vodafone

Connecting for Net Zero:

Addressing the climate crisis through digital technology

A WPI report for Vodafone UK

September 2021

vodafone

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WPI Strategy is one of the UK's leading political communications consultancies, with a track record of delivering high impact public affairs campaigns. We offer senior strategic counsel and work extensively with our sister company, WPI Economics, to ensure that campaigns are underpinned by evidence-based content.

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About WPI Economics

WPI Economics is a specialist economics, data insight and public policy consultancy. We provide a range of public, private and charitable clients with research, modelling and advice to influence and deliver better outcomes through improved public policy design and delivery. This report for Vodafone was authored by Joe Ahern, Senior Consultant and Mark Williams, Consultant.

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About Vodafone

Vodafone is a technology communications company that connects people, businesses and devices to help our customers benefit from digital innovation. Our services span mobile, fixed line connections, home and office broadband, and the Internet of Things (IoT).

We have a strong track record as a tech pioneer, making the UK's first mobile phone call, sending the first text message, and making the UK's first live holographic call using 5G in 2018. We were also the first to start carrying live 5G traffic from a site in Salford, Greater Manchester. We have 5G in 100 locations in the UK and 240 across Germany, Spain, Italy and Ireland.

Our 4G network coverage currently reaches more than 99% of the UK population. And in October 2020, Vodafone was named Network Provider of the Year by readers of leading technology advice website, Trusted Reviews.

Today, Vodafone serves more than 18 million mobile and fixed-line customers in the UK. To help deliver Gigabit UK, our full-fibre broadband roll-out programme now covers 15 UK towns and cities through partnerships with CityFibre and Openreach.

For more information about Vodafone UK, please visit: **www.vodafone.co.uk**

Foreword

Andrea Donà
Chief Network Officer at Vodafone

If the UK is to meet its climate change goals, it needs to deliver emissions reductions that are as big, fast and cheap as possible. And it needs to adopt as many different emissions reduction techniques as possible, too. Big, because net zero by 2050 is an ambitious goal. Fast, because action is required now to take as much greenhouse gases out of the atmosphere as possible and achieve net zero. Cheap, because while the pivot to a greener economy is essential, there's no escaping the fact that changing the way we do things has an upfront cost. And multi-faceted, because different areas of the economy, and different carbon-emitting activities, will require different emissions reduction solutions. Nothing will work across the board, and everything that has an impact on reducing greenhouse gas emissions makes a positive contribution to the overall effort.

That's why digital technology is such an exciting part of the picture. In three crucial, high emission sectors in the UK, manufacturing, agriculture and transport, Internet of Things (IoT) technology has the potential to shift the dial dramatically. As this report shows, digital technology could generate annual greenhouse gas reductions in these three sectors of as much as 17.4 million tonnes of CO_2e, similar to the total annual emissions output for the North East of England.

Tech companies such as Vodafone are not always the first to come to mind when people think about tackling climate change. But we have already made big commitments about our own emissions: across the whole Vodafone Group, we committed to net zero for our own operations by 2030, and for our full carbon footprint by 2040. And in the UK, we are going even faster, eliminating all carbon emissions from our UK operations and significantly reducing our emissions from our supply chain and use of products by 2027.

But that's not all. We also set ourselves the target to enable our customers to save 350 million tonnes of CO_2e globally by 2030.

Some of our carbon savings wouldn't be possible without digital technology. For example, we are using IoT and artificial intelligence (AI) to monitor our base stations; Smart Sites allows us to manage issues remotely, eliminating the need to send out field engineers and reducing our carbon footprint. And the connected technology we provide can significantly cut emissions for others too – including in the three sectors this report focuses on.

In manufacturing, the efficiency gains that can be delivered by increased use of industrial digital technology such as AI, machine learning, and 3D printing promise to cut overall emissions simultaneously as they improve productivity and create jobs. In agriculture, digital technology can help monitor crops, soil, fertiliser, feed and water through connected devices, substantially reducing waste and emissions while at the same time increasing yields. And in transport, telematics and traffic management systems can reduce fuel use and control congestion and travel demand, again cutting emissions. It is in the transport sector that the biggest emissions reductions are found – up to 9.3 million tonnes of CO_2e.

We have chosen these three sectors not only because they make a significant contribution to the UK's overall emissions, and not just because digital technology can play a decisive role in decarbonising all three, but also because they illustrate how all parts of the country, urban and rural, need to be taken into account. As the report demonstrates, while overall emissions are – as one might expect – generally higher in more densely populated areas, per person emissions are highest in rural areas with a lower population.

The faster we all implement innovative methods for cutting emissions, the faster we will all see the benefits. When it comes to reducing our carbon footprint, everyone has a part to play, and technological solutions are among the easiest to put into effect.

Executive summary

Vodafone's Climate Commitments

Vodafone is committed to reducing its global carbon emissions to net zero by 2040. By 2030, Vodafone will eliminate all carbon emissions from its own global operations and will halve carbon emissions from Scope 3 sources, such as supply chain and business travel.

In the UK, Vodafone will go faster and eliminate all carbon emissions from its own operations and significantly reduce its Scope 3 emissions by 2027.

In addition, Vodafone has set itself the target to enable business customers to reduce their carbon emissions by a total of 350 million tonnes globally by 2030.

As the hosts of COP26 later this year, the UK needs to demonstrate global leadership by implementing domestic policies to deliver its major goals around emissions reduction – including the new Sixth Carbon Budget target of 78% reductions in emissions by 2035 and net zero emissions by 2050.

The UK has made steps towards reducing emissions, but this has been limited in key sectors such as agriculture, manufacturing, and transport. Slower progress in reducing emissions now means that more radical action will be needed later, causing significant economic harm, according to modelling by the Bank of England.[1] Optimising energy and resource consumption is the single biggest currently available lever to reduce emissions in the near term. Existing IoT technology has the ability to considerably shift the dial in these areas, helping the UK to achieve significant reductions in the next decade and deliver the Sixth Carbon Budget target.

Applying those savings to current emissions from transport, agriculture and manufacturing yields estimated annual greenhouse gas reductions of between 11.7 million tonnes CO_2e in the low scenario (2.7% of national emissions, larger than the total emissions of West Yorkshire), 14.1 million tonnes CO_2e in the mid scenario (3.2% of greenhouse gas emissions similar to the total emissions of Greater Manchester) and 17.4 million tonnes CO_2e in the high scenario (4% of UK emissions, similar to the total emissions in the North East of England).

Manufacturing...

...previous success in reducing manufacturing-related emissions has slowed in recent years, but IoT and 5G-enabled technology such as 3D printing, smart sensors and automation has the potential to...

...reduce emissions by **2.7-3.3 million** tonnes of CO_2e annually.

Transport...

...emissions from surface transport have remained virtually unchanged since 1990, making transport the largest source of emissions in the UK. Digital solutions can help reduce traffic and congestion, therefore limiting the unnecessary use of fuel. This has the potential to...

...reduce emissions from transport by **6.6-9.3 million** tonnes of CO_2e annually.

Agriculture...

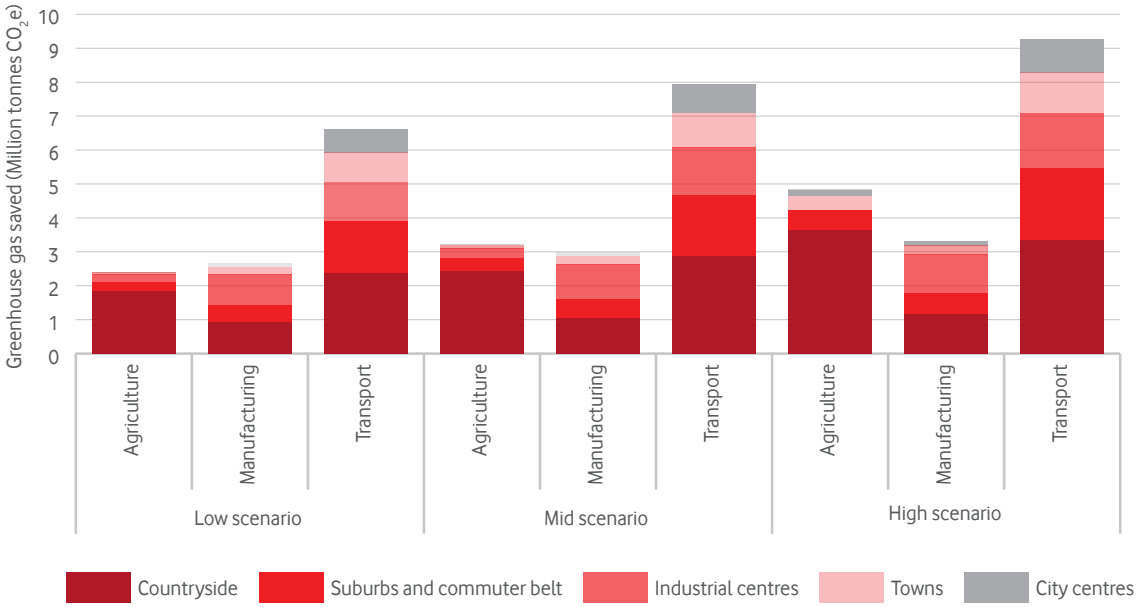
...this is another stubbornly high area of emissions, and people in the UK face difficult decisions about changes to their lifestyles if these are to be tackled. Sensors and other connected technology can significantly reduce the waste of resources used in farming, and across the country could...

