Superfast Cornwall Environmental Monitoring

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Document History

Version	Date	Author	Changes
0.1	01/04/2015	Graham Seabrook	First draft for comment
0.2	02/04/2015	Graham Seabrook	Additional details provided throughout
0.3	16/04/2015	Graham Seabrook	Internal (working document)
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Distribution

BT Superfast Cornwall Team
CDC Programme Team

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Executive Summary

It has long been recognised that Information & Communication Technologies (ICTs) have an important role to play in combatting climate change. The Smart 2020 report[1], published in 2008 and the subsequent Smart 2020 report[2] published in in 2012 have both sought to quantify the net positive impact of ICT in reducing carbon emissions: that is to say, the reduction in carbon emissions resulting from other activities, which ICT can replace. For example, replacing travel with audio or videoconferencing.

Superfast Cornwall, funded jointly by the European Union and BT, provided an ideal opportunity to study the environmental impact of what is perhaps the most pervasive of information and communication technologies: superfast broadband. We have sought to quantify both the negative impact of deploying a superfast broadband network and the positive impact that the network can have on end users and the societies in which they live.

Our original plan was to capture real energy consumption and carbon emissions from end users – both consumers and business users – along with data which would allow us to estimate the carbon abatement that the network was delivering. One disappointment of the study was the degree of difficulty we encountered in maintaining participation in the trials. Whilst initial interest was good, we found it almost impossible to maintain and as a result we were unable to secure enough primary data to infer statistically significant outcomes. Our analysis of carbon abatement has therefore drawn heavily on BT's Net Good methodology[3] and is based, where possible, on results and conclusions of other studies. Nevertheless the following results have been independently reviewed and endorsed by the Carbon Trust.

The results have been surprising: assuming a grid average carbon emissions factor for electricity used to power the network the total emissions over a 9 year period, including planning and building the network, connecting up customers and operating the network "in-life" have been estimated as **31,248 tCO_2e.** The total carbon abatement which the network *could* facilitate over this time frame, based on the adoption rates which we have witnessed in Cornwall and extrapolated out to an assumed 50% capacity, is of the order of **581,146 tCO_2e,** driven by annual carbon savings per subscriber of approximately **1 tCO_2e per annum**. It is interesting to note that this level of abatement is some **25 times** the carbon emissions associated with the Superfast Cornwall network (at least those considered as being in-scope; i.e. within the system boundaries as discussed in the report).

It could, of course, be argued that the resources required to deliver Superfast Cornwall have been able to draw a much wider set of support functions in BT and that the roll-out would not have been possible without this support; similarly it could be argued that the system boundary could have been wider to capture a broader set of carbon impacts. On the other side of the equation it is possible that we have been too generous in our estimates of the carbon abatement potential of the network. But even with these considerations taken into account it is still evident that the net impact of Superfast Cornwall, given the assumptions we have made in this study, is overwhelmingly positive; a conclusion which strongly endorses those of the Smart 2020 and Smarter 2020 reports and further

[1] www.smart2020.org
[2] www.gesi.org/smarter2020
[3] www.btplc.com/Betterfuture/NetGood/OurNetGoodMethodology/index.htm

reinforces the view that ICTs have an important role to play in helping society adapt to the challenges of climate change.

1. Background

Under section 2.11.3 of the Cornwall Next Generation Broadband Access (202385) scheme let between South West Development Agency (SWRDA) and BT PLC dated 31st August 2010, BT was required to undertake activities in order to monitor the Environmental Impact of "Superfast Cornwall". In response BT proposed a project which would seek to quantify the carbon impact of Superfast Cornwall.

The primary objective of the project was to estimate the carbon emissions resulting from the roll-out and on-going operation of the Superfast Cornwall network (i.e. the carbon footprint of the network).

A secondary objective was to try and quantify the positive environmental impacts – specifically the carbon abatement – that a superfast broadband network can deliver to predominantly rural communities such as Cornwall. This carbon abatement was expected to result principally through changes to end-users' behaviour – in particular, travel patterns.

By aggregating the carbon footprint and the carbon abatement it was hoped that we would then be able to ascertain the net carbon impact of Superfast Cornwall.

A project was therefore proposed which would seek to quantify these two components through four distinct phases:

> **Phase 1**: Estimation of the aggregate base-line carbon footprint of end users prior to adoption of Superfast Cornwall
>
> **Phase 2**: Estimation of the carbon footprint of the Superfast Cornwall project itself
>
> **Phase 3**: Periodic re-estimation of the carbon footprint of the end-user group with Superfast Cornwall installed.
>
> **Phase 4**: Estimation of the net carbon impact of Superfast Cornwall

1.1. Phase 1: establishing base-line end-user carbon footprints

Our original proposal was to adopt a "broad and shallow" approach for the majority of end users, collecting data via a web-based carbon calculator, with variants pertinent to consumers and businesses.

We had also hoped to identify a smaller subset of consumers and business users who would be willing to complete a 1-week "carbon diary" in order to provide a more detailed insight into their typical weekly travel profiles prior to and after installation of Superfast broadband.

1.2. Phase 2: Carbon Footprinting the Superfast Cornwall network

We planned to estimate the carbon footprint of the Superfast Cornwall project and to then calculate a representative annual carbon footprint per Superfast Cornwall line.

The carbon footprint of the network was to be considered in terms of three components:

- customer premises equipment (CPE)

- network service platforms
- operational activities, service wrap and non-ICT infrastructure

Boundaries for the system under study were set according to the WRI GHG Protocol and ISO 14064 "Control" approach for boundary setting:

Control approach: an organisation accounts for 100 per cent of the GHG emissions from operations over which it has control. It does not account for GHG emissions from operations in which it owns an interest but has no control. Emissions sources which were therefore deemed to be in-scope included:

Emission Source	
1)	Superfast Cornwall network build: Openreach resources and fuel used
2)	Superfast Cornwall network: equipment and infrastructure including: • Equipment in BT Exchanges • Street Cabinets used to deliver Fibre to the Cabinet (FTTC) • Passive infrastructure (fibre, cabinets, etc).
3)	Customer Premise Equipment (BT provided) including: • The Fibre to the Premises (FTTP) NTE (Network Termination Equipment)
4)	BT / CDC personnel employed on deployment, delivery and maintenance of Superfast Cornwall

In each case, a materiality test was to be applied: specifically we proposed to employ a materiality threshold of 5% of total carbon emissions.

Our intention was to estimate the carbon footprint of the network, based substantially on power consumption information collected from supplier's data sheets, supported where practical through measured power consumption data collected from BT exchanges and street cabinets.

It should be noted it was agreed that the geographic boundary under study be limited to mainland Cornwall – excluding the Isles of Scilly – as when the original project was proposed it was unclear which technologies would be used to deliver Superfast Cornwall to the Isles.

1.3. Phase 3: Re-assessing end-user carbon footprints

At 12-monthly intervals after installation of Superfast Cornwall, we planned to reassess the carbon footprint of the end user group (using the same approaches as used at the initial base-lining) in order to identify and quantify any changes in behaviour which are attributable to the deployment of Superfast Cornwall.

1.4. Phase 4: Analysis

From Phase 2 we hoped to derive a representative annual carbon footprint per Superfast Cornwall broadband line based on the total carbon footprint of the solution and its agreed lifespan divided by the total capacity of the network.

From Phases 1 and 3 we hoped to understand the carbon impact of Superfast Cornwall on end users and to define a set of typical footprints for different classes of end user. We will use these representative carbon impacts to

(i) draw conclusions about the likely impact of Superfast Cornwall on different classes of end user and;

(ii) model a representative carbon footprint for Superfast Cornwall were it fully populated with users.

1.5. Risks / Issues / Dependencies

It was recognised that the proposed approach was not without risks or dependencies. These included:

1. An inability to get sufficient numbers of consumers and businesses to participate in the project
2. A dependency on participants having access to details of their energy usage and travel profile
3. A dependency on the final split between FTTC, FTTP and In-fill
4. A dependency on being able to access smart meters in cabinets and exchanges
5. Continued participation of consumers and businesses throughout the project

1.6. Report structure

The following report is broken into four parts covering

- Phase 1: Summary of activities and outcomes
- Phase 2: Estimating the carbon footprint of the Superfast Cornwall network
- Phase 3: Estimating the level of carbon abatement facilitated by Superfast Cornwall
- Phase 4: Conclusions: the net carbon impact of Superfast Cornwall

2. Phase 1: Summary of Activities and outcomes

2.1. The Green Gauge Carbon Calculator

In order to establish base-line carbon footprints for typical end-users it was decided to utilise a web-based carbon calculator. Such a calculator would provide an easily accessible method for collecting data from a large number of participants. A detailed analysis of existing online carbon calculators was carried out and summarised in the report titled "Comparison of Carbon Calculators" embedded below.

Microsoft Word
Document

Comparison of Carbon Calculators 1

The conclusion of this analysis was that none of the then available calculators met our needs and it was decided to tender for a calculator specifically for the project.

We subsequently became aware of other projects managed by the Cornwall Development Company which were also considering tendering for a similar carbon calculator and after a number of meetings decided to join forces. A specification was produced which met all partners needs and the production of what became known as the "Green Gauge" was put out to tender.

Microsoft Word
97-2003 Document

Carbon Calculator Specification 1

The successful tenderer was Carbon Footprint Ltd, whose proposal was to develop and enhance and existing, established on-line calculator to meet our joint requirements. One particular requirement, in order to capture seasonal differences, was that data should be collected monthly. An automated email reminder system was set up and it the burden of regular monthly data collection was minimised by enabling users to copy data from previous months as a starting point.

The calculator was subsequently developed and jointly launched by the partners – appearing on the Superfast Cornwall website, the Visit Cornwall website, CDC Low Carbon website, the Eden Project and the COAST website.

A marketing plan was developed in order to publicise the availability of the calculator utilising the resources of all four partners: activities included e-mail shots, press briefings, webinars and other marketing channels.

The Green Gauge calculators (one targeting business users and the other consumers) were launched in March 2012 and by the end of September 2012 had 141 registered accounts

2.2. Carbon Diem

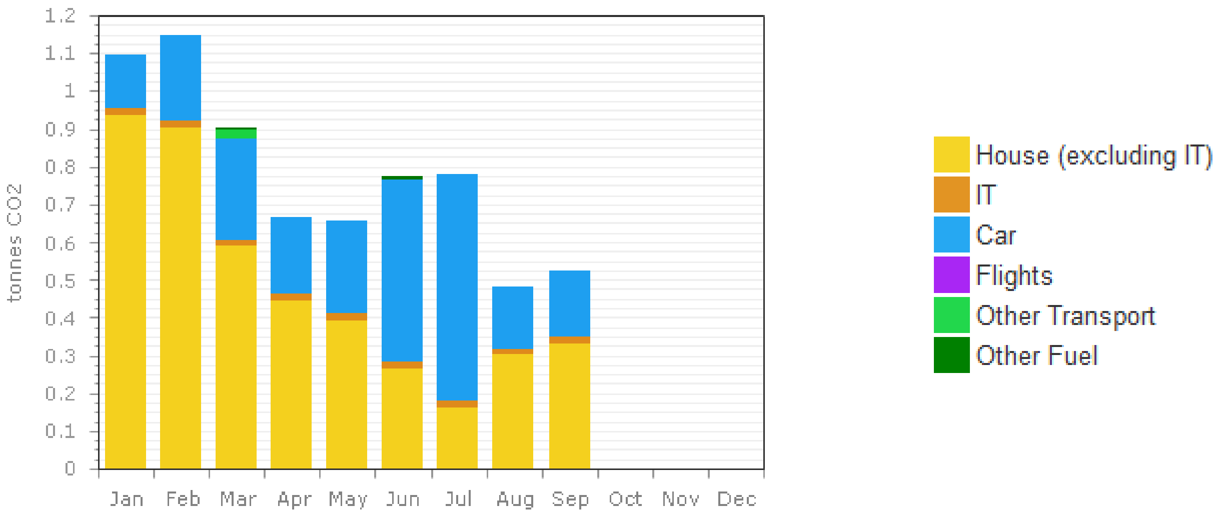
In addition to launching the Green Gauge carbon calculator, we became aware of an opportunity to trial an innovative smartphone app called Carbon Diem. The app runs in the background on compatible smartphones and non-intrusively tracks the owners travel, intelligently selecting the most likely travel mode and calculating the resultant carbon footprint.

