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Shadow Carbon Pricing in Network Rail

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Shadow carbon pricing in Network Rail

1. Introduction

As part of the implementation of its strategy to be a net-zero railway by 2050 (and by 2045 in Scotland), Network Rail intends to introduce shadow carbon pricing in relation to its capital investment projects[1]. Shadow carbon pricing places a monetary value on the changes in greenhouse gas (GHG) emissions attributable to Network Rail that resulting from capital investment projects. It allows the social and environmental implications of GHG emission changes to be monetised in the same way as other project costs. The use of shadow carbon pricing will facilitate the organisation in adopting solutions that are consistent with the organisation's net-zero goal.

Shadow carbon pricing is only a decision-support tool to ensure that the business takes decisions in relation to its capital investments that are consistent with its strategic goals. It does **not** result or require a direct transfer of financial value from Network Rail to any external party, or across different parts of Network Rail.

This note provides guidance to help implement shadow carbon pricing within capital investment projects. It is split into five further sections:

- Section 2 considers when in the PACE process shadow carbon pricing should be applied;
- Section 3 addresses which GHG emissions should be subject to a shadow carbon price and how these should be identified;
- Section 4 identifies the carbon prices to be applied within the assessment;
- Section 5 provides a worked example, using a complementary spreadsheet tool 'Network Rail Internal Carbon Pricing Tool'
- Section 6 discusses how the results of shadow carbon pricing should be used.

[1] There may be scope to apply shadow carbon pricing in other Network Rail decision-making processes. Annex 2 discusses the potential future application of shadow carbon pricing into procurement decisions.

2. When in the PACE process should shadow carbon pricing be used?

Shadow carbon pricing should be used at two points within the delivery of a capital investment project using PACE:

- During the period leading up to ‘single option identified and endorsed’ (ES3) where shadow carbon pricing can help inform which single option is preferable.
- During the period leading up to ‘design standards approved and Approval in Principle’(ES4), where shadow carbon pricing can help inform which design features to incorporate within the endorsed single option.

The business recognises that applying shadow carbon pricing in all contexts would not be proportionate. In order to support streamlined and efficient decision-making, and to focus shadow carbon pricing in cases where it can facilitate material GHG emission reductions, Table 1 sets out how the application of shadow carbon pricing varies by a project’s Level of Control (LoC)/Project Complexity Assessment (PCA) and PACE stage.

Table 1 The use of shadow carbon pricing by PACE stage and LoC/PCA tier

	LoC/PCA 1	LoC/PCA 2	LoC/PCA 3	LoC/PCA 4
Shadow carbon pricing to inform identification of single option (ES3)	Required	Required	Optional	Optional
Shadow carbon pricing to inform specific design features (ES4)	Required	Optional	Not required	Not required

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3. Which GHG emissions should be subject to shadow carbon pricing?

This section sets out how emissions should be assessed for the purposes of undertaking shadow carbon pricing. It first presents generic considerations that apply whenever Network Rail undertakes shadow carbon pricing, and then provides specific guidance for the application of shadow carbon pricing at ES3 and ES4, respectively.

In all cases, users will need to define the 'system boundary' for the assessment of GHG emissions. This term describes the set of criteria that collectively define the scope of the emissions to be included for the purposes of shadow pricing. The system boundary consists of three dimensions:

a. The spatial aspect or the 'system element and factors'. This requires determining which assets or set of assets and components (hardware) should be included (and which can be excluded). For the purposes of shadow carbon pricing, the system element should ideally cover all of the assets (or asset system) that comprise the capital investment project.
b. The temporal or 'reference study period'. This defines the time period over which GHG emissions will be assessed. For the purposes of shadow carbon pricing, this should ideally correspond to the expected functional life of the asset or asset system within the capital investment project.
c. The 'PAS 2080 life cycle modular scope'. PAS 2080[2] identifies 15 modules which provide a convenient way of thinking about the emissions of a capital investment project over its lifetime e.g. emissions associated with raw material supply, emissions associated with operational energy use. The user needs to consider which of these modules are appropriate. Guidance relating to the choice of the life cycle modular scope will be available in a forthcoming guidance note on whole-life carbon (NR_GN_ESD07).

