UK Government

Valuation of energy use and greenhouse gas (GHG) emissions

Supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government

Department for Energy Security and Net Zero (2026)



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1 Introduction and background

1.1 This document is a supplement to HM Treasury's Green Book[1], providing specific guidance on how analysts should quantify and value energy use and emissions of greenhouse gases (GHGs). It is intended to aid the assessment of proposals that have a direct impact on emissions, energy use, and energy supply. It is also appropriate for proposals with an indirect impact through planning, land use change, construction or the introduction of new products that use energy. It is appropriate for undertaking options appraisal for policies, programmes and projects (including options appraisal when applying the Environmental Principles Policy Statement)[2]; for use in building business cases; and for conducting impact assessments. It can also be used to inform the evaluation of policies.

1.2 This guidance should be used in conjunction with the Green Book, and the Green Book guidance on Business Cases[3]. The development of policy options uses HMT's five case model. The strategic case sets out the rationale and objectives of proposals, and the constraints and dependencies it is under, such as the UK's Net Zero target. The economic case sets out the appraisal of options against the objectives set out in the strategic case. This guidance supports the modelling of GHG impacts where they are relevant to decision making. Further guidance on risk management is available in HMT's Orange Book[4] and on policy evaluation in HMT's Magenta Book[5]. The Regulation Directorate in the Department for Business, Innovation, Science and Trade publishes guidance on regulatory Impact Assessments[6].

1.3 This guidance has been prepared by the Department for Energy Security and Net Zero and has been reviewed across government through the GES Chief Economist Group. It is accompanied by:

- an Excel-based calculation toolkit, to convert increases or decreases in energy consumption into changes in GHG emissions, and value these changes,
- Data Tables containing the latest published assumptions for appraisal value of carbon, energy prices, long run variable energy supply costs, emission factors and air quality activity costs, and
- a background information document (including explanations of the methodologies used in this guidance).

[1] The Green Book
[2] The Environmental Principles Policy Statement
[3] Green Book guidance on business cases
[4] The Orange Book
[5] The Magenta Book
[6] Guidance on Impact Assessments

1.4 This guidance and the listed accompanying documents can be found at the Green Book supplementary guidance section of the GOV.UK website along with the toolkit[7]. Any questions should be addressed to: GHGappraisal@energysecurity.gov.uk.

[7] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

2 How to undertake energy and GHG emissions appraisals

Introduction

2.1 Each appraisal of energy and GHG emissions presents different challenges, as well as common calculations. The steps below show the analytical process and calculations required when valuing energy and GHG impacts, and the relevant sections within this guidance which provide more detail.

Step 1: Identify energy and emissions counterfactual (Chapter 2)

- What would GHG emissions and energy consumption be/have been without this action?
- What is/would have been likely to happen without the policy?

Step 2: Identify policy interactions (Chapter 2)

- Would some of the identified impacts of this policy already be accounted for (overlaps)?
- Could existing policy increase the success of the intervention (complementary policies)?

Step 3: Identify and quantify changes in, where applicable (Chapters 3 & 4):

- Fuel use: For each option; For each fuel; In each year
- Emissions: From change in fuel use (using emissions factors); From non-fuel use sources; Allocate to traded and non-traded sectors
- Other impacts: E.g. air quality and wider environmental impacts, energy security and resilience, distributional impacts etc.

Step 4: Value changes in, where applicable (Chapters 3 & 4):

- Fuel use: Long run variable cost (LRVC) savings; Rebound effects
- Emissions: Use appraisal value of carbon (Data Table 3)
- Other impacts: E.g. activity cost, damage cost etc.

Step 5: Calculate cost-effectiveness (Chapter 5):

- Net Present Value (NPV)
- Cost per tonne CO_2e saved
- GHGe cost comparators
- Value for money (VFM)

Framing the analysis

Planning and preparation

2.2 In order to aid planning, analysts should establish at the outset:

- the objectives of the analysis,
- what specific questions must be answered, and
- outputs required.

2.3 Chapter 6 provides further information on establishing the necessary outputs. Analysts should work backwards to determine what information is required, and how this information is going to be obtained.

Base case or counterfactual

2.4 A project, policy or other proposal will generate costs and benefits, which could differ across options. The first step to assess these impacts is to consider what would happen if the policy or project was not carried out. This default course of action is known as the 'business as usual' option and provides the base case, or counterfactual. Analysts need to appraise costs and benefits of each option relative to their counterfactual (see Box 2.1 for an example).

2.5 Analysts need to carefully consider which is the most appropriate counterfactual, as it could significantly change the projected impact of a proposal. If the counterfactual is uncertain, the analyst should highlight and explain the impacts of varying the counterfactual.

2.6 The counterfactual should include all policies to which the government is already committed and which have funding. DESNZ's latest Energy and Emissions Projections will therefore need to be referred to[8].

Box 2.1 Example – identifying the counterfactual

Consider the case of a one-off policy, funded from general taxation that provides heat pumps to households with existing boilers that are below a certain efficiency standard.

To understand the true costs and benefits of this policy, one must identify what would have happened had this policy not come into existence. A study reveals that ten per cent of households with boilers below this standard would naturally replace them with more efficient boilers anyway. This means that the carbon savings delivered through the heat pump installations will be slightly lower than if all households had kept their inefficient

[8] Latest projections at time of publishing in October 2026: Energy and emissions projections: 2024 to 2050 - GOV.UK

boilers in the counterfactual, because the ten per cent that would have upgraded establish a lower carbon emissions baseline.

As a result, the additional benefits are slightly lower than without the boiler upgrades in the counterfactual.

Policy interactions

2.7 Analysts should ensure that all changes in energy use and UK GHG emissions factor in the interactions that policies and projects in one sector can have on other sectors. For instance, planning decisions may impact on transport emissions as well as emissions from buildings.

2.8 The impacts of policies or projects might also overlap or reinforce each other, impacting their combined effectiveness, and the analysis should account for any interaction. For example, the savings from a new efficient boiler will be lower in a house that already has cavity wall insulation.

3 Quantifying and valuing energy and GHG emissions

Introduction

3.1 This chapter is about quantifying and valuing the energy use and GHG emissions resulting from a proposed policy, programme or project. Chapter 4 covers additional impacts including air quality, energy security and wider environmental impacts.

3.2 This guidance is applicable when there are no significant wider impacts on the energy market, specifically when analysing marginal policies where bespoke modelling is not required. If assessing policies with large and non-marginal impacts such as significantly changing energy demand or prices, analysts should consider developing detailed modelling to account for these impacts.

Valuing Changes in Energy Use

3.3 Changes in energy consumption impact the use of resources in the production, transportation, and final supply and use of energy. In order to value these impacts, analysts should use the long-run variable cost (LRVC) of energy supply. The calculation required is demonstrated in Box 3.1.

Box 3.1 Valuing changes in energy use

$$V_{i,t} = \Delta(EU)_{i,t} \times (VC)_{i,t}$$

$V_{i,t}$ = Value of change in use of fuel *i* in year *t* (£)

$\Delta(EU)_{i,t}$ = Change in use of fuel *i* in year *t* (kWh)

$(VC)_{i,t}$ = Year *t* long run variable supply cost of fuel *i* (£ / kWh)

3.4 The LRVC is used instead of the retail energy price, because energy prices include:

- fixed costs that will not change in the long run with a small, sustained change in energy use, and
- taxes, margins, and other components (such as costs imposed by the UK Emissions Trading Scheme) which reflect transfers between groups in society.

3.5 Supply costs vary by fuel, category of end user, and over time because each fuel has different energy demand profiles and networks costs, which vary over time. Accordingly, the LRVC values used in an appraisal should be fuel, sector, and time-specific.

3.6 Data Tables 9-13 provide projected long-run variable supply costs that are consistent with the 2023 fossil fuel price assumptions. We strongly advise the use of the full range of prices in all analysis due to the current uncertainty in energy prices, especially where the level of price has a material impact on your outcomes. This is due to the significant uncertainties.

3.7 For a detailed explanation of the methodology underpinning the LRVCs in these Data Tables please consult Chapter 5 in the additional background documentation available alongside this guidance[9].

Valuing Direct Rebound Effects

3.8 Proposals that improve energy efficiency (such as heating or lighting policies or projects) have the effect of reducing the overall amount of energy used. An immediate result will be a reduction in energy bills. This frees up funds which can be spent on energy or other goods and services. Any resulting increase in energy use is known as the 'rebound effect'[10].

3.9 A financial saving or expenditure that changes the consumption of the same energy product is defined as a direct rebound effect. Conversely, a saving or expenditure that changes consumption of other energy products or other goods is defined as an indirect rebound effect. A more detailed explanation of rebound effects can be found in the background documentation published alongside this guidance[11].

3.10 Box 3.2 provides an example of how a proposal to install wall insulation can generate a rebound effect. High-quality wall insulation reduces the loss of heat and generates bill savings through reduced gas consumption. However, part of the savings may also be spent on energy, offsetting some of the energy savings.