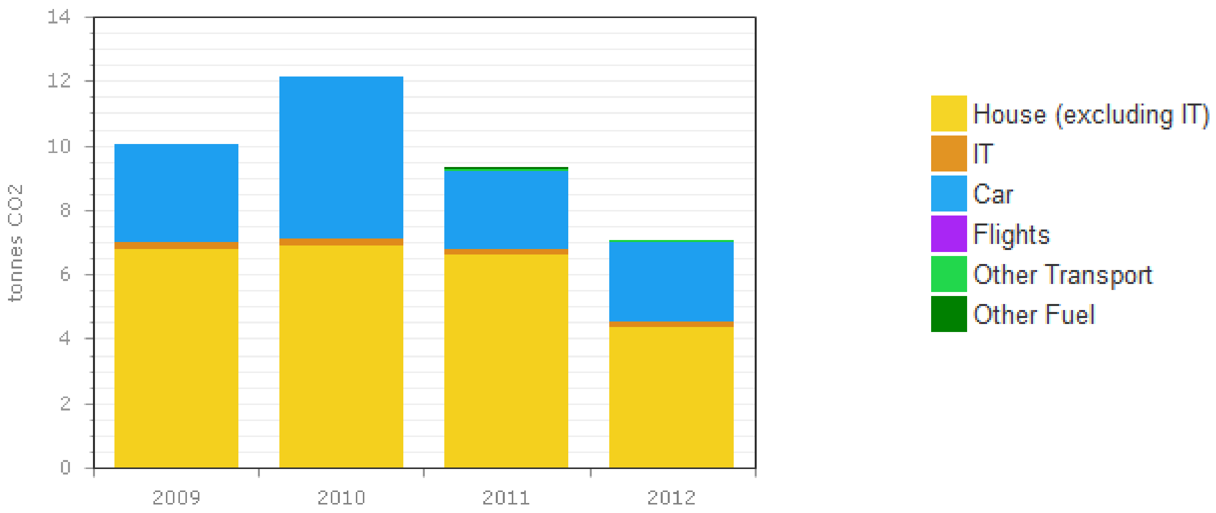
The app appeared to provide us with an easy way of collecting travel-related carbon emissions and thus, after negotiations with the apps developers, we placed a contract for Superfast Cornwall users to gain access to the app. The following diagram is a screen shot of the Carbon Diem web interface (similar to that displayed on the smartphone).

2.3. Combining Green Gauge with Carbon Diem

In order to minimise the effort required to participate in the trial it was recognised that the Carbon Diem app needed to be integrated as seamlessly as possible with the Green Gauge calculator such that travel-related carbon emissions could be seamlessly uploaded into the relevant sections of the Green Gauge. A contract was duly placed with Carbon Footprint Ltd (providers of the Green Gauge calculator) to add this functionality.

The combined system (Green Gauge + Carbon Diem) worked very well, functionally. The following screen shots are real examples from one of the trial users. They demonstrate the effectiveness of the tool in building up a month by month profile of the user's carbon footprint, showing clear seasonal differences driven by lower household energy usage during the summer months and higher transport energy usage (resulting from summer holidays):





Year	Months Of Data	House (excluding IT)	IT	Car	Flights	Other Transport	Other Fuel	Total
2009	1	6.80	0.22	3.02	0.00	0.00	0.00	10.04
2010	2	6.88	0.22	5.04	0.00	0.00	0.00	12.14
2011	1	6.59	0.21	2.42	0.00	0.05	0.04	9.32
2012	9	4.34	0.16	2.50	0.00	0.03	0.01	7.05
Total		24.61	0.82	12.98	0.00	0.08	0.06	38.55

2.4. Other initiatives

In addition to the carbon calculator and CarbonDiem, a number of other initiatives were also kicked-off in order to try and drive greater participation in the trial. These included:

- Reviewing and revamp the carbon calculator, simplifying it where possible and improving the user interface
- Focussing efforts predominantly on SMEs, not consumers
- Leveraging the "Green 100" – a subset of companies with strong environmental credentials - to attract and retain SMEs
- Establishing an agreement with a local accountancy firm, Frances Clarke, who were seeking to establish a business delivering carbon accounts for SMEs
- Presenting at the Visit Cornwall conference
- Continuing to leverage Superfast Cornwall subscriber's database.

Superfast Cornwall also incorporated the Carbon Calculator and CarbonDiem tools in a place-based research study called 'Superfast Wadebridge' in the Cornish town of Wadebridge, in partnership with Wadebridge Renewable Energy Network and Community Energy Plus. However, few businesses and residents engaged with the tools, despite considerable efforts to encourage participation. Consequently, while the project gathered evidence to show that the introduction of fibre broadband resulted in an attitudinal change in Wadebridge towards homeworking and environmental issues, there was insufficient evidence to support quantifiable change.

Other initiatives have gathered qualitative data into the environmental impact of Superfast. This includes a longitudinal survey with fifty businesses in Cornwall which showed 47% of surveyed businesses felt their travel usage had reduced as a result of utilising more sophisticated internet functions. This SERIO report is available from the Superfast Cornwall website (www.superfastcornwall.org). Other research initiatives have demonstrated how fibre broadband is an *enabler* to better understand and reduce energy usage, including:

- The Eservices Upon Demand project at the University of Falmouth which uses environmental monitoring devices in a care home (see University of Falmouth project report)
- The Smart Energy project which installed energy monitoring devices on appliances in 55 residential and business premises. Through the use of an online portal, the Superfast connection made it possible for residents and businesses to monitor their energy usage and take steps to reduce it (see Anient Ltd project)
- An environmental network study into how the fibre network will enable businesses and universities to collate environmental data across the region (ESI, Exeter University, report forthcoming)
- A One Planet MBA dissertation into how Superfast enables flexible working (University of Exeter).
- A One Planet MBA dissertation into how businesses can be encouraged to shift to the cloud (University of Exeter).

Alongside these projects, Superfast Cornwall supported Unlocking Potential activity which encouraged businesses to use video-conferencing for the first time. Superfast Cornwall also maintained a flexible working website (www.flexible-working.org) to foster greater understanding of the organisational and employee benefits.

2.5. Outcome

Unfortunately, as noted above, despite the efforts which went into marketing the tool and raising awareness amongst Superfast Cornwall subscribers, take-up of the tool remained very low throughout the trial period. Similarly, our other attempts to quantify carbon benefits resulting from changes to consumer and business behaviour as a result of the availability of Superfast Cornwall had disappointing outcomes: none resulted in sufficient data to establish meaningful baseline carbon footprints for Superfast Cornwall users or to formulate any statically significant results.

For the purposes of this study and report we have therefore adopted an approach previously used by BT (and endorsed by the Carbon Trust), in order to estimate the carbon abatement delivered more broadly by BT's products and services and formalised in the form of BT's "Net Good" programme. This approach uses published reports and papers to establish the likely magnitude of carbon abatements per user for different products and services.

This approach is covered in detail in Part 4 of the report.

3. Phase 3: Establishing the carbon footprint of Superfast Cornwall

As detailed in the Introduction, the "system boundary" for Superfast Cornwall was restricted to the following components:-

1) Superfast Cornwall network plan, build and installation

2) Superfast Cornwall network operational emissions – including:

(i) Equipment and infrastructure including:

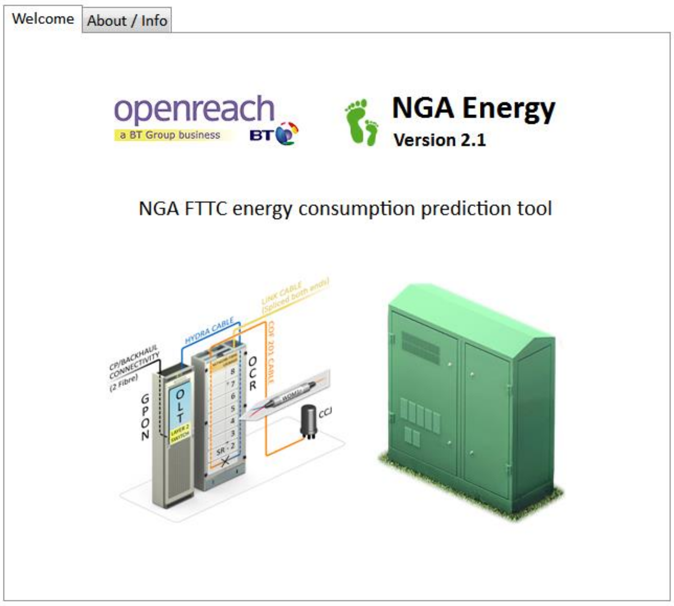
- Equipment in BT Exchanges
- Street Cabinets ("DSLAMS") used to deliver Fibre to the Cabinet (FTTC)

(ii) Customer Premise Equipment (BT provided), specifically:

- NTE (Network Termination Equipment) at the customers' premises
- The home hub through which the end user connects to Superfast Cornwall [4]

3) BT, Openreach and Cornwall Development Company staff and contractors, involved with the build, operation and maintenance of the network.

In order to estimate the carbon footprint of the Superfast Cornwall network itself – i.e. the plan and build phase and the electricity used to power the network in-life - BT developed an NGA (Next Generation Access) FTTC Energy Prediction Tool:



[4] NB: the modem through which the customer connects to the network (FTTC) or the NTE (FTTP) was originally deemed to be out of scope, since Superfast Cornwall neither funds or has influence over the modem selected; however it was decided to include these devices as they are a necessary component of all superfast broadband connections and were anticipated to have a material impact on the carbon footprint of the network.

The tool was designed to forecast the energy consumption (and associated carbon emissions) of the fuel used by BT vans during the Plan, Build and Install phase (often referred to as "truck rolls") and the energy consumed by the in-scope network equipment during its operational life. To this we have then added estimates of the carbon emissions associated with BT and Openreach staff deployed during each phase of the project.

In all cases energy consumption is converted to carbon emissions using grid average emissions factors for different fuel types, e.g. electricity, gas, petrol and diesel, taken from the Defra Carbon Factors for 2014, available at:- http://www.ukconversionfactorscarbonsmart.co.uk/

3.1. Superfast Cornwall network plan and build

Principal activities which we have considered during the Plan, Build and Install phase include:-

1) Installation of the 700+ DSLAMS (roadside FTTC cabinets)
2) Installation of the Fibre headend equipment in 15 key BT Exchanges across Cornwall (excluding Isles of Scilly)
3) Installation of "splitters", "joints", manifolds and other passive components; although no "active" (i.e. powered) components themselves each unit required a number of site-visits by BT engineers
4) Installation of new poles in order to carry overhead fibre optic cabling

Our original plan was to estimate the number of "truck rolls" associated with the build of FTTC cabinets, the fitting out of Exchange head-ends and the installation of FTTP splitters through reference to records maintained by Openreach. In practice, the varied nature of the activities undertaken by BT / Openreach engineers meant that it was impossible to identify journeys which were solely related to Superfast Cornwall. We have therefore sought to gather anecdotal evidence from engineers involved with the roll-out to estimate both the number of truck rolls and the average number of miles travelled per network element.

3.1.1. Network infrastructure build

Exchanges used to support the Superfast Cornwall network are classified as either "Primary Exchanges", of which there are 15, or "Secondary Exchanges", of which there are 79. Only the Primary exchanges contain NGA head-ends (active electronics); the secondary exchanges simply being "pass-through" points in the network.

