policy connect

IS STAYING ONLINE COSTING THE EARTH?

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Foreword

Digital connectivity is the backbone to many social interactions and businesses in the UK. Every sector is adapting to a digital future to deliver services and do business. Planning is underway for GP appointments to be undertaken via live video, for court cases to be settled entirely online and for driverless trucks to deliver goods around the country. The Government has adopted a policy of 'digital by default', using digital technology to re-imagine services and systems and make them easier, simpler and cheaper. The newly published Industrial Strategy stresses the importance of high speed connectivity and digital skills to the UK's future as a world-leading economy resilient to change and fit for the future.

New digital technologies can play a vital role in combatting climate change, facilitating greater energy efficiency within businesses and society, potentially leading to significant reductions in carbon emissions. For example, electrification of the transport system combined with technology-enabled urban planning and design can drive down transport emissions, which currently account for nearly a quarter of the UK's greenhouse gas emissions.[1] Automated industrial processes can raise UK productivity and competitiveness, as well as reduce the environmental impact through more efficient manufacturing and industrial processes and more optimised supply chains.[2] Digitalised energy systems in the future should be able to identify who needs energy and deliver it at the right time, in the right place and at the lowest cost, reducing carbon emissions along with energy bills.[3]

However, this increased connectivity comes with an energy and carbon cost. Energy is required to manufacture, distribute and power devices, to establish a connection to the Internet and to transmit data across it. The energy used to support our access to the Internet is substantial. While the energy supply remains dependent on fossil fuels, this will have a carbon footprint. As the Government strives towards an economy that offers high speed connectivity everywhere, at any time and for a low price, the UK should better leverage carbon-saving digital technologies to tackle climate change and encourage best practice for energy management of ICT and an 'energy efficiency by design' approach.

This report aims to support debate around our digital future in Parliament. Specifically, it sets out areas where researchers, companies and governments can act to harness the substantial opportunities the Internet offers to reduce our carbon footprint and ensure our digital backbone is both efficient and effective into the future.

Antoinette Sandbach, Conservative MP for Eddisbury

Inquiry Co-Chair

Daniel Zeichner, Labour MP for Cambridge

Inquiry Co-Chair

[1] DfT (2016), https://www.gov.uk/government/statistics/transport-statistics-great-britain-2016. Accessed 1st February.
[2] J. Maier (October 2017), Made Smarter Review. Available at: https://www.gov.uk/government/publications/made-smarter-review
[3] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

Introduction

Digital technologies have changed our lives for the better. But have they done the same for our planet? Demand for all things ‘smart’ and ‘connected’ continues to grow and a future with smart fridges, virtual reality headsets and electric driverless cars is in sight. There is an increasing expectation that everything is available online, instantly, and in multiple locations.

There is also a growing recognition of the contribution digital technologies can make in transitioning to a low carbon economy. However, the energy consumption of the digital economy should not be ignored by policy makers. To date, the energy cost and carbon impact of the digital economy has not increased to the epic proportions once predicted. High energy bills, new efficient ICT technologies, and regulations have kept the proportion of electricity used by ICT products and services in check. However, there is a risk that with a growing dependence on connected devices and digital technologies, energy efficiency gains may slow or even stall.

So how sustainable is the energy use of this expanding connectivity? And to what extent can the connected world really help to manage the energy use and carbon footprint of the UK?

In this new era of digital activity, it is time to take stock of the energy and carbon cost of our digital economy, to recognise that the Internet itself is powered by electricity, and to ensure that the UK reaps the benefit of new technologies to help mitigate global climate change impacts. This report will consider two aspects: the energy use and carbon impact of expanding ICT use and connectivity; as well as the potential to reduce energy use and carbon emissions in other sectors facilitated by digital technologies.

This report will consider three key aspects of ICT, namely: data centres housing servers that store, process and distribute large amounts of data; data transmission networks that provide connectivity; and connected devices including consumer electronics, appliances and other devices that can be connected to networks and interact with the network or other devices. Various emerging digital technologies and solutions, such as artificial intelligence, the Internet of Things, machine learning, the Cloud, robotics, analytics and improved connectivity e.g. 5G, predicted to bring around transformational change to the UK economy, are also considered.

The report calls on policy makers to recognise the carbon emissions of the growing UK digital economy, the need to ensure that energy efficiency gains across ICT continue, and to promote the importance of furthering the take-up of digital technologies that can reduce the UK carbon footprint.

Key findings

FINDING 1: Information and communications technologies (ICT), including data centres, data transmission networks and connected devices, use a significant amount of energy.[4] Measurements and data on energy use are very limited.

FINDING 2: There is a range of estimates on the current and future global electricity demand of ICT and associated carbon impacts. As there is no way to systematically measure energy use on a national level, estimates depend largely on modelling. It is estimated that ICT (data centres, networks and connected devices) corresponds to around 3.6% of global electricity and around 1.4% of global carbon emissions. Definitions vary and if entertainment (film, music, games etc.), media (TV, radio, news, books, magazines etc.[5]) and office printers are included, this increases to roughly 6% of global electricity[6] and about 2.4% of global carbon emissions[7].[8]

FINDING 3: As billions more devices and machines are connected over the coming years, they will draw electricity at the plug while driving growth in demand for – and energy use by – data centres and network services.[9]

FINDING 4: Over recent years, total global energy consumption and carbon emissions from ICT have levelled and in some cases decreased due to both energy efficiency improvements and increased use of renewable energy.[10] Over the longer term the key uncertainty is how well efficiency improvements keep pace with the growth of data and demand for digital services.[11]

FINDING 5: It has been estimated that ICT solutions have the potential to enable a reduction in global greenhouse gas emissions of up to 15.3% by 2030.[12]

Recommendations

RECOMMENDATION 1: Government should commit to collating available data on energy consumption of ICT, identifying gaps and measuring the energy use that is still unknown.

RECOMMENDATION 2: Government needs to shore up technical expertise in this complex area as the UK considers its future relationship with the European Union.

RECOMMENDATION 3: Government must consider a whole systems approach to understand the life cycle energy consumption and carbon emissions of ICT, making use of the data and expertise from recommendations 1 and 2.

RECOMMENDATION 4: The public sector should lead by example in implementing energy management best practice, e.g. consolidating data centres into more efficiently run facilities, and purchasing renewable energy.

RECOMMENDATION 5: Government should support the development and wide-scale adoption of emerging technologies that can optimise systems and facilitate energy efficiencies and provide UK with export opportunities.