3.11 Rebound effects can apply to households, businesses, government institutions, and other economic agents. Therefore, an appraisal should consider the rebound effects for all parties impacted by a proposal.

3.12 Analysts should consider valuing direct rebound effects in appraisals, where there is evidence of this behaviour, since there is a welfare benefit directly related to the policy or project. It is not essential to value indirect rebound effects, as this requires an analysis of changes in disposable income and expenditure that is disproportionate in most appraisals. Where appropriate, analysts should consider how the outcomes of the project would differ if there were significant indirect rebound effects. The direct rebound effect should be valued at the retail price of the energy as this captures the

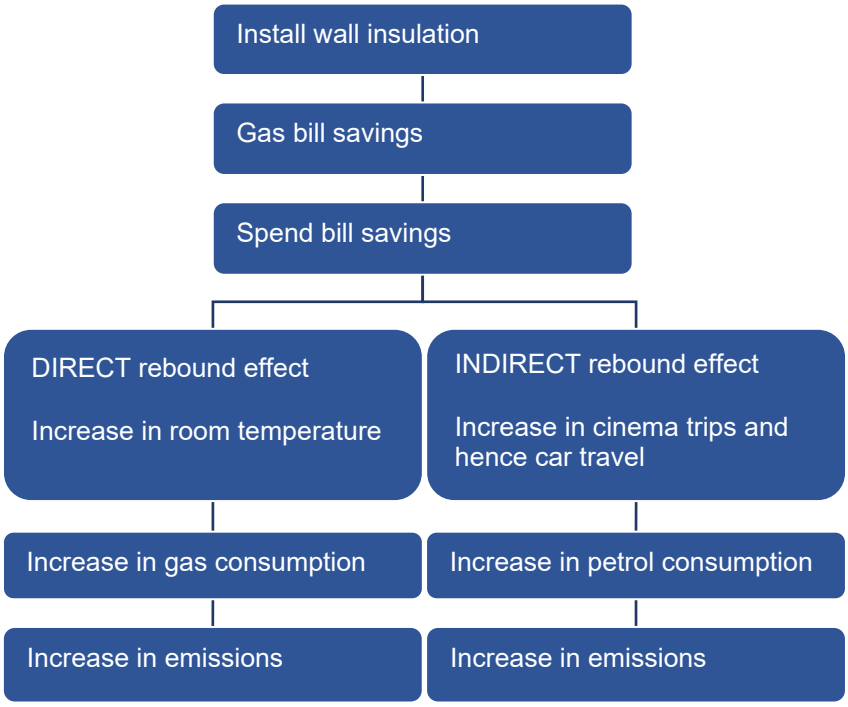
[9] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[10] On the rebound effect see also UK ERC (2007): http://www.ukerc.ac.uk/programmes/technology-and-policy-assessment/the-rebound-effect-report.html
[11] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

gain in welfare (the retail price acts as a proxy for the consumer's willingness to pay). Box 3.2 summarises the rebound effects, and an example is given in Box 3.3.

3.13 Box 3.2 explains that if a householder with gas heating has new wall insulation installed, this will result in less heating being used which in turn reduces the amount of gas used and so they will see savings in their bills. The money from this saving may be spent in different ways:

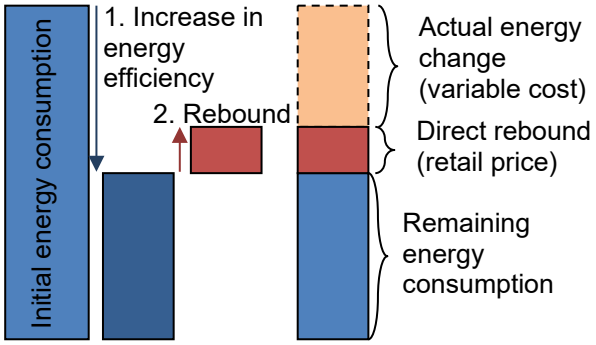
- They may choose to heat their home to a higher temperature – this results in more gas being used and therefore an increase in GHG emissions. This is considered a direct rebound effect where the benefits are not fully realised due to increased consumption.
- They may choose to spend the money on other recreational activities e.g. going to the cinema. If a petrol car is used for travel, this will increase the use of petrol and thus an increase in GHG emissions. This is considered an indirect rebound effect as the impacts are resulting from activities further down the chain.

Box 3.2 Rebound effect from wall insulation



3.14 In this example, both the actual energy change relative to the counterfactual and the direct rebound effect can be quantified. The net energy change is the reduction in energy consumption due to the efficiency improvement, minus the subsequent increase in energy consumption due to the direct rebound effect. The net change in energy consumption should be valued using the long-run variable cost (LRVC) of energy supply as described above and should be used to calculate and value the changes in emissions. The direct rebound should be valued using the retail price. Figure 3.1 shows a summary of these two parts.

Figure 3.1 Valuing energy changes with direct rebound effects



3.15 In addition, the Excel-based toolkit available with this guidance includes a tool to value direct rebound effects. Further details on the rationale for the approach to valuing rebound effects is available in the background documentation.

Box 3.3 Valuing energy consumption changes and rebound effects

A new policy in 2026 drives take-up of insulation in households using boilers. For the target group (who use 1 TWh of gas per annum with their existing boilers), the improvement in energy efficiency means the same internal temperature can be achieved with 10% less energy (100GWh savings). This gives the household the ability to spend some or all of the resulting cost savings, either to heat their home to a higher temperature or on other items in their basket of spending. If they increase the temperature of their home above the pre-insulation level, this could result in their spending increasing, for example by 5%. If so, the rebound effect is 45GWh (5% of 900GWh). The energy impacts (first two years only) are valued as follows (values are rounded to one decimal place). Note that analysts should also value the carbon impacts of the net change in energy use, the 55 GWh of energy.

		2026	2027
Net energy savings	GWh	55	55
LRVC (gas) (Data Table 10)	p/kWh	4.5	4.1
Value of net energy savings	**£m**	2.5	2.3
Rebound	GWh	45	45
Retail price (Data Table 5)	p/kWh	8.0	8.1
Value of rebound effect	£m	3.6	3.6
Value of energy impacts (undiscounted)	**£m**	6.0	5.9

Time of Use Energy Valuation

3.16 The above example shows the value of saving gas, which has the same value irrespective of when it is used by the household. However, the value of changes in electricity use varies depending on when that electricity is used or saved. This is because the generation mix supplying electricity changes throughout the day. Typically, electricity supplied at off-peak times will have a lower wholesale price than during peak times, because the price is set by the marginal generation technology needed to meet demand once all the cheaper ones have been deployed.

3.17 Wholesale prices change half hourly every day in order to match supply to demand. This means the LRVC value of the electricity supplied to households and businesses, where there has been a change in when energy is used, will be different to when there is a flat change in energy consumption throughout the day.

3.18 An example of this is when a property's heating system changes from a boiler to a heat pump. The value of the boiler's fuel (either gas or oil) will be the same irrespective of when the boiler is used during the day. A heat pump, however, will use more electricity during the off-peak hours of the day and less during the peak hours than previously used. This is because of the way in which heat pumps are used, providing a more continuous level of lower temperature ambient heat, compared to boilers that are typically used to provide higher temperature heat for shorter periods of the day.

3.19 Analysts should highlight the impact of their policies and the way in which they alter the amount of peak and off-peak electricity demand through the non-monetised costs/benefits of the policy.

3.20 In addition to the time of use LRVCs, time of use electricity tariffs are an established part of today's energy market. Analysts are encouraged to use these as examples of the potential impact of their policies on energy bills, where it is deemed appropriate to use them, providing evidence of how this market information has been used and why it is assumed households or businesses will use these tariffs. This should be used to supplement the results using the existing retail price series from this Supplementary Guidance.

Quantifying and valuing GHG emissions

3.21 To appropriately quantify GHG emissions, analysts should identify key drivers of emissions impacted by a policy or project proposal and the length of time these impacts occur. Policies and projects can affect emissions of GHGs in a number of ways, either directly through changes in energy use, or indirectly through planning, land use change, construction or the introduction of new policies that use energy. Emissions impacts also occur over varying time horizons and practitioners should consider a suitable appraisal period in line with Green Book guidance.

3.22 Another aspect to consider is where a proposal has a significant impact on emissions produced abroad, especially in cases where they are embedded in imported materials. Specific guidance is available from paragraph 3.48 onwards.

Expressing GHG emissions in a common unit

3.23 GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The last four gases are collectively referred to as fluorinated gases or F-gases. Each GHG has a different potential to accelerate global warming. Emissions of each GHG are therefore weighted by its global warming potential (GWP), so that total GHG emissions can be reported on a consistent basis in carbon dioxide equivalent (CO_2e) units. The GWP for each gas can be defined as its warming influence in relation to that of CO_2 over a 100-year period.

