The Enablement Effect

The impact of mobile communications technologies on carbon emission reductions

Contents

The GSMA represents the interests of mobile operators worldwide, uniting more than 750 operators with almost 400 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The GSMA also produces the industry-leading MWC events held annually in Barcelona, Los Angeles and Shanghai, as well as the Mobile 360 Series of regional conferences.

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Established in 2001, the Carbon Trust works with businesses, governments and institutions around the world, helping them contribute to, and benefit from, a more sustainable future through carbon reduction, resource efficiency strategies, and commercializing low carbon businesses, systems and technologies. Headquartered in London, the Carbon Trust has a global team of over 30 nationalities based across five continents.

Foreword

To avoid the worst impacts of climate change, the science tells us to halve global carbon emissions by 2030. That was the stark picture painted by the IPCC special report 'Global Warming of 1.5°C'.

The mobile telecommunications industry has already demonstrated leadership with a focus on investment, innovation and efficiency resulting in substantial carbon reductions.

The sector's ongoing development of connected technologies, is releasing a wave of low carbon innovation across many other sectors of industry and society.

But can the global impact of these technologies be captured and quantified?

The Carbon Trust, has worked closely with the GSMA to examine the enabling role that mobile telecommunications are having on reducing carbon emissions across the economy.

It was astonishing to see that this enabled over 2,000 million tonnes of CO_2 in 2018 alone. This is almost ten times greater than the total CO_2 emissions of the mobile networks globally.

It's a great start, but we cannot be complacent. To harness its full potential, governments, businesses and consumers should explore and embrace the opportunities presented in this technological revolution.

Tom Delay, Chief Executive of the Carbon Trust

The global mobile industry recently came together to take collaborative action to tackle the climate emergency, demonstrating how the private sector can show leadership and responsibility in addressing one of the gravest challenges facing our planet.

As part of a major new GSMA-led initiative, more than 50 mobile operators are now disclosing their climate footprint, energy and greenhouse gas (GHG) emissions via the internationally recognised CDP global disclosure system. And that's just the start. By 2020, we will have in place a decarbonisation pathway for the mobile industry that will set the parameters for achieving net zero GHG emissions in line with the Paris Agreement.

However, while getting our own house in order is important, mobile's greatest positive climate impact lies in its potential to enable other sectors of the economy to reduce their own emissions.

Today mobile connects more than five billion people - around two-thirds of the global population. We're increasingly connecting machines and 'Things' too, thanks to advancements in technologies such as M2M and IoT. These two trends provide us with a unique opportunity to use mobile as a tool to decarbonise elsewhere in the economy.

To understand the scale of this opportunity we have worked with the Carbon Trust to update and expand previous research on avoided emissions. This study considers six different categories, across 33 subcategories and 14 different countries. It has resulted in a powerful appraisal of where the mobile industry is having the greatest impact and where we can do more.

Climate is the defining issue of our time and taking the right course of action has never been more important. A decarbonised world is a digital world and we are calling on every sector of the global economy to work with us to rise to this challenge.

Mats Granryd,
Director General, GSMA

Executive Summary

Climate change is the most urgent, global issue that we face today and is one which will impact generations to come. Delaying or limiting decarbonisation efforts will be disastrous for society and will limit our ability to transition to a low carbon economy.[1] Transitioning within the necessary timeframe will require the use of technologies that enable rapid emission reductions.

This is where the mobile sector has a key role to play. By increasing connectivity, improving efficiency and impacting behaviour change, mobile network enabled technologies are helping avoid emissions. In 2018, the enabling impact of mobile communication technologies globally was estimated to be around 2,135 million tonnes CO_2e – similar to the total GHG emissions emitted by Russia in 2017.[2]

The total annual emissions of the mobile sector are approximately 220 $MtCO_2e$,[3] which is about 0.4% of total global emissions. Compared to the global carbon footprint of mobile networks themselves, the level of avoided emissions enabled by mobile communications technologies is 10 times greater – a tenfold positive impact.

The majority of these avoided emissions result from a decrease in electricity, gas, and fuel consumption. In 2018, mobile communications technologies enabled a decrease in 1.44 billion MWh of electricity and gas, and 521 billion litres of fuel, globally. These totals would be enough electricity and gas to power more than 70 million houses for an entire year in the US,[4] and enough fuel for all 32.5 million registered UK passenger cars to drive for 19 years.[5]

Digitisation is expected to disrupt all parts of the economy over the next decade and, if sufficient policy and investment is received, has the potential to be a key driver of low carbon development.

A similar 2015 report, with a European and North American scope, concluded that mobile technologies had a 5:1 enablement ratio compared to the footprint of the industry.[6] Published four years later, this report has seen a doubling in enablement savings, to 10:1. By 2025, estimates based on projections of smartphone users and increases in number of IoT connections could result in a further doubling of the avoided emissions enabled by mobile technologies.

The world needs to halve emissions by 2030 to limit global overheating to 1.5°C. Mobile network enabled technologies form an important part of the decarbonisation solution, enabling rapid emission reductions while improving quality of life and supporting economic growth. The Carbon Trust has developed this report for GSMA to provide a global overview of the enablement impact that mobile communications technologies currently have on reducing GHG emissions, across various sectors. The report offers context and provides a high-level analysis of six categories of enabling mechanisms, along with case studies.

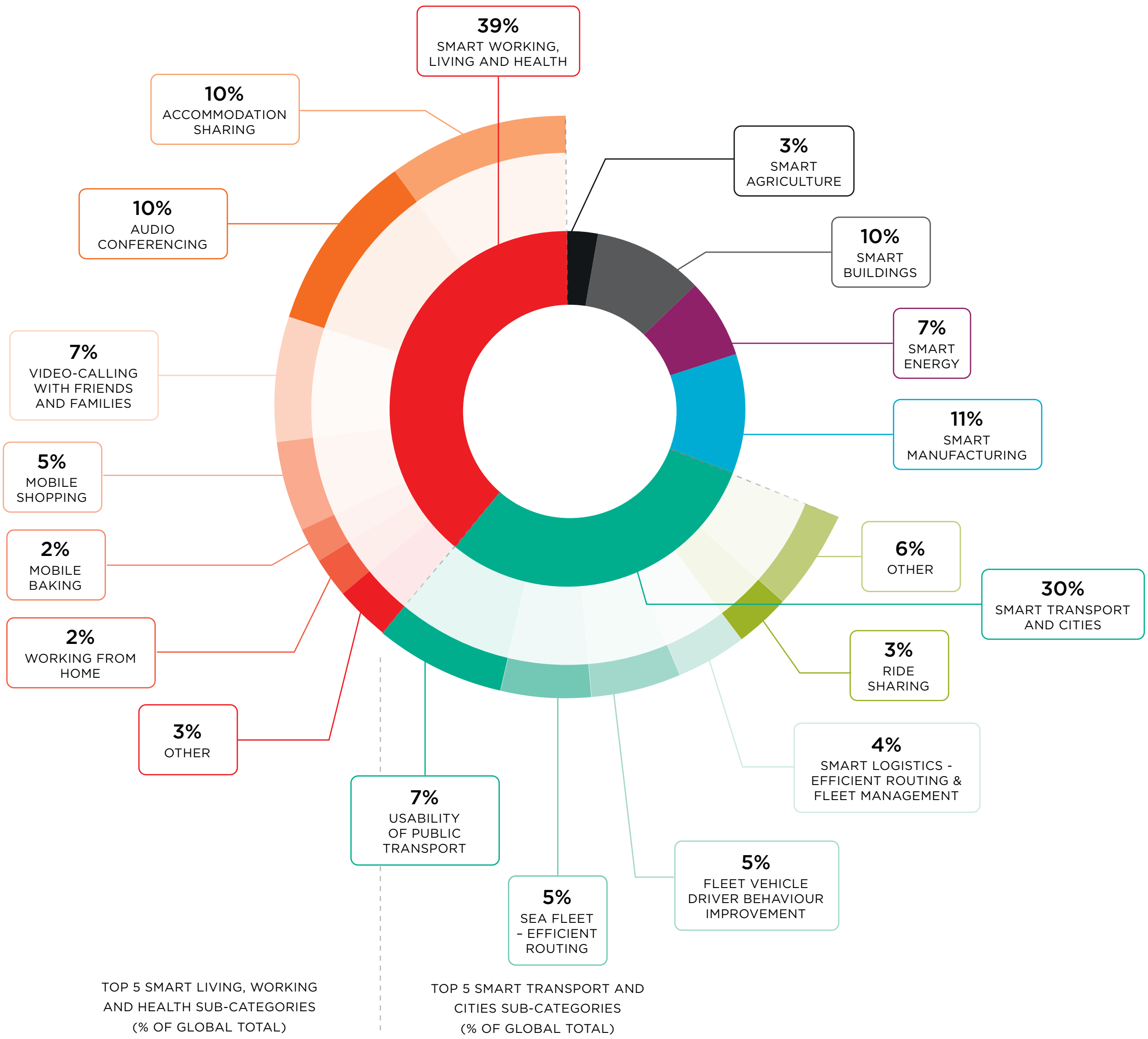
The six different categories are:

- Smart Buildings
- Smart Energy
- Smart Living, Working, and Health
- Smart Transport and Cities
- Smart Agriculture
- Smart Manufacturing

1. IPCC (2014), *Summary for Policymakers, Climate Change 2014: Mitigation of Climate Change*, pp. 12.
2. OECD.Stat, Greenhouse Gas Emissions, https://stats.oecd.org/Index.aspx?DataSetCode=AIR_GHG#
3. Mobile sector emissions of 220 $MtCO_2e$ includes the energy to operate the networks, the embodied emissions of the networks, and the emissions of handsets (see Appendix 2 for details).
4. IEA Statistics
5. Department of Transport – GOV.UK (2018), VEH0105 and TRA0101; BEIS (2018), Conversion Factors
6. GeSI (2015), *Mobile Carbon Impact*

This is the first time a report has attempted to assess the enablement impact of mobile communications technology at a global scale. To quantify the total global avoided emissions, 14 countries (in six regions) were identified as a representative global sample from which to extrapolate. This sample consists of France, UK, Spain, Germany, Kenya, Egypt, South Africa, South Korea, China, India, Brazil, Mexico, US, and Australia.

FIGURE 1
Enabled Avoided Carbon Emissions by Category in 2018



Main Findings

Two forms of enablement were assessed; smart technologies connecting one machine to another (M2M technologies), also known as the internet of things (IoT), and behaviour changes from the personal use of smartphones.

The majority of avoided emissions from M2M technologies are primarily in buildings, transport, manufacturing, and the energy sector:

- Savings in buildings are a result of technologies that improve energy efficiency and encourage behaviour change, reducing gas and electricity consumption. Among these technologies are building management systems and smart meters.
- Mobile communication technology enables the reduction of transport emissions in various ways. It acts as a catalyst for the increase in electric vehicles by facilitating the use of charging points, and, through telematics, creates an improvement in route optimisation and vehicle fuel efficiency.
- Within manufacturing, the use of mobile technology for storage and inventory management greatly reduces the overall level of inventory and area needed, increasing efficiency and decreasing energy use for lighting and cooling.
- Smart grids within the energy sector utilise mobile communications technology to help monitor and regulate electricity demand and transmission, to improve coordination and distribution efficiency. Additionally, small-scale renewable electricity generators are able to participate in the wider market by using M2M connections, increasing the amount of green and local energy in the national grid.

To analyse the use of smartphones to facilitate behaviour change, the Carbon Trust commissioned a global survey study of more than 6,000 smartphone users in the UK, China, India, USA, Mexico, Brazil, and South Africa. From this research, significant avoided emissions were seen in the areas of:

- Reduced travel for commuting and for leisure
- Increased use of public transport by using apps providing real-time updates
- Accommodation sharing for short stays and holidays
- Reducing travel by use of mobile shopping and mobile banking apps

Categories of enablement such as agriculture and health are not currently showing a significant impact on avoided emissions. However, both are important as they hold significant future opportunities of enablement by mobile communications technology.

Background

Climate change is the current most pressing global issue; if left unchecked, it will cause momentous disruption. Changes in the environment could displace millions, transforming entire communities into climate refugees, and devastate the natural resources our economies and societies rely on.

In the Paris Agreement, governments worldwide committed to maintain the global average temperature rise at well below 2°C, and to aim for 1.5°C, compared to pre-industrial levels.[7] Keeping global temperature rise at this level is essential to avoid severe consequences caused by climate change. However, at current temperature rising rates, 'business as usual' and reduction initiatives will not be sufficient. Companies must therefore look beyond reducing their own direct emissions and understand how they can better abate other sectors' emissions too.

Enablement, also referred to as the enablement effect, is any mechanism which, through its use, facilitates the avoidance of carbon emissions. An example of an enablement mechanism is mobile banking, which allows customers to avoid travelling to a bank branch. On the other hand, smart meters, made operable by M2M mobile technology, stimulate emission reduction behaviour change by increasing awareness and providing easy monitoring systems of energy and water use.

With growing consumer pressure and the need to mitigate climate risk, investors, rather than focusing solely on divesting investments in high emission companies, are favouring companies who actively provide solutions that tackle climate change. Investors and financial institutions want to have a better understanding of the types of key technologies and business models that will assist in the transition and succeed in a future low carbon economy. Analysing avoided emissions allows companies to demonstrate how their product or service has both a positive impact and is a secure investment.

With the scale of investment required, the private sector will play an important role in financing climate change mitigation. Institutions and organisations are now providing guidance for those looking to invest. One such example is the anticipated EU Taxonomy, which will provide specific criteria for investors to use to help identify which sustainable activities to invest in. The ICT sector is one of its seven sectors of focus, and this report's methodology and its findings will complement the EU Taxonomy, providing both an assessment approach and evidence of the avoided emissions enabled by mobile communications technology.

Development banks are also taking action on climate change. We are seeing an increase in the uptake of policies requiring future investments to contribute in some form to climate change mitigation or adaption, regardless of the sector. As development banks begin to assess the impact their investments have on climate change mitigation and adaptation, the need for available metrics and the ability to quantify impact becomes increasingly necessary.

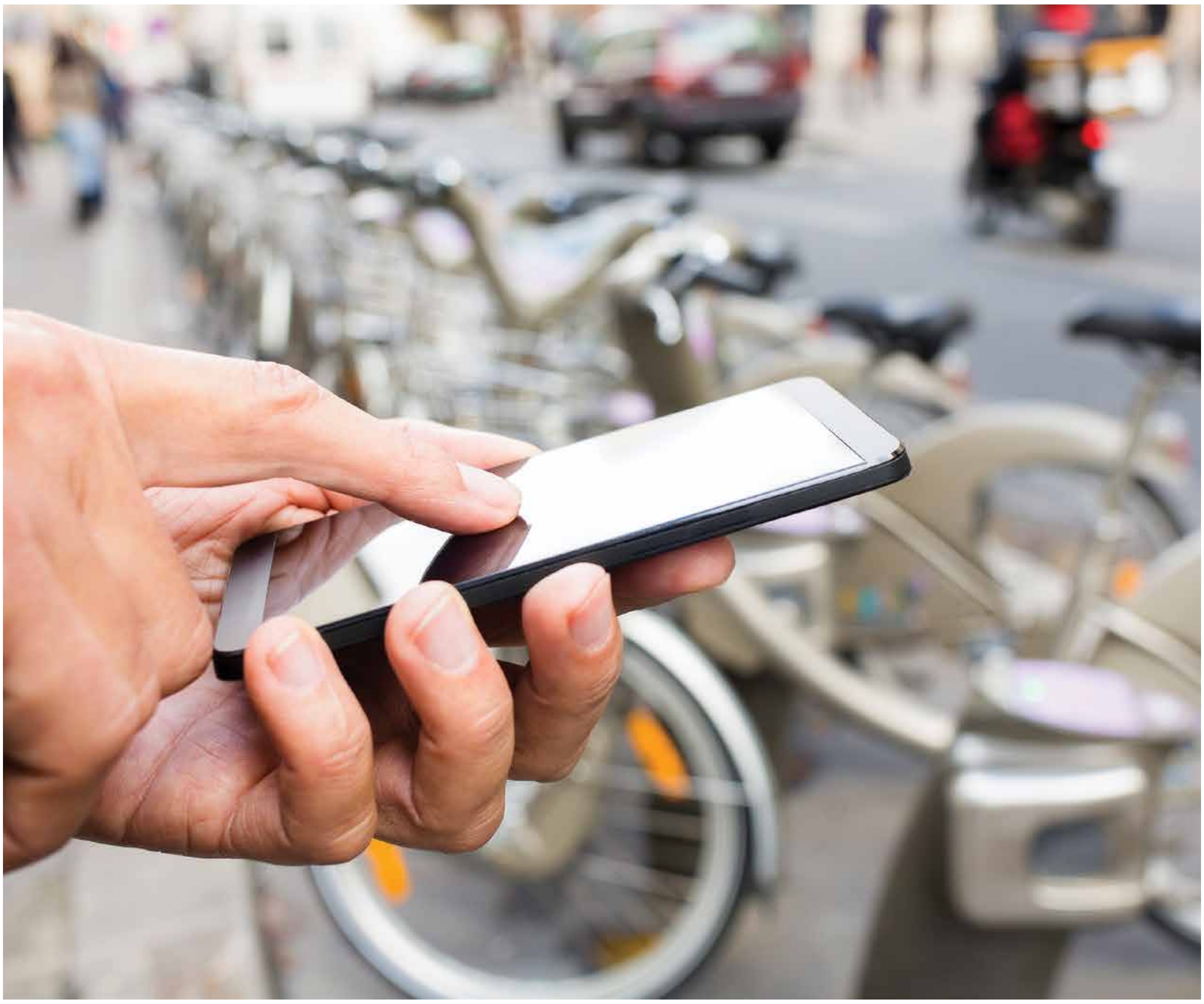
Work on avoided emissions for the ICT sector has existed for over 10 years, with some of the early analysis produced by GeSI with its SMART2020 report and its Enablement Methodology report, published in 2008 and 2010 respectively. Other work has built on these original reports, including work currently underway in the ITU. Over the last five years a number of mobile network operators and other ICT companies have been assessing their own enablement impact, in addition to their carbon footprint reduction initiatives. Specific to

7. "The Paris Agreement." *UNFCCC*, unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

mobile, GeSI, in 2015, along with the Carbon Trust, developed the first report quantifying mobile enabled avoided emissions.[8]

This current report goes beyond previous studies and comes at a much-needed time, as investors increasingly look towards sustainable ventures and mobile network operators begin to issue their own green bonds. With the biggest proportion of the projected increase in the uptake of mobile communications technologies coming from emerging economies and developing countries (Asia-Pacific and Africa),[9] this report not only updates previous research, but also expands its outlook globally.

Mobile communications technology, including smartphones and M2M technology, is increasingly connecting everything.[10] This has the potential to transform future climate mitigation and green investment. Through the enablement effect, mobile communications technologies provide alternative solutions to high emission products and services across all sectors. They have the capacity to enable global emissions reductions without the imposition of government bans or requiring the trade-off between the environment and economic gains.[11] Due to this, mobile communications technology will be an important agent to help keep global temperature rise within adequate limits and assist in the transition to a low carbon economy.



8. GeSI (2015), *Mobile Carbon Impact*, pp.9
9. GSMA (2019), *The Mobile Economy.*
10. GMSA (2012), *Mobile's Green Manifesto 2012*, pp. 11
11. GeSI (2015), *Smarter2030*, pp. 8.

Summary of Findings

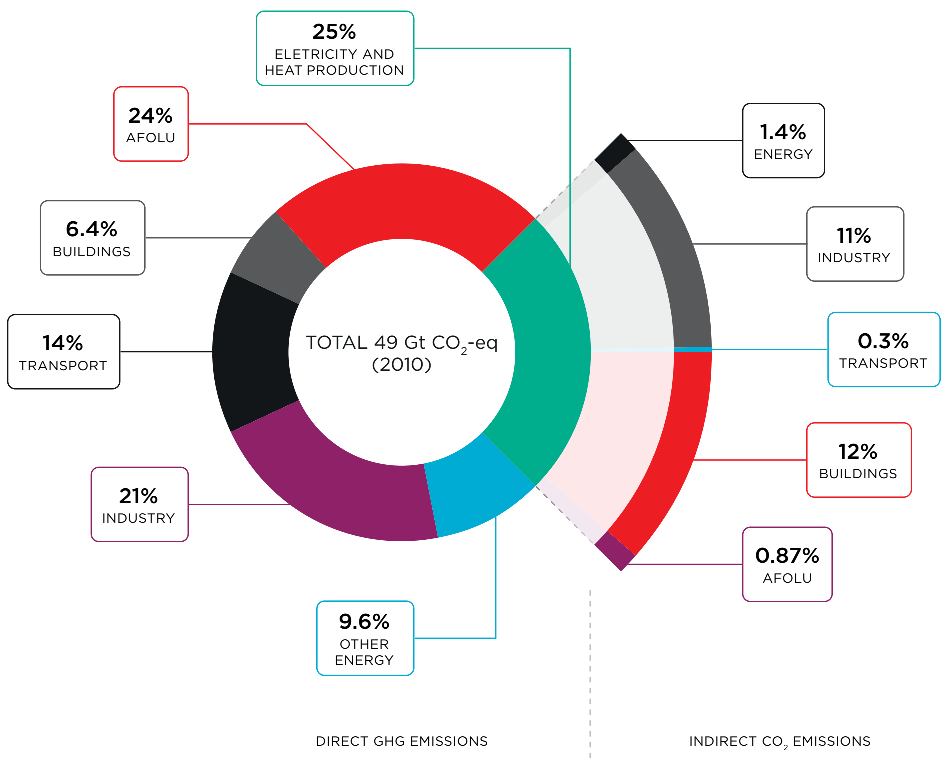
The high-level analysis of this report was done across six different categories (33 subcategories) in 14 different countries, to gain a well-rounded global understanding of the current enablement impact of mobile communications technology and its potential to help assist global decarbonisation.

The methodology used for the calculations and analysis is provided in Appendix 2. Appendix 3 provides a breakdown of the results and the assumptions used in the calculations.

The results indicate an even split between the enablement effect of Machine-to-Machine (M2M)/ IoT technologies, and those enabled through behaviour changes from the personal use of smartphones. The majority of avoided emissions from M2M technologies are primarily in buildings, transport, manufacturing, and the energy sector. This is significant as these sectors make up a big portion of global greenhouse gas emissions, and are therefore those that must most urgently decarbonise.