As shown on the map below, the primary exchanges are evenly distributed across Cornwall from Penzance in the South to Bude in the North:

In practice, primary exchanges were typically fitted out by engineers based in the main Superfast depot at Threemilestone, near Truro; hence journey distances to the fifteen "primary exchanges" are as follows-

Exchange	Distance from Threemilestone (miles)	Exchange	Distance from Threemilestone (miles)
TRURO	3	BODMIN	27
REDRUTH	10	PENZANCE	27
FALMOUTH	11	CAMELFORD	35
NEWQUAY	13	LISKEARD	36
CAMBORNE	14	LAUNCESTON	47
ST AUSTELL	15	CALLINGTON	50
HELSTON	17	BUDE	52
WADEBRIDGE	25		

Our model therefore takes into account the average mileage to these exchanges of approximately 24 miles or 48 miles for a return journey. We have assumed that each Primary Exchange requires two visits: one for installation and one for commissioning (any additional exchange work such as extra power/ventilation is not included). Generally, for all truck rolls we have assumed a 40:60 ratio of petrol to diesel powered vans.

For installation of the DSLAMs, following discussions with Openreach engineers involved in the actual roll-out, we have assumed an average of 6 visits per DSLAM for installation and commissioning. However we have assumed that installation of the DSLAMS was carried out by engineers based at either the head ends of other local exchanges with an average round trip journey of 24 miles (i.e. average of 12 miles from home exchange to the DSLAM), based on consideration of the distances between primary exchanges and the clustering of cabinets around the main centres of population which, by and large, are where the primary exchanges are also located.

Considering the impact for a single Primary Exchange and a single DSLAM the model produces the following Plan & Build carbon footprints :-

DSLAM Builds	
Truck per rolls per DSLAM	6
Miles per truck roll	24
$kgCO_2e$ / DSLAM	54.46

Ratio of petrol to Diesel	
% of petrol vans	40%
& of diesal vans	60%

Exchange Builds	
Truck per rolls per Exchange Build	2
Miles per truck roll	48
$kgCO_2e$ / Exchange	36.31

Emissions factors	
Petrol ($kgCO_2e$/mile)	0.339811
Diesel ($kgCO_2e$/mile)	0.403822

To deliver the network BT / Openreach engineers built over 4,500 network components thus:-

Units Built	Items	Avg Built /day	Total Days
1321	Nodes/Splitter/FDP	2	661
670	Track Joints	1	670
1526	O/H Manifolds	10	153
1041	U/G Manifolds	10	104
Estimated Total Truck Rolls			**1587**

This results in average number of truck rolls per "unit" of almost exactly 1 and application of the model to the build of these components generates the following carbon footprint:--

Network Component Builds	
Truck rolls per unit	1
Miles per truck roll	24
$kgCO_2e$ / Splitter	9.08

Lastly a significant number of new poles were also installed to carry overhead fibres and it has been assumed that these also incur a similar level of carbon emissions to the other network components.

Pole Installation	
Truck rolls per pole	1
Miles per truck roll	24
kgCO_2e / Pole	9.08

3.1.2. Connection of customers to the network

The next factor to be considered in the Plan, Build & Install phase was the connection of FTTC customers at their local cabinet and the installation of FTTP customers at the customer premises themselves.

Connection of FTTC customers requires an engineer to visit the relevant cabinet and physically connect the customer to the superfast broadband network. This can usually be accomplished in a single visit. FTTP on the other requires a minimum of two, typically three and occasionally more visits to the customer's house or business premises for survey, planning and commission of the connection. Assuming the same average mileage of 24 miles per truck roll gives the following carbon footprints for connection:-

FTTC Connection	
Truck rolls per FTTC install	1
Mileage per truck roll	24
kgCO_2e / Customer Install	9.08

FTTP Installation	
Truck rolls per FTTP install	3
Mileage per truck roll	24
kgCO_2e / Customer Install	27.23

For the purposes of this report we have looked at the number of subscribers in each PCP

3.1.3. Carbon impact of engineers and office-based staff

Finally, to the above figures we need to add carbon emissions for all staff deployed on the Plan, Build and Install activities.

We have estimated the following PB&I resource profile, over both the 5 years of the initial roll-out and the subsequent 5 years of operation to 2020:

	2011 -12	**2012 -13**	**2013 -14**	**2014 -15**	**2015 -16**	**2016 -17**	**2017 -18**	**2018 -19**	**2019 -20**
Engineers (PB & I)	46	97	98	85	85	6	5	4	3
Office-based staff (PB & I)	40	48	60	50	50	20	15	10	5
Total (PB&I)	86	145	158	135	135	26	20	14	8

To calculate the carbon impact associated with these resources we have drawn upon data published in the Energy Consumption Guide 19[5] which details average energy consumption and carbon emissions for different types of office accommodation (per metre squared). We have then multiplied these figures by an average 14.8 m^2 per employee derived from a 2013 study by CoreNet Global[6].

This results in an average consumption per person of 1.641 tCO_2e pa per office worker. Engineers are predominantly "van-based" and as such their primary carbon emissions relate to the vans they are driving. However we have included carbon emissions equivalent to 50% of an office work (0.82 tCO_2e pa) per engineer to reflect additional emissions for which they are responsible. Combined this gives the following emissions estimates ($kgCO_2e$ pa):-

	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Engineers	37,752	79,607	80,428	69,759	69,759	4,924	4,103	3,283	2,462
Office staff	65,655	78,786	98,483	82,069	82,069	32,828	24,621	16,414	8,207
Total ($kgCO_2e$ pa)	103,407	158,393	178,911	151,828	151,828	37,752	28,724	19,697	10,669

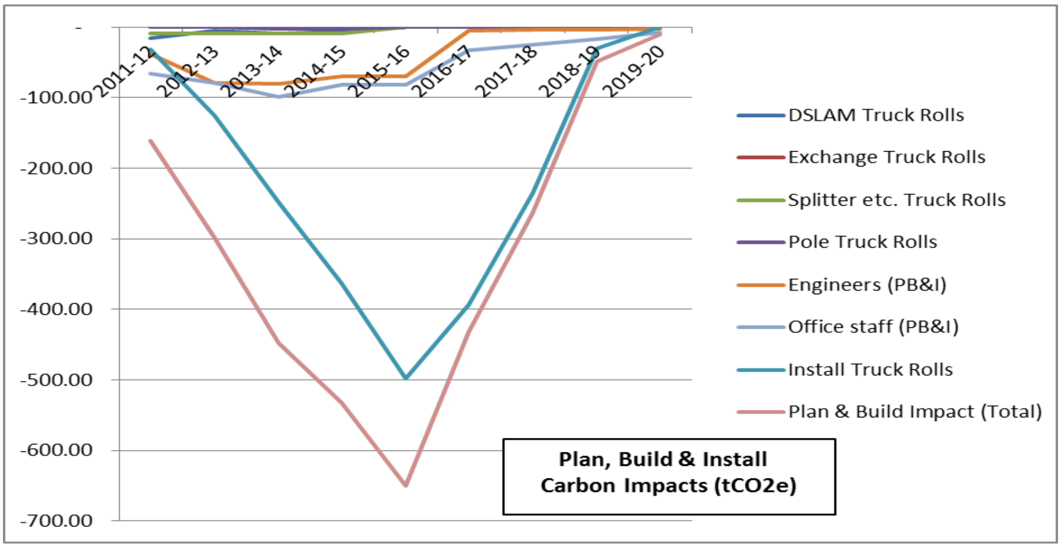
3.1.4. Plan, Build & Install Carbon Footprint – total impact

Aggregating the above emissions results in a **total PB&I carbon footprint over the 9 year period from 2011 to 2020 of 2,844 tCO_2e**, calculated thus:-

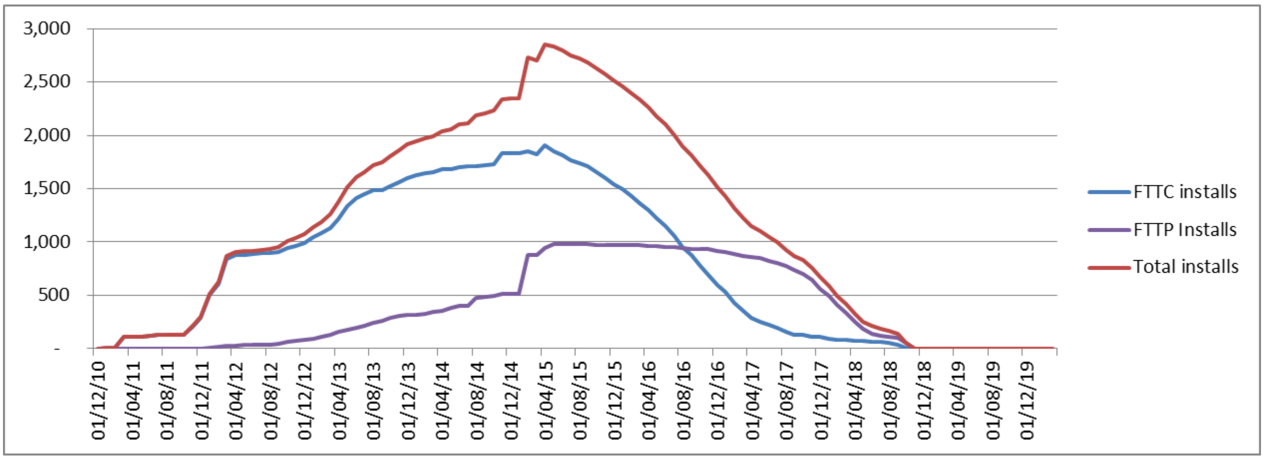
Element	Number of elements	Emissions per element ($kgCO_2e$)	Total emissions ($kgCO_2e$)
Headend build	15	36.31	399
DSLAM build	703	54.46	35,238
Splitter, etc. build	4,558	9.08	38,187
Pole installation	500	9.08	4,539
FTTC connections	85,656	9.08	780,877
FTTP installations	41,984	27.23	1,143,226
Office staff (FTE)	419	1,641	489,132
Engineers (FTE)	429	821	352,077
Total			**2,843,675**

[5] http://www.targ.co.uk/other/guide19.pdf
[6] http://www.bdcnetwork.com/corenet-office-space-worker-shrinks-150-sf

When mapped across the period under study, the profile of emissions highlights the dominance of the emissions associated with connection of customers to the network: that is to say the emissions associated with fuel burnt by vehicles when connecting FTTC subscribers in roadside cabinets or FTTP subscribers in their homes (“Install Truck Rolls”). Although the number of FTTP subscribers is lower than FTTC, each new installation typically takes between 2 and 4 visits to the customer’s home or business, resulting in approximately 3 times the carbon emissions.



