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Industry pathways to net zero

Mobile and digital technology in support of industry decarbonisation

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We would like to thank the Carbon Trust as a trusted advisor in the analysis and modelling for this research.

Carbon Trust
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 commercialising low carbon businesses, systems and technologies.

Contents

Executive summary

Reducing carbon emissions to ensure the sustainability of the planet, society and industries is the prime challenge of the current era. A raft of choices and steps need to be taken for any industry to reduce its carbon footprint, as is the case for a company or country. Some will involve the use of technology; some will entail changes to consumer and business behaviour; and some will centre on regulations.

The use of mobile and digital technology is a key enabler of the decarbonisation transition. Telecoms operators, vendors and supporting ecosystem partners play a key role in the move to digital and low-carbon economies, particularly where it involves the enterprise segment and asset-intensive sectors using technology to lower emissions.

Smarter use of mobile and digital technology results in carbon savings

In this report, we outline a high-level quantification of decarbonisation and associated strategies for four key industries that account for 80% of global emissions – manufacturing, power and energy, transport, and buildings. We also outline a set of forward-looking implications.

The implementation of specific mobile and digital technologies could result in substantial CO_2 savings for each industry. In aggregate, the savings enabled by the technologies amount to just under 40% (equivalent to 11 gigatonnes) of the carbon emissions savings that these industries will need to achieve over the next decade, assuming an end goal of net zero by 2050.

To put this in perspective at an industry level:

- The annual global CO_2 savings from smart manufacturing would equate to 28 million roundtrip flights from London to Los Angeles.
- The potential CO_2 savings from using smart meters in North American residential premises would be enough to power 25 million homes (20% of households in the US) for a year.
- The savings from the switch to electric vehicles (EVs) worldwide would equate to removing 180 million petrol-fuelled cars from roads over the next 10 years.

IoT, LTE and 5G drive digitisation and decarbonisation

Digitisation and decarbonisation are enabled by a range of mobile connectivity products and network services working in sync with artificial intelligence (AI) and machine-learning algorithms in the cloud to drive productivity gains. IoT sensors, LTE and 5G connectivity (including for private networks) are being deployed across the industries profiled in this analysis, along with a raft of other solutions.

- In manufacturing, for example, smart factories are underpinned by IoT sensors, robotics and AI that automate dynamic shifts to production capacity and the remote repair of machine faults. This reduces reliance on manual labour, increases productivity and lowers overall factory energy consumption and emissions compared to premises not fitted with these technologies.
- In buildings, intelligent architectural design and the use of sustainable materials in the construction process are augmented by smart electricity and gas systems that optimise the use of energy based on occupancy levels and prevailing external climatic conditions. In homes, smart electricity meters are linked to smart home controls through a central interface that can offer energy savings of up to 5% and, in some cases, the ability to sell excess energy from the consumer to the grid.
- In transport, the use of on-board cellular telematics can improve shipping fuel efficiency and enable a more optimised model for cargo arrivals and departures from ports, due to reductions in idling time and better coordination with trucks for onward distribution of goods.

The ubiquity of mobile and digital technologies in these examples demonstrates their ability to deliver greater energy efficiency and productivity for industries globally. This requires a long-term and holistic investment approach.

The benefits of digitisation go beyond decarbonisation

While industry decarbonisation can help mitigate the risks of global warming, there are other important socioeconomic benefits. Examples include the following:

- **Public health outcomes –** Reducing CO_2 in the power sector will result in lower concentrations of harmful particulate matter and gases such as nitrogen dioxide. A similar effect is expected to prevail as electric vehicles replace petrol- and diesel-fuelled cars, and through a higher share of the population working at home.
- **Economic diversification –** Moving to digital operating models in industries such as manufacturing and transport will create new jobs and sources of national value growth. Digital operating models can also increase access to public services and civic engagement.
- **Productivity –** Digitisation drives fundamental improvements in productivity, which form the basis of new business models across industries.

These are whole subjects in their own right and topics for future research. We cite them here to emphasise that greater disclosure from private sector companies on these fronts will increasingly be required for future sustainability reporting.

Our projections are designed to show the art of the possible if technology is used and implemented. The good news is that corporate commitments to net zero across several industries are more ambitious than the legislated policy positions laid out by governments. According to the Energy and Climate Intelligence Unit, of the 130 countries that have committed to carbon neutrality, only 15 (representing 12% of global emissions) have either achieved or legislated their targets into law – the only genuine measure of commitment. In the private sector, 20% of the world's largest companies have made a commitment. The pace will pick up in the wake of COP26 given commercial and public demand, and rising adoption of globally recognised measurement standards – notably, the Science Based Targets initiative (SBTi).

This research demonstrates the clear, practical and beneficial impact of using mobile and digital technologies in the largest and most relied upon industries. These are, in the main, ready-made options. While investment outlays and deployment costs are required (a particular challenge for smaller companies), these will decrease over time as scale grows. The long-term return on investment from a financial perspective (higher productivity) and sustainability angle (lower emissions) is highly significant. Market participants in the telecoms, media and technology sectors are unique in being both suppliers and consumers of the technologies. In this capacity, we hope this report and ensuing industry case studies add to the best practice driving decarbonisation in the years ahead.

1. Industry decarbonisation: strategies and roadmaps

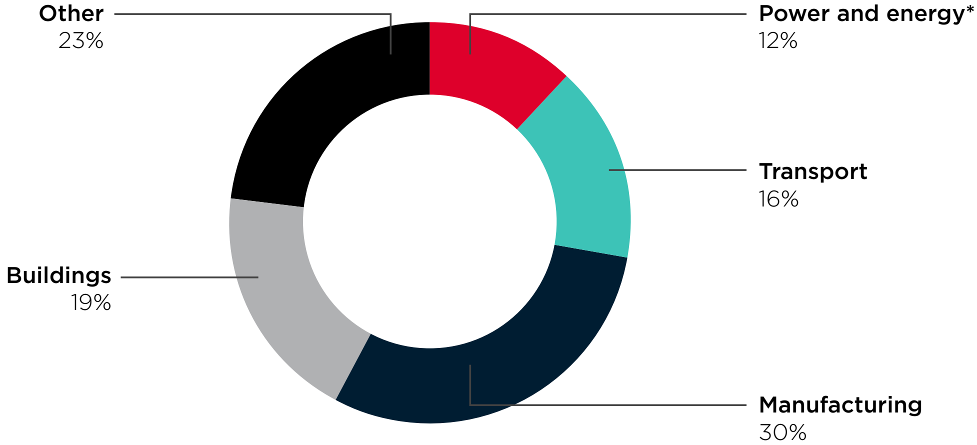
Actions and investments to support decarbonisation across different sectors of the economy have increased rapidly since the seminal United Nations Climate Change Conference (COP21) in Paris in 2015. The COP26 conference in Glasgow provides a crucial staging ground, progress check and forward-looking view of how further collaborations can support the core Paris goal of limiting the rise in global temperatures this century to a maximum of 1.5°C above pre-industrial levels. A raft of choices and steps need to be taken for any industry to reduce its carbon footprint, as is the case for a company or country. Some will involve the use of technology; some will entail changes to consumer and business behaviour; and some will centre on regulations.

Within this context, the use of mobile and digital technology is a key enabler and accelerator of the decarbonisation transition. Telecoms operators, vendors and supporting ecosystem partners play a key role in the move to more digital and low-carbon economies, particularly where it involves the enterprise segment and asset-intensive sectors using technology to lower emissions. In this report, we outline a high-level quantification of decarbonisation and associated strategies for four key industries that account for 80% of global emissions – manufacturing, power and energy, transport, and buildings. We also outline a set of forward-looking implications.

The four industries analysed account for approximately 40 gigatonnes (Gt) of CO_2 emissions per year worldwide. This is equivalent to just under 80% of the total, with the remainder from agriculture, food production and a range of natural sources. The industries therefore provide a representative cross section for the methods and scale of decarbonisation that the world will need to achieve if we are to reduce CO_2 emissions by 50% over the next 10 years and remain on course for the 1.5°C target.