...reduce emissions from agriculture by **2.4-4.8 million** tonnes of CO_2e annually.

Anyone seeking to tackle the climate crisis in their area, whether countryside, suburbs, industrial centres, towns or city centres, should be engaged in how digital technology, such as IoT and 5G, can help to deliver this. Digital technology has strong potential to reduce emissions across the whole of the country. In city centres, most of the savings from digital tech (87%) will come from transport, whereas in the countryside 38% of the savings will come from its use in agriculture.

Furthermore, digital technology can also play a role in protecting and creating jobs. 5G and IoT can radically improve the economic performance of the UK's manufacturing sector. A recent Vodafone report found that 5G could add £6.3 billion to the value of UK manufacturing by 2030, with the biggest benefits seen in Wales, the West Midlands, East Midlands, North West and North East.[2] Other analysis suggests it could add 175,000 additional jobs across the economy.[3] In addition, digital technology can reduce the congestion of urban transit and therefore strengthen the economic performance of cities such as Leeds, Birmingham and Manchester whose growth is currently limited by the capacity of their transport systems.

Figure 1: Total potential annual CO_2e savings from digital technology in each area category by sector and scenario



In order to fully realise the benefits of IoT and digital technology, the Government should do a number of things, including:

- Setting targets for the adoption of digital technology in its forthcoming net zero strategy, to realise the enormous benefits that 5G and IoT can bring in improving energy efficiency and reducing emissions.
- Building on the Super Deduction[4] and Help to Grow: Digital scheme,[5] the Government should incentivise the adoption of IoT and 5G technologies in key sectors to accelerate their emissions reductions. Government should also further increase the weighting of carbon reduction technologies – and business carbon reduction targets – in procurement processes.
- Expanding the Digital Catapult and Connected Places Catapult programmes to enhance the digital capabilities of businesses and local authorities in this regard. This will also help to bridge the knowledge gap within the industry.
- Make £500 million of public funding available for regional innovation centres to develop further IoT and 5G applications that will help cut CO_2 emissions.
- Introducing regulation to drive consistency in the security and data standards of IoT devices in order to improve interoperability, building on recent steps to regulate on the consumer code of practice on IoT.[6]
- Introducing a regulatory and policy framework that creates the right signals for investment in mobile network rollout and upgrades to realise the environmental benefits of digital technology across the UK.

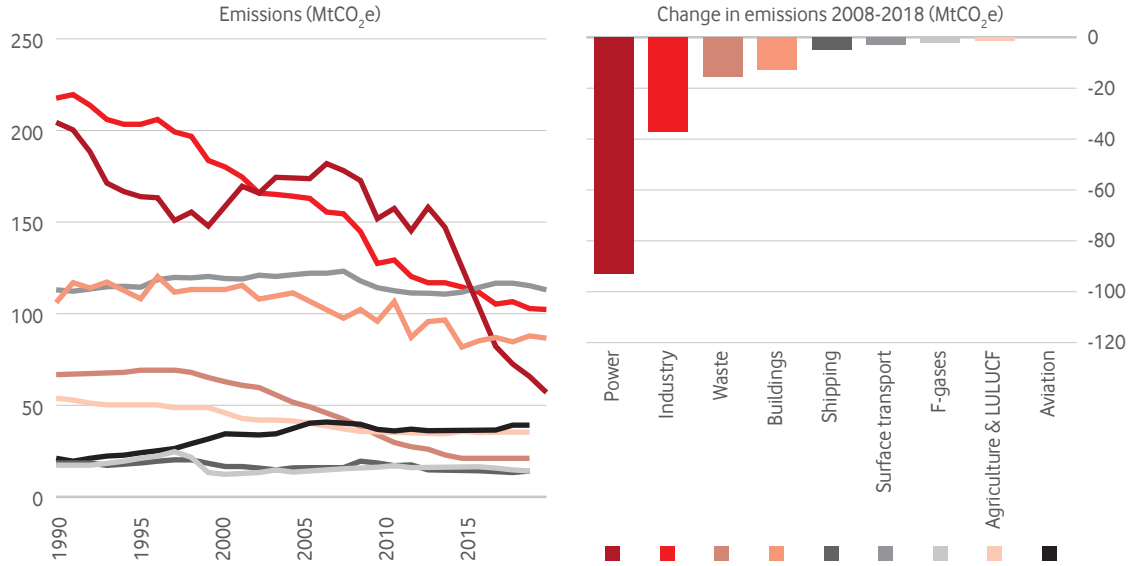
Introduction

November 2021 will see the crucial COP26 talks in Glasgow, which US Climate envoy John Kerry has described as the world's "last best chance" of averting climate catastrophe.[7] Success at these talks will rely, to a great extent, on successful climate diplomacy on the part of the UK, a prerequisite of which is an ability to point to bold ambitions and actions domestically.

The Government has already set strong ambitions in advance of the talks, with the Prime Minister pledging to cut UK emissions by 78% by 2035 from 1990 levels and achieving net zero by 2050.[8] These short-term targets are vital as radical emissions reductions early on are needed to prevent the onset of a cycle of climate breakdown, in addition to achieving the net zero target.

More broadly, the UK has made excellent progress in addressing the emissions of many of its sectors. In particular, it has successfully decarbonised much of the generation of electricity, with government working effectively in partnership with the energy sector to dramatically increase the scale and reduce the cost of offshore wind. However, progress has been unevenly split, with sectors such as agriculture and surface transport (i.e. non shipping or aviation related transport) remaining stubbornly high sources of emissions.[9] Furthermore, areas of relative success such as industry are beginning to see emission reductions slow, just at the point at which we need to see more significant falls.[10]

Figure 2: UK greenhouse gas emissions by sector 1990-2019



Source: BEIS (2020) 2019 UK Greenhouse Gas Emissions, Provisional Figures; BEIS (2020) 2018 UK Greenhouse Gas Emissions, Final Figures; CCC analysis.

Notes: The chart on the right-hand side shows changes in sectoral emissions between 2008 and 2018 for all sectors. Data are not temperature-adjusted.

The nature of the climate challenge also varies significantly around the country, with industrial centres, the countryside, towns, suburbs, and city centres all facing different patterns of emissions.[11]

A previous report for Vodafone by WPI Economics focussed on the challenge of decarbonising commercial buildings, and the role that existing IoT and digital technology could play in helping to address their emissions.

This report will look at how digital technology could help reduce the carbon emissions of three of the UK's most greenhouse gas intensive sectors – manufacturing, agriculture, and transport – and will include assessing the scale and nature of their emissions and how they manifest themselves in different parts of the country.

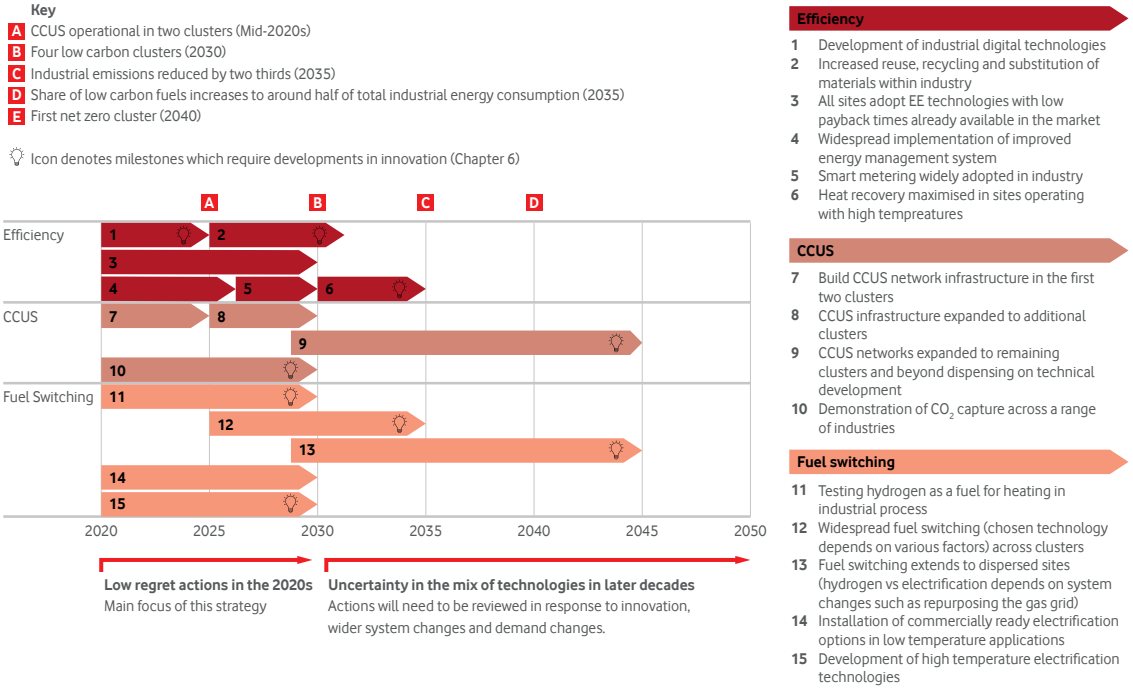
Manufacturing

Manufacturing has made good strides towards decarbonisation. There were very significant reductions in manufacturing emissions from the early 90s until the mid-2000s, but this has slowed in recent years. As a result, manufacturing is still a relatively high source of emissions in the UK. Around 82 million tonnes of CO_2e were being emitted as a result of this activity in 2019, 15% of total UK emissions.[12]

The Government's industrial decarbonisation strategy, which covers manufacturing alongside other areas such as refining and mining, suggests that earlier reductions to emissions from industry generally resulted from the changing nature of the manufacturing sector, energy efficiency savings, and a switch to lower carbon fuels. For the UK to keep pace in delivering the necessary manufacturing emissions reductions to get to net zero by 2050, bolder and more innovative steps will be necessary.

