Public

December 2024 / Issue 10.1 Draft

Options Assessments

Annex describing the core options assessment process

NESO
National Energy
System Operator

Overview

This section describes the assessment process used to produce a recommendation for each reinforcement, taking into account the assessment criteria. The options will be evaluated using a multi-criteria assessment approach, similar to the process used in the Beyond 2030 analysis:

- Economic
- Environmental impact
- Community impact
- Deliverability and operability.

The economic assessment is conducted first, since without a justification for the reinforcement based on positive economic benefit, no further analysis is needed.

5.1 Economic options assessment

5.1.1 Cost-benefit analysis overview

1. The cost-benefit analysis compares forecast capital costs and monetised transmission benefits over the project's life to inform the investment recommendation. The majority of the economic benefit will be the forecast reduction in constraint costs but may include other elements such as the reduction in the societal cost of carbon[1].
2. The economic assessment provides investment recommendations based on the Single Year Regret Decision Making process. If NESO's recommendation is **"Proceed – Critical"** and triggers a LOTI / MSIP for a RIIO Needs Case, NESO will assist the TOs to produce a Needs Case by undertaking a more detailed cost-benefit analysis.
3. The purpose of the Single Year Regret Decision Making process along with the other assessment criteria is to inform investment recommendations regarding wider transmission works. The main output of the process is a list of recommended wider works reinforcement options to receive either a **"Proceed – Critical"** recommendation or a **"Proceed – Maintain"** recommendation for the next year.
4. The methodology for a LOTI cost-benefit analysis follows the Large Onshore Transmission Investments (LOTI) Re-opener Guidance document published by Ofgem. A Needs Case is submitted by the TO that proposes the option to the regulator, and which includes a cost-benefit analysis section that outlines the financial case for the option. The output of this process is a recommendation as to whether the option should progress.

5.1.2 Cost-benefit analysis methodology

1. A separate economic assessment is performed for each FES scenario. When the number of transmission system reinforcement options proposed is considered large enough to require

---

[1] Valuation of greenhouse gas emissions: for policy appraisal and evaluation - GOV.UK

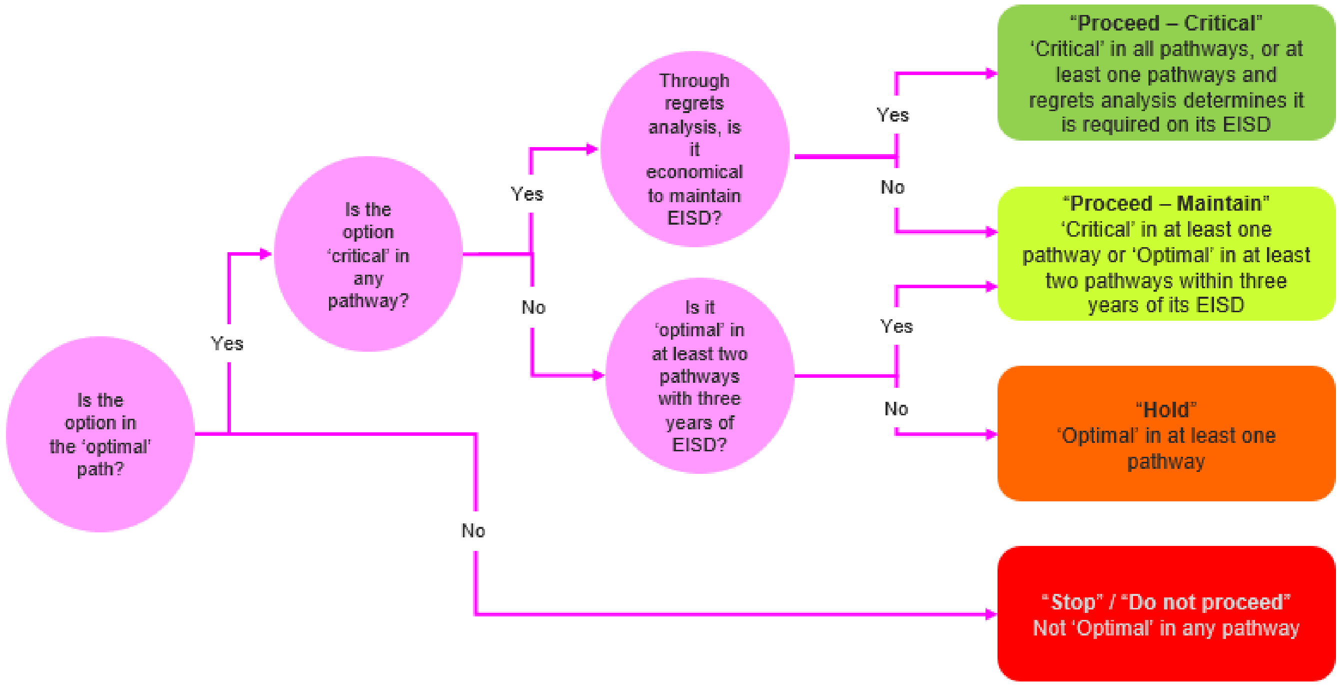
it, the country may be split into regions and each option is primarily allocated to one of the regions. Otherwise, all options will be assessed for the whole of GB at the same time.