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4 IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
5 Paper has not been included in this calculation in order to focus on use of electrical and electronic devices and networks.
6 This figure refers to operational electricity consumption, production not included
7 This figure refers to all production carbon emissions, but not the production of paper itself
8 J. Malmodin, D. Lundén (2018), 'The energy and carbon footprint of the global ICT and E&M sector 2010-2015'. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.
9 IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
10 J. Malmodin, D. Lundén (2018), 'The energy and carbon footprint of the global ICT and E&M sector 2010-2015'. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.
11 IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
12 J. Malmodin, P. Bergmark, (2015), 'Exploring the effect of ICT solutions on GHG emissions in 2030.'

RECOMMENDATION 6: ICT is not constrained by national boundaries - the UK should continue to work with the International Energy Agency and the G20 to drive global discussion and action on the issue of ICT energy consumption.

RECOMMENDATION 7: The Digital Service Standards for digital public services should include a criterion for 'energy efficiency by design.'

1. Mechanics of ICT

1.1 Does the digital economy have a carbon footprint?

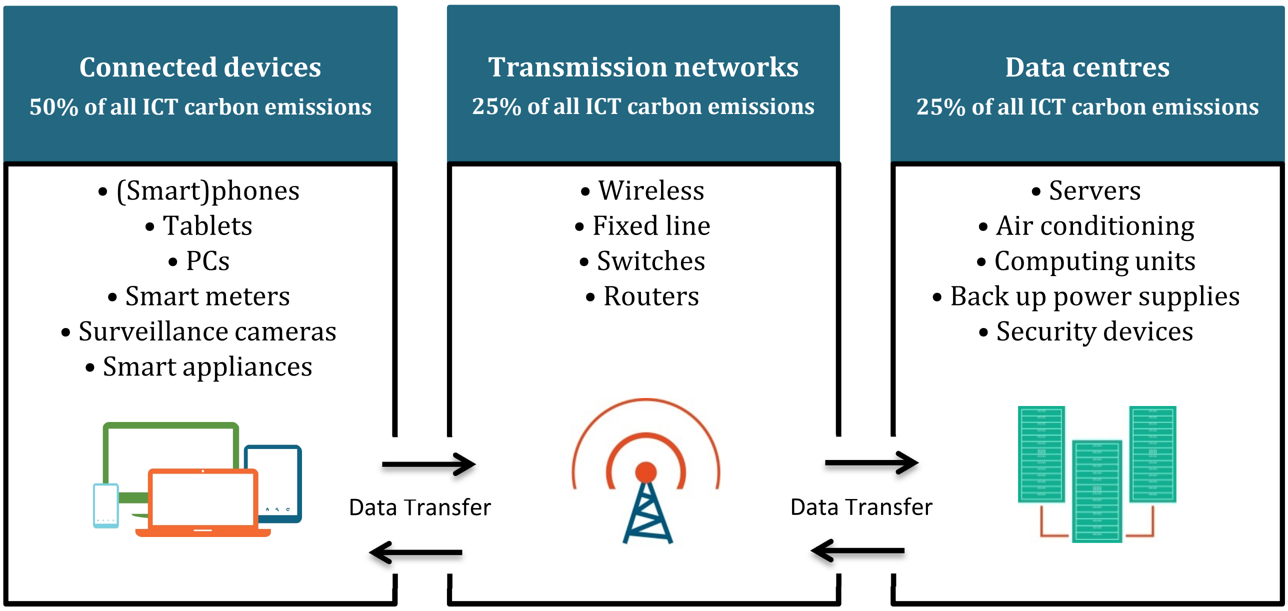
Yes. ICT uses energy and has a carbon footprint. Across the different parts of the digital world, energy is consumed in:

- Manufacturing and transporting devices that connect to form the Internet (servers, networking equipment, laptops, phones, etc.)
- Powering devices in use, including when they are on standby and when idle
- Manufacturing, transporting and constructing the infrastructure that supports the ICT equipment
- Powering equipment that maintains an appropriate operational environment for ICT equipment(e.g. by stopping servers from overheating)
- Powering and operating connections between networked equipment
- Creating and storing digital content, for example, to upload onto laptops and phones and share online
- Recycling and disposing of devices such as computers, smartphones, chargers etc.

1.2. What is ICT and how do its constituent parts cause carbon emissions?

There are three main areas of energy demand in ICT networks: devices that connect to the Internet, networking equipment that transmits data between devices and servers, located either in-house or in data centres, that provide the power required to process information.

Connected devices account for roughly 50% of overall estimated carbon emissions arising from the use of ICT, with data centres and data transmission networks accounting for around a further 25% each.[13]



[13] Networks correspond to 25% of the total global carbon emissions for in-use ICT, data centres to 22% and connected devices to 53% according to J. Malmodin, D. Lundén (2018), 'The energy and carbon footprint of the global ICT and E&M sector 2010-2015'. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.

i. Connected devices

Devices that connect to the Internet include personal computers, smartphones, smart watches, tablets, etc. The Internet of Things (IoT) is a new concept where everyday objects will also be connected to networks, such as coffee makers, lighting, heating and other appliances, which can be turned on and off from a smartphone, and real time data can be measured and monitored online. IoT can change how we use energy on a system level by organising future demand response and generating new data and insights.

User devices, including home networks, were estimated to have used 1.6% of global electricity in 2015.[14] The number of connected devices is increasing exponentially. For example, globally, the number of smartphones is expected to increase from 3.8 billion in 2016 to almost 6 billion by 2020.[15] In the same period, the number of devices connected to IoT is expected to triple from about 6 billion in 2016 to over 20 billion worldwide by 2020.[16]

The energy efficiency of devices has improved significantly. Regulatory initiatives (such as the EU Energy related Products Directive) and energy labelling agreements have contributed to keeping energy demand down. For example, ENERGY STAR labels for office equipment shows that a product has achieved minimum energy efficiency standards. A move in the market towards smaller, more energy efficient devices, such as smartphones and tablets, has also played a part in reducing overall energy use. Connected devices are, nevertheless, estimated to correspond to around 50% of all carbon emissions for ICT.[17] Standby power consumption is a particular concern, with devices such as smart TVs and connected appliances using energy continuously to maintain connectivity, and their number set to increase.[18]

ii. Networks

Access and core networks (collectively referred to as data transmission networks), such as those provided by Internet Service Providers, use energy to transmit information between connected devices through both fixed and mobile networks. Data transmission networks consist of routers, switches, telecommunications equipment and lines, base stations and fibre optic trunk lines.