Technology is at the forefront of key actions within the Government's strategy in the coming years, which include deploying solutions such as Industrial Digital Technologies (IDT), which includes IoT, Augmented Reality, Virtual Reality, Robotics and additive manufacturing (3D printing). These measures complement other key actions around switching parts of industry to using lower carbon sources of fuel and scaling and deploying Carbon Capture, Usage and Storage (CCUS) technology.

Figure 3: Government technology strategy to decarbonise industry



Source: Industrial Decarbonisation Strategy[13]

The use of 5G in industrial settings such as manufacturing could be facilitated by 5G mobile private networks (MPNs) - bespoke 5G networks built to deliver the specific connectivity needs of a business or organisation.

The use of digital technology and IoT in manufacturing also has significant potential to support the competitiveness of the UK economy, as well as supporting jobs in lower employment areas of the country which have been hard hit by the pandemic. Vodafone's recent report on the potential productivity benefits of 5G in manufacturing found that the greatest impact would be felt in Wales, the North East and North West and the East and West Midlands, because of the distribution of manufacturing around the country.[14]

Agriculture

Agriculture and land use are rightly major priorities for emissions reduction, with 46.3 million tonnes of CO_2e emissions in 2019.[15] This sector contributed around 9% of overall UK emissions in 2019,[16] and has remained fairly static at this level over the last 15 years.

Agriculture is different to other areas of emissions for two key reasons:

- **Its main greenhouse gas emission is not CO_2** – methane and nitrous oxide are the primary greenhouse gases (GHGs) due to the nature of agricultural activity.
- **It both contributes to climate change and acts as part of the solution** – trees, grass, and other non-crop plants on land managed by farmers capture CO_2 from the atmosphere.

The UK's farming sector is world leading in its approach to sustainability, such as through the limiting of water use as well as the storage of CO_2 within grassland.[17] Building on the UK's success in relatively low emissions farming practices when compared with other countries will undoubtedly play a significant role in addressing the challenges ahead.

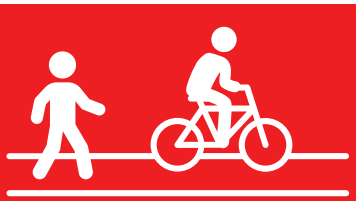
There will also be difficult trade-offs if the UK is to be able to meet its emissions reduction targets. In particular, the Climate Change Committee (CCC) suggests a reduction of around 20% in the amount of beef, lamb and dairy eaten per person by 2050.[18] Even bolder pathways for decarbonisation, such as delivering net zero by 2040, would require the near elimination of demand for livestock-related products, according to modelling produced by Energy Systems Catapult.[19]

Digital technology can help to address several challenges for agriculture, making a sizeable contribution to total emissions reduction in some parts of the country, and potentially softening some of the hard choices that need to be made in relation to our lifestyles in the coming decades.

Transport

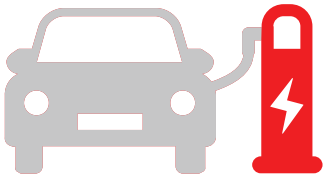
According to the CCC, transport is now the largest source of emissions in the UK, with emissions from surface transport (non-aviation and shipping related transport) having remained largely unchanged since 1990,[20] with 113 million tonnes of CO_2 in 2019, or 22% of overall UK emissions. [21] Around 78% of surface transport emissions come from cars and light vans. This is despite strong efficiency savings the sector has made, which have been offset by increases in demand.

Decarbonising road transport remains a substantial challenge in terms of the quantum of emissions reduction required to deliver net zero, and in terms of the technological and lifestyle transformation to achieve this. Inevitably, any successful strategy to address these emissions will involve two key planks:



Modal shift – ensuring that more people use alternative transport to cars, such as trains, buses, cycling, and walking. This is vitally important but can only realistically achieve a small proportion of the emissions reductions needed to deliver net zero (10% according to one study).[22]

Electrification – the Government's 2030 ban on the sale of new petrol and diesel vehicles has been described by Green Alliance as the single most important policy intervention in delivering net zero.[23]



The rollout of electric vehicles will have a major impact on delivering net zero in the long term, but this will be limited in the short term due to the 2030 target being nearly a decade away. Significant emissions reductions in the years preceding that are also essential to stop climate change.

IoT as it exists today can play a significant role in bridging this gap by delivering emissions reduction in the short term through changing driver behaviour, while providing the bridge to connected and autonomous vehicles and, ultimately, electric vehicles.

Digital technology has the potential to reduce emissions, unlock productivity and enable economic growth across the UK. Vodafone-commissioned research has found that 5G could add over £150 billion to the UK economy by 2030.[24] But to achieve these environmental and societal benefits, significant investment is required to roll out and maintain 5G networks, build more mobile sites and develop new 5G applications and technologies. Mobile network operators are faced with these investment demands at a time when the industry is under serious cost pressures, for example through the requirement to swap equipment, increasing operating costs and high regulatory and spectrum costs.

To achieve its full potential, mobile operators need 5G to deliver an investment boost via the industrialisation of new 5G technologies. This would lead to improvements to the current low return on capital employed in the UK for mobile infrastructure.

This boost could be delivered by the uptake of digital technology across manufacturing, agriculture and transport, which would not only reduce emissions and support the Government's net zero target, but would also create a virtuous circle by opening up new revenues for mobile network operators. These new revenue streams can then be reinvested in the rollout of 5G network infrastructure and the development of new applications which will also benefit consumers and smaller businesses across the UK.

Chapter 1: The climate challenge across the country

The climate challenge varies significantly between different parts of the UK, both in terms of the overall levels of emissions and the distribution between different sources. The population density and nature of economic activity in different areas are key determinants of their emissions profile, with the following points particularly noteworthy:

- As shown by the map in Figure 4, emissions vary greatly between different areas, with emissions per person typically lower in cities and higher in the countryside and more industrial areas. For example:
    - London boroughs have some of the lowest per person emissions (shown as a lightly shaded area on the map) because the typical Londoner – as a result of driving less and living in smaller homes – releases fewer emissions over the course of a year than people living in other parts of the country.
    - Some areas, including the North East of England, have more spread-out populations and a greater manufacturing presence, meaning that the average person here emits more than the average person in London. Of course, with a greater population, total emissions in London are still higher.
- Per person emissions are useful to show the relative CO_2e intensity of different areas, rather than the absolute level. The relative – per person – levels of emissions show how the scale and nature of the decarbonisation challenge varies in different areas, but it is total emissions (per capita emissions multiplied by the population) that matters in averting climate change.
- Some emissions attributed to areas will be generated by businesses producing food or goods for people living elsewhere, meaning that the emissions of each area do not fully reflect the impact that local residents truly have on the atmosphere. Cornwall's agricultural emissions, for instance, will include greenhouse gases produced by farmers supplying milk to London. Likewise, manufacturing emissions in Sunderland will include carbon released as result of cars made for export. Carbon embedded in imported goods is also not accounted for here.

