BT Group Carbon Enablement Methodology

June 2025

BT Group

Contents

1 Introduction

BT Group is the UK's leading provider of fixed and mobile telecommunications and related secure digital products, solutions and services. The company also provides managed telecommunications, security and network and IT infrastructure services to customers across 180 countries.

We have been a leader on sustainability and climate action for over thirty years and have a target to be a net zero carbon emissions business by end of March 2031 for our own operations, and by the end of March 2041 for our supply chain and customer emissions (all Scope 3 emissions).

Acting on climate change has never been more important. In 2015, 196 parties adopted the Paris Agreement, aligning on aiming to limit global warming to 1.5°C above pre-industrial levels. Since then, the Intergovernmental Panel on Climate Change (IPCC) has shown the importance of limiting warming to a maximum of 1.5°C. To achieve this goal, global greenhouse gas emissions need to halve every decade, reaching net zero by 2050.

BT Group has a role to play, not only in reducing our own end-to-end emissions, but also in providing products and services that help our customers and wider society to transition to a low carbon economy. Between 2013 and 2019, we delivered on a commitment to achieve a '3:1 Net Positive ratio' – enabling our customers to avoid three times the emissions of our own end-to-end carbon footprint.

Building on this success, we're continuing our focus on providing products and services from growth technologies such as full fibre broadband (or FTTP, Fibre to the Premise), mobile 4G/5G solutions, cloud computing and the Internet of Things (IoT).

We report annually on the cumulative carbon emissions avoided by our customers through their use. We recognise that carbon enablement is often the result of multiple technologies or services working together. As there is currently no consistent way to allocate emissions reductions across multiple service providers, we follow leading practice by calculating the total impact of any solution in which a BT Group product or service plays a 'fundamental' role. This could lead to 'double counting' across companies. For more information on our approach to 'allocation' - see page 9.

To note the following considerations about our methodology:

- the methodology and case studies represent the best available data to us at the time of publication, and we recognise the need to periodically update the methodology and our case studies as information and available data evolve
- the methodology has been developed based on previous work we've undertaken in this area while conducting literature and peer reviews
- rebound effects have been considered, acknowledged and documented and are quantified where possible
- in recognition that enablement methods are under development, that there is no common approach, and that this is a complex area to accurately measure, our results should not be considered directly comparable to similar models published by our peers.
- we're sharing our methodology and case studies to drive transparency in the hope of stimulating further learning, and we welcome any feedback

We have now updated our methodology and included additional business to business solutions - Digital Collaboration Tools, Dashboards, and Sustainable Buildings.

This document outlines our approach to calculating the enablement impact of the following areas and technologies:

Impact area	Enabling technology and application
Remote working	Full fibre broadband Business collaboration tools (Global Voice) Digital collaboration tools Virtual Events
E-commerce (online shopping)	Full fibre broadband 4G/5G mobile connectivity
Healthcare	Full fibre broadband (virtual consultations)
Transportation	4G/5G mobile connectivity (personal navigation and public transport apps) Internet of Things (IoT) (Telematics)
B2B network management	Software-Defined Wide Area Networks (SD-WAN) B2B cloud services Carbon Network Dashboard Digital Carbon Calculator
Infrastructure	Sustainable buildings

Section 2 of this document provides an overview of our general approach to calculating carbon enablement, including the key components and principles that underpin our methodology.

Section 3 provides detail on how the methodology has been applied to the technologies we assessed to determine their enablement impact. Throughout this document, we use the terms ‘technology’ and ‘applications’ to describe the products or services that we sell to our consumer and business customers.

2 Methodology overview

Stakeholders increasingly recognise that in parallel to asking companies to demonstrate how they are reducing their own emissions, there is a critical need to understand and measure how their products and services are helping society to decarbonise. Assessments of carbon enablement will help ensure that capital shifts to more sustainable solutions, while also accelerating the scale-up and adoption of those solutions. [1]

While there is growing evidence that the enablement impact of information and communications technology (ICT) is significant and accelerating, there is currently no official or standardised calculation methodology. To ensure our approach aligned with leading practice and emerging techniques, we assessed our previous carbon enablement work and conducted an extensive literature review covering more than 30 academic and non-academic papers.

We also considered the methodologies and latest thinking published by a range of other peers and industry organisations including:

- AT&T: 10x methodology (2017) and global progress updates
- Vodafone: Connecting for Net Zero: Addressing the climate crisis through digital technology (2021)
- AWS: The Carbon Reduction Opportunity of moving to Amazon Web Services (2019)
- Liberty Global: Connecting a sustainable future: The power of Gigabit connectivity (2022)
- GeSI: SMARTer2030 – ICT Solutions for 21st Century Challenges (2015)
- GSMA: The Enablement Effect: The impact of mobile communications technologies on carbon emission reductions (2019)
- Huawei: Green 5G: Building a Sustainable World (2020)

In the absence of a standardised calculation framework, the literature review identified leading practice for approaching variables such as baseline selection, rebound effects and allocation from the existing methodologies outlined below:

- Mission Innovation: Avoided Emissions Framework (2020)
- WRI: Estimating and Reporting the Comparative Emissions Impacts of Products (2019)
- ICCA & WBCSD: Addressing the Avoided Emissions Challenges (2013)
- ILCA: Guidelines for Assessing the Contribution of Products to Avoided Greenhouse Gas Emissions (ILCA) (2015)
- GeSI: Evaluating the carbon reducing impacts of ICT (2010)
- ITU: Methodology for Environmental Life-Cycle Assessment of Information and Communication Technology Goods, Networks and Services (2014)

Our methodology incorporates many of the principles, definitions and guidance documented in Mission Innovation's Avoided Emissions Framework (2020), which was developed with input from BT Group. References for all documents included in our review are found in Appendix A.

This document will be updated periodically to account for additional technologies and improved data sources that support the methodology.

[1] Mission Innovation and Net Zero Compatible Innovations Initiative (2020)

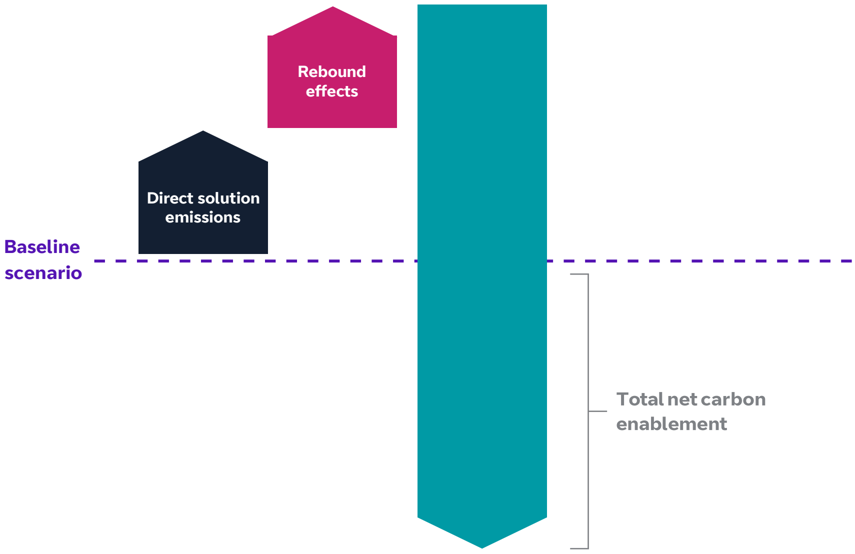
2.1 General methodology

Our carbon enablement calculations provide an estimation of the greenhouse gas (GHG) emissions, calculated in CO2e, that are avoided or reduced through using BT Group's products and services. This is done by comparing the emissions from a 'before' (or baseline) scenario, with those from the 'after' (or technology-enabled) scenario. The baseline scenario represents the most likely process that would have occurred without the enabling technology. For example, the most likely alternative to shopping for clothing, groceries or household goods online is physically travelling to a store.

Carbon enablement is achieved when the activities included in the enabled scenario have been assessed to result in an incremental, net positive impact over the baseline scenario. When calculating the impact of the enabled scenario, the technology's direct solution emissions and rebound effects – which are described in more detail below – must also be considered. Our methodology calculates the total carbon enablement impact of a technology application as follows:

Total net carbon enablement = [Enabling effects] – [Direct solution emissions] – [Rebound effects]

Figure 1: Components of the total carbon enablement calculation
Source: Avoided Emissions Framework

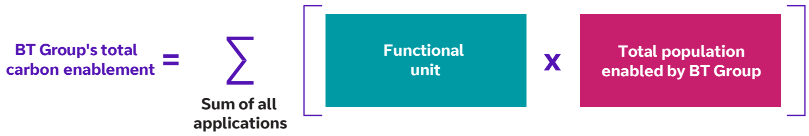


Our carbon enablement calculations are carried out at the individual application level. Each application is assessed by determining a carbon enablement factor, or 'functional unit', that reflects the net avoided emissions per unit of the solution implemented. The functional unit describes the system boundaries in which the baseline scenario can be compared to the enabling solution. They are clearly defined, measurable, and include a description of quantity and time. For comparison purposes, all the functional units used in our calculations are expressed over an annual period. For example, the functional unit used for online shopping is the 'average carbon enablement (in kg CO_2e) per e-commerce user per year'.

To calculate the total carbon enablement for a given application, over a specific time period, the functional unit is multiplied by the total population enabled by BT Group. The impact of each technology application is then aggregated to provide a portfolio-level impact assessment.

Figure 2: Calculation of total carbon enablement, using functional units

Source: Avoided Emissions Framework



Each of the technologies and applications included in our calculations were selected on the basis that they are likely to achieve net avoided emissions today, and/or are important contributors to our future growth. This has allowed us to focus data collection and methodological developments on the areas that are likely to make the most significant contribution. Over time, we will expand the number of enabling technologies and applications that are included in our calculations. At present, except for digital workplace tools, our calculations only measure the net avoided emissions resulting from the use of our products and services in the UK.

2.2 Key methodological components

Enabling effects

Enabling effects are the emissions that are avoided as a result of using a specific technology. These effects are further divided into primary and secondary enabling effects.

Primary enabling effects are those that cause an immediate reduction of emissions (compared to the baseline scenario) as a result of the technology being implemented. It is leading practice to include all primary enabling effects in carbon enablement calculations if they can be quantified. Our current methodology incorporates at least one primary effect per application, but there is scope to include additional primary effects in the future if data becomes available.

Secondary enabling effects, or indirect effects, tend to have an impact over a longer time period and require a number of assumptions to be made. This includes the enablement impact's correlation to the enabling technology, the likelihood of these impacts occurring, and the scale of technology adoption. Secondary effects have been excluded from our calculations but have been acknowledged and documented where relevant following leading practice (as per the documents referenced at the beginning of this section).

We have also identified instances where the enabling effects of more than one technology could potentially overlap. To avoid double-counting, functional units and technology boundaries have been clearly defined, and conservative assumptions have been included in the calculations. For example, secondary data on internet usage patterns have been incorporated to make a distinction between the online shops that are likely to be made at home using full fibre broadband versus those made on a 4G/5G mobile connection.

Direct solution emissions

Direct emissions are the life cycle emissions of the technology that is causing the enabling effect. The ITU defines these as 'direct environmental effects associated with the physical existence of an ICT solution, i.e., the raw materials acquisition, production, use and end-of-life treatment stages, and generic processes supporting those including the use of energy and transportation.'[3] The emissions that are specifically related to the manufacturing of a technology are known as 'embodied emissions'. Direct emissions (and embodied emissions in particular) are difficult to quantify and require a comprehensive Life Cycle Assessment encompassing manufacture, operation, maintenance and end of life to quantify accurately. We have estimated the embodied emissions of the devices used in our SD-WAN solutions, but do not have the data available to do so for our other in-scope technologies. This might be assessed in future iterations of BT Group's carbon enablement model.