Data transmission networks (including fixed, mobile and core networks) consumed an estimated 1% of global electricity in 2015.[19] Globally, data transmission networks consumed around 1% of total electricity demand in 2015, with mobile networks accounting for around two-thirds of that.[20] Operators are continually improving their energy efficiency through initiatives such as replacing old, inefficient equipment, technology upgrades and better management of energy. It is unknown how future trends will develop and there is a risk that by 2021 electricity consumption of networks could increase by up to 70%, fall by 15% or rest somewhere in between, depending on future efficiency trends.[21]

[14] J. Malmodin, D. Lundén (2018), 'The energy and carbon footprint of the global ICT and E&M sector 2010-2015'. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.
[15] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[16] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[17] GeSI (2015), '#SMARTer2030: ICT Solutions for 21st Century Challenges.' Available at: http://gesi.org/report/detail/smarter-2030
[18] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[19] J. Malmodin, D. Lundén (2018), 'The energy and carbon footprint of the global ICT and E&M sector 2010-2015'. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.
[20] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[21] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

iii. Data centres

Data centres are purpose-built sites where servers, storage devices, and networking equipment are kept secure and within safe operating temperature and humidity range.[22] These computers store, process and distribute data and usually run 24/7 all year round. Continuous running, plus the fact that hundreds or thousands of servers may be densely packed in racks at a single site, mean that data centres are very energy intensive and produce a lot of waste heat. Data centres use energy to power both the IT equipment (e.g. servers, storage and network devices) and the supporting infrastructure such as cooling (e.g. air-conditioning units to prevent servers from overheating).

In 2015, data centres were estimated to account for 1% of global energy consumption.[23] Over recent years, attention has been paid to consolidation and virtualisation efforts in order to reduce server energy consumption, while optimising cooling technologies, for example, to rely more on using free air cooling technologies that utilise cold outside ambient temperature to cool servers when possible.

Although data centre workload is forecast to triple by 2020, energy demand is expected to grow by only 3% thanks to continuing efficiency gains from servers and cooling equipment.[24] Given the substantial energy costs associated with powering and cooling equipment, there are strong financial and reputational, as well as environmental, incentives for operators to reduce the energy consumption of data centres. It is generally agreed that data centre energy consumption is growing faster than network energy, meaning that energy efficiency gains must be sustained to prevent the risk of future growth in this area.[25] Every organisation that uses digital services is likely to make use of one or more data centres, which can be big or small, kept in-house or outsourced, centralised or distributed, or local or located overseas.

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[22] techUK, (July 2013), 'Er, what IS a data centre?' Available at: http://www.techuk.org/insights/reports/item/273-er-what-is-a-data-centre

[23] J. Malmodin, D. Lundén (2018), 'The energy and carbon footprint of the global ICT and E&M sector 2010-2015'. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.

[24] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

[25] Carbon Trust, Submission to Policy Connect, January 2017.

In-house data centres

- **Large scale data centres** built by global digital businesses, such as Google and Facebook, are run very efficiently with the advantage of economies of scale, advanced technologies and millions of pounds worth of investment in energy management.[26] Google and Microsoft have invested over $900M in energy reduction measures since 2010. Some types of large-scale data centres may have more freedom when choosing locations so can take advantage of cheaper and greener power in Scandinavia, for instance (although this may not be possible for data centres that need to be located close to point of demand to ensure reliable and fast connection, such as content servers used for video streaming)
- **Smaller data centres**, typically found within local government, corporate banks, law firms and insurance companies, vary from large and well-run to small-scale and inefficient. Some IT functions are not consolidated into data centres but are performed by servers in cupboards and closets, sometimes referred to as server rooms. This is called 'distributed IT' and is the least efficient approach Outsourcing can reduce energy demand by around two thirds, yet in-house activity still represents 50-70% of the data centre market. [27] In the public sector, 80% of data centres are small server rooms comprising less than 25 racks, according to the EURECA project.[28] Figure 1 presents a case study of the financial benefits of outsourcing.

Outsourced data centres:

- **Colocation data centres** are professionally run facilities that lease space and power to third parties. They can take advantage of the energy efficiency gains offered by new, innovative equipment and, because they have to remain competitive, are generally run more efficiently than small in-house data centres. The UK data centre market is the largest in Europe and London represents 41% of the total data centre supply in the four largest European markets
- **Cloud services** are similar to colocation data centres except the providers own and manage the IT equipment (whereas in colocation data centres, tenants own the IT equipment).

Figure 1: A case study on the financial benefits of consolidating public sector data centres in Northern Ireland

Case study: Financial benefits of outsourcing and consolidation

The Department of Finance, Northern Ireland Government, conducted a consolidation and virtualisation of public sector data centres exercise leading to significant cost, energy and CO_2 savings.

In this case, three public bodies were able to achieve savings each year of £500,000 through consolidation on an initial spend of £1.8 million and reduced carbon emissions by 636,998kg. An earlier separate data centre and server consolidation project, focussed on Northern Ireland Civil Service, generated considerably more savings and was responsible for reducing the server population by almost 1000 physical servers.

Fewer servers after the latest consolidation project means IT support staff now have capacity to focus on providing new and better-quality services to both internal staff and citizens. The new consolidated facility is hosted at a colocation data centre, providing a higher level of availability and resilience compared to the distributed IT support that was in place.

Source: Department of Finance, Northern Ireland Executive

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[26] Ed. by G. Fagas, L. Gammaitoni, J. Gallagher, D. Paul (2017), ICT- Energy Concepts for Energy Efficiency and Sustainability. Available at: https://www.intechopen.com/books/ict-energy-concepts-for-energy-efficiency-and-sustainability

[27] techUK, Submission to Policy Connect, November 2017.

[28] R. Bashroush, (November 2017) 'Making the Business Case for Energy Efficiency in Data Centres.' Available at: https://www.dceureca.eu/?page_id=2138

2. Trends

2.1. What have trends looked like until now?

In the past, the absolute energy required to power up data centres, data transmission networks and connected devices has increased with increased use, increased number of connected devices and increased data traffic.

Fortunately, in the UK and other mature markets, this energy increase is now levelling off, and for end-user devices it is decreasing overall.[29] This is down to two major factors: energy efficiency gains and renewable energy use. Policymakers and industry should concentrate on driving continued efficiency, wherever feasible, in order to ensure that this trend is not reversed.