Figure 1

Share of global CO_2 emissions by industry

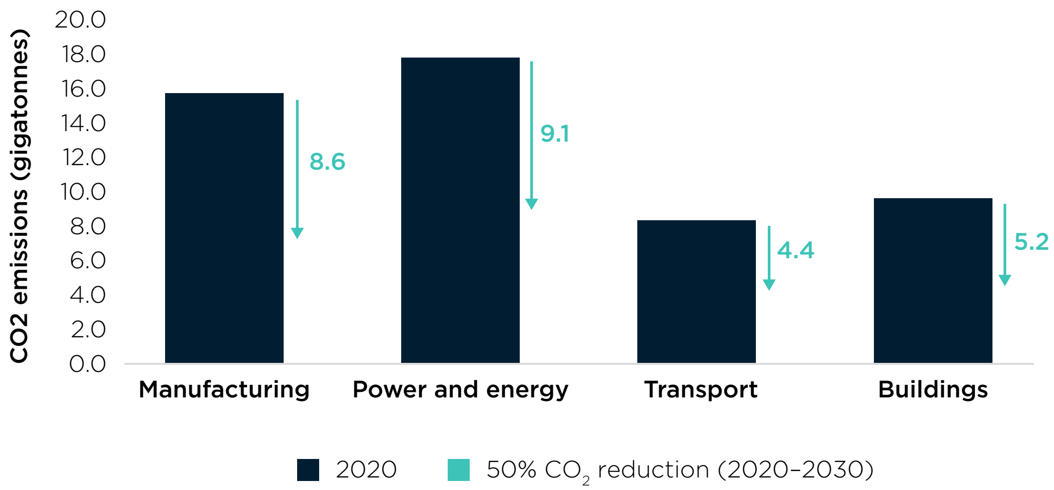


*Sector's own emissions. The rest of this report shows data for emissions that the power and energy sector can directly influence, including energy production for other sectors.

Source: Exponential Roadmap, GSMA Intelligence

Figure 2

The 50% reduction glidepath to 2030



Note: 50% reductions on 2020 levels are approximate.

Source: GSMA Intelligence, Exponential Roadmap, Carbon Trust

Our analysis follows a common format for each sector:

- **Industry context and reduction path to net zero –** Reviews the sector's overall CO_2 footprint and reduction path (assuming net zero by 2050), before outlining the high-level strategies for decarbonisation.
- **Decarbonisation strategies: mobile and digital tech impact –** Profile and analysis of which mobile and digital technologies can help along the sector's path to decarbonisation, how they work and can be implemented, and examples of companies deploying them. While there are a host of relevant and viable strategies and approaches to reducing carbon footprints that do not involve mobile and digital technology, they are outside the scope of this report.
- **How much it could all add up to –** Quantification of the potential CO_2 emissions savings as a result of the use of the specific mobile and digital technologies profiled, over a 10-year period to 2030. Figures are expressed in megatonnes and as a percentage of total sector savings over the period, with the latter using data from Exponential Roadmap[1] as the baseline for overall industry CO_2 levels. A more detailed methodology for the calculations can be found in the Appendix.

Following this report, we will also be publishing a complementary series of industry case studies that profile decarbonisation strategies for each sector in more detail and provide company examples to illustrate.

[1] J. Falk, O. Gaffney, et al. Exponential Roadmap. 1.5.1 (2020). www.exponentialroadmap.org

2. Manufacturing

Industry context and reduction path to net zero

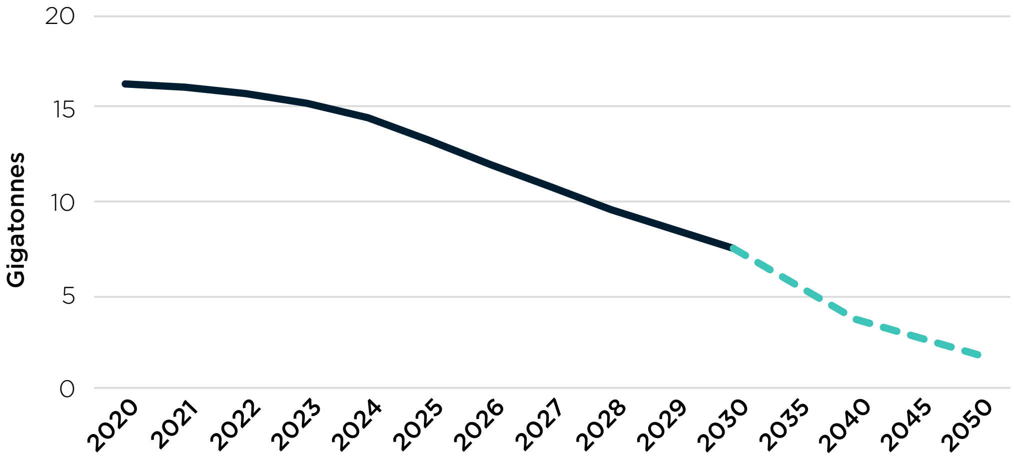
Manufacturing is one of the largest and most disparate industries, with sub-segments including automotive, aerospace, industrials and chemicals. The shift in production towards emerging markets since China's market liberalisation in the late 1990s has resulted in a steady increase in carbon emissions. In aggregate, the manufacturing sector is responsible for approximately 16 Gt of CO_2 per year,[2] equating to around a third of all industries. To put this in perspective, the emissions are roughly the same as those emitted by 4,000 coal-fired power plants in a year.

Using a 50–50–50 approach (i.e. 50% reductions in CO_2 each decade to 2050), emissions reductions of 8.6 Gt over the next 10 years from 2020 levels are required to remain on track for net zero by 2050 (see Figure 3). Industry participants are, however, highly advanced in the use of digital technology as part of the broader overhaul of factory-floor and warehouse operations associated with Industry 4.0 (the umbrella term for the digitisation of manufacturing). Much of this involves the use of higher grade automated production equipment with IoT sensors that can be monitored and adjusted in real time by machine learning algorithms in the cloud. Installing low-latency connectivity, including through private LTE and 5G networks, is an important infrastructural underpinning. The net effect is higher productivity, energy efficiency and lower carbon emissions directly and indirectly.. Outside of investment in digitisation, a host of strategies involve factory and warehouse design, more sustainable use of materials, reduced use of plastics in production, and the overarching development of a viable circular economy.

[2] J. Falk, O. Gaffney, et al. Exponential Roadmap. 1.5.1 (2020). www.exponentialroadmap.org

Figure 3

Manufacturing industry CO_2 glidepath to net zero (worldwide, 50% reduction by 2030)



Source: Exponential Roadmap

Decarbonisation strategies: mobile and digital tech impact

Decarbonisation from technology is primarily being driven by productivity and energy-saving yields as a consequence of digitisation. Industry 4.0 was a term coined in Germany 10 years ago in heed to its domestic strength in manufacturing. However, it has become a macro term for the sector. The industry has a complex value chain, even for digital tech, which has evolved into a spectrum from automation through to higher level applications that require ultra low latency, such as AR, VR and edge compute. Figure 4 shows the value chain at a high level. While robotics and automation software are among the most advanced elements of a smart factory, IoT sensors and high-grade cellular networks (ultra high speed, ultra low latency) are fast maturing in the pilot and full commercial deployment phases. A host of large tech groups, systems integrators and equipment vendors are active here, with many (e.g. Microsoft, Bosch, Siemens and PTC) operating at multiple levels of the value chain.