2. When the assessment is performed by region, the cost-benefit analysis is conducted in isolation for each region and the annual boundary capability outside the region is fixed to a pre-determined value, which may vary by scenario. This is usually based upon the recommendations of the most recent NOA report. The size of a region and how it is defined may change from year to year.
3. The process is iterative and involves adding a single reinforcement at a time and then evaluating the effect that this change has had on the forecast transmission constraint (and other) costs. During this stage, reinforcements are assessed on their earliest in-service date (EISD). This analysis starts from an initial position where none of the options to be assessed are selected. Output from the market modelling tool (see *Table* 2.1, Annex 1 for a description) based on the initial position provides a base-case against which the output of subsequent iterations can be compared. In addition to forecast costs, the output of the model provides information about which boundaries within the region are likely to benefit from reinforcement and the year in which the option is required. For each iteration the model will be run with a different combination of options, so that when this stage of the process is complete each option has been assessed with various combinations of other options. The outputs from each iteration are compared to determine whether each option provides economic benefit and to identify the combination of options that provide the maximum economic benefit.
4. It is assumed that each transmission asset has a 40-year asset life. Since the market modelling tool only provides a forecast for 20 years, the forecast costs in year 21 onwards are assumed to be the same as year 20 (note that this limitation occurs because the scenarios do not contain detailed ranking orders beyond 20 years). Cost forecasts are discounted using HM Treasury's Social Time Preferential Rate (STPR) to convert the forecasts into present values. The capital cost for each option selected is amortised over the asset life by applying the Spackman methodology, using the prevalent WACC and discounted using the STPR. The present value of the base-case cost is then compared to the present value of the reinforced-case cost plus the amortised present value of the capital costs, to give the net present value (NPV) for this option.
5. The optimal delivery year for each option is found by calculating the present value (PV) sum of forecast costs and capital costs for combinations of delivery year for all options that were found to provide benefit. For instance, it may be economically optimal to deliver an option two years after its EISD because the forecast benefit in the first two years does not justify an earlier delivery year when considering the time value of money in relation to capital costs.
6. The cost-benefit analysis considers the outage restrictions when deciding the optimal delivery years of the options. The delivery years are chosen so that the combined economic benefit of all the options that were found to be required in each scenario is maximised when taking in to account the interactions between options and the resulting outage restrictions.
7. The outcome of this process is a list of reinforcement options, for the current region and scenario, and the optimum year for each. This is referred to as a 'reinforcement profile'. Once the reinforcement profile for each scenario within a region has been determined, the 'critical' options for that region can be determined.

8. An option’s recommendation is ‘critical’ if its optimal delivery year is equal to its earliest in-service date under at least one scenario.
9. To align with the Treasury Green book, the societal cost of carbon is considered within the economic benefit for options that reduce carbon emissions (by enabling greater low-carbon generation).

5.1.3 Recommendation and single year least worst regret decision making

Figure 5.1 - Flow diagram of the decision tree for recommendations



1. Figure 5.1 above shows the decision tree for determining the recommendation for each option. Where an options optimal delivery year is equal to its EISD in at least one scenario, the single year least worst regret methodology is used to determine one of the following recommendations:
    a. **“Proceed - Critical”** - the option to be delivered on its EISD;
    b. **“Proceed - Maintain”** - the option to be delivered up to three years after its EISD.
2. Where an options optimal delivery year is equal to its EISD in all scenarios its recommendation is **“Proceed - Critical”** (and the single year least regret methodology is not required).
3. Where an options optimal delivery year is within 3 years of its EISD in at least two pathways (but not equal to its EISD in at least one scenario) its recommendation is **“Proceed - Maintain”**
4. Critical options that are recommended to be delivered more than three years after its EISD are given a ‘Hold’ recommendation.