When broken down to a more granular monthly level the relative emissions associated with FTTC and FTTP installs can be clearly seen:-

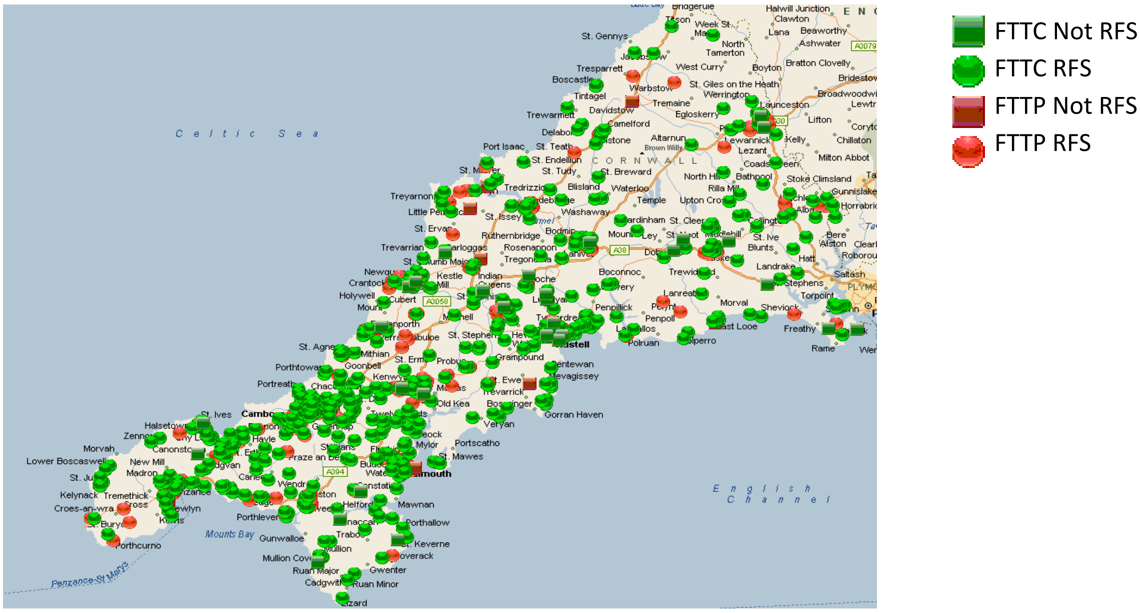


In both cases, the rural and distributed nature of the population in Cornwall will clearly have increased the carbon burden of these activities to levels which are likely to be significantly higher than in densely populated areas or cities.

3.2. Superfast Cornwall In-Life Carbon Footprint

As noted above the fully deployed network will be comprised of 1071 Primary Connect Point (PCP) areas of which 703 will be served by Fibre to the Cabinet (FTTC) and 367 will be Fibre to the Premise (FTTP). As the name implies, FTTC connections are delivered via a cabinet (“DSLAM”) which contains active electronics; FTTP on the other hand is a passive optical network with no active electronics between the BT Exchange where the head end equipment is located and the customer premises.

The PCPs are broadly distributed across Cornwall with higher concentrations around larger towns and cities including Truro, Falmouth, Cambourne, Penzance, Newquay, St Austell and Launceston:-



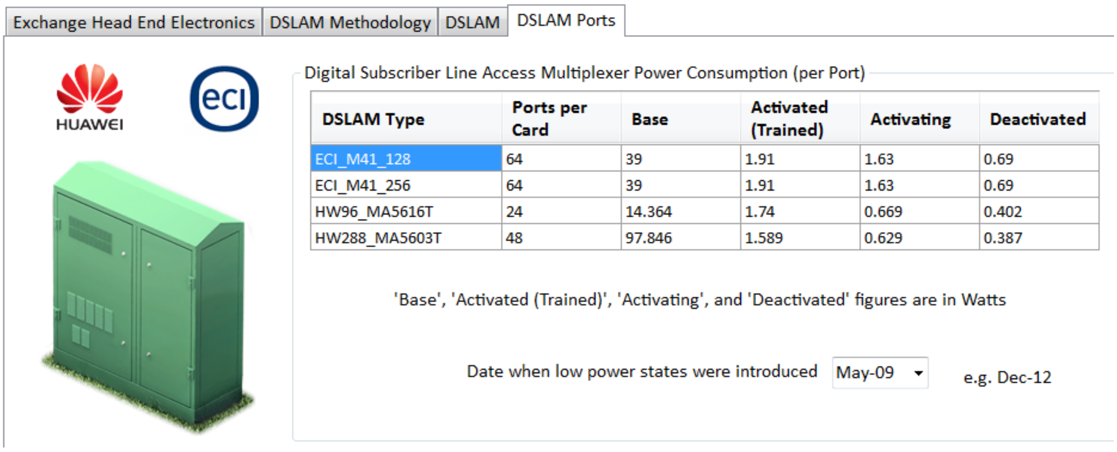
During the operational (“in-life”) phase we have forecast the electricity consumed by the equipment in all the DSLAMs (cabinets) and Exchange head-ends. In addition we have taken into account the carbon emissions associated with the NTE (network termination equipment) provided by Openreach and, although not originally considered as “in-scope”, the home hub / router / modem through which the customer connects to the network. As for the Plan, Build and Install phase, we have then added estimates of the carbon emissions associated with BT and Openreach staff deployed during the operational phase of the project.

3.2.1. FTTC Cabinet Carbon Emissions

Each FTTC PCP is serviced by a cabinet or DSLAM, equipped with equipment supplied by one of two manufacturers, ECI and Huawei, and a smart meter from which BT collects real time energy consumption data.

Of the 703 cabinets, 385 are equipped with Huawei equipment and 318 with ECI. The NGA Energy Model calculates the power consumption associated with each of these cabinets. As illustrated below, we take into account:-

1) Equipment vendor associated with each cabinet
2) Utilisation of the cabinet, given that deactivated ports can be left in a low power state pending activation
3) The number of line cards and the number of ports per card to give the total number of available ports
4) The base power load of the DLSAM



DSLAM Type	Ports per Card	Base	Activated (Trained)	Activating	Deactivated
ECI_M41_128	64	39	1.91	1.63	0.69
ECI_M41_256	64	39	1.91	1.63	0.69
HW96_MA5616T	24	14.364	1.74	0.669	0.402
HW288_MA5603T	48	97.846	1.589	0.629	0.387

Figure 1: NGA Energy Model configuration: DSLAMS

In order to calculate the carbon emissions associated with the cabinets we took as our base data

1) The Ready for Service (RFS) date of each cabinet
2) The number of live orders taken for each cabinet as of 5/1/15
3) The Total Homes Passed (THP)[7] for each PCP – representing the maximum potential capacity for the PCP
4) The current take up as a percentage of THP

We then assumed that the live orders has been acquired linearly from the RFS date to 5/1/15. (In practice the connection profile would been non-linear but the linear allocation was thought to offer a good approximation to take into account the increasing power consumption at each cabinet *but also* the increasing carbon levels of carbon abatement (see section 4 below) attributed to each line.

We then considered the take-up rates across all cabinets since their RFS dates. The THP for *all* FTTC cabinets is 170,739, of which 50,343 were connected as of 5/1/15; i.e. 32%. However when broken down by year the connection profile appears thus:-

Years since RFS date	Percentage of THP connected
>3 years	32%

[7] Includes business premises

>2 years	34%
>1 years	33%
<1 year	18%

However it was also noticeable that a significant number of the longest serving cabinets had take-up in excess of 40% and in some cases as high as 70%.

BT has an aspiration that, in due course, 50% of THPs will be connected to the Superfast Cornwall network. We therefore extrapolated continued linear growth beyond January 2015 to the point at which take-up within each PCP was 50%. We determined that growth rate by assuming that the time to populate a new PCP (with zero connections) to 50% would be 3.5 years (42 months); i.e. we applied a growth factor of 1/42th of the target (50%) occupancy per month, up to the point at which the PCP was showing 50% take-up.

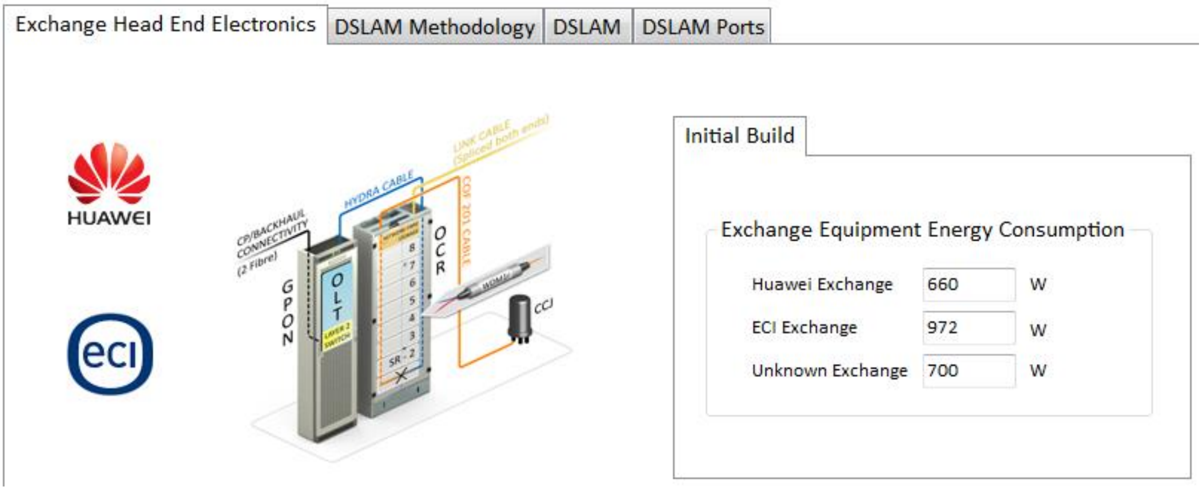
On the basis of the above assumptions, the In-Life carbon emissions associated with the powering of the DSLAMs was calculated to be 6,852tCO_2e assuming a grid average carbon emissions factor.

In practice, however, BT purchases 100% of its electricity from renewable sources and therefore claims a carbon emissions factor of zero with resultant carbon emissions of 0tCO_2e.

3.2.2. Head End Exchange Carbon Emissions

The second key element in delivering Superfast Cornwall is the equipment at the NGA head-end, typically within a BT Exchange.

BT has 15 primary (parent) exchanges (Head Ends) and 79 secondary (child) exchanges which have been upgraded to support Superfast Cornwall. Like the DSLAMS, the head ends are configured with either ECI or Huawei equipment and the model assumes a single power consumption figure for each vendor, regardless of specific configuration (future iterations of the model may be enhanced to consider specific card configurations):



The Deployment Plan is then used to calculate the power consumption profile of the network, both during the plan & build and operational phases

From this data we calculated the carbon emissions associated with the electricity consumed by the cabinets and exchanges during operational life.

As noted above, as a consequence of BT's 100% green energy contract the net carbon emissions associated with powering the exchange headends is 0kgCO_2e. However, for comparison calculating carbon emissions assuming grid average carbon factors as supplied by DEFRA results in total in-life emissions of 510 tCO_2e for the Headend Exchanges.

3.2.3. Network Termination Equipment (NTE)

Each Superfast Cornwall broadband line is terminated in the customers' premises: with a piece of equipment referred to as the "NTE" (Network Termination Equipment). The NTE is mains powered and consumes, on average, 10W of electricity. The devices will typically be left powered on 24*365 hours per year and the carbon emissions associated with each box have been calculated to be about 43.4 kgCO_2e per annum

The 367 FTTP PCPs in the Superfast Cornwall network will support up to 83,968 subscribers if fully populated. To January 2015, average take-up across all PCPs was running at approximately 15% (8,487 subscribers) but for cabinets installed for greater than 3 years take-up has reached in excess of 30%. As for FTTC, in this model we have assumed that take-up will continue to grow up to a maximum of 50% of capacity in all PCPs, or approximately 42,000 FTTP subscribers. **This results in a total carbon footprint associated with FTTP NTE of 7,618 tCO_2e.**

3.2.4. Home hub, router or modem

In the original proposal it was proposed to exclude the impact of the home hub through which the end user connects to Superfast Cornwall, since we have no direct influence over the selection of the particular home hub; this being provided by the respective service provider. (It should be noted that BT Retail is only one of a number of service providers with whom the customer could potentially contract for superfast broadband).

However, after discussion and review with The Carbon Trust it was agree to incorporate an estimate of the impact of the home hubs since these are a necessary component in all cases to provide connectivity into the network. The impact of the home hub was also expected to be material, since, whilst the power consumption of the devices themselves is relatively low, the volume of devices being deployed is significant (i.e. 1 device per connection).

In line with our forecast we have estimated that by 2020 there will be in the region of 128,000 subscribers.

