Carbon Reporting Methodology

Open Networks | WS1A P7
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DOCUMENT CONTROL

Authorities

Version	Issue Date	Authorisation	Comments
1	20/06/2022	Open Networks Workstream 1A	
1.2	17/11/2022	Open Networks Steering Group	

Related documents

1	Smart Systems and Flexibility Plan https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021
2	ON22-PRJ 2022 Project Initiation Document (PID) (13 Jan 2022) Published

Change history

Version	Description
1.1	Updates made following consultation feedback. Expanded the discussion on choice of grid intensity factors and DTU/GTD methodology. Updated timeframes in recommendation on future work in relation to energy efficiency.

Distribution

Published on the ENA website.

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Introduction

About ENA

Energy Networks Association (ENA) represents the owners and operators of licenses for the transmission and/or distribution of energy in the UK and Ireland. Our members control and maintain the critical national infrastructure that delivers these vital services into customers' homes and businesses.

ENA's overriding goals are to promote UK and Ireland energy networks ensuring our networks are the safest, most reliable, most efficient and sustainable in the world. We influence decision-makers on issues that are important to our members. These include:

- Regulation and the wider representation in UK, Ireland and the rest of Europe
- Cost-efficient engineering services and related businesses for the benefit of members
- Safety, health and environment across the gas and electricity industries
- The development and deployment of smart technology
- Innovation strategy, reporting and collaboration in GB

As the voice of the energy networks sector, ENA acts as a strategic focus and channel of communication for the industry. We promote interests and good standing of the industry and provide a forum of discussion among company members.

About Open Networks

Britain's energy landscape is changing, and new smart technologies are changing the way we interact with the energy system. Our Open Networks programme is transforming the way our energy networks operate. New smart technologies are challenging the traditional way we generate, consume and manage electricity, and the energy networks are making sure that these changes benefit everyone.

ENA's Open Networks programme is key to enabling the delivery of Net Zero by:

- opening local flexibility markets to demand response, renewable energy and new low-carbon technology and removing barriers to participation
- providing opportunities for these flexible resources to connect to our networks faster
- opening data to allow these flexible resources to identify the best locations to invest
- delivering efficiencies between the network companies to plan and operate secure efficient networks

We're helping transition to a smart, flexible system that connects large-scale energy generation right down to the solar panels and electric vehicles installed in homes, businesses and communities right across the country. This is often referred to as the smart grid.

The Open Networks programme has brought together the nine electricity grid operators in the UK and Ireland to work together to standardise customer experiences and align processes to make connecting to the networks as easy as possible and bring record amounts of renewable distributed energy resources, like wind and solar panels, to the local electricity grid.

The pace of change Open Networks is delivering is unprecedented in the industry, and to make sure the transformation of the networks becomes a reality, we have created six workstreams under Open Networks to progress the delivery of the smart grid.

2022 Open Networks programme Workstreams

- WS1A: Flexibility Services
- WS1B: Whole Electricity System Planning and T/D Data Exchange
- WS2: Customer Information Provision and Connections
- WS3: DSO Transition
- WS4: Whole Energy Systems
- WS5: Communications and Stakeholder Engagement

Our members and associates

Membership of Energy Networks Association is open to all owners and operators of energy networks in the UK.

- Companies which operate smaller networks or are licence holders in the islands around the UK and Ireland can be associates of ENA too. This gives them access to the expertise and knowledge available through ENA.
- Companies and organisations with an interest in the UK transmission and distribution market are now able to directly benefit from the work of ENA through associate status.

ENA members

ENA associates

- Chubu
- EEA
- Guernsey Electricity Ltd
- Heathrow Airport
- Jersey Electricity
- Manx Electricity Authority
- Network Rail
- TEPCO

Executive Summary

The Smart Systems and Flexibility Plan [1] sets out Ofgem and BEIS' approach to facilitating the transition to a smarter and more flexible energy system on a pathway to net zero greenhouse emissions by 2050. The plan sets out several actions for the Open Networks programme. Action 3.6 requires networks and system operators to have consistent methodologies for carbon reporting by 2023. The product 7 (P7) team was formed to deliver this objective.

This report contains the proposed methodology that all Distribution System Operators (DSO) will adopt for consistent reporting. Additional notes have also been provided to explain the rationale and limitations of the methodology and recommendations to Open Networks as areas for further work. A report summarising the different carbon accounting methodologies, an earlier P7 deliverable, is included as an appendix.

This report was updated based on feedback received in the 2022 Open Networks flexibility consultation. Areas for future work recommended in this report are also indicative with dependency on Open Networks scoping of future programmes.

The use of flexibility services can increase or reduce carbon emissions. These impacts have been categorised into direct, consequential, and indirect impacts. Direct impacts can include emissions from burning fuel in the case of a generator when dispatched, consequential impacts can include displacing another generator as a result of changing the energy balance, and indirect impacts can include emissions embedded in the materials used by the flexible asset. There are also counterfactual carbon impacts, such as network reinforcement or using a backup generator, from which flexibility services impacts could be evaluated.

The methodology contained in this document specifies the calculation of direct and consequential impacts, whilst indirect impacts are recommended for inclusion as part of future work from 2024. The P7 team came to this conclusion after consideration of the policy drivers to ensure that the approach is comparable with the Electricity System Operator (ESO) and is consistent between DSO reports. Counterfactual carbon impact calculations and optioneering is beyond the scope of P7.

Methodologies are standardised depending on whether the resource is generation, storage, or demand. But within these broad groupings there are sub categorisations such as the type of generation, which determines the conversion factors used, such as fuel emission factors or generator efficiencies. These factors generally come from standard industry accepted sources.

The format of presenting the impacts is also specified in the methodology for inclusion in each DSO' Distribution Flexibility Services Procurement Report, as required under the distribution licence.

Introduction

The P7 team was formed to develop a methodology for DSO to calculate and report the carbon impact of flexibility service actions. The scope of P7 this year is detailed in the Open Networks 2022 Programme Initiation Document [2] and subsequently in the approved P7 scope. In developing this methodology, the product team also conducted a review of other carbon accounting methodologies as given as appendix to this report.

This is a new area of work for the Open Networks programme, based on action 3.6 in the Smart Systems and Flexibility Plan, to develop common methodologies for carbon reporting and monitoring of flexibility markets by 2023 as part of Licence Condition 31E reporting.

This report contains the proposed methodology that all DSO will adopt for consistent reporting. Additional notes have also been provided to explain the rationale and limitations of the methodology and recommendations to Open Networks as areas for further work. This report will be published as part of the summer 2022 consultation and will be subject to revision later in 2022 based on industry feedback.

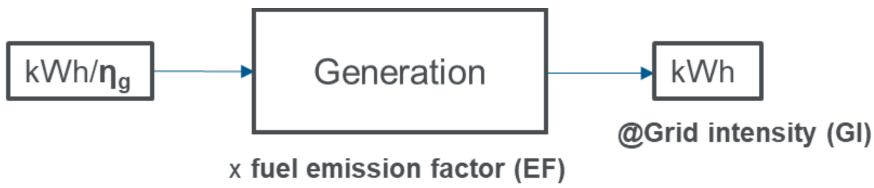
Methodology

Formula

- The calculations apply to flexibility services requested for an increase in exports or reduction in imports. This is the most prevalent application of flexibility services currently.
- DSO will perform the calculation by technology category without input from providers, except to confirm the technology category where required.
- The calculation includes direct (such as fuel combustion) and consequential carbon impacts (such as battery charging) but excludes indirect impacts (such as embedded emissions in the materials).
- The general formula varies by generation, storage, and demand. In the formulae, kWh is the energy delivered (as opposed to requested) measured at the site of the resource, and η is the energy conversion efficiency.