FIGURE 2

Global Greenhouse Gas Emissions by Economic Sector (Final Use)[12]

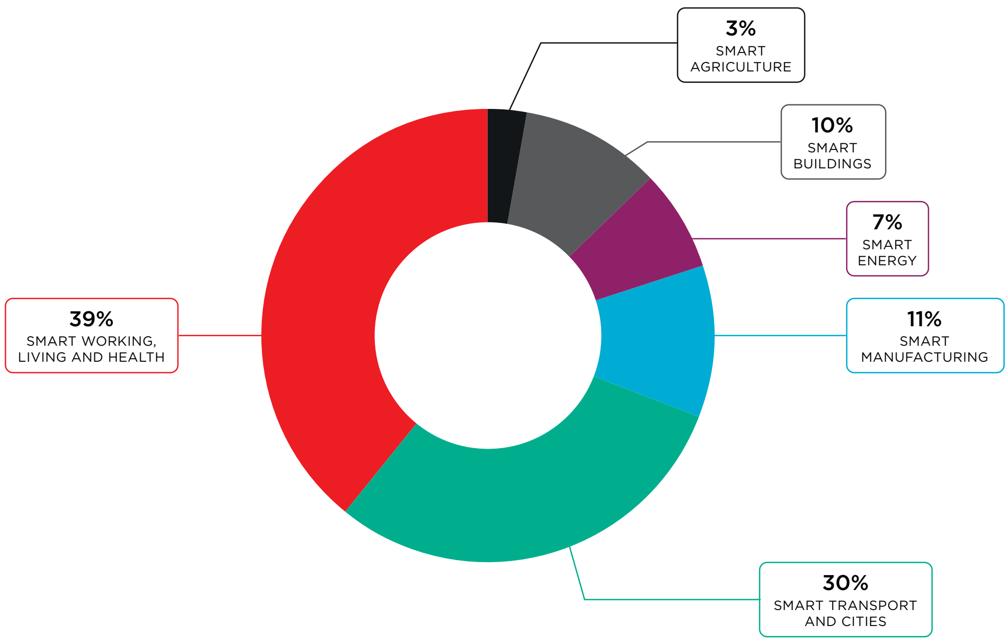


AFOLU – agriculture, forestry and other land use

12. IPCC (2014), *AR5 Synthesis Report*, pp. 47.

The following subsections will provide a summary of our findings by category of mobile communications technology. This will highlight key mechanisms assessed within each category, and include background information and case studies to provide context and exemplify some of the promising developments.

FIGURE 3
Enabled Avoided Carbon Emissions by Category in 2018



Smart Buildings

Accounting for around 19% of total global GHG emissions,[13] buildings are in need of decarbonisation and offer great potential. Current emissions' reductions in buildings are being facilitated by the use of mobile communications technologies, which enable energy efficiency improvements and encourage behaviour change, reducing gas and electricity consumption. Among these technologies are building management systems, smart meters, and HVAC (heating, ventilation, and air conditioning) control systems.

The automation of systems and remote monitoring capabilities facilitated by M2M technology is of significant importance. Direct communication between systems, allowing them to respond without manual intervention, considerably enables carbon reduction. M2M assisted automated monitoring and control of HVAC systems, based on occupancy and temperature, is the biggest current enablement mechanism in this area, having enabled the avoidance of approximately 103 million tCO_2e in 2018. This alone enables the avoidance of emissions

13. IPCC (2014), *AR5 Synthesis Report*, pp. 47.

greater than that emitted by the cities of Seoul, Korea and New York City, USA combined.[14]

On the other hand, smart meters, as they are increasingly rolled out worldwide, display a promising potential. By increasing consumption awareness through easy monitoring systems of energy and water use, smart meters stimulate emissions reduction behaviour change. This technology is further enhanced through smart home controls on smartphone apps, which can operate appliances, heating, and cooling remotely, even when one is not at home.

These various mechanisms are globally important in facilitating the decarbonisation of buildings. In developed countries, where a greater proportion of existing buildings will continue in use for the foreseeable future, these mechanisms allow for a decrease in emissions without structural changes; while for developing countries, they enable a more economical form of energy efficiency where perhaps proportionally less capital is available to invest in high energy efficiency buildings and where there are strains on electricity availability, due to rising demand.

Optimising Energy Use in Buildings

CASE STUDY – SMART BUILDINGS

Mobile technologies can be utilised to give building managers a deeper understanding of their energy use and spending. One mobile network provided a high-end hotel with a customised, end-to-end service that can measure, control, and monitor energy consumption and spending. Geared towards customers with a high-energy consumption, such as those in industry, utilities, and customer services (e.g. banking, hotels etc.), this centralised service can be used remotely, from anywhere in the facility. It focused on high consumption points such as air conditioning, heating, and lighting to locate areas where efficiency could be improved.

The benefits include lower energy consumption and cost, improved efficiency, better investment decisions based on data, and centralised access. Employees were able to provide better customer service by forming predictions based on historical data. The service was able to detect deviations and provide alerts to the user, simulate bills, suggest improvement opportunities, and ultimately decreased energy costs by 12%.

GSMA (2019). *"Take Things Further" Smart Energy Case Study Internet of Things.* [online] GSMA.
Available at: https://www.gsma.com/iot/wp-content/uploads/2019/09/Beyond-Connectivity-Telefonica-Smart-Energy-case-study.pdf
[Accessed 28 Oct. 2019].

14. CDP, Citywide Emissions, https://data.cdp.net/Emissions/2016-Citywide-Emissions-Map/iqbu-zjaj

Smart Energy

The move towards a cleaner, lower carbon economy requires greater efficiency of electricity distribution and an increase in the quantity of renewable energy, such as solar and wind. The energy sector is currently utilising smart grids and small-scale generation to achieve this, emerging as a more decentralised, resilient, and reliable system.

Enabled by mobile, smart grids are revolutionising the energy distribution process. By utilising M2M technology, energy demand and transmission is more easily monitored and regulated. This improves coordination and distribution efficiency, increasing the stability and resilience of the system, while decreasing its cost and environmental impact. Specifically, this report examined smart grids' ability to monitor distribution, which not only improves efficiency but also assists utilities companies to identify specific issues in the grid, allowing for preventive and rapid repairs.

Decarbonisation of the energy sector also requires an increase in green energy in the grid. This increase can, in part, be accomplished through small-scale renewable electricity generation by individuals or non-utility businesses. Mobile is facilitating the participation of these new energy sources into the wider system, by providing the automatic collection of generation data, communicating the capacity and pricing, and enabling payment.

With the increase in new energy sources, smart grids' utilisation of M2M removes the need to expand costly physical infrastructure.[15] This is particularly important in developing countries, where demand for electricity is growing. As an added benefit in the form of adaptation to climate change, the widening geographic distribution of the system of electricity increases resilience to extreme climate-related events, which are likely to increase over the next decades. Mobile communications technology allows for more decentralised systems to develop, addressing fuel poverty and enabling communities to advance directly into a sustainable energy system.

15. https://www.edsoforsmartgrids.eu/home/

Affordable Solar Power

CASE STUDY – SMART ENERGY

Access to energy provides heat, light, water, communication between people, and essential services like education and healthcare. However, 1.4 billion people worldwide still struggle to access electricity, with 85% of them living in rural, off-grid areas. Mobile network operators and innovative energy service companies are joining forces to bring clean, reliable, and affordable power to those most in need. By combining solar power systems with lease-to-own schemes that leverage Machine to Machine (M2M) technologies and mobile money payments, people who previously relied on expensive, price-fluctuating and harmful energy sources, like kerosene, can now rely on green energy. This benefits not only the environment but also has health benefits, as the WHO estimates that 4.3m people die every year from the effects of kerosene fumes.

In Kenya, 46% of people live in poverty. For these people, 30% of income goes towards energy costs. This pilot project offered customers the chance to buy an 8W solar panel with 2 LED lights, a portable lamp, and a phone-charging point, starting with a down payment of $33 and daily payment of $0.45. After a year, they own the system outright. These payments are made using a mobile money service via the GSM/GPRS M2M module embedded in the unit. Through this finance plan, 100,000 households are now using solar as their energy source, resulting in 12.5m hours of kerosene-free lighting and a $750 per year energy bill savings per household. Traction for these technologies is gaining as the price drops, and similar uses of these technologies could open up opportunities in a range of markets, from agriculture to health and education.

GSMA (2015). *Mobile Policy Case Studies Policy in Practice.* [online] pp.9–13.
Available at: https://www.gsma.com/publicpolicy/wp-content/uploads/2016/09/GSMA2015_Report_MobilePolicyCaseStudies_English.pdf
[Accessed 28 Oct. 2019].

Smart Living, Working, and Health

Living, working, and health are integral parts of society's daily life. Through personal lifestyle choices, avoided emissions are being enabled by a combination of M2M technology and mobile facilitated behaviour change.

FIGURE 4
Top 5 Smart Living, Working, and Health Sub-Categories
FIGURES ARE PERCENTAGES OF GLOBAL AVOIDED EMISSIONS

Living

Smartphone use has become an instrumental part of a person's day-to-day, with apps being created to simplify every aspect of life. Therefore, 'smart living', within the context of this report, refers to the use of apps on smartphones enabling consumers to reduce their carbon footprint. To analyse the use of smartphones to facilitate behaviour change, a global survey study of more than 6,000 smartphone users in the UK, China, India, USA, Mexico, Brazil, and South Africa was undertaken. These countries were chosen from the list of the 14 analysed throughout the report, to represent a smaller, yet global sample. The survey revealed the high impact that behaviour change is having on avoided emissions.

The largest area of avoided emissions within Smart Living arises with the ability to perform activities remotely, avoiding the need to travel. The areas explored by the survey covered online services, such as mobile banking and mobile shopping, as well as video-calling with friends and families (e.g. using WhatsApp and FaceTime thus reducing physical travel). Combined, these accounted for more than 302 million tCO_2e of avoided emissions globally.

Mobile communications technologies also have an enablement effect by facilitating 'sharing'. Sharing apps provide the platform for goods, including clothes and electronics, to be sold, rented, or given away, reducing waste and promoting a circular economy. Services are also being shared. Accommodation sharing, through apps such as Airbnb, helps avoid the higher emissions associated with hotel stays, while ride-sharing decreases the quantity of cars making similar journeys. Accommodation sharing alone accounted for more than 10% of the total avoided emissions calculated in this report.

Work

For work, the ability to engage and work remotely has for decades transformed employment globally. More recently, it has redefined the concept of a work location. Mobile communications technology allows companies to conduct business remotely, through audio conferencing and collaborative working software, allowing employees to work from home. The former and the latter facilitate the avoidance of emissions from travel for business and daily commuting respectively. Working from home additionally enables further avoided emissions by reducing energy consumption in office buildings, as more employees working remotely entails smaller office areas. Although working from home requires energy use at the home (a 'rebound effect'), on average this is outweighed by the carbon savings of avoided commuting.

Telecommuting

CASE STUDY – SMART WORKING

Mobile technology has been highlighted by business leaders for its usefulness in increasing work flexibility and business efficiency. It allows employees to work from home by providing them with access to their files and the ability to attend meetings remotely. Telecommuting allows savings where otherwise facilities would need to be implemented and maintained for employees, and it also has shown, in several trials, to save considerable amounts of carbon. Utah's government recently introduced teleworking, and predicts tens of millions of dollars of savings in real estate and a reduction in carbon emissions by 1.3 tonnes of CO_2e per month. Tennessee's government has already had success; its employees have saved an average of $1,800 per year in fuel costs and reduced real estate costs by $6.5 million.

Dell's Connected Workplace program has shown its effectiveness at improving productivity and work-life balance for employees. Most importantly, it reduces the frequency of their commute, therefore reducing their fuel consumption and related vehicle carbon emissions. Dell interviewed 1300 of its U.S. employees, and found that by working from home, they are reducing their footprint by over one tonne of CO_2e per year, even when taking into account the rebound effects of the increased energy consumption in employees' homes. Dell's U.S. employees also save an average of 796 litres of fuel per year – over $12 million in costs. As a result of this Connected Workplace program, Dell saved $21 million in real estate and reduced its emissions by 9,800 tonnes of CO_2e. The magnitude of these benefits is found to be similar to other studies on telecommuting.

Through Xerox's Virtual Workforce Program, more than 8,000 Xerox employees, or 11% of its workforce, work from home full time. Through telecommuting, Xerox has reduced its emissions by 40,894 tonnes of CO_2e in 2014, since its remote staff use 21 million fewer litres of fuel by avoiding the daily commute. At Aetna, 43% of its current workforce telecommute. Aetna credits this virtual work system with emission reductions of 46,700 tonnes of CO_2e in 2014 alone. Aetna employees reduced their commutes by 127 million miles – around 24 million fewer litres of fuel consumed.

It is evident from these sources that telecommuting is one of the largest areas for carbon abatement, and it is encouraging that the number of employees working remotely is predicted to increase steadily worldwide.

Muresianu, A. (2019). Utah Is Letting Lots of Government Employees Work from Home. [online] Reason.com.
Available at: https://reason.com/2019/07/30/utah-is-letting-lots-of-government-employees-work-from-home/ [Accessed 14 Nov. 2019].

Pflueger, J., Gibson, S. and Normand, C. (2016). The Sustainability Benefits of the Connected Workplace. [online] Dell.
Available at: https://i.dell.com/sites/doccontent/corporate/corp-comm/en/Documents/telecommute-study.pdf [Accessed 14 Nov. 2019].

Sutton, S. (2015). How Telecommuting Reduced Carbon Footprints at Dell, Aetna and Xerox. [online] Entrepreneur.
Available at: https://www.entrepreneur.com/article/245296 [Accessed 14 Nov. 2019].

Loubier, A. (2017). Benefits of Telecommuting for the Future of Work. Forbes. [online] 21 Jul.
Available at: https://www.forbes.com/sites/andrealoubier/2017/07/20/benefits-of-telecommuting-for-the-future-of-work/#7ca1bc8c16c6
[Accessed 14 Nov. 2019].+

Health

Lastly, within health, innovative thinking is leading the way for potential global-scale avoided emissions, through mobile communications technology, by changing the way healthcare is accessed. Initiatives such as preventative healthcare through monitoring and mobile accessed health platforms can reduce the need for hospital visits and stays. The current biggest area of avoided emissions through the use of mobile technology can be seen in the remote monitoring of patients using M2M technology, reducing both travel for health professionals and patients alike and has the added benefit of reducing overcrowding in hospitals. Increasing the ability to remotely monitor patients provides a great potential for social benefit, particularly in remote areas with limited access to daily healthcare professionals.

Mobile-Based Health Platform

CASE STUDY – SMART HEALTH

Healthcare systems are being increasingly strained by growing and ageing populations. The cost of delivering quality essential services is being combated by focusing on preventative care. Mobile platforms allow for better, more consistent, and more efficient healthcare provision by increasing access to health services. Mobile connectivity empowers individuals to manage their own well-being, even when they live far away from a health facility.

Hello Doctor, which began in South Africa, has proved effective in the delivery of preventative healthcare advice and support where medical services are scarce. Just over 100 doctors can now reach 600,000 users – much greater numbers than previously possible. The service gave users a means of conversing with a doctor and access to the latest healthcare advice 24 hours per day. General healthy living advice is free via the app, as are very low-cost Q&A text consultations, and in-depth telephone consultations for $4 are also available. It provides peace of mind to many people for whom a doctor is inaccessible due to geography and/or cost. As a result of its success, it now operates across Africa and Asia. This case study is a clear example of how mobile health can reduce the number of journeys taken to doctors' offices, pharmacies and hospitals, and that pre-emptive care can remove the need for hospital visits, reducing the emissions from hospitals themselves.

GSMA (2015). *Mobile Policy Case Studies Policy in Practice*. [online] pp.9–13.
Available at: https://www.gsma.com/publicpolicy/wp-content/uploads/2016/09/GSMA2015_Report_MobilePolicyCaseStudies_English.pdf
[Accessed 28 Oct. 2019].

Hellodoctor.co.za. (2019). *Medical App & Medical Advice with Hello Doctor*. [online] Available at: https://www.hellodoctor.co.za/
[Accessed 28 Oct. 2019].

Healthcare Network Infrastructure

CASE STUDY – SMART HEALTH

In the UK, the National Health Service deals with over 1 million patients every 36 hours. The N3 network is a secure national broadband network built for the NHS, connecting over 1.3 million staff, and every GP, clinic, and hospital. It allows healthcare professionals quick and easy access to information, ensuring the best patient care. It also allows for 39,000 hospital appointments to be booked electronically, for 675,000 prescriptions to be sent daily, and offers a range of services like videoconferencing and mobility solutions. N3 Managed Videoconferencing allows healthcare professionals to take part in video meetings, resulting in savings of £11.7 million and reducing carbon emissions from travel by 2,100 tonnes of CO_2e. With the N3 network, treatment is more convenient, diagnosis faster, emergency services quicker and hospital stays shorter; this all reduces strain on the NHS, its resources, and its consumption.

The N3 network has saved the NHS an estimated £926 million and reduced NHS carbon emissions by more than 50,000 tonnes of CO_2e in the near decade it has been operational.

Nhsconfed.org. (2017). NHS Statistics, Facts and Figures. [online] Available at: https://www.nhsconfed.org/resources/key-statistics-on-the-nhs [Accessed 14 Nov. 2019].

BT (2012). NHS N3 Network Case Study | BT Business. [online] Bt.com. Available at: https://business.bt.com/solutions/resources/nhs-n3-infrastructure/ [Accessed 14 Nov. 2019].

Smart Transport and Cities

The transportation sector, encompassing land, air, and sea, accounts for around 14% of the global greenhouse gas emissions.[16] Mobile communications technology enables transport emissions reduction through a combination of M2M technology and impacting behaviour change with the use of smartphones.

Broadly, it creates an improvement in route optimisation and vehicle fuel efficiency through telematics, and acts as a catalyst for the increase in electric vehicles by facilitating the use of charging points. The main area of impact was found to be fleet vehicle driver behaviour improvement, enabled through vehicle monitoring telematics, avoiding approximately 105 million tCO_2e in 2018. This avoided as much tCO_2e as taking 23 million passenger cars off the road in the US, for an entire year.[17]

Reducing Emissions in HGVs

CASE STUDY – SMART TRANSPORT

Lorries, coaches and buses produce around a quarter of all CO_2e emissions from road transport in the EU, equivalent to about 6% of the EU's total CO_2e emissions. As a result, the EU Commission has proposed to set the first emission standards for HGVs in the EU, requiring a 30% decrease by 2030.

Collaboration between service providers, mobile networks, and heavy-goods vehicle (HGV) companies has resulted in the creation of a single interface. This Neste SmartTruck service allows professional drivers to access applications like mobile refuelling, fuel consumption optimisation, GPS positioning, and tachograph data transfer optimisation. The Neste app also allows for in-app payment, making refuelling faster and safer, and its connected health solution allows for monitoring of the wear and tear of the fleet in order to carry out both preventative measures and essential repairs, saving time and cost. This system helps both drivers and managers plan and drive individual HGVs and the fleet more efficiently, saving up to 15% of the vehicle's fuel consumption and therefore reducing emissions.

Telia Company (2018). Telia Company in Co-Operation to Lower Emissions from Transports. [online] Teliacompany.com. Available at: https://www.teliacompany.com/en/news/news-articles/2018/telia-company-in-co-operation-to-lower-emissions-from-transports/ [Accessed 12 Nov. 2019].

16. IPCC (2014), *AR5 Synthesis Report*, pp. 47.
17. United States Environmental Protection Agency, *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

A promising area of enablement is the facilitation of charging points for electric vehicles. This can be exemplified within the context of Brazil, where certain projections show the potential circulation of 2 million electric and hybrid vehicles by 2030.[18] However, the current market and demand for electric vehicles, and the available necessary infrastructure, in Brazil is limited.[19] At currently less than a thousand charging points throughout the country, a development and decarbonisation of this scale will rely on the use of M2M technologies, with CPFL Energia estimating a necessary 80,000 charging points by 2030 to match this rapid scale up.[20]

Cities

Within cities, transport is being facilitated by the development and integration of technology. The main areas of avoided emissions within cities are around improved traffic congestion monitoring and management, enabled by the incorporation of M2M technology into city infrastructure, and the reduction of vehicle emissions, through the increase of the usability of public transport enabled by smartphone apps.

As urban populations grow and suburban areas expand, not only does the number of cars within a city increase, but so does the level of congestion. For every hour that the average car is caught in congestion, it will emit around 2.3 litres of petrol.[21] This is enough petrol for the average new car in the UK to travel 46 kilometres.[22] Introducing mobile communications technology to create smart monitoring and management of traffic congestion is enabling the redirection of traffic to avoid further congestion and optimise routing. Smart monitoring is also improving traffic flow by enabling communication between lights to optimise wait times at junctions. Overall, this prevents traffic delays and allows drivers to maintain a more consistent speed, reducing fuel consumption and emissions.

Smartphones enabling behaviour change can also have a significant impact. A survey commissioned by the Carbon Trust explored the effect that smartphone apps had on the uptake of public transport and use of bikes. The survey found that 80% of respondents are more likely to use public transport as a result of apps detailing routes and transportation timetables. On the other hand, bike and scooter sharing in cities is helping replace travel that would have been done by car or public transport. The survey also examined aspects of travel by car. In circumstances in which travel is done by car, emission reductions are enabled by the use of mobile navigation apps – which improve route efficiency and enable traffic avoidance – and through the use of ride-hailing to substitute own car journeys, as cars hailed are statistically more energy efficient than personal cars.

18. CPFL, *CPFL Energia prevê 80 mil eletropostos em 2030 para acompanhar expansão de veículos elétricos no Brasil,* https://www.cpfl.com.br/releases/Paginas/cpfl-energia-preve-oitenta-mil-eletropostos-em-vinte-trinta-para-acompanhar-expansao-de-veiculos-eletricos-no-brasil.aspx
19. GIZ, *German-Brazilian project promoting electromobility* (PROMOB-e), https://www.giz.de/en/worldwide/63337.html
20. CPFL, *CPFL Energia prevê 80 mil eletropostos em 2030 para acompanhar expansão de veículos elétricos no Brasil,* https://www.cpfl.com.br/releases/Paginas/cpfl-energia-preve-oitenta-mil-eletropostos-em-vinte-trinta-para-acompanhar-expansao-de-veiculos-eletricos-no-brasil.aspx
21. Verizon, *Making Cities Smarter and Greener,* https://www.youtube.com/watch?v=K1Ag0DNWeSU
22. Department of Transport – GOV.UK, Average New Car Fuel Consumption (ENV0103)

Smart Parking

CASE STUDY – SMART CITIES

Two smart parking pilots, powered by Narrowband Internet of Things (NB-IoT) technology, were deployed to investigate how mobile networks can benefit cities. The first involved the installation of smart parking sensors across 4,000 spaces, and the second involved 6 sets of entrance and exit systems, and a parking management system in a lot of 300 bays. The sensors detect when a space is available and communicate this to drivers, and they begin charging once occupied. These sensors are fit for purpose: they require low power consumption and are battery-powered, allowing for easy installation, and have a long lifecycle, requiring little maintenance. Based on LTE networks, NB-IoT is a good fit for smart parking as it offers improved secure coverage which allows sensors to be placed in any location.

This access to reliable, up-to-date data makes it easier for drivers to find parking spots, reducing the congestion and pollution created by hunting for a space, by guiding them directly to one available. The time taken to enter and exit car parks is greatly reduced as the mobile network removes the need to queue and pay. Disputes are managed much more easily as a data source is available to investigate. The smart parking solution consists of parking bay detection, license plate recognition, mobile payments, parking guidance for drivers and an intelligent parking management system, and cities can better manage their parking assets and maximise the revenue available to them as a result.

China Mobile Smart Parking – Internet of Things Case Study. (2019). Smart Cities. [online]
Available at: https://www.gsma.com/iot/wp-content/uploads/2018/03/iot_china_mobile_parking_04_18.pdf [Accessed 21 Oct. 2019].