3.24 The standard approach, as required for national GHG inventory reporting under the Paris Agreement and UNFCCC, is to use 100-year GWPs from the IPCC's Fifth Assessment Report (AR5)[12] as shown in Table 3.1, below. For example, a tonne of nitrous oxide has the equivalent global warming potential of 265 tonnes of CO_2. If a policy increases emissions of nitrous oxide by one tonne, this counts as an increase of 265 tCO_2e.

3.25 GWPs can change over time, and so users should always be transparent about which GWPs they have used and be careful when comparing outputs to other outputs which may have used different GWPs.

Table 3.1[13] Factors for converting greenhouse gases to their equivalent in carbon dioxide

Greenhouse Gas	Global warming potential per unit mass (relative to CO_2) AR5 without climate feedback.
Carbon Dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous Oxide (N_2O)	265
HFC-134a	1,300
HFC-125	3,170
HFC-143a	4,800

[12] National Inventory Reports | UNFCCC
[13] Further info on AR5 GWP values can be found in table 6.4 of Final 1990-2024 UK GHG emissions statistics: www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-statistics-1990-to-2024.

Sulphur hexafluoride	23,500
Carbon Dioxide as Carbon[14]	3.67

3.26 The GHG emissions associated with the use of energy may be estimated by applying a fuel-specific emissions factor. By multiplying the energy use (measured in kWh) by an emissions factor (measured in $kgCO_2e/kWh$), one obtains the quantity of GHG emissions produced, measured in terms of the equivalent mass of carbon dioxide emissions ($kgCO_2e$).

3.27 In order to quantify changes in GHG emissions resulting from changes in energy use, net changes in energy use should first be quantified, by calculating the change in use of each fuel type in the years being analysed, making sure to include the impact that any rebound effect may have (see paragraph 3.8). Marginal emissions factors for each fuel type and over the years being analysed are then applied to these energy use changes as demonstrated in Box 3.4.

Box 3.4 Converting changes in fuel use to GHG emissions

$$\Delta c_{i,t} = \Delta(EU)_{i,t} \times M_{i,t}$$

$\Delta c_{i,t}$ = Change in emissions from fuel *i* in year *t* ($kgCO_2e$)

$\Delta(EU)_{i,t}$ = Change in use of fuel *i* in year *t* (kWh)

$M_{i,t}$ = Year *t* marginal emissions factor for fuel *i* ($kgCO_2e$ / kWh)

3.28 For estimating changes in emissions from changes in direct fuel use, such as burning coal or gas, analysts should use the emissions factors found in Data Tables 2a and 2b. The marginal emissions factor is assumed to be constant across different levels of supply / demand (i.e. the average and marginal emissions factors are identical), and also over time. While there are minor variations in the emissions produced from these fuels over time resulting from differences in the average chemical composition, it is reasonable to assume that this variation is insignificant for appraisal purposes.

3.29 For estimating changes in emissions from changes in grid electricity use, analysts should use the (long run) marginal grid electricity emissions factors in Data Table 1. These emission factors will vary over time as there are different types of power plants generating electricity across the day and over time, each with different emissions factors. An example of the calculation is presented in Box 3.5.

[14] Prior to 2007, figures for changes in GHG emissions were presented in terms of carbon (C). Any such figures should be converted into units of CO_2e using the conventional conversion factor of 44/12 (e.g. 1 tonne of C emissions is equivalent to 1 x (44/12) = 3.67 tonnes of CO_2e).

Box 3.5 Using emissions factors to convert electricity use changes into GHG emissions changes

An energy efficiency programme which reduces the use of electricity by households is being considered. Electricity consumption is predicted to be cut by 10GWh (10 million kWh) relative to the 'business as usual' option in each year between 2026 and 2046. The calculations below demonstrate how this change in energy use is multiplied by the appropriate marginal emissions factor (see Data Table 1) to derive the change in emissions.

Year	Change in electricity use	Marginal emissions factor (Data Table 1) - Domestic Households		Change in emissions
	GWh	$kgCO_2e$ /kWh	tCO_2e /GWh	tCO_2e
2026	-10	0.191	191	-1907
2027	-10	0.177	177	-1773
…	…	…	…	…
2044	-10	0.024	24	-242
2045	-10	0.024	24	-241
2046	-10	0.024	24	-241

3.30 There are complex mechanisms that determine the effects of sustained but marginal changes to the grid electricity supply (from either displacement with other generation or a demand reduction). A small reduction in grid electricity consumption will be met through a reduction in supply from a small subset of plants, rather than through an equal drop across all generation plants. Very temporary changes in consumption will likely only result in short run changes to generation levels, rather than changes in capacity. However, sustained larger changes in consumption will result in changes to generation capacity – in terms of the timing, type, and amount of generation plant built and / or retired – as well as changes in generation levels. Further information may be found in Chapter 2 of the background documentation accompanying this guidance.

3.31 The grid electricity emissions factors also capture whole system impacts in their values as these are built into the power system models which inform these factors.

3.32 The emissions factors are based on a change in electricity throughout the day and year. If a policy affects electricity consumption at a specific time of day or year, e.g. at periods of peak or off-peak demand, this will affect the emissions factors because of the different mix of generation technologies typically being deployed at those times. These will lead to higher emissions during peak demand and lower during off-peak times. Future guidance will present alternative emissions factors for cases such as

these. In the meantime, analysis should present the change in emissions associated with the policy using existing emissions factors, alongside a description of the non-monetised costs / benefits when the policy leads to higher / lower emissions because of the time of day and year electricity is used.

3.33 When a policy or project results in a switch from using one fuel to another, this may be analysed in a similar way as when only one fuel is affected. In such situations, it is necessary to consider the impact on the consumption of each fuel separately and apply the appropriate emissions factor to the change in consumption of each fuel (an increase in one, and a reduction in the other).

Measuring the emissions footprint of an entity from energy use

3.34 For some purposes we wish to know the level of GHG emissions attributable to a particular sector, organisation, or building, based on its share of the fuel use in the UK, known as the emissions footprint.

3.35 For fossil fuel use, analysts should simply use the emissions factors in Data Tables 2a and 2b.

3.36 For grid electricity use the total mix of generation plant used will determine the average emissions factor. This will differ from the mix of plant used to calculate the marginal emissions factor and will also vary over time. The electricity emissions footprint of an entity is its share of emissions from electricity generation across the grid and analysts should use the average emissions factors in Data Table 1. An example of how to conduct emissions footprinting is given in Box 3.6. Further explanation of marginal and average electricity emissions factors may be found in the background documentation.

Box 3.6 GHG emissions from energy footprinting

As part of a report, an analyst may wish to present the amount of the UK's emissions resulting from the consumption of gas and electricity by one small, non-energy intensive commercial sector in 2026. They have information on the final energy consumption by the industry of both fuels in 2026 (500GWh for gas and 1,500GWh for electricity) and need to convert these to an emissions footprint.

To conduct this calculation, analysts should use average emissions factors, which give the amount of emissions produced through consumption of energy, expressed as the ratio of all GHG emissions and total energy consumption. In these circumstances, it would not be appropriate to use marginal emissions factors, as the analyst is not considering the emissions impact of changes in energy consumption by the industry. Instead, they wish to know what share of emissions this industry is responsible for.

For gas consumption, the average emissions factor is the same as the marginal emissions factor. For electricity consumption, the average emissions factor is not the same as the marginal emissions factor. Analysts should do the following calculation:

		Gas	Electricity (commercial)
Consumption	GWh	500	1500
Average emissions factor in 2026[15]	kgCO_2e/kWh	0.18	0.12
Average emissions factor in 2026 converted[16]	MtCO_2e/GWh	0.0002	0.0001
GHG emissions	MtCO_2e	0.09	0.18

Valuing GHG emissions

3.37 This section provides guidance on valuing impacts of carbon on society. Once the change in GHG emissions (measured in tCO_2e) resulting from the project or policy proposal has been quantified using the methodology above, these emissions should be given a monetary value. It is important to value both the changes in emissions from fuel use, and also the changes in emissions from other sources.

3.38 In valuing emissions for appraisal purposes, the UK government adopts a target-consistent approach, based on estimates of the abatement costs consistent with meeting emissions reduction targets. The approach on valuing GHG emissions was substantively changed in 2021 and is regularly reviewed for accuracy.

3.39 A policy or project that increases or decreases GHG emissions domestically or internationally relative to a 'business as usual' scenario results in a change in emissions that should be quantified. All changes in emissions should be valued by using the carbon values presented in Data Table 3 of the accompanying spreadsheet. This includes emissions captured within trading schemes, such as the UK Emissions Trading Scheme. Where necessary, appraisers should update carbon values to the relevant base year for analysis. An example of the calculation required is shown in Box 3.7 below.

3.40 To value GHG emissions for Official Development Assistance projects, please contact GHGemissions@energysecurity.gov.uk.

Box 3.7 Using carbon values

An energy efficiency programme reduces the use of gas and grid electricity by small businesses. Consumption of grid electricity (which indirectly reduces emissions in the traded sector) is cut by 15GWh while their gas consumption (producing GHG emissions in the non-traded sector) is cut by 10GWh. These are annual differences from the

[15] See Data Tables
[16] See Annex B for conversion factors

counterfactual ‘business as usual’ option for each year between 2026 and 2050. The tables below show how to value the emission reductions using the carbon values for appraisal (Data Table 3). These monetary savings can then be discounted in the usual way following Green Book guidance. (Figures are rounded to the nearest integer).