For demand-turn-up and generation-turn-down flexibility services, refer to the Supporting Notes.

Generation



- For **generation export**, the carbon impact is:
    1. combustion of the fuel (direct) = + $\mathbf{kWh/\eta_g \times EF}$
    2. displacing grid generation (consequential) = **- kWh x GI**

- If the generator is displacing imports, the carbon impact is the same as the equivalent amount exported directly to the grid.
- For bioenergy, report on both inclusive and exclusive of biogenic CO_2 released during burning of biomass and biofuels by using the relevant emission factors.

Storage

- For **storage export**, the carbon impact is:
  1. carbon intensity of the input energy (consequential) = + **kWh/η_s x GI_i** (if from grid), or + (**kWh/η_s)/η_g x EF** (if from generator)
  2. displacing grid generation at export (consequential) = - **kWh x GI_e**
- If storage input energy is physically supplied from a renewable generator assume zero carbon, this does not apply to non-physical supplies of low carbon electricity, which should assume grid intensity.
- If storage discharge is displacing imports, the carbon impact is the same as the equivalent amount exported directly to the grid.
- Storage import reduction should be calculated as demand, assuming shifted load (100% payback). Where DSO are unsure whether storage is providing export increase or import reduction, use the storage calculation. This ensures carbon impacts are not underestimated and incentivises additional information to be provided.

Demand

- For **demand reduction**, the carbon impact is:
  1. reduced grid imports during the turn-down (direct) = - **kWh x GI_{td}**
  2. increase in grid imports during "payback" (consequential) = + **kWh x payback% x GI_i**

- If demand is shifted, such as deferred EV charging, then payback% is 100%. Otherwise, assume an associated payback as a percentage of the turn-down energy of 21%. Where DSO are unsure, assuming load shifting. This ensures carbon impacts are not underestimated and incentivises additional information to be provided.

Conversion factors

- DSO should use the conversion factor sources presented in the following table.
- The data source used for grid intensity is a static value, all grid intensity factors is therefore equal. In the case of storage, $GI_i = GI_e$ and in the case of demand, $GI_{td}=GI_i$. The different notations in the formula allows for inclusion of time series grid intensity factors in future. See Supporting Notes for further discussion on use of grid intensity factors.

Factor type	Source	Notes
Fuel emission factors	BEIS/Defra	CO_2e, Gross CV. Updated annually.
Efficiency	BEIS Electricity Generation Costs 2020 – [A] Coal – DUKES – [B] BEIS Storage Costs and Assumptions 2018 – [C]	The DUKES report is updated annually, however the others are one-off reports.
Grid intensity	Green Book data tables	Average of consumption long-run marginal factors, use most recently updated value rather than forecasts (2021 at time of writing). Irregularly updated.
Payback%	Low Carbon London report	From a one-off innovation trial. Assume 21% for reduction services, based on the average of trial events. Assume 100% for load shifting solutions.

Technology categorisation

- The technology categorisations are given in the following table, which maps LC31 technology categories by the relevant technology categories required for selecting the appropriate conversion factor. This is advisory rather than prescribed to allow for some flexibility where the mapping is incomplete.

- The P7 team also recommends that Ofgem allow the addition of subcategories based on Embedded Capacity Register / G99 to allow for more granular categorisation to support standardisation and reporting.

LC31 Technology Categorisation	Emissions Factor (and Grid intensity factor)	Efficiency	Demand payback
Advanced Fuel (produced via gasification or pyrolysis of biofuel or waste)		Advanced Conversion Technologies [A]	
Biofuel - Biogas from anaerobic digestion (excluding landfill & sewage)		Anaerobic digestion (AD) [A]	
Biofuel - Landfill gas	Biogas - Landfill gas		
Biofuel - Other	Biogas - Biogas	Energy from Waste (EfW) [A]	
Biofuel - Sewage gas	Biogas - Biogas		
Biomass	Biomass - wood logs, wood chips, wood pellets, grass/straw	Biomass – dedicated [A]	
Demand	Grid intensity		Payback (21%), shifting (100%)
Fossil - Brown coal/lignite			
Fossil - Coal gas			
Fossil - Gas	Gaseous fuels - natural gas	OCGT, CCGT, Recip [A]	
Fossil - Hard coal	Solid fuels - Coal (electricity generation)	Coal [B]	
Fossil - Oil	Liquid fuel - Diesel (average biofuel blend)	Diesel [A]	
Fossil - Oil shale			
Fossil - Other	Other factors available		
Fossil - Peat			
Geothermal			

Hydrogen			
Nuclear			
Solar			
Stored Energy (all stored energy irrespective of the original energy source)	Grid intensity	Pumped hydro, CAES, thermal energy storage, Lithium Ion, Zonc, Flow, Sodium Sulphur [C]	
Waste Water (flowing water or head of water)			
Wind			
Other			

Report format

- A table in the following format should be included in the Distribution Flexibility Services Procurement Report showing energy (requested and delivered) and carbon impact (broken into direct and consequential). An accompanying narrative should explain what the data shows and use of charts to present the information is encouraged.
- Energy delivered can differ to energy requested due to under or over delivery. Over-delivery is capped at 150% (captures over-delivery but excludes scenarios where over delivery may not be a consequence of the dispatch). Delivered energy is used to calculate carbon impacts.
- Subject to agreement with Ofgem to update the data template, the carbon impact per dispatch should be added as another column in the template. In addition, technology sub categorisations based on Embedded Capacity Register / G99 should also be added to reflect different solutions within each LC31 category, for example if demand is shifted or reduced or the different types of Stored Energy.
- For bioenergy, add an additional column to “Direct carbon impact”. In the first of these columns, report on the carbon impact exclusive of biogenic CO_2 using the default emission factors, and in the second column report on the biogenic CO_2 using the “outside of scope” emission factors, from the BEIS/Defra conversion factors (full set). The former calculation nets off the CO_2 released at combustion with the CO_2 absorbed during the growth phase of the bioenergy, whilst the latter calculation reports the CO_2 released at combustion. This is in line with the GHG Protocol guidance for corporate accounting.
- Provide the dispatch intensity metric (total carbon impact divided by the total energy delivered).

LC31 Technology Category	Requested energy (MWh)	Delivered energy (MWh)	Direct carbon impact (kgCO2e)	Consequential carbon impact (kgCO2e)
Fossil – Gas				
Demand				
Stored Energy				
…				
…Total				

Supporting notes

This section provides commentary on the considerations and rationale in the development of the methodology.

Purpose of report

The purpose of the report is to make carbon impacts of flexibility services actions transparent and consistent between DSO. It sets the foundation and will inform future developments and interventions that may be required to ensure flexibility markets are consistent with net zero.