Rebound effects

Rebound effects occur when the efficiencies created by an enabling technology are offset, often unintentionally, by greater consumption of resources, products or services with an emissions impact. For example, the convenience of shopping online may result in consumers buying more items and/or shopping more frequently than they would if they could only shop at a physical store. These 'extra' shops will have an emissions impact linked to the increased parcel deliveries.

Rebound effects have been included in the calculation of avoided emissions in two instances where they are considered to be significant and can be quantified. This includes the increase in energy used when working from home, and the increase in parcel deliveries resulting from online purchases. Where other potential rebound effects have been identified but are not quantifiable, they have been described qualitatively.

2.3 Guiding principles

To ensure alignment to leading practice, our methodology uses the following principles:

Data quality

The data used in enablement calculations should reduce bias and uncertainty as far as practicable by using the best quality data available. The data included in our calculations are either primary, secondary or modelled. Priority is given to primary data from BT Group or our customers (via surveys or case studies), but where this is not available secondary data from credible sources are used. Where multiple secondary sources were found for a single input, the source with the highest temporal and geographical representativeness was selected. In cases where data from equally representative sources conflicted, the most conservative figures were used to avoid overestimating our impact.

Where secondary data was not available, conservative assumptions were used. Given the lower level of confidence in assumptions (compared to primary or secondary data) a degree of caution has been taken when interpreting the calculated impacts. In line with leading practice, assumption ranges have been stress tested where required, and all assumptions were reviewed with internal product teams. All data sources and a description of the basis of our assumptions have been clearly documented.

[3] ITU Methodology L_1480 Enabling the Net Zero transition

Future solutions

Inherently, there will be greater uncertainty when predicting the future carbon enablement impact of our technologies. We use emissions factors that are adjusted over time to reflect the projected decarbonisation of the UK electricity grid, and the transition to electric vehicles. We also clearly document where any assumptions or data sources change in future years.

Attribution and allocation

Carbon enablement is often the result of multiple technologies or services working together, making it impossible for one solution alone to claim all the avoided emissions. For example, to work effectively from home, our customers require a reliable, high-speed broadband connection, but also personal ICT equipment such as laptops and smartphones, and remote access to cloud-based servers.

The following guidance on attribution and allocation is found in the Avoided Emissions Framework[4]:

'There is currently no consistent way to allocate avoided emissions, thus it is common practice to attribute all the avoided emissions to a solution where that solution has a fundamental role in enabling the avoided emissions. The test of a fundamental role may be determined by whether the avoided emissions would only be realised with the existence of the solution (i.e., if the solution did not exist would the avoided emissions still take place?).'

In line with this guidance, all the technologies included in our methodology are assumed to have a fundamental role in enabling the carbon savings, and therefore the whole carbon enablement from the enabling technology is claimed.

2.4 Summary of steps taken to quantify the net carbon enablement

The below steps were followed to quantify the carbon enablement of the selected BT Group technologies:

1. Identification of the technologies and applications to be assessed

Each of the technologies and applications included in our current calculations were selected on the basis that they were likely to achieve net avoided emissions today, and/or were important contributors to our future growth strategy. We established that the enabling effects did not include a reduction of our own emissions.

2. Establishment of the system boundary, carbon saving mechanisms, and baseline scenarios

For the chosen solutions, we established the mechanism that is causing the enabling effect – for example, reduced travel or energy savings. We also confirmed that the enabling effect could be directly attributed to the technology, meaning the whole carbon enablement can be claimed. Baseline scenarios representing the technology application's most likely alternative were identified to ensure that only
the incremental impact of each technology was calculated. Functional units – describing the system boundaries in which the baseline scenarios could be compared to the enabling solution – were clearly defined, and risks of double counting were identified.

[4] Mission Innovation and Net Zero Compatible Innovations Initiative (2020) The Avoided Emissions Framework (AEF), Module 2

3. Documentation of the methodology and identification of the data requirements

Carbon enablement mechanisms, boundaries and calculation methodologies for each technology and application were documented and visualised through the creation of causal models. This enabled the initial methodology and any underlying assumptions to be reviewed and validated by internal product teams and helped us identify the primary and secondary data required for each calculation. These documents have been refined throughout the development of the methodology.

4. Test of the mechanism

At multiple stages, the enablement methodology and data requirements were reviewed by product specialists, both internal and external to BT Group. This process allowed the assumptions and proposed methodology to be tested to ensure they were validated and reasonable.

5. Identification of the studies and determination of the carbon enablement factor

Research was conducted to collect data and studies that provide a quantitative basis for the calculation of the functional unit, including the baseline, enabling effects, direct effects and rebound effects (where this can be quantified). This included primary data, academic studies, other published data and reports, and customer surveys. Over time, methodologies will be refined and examined with case studies and other data sources.

6. Collection of data for volumes and carbon enablement factor

Primary data collection from our product teams and customers was completed to determine the size of the population enabled by each technology. Where BT Group data did not exist or needed to be extrapolated to the end of March 2030, assumptions were made and validated with internal product teams.

7. Calculation of the carbon enablement

The total carbon enablement was calculated by multiplying the carbon enablement factor by the volume for each solution, and then aggregating the results for all the products being assessed. The calculations considered potential overlaps between solutions to ensure there is no double counting of the same avoided emissions being enabled by different solutions.

8. Final documentation and validation of the process

The methodology and calculation process has been fully documented in this report, including the assumptions and data sources.

3 Application of methodology to specific enablement mechanisms and technologies

3.1 Remote working

Technologies that provide individuals with the ability to work remotely (including working from home and virtual attendance at work-related events) can help reduce carbon emissions related to commuting and travelling for work. There may be secondary enablement effects, such as reduction in energy usage required to power devices being used in an office or other work environment.

3.1.1 Fibre to the Premises (FTTP)

BT Group's Full Fibre broadband offering, or fibre to the premises (FTTP), provides ultrafast internet speeds, improved reliability, and the ability to operate multiple devices simultaneously on home broadband. Unlike fibre to the cabinet (FTTC), FTTP broadband is delivered by fibre optic cables directly to consumers' homes, bypassing localised cabinets and eliminating the use of less efficient copper wiring.

Carbon Savings Mechanism (Enabling effects)
The speed and reliability of FTTP is integral in enabling the effective operation of remote work tasks. By providing the ability to work from home, FTTP can help reduce carbon emissions by eliminating the need for a daily commute to a workplace. In addition, FTTP can also help reduce energy consumption in a workplace by reducing the number of computers, lights, and other devices that need to be powered, and by reducing energy related to heating and cooling.

Calculation Methodology
The carbon enablement was calculated as the average annual carbon enablement per homeworker per year multiplied by the number of homeworkers enabled by BT Group's FTTP offering per year, less the increase in emissions from homeworking (heating and office equipment).

The average annual carbon enablement per homeworker per year was estimated as the average number of days working from home per year, multiplied by the proportion of homeworking days enabled by FTTP, multiplied by the emissions per round trip commute to the workplace.

Formula
Carbon enablement (tCO_2e) = [Average annual carbon enablement per homeworker (tCO_2e/homeworker) × Number of homeworkers enabled by BT Group FTTP per year (#/year)] – Emissions from increased home energy use (tCO_2e/year)

Where: Average annual carbon enablement per homeworker (tCO_2e/homeworker/year) = Average number of days working from home per week (#) × Proportion of days working from home enabled by FTTP (%)

× Average emissions per round trip commute to the workplace (tCO_2e/trip)

Functional Unit
Average carbon enablement per homeworker per year.

Assumptions

1. The number of days worked from home per week per homeworker is estimated as a weighted average of days worked from home post COVID-19 from respondents of a survey commissioned by AWA in 2022.
2. The number of working weeks per year is assumed to be 46 in line with the UK average.
3. The number of homeworkers in the UK population for 2022 is taken from the Office of National
4. Statistics: Labour market overview, UK: November 2022. The number of homeworkers is assumed to grow in line with projected UK labour force growth sourced from OECD: Labour force forecast to 2030, with a consistent 33.2% share of the total UK labour force.
5. Total emissions from office working per employee per day is taken as the total emissions from office heating and electricity per employee per working year (sourced from Energise: Working from Home Carbon Emissions) divided by 232 days (UK average number of working days per year).[5]
6. The average number of hours per day working from home per homeworker is assumed to be 8 hours based on the UK average.
7. Total commuting distance (in miles) for each mode of transport is sourced from the Department for Transport Statistics: National Travel Survey 2021. These figures were extended to 2030 without change
8. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of Battery Electric Vehicles (BEVs) to 2029/30.
9. In the absence of secondary data, the proportion of homeworking days enabled by FTTP (incremental effect of FTTP over previous broadband connection) is assumed to be 30% as a baseline. This share increases by 5% YoY to reflect that these remote working applications will become more data intensive and rely more on increased speed and reliability. As the confidence of this data point remains low, a range of 10-50% has been assigned to allow the user to assess variations in the incremental effect of FTTP on the carbon enablement potential of the application.
10. Primary data on the number of Consumer FTTP lines in the UK were sourced from BT Group. Total UK Consumer FTTP lines are 'residential only'. Consumer FTTP lines are also residential only and inclusive of connections from BT, EE and Plusnet, along with connections sold to consumers through third-party wholesalers.
11. The number of homeworkers using FTTP is estimated by multiplying the total number of homeworkers in the UK population by the proportion of Consumer broadband lines in the UK that are FTTP. This assumes all homeworkers require a broadband connection to work from home and is reduced to BT Group's FTTP market share to derive the total number of homeworkers using a BT Group FTTP connection per year.

[5] Department for Transport (2021)
NTS0409: Average number of trips and distance travelled by purpose and main mode

Data sources

Data point	Source
Number of Total UK Consumer FTTP lines	BT Group
Number of BT Group Consumer FTTP lines Total UK Broadband lines	BT Group BT Group
Average number of days working from home per homeworker per week	AWA, 2022
Number of homeworkers in UK population	ONS, 2022
Total emissions from office working per employee	Energise, 2021
Total commuting distance per commuter per year (all modes of transport)	Department for Transport Statistics, 2021
Average number of commutes per commuter per year	Department for Transport Statistics, 2021
Emission factors for all modes of transport	DEFRA, 2024

Rebound effects

The following rebound effect was quantified in the carbon enablement calculation for homeworking:

Increase in homeworking energy use

The carbon enablement methodology determined the net increase in CO_2e emissions per homeworker per year resulting from increased home energy consumption by deducting the total emissions from heating and office equipment at the office per homeworker (sourced from Energise: Working from Home Carbon Emissions) from the total emissions from heating and office equipment at home per homeworker (based on emissions factors from BEIS and an average 8-hour UK workday).

Other rebound effects (not quantified)

Several studies indicate homeworking may incentivise hybrid workers to move further away from their employer's premises, increasing commute distance. Whilst this remains a plausible consequence of greater working flexibility, such studies do not typically establish the direction of causality (i.e., do people working from home do so to avoid a longer commute or do they choose to live further from their employee's premises because their employer enables them to do so?)[6]

The inclination of homeworkers to travel more on non-working days due to reduced social interaction and greater time spent at home during the week also remains a possible outcome of greater homeworking. While this effect is not currently investigated in secondary literature, it was identified as a notable potential rebound effect during development of the carbon enablement methodology.

The reduced need for commuting in a personal vehicle may also lead to increased use of the personal vehicle by other household members during working hours in which the personal vehicle would otherwise have been unavailable.

Secondary effects

Requirements for office space are expected to reduce as the flexibility to work from home post-pandemic becomes entrenched.[7] Carbon savings will arise from reduced office energy use (heating, lighting, and office equipment) and dematerialisation (reduced desk/building space).