		2026	…	2050
Change in energy use (electricity)	GWh	-15	…	-15
Marginal emissions factor (electricity, Table 1)	tCO_2e/GWh	187	…	24
Total Emissions saving	tCO_2e	2808	…	355
Carbon values for appraisal (Data Table 3)	2025 £/tCO_2e	317	…	455
Value of GHG savings (undiscounted)	2025 £’000	890	….	161

		2026	…	2050
Change in energy use (gas)	GWh	-10	…	-10
Emissions factor (gas, Data Table 2a)[17]	tCO_2e/GWh	183	…	183
Emissions saving	tCO_2e	1826	…	1826
Carbon values for appraisal (Data Table 3)	2025 £/tCO_2e	317	…	455
Annual Value of GHG savings (undiscounted)	2025 £’000	579	….	830

Mapping emissions into traded and non-traded sectors

3.41 To ensure emissions are accurately accounted for in appraisal, and separately for reporting on our carbon budgets, changes in GHG emissions resulting from a project or policy proposal must be mapped to either the traded (UK ETS) sector, or the non-traded sector. More information on this is set out in the section ‘Reporting for carbon budgets’.

[17] Based on the latest greenhouse gas reporting conversion factors at the time of publication which are: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2026

3.42 In economic appraisal, all emissions should be valued using the appraisal carbon values presented in Data Table 3 of the accompanying spreadsheet, 'Data tables 1 to 18: supporting the toolkit and guidance'. This includes emissions captured within trading schemes, such as the UK Emissions Trading Scheme[18].

3.43 A worked example of a policy with an impact on traded and non-traded carbon emissions is provided below.

Adjusting the Financial Case for ETS Allowances

3.44 Where emissions impacts occur in the traded sector, there are two values to be aware of: the appraisal value of the carbon and the market price of the ETS allowance. Economic appraisals should value changes in greenhouse gas emissions using the carbon appraisal value (Data Table 3).

3.45 Businesses may purchase (or sell) allowances under the ETS as a result of a policy change. The cost of the ETS allowances should be considered in the Financial Case of business cases. Analysts should use the latest 'traded carbon values for modelling purposes' from the carbon valuation publication[19]. For years beyond the published series, it is advised to contact GHGappraisal@energysecurity.gov.uk.

Box 3.8 Example Policy with Traded and Non-Traded Sector Emissions Appraisal

Consider a policy that drives the uptake of ground source heat pumps by households, beginning in 2026 and lasting 10 years (2026 – 2035, inclusive). It results in annual emissions reductions in the non-traded sector of around 10,000 tCO_2e from avoided gas consumption (or 100,000 tCO_2e of cumulative non-traded emissions savings). It will also increase electricity demand by 1GWh each year, which will increase traded sector emissions (as grid electricity demand is in scope of the UK ETS), calculated below.

The profile of the policy's costs and benefits are shown below, including how traded sector emissions were derived.

	2026	2027	…	2035
Non-traded emissions (ktCO2e)	10	10	…	10
Appraisal value (£/tCO2e, Table 3)	316.9	321.8	...	363.1
Undiscounted benefits (£ 000s)	**3169**	**3218**	**…**	**3631**

[18] When assessing traded or non-traded emissions, only the direct changes in emissions from the policy should be valued using the carbon values from table 3 of the data tables. Appropriate adjustments may be made when calculating the embedded emissions in the production of a good or service that is subject to carbon pricing. For example, if a policy increases the production of a good in the UK where the price of that good already reflects a carbon price then the carbon price should be accounted for to avoid double counting. For more information, please contact GHGapprasial@energysecurity.gov.uk.

[19] The latest set of traded carbon values can be found here: Carbon valuation - GOV.UK. The traded sector values for modelling purposes are not carbon values for appraisal. For more information please contact GHGapprasial@energysecurity.gov.uk.

Increased electricity demand (GWh)	1	1	…	1
LRVC of electricity (Table 9, p/kWh)	13.7	13.3	…	13.1
Undiscounted cost of increased electricity (£ 000s)	137.1	132.6	...	131.0
LR Marginal Electricity Emissions Factors (kgCO2e/kWh, Table 1, domestic sector)	0.191	0.177	...	0.039
Traded emissions (tCO2e)	190.7	177.3	…	38.6
Undiscounted cost of traded emissions (£ 000s)	60.4	57.1	...	14.0
Undiscounted costs (£ 000s)	**198**	**190**	**...**	**145**

3.46 Table 3.2and Table 6.1 explain which emissions should be allocated to each sector. For example, emissions from gas consumption by households for space heating should be attributed to the non-traded sector. However, emissions resulting from gas consumption by an installation that participates within the UK ETS would be counted in the traded sector.

3.47 If it is unclear whether emissions changes resulting from a proposal are attributable to the traded or non-traded sectors - or for more information on the UK ETS - advice should be sought by contacting GHGappraisal@energysecurity.gov.uk.

Table 3.2 Mapping emissions to the traded and non-traded sectors

Traded sector GHG emissions
Grid electricity use by all sectors[20]
Direct fuel use and manufacturing processes by UK ETS participants (although certain GHGs are exempt)[21]
Direct fuel use in aviation in UK ETS[22]

[20] Generators that equal or are over 20MW are included in the traded sector. However, a small proportion of grid electricity (generators below 20MW) is produced by non-UK ETS participants including electricity generated by EfW. However, almost all of this generation is from zero-emissions rated plant, for example resulting from Feed in Tariffs (FiTs). Therefore, it is a reasonable approximation to allocate all grid electricity emissions to the traded sector.

[21] Includes power and heat generation (sites exceeding 20 MW input), and GHG-intensive industry sectors including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals.

[22] Only domestic flights and outgoing flights to EEA countries and Switzerland are covered under the UK ETS.

Direct fuel use in maritime in UK ETS[23]
Non-traded sector GHG emissions
Direct fuel use by households
Direct fuel use in non-aviation transport
Direct fuel use by private and public sector organisations from installations that do not participate within the UK ETS[24]
Emissions from land use, land use change, and forestry (LULUCF)
Emissions from landfill[25]
Emissions from agriculture

Treatment of Emissions Embedded in Imported Materials

3.48 When analysing projects that result in a large change to the amount of imported goods, commodities or services, it is best practice to consider the emissions associated with these imports[26].

3.49 For appraisal purposes, the 'GHG emissions content' of all materials used to implement a proposal should be considered to inform the decision-making process[27].

Box 3.9 Valuing non-domestic CO_2 emissions changes and embedded emissions in waste policy

A nationwide scheme that encourages households to recycle paper reduces the quantity of paper that is sent to landfill. It is estimated that during the scheme (2026 – 2030) the

[23] From 1st July 2026, emissions from maritime activities are included in the UK ETS. Only domestic maritime and 50% of maritime to EEA countries are covered under the UK ETS.
[24] Note that organisations may be responsible for emissions both in and out of the UK ETS, and therefore in both the traded and non-traded sectors.
[25] Note the Landfill Allowance Trading Scheme (LATS) ended following the 2012/13 trading year.
[26] Although there is no requirement to include embedded emissions in the UK inventory, the Environmental Principles Policy Statement requires that the decision making and appraisal process for some policies should consider the impact of UK policy on consumption emissions – including emissions from abroad – where it is relevant and proportionate. Consideration should therefore be given to providing separate assessments for UK emissions and global emissions, including from imported goods and services.
[27] Some imports may be from countries without carbon pricing arrangements and so the material costs will not include the cost of the GHG emitted in their production. It is reasonable in these circumstances to consider adjustments to account for the value of the externality. Appraisal should account for the additional costs of the policy due to emissions overseas (an example can be found at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230482/RO_Biomass_Sustainability_Govt_Response_-_Impact_Assessment_-_19-August-2013_FINAL_for_pdf.pdf). Where needed, further advice can be obtained by contacting GHGappraisal@energysecurity.gov.uk.

reductions in paper sent to landfill result in savings of 200 $ktCO_2e$ per year from sites within the UK.

In addition, the production of recycled paper within the UK significantly reduces the quantity of paper imported into the UK from countries with no applicable emissions cap or carbon pricing mechanism. Using trade data and levels of carbon intensity attributed to the non-capped countries, it is estimated the reduction in imported paper saves 120$ktCO_2e$ per year of GHG emissions from the non-capped country through reduced production of paper. These emissions should be valued using the carbon value estimates reported in Data Table 3.