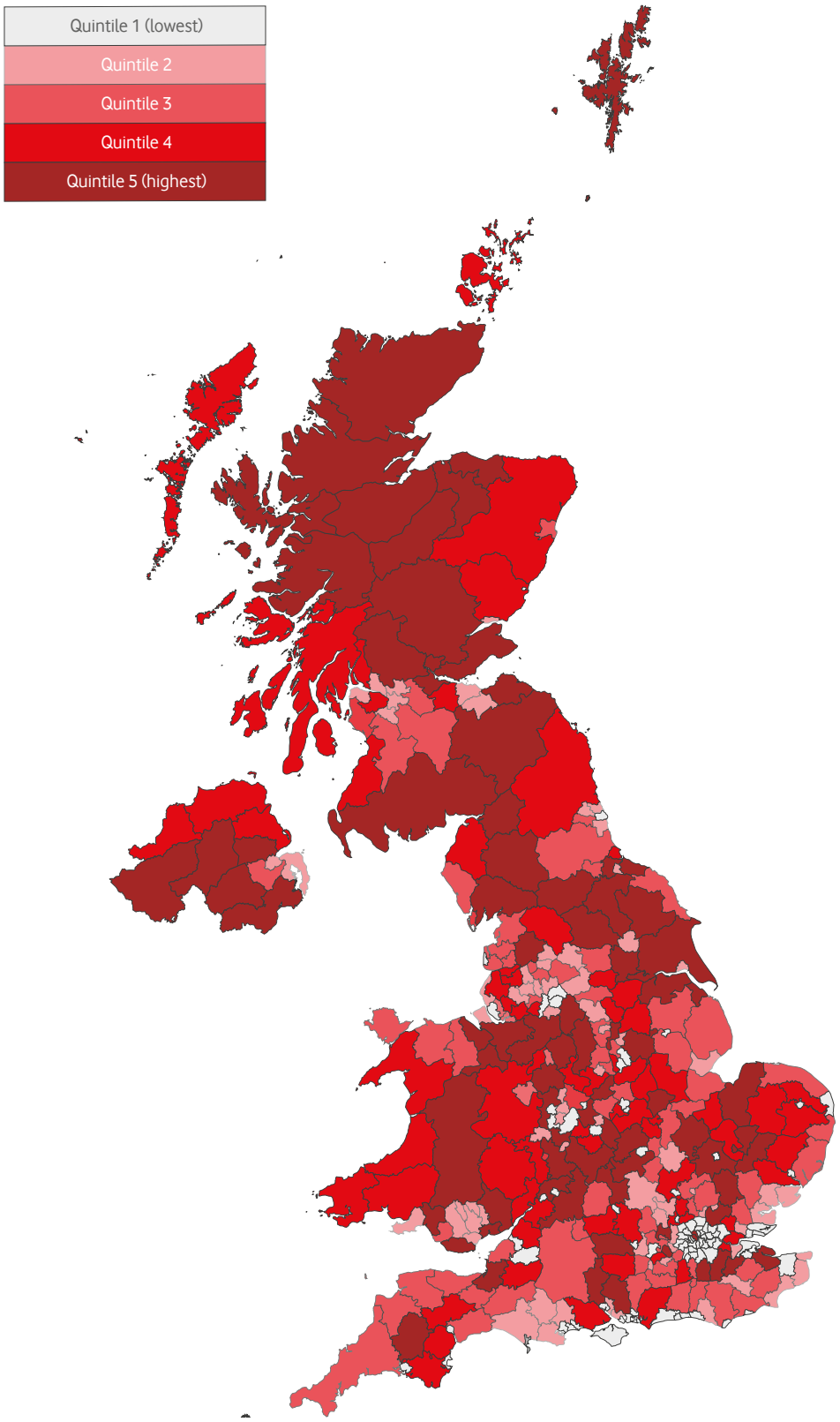
The geography of climate change matters hugely – different areas need different action to deliver net zero. Furthermore, the coordination of decarbonisation at a local level, and creating local ownership of long-term strategies, are essential components of any successful approach.

In addition to tackling climate change, many different areas across the country also have a significant challenge in sustaining high numbers of good quality jobs – particularly in the aftermath of the pandemic. For example, recent research by WPI Economics for the Covid Recovery Commission has shown that those areas with high pre-existing rates of unemployment faced the largest increases in their claimant count during the pandemic.[25] There is a risk that decarbonisation exacerbates these inequalities. Research by Onward finds that the 51% of jobs in carbon intensive industries are located in the Midlands, North of England, and Scotland.[26]

It is vital to address the climate and jobs crises in tandem where possible, both in building and maintaining public support for tackling climate change, and in enabling a 'just transition' where decarbonisation is not achieved on the backs of the poorest.

In order to demonstrate the interaction between these factors, we have developed a series of categories that group areas together according to the relative scale of the emission challenge they face in terms of the three sectors we have identified, as well as several key economic indicators.

Figure 4: CO_2 emissions per person per year by Local Authority, quintiles



Local authority categories

The categories were created by taking groups of Local Authorities produced by the Office for National Statistics based on economic and demographic information and merging them into five similarly sized areas (between 11.2 and 16 million people, roughly a fifth of the population) that share relevant characteristics when it comes to using digital technology to reduce greenhouse gas emissions. The five categories are:

Industrial centres: Areas including the Welsh Valleys, Scottish Central Belt and parts of the North and Midlands of England. They are the historic heartlands of British industry and still produce high greenhouse gas emissions from manufacturing. The relatively poor economic outcomes in these areas present both a challenge and an opportunity for decarbonisation.

Countryside: Making up three-quarters of the UK's landmass, countryside areas are spread all over the four nations, away from large towns and cities. With low population densities and a focus on agriculture, they see the highest per-person carbon and greenhouse gas emissions, although their total emissions are often lower.

Towns: Major conurbations that are not among the largest or densest cities. They have diverse economies, mixing manufacturing and services and have the second lowest greenhouse gas emissions.

Suburbs and commuter belt: Primarily surrounding London, but also in areas like Cheshire which are close to other major cities, the suburbs and commuter belt share the economic prosperity of cities but with far higher emissions, especially from transport.

City centres: The dense and highly productive centres of London, Birmingham and Manchester join regional hubs such as Brighton and Cambridge as the category with the greatest wealth and lowest per-person emissions. 11.2 million people live in these areas, despite them making up less than 1% of the land.

Figure 5 shows how the different categories are spread across the UK and Table 1 presents more details about the demographic, economic and emissions profiles of the categories.

Figure 5: Local Authorities by category

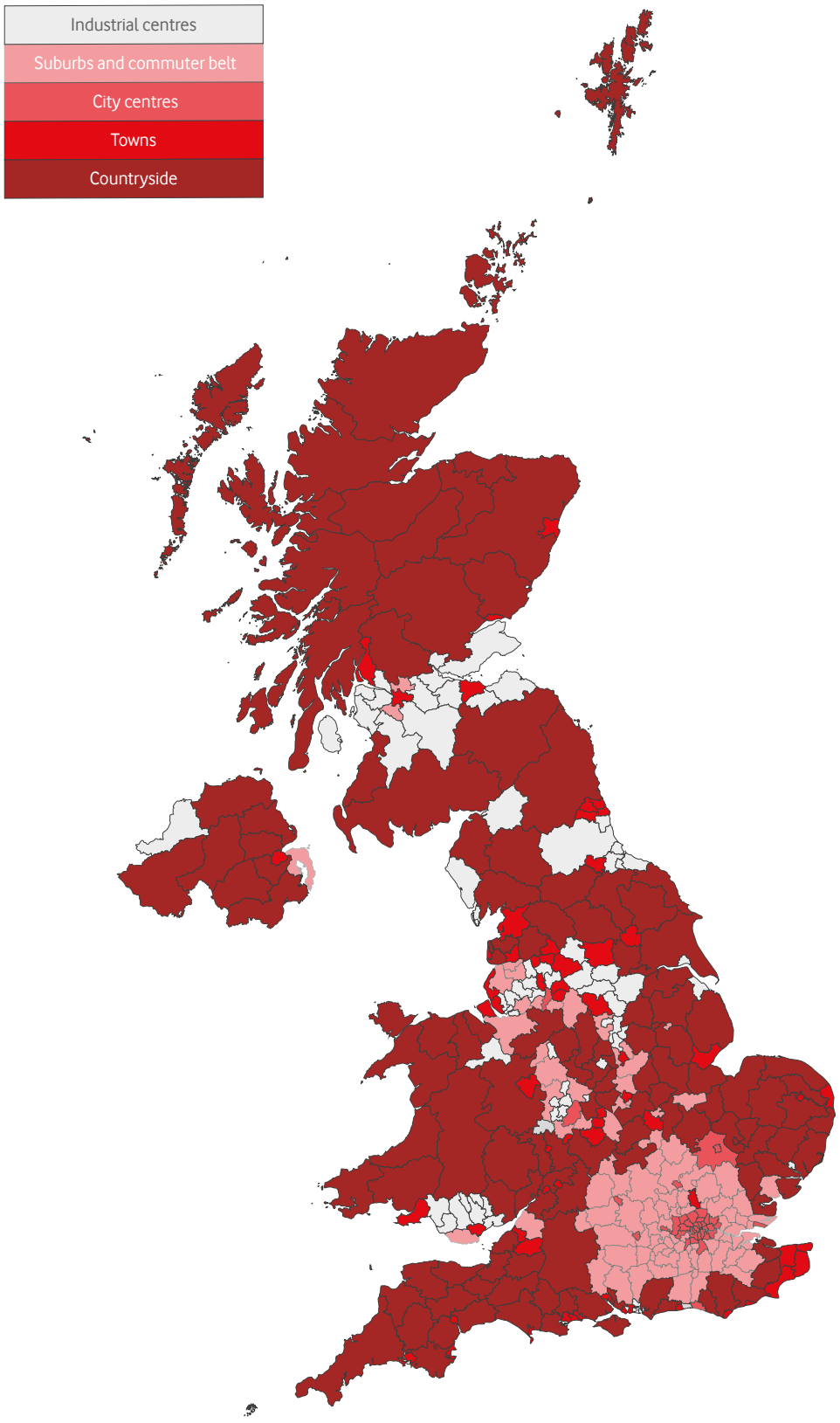
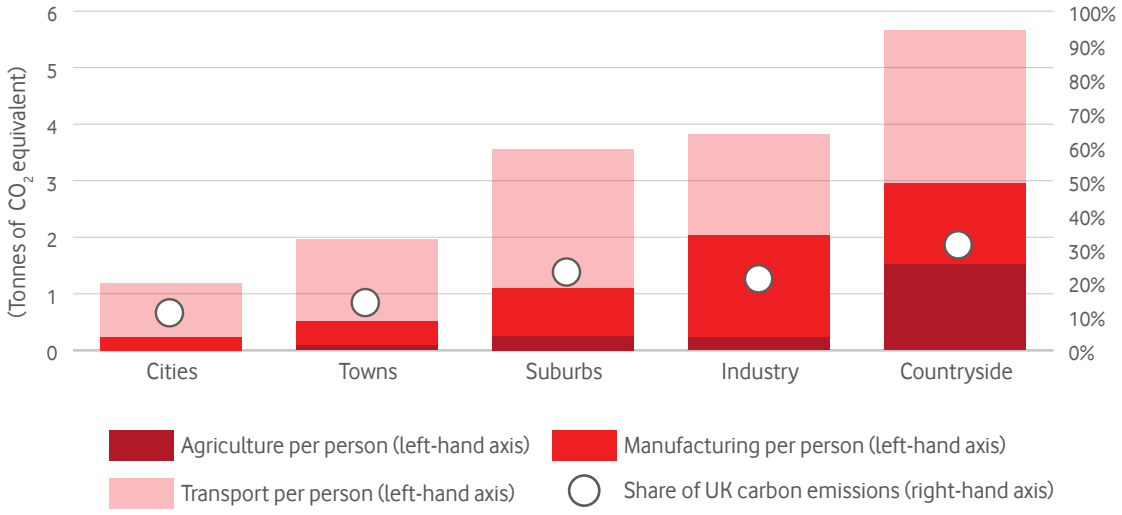