Figure 4

Smart manufacturing: multiple layers in the value chain

Area	Adoption	Example vendors
Industrial automation	Growing	ABB, Bosch/Rexroth, Rockwell Automation, Schneider, Siemens
Manufacturing software	Advanced	Dassault Systemes, Microsoft, PTC, SAP, SAS
Robotics	Advanced	ABB, Fanuc, Kuka, Mitsubishi, Yaskawa
Networks and connectivity	Growing	Cisco, Dell, Ericsson, HPE, Netgear, Nokia, Siemens
IoT	Growing	Bosch, Ericsson, Fujitsu, Microsoft, Nokia, PTC, Siemens, Telit
AR/VR	Early	Dassault Systemes, Microsoft, PTC
Edge computing	Growing	Amazon, Ericsson, Fujitsu, HPE, Intel, Microsoft, Nokia, Nvidia

Note: non-exhaustive list of vendors provided. Examples given are generally large, established and high profile.
Source: GSMA Intelligence

Manufacturing groups typically look to industrial-grade solutions with simplicity, security, reliability and cost efficiency as key purchasing criteria in assessing industrial connectivity options. Performance can be defined in multiple ways, with speed of transmission, reliability, redundancy, latency, jitter and support of common industrial protocols as key performance indicators (KPIs). With the proliferation of data and sensors, manufacturers have begun to realise the limitations in wired connectivity. Industrial ethernet is increasingly being complemented with LTE and 5G as a longer term alternative. The rise of 5G, emergence of private networks and falling sensor costs all contribute to our outlook for manufacturing being one of the most bullish among IoT verticals. We forecast smart manufacturing IoT connections to rise more than 3× to 1.5 billion by 2025. Industry sentiment further reflects its prominence, with 56% of manufacturing groups considering IoT transformational to their businesses, according to the GSMA Intelligence Enterprise in Focus Survey.

The adoption of mobile and digital technology in connected (or smart) factories and warehouses drives decarbonisation through increased automation and productivity. We have segmented the technology options in Table 1 for comparison. IoT sensors can, for example, be embedded in machinery and robotic elements of the production process, sending real-time data over a high-speed link to the cloud where AI and machine learning algorithms are run to monitor and adjust output volumes. The same can be done for diagnostics and fault management, saving time and what may otherwise require human labour to rectify.

The underpinning is increasingly switching to private cellular networks and slices (LTE or 5G) that offer a guaranteed quality of service (QoS). These may integrate with existing industrial ethernet connections that handle a portion of existing intra-factory data connectivity. 5G is particularly important in Industry 4.0 and decarbonisation because of its low-latency benefits enabling production machinery and warehouse inventory tasks to be automated and performed more quickly, particularly where no existing wired connections are in place. An example is in aircraft maintenance checks. Lufthansa successfully completed a test case using a 5G private network at its Hamburg hangar in partnership with Vodafone and Nokia. Engineers at a remote location could conduct a safety inspection of engine parts via AR over the high-speed link.[3] Taken together, industry reporting and interviews conducted for our research suggest annual productivity and energy-saving gains of 10–20% can be realised through the conversion to smart manufacturing.

> "Annual productivity and energy-saving gains of 10–20% can be realised through the conversion to smart factories"

[3]"Premiere for 5G networks in aircraft maintenance", Lufthansa Technik, February 2020

Table 1

How mobile and digital tech can help decarbonise

	Smart factories	Smart warehouses
Tech option		
IoT	• Factories and assembly lines equipped with IoT sensors connected to machinery and related equipment • Diagnostics and maintenance • Troubleshooting and quality control	• Diagnostics and maintenance • Troubleshooting and quality control
Cellular connectivity (LTE and 5G)	• Mobile connectivity • Private networks (and slicing) • AR/VR/digital twins for equipment/ plant maintenance • Drones and other mobile robots used for moving parts/finished products around a plant • Autonomous mobile robots (AMRs) for moving and repairing parts	• Mobile connectivity • Private networks (and slicing) • Asset tracking (inbound and outbound) • Inventory management and fault repair via AMRs, smart forklifts and automated storage/retrieval systems (AS/RS)
Cloud and analytics	• AI for high-volume parametric data crunching from production lines for machine diagnostics	• Image and video processing AI functions, including video analytics

Source: GSMA Intelligence

How much it could all add up to

According to our base case forecast, the shift to smart manufacturing could result in CO_2 emissions reductions of 1.2 Gt over the 10-year period to 2030, accelerating in particular during the latter half of the decade. This equates to approximately 15% of CO_2 reductions for the total sector over the period.

To put this in perspective, the annual global CO_2 savings from smart manufacturing would equate to 28 million roundtrip flights from London to Los Angeles, or 24 million cars taken off the roads.

Key assumptions (non-exhaustive):

- **Footprint –** Total factories in operation worldwide are estimated at 9.6 million as of 2020 and extrapolated forward on recent growth trends. Using average IoT density figures, an estimated 130,000 smart factories were in operation as of 2020, or 1.4% of the global total. We forecast this to rise to 5.7% of factories by 2030.
- **IoT density in smart factories –** We assume 0.5 IoT sensors per square metre are required for the average smart factory.
- **Emissions factors –** Electricity emissions factors are extrapolated forward for each region annually based on the declining rate for the UK (Department for Business, Energy and Industrial Strategy figures).
- **Energy savings –** 15% per year for an average smart factory, as an average of reported data.

Table 2

Projected CO_2 emission savings from smart manufacturing (worldwide)

	2021–2025			2026–2030		
	Low	Base	High	Low	Base	High
Smart manufacturing						
CO_2 reductions (Mt)	362	452	543	632	790	948
Contribution to sector CO_2 reduction (%)	12.2%	15.3%	18.3%	11.2%	14.0%	16.8%

Note: Mt = megatonne (1 million tonnes). Low = base –20%; high = base +20%.
Source: GSMA Intelligence, Exponential Roadmap, Carbon Trust

Industry context and reduction path to net zero

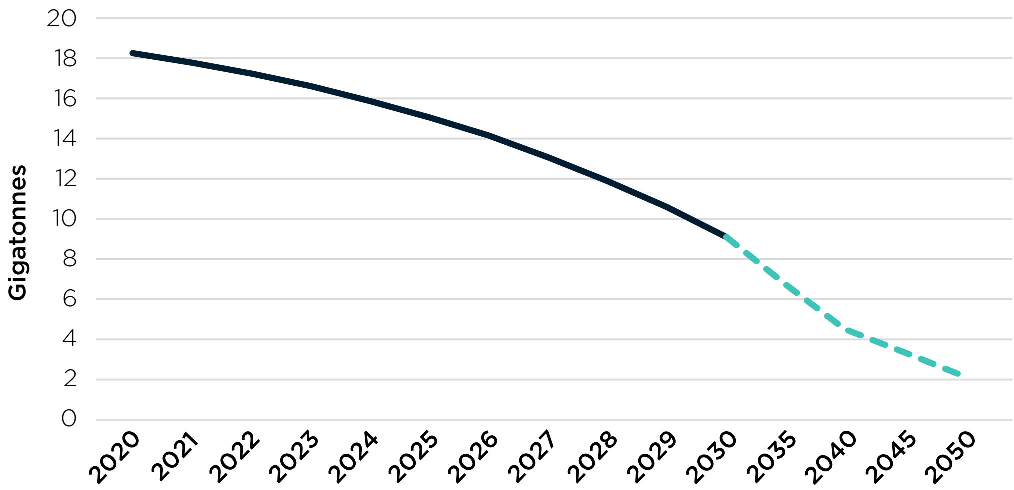
The power sector provides energy to all other sectors and residential customers. CO_2 emissions are 18 Gt, around 35% of the global total. Our analysis covers the emissions the sector can directly influence, which are those from the industry's own activities in extraction and refinement of fossil fuels, distribution and electricity produced for use by other sectors[4] (it does not include indirect use such as petrol/diesel fuels for transport verticals). The power sector is the highest source of CO_2 emissions globally. Without intervention, the sector's emissions would continue to rise. This reflects the relatively higher importance of heavy industry in high-growth economies such as China and India, and a balance of energy production in which fossil fuels are the firm majority, with renewables growing from a smaller base due to the lower levels of grid capacity in parts of Southeast Asia and Africa. While China and India have seen an expansion of renewables (particularly solar and hydro), fossil fuels are still the dominant fuel source to power industrialisation.

According to a 50–50–50 model, the sector will need to reduce CO_2 emissions by 9 Gt over the next 10 years. Participants in the industry include power plant groups, grid operators (legacy and emerging, particularly in renewables), retail energy providers and providers of smart energy system components, which includes telecoms operators. The power sector has a number of avenues available to it to reduce CO_2 emissions. The shift to renewables is paramount, as are other clean fuel transitions such as to hydrogen-based fuels. There are also reductions to come from reduced by-products – principally methane.