[6] Hook et al. (2020) A systematic review of the energy and climate impacts of teleworking
[7] Bloomberg (2022) WFH crushes London office needs as 45% of respondents downsize

3.1.2 Global Voice

BT facilitates access to global business collaboration programs, including Microsoft Teams, Zoom and Cisco Webex, as well as UK-only platforms (Ring Central and MyCloud). Business customers can purchase licenses providing "seats" for their employees, giving those employees access to a reliable platform on which to collaborate with both internal and external parties, regardless of where employees are located. This collaboration may be in the form of instant messaging, video calls and meetings, shared live documents, and more, reducing the need to work from the office.

Carbon Savings Mechanism (Enabling effects)
BT's Global Voice service allows customers' employees to easily access a reliable platform for collaboration from wherever they are located. The ability to continue to work efficiently with colleagues and clients is instrumental in enabling employees to work from home. By providing this ability, Global Voice can help reduce carbon emissions by eliminating the need for a daily commute to a workplace. In addition, Global Voice can also help reduce energy consumption in a workplace by reducing the number of computers, lights, and other devices that need to be powered, and by reducing energy related to heating and cooling.

Calculation Methodology
The carbon enablement was calculated as the average annual carbon enablement per homeworker per year multiplied by the number of homeworkers enabled by BT's Global Voice offering per year, less the increase in emissions from homeworking (heating and office equipment).

The average annual carbon enablement per homeworker per year was estimated as the average number of days working from home per year, multiplied by the proportion of homeworking days enabled by Global Voice, multiplied by the emissions per round trip commute to the workplace.

As Global Voice provides business collaboration tools globally, different assumptions have been made depending on the region of the end user (i.e., the employee using the "seat" purchased by a business customer). These are further detailed in the Assumptions section below.

Formula
Carbon enablement (tCO_2e) = [Average annual carbon enablement per homeworker (tCO_2e/homeworker) × Number of homeworkers enabled by Global Voice per year (#/year)] – Emissions from increased home energy use (tCO_2e/year)

Where: Average annual carbon enablement per homeworker (tCO_2e/homeworker/year) = Average number of days working from home per week (#) × Proportion of days working from home enabled by Global Voice (%) × Average emissions per round trip commute to the workplace (tCO_2e/trip)

Functional Unit
Average carbon enablement per homeworker per year.

Assumptions

1. The number of working weeks per year is assumed to be 46 for all regions, in line with the UK average.
2. The number of homeworkers in the UK population for 2022 is taken from the Office of National Statistics: Labour market overview, UK: November 2022. The number of homeworkers is assumed to grow in line with projected UK labour force growth sourced from OECD: Labour force forecast to 2030, with a consistent 33.2% share of the total UK labour force.
3. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of Battery Electric Vehicles (BEVs) to 2029/30.

For homeworkers in the UK:

1. The number of days worked from home per week per homeworker is estimated as a weighted average of days worked from home post COVID-19 from respondents of a survey commissioned by AWA in 2022.
2. Total commuting distance (in miles) for each mode of transport is sourced from the Department for Transport Statistics: National Travel Survey 2021. These figures were extended to 2030 without change
3. The proportion of homeworkers that are simultaneously enabled by BT Group's FTTP service (see above) are considered to have already been captured by the methodology and are therefore excluded from the Global Voice figures. This is done by taking the inverse of BT Group's market share for FTTP as a conservative approximation of the proportion of homeworkers using BT Group's services that have not yet been counted.

For homeworkers in the US:

1. The number of days working from home per homeworker per year is estimated based on 2022 data published by the World Economic Forum.
2. The average commute distance for employees living in the US was taken from average statistics published for 2021 by the US Government's Bureau of Transportation Statistics.

For homeworkers in the EU:

1. The commute distance travelled uses the same assumptions as UK homeworkers, with an uplift factor applied to account for additional days worked in the office on average. This data was obtained from a 2023 CESifo survey.

Data sources

Data point	Source
Number of Total UK Consumer FTTP lines	BT Group
Number of BT Group Consumer FTTP lines Total UK Broadband lines	BT Group BT Group
Average number of days working from home per homeworker per week - UK	AWA, 2022
Average number of days working from home per homeworker per week – US	World Economic Forum, 2022
Average number of days working from home per homeworker per week - EU	CESifo, 2023
Number of homeworkers in UK population	ONS, 2022
Total commuting distance per commuter per year (all modes of transport) – UK and EU	Department for Transport Statistics, 2021
Total commuting distance per commuter per year (all modes of transport) – US	Bureau of Transportation Statistics, 2021
Average number of commutes per commuter per year	Department for Transport Statistics, 2021
Emission factors for all modes of transport	DEFRA, 2024

Rebound effects
The rebound effects caused by increased rates of working from home are discussed in section 3.1.1 above with regards to FTTP.

Secondary effects
The secondary effects caused by increased rates of working from home are discussed in section 3.1.1 above with regards to FTTP.

3.1.3 Digital Collaboration Tools

BT offers digital collaboration tools which enable individuals to work remotely. These include Cloud Voice, Cloud Voice Express, Wholesale Hosted Communications (WHC), WHC Express, Cloud Work, Cloud Work, Teams), Zoom, Webex (80% UK, 20% other regions).

Carbon Savings Mechanism (Enabling effects)
The enablement of digital collaboration tools through our licenses to Cloud Voice, WHC, Cloud Work, Teams, Zoom, Webex services allow customers to communicate and work remotely. The transition from office working to home working can reduce commuting, equipment, and energy usage in the office.

Calculation Methodology
The carbon enablement methodology assumes a transition from office working to home working. This is calculated as the carbon enablement per homeworker, multiplied by the number of homeworkers enabled by digital collaboration tools per year, less the increase in emissions from homeworking (heating and office equipment).

The average annual carbon enablement per homeworker per year was estimated as the average number of days working from home per year, multiplied by the proportion of homeworking days enabled by digital collaboration tools, multiplied by the share of customers where licenses enable them to work from home. The share of customers that BT Group already provides with FTTP is also considered.

Formula

Carbon enablement (tCO_2e) = [Average annual carbon enablement per homeworker (tCO_2e/homeworker) × Number of homeworkers enabled by our digital collaboration tools per year (#/year) x Share of customers that don't have FTTP from BT Group)]– Emissions from increased home energy use (tCO_2e/year)

Where:

Average annual carbon enablement per homeworker (tCO_2e/homeworker/year) = Average number of days working from home per week (#) × Proportion of days working from home enabled by digital collaboration tools (%) × Average emissions per round trip commute to the workplace (tCO_2e/trip)

Functional Unit

Average carbon enablement per participant per year.

Assumptions

1. The number of working weeks per year is assumed to be 46 for all regions, in line with the UK average.
2. The number of homeworkers in the UK population for 2022 is taken from the Office of National Statistics: Labour market overview, UK: November 2022. The number of homeworkers is assumed to grow in line with projected UK labour force growth sourced from OECD: Labour force forecast to 2030, with a consistent 33.2% share of the total UK labour force.
   US data is based on WEF, EMEA data is based on CESifo, and APAC data is based on OECD.
3. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of Battery Electric Vehicles (BEVs) to 2029/30.
   US emission factors were provided from EPA, 2024.
4. Number of commuters is assumed proportional to the working population and has the same projected growth rate
5. The avoided emissions are based on the number of licenses to digital collaboration tools (Cloud Voice, WHC, Cloud Work, Teams, Zoom, Webex)
6. The number of saved trips per person with digital collaboration tools (Cloud Voice, WHC, Cloud Work, Teams, Zoom, Webex) access can be yearly updated based on numbers from BT Group.
7. Emissions related to laptop/computer usage is assumed to be similar at home and in the office.
8. Webex users are 80% UK based, 20% other regions. 20% was divided equally.
9. Share of customers that BT Group does not already provide FTTP (%) to were considered in the UK based calculations.
10. Most of the EMEA segment customers are based in the EU.

For homeworkers in the UK:

1. The number of days worked from home per week per homeworker is estimated as a weighted average of days worked from home post COVID-19 from respondents of a survey commissioned by AWA in 2022.
2. Total commuting distance (in miles) for each mode of transport is sourced from the Department for Transport Statistics: National Travel Survey 2021. These figures were extended to 2030 without change.
3. The proportion of homeworkers that are simultaneously enabled by BT Group's FTTP service (see

above) are considered to have already been captured by the methodology and are therefore excluded from the Digital Collaboration figures. This is done by taking the inverse of BT Group's market share for FTTP as an accelerated approximation of the proportion of homeworkers using BT Group's services that have not yet been counted.

For homeworkers in the US:

1. The number of days working from home per homeworker per year is estimated based on 2022 data published by the World Economic Forum.
2. The average commute distance for employees living in the US was taken from average statistics published for 2021 by the US Government's Bureau of Transportation Statistics.

For homeworkers in the EMEA:

1. The commute distance travelled uses the same assumptions as UK homeworkers, with an uplift factor applied to account for additional days worked in the office on average. This data was obtained from a 2023 CESifo survey.

For homeworkers in the APAC:

1. The commute distance travelled uses the same assumptions as UK homeworkers, with a factor applied to account for additional days worked at home on average. This data was obtained from OECD.

Data Sources

Data point	Source
Cloud Voice, Cloud Voice Express, WHC, WHC Express, Cloud Work, Cloud Work, Teams, Zoom, Webex licenses	BT Group
Average one way distance travelled (from or to the office) per day - UK	Assumption based on literature review below: Department for Transport Statistics, 2021. Bureau of Transportation Statistics, 2023.
Average number of days working from home per homeworker per week - UK	AWA, 2022
Average number of days working from home per homeworker per week – US	World Economic Forum, 2022
Average number of days working from home per homeworker per week - EMEA	CESifo, 2023
Average number of days working from home per homeworker per week - APAC	The Register, 2024 (based on OECD data)
Number of homeworkers in UK population	ONS, 2022
Total commuting distance per commuter per year (all modes of transport) – UK and EU	Department for Transport Statistics, 2021
Total commuting distance per commuter per year (all modes of transport) – US	Bureau of Transportation Statistics, 2023
Average number of commutes per commuter per year	Department for Transport Statistics, 2021
Emission factors for transport and home electricity	DEFRA, 2024

Emission Factors for US transportation	EPA, GHG Emission Factors Hub, 2024. Business Travel and Category 7: Employee Commuting
Emissions Factor for US home electricity	BT Group
Emissions Factor for EU home electricity	European Environment Agency

Rebound effects

The following rebound effect was quantified in the carbon enablement calculation for homeworking:

Increase in homeworking energy use

The carbon enablement methodology determined the net increase in CO_2e emissions per homeworker per year resulting from increased home energy consumption by deducting the total emissions from heating and office equipment at the office per homeworker (sourced from Energise: Working from Home Carbon Emissions) from the total emissions from heating and office equipment at home per homeworker (based on emissions factors from BEIS and an average 8-hour UK workday).

Other rebound effects (not quantified)

Several studies indicate homeworking may incentivise hybrid workers to move further away from their employer's premises, increasing commute distance. Whilst this remains a plausible consequence of greater working flexibility, such studies do not typically establish the direction of causality (i.e., do people working from home do so to avoid a longer commute or do they choose to live further from their employee's premises because their employer enables them to do so?) [6]

The inclination of homeworkers to travel more on non-working days due to reduced social interaction and greater time spent at home during the week also remains a possible outcome of greater homeworking. While this effect is not currently investigated in secondary literature, it was identified as a notable potential rebound effect during development of the carbon enablement methodology.

The reduced need for commuting in a personal vehicle may also lead to increased use of the personal vehicle by other household members during working hours in which the personal vehicle would otherwise have been unavailable.

Secondary effects

Requirements for office space are expected to reduce as the flexibility to work from home post-pandemic becomes entrenched.[7] Carbon savings will arise from reduced office energy use (heating, lighting, and office equipment) and dematerialisation (reduced desk/building space).

3.1.4 Virtual Events

BT offers Virtual Events services specifically Microsoft Teams Live Event, Zoom Webinar and Webex Webinar. Virtual Events solutions allow customers to run seamless, effective online events where otherwise events may be held in person.