The methodology in this report covers **outturn** carbon impacts from flexibility services actions. It does not include **counterfactual** impacts (such as network reinforcement or displacing mobile generators), or even **relative** impacts (the difference between outturn and counterfactual impacts) which would be required to evaluate between different interventions. Counterfactual calculations are out of scope of P7. The calculations specified in this methodology however could form part of that evaluation, such as under the Common Evaluation Methodology developed in P1.

As will be discussed later, the outturn carbon impact calculation in this methodology does not include all impacts, omitting indirect impacts. Users should therefore be mindful of this limitation when interpreting the values and comparing between technologies.

Accordingly, the proposed reporting format only covers outturn carbon impacts. DSO can include relative impacts optionally with appropriate narrative explanations to allow the user to understand what assumptions have been used. The calculation of counterfactual and relative impacts has not been standardised.

Comparable with ESO

The scope of P7 is DSO reporting. However, in accordance with the policy objective the team sought to ensure that the methodology was comparable with the ESO approach. This was achieved by adopting a narrow reporting boundary and presenting direct and consequential impacts separately in the report. However, differences in approach remain as it was necessary and desirable for this DSO methodology.

The ESO approach calculates direct emissions from large transmission connected assets in the Balancing Mechanism, presents impacts in terms of the change in grid intensity, publishes information on a half-hourly basis, and uses CO_2 emissions factors (excludes other greenhouse gases).

For DSO reporting, which is on an annual submission cycle, it was necessary to include methodologies for smaller distributed energy resources. The product team decided that for storage and demand, the inclusion of consequential impacts of charging and load payback respectively would be more reflective of impacts than just considering impacts at dispatch. The team also decided that CO_2e emissions factors should be used to capture all greenhouse gases. Currently most DSOs do not calculate and report on grid intensity of their networks which makes reporting the impact in terms of a change in grid intensity more difficult as a starting position, but the team has recommended exploring the presentation of this metric in any future work.

Methodology scope boundary

The team's review of other carbon accounting methodologies identified two main types of reporting methodologies being inventory or life-cycle assessments. Carbon inventories tend to have a narrow reporting boundary which records emissions directly attributable to the reporting entity, whilst life-cycle assessments include all emissions with respect to a project or activity.

The following table show different sources of carbon impact from flexibility services and how they have been categorised into direct, indirect, and consequential impacts. Direct impact is dispatch (and standby where applicable) whilst consequential impacts are considered as second-order effects such as displacing other grid generation or demand payback. The indirect effects relate to embodied and end-of-life emissions.

Stage in flexibility life-cycle >	Investment decision	Procurement	Pre-dispatch	Dispatch	Post-dispatch	Decommission
Counterfactual emissions	Emissions from network solution	Alternative DERs contracted	Alternative DERs contracted	Alternative DERs dispatched	Alternative DERs dispatched	Network solution or alternative DER end-of-life emissions
Attribution to DSO flexibility service (first order effects)	Emissions from flexibility services	Embedded emissions from contracted DERs (Indirect)	Standby emissions – e.g. part loaded DER if required on hot-standby (Direct)	Dispatch emissions - e.g. fuel combustion, reduced electricity consumption. (Direct)		End-of-life emissions from contracted DER (Indirect)
Consequential	Emissions from higher network losses due to higher grid utilisation	Change in wider market e.g. wholesale, balancing. (Consequential)	• BESS pre-charging. • Change in wider market e.g. wholesale, balancing. (Consequential)	• Ramp-up/down emissions. • Change in wider market e.g. wholesale, balancing. (Consequential)	• Energy efficiency rebound effect. • DSR payback. (Consequential)	Change in wider market e.g. wholesale, balancing. (Consequential)

Out of P7 scope (Counterfactual emissions row)

Out of P7 scope (Investment decision column)

The team decided to include direct and some consequential impacts (storage import, demand payback, and grid generation displacement) in the calculation but not indirect impacts for the following reasons.

- this keeps the report comparable with ESO direct-only reporting;
- direct emissions data sources are standard and readily available which ensures consistency;
- conversely, indirect emissions data sources and assumptions are less standard and less available, reducing consistency and subject to higher uncertainty;
- for storage and demand, it was considered more reflective of impacts to include the carbon impacts of input energy and payback respectively;

- the Pro Low Carbon project calculated that indirect impacts were a relatively small contributor to overall carbon impacts; and
- this was achievable within this year's Open Networks timetable.

The team recognises however that it would be desirable to include indirect impacts into the methodology as part of future work from 2024 onwards to capture the full carbon impact.

The inclusion of the displacement of grid generation is the approach taken for quantification of Scope 2 emissions for company reporting as defined under the GHG Protocol where electricity used, and hence not used, is at the grid intensity of grid generation to supply the load. Increases in grid exports is treated in the same way as reduction in grid imports as it has the same impact on the system. This will also enable calculation of carbon differentials for storage solutions using time-series grid intensities.

The P7 team also discussed whether grid generation displacement would apply to constraint management, which is the main application for DSO flexibility services. Load exceeding network limits, allowed to materialise and managed using flexibility services, would not be allowed to be supplied from beyond the constrained network as this would breach secure network limits. However, since the constraint is generally an N-1 constraint any excess load would still be physically supplied from outside the constrained network and it was therefore considered appropriate to include this component. This may not apply when the network is islanded. Networks that are not intact have not been considered in this methodology.

Consistent approach

The calculations are performed by DSO using standard assumptions by technology to ensure consistency. The team recognises that not including asset specific information could reduce accuracy but decided that the first iteration should start on a consistent basis as a foundation for future improvements.

In other carbon accounting methodologies reviewed such as under the Emissions Trading Scheme, the calculation is performed by the owner/operator of the asset with independent verification. The team recommends future work to consider developing a framework for incorporating provider information, such as plant specific efficiencies, where it can improve accuracy.

Data sources

The conversion factors adopted have used industry accepted sources. The only exception is the assumption on payback for demand which comes from a previous innovation trial based on a small number of activations.

Static plant efficiency factors has the limitation that it does not change based on plant loading.

There were three sources of grid intensity factors identified:

- BEIS/Defra's average grid intensity factors;
- Green Book data table average and marginal grid intensity factors; and
- ESO's time-series average grid intensity factors.

A marginal grid intensity factor is considered more appropriate when evaluating the impact of a change whilst an average is generally used for carbon foot printing.

Network losses are included in the calculation which, in the case of ESO and Green Book data tables, is included in the grid intensity factor.

The ESO time-series grid intensity factor is derived from CO_2 emissions and does not include all Greenhouse Gasses (GHG) unlike the other two sources.

Time-series data is preferable to static grid intensity factors since the latter does not account for potentially lower grid intensity periods to which load has shifted and thereby increasing the carbon impacts of demand and storage flexibility. However, realistic assumptions are required on demand and storage behaviour in order to make use of time-series data.

The Green Book factor would overestimate the carbon impact (static factor) whilst the ESO's time-series data will underestimate the carbon impact (average factor exclusive of all GHGs). The P7 team also needs to undertake further stakeholder engagement and collect more evidence to make informed assumptions on storage and demand behaviour (assuming load shifts from demand and storage are always to off-peak, low-carbon, periods could underestimate impacts).

P7 recommends using the Green Book grid intensity factor to start with and to move to time-series factors in future. It is generally better to overestimate than underestimate impacts in order to encourage more information to be provided from stakeholders.