[4] J. Falk, O. Gaffney, et al. Exponential Roadmap. 1.5.1 (2020). www.exponentialroadmap.org

Figure 5

Power and energy industry CO_2 glidepath to net zero (worldwide, 50% reduction by 2030)



Source: Exponential Roadmap

Decarbonisation strategies: mobile and digital tech impact

The use of digital technology by power sector organisations and retail energy providers spans a number of use cases – from smart grids, to batteries for energy storage, to expanding the production of renewables. These are interlinked in the drive to scale smart energy systems (SES) and the use of connected IoT sensors. In our analysis, we focus on two main use cases intrinsically linked to other technologies within SES:

- **Connected solar grids –** Connected power grids to manage and distribute solar energy. Grids are equipped with IoT sensors that in turn connect to a mobile network, cloud and/or end-user premises (residential or commercial) through cellular or non-cellular protocols.

- **Connected wind grids –** Connected power grids to manage and distribute wind energy. Grids are equipped with IoT sensors that in turn connect to a mobile network, cloud and/or end-user premises (residential or commercial) through cellular or non-cellular protocols.

SES refers to the whole network of energy production, distribution and customer use being interlinked through connected sensors and analytics. The reduction in carbon emissions comes from substitution to renewable energy (principally solar, wind, hydro and biomass), efficiencies in distribution and smarter use of energy by customers with smart meters. Connected solar and wind grids are therefore an integral part of SES and represent one of the most pronounced shifts in the energy sector over the last five years. Europe is the global leader in this respect, benefitting from a combination of regulation, political commitment, capacity increases and a decline in prices. For the world to stay in line with the 1.5°C target, all countries will ultimately need to transition to renewables as the majority energy source. Combined with the continued proliferation of IoT in power and utility sector contexts, this drives our expectation that the share of solar and wind grids that are IoT connected will rise to 75% by 2050 (from 35% and 10% respectively in 2020).

The connectivity used by IoT sensors is likely to change to a mix of cellular networks and unlicensed options such as Wi-Fi and low power (LPWA) variants. There is also the potential for LTE and 5G private networks to service connected grids at scale by assisting with distributed automation. Low-latency connectivity and analytics support are key influencing factors behind the higher efficiency of SES that drives CO_2 reductions compared to legacy grids with fossil fuels.

Residential and commercial smart meters are also a major part of the story, particularly in countries where regulation requires their installation (new build or retrofits). For example, the UK requires them for all properties by 2025. Their impact on home energy usage comes from reduced consumption, differentiated charging (pricing incentives to consume energy off-peak) and potentially the monitoring of low-carbon heat pumps. These impacts filter through to reduced CO_2, though we allocate that to buildings. There is also an indirect impact on grid efficiency by better matching supply and demand in real time for local areas, and reselling excess energy back to the grid to increase the available supply of electricity. Ultimately, using wireless technologies to monitor the low-voltage portion of the distribution grid confers the ability to manage demand response digitally and can create a positive impact in terms of CO_2 emissions and grid reliability.

> "Low-latency connectivity and analytics support are key influencing factors behind the higher efficiency of SES that drives CO_2 reductions"

Table 3

How mobile and digital tech can help decarbonise

	Connected solar grids and connected wind grids
Tech option	
IoT	• Sensors embedded on solar photovoltaic installations (e.g. a micro grid run by a smallholder or large-scale solar farm) to monitor production and distribution • Sensors at grid switching points (could also use LTE or 5G connectivity) • Manage smallholder or CPO battery installations for energy storage and flexibility

Cellular connectivity (LTE and 5G)	• Private networks (or slices)
	  • Service solar grids (could combine with massive IoT deployments)
	  • Private LTE installations can also automate plant operations (hydro or nuclear)
	• Detection and/or prediction of demand spikes or overloads
	• Manage behind the meter solar and storage installations
	• Implement demand response schemes for residential and industrial consumers
	• Field area network connectivity to automate grid function, reducing truck rolls

Cloud and analytics	• AI processing of sensor data on energy flows. Could trigger feedback loop that, for example, shifts capacity to a specific area • Asset performance monitoring • Predictive maintenance to reduce truck rolls • Forecast demand peaks (year ahead, month ahead, day ahead and intra-day) • Manage demand/response (peak shaving)

Source: GSMA Intelligence

How much it could all add up to

According to our base case forecast, the shift to connected solar and wind grids could reduce CO_2 emissions by 3.0 Gt and 1.1 Gt respectively over the 10-year period to 2030 (see Table 4). This equates to approximately 33% and 13% of total sector CO_2 reductions over the period.

To put this in perspective, CO_2 savings over the next five years alone in Asia would equate to taking around 300 coal-fired power plans offline or 287 million cars off the roads.

Key assumptions (non-exhaustive):

- **IoT penetration –** We use a 2020 starting point where 35% of solar and 10% of wind grids are fitted with IoT technology. Our assumption is that these both increase on a straight line to 75% by 2050.
- **Renewables capacity –** We assume that solar and wind capacity increase at the 2020 rate (with solar based on International Energy Agency data, and wind on Global Wind Energy Council data) each year to 2030.
- **Emissions factors –** Electricity emissions factors are extrapolated forward for each region annually based on the declining rate for the UK (Department for Business, Energy and Industrial Strategy figures).

Table 4

Projected CO_2 emission savings for the power and energy sector (worldwide)

	2021–2025			2026–2030		
	Low	Base	High	Low	Base	High
Connected grid – solar						
CO_2 reductions (Mt)	983	1,229	1,474	1,433	1,791	2,149
Contribution to sector CO_2 reduction (%)	31%	38%	46%	24%	30%	36%
Connected grid – wind						
CO_2 reductions (Mt)	353	442	530	577	721	865
Contribution to sector CO_2 reduction (%)	11%	14%	17%	10%	12%	15%

Note: Mt = megatonne (1 million tonnes). Low = base –20%; high = base +20%.
Source: GSMA Intelligence, Exponential Roadmap, Carbon Trust

4. Transport

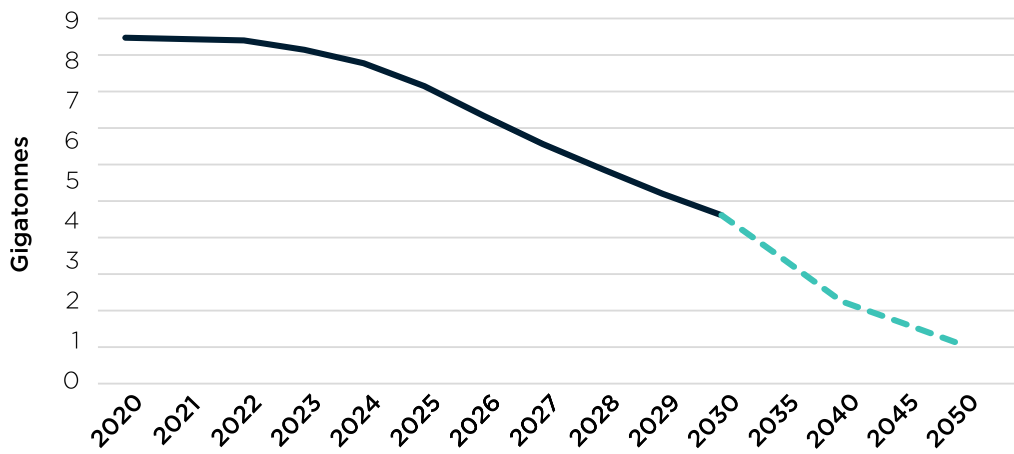
Industry context and reduction path to net zero

As with manufacturing, the transport sector comprises multiple parts – automotive and truck haulage, aviation, rail and freight, shipping and maritime, and public transport. In aggregate, the sector accounts for around 8.5 Gt of CO_2 per year, equivalent to 16% of the global total. The net-zero glidepath requires a reduction of around 4.5 Gt over the next 10 years (see Figure 6). Analysis of data from Exponential Roadmap indicates that the majority of emissions comes from short journeys, typically around cities from home to work or other functional purposes such as grocery shopping. Long-range journeys are well under 50% of the sector total, though largely by a small share of the population (e.g. business travel).