Carbon Savings Mechanism (Enabling effects)

The enablement of online events through BT's Virtual Events services allows customers to communicate and work remotely. The transition from an in-person event to a virtual equivalent can reduce travel, resources and energy consumption during the planning, preparation and execution of the event, as well as accommodation for overnight stays.

Calculation Methodology

The carbon enablement methodology assumes a transition from in-person to virtual events. This is calculated as the carbon enablement per participant, multiplied by the number of virtual conference participants avoiding an in-person meeting per year. The carbon enablement per participant is calculated as the difference between the carbon footprint of an in-person and a virtual event. The total number of virtual conference participants avoiding an in-person meeting is calculated by multiplying the number of events by the number of participants per event and applying reduction factors, considering that not all virtual conferences replace travel to meetings (meeting avoidance factor) and that even when a virtual meeting does replace travel, it does not necessarily do so for everyone (participants avoiding travel factor).

Formula

Carbon enablement (tCO_2e) = Carbon enablement per participant (tCO_2e/participant) × Total number of virtual conference participants avoiding an in-person meeting (#/year)

Where: Carbon enablement per participant (tCO_2e/year/participant) = Carbon footprint of in-person conference per participant (tCO_2e/participant) - Carbon footprint of virtual conference per participant (tCO_2e/participant)

And: Total number of virtual conference participants avoiding an in-person meeting (#/year) = Total number of virtual events (globally) (#) × Meeting avoidance factor (%) × Average number of attendees per event (#) × Participants avoiding travel factor (%)

Functional Unit

Average carbon enablement per participant per year.

Assumptions

1. This BT service has been available from March 2023 onwards, so its impact is not included in calculations made in 2021/22 or 2022/23.
2. Not all virtual conferences replace travel to meetings; for example, some virtual conferences may not be essential, but are held due to the ease of doing so. The meeting avoidance factor (the share of in-person meetings that can be replaced due to Digital Workplace Tools) is assumed to remain static from 2023 to 2030 and was informed by existing BT Group data of past events held in-person.
3. When a virtual meeting does replace travel, it does not necessarily do so for everyone. The proportion of participants avoiding travel factor is assumed to remain static from 2023 to 2030.
4. Based on a 2021 optimisation study, avoided emissions includes emissions from transportation, video-conferencing technology, and auxiliary emissions from resource and energy consumptions, such as conference planning and preparation, execution, catering, and accommodation during the conference.
5. The 2021 optimisation study results consider different scenarios for transport mode (car, rail and plane) and for travel distances (up to 10,000 km) based on different hub locations on a global scale.
6. Forecast number of virtual events for 2023/2024 is based on historical data from BT Group's legacy managed event service.
7. Forecast number of virtual events from 2024 to 2030 is based on market growth projections.
8. There will be the same number of attendees per event (130 average number) from 2023 to 2030.
9. Assumptions around grid decarbonisation and transition to Electric Vehicles (EVs) not included.

The carbon enablement per participant is not-UK specific, therefore we cannot apply a UK decarbonisation rate or assumptions about the UK's transition to EVs as with other applications.

Data sources

Data point	Source
Carbon footprint of in-person and virtual conference per participant	Tao, Y., Steckel, D., Klemeš, J.J. and You, F., 2021. Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy. Nature communications, 12(1), pp.1-14.
Meeting avoidance and participants avoiding travel factors	Assumption based on literature review and validated with BT Group in line with existing data of past events held in-person.
Market growth	Wainhouse Research, 2022. Market Sizing & Forecast - 2022 Cloud Engagement Solutions and Services. (NB: Behind a paywall)
Number of virtual events and participants	BT Group

Rebound effects
Fewer trips, especially overseas, due to avoided attendance to in-person events, may result in more time and company budget to increase local travel for similar events.

Secondary effects
As the number of in-person events for business purposes resulting in travel is reduced, the use of and need for company cars diminishes. The total number of vehicles owned by a company may consequently also decrease, resulting in a long-term reduction in emissions from the manufacture of new vehicles. Similarly, this could contribute to a reduced number of new aircraft manufactured, as overall passenger numbers decline.

3.2 E-Commerce

Technologies that allow users to shop online or via mobile applications can help reduce carbon emissions through the reduction of personal travel, as postal deliveries of e-commerce purchases replace individuals' physical trips to stores. As delivery vehicles service all deliveries on a given route, this is a more efficient mechanism for the movement of goods than individuals travelling separately to stores.

3.2.1 FTTP

As noted above, FTTP provides improved speed, reliability, and efficiency to broadband customers.

Carbon Savings Mechanism (Enabling effects)
The use of online and app-based shopping has increasingly replaced physical shopping trips with postal deliveries, resulting in a reduction in personal travel. The speed and reliability of FTTP broadband is expected to boost this capability, particularly at rural premises where previously slower connection speeds (e.g., fibre to the cabinet) have limited customers' access to online shopping.

Calculation Methodology
The carbon enablement was calculated as the average annual carbon enablement resulting from online shopping per user per year multiplied by the number of e-commerce users enabled by BT Group FTTP per year, less the increase in emissions from parcel delivery services per user per year.

The average annual carbon enablement due to online shopping using FTTP per user per year was estimated as the average number of online shops resulting in home delivery per user per year, multiplied by the proportion of online shops enabled by FTTP, multiplied by the emissions per physical shopping trip per user.

Formula
Carbon enablement (tCO_2e) = [Average annual carbon enablement due to online shopping per user per year (tCO_2e/user/year) × Number of e-commerce users enabled by BT Group FTTP per year (#)] – Increase in CO_2e emissions from parcel deliveries (tCO_2e/year)

Where: Average annual carbon enablement due to online shopping per user per year (tCO_2e/user/year) = Average number of online shops resulting in home delivery per user per year (#) × Proportion of online shops that are enabled by FTTP (%) × Proportion of online shops done on FTTP rather than a mobile network (%) × Emissions per shopping trip per user (tCO_2e)

Functional Unit
Average carbon enablement per e-commerce user per year.

Assumptions
1. Each online purchase attributed to FTTP is a direct replacement for a physical shopping trip.
2. Primary data on the number of Consumer FTTP lines in the UK were sourced from BT Group. Total UK Consumer FTTP lines are 'residential only'. BT Group Consumer FTTP lines are also residential only and inclusive of BT, EE and Plusnet connections, along with connections sold to consumers through third-party wholesalers.
3. Total shopping distance (in miles) per year for each mode of transport and the average number of shopping trips per user per year were sourced from the Department for Transport Statistics: National Travel Survey 2021. Values from the National Travel Survey 2019 were used for 2022/23 to account for a post-COVID recovery in physical shopping trips and aligned with historical trends over the past ten years to 2029/30.
4. The average number of online shops resulting in home delivery per user per year is sourced from a survey with a sample size of approximately 22,000 commissioned by the IPC, in which respondents were asked how often they purchased physical goods online.[8] Growth in the average number of online shops was indexed to forecast revenue from e-commerce from 2021/22 to 2030/31.
5. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in auto-motive market share of EVs to 2030.
6. The number of e-commerce users in the UK population is estimated from data provided by the Office for National Statistics (ONS), showing approximately 87% of UK adults shopped online in 2020. Data on the 2020 and forecast 2030 UK population is sourced from ONS and OECD respectively. The UK adult population (taken as individuals over the age of 16) is assumed to grow in line with the total UK population, at 0.32% per year to 2030. The methodology therefore does not account for an aging UK population.
7. The proportion of online shopping enabled by FTTP (incremental effect of FTTP over previous broadband connections) is assumed to be 30% as a baseline. This share increases by 5% YoY to reflect that these applications may become more data intensive in future and rely more on increased speed and reliability. As the confidence of this data point remains low, a range of 10-50% has been assigned to allow the user to assess variations in the incremental effect of FTTP on the carbon enablement potential of the application.
8. The number of UK users shopping online using FTTP is estimated by multiplying the total number of e-commerce users in the UK population by the proportion of Consumer broadband lines in the UK that are FTTP. This is then reduced to BT Group's FTTP market share to derive the total number of e-commerce users on a BT Group FTTP connection per year.

9. To distinguish between online purchases made using mobile data and FTTP (and to prevent double counting with 4G/5G e-commerce), the proportion of online shops made using FTTP was estimated based on research from U-Switch and incorporated into the calculation methodology.

[8] IPC (2021) IPC Cross Border E-commerce Shopper Survey

Data sources

Data point	Source
Number of Total UK Consumer FTTP lines	BT Group
Total UK Broadband lines	BT Group
Average number of online purchases resulting in home delivery per user per year	IPC, 2021
Average number of shopping trips per user per year	Department for Transport Statistics, 2021
Total distance travelled for shopping per user per year	Department for Transport Statistics, 2021
Emission factors for all modes of transport and emissions per parcel delivery drop	DEFRA, 2024
Proportion on online shops made using FTTP rather than mobile data	U-Switch, 2023

Rebound effects

The following rebound effect was quantified and included in the carbon enablement calculation: Increase in emissions from parcel delivery drops.

Increase in emissions from parcel delivery drops

The average emissions per parcel delivery drop were sourced from an article published by ABTS logistics[9] outlining the environmental impact of home deliveries. This is then multiplied by the average number of online shops per user per year to determine the rebound effect, which is deducted from the total carbon enablement per user per year. Over time, the rebound effect from increased parcel deliveries is likely to reduce as delivery companies transition to electric vehicles. However, this is not currently reflected in our methodology.

Other rebound effects (not quantified)

Whilst it remains plausible that the convenience of e-commerce may result in an increased number of purchases made online versus physical shopping trips, reliable secondary data to quantify this effect is not currently available.

Secondary effects

Studies predict increases in e-commerce will continue to incite new distribution strategies, with businesses becoming more 'demand responsive'.[10] This is expected to lower aggregate product inventories (dematerialisation), with a subsequent reduction in warehouse space as companies move to shipping directly to customers.

[9] ABTS Logistics (2009) Shopping trip or home delivery: which has the smaller carbon footprint?
[10] Lake (2008) The Impacts of e-Work and e-Commerce on Transport, the Environment and the Economy

3.2.2 4G/5G Mobile Networks

4G networks operate on Long Term Evolution (LTE) technology, which offers faster data speeds, better network capacity, and improved call quality. 5G networks operate on the latest 5G technology, which provides faster data speeds, lower latency, and higher network capacity than 4G, offering high-speed data connectivity to customers across the country.

Carbon Savings Mechanism (Enabling effects)
4G and 5G mobile networks with greater data transfer speeds than legacy networks (such as 3G) have facilitated users to shop online in instances where broadband connectivity is unavailable, and the speed of previous mobile networks was inadequate (such as when travelling or in remote locations). The carbon enablement methodology therefore included carbon savings associated with online shopping using 4G and 5G mobile data, in addition to FTTP.

Calculation Methodology
The carbon enablement was calculated as the average annual carbon enablement resulting from online shopping per user per year, multiplied by the number of e-commerce users enabled by BT Group's 4G and 5G networks per year, less the increase in emissions from parcel delivery services per user per year.

The average annual carbon enablement resulting from online shopping per user per year was estimated as the average number of online shops resulting in home delivery per user per year, multiplied by the emissions per physical shopping trip per user.

Formula
Carbon enablement (tCO_2e) = [Average annual carbon enablement due to online shopping per user per year (tCO_2e/user/year) × Number of e-commerce users enabled by BT Group 4G and 5G networks per year (#)] – Increase in CO_2e emissions from parcel deliveries (tCO_2e/year)

Where: Average annual carbon enablement due to online shopping per user per year (tCO_2e/user/year) = Average number of online shops resulting in home delivery per user per year (#) × Emissions per shopping trip per user (tCO_2e)

Functional Unit
Average carbon enablement per e-commerce user per year.