Energy efficiency gains

Technical developments across all parts of the Internet, as well as use of improved energy management techniques in data centres and network operators, has meant that its overall energy efficiency has improved significantly. For example, the energy required to transmit a gigabyte of data through fixed data transmission networks halved every two years from 2000 to 2015.[30] Reasons for greater efficiency include:

- Technological developments, replacement of old equipment, minimum energy performance standards, procurement schemes and industry initiatives
- Market trends such as the move to using smaller smart phones and tablets and away from large PCs and TVs with improved energy performance and battery capacity[31]
- Trend of organisations outsourcing their data centres or server rooms to providers with guaranteed levels of energy efficiency and security.

Renewable energy use

Use of renewable energy for ICT is increasing, resulting in a decrease in carbon emissions. The ICT sector has taken big steps towards making an Internet powered by low carbon energy. Facebook, Apple and Google first made 100% renewable commitments four years ago and have since been joined by nearly 20 Internet companies. Companies reach this goal by buying the same amount of megawatt-hours (MWh) of renewable energy as the amount of MWh of electricity they consume in operations. All major UK telecoms operators (BT, EE, O2 and Vodafone) have renewable energy targets and Google is the world's largest corporate purchaser of renewable energy.[32]

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[29] J. Malmodin, D. Lundén (2016), 'The energy and carbon footprint of the ICT and E&M sector in Sweden 1990-2015 and beyond'. Available at: https://www.ericsson.com/en/publications/conference-papers/the-energy-and-carbon-footprint-of-the-ict-and-em-sector-in-sweden-1990-2015-and-beyond

[30] J. Aslan, K. Mayers, J. Koomey, C. France (2017), 'Electricity Intensity of Internet Data Transmission: Untangling the Estimates.' Available at http://onlinelibrary.wiley.com/doi/10.1111/jiec.12630/abstract

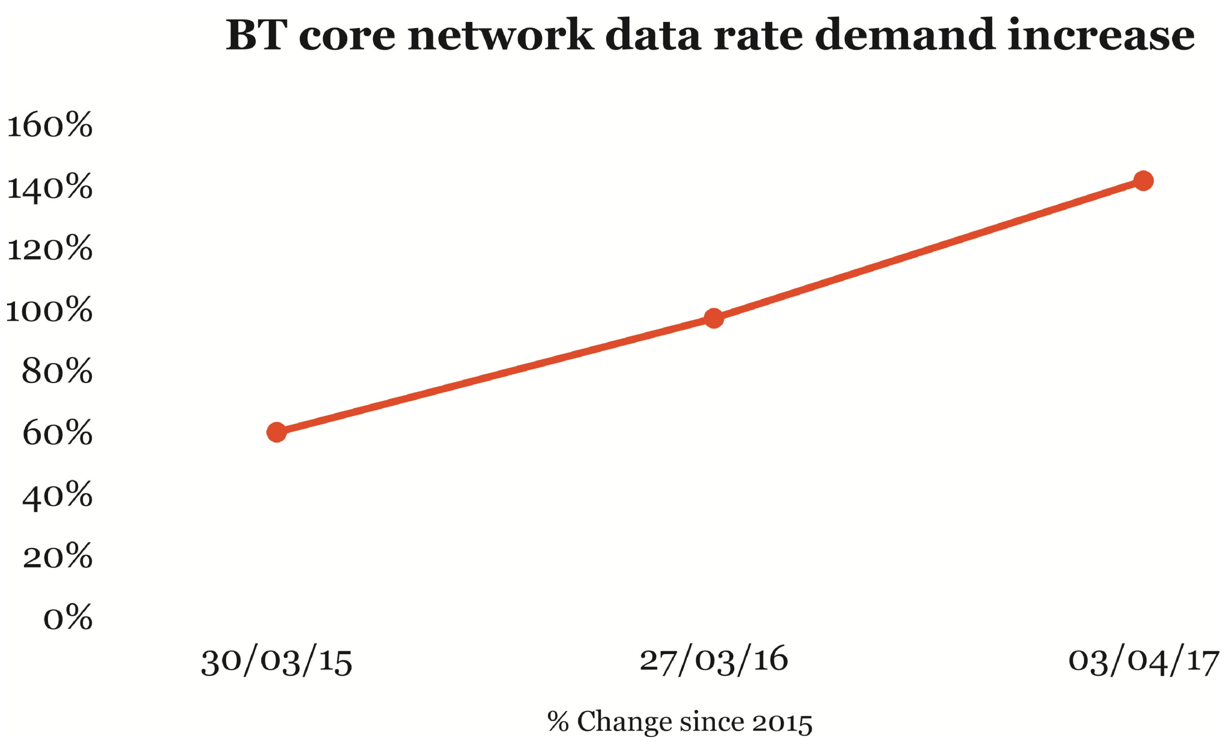
[31] J. Malmodin, D. Lundén (2016), 'The energy and carbon footprint of the ICT and E&M sector in Sweden 1990-2015 and beyond'. Available at: https://www.ericsson.com/en/publications/conference-papers/the-energy-and-carbon-footprint-of-the-ict-and-em-sector-in-sweden-1990-2015-and-beyond

[32] Bloomberg New Energy Finance database for wind and solar energy PPAs. Accessed December, 2016

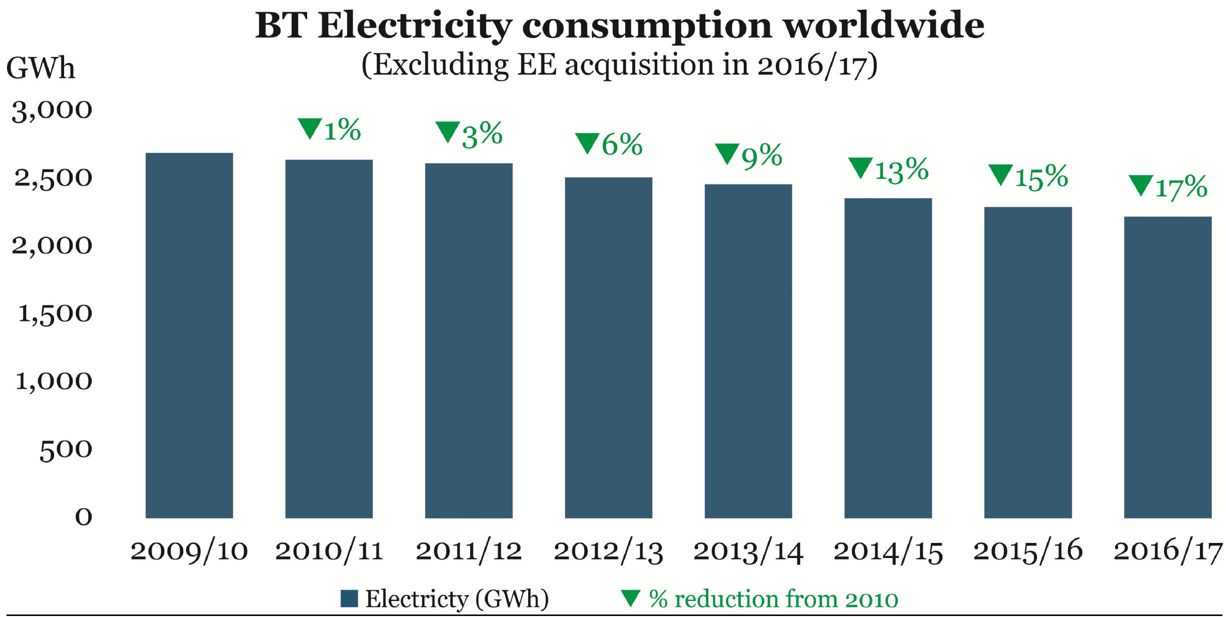
Analysis from BT: energy use with increased data demand