The system boundary for the purpose of assessing GHG emissions for shadow carbon pricing covers those emissions associated with Network Rail developing, constructing, operating and disposing of infrastructure assets. The use of the infrastructure may prompt further changes in GHG emissions through, for example, encouraging modal shift from road to rail. These changes in emissions are not within the system boundary for the purposes of applying shadow carbon pricing. However, these other emission changes are captured in the socio-economic business case assessments (of enhancement projects). This business case assessment is, in turn, informed by an assessment of an infrastructure project's costs, including its monetised carbon cost.

[2] PAS 2080 is a global standard for managing carbon from infrastructure assets and projects.

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The Rail Carbon Tool provides an easy and practical way in which users can assess the GHG emissions associated with capital investment projects. It is a web-based calculator that assesses the GHG emissions associated with capital investment projects based on an assessment of the GHG emissions intensity of the inputs into that capital investment project. While it was not originally designed to accommodate life cycle emissions assessments – in other words, to allow assessment of all 15 of the lifecycle modules within PAS2080 – new templates have recently been developed which extend the functionality of this tool.

It is expected that carbon dioxide (CO_2) will be the most important GHG across Network Rail's activities, and most effort should be focused in collecting information on this gas. However, where other major GHGs emissions are believed to be material these should also be included in the assessment. Other GHGs are methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). For example, switchgear used on the railway is often insulated with SF_6. Non-CO_2 GHGs should be converted into CO_2-equivalents (CO_2e) using the conversion factors identified by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report, as reported by the Greenhouse Gas Protocol. These conversion factors express the expected warming impact of different GHGs relative to the warming impact of CO_2. For example, the conversion factor of N_2O is 265 meaning that each tonne of N_20 released into the atmosphere is considered to have a warming impact 265 times greater than each tonne of CO_2. The Rail Carbon Tool automatically includes all of these GHG emissions and converts them into CO_2e using appropriate conversion factors.

GHG emissions need to be quantified on an annual basis. This is a standard output from the Rail Carbon Tool.

3.1 Assessing emissions at ES3

At ES3, shadow carbon pricing will help inform which single option is preferable. For example, it can help assess which option might be best to adopt for stabilising a rail embankment. Alternatively, it can be used to inform whether to proceed with an energy efficiency retrofit of some of Network Rail's property portfolio.

At ES3, the absolute[3] emissions associated with *each* of the options under consideration should be assessed. As far as possible, a consistent approach to defining the system boundary (across all three dimensions – spatial, temporal and modular scope) should apply to each option under consideration.

Network Rail recognises that the uncertainty surrounding GHG emission projections associated with different capital investment options at ES3 may be particularly pronounced. However, this should **not** be used as a reason to avoid the application of shadow carbon pricing; the sooner within the capital investment planning and delivery

[3] This is equivalent to saying that the emissions should be assessed relative to a baseline in which the capital project does not proceed

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process that GHG emissions are considered, the greater is the ability to control and reduce GHG emissions. Where necessary, scenario analysis[4] can be used to understand whether the uncertainty in future GHG emissions, for the purposes of applying shadow carbon pricing, is significant.

When applying shadow carbon pricing at ES3, the roles and responsibilities of different stakeholders will be as set out in Table 2 below. With the asset owner or client, responsibility (and accountability) for shadow carbon pricing is expected to be assumed by the Project Manager, subject to any further clarifying guidance that may be provided in the guidance note on whole life carbon assessment (NR_GN_ESD07).

Table 2 RACI matrix for undertaking shadow carbon pricing at ES3

	Client/ asset owner	Lead designer	Constructors	Product/ materials suppliers
Undertaking shadow carbon pricing at ES3	Responsible and Accountable	Consulted	Consulted	Informed

3.2 *Assessing emissions at ES4*

At ES4, shadow-carbon pricing can be used to define whether a particular low-carbon design feature should be incorporated within the design of the single option. For example, it might inform decisions as to whether track systems should include low-carbon sleepers, different platform design and construction material options, or the appropriate use of different types of cable troughing products.

In this case, the emissions associated with different design options should be calculated using a baseline in which the capital investment proceeds using conventional technologies or products. The emissions assessment should then identify how much lower (or higher) GHG emissions would be with alternative design option(s). Each design option under consideration should be assessed. A consistent approach to defining the system boundary of each option should be applied.