Energy efficiency

The carbon impact of energy efficiency is expected to be similar to demand-side-response but with additional complexities. These complexities may relate more to the calculation of the energy saved than to the conversion of energy into a carbon impact, which would also use grid intensity factors. DSOs have limited experience of deploying energy efficiency programmes and therefore the P7 team have decided that this should be reviewed in future work as DSOs start developing such programmes.

Forecasting

Whilst it is possible to forecast the flexible capacity and potentially energy that may be required based on projected load growth, establishing what technologies will be providing the energy can be highly uncertain where contracts have yet to be awarded and the dispatch merit order unknown. The team therefore recommends inclusion as part of future work to review whether forecasting of carbon impact is possible to a reasonable degree of accuracy.

Flexible connection and DTU/GTD

This section describes the approach to calculating actions in the opposite direction to that of the main methodology. There are two applications where this reporting methodology applies:

- Demand Turn Up (DTU) or Generation Turn Down (GTD) flexibility services can be used to manage constrained networks due to high volumes of generation. DTU/GTD is still nascent but is expected to grow in importance in future. As a flexibility service, DTU/GTD is within scope of the LC31E reports and should be reported consistent with the methodology in this section.
- Flexible connections enable customers to connect to constrained part of network quickly and cheaply but with access restrictions when the constraint occurs – this may involve curtailing customer exports. Generally, these are generation or storage assets, and curtailment is a reduction in export. Restrictions on import is less prevalent and so has not been considered further here. Flexible connections is not a flexibility service and therefore does not need to be included in the LC31E reports.

Outturn carbon impacts of DTU/GTD flexibility services is expected to be similar to curtailment actions as direction of service is the same. However, there could be differences due to commercial frameworks or method of dispatch. One main difference is flexible connections are designed to allow more renewable generators to connect than would have been possible otherwise in constrained areas of network. This is a counterfactual carbon impact which is not within scope of this reporting methodology but were it to be considered could outweigh the impacts of curtailment actions.

The following table presents the carbon impacts by direction of service. The first column is the current methodology for flexibility services whilst the second column is services in the opposite direction.

- Carbon impacts of GTD is the inverse of Generation Turn Up (GTU), where there is less fuel combusted and more grid generation replacing the reduction in exports.
- Storage export reduction assumes a temporary delay to exports. This means that the carbon embedded in the stored energy is not considered.
- Demand increases may result in reduced demand later so an equivalent "payback%" assumption, as used in the Demand Turn Down (DTD) methodology, will be required. There is insufficient information available currently for the P7 team to make recommendations on a suitable DTU payback% assumption.

Solution	Export increase / import decrease	Export decrease / import increase
Generation	• combustion of fuel (direct) = **+kWh/η_g x EF** • displace grid generation (consequential) = **-kWh x GI**	• reduced combustion of fuel (direct) = **-kWh/η_g x EF** • replaced by more grid generation (consequential) = **+kWh x GI**
Storage (export)	• input energy (consequential) = **+kWh/η_s x GI_i** (if from grid), or **+(kWh/η_s)/η_g x EF** (if from generator) • displace grid generation (consequential) = **-kWh x GI_e**	• replaced by more grid generation (consequential) = **+kWh x GI** • displace grid generation (consequential) = **-kWh x GI**
Demand	• reduced grid imports (direct) = **-kWh x GI_{td}** • increased grid imports (consequential) = **+kWh x payback% x GI_i**	• increased grid imports (direct) = **+kWh x GI** • reduced grid imports (consequential) = **+kWh x "payback%" x GI**

Further work

Implementation

This methodology was issued for consultation in the summer of 2022 and has been revised based on feedback received.

The P7 team also recommends that P7 should reconvene to make updates, corrections, and issue clarifications as DSO start implementing the methodology ahead of April 2023. This can occur during Q1 2023.

Potential future work

The P7 team highlights the following areas that should be considered as part of future work. Some of these can be part of next year's Open Networks programme subject to prioritisation of all activities across the workstreams.

Priority	Activity	Delivery year
1	Review stakeholder feedback post Distribution Flexibility Services Procurement Report publication	2023
2	Review of technology categorisations to follow market and technology developments	2023
3	Work with providers to incorporate asset specific information or calculations to increase accuracy	2023
4	Evaluate source and use of granular grid intensity time series data to improve accuracy, and hence suitable assumptions on timing of storage charging and demand payback	2023
5	Review other applications of flexibility for inclusion in the methodology	2023
7	Sensitivity analysis in reporting	2023
8	Review whether accurate forecasting of carbon impacts is possible	2023
9	Enduring governance on carbon reporting methodology, including a repository for data and assumptions	2023
10	Inclusion of indirect carbon impacts for more complete impact	2024
11	Investigate treatment of energy efficiency impacts as DSO implement programmes	Timescales linked to introduction of energy efficiency by DNOs

Glossary

Reporting Boundary	defines the scope of the calculation. This can include direct impacts (such as combustion of fuel to generate electricity), consequential impacts (such as the carbon emissions from grid generation to produce and transport electricity imported by a battery), or indirect impacts (such as embedded and end of life emissions attributed to the assets). We also describe narrow or wide boundaries to refer to the extent to which the calculation focuses on direct or whole-life emissions respectively.
Grid intensity	refers to the carbon intensity of electricity that is imported from the grid in kgCO2e/kWh taking into account the carbon emissions from grid generation, interconnector imports, and potentially network losses.
Conversion factors	used in this report as a general term to describe factors that are used in the calculations which can include fuel emission factors, grid intensity factors, and plant efficiency assumptions.
Payback	otherwise known as rebound or bounce back, refers to when demand side response load increases after a turn-down event as the site recovers to pre-event conditions, for instance an increase in cooling load in a building having warmed up during the turn-down event. This could also refer to a similar rebound effect following realisation of economic benefits as a result of an energy efficiency saving measure.

Appendix – Report on existing carbon reporting methodologies

Summary

The product 7 team was formed to develop a methodology for DSOs to calculate and report the carbon impact of flexibility service actions. This is a new area of work for the Open Networks programme, based on action 3.6 in the Smart Systems and Flexibility Plan, to develop common methodologies for carbon reporting and monitoring of flexibility markets by 2023 as part of Licence Condition 31E reporting.

The product team reviewed and summarised seven different carbon reporting methodologies as given below that are prominent in the UK (which may also be applicable in other jurisdictions), drawing primarily on published materials.

- ESO Carbon Intensity for GB electricity system
- EU ETS monitoring and reporting
- The GHG Protocol for corporate GHG inventories
- The Green Book and supplementary guidance
- IPCC Guidelines for national GHG inventories
- PAS 2080 for Carbon Management in Infrastructure
- Pro Low Carbon innovation project from WPD

The report does not conclude on which approach should be adopted but seeks to inform the potential options for consideration by the team in the next stage of the project.

The team discussed their similarities and differences and relevance to DSO reporting by investigating the purpose of the report, the reporting boundary, their approach to calculation, emission factors used, and what emissions sources were included.

The team broadly categorised the approaches by their reporting purpose - GHG inventories, life-cycle assessments, and grid intensity approaches. GHG inventories as adopted by national and corporate inventories tend to have standardised and narrower reporting boundaries (focus on direct impacts) than life-cycle assessments such as PAS 2080.