Semiconductor Digest. (2019). Smart Parking and Sensors in the Age of IoT - Semiconductor Digest. [online]
Available at: https://www.semiconductor-digest.com/2019/07/01/smart-parking-and-sensors-in-the-age-of-iot/ [Accessed 13 Nov. 2019].
[Image ref].

Electric City Pod Taxis

CASE STUDY – SMART CITIES

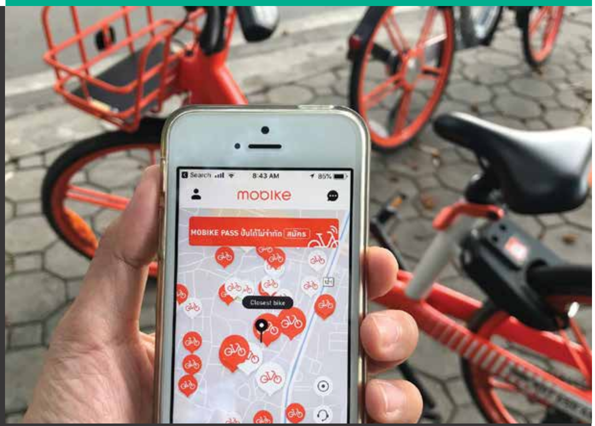
According to a recent WHO report, 91% of people across the world live in places where the air quality surpasses WHO guideline safety limits. Air pollution is linked to a range of serious diseases and kills 4.2 million people a year. A new type of inner-city transport aims to tackle this issue.

Battery powered, three-wheeled pod taxis are being trialled in Sweden. With a maximum speed of 45km/h, they are perfect for short trips across the city centre, and can run for 72 km before needing a charge. Designed to fit two customers, they aim to combat congestion and pollution problems in cities. Riders can order and pay for the pod taxi through a mobile app, and they are cheaper than many other taxi options at just 40 SEK (£3.21) per km. The firm promises that this doesn't mean low pay for the drivers, like some others in the industry, but explains that the pod taxis are cheap to run and funded through advertising and low profit margins. The best part? Use of the pod taxis is completely emission free as they run on renewable energy.

WHO (2019). Air Pollution. [online] World Health Organization. Available at: https://www.who.int/airpollution/en/ [Accessed 23 Oct. 2019].

Business Insider UK (2016). *Sweden's Launching a Battery-Powered Taxi to Help Combat Pollution - Business Insider*. [online] Business Insider. Available at: https://www.businessinsider.com/battery-powered-pod-taxi-bzzt-sweden-gothenburg-stockholm-congestion-problems-stockholm-2016-12?r=US&IR=T [Accessed 23 Oct. 2019].

Bzzt Podtaxi (2014). FAQ. [online] Bzzt Podtaxi. Available at: https://www.bzzt.se/faq [Accessed 23 Oct. 2019].



Bike Sharing

CASE STUDY – SMART CITIES

It is not surprising that the world's most populated country has over 300m vehicles and almost half of the world's most congested cities. These issues are costly to China's economy and public health. One firm finding a solution is Mobike, a dockless bicycle-sharing scheme. Since launching in Shanghai in April 2016, Mobike's success has seen it expand into 200 cities in China and abroad.

The solution involves smart bikes, which are accessed through a smartphone app. Users can reserve the bikes, locate them with GPS and scan a QR code to unlock the proprietary smart-lock technology. When the users reach their final destination, the bikes are locked and left for the next user. Payment is done via their mobile, one of the greatest factors for its success. Mobile payments in China hit a record of CN 81tn from January to October 2017 – 50 times those in the US.

Mobike stated that they have "one of the largest, most complex IoT networks anywhere in the world". This is achieved through partnerships with mobile networks. IoT technology involved in the smart locks allows them to be unlocked remotely, and this connectivity allows Mobike to continuously monitor in real-time their 8 million bike fleet across 200 cities. The big data collected is used to evenly distribute the fleet across the city, predict demand, and integrate with public transport, combating the first and last-mile challenge.

In the first year of Mobike's operation, users collectively rode over 5.6 billion km. This equates to a carbon abatement of 1.2 million tonnes of CO_2e – the same as taking 350,000 cars off the road for a year. If Mobike were to launch in 500 more cities, the estimated carbon abatement is 30-60m tonnes of CO_2e, saving 1.3-2.6 billion US dollars in carbon reduction measures.

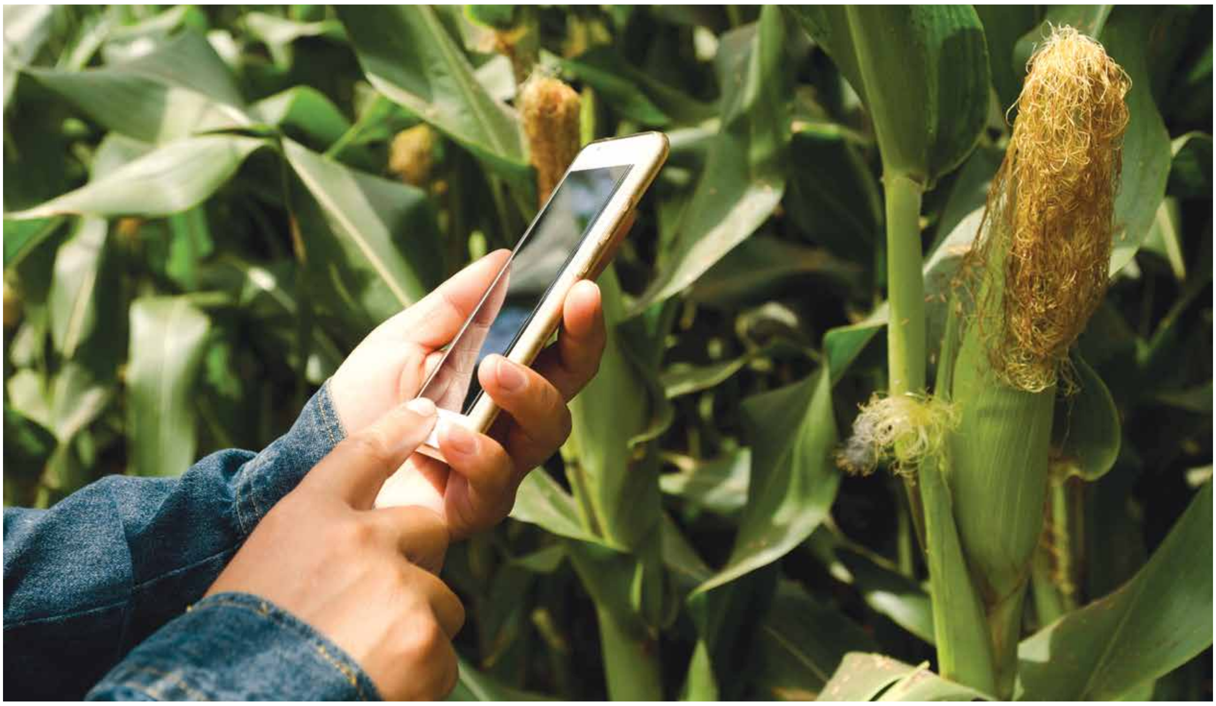
Ellenmacarthurfoundation.org. (2016). The Bike Sharing Phenomenon and Impact. [online]
Available at: https://www.ellenmacarthurfoundation.org/case-studies/bike-sharing-in-china [Accessed 1 Nov. 2019].

Smart Agriculture

An estimated 2 billion more people will need to be fed by 2050, which the Food and Agriculture Organisation has estimated to result in a demand increase of 56% more crop calories, relative to the quantity produced globally in 2010.[23] This entails an additional 593 million hectares of agricultural land needed to meet demand, equivalent to an area almost twice that of India.[24]

However, unless the current processes of agriculture and food production change significantly, they will counteract the global move towards a low carbon economy. Agriculture, forestry and other land uses currently account for 25% of global GHG emissions,[25] due in part to high emissions from fertiliser use, irrigation systems, and food waste. This, coupled with the need for available land to sequester carbon, affirms that there is an urgent need for this sector to decarbonise.

Improvements in crop management can go a long way to tackle this. The EPA WaterSense programme estimates that due to inefficient systems, up to 50% of water used for irrigation is wasted.[26] For food, around 25% of global food production is lost or wasted,[27] with high proportions in Sub-Saharan Africa and South East Asia being lost during the farming stage.[28] Mobile technology enables farmers to better regulate and remotely monitor irrigation and soil conditions. This allows for more efficient land use, decreases the quantity of fertiliser use, and reduces food loss. Improvement in food production and fertiliser use efficiency will be key in lessening the impact of the agricultural sector on climate change while simultaneously tackling future food and water scarcity.



23. World Resources Institute (2018), *Creating a Sustainable Food Future* (Synthesis Report), pp. 1.
24. World Resources Institute (2018), *Creating a Sustainable Food Future* (Synthesis Report), pp. 1.
25. IPCC (2014), *AR5 Synthesis Report*, pp. 47.
26. https://www.epa.gov/sites/production/files/2017-03/documents/ws-factsheet-outdoor-water-use-in-the-us.pdf
27. World Resources Institute (2018), *Creating a Sustainable Food Future* (Synthesis Report), pp. 14.
28. World Resources Institute (2013), *Instalment 2 of "Creating a Sustainable Food Future" Reducing Food Loss and Waste,* WRI Working Paper, pp. 9.

The Connected Mangroves Reforestation Project

CASE STUDY – SMART AGRICULTURE

The Pampanga River in the Philippines is home to mangrove forests. These forests are habitats for a range of wildlife and act as natural shields against tropical weather for coastal communities, where the local fishermen can face up to 20 typhoons a year. The mangroves are also climate change fighters as the trees catch CO_2 with their roots. But over time, deforestation, pollution and industry destroyed many trees, causing a drastic decrease in the wildlife population and endangering the local community.

This reforestation project, which began in 2017, sought to explore how mobile technology could restore such mangrove forests. It enables the local community to remotely monitor water, soil and humidity conditions. This is achieved through using solar-powered sensors and real-time camera footage to collect and present critical data to local communities on a digital dashboard.

The results are immediately tangible; since the project conception, an increase in the size of fishermen's catches and the numbers of migratory birds returning to the area have been recorded. Black-faced spoonbills, a species of coastal bird classified as endangered in 2000 and last seen in the Pampanga river 100 years ago, were spotted flying there in early 2019. The fishermen can monitor the water and weather conditions so as to avoid typhoons. This project is proof that IoT technologies can be used to mitigate climate change, restore livelihoods, and combat dwindling bird populations.

Ericsson.com. (2019). Latest from the Connected Mangroves reforestation project. [online]
Available at: https://www.ericsson.com/en/blog/2019/10/latest-connected-mangroves-reforestation-project [Accessed 21 Oct. 2019].

Out of Town Blog. (2019). Smart and Ericsson Launch First Internet of Things Project in Pampanga, Philippines - Out of Town Blog. [online]
Available at: https://outoftownblog.com/smart-and-ericsson-launch-first-internet-of-things-project-in-pampanga-philippines/
[Accessed 21 Oct. 2019].

Asparagus' Water Footprint

CASE STUDY – SMART AGRICULTURE

Mobile technology has the capability to make high-volume organic farming more efficient. In California, agriculture employs around 3% of the workforce and accounts for 2% of the GDP. However, it also represents 80% of all water use. Roughly 9 million acres of farmland are irrigated, and since California has a drought tendency, resource efficiency is vital. Farmers with this concern in mind, along with rising wages and pricing pressures, are compelled to be more innovative to compete.

Californian asparagus farmers traditionally walk the rows of asparagus and manually probe the ground to check moisture levels – an inefficient, time-consuming and costly process. But this practice no longer occurs since the installation of small, solar-powered sensors across the fields, which collect information on soil moisture and condition. The sensors require no maintenance and are placed under the foliage so they won't interfere with field operations and harvests. This data is sent securely to a communications hub thousands of feet away over the LTE network to the cloud, where it is analysed to determine which areas need more or less water. Farmers can control irrigation timing and duration 24/7 via a smartphone app.

The team estimates a 6% water reduction (equivalent to over 3.4 million litres), 5% greenhouse gas emissions reduction, 5% labour cost reduction and decreased nutrient use in their first season of use. Crop production more than doubled, and human error was effectively eliminated. The cost and environmental savings this could inspire in other farmers would make a significant impact on the planet.

AT&T (2018). *AT&T IoT for Good Case Study: Asparagus Has a Lower Water Footprint Thanks to Devine Organics, WaterBit and AT&T.* [online] Available at: https://www.business.att.com/content/dam/attbusiness/reports/iot-for-good-waterbit-and-devine-organics-case-study.pdf [Accessed 23 Oct. 2019].

Creating Value in Strawberry Production

CASE STUDY – SMART AGRICULTURE

Strawberry production in China is a highly competitive market; prices fluctuate depending on factors like quality, labour, time in the season, and the amount of water and fertiliser used. Since China's government has committed to the UN's Sustainable Development Goals, as well as further targets like zero-growth for the use of fertilisers by 2020, and limiting national water consumption to below 700 billion cubic meters by 2030, profit is now no longer the only consideration. The greenhouse strawberry producer faces challenges such as bringing the first crop harvest forward and reducing water and fertiliser use, to maximise yield and quality and to decrease environmental impact.

Using IoT sensors, data was collected about the growth environment and sent via a mobile network to a cloud-based Software-as-a-Service (SaaS), giving the farmer the ability to view and control air and soil temperature, light, water, CO_2 and nutrient levels. As a result of this system, one greenhouse strawberry grower's harvest started 20 days earlier than the traditional greenhouses, allowing for produce to be sold at a premium price – making a key difference to farmers' incomes. Across the season, the harvest increased by 100%, water and fertiliser use reduced by 50% and profit increased by 75% in the first year, compared to traditional farming. Labour costs were reduced by 50% per kg of strawberries, as less manual labour was required to observe the fruit and adjust the growth environment. The system paid for itself in the first year. And it's not just applicable to strawberry crops; this IoT solution can be adapted to any greenhouse production, helping to drive value and decrease environmental impact.

GSMA (2019a). Beyond Connectivity: IoT Solutions | Internet of Things. [online] Internet of Things.
Available at: https://www.gsma.com/iot/beyond-connectivity/#spotlight-feature-china-mobile-strawberry-farming
[Accessed 11 Nov. 2019].

Drone Reforestation & Farming

CASE STUDY – SMART AGRICULTURE

Every year, 15 billion trees are destroyed through natural and anthropogenic causes. Governments have made commitments to restore 250 million hectares of degraded land – an area that could support 300 billion trees – by 2030. If mobile technology can be applied to creating forests at the same or greater rate than they are deforested, it could support a sustainable industry and carbon neutrality, or even positivity.

One case study uses drones to aid reforestation. The drones survey and identify ideal environments, collect detailed terrain data, and generate high quality 3D maps of the reforestation area. The typography of the soil is mapped, appropriate species selected, and planting patterns agreed on by the team. The drones then disperse biodegradable seedpods, using pressurised air, into the ground across large areas. The seedpods are filled with a germinated seed, nutrients, and other essentials, and when they penetrate the ground and reach moisture, they activate and grow. One drone can carry 150 seedpods, firing them once a second.

Using this fully automated solution, one drone can reforest one hectare every 20 minutes, and trees are planted 4-10 times cheaper than by hand. One human can plant around 1,500 seeds per day; a pair of drones can manage nearly 100,000 per day. They can match and even exceed the rate at which forests are being destroyed. The team hopes to plant 500 billion trees by 2060. The technology can be used to sow grasses and shrubs, and hopes to seed in micro-organisms and fungi in the future to encourage long-term ecosystem sustainability. This will help feed around 200 million people. The seedpods could also restore wetlands, which would sequester carbon at rapid rates.

Another application of drones in agriculture occurs in farming. Here, drones capture high-resolution data on farmland that supports trend analysis, so as to better monitor the crop and manage planting and maintenance activities. Drones then automatically carry out the planting, as well as manure, herbicide and fertiliser application based on pre-set parameters entered via an app by the user. Drones can identify and target only the infected plants, which saves on pesticide use and cost. Using drones is far more accurate and much faster than applying the pesticides by hand.

SYSTEMIQ (2018). *Biocarbon Engineering Receives Us$2.5 Million in Seed Investment to Advance Drone Technology for Replanting Ecosystems*. [online] SystemIQ. Available at: https://www.systemiq.earth/news-1/2018/4/17/biocarbon-engineering-receives-us25-million-in-seed-investment-to-advance-drone-technology-for-replanting-ecosystems

Interface (n.d.). *BioCarbon Engineering: Scaling up reforestation by using drones to plant a billion trees every year.* [online] Available at: http://interfaceinc.scene7.com/is/content/InterfaceInc/Interface/Americas/WebsiteContentAssets/Documents/CaseStudies/CTB/BioCarbon%20Engineering/wc_am-biocarbonengineeringctb.pdf [Accessed 23 Oct. 2019].

BioCarbon Engineering (2019). Services. [online] BioCarbon Engineering: Industrial-scale Ecosystem Restoration. Available at: https://www.biocarbonengineering.com/services [Accessed 23 Oct. 2019].

South China Morning Post (2019). *Pesticide-spraying Drones Rise to Challenge of China's 'Intelligent Agriculture' Ambition. YouTube.* Available at: https://www.youtube.com/watch?v=8ZbhJT6NinM [Accessed 23 Oct. 2019].

Smart Manufacturing

With the widespread variety of processes involved in manufacturing, there is a great enablement potential to increase efficiency and decrease energy consumption. The enablement impact of mobile technology on storage and inventory management is considerable, due to the proportionally higher emissions and costs caused by inefficiency. Inventory management systems reduce the overall level of inventory needed. As a result, less warehouse storage space is necessary, requiring less energy for lighting and cooling. For 2018, this alone amounted to around 240 million tCO_2e of avoided emissions globally.

However, the enablement potential of mobile communications technologies for manufacturing goes far beyond this. Manufacturing is being transformed by innovation and automation, becoming increasingly simplified and efficient. As the cost of these technologies decreases and becomes easier to implement, mobile communications technologies will have great potential to enable the decarbonisation of manufacturing.

Connected, Reusable Pallets

CASE STUDY – SMART MANUFACTURING

Billions of consumer goods move through complex supply chains every day. The majority will have depended at some point on a wooden shipping pallet, of which there are approximately 10 billion in operation today. There are large financial and environmental costs to disposing of these pallets, and both consumer and operator hazards from the porous and sharp surfaces. Inefficiencies appear in the supply chain where these pallets are broken or lost. Whereas digital automated warehouses are now the norm, the challenges using wooden pallets remain.

More durable pallets made from composite materials mean that pallets are lighter, smaller, more easily repaired, and needing replacement less often. They are however costlier to produce. Pallet pooling, where users can rent pallets, removes the need for high capital investment, but fails to address the problem of pallet loss. Using IoT technology to connect these pallets to the internet allows users to maintain oversight of an inventory. This connectivity enables widespread adoption of connected pallets, generating financial and environmental benefits – reduced fuel consumption from reduced load weight, reduced waste from broken pallets, reduced raw material use as the more durable pallets can be used 162 times before the end of life, compared to ~18 for wooden pallets. If 1 million wooden pallet trips were replaced with composite pallets, 640 tonnes of CO_2e would be reduced per year. That is a 21% reduction in CO_2e emissions.

AT&T (2017). AT&T 10x Case Study: Unlocking the Potential of Connected, Reusable Pallets. [online] Available at: https://about.att.com/ecms/dam/csr/2019/reducing-emissions/ATT-Connected-Pallets-Case-Study-2017.pdf [Accessed 4 Nov. 2019].

Material Handling 24/7 (2017). BLOCKPal Pallets - Material Handling 24/7. [online] Materialhandling247.com. Available at: https://www.materialhandling247.com/product/blockpal_pallets/RM2 [Accessed 4 Nov. 2019].

Energy Efficient Frozen Food

CASE STUDY – SMART MANUFACTURING

Frozen food ensures food safety, prevents waste, and is a convenient option for shoppers. As a result, the global food cold chain is expecting growth of 13.9% through 2020. Lineage, a food warehousing and distribution company that operates more than 120 warehouses worldwide and handled over 15,900 tonnes of food products in 2017, aimed to optimise energy usage and costs in its sites. With their electricity bill reaching tens of millions of dollars and with sustainability becoming increasingly important to their clients, Lineage saw an opportunity to lower cost and their environmental footprint.

Engaging ndustrial.io, a company specialising in detailed operational data for industry and IoT technology, Lineage was able to create heat maps of its warehouses and an alert system to best monitor its cooling operations. Smart meters and sensors were installed to collect granular temperature data which was combined with energy and food throughput data, creating a heat map to display the temperature gradient across the facility. Using this system, Lineage can tackle “demand charges” where electric utilities have a higher rate during peak usage times. By super-cooling its warehouses during off-peak hours and turning off the chillers in peak hours, the temperature can be monitored while the temperatures rise to ensure food safety whilst reducing cost. IoT connectivity is essential to ensure timeliness and accuracy in this process.

This information has enabled Lineage to develop cold storage management processes that have reduced cost, energy usage, and greenhouse gas (GHG) emissions. Lineage, since 2014, has reduced its yearly energy costs by 8% at the 78 warehouses where the system has been installed. Remarkably, as the business had plans for expansion, the throughput at these warehouses actually increased over the same time period, meaning that energy intensity – the cost of electricity used for each item of food – has decreased by 34%. In total, there has been a $4 million reduction in cost, 33m kWh reduction in usage, and a reduction in emissions equivalent to 10.9 million litres of petrol.

AT&T (2018). AT&T 10x Case Study: Energy Efficient Frozen Food. [online]
Available at: https://about.att.com/ecms/dam/csr/2019/reducing-emissions/Lineage%2010X%20Case%20Study.pdf
[Accessed 4 Nov. 2019].

High level methodology description

The overall approach to assessing the enabling impact of mobile telecommunication technologies was to identify a number of common use-cases, where the technology provides a mechanism that enables carbon emissions to be avoided. The most common of these are either where travel is avoided or reduced resulting in avoided travel emissions, or where energy use is avoided or reduced resulting in avoided energy emissions. The calculation process is to multiply an avoided emissions factor by the relevant quantity metric:

AVOIDED EMISSIONS [kgCO_2e]
=
AVOIDED EMISSIONS FACTOR [kgCO_2e/QTY]
X
QUANTITY [QTY]

For the majority of cases the quantity metric used was either the number of M2M IoT connections or the number of smartphone users.

For example, for building energy management systems (BEMS) an avoided emissions factor per IoT connected smart meter was multiplied by the number of relevant IoT connections. The factor was derived from the energy consumption per square metre, the percentage reduction in energy enabled by the BEMS (from a range of published studies), the number of smart meters per square metre, and the electricity grid emission factor for the relevant country.

The avoided emissions factor is derived either from published studies, or developed using publicly available data and supported by assumptions where necessary. Additionally, a consumer survey was commissioned to provide data on smartphone user behaviour.

The appendices to this report provide a detailed list of the assumptions and data sources used for each of the use-cases, the generic data sources used and a list of references to reports and other data sources used for the calculations.

The approach identified 30 use-cases with impacts on different sectors. The choice of these use-cases was determined from previous published research and also informed by work that the Carbon Trust has undertaken with various telecommunications companies. The use-cases that were selected were those likely to contribute most to the overall avoided emissions impact.