When applying shadow carbon pricing at ES4, the roles and responsibilities of different stakeholders will be as set out in Table 3 below. As at ES3, responsibility and accountability for shadow carbon pricing expected to be assumed by the Project Manager, subject to any further clarifying guidance that may be provided in the guidance note on whole life carbon assessment (NR_GN_ESD07).

[4] Scenario analysis would involve developing more than one estimate of the GHG emissions associated with the option/design feature under consideration.

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Table 3 RACI matrix for undertaking shadow carbon pricing at ES4

	Client/ asset owner	Lead designer	Constructors	Product/ materials suppliers
Undertaking shadow carbon pricing at ES3	Responsible and Accountable	Consulted	Consulted	Informed

4. How should the shadow carbon pricing calculation be undertaken?

The annual change in GHG emissions associated with each option/design feature should be multiplied by the monetary value of a tonne of CO_2e emissions in that year, using the values reported in Table 2. This series of carbon values is based on those provided by the Department for Business Energy and Industrial Strategy (BEIS). These are estimates of the value that need to be attached to GHG emissions in order for the UK to meet its net-zero goal by 2050 i.e. they are 'target consistent' carbon values. Given that Network Rail also has a net-zero by 2050 goal[5], it uses the same carbon values.[6] The same carbon values are also suggested to be applied in Scotland as, although it has an earlier net zero target (2045 versus 2050), both for the country as a whole and within Network Rail, this reflects the lower expected costs associated with meeting this goal within Scotland.

The carbon prices provided by BEIS and reported in Table 4 are provided in real 2020 prices. It is important that carbon costs are reported on the same price basis as the other costs of the option/design feature under consideration. This has one of two implications:

- In the event that the other project costs are also in real prices then the values in Table 4 should be used, with all carbon values adjusted by the same factor to convert them from 2020 prices to the real price base in which the other project costs are reported. This factor will be the relative price level in the year in which the other project cashflows are reported divided by the price level in 2020. Network Rail's practice is that the Consumer Price Index should be used to adjust for price levels in renewals projects and the Retail Price Index should be used for enhancement projects.[7]
- In the event that other project costs are in nominal prices then the values in Table 4 will need to be converted into nominal prices. This will involve multiplying, for each year in which GHG emissions arise, the carbon values in Table 4 by the ratio of the estimated price level in that year and the price level in 2020. As discussed

[5] And in the absence of any information to suggest that Network Rail's decarbonisation will be cheaper/easier than for the country as a whole.

[6] It is acknowledged that, in some cases, some of the life-cycle emissions associated with investment options or design features will already be partly captured in market prices through policy instruments such as the UK Emissions Trading System. However, at this initial stage in the implementation of shadow carbon pricing in Network Rail, it is not recommended to make an adjustment to account for this. This makes the application of shadow carbon pricing considerably easier than otherwise. It also reflects both that the carbon price in the UK ETS is notably lower than those identified by BEIS and because design features of the UK ETS may prevent carbon prices being reflected in product prices. This will be revisited in future as UK policy ambition increases.

[7] For example, other project costs of a renewal project may be reported in 2019 prices. The Office for National Statistics reports that the value of the Consumer Price Index was 107.8 in 2019 and 108.9 in 2020. In this case, all of the values in Table 4 would be multiplied by the factor 107.8/108.9=0.99.

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above, the estimated future price level should refer to the Consumer Price Index for renewals projects and the Retail Price Index for enhancement projects.[8]

When assessing other project costs, Network Rail discounts future costs to place less weight on costs that arise further into the future. The same practice should be followed in relation to the carbon costs of an option or design feature. The appropriate discount rate to use will depend on whether the carbon costs have been expressed in real or nominal terms:

- In the case that carbon costs are expressed in real terms, then the discount rates of HM Treasury's Green Book should apply, these are 3.5 % for years 0-30, 3.0 % for years 31-75 and 2.5 % for years 76 and beyond.
- In the case that project costs are expressed in nominal terms, then the real discount rate needs to be adjusted for the estimate of inflation in that year. The formula for converting a real discount rate to a nominal discount rate is:

$$Nominal\ discount\ rate\ (\%) = \big(1 + real\ discount\ rate(\%)\big) * (1 + inflation\ rate(\%)) - 1$$