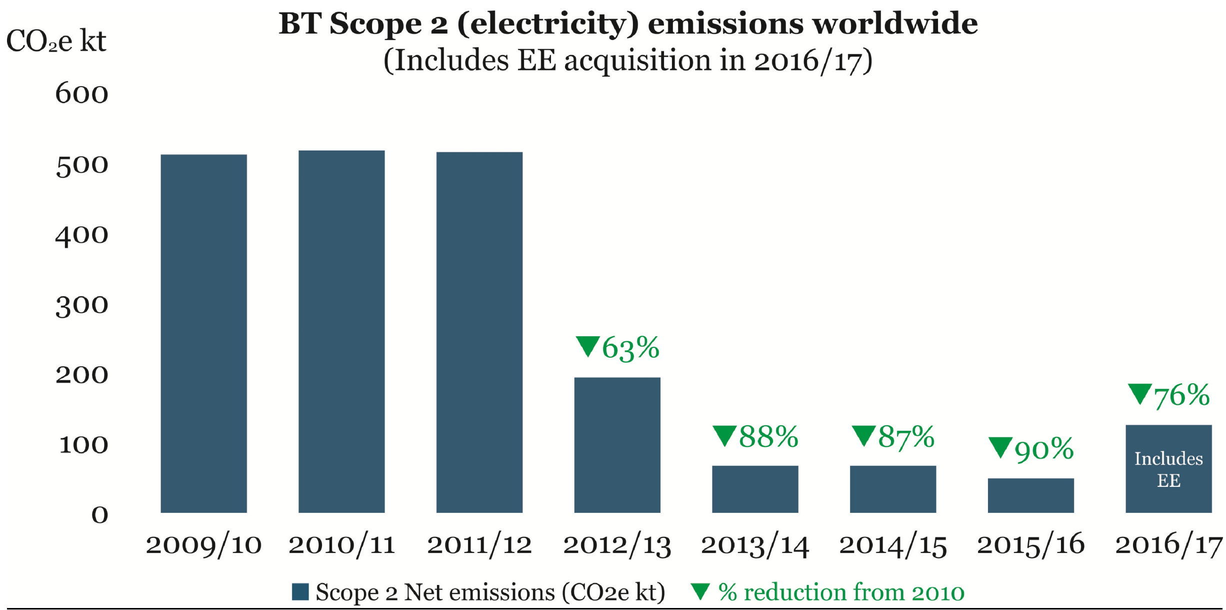
BT is the largest provider of fixed and mobile services in the UK and, together with EE, uses around 0.65% of electricity in the UK. It is also one of three companies in the world to have set a science-based target to reduce its emissions in line with achieving the Paris Agreement's 1.5°C goal for global temperature increase.[33[1]] Data from BT demonstrates that increased data traffic has not resulted in an increase in either electricity consumption or carbon emissions. Despite increases in the transmission of data estimated of around 40% per year, BT has consistently reduced its electricity consumption, and since 2009/10 is using 17% less. BT also purchases 100% renewable energy in the UK. Figure 2 shows how for BT, demand for data has increased, but electricity and emissions have in fact have decreased.

Figure 2: A comparison of BT data demand, electricity emissions and electricity consumption



33[1] Tesco and the Carlsberg Group have also set a 1.5°C goal and over 300 companies have registered with the Science Based Targets Initiative to set targets consistent with 2°C global temperature rise





Source: BT Submission to Policy Connect, November 2017

3. Opportunities

3.1. How can ICT help reduce our carbon footprint?

In the UK, digital technologies have revolutionised the ways in which people communicate, businesses run and governments engage citizens. There is a growing recognition of the crucial role ICT can play in reducing the UK energy and carbon footprints. The take-up of emerging technologies, such as artificial intelligence, the Internet of Things, robotics, and analytics, etc., can bring significant enhancements to performance and productivity in a range of industries and reduce the UK energy and carbon footprint in sectors ranging from transport to manufacturing.

There are estimates that digital technologies could far outweigh the energy cost associated with their use. A 2015 report by Ericsson Research estimates that ICT solutions have the potential to enable a 15.3% reduction in global greenhouse gases for 2030 (in a high reduction potential scenario).[34] A further 2015 report by the Global e-Sustainability Initiative (GeSI), a partnership of ICT companies, suggests that ICT has the potential to enable a 20% reduction of global carbon emissions by 2030.[35]

ICT undoubtedly has substantial potential to help mitigate climate change, and to help the UK meet the fourth and fifth carbon budgets. Policy makers can play a role in ensuring this potential is leveraged as consumers start to adopt new technologies.