The analysis is for the full year 2018, and uses the most recent data, where it is available. The geographical scope covers the entire world, with separate analysis carried out for each continental region: Europe, Northern America, Latin America, Asia, Middle East and Africa

A fuller description of the methodology and considerations is included in Appendix 2.

Conclusion

Mobile communications technology has revolutionised how we live, with its influence rapidly extending to new markets and sectors at an ever-increasing rate. With the high levels of connectivity and data sharing, mobile is having extensive spill over benefits, opening up possibilities for innovative forms of emissions reductions.

It is clear that mobile communications technologies are not only having a positive impact, but are facilitating decarbonisation across sectors. By analysing the mechanisms within the various categories, this report has calculated the current enabling impact of mobile communications technologies to be around 2,135 million tCO_2e for the year 2018, amounting to more than twice the total yearly GHG emissions released by the EU's highest emitting country.[29] Compared to the carbon footprint of mobile networks themselves, the level of avoided emissions enabled by mobile communications technologies is 10 times greater, globally.

As exemplified by these numbers, many of the mobile technologies that can enable a transition to a low carbon economy already exist. Widespread investment and implementation of these technologies will help reduce the future costs of climate change for businesses, governments and societies alike. Due to the inherent high-emissions nature of many of the sectors discussed throughout the report, without assistance, decarbonisation to the levels required will be extremely difficult. Through the enablement effect, mobile network operators have the capacity to act as a catalyst to transform how sectors can decarbonise. By providing alternative solutions, improving energy and fuel efficiency, and promoting positive behaviour change, they can enable sectors to decarbonise in a faster, yet methodical and sustainable manner.

29. OECD.Stat, Greenhouse Gas Emissions, https://stats.oecd.org/Index.aspx?DataSetCode=AIR_GHG#

Appendices

Appendix 1 – Table of Detailed results

2018 Avoided Carbon Emissions in $MtCO_2e$

CATEGORY	EUROPE	NORTHERN AMERICA	LATIN AMERICA	ASIA	MIDDLE EAST AND AFRICA	GLOBAL
SMART AGRICULTURE	16.6	35.5	1.5	1.2	0.1	54.9
SMART BUILDINGS	27.8	80.0	4.4	83.7	14.7	210.4
SMART ENERGY	19.8	20.9	1.9	111.7	5.0	159.4
SMART MANUFACTURING	21.8	86.2	3.3	120.6	8.0	240.1
SMART TRANSPORT AND CITIES	127.7	115.8	39.5	287.4	73.0	643.5
SMART WORKING, LIVING AND HEALTH	110.2	128.4	71.2	366.0	151.8	827.6
TOTAL	**324.0**	**466.9**	**121.8**	**970.6**	**252.6**	**2,135.9**

2018 Avoided Carbon Emissions in $MtCO_2e$ by sub-category and region

CATEGORY	SUB-CATEGORY	EUROPE	NORTHERN AMERICA	LATIN AMERICA	ASIA	MIDDLE EAST AND AFRICA	GLOBAL
SMART AGRICULTURE	Crop management	16.6	35.5	1.5	1.2	0.1	54.9
SMART BUILDINGS	Building energy management systems (electricity commercial)	3.6	9.5	0.6	14.1	2.1	30.0
SMART BUILDINGS	Building energy management systems (gas commercial)	3.4	4.7	0.5	6.9	0.8	16.4
SMART BUILDINGS	HVAC control - commercial buildings	13.6	41.2	2.2	39.5	6.7	103.2
SMART BUILDINGS	Smart meters (electricity residential)	7.1	24.5	1.1	23.1	5.0	60.8
SMART ENERGY	Electric vehicle connection	0.2	0.2	<0.1	0.1	<0.1	0.7
SMART ENERGY	Micro generation (solar)	13.9	13.0	0.9	93.1	3.4	124.3
SMART ENERGY	Micro generation (wind business)	4.9	3.9	0.6	13.8	0.3	23.4
SMART ENERGY	Smart grids - electric network management	0.9	3.8	0.3	4.6	1.3	11.0
SMART MANUFACTURING	Inventory management	21.8	86.2	3.3	120.6	8.0	240.1

CATEGORY	SUB-CATEGORY	EUROPE	NORTHERN AMERICA	LATIN AMERICA	ASIA	MIDDLE EAST AND AFRICA	GLOBAL
SMART TRANSPORT AND CITIES	Car sharing (car clubs)	0.9	0.2	<0.1	<0.1	0.0	1.2
SMART TRANSPORT AND CITIES	Fleet vehicle driver behaviour improvement	24.6	25.0	5.1	44.4	6.0	105.1
SMART TRANSPORT AND CITIES	Navigation apps	7.2	8.1	3.6	21.0	8.5	48.5
SMART TRANSPORT AND CITIES	Ride hailing	-2.1	0.2	-3.4	-26.1	0.7	-30.7[30]
SMART TRANSPORT AND CITIES	Ride sharing	3.0	5.9	6.5	46.9	11.8	74.1
SMART TRANSPORT AND CITIES	Sea Fleet - Efficient Routing	21.3	30.0	5.4	47.3	6.4	110.4
SMART TRANSPORT AND CITIES	Smart logistics - efficient routing & fleet management	19.0	16.8	3.6	31.5	4.3	75.1
SMART TRANSPORT AND CITIES	Smart logistics - loading optimisation	7.6	6.7	1.4	12.6	1.7	30.0
SMART TRANSPORT AND CITIES	Traffic congestion management	1.6	4.4	0.1	2.0	0.5	8.5
SMART TRANSPORT AND CITIES	Traffic congestion monitoring (road signs and traffic lights)	2.3	3.0	0.5	5.0	1.2	12.0
SMART TRANSPORT AND CITIES	Usability of public transport	27.3	4.5	14.5	74.1	27.6	148.0
SMART TRANSPORT AND CITIES	Usage-based car insurance	12.5	8.5	0.8	8.3	0.6	30.6
SMART TRANSPORT AND CITIES	Bike sharing	2.6	2.5	1.4	20.4	3.7	30.6
SMART WORKING, LIVING AND HEALTH	Accommodation sharing	24.8	7.8	8.2	146.0	34.9	221.5
SMART WORKING, LIVING AND HEALTH	Audio conferencing	20.7	20.8	28.2	85.0	49.0	203.7
SMART WORKING, LIVING AND HEALTH	Video-calling with friends and families	16.9	16.9	16.2	78.0	21.3	149.2
SMART WORKING, LIVING AND HEALTH	Mobile banking	8.3	8.0	5.4	15.9	10.9	48.5
SMART WORKING, LIVING AND HEALTH	Mobile shopping	19.0	31.1	7.9	24.7	21.6	104.3
SMART WORKING, LIVING AND HEALTH	Multi-functional device	0.4	0.3	0.2	1.5	0.4	2.8
SMART WORKING, LIVING AND HEALTH	Sharing economy (goods sharing)	1.1	0.6	0.7	4.1	1.0	7.5
SMART WORKING, LIVING AND HEALTH	Smart health - home care	2.9	4.7	1.9	4.3	1.3	15.1
SMART WORKING, LIVING AND HEALTH	Smart homes	2.9	16.0	0.3	6.1	2.5	27.8
SMART WORKING, LIVING AND HEALTH	Working from home	13.3	22.2	2.3	0.3	9.0	47.0
TOTAL		**324.0**	**466.9**	**121.7**	**970.5**	**252.6**	**2,135.9**

30. Negative avoided emissions for 'ride-hailing' are due the emissions of the ride hailing vehicle, which for most countries analysed were greater than the avoided emissions of the alternative transport – see discussion of rebound effects in Appendix 2.

2018 Avoided Emission Factors per unit in $kgCO_2e$ by sub-category and region

CATEGORY	SUB-CATEGORY	UNIT	EUROPE	NORTHERN AMERICA	LATIN AMERICA	ASIA	MIDDLE EAST AND AFRICA	GLOBAL
SMART AGRICULTURE	Crop management	$kgCO_2e$/ connection	23,500.5	35,643.9	8,242.8	764.3	580.7	10,726.8
SMART BUILDINGS	Building energy management systems (electricity commercial)	$kgCO_2e$/ connection	364.8	660.7	398.5	708.4	892.6	604.9
SMART BUILDINGS	Building energy management systems (gas commercial)	$kgCO_2e$/ connection	3,888.8	3,731.6	3,882.0	3,923.1	3,882.0	3,882.5
SMART BUILDINGS	HVAC control - commercial buildings	$kgCO_2e$/ connection	3,673.5	7,702.3	3,901.9	5,322.0	7,652.4	4,720.1
SMART BUILDINGS	Smart meters (electricity residential)	$kgCO_2e$/ connection	33.8	173.7	19.4	46.1	61.0	59.6
SMART ENERGY	Electric vehicle connection	$kgCO_2e$/ connection	2,524.5	1,680.5	2,289.9	695.5	572.3	1,528.4
SMART ENERGY	Micro generation (solar)	$kgCO_2e$/ MW of renewable energy capacity	121,290.0	166,656.0	151,200.0	314,925.0	355,680.0	239,014.8
SMART ENERGY	Micro generation (wind business)	$kgCO_2e$/ MW of renewable energy capacity	29,968.0	38,235.6	26,980.8	59,502.3	60,128.6	47,389.8
SMART ENERGY	Smart grids - electric network management	$kgCO_2e$/ connection	236.3	1,514.7	324.0	518.3	901.2	698.9
SMART MANUFACTURING	Inventory management	$kgCO_2e$/ connection	8,242.2	35,235.0	9,922.5	21,344.4	22,226.4	16,774.1
SMART TRANSPORT AND CITIES	Car sharing (car clubs)	$kgCO_2e$/ car club car	15,507.2	9,398.3	2,349.6	2,349.6	2,349.6	7,675.3
SMART TRANSPORT AND CITIES	Fleet vehicle driver behaviour improvement	$kgCO_2e$/ connection	895.3	646.1	728.2	728.2	728.2	778.4
SMART TRANSPORT AND CITIES	Navigation apps	$kgCO_2e$/ smartphone	15.6	29.1	14.1	12.3	20.1	18.2
SMART TRANSPORT AND CITIES	Ride hailing	$kgCO_2e$/ smartphone	-4.6	0.9	-13.1	-15.3	1.6	-8.4
SMART TRANSPORT AND CITIES	Ride sharing	$kgCO_2e$/ smartphone	6.5	21.1	25.0	27.6	27.7	32.4
SMART TRANSPORT AND CITIES	Sea Fleet - Efficient Routing	$kgCO_2e$/ connection	354,117.7	354,117.7	354,117.7	354,117.7	354,117.7	354,117.7
SMART TRANSPORT AND CITIES	Smart logistics - efficient routing & fleet management	$kgCO_2e$/ connection	691.8	432.6	515.9	515.9	515.9	569.0
SMART TRANSPORT AND CITIES	Smart logistics - loading optimisation	$kgCO_2e$/ connection	276.7	173.0	206.4	206.4	206.4	227.6
SMART TRANSPORT AND CITIES	Traffic congestion management	$kgCO_2e$/ connection	38,903.5	69,892.8	14,790.0	20,351.4	21,234.8	27,916.6
SMART TRANSPORT AND CITIES	Traffic congestion monitoring (road signs and traffic lights)	$kgCO_2e$/ connection	27,925.1	23,736.4	25,132.6	25,132.6	25,132.6	25,970.4

CATEGORY	SUB-CATEGORY	UNIT	EUROPE	NORTHERN AMERICA	LATIN AMERICA	ASIA	MIDDLE EAST AND AFRICA	GLOBAL
SMART TRANSPORT AND CITIES	Usability of public transport	$kgCO_2e$/ smartphone	59.2	16.3	55.9	43.5	64.8	47.9
SMART TRANSPORT AND CITIES	Usage-based car insurance	$kgCO_2e$/ connection	384.2	357.6	233.2	216.0	200.0	290.0
SMART TRANSPORT AND CITIES	Bike sharing	$kgCO_2e$/ smartphone	5.7	8.8	5.4	12.0	8.8	13.0
SMART WORKING, LIVING AND HEALTH	Accommodation sharing	$kgCO_2e$/ smartphone	53.7	27.9	31.7	85.7	81.9	56.2
SMART WORKING, LIVING AND HEALTH	Audio conferencing	$kgCO_2e$/ smartphone	45.0	74.6	108.9	49.9	115.1	78.7
SMART WORKING, LIVING AND HEALTH	Video-calling with friends and families	$kgCO_2e$/ smartphone	36.6	60.5	62.4	45.8	50.0	51.1
SMART WORKING, LIVING AND HEALTH	Mobile banking	$kgCO_2e$/ smartphone	18.0	28.8	20.8	9.3	25.7	19.0
SMART WORKING, LIVING AND HEALTH	Mobile shopping	$kgCO_2e$/ smartphone	41.1	111.6	30.6	14.5	50.8	49.7
SMART WORKING, LIVING AND HEALTH	Multi-functional device	$kgCO_2e$/ smartphone	0.9	0.9	0.9	0.9	0.9	0.9
SMART WORKING, LIVING AND HEALTH	Sharing economy (goods sharing)	$kgCO_2e$/ smartphone	2.4	2.1	2.6	2.4	2.3	2.4
SMART WORKING, LIVING AND HEALTH	Smart health - home care	$kgCO_2e$/ connection	411.8	411.4	411.6	411.5	411.6	411.6
SMART WORKING, LIVING AND HEALTH	Smart homes	$kgCO_2e$/ smartphone	6.3	57.4	1.0	3.6	5.9	8.8
SMART WORKING, LIVING AND HEALTH	Working from home	$kgCO_2e$/ smartphone	28.8	79.7	8.7	0.2	21.0	27.7
TOTAL			**633,150.7**	**750,919.5**	**606,001.9**	**812,071.1**	**857,950.7**	**743,754.0**

The following table shows the total avoided emissions per unit by region.

2018 Avoided Emission Factors per unit in $kgCO_2e$ by region

UNIT	EUROPE	NORTHERN AMERICA	LATIN AMERICA	ASIA	MIDDLE EAST AND AFRICA	GLOBAL
AVOIDED EMISSIONS FACTOR PER SMARTPHONE	315	520	355	292	477	398
AVOIDED EMISSIONS FACTOR PER CONNECTION	466,070	536,110	425,117	435,002	439,316	449,276
AVOIDED EMISSIONS FACTOR PER MW OF RENEWABLE ENERGY CAPACITY	151,258	204,892	178,181	374,427	415,809	286,405
AVOIDED EMISSIONS FACTOR PER CAR CLUB CAR	15,507	9,398	2,350	2,350	2,350	7,675

The following table shows the energy (electricity and gas) and fuel savings that were calculated for each sub-category in assessing the avoided emissions.

For categories that show no energy or fuel savings, then the avoided emissions are calculated from resource reduction (e.g. fertiliser savings, water savings) or from generation of renewable electricity. Units are terawatt-hours of energy and million litres of fuel.

2018 Energy and Fuel savings

CATEGORY	SUB-CATEGORY	ENERGY (TWh)	FUEL (MILLION LITRES)
SMART AGRICULTURE	Crop management	-	-
SMART BUILDINGS	Building energy management systems (electricity commercial)	50.2	-
SMART BUILDINGS	Building energy management systems (gas commercial)	78.3	-
SMART BUILDINGS	HVAC control - commercial buildings	235.0	-
SMART BUILDINGS	Smart meters (electricity residential)	110.9	-
SMART ENERGY	Electric vehicle connection	-	293
SMART ENERGY	Micro generation (solar)	-	-
SMART ENERGY	Micro generation (wind business)	-	-
SMART ENERGY	Smart grids - electric network management	18.5	-
SMART MANUFACTURING	Inventory management	397.8	-
SMART TRANSPORT AND CITIES	Car sharing (car clubs)	-	506
SMART TRANSPORT AND CITIES	Fleet vehicle driver behaviour improvement	-	45,261
SMART TRANSPORT AND CITIES	Navigation apps	-	20,787
SMART TRANSPORT AND CITIES	Ride Hailing	-	- 13,021
SMART TRANSPORT AND CITIES	Ride sharing	-	31,710
SMART TRANSPORT AND CITIES	Sea Fleet - Efficient Routing	-	34,717
SMART TRANSPORT AND CITIES	Smart logistics - efficient routing & fleet management	-	28,944
SMART TRANSPORT AND CITIES	Smart logistics - loading optimisation	-	11,578
SMART TRANSPORT AND CITIES	Traffic congestion management	-	3,738

CATEGORY	SUB-CATEGORY	ENERGY (TWh)	FUEL (MILLION LITRES)
SMART TRANSPORT AND CITIES	Traffic congestion monitoring (road signs and traffic lights)	-	5,183
SMART TRANSPORT AND CITIES	Usability of public transport	-	62,990
SMART TRANSPORT AND CITIES	Usage-based car insurance	-	13,226
SMART WORKING, LIVING AND HEALTH	Accommodation sharing	435.9	-
SMART TRANSPORT AND CITIES	Bike sharing	-	13,029
SMART WORKING, LIVING AND HEALTH	Audio conferencing	-	92,023
SMART WORKING, LIVING AND HEALTH	Video-calling with friends and families	-	79,196
SMART WORKING, LIVING AND HEALTH	Mobile banking	-	20,847
SMART WORKING, LIVING AND HEALTH	Mobile shopping	-	49,753
SMART WORKING, LIVING AND HEALTH	Multi-functional device	-	-
SMART WORKING, LIVING AND HEALTH	Sharing economy (goods sharing)	-	-
SMART WORKING, LIVING AND HEALTH	Smart Health - home care	43.4	8
SMART WORKING, LIVING AND HEALTH	Smart homes	71.6	-
SMART WORKING, LIVING AND HEALTH	Working from home	-	20,665
TOTAL		**1,442**	**521,431**

Appendix 2 – Methodology

Methodology summary

The overall approach to assessing the enabling impact is to multiply an avoided emissions factor by the relevant quantity metric:

AVOIDED EMISSIONS [kgCO_2e]
=
AVOIDED EMISSIONS FACTOR [kgCO_2e/QTY]
X
QUANTITY [QTY]

The approach is consistent with the methodology described by the Avoided Emissions Framework.[31]

For the majority of cases considered in this report the quantity metric used was either the number of M2M IoT connections, or the number of smartphone users.

The avoided emissions factor is derived either from published studies, or developed using publicly available data and supported by assumptions where necessary. Additionally, a consumer survey was commissioned to provide data on smartphone user behaviour.

30 use-cases were analysed to calculate their impacts on different sectors. The choice of these use-cases was determined from previous published research and also informed by work that the Carbon Trust has undertaken with various telecommunications companies. The use-cases that were selected were those considered likely to contribute most to the overall avoided emissions impact.

The analysis is for the full year 2018, and uses the most recent data, where it is available. The geographical scope covers the entire world, with separate analysis carried out for each continental region: Europe, Northern America, Latin America, Asia, Middle East and Africa

Scope and Use-cases

The scope of the analysis is to assess the avoided emissions enabled by mobile telecommunications technologies. Also assessed are the fuel and energy savings related to the avoided emissions.

The scope covers all greenhouse gases, and the avoided emissions calculated in kgCO_2e.

The geographical scope is global, based on analysing each continental region, using representative countries.

The temporal scope is for the calendar year 2018, using either 2018 data, or latest available data, where 2018 data is not available.

The use-cases analysed were the following:

CATEGORY	SUB-CATEGORY
SMART AGRICULTURE	Crop management
SMART BUILDINGS	Building energy management systems (electricity commercial)
SMART BUILDINGS	Building energy management systems (gas commercial)
SMART BUILDINGS	HVAC control - commercial buildings
SMART BUILDINGS	Smart meters (electricity residential)
SMART ENERGY	Electric vehicle connection

31. Avoided Emissions Framework Methodology, https://www.misolutionframework.net/

CATEGORY	SUB-CATEGORY
SMART ENERGY	Micro generation (solar)
SMART ENERGY	Micro generation (wind business)
SMART ENERGY	Smart grids - electric network management
SMART MANUFACTURING	Inventory management
SMART TRANSPORT AND CITIES	Car sharing (car clubs)
SMART TRANSPORT AND CITIES	Fleet vehicle driver behaviour improvement
SMART TRANSPORT AND CITIES	Navigation apps
SMART TRANSPORT AND CITIES	Ride hailing
SMART TRANSPORT AND CITIES	Ride sharing
SMART TRANSPORT AND CITIES	Sea Fleet - Efficient Routing
SMART TRANSPORT AND CITIES	Smart logistics - efficient routing & fleet management
SMART TRANSPORT AND CITIES	Smart logistics - loading optimisation
SMART TRANSPORT AND CITIES	Traffic congestion management
SMART TRANSPORT AND CITIES	Traffic congestion monitoring (road signs and traffic lights)
SMART TRANSPORT AND CITIES	Usability of public transport
SMART TRANSPORT AND CITIES	Usage-based car insurance
SMART TRANSPORT AND CITIES	Bike sharing
SMART WORKING, LIVING AND HEALTH	Accomodation sharing
SMART WORKING, LIVING AND HEALTH	Audio conferencing
SMART WORKING, LIVING AND HEALTH	Video-calling with friends and families
SMART WORKING, LIVING AND HEALTH	Mobile banking
SMART WORKING, LIVING AND HEALTH	Mobile shopping
SMART WORKING, LIVING AND HEALTH	Multi-functional device

CATEGORY	SUB-CATEGORY
SMART WORKING, LIVING AND HEALTH	Sharing economy (goods sharing)
SMART WORKING, LIVING AND HEALTH	Smart health - home care
SMART WORKING, LIVING AND HEALTH	Smart homes
SMART WORKING, LIVING AND HEALTH	Working from home

Data sources

Quantity data

For almost all use-cases the quantity metric was either the number of M2M (IoT) connections, or the number of smartphone users.

The number of M2M connections used the GSMA Intelligence IoT connections dataset, using figures for the year 2018. This data provides number of IoT connections by country, region, and by category. Where necessary, the IoT categories were allocated to the more specific use-case categories using allocation factors that had been derived from previous analysis.

The number of smartphone users was sourced from the Newzoo 2018 Global mobile market report. This provides number of smartphone users globally, by region, and by country. The figures for the year 2018 were used. This was also cross-checked against GSMA Intelligence 2018 data for smartphone connections. The GSMA figures were higher than the Newzoo data, this being due to the GSMA data reflecting the number of active smartphone connections, while the Newzoo data is for active smartphone users. Thus a dual-SIM smartphone would show as two connections in the GSMA data, whereas a smartphone user with two phones would show as only one user in the Newzoo data, thus explaining the difference in overall numbers. We used the Newzoo data as it more closely relates to the analysis that we were modelling – i.e. avoided emissions per smartphone user. Also as the Newzoo figures are lower, they result in a more conservative avoided emissions result.

Three use-cases used different quantity metrics. These were:

- Car sharing (car clubs)
    - This used the number of car club vehicles from the Berkley TSRC report: *Innovative Mobility Carsharing Outlook. Carsharing Market Overview, Analysis, and Trends - Winter 2016* [174]
- Micro generation (solar)
    - This used the Solar PV capacity (in MW) per country or region. Various sources were used for this data, depending on location – see assumptions table for subcategory Micro generation (solar) in Appendix 4 for all references.
- Micro generation (wind business)
    - This used the onshore installed wind capacity (in MW) per country or region. Various sources were used for this data, depending on location – see assumptions table for subcategory Micro generation (Wind) in Appendix 4 for all references.