Table 4 Carbon price values (in £2020 prices) for use in shadow carbon pricing

Year	Value (£2020 prices)		Year	Value (£2020 prices)
2020	241		2036	307
2021	245		2037	312
2022	248		2038	316
2023	252		2039	321
2024	256		2040	326
2025	260		2041	331
2026	264		2042	336
2027	268		2043	341
2028	272		2044	346
2029	276		2045	351
2030	280		2046	356

[8] For example, in the event that the other project costs of an enhancement project are in nominal terms, then the future estimated value of the retail price index (RPI) would need to be estimated, drawing either from existing Network Rail sources or, for example, the Office for Budget Responsibility. These estimates might suggest that the value of the RPI is expected to be 296.2 for 2021 and 298.4 for 2022. This compares with 293.1 for 2020. This means that the 2021 carbon price value of £245 would need to be multiplied by a factor of 296.2/293.1=1.011 which would give a carbon price value of £248 (rounded to the nearest £) and that the 2022 carbon price value of £248 would need to be multiplied by a factor of 298.4/293.1=1.018 giving a value of £252 (rounded to the nearest £).

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2031	285		2047	362
2032	289		2048	367
2033	293		2049	373
2034	298		2050	378
2035	302			

Source: BEIS (2021) Valuation of greenhouse gas emissions: for policy appraisal and evaluation
Note: Values beyond 2050 can be estimated by applying a real annual growth rate of 1.5 % in each subsequent year.

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5. Worked example

The accompanying spreadsheet 'Network Rail Internal Carbon Pricing tool 081221' can be used to undertake the internal carbon pricing assessment. This section discusses how the tool can be used and provides a worked example.

The key data entry sheet is the 'Emissions Forecast' sheet. In this sheet, the user should enter four pieces of information:

- The number of options (ES3) or design features (ES4) under consideration should be entered in cell C7.
- In cell B9, the user should identify the year of project initiation. This is the first year in which there is activity associated with any of the options or design features being analysed.
- In cell B11, the user should identify whether the other (conventional) costs associated with the options or design features are expressed in nominal or real terms. If the other conventional costs are expressed in real terms, then the price base for these real costs (the price reference year) should be specified in cell D9.
- The PAS 2080 modular scope of the assessment should be defined through entering a series of 'yes' or 'no' responses in cell C15 and below.
- The GHG emissions, in tCO2e relative to the baseline, for each option or design feature, in each year, and for each PAS2080 module determined to be within the system boundary of the assessment, should be entered in columns D to AH. These will be an output of the Rail Carbon Tool.

The hypothetical example below shows a case in which the tool is being applied in ES3 to help inform single option identification. In this case, two options are considered, the earliest year in which activity associated with either option commences is 2022, the other cost associated with both options have been prepared in nominal prices, and all of the PAS 2080 modules are included except for 'preliminary studies, consultations' and 'refurbishment'. Figure 1 shows information regarding number of options, year of initiation and price base, Figure 2 shows the emissions for Option 1 – which is a higher emissions option – and Figure 3 for Option 2 – a lower emissions option.

Figure 1 Hypothetical entry of information associated with number of options, year of initiation and price base information in the Internal Carbon Pricing tool

Number of Options or Design Features Under Consideration		2	
Year of Project Initiation		2022	
Real or Nominal?	Nominal	Price Reference Year	

This is the year in which activity associated with theoptions or design feature is first undertaken. If different options or design features have different initiation dates, then the earliest year across all of the options should be stated.

The price reference year refers to the year whose price level is used as a basis for real prices. For example, costs which use 2020 prices as a reference year are refered to as 2020 GBP. This cell can be left blank if the analysis is being undertaken in nominal prices.

Figure 2 Hypothetical entry of emissions associated with Option 1 into Internal Carbon Pricing tool