5. Options that are not found to be optimal are given a **'Do not start'** or **'Stop'** recommendation.
6. For each option assessed by the single year least regret methodology the present value cost is calculated for all permutations of delivery year (EISD, EISD+1, etc) and for each scenario. Operational and capital costs are taken into account in addition to forecast costs from the market modelling tool.
7. For each scenario one of the permutations will have the lowest present value cost; this is set as a reference point against which all the other permutations for that scenario are compared. The regret cost is calculated as the difference between the present value cost of the permutation for a scenario and the present value cost that is lowest of all permutations for the scenario. This results in one permutation having a zero-regret cost for each scenario.
8. The following section is a worked example of the least worst regret decision making process. Two options have been determined to be 'critical' in this region, the EISD for option 1 is 2027 and the EISD for option 2 is 2028. The optimum years for scenarios A, B and C are shown in Table 5.1.

   Note that the scenarios are colour-coded; this is used for clarity in the following tables.

Table 5.1 – Example of optimum years for two critical reinforcements

Scenario	**Option 1**	**Option 2**
A	2027	2028
B	2027	2029
C	2032	Not Required

Table 5.2 - Example decision tree

Permutation	Year 1 Recommendations	Completion Date	PV of cost	Regrets	Worst regret for each permutation
1	“Proceed - Critical” Option 1 & “Proceed - Maintain” Option 2	Option 1: 2027 Option 2: 2029	£149m	£102m	£102m
		Option 1: 2027 Option 2: 2029	£100m	£35m	
		Option 1: 2031 Option 2: Cancel	£145m	£5m	
2	“Proceed - Maintain” Option 1 & “Proceed - Critical” Option 2	Option 1: 2028 Option 2: 2028	£98m	£51m	£51m
		Option 1: 2028 Option 2: 2029	£65m	£0m	
		Option 1: 2032 Option 2: Cancel	£140m	£5m	
3	“Proceed - Critical” Option 1 & “Proceed - Critical” Option 2	Option 1: 2027 Option 2: 2028	£200m	£153m	£153m
		Option 1: 2027 Option 2: 2029	£98m	£33m	
		Option 1: 2032 Option 2: Cancel	£135m	£0m	
4	“Proceed - Maintain” Option 1 & “Proceed - Maintain” Option 2	Option 1: 2028 Option 2: 2029	£47m	£0m	£15m
		Option 1: 2028 Option 2: 2029	£68m	£3m	
		Option 1: 2031 Option 2: Cancel	£150m	£15m	

9. Table 5.2 is an example of a least worst regret decision tree for two ‘critical’ options, which results in four permutations. For each scenario one of the four permutations is the optimum and therefore there is one £0m value of regret for each scenario. The table’s PV column indicates the present value cost for each of the permutations in each of the scenarios.
10. The causes of the regret costs vary depending upon the optimum year for the reinforcement and scenario:
    - If the option is delayed and cannot meet the optimum year, then additional constraint costs will be incurred.
    - If the option is delayed unnecessarily then there will be additional delay costs.
    - If the option is progressed too early, then there will be inefficient financing costs.
    - If the option is progressed and is not needed, then the investment will provide less benefit than its cost.

    The regret costs for each permutation under all scenarios are then compared to find the greatest regret cost for each permutation. This is referred to as the worst regret cost. The permutation with the least ‘worst regret’ cost is chosen as the recommended option and appears in the report’s investment recommendation. In the example shown above the least ‘worst regret’ permutation (no. 4) is to give a **“Proceed – Maintain”** to both options 1 and 2 which has a worst regret of £15m and is the least worst regret of the four permutations.

11. As the scenarios represent an envelope of credible outcomes it is possible that a reinforcement option is justified by just one scenario which doesn't always guarantee efficient and economic network planning if industry evolution were to follow a different path. In this event, NESO would examine the single year regret analysis result to establish the drivers and then examine the scenario further. How we do this varies but an example would be to consider the sensitivity of the cost-benefit analysis to specific inputs. This informs our view on the robustness of the outcome and thus whether to make a recommendation based upon this scenario. NESO supports all the TOs in this manner to optioneer and develop their projects to minimise the cost, such as reducing any frontloading of expenditure if there is doubt about the need for the reinforcement option or downgrading the importance of the investment completely. NESO examines any sensitivity studies in the same way to ensure that none skew the results unfairly. For example, if a change in policy were to occur after the publication of the FES document, significant amounts of generation in the scenarios may be affected and their connection may then be delayed or unlikely to go ahead. We would flag this kind of background update and identify in the single scenario driven investments where this is likely to be creating a skewed outcome.