3.2. What are the advantages for the UK?

ICT-enabled solutions can reduce carbon emissions in sectors such as:

Energy

Faced with ageing infrastructures, rising carbon emissions and a disruption of core business processes by local and renewable energy sources, utility companies are looking for ways to improve the grid and allow for further integration of distributed and renewable energy. Machine-to-machine learning, advanced data analytics and distribution management systems can significantly improve the efficiency of existing grids by increasing grid flexibility and supporting demand response, while paving the way for a clean energy revolution. With annual cost savings of between £17-40bn for consumers in 2050, an ICT-enabled grid is central in supporting the 65% reduction in power sector emissions by 2030.[36]

Open Energi, for example, is a growing company that utilises sensors to identify short-term strains on the National Grid and adjust the amount of electricity being consumed by industrial equipment (such as refrigerators or heating systems) for short bursts. These adjustments have little or no effect on operational processes, but perform a service to the grid in helping to balance electricity supply and demand. Future advances will see digital technologies used to connect sets of factories or supply chains, or even local clusters of factories, to deliver grid services such as demand shifting, peak-lopping and frequency response.[37]

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[34] J. Malmodin, P. Bergmark, (2015), 'Exploring the effect of ICT solutions on GHG emissions in 2030.' Available at: https://www.ericsson.com/en/publications/conference-papers/exploring-the-effects-of-ict-solutions-on-ghg-emissions-in-2030

[35] GeSI (2015), '#SMARTer2030: ICT Solutions for 21st Century Challenges.' Available at: http://gesi.org/report/detail/smarter-2030

[36] Committee on Climate Change (2017), 'Report to Parliament: Meeting Budgets Closing the Policy Gap.' Available at: https://www.theccc.org.uk/wp-content/uploads/2017/06/2017-Report-to-Parliament-Meeting-Carbon-Budgets-Closing-the-policy-gap.pdf

[37] J. Maier (October 2017), Made Smarter Review. Available at: https://www.gov.uk/government/publications/made-smarter-review

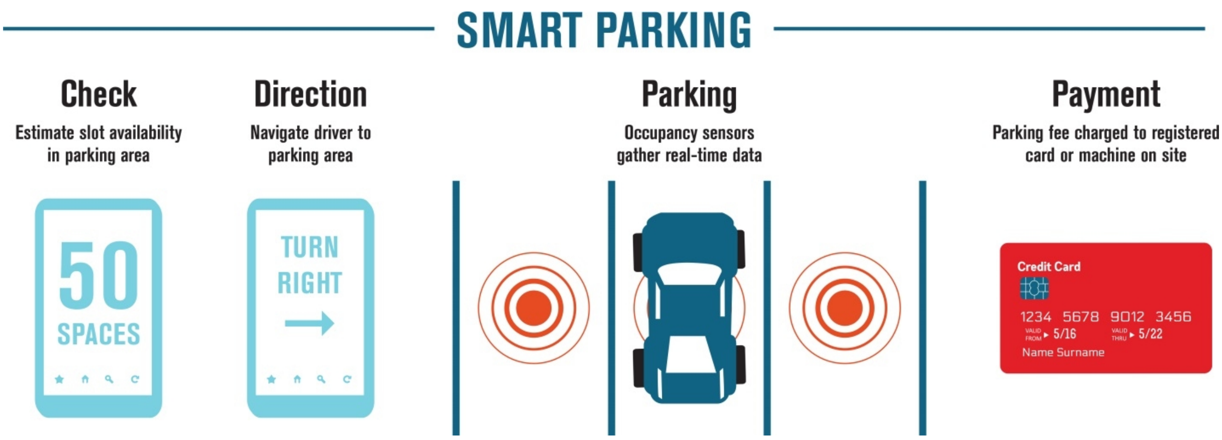
Transport and logistics

Transport currently accounts for around a quarter of UK greenhouse gas emissions.[38] Already ICT is saving an estimated 2.34m tonnes of greenhouse gases from transport and logistics largely through smarter logistics, by supporting individual transport choices and by encouraging better driving behaviour. In the logistics and commercial sector, intelligent convoys, data-driven automation of supply chain management and more efficient drivers will deliver further carbon savings. Upgraded digital signalling technologies can also help to increase the capacity of the rail network by allowing trains to run closer together.

Digital technology can support ride-sharing, electrical and autonomous vehicles or simply connecting car drivers to information on available parking and traffic avoidance. This should drive a cleaner, more efficient transport network by shortening journeys, ensuring they are less fuel intensive, improving route planning and by supporting improved driver behaviour.

In Milton Keynes, for example, a smart parking system is helping to reduce air pollution, congestion, journey times, and carbon emissions by collecting and analysing real-time information on parking spaces from sensors on lampposts via wireless technologies. Roadside displays and smartphone apps guide drivers towards free parking spaces, contributing to 50% less traffic congestion and reduced fuel use and vehicle emissions. Figure 3 provides a visual description of how smart parking can operate.

Figure 3: Diagram illustrating the concept of smart parking



Industry and manufacturing

The automation of manufacturing processes, coupled with real-time process monitoring and re-engineering, can result in radical improvements in accuracy and precision, coupled with energy, carbon and cost efficiencies. More efficient manufacturing and industrial processes and more optimised supply chains can improve the resource efficiency of the UK's industrial base and reduce its environmental impact as well as help raise UK productivity and international competitiveness.[39]

[38] DfT (2016), https://www.gov.uk/government/statistics/transport-statistics-great-britain-2016. Accessed 1st February.
[39] J. Maier (October 2017), Made Smarter Review. Available at: https://www.gov.uk/government/publications/made-smarter-review

For example, automation could increase productivity growth in food processing and wholesaling from 1.4% to 3% per annum. Furthermore, it could reduce greenhouse gas emissions by an estimated 29 percent throughout the food supply chain by 2027 due to efficiencies from digitally managed processes in manufacturing and distribution.[40] There would also be a corresponding reduction in waste management and food waste of 17.6 million tonnes over the next decade, factoring in greater visibility of shelf life.[41]

GAMBICA, the Trade Association for Instrumentation, Control, Automation and Laboratory Technology in the UK, considers that considerable energy can be saved by simply switching systems off when not needed through automation and that reducing speed by 20% can result in a 50% energy saving on some pump or fan systems.[42]

Buildings: smart heating and lighting

Residential energy use is estimated to result in the emission of around 13% of the UK's 2015 greenhouse gases.[43] The UK expects to build 300,000 new houses per year, yet the construction and operation of buildings remains highly resource and energy intensive, with buildings accounting for around 40% of global energy consumption.[44] Improving the efficiency of buildings is essential for enabling energy and resource savings and reducing the UK's overall climate change impact.

Automated building heating, cooling, ventilation and lighting control systems are already gaining ground, based on motion and light sensors, turning lighting off when there is enough daylight, or turning heating off when no one is around. It is also becoming possible for people to integrate their personal calendars into the system to enable it to adjust to their specific schedules automatically. In addition, smart technologies will also offer users full integration with the local smart grid, which permits on-site generation of renewable energy and the selling of energy back into the grid.[45]

These solutions could be applied to large commercial and industrial complexes or smaller homes and condominiums, helping to drive the more efficient use of resources and energy.[46] Connected buildings are already saving at least 2.9m tonnes of carbon dioxide a year in the UK via advanced building energy management system; improved heating, ventilation and air conditioning controls; and, via smart meter installations.