Option/Design feature 1

Life Cycle Stag	Life Cycle Sub-	Include	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Before use	Preliminary studies, consultations	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Raw material supply	Yes	5,000	5,000	5,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport	Yes	2,000	2,000	2,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Manufacture	Yes	5,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport to works site	Yes	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Construction / installation processes	Yes	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Use	Yes	0	0	0	200	200	200	200	200	200	200	200	200	200	200	200	200
Use stage	Manufature	Yes	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
Use stage	Repair	Yes	0	0	0	0	0	50	0	0	50	0	0	50	0	0	0	0
Use stage	Replacement	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	0
Use stage	Refurbishment	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Deconstruction	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Transport	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Waste processing for recovery	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Disposal	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Life Cycle Stag	Life Cycle Sub-	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Before use	Preliminary studies, consultations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Raw material supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Manufacture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport to works site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Construction / installation processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Use	200	200	200	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Manufature	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Repair	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Refurbishment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Deconstruction	0	0	0	0	500	500	0	0	0	0	0	0	0	0	0
End of life stage	Transport	0	0	0	0	100	100	0	0	0	0	0	0	0	0	0
End of life stage	Waste processing for recovery	0	0	0	0	0	20	20	0	0	0	0	0	0	0	0
End of life stage	Disposal	0	0	0	0	200	200	0	0	0	0	0	0	0	0	0

Figure 3 Hypothetical entry of emissions associated with Option 2 into Internal Carbon Pricing tool

Option/Design	Feature 2																
Life Cycle Stag	Life Cycle Sub-!	Include	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Before use	Preliminary studies, consultations	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Raw material supply	Yes	2,000	2,000	2,000	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport	Yes	500	500	500	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Manufacture	Yes	4,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport to works site	Yes	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Construction / installation processes	Yes	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Use	Yes	0	0	0	250	250	250	250	250	250	250	250	250	250	250	250
Use stage	Manufacture	Yes	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10
Use stage	Repair	Yes	0	0	0	0	0	50	0	0	50	0	0	50	0	0	0
Use stage	Replacement	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000
Use stage	Refurbishment	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Deconstruction	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Transport	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Waste processing for recovery	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Disposal	Yes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Life Cycle Stag	Life Cycle Sub-!	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Before use	Preliminary studies, consultations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Raw material supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Manufacture	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Transport to works site	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Before use	Construction / installation processes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Use	250	250	250	250	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Manufacture	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Repair	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Use stage	Refurbishment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End of life stage	Deconstruction	0	0	0	0	0	500	500	0	0	0	0	0	0	0	0	0
End of life stage	Transport	0	0	0	0	0	100	100	0	0	0	0	0	0	0	0	0
End of life stage	Waste processing for recovery	0	0	0	0	0	0	20	20	0	0	0	0	0	0	0	0
End of life stage	Disposal	0	0	0	0	0	200	200	0	0	0	0	0	0	0	0	0

The sheet ‘Carbon Prices’ provides the internal carbon prices used within the tool, in real 2020 prices. These have been pre-set and do not need to be adjusted by the user.

The sheet ‘Inflation’ only requires user input in cases where the other project costs are expressed in nominal terms. When this is the case, the user must enter inflation estimates to allow the tool to convert the real 2020 carbon prices into nominal prices. The tool provides flexibility to use either Network Rail’s own inflation estimates or those from the Office for Budget Responsibility (OBR) The source is selected in cell B8 and annual inflation rates are added in rows 15 and 16 (in cases where Network Rail inflation estimates are used), or 19 and 20 (in cases where OBR inflation forecasts are used). The tool makes use of inflation forecasts using both the Consumer Price Index (used by Network Rail for inflation forecasting in renewals projects) and the Retail Price Index (used by Network Rail for inflation forecasting in enhancement projects). The spreadsheet provides detailed instructions on how the inflation forecasts can be updated. Figure 4 below illustrates a case where OBR inflation estimates have been used.

Figure 4 Applying inflation estimates within the Network Rail Internal Carbon Pricing Tool

Series used	OBR																	
Historical Data	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**							
CPI (2015 = 100)	90.1	93.6	96	98.2	99.6	100	101	103.6	106	107.8	108.9							
RPI (1987 = 100)	223.6	235.2	242.7	250.1	256	258.5	263.1	272.5	281.6	288.8	293.1							
NR Forecasts	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
CPI											0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
RPI											0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
OBR Forecasts	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
CPI											0.9%	2.3%	4.0%	2.6%	2.1%	2.0%	2.0%	2.0%
RPI											1.5%	3.6%	5.0%	3.4%	2.8%	2.8%	2.9%	2.9%
100)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
CPI	82.7	86.0	88.2	90.2	91.5	91.8	92.7	95.1	97.3	99.0	100.0	100.9	103.2	107.3	110.1	112.4	114.6	116.9
RPI	76.3	80.2	82.8	85.3	87.3	88.2	89.8	93.0	96.1	98.5	100.0	101.5	105.2	110.4	114.2	117.4	120.7	124.2

Notes: Depending on the inflation estimate series selected, the relevant cells to fill in are automatically highlighted in teal.