We have assume that the BT Home Hub 5a and 5b are indicative of the kind of device that will be deployed by service providers. Both devices support low power "idle" modes and standby modes. We have assumed that a typical user profile will see the device being operational (full power) for 6 hours/day; idle for 6 hours/day and in standby for 12 hours/day and that there will be equal numbers of both devices. On this basis the average power consumption across all devices was estimated as 4.663W thus:-

	BT Home Hub 5A	BT Home Hub 5B
In operation	9.2	14
Idle	6.3	7.2
Standby mode	0.2	0.1
Average W	3.975	5.35
Average across 5A and 5B (W)	4.663	

The resultant carbon emissions across the 9 year study period are estimated to be 13,275 tCO_2e.

3.2.5. BT, OR and CDC staff

We have estimated the carbon footprint of staff responsible for delivery and support of the operational services using the same approach a outlined for PB&I resources above. The In-Life resource profile, has been assumed to be thus:

	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Engineers (In-Life)	2	3	4	4	4	4	4	4	4
Office-based staff (In-Life)	16	17	19	17	6	0	0	0	0

Using the same carbon footprint estimates of 1.64tCO_2e per office worker and 0.82tCO_2e per engineer gives the following cumulative emissions estimates ($kgCO_2e$ pa):-

	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Engineers	1,641	2,462	3,283	3,283	3,283	3,283	3,283	3,283	3,283
Office staff	26,262	27,904	31,186	27,904	9,848	-	-	-	-
Total (kgCO2e)	27,904	30,366	34,469	31,186	13,131	3,283	3,283	3,283	3,283

In total the in-life staff are forecast to be responsible for **150 tCO_2e across the 9 year period**.

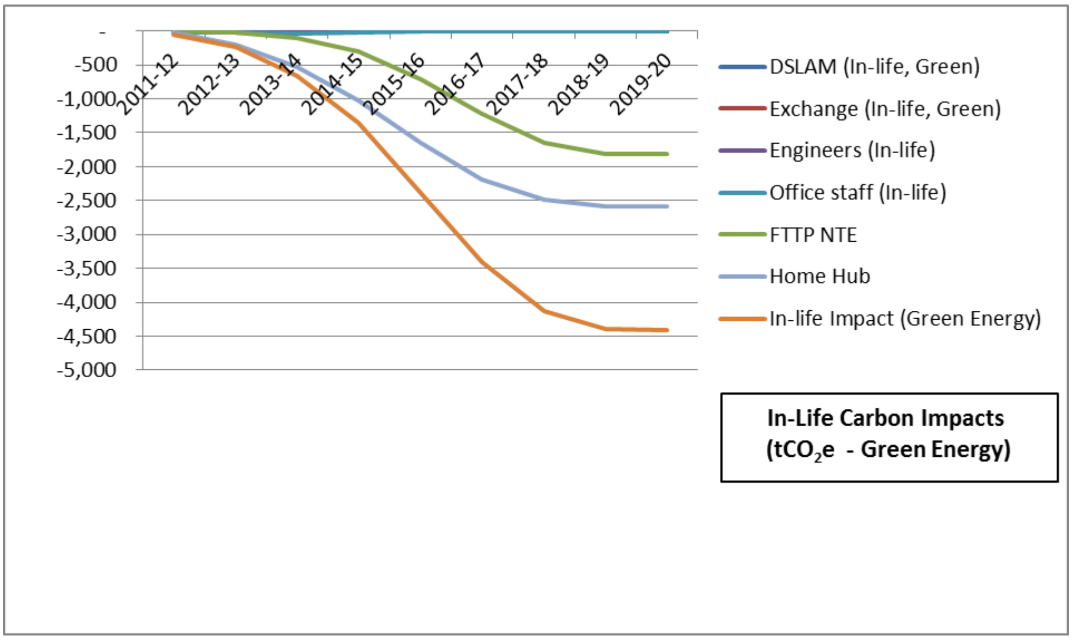
3.2.6. In-Life Carbon Footprint – total impact

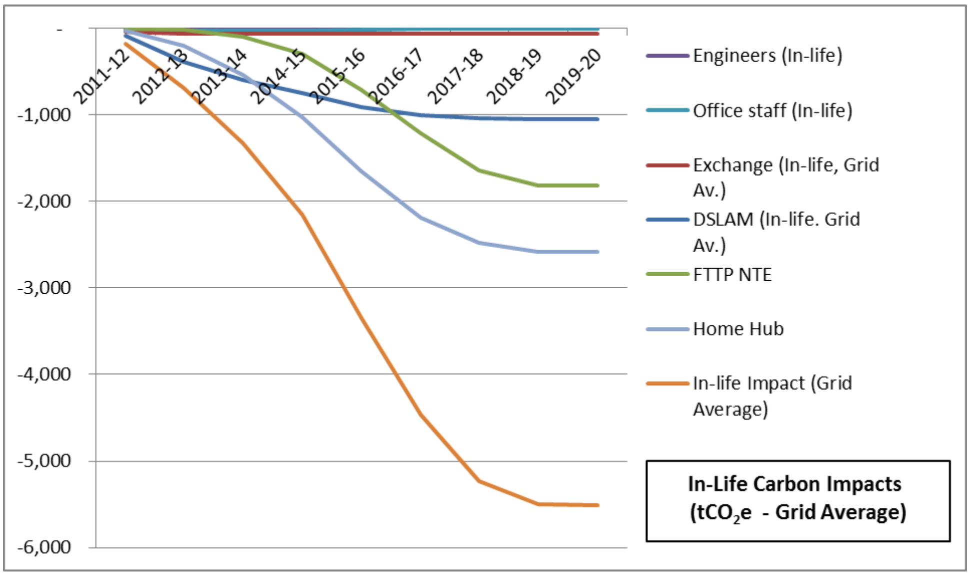
Combining the above contributions results in a **total in-life carbon footprint over the 9 year period from 2011 to 2020 of 21,043 tCO_2e**. As noted earlier, BT procures 100% of electricity used to power our networks and buildings from renewable sources. As a consequence the net carbon emissions resulting from these are 0$kgCO_2e$. We have assumed that all Superfast Cornwall subscribers do not purchase green energy and have therefore accounted for emissions associated with the customer premises NTE supplied by BT, but powered by the customer at grid average.

If grid average emissions are assumed for all components the in-life footprint increases to 28,405 tCO_2e.

Element	Total emissions (tCO_2e) (Green Energy)	Total emissions (tCO_2e) (Grid Average)
DSLAM	0	6,852
Exchange	0	509
FTTP NTE	7,618	7,618
Home Hub	13,274	13,274
Engineers	27	27
Office staff	123	123
Total	**21,043**	**28,405**

The following graphs illustrate the profile of in-life carbon emissions, on an annualised basis, both with and without the impact of BT's purchase of green energy:



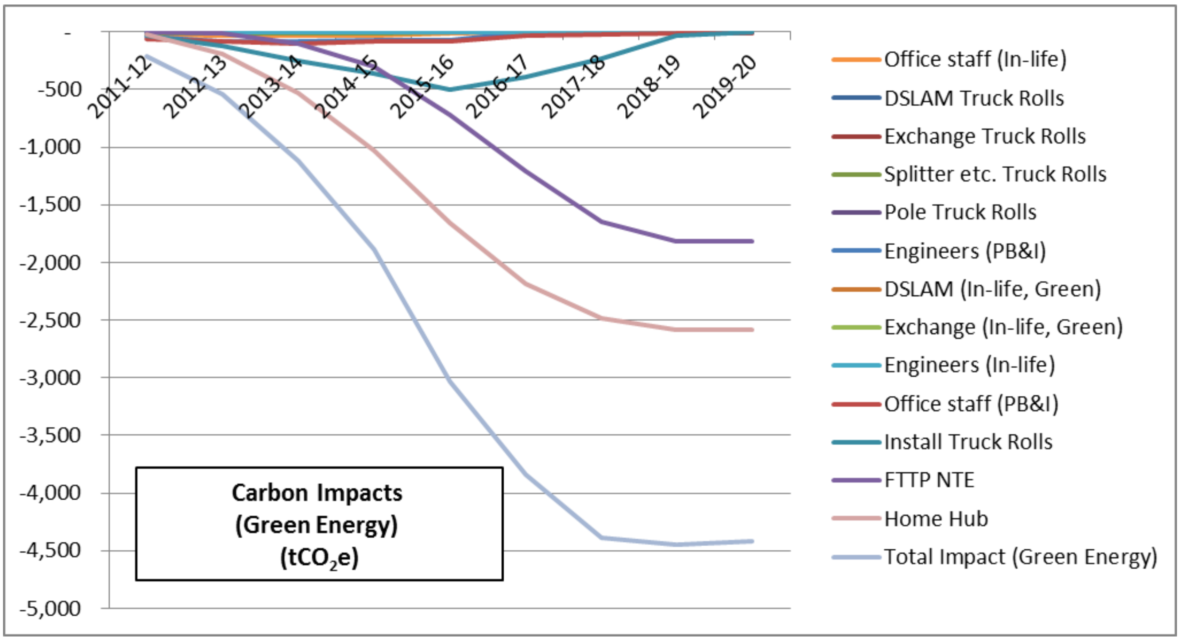


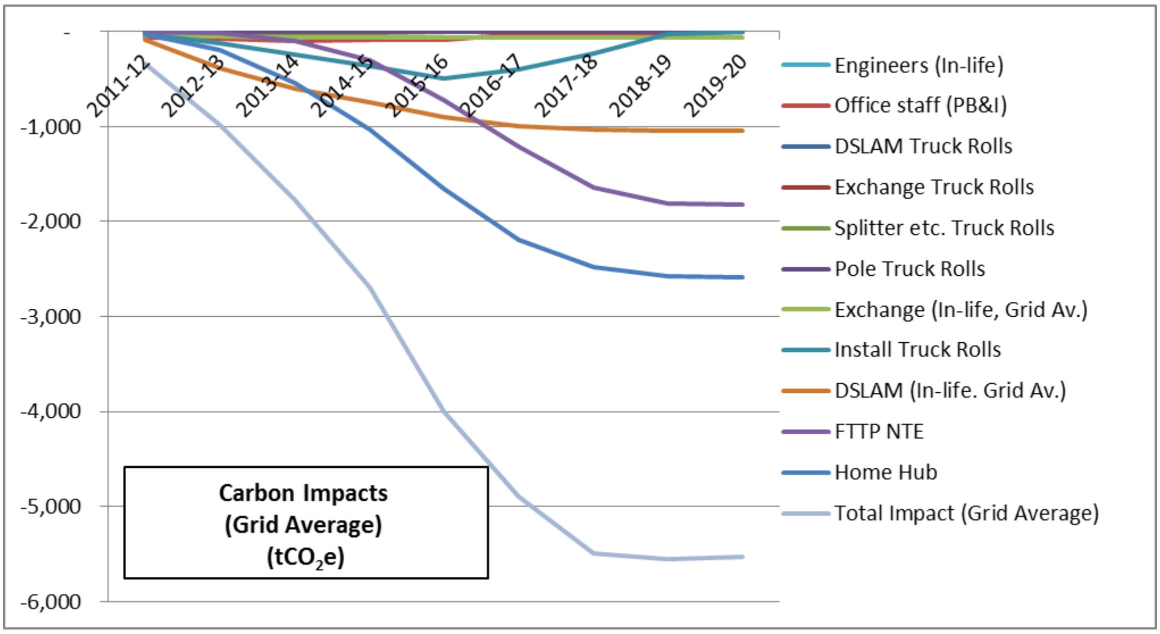
Clearly, in-life, the single most dominant factor is the power consumed by the Home Hubs and the Network Termination Equipment (NTE). Although these are a relatively low power devices (average 5W and 10W respectively), the high volume of devices and the fact that they are permanently active, even if in standby mode for some of the time, has a big impact on the overall carbon footprint.