[40] J. Maier (October 2017), Made Smarter Review. Available at: https://www.gov.uk/government/publications/made-smarter-review
[41] J. Maier (October 2017), Made Smarter Review. Available at: https://www.gov.uk/government/publications/made-smarter-review
[42] GAMBICA (January 2016), 'Driving Energy Efficiency.' Available at: http://www.gambica.org.uk/resourceLibrary/gambica-article-mad-guide-2016-pdf.html
[43] BEIS (2015), '2015 UK Greenhouse Gas Emissions.' Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/589602/2015_Final_Emissions_Statistics_one_page_summary.pdf
[44] Accenture Study on Smart Building Solutions http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Smart-Building-Solutions-Brochure.pdf
[45] GeSI (2015), '#SMARTer2030: ICT Solutions for 21st Century Challenges.' Available at: http://gesi.org/report/detail/smarter-2030
[46] GeSI (2015), '#SMARTer2030: ICT Solutions for 21st Century Challenges.' Available at: http://gesi.org/report/detail/smarter-2030

4. Future challenges

4.1. What will drive the trends of the future?

Increasing number of people online

More than 40% of the global population is now online – but four billion still lack access to the Internet.[47] And the population is growing.

Increasing number of connected devices

By 2020, globally more than 20 billion connected IoT devices and nearly six billion smartphones are expected to be online.[48] As more and more of our devices, appliances and controls become 'connected', they will consume a certain amount of energy to maintain connectivity, even when powered-down to sleep or standby. They would also produce more and more data that will require further power to process.

Growing transmission of data

Data traffic and especially mobile data traffic keeps growing. Global Internet data traffic has increased more than fivefold since 2010 and there are predictions of growth of 42% per year to 2020.[49] It is predicted that consumer markets (80% of all data demand)[50] will be the most influential factor for driving the pace of data demand and video will account for 82% of all Internet traffic by 2021, up from 64% in 2014.[51]

New technologies

Consumers are constantly adopting new technologies and new ways of connecting with and using the Internet. Potentially transformative technologies, for example, autonomous cars, intelligent home systems and machine learning, are on the horizon. While the rise of new technologies such as blockchain and cryptocurrencies will put further strain on energy consumption due to the sheer amount of compute power and the large-scale data redundancy they require, advances in technologies such as artificial intelligence will provide an opportunity to improve efficiency.

Efficiency dilemma

Care needs to be taken when discussing projected efficiency gains. Increased efficiency can lead to increased consumption that is difficult to account for and even more problematic to reflect accurately in studies. For example, if ICT enables more efficient, affordable and convenient transport, more people may then choose to travel more often.

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[47] World Bank Group (2016), 'Digital Dividends.' Available at: http://documents.worldbank.org/curated/en/896971468194972881/pdf/102725-PUB-Replacement-PUBLIC.pdf
[48] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[49] J. Aslan, K. Mayers, J. Koomey, C. France (2017), 'Electricity Intensity of Internet Data Transmission: Untangling the Estimates.'
[50] IEA (2017), Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[51] Cisco (2017), 'The Zettabyte Era: Trends and Analysis.' Available at: https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/vni-hyperconnectivity-wp.html

4.2. What challenges do policy makers face?

Policy making in a dynamic industry

Alongside initiatives led by industry and UK Government, the European Commission has been an important driver for energy efficiency in the UK. The Ecodesign Directive ensures that products coming to the market are more energy-efficient, and the Energy Labelling Directive ensures that consumers are encouraged and empowered to buy the most efficient products based on useful information.

Minimum energy standards for ICT products such as servers, standby power, cables, games consoles, set top boxes and computers already exist. Setting standards for ICT products, however, is difficult because of uncertainty about future market developments, the speed of innovation in the sector and the increased connectivity of ICT products.

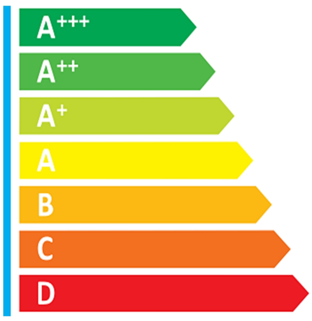
The Ecodesign/Energy Labelling process takes around four years on average to establish,[52] yet the tech market moves much more quickly. Legislation needs to anticipate technological change in order to maintain high standards regarding the environment and beyond.

In this era of increased connectivity, defining the boundaries of the Internet poses another challenge to regulating the sector. With the development of the Internet of Things and the predicted growth in embedded microprocessors and sensors, computers are becoming more and more embedded into our lives in new and different ways. Policy must remain flexible to deal with appliances, products and services that become 'connected'.

Historically, energy efficiency gains have been impressive; for example, the energy required to transmit a gigabyte of data through fixed transmission networks halved every two years from 2000 to 2015.[53] Given the speed of improvements, policy has to ensure that standards are feasible, sufficiently ambitious in terms of improving energy efficiency, and in-step with rapid technological advances. Energy efficiency standards should, therefore, be regularly reviewed and kept up-to-date.

In the Clean Growth Strategy, the Government committed to having the same energy efficiency standards as those in Europe, unless it is in the national interest to go further.[54] The UK must continue to develop policy capabilities around energy efficiency and drive greater efficiency in the sector in order for the UK to remain competitive and to continue to reduce UK carbon emissions. This will require the UK to retain and develop policy expertise.

Figure 4: European Union Energy Label that rates appliances in terms of a set of energy efficiency classes from A+++ to G



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[52] European Commission (November 2016), 'Eco-design Working Plan: 2019-2019.' Available at: https://ec.europa.eu/energy/sites/ener/files/documents/com_2016_773.en_.pdf
[53] J. Aslan, K. Mayers, J. Koomey, C. France (2017), 'Electricity Intensity of Internet Data Transmission: Untangling the Estimates.' Available at http://onlinelibrary.wiley.com/doi/10.1111/jiec.12630/abstract
[54] BEIS (October 2017), 'Clean Growth Strategy.' Available at: https://www.gov.uk/government/publications/clean-growth-strategy

‘Energy efficiency by design’

‘Privacy by design’ is an approach to systems engineering that takes privacy into account at all stages of the engineering process. ‘Security by design’ means that software has been designed from the ground up to be secure. As the UK moves to ‘digital by default’ standards for public facing services, such digital services should be designed through an ‘energy efficiency by design’ approach. This will mean working with architects and developers to drive innovation and consideration for energy efficiency at all levels of design, implementation and delivery of services.