The sheet 'Discount rate' identifies the appropriate discount rate to be used in the analysis. In cases where the project costs and carbon prices are in real terms, the discount rates directly reported in the HM Treasury's Green Book are used. In the event that project costs and carbon prices are converted into nominal terms, it is necessary to use the nominal equivalent of these discount rates. This calculation is undertaken automatically – there is no need for any user input.

The 'Cost of Emissions' sheet provides the key output from the analysis. For each of the options under consideration, the user should specify in row 8 which carbon price series is to be used (with the default being the central value) and whether the assessment is in the context of a enhancement or renewals programme[9]. With this information, the tool determines the carbon costs and the net present value of those costs over the period to 2050. Figure 5 shows the results using the GHG emissions entered in Figure 1 and 2. In this example, the discounted value of the carbon cost in Option 1 is around £5.7m and in Option 2 is around £1.5m. In other words, in terms of carbon costs, Option 2 is £4.2m cheaper.

Figure 5 Carbon cost comparison of Options 1 and 2 using the Network Rail Internal Carbon Pricing tool

Number of Options Under Consideration		2		
Real or Nominal Costs?	Nominal	Reference Ye	N/A	
Option 1			**Option 2**	
Carbon Price Scenario	Central		Carbon Price Scenario	Central
Proposal Type	Enhancement		Proposal Type	Enhancement
Inflation Rate	RPI		Inflation Rate	RPI

Option 1	**NPV (to 2100)**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Before use	£5,103,557	£0	£0	£1,863,111	£1,803,010	£1,771,402	£0	£0	£0	£0	£0	£0
Use stage	£547,309	£0	£0	£0	£47,928	£47,088	£57,597	£45,950	£45,332	£55,357	£44,091	£43,469
End of life stage	£91,622	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Total	**£5,742,489**	**£0**	**£0**	**£1,863,111**	**£1,850,938**	**£1,818,490**	**£57,597**	**£45,950**	**£45,332**	**£55,357**	**£44,091**	**£43,469**

Option 2	**NPV (to 2100)**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Before use	£801,845	£0	£0	£801,845	£0	£0	£0	£0	£0	£0	£0	£0
Use stage	£649,487	£0	£0	£0	£59,340	£58,299	£68,674	£56,891	£56,125	£66,003	£54,588	£53,819
End of life stage	£91,622	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0	£0
Total	**£1,542,955**	**£0**	**£0**	**£801,845**	**£59,340**	**£58,299**	**£68,674**	**£56,891**	**£56,125**	**£66,003**	**£54,588**	**£53,819**

[9] As noted above, this determines the inflation series used to convert the real carbon price into a nominal carbon price. Once the user selects either 'renewal' or 'enhancement', the tool automatically selects the appropriate price series.

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The tool also provides a graphical representation of the carbon costs in the sheet 'charts'. Figures 6 and 7 provide a graphical comparison of the carbon costs by year of the two options.

Figure 6 Carbon cost of Option 1 using the Network Rail Internal Carbon Pricing tool