The emissions reduction path for transport entails an equal mix of technology, behavioural change and political choices. We discuss and quantify several mobile and digital technologies below. Electric vehicles (EVs) are not digital per se, but there is a direct enabling effect from IoT systems used in charging, and from onboard telematics to improve fuel efficiency. Working from home is worth watching closely as its popularity may well increase further than our estimates. Beyond these, much of the transport sector reductions will come from behavioural changes, including substituting car journeys with public transit, ride-sharing and (eventually) autonomous vehicles.

Figure 6

Transport industry CO_2 glidepath to net zero (worldwide, 50% reduction by 2030)



Source: Exponential Roadmap

Decarbonisation strategies: mobile and digital tech impact

Transport companies and public transit authorities are highly advanced in their use of mobile and digital technology to assist in their decarbonisation. Automotive manufacturers have made and continue to make structural investments to shift production to electric vehicles (EVs) and ultimately self-driving cars. This offers the prospect of reducing the CO_2 emissions for those vehicles that remain on the road and cutting overall mileage through shared journeys (extrapolating the Uber model to a larger scale for everyday journeys to work). Smart routing systems for commercial trucks, freight and ships are now widely used. Urban traffic management systems that use IoT sensors and 5G connectivity can also help reduce congestion and the emissions from idling. Finally, the pandemic's influence on home working is likely to be a permanent change, implying significant savings from the reduction in journeys, especially in cities or countries where cars still predominate.

In our analysis of the transport sector, we focus on four use cases. While there are many others, we have selected these to offer a quantified view of impact savings and the range of implementation models available to automakers and transit/logistics operators:

- **Electric vehicles –** Vehicles that run on battery charging from a network of charging points. This leads to a reduction in CO_2 emissions through the substitution of petrol- or diesel-based mileage. There is a minimal offset level from charging if drawing electricity from non-renewable sources.
- **Smart routing, fleet management and port operations**
  - **Heavy goods vehicles (HGVs) –** The use of on-board connected telemetry sensors to optimise the route and speed of HGVs. CO_2 is saved by driving fewer miles and optimising consignment collections and deliveries.
  - **Commercial shipping –** Use of on-board connected telemetry sensors to optimise the route and speed of commercial shipping vessels. CO_2 is saved by travelling fewer miles and, crucially, spending less time idling for transit seaways and at ports. Improved scheduling of consignment deliveries and collections is at the heart of a just-in-time system in which container ships immediately transfer cargo to trucks for onward transport, minimising downtime and the risk of congestion at ports and the roads servicing them.

- **Working from home –** The overall effect on CO_2 emissions from a larger share of the labour force working at home. This is based on eligible workers having the capability to work from home, including having access to devices and the internet (via LTE, 5G, fixed wireless or fixed broadband). The reduction is driven by fewer transit journeys to offices or other workplaces, with a minimal offset from increased energy usage while at home.

There are also savings to be made in air and rail travel, but much of these are behaviour-driven. Business class travellers, for example, carry a CO_2 impact that is 3–4× times that of economy class, which is why the majority of airline emissions are accounted for by a small minority of the population. The pandemic has already mitigated this to a certain extent, following travel restrictions, but a reduction in overall corporate travel is likely to be a permanent change because of the CO_2 burden, costs and the widespread availability of virtual meeting platforms.

IoT and advanced mobile connectivity both have a role to play. IoT telematics sensors are, for example, used in commercial haulage and shipping operations to optimise the route a driver takes based on known and anticipated traffic patterns and, crucially, the prioritisation of vehicles scheduled for consignment deliveries at warehouses, ports and other onward distribution points. Research suggests this can reduce HGV fuel consumption by 5%. The same principle holds in shipping (with a slightly lower fuel reduction rate of 2% on average). Idling causes needless emissions if ships can otherwise plug into electricity sources on shore or arrive only when a port slot is available. The distribution model for vendors, telecoms operators and enterprise software-as-a-service (SaaS) providers often works in combination as joint bids rather than one company providing all services under one roof. Maersk, for example, now invests $1 billion per year in energy-efficient technology directly and via its supply chain. The latter is important given the obvious interlinkages with trucks to manage deliveries to and from ports. The company has suggested that electric trucks can carry a maximum load of two containers over 800 kilometres on a single charge – better than diesel but still far below the efficiency of seaborne shipping.

Port operators are also using LTE and 5G private networks for their point proximity and guaranteed QoS across the coverage footprint. This offers a range of connected services, including data connectivity to cranes, video surveillance (including on drones), connectivity for automated vehicles (such as forklifts for loading and unloading containers), asset tracking of goods transported from ship to truck, and weather monitoring. The ability to monitor and adjust settings from a centralised control panel means port operators can respond in real time to ensure the smooth flow of goods – a crucial competitive differentiator in becoming a reliable hub for facilitating cross-border trade. The partnership between Nokia, Deutsche Telekom and the Port of Hamburg – a facility spanning 43 square kilometres – is an example here.[5]

Working from home has perhaps the greatest potential impact, though this depends on the extent to which pandemic-driven behaviours carry forward, which will vary by industry. Our analysis based on a study by McKinsey[6] and employment rates suggests that working from home will reach close to 70 days per year in the US. Even in manufacturing-heavy countries such as Mexico, Brazil, China and India – where labour is overall less suited to remote working – it will reach 40–50 days per year due to the rising prevalence of LTE, which itself can act as a Wi-Fi hotspot. The ubiquitous nature of broadband connectivity and impending rise of 5G both augur for working-from-home rates to increase on a permanent basis, with 5G potentially more price competitive than fibre.

> "Working from home has perhaps the greatest potential impact, though this depends on the extent to which pandemic-driven behaviours carry forward"

[5] "Port authorities and terminal operators: private networks and public slices in sea ports", Enterprise IoT Insights, July 2019
[6] "What's next for remote work: An analysis of 2,000 tasks, 800 jobs, and nine countries", McKinsey Global Institute, November 2020

Table 5

How mobile and digital tech can help decarbonise

	EVs	Routing (HGVs)	Routing (shipping and ports)	Working from home
Tech option				
IoT	• Sensors on EV charging points • Batteries	• IoT telematics embedded in engine and navigation systems. Reduces distance and optimises just-in-time deliveries		N/A
Cellular connectivity (LTE and 5G)	• Autonomous EV mapping and navigation systems	• Navigation systems connectivity, including cross-border roaming (could pair with satellite) • Autonomous trucks (including platooning vehicles to reduce drag)	• Container logistics including container port management and tracking • Navigation systems connectivity, including cross-border roaming (could pair with satellite)	• Mobile connectivity (calls and data) • 5G fixed wireless broadband
Cloud and analytics	• Autonomous EV mapping and navigation systems • Speed, fuel and performance adjustments • Outbound recommendations on optimal charging times (to take advantage of excess energy in the grid)	• Driver behaviour monitoring (e.g. speed, braking) and recommendations for improvement • Optimised fuel economy • AI-driven predictive maintenance (rather than at set mileage frequencies)	• AI-driven analytics of port operations (ship positioning, video surveillance, overall capacity levels)	N/A

Source: GSMA Intelligence

How much it could all add up to

We forecast CO_2 reductions of 1 Gt from EVs, 0.5 Gt from HGV smart routing, 0.9 Gt from shipping smart routing and 0.4 Gt from working from home. These equate to 24%, 12%, 21% and 9% of transport sector reductions respectively over the next 10 years.

To put this in perspective, the use of EVs alone would mean a reduction in CO_2 that is equivalent to taking 180 million cars off the roads worldwide over the next 10 years.

Key assumptions (non-exhaustive):

General

- **Emissions factors –** Electricity emissions factors are extrapolated forward for each region annually based on the declining rate for the UK (Department for Business, Energy and Industrial Strategy figures).