UK non-traded savings: (200ktCO2e ×carbon value) (Figures are rounded to the nearest integer)

	2026	…	2029	2030
Emission savings ($ktCO_2e$)	200	…	200	200
Carbon value for appraisal (2025 £/tCO_2e) (Data Table 3)	317	…	332	337
Value of savings (2025 £m)	63.4	…	66.3	67.3

Embedded carbon savings: (120tCO2e × carbon value) (Figures are rounded to the nearest integer)

	2026	…	2029	2030
Emission savings ($ktCO_2e$)	120	…	120	120
Carbon value for appraisal (2025 £/tCO_2e) (Data Table 3)	317	…	332	337
Value of savings (2025 £m)	38.0	…	39.8	40.4

3.50 Where appropriate, proportionate and possible to identify the impact of the proposal on emissions overseas or those that occur outside the target framework (e.g. radiative forcing from aviation), the change in emissions overseas should be valued at the carbon value for appraisal (Data Table 3).

3.51 There are important practical complications in assessing the carbon impact of imported products. There may be circumstances where it may not be possible to quantify the impact of emissions in imported goods and services and the recommended methodology above is not appropriate. Also, for many proposals, assessment of emissions from imported goods could be disproportionate. Advice can be obtained by contacting GHGappraisal@energysecurity.gov.uk.

3.52 It should be noted that DESNZ will not include the GHG emissions of imported materials as part of the UK's national inventory. This is because the government has agreed to report national territorial emissions at the point of release, as recommended by the Intergovernmental Panel on Climate Change. In principle this means that the national inventory includes all greenhouse gas emissions generated as part of the production of goods and services within a country (e.g. the UK) regardless of where these are consumed (either in the UK or exported)[28].

Treatment of GHG emissions occurring in international sectors

3.53 The effects of climate change are global. The full impact of a policy intervention on the global stock of GHG emissions must therefore be appraised when undertaking social cost benefit analysis, regardless of where emissions occur. The 2026 HMT Green Book states that "practitioners should consider whether a proposal might have a significant impact on emissions produced abroad".

3.54 At the same time, the UK is legally committed to GHG emissions targets that cover domestic emissions plus - from the start of the 6th carbon budget (CB6) period in 2033 - the UK's share of emissions from international aviation and international shipping (IAIS emissions). Appraisers must separately calculate the impact of a policy on UK emissions for reporting against carbon budgets (see Chapter 6).

3.55 It is important to set out what difference, if any, accounting for international emissions can have on the value-for-money of a proposal versus accounting for only those emissions in the UK's 'net carbon account'. When appraising changes in emissions that occur outside of the UK, practitioners should therefore present two separate value-for-money metrics showing the impact of an intervention on:

- The total, global stock of GHG emissions. This should include all impacts on the total stock of GHG emissions globally. This should be prioritised for value-for-money assessments.
- The stock of GHG emissions within the UK's 'net carbon account'. This covers emissions within UK territory as well as the UK's share of emissions from sectors such as International Aviation and International Shipping[29].

[28] For more information, please consult http://www.ipcc-nggip.iges.or.jp

[29] The exact methodology for determining the UK's share of IAIS emissions for the purposes of measuring and reporting UK GHG emissions from CB6 onwards will be decided before laying the first annual statement of UK emissions for the CB6 period. In advance of this decision, for carbon budget planning purposes, only the GHG emissions from UK departing flights and 50% of the GHG emissions produced on maritime journeys between a UK port and a non-UK port should be treated as UK GHG emissions.

4 Consideration of other additional impacts

Introduction

4.1 Proposals that affect energy consumption or supply, or result in changes to GHG emissions, are also likely to have impacts that are not accounted for in either the costs of energy supply or in the carbon values described in Chapter 3. This chapter explains the most common of these additional impacts. Analysts should ensure that all significant impacts of a proposal are accounted for, and this may mean considering some, or all, of the following. For air quality and wider environmental impacts, further information and guidance should be sought from Defra's pages on the GOV.UK website in the first instance.

4.2 In addition, this chapter describes possible approaches to other analytical issues that are often present in energy and emissions-based policies and projects, including distortions from the presence of indirect taxation, and accounting for the costs of private finance.

Air quality impact

4.3 Air pollution can generally be defined as airborne chemicals, particulates, and biological materials that cause harm to humans or damage the environment. Under this definition, there are three key groups of impacts:

- adverse health impacts (including mortality and morbidity)
- immediate environmental impacts (such as acidification and soil eutrophication), and
- long-term environmental impacts (which include climate change).

4.4 Air quality policies typically focus on human health and immediate environmental impacts, while climate change policy focuses primarily on the long-term climate change potential. Given this definition, there are clear links between climate change mitigation policies and air quality policies. Though the majority of overlaps are mutually beneficial, i.e. a policy option designed to reduce CO_2 will also reduce other air pollutants (and vice versa for air quality policies), in some cases there are trade-offs[30].

[30] Information on the potential synergies and trade-offs between climate change mitigation and air quality can be found in the 2007 Air Quality Environment Group (AQEG) report "Air quality and climate change: a UK perspective".
http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/environment/quality/air/airquality/publications/airqual-climatechange/documents/fullreport.pdf

4.5 To account for these synergies and trade-offs, and ensure they contribute appropriately to the decision-making process, policymakers should build the air quality impacts of their policy into their appraisal process, where possible, using monetary values. The Interdepartmental Group on Costs and Benefits (IGCB), a Defra-led panel of experts, has developed a number of monetisation methodologies to aid such policymakers. The approach to be taken depends on the characteristics of the project in question. In this guidance we refer to some of the most common approaches used: the impact pathway, damage costs and the activity costs approaches. Further information can be found in Defra's air quality appraisal guidance.

The impact pathway approach

4.6 For localised impacts, policies where air quality is a major part of the appraisal and when sufficient modelling capability is available, analysts should consider whether the impact pathway approach (IPA), a bespoke air quality impact valuation, is most appropriate[31].

4.7 The impact pathway approach uses dispersion modelling to estimate how emissions change ambient pollutant concentrations and the resulting health and environmental impacts. Therefore, impacts vary based on a range of considerations (such as dispersion and toxicity) that arise from differences in geographical location and population exposed.

4.8 The IPA is used to produce air quality damage and activity costs – a set of pre-calculated values expressed in cost per tonne of emissions (£/tonne), pence per kilowatt hour (p/kWh) and pence per litre consumed (p/litre). Further information on the IPA method of estimating air quality impacts can be found in Defra's air quality appraisal guidance.

The damage costs approach

4.9 When impacts are less localised, the emissions source is well represented by a particular damage cost value or rapid estimates are required it is recommended to value impacts using the damage costs approach. An online calculator provided in Defra's air quality appraisal guidance can be used to monetise the costs[32].

4.10 Damage costs have been calculated using a range of representative emissions in order to estimate an average marginal effect for each additional tonne of pollutant introduced into the atmosphere. These primarily value health impacts[33], though non-health impacts are also included. Damage costs are not linked to limit values being

[31] https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-impact-pathways-approach

[32] Defra's Air Quality Guidance can be found at: https://www.gov.uk/government/publications/assess-the-impact-of-air-quality. For further information on valuing Air Quality impacts, contact the IGCB: igcb@defra.gsi.gov.uk

[33] Health impacts: Morbidity and mortality impacts used in the model are based on recommendations by the Committee on the Medical Effects of Air Pollution (COMEAP). Health impacts evaluated in the model are linked to incidences of respiratory or cardiac disease, but do not include others where the evidence is less robust, for example, long-term exposure effects or increased likelihood of asthma in children.

exceeded. It must be noted that these monetary values do not include all the likely impacts of air pollution, such as non-health impacts on acidification and soil eutrophication, and do not include the impacts on visibility, ozone depletion or all ecosystems.

4.11 The Impact Pathways approach has been used to produce damage costs estimating the impact of quality for five pollutants: nitrogen oxides (NOx), particulate matter (PM2.5), sulphur dioxide (SO_2), volatile organic compounds (VOCs) and ammonia (NH_3).

4.12 The latest damage cost values and the accompanying appraisal guidance on how to correctly apply them can be found in Defra's air quality appraisal guidance.

The activity costs approach

4.13 Activity costs present the impact of air pollution per unit of activity, rather than per tonne of pollutant emitted, as is the case with damage costs. As such, activity costs are appropriate when an appraisal focuses on changes in energy use or fuel consumption and where changes in emissions arising from a policy are unknown, which prevents the use of the damage costs.

4.14 Changes in energy or fuel use can be used to estimate the changes in the level of pollutants emitted. Data Tables 14 and 15 provide air quality valuations for changes in the use of road transport fuels and other energy sources. Activity costs are differentiated by location of fuel use to account for the fact that a policy that targets the reduction in fuel use in inner cities will reduce the costs of air pollution more than a policy that addresses rural fuel use (due to differences in the size of the population exposed).

Wider environmental impacts

4.15 GHG emissions are just one impact amongst many on our natural environment. HMT's Green Book recognises the benefits that the broad environment provides; and the need not just to protect and enhance it for its own sake, but for the value it supports in the rest of society and the economy. The Green Book requires that we should account for the impacts of our policies on the environment alongside other societal costs and benefits. The Green Book's supplementary guidance Enabling a Natural Capital Approach (ENCA)[34] provides detailed guidance, data, and tools to help you understand how to develop impacts on the environment so they can be integrated into policy appraisal alongside other social costs and benefits.

