BT's 3:1 carbon abatement methodology

For Financial Year 2019/20

1 OVERVIEW

This document provides a description of BT's 3:1 carbon abatement calculations, assumptions and data. The original work on the methodology and calculations was carried out by BT in early 2012 and was then reviewed by the Carbon Trust and Camanoe Associates (researchers from MIT), working closely with BT, over the period January to April 2013.

BT's 3:1 ambition and methodology were published in June 2013. This document is updated from that published in June 2013 (and previously revised in May 2014, April 2015, April 2016, May 2017, May 2018 and May 2019), and reflects changes in the 3:1 methodology and calculations during BT's financial year 1 April 2019 – 31 March 2020. See section 8 for identification of changes and additions to the methodology compared to the previous financial year.

2 INTRODUCTION

In 2013 BT launched a new vision "to help society live within the constraints of our planet's resources through our products and people." Alongside this vision is a 2020 ambition to help customers reduce carbon emissions by at least three times the end-to-end carbon impact of BT's business.

This 3:1 ambition compares the carbon abatement effect of BT's products and services against BT's end-to-end carbon footprint, including Scope 1, 2 and 3 emissions.

BT routinely reports its corporate Scope 1 and 2 emissions, and has estimated the carbon emissions associated with Scope 3 categories as appropriate, including its supply chain based on an environmentally extended input/output analysis.

BT has identified a number of products and services, such as conferencing, that could cut customers' carbon emissions and has developed calculations to determine their carbon abatement potential.

During financial year 2019/20, BT again engaged the Carbon Trust to work with BT to review, refine and endorse the methodology, assumptions and calculations used to underpin the 3:1 ambition.

3 HISTORY/CONTEXT

BT set its first carbon reduction target in 1992 and thus has a long history of measuring and reducing its CO_2 emissions, and the current work on the 3:1 ambition is a natural continuation of previous activities.

Some highlights of BT's carbon journey are summarised here:

- Energy and carbon reduction targets
- Renewable energy programme
- Olympics London 2012 Sustainability Partner
- Scope 3 measurement
- Methodology development, working specifically under the auspices of the Greenhouse Gas Protocol
- Product foot printing

4 METHODOLOGY AND APPROACH

4.1 Introduction

The BT 3:1 ambition is "to help customers reduce carbon emissions by at least three times the end-to-end carbon impact of BT's business", by 2020.

This 3:1 ambition compares the carbon abatement effect of BT's products and services against BT's full corporate carbon footprint, including Scope 1, 2 and 3 emissions.

BT has undertaken work to:

- quantify the total value chain emissions (Scope 1, 2 and 3), and
- quantify the carbon abatement potential of various products and services

5 SCOPE 1 & 2

5.1 Approach

BT follows the Climate Disclosure Standards Board framework, which builds on the World Resource Institute/World Business Council for Sustainable Development Greenhouse Gas Protocol in calculating its Scope 1 and 2 emissions.

In addition, following the GHG Protocol Scope 2 Guidance, BT calculates and publishes the carbon footprint of its own operations as both a location-based and as a market-based figure (formerly reported as gross and net figures). The location-based figure includes renewable and low carbon energy at the grid average carbon intensity. The market-based figure accounts for electricity purchases of renewables based on market contracts, and effectively subtracts out purchased renewable and low carbon energy. The 3:1 ratio is based on the market-based figure.

5.2 Scope 1 & 2 - review process

BT has 20 years' experience measuring its corporate carbon emissions and has its report assured by Lloyd's Register (LR).

Given that LR provides assurance of BT's carbon data, and that the data is also reviewed as part of the Carbon Trust Standard certification, no additional review was carried out by the Carbon Trust of BT's Scope 1 and 2 data and calculations.

6 SCOPE 3

6.1 Approach

BT follows the Greenhouse Gas Protocol's Scope 3 Standard to calculate its emissions for the different Scope 3 categories defined in the standard. Some of the categories are either negligible or not applicable to BT. A separate report describes the Scope 3 calculations and methodology in more detail.

The most significant Scope 3 emissions for BT are from the products and services that it purchases, and from the use of the products that it sells.

In order to estimate BT's scope 3 supply chain emissions, extensive use has been made of environmentally extended input-output analysis (EEIO). This technique combines macro-economic data on the output of industries and the trade between them with data on the total emissions arising directly from each industry to assess the direct and supply chain emissions attributable per unit of output of each industry.

In the overall assessment of scope 3 emissions, elements of process based life cycle analysis have been substituted in to replace elements of the EEIO-based estimates, wherever available data makes a more accurate estimate possible. Whenever this is done, care is taken to maintain consistent boundaries for the analysis and to avoid double counting. The resulting model is a hybrid between EEIO and process based life cycle analysis. Currently this hybrid approach is applied to the supply chains of energy, travel, transport, TV royalties, employee commuting (including home working), and waste. To further increase the hybridisation of the model, BT also now substitute suppliers' operational Scope 1 and 2 emissions intensity data as reported to the CDP.

BT worked with Small World Consulting again to undertake these calculations.

It is, in theory, possible to apply the same technique to the suppliers' suppliers, and even to further tiers in the supply chain, although the work involved goes up and the returns become more limited. If company reporting to the CDP becomes the industry norm alongside a consistent approach to supply chain emissions reporting in which companies routinely adopt this substitution technique, it may be possible to move towards a position in which BT's own emissions are mainly drawn from CDP data, with EEIO accounting for only a minority remainder of emissions.

The following table summarises the methodologies used for the calculation of the Scope 3 emissions:

Scope 3 area	Reporting / calculations
Scope 3: upstream (supply chain procurement)	Small World Consulting report assessing BT's upstream Scope 3 emissions from procurement spend data using an environmentally extended input-output analysis. Existing BT annual carbon statement which covers: • employee business travel (rail, air and car hire) • non-Kyoto refrigerant gases (e.g. CFCs) • an estimate for home workers' carbon footprint
Scope 3: downstream (customers' use of sold products)	Analysis of downstream Scope 3 emissions – energy use of sold products and end-of-life emissions. This calculation is based on power consumption, life span and use profile for each of the types equipment sold, including both networking equipment and office equipment supplied to BT business customers, as well as equipment supplied to BT residential customers, multiplied by the volumes of equipment sold. UK Department for Business, Energy & Industrial Strategy (BEIS) "all scopes UK electricity emissions factor" which includes the supply chain was used to calculate emissions from power consumption. To model the end of life waste treatment processes, waste material quantities by type for products sold in the UK and Process Life Cycle Analysis (LCA) data from the UK Department for Business, Energy & Industrial Strategy (BEIS) have been used. The UK data has been extrapolated to cover end of life treatment of products sold outside the UK.

6.2 Scope 3 – review process

The approach taken by the Carbon Trust review team was as follows:

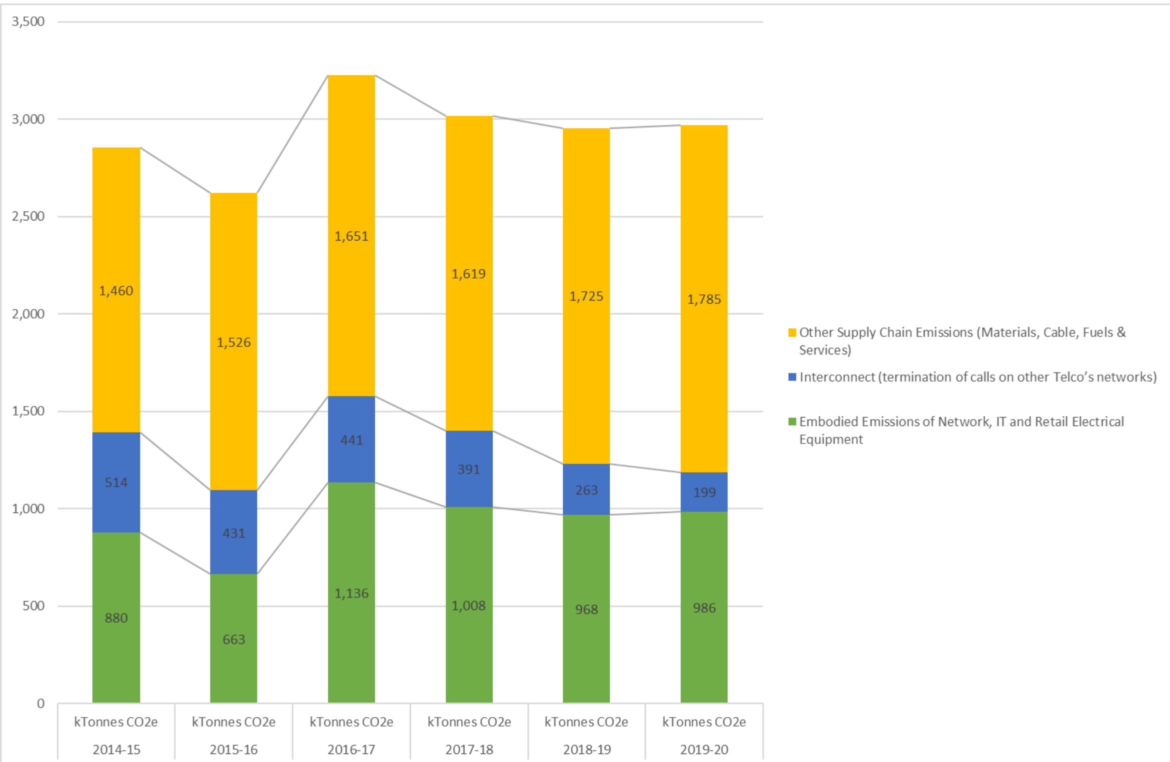
- Discussions with BT to understand approach taken
- Review report produced by Small World Consulting (SWC)
- Review spreadsheet calculations for Scope 3 emissions
- Review methodology and assumptions for each of the Scope 3 categories

6.3 Scope 3 – supply chain emissions

The following table and graph show BT's supply chain emissions for 2019/20 and compares this with previous years:

Breakdown of upstream (supply chain) Scope 3 emissions (kilotonnes CO_2e)

	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Embodied Emissions of Network, IT and Retail Electrical Equipment	880	663	1,136	1,008	968	986
Interconnect (termination of calls on other Telco's networks)	514	431	441	391	263	199
Other Supply Chain Emissions (Materials, Cable, Fuels & Services)	1,460	1,526	1,651	1,619	1,725	1,785
Scope 3: Upstream Total	**2,854**	**2,620**	**3,228**	**3,018**	**2,955**	**2,970**



As for previous years the underlying EEIO model was updated using more recent industry data made available by the Office of National Statistics. The improved model has also been applied retrospectively to supply chain carbon assessments for previous years in order to maintain consistency and comparability between years.

7 CARBON ABATEMENT METHODOLOGY

7.1 Overview of carbon abatement

The overall approach to quantifying carbon abatement afforded by BT's products and services has been to identify each proposition within BT's portfolio that has the potential to reduce carbon emissions.

For each of these propositions (a product, service, or combination thereof), a quantity (unit of measure) and a carbon factor per unit of quantity are identified and multiplied by each other. The quantity portion of this equation might be a number of contracts, users, or vehicles removed for example.

The carbon factor for each proposition assumes some carbon abatement mechanism for that particular proposition and is derived from either an external study, an internal BT study, or documented expert assumptions. Critically, the carbon reduction factor is determined based on a comparison with an assumed "business as usual" (BAU) baseline or current practice from which abatement is determined.

7.2 Carbon Abatement - review process

The approach taken by the review team was as follows for each of the individual products:

- Understand the product/service through discussions with experts within BT to determine the nature, status, and scope of the product/service, BT's role in offering this product or service (in the cases where multiple partners are involved) and general comments on how abatement might be quantified (what data exist within BT) or growth projected.
- Review the carbon footprint model including the general approach or assumptions used to calculate carbon abatement based on product/service function.
- Review the carbon factor including the values and sources used in the model.
- Where relevant, review the external study used as the basis for the carbon factor.
- Where relevant, conduct research to identify any additional sources of data for the carbon factor calculation for purposes of comparison and to provide a sense check.

The following was then documented following the detailed verification review for each product/service:

- The **approach** taken initially by BT in its assessment.
- The key **assumptions** that underlie this approach.
- The **comments and challenges** offered by the external review team.
- The **data sources** used to make the calculations. These data sources are evaluated based on their quality in several categories including verified/reliability (published versus personal information), temporal appropriateness (how old are the data and how old is the assumed baseline as a result), and geographical relevance (where was the study performed)
- The **results** from these analyses and then a summary of the **conclusions** for each proposition including the key changes made from the original methodology.
- Confirm **endorsement** of the final calculation included in the methodology

7.3 Carbon Abatement – key assumptions

There are several overall assumptions that should be mentioned to provide context for the detailed verification described below. These include:

- The BAU baseline assumption was, as much as possible, around the year 2012. However, this is dependent on the date of any study that was used. This assumption does not currently consider how this BAU baseline might change between 2012 and 2020. In some cases, the review team recommended modification of the BAU baseline over the original assumptions and potentially over time.

- The energy mix for the electricity grid is updated annually (using the UK Department for Business, Energy & Industrial Strategy (BEIS) published factors) and is assumed to remain constant for the purposes of future projections.
- Other key factors, such as fuel efficiency of vehicles, are currently assumed to be static for the course of the analysis.
- For some propositions, the BT product or service is only partly responsible for the carbon abatement. In cases where some allocation to BT's specific role was possible, this was performed. However, more generally the assumption was made that if the BT product or service has a fundamental role in providing the enabling effect (in other words the outcome would not happen without the BT product/service), then 100% of the savings are counted. This assumption will lead to double counting, as another company may also then claim that they have enabled this savings.
- One critical concept present in any abatement calculation is the possibility of rebound effects. For example, in the case of telecommuting, consumers who work from home consume energy for heating and lighting of the home. In general, rebound was not explicitly considered, but it has been considered as part of some of the external studies used in the carbon factors.
- For products and services that have a multiple year contract, the carbon abatement is accounted for in each year of the contract rather than upfront in the year of signing of the contract[1]. Beyond the end of the contract, no carbon abatement is credited to BT, as the approach is specifically considering the carbon savings of BT customers. Thus even if the users of the product/service continue to gain carbon savings after the contract has finished, then BT only takes credit for the period of the contract, as outside of the contract BT has no longer any direct role in the carbon abatement, and outside the contract the user making the carbon savings is strictly no longer a customer of BT for this service.

[1] Note this is a change from the methodology used for FY 2012/13 and was introduced for the 2013/14 report, as the new approach is more conservative.

7.4 Carbon abatement - summary

The following sections detail the methodology used to calculate the carbon abatement potential of the current BT products / services included in the BT 3:1 carbon abatement calculations. The following table provides a summary.

BT Product	Carbon benefit enabled	Unit of measurement	Carbon abatement (tCO_2e per unit)
Broadband enabled Telecommuting	Telecommuting to avoid commuting travel	Number of telecommuters enabled by BT	0.95
Flexible working services	Reduced energy consumed by offices employing flexible working	Number of contracts	560.2
Audio conferencing	Teleconferencing substituting for business travel	Number of conference calls	0.0281
Video conferencing (Telepresence)	Teleconferencing substituting for business travel	Number of Telepresence suites	94.4
Broadband enabled e-commerce	Reduced energy consumption by commercial, retail and wholesale space replaced by e-commerce	Number of business broadband connections	0.083 [see note 1]
Broadband enabled dematerialisation	Dematerialisation and reduced consumer travel due to use of internet	Number of residential broadband connections	0.032
BT Vision	Reduced travel and dematerialisation of disc media	Number of films downloaded	0.00084
Field Force Automation	Information services reducing miles travelled by vehicle service fleets	Number of vehicles	4.80
Data centre services	Reduction in energy by moving from dedicated on site hosting to shared centralised hosting.	Number of virtual machines	1.81
Cloud Contact	Reduction in energy by virtualisation of the hosted network switching platform	Number of customers	1.63
One Cloud	Reduction in energy by moving from customer based PABX or IPT server to virtualised network switching.	Number of users	0.00103
Managed mobility	Reduction in travel by flexible working practices enabled by the N3 NHS network	"one off" calculation for the N3 network	N/A
Inbound calling	Conference calling facilities, where BT provides communications infrastructure	Number of conference calls	0.0281
Super-fast broadband enabled dematerialisation	Additional dematerialisation and reduced consumer travel due to use of super-fast broadband (fibre-optic internet access).	Number of residential fibre broadband connections	0.418
Broadband enabled SME use of Cloud Computing	Reduction in energy by SME's adopting the cloud based services -email, CRM and groupware.	Total carbon abatement for all UK SMEs	Proportion of UK total allocated to BT

BT Product	Carbon benefit enabled	Unit of measurement	Carbon abatement (tCO_2e per unit)
Recycling of copper cables	Reduced production and pre-processing of virgin metals	Tonnes of cables recycled	1.67
BT Connect Payments	Reduction in cash drops	£1,000,000 transferred	0.14
SafePay	Reduction in cheque postage and processing	1000 SafePay transactions	0.082
TRIAD	The saving in carbon comes from not having CCGT plants on warm-up, stand-by and shut-down.	MWh generated for a one hour TRIAD period	0.503 [see note 2]
Fleet engine remapping	Engine remapping optimises engine performance for better fuel efficiency, resulting in reduced fuel consumption.	Vehicle remapped per year	0.32 [see note 3]
IP Communications	Reduction in desk phones and switches, resulting in reduction in both embodied carbon and energy usage.	Number of seats	BT Cloud Phone: 0.04 BT Cloud Voice: 0.04 BT Cloud UC: 0.04
BT Mobility	Reduction in desk phones or mobile phones and switches, resulting in reduction in both embodied carbon and energy usage. In some cases additional Pico cells are required.	Number of users	BT One Phone: 0.03 BT Autobalance: 0.04
BT Apps – remote collaboration tools	Reduced business travel and overnight hotel stays.	Number of users	0.45
BT M2M	Taxis – reduced fuel consumption.	M2M connections	0.29
	ATMs – reduced maintenance visits.	M2M connections	0.0062
	Traffic Management – reduced traffic congestion and reduced fuel consumption.	M2M connections	18.13
	Smart meters (business use) – reduced heating and electricity consumption in commercial buildings.	M2M connections	2.65
	Smart meters (domestic use) – reduced heating and electricity consumption in the home.	M2M connections	0.04
	Connected Car – UBI – reduced fuel consumption.	M2M connections	0.13
	Fleet Management / Vehicle Telematics – reduced fuel consumption.	M2M connections	0.81
	Street Lighting – reduced electricity consumption.	Number of connected street lights	0.035
Maps / Traffic Apps	Reduction in fuel consumption, due to improved routing.	Number of smartphone users	0.0023

BT Product	Carbon benefit enabled	Unit of measurement	Carbon abatement (tCO2e per unit)
Cloud Connect	Reduction in energy by moving from dedicated on site servers to third party provided cloud computing.	Number of customers	7.97
BT Renewable Energy for Employees	Reduced carbon intensity of electricity consumption due to move to renewable energy incentivised by BT.	Number of employees	1.76 [see note 4]
Connect Services Platform	Reduction in electricity consumption by replacing a number of existing network devices with a single network device.	Number of customer sites	0.06
BT Half SIMs	Reduction in material and energy requirements along the entire lifecycle of the SIM, by reducing its size by roughly half.	Number of customers	0.000014

Note 1: For 'Broadband enabled e-commerce' higher abatement factors are used for higher bandwidths (see table in section 7.9.2).