Table 1: Profiles of Local Authority categories

	Industrial centres	Countryside	Towns	Suburbs and commuter belt	City centres
Total carbon emissions per person (tonnes of CO_2/year)	5.89	6.9	4.03	5.54	3.35
Manufacturing greenhouse gas emissions per person (tonnes of CO_2e/year)	1.81	1.45	0.44	0.85	0.23
Transport greenhouse gas emissions per person (tonnes of CO_2e/year)	1.78	2.7	1.44	2.45	0.95
Agriculture greenhouse gas emissions per person (tonnes of CO_2e/year)	0.23	1.52	0.09	0.26	0.01
Population	12.4m	16m	12.6m	14.8m	11.2m
Population density	562 people/km^2	86 people/km^2	1,261 people/km^2	522 people/km^2	5,666 people/km^2
Pre-covid unemployment	4.09%	2.26%	3.41%	2%	3.57%
Increase in unemployment during Covid pandemic	3.26ppt	2.57ppt	3.33ppt	3.04ppt	5.28ppt
Economic output (GVA) per person	£19,831	£21,275	£26,691	£29,616	£47,278

Figure 6 shows how the decarbonisation challenge posed by agriculture, transport and manufacturing varies in both scale and nature across the five categories. At 3.35 and 4.03 tonnes of CO_2 per person respectively, city centres and towns have the lowest per person emissions because of the more energy-efficient lifestyles enabled by dense urban living. However, city centres and towns still account for a quarter of the CO_2 produced in the UK, with transport playing a significant role in emissions. The industrial centres (5.89 tonnes of CO_2 per person) and suburbs and commuter belt (5.54 tonnes of CO_2 per person) have similar overall levels of emissions, but with transport making up a greater share in suburbs and the commuter belt and manufacturing being more prominent in industrial centres. With per head carbon emissions of 6.9 tonnes, the countryside has the highest overall emissions, with the highest for both agriculture and transport and the second highest for manufacturing.

Figure 6: Greenhouse gas emissions per person from transport, agriculture and manufacturing by category (left-hand axis) alongside proportion of total UK CO_2 emissions by category (right-hand axis)



Chapter 2: The role of technology in delivering net zero

Technology holds a vital role in tackling climate change. IoT and 5G technology have broad transformative potential to improve social and economic outcomes. As set out in previous reports for Vodafone, this includes improving economic productivity[27] and healthcare,[28] reducing loneliness,[29] and making the use of modernising transport.[30]

Another major benefit of IoT – as it exists today – is in helping the world to address the climate crisis. The ability of devices to connect and communicate with each other can ensure they perform their functions at optimal efficiency in near perfect coordination with each other, thus limiting the consumption of energy. Improving energy efficiency will help deliver more than 40% of the emissions abatement potential required by 2040, according to the International Energy Agency (IEA).[31]

At the level of the whole energy system, digital technology allows devices in homes, vehicles and business premises to communicate their usage of energy with the grid, allowing use, supply and storage to adapt to each other accordingly. This is an essential prerequisite for a successful shift to a society which is dependent on renewable energy such as wind and solar, whose supply is variable, from one dependent on fossil fuels which are more easily stored and burned to make electricity on demand.[32]

More specifically, IoT and digital technology have important practical applications in improving the efficiency of several of the sectors we have considered in the context of this report – as well as others we've considered previously such as commercial buildings (see box below).

Digital Buildings

A previous report by WPI Economics for Vodafone analysed the environmental benefits of technology such as:

- **Smart Heating, Ventilation and Air Conditioning (HVAC)**
- **Smart Lighting**
- **Predictive maintenance**

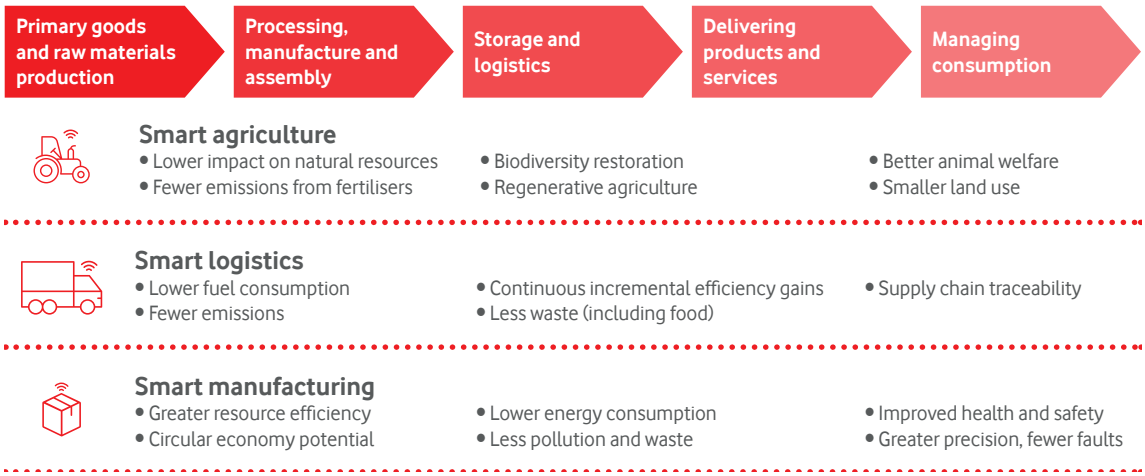
Quantitative analysis concluded that this technology could deliver reductions in emissions associated with the use of non-residential buildings by between 4 and 8 million tonnes of CO_2e a year, the equivalent of between 5% and 10% of the emissions of all of the UK's building stock.

The report made a number of recommendations to strengthen take-up of this technology across public sector and commercial buildings, including by mandating operational energy use certificates for larger buildings and using public procurement to drive adoption of more consistent IoT security standards.

Source: WPI Economics for Vodafone (2020) Digital Buildings.[32]

Crucially, much of the IoT technology that we describe is already available today, and can be rolled out quickly to reduce emissions in the short term. This is vital, because the emissions reductions we are able to achieve in the immediate future have the greatest impact in preventing the worst of climate change.[34]

Figure 7: Connected IoT and digital technology



Source: Vodafone[35]

IoT.nxt

IoT.nxt is a platform which uses enhanced technology to enable a truly interconnected world, helping to create the businesses, buildings, factories and cities of the future. A key aspect of this technology is the integration capability, which brings together all the data from various IoT solutions, including applications and sensors. Using this technology in buildings and offices facilitates real-time monitoring of where people are located and also where the empty spaces are. Amongst other things, this allows for smart desk booking and increased efficiency by automatically adjusting lighting and heating in unused areas.

The collecting and recording of data relating to air quality, temperature, humidity and lighting levels can also be used to determine precisely which settings are most suitable for locations throughout a building, optimising energy consumption, which can lead to energy savings of up to 30%.

Constellations

Vodafone has partnered with UK Power Networks to help deliver Constellation, a revolutionary smart substation trial. Vodafone will provide 5G connectivity to electricity substations to improve their efficiency. This will enable more clean energy sources and low carbon technologies like electric vehicles to connect to the network. The project aims to supercharge the UK's net zero carbon ambitions by creating extra room for renewables on the network.

Smart Manufacturing

The UK was once considered a world leader in manufacturing. Many have remarked, however, that the benefits of the third industrial revolution have accrued to other manufacturing countries.[36] Nevertheless, the UK remains the eighth largest manufacturer in the world, with a report by cloud software company Sage suggesting that the widespread adoption of IDT could support the UK to become the fifth largest manufacturing economy in the world.[37]

The term IDT refers to technologies within five groups, all to a large extent powered by 5G and IoT:

1. Artificial intelligence, machine learning and data analytics
2. Additive manufacturing (otherwise known as 3D printing)
3. Robotics and automation
4. Virtual reality and augmented reality
5. The Industrial Internet of Things (IIoT) and connectivity [38]

Magna

Vodafone Business supports the Magna, a mobility technology company for automakers, in the collection and analysis of energy consumption data in its factories. As a result, the company is able to reduce its energy consumption and related costs by 5-10%. The energy consumption data is collected by an IoT datalogger on the energy meters and transferred to the IoT SIM card, which supports a secure transfer of the data to the cloud, where it can be analysed in a web-based portal.