The Government has identified 18 criteria to help them create and run digital services, for example, considering privacy and security issues and user experience.[55] Given the importance of ensuring that energy efficiency gains continue, it is essential to take an ‘energy efficiency by design’ approach to designing, building and operating digital services, ensuring that energy efficiency solutions are required for ICT devices and services at the system level (e.g. employing carbon footprint and life cycle approaches that consider entire product/service systems).

Lack of visibility of data

Estimating total global electricity use by ICT is very difficult and mostly relies on modelling and assumptions, as measuring the power consumption of remote or wide-spread internet networks is not feasible. Existing studies present varying estimates and are difficult to compare because of differing methodologies and scope. There are a range of estimates on the current and future global electricity demand of ICT and associated carbon impacts. As there is no way to systematically measure energy use, all estimates depend on modelling to determine global impacts. It is estimated that ICT (data centres, networks and connected devices) corresponds to around 3.6% of global electricity and around 1.4% of global carbon emissions. Definitions vary and if entertainment (film, music, games etc.), media (TV, radio, news, books, magazines etc.[56]) and printing are included, this increases to roughly 6% of global electricity and about 2.5% of global carbon emissions.[57]

Analysis has been undertaken in Sweden[58] and Germany[59] to determine the annual energy demand by the ICT sector for each country. However, estimating the energy demand in the UK compiling information from data centres, network operators and connected devices has not been attempted. In order to develop policy that helps to manage the UK carbon footprint of ICT, it must first be possible to understand the energy consumption of ICT components in the UK.

A global picture

Looking at the carbon footprint of the Internet in the UK does not provide us with a full picture. Software is largely designed in North America. Devices are mainly manufactured in Asia. On the other hand, London represents 41% of the total data centre supply in the four largest European markets and carbon emissions attributed to the UK are used to run services that are used across Europe. The carbon footprint of the Internet is a global issue and an area where the UK should take global leadership, building on its cutting edge data centre industry, as well as OEM technology manufacturers such as ARM (acquired by Softbank for £24.3 billion in 2017).

The UK is a world leader in tackling climate change and was the first country to introduce long-term, legally-binding national legislation to tackle climate change through the 2008 Climate Change Act. The UK should start engaging with a range of stakeholders in the UK and abroad (e.g. manufacturers, standardisation bodies, user groups, policy makers, etc.). This requires engaging in global discussions and actions in these areas, to specifically consider how to maximise opportunities for carbon savings and ensure energy efficiency of the Internet while also facilitating UK innovation and industrial leadership.

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[55] Gov.UK, ‘Digital Service Standard.’ Available at: https://www.gov.uk/service-manual/service-standard Accessed 1st February, 2017.
[56] Paper has not been included in this calculation in order to focus on use of electrical and electronic devices and networks.
[57] J. Malmodin, D. Lundén (2018), ‘The energy and carbon footprint of the global ICT and E&M sector 2010-2015’. Paper accepted for publication and presentation at: *ICT for Sustainability* (ICT4S), Toronto, Canada, 14-18 May 2018.
[58] J. Malmodin, D. Lundén (2016), ‘The energy and carbon footprint of the ICT and E&M sector in Sweden 1990-2015 and beyond’.
[59] Federal Ministry for Economy Affairs and Energy (2015), ‘Development of ICT-related electricity demand in Germany’.

Conclusions

Historically, economic growth meant a simultaneous growth in carbon emissions but technological improvements mean that economic growth can continue without necessarily increasing carbon emissions and resource usage. [60] The UK has cut emissions by 42% since 1990 while growing the economy by two-thirds.[61]

Digital technologies offer the UK remarkable opportunities to continue along this positive trajectory, to tackle carbon emissions and meet the ambitious targets in the Paris Agreement. Smart traffic management systems, intelligent street lighting, on demand refuse collections and parking space management services have yet to be deployed at scale but are already reducing carbon emissions by an estimated 435,000 tonnes a year in the UK.[62]

But there is much work to be done to ensure that the digital economy remains sustainable. The energy challenge of the Internet is not new. Software designers have invested time and money into improving the energy efficiency of devices. In addition, the UK's highly competitive telecommunications market has helped to drive better energy management in order to decrease costs and remain competitive.

Until now, improvements to technology, consolidation of ICT facilities and improved energy management have kept pace with increased Internet use and have prevented energy consumption rising at the same pace as Internet usage. Increased use of renewable energy is playing an important part in ensuring that less carbon dioxide is emitted by ICT. This trend is expected to continue over the next five years.[63] Beyond that, in such a fast developing sector, the future is more uncertain. It is unknown whether efficiency gains will continue, or whether they will slow or even stall. The public sector, with its influential spending power, must lead by example in taking forward an 'energy efficiency by design' approach to delivering digital services, purchasing renewable energy and implementing best practice for energy management in order to ensure that energy efficiency gains continue and ICT energy use and carbon emissions are kept in check.

[60] GeSI (2015), '#SMARTer2030: ICT Solutions for 21st Century Challenges.' Available at: http://gesi.org/report/detail/smarter-2030
[61] BEIS (October 2017), Claire Perry's speech launching the Clean Growth Strategy. Available at: https://www.gov.uk/government/speeches/launch-of-the-clean-growth-strategy
[62] techUK, Submission to Policy Connect, November 2017
[63] IEA (2017) Digitalization and Energy. Available at: https://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf

Methodology and Steering Group

Methodology

Scoping for *Is staying online costing the Earth?* began in summer 2016. The steering group was convened to provide guidance on sources of information and evidence, to aid the exploration and scrutiny or key issues and to discuss key recommendations and findings. Two steering group sessions were held between October 2017 and November 2017, led by the inquiry Co-Chairs Daniel Zeichner MP and Antoinette Sandbach MP.

Interviews with academics, industry members and independent experts were carried out between November 2017 and January 2018.

The findings and policy recommendations herein are based on a review of pertinent literature, semi-structured interviews and responses to a written call for evidence.

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Policy Connect is the go-to cross-party think tank, successfully delivering new policy ideas through research, evidence, political meetings and sector engagement. With no set ideology, we recommend the best approach from facts and data, and help influence policy decisions and law-making. We find the common ground and build consensus to improve public policy. We do this by running forums, commissions and All-Party Parliamentary Groups. We have overseen the research and delivery of more than 50 key publications.

This report is not an official publication of the House of Commons or the House of Lords. It has not been approved by either House or its committees.

The findings and policy recommendations in this report are based on a review of pertinent literature and evidence collected through events and in-depth interviews with Parliamentarians, industry leaders, central and local government representatives, consultants, academics and third sector professionals. The end report and its conclusions are the sole responsibility of the authors.

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