Note 2: For TRIAD other carbon abatement factors are used for longer TRIAD time periods (see table in section 7.23.1).

Note 3: This figure is a calculated average annual figure for all the customer vehicles that were remapped. The calculation of the carbon abatement used the actual mileage and fuel savings for each customer, and then summed these to give a total abatement figure.

Note 4: The figure will vary dependent on the carbon intensity of the previous electricity supply. The figure quoted here is a typical figure.

7.5 Broadband enabled telecommuting

7.5.1 Approach

Through the provision of a broadband network, BT enables workers to telecommute. That is, a telecommuter is someone who is able to work remotely (typically at home, using a broadband connection, avoiding the need to travel to a company office).

The major assumption here is that where BT provides a physical broadband line then BT can take credit for the carbon savings.

Typically, there are avoided emissions from telecommuting associated with not having to travel into and from the office. There may also be reduced energy use within the office environment, although this will at least be partially offset through increased energy use in the telecommuter's home.

The modelling approach taken infers that BT can claim the enabling effect for every broadband line that it provides (i.e. the broadband infrastructure) even if someone else provides the end broadband package to the final user.

$$\begin{aligned}&\text{Telecommuting carbon saving}\\&\qquad\qquad = \text{Average carbon saving per telecommuter}\\&\qquad\qquad \times \text{Number of telecommuters enabled by BT}\end{aligned}$$

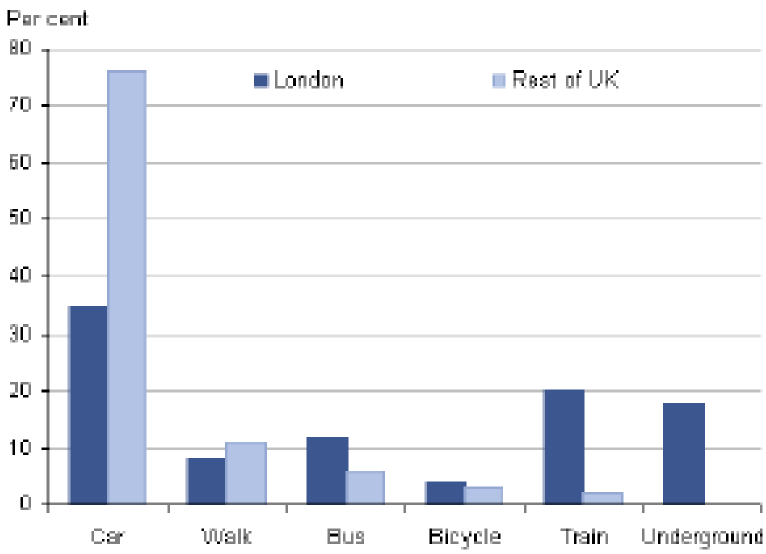
7.5.2 Assumptions

7.5.2.1 Carbon abatement per telecommuter

Mode of transport - It should be noted that for each of the emission factors under discussion, only commuting to work by car has been considered. This is obviously not true of the entire UK population, and so it should be acknowledged that these calculated savings will be slightly higher than the true savings. That being said, transport by car is probably the most likely mode to be avoided due to the implied distance and costs associated with that form of commuting; somebody who simply has to walk or cycle into work is less likely to want to work from home.

A split of the typical methods of commuting to work for the UK is given in Figure 1. However, this in itself is not enough to refine the modelling as it does not specify the split in modes of transport that an average telecommuter avoids. In the absence of more granular data regarding which mode of transport telecommuters are avoiding, this was considered to be the best approach and in-line with other studies in this area.

Percentage of workers by method of travel, London and Rest of the UK, October-December, 2009, United Kingdom



Source: Labour Force Survey - Office for National Statistics

Figure 1: Split of transport modes for commuting in the UK (1)

The figure used for the number of telecommuters was taken from the ONS survey data.

The 'Days per week to Telecommute' was calculated by taking survey data within the Yankee Group report.

About how often do you telecommute rather than going into a company facility?							
	Total	Germany	Italy	France	U.K.	Spain	U.S.
Sample size	1,021	205	158	120	164	173	201
Every day	31%	30%	25%	39%	34%	27%	31%
Two to four days per week	24%	28%	25%	18%	23%	25%	24%
One day per week	18%	14%	21%	18%	18%	22%	18%
One day every two weeks	6%	7%	7%	9%	5%	4%	6%
One day per month	5%	5%	7%	3%	5%	6%	5%
Less than one day per month	15%	15%	15%	14%	15%	15%	14%

Table 1: Survey data of frequency of working from home for each telecommuter (2)

This data was then manipulated to calculate an 'effective number of days worked from home per week for an average teleworker'.

Number of days per week	Frequency	Weighted number of days
5	34%	1.70
3	23%	0.69
1	18%	0.18
0.5	5%	0.03
0.25	5%	0.01
	TOTAL:	**2.61**

It was therefore assumed that a teleworker in the UK telecommutes on average for 2.6 days in every week.

The mean daily commute was also adjusted to reflect the UK average from the report's survey i.e. 19.55km x 2.

A Monte Carlo simulation was then rerun using these inputs giving an average saving per telecommuter of 0.95 metric tons CO_2e.

7.5.2.1.1 Alternative carbon abatement per telecommuter figures

Two alternative figures could have been used. The first figure is the one calculated in the BT case study on telecommuting (1.4tCO_2e per telecommuter per annum). The second was calculated from a 'Carbon Intent Project' paper (see analysis below) which gave a saving of 1.14tCO_2e per telecommuter per annum. However, the figure calculated through the Yankee Group study was used to err on the conservative side.

Emission factor derived from 'The Carbon Intent Project: ICT Enabling Low Carbon Business: Homeworking and Teleconferencing'

A method to derive a figure from the 'The Carbon Intent Project: ICT Enabling Low Carbon Business: Homeworking and Teleconferencing' report by the Communications Management Association (CMA) is outlined below:

- The report 'estimates a typical carbon dioxide emissions reduction for a UK-based Homeworker at 9 kg CO2/per employee-day worked at home rather than a central office.'
- Assuming 226 working days in a year (24 days holiday + 8 days bank holiday + 3 days sick leave) and the average number of days worked from home by a teleworker is 2.8 per week, then the average saving per telecommuter per year is 1.14tCO_2e.

7.5.2.2 Number of telecommuters enabled by BT

ONS statistics for the number of teleworkers in the UK were obtained from 2012/13 to 2019/20.

It is worth noting the effect of the increase of number of telecommuters on the average carbon savings per telecommuter as over time, the average saving per telecommuter is likely to decrease as the 'easy wins' (those who have furthest to travel and therefore the largest carbon savings) have already been taken. It should also be noted that the carbon savings per telecommuter are likely to decrease over time as vehicles become more efficient.

ONS Teleworker figures 2019

Year	Works mainly in own home	Works in different places using home as a base	Total
1997	660,264	1,593,940	2,254,204
1998	680,947	1,818,860	2,499,807
1999	647,706	1,948,799	2,596,505
2000	673,930	1,974,162	2,648,092
2001	677,930	1,927,165	2,605,095
2002	696,706	2,087,471	2,784,177
2003	729,629	2,244,806	2,974,435
2004	779,560	2,281,198	3,060,758
2005	761,201	2,343,081	3,104,282
2006	795,568	2,459,874	3,255,442
2007	822,838	2,394,675	3,217,513
2008	864,095	2,398,120	3,262,215
2009	904,211	2,433,033	3,337,244
2010	850,953	2,398,115	3,249,068
2011	1,028,359	2,372,857	3,401,216
2012	1,458,745	2,518,521	3,977,266
2013	1,436,560	2,599,412	4,035,972
2014	1,543,309	2,650,753	4,194,062
2015	1,651,269	2,696,151	4,347,420
2016	1,754,476	2,631,135	4,385,611
2017	1,794,397	2,580,282	4,374,679
2018	1,871,958	2,606,186	4,478,144
2019	1,940,508	2,659,807	4,600,315

The percentage of broadband lines that BT provides in the UK is calculated as the number of broadband lines provided by BT, divided by the total number broadband lines in the UK.

7.5.3 Data sources

Office of National Statistics – number of teleworkers https://www.ons.gov.uk/file?uri=/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/adhocs/11512homeworkersbyoccupationandindustry2012to2019/pubvhomeonlyxsic1soc11219.xls

- BT Agile Worker Energy & Carbon Study, BT case study carried out for Smart 2020, http://www.smart2020.org/case-studies/bt-agile-worker-energy-and-carbon-study/
- Measuring the Energy Reduction Impact of Selected Broadband-Enabled Activities Within Households, Yankee Group and GeSI, 2012 http://gesi.org/portfolio/report/26
- The Carbon Intent Project: ICT Enabling Low Carbon Business - Homeworking and Teleconferencing, Communications Management Association, April 2009

7.6 Flexible working services

7.6.1 Approach

BT offers a service to help companies introduce a flexible working system. BT helps to implement this using applications, processes, support and professional services. This is not merely limited to encouraging people to work from home – a large part of the service is about improving the efficiency of office space used by people who work in the office. This could mean an increase in the proportion of shared desks to improve desk occupancy rates (desks can quite often be unoccupied while workers are in meetings, out of the office at a client, or on holiday, for example). The net reduction in office space required leads to a reduced energy use within the office. It is this reduction in office energy use (and the associated emissions) that has been the focus of the modelling.

BT has data from a number of customers on the number of desks in each workstyle category (Fixed Desk; Team Desk; Mobile; Home Enabled; Home Based). BT also has a typical percentage for desk reduction for each workstyle category. Applying this reduction across each customer, BT can calculate an average number of desks removed per customer.

BT also has data on the average area of office space required per desk. Using the average number of desks removed per customer, BT can calculate the average reduction in office area required per customer. This can then be converted to an average energy saving per customer using figures from Energy Consumption Guide 19 – Energy Consumption in Offices.

$$\begin{aligned}\mathrm{CO_2e\ saving} &= \mathrm{Number_{Contracts}} \times \mathrm{Number_{Desks}} \times \mathrm{Area\ per\ desk} \\ &\quad \times \sum_{\substack{\text{across}\\ \text{different}\\ \text{energy types}}} (\text{Energy consumed per unit area} \times \text{Emission Factor})\end{aligned}$$

Where,
$\mathrm{Number_{Contracts}}$ = Number of FWS contracts that BT has in place in that year [contracts]
$\mathrm{Number_{Desks}}$ = Reduction in number of desks for an average contract [desks]
Area per desk = Typical office area required per desk [m^2/desk]
Energy consumed per unit area includes gas and electricity [KWh per m^2 per year]

This approach does not model any increased home energy use for workers who then work from home. However, it is difficult to ascertain what proportion of this service results in increase of homeworking versus desk efficiency savings resulting from, for example, people being in meetings and not requiring a desk.

7.6.2 Assumptions

BT projections were used for number of contracts per year.

Average area of office space required per desk = 12m^2/desk

Type of Office		Energy Requirements (KWh/m^2 per year)	
		Gas	Electricity
Naturally ventilated cellular	Good Practice	79	33
	Typical	151	54
Naturally ventilated open-plan	Good Practice	79	54
	Typical	151	85
Air-conditioned, standard	Good Practice	97	128
	Typical	178	226
Air-conditioned, prestige	Good Practice	114	234
	Typical	210	358

Table 2: Annual office energy use per year (KWh/m^2) (3)

The average energy savings across each type of office (both 'good practice' and 'typical' office) was taken.

An assumption within the modelling is that, before implementation of BT's solution, there is 1 desk per employee.

7.6.3 Data sources

- BT
- Action Energy. Energy Consumption Guide 19 - Energy Consumption in Offices, 2003 http://www.cibse.org/pdfs/ECG019.pdf

7.7 Audio conferencing

7.7.1 Approach

BT's audio conferencing service, branded as *BT MeetMe*, makes use of conventional voice telephony to enable multiple parties to have a meeting. BT has contracted with Professor Peter James from the University of Bradford to conduct surveys of BT's internal use of conferencing (which can also include web and video conferencing) in 2002, 2004, 2006, 2007, 2008, and 2012. The survey asks users of the conferencing service about the nature of their meetings (e.g., length of the meeting and number of participants) and whether a physical meeting was avoided. The latter element is particularly relevant to carbon abatement studies because it enables a calculation of avoided carbon due to transportation that would have occurred had there been a physical meeting. The Bradford study calculates such carbon avoidance for BT based on the survey responses using a fairly rigorous methodology.

BT used the survey results from the 2012 University of Bradford study to calculate a carbon savings for an individual call and then multiplied this by the total number of calls made by all customers who used the *BT MeetMe* service. The calculation for GHG savings from the audio conferencing service (Audio conferencing $GHG_{savings}$) is as follows:

Audio conferencing $GHG_{savings}$ = $GHG_{\text{AC avoided per call}}$ x $BT_{\text{conference calls}}$

where:
$GHG_{\text{AC avoided per call}}$ = GHG emissions avoided from one call
$BT_{\text{conference calls}}$ = Number of conference calls using BT service in one year

7.7.2 Assumptions

The following assumptions were used in this calculation.

1. The estimated abatement from the survey sample is representative of the rest of BT.
2. The estimated abatement for BT in the UK is representative of BT's worldwide customers.
3. The abatement will continue at the same level in the future. That is, the BAU remains the same.
4. A carbon abatement of 28.1kg of CO2e per call.

7.7.3 Data sources

- BT internal data
- The most recent University of Bradford BT study was used: Peter James, *Conferencing at BT: Results of a Survey on its Economic, Environmental and Social Impacts*, October 2012. http://www.btconferencing.co.uk/case-studies/case-study-on-bt-sustainability-value-in-a-virtual-world_en.pdf

7.8 Telepresence

7.8.1 Approach

BT's *Telepresence* product is a videoconference platform that makes use of high definition cameras and televisions to create a life-like feeling in a virtual meeting between multiple parties. The use of such a platform can eliminate the need for travel to physical meetings, thereby abating GHG emissions. BT provides customers with this service on both a *Telepresence* room basis and a *Telepresence* system basis.

The calculation method for carbon abatement from *Telepresence* (Telepresence $GHG_{savings}$) is as follows:

Telepresence $GHG_{savings}$ = $GHG_{\text{telepresence savings}}$ x $Rooms_{telepresence}$

where:
$GHG_{\text{telepresence savings}}$ = GHG savings from using a single *Telepresence* room
$Rooms_{telepresence}$ =Number of *Telepresence* rooms

7.8.2 Assumptions

The following assumptions were used:

1. The estimated abatement from a particular BT case study is representative of BT's worldwide customers.
2. The abatement will continue at the same level in the future. That is, the BAU remains the same.

3. The BT case study that was used calculated an annual abatement of 94.4 t CO2e for each *Telepresence* room.
4. For *Telepresence* systems the carbon abatement figure was factored based on average utilisation rates, to give a figure of 45.5 t CO2e for each *Telepresence* system.

7.8.3 Data sources

The key data on the abatement for *Telepresence* is from a BT internal report, which was a case study of a BT customer using BT's Telepresence service. A summary of the BT case study can be found in the GeSI SMARTER2020 report: http://gesi.org/portfolio/project/71

7.9 Broadband enabled e-commerce benefits

7.9.1 Approach

Through the provision of a broadband network, BT enables e-commerce activities. The carbon savings from B2B and B2C are estimated from the decrease of space (square footage) of commercial, retail and wholesale as a result of E-commerce activities. This translates to the saving of energy to build and operate these facilities.

Broadband enabled e-commerce CO_2e savings = $GHG_{per\ person}$ x $Vol._{Broadband}$

Where,

$GHG_{per\ person}$ = Savings per person from E-commerce = 0.083 tCO_2e
$Vol_{Broadband}$ = Volume of BT broadband *business* customers

This infers that BT can claim the enabling effect for every broadband line that it provides (i.e. the broadband infrastructure).

The ACI study estimated the square footage of retail and warehouse space that will have been avoided by 2007 from B2C and B2B commerce (combined) in the US, as well as the associated reduction of GHG emissions. The ACI study also assumed that the decrease of energy use will lead to fewer power plants being constructed.
B2B-B2C Dividends $CO_{2\ savings}$ = $GHG_{building\ space}$ x (A_{retail} + $A_{warehouses}$) + $GHG_{Power\ plants}$
B2B-B2C Dividends $CO_{2\ savings}$ = 17.3MtCO_2 + 20.2 Mt CO_2 = 37.5 Mt CO_2

Where,
A_{retail} = Area of retail space avoided from e-commerce (sq-ft)
$A_{warehouses}$ = Area of space warehouses avoided from e-commerce (sq-ft)
$GHG_{building\ space}$ = GHG emissions avoided from reduction of retail and warehousing building space
$GHG_{Power\ plants}$ = GHG emissions avoided from reduction of power plants not being constructed

It was considered that the savings attributed to power plant reduction were not justifiable to include, and thus the figure for $GHG_{Power\ plants}$ of 20.2 Mt CO2e were subtracted from the total savings.

7.9.2 Assumptions

ACI study

- ACI estimated the square footage of retail and warehouse space that will have been avoided by 2007 from B2C and B2B commerce (combined) in the US.
  - 1.5 billion square feet of retail space
  - 1 billion square feet of warehouses
- For every billion square feet saved 8.49 million tons of greenhouse gases will be not emitted and Energy Information Association (EIA) estimates that 6.4 kWh are consumed for every square foot of warehouse space.
- Total savings of 17.3 million tons CO_2e in the US (excluding factor for $GHG_{\text{Power plants}}$)

Normalisation by workforce:

- US working age population is 209 million
  - Normalizing savings number US working age population gives savings of 0.083 tCO_2e

Temporal and geographical representativeness of the ACI study are questionable. However, no more current or appropriate studies were to be found.

Impact of bandwidth on abatement

In 2014/15, a review was undertaken of the impact that bandwidth has on carbon abatement. This was part of a review of connectivity provided by BT in order to include connectivity products other than only business broadband, such as “Ethernet Connect” and “IP Connect”.

It is reasonable to expect an increase in abatement with higher bandwidths, because higher bandwidths allow increased data transfer which is related to increased activity. Additionally, for certain premises, e.g. offices, a higher bandwidth reflects more people using the connectivity. However, there are conversely some applications where higher bandwidth is required, but this does not represent increased carbon abatement.

No specific data relating carbon abatement to bandwidth for business use was available, however, analysis by BT demonstrated a logarithmic relationship between usage and bandwidth for residential use of broadband. For business use this is also a reasonable assumption, as higher bandwidth generally represents greater usage.

A pragmatic approach was chosen to have three bandwidth bands with a different carbon abatement factor for each band. The factors are based on a log10 relationship between carbon abatement and bandwidth. The carbon abatement factor used for the lowest band (up to 10 Mbps) is the same as was previously used for "Broadband enabled e-commerce". The factors are as shown in the table below.