5.1.4 Probability Analysis - Least Worst Weighted Regret (LWWR)

1. The effect of varying the probability of each scenario occurring is also explored using the technique called Least Worst Weighted regret (LWWR).
2. The LWR technique assumes that each scenario is equally likely to occur. NESO does not assign probabilities to any of the FES scenarios, however LWWR provides us with a technique to explore the effect of varying the probabilities. This is particularly useful when regrets between various options are close. This can be used to see how stable a solution is to changes in the probabilities occurring, and hence aid in the evaluation of particular options.
3. The LWWR technique works by taking the initial LWR results, which have implicit equal (0.25 probability) weighting for each scenario, then changing these weightings between 0 and 1 for each scenario individually and performing the LWR technique at every possible permutation of weightings. At each permutation the option with the least worst regret is found, allowing us to see which options provide the least regret at every possible combination of weightings.

5.1.5 Sensitivities and additional analysis

1. Sensitivities are used to enrich the analysis for particular boundaries to ensure that relevant boundary issues are captured, such as the sensitivity of boundary capability to the connection of a large generator or interconnector. NESO and TOs use a Joint Planning Committee subgroup as appropriate to coordinate sensitivities. This allows regional variations in generation activity and anticipated demand levels that still meet the scenario objectives to be appropriately considered.
2. For example, the contracted generation background on a national basis far exceeds the boundary requirements under the four main scenarios, but on a local basis, the possibility of the contracted generation occurring is credible and there is a need to ensure that we are able to meet customer requirements. A “one in, one out” rule is applied: any generation added in a region of concern is counter-balanced by the removal of a generation project of similar fuel type elsewhere to ensure that the proportion of each generation type is maintained in the scenario. This effectively creates sensitivities that still meet the underlying assumptions of the main scenarios but accounts for local sensitivities to the location of generation.
3. The inclusion of a local contracted scenario generally forms a high local generation case and allows the maximum regret associated with inefficient constraint costs to be assessed. In order to ensure that the maximum regret associated with inefficient financing costs and increased risk of asset stranding is assessed, a low generation scenario where no new local generation connects is also considered. This is particularly important where the breadth of scenarios considered do not include a low generation case.
4. Interconnectors between GB and Europe give rise to significant swings of power on the network due to their size and because they can act as both a generator (when importing energy into GB) and demand (when exporting energy out of GB). For example, when interconnectors in the South East are exporting to mainland Europe, this changes the loading on the transmission circuits in and around London and hence creates different boundary capabilities.
5. NESO models interconnector power flows from economic simulation using a market model of forecast energy prices for GB and European markets. The interconnector market model covers full-year European market operation. The results of the market model are then used to inform which sensitivities are required for boundary capability modelling. Sensitivities may be eliminated for unlikely interconnector flow scenarios.
6. NESO and TOs extend sensitivity studies to test credible conditions that may cause constraints. FES data tends to produce boundary flows in one direction, such as north to south. In some circumstances, flows may be reversed. NESO develops relevant sensitivities in consultation with stakeholders to produce boundary capabilities for these sensitivity cases.
7. The resulting boundary capabilities from sensitivity studies are used by the market modelling tool to forecast the constraint costs for different network scenarios.
8. Storage, hydrogen electrolysis and other whole system solutions can also be considered as part of sensitivity analysis by varying the volume and location of their deployment.
9. In addition to the above, analysis will be performed for the purposes of providing further information and context to NESO’s recommendations. This additional analysis may vary

depending on the circumstances encountered at the time of the assessment, and as required, but may include:

- Calculation of sensitivities to show the impact of changing the capital costs for options on the forecast net benefit,
- Calculation of benefit cost ratios to indicate value-for-money or identify options that may be marginal, or sensitive to a change in inputs such as an options capital costs,
- Assessment of options using different modelling assumptions, for instance to assess the impact of expected industry reform,
- Calculate the level of emissions and percentage of clean power associated with certain options or combinations of options.