Electric vehicles

- **EV charge points –** We assume 1% of smart city IoT connections in 2021, rising to 10% by 2030.
- **Electricity consumption –** A total of approximately 3700 kWh is used per charging point per year.

Smart routing (HGVs)

- **HGVs –** Of the 60 million HGVs in active use worldwide, we assume 50% are fitted with IoT telematics sensors, equating to 30 million connected HGVs.
- **Fuel savings –** We assume an average of 5% per connected HGV, per year.

Smart routing (shipping)

- **CO_2 output –** Approximately 17,000 kg of CO_2 per year, per ship.
- **Fuel savings –** We assume an average of 2% per connected ship, per year.

Working from home

- **Home working days per week, per eligible worker –** Regional assumptions are made based on country data derived from a McKinsey study: UK (1.3), US (1.2), Brazil (0.9), Mexico (0.9), India (0.7), China (0.8) and South Africa (0.9).
- **Employment rate –** 70% of working age population for all regions.
- **Internet penetration –** Population averages use a combination of fixed line broadband (primary access point for high-income countries) and LTE connections (primary access point for low- and middle-income countries).

Table 6

Projected CO_2 emission savings for the transport sector (worldwide)

	2021–2025			2026–2030		
	Low	**Base**	**High**	**Low**	**Base**	**High**
Electric vehicles						
CO_2 reductions (Mt)	196	245	294	638	797	957
Contribution to sector CO_2 reduction (%)	17%	21%	25%	20%	25%	30%
Smart routing and fleet management (HGVs)						
CO_2 reductions (Mt)	147	184	221	257	322	386
Contribution to sector CO_2 reduction (%)	13%	16%	19%	8%	10%	12%
Smart routing and fleet management (commercial shipping)						
CO_2 reductions (Mt)	272	339	407	448	560	671
Contribution to sector CO_2 reduction (%)	23%	29%	35%	14%	18%	21%
Working from home						
CO_2 reductions (Mt)	148	185	222	154	192	231
Contribution to sector CO_2 reduction (%)	13%	16%	19%	5%	6%	7%

Note: Mt = megatonne (1 million tonnes). Low = base -20%; high = base +20%.
Source: GSMA Intelligence, Exponential Roadmap, Carbon Trust

5. Buildings

Industry context and reduction path to net zero

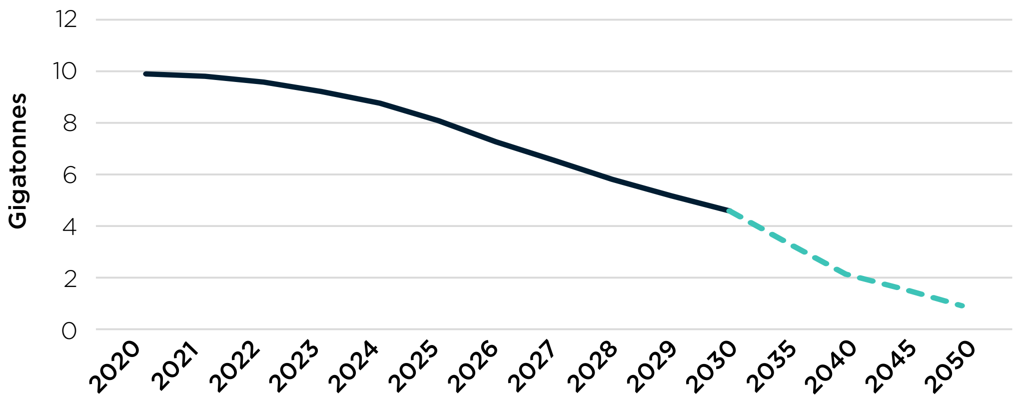
The temporary slowdown in activity for the buildings sector (encompassing residential, commercial and some industrial settings) as a result of Covid-19 is now rebounding. As with manufacturing, building activity, whether new build, repairs or renovations, tends to move in line with the wider economy. In aggregate, the sector accounts for around 20% of global CO_2 emissions. The reduction path requires a decrease of around 5 Gt over the next 10 years. Fundamental changes to the way homes are insulated, heated and designed will be key drivers. Behavioural change will also play a major part from households using less energy, though there are several interlinkages with digital technology in the form of smart meters and energy management systems. Urban planning in high-density central business districts entails linking office sites closer to public transport stations, alongside a growing range of public-private partnerships to finance cost-effective bicycle and scooter hire networks.

In the commercial sector, office building and other property developers are incorporating energy-efficiency guidelines into the architecture at the design, construction and building management levels. Digital technologies are being incorporated into the design of office buildings through 3D and 4D renderings and simulations of energy usage based on changing capacity levels. Construction is being optimised through the use of sustainable and recycled materials (including polymer substitutes for steel) and low carbon-emitting machinery, including robotic cranes and related site equipment. Kone, for example, has engineered the ability for construction workers to utilise internal elevator shafts to be transported upwards, obviating the need for new external hoists and reducing build times by months. The building management level is being overhauled through the use of IoT sensors, mobile technology and AI to optimise energy-usage levels based on occupancy rates rather than the status quo ‘always on’ model. In this context, Kone has also developed a partnership with IBM to use its cloud AI platform (Watson) to offer predictive analytics for maintenance and repair of faults in elevators and other internal systems.

There is also a major behavioural aspect to consider from a potential structural reduction in footfall to offices as a result of a pandemic-led shift in working patterns. This is not accounted for in our forecasts but is a factor to follow closely.

Figure 7

Buildings industry CO_2 glidepath to net zero (worldwide, 50% reduction by 2030)



Source: Exponential Roadmap

Decarbonisation strategies: mobile and digital tech impact

To understand the mobile and digital technology role in decarbonisation strategies, we have separated residential premises (smart electricity meters) from commercial premises (smart meters and HVAC systems).

There are a host of ways digital tools are being applied in residential and commercial premises, as well as urban planning more broadly. In our quantitative analysis of the buildings sector, we focus on a subset around optimising energy usage:

- **Smart electricity meters (residential) –** Connected electricity meters for residential premises. These can run on cellular or non-cellular protocols and allow for smarter and more efficient use of energy based on usage patterns, time of day and capacity levels of national or local energy grids. In many cases, connected electricity meters are part of a broader smart home suite of services controlled by a central platform, which is usually voice-activated through smart speakers (e.g. Amazon Alexa, Google Home or Apple Homekit).
- **Smart electricity meters (business) –** Refers to the use of smart sensors to optimise electricity usage within commercial buildings (e.g. offices, campuses or hospitals). This may include elevators and lighting systems and is typically enabled by AI and machine-learning algorithms in the cloud that drive dynamic adjustments to energy use based on occupancy rates, time of day and seasonality. In some commercial premises (particularly business parks or campuses), this may be linked to micro-scale renewable energy generation and on-site batteries that allow excess energy to be sold back to the grid. Several mobile operators are engaged in such operations.
- **Smart gas meters (business) –** Refers to the use of smart sensors to optimise gas usage in commercial buildings. This primarily targets heating systems. As with the electricity use case, these sensors transfer data streams to the cloud for analytics, enabling heating output to be adjusted dynamically.
- **Heating, ventilation and air conditioning (HVAC) systems –** These optimise energy consumption in commercial premises and transport settings (e.g. underground trains or airplanes) based on occupancy levels.

From a telco perspective, IoT is the main sell-in product to residential home owners and office landlords where there is a cellular connectivity deployment (some commercial smart meters and HVAC systems will function on Wi-Fi or other unlicensed protocols). Retail energy companies are regular partners of mobile operators in offering smart meters as part of wider smart home suites. The energy savings from smart meters for the average household have been reported at 2–10% per year. The commercial premises strategy being used by property developers and landlords now takes a comprehensive approach of linking electricity and gas meters to a single management system and user interface. HVAC units similarly integrate heating and air conditioning power into a single user interface. These have been produced for several years from groups such as Hitachi and GE, but prices have now fallen and adoption has grown. While HVAC systems still represent a small share of cellular IoT volumes (less than 1%), this still equates to 15 million units globally – a 50% rise from 2018, with a further increase to 25 million forecast by 2030.