3.3. Superfast Cornwall Total Carbon Footprint – Plan, Build, Install and In-life

When the above emissions from PB&I and In-life are combined the total carbon footprint of the network over the 9 year period is equivalent to **23,887 tCO_2e (green energy) or 31,248 tCO_2e (grid average).**

		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Total (tCO2e
Plan, Build and Install	DSLAM Truck Rolls	- 15.63	- 4.96	- 8.61	- 6.05	-	-	-	-	-	- 35
	Exchange Truck Rolls	- 0.33	- 0.04	-	- 0.04	-	-	-	-	-	- 0
	Splitter etc. Truck Rolls	- 9.55	- 9.55	- 9.55	- 9.55	-	-	-	-	-	- 38
	Pole Truck Rolls	-	- 0.18	- 2.18	- 2.18	-	-	-	-	-	- 5
	Install Truck Rolls	- 31.76	- 124.98	- 248.34	- 363.00	- 498.33	- 393.66	- 234.43	- 29.62	-	- 1,924
	Engineers (PB&I)	- 37.75	- 79.61	- 80.43	- 69.76	- 69.76	- 4.92	- 4.10	- 3.28	- 2.46	- 352
	Office staff (PB&I)	- 65.66	- 78.79	- 98.48	- 82.07	- 82.07	- 32.83	- 24.62	- 16.41	- 8.21	- 489
	Plan & Build Impact (Total)	- 161	- 298	- 448	- 533	- 650	- 431	- 263	- 49	- 11	- 2,844
In-Life Impact (Grid Ave	DSLAM (In-life. Grid Av.)	- 88	- 391	- 601	- 742	- 905	- 999	- 1,037	- 1,044	- 1,044	- 6,852
	Exchange (In-life, Grid Av.)	- 33	- 56	- 58	- 59	- 61	- 61	- 61	- 61	- 61	- 510
	FTTP NTE	- 0	- 16	- 100	- 297	- 717	- 1,214	- 1,643	- 1,812	- 1,820	- 7,618
	Home Hub	- 25	- 197	- 536	- 1,029	- 1,653	- 2,187	- 2,483	- 2,580	- 2,585	- 13,275
	Engineers (In-life)	- 2	- 2	- 3	- 3	- 3	- 3	- 3	- 3	- 3	- 27
	Office staff (In-life)	- 26	- 28	- 31	- 28	- 10	-	-	-	-	- 123
	In-life Impact (Grid Average)	- 175	- 690	- 1,329	- 2,159	- 3,349	- 4,464	- 5,227	- 5,500	- 5,513	- 28,405
	Total Impact (Grid Average)	- 335	- 988	- 1,776	- 2,691	- 3,999	- 4,895	- 5,491	- 5,550	- 5,524	- 31,248
In-Life Impact (Green E	DSLAM (In-life, Green)	-	-	-	-	-	-	-	-	-	-
	Exchange (In-life, Green)	-	-	-	-	-	-	-	-	-	-
	FTTP NTE	- 0	- 16	- 100	- 297	- 717	- 1,214	- 1,643	- 1,812	- 1,820	- 5,798
	Home Hub	- 25	- 197	- 536	- 1,029	- 1,653	- 2,187	- 2,483	- 2,580	- 2,585	- 10,690
	Engineers (In-life)	- 2	- 2	- 3	- 3	- 3	- 3	- 3	- 3	- 3	- 24
	Office staff (In-life)	- 26	- 28	- 31	- 28	- 10	-	-	-	-	- 123
	In-life Impact (Green Energy)	- 54	- 243	- 670	- 1,357	- 2,383	- 3,404	- 4,129	- 4,395	- 4,408	- 21,043
	Total Impact (Green Energy)	- 214	- 541	- 1,117	- 1,890	- 3,033	- 3,836	- 4,393	- 4,445	- 4,418	- 23,887





4. Estimating the carbon abatement per Superfast Cornwall line

4.1.1. Carbon Abatement – Methodology

Our interest is in establishing an estimate of the likely carbon benefit that will have resulted from deployment of Superfast Cornwall. Our approach is to estimate the impact per user across a range of applications which are enabled by Superfast broadband, and then to scale these numbers up to reflect the fully populated Superfast Cornwall network.

As noted above, our original intention was to use primary research data in order to identify the levels of carbon abatement that could be forecast. In the absence of this primary data we have reverted to alternative data sources in order to estimate the likely carbon abatement being delivered by the network.

In particular we have drawn upon BT's own research underpinning the Net Good model. Net Good is one of three work streams that underpin BT's Better Future programme. The Net Good goal is to help BT's customers to reduce carbon emissions by at least three times BT's own end-to-end carbon impact by 2020.

In order to track this progress towards this goal BT developed and published the Net Good Methodology, reviewed and endorsed by The Carbon Trust:
http://www.btplc.com/Betterfuture/NetGood/OurNetGoodgoal/BTNetGoodMethodology2014-Report_2.pdf

The underlying principle of the methodology is that for each of product, service, or combination thereof which is believed to deliver some element of carbon abatement, a quantity (unit of measure) and a carbon factor per unit of quantity were 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.

When considering Superfast Cornwall and the potential carbon abatement mechanisms that the network supports subscribers were split in two broad groups: Business subscribers and Residential subscribers. After due consideration it was decided to treat FTTC and FTTP subscribers equally: it is anticipated that, over time, the higher bandwidths that can be delivered by FTTP will result in a range of new applications that have the potential to deliver higher levels of carbon abatement; however we have not tried to quantify this in this study.

4.1.2. Source of carbon abatement

The principal sources of carbon abatement applicable to superfast broadband have been identified as:-

1) De-materialisation and Consumer Travel
2) Telecommuting
3) eCommerce
4) Business travel
5) Cloud services

4.1.3. Carbon Abatement – Dematerialisation and Consumer Travel

For consumers, it is recognised that carbon abatement can be delivered through a range of applications facilitated by superfast broadband, referred to in the Net Good Methodology as "Superfast Broadband Dematerialisation". The principle behind dematerialisation is that applications supported by superfast broadband replace or reduce the need to manufacture, 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 and travel CO_2e savings were calculated as:

- CO_2e per person X number of superfast broadband lines

The primary study drawn upon by the Net Good model and our analysis here is the Yankee Group study (2012) "Measuring the Energy Reduction Impact of Selected Broadband-Enabled Activities Within Households".[8]

The Yankee Group study consider the enabling impacts of online news, music streaming, online banking, online shopping, online education, digital photos and e-mail. The table below provides the carbon savings figures based on the Yankee Group study 2012 in $kgCO_2e$ per working-age person in the five EU countries studied in the report (France, Germany, Italy, Spain and UK):

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

Application	Carbon Abatement
News	0.364
Music	3.195
Banking	7.736
Shopping	7.849
Education	1.681
Photos	7.804
Mail	2.668

This leads to a total savings of 31 $kgCO_2e$ per working-age person which represents the average savings achieved by a broadband user in 2012.

Within the Net Good model BT adopted this factor as the starting point for potential carbon abatement from superfast BB lines. Where the original Yankee model did not anticipate any growth in abatement, BT research suggests that, in line with the per-line growth in traffic on superfast broadband lines, the increased speeds associated with superfast BB are likely to drive significant increases in carbon abatement.

To forecast the levels of abatement out to 2020 a number of factors were considered:-

1. The quantity of good purchased in the UK
2. The percentage of those goods delivered electronically
3. The rate at which dematerialisation has occurred in each category (with an assumption that changes continues at a similar rate)
4. Distances travelled for shopping activities (derived from national statistics)
5. The growth in courier / parcel deliveries

(Whilst it is also recognised that there will be substantial growth in electronic devices within the home, the energy consumption and carbon emissions of which will partly offset the carbon abatement, to be consistent with our original boundaries we have not taken this into account since Superfast Cornwall does not have influence over devices purchased by subscribers).

Recognising the inherent uncertainties in much of the data used for this research a Monte-Carlo simulation was used to better quantity potential savings. **This resulted in a forecast abatement per superfast broadband line in 2020 of 597 $kgCO_2e$ per annum.**

Annualised carbon emissions across the entire subscriber base grow dramatically from 107 tCO_2e in 2011-12 to 12, 261 tCO_2e in 2014-15 and 65,640 tCO_2e in 2019-20.

4.1.4. Carbon Abatement – Telecommuters

A number of the studies such as "*The Broadband Bridge: Linking ICT with Climate Action for a Low-Carbon Economy – a report by the Broadband Commission*", March 2012 provide useful anecdotal evidence of the impact of broadband on enabling telecommuting.

Other reports address the challenge of estimating the potential carbon benefits of home working versus office working and whilst there is some variation a growing body of evidence supports the view that savings of approximately 1 tCO_2e per telecommuter are realistic:

"*UK Broadband Impact Study - Literature Review*" carried out by SQW as input to the UK Broadband Impact Study commissioned by the Department for Culture, Media and Sport (DCMS), February 2013, reports work done by The Carbon Trust which estimated that an average UK employee working from home two days a week, can save 390 $kgCO_2e$ per annum; a full time homeworker could therefore expect to save in the region of 975$kgCO_2e$ pa. The report also cites a BT case study which found that net annual saving per home-based employee were 1,400 $kgCO_2e$.

The aforementioned Yankee report *"Measuring the Energy Reduction Impact of Selected BB-Enabled Activities within Households"* (Yankee 2012, sponsored by GeSI and members (inc BT), included Telecommuting in the set of applications which were considered, although the data was averaged across the entire working age population of the five European countries collectively referred to as the "EU-5". When adapted, by BT, to reflect the UK telecommuting population the Yankee Group Monte Carlo simulation model generates a figure of 0.95 tCO_2e. This assumes:

- Average 2.6 days per week working from home [ONS survey data9]
- Mean daily commute 24 miles [survey]
- Energy reduction in corporate offices is considered
- Rebound effects of increased energy use at home are taken into account
- Rebound effects of additional personal errands are taken into account

'The Carbon Intent Project: ICT Enabling Low Carbon Business: Homeworking and Teleconferencing' by the Communications Management Association (CMA) estimates a typical CO2e emissions reduction for a UK-based Homeworker at 9 $kgCO_2e$/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.

To err on the cautious side we have therefore adopted the Yankee-derived figure of 0.95 tCO_2e per telecommuter.

The question we must then turn to is the number of employees of Cornish businesses who may be telecommuting.

The Office of National Statistics estimated that in 2013 there were about 1.9 million 'TC teleworkers' in the UK (people who mainly work in their home, or in different places using home as a base, in their main job, and who could not do so without using both a telephone and a computer) – up from 0.7 million in 1997. This was equivalent to about 6.3% of UK workers. In estimating BT's Net Good

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impact this figure was projected to grow to 3.7M in 2014/15, equivalent to 17% of the total working population.

When considering the specific profile of businesses in Cornwall we know from the "*Superfast Cornwall Evaluation Final Midterm Report"* (November 2013; SERIO) that 50% of businesses surveyed indicated that superfast broadband had enabled remote working or more efficient home working; "*Superfast Cornwall, Longitudinal Business Survey, Wave One Final Report*" (April 2014; SERIO) extends this to 60% (48% strongly and 13% slightly). However neither report details the number of days spent home working or the number of employees per business that are home working.

To estimate the average number of employees who are likely to be commuting in Cornwall we have, once again used the data provided by the Yankee 2012 Report. This report showed the following spread within the UK (which is broadly in line with the much larger sample taking across the EU-5):-

For the purposes of our analysis we have assumed the figure of 17% of employees who telecommute quoted above and applied this to number of people of working age referenced in the Yankee report.

This results in a total of 16,722 tCO_2e attributable to 17,455 telecommuters in 2020. Over the 9 year period under study the total carbon abatement from telecommuting is estimated as 86,068 tCO_2e.

In practice, we anticipate that the percentage of employees who telecommute is likely to rise steadily as more and more people discover the benefits (financial, personal and social) or telecommuting, enabled by Superfast Cornwall.

4.1.5. Carbon Abatement – eCommerce

A detailed study by the American Communications Institute (ACI) *"Broadband Services: Economic and Environmental Benefits", 2007* concluded that the provision of broadband services would result in a significant reduction in commercial, retail and wholesale space required by B2C and B2B businesses.