Bandwidth range	Carbon abatement factor
(Mbps)	tCO2e/circuit/year
Up to 10 Mbps	0.083
10 - 99 Mbps	0.30
100 Mbps and above	0.50

7.9.3 Data sources

- ACI (2007). The American Consumer Institute. "Broadband services: Economic and Environmental Benefits" http://www.theamericanconsumer.org/2007/10/31/broadband-services-economic-and-environmental-benefits/
- Joseph Romm (2002) "The Internet and the New Energy Economy," Center for Energy and Climate Solutions, Global Environment and Technology Foundation http://192.5.14.43/content/dam/rand/pubs/conf_proceedings/CF170z1-1/CF170.1.romm.pdf
- US Department of Labor
- http://www.tradingeconomics.com/

7.10 Broadband enabled dematerialisation

7.10.1 Approach

The carbon savings from residential carbon dividends are estimated after the benefits from the convergence of telecommunications and computers (i.e., "E-materialization") replaces the need to manufacture, publish, print and ship newspapers, documents, books, CDs and DVDs for residential customers. Instead these and other services are available digitally on-line.

Broadband enabled de-materialisation CO_2e savings: $GHG_{per\ person}$ X $Vol._{Broadband}$

Where,

$GHG_{per\ person}$ = Savings per person from E-materialization = 0.031 tCO_2e
$Vol_{Broadband}$ = Volume of BT broadband customers for residential in each line of business

This infers that BT can claim the enabling effect for every broadband line that it provides, i.e. the broadband infrastructure.

7.10.2 Assumptions

The assumptions for the carbon abatement were based on the Yankee Group study (2012) "Measuring the Energy Reduction Impact of Selected Broadband-Enabled Activities Within Households".

Based on the available data within the Yankee Group study, the particular mechanisms considered are online news, music streaming, online banking, online shopping, online education, digital photos and e-mail.

To determine the carbon abatement figure the total savings calculated within the Yankee Group study for the EU-5 (without the telecommuting which is calculated in a separate proposition) were converted from million barrels of oil to metric tons of CO2e and then allocated to individual people (normalizing that total number by the working age population of the EU-5).

It should be noted that the mechanism for savings for online shopping in the Yankee study differs from that described in the ACI study used in "broadband enabled e-commerce" benefits. Instead of retail and warehouse savings, the online shopping abatement described in the Yankee Group study is attributed to customer travel distance that would be eliminated in an e-setting.

The table below provides the carbon savings figures based on the Yankee Group study 2012 in tons CO2e per working-age person.

News	0.000364
Music	0.003195
Banking	0.007736
Shopping	0.007849
Education	0.001681
Photos	0.007804
Mail	0.002668

Leading to a total savings of 0.031 t CO2 per working-age person.

7.10.2.1 Alternative carbon abatement figure per person

An alternative figure was calculated for comparison. This was based on the ACI study of 2007.

ACI study

The ACI study covers slightly different carbon saving mechanisms than the Yankee Group study. The ACI study covers mail, plastic CDs, newspapers, office paper, household paper and tele-medicine, whereas the Yankee Group study covers online news, music streaming, online banking, online shopping, online education, digital photos and e-mail.

The ACI study estimates the US annual savings in millions of tons CO_2e resulting from E-materialization in the year 2007 as follows:

Estimated savings from mail	1.4
Saving plastic by downloading music	0.5
Estimated Savings from Lower Newspaper Circulation	7.9
Estimated Savings from Reduction in Office Paper	2.9
Estimated Savings from Reduction in household paper	0.7
Estimated Savings from Tele-medicine (e.g., in-home health care)	1.6

Total 15 million tons CO_2e for US.

US/UK working age population:

- Total savings in US is then proportioned by UK by working age population resulting in 3.151 million tons CO_2e (ratio: ~0.2)
- Assumed UK working age population is 50 million*
    - Normalizing savings number by UK workforce gives savings of 0.063tCO_2e potential carbon benefits if fully adopted by all people of working age.

* The working age population for 2012 was actually closer to 40 million

Temporal and geographical representativeness of the ACI study is less appropriate than the Yankee Group study, and thus the Yankee Group study has been used. This also gives a more conservative figure for the carbon savings per person.

7.10.3 Data sources

- ACI (2007). The American Consumer Institute. “Broadband services: Economic and Environmental Benefits” http://www.theamericanconsumer.org/2007/10/31/broadband-services-economic-and-environmental-benefits/

- Joseph Romm (2002) “The Internet and the New Energy Economy,” Center for Energy and Climate Solutions, Global Environment and Technology Foundation http://192.5.14.43/content/dam/rand/pubs/conf_proceedings/CF170z1-1/CF170.1.romm.pdf
- US Department of Labour
- Measuring the Energy Reduction Impact of Selected Broadband-Enabled Activities Within Households, Yankee Group and GeSI, 2012 http://gesi.org/portfolio/report/26

7.11 BT Vision

7.11.1 Approach

BT Vision allows customers to download films on demand over a broadband connection, as opposed to having to travel to a rental store to physically collect and return a film or renting a DVD by mail.

$$\text{BT Vision CO}_2\text{e saving per year} = \text{Number}_{\text{films downloaded per year}} \times \text{Emission factor per rental}$$

Zentner et al. noted that the most popular 100 titles accounted for 85% of in-store rentals, but only 35% of the company’s online rentals (How Video Rental Patterns Change as Consumers Move Online, *Alejandro Zentner, Michael D. Smith, Cuneyd Kaya,* October 2012). Additionally, the majority of companies now offer a subscription service (i.e. pay a flat monthly subscription and are able to rent DVDs as they choose). Given this, it was deemed reasonable to include Subscription Video On Demand downloads (which tend to be older titles/not new releases) as well as Transactional Video On Demand in the number of films downloaded per year.

The carbon saved per rental is a weighted average of the emissions associated with rental of a DVD from a physical store and rental of a DVD by mail.

$$\text{Emission factor per rental} = \text{Proportion}_{\text{store}} \times \text{EF}_{\text{store}} + \text{Proportion}_{\text{mail}} \times \text{EF}_{\text{mail}}$$

The proportion of store rentals to mail rentals were taken from a US study on DVD rental patterns (Zentner et al.).

The embodied carbon for a DVD was divided by the average number of rentals per DVD to get the average embodied emissions per DVD per rental (which is the same for both store rental and rental by mail).

$$\text{EF}_{\text{embodied}} = \text{Embodied CO}_2\text{e per DVD/Average number of rentals per DVD}$$

$$\text{EF}_{\text{store}} = \text{EF}_{\text{embodied}} + \text{EF}_{\text{collection and return to store}}$$
$$\text{EF}_{\text{collection and return to store}} = \text{Average distance to store} \times 2 \times \text{Average transport emission factor}$$

$$\text{EF}_{\text{mail}} = \text{EF}_{\text{embodied}} + \text{EF}_{\text{delivery and return by mail}}$$
$$\text{EF}_{\text{delivery and return by mail}} = \text{Average emissions per mail delivery} \times 2$$

7.11.2 Assumptions

Rentals via mail: 68.3%. Rentals via physical store: 31.7%. (Zentner et al.)

Average round trip to collect/return a DVD from rental store = 2 x 3.6miles (Zentner et al.). Note this figure is for the US, but seems reasonable.

Emissions per DVD = 0.44kg CO2e per DVD and packaging (source: Digital Entertainment Group, 2008, http://www.enviro-news.com/news/packaging_reductions_lowering_carbon_footprint_of_dvds.html)

Emissions from postage per rental = 0.015kg CO_2e per delivery (source: Postal Sector Sustainability Report 2010, International Post Corporation)

Vehicle emission factor = 0.2kg CO_2e/km (Source: Carbon Trust Footprint Expert Database, Diesel Car – average passenger – UK).

7.11.3 Data sources

- BT
- Carbon Trust Footprint Expert Database
- How Video Rental Patterns Change as Consumers Move Online, *Alejandro Zentner, Michael D. Smith, Cuneyd Kaya,* October 2012 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1989614
- Digital Entertainment Group, 2008, http://www.enviro-news.com/news/packaging_reductions_lowering_carbon_footprint_of_dvds.html
- http://business.time.com/2009/08/12/the-battle-of-the-1-dvd-rentals-heats-up/
- Postal Sector Sustainability Report 2010, International Post Corporation

7.12 Field Force Automation

7.12.1 Approach

BT's *Field Force Automation (FFA)* service enables organisations with mobile teams to improve their productivity through a variety of services that can automate scheduling and reporting. Productivity gains come in the form of fewer miles travelled and less labour required to fulfil customer requests.

The fewer miles travelled is the primary mechanism for carbon abatement in the BT abatement analysis. The data is drawn primarily from a case study of Northumbrian Water, a BT customer who uses *FFA*. BT provides different combinations of solutions as part of *FFA* depending on the customer requirements. These range from mechanisms for delivering work orders to fully automated scheduling and distribution of work. Carbon abatement gains are expected to be greater for more extensive solutions. Northumbrian Water's implementation of *FFA* was rather extensive and hence, likely represents a more significant carbon abatement level than customers with less extensive services.

Thus the method for calculating annual carbon abatement from *FFA* (FFA $GHG_{savings}$) based on number of vehicles is as follows:

$$\text{FFA GHG}_{\text{savings}} = \text{GHG}_{\text{FFA savings per vehicle}} \times \text{Vehicle}_{\text{all contracts}}$$

where:

$\text{GHG}_{\text{FFA savings per vehicle}}$ = Annual GHG savings from use of *FFA* per vehicle
$\text{Vehicle}_{\text{all contracts}}$ = Number of vehicles across all BT *FFA* contracts

The number of vehicles across all contracts can be based on existing data to determine an average number of vehicles in each contract, or this can be adjusted based on expected changes in the number of vehicles in each contract over time.

The annual GHG savings from use of *FFA* per vehicle ($GHG_{\text{FFA savings per vehicle}}$) has been estimated based on the data from the Northumbrian Water case as follows:

$GHG_{\text{FFA savings per vehicle}} = Fuel_{\text{FFA fleet fuel savings}} / Vehicles_{\text{fleet}} / GHG_{\text{vehicle}}$

where:

$Fuel_{\text{FFA fleet fuel savings}}$ = Total fuel savings from the use of *FFA* across the entire fleet per year
$Vehicles_{\text{fleet}}$ = The total number of vehicles in the fleet
GHG_{vehicle} = Emissions factor for a single vehicle

Using values of $Fuel_{\text{FFA fleet fuel savings}}$ = 250,000 gallons per year and $vehicles_{\text{fleet}}$ = 760 vehicles from the Northumbrian case study, and GHG_{vehicle} = 3.21 kg CO2e/l from the Defra emissions database for diesel fuel, we calculate a value for $GHG_{\text{FFA savings per vehicle}}$ of 4.8 tons of CO2e per vehicle per year.

This is then used in the abatement analysis to calculate abatement emissions from *FFA*, making use of growth volumes in terms of total numbers of vehicles across all *FFA* contracts.

7.12.2 Assumptions

The following assumptions were used:

1. The fleet size, mileage driven for each vehicle, transportation emissions factor, and mileage reduction due to *FFA* in the Northumbrian Water case study is representative of all contracts.
2. The abatement will continue at the same level in the future. That is, the BAU remains the same.

7.12.3 Data sources

BT relies on data from a case study of Northumbrian Water: *Mobile staff optimisation allows a more sustainable business*.
http://www.btplc.com/Responsiblebusiness/Ourstory/Casestudies/Europe/NorthumbrianWater.htm

7.13 Data centre services

7.13.1 Approach

BT provides data centre services in a number of ways, including:

- **BT Virtual Data Centre** - Virtualised servers, storage and networking. Managed via an online portal, hosted in our data centres.
- **Managed hosting** - BT designs and builds the data centre solution with a choice of hardware and operating systems. BT monitors and manages the data centre, infrastructure, server hardware, and manages the operating system to a standard agreed Service Level Agreement.
- **Telehousing / co-located services** - Customer owned equipment in a BT data centre environment. The customer designs, builds, and manages the solution and has access to the data centre.
- **Customer premise managed hosting** - A managed service within the customer's premise. BT either takes on the IT management of the customer's existing IT estate or the customer designs and delivers a new service all within their own premises.

When implementing the BT Data Centre Services solution, a customer moves from a combination of dedicated IT and private cloud servers to a BT public cloud solution.

- **Dedicated IT:** each office has their own dedicated IT systems with their own servers, software applications and development platforms (4)
- **Private Cloud:** a company has consolidated all their disparate servers and applications onto one company wide system that is maintained behind their firewall and can be accessed across their intranet (4)
- **Public Cloud:** Instead of owning and running their own IT systems and hardware, a company procures the service from specialist providers and can access the service from anywhere on the internet (4)

There are significant carbon savings to be realised from moving to the 'cloud'. The sources of these savings tend to be:

1. Increased utilisation of servers – for example, dedicated IT has to be built to handle peak demand, which may only be needed once a month. Cloud computing allows smoothing of peak loading requirements over a number of companies.
2. Improved Power Usage Effectiveness (PUE) – the ratio of energy required on top of direct server energy requirements (e.g. for cooling). Cloud based services tend to have a better PUE performance.

Definitions:
VM = Virtual Machine
PUE = Power Usage Effectiveness

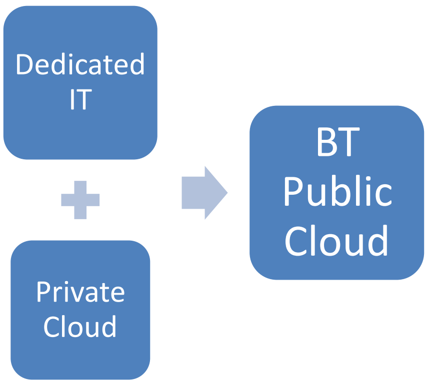
The following approach was used for calculating the CO_2e savings:

Annual CO_2e savings = CO_2e emissions per server in pre-BT configuration x No. of virtual machines deployed by BT

Three different types of servers were looked at:

- Public cloud computing
- Private cloud computing
- Dedicated IT

The modelling assumes a customer moves from a typical mix of private cloud computing and dedicated IT to BT public cloud computing. Through this move, the customer will benefit from greater server utilisation and an improved PUE, and therefore lower energy use and carbon footprint.



CO_2e emissions were calculated per server for a customer before BT has implemented their solution; this reflects a typical split between private cloud computing and dedicated IT for an enterprise.

Total annual CO_2e savings were modelled as:

$$\text{Total annual } CO_2\text{e savings} = EF_{Before} \times \text{Number of VMs}$$

Where,

EF_{Before} = Average CO_2e emitted per server before BT solution

Number of VMs = Number of Virtual Machines deployed by BT

It should be noted that the increased emissions for BT do not need to be considered here as they are included within BT's scope 1, 2 and 3 emissions.

Modelling methodology

A weighted average power consumption for a physical server was calculated. Data was found for small, medium and large volume servers for:

- Total installed base worldwide (volume)
- Typical server power

The weighted average power consumption for a server was calculated as:

$$\text{Power}_{average} = \frac{(\text{Power}_{small} \times \text{Volume}_{small} + \text{Power}_{medium} \times \text{Volume}_{medium} + \text{Power}_{high} \times \text{Volume}_{high})}{\text{Volume}_{total}}$$

where the powers in the equation are the typical server powers for that class of server.

For the purpose of calculations, a notional number of 100 physical servers was used before BT's service was implemented. This number of physical servers was then converted to an equivalent number of Virtual Machines (VMs) so that the CO_2e saving per virtual machine could be calculated. The split between private cloud and dedicated IT was taken for a typical enterprise.

$$\propto = \text{Number of Virtual Machines per 100 physical servers pre-BT's solution}$$

The CO_2e emissions were calculated for a typical customer before BT's involvement (with the notional total number of physical servers of 100 used for the calculations).

$$\begin{aligned}\beta = {} & CO_2\text{e emissions per 100 physical servers pre-BT solution} \\ & = \text{Power}_{average} \times \text{Grid Emission Factor} \times T \times 100 \\ & \times [(\text{Proportion}_{private\ cloud} \times \text{PUE}_{private\ cloud}) \\ & + (\text{Proportion}_{dedicated\ IT} \times \text{PUE}_{dedicated\ IT})]\end{aligned}$$

Where:

$\text{Proportion}_{private\ cloud}$ = Typical proportion of physical servers that are private cloud

$\text{Proportion}_{dedicated\ IT}$ = Typical proportion of physical servers that are dedicated IT

T = time servers run for annually

Based on BT experience:

$\text{Proportion}_{private\ cloud} = 40\%$

$\text{Proportion}_{dedicated\ IT} = 60\%$

This is in line with other sources – Veeam report that 38.9% of all servers within enterprises are virtual.

To convert this to a CO_2e emission per virtual machine, the number of virtual machines per physical server was calculated. The assumptions were that:
For dedicated IT, 1 virtual machine maps to 1 physical server.
For private cloud, the conversion ratio for number of virtual machines per physical server was calculated as:

$$\text{Conversion ratio} = \frac{\text{Average Utilisation}_{\text{private cloud}}}{\text{Average Utilisation}_{\text{dedicated IT}}}$$

The CO_2e emissions for a customer per virtual machine in the non-BT configuration were calculated as:

$$\text{EF}_{\text{before}} = \text{CO}_2\text{e emissions per virtual machine pre-BT solution} = \frac{\beta}{\propto}$$

7.13.2 Assumptions

- Assumes a company who BT wins a contract with will have a typical split between private cloud computing and dedicated IT.
- It is also assumed that BT implements the solution within the original country where the non-BT servers were located i.e. does not achieve carbon savings by moving servers to a different country with a lower grid emission factor.
- Assumes servers run 24/7 throughout year.
- Assumes customers are global (and hence a global grid electricity emission factor has been used, source: Carbon Trust Footprint Expert Database)
- Weighted average server power consumption 295 W
- Customer dedicated PUE = 2, Customer private cloud PUE = 1.8
- It was also assumed that the average length of contract is 3 years.

7.13.3 Data sources

- BT
- Carbon Trust Footprint Expert Database
- http://hightech.lbl.gov/documents/data_centers/svrpwrusecompletefinal.pdf
- http://ericksonstrategies.com/wp-content/uploads/2014/06/2011_Cloud-Computing-The-IT-Solution-for-the-21st-Century.pdf
- http://www.computerweekly.com/tip/Data-centre-cases-where-PUE-or-power-usage-effectiveness-doesnt-work
- http://www.veeam.com/news/veeam-v-index-q3-results-are-released148.html

7.14 Cloud Contact

7.14.1 Approach

BT's Cloud Contact is a hosted contact centre management service including call management, reporting, integration toolkit, recording of customer calls, and contact prioritization. Cloud Contact provides all web-based access channels, including email, chat, co-browsing, voice and call back, included as needed by the customer.

Migrating services from individual sites to a cloud based solution results in a net carbon reduction from the economies brought through an efficient use of shared and virtualised infrastructure. The same approach for calculation of the carbon abatement has therefore been adopted as for Data Centre Services. Please see section 7.13 for further detail.

7.14.2 Assumptions

Average power consumption per server is 295 W.
Customer PUE factor is 2.
Servers are running 24 hours per day, 365 days per year.
This gives a figure of 1.63 t CO_2e per server per year.

The carbon abatement assumes that 50% of the servers migrated are from external customers (the remaining being migration of BT operated servers). The emissions from BT's servers are already accounted for within BT's Scope 1 & 2 emissions, and therefore are excluded from the carbon abatement calculations.

An average of 20 servers per customer was assumed.

Thus giving a carbon abatement per customer of 1.82 x 50% x 20
= 18.2 t CO_2e per customer.

7.14.3 Data sources

BT internal data.
(See also data sources for Data Centre services, section 7.13.3).