Taken together, these technologies carry major benefits in terms of greater productivity, quality and efficiency in a range of different manufacturing sectors. Analysis by Accenture for the Government's Made Smarter Review in 2017, found that greater innovation and adoption of IDT could increase manufacturing growth between 1.5% and 3% per annum, with a conservative net gain of 175,000 additional jobs across the economy.[39] Furthermore, the efficiency gains could have the result of reducing the sector's CO_2 emissions by 4.5%, which will have a major impact on emissions in certain parts of the country, as we outline in the economic analysis in Chapter 3.

Smart Agriculture

Agriculture as a sector faces a number of macro challenges around sustainability, keeping pace with a growing global population, and disruptions to supply chains – many of which have been accentuated by the Covid pandemic.[40] Various types of digital technology can help farmers to manage their crops and livestock more efficiently, enabling them to build resilience to some of these challenges. However, adoption of digital technology is low in agriculture relative to a range of other sectors.[41]

Digital technology enables the better monitoring of crops, soil, fertiliser, feed, and water[42] through connected devices – and this can lead to substantially reduced waste. Vodafone offers a number of technologies across its business to support the agricultural sector to improve its resource efficiency.

Mezzanine's MyFarmWeb

Farmers require access to data to maximise yields and profitability while also minimising their impact on the environment.

Mezzanine, a Vodafone Company, offers the cloud-based platform MyFarmWeb - an easy-to-use app that enables farmers to store, visualise and view information gathered through agricultural IoT sensors and other data sources in the field.

MyFarmWeb collates data from multiple sources, like soil quality, nutrient concentrations and yield, and turns it into commercially workable information, ensuring farmers can make faster and more informed decisions, maximising their efficiency, reducing waste of water and use of pesticides. The platform is currently used by more than 6,500 farmers across Africa, Australia, New Zealand and the USA, covering over 2 million hectares of land.

Alltech Farming Solutions Limited

Alltech Farming Solutions Limited, an Irish manufacturer of diet feeders for livestock, is using Vodafone's IoT solutions to enable farmers to measure, monitor and manage feed efficiency. This leads to a reduction in feed waste and an overall improvement in animal health. The company's diet feeders are used on farms across Europe and globally. Their diet feeders automate the mixing and delivery of feed to livestock, and, with IoT connecting the machines to the cloud, farmers can easily monitor and analyse the resulting data.

Sensing4Farming

Emilio Moro, a Spanish wine producer, uses Vodafone's Sensing4Farming solution to maximise efficiency and minimise the environmental impact of its wine production.

A network of sensors installed in the vineyards and high-resolution satellite images obtained in real time, allow the measurement of key environmental factors, such as humidity, temperature, soil conductivity, and water absorption. The data is sent to experts who determine the ideal quantity of irrigation and fertiliser needed and when to harvest.

Vodafone's technology has achieved efficiency improvements of around 20% in agricultural processes, vastly improving resource efficiency and reducing the overall emissions of the farms that it works with. Scaled across 50% of farms in the UK, this could have a significant impact on the total emissions of the countryside and industrial towns.[43]

Smart Transport

Working alongside the revolution in vehicle electrification, there is a role for technology such as IoT and 5G to deliver a broad range of improvements in transport efficiency through Intelligent Transportation Systems (ITS). The majority of ITS have the potential to indirectly reduce emissions through their main benefits of improving passenger safety, mobility and convenience. The systems work by improving efficiencies of transportation system operations and thereby reduce overall GHG emissions as a secondary benefit. Typically, the reduction in emissions is in the range of 5 to 15% - most of the benefits are additive and greater benefits are to be expected if multiple ITS programs are put into place.[44]

Vodafone Business Fleet Analytics

Vodafone Business has partnered with Geotab, world leading commercial telematics provider to create Vodafone Business Fleet Analytics (VBFA). With VBFA, customers can access vehicle data and gain actionable insights from the analysis of this data to monitor and enhance the safety, performance and security of their drivers. The solution also supports customers on their journey to a sustainable fleet. For example, emissions can be reduced through monitoring fuel consumption, optimising routes and reducing idle time. The technology facilitates the switch to electric vehicles as it allows customers to select the best-fit electric vehicle for different business needs based on real data.

In general, ITS can be categorised into three target areas:

- **Vehicle systems** – through vehicle systems (modern control systems, wireless communication features etc), traffic is able to flow more freely and accident-related congestion is reduced which translates into GHG emission reductions. Figures published by the RAC suggest that telematics alone has helped to reduce fuel use by up to 15% when used for the fleets of some businesses.[45]

- **Traffic management systems** – these can help control congestion and travel demand by providing transportation managers with better real-time information and new data processing techniques to better manage traffic flow. In Helmond, Netherlands, the use of eCoMove dynamic green wave for traffic lights resulted in a 4.1% reduction in CO_2 emissions during peak periods and a 3.6% reduction during off-peak periods (eCoMove is a major programme in the EU focusing on avoidable energy use reductions in road transport).[46]
- **Travel information systems** – these include route guidance systems and geo-location systems, which can cut back on unnecessary travel that may occur when a driver gets lost or chooses a long, out-of-the way path.

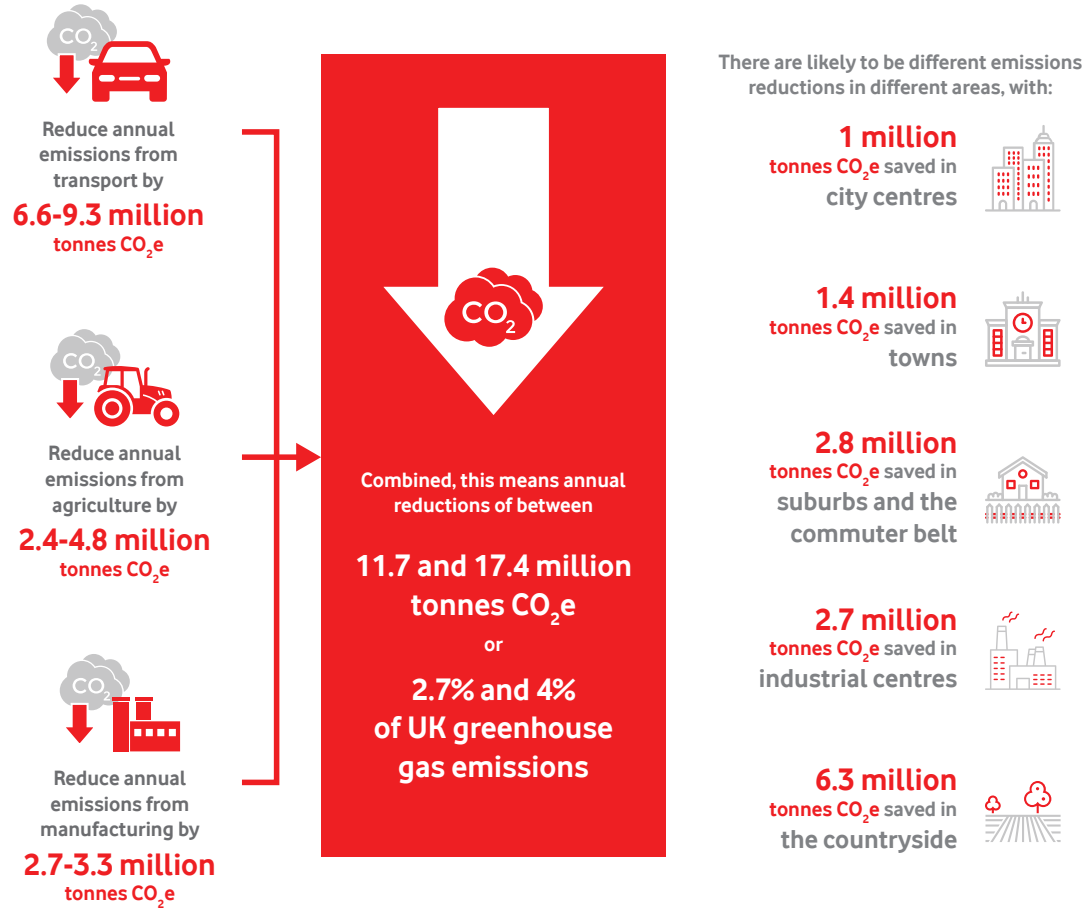
EVUM Motors

Vodafone Automotive supports EVUM Motors, a pioneer in utility electric vehicles, with Vodafone Business Fleet Analytics. At the forefront of EVUM Motors' fleet is the new aCar, a compact, emission-free all-electric 4-wheel drive primarily used in agriculture, last-mile logistics and municipal transport. The Vodafone Automotive solution combines connected devices, a telematics platform and data analytics capabilities to help fleet managers transform vehicle data into valuable insights to save costs, enhance driver safety and increase productivity.