[34] Enabling a Natural Capital Approach guidance (accessible) - GOV.UK

Energy security & resilience

4.16 Energy security is achieved by having a secure, affordable supply and a system resilient enough to mitigate and withstand shocks, so that energy reaches people, businesses and critical services with minimal disruption. This comprises a secure supply, ensuring enough energy is available to meet demand at an affordable price; and resilience, ensuring the energy system can anticipate, prevent, withstand, and recover from disruption. For appraisal, analysts should consider this through three dimensions: supply security, whether sufficient energy sources and infrastructure capacity are available to meet normal and peak demand; price exposure, vulnerability to international and geopolitical price shocks; and resilience, the ability to anticipate, prevent, withstand, and recover from disruption. As a whole-system challenge, energy security also depends on a range of enabling factors, including infrastructure, markets and regulation, digital and data capabilities, workforce skills, supply chains and international partnerships.

4.17 Any policy that has an impact on the supply of, or demand for, energy or energy services, including by affecting the way energy markets function, could therefore affect the UK's energy security and resilience.

4.18 Energy security and resilience impacts should be assessed using qualitative and, where proportionate and supported by evidence, quantitative analysis.

Qualitative approach

4.19 A qualitative assessment should consider how a policy could affect energy supply security, price exposure and resilience, including any national, regional or local impacts. It may be used where robust quantification is not possible or to identify material impacts that are not captured by quantitative analysis.

4.20 Analysts should consider how a policy affects energy-market functioning, competition, price signals and investment incentives. Markets may not fully reflect the wider social value of energy security and resilience, particularly where benefits are dispersed or investments protect against low-likelihood, high-impact events.

4.21 The assessment should consider relevant characteristics of the energy system, including the availability, reliability, flexibility and diversity of supply and infrastructure; the level and responsiveness of demand; exposure to international price shocks; and the ability to anticipate, withstand and recover from disruption. Analysts should also consider dependencies on other energy systems, critical sectors, workforce capability and supply chains.

Quantitative approach

4.22 Quantitative assessment should identify how a policy could affect energy supply, demand, infrastructure or other relevant characteristics of the energy system. Where disruption scenarios are relevant, analysts should assess both their likelihood and

potential impacts, including the duration, scale and consequences of disruption. Where uncertainty is significant, analysts should consider a range of plausible outcomes rather than relying on a single estimate.

4.23 Depending on the policy and available evidence, methods may be used to assess the resulting welfare and wellbeing impacts, including Value of Lost Load, health measures where material health impacts arise, and modelling of output losses or supply-chain effects. Macroeconomic effects should be considered separately. Impacts should be assessed over the policy's lifetime and compared with the appropriate counterfactual. Assumptions, uncertainties, and material impacts that cannot be monetised should be clearly presented. Analysts should engage with DESNZ where sector-specific modelling or evidence may be required.

4.24 Further guidance on qualitative and quantitative assessments, including detailed factors to consider across supply security, price exposure, and resilience, is provided in the "Energy Security and Resilience" section of Chapter 6 of the background documentation. Advice can be obtained by contacting GHGappraisal@energysecurity.gov.uk.

5 Cost-effectiveness

Introduction

5.1 In an appraisal, choosing the best option for a proposal is ultimately up to the decision-maker. To help inform this decision, they will usually consider whether the policy or project is expected to deliver its objectives cost-effectively.

5.2 There are different ways of assessing cost-effectiveness which depend on the specific objective in mind. The first and most straightforward way of assessing whether a project is good value-for-money is to consider the Net Present Value (NPV). This is the sum of all monetised costs and benefits, discounted to the base year chosen. Within this NPV, there will be a valuation of the changes in traded and non-traded GHG emissions resulting from the proposal.

5.3 If the NPV is positive, the policy is estimated to provide a net monetised benefit, and conversely if the NPV is negative, then the policy is estimated to result in an overall monetised cost to society.

Ranking policies and projects

5.4 The subsequent two sections describe the cost-effectiveness indicator and weighted average cost comparator when trying to understand effectiveness of emissions reductions for policies.

5.5 Policies and projects should generally be ranked using the overall results of the Green Book appraisal, including monetised energy and GHG impacts alongside all other relevant costs and benefits. Where the primary objective is to achieve a specified emissions outcome at least cost, analysts may also present cost-effectiveness metrics, such as cost per tonne of CO_2e abated. Rankings should clearly distinguish between monetised results and material non-monetised impacts and should explain how these have informed the preferred option.

Cost-effectiveness Indicator

5.6 For energy and climate change policy, it is to be expected that a primary objective would be to reduce GHG emissions. In this case, it would be appropriate to consider cost-effectiveness in terms of the average cost of saving each tonne of carbon dioxide (equivalent). The focus of this chapter is on how to make these calculations of the cost-effectiveness of reducing GHG emissions.

5.7 The cost-effectiveness indicator can be applied to emissions in the traded sector, the non-traded sector, or both.

5.8 Generally, if the policy affects both sectors, a cost-effectiveness indicator should be calculated to cover both traded and non-traded emissions. However, the choice of which indicator may depend on the policy; if the objective of the proposal is to reduce GHG emissions in the non-traded sector, then calculating the non-traded sector emissions cost-effectiveness indicator would be appropriate, and similarly the traded sector emissions cost-effectiveness indicator would be used for calculating the cost of reducing UK traded sector emissions.

5.9 The indicators of cost-effectiveness should be calculated as described in Box 5.1[35]. These indicators are calculated as (the negative of) the NPV excluding the value of the emissions saved in the sector of interest, divided by the carbon equivalent saved in this sector. The numerator calculates the total, social cost (or, where PVCs < NPV, the social benefit) of delivering emissions savings in that sector, whilst the denominator simply sums emission savings over time.

Box 5.1 The cost-effectiveness indicator of GHG emissions savings

$$\mathrm{CE}_s = -\frac{\mathrm{NPV} - \mathrm{PVC}_s}{\sum_{t=1}^{t=Y} \mathrm{C}_{s,t}}$$

CE_s = Cost-effectiveness in sector *s* (£/tCO_2e)

NPV = Net present value of option (£)

PVC_s = Present value of change in GHG emissions in sector *s* (£)

$C_{s,t}$ = GHG emissions change in sector *s* in year *t* (tCO_2e)

Y = End of the time horizon for the policy

Weighted average cost comparator

5.10 To determine whether emissions savings are being delivered cost-effectively, the cost-effectiveness indicator must be compared against a benchmark. This is given by the weighted average cost comparator. This can be split out into comparators for either traded or non-traded emissions.

5.11 The weighted average cost comparator represents the benchmark level of the social cost to abate the average tonne of emissions (WACC). It is the (weighted) average (discounted) appraisal value of carbon, over the period of the policy under

[35] It is important to note the sign convention. A positive number of the indicator represents a net cost per tonne of CO_2, whilst a negative number is a net benefit per tonne of CO_2e.

consideration. A WACC should be calculated for whichever sector (traded, non-traded, or total emissions) you calculate the cost-effectiveness indicator for.

5.12 If the cost-effectiveness indicator is lower than the relevant comparator, then the emissions are, on average, being abated in a cost-effective way. Otherwise, the emissions are not being abated cost-effectively.

5.13 To identify the appropriate cost comparator to use, analysts should follow the steps described here, which use the Traded Cost Comparator as an example.

Step 1: Identify the change in traded sector emissions in each year that there are impacts.
Step 2: Obtain the emissions weightings by year (in-year change in traded sector emissions as a proportion of lifetime savings).
Step 3: use the appraisal value of carbon (CV) from Data Table 3 of the accompanying spreadsheet.
Step 4: Discount the appraisal value of carbon to calculate present values (based on the Green Book discount rates).
Step 5: Multiply the annual values from steps 2 and 4 (weight x discounted CV).
Step 6: Sum all the years in step 5 to give the Traded Cost Comparator.

5.14 The weighted average cost comparator (WACC) is summarised in Box 5.2. A worked example is demonstrated in Table 5.1 using a policy delivering 1.7Mt of net emission savings in the traded sector across a three-year period.

Box 5.2 The weighted average cost comparator

$$\mathrm{WACC}_s = \sum_{t=1}^{t=Y} \beta_t \mathrm{CV}_t \frac{\mathrm{C}_{s,t}}{\mathrm{C}_s}$$

WACC = Weighted Average Cost Comparator for this project (lasting Y years) for sector *s* (where s can be either the traded, non-traded sector or both)

β_t = discount factor in year *t*

CV_t = appraisal value of carbon in year *t* (£/tCO_2e)

$\mathrm{C}_{s,t}$ = GHG emissions in year *t* in sector *s* (tCO_2e)

C_s = lifetime GHG emissions in sector *s* (tCO_2e)

Table 5.1 Example of Traded Cost Comparator calculation

Year	2026	2027	2028	Total
$mtCO_2e$ (net)	0.60	0.70	0.40	1.70

Weighting (in-year emissions/ lifetime emissions) (proportions)	0.35	0.41	0.24	1.00
Appraisal value of carbon (CV) (£/tCO2e) (Data Table 3)	317	322	327	
Appraisal value of carbon (£/tCO2e), discounted	317	312	308	
Weight x discounted CV	111.9	128.6	72.5	
Traded cost comparator (TCC) =				**313.0**

5.15 It is easier to understand the approach by considering a worked example. Box 5.3 gives an example with savings across both sectors and over a number of years.