Table 7

How mobile and digital tech can help decarbonise

	Smart electricity meters (residential)	Smart electricity meters (business)	Smart gas meters (business)	HVAC systems
Tech option				
IoT	• IoT sensors fitted on meters to track energy usage and transmit onwards to cloud platform	• IoT sensors fitted on meters to track energy usage and transmit onwards to cloud platform • Weight sensors monitor prevailing occupancy in office space and associated electricity and gas usage changes		• Sensors embedded on HVAC system units to transmit data in real time on occupancy rates and external weather conditions
Cellular connectivity (LTE and 5G)	• Smart home systems that underpin utility meters utilise a combination of cellular and Wi-Fi connectivity	• Can be used to underpin IoT sensors and data transmission to the cloud • Private cellular networks may be used in industrial estates or campus settings, enabling connectivity for electricity and gas meters • HVAC systems: could utilise small cells in tunnels and other transport settings to enable a hook-up to private network deployment		
Cloud and analytics	• AI algorithms monitor home energy usage and offer recommendations to improve economy (including use of low-carbon heat pumps), draught proofing and external weather patterns • In future, this could extend to dynamic energy purchasing models that would reduce provider lock-in	• Analysis of data streams from smart meter sensors, elevators and external weather patterns • Automatically adjust lighting and temperature control based on occupancy rates and weather conditions • Non-digital use cases: AI is also used heavily in building design through 3D architectural drawings to, for example, predict structural response to extreme weather events		• Ventilation system monitoring and control based on changes to occupancy, external temperatures, and harmful particulate matter in building vicinity • Dynamic power down of air-conditioning and power up of natural, cool air ventilation • Predictive suggestions to building/facilities managers for optimising energy consumption

Source: GSMA Intelligence

How much it could all add up to

We forecast CO_2 reductions of 0.8 Gt from residential smart meters, 0.3 Gt from commercial smart electricity meters, 0.5 Gt from commercial smart gas meters and 0.6 Gt from HVAC units. This equates to 16%, 6%, 9% and 12% of buildings sector CO_2 reductions, respectively, over the next 10 years.

To put this in perspective, the savings from the use of smart meters in North American residential premises would be enough to power 25 million homes (20% of households in the US) for a year.

Key assumptions (non-exhaustive):

General

- **Emissions factors –** Electricity emissions factors are extrapolated forward for each region annually based on the declining rate for the UK (Department for Business, Energy and Industrial Strategy figures).

Smart electricity meters (residential)

- 80% of all smart meter IoT connections are residential.
- **Energy savings –** Households with smart meters use 3% less energy per year on average.

Smart meters (business)

- **Energy savings –** Businesses with smart electricity and gas meters save on average 10–15% and 20–25%, respectively, compared to those with legacy meters.

HVAC systems

- **Energy savings –** Commercial settings with HVAC units (offices, campuses or transport infrastructure) use 15% less energy per year compared to those without.

Table 8

Projected CO_2 emission savings for the buildings sector (worldwide)

	2021–2025			2026–2030		
	Low	Base	High	Low	Base	High
Smart electricity meters (residential)						
CO_2 reductions (Mt)	305	381	457	364	455	546
Contribution to sector CO_2 reduction (%)	17%	22%	26%	11%	13%	16%
Smart electricity meters (business)						
CO_2 reductions (Mt)	102	127	152	147	184	221
Contribution to sector CO_2 reduction (%)	6%	7%	9%	4%	5%	7%
Smart gas meters (business)						
CO_2 reductions (Mt)	126	157	189	249	311	373
Contribution to sector CO_2 reduction (%)	7%	9%	11%	7%	9%	11%
HVAC systems						
CO_2 reductions (Mt)	252	315	379	242	303	364
Contribution to sector CO_2 reduction (%)	14%	18%	22%	7%	9%	11%

Note: MT = megatonne (1 million tonnes). Low = base -20%; high = base +20%.
Source: GSMA Intelligence, Exponential Roadmap, Carbon Trust

6. Implications and outlook

The extent to which industries are successful in decarbonising is of paramount importance to collective sustainability. However, it is also a crucial step in economic diversification if major economies are to transition to a 'green-first' model. These are likely to feature as prominent discussion topics at COP26 – the successor to Paris 2015. A notable change since 2015 is that two key dependencies to successfully decarbonising economies are far better understood: the necessity for companies to commit to net zero of their own volition, and the need for cross-industry partnerships due to the interconnected nature of global supply chains.

Walking the walk

Corporate commitments to net zero across several industries are now more ambitious than the legislated policy positions and glidepaths set out by governments. According to the Energy and Climate Intelligence Unit, more than 130 countries have committed to carbon neutrality by 2050. However, only 15 countries (representing 12% of global emissions) have either achieved or legislated their targets into law – the only genuine measure of commitment.[7] In the private sector, 20% of the world's largest companies – many of whom are represented in the four industries covered in this report – have committed. We expect the pace of commitments to continue to grow in the wake of COP26 given the public focus and the adoption of globally recognised measurement standards – notably, the Science Based Targets initiative (SBTi).

For the telecoms sector specifically, net-zero commitments have been made by companies accounting for a third of global market share (2.5 billion mobile subscribers – see Figure 8). The highest share has committed to a 30-year timeframe by 2050, in line with the stance from Paris and most of its nation state signatories. However, it is telling that a significant proportion have opted for a more aggressive timeline. BT, Vodafone, Verizon and Orange have committed to 2040, with Telefónica and Telia (operating in the Nordics) even sooner, at 2030.

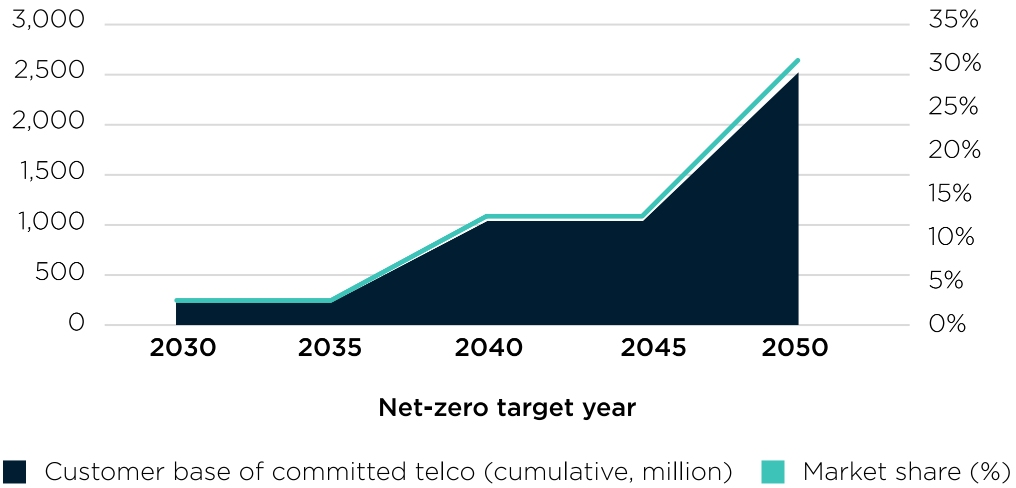
[7] https://eciu.net/netzerotracker

The European skew of early commitments reflects a number of factors. Emissions reductions and sustainability more broadly are now firmly a corporate and strategic priority, buttressed by links to regional initiatives such as the EC's Green New Deal.[8] More importantly, Europe benefits from an advanced renewable energy market and increased liquidity of forward purchase contracts enabling mobile operators to lock in renewables at high capacity over several years. Emerging market groups are, by contrast, less well represented, with renewable capacity far less developed.