Chapter 3: The potential impact of IoT and digital technology

Quantifying the greenhouse gas savings from technology

To see the potential impact that the technologies discussed above might have on greenhouse gas emissions in the UK and how this varies across different categories of area, we have undertaken modelling that shows that IoT and 5G have the potential to:

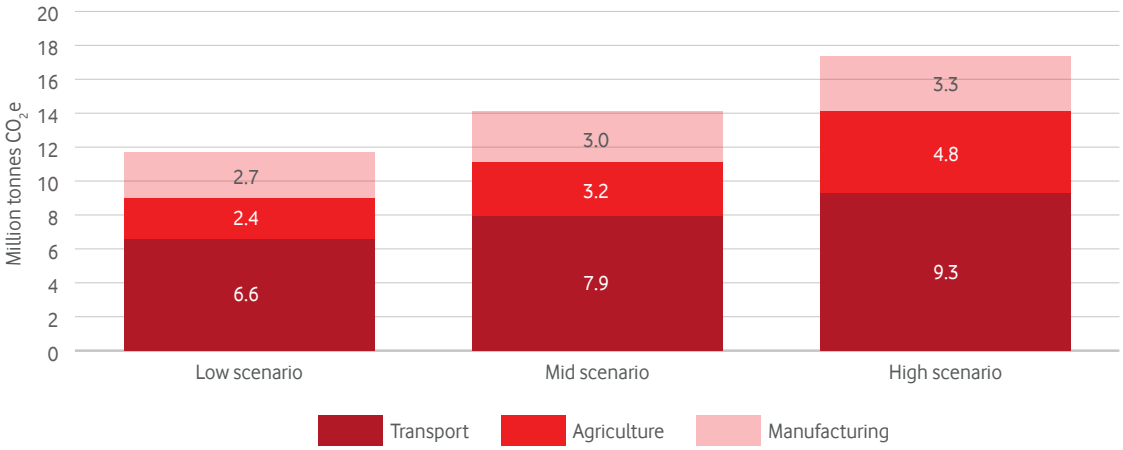


These figures were estimated by taking the existing greenhouse gas emissions from the transport, agriculture and manufacturing sectors in every Local Authority in the UK and applying a range of potential emissions savings to them. We used a low, medium and high assumption about the potential savings of the three sectors we are looking at to account for the uncertainty in the impact that new technology might have on emissions patterns. These assumptions are detailed in the annex, alongside the questions of penetration and rebound effects that feed into the uncertainty inherent in estimating the impact of technology on greenhouse gas reductions.

When applied to current emissions from transport, agriculture and manufacturing we see estimated annual greenhouse gas reductions of between 11.7 million tonnes CO_2e in the low scenario (larger than the total emissions of West Yorkshire), 14.1 million tonnes CO_2e in the mid scenario (similar to the total emissions of Greater Manchester) and 17.4 million tonnes CO_2e in the high scenario (similar to the total emisisons in the North East).

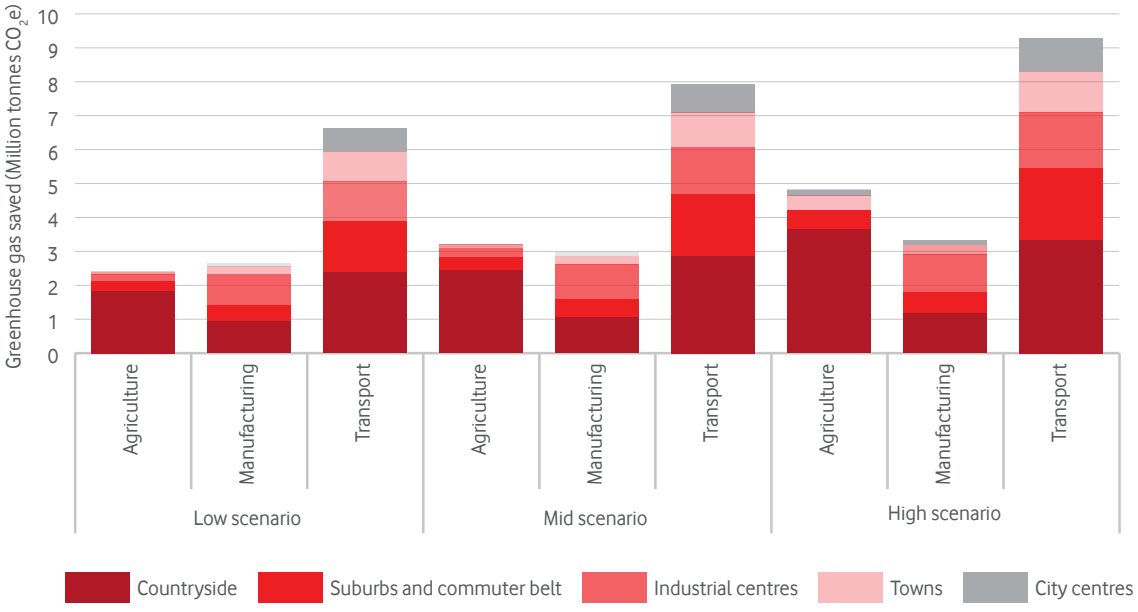
Figure 8 shows the sectors that these savings come from. Under all three scenarios, the majority of the reduction in greenhouse gases comes from the transport sector, making that the sector with the greatest potential for digital technology.

Figure 8: Estimated greenhouse gas savings from digital technology by sector and scenario



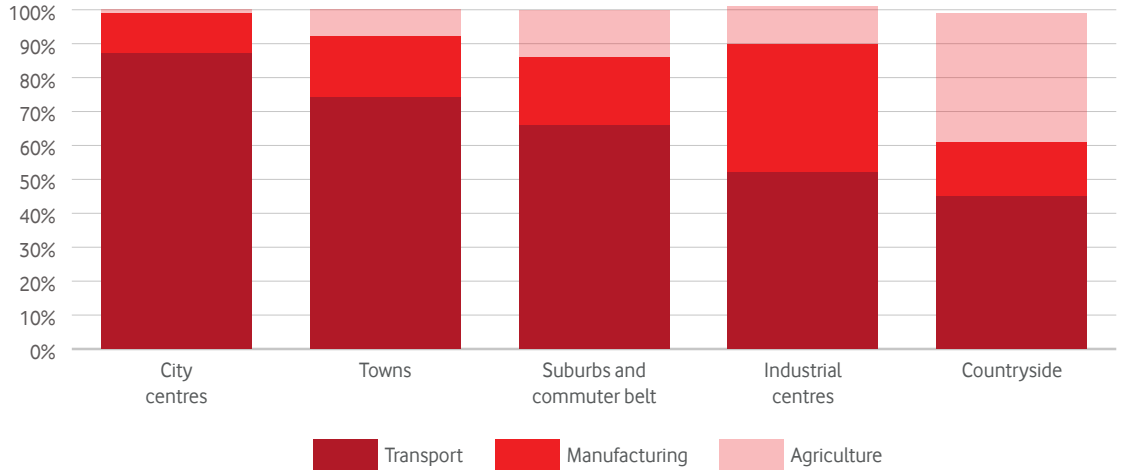
Applying the greenhouse gas emission savings to the categories set out in Chapter 2 demonstrates how the opportunities from digital technology are likely to impact different parts of the country and can help guide efforts to moving towards net zero. As shown in Figure 9, the emissions reductions in some sectors are strongly concentrated in certain parts of the country, whilst other savings are more broadly based. Greenhouse gas reductions from agriculture are, unsurprisingly, almost exclusively found in countryside areas. Equally, the majority of manufacturing emissions savings are in industrial centres and the countryside. Transport, on the other hand, is a sector that reaches across the country much more evenly and there are significant emissions reductions to be made in this sector in all five of our categories, despite lower per-capita usage in city centres and towns.

Figure 9: Total potential annual CO_2 savings from digital technology in each area category by sector and scenario



It is also instructive to look at the breakdown of potential savings within each of the area categories. Doing so, as in Figure 10, reveals that all parts of the country can make a significant contribution to working towards net zero. Although city centres and towns have lower emissions per person than other parts of the country, they are still among the highest-emitting areas overall, and there are still significant savings that can be made there, primarily from transport. 87% of the greenhouse gas savings from digital technology in city centres is accounted for by transport. Equally, in areas that appear dominated by one sector or another, such as agriculture in the countryside or manufacturing in industrial centres, there are still major reductions that can be made in other sectors. For example, only 38% of emissions savings from digital tech in the countryside comes from agriculture, with transport making up 45% of the savings. This means that businesses and leaders in all areas and sectors should be receptive to the potential of digital technology.

Figure 10: Proportion of greenhouse gas reduction by sector and area category (mid scenario)



Digital technology and jobs

The UK faces a potential jobs crisis in the aftermath of the pandemic, triggered by the necessary closing down of parts of the economy in order to save lives, and the sharpest economic downturn since 1709.[47] The analysis under our categories demonstrates that this is unevenly spread across the country, with cities (8.85%) and industrial centres (7.34%) having the highest unemployment benefit claimant rate in February 2021.

Industrial centres are more heavily reliant on manufacturing than other areas – and so it is reasonable that the protection and growth of jobs in these parts of the country should focus to a greater extent on supporting this sector. Analysis for the Government's Made Smarter review identified the potential for jobs growth of 170,000 if there is stronger rollout of IDT among manufacturers, particularly SMEs.[48] In addition, analysis by the Place Based Carbon Action network and UK100 found that manufacturing as a sector will have the second highest level of green jobs demand in the future, after construction. [49]

For cities, better transport is a key contributor to better economic performance and jobs growth, and ITS can support improved mobility through lower congestion and fewer accidents. This is particularly true of cities outside London where a larger proportion of people still rely on a car to get to work. Analysis by the Centre for Cities finds that congestion is a particular problem in London, Manchester, Birmingham, Bristol and Leeds, and major investment is needed to improve this.[50]

ITS can support local and sub-national government leaders to better manage the congestion in their city centre. This creates benefits not just around emissions reduction and air quality, but also improving journey times for public transport as well as private car transport to support the expansion of city centre economies.