Box 5.3 Example of cost-effectiveness indicators

Consider a policy that drives the uptake of ground source heat pumps by households, beginning in 2026 and lasting 10 years (2026 – 2035, inclusive). It results in annual emissions reductions in the non-traded sector of around 10,000 tCO_2e from avoided gas consumption (or 100,000 tCO_2e of cumulative non-traded emissions savings (C_{NT})), and an increase in emissions in the traded sector of around 1,000 tCO_2e in each year (or 10,000 tCO_2e of cumulative traded emissions increase (C_T)) from increased electricity consumption.

The NPV of the policy is £1.5m, which is broken down as follows (note the figures below are illustrative):

	NPV £m
Capital costs	-25.48
Cost of Traded emissions (Electricity) (PVC_T)	-2.97
Saving of Non-traded emissions (Gas) (PVC_{NT})	29.73
Savings from Energy consumption (Elec & gas)	0.23
Total	1.50

Savings from energy consumption are calculated as the difference between the monetised benefit of decreased gas consumption and the cost of increased electricity

consumption (as heat pumps displace gas-heating systems), calculated using the long-run variable costs of both energy sources over the 10-year appraisal period.

The weighted average cost comparator across both sectors (WACC) is £297 per tCO_2e and was calculated separately using the methodology described in Table 5.1.

The cost-effectiveness indicator (CE_{NT+T}) across both traded and non-traded sectors is calculated as:

$$CE_{NT+T} = -\frac{NPV - (PVC_{NT} + PVC_T)}{C_{NT} + C_T} = -\frac{£1.5m - (£29.7m - £3m)}{100{,}000 - 10{,}000\ tCO_2e} = £280 \text{ per } tCO_2e$$

The policy delivers each tonne of carbon savings at a cost of £280 per tCO_2e. This is lower than the WACC of £297 per tCO_2e, implying that the policy is cost effective.

The same process can be undertaken for the non-traded sector[36]. In this instance, the weighted average Non-Traded Cost Comparator (NTCC) is the same as the WACC at £297 per tCO_2e, calculated using the methodology described in Table 5.1.

The cost-effectiveness indicator for the non-traded sector is:

$$CE_{NT} = -\frac{NPV - PVC_{NT}}{C_{NT}} = -\frac{£1.5m - £29.7m}{100{,}000\ tCO_2e} = £282 \text{ per } tCO_2e \text{ in the non-traded sector}$$

The policy delivers each tonne of non-traded carbon savings at a cost of £282 per tCO2e, lower than the NTCC and again implying the policy is cost effective.

[36] The traded sector cost-effectiveness indicator does not apply in this instance as the policy generates emissions. It would be calculated at -£447 per tCO_2e, calculated as $-\frac{NPV-PVC_T}{C_T} = -\frac{£1.5m+£3m}{10{,}000 tCO2e}$. Such a calculation would falsely imply that there is a social benefit of £447 per tCO_2e abated, when the policy in fact generates emissions.

6 Presenting findings

Introduction

6.1 Communicating analysis clearly is essential. This chapter explains the reporting requirements for impact assessments, and also for Carbon Budgets.

Impact assessments

6.2 Analysts are provided with a template for reporting emissions savings[37]. GHG emissions savings in both the traded and non-traded sectors should normally be provided in the template. This template can also be used to present emissions savings for other analytical documents such as business cases.

6.3 For policies that have a significant impact on GHG emissions, and for policies which are specifically targeting GHG emissions, it is best practice to present further information within the supporting evidence base section. This additional information will include, where relevant:

- the emissions counterfactual;
- the interactions and correlations with other energy and GHG policies;
- time profiles of emissions savings, in both the traded and non-traded sectors, and the economic sector (domestic, industrial, power generation etc.);
- how impacts are felt between different affected groups (e.g. low- and high-income households, the exchequer, energy suppliers, etc.)
- the valuation of the annual carbon savings;
- the valuation of the annual energy savings;
- the cost-effectiveness of the carbon savings;
- air quality impacts; and
- impact on achieving fuel poverty objectives (if appropriate).

Reporting for carbon budgets

6.4 Under the Climate Change Act (2008) the government is committed to legally binding carbon budgets. These set limits on UK GHG emissions over successive five-year periods and are required to be set twelve years in advance of each five-year period.

[37] See template on this page: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

The first seven Carbon Budget periods have been set, covering: 2008-12, 2013-17, 2018-22, 2023-2027, 2028-2032, 2033-2037, and 2038-2042.

6.5 Given the legal requirements to meet these budgets, monitoring progress is of great importance. Consequently, when appraising policy it is worth bearing in mind the requirements for carbon budget accounting and reporting, which go beyond the minimum required for impact assessments. This involves reporting on the following:

6.6 The annual change in UK territorial GHG emissions in $MtCO_2e$ (relative to the 'business as usual' counterfactual option and accounting for policy overlaps), broken-down by sector (Power Generation, Industry, Fuel Supply, Buildings, Agriculture, LULUCF, Waste, F-gases, Domestic Transport and International Aviation and International Shipping[38]) and by incidence in the UK Emissions Trading Scheme (ETS) or non-ETS sector[39]. See Chapters 2 and 3 above for details on how to calculate these changes.

6.7 A headline figure of the total emission impact of the policy (in $MtCO_2e$) broken-down by the ETS and the non-ETS sectors. Providing traded savings allows decision makers to understand the likely distribution of emissions under the ETS across sectors and the impact across different time periods. The emissions impact should break out any forecast, if applicable, of the purchase of offset credits by UK organisations that a policy may incentivise or require for compliance.

6.8 Annual figures for the net change in energy use in TWh/GWh broken down by fuel, user and sector (relative to the 'business as usual' counterfactual option and accounting for policy overlaps).

6.9 Figure 6.1 below shows a suggested template for presenting these figures in Impact Assessments, which is also available on the Green Book supplementary guidance section of the GOV.UK webpage.

6.10 The total change in GHG emissions reported should be owing to the policy, whether the policy leads to greater GHG emissions or GHG emissions savings. Analysts are encouraged to disaggregate their policy package as far as possible and report each policy's associated change in GHG emissions.

6.11 To report total GHG emission impacts, both the CO_2 and non-CO_2 (converted to CO_2e) must be included by using the conversion factors in Table 3.1. This means that, as well as identifying the change in emissions from a change in energy fuel use, the impact on major greenhouse gases must be reported and converted into the carbon dioxide equivalent. This includes methane from landfill and agricultural livestock, nitrous oxide from fertiliser use and production and F-gas emissions (HFCs, PFCs and SF_6).

[38] Emissions from International Aviation and International Shipping only count directly towards our 6th and 7th Carbon Budgets. However, DESNZ analysts monitor these emissions across all periods to assess performance against the Carbon Budgets.
[39] If the policy has impacts in multiple sectors, these should be reported separately.

6.12 If your policy includes material non-CO_2 impacts (e.g. as a proportion of its total impact, or in absolute terms), it is necessary to provide the impact of the policy on each gas (in $MtCO_2e$) separately.

6.13 To allocate the emissions changes to the correct sectors for the purpose of Carbon Budgets reporting, Table 6.1 below provides the general rules for allocation. For emissions that are not covered within this table and where it is not clear on how they should be allocated, please contact GHGappraisal@energysecurity.gov.uk.

Figure 6.1 Template for Carbon Budgets reporting

Sector		Emission Changes* (MtCO2e) - By Budget Period							Emission Savings (MtCO2e) - Annual Projections																					
		CB I: 2008-2012	CB II: 2013-2017	CB III: 2018-2022	CB IV: 2023-2027	CB V: 2028-2032	CB VI: 2033-2037	CB VII: 2038-2042	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Power sector	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Industry	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Fuel Supply	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Buildings	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Waste	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Agriculture	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
LULUCF	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
F-gases	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Domestic Transport	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
International Aviation and Shipping	Traded	0	0	0	0	0	0	0																					
	Non-traded	0	0	0	0	0	0	0																					
Total	**Traded**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Non-traded	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Important note: Please enter net emission savings as positive numbers and net emission increases as negative numbers.

6.14 For policies that can be disaggregated into the traded and non-traded sectors, testing for cost-effectiveness can be done using the methodology described in detail in Chapter 5.