Survey data
A survey into Consumer Smartphone Trends was commissioned for this report and carried out by B2B International.

52 questions were asked on behavioural use of smartphones covering the following 12 use-cases:

- Working from home
- Video-calling with friends and families
- Usability of public transport
- Accommodation sharing
- Mobile banking
- Use of Navigation apps
- Sharing economy (goods sharing)
- Ride-sharing
- Mobile shopping
- Bike sharing
- Ride-hailing
- Conference Calls

For each topic typical questions would be:

- Do you use your smart phone for this activity?
- Could you do this activity without your smart phone (if relevant)
- How frequently do you do this activity using your smart phone? (e.g. times per week, times per year, days per week)
- What is the typical distance (if relevant)

The survey was conducted by 6,115 online interviews in the following 7 countries (number of respondents in brackets):

- Europe: UK (1,027)
- N. America: USA (1,040)
- Latin America: Mexico (507) and Brazil (527)
- Asia: China (1,014) and India (1,000)
- Middle East and Africa: South Africa (1,000)

The survey interviews were conducted across 2 weeks from 7th to 18th October 2019.

Who we Spoke to and Methodology

RESPONDENT LOCATION

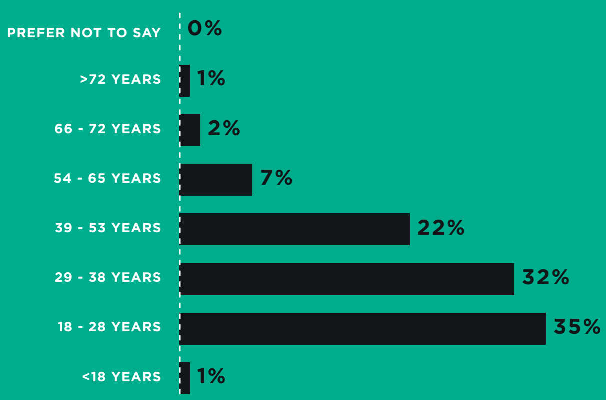
GENDER

METHODOLOGY

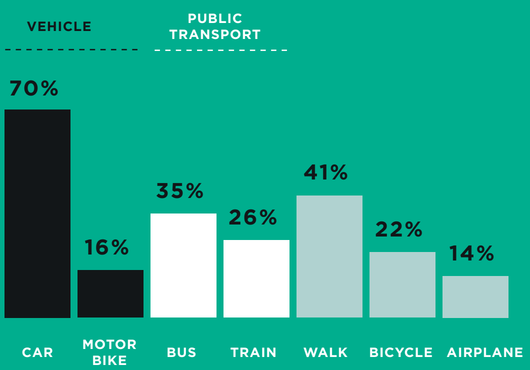
6,115

QUANTITATIVE INTERVIEWS CONDUCTED ONLINE WITH SMARTPHONE USERS.

AGE



MODES OF TRANSPORT USED



METHODOLOGY

ALL INTERVIEWS WERE CONDUCTED ACROSS

2weeks

IN OCTOBER 2019

Source: B2B INTERNATIONAL

General Data

All assumptions and data specific to individual use-cases are described in the Assumptions Table (Appendix 3) and the data sources referenced in the References Table (Appendix 4). Other generic data has been collated by Carbon Trust from nationally published statistics, for example average number of vehicles and average annual distance travelled by vehicle type.

Emission factors are generally sourced from BEIS "Greenhouse gas reporting: conversion factors 2019" [ref. 219]. Electricity grid emission factors are from *IEA Emission Factors 2018*.[32]

Mobile Sector emissions

The results of the analysis are presented as a total of avoided emissions in tonnes CO_2e, and also as a ratio compared to the emissions of the mobile sector itself. The emissions of the mobile sector have been calculated from the following sources:

- Malmodin (2018a): Malmodin and Lundén, The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015, *Sustainability 2018*, 10(9), 3027
- Malmodin (2018b): Malmodin and Lundén, ICT Networks, "The electricity consumption and operational carbon emissions of ICT network operators 2010-2015, Report from the KTH Centre for Sustainable Communications Stockholm, Sweden 2018
- L.1470: ITU, GHG emissions trajectories for the ICT sector compatible with the UNFCCC Paris Agreement, draft published for comments, 16th September 2019.
- The total emissions of the mobile sector are calculated as 220 $MtCO_2e$, including the energy required to operate the mobile networks, the embodied emissions of the networks, and the emissions (both operational and embodied) of handsets.

	$MTCO_2E$	REFERENCE
MOBILE NETWORK OPERATIONS	98.4	L.1470
+ UPSTREAM AND T&D LOSSES	16.6	L.1470
NETWORK EMBODIED EMISSIONS	17.3	Calculated at 15% of operational emissions: Malmodin (2018b) page 5.
SMARTPHONES EMBODIED	64.5	Malmodin (2018b) – supplementary material.
SMARTPHONES OPERATIONAL	6.7	Malmodin (2018b) – supplementary material.
FEATURE PHONES EMBODIED	13.4	Malmodin (2018b) – supplementary material.
FEATURE PHONES OPERATIONAL	3.1	Malmodin (2018b) – supplementary material.
TOTAL	**220.0**	

Note 1: the Mobile Network Operations figure includes the network operators' internal data centres.

Note 2: the 220$MtCO_2e$ represents approximately 0.4% of total global emissions. This is based on a figure of global GHG emissions of 53,500 $MtCO_2e$ from the UNEP Emissions Gap report 2018. (Figure for year 2017).

32. Note that this work is partially based on the Emission Factors 2018 developed by the International Energy Agency, © OECD/IEA 2018, but the resulting work has been prepared by Carbon Trust and does not necessarily reflect the views of the International Energy Agency.

Key Methodological considerations

The overall approach follows the methodology described by the Avoided Emissions Framework.[33] A key principle of this is that of comparing the enabled scenario with the **business-as-usual base case**. It can be a challenge to determine what the base case would have been in the absence of the new solution. This is even more challenging for the mobile telecommunications sector, where the technology is changing rapidly, and what would have been considered to be the base case only a few years ago, has already been replaced as the new normal by new technologies and new behaviour patterns. Therefore, this report relies heavily on using a range of other studies and data points to establish the difference between the enabled solution and a nominal base case. Often this is then expressed as a percentage value of the savings (which are typically fuel or energy savings).

A second key consideration is that of **allocation** – any enablement solution typically also relies on other technologies – for example, video-conferencing requires not just the telecommunication technology, but also the video equipment, and cloud-based servers. It is difficult to come up with a reliable and consistent approach that allocates the avoided emissions between the different technologies. It is therefore common to simply state that the technology enables the full avoided emissions, and not attempt any arbitrary allocation. The test being that if the technology plays a fundamental role in delivering the outcome then it can be said to enable the avoided emissions – the test for fundamental is that without the technology the overall solution would not function. This approach is the only practical approach currently, however, it does lead to criticism of potentially double counting the avoided emissions – this in itself is not a problem unless there is an attempt to sum all the avoided emissions from different technologies. There are other examples of double counting in carbon accounting, such as for scope 3 emissions of one company includes scope 1 and 2 emissions of other companies, and likely also scope 3 emissions of other companies – but you would not attempt to add all the scope 3 emissions for all companies.

A further consideration is that of **rebound effects**. This is where known, unexpected or unintended effects cause an increase in emissions, which should be considered when calculating the avoided emissions. Again it is challenging to identify and include rebound effects. Generally, we have not explicitly included rebound effects in the analysis. There are two specific use-cases where we have explicitly included rebound effects, as they are clearly identifiable, and it is possible to use a methodology to quantify the rebound effects.

> For the 'working from home' use-case we considered the emissions avoided by not travelling to work, however there is a rebound effect of additional energy requirements, primarily from heating at home. We estimated this based on an allowance of additional heating energy and additional electricity use. The avoided emissions are calculated from the consumer survey results, and vary by country based on percentages of people that work from home, their average commuting distances, and mode of travel. The rebound emissions from the additional home energy use vary partly on the country grid electricity emission factor. Based on the survey data and the assumptions that we used for additional home energy, in China where car use for commuting was low and the grid emission factor is high, the rebound effects outweighed the avoided emissions representing a net increase in emissions, while in USA where the main form of commuting was significantly by car the avoided emissions were roughly double the rebound effects of additional home energy. There is a further secondary rebound effect that we did not consider that is less energy is required for offices (and indeed less office space is required) because of people working from home.
>
> For the 'ride hailing' use-case the avoided emissions are from people not travelling with an alternative transport mode, and although

33. Avoided Emissions Framework Methodology, https://www.misolutionframework.net/

often this was by car, in the majority of cases it would have been by public transport. However, the very clear rebound effect is that of the emissions of the ride hailing vehicle itself. On balance for most countries analysed the rebound emissions were larger than the avoided emissions representing a net increase in emissions. The calculations were based on results from the consumer survey.

The total results of the analysis are calculated and presented at the regional level for the following **geographical regions**:

- Europe
- Northern America
- Latin America
- Asia
- Middle East and Africa

The analysis of the avoided emissions factor was calculated at the country level for the following countries:

- UK
- Germany
- Spain
- France
- USA
- China
- Brazil
- India
- South Korea
- Kenya
- Egypt
- South Africa
- Mexico
- Australia

The countries were chosen to provide representation across the regions, and to include some of the largest countries by population. The avoided emission factors for the regions were then based on using specific countries in the region as proxies. The total avoided emissions were calculated by multiplying the regional factor by the relevant quantity values for the region.

For the use-cases that were based on data from the consumer survey, only the following countries were included:

- UK
- USA
- Brazil
- Mexico
- India
- China
- South Africa

Uncertainty

The nature of this analysis is necessarily subject to significant uncertainty. The analysis uses averages, assumptions and proxies, and then aggregates these to a global level. Recognising the level of uncertainty, we adopted a conservative approach in selecting methods and choosing assumptions. Indeed the approach has an inherent conservative bias built in, because only a finite number of use-cases have been selected, and by definition, certain use-cases have been excluded and some have not even been identified. Although the use-cases were selected with the aim of including at least 95% of the avoided emissions (by analysing the use-cases from previous research).

Discussion

Where possible, we have used publicly available reliable sources for data. These include studies and reports from reliable sources, and publicly available national statistics. As far as possible we have documented in the appendices to the report, references for all of the sources that have been used.

Generally, we have erred on the more conservative when selecting data and choosing assumptions. For some categories, namely smart agriculture and smart manufacturing, we have only analysed a single use-case. These have been selected as they are likely to have the most significant impact for that category, but this is inevitably excluding other use-cases. Particularly for smart agriculture there are other known use-cases (some that we reference with case study examples), however it is very challenging to get reliable and representative data to be able to calculate the avoided emissions.

Some areas are particularly difficult to quantify, for example, new solutions where there is little operational experience or data, or disruptive solutions where it is difficult to assess the impact and the avoided emissions mechanism. So, by definition, these cases will have been excluded.

The consumer survey was essential in being able to quantify behavioural adoption and use of smartphones for avoiding emissions. It showed clearly that some behaviours have been rapidly increasing compared to similar surveys of only a few years ago. For example, it showed a majority of people regularly using their smartphones for conference calls, and surprisingly high proportions of people that said that they regularly worked from home, (although the survey responses on average commuting distances were lower than from other surveys and national statistics).

Where possible and appropriate, we cross-checked assumptions and data with other sources, and applied “reasonableness” checks. In some cases we would replace data or factors with more conservative values from proxies, where there was doubt over the original data points.

However, in summary, the analysis carried out is done at a very detailed and transparent level, and we have good confidence in the overall level of the results.

Appendix 3 – Assumptions

Detailed below are the assumptions and proxies used in the calculation of avoided emissions.

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART AGRICULTURE		
	TECH SUBCAT	CROP MANAGEMENT		
	MECHANISM	Better use of resources (labour, fuel and water) and increase in productivity can lead to increased yield and reduced wastage. It can also lead to a reduction in the volumes of fertiliser and water required, as it can be allocated to the appropriate areas as well as reduced irrigation (e.g., plants tweeting when need to be watered!).		
	METHODOLOGY	Fertiliser reduction: this calculation was based on the amount of fertiliser used per farm per year, and the country specific emission factor of fertilisers used. Previous studies give an estimation on the reduction of fertiliser used as a result of mobile enabled soil and water sensors. Water reduction: this calculation was based on the amount of water used per farm per year, and the country specific emission factor for water used. Supporting sources give an indication as to the water savings that can be achieved through digital farming techniques.		
ASSUMPTION 1	ASSUMPTIONS	Smart technology can reduce expenditure on chemical inputs by 40% per hectare. Using this figure, it was assumed that a reduction in expenditure is directly equivalent to a reduction in product quantity used.	74	GSMA, Agri M2M
ASSUMPTION 2	ASSUMPTIONS	Smart technology has led to improvements on nitrogen efficiency in Germany between 10-15% (supporting reference).	92A	JRC, Precision Agriculture
ASSUMPTION 3	ASSUMPTIONS	Where precision agriculture is widely used across the USA, water and fertiliser use can go down by between 20-40%.	220	USA Nature Conservancy, Precision Agriculture
ASSUMPTION 4	ASSUMPTIONS	Case studies from South Africa have revealed that precision agriculture and fertilisation systems through digital farming techniques have resulted in fertilisation water savings of 40%.	250	NETAFIM 2019
	TECH CATEGORY	SMART BUILDINGS		
	TECH SUBCAT	BUILDING ENERGY MANAGEMENT SYSTEMS (ELECTRICITY COMMERCIAL)		
	MECHANISM	Energy management systems lead to optimised energy and heating demand resulting in energy savings.		

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	METHODOLOGY	The calculation was based off an estimated percentage saving of average office electricity consumption due to smart meters. It was assumed that there is more than one M2M connections per office. An average electricity saving per m^2 was calculated based on the national electricity consumption per business and the assumed saving percentage from smart meter use. Considering the number of meters per m^2 and the national electricity emission factor, a CO_2e abatement factor per country was calculated.		
ASSUMPTION 1	ASSUMPTIONS	A 14.3% electricity saving from smart meter use in commercial buildings was assumed. This is an average value based on the following three studies:	-	-
ASSUMPTION 2	ASSUMPTIONS	This source suggests a 12% electricity saving from a controlled trial involving 538 SMEs.	101	CT Study
ASSUMPTION 3	ASSUMPTIONS	This source suggests a GE case study results: 16% electricity saving.	148	Building Centre
ASSUMPTION 4	ASSUMPTIONS	Studies show MM&T can typically deliver energy use savings of between 5 - 15%.	112	CT EM Study
ASSUMPTION 5	ASSUMPTIONS	Estimated 0.02 electricity meters per m^2.	-	Carbon Trust analysis of Low Carbon Workplace (LCW) data
	TECH CATEGORY	SMART BUILDINGS		
	TECH SUBCAT	BUILDING ENERGY MANAGEMENT SYSTEMS (GAS COMMERCIAL)		
	MECHANISM	Energy management systems lead to optimised energy and heating demand resulting in energy savings.		
	METHODOLOGY	This calculation was based off an estimated percentage saving of average office gas consumption due to smart meters. It was assumed that there is more than one M2M connections per office. An average gas saving per m^2 was calculated based on the national gas consumption per business and the assumed saving percentage from smart meter use. Considering the number of meters per m^2 and the gas emission factor, a CO_2e abatement factor per country was calculated.		
ASSUMPTION 1	ASSUMPTIONS	A 21% gas savings was assumed from smart meter use in commercial buildings. This is based on the following four studies (the 7% figure is based on a reasonable large sample, but only considered SMEs, therefore it is reasonable to assume a higher saving):	-	-
ASSUMPTION 2	ASSUMPTIONS	A 42% saving was suggested from a GE case study.	148	BBP
ASSUMPTION 3	ASSUMPTIONS	This source suggests a 4.5% gas consumption reduction in the non-domestic sector.	100	DECC

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 4	ASSUMPTIONS	A 7% gas saving was found from a controlled trial involving 538 SMEs. (Non-SMEs are likely to have higher savings).	101	CT Study
ASSUMPTION 5	ASSUMPTIONS	Phased approach to MM&T was adopted. Gas represented 90% of the site consumption, so gas sub-metering was introduced. The result was a 29% decrease in energy consumption. (Caution with using this figure as MF company had high levels of gas consumption).	111	CT EM Study
ASSUMPTION 6	ASSUMPTIONS	0.001 gas meters per m^2 is assumed.	-	Carbon Trust analysis of Low Carbon Workplace (LCW) data
	TECH CATEGORY	SMART BUILDINGS		
	TECH SUBCAT	HVAC CONTROL - COMMERCIAL BUILDINGS		
	MECHANISM	Monitoring and control of HVAC systems, including automatic reaction based on occupancy, leads to a reduction in energy consumption.		
	METHODOLOGY	The calculation involved estimating average energy consumed by a HVAC system in an average office building by multiplying the energy per m^2 by the average floor space and the percentage of energy consumed by HVAC system. This is multiplied by the percentage reduction in energy consumption caused by HVAC control systems and by the energy emission factor to calculate an average abatement factor.		
ASSUMPTION 1	ASSUMPTIONS	A 27.5% energy saving was assumed from HVAC controls for the USA. This is based on the PNNL study, which suggests HVAC controls will offer energy savings of 24%-35% in commercial buildings.	143	PNNL Study
ASSUMPTION 2	ASSUMPTIONS	A 20% Energy savings was assumed from HVAC controls for Europe. This is from the CT study, which suggests HVAC controls will offer energy savings of 20% in commercial buildings.	144	CT Study
ASSUMPTION 3	ASSUMPTIONS	The CIBSE Journal article quotes that cooling & ventilation accounts for 21% and heating for 20% of the average electricity consumption in UK office buildings, so we assume that 41% of energy is consumed by HVAC systems in commercial buildings.	141	CIBSE
ASSUMPTION 4	ASSUMPTIONS	The sample mean of workplace density is $9.6m^2$, so it is assumed that is the average floor space per worker in m^2.	142	BCO
ASSUMPTION 5	ASSUMPTIONS	Analysis from the BEES report 2014-2015 allows for an approximate breakdown of gas and electricity consumption to be calculated. 71% electricity and 29% gas.	247	BEES 2014-15
ASSUMPTION 6	ASSUMPTIONS	European electricity and gas consumption figures provided, based on previous model analysis.	248	Entranze energy data

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 7	ASSUMPTIONS	U.S electricity and gas consumption figures provided, based on previous model analysis.	249	EIA
ASSUMPTION 8	ASSUMPTIONS	Heating, ventilating, and air-conditioning (HVAC systems) account for 39% of the energy used in commercial buildings in the United States.	251	WDBG
	TECH CATEGORY	SMART BUILDINGS		
	TECH SUBCAT	SMART METERS (ELECTRICITY RESIDENTIAL)		
	MECHANISM	Use of smart meters enables monitoring of energy used, raises awareness, and leads to behaviour change reducing energy consumption and therefore emissions.		
	METHODOLOGY	The average CO_2e abatement factor was estimated based on the average electricity consumption per household, the average electricity emission factor per country, and the reduction in electricity consumption from smart meter use in residential buildings. One M2M connection per household was assumed.		
ASSUMPTION 1	ASSUMPTIONS	An electricity saving from smart meter use of 3% was assumed. This is based on the following four references; a lower figure from the range provided by these studies was selected.	-	-
ASSUMPTION 2	ASSUMPTIONS	Electricity saving from smart meter use found to be 2.8%.	100	DECC
ASSUMPTION 3	ASSUMPTIONS	Electricity saving from smart meters found to be 5-15%.	31	NRDC
ASSUMPTION 4	ASSUMPTIONS	Electricity saving from smart meters found to be 2-3%.	190	Irish Smart Meter study
ASSUMPTION 5	ASSUMPTIONS	For electricity, smart-type meters enabled an average annual reduction compared to traditional meters of 2.3% with 95% confidence intervals between 1.6% and 2.8%.	221	DECC 2015
	TECH CATEGORY	SMART ENERGY		
	TECH SUBCAT	ELECTRIC VEHICLE CONNECTION		
	MECHANISM	Smart grids enabling connection of electric vehicles, therefore increasing shift from petrol and diesel cars to electric cars.		
	METHODOLOGY	The total kilometres driven per charging point was estimated using the total kWh charged, divided by the total number of charging points and multiplied by the kilometres driven per kWh. The emission factor for an Electric Vehicle was calculated by multiplying electric vehicle energy use by the electricity emission factor. Then the difference in emissions when total kilometres are driven by an average car compared to an electric car was calculated from their respective emission factors.		