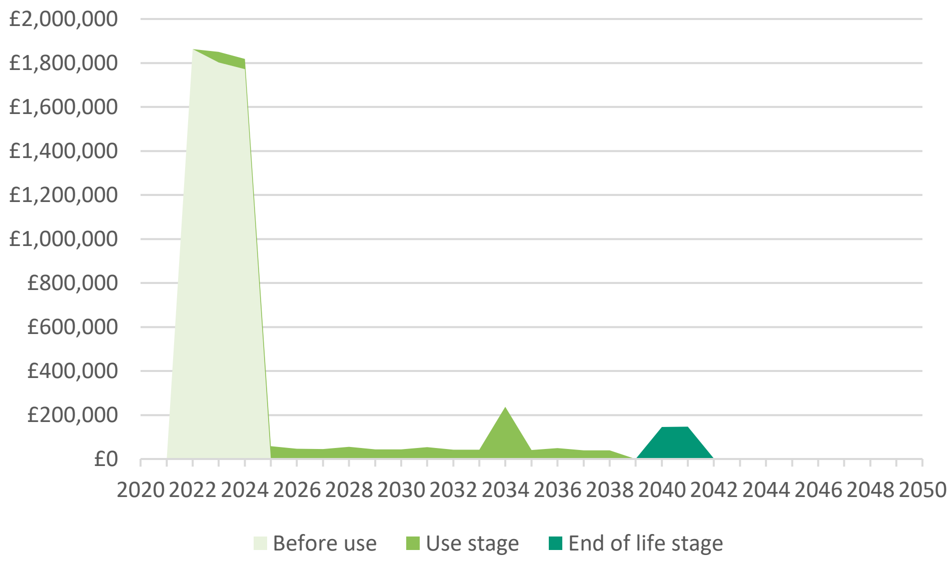
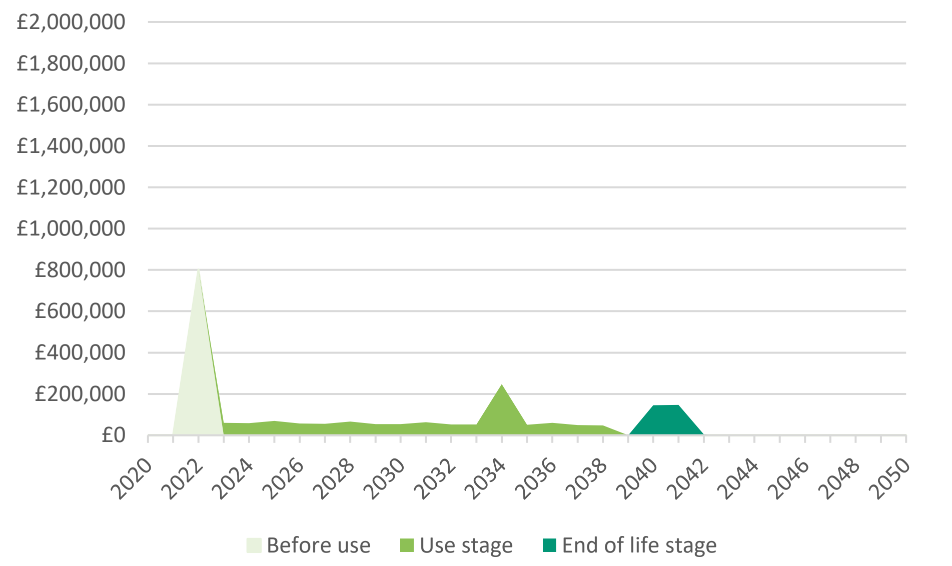


Figure 7 Carbon cost of Option 2 using the Network Rail Internal Carbon Pricing tool



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6. How should the results of shadow carbon pricing be used?

For options (ES3) and design features (ES4) that result in a net increase in GHG emissions, this exercise will result in a flow of additional costs. Conversely, for options and design features that generate a net reduction in GHG emissions, the result will be a flow of negative costs (or rebates). For the purposes of deciding whether or not to proceed with the project, these increases or decreases in costs should be treated in the same way as the conventional monetary costs of the option/design feature under consideration.

This should lead to changes in the capital investment decisions reached by the company. In particular, in the absence of shadow carbon pricing, there may have been some options/design features associated with lower emissions that were perceived as too costly compared to the alternative. With the introduction of shadow carbon pricing, this should change and options/design features that result in reductions in emissions, or smaller increases in emissions than their alternatives, are expected to become more attractive.

However, there can be a range of non-cost factors that may make it challenging to introduce lower carbon or emission reduction options or design features. There may also be some cases where there is a particularly strong strategic imperative to pursue an emission reduction option. There is also some intrinsic uncertainty regarding the most appropriate series of carbon values to use.

Recognising these challenges, and on a case-by-case basis, Project Managers[10] may want to apply a sensitivity analysis to the shadow carbon pricing analysis. This sensitivity analysis can make use of the high and low carbon prices reported in Tables 5 and 6 in Annex 1. The application of these low and high values depends on the context:

- In many cases, Project Managers will be comparing options or design cases where all of the permutations under consideration will increase emissions, but some of these permutations increase emissions by less than others. In cases where the application of the prices in Table 4 leads to the selection of the lower-carbon option or design feature, Project Managers may wish to consider whether this conclusion remains robust when using the 'low' values reported in Table 5. If the lower-carbon option or design feature still remains the most cost attractive option, this creates a strong presumption in favour of selecting that option. By contrast, if the use of 'low' prices in Table 5 means that the lower-carbon option or design feature is no longer considered the most attractive, Project Managers may wish to apply judgement as to the appropriate option or design features to select.