5.2 Environmental and Community impacts and risks of options

1. As the TOs design and develop their options, their understanding of the environmental impacts of options improves. The TOs indicate the maturity level of their options which helps to highlight where the environmental impact needs further development. NESO gives a similar indication on options that it is leading. As the tCSNP2 Refresh is the first step in an analysis of the need for reinforcement of the national electricity transmission system, it cannot provide a final environmental assessment of those options. The TO will take any appropriate and timely environmental considerations into account as part of their investment process and according to relevant planning laws.
2. Different planning legislation and frameworks apply in Scotland from those in England and Wales and some reinforcements cross more than one planning framework. The TOs have the specialist knowledge for planning and consents and provide the relevant commentary.
3. The TOs provide views on the environmental impact of the options that they have proposed, in accordance with the NESO's onshore assessment methodology. The NESO uses this information to help understand the environmental, social and community challenges of proposed options, and while the information does not form part of the economic analysis, it is possible that an option (or specific combination of options) is omitted because of the assessment.
4. Both environmental and community impacts will be assessed together prior to and during the economic analysis to understand the overall impact of options. This can also be provided to the committee to help inform their decision, as detailed in the Governance annex.
5. Options that have high certainty of environmental and community challenges will not be progressed in the analysis at this stage and the marginal options will be taken to the governance meetings to decide how they should be progressed.
   As part of this analysis, we will be adopting the principles set out within the Pathway to 2030's environmental assessment methodology and which were used in the Beyond 2030 report's analysis.

5.3 Deliverability and Operability of Options

1. Deliverability and Operability is one of the assessment criteria in determining tCSNP2 Refresh recommendations. Deliverability and Operability means categorising initial design(s) against several aspects such as complexity, interfaces, technology maturity and timing. The schemes will still need to meet the code and standards requirements such as the Security and Quality of Supply Standards (SQSS).
2. The consideration points are set out below and further described in HNDFUE Methodology. These points are not intended to be a complete list, as the options appraisal looks at high-level design that will progress to Detailed Network Design (DND). Each option will be appraised for their deliverability and operability impact. This assessment will be conducted as a Black – Red – Amber – Green (BRAG) focus considering:
   - Design complexity; technical difficulty in realising a design i.e. interface / landing points, interconnectivity of sites, cabling, and/or offshore substation.
   - Construction complexity: To realise the design including potential risks of a particular design option for both onshore and offshore activities.
   - Technology Readiness Level: The maturity of the proposed assets from well established, tried, and tested technology such as 400kV AC equipment through to new technology such as HVDC circuit breakers that the industry has little experience with and carry higher initial risk.
   - Supply chain availability to meet the required design complexity, material quantities and connection programme.
3. To allow the comparison and refinement of options, with the possible rejection of infeasible designs, each will be assigned a BRAG rating. Table 5.3 provides a description of the BRAG definitions used for deliverability. The design options are developed in accordance with the technical design rules - so none should fall into the black rating. The output of this stage is a set of design options using the previously identified routes and sites. The design options will feed the economic assessment stage.
4. Deliverability for each initial option is also determined by likelihood of achieving the design by 2030-2035. The BRAG for each topic is described in Table 5.3. If a design is determined as 'Black' it shall not progress onto the economic assessment stage.

Table 5.3: BRAG definition for Deliverability

Colour Rating	Description
⬛	Highly complex design(s) with new or emergent technology unlikely to be deliverable for 2030-2035. The design is subject to high likelihood of constraints and risks affecting the construction, consenting and/or operability to such a degree that the option should not be considered further.
🟥	Design that features some complex elements or technology that may be challenging to deliver for 2030-2035. The design is subject to constraints that are likely to affect construction, consenting or operability to such a degree that the option should not be included without potential solutions identified.
🟨	Design of moderate to significant complexity, with constraints or risks which may impact constructability, consenting or operability. Design is likely to be achievable and issues capable of resolution
🟩	Design of low to moderate complexity using proven technology. The design is subject to low likelihood of constraints affecting construction and/or consenting. Option likely to be achievable by 2030 - 2035.

5. This methodology is to be used as an aid to support consistent, evidence-based assessment for each of the option paths.