Grid intensity reports as produced by the ESO also has a narrow reporting boundary and caters for use by consumers for carbon foot printing. WPD's Pro Low Carbon project was the only methodology specifically designed for DSO flexibility services, recommending inclusion of direct and indirect carbon impacts in a relatively standardised way.

Generally, the wider the reporting boundary the more complex and divergent the calculation may become particularly as they demand more data which may not be readily available.

The calculation approaches were broadly similar, by multiplying an activity data by an emissions factor and expressed in terms of CO2 equivalent. There was a range of emissions factors used from fuel emissions factors, grid intensity factors, and embodied carbon factors from several different sources.

In the next stage of the team's work, the team will design an appropriate methodology for DSO reporting drawing on the approaches reviewed in this report.

Introduction

The product 7 team was formed to develop a methodology for DSOs to calculate and report the carbon impact of flexibility service actions. The scope of the group is detailed in the WS1A P7 Carbon Reporting Scope document [1]. This report is the second deliverable from the product team as set out in the Project Initiation Document [2].

This is a new area of work for the Open Networks programme, based on action 3.6 in the Smart Systems and Flexibility Plan, to develop common methodologies for carbon reporting and monitoring of flexibility markets by 2023 as part of Licence Condition 31E reporting.

This report reviews and summarises existing carbon reporting methodologies prominent in the UK (but may also be applicable in other jurisdictions) and considers their applicability for DSO flexibility services. The report does not conclude on which approach should be adopted but seeks to inform the potential options for consideration by the team in the next stage of the project.

Methodology of review

The following seven methodologies were reviewed and their summary included in the Appendix.

- ESO Carbon Intensity for GB electricity system
- EU ETS monitoring and reporting
- The GHG Protocol for corporate GHG inventories
- The Green Book and supplementary guidance
- IPCC Guidelines for national GHG inventories
- PAS 2080 for Carbon Management in Infrastructure
- Pro Low Carbon innovation project from WPD

The product team used public and freely available materials to undertake this review for the exception of PAS 2080 which relied primarily on within-team expertise. The team also drew on the study conducted under the Pro Low Carbon project by WPD to help complete the summary, as the project performed a similar review of methodologies as included in their published reports. Additional methodologies, although omitted in this report, has been considered by the team as part of review of the Pro Low Carbon project report[1].

Comparison between carbon reporting methodologies

Purpose of each report

Each carbon reporting programme has developed guidelines and methodologies to meet their specific purpose. This can be broadly categorised into three main types as given below.

[1] Pro Low Carbon: Carbon assessment methodologies - https://www.westernpower.co.uk/downloads/149422

- **Carbon inventories** – standardised methodologies to calculate the carbon impact attributable to a reporting entity such as a country, company, or installation within specified boundaries to comply with legal, regulatory, or voluntary requirements such as the EU ETS or corporate GHG inventories.
- **Life cycle assessments (LCA)** – a framework methodology to calculate the life cycle environmental impact of an activity or project, compared to a baseline, affording a greater degree of flexibility to define the scope of the report such as under PAS 2080 for infrastructure projects or evaluating policy interventions using supplementary guidelines for The Green Book.
- **Grid intensity** – methodologies to calculate the carbon intensity of the electricity grid, such as the ESO's carbon intensity report, can be used by electricity consumers such as individuals and organisations to calculate their carbon footprint.

Table 1: Existing methodologies by report purpose categorisation

	Carbon inventory	**Life cycle assessments (LCA)**	**Grid intensity**
ESO Carbon Intensity for GB electricity system			✓
EU ETS monitoring and reporting	✓		
The GHG Protocol for corporate GHG inventories	✓		
The Green Book and supplementary guidance		✓	
IPCC Guidelines for national GHG inventories	✓		
PAS 2080 for Carbon Management in Infrastructure		✓	
Pro Low Carbon innovation project from WPD		✓	

A standardised carbon inventory with narrowly set boundaries are simpler to implement and compare between DSO reports, whilst a LCA is inherently more complex with wider boundaries and baselines which increases the scope for divergence on assumptions and calculations. Even where the framework of a LCA is standardised such as under PAS 2080, the lack of standard datasets increases calculation complexity and divergence.

The LCA is however more suitable for inclusion in options appraisals and could therefore be more useful as an input to the Common Evaluation Methodology (CEM) and whole-systems CBA which are both evaluation tools and methodologies developed through Open Networks. Note that the product 7 team will not develop methodologies for comparing carbon impact of different options as agreed in the product team scope [2].

Under the RIIO-2 framework, the ESO are required to report on the carbon intensity of their actions which is currently using the grid intensity forecasting methodology[2]. Actions taken through the Balancing Mechanism is presented as the change in average grid intensity, and hence reflects the impact it has on electricity consumer's carbon footprint.

Reporting boundary

Carbon inventories require clearly specified boundaries of what is included and excluded from the accounts. This can be broadly defined at the programme-level for consistency, but the reporting entity needs to specify exact boundaries, such as what is under the company's operational control for corporate GHG accounting. Alternatively, the guidelines can accept user defined boundaries based on what is considered by the user as a significant source of carbon emissions.

The boundary can be defined based on the type of carbon impact it includes or excludes:

- **Direct impact** – the carbon impact that can be directly attributed to the activity such as the combustion of fuel or reduction in process emissions. This can be considered Scope 1 emissions under the GHG Protocol, and Scope 2 for electricity consumption, or operational impacts under Pro Low Carbon.
- **Consequential impact** – the carbon impact that occurs because of the activity such as the change in grid intensity due to the consequential change in the supply-demand balance by dispatching flexibility services. This is included in the operational impacts under Pro Low Carbon or can be Scope 3 under the GHG Protocol.
- **Upstream indirect impact** – the carbon impact of previous activities such as materials extraction and transportation. Known as Scope 3 under the GHG Protocol or non-operational impacts under Pro Low Carbon.
- **Downstream indirect impact** – the carbon impact of subsequent activities such as end-of-life emissions. Known as Scope 3 under the GHG Protocol or non-operational impacts under Pro Low Carbon.
- **Baseline/counterfactual impacts** – the carbon impact of the counterfactual(s) which is required under options appraisals and LCA to understand the relative carbon impacts.

The Pro Low Carbon project, which is a WPD flexibility services innovation project, recommended inclusion of direct, consequential and indirect carbon impacts for a more complete representation of carbon impact. Whereas the ESO carbon intensity and EU ETS reporting boundaries only captures direct impacts.

[2] The Electricity System Operator Reporting and Incentives Arrangements: Guidance Document

Corporate GHG inventories require reporting on direct and electricity consumption impacts, with optional disclosure on upstream and downstream impacts. LCA approaches would include all impacts whilst an options appraisal will require the counterfactual impacts from which to compare.

A suitable reporting boundary for flexibility services should be specified in accordance with the purpose of the report as discussed in the earlier section.

Calculation approach

The calculation of carbon impact is broadly similar across the methodologies considered, which involve multiplying activity data by an emissions factor and is given in terms of CO2 equivalent using the IPCC's Global Warming Potential for different GHGs involved.

There were two noteworthy observations on the approach to calculations which may warrant further exploration.