7.15 One Cloud

7.15.1 Approach

BT's One Cloud service provides hosted unified communications for BT's customers, providing one global network for all of a customer's communications including voice, web and video conferencing, presence and mobile devices.

The carbon abatement for One Cloud is due to replacing equipment with more energy efficient equipment and involves moving to a virtualised Cisco UCS platform (thus providing private network switching in BT's network as opposed to a customer based PABX or IPT server). A similar approach has therefore been adopted as for Data Centre Services (in terms of calculating the energy a customer no longer directly uses due to switching off equipment). Please see section 7.13 for further detail.

7.15.2 Assumptions

Average power consumption per 1000 users is 372 W. [BT internal data].
Equipment is running 24 hours per day, 365 days per year.
This gives a figure of 1.03 t CO_2e per 1000 users per year.

The carbon abatement assumes that 50% of the equipment is migrated from external customers (the remaining being migration of BT operated equipment). The emissions from BT's equipment are already accounted for within BT's Scope 1 & 2 emissions, and therefore are excluded from the carbon abatement calculations.

7.15.3 Data sources

BT internal data.
(See also data sources for Data Centre services, section 7.13.3).

7.16 Managed mobility

7.16.1 Approach

Telecommunication services provided by BT enable employees to work flexibly while away from the office. This enables mobile workers to access their enterprise network, data and applications through a secure broadband connection.

A specific example of this is the N3 network that BT provides to the NHS. There are a number of examples where use of the N3 network enables more flexible working and thus carbon savings. The BT NHS N3 case study identifies carbon savings of 1,250 tCO2e from use of the N3 VPN (Virtual Private Network) by NHS staff using remote access to the network and thus avoiding travel.

7.16.2 Assumptions

NHS Case Study reports annual savings of 1,250tCO_2e.
(This saving will be accounted for each year that BT provide the N3 network service to the NHS).

7.16.3 Data sources

N3SP Case Study: NHS + N3 = Sustainability
https://www.btplc.com/Betterfuture/NetGood/OurNetGoodMethodology/N3NHSSustainabilityv6[1].pdf

7.17 Inbound calling

7.17.1 Approach

BT's Inbound calling service provides global call management and routing services. Part of the Inbound calling service is sold to external third party conferencing providers. BT provides the global infrastructure of switches and connections to support the conferencing capability provided by the external conferencing providers.

In a bit more detail, the following describes the process:

> The Inbound calling product provides the external wholesale conferencing provider with telephone numbers for all the countries in which they buy service from BT.
>
> When an end user customer wants to join a conferencing bridge, they make a call, usually from a domestic in-country public network somewhere in the world and a local provider connects that call to the nearest BT point of presence in that country. (The local connection is paid for by BT and provided as part of the Inbound Calling service).
>
> The call is then switched in the BT point of presence in a BT data centre onto BT's global network, which carries the call to another BT point of presence where it is switched to the wholesale conferencing provider's conferencing bridge. The conferencing bridge provides the functionality to join the separate individual calls into the conference.

The carbon abatement is due to avoided travel, as the conference participants do not travel to a physical meeting, but hold the meeting by audio-conferencing instead. As BT provides the infrastructure which allows the conference calls to take place, and without this it would not be possible, the carbon savings are attributed to BT's Inbound Calling service.

The carbon savings per conference call are calculated on the same basis as for Audio Conferencing (see section 7.7), based on the conferencing study survey carried out by the University of Bradford. This study considers a number of factors including: length of meeting, number of call participants, whether a physical meeting was avoided, number of participants avoiding travel and travel distance avoided. Based on these factors the study determined an average carbon abatement of 28.1kg of CO_2e per call.

The number of conference call minutes sold as part of the Inbound Calling service to external conferencing services, was converted to the number of calls, based on an average number of billable minutes per call. The number of conference calls per year was then multiplied by the carbon abatement per call to calculate the total carbon abatement per year, as follows:

Inbound calling conferencing $GHG_{savings} = GHG_{\text{AC avoided per call}} \times BT_{\text{Inbound calling conference calls}}$

where:
$GHG_{\text{AC avoided per call}}$ = GHG emissions avoided from one call
$BT_{\text{Inbound calling conference calls}}$ = Number of conference calls using the BT Inbound Calling service in one year

7.17.2 Assumptions

The following assumptions were used in this calculation.

1. The estimated abatement from the University of Bradford survey sample is representative for the Inbound Calling conference calls. (This is likely to be a conservative estimate, as the University of Bradford study relates to use of conferencing by BT staff predominantly in the UK, while the Inbound Calling conferencing is likely to be more global in nature and therefore would have a higher carbon abatement per call).
2. The abatement will continue at the same level in the future. That is, the BAU remains the same.
3. A carbon abatement of 28.1kg of CO_2e per call.

7.17.3 Data sources

BT internal data (for number of call minutes and number of calls).
The most recent University of Bradford BT study was used: Peter James, *Conferencing at BT: Results of a Survey on its Economic, Environmental and Social Impacts*, October 2012.
A summary of which is available at: http://www.btconferencing.co.uk/case-studies/case-study-on-bt-sustainability-value-in-a-virtual-world_en.pdf

7.18 Super-fast broadband enabled dematerialisation

7.18.1 Approach

BT provides two different types of broadband: Asymmetric Digital Subscriber Lines (ADSL) and Next-Generation Access (NGA) lines. NGA uses fibre optic cables and is also known as super-fast broadband. ADSL provides line speeds up to 20 Mbps, at an average of 8 Mbps; NGA speeds can be up to 80 Mbps with an average of 35 Mbps.

The model for 'Broadband Enabled Dematerialisation' (i.e. for ADSL) does not anticipate any growth in the carbon savings per broadband line. This is consistent with the fact that the rate of traffic growth on this network has slowed.

However, per-line traffic on the superfast broadband network is growing strongly. This suggests that the increased access speeds associated with Next-Generation Access (NGA) broadband are driving the uptake of benefits associated with digital distribution of goods and services.

BT has developed a methodology to quantify these abatement benefits. The benefits are dematerialisation and travel savings, which are partially offset by increased home energy use (such as laptops, e-reader, etc.) and server energy use.

Carbon benefits

The benefits considered are abatement of:

- Embodied carbon from the de-materialisation of CDs, DVDs, Games, Books, newspapers and mail. Benefits from video rentals are not considered as these benefits are captured in the service offering 'BT Vision'.
- Transport emissions savings from personal travel reductions associated with shopping. These savings are offset to a certain extent by an increase in courier travel

Carbon costs

These benefits are off-set against the increased carbon emissions (or carbon costs) associated with use of the Internet:

- The emissions associated with data centres which support the electronic goods and services
- Additional electronic equipment within the home, specifically laptops, PCs, smartphones, games consoles, e-readers and tablet computers. The BT home hub and BT vision box are not included as these are captured elsewhere in the 3:1 carbon abatement model. The model also excludes TVs, TV-related set top boxes and music players as there is no indication of a growth in these devices being triggered by network based services. For example, an internet-enabled music player often replaces a portable cassette or CD player.

Modelling methodology

The model used a baseline year of 2007 (before noticeable de-materialisation had occurred). National trends were then used to model the potential carbon savings and costs out to 2020. Due to inherent uncertainty in some of the projected figures, a Monte Carlo simulation was run to identify the most likely net carbon benefit. This benefit was then allocated on a per-NGA line basis to get the carbon saving per NGA broadband line.

The Monte Carlo simulation was also run for 2012 and the output closely matched the figure used for ADSL (i.e. the result from the Yankee Group study).

A straight line project was used to model the change in carbon benefit between now and 2020.

Note: The abatement for superfast broadband for 2012/13 was captured in the ADSL broadband abatement (as the carbon saving per broadband line for superfast broadband in 2012/13 was the same as for ADSL).

7.18.2 Assumptions

To estimate the amount of de-materialisation, data was used that was available at a national level on the quantity of goods purchased within the UK. In some cases, the move to electronic delivery has also led to an increase in the number of sales; in this situation the volume of goods is based on data from 2007 - before noticeable dematerialization occurred (i.e. to avoid including the 'rebound effect'). Industry statistics were used on the percentage of those goods that are delivered electronically.

To estimate the travel savings, national statistics are used which show both how the distance travelled for shopping activities has declined and how the courier/parcel delivery sector has grown. Whilst the recession and high fuel prices could be considered as the reason behind the decline in shopping related travel, it is suggested that this is in fact a push-pull situation – the push being the fuel cost and the pull being the availability of a low cost ICT-based alternative. The carbon savings have been calculated based on the carbon footprint for each mode of transport weighted by proportion of the travel distance that use that form of transport, again based on national travel statistics.

To model the costs associated with the increased use of electronic devices within the home, data has been gathered on: penetration of different device types within the home; typical power consumption; lifetime energy use; and embodied energy for each of these device types. A share of the in-use and embodied carbon has been allocated as a network cost, the share being device dependent. For laptops and PCs, the total device use time was compared to the time spent on the network. For devices such as e-readers, 100% of the cost was allocated against the network as these devices fundamentally rely upon the network connectivity. For smartphones 50% was allocated to the fixed network and 50% allocated to a mobile network.

7.18.3 Data sources

Data	Source
Laptop, PC, games machine: device penetration	Ofcom
Laptop, PC, smart phone: embodied and in use energy	http://www.apple.com/uk/environment/reports/
Games machine: embodied and in use energy	Assumed similar to PC/laptop
Percentage of time in use where devices are allocated to network	Ofcom
Mobile phone: device penetration	Assume grows to laptop levels by 2020
Small games: device penetration	Assume grows to game machine levels by 2020
Small games: embodied energy and in use energy	Assumed same as iTouch http://www.apple.com/uk/environment/reports/
ereader: device penetration	Assume grows to game machine levels by 2020
ereader: embodied energy and in use energy	Assumed same as iTouch http://www.apple.com/uk/environment/reports/
tablet: device penetration	Assume grows to laptop levels by 2020
tablet: embodied energy and in use energy	Assumed same as iTouch http://www.apple.com/uk/environment/reports/
External data centre/network emissions	Used BT Energy model and Smart2020 outputs
Number of music items bought a year in UK	http://www.bpi.co.uk/assets/files/music%20sales%20slip%20in%202011%20but%20digital%20grow%20strongly.pdf
Number of videos bought a year in UK	http://www.guardian.co.uk/media/2010/nov/29/dvd-industry-sales-slump-blu-ray
Number of computer games bought a year in UK	http://www.eraltd.org/info-stats/overview.aspx
Number of books bought a year in UK	http://news.bbc.co.uk/1/hi/business/7886420.stm
Number of newspapers bought a year in UK – based on 2007 levels and rate of decline	http://www.theguardian.com/media/2013/sep/06/daily-mail-mirror-star-circulation-august http://www.theguardian.com/media/2010/jun/17/newspaper-circulation-oecd-report
Number of items mailed a year in UK	Ofcom CMR 2013
% music items digital	http://www.bpi.co.uk/assets/files/music%20sales%20slip%20in%202011%20but%20digital%20grow%20strongly.pdf
% videos digital; % games digital	http://www.eraltd.org/news/era-news/digital-entertainment-exceeds-£1bn-in-sales-for-the-first-time.aspx
% books digital	www.nytimes.com/2011/05/20/technology/20amazon.html?_r=0
% newspapers digital	Assume all papers no longer printed have been replaced by digital news alternatives; assume current rate of decline continues to 2020
% mail digital	Ofcom CMR 2013
Embodied CO_2e per disc	Weber, 2010

Data	Source
Embodied CO_2e per book	Minimum value: academic calculation (Quantis 2011, Borggren 2011, Pihkola 2010); Mid value: Penguin Books, trusted UK industry – http://www.penguin.co.uk/static/cs/uk/0/aboutus/greenpenguin/whatwecandotohelp.html; Max value: US book industry, http://www.ecolibris.net/bookpublish.asp
Embodied CO_2e per newspaper	http://www.theguardian.com/environment/green-living-blog/2010/nov/04/carbon-footprint-newspaper for footprints of different newspapers. Use typical sales of each paper: http://www.businesspost.ie/#!story/Home/Media+And+Marketing/British+newspaper+sales+plummet+in+new+ABC+figures/id/19410615-5218-4f10-6d60-cbed55918080 ; and UK recycling rates: http://www.businesspost.ie/#!story/Home/Media+And+Marketing/British+newspaper+sales+plummet+in+new+ABC+figures/id/19410615-5218-4f10-6d60-cbed55918080 to estimate of footprint of average UK newspaper
Embodied CO_2e per mail item	http://www.eauc.org.uk/file_uploads/7__calculation_of_the_ef_of_a4_paper_use_by_nicola_hogan.ppt
Weighted CO_2e per person mile	Carbon footprint for each mode of transport (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69554/pb13773-ghg-conversion-factors-2012.pdf) weighted by proportion of people miles that use that form of transport (https://www.gov.uk/government/statistical-data-sets/nts04-purpose-of-trips). Trends in improvement in transport efficiency taken from http://assets.dft.gov.uk/statistics/series/energy-and-environment/climatechangefactsheets.pdf
Baseline miles travelled (shopping only)	Average from National Travel Statistics, 2000-2007
% miles saved per year	Projection of miles saved since 2007 out to 2020 (https://www.gov.uk/government/statistical-data-sets/nts04-purpose-of-trips) This figure is then adjusted for growth observed in the courier/parcel sector (https://www.gov.uk/government/statistical-data-sets/env02-greenhouse-gas-emissions)

7.19 Broadband enabled SME use of Cloud computing

Background

Cloud-based services help organisations meet corporate IT needs without the need to own, operate and maintain their own physical IT assets. Numerous studies have shown that cloud services offer a more energy (and carbon) efficient delivery of services[2][3][4].

The primary energy and carbon savings offered by cloud services result from:

- Higher server utilization as a result of using virtualization technologies, or virtual machines
- Improved Power Use Effectiveness (PUE) as a result of more efficient mechanical and electrical systems to power and cool the IT equipment
- Data centre and cloud service providers increasingly buying renewable energy to offset carbon emissions from their infrastructure

The transition to hosted Cloud services is a significant trend across businesses of all sizes and is enabled by reliable high-speed broadband infrastructure.

Cloud services include software applications that are accessible to customers from various devices via a web browser or another program interface, collectively known as Software as a Service (SaaS). These include:

- E-mail (e.g. Google mail, Yahoo mail, Microsoft Exchange email etc.)
- CRM (e.g. Salesforce)
- Groupware (e.g. MSFT SharePoint)
- Office productivity (e.g. Microsoft O365, Google Apps)
- Accounting (Financial management software),
- Document Management (e.g. Dropbox)
- IT asset and operations management and security services
- Human resource management systems,
- Field service software, and other productivity enhancing applications (e.g. BT Field Force)

Other cloud services include:

- Infrastructure as a Service (e.g. Amazon, IBM, BT)
- Platform as a Service (e.g. Salesforce, Amazon, Microsoft Azure)
- Colocation data-centre services

7.19.1 Approach[5]

The carbon abatement is due to transition to hosted cloud services by SMEs, thus saving energy due to consolidation of servers, virtualisation and cloud efficiencies. The carbon abatement allocated to BT is based on the percentage of broadband lines that BT provides to the SME market, i.e. the broadband infrastructure provided by BT that enables the transition to the cloud.

The scope of this current cloud enabled carbon abatement is limited to three SaaS applications: email, CRM and Groupware. Additional cloud applications and services may be added in the future. The scope is limited to Small to Medium-Sized Enterprises (SMEs) up to 1000 employees.

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[2] GeSI (2012). SMARTer 2020: The Role of ICT in Driving a Sustainable Future. The Global e-Sustainability Initiative.
[3] Accenture (2011). Cloud Computing and Sustainability: The Environmental Benefits of Moving to the Cloud. Accenture & WSP;
[4] Carbon Disclosure Project (2011). Cloud Computing – The IT Solution for the 21st Century. Carbon Disclosure Project & Verdantix, London, UK.
[5] The methodology for the carbon abatement of broadband enabled SME use of Cloud Computing was developed by Anthesis for BT.

The before-Cloud "base case", assumes email, CRM and Groupware applications are hosted on on-site servers. The post-Cloud scenario assumes the applications are hosted on cloud servers. A nominal base-year of 2007 is used, which is the date Google's gmail, one of the earliest widely used cloud-based email service was made available for general public use. 2007 also coincides with the start of exponential growth in the number of subscribers to leading cloud-based CRM services provided by Salesforce and Microsoft Dynamics[6].

The calculation to determine the GHG reduction associated with BT broadband services is summarised as:

Cloud services enabled CO_2e savings	=	On-Site CO2e reduced from a move to cloud services*	-	CO2e generated by replacement cloud services**
*On-Site CO2e reduced from a move to cloud services	=	Annual CO2e generated by on-site computer services	x	Cloud services adoption rate
**CO2e generated by replacement cloud services	=	Annual CO2e generated by replacement cloud services	x	Cloud services adoption rate

The scope of the emission sources included and excluded from the analysis are provided in the following table:

Table: <u>Scope of cloud enabled GHG reductions.</u>

	Primary	Secondary
A direct decrease in emissions	In Scope: GHG emissions saved by switching off on-site servers Out of scope: dematerialisation (e.g. no more CD's for software)*	Out of scope: additional applications
A direct increase in emissions	In Scope: GHG emissions associated with the full lifecycle (build use, disposal) of replacement cloud infrastructure	No secondary direct ICT emissions
An indirect increase "rebound effect"	Out of scope: the potential that cloud may increase demand for computing	Out of scope: the potential that enterprises redeploy redundant on-site servers for new capacity

* It should be noted that dematerialisation caused by moving from in-house to cloud-based services is captured elsewhere in the 'Broadband enabled dematerialisation' section of the 3:1 carbon abatement model (section 7.10).

It is assumed that Cloud services would not be viable in the UK without reliable high speed broadband infrastructure being available and as a result, BT can claim the enabling effect for each business broadband line that it provides (i.e. the broadband infrastructure).

[6] http://leontribe.blogspot.com/2010/07/dynamics-crm-vs-salesforce-user.html

7.19.2 Assumptions

While this analysis found a lack of studies that explicitly correlate the uptake of cloud services with the availability of reliable high-speed broadband infrastructure, it is assumed for the purposes of this analysis that it is a fundamental “enabler”:

- Bandwidth requirements for cloud services is a complex topic and depends on the cloud service being used; e-mail tends to be fairly easy on the bandwidth; more complex Groupware like SharePoint can place heavy per-user demands on an Internet connection. On top of bandwidth, there are also important latency considerations. Spikes in latency and shortages in bandwidth at best mean that e-mails will trickle in a little more slowly. At worst, they'll sap productivity or bring down the phone lines[7].
- A SME will typically utilise a range of standard business applications concurrently that require broadband network access, including web browsing, voice & video, conferencing and file sharing services. Cloud services are typically layered on top of these existing applications, giving rise to further demand for bandwidth.
- Various network bandwidth calculators available from network and cloud service providers on the Internet illustrate bandwidth requirements that necessitate broadband infrastructure. An example is provided in the data sources, which shows estimated upload and download speeds required by an illustrative business services SME.
- Reliability of internet connection and service is also an important driver for cloud services. Poor network reliability can severely undermine the value of cloud services to business. BT’s broadband infrastructure provides consistently reliable bandwidth, backed by a customer service level commitment covering internet access, email availability and website hosting, which are important enablers for cloud service providers.