As well as helping to address climate change, policies that support the proliferation of digital technology, 5G and IoT across the UK will help to strengthen the UK's job performance in the aftermath of the pandemic.

Chapter 4: Conclusions and recommendations

Substantially accelerating emissions reduction across several of the areas identified in this report will be a defining challenge of the next decade. The UK faces difficult choices to meet vital near-term goals on reducing emissions and continuing to demonstrate global leadership on climate change. Digital technology will be at the forefront of getting the UK on the right path.

Better energy and resource efficiency across a whole range of activities and sectors is an essential prerequisite for the Government meeting its short and long-term targets to tackle climate change. Digital technology – through IoT and 5G – can make a substantial contribution to achieving these efficiency gains.

To fully realise the benefits of IoT and 5G technology, Government should create a regulatory and policy framework that removes barriers to adoption and incentivises the uptake of digital tech across the economy. This could include:

- **Net zero strategy** – the UK Government has committed to bring its net zero plans together in an overarching net zero strategy, due to be published later this year. To realise the benefits that 5G and IoT can bring in improving efficiencies and reducing emissions, and to show its commitment to digital tech solutions, the Government should use the strategy to set targets for the adoption of digital technology to reduce carbon emissions. This should include an operational review looking at how emissions can be reduced across all Government departments.

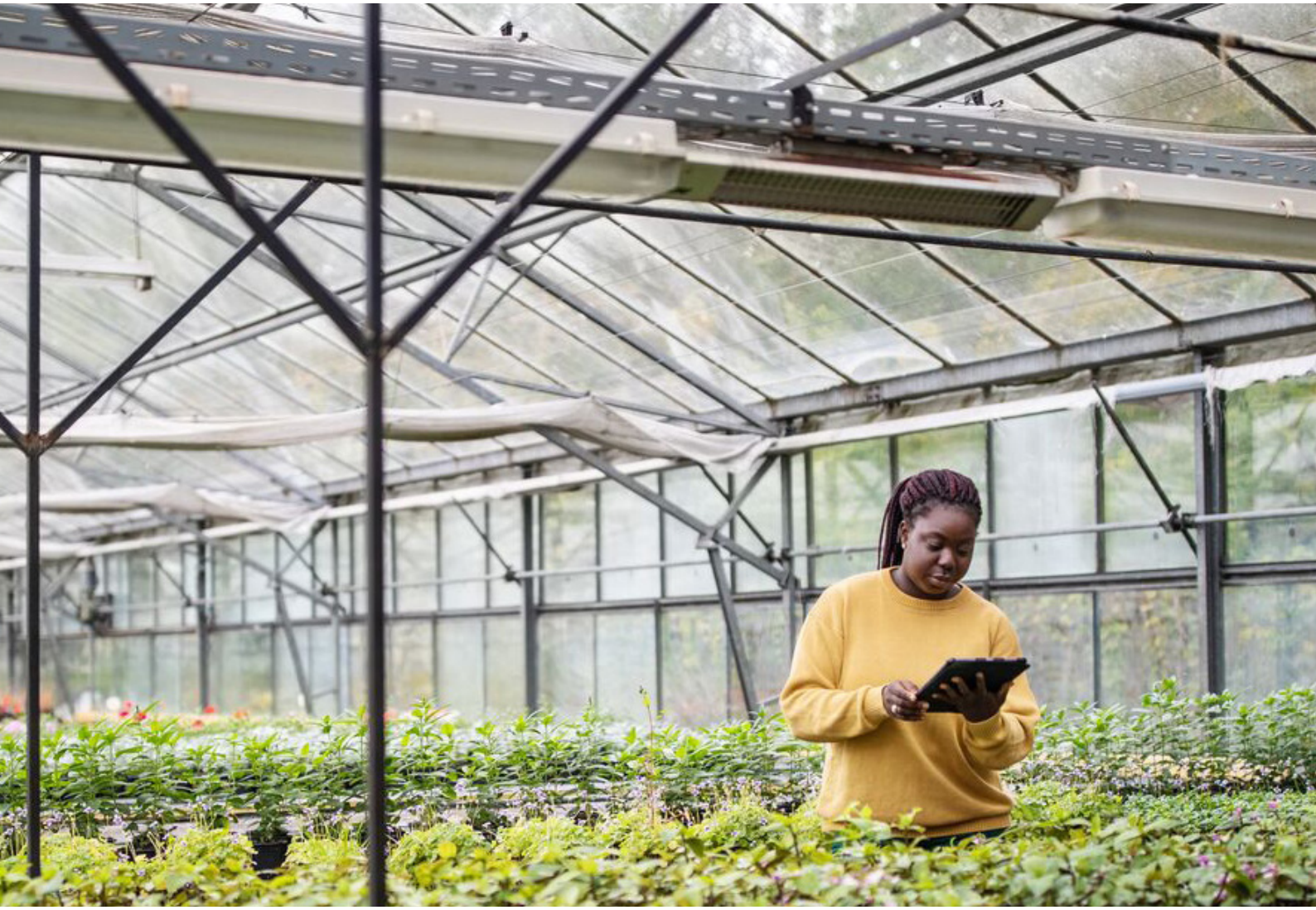
- **Incentives & procurement** – A lack of access to the upfront investment needed to be able to realise the benefits of IoT and 5G can be a barrier to adoption by businesses. Building on the Super Deduction[51] and Help to Grow: Digital scheme,[52] the Government should incentivise the adoption of IoT and 5G technologies in key sectors to accelerate their emissions reductions. In addition, the Government should further increase the weighting of carbon reduction technologies – and business carbon reduction targets – in procurement processes. Each Government department should assess the extent to which digital technologies can help to reduce their emissions.

- **Digital capability** – Businesses and Local Authorities play a key role in procuring and adopting digital technology to reduce emissions. However, without the right knowledge and digital capabilities, organisations will be slow to take up digital technology to decarbonise their operations. Government should work with industry to bridge this knowledge gap. Existing initiatives such as the Digital Catapult and Connected Places Catapult could be expanded to deliver a programme to enhance the digital capabilities of businesses and local authorities in this regard.

- **Future tech** – IoT is available now to reduce carbon emissions across some of the UK's most carbon intensive industries. And as technology develops, the carbon saving potential of digital tech will only increase. The existing model of the Catapults provides a clear framework to strengthen innovation in these areas, and as a result the Government should increase their resources to levels similar to the Fraunhofer institutes in Germany, as suggested by the Covid Recovery Commission.[53] In addition, the Government should make available £500 million of public funding for regional innovation centres specifically to develop future IoT and 5G applications that will help cut carbon emissions in key sectors.

- **Interoperability** – The primary barrier for procurement of IoT is the often limited interoperability of devices from different vendors. According to research by McKinsey, up to 60% of the potential economic value of IoT is contingent on delivering its full interoperability.[54] Whilst solutions such as Vodafone's IoT.nxt platform allows businesses to integrate their various IoT devices, the Government should introduce regulation to drive consistency in the security and data standards of IoT devices in order to improve interoperability, building on recent steps to regulate on the consumer code of practice on IoT.[55]

- **Network infrastructure** – IoT and 5G technology relies on secure, resilient, and reliable mobile network infrastructure. To realise the environmental benefits of digital technology across the UK, the Government should introduce a regulatory and policy framework that creates the right incentives for investment in network rollout and upgrades and delivers a good return on capital employed and investment. Government should also continue to remove barriers to network rollout, such as planning policy and businesses rates, as quickly as possible.



Annex: Methodology

As stated above, the three scenarios in the report are designed to take into account the potential uncertainty in the numbers arising from the following:

- **Rebound effects** – improvements in the energy efficiency of certain activities can lead to people carrying these out more frequently. For example, using digital technology to decrease the amount of time people spend stuck in traffic may increase their willingness to drive. This can reduce total emissions savings from energy efficiency measures, and so modelling should take this effect into account. A meta-analysis conducted for the OECD found rebound effects in road transport in the region of 12% in the short run (taking into account direct behaviour change, such as people with cars driving less/more) and 32% in the long run (taking into account effects beyond this, such as more people buying cars).[56]
- **Existing penetration levels** – or the extent to which this technology being used across transport, manufacturing, and agriculture at present, as this places a ceiling on the ability to improve this through further take-up. There is some data on this, but some of this is several years old, such as in the case of the Made Smarter review.[57]
- **Possible penetration levels** – or the full actual market potential of this technology, which places a ceiling on potential emissions reductions in a similar way to existing penetration levels. For example, Vodafone's work on smart farming assumes a 50% penetration rate across large farms in Europe, [58] but the maximum could be lower or higher.

Table equivalent to Figure 1: Scenarios for greenhouse gas efficiency savings by sector

	Potential GHG reduction		
Sector	**Low scenario**	**Mid scenario**	**High scenario**
Road transport (place within range determined by congestion levels)	5% - 10.7%	6%-12.9%	7%-15%
Agriculture	7.5%	10%	15%
Manufacturing	4%	4.5%	5%

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