Assumptions

1. Each online purchase made using 4G or 5G is a direct replacement for a physical shopping trip.
2. Primary data on the number of 4G and 5G mobile users in the UK, and BT Group's 4G and 5G customer base was sourced from BT Group. The mobile user base is 'Consumer' only (both for total UK users and BT Group users).
3. Total shopping distance (in miles) per year for each mode of transport and the average number of shopping trips per user per year were sourced from the Department for Transport Statistics: National Travel Survey 2021. Values from the National Travel Survey 2019 were used for 2022/23 to account for a post-COVID recovery in physical shopping trips and aligned with historical trends over the past 10 years to 2029/30.
4. The average number of online shops resulting in home delivery per user per year is sourced from a survey with a sample size of approximately 22,000 people commissioned by the IPC, in which respondents were asked how often they purchased physical goods online.[11] Growth in the average number of online shops was indexed to forecast revenue from e-commerce from 2021/22 to 2030/31.
5. To distinguish between online purchases made using mobile data and FTTP (and to prevent double counting with 4G/5G e-commerce), the proportion of online shops made using FTTP was estimated based on research from U-Switch and incorporated into the calculation methodology.
6. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of EVs to 2030.
7. The number of e-commerce users in the UK population is estimated from data provided by the Office for National Statistics (ONS), showing approximately 87% of UK adults shopped online in 2020. Data on the 2020 and forecast 2030 UK population is sourced from ONS and OECD respectively. The UK adult population (taken as individuals over the age of 16) is assumed to grow in line with the total UK population, at 0.32% per year to 2030. The methodology therefore does not account for an aging UK population.
8. The total number of 4G and 5G users enabled by BT Group is inclusive of 4G and 5G connections provided directly by BT Group to consumers, as well as connections provided to consumers via third-party wholesalers.
9. The number of 4G and 5G e-commerce users enabled by BT Group to shop online using a mobile network is calculated as the total number of 4G and 5G users enabled by BT Group, multiplied by the percentage of 4G and 5G users shopping online in the UK.

Data sources

Data point	Source
Number of 4G and 5G users enabled by BT Group	BT Group
Total 4G and 5G users in the UK	BT Group
Average number of online purchases resulting in home delivery per user per year	IPC, 2021
Average number of shopping trips per user per year	Department for Transport Statistics, 2021
Total distance travelled for shopping per user per year	Department for Transport Statistics, 2021
Emission factors for all modes of transport and emissions per parcel delivery drop	DEFRA, 2024

[11] IPC (2021) IPC Cross Border E-commerce Shopper Survey

Rebound effects
Rebound effects for e-commerce using 4G and 5G mobile data are considered to be the same as for FTTP, including increased emissions from parcel delivery services and a potential increase in the number of online purchases made due to the convenience of online shopping when compared to physical shopping trips.

Secondary effects
Secondary effects for e-commerce using 4G and 5G mobile data are considered to be the same as for FTTP, including dematerialisation from reduced company product inventories and a reduction in commercial warehouse and high street shopping space.

3.3 Healthcare

BT aims to work with healthcare partners to build smarter, safer, more efficient services for everyone. Our digital solutions and full fibre broadband give patients access to the healthcare services they need remotely, safely and conveniently, outside of a hospital setting.

3.3.1 FTTP-enabled virtual consultations

As noted above, FTTP provides improved speed, reliability, and efficiency to broadband customers.

Carbon Savings Mechanism (Enabling effects)
Virtual consultations (e-health) via video conferencing technology, replacing the need for patients to travel to in-person appointments. The number of virtual consultations has increased significantly due to social distancing restrictions enforced due to COVID-19, and is expected to persist as a product of modernisation in the healthcare sector. Improved connectivity through use of FTTP will continue to boost the adoption of virtual consultations, particularly in areas where previously slow, unreliable broadband connections had prevented its use.

Calculation Methodology
The carbon enablement methodology was calculated as the average annual carbon enablement per e-health user per year multiplied by the number of e-health users enabled by BT Group FTTP per year.

The average annual carbon enablement per e-health user per year was estimated as the average number of e-health consultations per user per year, multiplied by the proportion of e-health consultations enabled by FTTP, multiplied by the emissions per physical consultation trip per user.

Formula
Carbon enablement (tCO_2e) = Average annual carbon enablement per e-health user per year (tCO_2e/user/- year) × Number of e-health users enabled by BT Group per year (#/year)

Where: Average annual carbon enablement per e-health user per year (tCO_2e/user/year) = Average number of e-health consultations per user per year (#/year) × Proportion of e-health consultations enabled by FTTP (%) × Emissions per GP visit (tCO_2e/visit)

Functional Unit
Average carbon enablement per e-health user per year.

Assumptions

1. The carbon enablement methodology assumes that each virtual consultation attributed to FTTP is a direct replacement for an in-person consultation requiring travel.
2. Primary data on the number of Consumer FTTP lines in the UK was sourced from BT Group. Total UK Consumer FTTP lines are 'residential only'. BT Group FTTP lines are also residential only and inclusive of BT, EE and Plusnet connections, along with connections sold to consumers through third-party wholesalers.
3. The average number of virtual consultations per e-health user per year was sourced from a report provided by OECD on the use of teleconsultations.
4. The emissions per GP visit were sourced from a study by Carbon Brief on calculating the carbon footprint of the NHS in England. This is assumed to stay constant to 2030.
5. Data on the 2020 UK population is sourced from ONS. The UK adult population (taken as individuals over the age of 16) is assumed to grow in line with the total UK population at 0.32% per year to 2030.
6. The percentage of adults using e-health services (5%) was sourced from a 2020 survey by Statista, which also showed that 58% of respondents would 'definitely consider' using digital health services to prevent the spread of Covid-19. We would expect Covid-19 to have a positive impact on e-consultation usage, and therefore assume that uptake will increase to 10% by 2030.
7. The proportion of virtual consultations enabled by FTTP (incremental effect of FTTP over previous broadband connection) is assumed to be 30% as a baseline. This share increases by 5% YoY to reflect that these applications may become more data intensive in future and rely more on increased speed and reliability. As the confidence of this data point remains low, a range of 10-50% has been assigned to allow the assessment of different variations in the incremental effect of FTTP on the carbon enablement potential of the application.
8. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of EVs to 2030.

Data sources

Data point	Source
Number of Total UK Consumer FTTP lines	BT Group
Number of BT Group Consumer FTTP lines	BT Group
Total UK Broadband lines	BT Group
Average number of virtual consultations per e-health user per year	OECD, 2020
Average emissions per GP visit	Carbon Brief, 2021
Adult (18 and over) population in the UK	ONS, 2021
Percentage of adults using e-health services	Statista, 2020

Rebound effects

Increased home energy use for virtual consultations is considered negligible. No other material rebound effects were identified.

Secondary effects

Increased use of e-health services could lead to a reduction in the number of local practices and healthcare facilities. In parallel with other applications contributing to reduced personal travel, virtual consultations have the potential to reduce traffic congestion.

3.4 Transportation

3.4.1 Private Navigation on 4G/5G Networks

As noted above, 4G and 5G networks offer faster and more reliable connectivity to customers across the UK.

Carbon Savings Mechanism (Enabling effects)
4G and 5G technologies improve the performance of navigation apps on mobiles by providing faster download and upload speeds, lower latency, and increased network capacity. This results in faster and more accurate mapping, real-time traffic updates, and improved GPS location accuracy, which enhances the user experience of using navigation apps. As more people use mobile apps - enabled by faster 4G and 5G services - the accuracy of the navigation apps will continue to improve.

Navigation apps such as Waze, Google Maps, and Apple Maps use real time data to optimise routes for users, taking into account factors such as traffic congestion and road closures. These apps can help to reduce fuel consumption by minimising the time cars spend on the road, resulting in fewer emissions from cars idling in traffic. In addition, the widespread adoption of electric vehicles (EVs) can further reduce emissions as they produce zero emissions while driving. The use of navigation apps can also help EV drivers plan their routes to include charging stations, which can alleviate range anxiety and encourage more people to adopt EVs.

As the adoption of 4G and 5G mobile networks becomes more widespread, the use of these apps, along with use of EVs, is expected to further decrease emissions. Overall, the use of 4G/5G networks in navigation has the potential to reduce carbon emissions from transportation.

Calculation Methodology
The carbon enablement was calculated as the average annual carbon enablement resulting from use of navigation apps while driving per user per year multiplied by the number of users enabled by BT Group 4G and 5G networks per year.

The average annual carbon enablement resulting from use of navigation apps per user per year was estimated as the average distance travelled per user per year using conventional vehicles and EVs, multiplied by the respective fuel saving factor of the vehicle used.

Formula
Carbon enablement (tCO_2e) = Average annual carbon enablement due to use of navigation app per user per year using conventional vehicle (tCO2e/conventional user/year) + Average annual carbon enablement due to use of navigation app per user per year using electric vehicle (tCO_2e/EV user/year) × Number of users enabled by BT Group 4G and 5G networks per year (#/year)

Where: Average annual carbon enablement per user per year using conventional vehicle (tCO_2e/conventional user/year) = Average distance travelled per year (km) ÷ Average fuel economy of conventional vehicle (km/litre) × fuel saving factor (%) × Emission factor of fuel (tCO_2e/litre)

Average annual carbon enablement per user per year using electric vehicle (tCO_2e/EV user/year) = Average distance travelled per year (km) ÷ Average energy economy of battery electric vehicle (km/kWh) × Energy saving factor (%) × Emission factor of UK grid electricity (tCO_2e/kWh)

Functional Unit

Average carbon enablement per navigation app user per year.

Assumptions

1. Average distance travelled (in miles) per year - using private transport was sourced from the Department for Transport Statistics: National Travel Survey 2021.
2. Average fuel economy of conventional vehicle and energy economy of BEV considered to estimate annual fuel and energy consumption was sourced from the Department for Transport.
3. Primary data on the number of 4G and 5G mobile users in the UK was sourced from BT Group.
4. All emission factors used in the calculation were sourced from the Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of BEVs to 2030.
5. The total number of 4G and 5G users enabled by BT Group is inclusive of 4G and 5G connections provided directly by BT Group to consumers, as well as connections provided to consumers via third-party wholesalers.
6. The number of 4G and 5G users enabled by BT Group to use navigation apps while driving is calculated as the total number of 4G and 5G users enabled by BT Group, multiplied by the percentage of 4G and 5G users using navigation while driving in the UK.
7. The percentage of users using navigation apps on a mobile device while driving is sourced from a survey conducted by a car finance provider in UK.[12] As the confidence of this data point remains low, a range of 10-30% has been assigned to allow the assessment of different levels of navigation app uptake. We assume a conservative (3%) year on year increase in use of navigation technology using a mobile device; this reflects 2022 research projecting that the public transport market size will grow at a CAGR of 10% by 2028.[13]
8. The proportion of journeys for which navigation apps are used was sourced from a study by Knapper et al, 2015 in which the use of portable navigation systems in everyday driving was assessed. As the confidence of this data point remains low, a range of 20-30% has been assigned to allow the assessment of different levels of navigation app usage.

[12] Motor Finance Online (2022) 40% of UK motorists rely on a satnav when driving

[13] Million Insights (2022) Global Navigation App Market Size, Share Report, 2021-2028

Data sources

Data point	Source
Number of 4G and 5G users enabled by BT Group	BT Group
Total 4G and 5G users in the UK	BT Group
Average annual distance travelled using private transport	Department for Transport Statistics, 2021
Average fuel economy of conventional vehicle	Department for Transport Statistics, 2021
Average energy economy of battery electric vehicle	Electric Vehicle database, 2022
Fuel saving factor	Lei et al, 2018
Total number of conventional vehicles in UK as of March 2022	Department for Transport, 2022
Total number of battery electric vehicles in UK as of March 2022	Department for Transport, 2022
Percentage decrease in fuel economy due to improved technology	IEA, 2019
Emission factors for fuel and UK grid electricity	DEFRA, 2024
Proportion of journeys for which navigation apps are used	Knapper et al, 2015

Rebound effects
Increased travel in private cars due to efficiency of navigation tools.

