use Case, with the cost of flexibility procurement being replaced by the cost of efficiency measures. The user should consider how some aspects of an energy efficiency scheme endure for longer than an equivalent flexibility procurement scheme (e.g. once LED bulbs are installed, their impact on peak load could ensure for a number of years). The user should ensure that the cost of such schemes, therefore, are time-limited, whereas the benefits of deferral and, say, carbon reduction, are reflected over the longer-term.

B.3.4 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.

B.3.5 Other associated Open Networks project products

Product 4 within Workstream 4 of the Open Network project has developed a Whole System CBA. This product can consider a range of costs and benefits across multiple parties and so can be used as an evaluation tool for considering the implications for solutions outside of the single DNO lens that the CEM tool has been developed for.