Table 6.1 Allocation of emissions changes to the correct sector

Emissions from energy use

Step 1 Identify source of emissions change	Step 2 Allocate to Traded or Non-traded sector	Step 3 Allocate to appropriate economic sector
Electricity	Traded Supplied through the grid from major power producers with the exception of Energy-from-Waste (EfW)[40]	Power sector – policies affecting carbon intensity of supply.
Electricity	Non-traded On-site electricity generation from small non-ETS operators and EfW.	Analysts should attribute these emissions to the sector generating the electricity (e.g. transport, industry, buildings, agriculture, waste)
Gas	Traded When used by ETS operators	Power sector - major power producers Industry - Heavy industry in UK ETS
Gas	Non-traded Otherwise	Transport, industry, buildings, agriculture, waste,
Fuel oil/heating oil	Non-traded	Transport, industry, buildings, agriculture, waste, public sector
Coal	Traded When used by ETS operators	Power sector - major power producers Industry - Heavy industry in UK ETS
Coal	Non-traded Otherwise	Transport, industry, buildings, agriculture, waste,
Biofuels	Non-traded	Transport, industry, buildings, agriculture, waste,
Fuel used for domestic aviation	Traded From 2013 onwards	Domestic transport
Fuel used for domestic aviation	Non-traded Before 2013	International Aviation and Shipping

[40] Major power producer Energy-from-Waste facilities are classified within the power sector but remain non-traded.

Fuel used for intra-European aviation	Traded From 2013 onwards	International Aviation and Shipping
Fuel used for intra-European aviation	Non-traded Before 2013	International Aviation and Shipping
Fuel used for other international aviation	Non-traded	International Aviation and Shipping
Fuel used for domestic maritime	Traded Domestic maritime from July 2026	Domestic transport
Fuel used for domestic maritime	Non-traded Domestic maritime before July 2026	Domestic transport
Fuel used for international maritime	Traded International maritime scope expansion from 2028.	International Aviation and Shipping
Fuel used for international maritime	Non-traded International maritime non-traded before 2028.	International Aviation and Shipping

Emissions from non-energy use

Step 1 **Identify source of emissions change**	**Step 2** **Allocate to Traded or Non-traded sector**	**Step 3** **Allocate to appropriate economic sector**
Methane from landfill	Non-traded Methane from landfill	Waste
Methane from agricultural livestock	Non-traded Methane from agricultural livestock	Agriculture
Methane from industry and fuel production	Non-traded Methane from industry and fuel production	Industry or Fuel Supply

Nitrous Oxide fertiliser use on farms	Non-traded Nitrous Oxide fertiliser use on farms	Agriculture
Nitrous Oxide fertiliser production	Non-traded Nitrous Oxide fertiliser production	Industry
F-gas-related emissions	Non-traded F-gas-related emissions	F-gases

7 Annex A: Checklist for analysts

1. Have you valued changes in GHG emissions using the carbon values for appraisal (Data Table 3) for the traded and non-traded sectors?
2. Have you specified the change in energy consumption?
3. Have you considered the existence of rebound effects?
4. Have you used the long-run variable cost of energy supply (LRVC) when valuing the costs and benefits to the UK of changes in energy use?
5. Have you used the full retail price, including tax, of energy when working out sub-sectoral distributional impacts and the value of any direct rebound effects (e.g. comfort taking)?
6. Have you valued the air quality impacts of changes in energy use?

8 Annex B: Unit conversion factors

ENERGY

1 tonne of oil equivalent (toe)	= 107 kilocalories
	= 396.83 therms
	= 41.868 GJ
	= 11,630 kWh
100,000 British thermal units (Btu)	= 1 therm

WEIGHT

1 kilogramme (kg)	= 2.2046 pounds (lb)
1 pound (lb)	= 0.4536 kg
1 tonne (t)	= 1,000 kg
	= 0.9842 long ton
	= 1.102 short ton (sh tn)
1 Statute or long ton	= 2,240 lb
	= 1.016 t
	= 1.120 sh tn

VOLUME

1 cubic metre (cu m)	= 35.31 cu ft
1 cubic foot (cu ft)	= 0.02832 cu m
1 litre	= 0.22 Imperial gallons (UK gal)
1 UK gallon	= 8 UK pints
	= 1.201 US gallons (US gal)
	= 4.54609 litres

1 barrel	= 159.0 litres
	= 34.97 UK gal
	= 42 US gal

PREFIXES

UK statistical practice uses the following prefixes for multiples of Joules, Watts and Watt hours:

kilo (k)	= 1,000	or 10^3
mega (M)	= 1,000,000	or 10^6
giga (G)	= 1,000,000,000	or 10^9
tera (T)	= 1,000,000,000,000	or 10^{12}
peta (P)	= 1,000,000,000,000,000	or 10^{15}

9 Annex C: Glossary

Carbon Budgets	A set of legally binding caps on the level of the UK's territorial GHG emissions, with each budget covering 5 years. The caps for the first seven budgets have been set and cover the years 2008-12; 2013-17; 2018-22; 2023-27; 2028-32; 2033-37, 2038-42.
Climate Change Act 2008	UK legislation establishing a legally binding framework to tackle the dangers of climate change which was amended by the Climate Change Act 2008 (2050 Target Amendment) Order 2019 to introduce the target of reducing Greenhouse Gas emissions to net zero by 2050[41].
Cost-effectiveness (carbon)	The extent to which it is beneficial for a society to deliver GHG emissions savings. Usually expressed as a monetary value per tonne of CO_2e (see chapter 5 for details on calculating the cost-effectiveness of a policy).
Counterfactual	The scenario comprising the developments that would occur in the absence of the policy option being appraised. This is required to identify the expected net impacts of a policy option.
Damage costs	A simple monetisation approach to assessing the reduction in societal welfare from emissions of pollutants (see Chapter 4).
DESNZ	Department for Energy Security and Net Zero
Embedded/embodied emissions	GHG emissions from all factors used in the production of a good or service, including those from abroad. (See Chapter 3)
UKA	UK Allowances: Permits that must be obtained (either through allocation or trading) and submitted for any GHG emissions qualifying under the UK ETS.
Final Energy Demand	All energy supplied to the final consumer for all energy uses.
GHG	Greenhouse Gas. A major contributing factor to global warming.
Global Warming Potential	The extent to which a GHG has the potential to contribute to global warming. Usually expressed as a multiple of the global warming potential of carbon dioxide. (See Chapter 3)
Green Book	Guidance published by HM Treasury setting out the principles for appraisal and evaluation of government policies[42].
HMT	HM Treasury: The UK’s finance ministry
IPCC	Intergovernmental Panel on Climate Change[43]

[41] http://www.legislation.gov.uk/ukpga/2008/27/contents
[42] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent
[43] http://www.ipcc.ch/

LRVC	Long Run Variable Cost (of energy supply). This should be used to value the change in social welfare from changes in final energy consumption. (See section 3)
LULUCF	Land Use, Land Use Change, and Forestry
Magenta Book	Guidance published by HM Treasury on conducting evaluation of government policies[44].
Non-traded sector	GHG emissions that fall outside the scope of the EU Emissions Trading Scheme (or future scheme)
NPV	Net Present Value (The sum of all annual costs and benefits discounted to a base year)
Optimism bias	The demonstrated, systematic, tendency for project appraisers to be overly optimistic (see the Green Book for further information).
Policy overlaps	Where the combined GHG emissions impact of the set of Government policies is different to the sum of the impacts of the individual policies if they were to act alone.
Post Implementation Review (PIR)	Post-implementation review (PIR) refers to the review of regulatory policy that complements the ex-ante appraisal contained in the impact assessment.
Primary Energy Demand	Direct use at the source, or supply to users without transformation, of crude energy. In other words, energy that has not been subjected to any conversion or transformation process.
Rebound effect	Direct: The change in consumption of an energy service (and hence GHG emissions) resulting from a change in the efficiency with which it may be delivered. Indirect: The corresponding change in consumption of other energy services (and hence GHG emissions) resulting from this change, comprising a change in disposable income and a change in relative prices of goods and services (see Chapter 3).
Impact Assessment (IA)	An appraisal of a regulatory policy, to help identify which proposals will achieve government's policy objectives, while minimising costs and administrative burdens[45].
RTFO	Renewable Transport Fuel Obligation[46]
Security of energy supply	The ability for consumers to have access to the energy services they need (physical security) at prices that avoid excessive volatility (price security). (See the 'Energy Security and Resilience' section of Chapter 6 of the background documentation))
tCO_2e	Tonnes of Carbon Dioxide Equivalent. An amount of GHGs with the equivalent global warming potential of one tonne of Carbon Dioxide.

[44] https://www.gov.uk/government/publications/the-magenta-book
[45] See Regulatory impact assessments: guidance for government departments - GOV.UK for further guidance
[46] See https://www.gov.uk/renewable-transport-fuels-obligation for further details

Traded sector emissions	GHG emissions that qualify under the UK Emissions Trading Scheme UK ETS (or future scheme) and for which UK Allowances (UKAs) must be obtained
UNFCCC	United Nations Framework Convention on Climate Change[47]
UK ETS	UK Emissions Trading Scheme

[47] http://unfccc.int/2860.php

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