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 1	ASSUMPTIONS	Total kWh used over a 3 month period: 51,957 (Sep 2013); 86,266 (June 2014)	82	TFL
ASSUMPTION 2	ASSUMPTIONS	Greater London now has 6,838 charging connectors that are currently in operation as of Sep 19.	231	Zap-Map 2019
ASSUMPTION 3	ASSUMPTIONS	The average energy consumption per EV vehicle in the UK is currently 289 Wh/mi (179.5 Wh/km). For the Netherlands, this figure is 285 Wh/mi (177 Wh/km). An average figure of 178 Wh/km is therefore taken.	232	EV database
ASSUMPTION 4	ASSUMPTIONS	There are currently 869 charging stations listed in Amsterdam, 522 stations in Berlin, 827 charging stations in Paris, 112 stations in Madrid.	233	Charge Map
ASSUMPTION 5	ASSUMPTIONS	The current average annual mileage of an EV is 13,200km. Based on electric nation trial, assumed share of charging demand is as follows: Residential charging - 74.6% Work - 14.7% Slow/Fast Public - 5.8% Rapid Public - 4.8%	245	Element Energy 2019
ASSUMPTION 6	ASSUMPTIONS	A rapid charging point has an assumed capacity of 50 kW. The observed effective charge rate is 50%, and the average energy per day (modelled kWh/day) for a rapid charger is 150 kWh/day.	246	TFL 2019
	TECH CATEGORY	SMART ENERGY		
	TECH SUBCAT	MICRO-GENERATION (SOLAR)		
	MECHANISM	Micro-generation enables electricity to be exported to the grid through decentralized low carbon energy generation. Communication of electricity capacity, pricing and payment is enabled through smart meters and M2M connection. This reduces energy consumption and ultimately emissions.		
	METHODOLOGY	The PV power output of a region was estimated using the Global Solar Atlas, and multiplied by an accompanying attribution factor and residual grid factor, to get an overall carbon abatement factor in terms of kWh renewable electricity enabled per MW of installed capacity.		
ASSUMPTION 1	ASSUMPTIONS	Using the Global Solar Atlas, PV power output assumptions (kWh/kWp) have been taken for key regions of the world.	257	Solar GIS, 2019
ASSUMPTION 2	ASSUMPTIONS	An attribution factor of 30% has been used - this represents the proportion of installed PV capacity that can be assumed to have remote connection through M2M and is therefore enabled by mobile telecommunications. This factor was derived from previous research on the number of M2M connections for PV sites compared to the total capacity. This analysis was done for UK, Germany and USA, and an average of the three countries used to determine the 30% attribution factor.	-	-

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 3	ASSUMPTIONS	Solar PV capacity (in MW) for India.	280	Gov. of India Ministry of Power -Central Electricity Authority
ASSUMPTION 4	ASSUMPTIONS	Solar PV capacity (in MW) for China	281	China Energy Portal
ASSUMPTION 5	ASSUMPTIONS	Solar PV capacity (in MW) for the USA.	282	Solar Energy Industries Association
ASSUMPTION 6	ASSUMPTIONS	Solar PV capacity (in MW) for Europe, Asia, Middle East and Africa.	283	EurObserv'ER
ASSUMPTION 7	ASSUMPTIONS	Solar PV capacity (in MW) for Europe, Asia, Middle East and Africa.	284	Solar Power Europe
ASSUMPTION 8	ASSUMPTIONS	Solar PV capacity (in MW) for Latin and North America.	285	IEA
	TECH CATEGORY	SMART ENERGY		
	TECH SUBCAT	MICRO-GENERATION WIND		
	MECHANISM	Micro-generation enables electricity to be exported to the grid through decentralized low carbon energy generation. Communication of electricity capacity, pricing and payment is enabled through smart meters and M2M connection. This reduces energy consumption and ultimately emissions.		
	METHODOLOGY	The total wind capacity factor for each country (%) was estimated, multiplied by an associated attribution factor (%) and number of hours in a year, and then multiplied by an overall residual grid emission factor to get an overall carbon abatement factor in terms of kWh renewable electricity enabled per MW of installed capacity.		
ASSUMPTION 1	ASSUMPTIONS	Cumulative onshore installations by country (MW).	258	GWEC 2015
ASSUMPTION 2	ASSUMPTIONS	Cumulative onshore installations by country (MW).	259	GWEC 2016
ASSUMPTION 3	ASSUMPTIONS	Cumulative onshore installations by country (MW).	260	GWEC 2017/18
ASSUMPTION 4	ASSUMPTIONS	UK cumulative onshore installations (MW).	261	UK Gov Wind Capacity
ASSUMPTION 5	ASSUMPTIONS	Spain cumulative onshore installations by country (MW).	262	Spain Wind Capacity
ASSUMPTION 6	ASSUMPTIONS	An attribution factor of 5% has been used - this represents the proportion of installed wind energy capacity that can be assumed to have remote connection through M2M and is therefore enabled by mobile telecommunications. This factor was derived from previous research on the number of M2M connections for wind energy sites compared to the total capacity. This analysis was done for UK, Germany and USA, and an average of the three countries used to determine the 5% attribution factor.	-	-

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART ENERGY		
	TECH SUBCAT	SMART GRIDS - ELECTRIC NETWORK MANAGEMENT		
	MECHANISM	By monitoring the transmission and distribution (T&D) elements of the network, utilities can identify points of loss. This leads to more efficient distribution network, resulting in reduced T&D losses.		
	METHODOLOGY	The percentage of the grid that is smart was estimated by assuming 100% of the grid is smart in 2050. The emissions caused from the proportion of the grid that is smart was calculated. The reduction in T&D losses possible with a smart grid was calculated and the reductions were applied to the proportion of smart grid emissions. This is divided by the number of M2M connections to get carbon abatement per connection.		
ASSUMPTION 1	ASSUMPTIONS	An average figure of 7% for T&D losses was used as a percentage of total electricity generation.	154	IEA
ASSUMPTION 2	ASSUMPTIONS	The SMART 2020 report estimates potential reduction in T&D losses from use of smart grids to be 30%.	153	Climate Group, GeSI
ASSUMPTION 3	ASSUMPTIONS	US DOE smart grid study estimates potential reduction in T&D losses from use of smart grids to be 5-10%.	170	US DOE
ASSUMPTION 4	ASSUMPTIONS	Using the two references above, the reduction in T&D losses from smart grids was assumed to be 7.5%. (The US DOE study was taken as more representative).	-	-
ASSUMPTION 4	ASSUMPTIONS	It is assumed that in 2050, 100% of the grid is smart. Hence, the percentage of grid estimated to be smart currently is measured by the ratio of connections in 2015 over connections in 2050. The connections in 2050 were derived by assuming a linear increase in connections from 2030 onwards based on the figures from 2025-2030.	-	-
	TECH CATEGORY	SMART MANUFACTURING		
	TECH SUBCAT	INVENTORY MANAGEMENT		
	MECHANISM	Inventory management systems reduce the overall level of inventory needed. As a result, less warehouse storage space is required. Smaller storage space requires less energy for lighting and cooling, resulting in energy savings and emissions reductions.		
	METHODOLOGY	SMARTer 2020 report identifies inventory savings of 24%; this increased efficiency is applied to the electricity consumption of a typical warehouse.		
ASSUMPTION 1	ASSUMPTIONS	Assume the average medium sized warehouse is 20,000ft^2.	214	EIA.GOV

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 2	ASSUMPTIONS	ICT enabled inventory management reduces inventory levels by up to 24%. It was assumed that this reduces the electricity consumption per warehouse by 24%. As this project is only considering the emissions saving from mobile telecommunications, as appose to all ICT systems, this 24% figure was reduced down to 15% to provide a more realistic of the emission savings from just mobile-telecommunication technology.	215	SMARTer 2020
ASSUMPTION 3	ASSUMPTIONS	Per warehouse gas consumption is 152.4 kWh/m^2 (14.15kWh/ft^2) for the U.S	244	EIA.GOV 2012
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	CAR SHARING (CAR CLUBS)		
	MECHANISM	Car sharing car clubs allow the shared use of a car by multiple users. Each vehicle owned by a car club operator is equivalent to one M2M connection. Smartphones are used to book, locate and unlock car club vehicles. Resulting reductions in carbon emissions are due to the improved fuel efficiency of car club cars compared to private cars, and to the fact that being in a car club reduces individual travel as non-essential journeys are no longer made by car, so car club members reducing their annual distance travelled by car.		
	METHODOLOGY	Savings per member are calculated by multiplying the average distance reduced by an average car emission factor. This is then multiplied by the average number of members per car to calculate the carbon abatement per car. The savings from more efficient cars is calculated by multiplying the average car club annual distance by the difference in emission factors for car club car compared to a typical average private car.		
ASSUMPTION 1	ASSUMPTIONS	33 members per car club car in England and Wales (outside of London), and average net reduction in mileage is 1,910 miles (3,074km) per member. Total average mileage is 3,500 per member.	119	Carplus
ASSUMPTION 2	ASSUMPTIONS	There are 25,773 car club members in England and Wales (excl London). 33 members per car club car in England and Wales. Car club cars in England and Wales produce 43% less CO_2 from tailpipe the average UK car. The average mileage driven by households in England with at least one vehicle is 7,800 miles (National Travel Survey, 2017) indicating that car club member drive almost 20% less distance (1,560miles, 2,510.58km) compared to an average England resident that owns a private vehicle. There are 14,391 active car club members in the survey. The car club cars contributed 364,000kg carbon savings over the year. So one car contributed 25.29kg (364,000/14,391) carbon tailpipe emissions.	21A	CoMoUK, England & Wales Car Club Annual Survey 2017/18

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 3	ASSUMPTIONS	Car-sharing in Beijing, 5.1/per car/day. Since China's shared vehicles currently use mainly electric vehicles, their energy consumption is 38% lower than the industry average, each shared car reduces carbon dioxide emissions by 1.7 tons per year.	22A	Research Institute of the Ministry of Commu-nications : 2017 China's first-tier cities share car travel reports
ASSUMPTION 4	ASSUMPTIONS	Zipcar has said that "every Zipcar takes at least 20 personally owned vehicles off the road."	23A	The Wharton University of Pennsylva-nia, 2015
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	FLEET VEHICLE DRIVER BEHAVIOUR IMPROVEMENT		
	MECHANISM	Improvement of driver behaviour, enabled through telematics systems connected via mobile networks in HGVs, leading to reduced overall journey distance, fuel consumption and lower emissions.		
	METHODOLOGY	The calculation methodology uses the weighted average emission per HGV per country multiplied by a 5% fuel saving from telematics, found from several sources, to find the CO_2e abatement factor per vehicle as well as the abatement factor for fuel per vehicle. The average emissions for cars, LGVs and HGVs was calculated from national data on total distance, number of vehicles, and standard emission factors, and the weighted average calculated assuming mix of car/LGV/HGV for M2M connections.		
ASSUMPTION 1	ASSUMPTIONS	That the percentage of fuel saving is the same across countries was assumed.	-	-
ASSUMPTION 2	ASSUMPTIONS	Average annual distances for cars/LGVs/HGVs were used based on national statistics and emission factors.	-	-
ASSUMPTION 3	ASSUMPTIONS	A mix of vehicle types (20% car/60% LGV/20% HGV) were assumed based on typical split of M2M connections for Fleet Management. (Carbon Trust analysis).	-	-
ASSUMPTION 4	ASSUMPTIONS	A 10% fuel saving due to improved driver behaviour was assumed. Various published and unpublished studies indicate savings from 5-15%, dependant on level of intervention. Examples of some published sources:	-	-
ASSUMPTION 5	ASSUMPTIONS	This source suggests telematics could introduce a 2-10% fuel saving; Jürgen Hase, VP of M2M Competence Centre at Deutsche Telekom.	50	Wireless article. (DT)

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 6	ASSUMPTIONS	This source suggests telematics could introduce a 9% saving in all fleet.	54	Fleet News
ASSUMPTION 7	ASSUMPTIONS	This source suggests telematics could introduce a 10-15% saving.	40	Guide to Telematics
ASSUMPTION 8	ASSUMPTIONS	This source suggests telematics could introduce up to a 20% saving.	41	'Telematics explained' [41]
ASSUMPTION 9	ASSUMPTIONS	This source suggests telematics could introduce a 10%-15% saving; Jari Salminen, Vodafone head of business development, M2M.	50	Wireless article. (VF)
ASSUMPTION 10	ASSUMPTIONS	This source suggests telematics could introduce an average of 5-10% savings on fuel costs - in many cases, this saving reaches 15%.	53	Mix Telematics [53]
ASSUMPTION 11	ASSUMPTIONS	This source suggests telematics could introduce a 14% saving.	54	Iron Mountain [54]
ASSUMPTION 12	ASSUMPTIONS	This source suggests telematics could introduce a 20% saving.	186	hetnieuwer-ijden
ASSUMPTION 13	ASSUMPTIONS	This source suggests telematics could introduce a 10% saving.	187	ANWB
ASSUMPTION 14	ASSUMPTIONS	This source suggests telematics could introduce a 15% saving.	188	EcoDrive
ASSUMPTION 15	ASSUMPTIONS	This source suggests telematics could introduce a 11.5% - 18.3% saving.	189	Sycada-Green
ASSUMPTION 16	ASSUMPTIONS	This study tested a connected vehicle application entitled Eco-Cooperative Adaptive Cruise Control (ECACC) that uses infrastructure-to-vehicle (I2V) communication to receive signal phasing and timing (SPaT) data, predict future constraints on a vehicle's trajectory, and optimise its trajectory to minimise the vehicle's fuel consumption level. The ECACC system is able to provide fuel savings within the vicinity of signalised intersections in the range of 5-30%.	12A	Kamalanath-sharma, R. K., & Rakha, H. A. (2016).
ASSUMPTION 17	ASSUMPTIONS	Market research has shown that the effective use of telematics can reduce fuel costs by as much as 14%.	13A	GEOTAB, 2016
ASSUMPTION 18	ASSUMPTIONS	Sycada's Green Fleet Monitor uses drive style analysis and – feedback to reduce fuel consumption of cars, LCV's, trucks and buses with typical savings of 10-20%.	14A	Department of Transport, UK, 2018.
ASSUMPTION 19	ASSUMPTIONS	For example, a provider of such systems - The Miles Consultancy – claims that their compliance, audit and driver chasing process typically reduces the cost of mileage claims by an average of 15.4%, equating to an average saving of 18.06 pence per litre.	15A	Syca-da-Green

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	NAVIGATION APPS		
	MECHANISM	Use of navigation apps such as Apple maps, Google maps, Waze etc. help to make car journeys more efficient (by avoiding congestion and avoiding getting lost), thus reducing carbon emissions.		
	METHODOLOGY	Data was collected from the B2B International Survey into Consumer Smartphone Trends. The carbon emissions abatement factor for those who use navigation apps was calculated by taking the number of people who use navigation apps, multiplied by the number of times per year that navigation apps are used, multiplied by the % reduction in emissions due to use of navigation apps, multiplied by the average car emission factor. This was then divided by the total number of respondents to the survey to get the carbon abatement per smartphone user.		
ASSUMPTION 1	ASSUMPTIONS	This question asked about the numbers of people using smartphones for navigation, and the frequency and average distance of trips.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	Assumed that use of navigation apps results in fuel savings of 1.9% based on the following two references:	-	-
ASSUMPTION 3	ASSUMPTIONS	The NREL Navigation API Route Fuel Saving Opportunity Assessment study (2018) quotes the following fuel savings opportunities from green routing (from other studies): 12.5% (ideal); 8.2%; 10%. The NREL study modelled results giving 12.2% fuel savings, applicable to 31% of routes, equivalent to an average saving of 3.8% for 'green routing'. Assume that current use of satnav gives 50% benefit that green routing would - i.e. 1.9% saving.	255	NREL Fuel saving Opportunity assessment study
ASSUMPTION 4	ASSUMPTIONS	For comparison the SWOV fact sheet on safety effects of navigation systems quotes a reduction of 16% in journey distances from use of satnav in unfamiliar areas. Assuming 10% of routes are in unfamiliar areas gives a saving of 1.6%.	88	SWOV fact sheet
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	RIDE HAILING		
	MECHANISM	Use of mobile technology allows smartphone users to hail and book taxis, reducing the need for other transport modes and thus reducing carbon emissions.		

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The carbon emissions abatement factor for those who use ride hailing was calculated by taking the number of times ride hailing is used per year, multiplied by the average length of the journey, multiplied by the proportion of other transport modes used if ride hailing is not, and their emission factors. From this the emissions due to the ride-hailing vehicle are subtracted. The resulting factor is adjusted by the total number of respondents to the survey to get the carbon abatement per smartphone user.		
ASSUMPTION 1	ASSUMPTIONS	This question on the survey asked people if and how often they use their smartphone for taxi hailing, the average distance they travel when using taxi hailing, and the main method of transport they would use if not using taxi hailing.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	Standard emission factors for the different transport modes used were derived from BEIS GHG emission factors. The emission factor used for the ride-hailing vehicle was for an average hybrid car, as a large proportion of such vehicles are more efficient than a standard average car.	219	BEIS emission factors
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	RIDE SHARING		
	MECHANISM	Use of smartphone apps that help people who are already driving long journeys to share rides with others, thus reducing carbon emissions by avoiding the need for alternative travel modes. e.g. blablacar.com, liftshare.com		
	METHODOLOGY	Data was collected from the B2B International Survey into Consumer Smartphone Trends. The carbon emissions abatement factor for those who use ride sharing apps was calculated by taking the number of people use these apps, multiplied by the average number of journeys by each transport type avoided and its emission factor, multiplied by the average journey distance. For cars, the emission abatement is per passenger as only one car journey is saved. This was then multiplied by the number of people who use ride sharing and divided by the total number of respondents to the survey to get the carbon abatement per smartphone user. "Other" percentages are negligible and answers to the B2B survey variant, and walking and biking release zero emissions, and so are not included in this emissions abatement.		
ASSUMPTION 1	ASSUMPTIONS	This question of the survey asked people if they used their mobile to arrange car sharing, how often per year they used ride sharing, the average distance travelled using ride sharing and the alternative method of transport taken if ride sharing not used.	-	The B2B International Survey into Consumer Smartphone Trends

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	SEA FLEET		
	MECHANISM	Tracking of sea fleets and real-time information updates through M2M connections allows for optimised routings, direction of ships to most appropriate port, reducing waiting and loading times at docks. This results in overall savings in transport fuel used and reduced emissions.		
	METHODOLOGY	SEMAFORS optimised ship routing estimates fuel savings of up to 5%. Using this information and taking a conservative estimate of real savings of 2%, this was applied to the average emissions of a commercial ship. The average is calculated from the overall global shipping emissions divided by the number of vessels. This information is obtained from the IMO (International Maritime Organization).		
ASSUMPTION 1	ASSUMPTIONS	Total annual emissions from the global shipping fleet were 972,000,000tCO_2e. This is based on 54,897 vessels.	171	IMO
ASSUMPTION 2	ASSUMPTIONS	Assume a conservative estimate of 2% savings.	172	SEMAFORS
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	SMART LOGISTICS - EFFICIENT ROUTING & FLEET MANAGEMENT		
	MECHANISM	Better routing and coordination of vehicle fleets, enabled through telematics systems connected via mobile networks in HGVs, results in the reduction of total distance travelled, avoiding areas of high congestion, optimising fuel usage and ultimately reducing emissions.		
	METHODOLOGY	The calculation methodology uses the weighted average emission per HGV per country multiplied by a 5% fuel saving from telematics, found from several sources, to find the CO_2e abatement factor per vehicle as well as the abatement factor for fuel per vehicle. The average emissions for cars, LGVs and HGVs was calculated from national data on total distance, number of vehicles, and standard emission factors, and the weighted average calculated assuming mix of car/LGV/HGV for M2M connections.		
ASSUMPTION 1	ASSUMPTIONS	A 5% fuel saving was assumed (various sources suggest 2-25% savings)	-	-
ASSUMPTION 2	ASSUMPTIONS	Average annual distances for cars/LGVs/HGVs were used based on national statistics and emission factors.	-	-

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 3	ASSUMPTIONS	A mix of vehicle types (20% car/60% LGV/20% HGV) were assumed based on typical split of M2M connections for Fleet Management. (Carbon Trust analysis).	-	-
ASSUMPTION 4	ASSUMPTIONS	That routing savings are only applicable to goods vehicles was assumed.	-	-
ASSUMPTION 5	ASSUMPTIONS	That the percentage of fuel saving is the same across countries was assumed.	-	-
ASSUMPTION 6	ASSUMPTIONS	This source suggests telematics could introduce a 2-10% fuel saving.	50	Wireless article (DT)
ASSUMPTION 7	ASSUMPTIONS	This source suggests telematics could introduce a 9% saving in all fleet.	54	Fleet News
ASSUMPTION 8	ASSUMPTIONS	This source suggests telematics could introduce a 10-15% saving.	40	Guide to Telematics
ASSUMPTION 9	ASSUMPTIONS	This source suggests telematics could introduce up to a 20% saving.	41	'Telematics explained' [41]
ASSUMPTION 10	ASSUMPTIONS	This source suggests telematics could introduce a 10%-15% saving; Jari Salminen, Vodafone head of business development, M2M.	50	Wireless article (VF)
ASSUMPTION 11	ASSUMPTIONS	This source suggests telematics could introduce a saving of 20-25%, by taking advantage of GPS vehicle tracking. Vehicles such as delivery trucks and school buses will have to decrease fuel consumption and carbon emissions by 25% compared to current standards. The estimation is a bit high; the percentage was halved to 10%.	9A	Verizon connect
ASSUMPTION 12	ASSUMPTIONS	For example, a provider of such systems - The Miles Consultancy – claims that their compliance, audit and driver chasing process typically reduces the cost of mileage claims by an average of 15.4% equating to an average saving of 18.06 pence per litre.	10A	Department of Transport, UK, 2018. How fleets can use technology to manage driver behaviour and vehicle efficiency

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	SMART LOGISTICS - LOADING OPTIMISATION		
	MECHANISM	Remote monitoring of vehicle loading, enabled through telematics systems connected via mobile networks in HGVs, allows for better utilisation of vehicles, reduced overall journey distance and lower emissions.		
	METHODOLOGY	The calculation methodology uses the weighted average emission per HGV per country multiplied by a 2% fuel saving from telematics, found from several sources, to find the CO_2e abatement factor per vehicle as well as the abatement factor for fuel per vehicle. The average emissions for cars, LGVs and HGVs was calculated from national data on total distance, number of vehicles, and standard emission factors, and the weighted average calculated assuming mix of car/LGV/HGV for M2M connections.		
ASSUMPTION 1	ASSUMPTIONS	A 2% fuel saving for loading optimisation of goods vehicles was assumed. Reference indicates that 10% of miles in the USA of leased freight is empty. A fifth of the 10% figure (i.e. 2%) is assumed to be able to be saved due to telematics. Various other sources suggest 2-15% savings due generically to telematics in vehicles. - e.g.	39	Carbon War Room, Road Transport
ASSUMPTION 2	ASSUMPTIONS	This source suggests telematics could introduce a 2-10% fuel saving.	50	Wireless article (DT)
ASSUMPTION 3	ASSUMPTIONS	This source suggests telematics could introduce a 9% saving in all fleet.	54	FleetNews
ASSUMPTION 4	ASSUMPTIONS	This source suggests telematics could introduce a 10-15% savings.	40	Guide to Telematics
ASSUMPTION 5	ASSUMPTIONS	This source suggests telematics could introduce up to a 20% saving.	41	'Telematics explained' [41]
ASSUMPTION 6	ASSUMPTIONS	This source suggests telematics could introduce a 10%-15% saving; Jari Salminen, Vodafone head of business development, M2M.	50	Wireless article (VF)
ASSUMPTION 7	ASSUMPTIONS	Average annual distances for cars/LGVs/HGVs were used based on national statistics and emission factors.	-	-

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 8	ASSUMPTIONS	A mix of vehicle types (20% car/60% LGV/20% HGV) were assumed based on typical split of M2M connections for Fleet Management. (Carbon Trust analysis).	-	-
ASSUMPTION 9	ASSUMPTIONS	That loading optimisation is only applicable to goods vehicles was assumed.	-	-
ASSUMPTION 10	ASSUMPTIONS	It was assumed that smart logistics increase the logistics capacity to up to 70%, which brings 16% emission reduction in 2020.	11A	WWF, 2010
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	TRAFFIC CONGESTION MANAGEMENT		
	MECHANISM	Traffic congestion management through signs and signals control, resulting in reduced traffic congestion, and therefore reduced fuel consumption.		
	METHODOLOGY	To calculate vehicle reduction per device, the number of vehicles passing through the congestion charge is taken and then divided by the number of traffic monitoring devices, taking into account previously recorded figures. The percentage reduction in the number of vehicles is then multiplied by the average journey distance. This is then multiplied by an emission factor for an average car to develop an overall abatement factor per device.		
ASSUMPTION 1	ASSUMPTIONS	Transport for London data shows a 14% reduction in vehicles entering the London congestion zone compared to pre-congestion charging. This percentage is taken together with the number of monitoring devices to calculate a vehicle reduction per device.	176	TFL
ASSUMPTION 2	ASSUMPTIONS	Supporting data showing that road pricing results in 16% less carbon emissions.	80	Urban Road Charges
ASSUMPTION 3	ASSUMPTIONS	Annual abatement is based on 260 working days per year (week days). This is multiplied by the average weekday driving distance to get an annual figure.	-	-
ASSUMPTION 4	ASSUMPTIONS	Average weekday trip driving distance data for Europe is from the European Commission JRC report.	205	JRC Driving and Parking