- **Methodology hierarchy** - under the IPCC and EU ETS guidelines, three tiers are defined, each tier corresponding to the level of complexity of the calculation increasing with the significance or uncertainty of the emissions source. The first and second tiers uses default and national emission factors respectively whilst the third tier uses installation specific calculations such as direct measurements of GHG. Even in LCA approaches, one of the initial steps of the calculation is to identify the most significant emission sources on which to focus the assessment.
- **The party responsible for the calculation -** the EU ETS monitoring and reporting requirements stipulate that the calculation of emissions is carried out by each installation which is then verified by a third party, whilst the monitoring plan itself needs to be approved by an authority. This differs to a centrally administered calculation such as the ESO grid intensity methodology and the Pro Low Carbon approach.

Emission factors

Emission factors converts an activity such as consumption of energy or combustion of fuel into a carbon emission value. These are normally given in terms of kg or tonne of CO2 equivalent per unit of fuel or energy. The following table summarises the three main types of emission factors that is more relevant to flexibility services and the main source of data as used in the methodologies considered.

Some of the methodologies have accuracy as a key principle, and therefore advocate use of bespoke, site-specific factors over default factors where they can provide more accurate results.

Conversion factor type	Data source

Fuel emission factors – for combustion of fuels	• BEIS' UK Conversion factors for GHG reporting - used by EU ETS, Pro Low Carbon, and in the Green Book supplementary guidance (via data tables). • IPCC international default values are used for lowest tier calculations under the EU ETS. • National GHG reporting under the NIR uses a range of sources including from the EU ETS and the 2004 Carbon Factors Review.
Life cycle emission factors – for the embodied and end of life emissions	• Ecoinvent data was used by the Pro Low Carbon project via the Carbon Trust (requires data licence). • Circular Ecology's Inventory of Carbon & Energy (ICE) V3.0 (embodied carbon only) * • Certified product Environmental Product Declarations (EPDs) *
Grid intensity factors – for grid electricity	• Pro Low Carbon uses the marginal grid intensity based on independent factors not available in public domain. • DUKES CO2 emissions from electricity supplied for different fuel types used for ESO Carbon Intensity calculations. • Data tables in The Green Book supplementary guidance provides marginal and average electricity emissions factors. • BEIS's UK Conversion factors for GHG reporting

* Not specified within methodology but was identified from in-team expertise as standard sources

Emission sources included

The methodologies that necessarily captures significant volumes of emissions/sinks such as the EU ETS, national GHG inventories, and ESO carbon intensity focuses on the major emission sources such as large generators, interconnector imports, and other energy intensive industries. Arguably some of these large-scale emission sources are less likely to be providing DSO flexibility services due the voltage level concerned.

Corporate GHG accounting and LCA allows the reporting entity to select what emissions sources to include, whilst Pro Low Carbon models the most common flexibility services technologies - batteries, demand-side response, diesel, and gas generation. Note that the type of technologies that are providing flexibility services and the configuration of those technologies, such as a combination of technologies behind the customer meter, are likely to be diverse and may present challenges in specifying standard emission factors.

The product team were also interested in the treatment of energy efficiency under the methodologies considered. Only The Green Book supplementary guidance provided explanations on how to calculate the energy savings. Whilst the SECR guidance for corporate GHG inventories does recommend a narrative explanation on energy efficiency actions taken. Note that measures of carbon intensity as compared between previous years can also offer some indication of energy efficiency.

Whilst not considered in this report, the International Performance Measurement and Verification Protocol (IPMVP)[3] is a widely adopted methodology for measurement and verification of energy efficiency projects albeit not extending into standardised quantification of carbon impact.

Conclusion

The product team reviewed and summarised seven different carbon reporting methodologies that are prominent in the UK drawing primarily on published materials. The team then discussed their similarities and differences and relevance to DSO reporting by investigating the purpose of the report, the reporting boundary, their approach to calculation, emission factors used, and what emissions sources were included.

The team broadly categorised the approaches by their reporting purpose - GHG inventories, life-cycle assessments, and grid intensity approaches. GHG inventories as adopted by national and corporate inventories tend to have standardised and narrower reporting boundaries (focus on direct impacts) than life-cycle assessments such as PAS 2080.

Grid intensity reports as produced by the ESO also has a narrow reporting boundary and caters for use by consumers for carbon foot printing. WPD's Pro Low Carbon project was the only methodology specifically designed for DSO flexibility services, recommending inclusion of direct and indirect carbon impacts in a relatively standardised way.

Generally, the wider the reporting boundary the more complex and divergent the calculation may become particularly as they demand more data which may not be readily available.

The calculation approaches were broadly similar, by multiplying an activity data by an emissions factor and expressed in terms of CO2 equivalent. There was a range of emissions factors used from fuel emissions factors, grid intensity factors, and embodied carbon factors from several different sources.

The team also reviewed how different technology types were treated in the methodologies. Pro Low Carbon modelled the main types for DSO flexibility services including residential level assets whilst the EU ETS captures large generation and other energy intensive industries. The corporate GHG inventory and life-cycle assessments allows the person reporting discretion in selecting the source of emissions.

In the next stage of the team's work, the team will design an appropriate methodology for DSO reporting drawing on the approaches reviewed in this report. Some of the key questions the team will consider in subsequent work include:

- Purpose - how will the DSO report be used and by whom?
- Boundary - where should the reporting boundary be set?
- Calculation - what is the right level of complexity of calculation?

[3] IPMVP - https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

- Data - is data available to support the approach?
- Technologies - how can the range of different flexible solutions be accommodated?

Appendix

The review of existing methodologies used available published documentation such as guidance and report submissions. The links are provided as reference to allow the reader to study the material in more detail.

ESO Carbon Intensity of GB electricity system

Category	Grid carbon intensity
Purpose	The Carbon Intensity dashboard, app, and API forecast is **designed to enable consumers or smart devices to optimise their behaviour to minimise their carbon footprint**. It provides GB and 14 regional grid carbon intensity forecasts up to 48 hours ahead. The dashboard also provides real-time intensity for every 30-minute period, historic weekly intensity since 2009, and the change in intensity following ESO actions in the Balancing Mechanism updated every hour.
Produced by	ESO, WWF, Environmental Defence Fund Europe and the University of Oxford department of Computer Science.
Boundary	• Electricity **generation from all large, metered power stations, interconnector imports, transmission, and distribution losses** (to convert to consumption point). • **Excludes upstream emissions** and indirect land use change impacts. • **Excludes emissions from unmetered and embedded generators** not visible to ESO (but includes estimate for embedded wind and solar)
GHGs	**CO2 only**
Calculation	• Generation dispatch is forecasted using historic data and forecasted demand, wind, and solar generation • Carbon intensity is the sum for all generation – carbon intensity (by fuel type) * output, divided by national demand. Then converted to consumption by adjusting for transmission losses. • Interconnector intensity uses imported generation mix * carbon intensity (by fuel type) • Effect of balancing actions is the difference between the carbon intensity of all the generators in the BM before and after balancing actions have been applied.
Reporting	Data and **forecasts** published on dashboard, app, and API, ESO data portal. This methodology is currently used to publish the carbon intensity of ESO actions as required under RIIO-2 framework.
Emission factors	• Carbon intensity, by fuel type, based on output-weighted average efficiency of generation in GB and DUKES CO2 emission factors (2017, which was derived from total CO2 emissions per electricity supplied by fuel type) • Interconnector carbon intensity factors (GridCarbon 2017 -> generation sources from Staffell, Ian 2017)