Secondary effects
Not identified.

3.4.2 Public Transportation using 4G/5G Networks

Carbon Savings Mechanism (Enabling effects)
The use of public transport apps – such as Citymapper, Tube Map, UK Bus checker, Trainline UK and Google Maps – provides access to real-time information on public transport services, incentivising greater use of public transport and encouraging travellers to switch from private to public modes of transport. The enablement effect from real-time public transport apps is expected to grow with the increased use of 4G and 5G mobile networks.

Navigation apps can disincentivise personal vehicle use by providing real-time traffic information that helps users make more informed decisions about their transportation options. Additionally, navigation apps that provide information on parking availability and costs can also encourage people to use alternative modes of transportation.

Calculation Methodology
The carbon enablement was calculated as the average annual carbon enablement per commuter using different modes of public transport instead of private transport per year, multiplied by the number of users enabled by BT Group 4G and 5G per year.

The average annual carbon enablement per commuter per year was estimated as the emissions resulting from the average distance travelled using private transport less the emissions due to decreased use of private transport plus the emissions arising from the use of different modes of public transport.

Formula

Carbon enablement (tCO_2e) = Average annual carbon emissions due to use of private transport per commuter per year (tCO_2e/commuter/year) - Average annual carbon emissions due to decreased use of private transport per commuter per year (tCO_2e/commuter/year) + Average annual carbon emissions due to increased use of public transport per commuter per year (tCO_2e/commuter/year) × Number of 4G and 5G users enabled by BT Group per year (#/year)

Where: Average annual carbon emissions resulting from use of private transport per commuter per year (tCO2e/commuter/year) = Average distance travelled per commuter per year using private vehicle (km) × emission factor (tCO_2e/km)

Average annual carbon emissions resulting from use of public transport per commuter per year (tCO_2e/commuter/year) = Average distance travelled per commuter per year using different mode of public transport (km) × emission factor of different modes of transport (tCO_2e/km)

Functional Unit

Average carbon enablement per public transport app user per year

Assumptions

1. Average distance travelled (in miles) per year using private transport as driver or passenger – weighted average was sourced from the Department for Transport Statistics: National Travel Survey 2021
2. Average distance travelled (in miles) per year using public transport (all modes of transportation) – weighted average was sourced from the Department for Transport Statistics: National Travel Survey 2021
3. Primary data on the number of 4G and 5G mobile users in the UK was sourced from BT Group.
4. All emission factors used in the calculation were sourced from Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022. The emission factor for 'average car' was adjusted to reflect a forecast increase in automotive market share of EVs to 2030.
5. The percentage of total population using mobile device apps to use public transport is assumed to be 20%. As the confidence of this data point remains low, a range of 10-30% has been assigned to allow the assessment of different levels of public uptake of transport apps. We assume a conservative (2%) year on year increase in the usage rate of public transport apps; this reflects 2020 research projecting that the public transport market size will grow at a CAGR of 8% by 2027 (due, in part, to use of transport apps).[14]
6. The frequency that public transport is used instead of private vehicles due to apps (15%) has been sense-checked using responses to a BT Group customer survey. As the confidence of this data point remains low (due to low response rate), a range of 10-20% has been assigned to allow the assessment of different levels of public transport usage. We assume a conservative (2%) year on year increase in the rate at which public transport is used in place of private transport; this reflects 2020 research projecting that the public transport market size will grow at a CAGR of 8% by 2027 (due, in part, to use of transport apps).[15]
7. The total number of 4G and 5G users enabled by BT Group is inclusive of 4G and 5G connections provided directly by BT Group to consumers, as well as connections provided to consumers via third-party wholesalers.
8. The number of 4G and 5G users enabled by BT Group to use real-time public transport apps is calculated as the total number of 4G and 5G users enabled by BT Group, multiplied by the percentage of 4G and 5G users using public transit apps.

[14] Akre, Sejal (2020) Public Transport Market Research Report: Information by Type (Bus, Light Rail, Regional Taxi, Metro and Tram), Application (City and Rural) and Region - Forecast till 2030

[15] ibid

Data sources

Data point	Source
Number of 4G and 5G users enabled by BT Group	BT Group
Total 4G and 5G users in the UK	BT Group
Average annual distance travelled using private transport	Department for Transport Statistics, 2021
Average annual distance travelled using different modes of public transport	Department for Transport Statistics, 2021
Emission factors for all modes if transport	DEFRA, 2024

Rebound effects
By making public modes of transportation more convenient and accessible, apps might increase usage among people who would have otherwise not travelled at all (e.g., to avoid sitting in traffic in their personal vehicle) or would have used lower emitting modes of transportation such as walking or cycling, but this effect has not been quantified.

Secondary effects
Not identified.

3.4.3 Telematics - Internet of Things (IoT)

IoT telematics solutions can collect, store, and analyse vehicle and roadway condition data using GPS technology, artificial intelligence (AI), and onboard diagnostics. Providing this data to fleet owners and managers can lead to reduced fuel consumption, and consequently emissions, through route optimisation and improved vehicle maintenance, driver operation, and cargo management.

Carbon Savings Mechanism (Enabling effects)
Vehicle telematics can help reduce fuel or energy consumption, by encouraging improved driver behaviours (more fuel-efficient driving techniques and speeds), as well as more efficient routing and logistics.

Calculation Methodology
Methodology 1 (currently used - based on secondary data):
The carbon enablement is calculated as the average emissions per vehicle multiplied by a fuel saving factor, multiplied by the number of vehicle telematics connections enabled by BT Group per year.

The average emissions per vehicle is derived from the average annual distance travelled per vehicle multiplied by the emissions factor for a given vehicle type.

Methodology 2 (for future use if primary data becomes available):
The carbon enablement can be calculated as the fuel saved per petrol or diesel vehicle and the energy saved per electric car vehicle multiplied by the relevant emission factors, multiplied by the number of vehicle telematics connections enabled by BT Group per year.

Formula

Methodology 1

Carbon enablement (tCO_2e) = Average emissions per vehicle (tCO_2e /vehicle) × Fuel saving factor (%) × Number of vehicle telematics connections enabled by BT Group per year (#/year)

Where: Average emissions per vehicle (tCO_2e/vehicle) = Annual distance travelled per vehicle (km/year/-vehicle) × Emission factor of vehicle type (tCO_2e/km)

Methodology 2

Carbon enablement (tCO2e) = Fuel/energy saved per vehicle (litre or kWh/year/vehicle) × Emission factor (tCO2e/litre or kWh) × Number of vehicle telematics connections enabled by BT Group per year (#/year)

Functional Unit

Average carbon enablement per vehicle telematics connection per year.

Assumptions

1. Studies as referenced in the GSMA Enablement Effect report[16] give a range of 5% to 15% for the fuel saving factor, depending on the vehicle type. As the type of vehicles and the specific system is unknown at this stage, an assumption of a typical 10% for the fuel saving factor is made.
2. Vehicles covered by the technology are unknown, however they will typically be commercial vehicles (vans), therefore a conservative assumption is to use an average van emission factor. However, it is considered that there will also be a percentage of private vehicles connected to telematics, using an average car emission factor. It is assumed that 90% of the fleet connected to telematics will be vans (diesel) and 10% private cars (mix of petrol, diesel and plug-in hybrid vehicles).
3. It is assumed that by 2030, 20% of the UK car and van fleet will be BEVs. See Appendix 2 for additional details on how this is calculated.

Data sources

Data point	Source
Average annual distance travelled per vehicle	Department for Transport, 2022. RFS0112: Average annual vehicle kilometres (loaded, empty and total) by type and weight of vehicle.
Fuel saving factor	GSMA, 2019. The Enablement effect: The impact of mobile communications technologies on carbon emission reductions.
Number of vehicle telematics connections enabled by BT Group per year	BT Group
Emission factor for vehicle type	DEFRA and BEIS, 2022. UK Government GHG Conversion Factors for Company Reporting.

Rebound effects

More efficient travelling may result in more trips and an increase in the number of new vehicles, but this effect has not been quantified.

[16] GSMA (2019) The Enablement Effect: The impact of mobile communications technologies on carbon emission reductions

Secondary effects
Avoided emissions are likely to result from reduced wear and tear on highway infrastructure and reduced maintenance. There could also be a reduction in emissions from the manufacture of new vehicles, resulting from more efficient use of vehicles and lower overall demand for new or replacement vehicles.

3.5 B2B network management

3.5.1 Software-Defined Wide Area Network (SD-WAN)

Software-Defined Wide Area Network (SD-WAN) is a technology that simplifies the management and operation of a wide area network (WAN). SD-WAN uses software to create a virtualised network overlay on top of physical network infrastructure, making it more agile and flexible. This overlay network extends an organisation's network to Infrastructure as a Service (IaaS) and multi-cloud environments, shifting some computing power from devices to the cloud and requiring smaller and lower energy consuming devices on organisation's sites. Using SD-WAN, organisations can quickly connect to all company data centres, core and campus locations, branches, colocation facilities, cloud infrastructure, and remote workers.

Carbon Savings Mechanism (Enabling effects)
In an SD-WAN environment, virtualisation is used to optimise the routing of traffic across a wide area network by using software to manage the routing of traffic across multiple connections. These connections may include broadband, mobile, and Multi-Protocol Label Switching (MPLS). This allows organisations to improve network performance and reduce costs. The potential benefit of using virtualisation in an SD-WAN network is the ability to use smaller and less energy intensive devices on premises. By using virtualisation to move some of the computing power of multiple physical routers into the cloud, organisations can have lighter and more efficient physical on-premises devices connecting to the network. This can result in energy and materials savings, as well as a reduction in costs.

Calculation Methodology

The carbon enablement is calculated in two parts and summed together:

- The average energy consumption of routers used in traditional WAN networks, which will be replaced by a one-edge device with an SD-WAN, less the average energy consumption of a one-edge device used with SD-WAN, multiplied by the emission factor for electricity use; plus
- The average embodied carbon of routers used in traditional WAN networks, which will be replaced by a one-edge device with an SD-WAN, less the average embodied carbon of a one-edge device used with SD-WAN.

The methodology uses revenue as the functional unit, meaning the carbon enablement calculation through the formula outlined above is then divided by the revenue per device (from actual/historical data) and then multiplied by the SD-WAN revenue forecast for a given future year.

Formula

Carbon enablement (tCO_2e) = Average annual carbon enablement per device (tCO_2e/year) / Average annual revenue per SD WAN device (£/year) x Total SD WAN revenue (£)

Where: Average annual carbon enablement per device (tCO_2e/year) = Average annual carbon savings from reduced energy consumption (tCO_2e/year) + Average annual carbon savings from embodied emissions in hardware (tCO_2e/year)

Average annual energy savings (kWh/year) = Energy consumption from legacy WAN devices replaced (kWh/year) – Energy consumption of SD WAN device (kWh/year)

Average annual carbon savings from reduced energy consumption (tCO_2e/year) = Average annual energy savings (kWh/year) x Emission factor for electricity in UK (tCO_2e/kWh)

Average annual carbon savings from embodied emissions in hardware = [Total embodied emissions from legacy WAN devices replaced (tCO2e) / Lifespan of device (years)] – [Total embodied emissions of SD WAN device (tCO_2e) / Lifespan of SD WAN device (years)]

Functional Unit

Average carbon enablement per revenue unit (£) per year.