Specifically, it was estimated that the 17.3 $MtCO_2e$ would be avoided across a population of 209M people of working age; equivalent to 0.083 tCO_2e per person.

Working with the Carbon Trust, BT has demonstrated a logarithmic relationship between bandwidth and usage for residential use of broadband: i.e. higher bandwidth = higher usage. This same relationship can be applied to carbon abatement; i.e. carbon abatement should grow logarithmically with bandwidth.

Rather than applying this relationship continuously, a pragmatic approach proposed by BT and endorsed by the Carbon Trust is to consider discrete bandwidth ranges and apply appropriate carbon factors for each range, thus:-

Bandwidth range	Carbon abatement factor
(Mbps)	*tCO_2e/circuit/year*
Up to 10 Mbps	0.083

10 - 99 Mbps	0.30
100 Mbps and above	0.50

Superfast Cornwall clearly falls into the middle band and hence we have applied the factor of 0.30 tCO2e per line / year to calculate the total carbon abatement resulting from ecommerce.

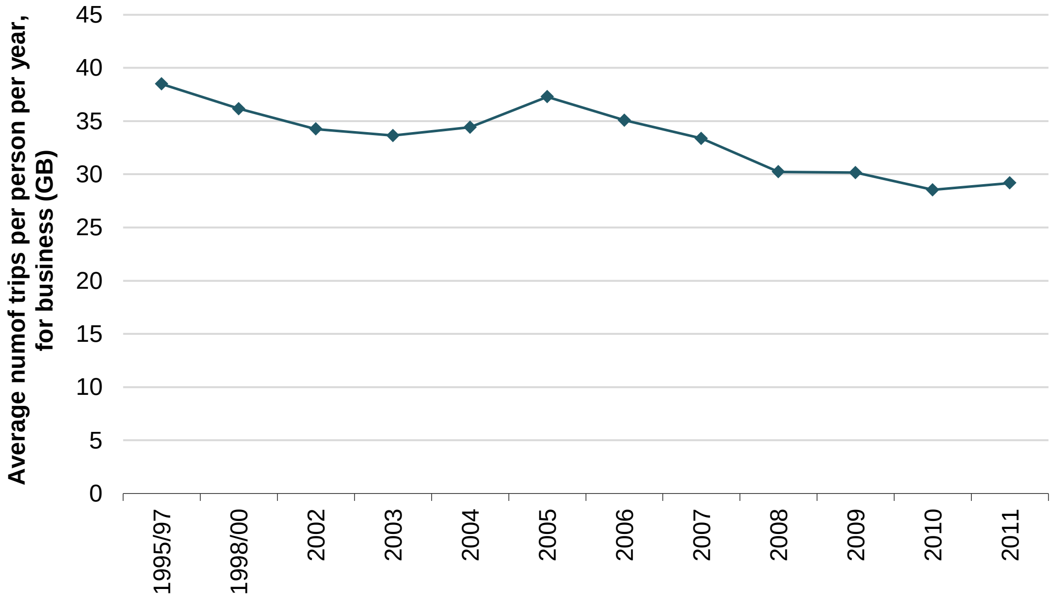
This results in a forecast 38,415 tCO_2e in 2019-20 and a total of 197,321 tCO_2e over the study period (2011 – 2020).

4.1.6. Carbon Abatement – Business Travel

Traditionally videoconferencing is recognised as having very significant carbon abatement potential. However, the majority of studies have looked at high-end videoconferencing systems (e.g. BT's Telepresence products). Such systems tend to be used by large global multinationals and are rarely found in use, today, by SMEs which dominate the business landscape in Cornwall: the "*EU investment strategy: Headline evidence base for Cornwall and Isles of Scilly*" reports that 88.6% of Cornish businesses are "micro-businesses" with less than 10 employees, 10% are "small" with 10 – 49 employees and 1.2% are "medium" businesses with 50 – 250 employees.

However it is clear from anecdotal evidence that broadband has the potential to significantly reduce business travel through e.g. desktop videoconferencing (e.g. Microsoft Lync / Skype) and online collaboration tools. For example, the 2013 report *'UK Broadband Impact Study'* commissioned by the Department for Culture, Media & Sport, a consortium led by SQW estimated that 5.3 billion kms in annual business travel (predominantly in car usage) could be saved by 2024 through the increased use of video and online collaboration tools by broadband-using firms. This is equivalent to 9% of the current total annual UK business travel distance.

Similarly, the SQW "*UK Broadband Impact Study*", 2013, notes that business travel has been reducing since 2005 in Great Britain, as illustrated in the chart below.



Source: National Travel Survey

Figure 4-1: Average number of trips per person per year, for business, in Great Britain

The conundrum highlighted in this report is that it is unclear what, if any, net contribution broadband has made to this reduction. On the one hand, as noted above, videoconferencing has been shown to reduce international flying considerably; on the other hand, it can be argued that by opening up firms to new customers and suppliers further afield, the broadband internet may actually be *increasing* international air travel.

Specific to Cornwall, the SERIO Final Report, "*Superfast Cornwall, Longitudinal Business Survey, Wave One Final Report", April 2014*, reported that "*The data suggests that superfast has had more of a positive impact on businesses' travel usage than premises energy use. For the majority of businesses (75%) the energy use of their business premises had not changed since connecting to superfast, while 47% felt their travel usage had reduced, and this was generally as a result of utilising more sophisticated internet functions."*

Despite the anecdotal evidence there is little hard data on which to base estimates of the actual reduction in travel attributable to broadband. One of the few studies we are aware of was carried out by O2: over a period of 6 months, 1500 employees kept diaries of their travel and recorded an average reduction in business-related travel of 650 miles p.a. The same study reported that on average employee's reduced overnight stays in hotels by 8 nights per annum. Using an estimate of 25kgCO_2e per hotel night suggests an additional carbon abatement of 200 kgCO_2e per employee per annum.

These figures relate to travel reduction related to business meetings (enabled by broadband): we feel that this can be appropriately applied to SMEs use of broadband in a business context and have therefore applied them to estimate the potential carbon reduction which could be delivered by Cornish businesses.

We have then considered the average number of employees in different sizes of business, based on Office of National Statistics data and assumed that different percentages of these actual realise travel reductions to generate the potential carbon reductions:-

Business Type (No of employees)	Average number of employees	% of average number of employees reducing travel
Micro (0-9)	2.88	30%
Small (0 - 49)	22.44	20%
Medium (50 - 249)	109.17	10%

This results in an estimated saving of 10,186 tCO_2e by 2019-20 and a total of 51,705 tCO_2e over the study period:-

Business travel	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Total (tCO_2e)
Micro	46	359	975	2,282	3,710	4,907	5,570	5,788	5,799	29,435
Small	27	210	571	1,336	2,173	2,874	3,262	3,389	3,396	17,238
Medium	8	16	167	390	634	839	952	989	991	5,032
Total	81	630	1,713	4,009	6,516	8,619	9.784	10,167	10,186	51,705

4.1.7. Carbon Abatement – SME Cloud Services

The final area for which carbon abatement has been identified, specific to Cornish businesses, is the use of cloud services to replace traditional on-site hosted servers.

The methodology employed was originally proposed by Anthesis with endorsement from the Carbon Trust, as input to BT's Net Good methodology.

The principle is straightforward: the infrastructure used to deliver cloud-based services is shared amongst multiple users and thereby delivery energy and carbon efficiencies over separate instances of privately owned infrastructure. This principle has been supported by numerous studies[10].

[10] GeSI (2012). SMARTer 2020: The Role of ICT in Driving a Sustainable Future. The Global e-Sustainability Initiative.

In addition to more efficient use of the infrastructure, cloud services also deliver benefits through higher server utilisation, highly efficient data centres with higher Power Usage Effectiveness (PEU), resulting from efficient cooling systems, and, often, low emissions resulting from use of renewable energy.

The kind of services that are well-suited to the cloud include applications which are typically accessed via an end-user's PC, including email, office productivity apps, accounting, CRM, document management software, etc. Many of these services lend themselves well to SMEs and are thus particularly applicable to Cornish businesses which are predominantly SMEs.

The levels of abatement that can be delivered take into account a "business as usual" scenario in which the services are hosted on local services as the base level and compare this with the energy consumption of a comparable cloud-based service.

A more detailed overview of the methodology is available in BT's Net Good Methodology Reports available via BT's website.

The methodology results in an estimate of the net carbon impact for businesses in the three size categories used by the Office of National Statistics, given as set of assumptions about the current adoption of cloud based services in each category:-

tCO_2e	**ONS Category 0-9**	**ONS Categories 10 - 49**	**ONS Category 50 - 249**
Annual Carbon emissions saved by cloud infrastructure (tCO2e) - 2012	**- 5,170**	**1,004,522**	**222,612**
Annual Carbon emissions saved by cloud infrastructure (tCO2e) - 2020	**- 5,170**	**1,881,541**	**504,049**

It is interesting to note that for micro-businesses, there is actually a small negative impact since the model assumes that 100% of employees in this category already use cloud services and there is thus the negative impact of the cloud infrastructure without the positive impact of retiring in-house infrastructure.

2012 adoption assumptions used in the model are:-

2012 Estimates				
Adoption rate of email by SMEs with Broadband	100%	100%	100%	100%
Adoption of cloud email (as % of total adoption rate)	100%	50%	33%	10%

Accenture (2011). Cloud Computing and Sustainability: The Environmental Benefits of Moving to the Cloud. Accenture & WSP;
Carbon Disclosure Project (2011). Cloud Computing – The IT Solution for the 21st Century. Carbon Disclosure Project & Verdantix, London, UK.

Adoption rate of CRM by SMEs with Broadband	0%	50%	75%	100%
Adoption of cloud CRM (as % of total adoption rate)	0%	80%	50%	10%
Adoption rate of Groupware by SMEs with Broadband	0%	50%	90%	100%
Adoption of cloud Groupware (as % of total adoption rate)	0%	50%	20%	10%

We have then assumed that adoption grows to the following levels in 2020 and extrapolated linearly between the two sets of assumptions:-

2020 Forecast				
Change in adoption rate from current through 2020				
User population 2013 (from further up the table				
Adoption rate of email by SMEs with Broadband	100%	100%	100%	100%
Adoption of cloud email (as % of total adoption rate)	100%	80%	60%	40%
Adoption rate of CRM by SMEs with Broadband	0%	75%	100%	100%
Adoption of cloud CRM (as % of total adoption rate)	0%	100%	80%	50%
Adoption rate of Groupware by SMEs with Broadband	0%	75%	100%	100%
Adoption of cloud Groupware (as % of total adoption rate)	0%	80%	60%	40%

When applied to the breakdown of Cornish businesses (micro, small and medium), result in a 2019-20 estimate of 5,394 tCO_2e per annum and a total of 24,110 tCO_2e across the 9 year study period:-

SME Cloud Services	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	Total (tCO2e)
Micro	- 0	- 1	- 3	- 8	- 13	- 17	- 19	- 20	- 20	- 101
Small	22	187	549	1,378	2,392	3,366	4,052	4,451	4,701	21,098
Medium	3	25	76	194	344	491	600	667	713	3,113
SME Cloud Services	25	211	621	1,564	2,723	3,840	4,632	5,098	5,394	24,110