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 5	ASSUMPTIONS	Average weekday trip driving distance for USA is from US Department of Transportation data.	206	US DOT NHTS
ASSUMPTION 6	ASSUMPTIONS	Statistics webpage showing the number of traffic count points in London is now 2,991.	224	DFT 2019
ASSUMPTION 7	ASSUMPTIONS	TFL statistics showing camera captures and confirmed vehicles seen in the congestion zone by month. From this data, the number of confirmed vehicles passing through the congestion zone is calculated from Oct-16 to Feb-19 - 98,483.	225	TFL 2019
ASSUMPTION 8	ASSUMPTIONS	There is a network of 197 camera sites which monitor every single lane of traffic at both exit and entry points to the charging zone.	226	TFL 2019 (1)
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	TRAFFIC CONGESTION MONITORING (ROAD SIGNS AND TRAFFIC LIGHTS)		
	MECHANISM	Smart monitoring of traffic congestion and traffic hotspots. Connected road signs direct traffic away from these areas to avoid further congestion and optimise routing. Smart monitoring of traffic flow to communicate between lights and optimise wait times at junctions. This will prevent traffic delays and allow drivers to maintain a more consistent speed, reducing fuel consumption and emissions.		
	METHODOLOGY	Smart traffic signals' and smart traffic lights ' emissions savings arise from being able to maintain a more consistent speed while driving, this is as a result of avoiding congestion areas. The associated carbon reduction was calculated by taking the distance travelled by an average car while being 'affected' by the sign/light as it passes. The distance affected was multiplied by the average car emission factor and the associated emission reduction attributed to the sign/light. Each year an estimated number of vehicles will pass each sign/light, so the annual carbon abatement was found by the number of cars passing a sign/light per day scaled up to a year.		
ASSUMPTION 1	ASSUMPTIONS	Assumed that one car arrives at a sign every 4 seconds during peak periods (7am-7pm).	-	-
ASSUMPTION 2	ASSUMPTIONS	Assumed that the sign impacts journey for 400m.	-	-

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 3	ASSUMPTIONS	Studies showed a 7% reduction in GHG emissions, as a result of intelligent traffic systems (US).	222	ITS US case study
ASSUMPTION 4	ASSUMPTIONS	Environmental ITS programmes in the EU have typically shown energy and emission reductions on the order of 5 - 15%. For the U.S, studies showed emissions reductions in the range of 5 - 10%.	223	Springer Transporta-tion paper
ASSUMPTION 5	ASSUMPTIONS	Based on the studies above showing a 5 - 15% emission reduction, an average figure of 10% is taken for EU countries. For the US, an average figure of 8.5% is taken from the 2 studies above.	-	-
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	USABILITY OF PUBLIC TRANSPORT		
	MECHANISM	Use of online, text or app-based access to real-time information on public transport services encourages greater use of public transport. This results in a modal shift from car to public transport, reducing carbon emissions.		
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The carbon emissions abatement factor for those who have access to real-time public transport information was calculated by taking the number of times public transport was chosen as the mode of transport as a result of access, multiplied by the average length of a public transport journey per country, multiplied by the difference in emission factors between driving and public transport. This is then multiplied by the number of mobile real-time info users and divided by the total number of respondents to the survey to get the carbon abatement per smartphone user.		
ASSUMPTION 1	ASSUMPTIONS	This question on the survey asked people if they have access to real-time information about public transport on their smartphone, if this makes them use public transport more and how much more often they use public transport as a result.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	It is assumed that use of public transport is replacing travel by car.	-	-
ASSUMPTION 3	ASSUMPTIONS	Average journey distance by public transport for different countries was taken from the following sources:	-	-
ASSUMPTION 4	ASSUMPTIONS	The average UK public transport journey distance was calculated from the graph in Transport Statistics Great Britain 2018.	264	UK average public transport journey distance

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 5	ASSUMPTIONS	The average USA public transport journey distance found from the 2019 Public Transportation Fact Book.	265	USA average public transport journey distance
ASSUMPTION 6	ASSUMPTIONS	The average Brazil public transport journey distance was calculated from the average of the average Rio and Sao Paulo public transport journey distances.	266	Rio de Janeiro average public transport journey distance
ASSUMPTION 7	ASSUMPTIONS	The average Brazil public transport journey distance was calculated from the average of the average Rio and Sao Paulo public transport journey distances.	267	Sao Paulo average public transport journey distance
ASSUMPTION 8	ASSUMPTIONS	The average Mexico public transport journey distance was sourced assuming that the value for Mexico City applies to the whole country.	268	Mexico average public transport journey distance
ASSUMPTION 9	ASSUMPTIONS	The average India public transport journey distance was found from an average of 12 Indian cities.	269	India average public transport journey distance
ASSUMPTION 10	ASSUMPTIONS	The average China public transport journey was sourced from the 2018 China City Commuting Report.	270	China average public transport journey distance
ASSUMPTION 11	ASSUMPTIONS	The average South Africa public transport journey distance was calculated from the average of: the average Pretoria and the average of 4 Cape Town public transport journey distances.	271	South Africa average public transport journey distance
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	USAGE-BASED CAR INSURANCE		
	MECHANISM	Telemetrics (black box) in car collects data on driving behaviour, and rewards safe driving with lower insurance premiums. This leads to improved driving behaviour, reduced fuel consumption and reduced repairs due to accidents.		
	METHODOLOGY	The calculation methodology is based on a fuel saving factor from eco driving, multiplied by average distance driven using a small car emission factor. This is added to calculated savings from reduced accidents: economic input output data showing the average emissions per £ spent on car repairs, multiplied by the reduction in the average car insurance claim for 17-25 year olds from having a black box installed.		

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 1	ASSUMPTIONS	0.2889 kgCO_2e per £ spent on car repairs (Carbon Trust analysis derived from EEIO factors).	-	Carbon Trust
ASSUMPTION 2	ASSUMPTIONS	Assumed 5% fuel saving due to improved driver behaviour.	-	-
ASSUMPTION 3	ASSUMPTIONS	A study by LexisNexis Risk Solutions of drivers in the UK found that the technology has helped reduce accidents among 17- to 19-year-old drivers by 35.3% since 2011.	16A	2016 Boltinc Solution
ASSUMPTION 4	ASSUMPTIONS	Telematics-based solutions can lift the combined ratio 15 - 20% over the traditional auto-insurance book.	17A	Boston Consulting Group
ASSUMPTION 5	ASSUMPTIONS	Average for private motor insurance in 2017 for people aged 18-20, 21-25 is £4,100 and £3,400.	18A	abi.org.uk
ASSUMPTION 6	ASSUMPTIONS	In 2017, the average for car insurance is $3,425 (£2,689).	19A	Insurance Information Institute
ASSUMPTION 7	ASSUMPTIONS	China Insurance Consumer White Book, 2018: In 2017, the per capita claim amount reached 8614 yuan ($1,230 or £966).	20A	PWC,2018
	TECH CATEGORY	SMART TRANSPORT AND CITIES		
	TECH SUBCAT	BIKE SHARING		
	MECHANISM	Use of mobile apps and online booking allows people to ride public bikes instead of using other transport methods, thus reducing carbon emissions.		
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The carbon emissions abatement factor for those who use bike sharing schemes was calculated by taking the number of times bike sharing schemes used per year, multiplied by the average length of the journey via bike, multiplied by the proportion of other transport modes used if bike sharing is not, and their emission factors. This is then multiplied by the number of bike sharing users and divided by the total number of respondents to the survey to get the carbon abatement per smartphone user.		
ASSUMPTION 1	ASSUMPTIONS	This question on the survey asked people if and how often they use their smartphone for bike sharing schemes, how far they travel when using bike sharing, and the main method of transport they would use if not using bike sharing schemes.	-	The B2B International Survey into Consumer Smartphone Trends

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	ACCOMMODATION SHARING		
	MECHANISM	Use of mobile technology facilitates booking accommodation in shared or unused houses, as opposed to in hotels (such as Airbnb). The average carbon impact of a night in a hotel is much greater than that of a residential house, and so carbon emissions are reduced.		
	METHODOLOGY	Data was collected from the B2B International Survey into Consumer Smartphone Trends. The carbon emissions abatement factor for those who use accommodation sharing was calculated by taking the number of people who use accommodation sharing apps, multiplied by the number of nights per year accommodation sharing used, multiplied by the % reduction in emissions from hotels, multiplied by the different hotel emission factors by country. This was then divided by the total number of respondents to the survey to get the carbon abatement per smartphone user.		
ASSUMPTION 1	ASSUMPTIONS	This question of the survey asked people if they used their mobile to book accommodation sharing, such as Airbnb, and how often per year they used accommodation sharing.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	An Airbnb report suggested 61% (US) - 89% (EU) reduction in emissions when using an Airbnb room compared to a hotel stay.	254	Average emission reduction from accommodation sharing vs hotels
ASSUMPTION 3	ASSUMPTIONS	For other regions a reduction of 50% was used to be more conservative, in absence of any specific data other than for US and EU.	-	-
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	AUDIO CONFERENCING		
	MECHANISM	Use of smartphones to join conference calls reduces the need for business travel, thus reducing carbon emissions.		
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The carbon emissions abatement factor for those who use their smartphones for conference calling was calculated by taking the number of times per year that the user conference calls, multiplied by the average distance travelled to a meeting if conference calling not used, multiplied by the proportion of conference calls that would be replaced by physical meetings if conference calling didn't exist, multiplied by the emission factors of the transport type taken. This is then multiplied by the number of conference call users and divided by the total number of respondents to the survey to get the carbon abatement per smartphone user.		

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 1	ASSUMPTIONS	This question on the survey asked people if and how often they use their smartphone for conference calls, if conference calling didn't exist, what proportion of calls would be replaced with physical meetings, the average distance travelled to physical meetings and what method of transport they would take.	-	The B2B International Survey into Consumer Smartphone Trends
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	VIDEO-CALLING WITH FRIENDS AND FAMILIES		
	MECHANISM	Use of mobile device for video calls to friends and family, thus reducing carbon emissions by reducing the need for travel to visit them.		
	METHODOLOGY	Data was collected from the B2B International Survey into Consumer Smartphone Trends. The carbon emissions abatement factor for those who have long-distance friends and family was calculated by taking the number of people with long distance friends, multiplied by the proportion of each transport type taken and its emission factor, multiplied by the average distance travelled over 2 hours on each transport type, multiplied by the difference between the frequency of visits without and with smartphones. This was then multiplied by the number of visits taken without smartphone calling and divided by the total number of respondents to the survey to get the carbon abatement per smartphone user. "Other" percentages are negligible and answers to the B2B survey variant, and so are not included in this emissions abatement.		
ASSUMPTION 1	ASSUMPTIONS	This question of the survey asked people if they had close friends and family who live over 2 hours travel away, and if they use their smartphone to call or video-call these friends and family. It then asked how often they physically visit these friends and family, the main method of transport used, and if smartphones didn't exit, how much more they would visit instead.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	The average distance travelled per mode of transport is assumed from the average distance able to be travelled by each mode of transport in 2 hours. This is 200km for each type, except by airplane, which is 1,800km, based off an average speed of 900km/h. This value for average speed of a passenger plane is taken from Ref Nr 253.	253	Average speed of a passenger plane
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	MOBILE BANKING		
	MECHANISM	Use of mobile phone for banking transactions, reducing the need to travel to a physical bank branch, thus reducing carbon emissions.		

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The carbon emissions abatement factor for those who use mobile banking was calculated by taking the number journeys saved per smartphone mobile shopper per year, multiplied by the average public transport emission factor per country, multiplied by the average distance travelled to their bank branch. This is then multiplied by the number of mobile bankers with a branch, divided by the total number of respondents to the survey to get the carbon abatement per smartphone user.		
ASSUMPTION 1	ASSUMPTIONS	This question on the survey asked people if they used their smartphones for mobile banking, if they have a branch, how often they visit their branch and how many journeys mobile banking saves them from making to their branch.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	The average distance to a physical bank branch in Germany was calculated from the average of the East (13km) and the West (9km).	278	Average distance to a local bank branch - Germany
ASSUMPTION 3	ASSUMPTIONS	The average distance to a physical bank branch in the UK was found to be 2.3miles.	279	Average distance to a local bank branch - UK
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	MOBILE SHOPPING		
	MECHANISM	Use of online and app-based shopping reduces the need to travel to shops, instead being delivered by post, thus reducing carbon emissions.		
	METHODOLOGY	Data was collected from the B2B International Survey into Consumer Smartphone Trends. The carbon emissions abatement factor for those who use mobile shopping was calculated by taking the number journeys saved per smartphone mobile shopper per year, multiplied by the proportion of each transport type taken and its emission factor, multiplied by the average distance travelled to the shop before mobile shopping. The average emissions per parcel delivery drop was multiplied by the number of times mobile shopping was used per smartphone user per year. The carbon abatement per smartphone user was calculated by taking the difference between the emissions of the journey taken by the shopper before mobile shopping and the delivery emissions, and divided by the total number of respondents to the survey to get the carbon abatement per smartphone user. "Other" percentages are negligible and answers to the B2B survey variant, and so are not included in this emissions abatement.		

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 1	ASSUMPTIONS	This question on the survey asked people if they used their smartphones for mobile shopping, how often, how many journeys it saves them from making and how far they would have to travel, and by what method, to a store if they didn't use mobile shopping	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	A study found that the average emissions per drop from parcel delivery was 0.316kgCO_2e.	256	Average emissions from parcel delivery
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	MULTI-FUNCTIONAL DEVICE		
	MECHANISM	Use of smartphone to replace multiple devices (e.g. camera, calculator, non-smartphone, music player, game console, alarm clock, satnav). Leading to reduced embodied emissions of multiple devices.		
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The percentage of smartphone users that say they replace devices with a smartphone was taken. The embodied carbon avoided was calculated by multiplying the percentage of smartphone users by the embodied carbon avoided from other device use and divided by the assumed replacement period in years.		
ASSUMPTION 1	ASSUMPTIONS	Percentage of smartphone users that say they replace devices with a smartphone is taken from consumer survey. UK: 58%, USA 62%, Spain 70%, Average 64%.	207	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	Embodied carbon footprint for different devices from industry study. Feature phone: 5.4 kgCO_2e. MP3 player: 10.3 kg CO_2e. Camera: 19 kg CO_2e. Game console: 31.6 kgCO_2e. Satnav device: 18.6 kgCO_2e. Smartphone: 41.9 kgCO_2e.	-	-
ASSUMPTION 3	ASSUMPTIONS	Percentage of smartphone users that use other functions on their smartphone - figures from consumer research.	207	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 4	ASSUMPTIONS	Assume typical replacement period for devices of 2 years.	-	-
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	SHARING ECONOMY (GOODS SHARING)		

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	MECHANISM	Use of mobile technology facilitates a market for second-hand goods. Renting equipment avoids the purchase and manufacture of new goods, thus reducing carbon emissions.		
	METHODOLOGY	Data was collected from the B2B International Survey into Consumer Smartphone Trends. The carbon abatement factor for people who use their smartphone to rent or share goods was calculated by the percentage of smartphone users who rent/share goods multiplied by the average annual embodied emissions of rented goods. The average annual embodied emissions of rented goods was calculated by finding the embodied emissions of the most common shared/rented goods, their annual lifetime replacement factor (if the product's lifetime is 10 years, then the replacement factor is 0.1) and the number of rentals of each type of good per year. The average annual embodied emissions of goods rented was calculated by the sum of the embodied emissions multiplied by the lifetime replacement factor, then divided by the number of type of goods.		
ASSUMPTION 1	ASSUMPTIONS	This question of the survey asked people if they used their smartphone to rent or buy second-hand items, and how often on average they did this per year.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	The embodied emissions of a lawnmower were found from this LCA.	272	Chalmers University of Technology
ASSUMPTION 3	ASSUMPTIONS	The embodied emissions of a drill were found from this LCA.	273	WRAP
ASSUMPTION 4	ASSUMPTIONS	The embodied emissions of sport shoes were found from this LCA.	274	Nike
ASSUMPTION 5	ASSUMPTIONS	The embodied emissions of a CD were found from this LCA.	275	Intel
ASSUMPTION 6	ASSUMPTIONS	The embodied emissions of a book were found from this LCA.	276	UQAC
ASSUMPTION 7	ASSUMPTIONS	The most frequently shared goods were identified from this French report, e.g. Gardening, Catering, Video equipment, Maintenance.	277	IDDRI
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	SMART HEALTH - HOME CARE		

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	MECHANISM	Monitoring of chronic or high risk patients at home is possible over mobile networks and thus car journeys to hospital are avoided. This monitoring also results in a reduction in number of days needed to stay at the hospital, and a reduction in travel for health professionals to visit patients at home. These reductions in travel and hospital emissions quantify the enablement.		
	METHODOLOGY	The calculation was based on the emission factor for a hospital stay multiplied by the distance for a round trip to hospital and the emission factor for a large car, then multiplied by the average annual admissions per patient per year.		
ASSUMPTION 1	ASSUMPTIONS	15,624,000 hospital admissions in the UK annually - this is divided by the UK population to give an average of 0.24 hospital admissions per person per year. It was assumed that this is representative of people with health monitors - in practise they will likely have a higher admission rate. *2019 GSMA update: Have used updated admission and population figures to update this calculation = 0.24*	107	NHS
ASSUMPTION 2	ASSUMPTIONS	Hospital stay emission factor (440 $kgCO_2e$ per hospital stay) is from Carbon Trust research, based on NHS data. The NHS sustainable development unit paper [243] from 2010 calculates an emission factor of 382 $kgCO_2e$ per inpatient admission. An average EF of 411 $kgCO_2e$ is therefore calculated.	-	-
ASSUMPTION 3	ASSUMPTIONS	Assumed travel to hospital in a large car, as likely to be a range of cars and ambulances.	-	-
ASSUMPTION 4	ASSUMPTIONS	Average distances to hospital are from OECD data for different countries.	-	-
ASSUMPTION 5	ASSUMPTIONS	Results from trialling telemedicine across selected NHS Trust's indicated a reduction in hospital admissions of 45%, 60% reduction in A&E attendances, 50% reduction in overall bed days, and 9% reduction in overall length of stay.	234	NHS (1)
ASSUMPTION 6	ASSUMPTIONS	In 2017/18 16.6 million finished admission episodes were recorded.	235	NHS (2)
ASSUMPTION 7	ASSUMPTIONS	The hospital admission rate for Germany is at 255 per 1,000 population, which is the third highest in the EU (21,111,450 total).	236	European Commission 2017

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
ASSUMPTION 8	ASSUMPTIONS	Statistics show that the number of admissions to full-time hospitalisation in healthcare facilities across France in 2015 was 12,114,847.	237	Statista 2015
ASSUMPTION 9	ASSUMPTIONS	In the U.S in 2016, there were about 35.7 million hospital stays with a mean length of stay of 4.6 days and a mean cost of $11,700 per stay.	238	Healthcare Cost and Utilisation Project (HCUP) 2018
ASSUMPTION 10	ASSUMPTIONS	Two studies of telemedicine trials found the following results. telehealth remote monitoring reduced hospital admissions significantly, including 56% for depression; 20% for diabetes; 40% for other mental health issues. In a separate study, a 51% reduction in readmission is recorded for cardiac patients who were monitored using telehealth technology. An average reduction in admission figure of 41.75% is therefore taken for the US, based on the studies above.	239	Ortholive 2019
ASSUMPTION 11	ASSUMPTIONS	Studies from Anker et al 2011 suggest that across France, telemonitoring led to a reduction of all hospitalisations of 47.2% vs 52.1%. An average figure of 49.5% for hospital admission reduction is therefore assumed for France.	240	Journal of clinical medicine 2018
ASSUMPTION 12	ASSUMPTIONS	In 2011 the number of hospitalisations in China was about 150 million.	241	China Growth Analysis
ASSUMPTION 13	ASSUMPTIONS	The total inpatient admission carbon footprint of the NHS was 382kgCO_2e.	243	NHS sustainable develop-ment unit, 2010
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	SMART HOMES		
	MECHANISM	Use of smart phone to remotely control devices in the home, thus reducing energy use.		

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ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	METHODOLOGY	We estimate the average annual emissions per person (for household gas and electricity emissions) and multiply this by the percentage of reduction in energy consumption due to remotely controlling devices through services such as Nest or Hive. We then multiply this energy reduction by the percentage of people who control devices in the home using a smart phone. This gives the carbon abatement per person for those who already control their devices remotely. The volume factor is the number of people with a smart phone.		
ASSUMPTION 1	ASSUMPTIONS	Studies by Nest Labs in 2001 indicates 10-12% savings on heating and 15% savings on cooling, or about $131-145 in savings a year. We assume the energy saving percentage by average is 12.5%	1A	2019 Techwalls
ASSUMPTION 2	ASSUMPTIONS	Statista research in the South Africa market has indicated that revenue is expected to show an annual growth rate of 37.1% in the next four years with an anticipated household penetration of 3.6 % in 2018 that is expected to hit 9.8 % by 2022	2A	Private Property. co.za,2018
ASSUMPTION 3	ASSUMPTIONS	8 million households in EU owns thermostats, accounting for 3.6%	3A	2019 Statista
ASSUMPTION 4	ASSUMPTIONS	1.5 million households in UK owns thermostats, accounting for 5.5%	4A	utilityweek 2019
ASSUMPTION 5	ASSUMPTIONS	15% households owns thermostats in U.S.	5A	archnews
ASSUMPTION 6	ASSUMPTIONS	Percentage Reduction of energy consumption due to remote controlling of device in China is 20% in average. Similar to the UK figure, we assume that this is likely to be estimated based on perfect conditions. Therefore, we lower this percentage and assume a 12.5% energy saving when remote controlling your home.	6A	2017, Smart Of Week. com
ASSUMPTION 7	ASSUMPTIONS	Studies by Nest Labs in 2001 indicates 10-12% savings on heating and 15% savings on cooling, or about $131-145 in savings a year. We assume the energy saving percentage by average is 12.5%	7A	2017, Smart Of Week. com

ASSUMPTION	LABEL	TEXT	REF NR	REF ABBREV
	TECH CATEGORY	SMART WORKING, LIVING AND HEALTH		
	TECH SUBCAT	WORKING FROM HOME		
	MECHANISM	Use of smartphone technology allowing people to work from home, reducing the need for business travel and thus reducing carbon emissions.		
	METHODOLOGY	The calculation methodology uses data from the B2B Consumer Smartphone Trends survey. The carbon emissions abatement factor for those who work from home using their smartphone was calculated by taking the number of times per year that the user worked from home, multiplied by the average distance travelled to the workplace, multiplied by the emission factors of the transport type taken into work. The rebound effects of increased home energy consumption were included in the calculation.		
ASSUMPTION 1	ASSUMPTIONS	The question on the survey asked people if and how often they worked from home (enabled by having a smartphone), how far they would travel to work from home and the main method of transport they use to get into work.	-	The B2B International Survey into Consumer Smartphone Trends
ASSUMPTION 2	ASSUMPTIONS	Home energy consumption was calculated based on assumptions of additional electricity used when working at home compared to an office, plus additional energy used for heating or cooling of one room at home. Assumptions were 20W of electrical power for 8 hours per day, and 1.5 kW of additional heating/cooling for 8 hours per day (but heating/ cooling only required for half of the year).	-	-

Appendix 4 – Data Sources and References

Detailed below are the data sources used to calculate the avoided emissions of mobile communications technology.