Activity data	Generation output uses ELEXON BMRS data, Interconnector generation mix from ENTSOE Transparency Platform
Technologies	Large generation (biomass, coal, gas, hydro, nuclear, oil, other, solar, wind) and interconnector imports. Not considered energy efficiency (impact of will be embedded in demand and demand forecasts)
Links	• ESO carbon intensity methodologies – https://carbonintensity.org.uk/ • ESO carbon intensity dashboard – https://dashboard.nationalgrideso.com/

EU ETS monitoring and reporting

Category	Carbon market compliance
Purpose	The EU Emission Trading Scheme (ETS) is a policy instrument to cut GHG emissions within the EU, through a cap-and-trade market mechanism (cap on total GHG emission by sector, reducing over time, each year parties must surrender allowances either allocated or purchased to cover their reportable emissions). The UK ETS replaced the UK's participation in the EU ETS in January 2021. The Monitoring and Reporting Regulation (MMR) and guidance sets out the rules relating to the compliance cycle.
Produced by	European Commission
Boundary	Applies to energy intensive industries, power generation, and aviation. Direct emissions only. Operators need to define the monitoring boundaries for each installation.
GHGs	CO2, N2O, PFCs (also expressed as CO2 equivalent using GWP)
Calculation	• Monitoring requirements increase based on size of emissions through tiers (like IPCC guidelines). Can be measured (GHG concentration and volumetric flow) or calculated. Calculation method can use emission factors or carbon mass balance. • Calculation for combustion emission = Activity Data (=Fuel Quantity * Net Calorific Value) * Emission Factor * Oxidation Factor (account for incomplete reaction). Calculation for process emission = Activity Data * Emission Factor * Conversion Factor
Reporting	Annual monitoring, reporting and verification as part of compliance cycle. Annual emissions report (AER) must be verified by accredited verifier before compliance checks by the Competent Authority. The Competent Authority also must approve monitoring plan before implementation. Templates available.
Emission factors	Lowest tiers usually apply an internationally applicable default value (such as IPCC standard factors). Second tier uses national factors (used for national GHG inventory). The highest tier usually requires the factor to be determined from laboratory analysis.
Activity data	Depending on tier as discussed above.
Technologies	Applies to energy intensive industries, power generation, and aviation. Eligible hospitals and small emitters can opt out.

Links	• Monitoring and Reporting Regulations and guidance documents – https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/monitoring-reporting-and-verification-eu-ets-emissions_en • UK ETS guidance – https://www.gov.uk/government/publications/participating-in-the-uk-ets/participating-in-the-uk-ets#permitting-monitoring-reporting-and-verification

The GHG Protocol

Category	Corporate GHG Inventory
Purpose	The GHG Protocol – A Corporate Accounting and Reporting Standard is a guidance for companies to quantify and report on GHG emissions using standardised approaches and principles. Other methodologies exist such as ISO 14064 but is similar to GHG Protocol. Large UK companies (using >40kWh energy, Large defined in Companies Act 2006) need to report their emissions publicly via the **Streamlined Energy and Carbon Reporting (SECR)** regulations.
Produced by	World Resource Institute (WRI) and World Business Council for Sustainable Development (WBCSD). Specific guidance for completing the SECR is available from BEIS which draws on the GHG Protocol methodology.
Boundary	• **Emissions are categorised into scopes**. Scope 1 – direct emissions from sources owned or controlled, Scope 2 **–** indirect emissions from electricity purchased for consumption, Scope 3 – other indirect emissions consequential of company activities but from sources not owned or controlled. Scope 3 reporting is voluntary, guidance under **GHG Protocol Corporate Value Chain Standard.** • **Define operational and control boundaries** – financial control boundary (ability to direct financial and operational policies of operations to gain economic benefits from its activities), **operational control boundary** (full authority to introduce and implement operating policies), and **equity share boundary**.
GHGs	**Seven GHG covered by Kyoto Protocol** – CO2, CH4, N2O, HFC, PFC, SF6, NF3. Other environmental impacts not considered. Report in **CO2 equivalent** based on IPCC's GWP.
Calculation	Identify emission sources (focus on most important sources), categorise their scope, select measurement approach (direct measurement, calculated via chemical mass balance or emissions factors), collect activity data, select emission factors, calculate using tools (**GHG emissions = activity data x emission conversion factor**), collate from all facilities.
Reporting	Under SECR, reported via Directors Report (large companies), Annual Report (quoted companies), Energy and Carbon Report (LLP). Use of **intensity ratio** (environmental impact per activity or financial metric) to aid comparison. The GHG Protocol methodology is also used by **Science Based Targets**.
Emission factors	Standard does not dictate which factors are used but provides database to aid selection. SECR guidance requires use of **UK emission factors** updated annually but some organisations can use site specific emission factors if more accurate.

Activity data	Scope 1 – purchased quantity of commercial fuels, mass balance, or direct measurement through monitoring, Scope 2 – metered electricity consumption, Scope 3 – calculated from activity data such as fuel use or passenger miles.
Technologies	Main emission sources in boundary. Under SECR, companies need to provide narrative on energy efficiency actions taken and if possible provide energy savings but no calculation guidance given. Use of intensity ratios can show efficiencies over time.
Links	• GHG Protocol – https://ghgprotocol.org/corporate-standard • SECR – https://www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance • Conversion factors 2021 – https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

The Green Book and supplementary guidance

Category	Policy/programme assessments
Purpose	The Green Book is used to appraise policies, programmes, and projects. Additional guidance is available to support quantification and valuation of energy use and GHG emissions for options appraisals to build business cases and impact assessments.
Produced by	The Green Book is issued by HM Treasury. The supplementary energy and emissions guidance is prepared by BEIS.
Boundary	Guidance given on assessing direct impact and indirect impact through planning, land use change, construction, or new products. Guidance only applicable for marginal changes and not wider changes to the market (as it will change values in data tables)
GHGs	Seven GHGs – CO2, CH4, N2O, HFC, PFC, SF6, NF3 – reported as CO2 equivalent using GWP. GHG emission factors in data tables incorporate CO2, CH4 and N2O. Can also consider additional wider impacts such as air quality and energy security.
Calculation	• Guidance is accompanied by excel-based calculation toolkit and data tables for latest assumptions. • Analytical process: identify key drivers of emissions impacted by policy/project; identify energy and emission counterfactual; identify policy interactions; quantify changes in fuel use, emissions (energy change x fuel-specific emission factor, use marginal emissions factor for changes in direct fuel use and average emission factors for foot printing), and other impacts (e.g. air quality); value these changes (split into emission traded/non-traded sectors); calculate cost-effectiveness. • Energy efficiency should be net of direct and indirect rebound effects (where available funds are spent on more energy). • Embedded emissions to be considered if appropriate, proportionate, and practical e.g., results in large change in imported emissions