Calculation methods and assumptions are based on the approach provide by the recent study led by Dr Peter Thomond (2013): “The Enabling Technologies of a Low-Carbon Economy: A Focus on Cloud Computing”[8] The approach is a hybrid life cycle assessment (LCA) approach, which combines LCA “Process Sum” data with Economic Input-Output (EIO) data to model the impact at a national level.

Based on the available data within the study the particular cloud services considered are the following applications:

- Email (based on Microsoft Exchange®)
- Customer relationship management (CRM) (based on Microsoft Dynamics CRM®)
- Groupware (based on Microsoft SharePoint®)

The table below provides a description of the systems and emission sources included in the assessment.

Table: System Description and emission sources

System	Description	Emission Sources included
“Cloud Computing”		In-use energy for:

[7] Meeting the bandwidth demands of taking your business into the cloud. Peter Bright, Sept 17 2013. http://arstechnica.com/information-technology/2013/09/meeting-the-bandwidth-demands-of-taking-your-business-into-the-cloud/

[8] Dr Peter Thomond (2013): “The Enabling Technologies of a Low-Carbon Economy: A Focus on Cloud Computing” Lead Sponsors: Microsoft & the Global e-Sustainability Initiative
http://gesi.org/assets/js/lib/tinymce/jscripts/tiny_mce/plugins/ajaxfilemanager/uploaded/Cloud%20Study%20-%20FINAL%20report_2.pdf

	Virtual distribution and use of computing services, via dedicated Data Centres	(1) servers (2) network services (3) server cooling systems (4) data centre buildings Embodied carbon in: (5) servers
Business as usual "On-site Computing"	Computing services provisioned via on-site servers	(1) servers (2) network services (3) server cooling systems (4) on-site server rooms/data centres

A number of updated assumptions have been made to Peter Thomond's study. Key changes are as follows:

Aspect	**Peter Thomond**	**BT**
SME demographics and employee Internet use	Eurostat (2010) Persons employed using computers connected to the Internet in their normal work routine at least once a week.	UK Office of National Statistics (ONS) company data 2012
SME demographics	3 Eurostat SME categories considered: • Small Enterprise (1-49) • Medium Enterprise (50-249) • Large Enterprise (250-999)	4 ONS SME categories considered: Category • 0-9 staff • 10 – 49 staff • 50 – 249 staff • 250 - 999 staff
SME employee email, CRM and groupware user	Estimates	Estimates updated by correlating with the proportion of employees using computers and the Internet Access for their work at least once a week in year 2013 (ONS data). For 0-9 staff SME's it is assumed they all use cloud-based email services and none of them use CRM or Groupware services.
Server Energy consumption	Analysis based on the number of servers shipped in 2010 worldwide (IDC/ Gartner data) applying the manufacturers power specification of top 10 models sold and an assumption that average power consumption is 70% of the manufacturer's specification	Weighted average used for all servers by the 3:1 carbon abatement model for Data Centre services
CRM, Email and Groupware Cloud adoption rates amongst SMEs	Due to lack of available industry data, assumptions are drawn from a cross-industry panel of ICT leaders.	These assumptions were adopted from the Peter Thomond Study. However, more industry survey data would be beneficial to improve confidence in estimated adoption rates.

BT Business allocation

The carbon abatement is calculated for SMEs using cloud based services for email, CRM and groupware as a whole in the UK, based on the assumptions described above. A portion of this is then allocated to BT, based on the estimated market share that BT has of the SME broadband market.

This percentage allocation is calculated based on the number of BT Business broadband lines, divided by the total UK business market of broadband lines.

7.19.3 Data sources

- Dr Peter Thomond (2013): "The Enabling Technologies of a Low-Carbon Economy: A Focus on Cloud Computing" Lead Sponsors: Microsoft & the Global e-Sustainability Initiative http://gesi.org/assets/js/lib/tinymce/jscripts/tiny_mce/plugins/ajaxfilemanager/uploaded/Cloud%20Study%20-%20FINAL%20report_2.pdf
- A number of assumptions and input data regarding on-site and cloud infrastructure requirements are adopted from this study, including: CRM, Email and Groupware Cloud adoption rates by SMEs, which due to lack of available industry data, assumptions were drawn from a cross-industry panel of ICT leaders.

Office of National Statistics:
- Number of Small to Medium Size Enterprises by Size Category and Sector (2013) – no update since
- Number of Employees in Small to Medium Size Enterprises by Size Category and Sector (2013) – no update since
- Internet and Software Adoption by Small to Medium Size Enterprises (2006 to 2011):
  - Proportion of businesses with Internet access and type of connection, by size of business,
  - Proportion of businesses using business software, by size of business,
  - Proportion of employees using computers and the Internet for their work at least once a week, by size of business.

Average Server Consumption is based on data in paper by Jonathan G. Koomey, Ph.D (Lawrence Berkeley National Laboratory and Stanford University), "Estimating total power consumption by servers in the U.S. and the world", which in turn is based on IDC data. http://hightech.lbl.gov/documents/data_centers/svrpwrusecompletefinal.pdf

Figures for the percentage of the UK Business broadband market served by BT, is from BT internal data.

Example Network Service Provider Bandwidth Calculator: http://www.integratelecom.com/resources/Pages/a/big-data-network-bandwidth-calculator.aspx For a SME company in the Business Services sector with 2 locations and 15 employees, this calculates a total bandwidth requirement of 8.7 Mbps upload speed, and 15.6 Mbps download speed.

7.20 Recycling of copper cables

7.20.1 Approach

As BT rolls out fibre optic cables, large quantities of older, predominately copper cables, can be recovered from disused networks across the UK and recycled. By recycling the copper and lead within the cables, BT is preventing the need to produce more copper and lead from virgin ore.

Our methodology follows a consequential approach, where the alternative would be to leave the copper cables in the ground. For copper, we have considered the most common pyro-metallurgical production process. Thus, recycling of the copper prevents the need for the energy intensive copper ore mining and beneficiation, and copper concentrate roasting and smelting processes. Scrap copper is added at the final process – electrorefining -thus leading to energy and carbon savings compared to copper production from virgin ore.

It is assumed that every tonne of recycled material produced prevents a tonne of material being produced from virgin ore, thus:

CO_2e savings from recycling BT copper cables	=	CO_2e generated though producing metals from virgin ore	-	CO_2e generated by recycling metals

The materials recovered from the copper cables have been identified as high grade copper, lower grade copper, lead, tarry lead, iron and waste. Tarry lead is poor quality lead that cannot be recycled as easily as high grade lead and is therefore excluded from the calculation. Low grade copper is excluded due to lack of data on the greenhouse gas emissions resulting from recycling it and it only equates to 2% of the weight. Iron is excluded as it is just 1% of the cables by weight and waste from the cables is also excluded as it cannot be recycled.

Thus, the carbon savings are calculated from recycling the high grade copper and the lead content from the cables. (Together these make up approximately 75% of the total cable by weight).

CO_2e savings from recycling high grade copper	=	CO_2e generated though producing virgin copper	-	CO_2e generated though recycling high grade copper
CO_2e savings from recycling lead	=	CO_2e generated though producing virgin lead	-	CO_2e generated though recycling lead

Suitable emission factors for copper and lead production were researched (see below for sources). For primary copper production (from virgin copper ore) the pyro-metallurgical process was assumed as this is globally much more common than the hydro-metallurgical process. Where emission factors were expressed in different functional units, these were converted into kgCO_2e/kg copper. For secondary copper production (from copper scrap), only emission factors for production from high grade scrap were used. Average emission factors were derived from the different factors that had been sourced.

A similar process was undertaken for lead emission factors, taking averages of secondary and primary lead emission factors. Emission factors that are based on a theoretical minimum energy requirement or are specific to a unique production process or country were excluded.

The following average factors were used in the calculations:

Production Process	Average emission factor ($kgCO_2e/kg$)
Primary copper production (from virgin copper ore using the pyro-metallurgical process)	3.62
Secondary copper production (from high grade copper scrap)	1.05
Secondary copper production (from low grade copper scrap)	2.93
Primary lead production (from virgin lead ore)	2.11
Secondary lead production (from lead scrap)	0.66

Taking account of the percentage mix of materials in the recycled cables, this gave an overall abatement figure of 1.67 tCO_2e per tonne of cable recycled.

7.20.1. Assumptions

- It is assumed that recycling copper prevents virgin copper being produced through the pyro-metallurgical process, as only a very small percentage of copper is produced through the more carbon intensive alternative hydro-metallurgical process of production.[9]
- It is assumed that recycling lead replaces lead production through the blast furnace process, the most common process.
- Transportation of the cables to recycling plants is excluded as initial calculations showed it to be less than 1% of the cables' abatement.
- It is assumed due to the poor quality of tarry lead, it is either not recycled or the recycling process requires so much energy that any abatement is de minimus.
- It is also assumed that abatement from iron is minimal as it is just 1% of the cable's material.

7.20.2 Data sources

Prof Sue Grimes, Prof John Donaldson, Dr Gabriel Cebrian Gomez (2008) "Report on the Environmental Benefits of Recycling". Commissioned by Bureau of International Recycling
http://cari-acir.org/wp-content/uploads/2014/08/BIR_CO2_report.pdf

- Primary copper emission factor
- Primary lead emission factor

Inventory of Carbon Energy (ICE) version 2.0, and Inventory of Carbon Energy (ICE) version 1.6a (University of Bath)

- Primary copper emission factors
- Secondary copper emission factors
- Secondary lead emission factor

Norgate, T E and Rankin, W J. (2000) Life cycle assessment of copper and nickel production.

[9] Bureau of International Recycling (aisbl) 2008. "Report on the Environmental Benefits of Recycling". http://cari-acir.org/wp-content/uploads/2014/08/BIR_CO2_report.pdf

http://www.minerals.csiro.au/sd/CSIRO_Paper_LCA_CuNi.htm

- Primary copper emission factor

Lina Piskernik, "A Comparison of the Effects of Primary Copper Mining in Chile and Secondary Copper Mining in Austria and the Resulting CO2 Emissions and Economic Revenues"

- Primary copper emission factor
- Secondary copper emission factor

Ecoinvent 2.2 CT Adapted

- Primary lead emission factors

Figures on the percentage breakdown of the recovered cables, and the weight of total material recycled was provided by BT.

7.21 BT Connect Payments online transactions

Background

Secure online payments transactions reduce the need to use physical cash when money changes hands. BT Connect Payments provides a wide range of connectivity options and has scale to transport billions of credit and debit card payments, and cash machine transactions per annum. It also provides a migration path from legacy technology to feature rich IP transactions, assisting the move toward faster payment solutions.

By providing this service in the UK and Italy, BT is preventing the need for cash to be transported to cash machines and collected from retail units.

7.21.1 Approach

The carbon abatement is due to the reduced need for cash transport with armoured vehicles. Through calculating the average emissions resulting per £ from cash drops, and making assumptions regarding exceptions where cash is not needed to be transported through a cash drop, carbon abatement from BT's Connect Payments service can be calculated.

Total value of transactions enabled by BT	=	Number of transactions	x	Average value of transactions
Total cash drops required to deliver the value of BT enabled transactions	=	Total value of BT enabled transactions	/	Average value of a cash drop
CO_2e from cash drops to the value of BT enabled transactions	=	Total cash drops required to deliver the value of BT enabled transactions	x	Average emissions of a cash drop

$CO2_e$ savings from reduced cash drops to cash machines	=	% of cash transactions requiring a cash drop to a cash machine	x	CO_2e from cash drops to the value of BT enabled transactions
$CO2_e$ savings from reduced cash collections	=	% of cash collections requiring a collection	x	CO_2e from cash drops to the value of BT enabled transactions
BT Connect Payments services enabled CO_2e savings	=	$CO2_e$ savings from reduced cash drops to cash machines	+	$CO2_e$ savings from reduced cash collections from retail units

This gave a carbon abatement factor of 0.14 tCO2e per £1million transferred.

7.21.2 Assumptions

A number of assumptions were made regarding when cash drops are reduced.

- The frequency of cash drops / collections is directly correlated to the volume of cash needing to be transported
- Cash collections result in the same emissions per £ as cash drops

All transactions prevent the equivalent amount of cash being both dropped at a cash machine, and collected from a retail unit in an armoured vehicle. With the exception of:

- Those paid in cash do not require cash to be dropped at a cash machine
- Cash machines at bank branches do not require cash drops
- Cashback transactions prevent the need for cash drops and cash collections
- Cash spent at microbusinesses does not require cash collections as they deal in small quantities of cash so are more likely to drop cash to bank on foot or via personal transport (travel to the bank via personal transport is excluded from calculations due to lack of data)
- It is assumed that abatement from online transactions is the same in Italy as it is in the UK.

7.21.3 Data sources

The total number of transactions enabled by BT and the average value of a transaction was provided by BT.

The average value per cash drop is a result of Carbon Trust research. The emission factor per cash drop used was 5 $kgCO_2e$ which is from a study carried out by the Carbon Trust for Loomis, and published in the relevant Product Emissions Report (available from the Carbon Trust on request).

UK Payment Statistics[10]

- Volume of wages paid in cash and direct into bank accounts (2014 estimate)
- Total number of transactions, and number with cashback (2009)

[10] Payments Council (2010) UK payment Statistics

Rhode and Ward, 2014[11]

- Percentage of UK turnover from microbusinesses (2013)

LINK[12]

- Number of UK cash machines, and number away from bank branches (2009)

7.22 SafePay online transactions

Background

BT SafePay enables businesses and charities to securely take card payments from their customers. The service enables payments to be made over the Internet and the phone, 24 hours a day.

This prevents the need for customers to make payment through traditional paper based methods, such as by cheque. Thus the customer no longer needs to post a cheque, and the bank does not need to process the cheque.

7.22.1 Approach

The carbon abatement is due to the reduced need for posting and processing cheques. Through calculating the emissions resulting from posting and processing cheques, the abatement of the SafePay service is quantified.

SafePay service enabled CO2e savings	=	CO_2e savings from a SafePay transaction	x	Number of SafePay transactions
CO_2e savings from a SafePay transaction	=	CO_2e emissions from posting a cheque	+	CO_2e savings from processing a cheque

This gave a carbon abatement factor of 0.082 tCO2e per 1,000 SafePay transactions.

7.22.2 Assumptions

A number of assumptions were made regarding the SafePay carbon abatement.

- Each SafePay transaction prevents the postage and processing of a cheque
- The emissions of posting a cheque are equivalent to the embodied emissions of an envelope and the emissions equivalent to posting a bill
- The embodied emissions of the cheque itself are ere excluded as they are assumed to be minimal and people will already have a cheque book from opening their bank account

[11] Ward & Rhodes (2014) Small Businesses and the UK Economy. http://www.parliament.uk/business/publications/research/briefing-papers/SN06078/small-businesses-and-the-uk-economy

[12] LINK. Tribute paid to cash machine inventor John Shepard-Barron. http://www.link.co.uk/Media/NewsReleases/Pages/Tribute-to-cash-machine-inventor.aspx

- The emissions from processing a cheque are assumed to not include the postage of the cheque as they are from a study commissioned by Bacs[13], a financial institution with a financial focus. (To note that this is an assumption as it is not clearly stated in the Bacs report.)

7.22.3 Data sources

BACS (2007) Bacs commissions Carbon Footprint Ltd to assess the carbon emissions of a Direct Debit

- Carbon emissions associated with processing a cheque

Carbon Trust Research (2012)

- Embodied emissions from an envelope and posting a bill (equivalent to posing a cheque) - this research was undertaken as part of a comparison between online and paper billing.

The total number of transactions enabled by SafePay was provided by BT.

7.23 TRIAD

7.23.1 Approach

The TRIAD programme is a Demand Response programme operated by the UK National Grid to reduce peak loading on the national grid electricity network. The TRIAD programme refers to the three settlement periods of maximum energy demand within one financial year in winter (usually from November until the end of February, particularly in the evening period). The determination of the TRIAD charges is achieved with the first half hourly (HH) system peak demand and the other two HHs of the next highest demand, which have to be isolated from the system peak demand and from each other by at least ten clear days.

BT takes part in the TRIAD programme by operating back-up diesel generators during forecast peak demand periods, thus supplying BT's own electricity and reducing the demand on the National Grid. This allows a reduction in the requirement to have reserve power plants on stand-by during these periods. These reserve power plants are typically Combined Cycle Gas Turbine (CCGT) plants.

Although generating electricity from diesel generators is more carbon intensive than generating from CCGT, the saving in carbon comes from not having the CCGT plants on stand-by and removing the warm-up and shut-down periods. Diesel generators can warm-up and shut-down very rapidly within 1-2 minutes, while CCGT plants typically require about half an hour for warm-up, and up to an hour for shut-down. Additionally, the CCGT plant may be on 'stand-by' for up to an hour awaiting dispatching instructions from the National Grid.

The carbon savings are calculated based on analysis carried out by the National Physical Laboratory (NPL) for BT. This analysis derived a carbon abatement of 0.503 tCO_2/MWh for a one hour TRIAD period (factors for other time periods are in the table below). The total carbon abatement is calculated by multiplying the relevant factor by the total MWh electricity generated by BT from diesel generators during peak demand periods.

CO_2 savings per MWh of energy generation

[13] BACS(2007) Bacs commissions Carbon Footprint Ltd to assess the carbon emissions of a Direct Debit http://www.bacs.co.uk/Bacs/DocumentLibrary/Carbon_footprint_of_DD_assess.pdf

Duration (hr)	CO_2 savings (tonneCO_2/MWh)
1.0	0.503
1.5	0.264
2.0	0.142
2.5	0.067
3.0	0.022
3.5	-0.013
4.0	-0.041

7.23.2 Assumptions

The key assumptions used in the NPL analysis are as follows:

Criteria	CCGT plant	Diesel generator
Load (capacity) factor	0.50	1.00 (For utility outages lasting a few minutes or a few hours, one or two times a year)
Usage	Standing reserve	Synchronise and standing reserve
Warm-up (start-up) duration	35 minutes	1 minute
Standby duration (awaiting dispatching instructions before generating energy)	0.5 – 1.0 hour	None (instantaneous generation)
Shut down duration	Within 1.0 hour	None
Additional fuel consumption during warm-up period	Yes, at different part-loads	No
Additional fuel consumption during Triad operation	Yes, at 15-20 % operating at part-load	No
Additional fuel consumption during shutdown period	Yes, at different part-loads	No
Hypothetical single set plant capacity	450 MW (gas turbine coupled with steam turbine)	1 MW each (with total of approximately 27 MW in this trial sample)
Transmission and distribution losses	7.7 percent	None
Efficiencies	50 – 52 % at part load; 58 – 59 % at full load	35 %
Carbon intensity	400-365 gCO_2/kWh	710 gCO_2/kWh (35% plant efficiency)

7.23.3 Data sources

E. T. Lau, L. Stokes, and V.N. Livina. "Assessment of carbon savings of the British Telecommunications (BT) participation in the Triad programme of the National Grid (NG)". Technical Report ISSN 1754-2960, National Physical Laboratory (NPL) London, 2014.

7.24 Fleet engine remapping

7.24.1 Approach

Light commercial vehicles are equipped with an Engine Control Unit (ECU) to control key operating parameters including throttle, revs, torque and speed. BT Fleet invested in a significant research programme to investigate ways the engine remapping could be used to optimise commercial vehicle performance to reduce customers' costs. Data findings were so conclusive that BT Fleet initially introduced engine remapping across 24,000 vehicles for the Openreach fleet, and now offers the service to all BT Fleet customers.