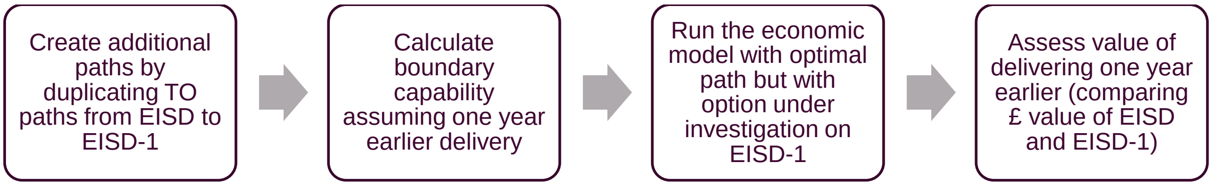
5.4 Options analysis outputs

1. Following single year least worst regret analysis and the assessment stages described above, a list of investment recommendations for the region is presented as described below:
    - **"Proceed - Critical"**: This option is critical to our future planning. Investment should be made in the next financial year to ensure the option's earliest in-service date remains on course.
    - **"Proceed – Maintain"**: This option is important and recommended soon after its earliest-in-service date. Investment can be made in the next financial year to maintain project momentum and ensure its earliest-in-service date is delayed by at most one year.
    - **"Hold"**: This option is important and recommended for the future, however it is not considered optimal on the submitted earliest-in-service date. Therefore, the delivery date of this option can be delayed by at least one year and the option can be reviewed in the next network planning cycle.
    - **"Stop"**: This option is not currently recommended within the optimal path of any scenario; delivery should be stopped and not be continued.
    - **"Do not start"**: This option is not currently recommended within the optimal path of any scenario; delivery work should not begin.
2. If despite the process described in Annex 3 (section 3.1.8), the optimal year for one or more options is primarily and adversely affected by the outage requirements NESO will bring the options to the attention of the tCSNP2 Refresh committee. NESO will present evidence to the Committee including: the outage interactions or restrictions that influenced the results; the expected economic impact and the steps taken during the process described in paragraphs 1 to 11 in Annex 3 (section 3.1.8) by the relevant TO if applicable. NESO may request that the TO also provides evidence or technical details.
3. NESO uses the output from the single year least worst regret analysis for the recommendation on whether a reinforcement option should receive a "Proceed - Critical" under the England and Wales Network Development Policy (NDP) framework.
4. If the investment signal triggers the TO's Needs Case, NESO will assist the TO in undertaking a more detailed cost-benefit analysis. NESO reconciles the results of the regret analysis and any other drivers such as NETS SQSS, as mentioned previously in the section on sensitivities before making a final recommendation.
5. If a TO does not follow a NOA recommendation, it must inform NESO at the earliest opportunity and tell NESO about the effect on the option's EISD. If the TO has discretion over the change, it should fully involve NESO in the decision process. The tCSNP2 Refresh Committee will monitor the process and the outcome.

5.5 EISD Advancement Benefit

1. The EISD advancement benefit is to support a substantial reduction in network constraint costs and is an outcome of the 5-point plan[2]. Reinforcement options are shortlisted that would provide significant constraint cost savings from earliest in-service date (EISD) advancement. The purpose of this exercise is to stimulate early delivery, or at least highlight the importance of delivering schemes on their published earliest in service date. The results of the analysis are shared with the relevant TO but not included in the report.
2. The options for EISD advancement are selected individually by identifying bottlenecks to providing higher capability using our standard options assessment toolset. These tools not only report boundary bottlenecks but also the cost associated with resolving these constraints. To be a candidate for advancement, the option being considered should have precursor reinforcements with earlier EISDs, such that bringing them forward poses no knock-on advancement of other options.
3. As an example, consider a path that has three reinforcements A, B, C. A and B could be built in 2029, but C had an EISD of 2030, after B is built, we have to wait until 2030 before C can be built providing the next uplift. It is noted that C relieves several boundary constraints, causing constraint costs to decrease significantly. As such C would be identified as a potential candidate for advancement to 2029.
4. To establish the benefit of advancing schemes one or more years earlier than the EISD requires input including the capability that the scheme releases on boundaries and capital costs associated with delivering the scheme to this earlier year. To establish this for every scheme requiring assessment would be resource intensive, and therefore a method that utilises existing data from the main tCSNP2 Refresh process was created. The following diagram highlights the main steps.

Figure 5.2 - Method for approximating EISD advancement benefit



5. Additional paths are added representing the capability released on each boundary by a scheme. The capability values are obtained from the EISD year's capability value, essentially duplicating this to a year earlier. This method focusses on quantifying the approximate constraint cost saving, and therefore other factors are considered equal.
6. Using these updated capability values an economic market simulation is performed to determine constraint costs. The potential benefit of bringing an option forward by one year is then calculated as the difference between constraint cost where the option is delivered on its EISD versus delivery one year earlier.

---

[2] Our 5-point plan to manage constraints on the system | National Energy System Operator

7. The findings are then communicated to the relevant TO who can then use the evidence to either advance the option or to maintain an option on its EISD in the case where conflicting issues may cause delay.