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
1	Carbon connections: Quantifying mobile's role in tackling climate change	Vodafone and Accenture	2009	https://www.vodafone.com/content/dam/vodcom/sustainability/pdfs/carbon_connections.pdf
1A	2019 Techwalls	Techwalls	2019	-
2A	Smart home become more popular in South Africa	Private Property.co.za	2018	https://www.privateproperty.co.za/advice/news/articles/smart-homes-becoming-more-popular-in-south-africa/6156
3A	Homes with Smart Thermal in EU	Statista	2019	https://www.statista.com/statistics/650536/homes-with-smart-thermostats-in-the-eu/
4A	Smart Thermal now in 1.5million homes	utilityweek	2019	https://utilityweek.co.uk/smart-thermostats-now-in-1-5-million-homes/
5A	Smart thermals are making their way into existing homes	archnews	2019	https://www.achrnews.com/articles/139920-smart-thermostats-are-making-their-way-into-existing-homes
6A	2017, Smart Of Week.com	Smart Of Week.com	2017	https://smarthome.ofweek.com/2017-06/ART-91005-8110-30149039_2.html
7A	2017, Smart Of Week.com	Smart Of Week.com	2017	https://smarthome.ofweek.com/2017-06/ART-91005-8110-30149039_2.html
9A	How a fleet management tool can help you reduce fuel costs	Verizon connect	2019	https://www.verizonconnect.com/resources/article/how-a-fleet-management-tool-can-help-you-reduce-fuel-costs/
10A	How fleets can use technology to manage driver behaviour and vehicle efficiency	Department of Transport, UK	2018	https://www.energysavingtrust.org.uk/sites/default/files/EST_Telematics%20guide.pdf
11A	Low-carbon communication solutions in China: emission reduction contribution and emission reduction potential	WWF	2010	www.wwfchina.org/content/press/publication/ChinaMobilechn.pdf
12A	Leveraging connected vehicle technology and telematics to enhance vehicle fuel efficiency in the vicinity of signalized intersections. Journal of Intelligent Transportation Systems, 20(1), 33-44.	Kamalanathsharma, R. K., & Rakha, H. A.	2016	-
13A	-	GEOTAB	2016	-

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
14A	How fleets can use technology to manage driver behaviour and vehicle efficiency	Department of Transport, UK	2018	https://www.energysavingtrust.org.uk/sites/default/files/EST_Telematics%20guide.pdf
15A	Green solution	Sycada-Green	2019	https://www.sycada-green.com/en/solutions
16A	Telemetrics auto-insurance	Boltinc Solution	2016	https://www.boltinc.com/telemetrics-auto-insurance/
17A	Insurance telemetrics tests insurers	Boston Consulting Group	2015	https://www.bcg.com/publications/2013/insurance-telematics-test-insurers.aspx
18A	Choosing the right insurance	abi.org.uk	2017	https://www.abi.org.uk/products-and-issues/choosing-the-right-insurance/motor-insurance/age-and-motor-insurance/
19A	Facts/statistics on auto insurance	Insurance Information Institute	2017	https://www.iii.org/fact-statistic/facts-statistics-auto-insurance
20A	China Insurance Consumer White Book, 2018	PWC	2018	http://finance.sina.com.cn/money/insurance/bxdt/2018-09-19/doc-ihkhfqns7236530.shtml
21A	CoMoUK, England & Wales Car Club Annual Survey 2017/18	CoMoUK	2019	https://como.org.uk/wp-content/uploads/2019/06/EW-report-v4.0.pdf
22A	2017 China's first-tier cities share car travel reports	Research Institute of the Ministry of Communications:	2018	https://36kr.com/p/5076239
23A	How green is the sharing economy	The Wharton University of Pennsylvania	2018	https://knowledge.wharton.upenn.edu/article/how-green-is-the-sharing-economy/
31	A Primer on the (Strong) Smart Grid and its Potential for Reducing GHG Emissions in China and the United States	NRDC White Paper	2010	-
39	Road Transport: Unlocking Fuel-Saving Technologies in Trucking And Fleets	CarbonWar Room	2012	-
40	A guide to Telematics	Energy Saving Trust	-	-
41	Telematics Explained	The Fleet Industry Advisory Group	-	-
50	Driving efficiency with fleet management systems	Wireless Magazine	-	http://www.wireless-mag.com/Features/27169/Driving_efficiency_with_fleet_management_systems_.aspx#sthash.UF4nBUaG.dpuf
53	Mix Telematics case study	Mix Telematics	-	http://www.mixtelematics.co.uk/resources/case-studies/

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
54	Iron Mountain cuts driving incidents 80% and achieves 14% fuel savings	FleetNews	2011	http://www.fleetnews.co.uk/fleet-management/iron-mountain-cuts-driving-incidents-80-and-achieves-14-fuel-savings/40287/
74	Agricultural machine-to-machine (Agri M2M): a platform for expansion	GSMA Intelligence	-	-
80	Urban road charge in European cities	Joint Expert Group Transport - EU Commission	2010	-
82	Electric vehicle Fact Sheet	TFL	2014	-
88	SWOV Factsheet - Safety effects of navigation systems	SWOV	2010	https://www.swov.nl/en/publication/safety-effects-navigation-systems
92A	Precision Agriculture: An opportunity for EU Farmers 2014-2020	European Commission	2014	-
98	Offender Management Statistics Annual Tables 2013	Ministry of Justice	2014	https://www.gov.uk/government/statistics/offender-management-statistics-quarterly-october-december-2013-and-annual
100	Smart meter roll-out for the non-domestic sector (GB)	DECC	2012	-
101	Advanced metering for SMEs: Carbon and cost savings	Carbon Trust	2007	-
107	Key statistics on the NHS	NHS Confederation	2015 (data from 2013/14	http://www.nhsconfed.org/resources/key-statistics-on-the-nhs
112	Energy management A comprehensive guide to controlling energy use	Carbon Trust	2011	-
119	Carplus annual survey of car clubs 2014/15	Carplus	2015	-
141	Lighting control technologies and strategies to cut energy consumption	CIBSE	2015	http://www.cibsejournal.com/cpd/2010-11/
142	Occupier Density Study	BCO	2018	http://www.architectsjournal.co.uk/Journals/2013/09/10/c/y/n/BCO-Occupier-Density-Study---Final-report-2013.pdf 2018 update: http://www.bco.org.uk/Research/Publications/Office_Occupancy_Density_and_Utilisation.aspx
143	Energy Savings and Economics of Advanced Control Strategies for Packaged Air-Conditioning Units with Gas Heat	Pacific Northwest National Laboratory	2013	-

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
144	Heating, ventilation and air conditioning (HVAC) equipment	Carbon Trust	2012	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/376178/ECA762_Heating__Ventilation_and_Air_Conditioning_Equipment.pdf
148	Better Metering Toolkit	The Building Centre	2011	Electricity saving from smart meters in commercial buildings for a GE case study: http://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/bbp-better-metering-toolkit.pdf
153	SMART 2020: Enabling the low carbon economy in the information age	The Climate Group, GeSI	2008	http://www.smart2020.org/_assets/files/02_smart2020Report.pdf
154	World Energy Outlook 2005	IEA	2005	-
170	Applications of Automated Controls for Voltage and reactive Power Management - Initial Results	US Department of Energy	2012	https://www.smartgrid.gov/files/VVO_Report_-_Final.pdf
171	Reduction of GHG Emissions From Ships. Third IMO GHG Study 2014 - Final Report	IMO	2014	http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf
172	SEMAFORS Shipping Routing	SEMAFORS	2014	-
173	Auf dem Weg zu einer neuen Mobilitatskultur	Carsharing.de	2015	http://carsharing.de/sites/default/files/uploads/ueber_den_bcs/pdf/bcs_jahresbericht_2014_final.pdf
174	Innovative Mobility Carsharing Outlook Carsharing Market Overview, Analysis, and Trends - Winter 2016	Berkeley TSRC	2016	http://innovativemobility.org/wp-content/uploads/2016/02/Innovative-Mobility-Industry-Outlook_World-2016-Final.pdf
176	Central London Congestion Charging Impacts Monitoring	TFL	2008	https://tfl.gov.uk/cdn/static/cms/documents/central-london-congestion-charging-impacts-monitoring-sixth-annual-report.pdf
186	-	Het Nieuwe Rijden	-	http://www.hetnieuwerijden.nl/wat-kunt-u-doen/rijstijltips/restyle-je-rijstijl-volg-de-tips-van-hnr/
187	-	ANWB	-	http://www.anwb.nl/auto/besparen/zuiniger-rijden/economisch-rijden
187	-	EcoDrive	-	http://www.ecodrive.eu/nl/mvo/het-nieuwe-rijden?gclid=CIL2jrXGr8UCFYfHtAodEA4AFQ
189	-	Sycada-Green	-	http://www.sycada-green.com/the-business-case
190	Results of Electricity Cost-Benefit Analysis	CER	2011	http://www.cer.ie/docs/000340/cer11080.pdf
205	Driving and parking patterns of European car drivers – a mobility survey	Joint Research Centre - European Commission	2012	http://publications.jrc.ec.europa.eu/repository/handle/JRC77079

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
206	Summary of Travel Trends - 2009 National Household Travel Survey	US Department of Transportation Federal Highways Administration (FHWA)	2011	http://nhts.ornl.gov/2009/pub/stt.pdf
207	The B2B International Survey into Consumer Smartphone Trends	B2B International	2019	-
214	Electricity Consumption and Expenditure Intensities for Non-Mall Buildings.	EIA	2003	http://www.eia.gov/consumption/commercial/data/archive/cbecs/cbecs2003/detailed_tables_2003/2003set10/2003html/c14.html
215	SMARTer 2020	GeSI & BCG	2012	https://gesi.org/public/research/gesi-smarter2020-the-role-of-ict-in-driving-a-sustainable-future
219	Greenhouse gas reporting: conversion factors 2019	BEIS	2019	https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019
220	Precision Agriculture: Potential and Limits	The Nature Conservancy	2017	https://www.nature.org/en-us/what-we-do/our-insights/perspectives/precision-agriculture-potential-and-limits/
221	Smart Metering Early Learning Project: Domestic Energy Consumption Analysis	DECC	2015	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/407542/2_ELP_Domestic_Energy_Consumption_Analysis_Report.pdf
222	ITS International: Benefits of traffic light synchronisation	ITS International	2011	https://www.itsinternational.com/sections/cost-benefit-analysis/features/benefits-of-traffic-light-synchronisation/
223	Intelligent Transportation Systems and Greenhouse Gas Reductions	Springer International	2015	https://link.springer.com/content/pdf/10.1007%2Fs40518-015-0032-y.pdf
224	DFT: Road traffic statistics	DFT	2019	https://roadtraffic.dft.gov.uk/regions/6
225	TFL congestion charge data	TFL	2019	https://data.london.gov.uk/dataset/vehicles-entering-c-charge-zone-month
226	TFL report on congestion charge camera systems	TFL	2019	http://content.tfl.gov.uk/cc-cameras.pdf
231	Charging point statistics 2019	Zap Map	2019	https://www.zap-map.com/statistics/#location
232	EV Database: Energy consumption of full electric vehicles	EV database	2019	https://ev-database.uk/cheatsheet/energy-consumption-electric-car
233	Charging points across EU cities	Charge Map	2019	Paris: https://chargemap.com/cities/paris-FR Berlin: https://chargemap.com/cities/berlin-DE Madrid: https://chargemap.com/cities/madrid-ES
234	Using telemedicine to reduce hospital admissions	NHS England	2014	https://www.england.nhs.uk/wp-content/uploads/2014/12/tecs-airedale.pdf

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
235	Hospital admitted patient care activity 2017-18.	NHS 2017-18	2018	https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2017-18
236	State of Health in the EU: Germany	European Commission 2017	2017	https://ec.europa.eu/health/sites/health/files/state/docs/chp_de_english.pdf
237	Full time hospitalisation in France, 2016	Statista	2015	https://www.statista.com/statistics/781707/hospitals-number-of-admissions-to-full-time-hospitalization-france/
238	Overview of U.S. Hospital Stays in 2016: Variation by Geographic Region	Healthcare cost and utilisation project (H-CUP, 2018)	2018	https://www.hcup-us.ahrq.gov/reports/statbriefs/sb246-Geographic-Variation-Hospital-Stays.jsp
239	Telehealth Improves Patient Satisfaction and Reduces Hospital Admissions	Ortholive 2019	2019	https://www.ortholive.com/blog/telehealth-improves-patient-satisfaction-and-reduces-hospital-admissions
240	Current Research and New Perspectives of Telemedicine in Chronic Heart Failure: Narrative Review and Points of Interest for the Clinician	Journal of clinical medicine	2018	https://pdfs.semanticscholar.org/1a13/ab92ce7d664f7f4d7045d8c144fd91cabcaa.pdf
241	China's Healthcare System	Swedish Agency for Growth Policy Analysis	2013	https://www.tillvaxtanalys.se/down-load/18.5d9caa4d14d0347533bc-f93a/1430910410539/direct
243	NHS sustainable development unit	NHS	2010	https://eur02.safelinks.protection.out-look.com/?url=http%3A%2F%2Fwww.sduhealth.org.uk%2Fdocuments%2F-publications%2FBed_Days.pdf&data-=02%7C01%7C%7Cf09e80b662e44b25b28508d-741934fa2%7C96e14e5a57ac48d7851d12f54eff5a60%7C0%7C0%7C637049973255674225&sdata=DGm-KI%2BrmgL86mR1Hb45yC5ZztIPRM3OzC0CKpwP-I3Ao%3D&reserved=0
244	EIA GOV 2012	EIA	2012	https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/c24.php
245	EV charging behaviour study final report	Element Energy	2019	http://www.element-energy.co.uk/wordpress/wp-content/uploads/2019/04/20190329-NG-EV-CHARGING-BEHAVIOUR-STUDY-FINAL-REPORT-V1-EXTERNAL.pdf
246	London EV infrastructure taskforce delivery plan	TFL	2019	http://lruc.content.tfl.gov.uk/london-electric-vehicle-infrastructure-taskforce-delivery-plan.pdf
247	Building Energy Efficiency Survey 2014-2015	BEES	2016	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/565748/BEES_overarching_report_FINAL.pdf
248	Entranze Enerdata	EU	2008	http://www.entranze.enerdata.eu/
249	Consumption and Efficiency	EIA	2019	http://www.eia.gov/consumption/commercial/data/2003/pdf/c1a.pdf converted total btu/ft² to kWh/m2

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
250	NETAFIM case study	NETAFIM	2019	https://www.netafim.com/en/success-stories/projects-south-africa-blueberries/
251	High performance HVAC	WDBG	2016	https://www.wbdg.org/resources/high-performance-hvac
253	Average speed of passenger plane	Flightdeckfriend	2019	https://www.flightdeckfriend.com/how-fast-do-commercial-aeroplanes-fly
254	Average emissions reduction from Airbnb compared to hotels	Airbnb	2014	https://blog.atairbnb.com/environmental-impacts-of-home-sharing/
255	Navigation API Route Fuel Saving Opportunity Assessment on Large-Scale Real-World Travel Data for Conventional Vehicles and Hybrid Electric Vehicles	NREL	2018	https://afdc.energy.gov/files/u/publication/navigation_api_route_fuel_saving.pdf
256	Average emissions from parcel delivery	Greenlogistics	2018	http://www.greenlogistics.org/SiteResources/343c5312-af8f-4cc0-a271-4191cb2ccdff_Edwards-McKinnon-ShoppingTripOrHomeDelivery-FocusLogisticsJuly2009.pdf
257	Global Solar Atlas 2019	Solar GIS	2019	https://globalsolaratlas.info/map?c=52.696361,58.623047,3
258	GWEC 2015	GWEC	2015	https://www.gwec.net/wp-content/uploads/vip/GWEC-Global-Wind-2015-Report_April-2016_22_04.pdf
259	GWEC 2016	GWEC	2016	http://files.gwec.net/files/GWR2016.pdf
260	GWEC 2018/19	GWEC	2019	https://gwec.net/wp-content/uploads/2019/04/GWEC-Global-Wind-Report-2018.pdf
261	UK Renewable electricity capacity and generation	BEIS	2019	https://www.gov.uk/government/statistics/energy-trends-section-6-renewables
262	Spain Wind Capacity	RED Electrica	2019	https://www.ree.es/en/datos/publications/national-statistical-series
263	Prius emissions factor	FleetNews	2018	https://www.fleetnews.co.uk/news/manufacturer-news/2018/02/13/toyota-increases-published-co2-emissions-for-prius-and-prius
264	UK average public transport journey distance	Department of Transport, UK	2018	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/787488/tsgb-2018-report-summaries.pdf
265	USA average public transport journey distance	APTA	2019	https://www.apta.com/wp-content/uploads/APTA_Fact-Book-2019_FINAL.pdf

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
266	Rio de Janeiro average public transport journey distance	Moovitapp	2019	https://moovitapp.com/insights/en-gb/Moovit_Insights_Public_Transport_Index-322
267	Sao Paulo average public transport journey distance	Moovitapp	2019	https://moovitapp.com/insights/en/Moovit_Insights_Public_Transit_Index-242
268	Mexico average public transport journey distance	Moovitapp	2019	https://moovitapp.com/insights/en-gb/Moovit_Insights_Public_Transport_Index-822
269	India average public transport journey distance	Centre for Sustainable Transport India	2009	http://www.wrirosscities.org/sites/default/files/India-Transport-Indicators.pdf
270	China average public transport journey distance	China City Commuting Report	2018	http://www.woshipm.com/user-research/1059617.html
271	South Africa average public transport journey distance	Journal of SA Institute of Civil Engineering	2015	http://www.scielo.org.za/pdf/jsaice/v57n3/05.pdf
272	Life cycle assessment of lawnmowers	Chalmers University of Technology	2010	http://publications.lib.chalmers.se/records/fulltext/141490.pdf
273	Life cycle assessment of drills	WRAP	2010	http://www.wrap.org.uk/sites/files/wrap/Environmental%20assessment%20of%20consumer%20electronic%20products.pdf
274	Life cycle assessment of sport shoes	Nike	2019	http://www.nikeresponsibility.com/report/uploads/files/Product_LCA_Method.pdf
275	Life cycle assessment of CDs	Intel	2009	http://download.intel.com/pressroom/pdf/CDsvsdownloadsrelease.pdf
276	Life cycle assessment of books	UQAC	2012	http://onlinelibrary.wiley.com/doi/10.1111/j.1530-9290.2011.00414.x/abstract
277	Sharing economy report	IDDRI	2014	https://www.iddri.org/sites/default/files/import/publications/st0314_dd-asn_sharing-economy.pdf
278	Distance to a local bank branch - Germany	DB Research	2019	https://www.dbresearch.com/servlet/reweb2.ReWEB?rwnode=RPS_EN-PROD$HIDDEN_GLOBAL_SEARCH&rwsite=RPS_EN-PROD&rwobj=ReDisplay.Start.class&document=PROD0000000000500570
279	Distance to a local bank branch - UK	Statista	2017	https://www.statista.com/statistics/719933/distance-between-branches-banks-united-kingdom-uk/
280	India installed PV capacity	Gov. of India Ministry of Power -Central Electricity Authority	2019	http://cea.nic.in/reports/monthly/installedcapacity/2019/installed_capacity-08.pdf
281	China installed PV capacity	China Energy Portal	2019	https://chinaenergyportal.org/en/2019-q12-pv-installations-utility-and-distributed-by-province/

REF	TITLE / TOPIC	AUTHOR / PUBLISHER	YEAR	URL
282	USA installed PV capacity	Solar Energy Industries Association	2010	https://www.seia.org/sites/default/files/us-solar-market-insight-report-q1-2011-120627093305-phpapp01.pdf
283	Europe, Asia, Middle East and Africa installed PV capacity	EurObserv'ER	2017	https://www.eurobserv-er.org/online-database/
284	Europe, Asia, Middle East and Africa installed PV capacity	Solar Power Europe	2017	https://www.solarpowereurope.org/wp-content/uploads/2018/09/Global-Market-Outlook-2018-2022.pdf
285	Latin, North America installed PV capacity	IEA	2017	https://www.iea.org/topics/renewables/solar/

Appendix 5 – Companies reporting avoided emissions

COMPANY NAME	TARGET	CURRENT ABATEMENT	CATEGORIES INCLUDED (IF DISCLOSED)
VERIZON	2020 Ambition: Enable the carbon savings of more than double the emissions its global operations produce (carbon abatement factor of 2)	In 2018, Verizon had a carbon abatement of 8.2 million metric tons of CO_2e emissions. It had an approximate carbon abatement factor of 1.68	• Business travel • Transportation • Buildings • Power grids • Healthcare • Parking • Production of goods
BT	2020 Ambition: Enable the carbon savings of at least three times the end-to-end carbon impact of its business (Carbon abatement factor of 3)	In 2018/19, BT had a carbon abatement factor of 2.6, enabling the avoidance of 11.7 million tonnes of CO_2e	-
AT&T	2025 Ambition: Enable carbon savings of 10 times the emissions produced by its operations (Carbon abatement factor of 10)	By the end of 2018, AT&T enabled a carbon abatement of 17.1 million metric tons of CO_2e. The carbon abatement factor was approximately 2.2	Emissions identified in 4 categories: • BAU system (emissions w/o enabling technology) • Enabling effects (carbon abatement in BAU derived from the use of technology) • Direct ICT emissions (emissions caused my implementing the technology) • Rebound effects (increase in BAU emissions due to the implementation of the technology)
TELEFONICA	2025 Ambition: Enable the carbon savings of 10 tons per 1 ton of CO_2 emitted by its services (Carbon abatement factor of 10)	In 2018, Telefonica enabled the carbon abatement of 1.4 million tonnes of CO_2. Its carbon abatement factor was 1.2	• Cloud service and virtualisation • Energy efficiency of buildings • Fleet management and mobility • Audio/video conference Teleworking
KPN	2020 Ambition: Enable the carbon savings equal to the amount of energy consumed by its operations	-	-
VODAFONE	2018 Ambition (achieved): Enable the carbon savings of more than double their emissions (2:1 target)	During 2019, Vodafone enabled the carbon abatement of 5.9 million tonnes of CO_2e emissions. Its carbon abatement factor was 2.9	• Smart energy meters • Smart cities • Smart logistics
DEUTSCHE TELEKOM		In 2017, DT Group in Germany had a carbon abatement factor of 1.71, enabling the avoidance of 11.9 million tonnes of CO_2e. It also had a carbon abatement factor of 1.21 for its combined European operations	Germany - Main categories: • Audio conferencing, ride sharing, and accommodation sharing Germany - All: • Video conferencing, broadband - cloud for SME, broadband - telecommunicating, dynamic cloud, dematerialization, car sharing, e-commerce Europe - All: • Video conferencing, broadband - cloud for SME, broadband - telecommunicating, dynamic cloud, dematerialization, car sharing, audio conferencing, smart logistics, accommodation sharing, e-commerce, ride sharing, dynamic workplace
SWISSCOM	2020 Ambition: Enable carbon savings of double the amount of CO_2e emissions its entire company emits, including supply chain	By the end of 2018, Swisscom had a carbon abatement factor of 1.3	-

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