BT alters the engine mapping in vehicles in order to reduce fuel use. BT has data for customers on the miles per gallon (mpg) before and after remapping. This difference in efficiency is multiplied by the vehicle mileage following remapping to give a quantity of fuel saved. This fuel saved is then multiplied by an emission factor.

$$\text{Carbon saving} = \text{Difference in fuel efficiency} \times \text{Vehicle mileage post remapping} \times \text{Emission factor}$$

7.24.2 Assumptions

The emission factor for petrol (rather than diesel) was used as this gives the most conservative approach.

7.24.3 Data sources

- Defra Carbonsmart (fuel emission factor)
- BT data on vehicle efficiency improvements and vehicle mileage

7.25 IP Communications

7.25.1 Approach

BT provides businesses with a telephony solution that delivers phone calls via the internet (Voice over IP – or VoIP) rather than through PSTN or ISDN. This solution enables BT's business customers to replace their existing telephone and switch equipment with IP Phones or software based calling applications.

BT offers three different IP Communication services, each suitable for different customers segments. BT Cloud Phone is aimed at small, local business with around 1 to 4 employees. Cloud Voice is aimed at offices with 5 to 50 employees and Cloud UC provides IP Communication services for offices with 100 to 600 employees.

BT's IP Communications products enable carbon savings for BT customers in two ways. First, they reduce the amount of equipment required. Desk phones can be replaced in part by headsets and business will no longer require switches on their premises. Second, the reduction in equipment will result in a reduction in energy usage from communications equipment.

BT provided data on the number of customers that are using each of the three services, as well as the number of seats and switches. BT also provided the percentage distribution of softphones and hardware for each service, as well as data on the power consumption of different phones, switch phones and the percentage split of these devices.

$$\text{IP Communication Carbon Saving} \\ = (\text{Average carbon savings from embodied emissions per seat} \\ + \text{Average carbon savings from energy usage per seat}) \times \text{Number of Seats}$$

A third way in which these products could offer carbon savings is via a reduction in maintenance trips. Fewer maintenance trips would be required as all services would be hosted and managed in the cloud, with support being offered remotely. However, the resulting carbon savings were excluded from the calculation, as maintenance trips to customers are mainly carried out by BT engineers and any reduction in emission would have already been covered under BT's business travel emissions (BT's scope 3 footprint).

7.25.2 Assumptions

Power consumption of phone devices and switches in an idle and in call state were estimated for certain devices based on their maximum power consumption and assuming that typical active power consumption is around 70% of maximum power consumption.

To measure the embodied emissions of an IP phone, it was assumed that these are similar to the embodied emissions of a BT DECT phone.

Embodied emissions of a switch were based on LCA data published by *Teehan and Kandlikar*.

An assumption throughout the modelling is that each seat only has one phone associated with it.

7.25.3 Data Sources

- Data provided by BT for the following items: Number of seats, customers and switches; Average number of phones per switch, Percentage split between Softphones/Hardware for different products; Lifecycle of switches and phones; Energy use and split of devices (Hardware and Switches); Carbon footprint of DECT phone; Average length of a call per year
- Embodied emissions of a headset - Elif Mine Ercan, *Global Warming Potential of a Smartphone: Using Life Cycle Assessment Methodology*, 2013 http://kth.diva-portal.org/smash/get/diva2:677729/FULLTEXT01.pdf
- Embodied emissions of a switch - Paul Teehan and Milind Kandlikar, *Life cycle inventories of newer IT products,* Institute for Resources, Environment and Sustainability, The University of British Columbia, 2011 http://lcacenter.org/lcaxi/final/343.pdf

7.26 BT Mobility

7.26.1 Approach

Under BT's Mobility service, two different products were considered that provide a carbon saving. These allow business to increase the functionality of their employee's mobile phones. BT's One Phone product provides business with the ability to provide their employees with a phone that serves as both a desk phone and mobile phone. BT Autobalance on the other hand allows employees to use their mobile phones both for business and personal use by allowing personal and business calls to be split out.

Both of these BT Mobility services enable carbon savings for BT's customers due to a reduction in physical communications equipment and the resulting reduction in energy usage.

BT One Phone removes the need for a desk phone and leaves employees with one mobile phone that is used both in the office and when mobile. The telephone switch in the office is no longer needed, however in some cases this is replaced by a PICO cell to provide a mobile signal within the office.

BT provided data on the total number of BT Autobalance and BT One Phone users, as well as data on the total number of PICO cells and the power consumption of a PICO cell. Switch and phone power consumption data was also available from BT.

$$\begin{aligned} &Carbon\ Savings\ from\ BT\ One\ Phone \\ &\qquad = (Embodied\ emissions\ of\ a\ desk\ phone + embodied\ emissions\ of\ a\ switch \\ &\qquad + Energy\ usage\ emissions\ from\ a\ switch) \\ &\qquad - (Embodied\ emissions\ of\ a\ PICO\ cell \\ &\qquad + Energy\ usage\ emissions\ of\ a\ PICO\ cell) \end{aligned}$$

Energy usage from desk phones was not included in the calculation for two reasons. First, although customers save the energy that would have been used by the desk phone, there is a possibility that the remaining mobile phone is now being used more frequently and consequently requires more energy. Second, the energy usage from desk phones is assumed to be minimal and as a result immaterial to the overall carbon saving.

BT Autobalance removes the need for employees to possess two separate mobile phones, leaving them with only one mobile phone for both business and personal use. Thus the savings are from the removal of one mobile phone.

$$Carbon\ Savings\ from\ BT\ Autobalance = Embodied\ Emissions\ of\ a\ Mobile\ Phone$$

The reduced energy usage from the additional mobile phone that is no longer requires are not included in the carbon savings, as the savings are minimal and uncertain, as energy usage of the remaining phone could increase as it is now used for both business and personal purposes.

7.26.2 Assumptions

Power consumption of switches were estimated based on their maximum power consumption and assuming that a typical active power is 70% of maximum power consumption.

The embodied emissions of an average desk phone were assumed to be similar to those of a BT DECT phone, while the average embodied emissions of a mobile phone were assumed to be an average of the embodied emissions of a Nokia Lumia1520 and an iPhone 5s. The embodied emissions of a mobile phone include the emissions from the materials and the energy used in the production process, transportation and the end-of life, but excludes the use phase of the devices. Embodied emissions of a switch were based on LCA data published by *Teehan and Kandlikar*.

7.26.3 Data sources

- Data provided by BT for the following items: Total number of BT Mobility Users; Split between BT One Phone and BT Autobalance; Lifecycle of switches and phones; Energy Use and split of devices (Hardware and Switches); Carbon footprint of DECT phone; Embodied emissions of a PICO cell; Power Consumption of a PICO cell
- Embodied emissions of a switch - Paul Teehan and Milind Kandlikar, *Life cycle inventories of newer IT products,* Institute for Resources, Environment and Sustainability, The University of British Columbia, 2011 http://lcacenter.org/lcaxi/final/343.pdf
- Embodied Emissions of a Nokia Lumia1520 – Microsoft, Footprints of our products, https://www.microsoft.com/about/business-corporate-responsibility/sustainable-devices/products-footprint/
- Embodied Emissions of an iPhone 5s – Apple, iPhone 5s Environmental Report, http://images.apple.com/euro/environment/pdf/a/generic/products/iphone/iPhone5s_PER_Sept2014.pdf

7.27 BT Apps

7.27.1 Approach

BT provides some of its business customers with cloud hosted software and storage. The carbon savings from cloud hosting is already accounted for elsewhere (namely under "Broadband enabled SME use of Cloud Computing" and "Data centre services"). However, the software licences provided by BT includes a number of remote collaboration tools, such as Lync, SharePoint and email products, which enable BT customers to communicate and work remotely. All of these products reduce business travel by BT customers and reduce the need for hotel stays on overnight business trips. These carbon savings are accounted for in this category.

The carbon savings are calculated based on reduced number business meetings travelled to in a year, and corresponding reduced number of hotel overnight stays. The assumptions are derived from a case study undertaken by a technology company that monitored the business travel for one of its teams over a 6 month period, while using remote collaboration tools to reduce travel.

$$\begin{aligned} &Carbon\ Savings\ from\ Remote\ Collaboration\ tools \\ &\qquad = Carbon\ Savings\ per\ User\ (CO2e\ savings\ from\ reduced\ train\ travel \\ &\qquad + CO2e\ savings\ from\ reduced\ car\ travel \\ &\qquad +\ CO2e\ savings\ from\ reduced\ hotel\ stays)\ x\ Number\ of\ Users \end{aligned}$$

Where

$$\begin{aligned} &CO2e\ savings\ from\ reduced\ train\ travel \\ &= (Average\ yearly\ meetings\ x\ \%\ of\ travel\ savings\ due\ to\ remote\ collaboration\ tools\ x \\ &\%\ journeys\ made\ by\ train\ x\ average\ roundtrip\ distance)\ x\ national\ rail\ emission\ factor \end{aligned}$$

$$\begin{aligned} &CO2e\ savings\ from\ reduced\ car\ travel \\ &= (Average\ yearly\ meetings\ x\ \%\ of\ travel\ savings\ due\ to\ remote\ collaboration\ tools\ x \\ &\%\ journeys\ made\ by\ car\ x\ average\ roundtrip\ distance)\ x\ car\ emission\ factor \end{aligned}$$

$$CO2e\ savings\ from\ hotel\ stays = Average\ yearly\ hotel\ stays\ x\ emission\ factor\ for\ hotel\ stay$$

BT provided data on the number of users of remote collaboration tools by type of tool.

7.27.2 Assumptions

Assumed travel avoided for 6 meetings per year per person.
Assumed 300 mile roundtrip distance per meeting.
It was assumed that the mode of transport for all business trips was split 50/50 between train and car journeys.
Assumed 2 overnight hotel stays avoided per year per person.

The emission factor for a stay at a hotel for one night was calculated using an average of a number of estimates for the emissions of a stay at a hotel for one night.

7.27.3 Data Sources

- Number of users of remote collaboration tools - BT
- Average number of yearly meetings, Percent of travel saving due to remote collaboration tools, Average roundtrip distance – Carbon Trust Analysis
- Petrol car and national rail emission factors – Footprint Expert database
- Hotel stays per year – Carbon Trust Analysis
- Emission factor for hotel stays –
  Dick Sisman & Associates. 2007. *Tourism Destinations Carbon Footprints*
  http://www.thetravelfoundation.org.uk/images/media/7._Carbon_footprint_calculation_guide.pdf
  Green Tourism. Green Tourism is Sustainable Tourism… http://www.green-tourism.com/about/the-benefits-of-green-tourism-for-the-planet/
  Carbon Trust Analysis
  IHG. 2013. Corporate Responsibility Report.
  http://www.ihgplc.com/files/pdf/2013_cr_report.pdf

7.28 BT M2M – Taxis

7.28.1 Approach

Through the provision of M2M connections, BT enables improved taxi dispatch systems ensuring optimised dispatching of taxis, avoiding unnecessary travel and reducing fuel consumption.
The M2M connections provided by BT enable solutions that reduce distance driven or reduce fuel consumption. This is either achieved due to an improvement in monitoring, route optimisation or through a reduction in the required distance travelled. The carbon savings are calculated per M2M connection.

$$Carbon\ Saving\ from\ M2M\ solution$$
$$= Annual\ reduction\ in\ fuel\ consumption\ per\ M2M\ x\ Number\ of\ M2M\ connections$$

7.28.1 Assumptions

The calculation of a taxi's annual average distance is calculated using the average distance travelled in a taxi per person per year by the UK population in 2014. This assumes that everyone in the UK travels by taxi for a certain number of kilometres per year and it also assumes that all journeys are taken unaccompanied. The percentage of fuel saving due to improved dispatching of taxis is assumed to be 5%.

7.28.2 Data Sources

- Average Distance travelled in a Taxi per person per year (miles) – DfT, Mode share, average number of trips: England (with chart), Table NTS0301, https://www.gov.uk/government/statistical-data-sets/nts03-modal-comparisons
- Total Number of Taxis in the UK in 2014 – DfT, Taxi and Private Hire Vehicle Statistics: England 2015, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456733/taxi-private-hire-vehicles-statistics-2015.pdf
- UK Population - United Kingdom population mid-year estimate, 2014, ONS, http://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/timeseries/ukpop

7.29 BT M2M – ATMs

7.29.1 Approach

Through the provision of M2M connections, BT enables improved monitoring and managing of ATM machines, which reduces the number of maintenance visits and the associated fuel consumption. Note that dual path provision (i.e. both mobile M2M and fixed line connectivity), allows remote monitoring and fault fixing when one of the communication paths is not working.

The carbon savings are calculated per M2M connection.

$$\begin{aligned}&Carbon\ Saving\ from\ M2M\ solution\\&= Annual\ reduction\ in\ fuel\ consumption\ per\ M2M\ x\ Number\ of\ M2M\ connections\end{aligned}$$

7.29.2 Assumptions

According to a study by Greičius, E. et al., ATMs fail on average 0.5 times per month. Assuming that this rate is constant throughout the year, then ATM's breakdown on average 6 times per year. It was assumed that a third of maintenance visits can be avoided due to remote monitoring. Average distance for maintenance call out visit was assumed to be 17km.

7.29.3 Data Sources

- Monthly failure rate of ATMs – Greičius, E. et al,2015 Maintenance of an ATM network: modelling of cash flows, analysis of cash demand and customer habits, http://www.wseas.us/e-library/conferences/2015/Rome/EVCO/EVCO-11.pdf
- Average weekday business trip length in the UK – Pasaoglu, G. et al, 2012, Driving and parking patterns of European car drivers - a mobility survey, European Comission, https://setis.ec.europa.eu/sites/default/files/reports/Driving_and_parking_patterns_of_European_car_drivers-a_mobility_survey.pdf
- Reduction in service visits to ATMs due to remote monitoring – Intel, 2012, Reaching More Customers With Smart ATMs, http://www.intel.co.uk/content/dam/www/public/us/en/documents/solution-briefs/reaching-more-customers-with-smart-atms-brief.pdf

7.30 BT M2M – Traffic Management

7.30.1 Approach

Through the provision of M2M connections, BT enables an installed traffic light system in Belfast to provide a smooth flow of traffic and reduced waiting time at traffic lights, enabling a more constant speed and a reduction in fuel consumption.

The carbon savings are calculated per M2M connection.

$$Carbon\ Saving\ from\ M2M\ solution$$
$$= Annual\ reduction\ in\ fuel\ consumption\ per\ M2M\ x\ Number\ of\ M2M\ connections$$

7.30.2 Assumptions

It was assumed that the savings are from synchronised traffic signals. BT are expecting case study data based on the implementation in Belfast. When case study data is available the assumptions will be updated. Currently, in the absence of other quantifiable data, the following assumptions were used: The number of cars that pass a traffic light per day is calculated by assuming that a car arrives at a traffic light on average every 4 seconds. It was assumed that this was applicable 12 hours a day and throughout the year, from this a total number of cars passing a traffic light per day was calculated. It was also assumed that traffic lights affect driving for 400 meters, and that the fuel savings over this distance were 5%.

7.30.3 Data Sources

- Emission reductions from Traffic management - Vodafone, Carbon Connections: Quantifying mobile's role in tackling climate change, 2009, https://www.vodafone.com/content/dam/vodafone-images/sustainability/downloads/carbon_connections.pdf

7.31 BT M2M – Smart meters – business use

7.31.1 Approach

Smart meters monitor energy use (electricity and gas) and provide connectivity for remote monitoring and data collection. In a business environment these are typically half-hourly meters, and they may be connected to control systems to monitor and reduce energy consumption in offices and other commercial buildings. Thus enabling energy savings and therefore carbon savings.

BT provides the M2M connectivity for the smart meters, and thus is enabling the energy and carbon savings.

The energy savings will depend on how the information from the meters is used, and so may vary significantly from installation to installation, thus an average saving per smart meter is used.

Calculations:

$$CO_2e\ abatement\ (business\ smart\ meters) = Average\ CO_2e\ abatement\ per\ business\ smart\ meter \times number\ of\ connected\ busines\ smart\ meters$$

7.31.2 Assumptions

- Average savings per smart meter were calculated from case studies including ASB Bank in New Zealand, three case studies from the Better Buildings Partnership of carbon savings across UK business premises and Carbon Trust research for number of smart meters per square metre floor space. The calculations used an energy saving for a building of 16.8% (this being the average of the percent savings quoted for the ASB Bank case study and the three UK based case studies).
- Half hourly meters provided are assumed to represent business meters, as opposed to non-half hourly meters which are assumed to be for residential use.

7.31.3 Data Sources

Average savings per smart meter:

- ASB Bank case study: Vodafone, 2012a. ASB Bank Case Study. ASB Bank cuts energy costs with a Vodafone M2M smart metering solution, http://www.vodafone.com/business/m2m/case-study/asb-bank-cuts-energy-costs-with-a-vodafone-m2msmart-metering-solution
- BBP, 2011, Better Metering Toolkit. A guide to improved energy management through better energy metering, http://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/bbp-better-meteringtoolkit.pdf

7.32 BT M2M – Smart meters – domestic use

7.32.1 Approach

Smart Meters for domestic use is the installation of energy meters in the home, which have the capability of remote connectivity and communication. They record the consumption of energy (gas or electricity) on frequent regular intervals (typically at least once per hour) and communicate the information to the energy utility company. The reporting from the Smart Meters is also available to the energy consumer, and this feedback provides a mechanism for reduction in energy use through behavioural change.

The energy savings will depend on how the information from the meters is used, and so may vary significantly from installation to installation.

Calculations:

$$CO_2e\ abatement\ (domestic\ smart\ meters) = Average\ CO_2e\ abatement\ per\ domestic\ smart\ meter \times number\ of\ connected\ domestic\ smart\ meters$$

Where:

$$Average\ CO_2e\ abatement\ per\ domestic\ smart\ meter = Average\ UK\ houshold\ electricty\ consumption \times \%\ savings\ from\ domestic\ smart\ meters \times Average\ UK\ electricity\ emission\ factor$$

7.32.2 Assumptions

- The key assumption is the percentage energy savings due to the installation of Smart Meters, which is derived from the Irish Smart Meter Study and the Ofgem Energy Demand Research Project study. This figure being 3% energy saving.
- The figures used to calculate the carbon savings are the % electricity saving and the % gas saving due to the installation of smart meters, these percentages are then applied to the average household domestic energy consumption figures for gas and electricity (as appropriate) to calculate the energy saving per household. These are then converted to CO_2e figures using standard emission factors.
- It is assumed that each M2M connection provides the connectivity for a single household (either gas or electric or both).
- Based on information from BT, 99% of smart meters provided by BT are only for electricity. It is therefore assumed that the savings will only be calculated for electricity consumption.
- Non half-hourly meters are assumed to be for residential use, as opposed to half hourly meters that are assumed to be for business use.