[10] The reference to Project Manager in this paragraph and below may be replaced by other individuals within the client/asset owner if indicated in the note on whole life carbon assessment (NR_GN_ESD07).

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- In some cases, Project Managers may be considering options or design features which result in a net reduction in life-cycle emissions. In cases where these options or design features do not appear cost competitive using the carbon prices used in Table 4, they may wish to use the 'high' carbon prices identified in Table 6. In cases where the use of the high carbon prices makes the option or design feature attractive, Project Managers may choose to proceed with this alternative. However, if the emission reduction option or design feature remains unattractive even with the application of the 'high' carbon price, it should be presumed that it is not attractive.

It should be stressed that if Project Managers decide not to proceed with the lowest cost option or design feature – inclusive of the shadow carbon pricing assessment – then this creates an emissions liability for Network Rail. To discharge this liability, other parts of the business will need to increase their decarbonisation efforts. This is very likely to lead to an overall increase in the cost that the company will face to meet its net zero target.

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Annex 1

Table 5 Low carbon price values (in £2020 prices) for use in shadow carbon pricing

Year	Value (£2020 prices)		Year	Value (£2020 prices)
2020	120		2036	153
2021	122		2037	156
2022	124		2038	158
2023	126		2039	161
2024	128		2040	163
2025	130		2041	165
2026	132		2042	168
2027	134		2043	170
2028	136		2044	173
2029	138		2045	176
2030	140		2046	178
2031	142		2047	181
2032	144		2048	184
2033	147		2049	186
2034	149		2050	189
2035	151			

Note: Values beyond 2050 can be estimated by applying a real annual growth rate of 1.5 % in each subsequent year.

Table 6 High carbon price values (in £2020 prices) for use in shadow carbon pricing

Year	Value (£2020 prices)		Year	Value (£2020 prices)
2020	361		2036	460
2021	367		2037	467
2022	373		2038	474
2023	378		2039	482
2024	384		2040	489
2025	390		2041	496
2026	396		2042	504
2027	402		2043	511
2028	408		2044	519
2029	414		2045	527
2030	420		2046	535
2031	427		2047	543
2032	433		2048	551
2033	440		2049	559
2034	447		2050	568
2035	453			

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Note: Values beyond 2050 can be estimated by applying a real annual growth rate of 1.5 % in each subsequent year

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Annex 2 Future application of shadow carbon pricing in procurement decisions

The same principle of shadow carbon pricing could also be applied in relation to Network Rail's non-capital project procurement programme. The intent would be to ensure that, in appraising the value for money of procurement options, Network Rail did not inadvertently select procurement options that were in contradiction with its net zero (and other emission reduction) goals. Shadow carbon pricing in this context would involve identifying the emissions implications of different procurement options and incorporating the cost of these emissions when determining their respective value for money.

In the short-term, the application of shadow carbon pricing in this context is challenging. Neither Network Rail nor its suppliers are likely to have good data on the emissions implications of different sourcing options, and there is the potential that suppliers might 'game' the system in the way that they identify emissions associated with the goods and services they are supplying. Therefore, in the short run, Network Rail does not intend to use shadow carbon pricing in relation to procurement decisions. Instead, it will continue to drive emission reductions in its procurement activity through the requirement that 75 % of its supplied have adopted Science-based Targets by 2025.

In the medium term, as emissions data associated with procurement decisions becomes available through its suppliers adopting Science-based targets, the opportunities for Network Rail to use shadow carbon pricing within procurement decisions will increase. The greatest opportunities are likely to be in relation to carbon intensive procurement decisions where data around the carbon intensity of activities is relatively standardised. An initial assessment suggests that this is likely to include: vehicle purchase and leasing and on-track machines. This requirement would be in addition to when these goods and services are acquired as part of a capital investment project. Indicatively, Network Rail intends to pilot the introduction of shadow carbon pricing into procurement of these goods and services by 2026 (the year after Network Rail intends that at least 75 % of its suppliers, by emissions, will have set their own science based targets).