Reporting	Report using template, providing further information e.g., on counterfactual and time profile of emissions, impact by group (households, suppliers). Include impact on UK territorial GHG emissions by sector to understand impact on UK Carbon Budgets. If policy includes material non-CO2 impacts, should provide impact on each gas separately.
Emission factors	• Provided in data tables – marginal and average grid intensity (given in emissions per unit of electricity consumed) and fuel emission factors. Factors mostly from Defra, and DfT for petrol, diesel gas and oil. • Bespoke emissions factors should be used where available instead of supplementary guidance emission factors
Activity data	Estimated change in energy use or supply
Technologies	Range of fuel emission factors provided. Guidance includes discussion on energy efficiency calculation incorporating rebound effects.
Links	• Green Book and supplementary guidance – https://www.gov.uk/government/collections/the-green-book-and-accompanying-guidance-and-documents • Data tables - https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

IPCC Guidelines for national GHG inventory

Category	National GHG inventory
Purpose	Guidelines used by countries that report to the **UN Framework Convention on Climate Change (UNFCCC)** to ensure reported GHG emissions is complete and comparable. The UK's annual **National Inventory Report (NIR)** meets its commitments as a Party under the UNFCCC, tracks progress against commitments under Kyoto Protocol (including UK's contribution to EU target), and against UK Carbon Budgets.
Produced by	The Intergovernmental Panel on Climate Change (IPCC) maintains the guidelines. The NIR is compiled by a consortium led by Ricardo on behalf of BEIS.
Boundary	All emission source and removal by sinks **since 1990** (excludes historic emissions), within defined **geographical territorial boundary, at point of release** (excludes emissions from imported goods and international air travel), includes adjustment for trades through the EU ETS.
GHGs	Seven direct GHGs under Kyoto Protocol – (CO2, CH4, N2O, HFC, PFC, SF6, NF3) and four indirect GHGs (NO, CO, NMVOC, SO2). Each gas is given a **Global Warming Potential (GWP)** expressed relative to CO2 equivalent.
Calculation	**Approach varies by significance of source and availability of data**, the more significant or uncertain the higher the "tier". Tier 1 is simplest using activity statistics and default emission factors. Tier 2 uses more country specific data. Tier 3 uses plant specific data. The **UK NIR mostly uses Tier2/3 methods**. Calculation of direct GHG for sources including power stations = **Emissions Factor (EF) x Activity Data (AD)**

Reporting	UK's annual NIR includes Common Reporting Format (CRF) tables. Each year the inventory is extended to cover another year and allows updates for new emission sources, revised estimates, and data revisions.
Emission factors	Emission factors in 2021 NIR is based on **UK specific data**. Predominately derived from EU ETS data (2005 onwards), refiner sector reporting (UK Petroleum Industry Association, 2020) and from the 2004 Carbon Factors Review (Baggott et al., 2004), with some solid fuel factors derived from UK research (Fynes and Sage, 1994); non-CO2 emission factors are predominately IPCC defaults (IPCC, 2006).
Activity data	DUKES for statistics on liquid, solid and gaseous fuels. EU ETS for emissions from installations. UK Petroleum Industry Association for refinery emissions, UK Iron and Steel Industry Annual Statistics for energy production/consumption in Iron and Steel industry.
Technologies	Covers all main categories of source/sinks of emissions including energy industries, industrial processes, agriculture and forestry, and waste. Energy efficiency not considered explicitly.
Links	• NIR 2021 – https://unfccc.int/ghg-inventories-annex-i-parties/2021 • Emissions factors, UK NAEI ("Energy background data") – https://naei.beis.gov.uk/ • IPCC 2006 – https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html • IPCC 2019 Refinement – https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html

PAS 2080

Category	Standard for infrastructure projects
Purpose	Common framework to help companies reduce volume of carbon used throughout a project, encouraging collaborative working through the supply chain for more effective **whole life cycle carbon** use. Was developed as a result of the 2013 Treasury Infrastructure Carbon Review to create a new specification for carbon reduction. Voluntary standard.
Produced by	Mott MacDonald and Arup with British Standards Institute
Boundary	Whole-lifecycle carbon management
GHGs	All, normalised to CO2e
Calculation	• Project level carbon accounting • Should include Whole Life Carbon Emissions of the infrastructure development project • Calculation methodology is not prescribed, although compliant tools exist • Carbon calculations should be done iteratively throughout a project lifecycle with the goal of taking project level action to reduce carbon emissions • Estimation at the design stages, moving to 'as built' emissions as the construction stage
Reporting	Reporting should be undertaken by all value chain members in a project lifecycle at key gateways where carbon emissions can be influenced

Emission factors	None – emissions factors are not specified within framework
Activity data	At discretion of person performing the calculation
Technologies	Emissions sources are reported in line with BS EN 15978:2011 (cradle to grave emissions).
Links	https://www.bsigroup.com/en-GB/our-services/product-certification/product-certification-schemes/pas-2080-carbon-management-in-infrastructure-verification/

Pro Low Carbon

Category	DSO flexibility services innovation project
Purpose	Pro Low Carbon (PLC) was part of a Western Power Distribution (WPD) **innovation project**, Future Flex, which investigated how to increase uptake of domestic flexibility. PLC reviewed methodologies and developed a **DSO specific methodology** for calculating the carbon impact of procuring flexibility services for different flexible technologies. To date these recommendations have not been adopted.
Produced by	PLC was a one-off study conducted by Everoze for WPD
Boundary	Categorises carbon impact into **non-operational** and **operational**. Non-operational impact attributed proportion of **embodied and end-of-life** emissions. Operational impact includes source impact and **offset in marginal grid impacts**.
GHGs	Includes all GHGs in CO2 equivalent (using GWP) for both operation and non-operational impacts.
Calculation	• Operational impact = carbon impact of energy generated/imported minus carbon impact of energy offset (grid intensity) • Non-operational impact = Non-operational emissions * % attributed (if investment in asset can be attributed to DSO services, and split based on percentage of DSO services to 10% internal rate of return) • Methodology retains some flexibility based on the technology and how emissions can be attributed to flexibility services
Reporting	Does not specify format or frequency of reporting.
Emission factors	• Carbon intensity of fuel emissions from UK Government GHG Conversion Factors for Company Reporting, 2020 • Marginal carbon intensity of grid offset uses independent dataset • Non-operational impact – Carbon Trust life cycle data using data from Ecoinvent through licence
Activity data	Source emissions forecasted via modelling scenarios, whilst non-operational attribution assumes DSO service revenue of £6k/MW/yr against different technology capital and operational cost.

Technologies	Project calculated intensities for batteries (domestic and large scale), DSR (commercial temp-controlled storage, domestic heat pump, EV charger), Diesel, Gas (natural, landfill). Energy efficiency was not considered.
Links	• Pro Low Carbon: Carbon impact of DSO flexibility services – https://www.westernpower.co.uk/downloads-view/206428 • Pro Low Carbon: Carbon assessment methodologies - https://www.westernpower.co.uk/downloads/149422

Glossary

ESO	Electricity System Operator
EU ETS	European Union Emissions Trading System
DSO	Distribution System Operator
DUKES	Digest of UK Energy Statistics
GHG	Greenhouse Gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
NIR	National Inventory Report
SECR	Streamlined Energy and Carbon Reporting
UNFCCC	United Nations Framework Convention on Climate Change
WPD	Western Power Distribution

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