7.32.3 Data Sources

Savings from domestic smart meters:

- DECC, 2010. GB-wide smart meter roll out for the domestic sector, https://www.ofgem.gov.uk/ofgem-publications/63551/decc-impact-assessment-domestic.pdf
- Irish Smart Meter Study: Commission for Energy Regulation (CER), 2011. *Smart Metering Information Paper 4 Results of Electricity Cost-Benefit Analysis, Customer Behaviour Trials and Technology Trials*, Available at: http://www.cer.ie/docs/000340/cer11080.pdf
- Average UK household electricity consumption: Office for National Statistics, 2019, Energy consumption in the UK, https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

7.33 BT M2M – Connected car – Usage based car insurance (UBI)

7.33.1 Approach

A 'black box' is fitted into vehicles and monitors how they are driven, offering feedback for improvement for safety, efficiency and best practice. Insurance companies use the data generated to determine risk and help to reduce insurance premiums for 'good' drivers. It is primarily aimed at the 17-25 year age group, who have higher insurance premiums and less road experience.

Carbon savings will be mainly for the "Pay how you drive" category, due to reduced fuel consumption due to improved driver behaviour as a result of feedback provided to the drivers, and the incentive for reduced insurance premiums. There are also carbon savings due to reduced number of accidents and the emissions associated with vehicle repairs.

Calculations:

$$CO_2e\ abatement\ (Usage\ based\ insurance) = CO_2e\ abatement\ (increased\ driving\ efficiency) + CO_2e\ abatement\ (accident\ reduction)$$

Where

$$CO_2e\ abatement\ (increased\ driving\ efficiency) = connected\ customers\ \times average\ number\ of\ trips\ (17/25yr\ olds) \times average\ distance\ of\ a\ trip\ \times typical\ fuel\ saving\ factor$$

Where

$$CO_2e\ abatement\ (accident\ reduction) = connected\ customers\ \times average\ insurance\ claim\ (17\ /\ 25yr\ olds) \times CO_2e\ \ per\ £\ car\ repair\ conversion\ factor \times reduction\ in\ car\ insurance\ claims$$

7.33.2 Assumptions

- It is assumed that all of those with this insurance are aged 17-25, whilst this is unlikely to be true for all cases this is the age range that the insurance is targeted at, and therefore will be representative
- It is assumed that a weighted average of the number of trips made by 17-20 year olds and 20-29 year olds is representative of the 17-25 years old age range
- 17-25 years olds are assumed to drive a small car
- Fuel savings are assumed to be 10% - the same figure as used for fleet management
- It is assumed, due to a lack of data, that the total value of car insurance payouts is spent on car repairs

7.33.3 Data Sources

- Average Annual Trips driven by 17-25 year olds: Department for Transport statistics, National Travel Survey, 2014, Table NTS0601, https://www.gov.uk/government/statistical-data-sets/nts06-age-gender-and-modal-breakdown
- Average distance of a trip: Department for Transport statistics, National Travel Survey, 2015, Table NTS0101, https://www.gov.uk/government/statistical-data-sets/nts01-average-number-of-trips-made-and-distance-travelled
- Typical fleet management fuel savings: Carbon Trust Research, 2014
- Average annual insurance claim by 17-25 year olds: Association of British Insurers, Age and Insurance: Helping customers understand insurers' use of age in motor and travel insurance, 2012, https://www.abi.org.uk/~/media/Files/Documents/Publications/Public/Migrated/Crime/ABI%20agreement%20on%20age%20and%20insurance.pdf
- Emission Factor for car repairs (kgCO2e/$ spent): Carbon Trust analysis derived from EEIO factors
- Percentage Reduction in insurance claims due to black boxes: The co-operative insurance, Young Drivers Report, 2013, https://www.grahamfeest.com/wp-content/uploads/2016/08/Co-op-Insurance-Young_Drivers_are_they_ready_for_the_road.pdf

7.34 BT M2M – Fleet Management / Vehicle Telematics

7.34.1 Approach

Fleet management and telematics covers a range of applications including satellite navigation, fleet tracking and dispatch, road tax collection, driver behaviour monitoring and fuel management amongst others. Mechanisms that cause abatement include targeted behaviour improvement to improve fuel efficiency, satellite navigation to reduce journey distance and avoid congestion, and optimised route planning.

Calculations:

$$CO_2e\ abatement\ (Fleet\ management\ telematics) \\ = Average\ CO_2e\ abatement\ per\ vehichle \\ \times number\ of\ vehicle\ telematics\ connections$$

Where:

$$Average\ CO_2e\ abatement\ per\ vehichle \\ = Fuel\ saving\ factor\ \times\ average\ annual\ distance\ travelled \\ \times average\ van\ emission\ factor$$

7.34.2 Assumptions

- Studies from other Carbon Trust projects give a range of 5% to 15% for the fuel saving factor, depending on the level of intervention. As it is not known what levels of interventions and what specific applications are covered in this category, an assumption of a typical 10% for the fuel saving factor is made.
- Vehicles covered by the technology are unknown, however they will typically be commercial vehicles, therefore a conservative assumption is to use an average van emission.
- Distances travelled by the vehicles are also unknown so it assumed they travel the average distance for UK road freight vehicles.

7.34.3 Data Sources

- Average annual distance travelled by commercial vehicles: Department for Transport, Road freight statistics: 2018 tables, Table RFS0112, https://www.gov.uk/government/collections/road-freight-domestic-and-international-statistics
Typical fleet management fuel saving factor: Carbon Trust Analysis

7.35 BT M2M – Street lighting

7.35.1 Approach

BT provide M2M connectivity for street light control systems. The systems provide monitoring and switching control for street lights. The street lights communicate with a concentrator using the 868 MHz band, and the concentrator communicates over the EE mobile network. A concentrator may cover between 1,000 to 10,000 street lights. The control system allows precise control of the switching times and power levels for the street lights, thus enabling reduced energy consumption. Improved monitoring also allows more efficient maintenance, thus reducing the number of maintenance visits.

Calculations:

$$CO_2e\ abatement\ (Streetlights) = CO_2e\ abatement\ \ (street\ light\ energy\ reduction) + \ CO_2e\ abatement\ (street\ light\ maintenance\ reduction)$$

Where

$$CO_2e\ abatement\ (Streetlight\ energy\ reduction) = Energy\ reduction\ \% \times Annual\ CO_2e\ emissions\ per\ street\ lgiht$$

Where

$$CO_2e\ abatement\ (Street\ lights\ maintenance\ reduction) = distance\ driven\ between\ streetlights\ \times annual\ trips \times van\ emission\ factor$$

7.35.2 Assumptions

- Street light energy reduction of 20% based on an energy and efficiency savings claim made by Telensa (provider of the street light control systems).
- It is assumed that without the monitoring system, a van would drive past each streetlight once a month to check it is working and each street light is 50m apart, to adopt a conservative approach it is also assumed the route the van takes is covered entirely by street lights to be checked at 50m intervals
- It is assumed the system leads to a 75% reduction in travelling for maintenance

7.35.3 Data Sources

- Street light energy and efficiency savings from CMS: Telensa, Telensa enhances street light control system with GPS, 7-pin NEMA and traffic flow adaptive lighting, 2014, http://www.telensa.com/2014/09/17/telensa-enhances-street-light-control-system-with-gps-7-pin-nema-and-traffic-flow-adaptive-lighting/
- Annual average emissions of a street light: Green Investment Bank, Low energy streetlighting: making the switch, 2014, http://www.greeninvestmentbank.com/media/5243/gib-market-report-low-energy-streetlighting-feb-2014-final.pdf

7.36 Maps / Traffic apps

7.36.1 Approach

Mobile phone customers will use apps on their smartphones with mapping and traffic information. This information can be used to plan shorter travel routes, avoid traffic congestion, and avoid getting lost. All of these have the potential to reduce carbon emissions from car travel. Additionally, this information and use of apps could encourage shift from car to public transport, again reducing carbon emissions.

Calculations:

$$CO_2e\ abatement\ (map\ apps) = CO_2e\ from\ connected\ smartphone\ users\ driving\ \times \%\ using\ map\ apps \times reduction\ in\ fuel\ used\ by\ sat\ nav\ users$$

Where:

$$CO_2e\ from\ connected\ smartphone\ users\ driving = Average\ car\ distance\ driven\ per\ driver\ (UK) \times medium\ car\ CO_2e\ conversion\ rate\ \times number\ of\ smartphone\ users$$

Where

$$\%\ using\ map\ apps = (\%\ people\ using\ satellite\ navigation\ on\ a\ smartphone - \%\ cars\ fitted\ with\ satellite\ navigation$$

Where:

$$Reduction\ in\ fuel\ used\ by\ sat\ nav\ users = \%\ fuel\ savings\ on\ unfamiliar\ journey \times \%\ journeys\ when\ sat\ nav\ is\ in\ use$$

7.36.2 Assumptions

- Trips made using satellite navigation in cars without a fitted satellite navigation system are assumed to be made using map apps.
- Studies from other Carbon Trust projects indicated a 16% reduction in distance travelled when using satellite navigation in unfamiliar areas, it is assumed map apps are only used in unfamiliar areas.
- It is assumed that people who use map apps when driving, do so for 10% of their journeys.
- Average annual mileage is derived from UK national statistics from the Department of Transport
- It is assumed that map apps will only be used in cars, as vans and other commercial vehicles are likely to be fitted with other satellite navigation systems, so distances driven by other vehicles are excluded.
- It is assumed a medium car (unknown fuel) is representative of the vehicles in which people use map apps.

7.36.3 Data Sources

- Percentage of drivers using satellite navigation: Automobile Association, Sat nav vs Maps, 2013, http://www.theaa.com/newsroom/news-2013/satnav-vs-maps.html
- Percentage of cars with satellite navigation, Total UK car distance driven, Number of UK licence holders, Percentage of UK adults with a driving licence: Department for Transport, National Travel Survey: 2012, 2013, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/243957/nts2012-01.pdf
- Fuel saving when using satellite navigation: D. M. Hoedemaeker, T. Vonk and T. van Rooijen, The effects of navigation systems on traffic safety, TNO, 2008, Netherlands.

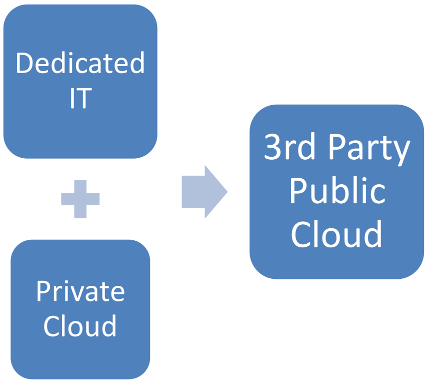
7.37 Cloud Connect

7.37.1 Approach

BT's Cloud Connect Direct service provides direct connectivity to third party cloud providers such as Microsoft Azure, Amazon Web Services, Salesforce, Oracle Cloud, and HPE Helion. The connectivity is from a company's virtual private network (VPN) providing improved performance, reliability and security.
By providing this direct connectivity, BT is enabling companies to use cloud services replacing the use of in-house computing infrastructure. This is more efficient and uses less electricity due primarily to increased server utilisation and improved Power Usage Effectiveness (PUE).

Calculations:
The methodology for calculating the resulting carbon savings is based closely on that used for Data Centre Services (see section 7.13).

The modelling assumes a customer moves from a typical mix of private cloud computing and dedicated IT to BT public cloud computing. Through this move, the customer will benefit from greater server utilisation and an improved PUE, and therefore lower energy use and carbon footprint.



The mix of Dedicated IT to Private Cloud is assumed to be 60% / 40%, based on BT's experience, and average server utilisation is assumed to be: Dedicated IT – 15%; Private Cloud – 40%; Public Cloud 65%. These assumptions are used to calculate the equivalent number of Virtual machines per physical server, and thus the energy used before the move to the cloud and the energy used after the move to the cloud. PUE factors used are: Dedicated IT – 2; Private Cloud – 1.8; Public Cloud – 1.2.
The annual energy saving per customer server is then the energy used by the customer server before the move to the cloud less the energy required for the equivalent proportion of servers (allowing for virtualisation and utilisation rates) after the move to the cloud.

A typical customer is assumed to have 250 users, this matches with the average bandwidth per customer provided by BT, using empirical evidence and on-line bandwidth calculators. For a customer of this size it was assumed that 8 physical servers on-site before migration to the cloud would be appropriate. (Based on expert opinion for a typical configuration of 4 physical servers hosting email, groupware, and file storage, with 4 additional servers for backup / cache / test).

The energy saving based on the 8 servers per typical customer was then converted to CO_2e emissions using specific electricity emission factors for the different cloud providers. The emission factors were derived based on the mix of energy type used by each provider as presented in the Greenpeace 'Clicking Clean 2017' report. Full life cycle emission factors were used (i.e. including upstream and T&D losses), to be consistent with the approach used for all products in the methodology. The electricity emission factor used for the customer before migration to the cloud was the standard UK average grid electricity emission factor.

7.37.2 Assumptions

- Assumes that customer before migration to cloud would have a typical split between dedicated IT and private cloud computing of 60% / 40%.
- Assumes servers run 24x7 throughout year.
- Assumes customers are UK based (and hence a UK grid electricity emission factor has been used, source: Carbon Trust Footprint Expert Database)
- Weighted average server power consumption 295 W
- Average server utilisation is assumed to be: Dedicated IT – 15%; Private Cloud – 40%; Public Cloud 65%.
- Customer dedicated PUE = 2, Customer private cloud PUE = 1.8, Public Cloud PUE = 1.2
- Average customer of 250 users requires 8 physical servers before migration to cloud
- Electricity emission factors for cloud providers were derived based on the mix of energy type used by each provider sourced from the Greenpeace 'Clicking Clean 2017' report.

7.37.3 Data sources

- BT provided data
- Carbon Trust Footprint Expert Database
- http://hightech.lbl.gov/documents/data_centers/svrpwrusecompletefinal.pdf
- https://www.cdproject.net/Documents/Cloud-Computing-The-IT-Solution-for-the-21st-Century.pdf
- http://www.computerweekly.com/tip/Data-centre-cases-where-PUE-or-power-usage-effectiveness-doesnt-work
- http://www.veeam.com/news/veeam-v-index-q3-results-are-released148.html
- http://bandwidthpool.com/bandwidth-calculator/
- http://www.psav.com/bandwidth_estimator/
- http://www.clickclean.org/international/
- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/542570/Fuel mixdisclosurewebpage2016__3_.pdf
- https://aws.amazon.com/blogs/aws/cloud-computing-server-utilization-the-environment/
- https://aws.amazon.com/about-aws/sustainability/

7.38 BT Renewable Energy for Employees

7.38.1 Approach

BT offers its employees a discount when switching to the energy provider Good Energy. Good Energy sources all of its electricity from renewables, therefore electricity supplied by Good Energy has close to zero carbon emissions associated with it. Good Energy also supply gas, of which a minimum of 6% is guaranteed to come from biomethane. This methodology calculates how much carbon emissions can be avoided by BT employees switching to Good Energy per year.

The carbon emissions avoided with a switch to Good Energy can be estimated by calculating the total energy consumption used by employees after the switch to Good Energy and the carbon emissions that would have been emitted had they stayed with their previous energy supplier. BT employees that switched in previous years will be included only if they are still BT employees.

The total energy consumption used by an employee after they switched to Good Energy will be estimated by using the employee's estimated average energy consumption per month (kWh) for both gas and electricity. The employee's energy consumption will only be calculated from the month they switched to Good Energy to the end of the year or until they leave Good Energy.
The carbon emissions emitted per kWh for each energy supplier is estimated by taking the fuel mix data for each supplier and multiplying it by the carbon impact of each fuel.

$$Total\ Carbon\ Abatement_{Electricity} = \sum \#\ months\ over\ a\ year\ with\ Good\ Energy_n \times monthly\ electricity\ consumption_n \times EF\ of\ previous\ energy\ supplier_n$$

The carbon abatement coming from employees switching to Good Energy gas is calculated by taking the total carbon emissions from gas an employee would've emitted if they hadn't switched to Good Energy and subtracting the amount of emissions emitted while the employee is with Good Energy. The percentage of biogas in the national grid supply is assumed to be at around 0.5%, while Good Energy supplies its gas customers with a minimum of 6% biogas.

$$Total\ Carbon\ Abatement_{Gas} = \sum ((Annual\ gas\ consumption\ while\ with\ Good\ Energy_n \times (100\% - 0.5\%) \times Natural\ gas\ EF) + (Annual\ gas\ consumption\ while\ with\ Good\ Energy_n \times 0.5\% \times Biogas\ EF)) - ((Annual\ gas\ consumption\ while\ with\ Good\ Energy_n \times (100\% - 6\%) \times Natural\ gas\ EF) + (Annual\ gas\ consumption\ while\ with\ Good\ Energy_n \times 6\% \times Biogas\ EF))$$

Where:

$$Annual\ gas\ consumption\ while\ with\ Good\ Energy_n = \#\ months\ over\ a\ year\ with\ Good\ Energy_n\ x\ average\ monthly\ gas\ consumption_n$$

7.38.2 Assumptions

-The calculations do not include the upstream and downstream emissions of electricity. As the upstream generation emissions of renewables are close to zero and the emissions from transmission and distributions losses are assumed to be identical between different sources of electricity, a conservative approach is taken by not accounting for the upstream and downstream emissions of non-renewable sources of electricity. If these had been included in the calculations, the carbon savings from employees switching to Good Energy would have been even greater.
-It is assumed that the mix of natural gas and biogas supply of all other suppliers is that of the average grid mix. It is assumed that the average biogas content of gas supplied from the grid is currently at 0.5%, based on a current biogas supply of 4TWh (http://www.greengas.org.uk/news/ggcs-event-using-green-gas-certificates-for-ghg-reporting-17-november-2016) and a total gas supply of 792TWh in 2015 in the UK (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/556250/Gas.pdf).
-The energy consumed while with Good Energy is calculated by taking an average monthly consumption and multiplying this by the number of months the employee was with Good Energy. Average monthly electricity and gas consumption figures have been used, thus seasonal changes in energy consumption have not been considered.
-Note that any data provided from Good Energy will not compromise the confidentiality agreement between Good Energy and its customers

7.38.3 Data Sources

Data from External Sources:

- Fuel Mix Disclosure for all UK Energy Suppliers: http://electricityinfo.org/fuel-mix-of-uk-domestic-electricity-suppliers/

- Carbon Impact of all Fuels (i.e. gas, coal, renewables, nuclear and other): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/542570/Fuel mixdisclosurewebpage2016__3_.pdf
- UK Government Natural Gas and Biogas GHG Emission Factors: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2016
- Average household energy consumption provided from BEIS statistics: https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
- Percentage of biogas in the national grid supply: Average biogas content of gas supplied from the grid is currently at 0.5%, based on a current biogas supply of 4TWh (http://www.greengas.org.uk/news/ggcs-event-using-green-gas-certificates-for-ghg-reporting-17-november-2016), and total gas supply of 792TWh in 2015 in the UK (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/556250/Gas.pdf)

Data from Good Energy:

- Date joined and/or left *Good Energy* for each employee
- Previous energy supplier (where available) for each employee

7.39 Connect Services Platform

7.39.1 Approach:

BT's Connect Services Platform provides Network Function Virtualisation (NFV), by enabling various network functions that previously would have been hardware-based to operate in a virtual environment. This allows for much more flexible and dynamic provision and deployment of the networking functions.