Assumptions

1. The approach considers two types of customers, depending on the SD-WAN solution employed:
   - Thin edge (VMware): Saves more hardware and energy due to moving more computing power to the cloud, so the devices require lower computing power and therefore smaller, more consolidated boxes.
   - Thick edge (Cisco, Fortinet, Nokia): Save some hardware and energy in comparison to WAN, as some computing power is moved to the cloud. However, this solution requires higher computing power at edge than thin edge, and therefore bigger boxes.
2. The average legacy WAN router used is the Cisco ASR 1000 series.
3. For the thin edge solution, the VMware SD-WAN Edge device is installed. For the thick edge solution, the Cisco 4000 Family Integrated Services Routers are installed.
4. Average power consumption of a legacy WAN router is 560 watts.
5. Average power consumption of an SD-WAN thin edge device is 30 watts, with an average weight of 1.3 kg.
6. Average power consumption of an SD-WAN thick edge device is 250 watts, with an average weight of 8.75 kg. This assumption is based on the median of all Cisco 4000 Family Integrated Services Routers.
7. Routers and SD-WAN devices operate continuously without any downtime, throughout the year.
8. All emission factors used in the calculation were sourced from the Department for Business, Energy and Industrial Strategy (BEIS): Government conversion factors for company reporting of greenhouse gas emissions 2022.
9. Primary data on the revenue generated from of SD-WAN in the UK was sourced from BT. Revenue data was attributed to thin edge and thick edge solutions according to the number of SD WAN devices sold and the cost ratio between the two solutions.
10. The embodied emissions of an average server in UK are used for calculations on the basis that legacy WAN routers and SD-WAN devices have on average the same types of components as a server The embodied emissions of all devices (both legacy WAN routers and SD-WAN devices) were estimated as a ratio of the embodied emissions of an average server in UK per weight.

Data sources

Data point	Source
Average weight of a legacy WAN router	CISCO datasheet
Average weight of SD-WAN thin edge devices	VMware SD-WAN Edge platform specifications
Average power consumption and weight of SD-WAN thick edge devices	CISCO datasheet
Average embodied emissions of a server in UK	Dell PowerEdge R640 estimated carbon footprint
Average weight of a server	Dell EMC PowerEdge R640 Technical Specifications
Average embodied emissions of devices	Calculated using the average embodied emissions of a server per one kilogram (from the two rows above)
Emission factors for UK grid electricity	DEFRA, 2024

Rebound effects

Not identified.

Secondary effects

Not identified.

3.5.2 B2B Cloud Services Computation Aggregation

Businesses use public cloud infrastructure as it gives them the ability to flexibly scale resources to track workload demand. Moving workloads to public cloud infrastructure also presents businesses with the opportunity to dramatically reduce the environmental footprint of their IT operations.

Carbon Savings Mechanism (Enabling effects)
BT's Cloud Connect Direct service provides direct connectivity to third party cloud providers (i.e., Microsoft Azure, Amazon Web Services). By providing this direct connectivity, BT is enabling companies to use cloud services, replacing the use of in-house computing infrastructure. Through this move, the customer will benefit from greater server utilisation and improved Power Usage Effectiveness (PUE). This can have the consequence of lower energy use and carbon emissions.

Calculation Methodology
The carbon enablement methodology assumes that a customer moves to public cloud from a typical mix of private cloud and dedicated IT. This is calculated as the average annual carbon enablement per customer, multiplied by the number of customers connected to public cloud enabled by BT per year.

The average annual carbon enablement per customer is calculated as the annual energy used per customer (prior to cloud services), multiplied by an emission factor for electricity less the equivalent annual energy used per customer (post cloud services), multiplied by an emission factor.

Formula
Carbon enablement (tCO_2e) = Average annual carbon enablement per customer (tCO_2e /year/customer) x Number of customers connected to public cloud enabled by BT per year (#/year)

Where: Average annual carbon enablement per customer (tCO_2e/year/customer) = [Annual energy used per customer (before) (kWh/year/customer) x Emission factor for electricity (customer) (tCO_2e/kWh)] – [Equivalent annual energy used per customer (after) (kWh/year/customer) x Emission factor for electricity (cloud provider) (tCO_2e/kWh)]

Customer's site (before public cloud scenario)
As explained in the assumptions below, an equivalent number of Virtual Machines (VM) was estimated, so that the energy consumption in the before and after scenario could be comparable.

Number of physical servers = 100 (assumed)

Equivalent number of virtual machines (VM) before public cloud (#) = Proportion of Dedicated IT servers (%) x Number of physical servers (100) + Proportion of Private Cloud servers (%) x Number of physical servers (100) x conversion ratio.

Conversion ratio = Private Cloud utilisation rate (%) / Dedicated IT utilisation rate (%)

- Server energy per year (kWh/server/year) = Server power (kW) x annual running hours (hours)
- Total annual servers energy (kWh/year) = Proportion of Dedicated IT servers (%) x Number of physical servers (100) x Server energy per year (kWh/server/year) x Dedicated IT PUE + Proportion of Private Cloud servers (%) x Number of physical servers (100) x Server energy per year (kWh/-server/year) x Private Cloud PUE
- Energy per customer server per year before cloud (kWh/ server/year) = Total annual servers energy (kWh/year) / Number of physical servers (100)
- Energy per VM per year before cloud (kWh/VM/year) = Total annual servers energy (kWh/year) / Equivalent number of virtual machines before public cloud (#)
- Annual energy used per customer (before) (kWh/year/customer) = Energy per customer server per year (kWh/server/year) x Number of physical servers on customer's site before migration to public cloud (#/customer)

Public cloud (after public cloud scenario)
Number of physical servers = 1 (assumed)

Equivalent number of virtual machines (VM) after public cloud (#) = Number of physical servers (1) x conversion ratio

Conversion ratio = Public Cloud utilisation rate (%) / Dedicated IT utilisation rate (%)

- Total annual servers energy (kWh/year) = Number of physical servers (1) x Server energy per year (kWh/server/year) x Public Cloud PUE
- Energy per public cloud server per year after cloud (kWh/ server/year) = Server energy per year (kWh/server/year) x Number of physical servers (1)
- Energy per VM per year after cloud (kWh/VM/year) = Total annual servers energy (kWh/year) / Equivalent number of virtual machines after public cloud (#)
- Equivalent annual energy used per customer (after) (kWh/year/customer) = Energy per VM per year after cloud (kWh/VM/year) x (Equivalent number of virtual machines before public cloud / Number of physical servers (100) (#number/server)) x Number of physical servers on customer's site before migration to public cloud (#/customer)

Functional Unit
Average carbon enablement per customer per year.

Assumptions

1. For the purpose of calculations, a notional number of physical servers (before migration to public cloud) was converted to an equivalent number of virtual machines so that the carbon saving per virtual machine could be calculated and used to compare the position before and after the migration to public cloud scenarios.
2. For dedicated IT, one virtual machine maps to one physical server.
3. Before the migration to public cloud, it is assumed that each customer would have a typical split between dedicated IT and private cloud computing of 60% / 40%.
4. It is assumed that servers run 24x7 throughout the year.
5. Weighted average server power consumption is 295 Watts.
6. Average server utilisation is assumed to be:
   - Dedicated IT – 15%
   - Private Cloud – 40%
   - Public Cloud 65%.
7. PUEs are assumed to be:
   - Customer dedicated PUE = 2
   - Customer private cloud PUE = 1.8
   - Public Cloud PUE = 1.2.
8. Studies indicate that the number of physical servers per enterprise may range from 1 - 100, depending on the number of employees. As the size of the different customers varies, an assumption of 51 physical servers per enterprise before migration to public cloud is made, based on the median value of the above range.
9. It is assumed that customers are UK based and therefore the UK grid electricity emission factor is used.
10. Electricity emission factors for cloud providers were calculated based on provider's average annual energy consumption during computation, storage, networking, memory usage, PUE and average emission factors of the grid electricity of different regions where the provider's data centres are located (calculation process described in Appendix B).

Data sources

Data point	Source
Proportion of Private Cloud servers	451 Research, 2019. The Carbon Reduction Opportunity of Moving to Amazon Web Services. Commissioned by Amazon Web Services.
Dedicated IT, Private and Public cloud utilization rate and PUE	CDP and Verdantix, 2019. Carbon Disclosure Project Study 2011 – Cloud Computing – The IT Solution for the 21st Century.
Typical server power	Weighted average using data from: Department of Energy/Berkeley Lab Centre of Expertise for Energy Efficiency in Data Centres (COE)
Number of physical servers on business's site	Applied Computer Research, Inc, 2011. Identifying IT Markets and Market Size by Number of Servers.
Emission factor for UK electricity	DEFRA and BEIS, 2022. UK Government GHG Conversion Factors for Company Reporting.
Emission factor for cloud providers (Microsoft Azure and AWS)	Calculated using data from: Thoughtworks, 2021. Cloud carbon footprint

Rebound effects
Not identified.

Secondary effects
Research indicates that carbon benefits may also arise in the form of lower embodied emissions when moving workloads to the cloud, as opposed to building their own infrastructure capacity. Hyperscale data centres are leaner and better utilised, and hyperscale supply chains for servers are highly optimised for lower use of materials, which in effect lowers the energy required to produce systems. In addition, cloud providers tend to use higher-performance processors than businesses because they can monetise them more effectively, so they require fewer servers to deliver the same overall performance. The reduction in embodied emissions could be added to the carbon enablement calculations in the future, if the impact is estimated as significant and data is available.

3.5.3 Carbon Network Dashboard

The Carbon Network Dashboard (CND) offers businesses a mechanism for achieving carbon savings by enabling them to monitor and analyse their carbon emissions in real-time.

Carbon Savings Mechanism (Enabling effects)
The CND facilitates informed decision-making, allowing companies to identify and implement energy-efficient practices and technologies that reduce their carbon footprint. Streamlining the process of carbon management helps our customers to achieve sustainability goals while potentially lowering operational costs.

Calculation Methodology
The carbon enablement methodology assumes that a customer reduces their energy consumption by using the CND, which offers recommendations on which devices could be powered down.

The average carbon enablement per customer is calculated as the emissions generated by registered devices from customers on the dashboard over a 12-month period, multiplied by the number of customers using dashboard tools.
The calculation methodology then factors the assumption that 10 to 20% are powered down following recommendations under different scenarios considered.

The calculation includes no specific rebound as the additional emissions created by the replacement of end-of-lifecycle devices have been accounted in reported emissions.

Formula
Carbon enablement (tCO_2e) = (Total amount of watts consumed by devices on CND (kWh) x Total number of hours with powered down devices (#)) x Global average emission factor in baseline year (tCO_2e/kWh) x Incremental savings percentage through CND (%)

Total amount of watts consumed by devices on CND (kWh): Number of customers per year (with FY29 and FY30 customers calculated assuming a 45% growth over MTP period of five year) for each segment x Average number of devices per customer per segment per year x Average number of Watts per device (0.005kW)

Total number of hours with powered down devices (#): (total number of hours in weekends per year (24x2x52) + total number of hours out of business during weekdays per year (12x5x52)) x total number of watts consumed for all devices per segment.

Functional Unit
Total energy consumed per device per year.

Assumptions
1. The avoided emissions are the indirect results of the use of the CND.
2. Emissions related to the use of the CND tools have also been accounted for in the emissions reduction.
3. All ports have the same potential of powering down out of business hours and devices are not powered down during working hours.
4. Growth rate of 40% to 50% over an MTP period for five years (based on the average values and the customers volume planned to be onboarded over five years).
5. Potential emissions savings are expected to be around 10-20% (Conservative: 10%; Accelerated: 15%; Ambitious: 20%).

Data sources

Data point	Source
Number of customers per year for CND	BT Group
Total number of devices/ports per year	BT Group
Average energy consumption per device on CND	BT Group
Average customer growth per year	BT Group
Number of hours out of business working hours per day	BT Group
Global average emission factor in baseline year	BT Group data using EcoInvent, GaBi Electronics Database and the PAIA tool

Rebound effects
Not identified.

Secondary effects
Not identified.