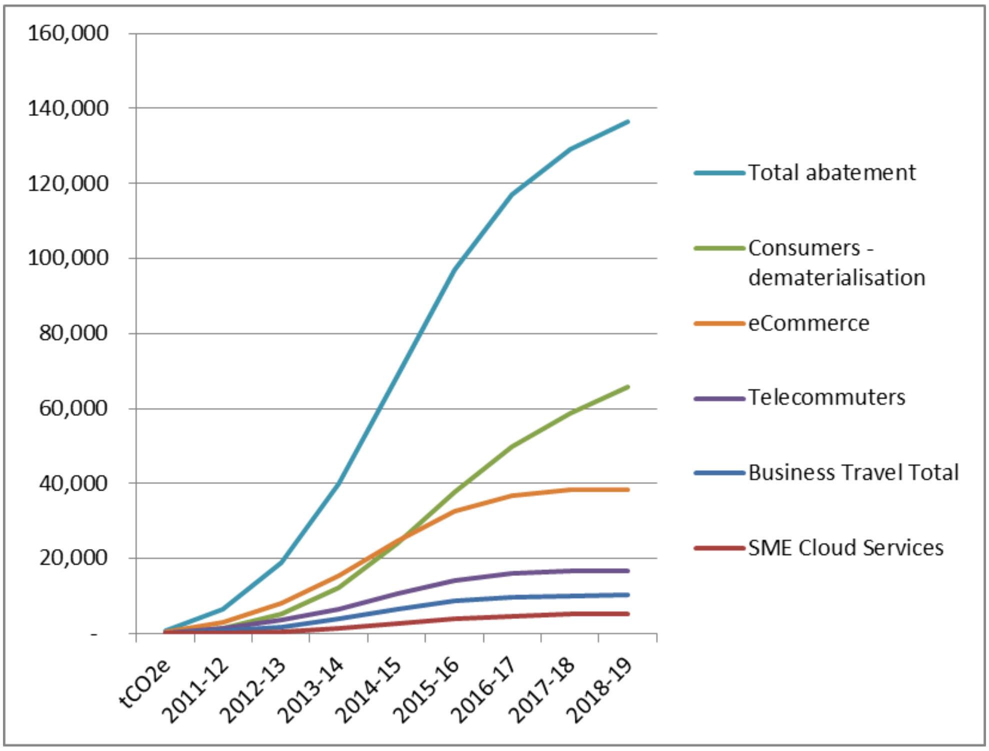
4.1.8. Carbon Abatement – totals

Combining the above estimates, we forecast that the total carbon abatement which Superfast Cornwall could be delivering by 2020 is over 11,625 tCO_2e per month (March 2020) or 136,357 tCO_2e per annum (April 19 – March 20), from an average of 128,051 subscribers across the same period:

equivalent to 1.487 tCO_2e per subscriber. Total carbon abatement delivered across the 9 years of the study period is estimated to be 614,174 tCO_2e.

Broken down by business and residential subscribers, the numbers look like:-

Line type	Carbon abatement per person (tCO_2e/year)	Total carbon abatement; 2019/20 (tCO_2e)	Total carbon abatement; 2011-20 (tCO_2e)
Business subscribers	2.849	53,995	273,136
Residential subscribers	0.755	82,362	341,038
Combined	1.065	136,357	614,174



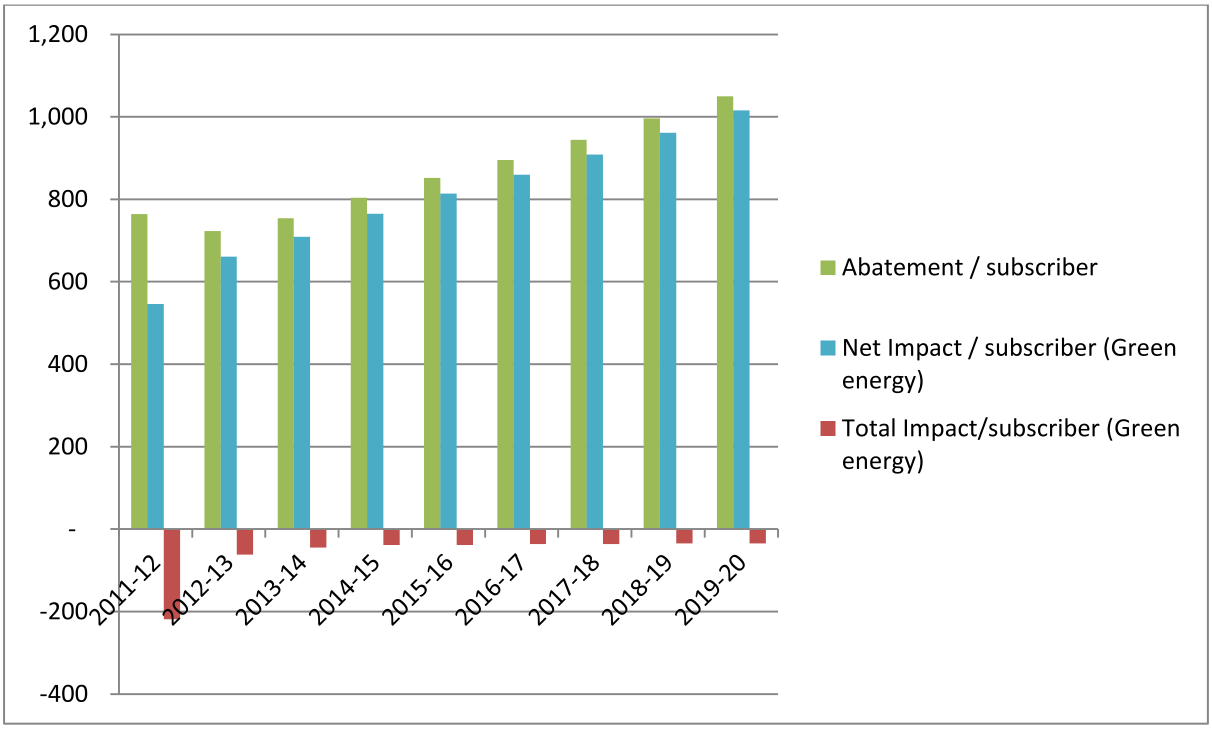
Carbon abatement by category (tCO2e)

The largest levels of abatement come from dematerialisation and associated reductions in consumer travel, whilst the online nature of eCommerce is believed to deliver significant wider benefits, primarily through the reduction real estate required to support online businesses compared with their non-online predecessors.

5. The Net Carbon Impact of Superfast Cornwall

It is clear from the data presented in Sections 3 and 4 above that the carbon abatement potential of Superfast Cornwall *far outweighs* the carbon impacts of both the Plan, Build and Install phase and the In-Life phase combined.

As a consequence **the Net Impact, increases steadily across the study period to a figure in excess of 1tCO_2e per subscriber / year by 2020:-**

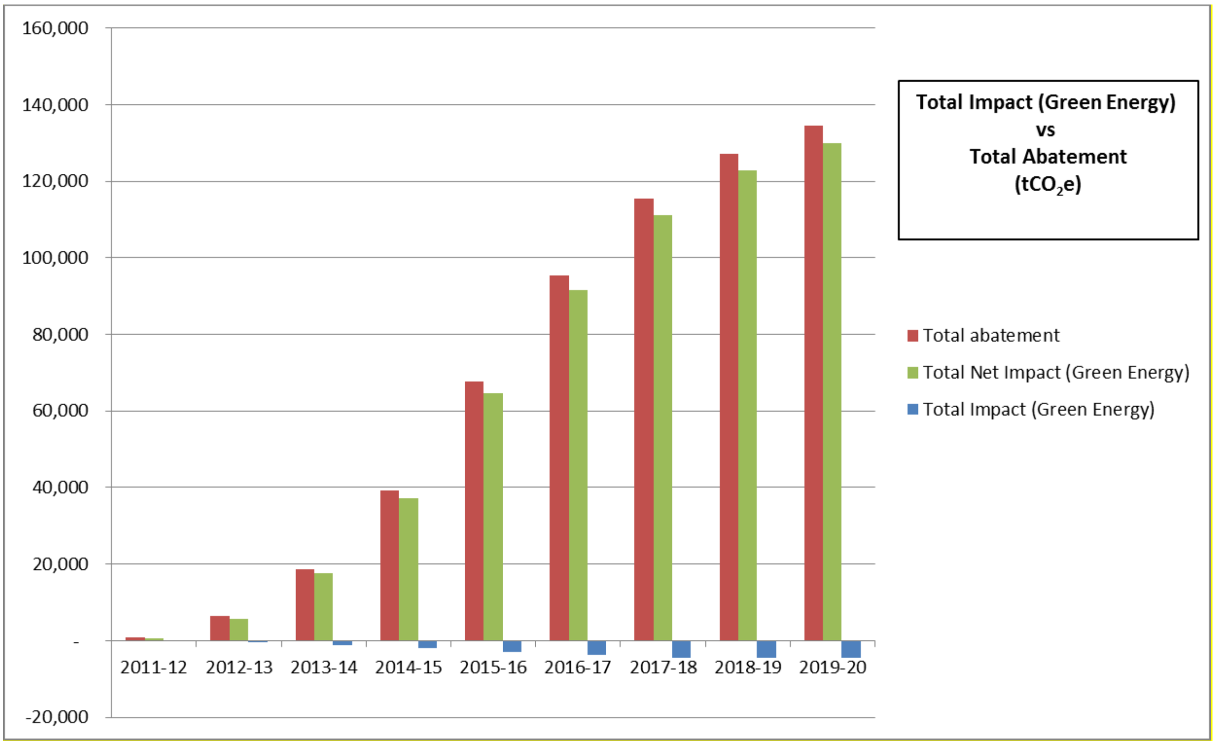


Taken over the entire subscriber base – current and projected - the total net positive impact grows from 415 tCO_2e pa in 2011/12 to 128,944 tCO_2e pa in 2019/20:

tCO2e	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Total abatement	750	6,320	18,700	39,143	67,553	95,486	115,399	127,214	134,468
Total Impact (Grid Average)	- 335	- 988	- 1,776	- 2,691	- 3,999	- 4,895	- 5,491	- 5,550	- 5,524
Total Net Impact (Grid Av.)	415	5,332	16,924	36,452	63,554	90,591	109,908	121,665	128,944

When the impact of BT's 100% renewable electricity contract is taken into account the Net Impact is even higher growing to 130,049 tCO_2e in 2019/20:-

tCO2e	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Total abatement	763	6,420	18,978	39,810	68,662	96,985	117,138	129,060	136,357
Total Impact (Green Energy)	- 214	- 541	- 1,117	- 1,890	- 3,033	- 3,836	- 4,393	- 4,445	- 4,418
Total Net Impact (Green Energy)	536	5,779	17,583	37,253	64,520	91,650	111,006	122,769	130,049



Over the full study period Superfast Cornwall thus has the potential to deliver a total net positive carbon impact of 581,146 tCO_2e, equivalent to 25 times the carbon impact of the network.

6. Conclusions

This report seeks to provide an insight into the

1) carbon impact of a regional superfast broadband network such as Superfast Cornwall
2) the likely magnitude of the carbon abatement that the network will facilitate by enabling end-users to reduce carbon emissions from other activities
3) the net impact of the network over a 9 year period

The data we have gathered shows unequivocally that technologies such as superfast broadband have a significant role to play in helping communities – including predominantly rural communities such as Cornwall – to reduce carbon emissions.

The magnitude of the net positive impact of Superfast Cornwall – estimated as **581,146 tCO_2e** over the 9 year study period and equivalent to 25 times the carbon emissions of the network - has surprised us; of course, we have, for practical reasons, limited the boundary of the system under study – and arguably the true carbon impact of the network is considerably higher if one extends the boundary beyond those aspects which are under the influence or control of Superfast Cornwall.

For example, it could be argued that delivery of the network is only possible given the support of many other functions within BT – a substantially higher level of resources than those *directly involved* in the roll-out, but out-of-scope for this study.

Nevertheless, given the number of subscribers that we have projected and the potential for carbon abatement climbing to **1 tCO_2e per person per annum**, it is easy to see how the net positive outcome can quickly build up.

These results underpin previous studies such as the GeSI Smart 2020 and Smarter 2020 reports which have forecast that the ICT sector as a whole has the potential to reduce carbon emissions from other sectors. Whilst side-by-side comparisons between this study and the GeSI studies cannot be made since the methods used and the system boundaries which were utilised differ, this study nevertheless highlights the significant levels of carbon abatement that can be delivered by telecoms technologies such as superfast broadband.