Through the provision of its Connect Services Platform offering, BT enables its customers to replace a number of existing network devices with a single network device - a Connect Services Edge (CSE). Although the CSE device might consume more energy than an individual device it replaces, it is assumed that it will consume less energy than the total number of devices it replaces.
The number of devices that a CSE device replaces varies between customers, but an average number of devices being replaced has been used.
The calculation for GHG savings from implementing BT's Connect Services Platform is therefore as follows:

$GHG_{\text{Savings}} = GHG_{\text{Previous Devices}} - GHG_{\text{CSE}}$

Where the savings (i.e. GHG_{Savings}) will be expressed in GHG savings per customer site, and

$GHG_{\text{Previous Devices}} = \sum$ GHG of n devices

where n equals 3 on average.

Connect Services Platform can enable further carbon savings, as the installed CSE device will have a lower cooling overhead than the devices it replaces, thereby reducing HVAC requirements. However, as it is unclear where the CSE might be located at individual sites – a CSE could be located within a separate server room with HVAC, or in an area without any HVAC requirements – these savings were excluded from the calculations.

In addition to potential HVAC savings, the Connect Services Platform also allows for more changes and maintenance requirements to be dealt with remotely, reducing the carbon emissions associated with a technician traveling to a site to complete installation and change of physical devices. However, as it is assumed that any maintenance/installation trips will be carried out by BT engineers, a reduction in trips will already be reported as a reduction in BT's scope 1 fuel use.

Applying the above approach, for a customer, who replaces between 4 and 6 devices with a single CSE device at 1,000 sites, this customer would be able to save between 500MWh and 1,300MWh of electricity and between £52k and £134k in energy costs per year, assuming an average price of electricity of 10.28p/kWh. This is equivalent to a saving of between 32% and 54%.

7.39.2 Assumptions:

The following assumptions were made:

1. A CISCO ENCS 5400 device was chosen as a typical CSE device.
2. To estimate the power consumption of the devices being replaced, it was assumed that the first three devices replaced by a CSE include a Router, a network optimisation device and a firewall.
3. It was assumed that any additional device replaced by the CSE would have a power consumption equal to the average power consumption of the three devices listed in Assumption 2.
4. It was assumed that an average number of three devices would be replaced by one CSE device.
5. All devices were assumed to be running 24 hours per day and 365 days per year.
6. As it is assumed that this service will be used all over the world, the weighted average global electricity emission factor was used to calculate carbon savings.
7. To calculate cost savings, an average UK electricity price for the non-domestic sector in the 3rd quarter of 2017 was used.

7.39.3 Data Sources:

- Power consumption of the CSE devices - BT
- Power consumption of a router, a network optimization device and a firewall – BT
- Number of devices replaced by each customer – BT
- Price of Electricity for non-domestic sector in the UK, 3rd quarter 2017 – BEIS, Gas and electricity prices in the non-domestic sector, Table_341, https://www.gov.uk/government/statistical-data-sets/gas-and-electricity-prices-in-the-non-domestic-sector

7.40 EE Auto Mate

7.40.1 Approach:

EE's Auto Mate service is a vehicle telematics solution targeted at the SME (small business) market. It is a self-install system that connects to a vehicle's diagnostics port, and collects on-board diagnostic data on the vehicle performance. The data is uploaded to the cloud where it is analysed to provide feedback to the vehicle users. Vehicle data can be monitored using the Auto Mate online portal or app.
Monitoring includes: engine condition, fuel consumption, battery condition, GPS and distance travelled, accelerometer (which can detect and distinguish for example: braking, cornering, collisions, potholes).
The feedback provides information on braking, cornering, speeding, health condition of vehicle, usage statistics, and fuel usage. This information is analysed to provide reports and dashboards of the data to feedback to the drivers to improve driving behaviour. This results in typical improvements in fuel consumption of 10%.
Reduced fuel consumption equates directly to reduced GHG emissions.

The calculation for GHG savings from implementing EE's Auto Mate service is therefore as follows:
EE Auto Mate GHG $_{Savings}$ = {Number of vehicles} x {Average annual distance per vehicle}
x {Emission factor for vehicle} x {percentage fuel saving}

7.40.2 Assumptions:

- Percentage fuel saving figure of 10% is used. This is based on analysis of use of the technology by a number of companies, with calibration and monitoring of fuel consumption and comparing to a baseline. This figure is also consistent with other published studies and case studies for similar technologies and interventions.
- Vehicles assumed to be those used by SME small fleets – either car or LGV. Emission factor used for an average van.
- Annual distance travelled assumed to be average distance for light goods vehicles (LGVs)

7.40.3 Data Sources:

- Annual vehicle distance for LGVs: Department for Transport, Road traffic statistics: Tables TRA01 and VEH04
https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra
- Emission factor for an average van: BEIS, Government emission conversion factors for greenhouse gas company reporting
https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

7.41 BT Half SIMs

7.41.1 Approach:

BT provides mobile phone connectivity through both BT Mobile and EE mobile network operators. The SIM (subscriber identity module) card provided as part of this service, is a plastic integrated circuit, used to identify and authenticate customers mobile devices on BT's network.

BT has replaced its traditional sized SIM cards with a new Half SIM product. The Half SIM product is comprised of the same plastic SIM card and cut-out surround, and a paper customer leaflet. The new Half SIMs product has been reduced in size by roughly half. This has been done by reducing the size of the plastic cut-out which surrounds the SIM itself, and reducing the size of the customer leaflet. This has resulted in lifecycle energy savings from:

- Plastic materials savings (SIM card)
- Paper materials savings (customer leaflet)
- Manufacturing energy savings
- Transport and distribution energy savings, and
- End of Life savings with less material waste processed.

These savings result in carbon abatement due to, reduced material, manufacturing, transport and waste emissions compared to the original full-size SIM product.

The annual carbon abatement per Half SIM product customer was calculated based on life-cycle assessments of both the Half SIM and original full-size SIM products. The carbon emissions of the Half SIM product and the full-size SIM were calculated at each stage of the product lifecycle, using the assumed production of 12 million SIMs per year. The total calculated emissions were divided by 12 million to give an emissions value per SIM product.

Life-cycle stage of SIM production	**Full-Sized SIM Average Total Emissions ($kgCO_2e$) per product p.a.**	**Half-SIM Average Total Emissions ($kgCO_2e$) per product p.a.**
Materials Plastic	0.0128	0.0063
Materials Paper	0.0002	0.0001
Manufacturing Plastic	0.0009	0.0005
Manufacturing Paper	0.0002	0.0001
Transport & Distribution	0.0122	0.0060
End-of-life	0.0003	0.0001
Total	**0.0266**	**0.0131**

The difference in emissions per SIM product between the old Full-sized SIM and the new Half-SIM product was calculated in order to obtain a carbon savings per product value.

Lifecycle stage of Half SIM production	**Savings in Average Total Emissions ($kgCO_2e$) per product p.a.**
Materials Plastic	0.0065
Materials Paper	0.0001
Manufacturing Plastic	0.0004
Manufacturing Paper	0.0001
Transport & Distribution	0.0062
End-of-life	0.0001
Total	**0.0135**

The annual carbon abatement factor per Half SIM product was calculated as 0.0000135 Tonnes of CO_2e.

The annual carbon savings from Half SIMs =

Carbon saving per Half SIM product (CO_2e savings from reduced material, manufacturing, transport and end of life emissions in the product lifecycle) x Number of annual BT mobile network customers

7.41.2 Assumptions

- Assumed no lifetime emissions from the use of the SIM product in mobile devices of customers.
- Lifecycle assessment calculations based on the assumption of 12 million SIMs produced per year.
- SIM card manufacturing process assumption based onWL-Smartlam8500 Full Auto Laminator card making machine. Assumed machine uses 50% of max power = 50kW, producing 24,000 cards per hour. 0.00208 kWh per Old full-size SIM card. 0.00114 kWh per half-size SIM card
- For kWh energy consumption per kg of paper production - used UPM Light Weight Coated Paper EPD figure of 600kWh/tonne of paper product. 0.6 kWh/kg
- Manufacturing process assumption only takes into account the production of plastic cards, and excludes manufacture of the integrated circuit and SIM, as this is present in the Half SIM and original sized SIM regardless.
- Transport and distribution assumptions of departure/arrival locations based on nearest major city to estimated region of departure/arrival.
- End of life processing emissions assumed that 100% of plastic SIM card foes to landfill. Paper assumed 60/40 split of closed-loop recycling/landfill.
- Assumptions on the material types and their emission factors were made. Plastic used in the SIMs were assumed to Acrylonitrile Butadiene Styrene (ABS) plastic, and paper leaflet material was assumed to be Lightweight coated paper.

7.41.3 Data Sources:

- BT
- UPM Paper EPD data on Light Weight Coated Paper for Paper emissions factors and for kWh energy consumption per kg of paper production: https://www.upm.com/siteassets/documents/responsibility/certificate-finder/environmental-product-declaration/paper-profile-with-carbon-footprint-upm-caledonian-lwc_pm1.pdf
- SIM card manufacturing energy consumption proxy data source: http://www.smartcardmakingmachine.com/sale-9344404-computer-control-credit-card-manufacturing-machine-id-card-making-machine-full-automatically.html
- Paper waste disposal assumption source: https://www.gov.uk/government/statistics/uk-waste-data

8 CHANGES TO METHODOLOGY FROM PREVIOUS YEAR

This section identifies changes and additions to the methodology compared to the previous financial year (FY), i.e. changes from FY 2018/19 to FY 2019/20.

8.1 Addition of new Products

The following new products were included into the methodology in FY 2019/20 (and are documented in this report):

- Half SIMs (see section 7.41)

Note that two products (Flexible Working Services and Fleet Engine Remapping) are no longer provided by BT, however the methodologies for these products are still included in this document for historical completeness.

In summary, in 2019/20, we worked with BT to quantify 29 ways in which BT's products and services help BT's customers to avoid carbon emissions.

9 RESULTS SUMMARY

The summary of the 3:1 carbon abatement results for the financial year 2019/20 is as follows:

- Carbon abatement of BT products and services: 12.8 Mt CO2e
- BT's end-to-end carbon footprint (the market-based scope 1, 2 and 3 carbon emissions): 4.2 Mt CO2e
- The ratio of the carbon abatement effect of BT's products and services compared to BT's end-to-end carbon footprint: 3.1 to 1
- Carbon emissions from BT's operations represent 7.6% of BT's end-to-end carbon impact.
- Carbon emissions associated with BT's upstream accounts for 68.8% and use of BT's products and services by its customers account for 23.6% of BT's end-to-end carbon impact.

10 REVIEW STATEMENT

The BT 3:1 methodology has been reviewed, refined and endorsed by the Carbon Trust.

ANNEX – WORKED EXAMPLES

TELECOMMUTING

Introduction / Overview

Through the provision of a broadband network, BT enables workers to telecommute. That is, a telecommuter is someone who is able to work remotely, typically at home, using a broadband connection, avoiding the need to travel to a company office.

Generally, there are avoided carbon emissions from telecommuting associated with not having to travel to and from the office. There may also be reduced energy use within the office environment. There are also rebound effects of increased energy use in the telecommuter's home.

The calculation approach used was:

$$\begin{aligned}\text{Telecommuting carbon saving} \\ &= \text{Average carbon saving per telecommuter} \\ &\times \text{Number of telecommuters enabled by BT}\end{aligned}$$

There are a number of external studies that have considered the carbon abatement due to telecommuting. These were separately reviewed as to their assumptions, rigour and relevance to the UK.

The studies that were considered were:

- ACI Study (2007)
- BT Case Study (2008)
- Carbon Intent Project (2009)
- Yankee Group Study (2012)

Typically, these studies looked at a carbon enabling effect at a national or regional level, and considered other ICT enabling effects as well as telecommuting. The approach was to derive a "per telecommuter" carbon saving figure per year from the studies which could then be factored by the number of telecommuters enabled by BT technology.

The Yankee Group study was used as a basis for the calculations for the BT project because it was the most rigorous and appropriate study for the UK and the most recent. The Yankee Group study carried out a separate analysis for USA and for a group of five European countries (France, Germany, Italy, Spain and the U.K. - referenced as the EU-5). It also included survey results (e.g. typical number of days working from home, by different categories, typical distance commuted), and included a Monte Carlo analysis to model the uncertainty ranges of some of the assumptions.

Key assumptions

A key assumption taken is that where BT provides a physical broadband line, then the carbon savings can be allocated to the provision of the broadband line by BT.

The key assumptions of the Yankee Group study were:

- Reduction in an individual's transportation energy consumption due to reduced commute between the residence and the place of employment. Assumption that commuting is by car.
- Reduction in energy required in commercial facilities that support employees on premise.
- Recognition of a rebound effect where people who work from home are consuming more energy in the home which is modelled using the "Home energy deflator" as described in the study.
- Recognition of a rebound effect where people who work from home carry out more personal errands (e.g. shopping at lunch time, collecting children from school), which is modelled using the "Personal trip deflator" as described in the study.

Adaptation of the Yankee Group study

The variables used in the Yankee Group Monte Carlo simulation were adapted to use figures specific for the UK, rather than the average figures used for the EU-5.

The 'Days per week to Telecommute' was calculated by using the survey data within the Yankee Group report which asked survey respondents on average how many days per week they telecommuted. A weighted average figure of 2.6 days per week was calculated.

The mean daily commute was also adjusted to reflect the UK average from the report's survey i.e. 19.55km x 2 (24 miles).

The Monte Carlo simulation was then re-run using these inputs, giving an average saving per telecommuter of 0.95 metric tons CO_2e.

Comparison with other studies

As stated in the introduction, other studies were considered in addition to the Yankee Group study:

- ACI Study (2007)
- BT Case Study (2008)
- Carbon Intent Project (2009)

The following table and discussion compare the other studies:

(Results are given in tons CO_2e per telecommuter per year).

Study	Year of Study	Result tCO_2e	Geography
ACI Study	(2007)	9.6	USA
BT Case Study	(2008)	1.4	UK
Carbon Intent Project	(2009)	1.14	UK
Yankee Group Study	(2012)	0.95	UK

The ACI study was inappropriate based on both temporal and geographic representativeness. The figure was unrealistically high, partly reflecting higher commuting distances in USA and less fuel efficient cars, but also because it included avoided construction emissions.

The BT Case study, although also quite old, was very detailed, but restricted to a specific sample set, namely BT employees working based at the BT research centre at Martlesham, Suffolk. It would have had a preponderance of people commuting above average distances by car due to the rural location of the offices. It was based on a detailed survey of BT employees.

A method to derive a figure from the 'The Carbon Intent Project: ICT Enabling Low Carbon Business: Homeworking and Teleconferencing' report by the Communications Management Association (CMA) is outlined below:

- The report "estimates a typical carbon dioxide emissions reduction for a UK-based Homeworker at 9 kg CO_2/ per employee-day worked at home rather than a central office."
- Assuming 229 working days in a year (24 days holiday + 8 days bank holiday + 3 days sick leave) and the average number of days worked from home by a teleworker is 2.8 per week, then the average saving per telecommuter per year is 1.14tCO_2e.

The Yankee Group Study (as explained previously) was carried out for both USA and for EU-5. The figure of 0.95 tCO_2e was calculated by the Carbon Trust by altering the variables in the Yankee Group study to be specific for the UK.

Number of telecommuters enabled

ONS statistics for the number of teleworkers in the UK were obtained from 2012/13 to 2019/20.

Results

The carbon abatement due to telecommuting for the year 2019/20 was 3,242 kt CO_2e.

This was based on a carbon abatement of 0.95 t CO_2e per telecommuter per year, and a total number of telecommuters in the UK of 4,600,315.

The percentage of telecommuters enabled by BT was calculated as the number of broadband lines provided by BT divided by the total UK broadband lines.

References

- Office of National Statistics – Number of teleworkers
- Broadband Services: Economic and Environmental Benefits, The American Consumer Institute (ACI), 2007

- BT Agile Worker Energy & Carbon Study, BT case study carried out for Smart 2020, http://www.smart2020.org/case-studies/bt-agile-worker-energy-and-carbon-study/
- Measuring the Energy Reduction Impact of Selected Broadband-Enabled Activities Within Households, Yankee Group and GeSI, 2012
- The Carbon Intent Project: ICT Enabling Low Carbon Business - Homeworking and Teleconferencing, Communications Management Association, April 2009

TELEPRESENCE

BT's *Telepresence* service is a videoconferencing platform that makes use of high definition cameras and televisions to create a life-like feeling in a virtual meeting between multiple parties. The use of such a platform can eliminate the need for travel to physical meetings, thereby avoiding carbon emissions.

The calculation approach used was:

$$\begin{aligned}&\text{Telepresence carbon saving}\\&\qquad = \text{Carbon saving per Telepresence room } \times \text{Number of Telepresence rooms}\end{aligned}$$

The carbon saving figure per *Telepresence* room was derived from an internal study carried out by BT in 2011 on the potential carbon savings from the global use of *Telepresence*. The study was of a large multi-national company that uses *Telepresence* provided by BT in 36 locations across 17 countries. The study analysed the use of the *Telepresence* service by the company over a 12 month period, and identified the number of virtual meetings taken place and the equivalent number of flights that could have been avoided. The study considered that only 32% of the *Telepresence* meetings that took place would actually replace a physical face-to-face meeting. (The assumption being that the remaining meetings would not have physically taken place, but would have been conducted by telephone, email, or not at all). The figure of 32% was based on research carried out by Cisco.

Taking the total carbon savings made by the company from using *Telepresence* over the 12 month period, and dividing this by the number of *Telepresence* rooms used by the company gave an annual carbon saving of 94.4 t CO_2e per *Telepresence* room.

The carbon abatement enabled by BT for the year due to the provision of *Telepresence* to its customers was thus calculated by multiplying the annual carbon saving of 94.4 t CO_2e per room by the total number of *Telepresence* rooms provided by BT.

References

- BT internal report: *Carbon Footprinting a Global Telepresence Solution*, March 2011.
- A summary of the BT case study can be found in the GeSI SMARTER2020 report: http://gesi.org/portfolio/project/71
- Data on the number of *Telepresence* rooms was provided by the Head of Video Services Product Management for BT.

BROADBAND ENABLED DE-MATERIALISATION

The avoided carbon emissions from residential ‘broadband enabled dematerialisation’ are due to the benefits from the convergence of telecommunications and computers (i.e., “E-materialization”), which replaces the need to manufacture, publish, print and ship newspapers, documents, books, CDs and DVDs for residential customers. Instead these and other services are available digitally on-line.

Through the provision of a broadband network, BT enables these carbon savings due to dematerialisation.

The calculation approach used was:

$$\begin{aligned}&\text{Dematerialisation carbon saving}\\&\qquad = \text{carbon saving per person}\\&\qquad \times \text{Number of residential broadband customers enabled by BT}\end{aligned}$$

The carbon saving figure per person was derived from the Yankee Group study [2012].
The carbon saving mechanisms considered in the Yankee Group study are online news, music streaming, online banking, online shopping, online education, digital photos and e-mail. The total carbon savings identified in the study for five European countries was divided by the number of working age people in those countries. The result was an annual carbon saving figure per person as in the table below:

Mechanism	Carbon saving (t CO_2e)
News	0.000364
Music	0.003195
Banking	0.007736
Shopping	0.007849
Education	0.001681
Photos	0.007804
Mail	0.002668

This gives a total saving of 0.031 t CO_2e per working age person per year.

References

- Measuring the Energy Reduction Impact of Selected Broadband-Enabled Activities Within Households, Yankee Group and GeSI, 2012 http://gesi.org/portfolio/report/26