3.5.4 Digital Carbon Calculator

The Digital Carbon Calculator (DCC) offers businesses an indirect mechanism for carbon savings by enabling them to monitor their carbon emissions in real-time and in future years.

Carbon Savings Mechanism (Enabling effects)

The DCC tool facilitates accurate forecast of energy consumption per device, informed decision-making, allowing companies to identify energy-intensive devices and implement actions that reduce their carbon footprint. Streamlining the process of carbon management helps our customers to achieve sustainability goals while potentially lowering operational costs.

Calculation Methodology

The carbon enablement methodology assumes that a customer indirectly reduces their energy consumption by using DCC.

The average carbon enablement per customer is calculated as the emissions generated by registered devices from customers on the dashboard over a 12-month period, multiplied by the number of customers using dashboard tools. The calculation methodology also considers the potential action gap among customers, as only 10-15% of customers are believed to act based on calculated emissions (see assumptions below).

The calculation includes no specific rebound as the additional emissions created by the replacement of end-of-lifecycle devices have been accounted in reported emissions.

Formula

Carbon enablement (tCO_2e) = Average emission reductions per year per customer (tCO_2e) x Estimated customer growth per year (#) x Incremental savings percentage through DCC (%)

Expected customer growth per size of onboarded devices (#) = Average volume of devices per segments (#) x Number of customers per segment per year (#).

Functional Unit

Average carbon enablement per customer per year.

Assumptions

1. The avoided emissions are the indirect results of the use of DCC.
2. Emissions related to the use of DCC tools have also been accounted for in the emissions reduction.
3. Emissions data has been estimated by BT from the dashboards.
4. Growth rate of 40% to 52% over an MTP period for five years. (based on the average values and the customers volume planned to be onboarded in five years)
5. Potential emissions savings are expected to be around 10% -15% (Conservative: 10%; Accelerated: 12.5%; Ambitious: 15%).

Data sources

Data point	Source
Number of customers per year for Carbon Network Dashboard and Digital Carbon Calculator	BT Group
Average customer growth per year	BT Group
Average emission saving per device on the DCC	BT Group
Average volume of devices per segment of customer on DCC	BT Group
Incremental savings percentage through Digital Carbon Calculator	BT Group
Global average emission factor	IEA (2023)

Rebound effects
Not identified.

Secondary effects
Not identified.

3.6 Sustainable Buildings

3.6.1 Meraki V-App

Businesses use Meraki V-APP devices to monitor and optimise their energy use. As office spaces are a main contributor to operational emissions for many businesses, the ability to reduce unnecessary energy consumption provides an opportunity to significantly reduce these.

Carbon Savings Mechanism (Enabling effects)
Meraki devices lead to emissions savings by reducing the energy consumption of devices that are dormant/not in use. Meraki ports automatically switch off according to predefined conditions set by users, such as turning off devices in a room if there are no staff present for 20 minutes. This allows businesses to passively reduce emissions associated with electricity consumption. Furthermore, through a real-time interactive dashboard, the ports can be effectively managed and monitored to analyse port usage opportunities for further optimisation of the Meraki ecosystem.

Calculation Methodology
The carbon enablement methodology assumes that carbon savings through Meraki devices remains constant over time, whereby savings are compared to the original ports being replaced. Additionally, the methodology assumes that Meraki devices are replacing older, less efficient products within the port ecosystem.
The carbon enablement is calculated as the average carbon saving per port per year due to Meraki

devices, multiplied by the average number of ports within each BT account and the number of BT accounts utilising ports controlled by Meraki V-APP.

The average amount of time saved per port from being switched off due to Meraki devices is used to work out typical energy savings per port. A weighted regional average is used to estimate the efficiency of the grid.

Formula

Carbon enablement (tCO2e) = Average carbon savings per port due to Meraki device (kgCO2e/device/year) x Average number of ports used in each account (#/year) x Number of BT accounts utilising ports controlled by Meraki V-APP (#/year).

Where:

Average carbon savings per port due to Meraki device (kgCO2e/device/year) = [Average energy usage of port when 'always on' (kWh/day) - Average energy usage of port using Meraki (kWh/day)] / Number of ports / Number of devices per port (2)

Functional Unit

Average carbon enablement per customer per year

Assumptions

1. Meraki devices have replaced older less efficient products thus leading to carbon savings.
2. Carbon savings of Meraki devices/ports remain constant throughout time whereby savings are compared to the original device being replaced.
3. Carbon savings per Meraki device/port is based on the average across the week whereby most devices (excluding security cameras and similar devices) are not in use during weekends as offices will be empty.

Data sources

Data point	Source
Average carbon savings per port	BT Group
Average number of ports per account	BT Group
Number of BT accounts utilising ports controlled by Meraki V-APP	BT Group
US Emissions Factor	BT Group
EU Emissions Factor	European Environment Agency
UK Emissions Factor	DEFRA, 2024

Rebound effects
Emissions impact of disposing of old devices to replace them with Meraki and the embodied emissions of the building of Meraki devices (not quantified).

Secondary effects
None identified

3.6.2 Johnson Controls

Johnson Controls allow businesses to increase the efficiency of their heating, ventilation, and air conditioning throughout office spaces to reduce energy consumption. As offices spaces are a main contributor to operational emissions for many businesses, the ability to reduce unnecessary energy consumption provides an opportunity to significantly reduce these.

Carbon Savings Mechanism (Enabling effects)
Through leveraging the Open Blue tool provided by Johnson Controls, BT customers can reduce their energy usage and associated carbon emissions. The Open Blue tool does this by providing recommendations on building optimisation solutions regarding Heating Ventilation and Air Conditioning (HVAC), lighting, elevators and other office appliances.

Calculation Methodology
The carbon enablement methodology assumes that most carbon savings associated with retrofitting a building with Johnson Controls devices occur within the first year due to increased optimisation, whereby savings are compared to the original HVAC systems being replaced. Additionally, the methodology assumes that Johnson Controls devices are replacing older, less efficient HVAC devices.

The carbon enablement is calculated as the average carbon savings per building size (small, medium, large) per year due to Johnson Control devices, multiplied by the average number of each building size per year. The total carbon savings are calculated by accounting for how savings change over a five year period whereby most savings occur within the first year of retrofitting and greatly reduce in the following years. Therefore, the total savings per year is calculated by accounting for the high savings of buildings within their first year of retrofit and the reduced savings of those in their second year, then third and so on.

A weighted average emissions factor is used based on customer location to represent the split of Johnson Controls customers geographically.

Formula

Carbon Enablement per building size (tCO2e) per year = Average five year energy savings per building size (kWh/building size) * Number of buildings being retrofit per size [#/year) * Percentage of five year savings per year since retrofit (%) * Weighted average emissions factor (based on customer location)

Functional Unit
Average carbon enablement per building size

Assumptions

1. Johnson Controls devices have replaced older less efficient products thus leading to carbon savings.
2. Most savings from retrofitting Johnson Controls devices into an existing building happens in the first year due to increased efficiency within the new HVAC systems.
3. Buildings no longer make new savings after five years since retrofit (year 6 = no new energy savings).
4. Emissions factors remain the same over a six year period from 2024-2030.
5. Breakdown of savings for five year period in year 1 assumed to be 85%.
6. Breakdown of savings for five year period in year 2 and year 3 assumed to be 5%.
7. Breakdown of savings for five year period in year 4 assumed to be 3%.
8. Breakdown of savings for five year period in year 5 assumed to be 2%.

Data sources

Data point	Source
Geographical breakdown of customers	BT Group
Share of buildings defined as 'Large', 'Medium' and 'Small'	BT Group
Average energy savings per building size per year	BT Group
Number of buildings being retrofit per year	BT Group
Share of energy savings per year over five year period	BT Group
US Emissions Factor	BT Group
EU Emissions Factor	European Environment Agency
UK Emissions Factor	DEFRA, 2024

Rebound effects
Emissions impact of retrofitting Johnson Controls devices and disposing of older devices and the embodied emissions of the building of Johnson Controls devices (not quantified).

Secondary effects
None identified

Appendix A References from literature review

Academic literature

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Appendix B Additional detail on calculation of emissions factors

Calculation of third-party cloud provider emission factor

Estimating CO_2e emissions for cloud compute and storage services, as well as networking and memory usage, depends on various factors such as the specific cloud provider, the location of their data centres, the energy mix used to power them, the efficiency of the data centres, and the usage patterns of the services. To estimate the CO_2e emissions for cloud compute and storage services, the cloud provider's own publicly reported emissions data should be used, if available. Some cloud providers disclose their carbon footprint and related information, such as the total emissions generated by their data centres and the percentage of renewable energy used to power them.

The methodology used to estimate the carbon footprint of cloud services, based on the user's own data inputs such as the number of servers, storage capacity, and network usage. It is important to note that the estimates generated by these methods are approximations and may not reflect the exact emissions of a specific cloud provider.

Energy estimates:

- Energy consumption during computation (based on server utilisation): When a server is idle, it consumes some power to run basic functions such as maintaining network connections. This is known as the "minimum power" or "base power" consumption. As the server utilisation increases, the amount of power consumed also increases to accommodate the additional processing and memory requirements.
  - Average energy consumption during computation = Min Power + 50% (Average Utilisation rate) x (Max Power - Min Power) x operating hours
- Energy consumption due to storage: The energy consumption due to storage can vary depending on the type of storage technology being used, such as hard disk drives (HDD) and solid-state drives (SSD). The estimated storage coefficient for HDD storage is 0.65 Watt-Hours per Terabyte-Hour and for SSD is 1.2 Watt-Hours per Terabyte-Hour.
  - Average energy consumption due to storage = Storage (TB-hr) x Storage coefficient (Wh/TB-hr)
- Energy consumption due to networking: The electricity used to power the internal network, such as switches, routers, and other networking equipment, is generally considered to be relatively small because the internal network is typically not responsible for the majority of the data processing and storage in a system. The energy consumption of the internal network can vary depending on the specific type and configuration of the networking equipment being used, as well as the amount of network traffic. Given these assumptions, the smallest coefficient available is 0.001 kWh/GB.
  - Average energy consumption due to Networking = Networking (GB) x Networking coefficient (kWh/GB)
- Energy consumption due to memory usage – to estimate the energy consumption of memory is to use the idle power consumption of the memory devices such as Dynamic Random-Access Memory DDR4 or DDR5. The estimated memory coefficient based on the average power consumption per GB memory is 0.000392 kWh/GB
  - Average energy consumption due to Memory usage = Memory (GB) x Memory coefficient (kWh/GB)
- Power Usage Effectiveness of data centre – After estimating the average energy consumption for compute, storage, networking and memory usage, it is necessary to multiply this by the cloud provider's Power Usage Effectiveness (PUE) to estimate the total energy consumption of the data centre. Here are the cloud provider PUEs being used – 1) AWS: 1.135, 2) GCP: 1.1, 3) Azure: 1.185

Carbon estimates:

- By using publicly available data on the emission factors for a given electricity grid and the cloud provider's data centre region, calculate the estimated CO_2e emissions for a specific amount of energy usage.
  - Average annual energy consumption of single cloud provider = Average energy consumption during computation + Average energy consumption due to storage + Average energy consumption due to Networking + Average energy consumption due to Memory usage + Data centre's PUE of cloud provider
  - Average annual carbon emissions = Average annual energy consumption × Emission factor of grid electricity (specific to region where data centre is located)
  - Carbon intensity = Total emissions due to all data centres (tCO_2e) / Total energy consumed by all data centre (kWh)
- Once a business has an estimate of the emissions associated with its usage of a cloud provider's services, the company can proportion the emissions due to the cloud provider based on their usage. This can be done by calculating the proportion of the cloud provider's total emissions that are attributed to the business's use of their services.
- For example, if a business's usage of a cloud provider's services is responsible for 1% of the provider's total emissions, then the business can say that 1% of the provider's total emissions is due to their usage.

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