> "For the telecoms sector, net-zero commitments have been made by companies accounting for a third of global market share"

Figure 8

A third of the global telecoms market (covering 2.5 billion subscribers) has public net-zero targets



Source: Mobile Net Zero, GSMA, 2021

[8] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

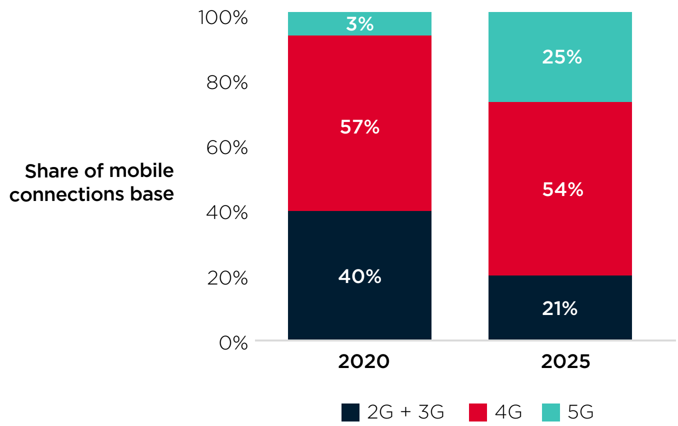
Tackling Scope 3 emissions: partnerships, partnerships, partnerships

Most industry activity so far has targeted direct greenhouse gas emissions and those associated with the electricity purchased by operators, commonly referred to as Scope 1 and 2. For telcos, the main reason for this is that 90% of energy consumption comes from the network (with 75% of this from RAN elements). Energy costs remain a highly material share of telecoms opex, at 20–40% overall. 5G is a step forward in energy terms as it is more spectrally efficient, using the NR standard. The issue is that the capacity and speed boost associated with 5G means average cellular data usage levels will rise across the board, even though 5G is more energy efficient per megabit. We forecast that 5G will account for around 25% of the mobile connections base globally by 2025 (2.2 billion connections). See Figure 9. A small cohort of countries led by the US, South Korea and Japan will have much higher take-up rates above 60%, while China will be the global number 1 in 5G subscribers by virtue of its population size. The urgency of energy efficiencies in these countries is a near-term issue.

Momentum has been boosted by network equipment vendor advances in kit technology on multiple fronts, such as more efficient batteries, cooling systems and AI-based network sleep states. Renewables capacity has also helped. **5G energy efficiencies** and **Going green: benchmarking the energy efficiency of mobile** provide further analysis on the network equipment upgrades to enable higher efficiencies.

Figure 9

Energy costs will only rise as 5G and its associated traffic burden grow

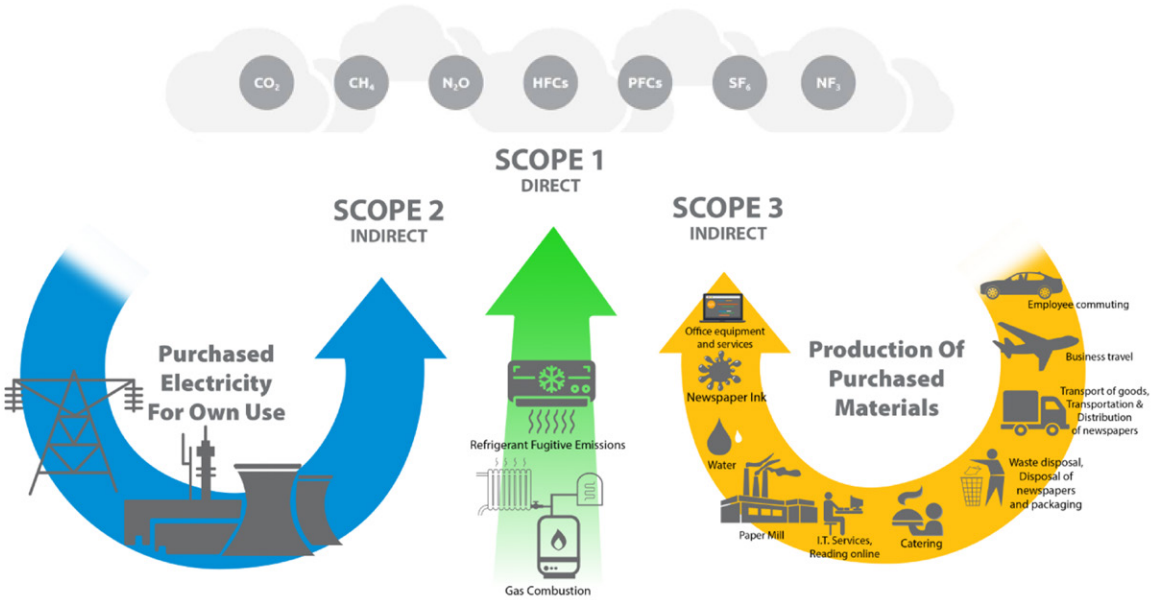


Source: GSMA Intelligence

By far the largest portion of a company's carbon footprint comes indirectly from its supply and distribution chains, and end customer use (Scope 3). Figure 10 illustrates the relationship between Scopes 1, 2 and 3. The size and indirect nature of Scope 3 emissions provide a dual opportunity for vertical industry use of mobile and digital technology: the reduction of direct emissions and those emitted indirectly as a result of supply chain partnerships with telecoms and tech businesses.

Figure 10

Scope 3 emissions are the last and largest frontier en route to net zero



Source: GHG Protocol, Compare Your Footprint

While industry decarbonisation can help mitigate the risks of global warming, there are other important socioeconomic benefits. Public health outcomes are an example. Reducing CO_2 in the power sector will result in lower concentrations of harmful particulate matter and gases such as nitrogen dioxide. A review of academic research in the US has concluded that decarbonisation has a disproportionately large impact on the most polluted days (more people travelling to work), the greatest impact in areas with the highest concentration of coal use, and financial savings from reduced strain on healthcare that can offset the implementation costs of green technology.[9] A similar effect is expected to prevail as EVs substitute petrol- and diesel-fuelled cars, alongside a higher share of the population working from home. Economic diversification is another change factor, as are the gains to productivity from digitised operations that are the basis for the economic growth story that many Western governments are courting as part of a so-called 'green economy'.

These are whole subjects in their own right and topics for future research. We cite them here to emphasise that increased disclosure from private sector companies on these fronts will increasingly be required for future sustainability reporting.

[9] "Integrating Air Quality and Public Health Benefits in U.S. Decarbonization Strategies", Frontiers, November 2020

Appendix

Methodology

The methodology for our impact modelling is designed to follow a consistent format across each of the four sectors. This involves understanding how a given mobile or digital technology can affect CO_2 emissions and then quantifying the extent of emissions reductions over a 10-year timeframe based on our projections for adoption in an industry and a set of supporting assumptions. 2050 is the most common target year to achieve net-zero emissions for governments and private sector companies. However, our analysis is focussed on the 10 years to 2030, as this is the most critical period for action if net-zero ambitions are to be achieved. The period also offers the greatest visibility for assumptions.

The methodology steps are as follows:

1. **Identify mechanisms –** This refers to the ways and means a mobile or digital technology can affect CO_2 emissions once implemented. For example, IoT-connected solar grids lower emissions by using clean energy and optimising the flows and distribution of electricity capacity based on real-time and predictive analytics for household and business consumption. As a further example, private cellular networks, IoT sensors and AI-based analytics in connected factories enable digitised processes and a higher rate of productivity, yielding energy and emissions savings compared to factories not fitted with these technologies.

2. **Forecast emissions factors –** Electricity emissions factors (EEFs) quantify the level of CO_2 emitted per unit of energy, typically expressed in kilowatt hours (kWh). EEFs are applied to our calculations in almost all use cases. Base-year readings are for 2019 and sourced from carbonfootprint.com. We have then projected these forward annually to 2030 at a regional level using a common reduction factor (i.e. declining growth rate) of –4.7% per year on average, based on data from the UK Department for Business, Energy and Industrial Strategy. The declining nature of the EEFs reflects the changing mix of energy production and usage in each country, driven by the decline of fossil fuels and rise of renewables (e.g. solar, wind, hydro and geothermal).

3. **Calculate the abatement factor –** The abatement factor is the estimated level of CO_2 equivalent (CO_2e) that can be saved per unit of deployed technology. This is typically a combination of variables. For example, the abatement factor for the use case of fleet management for HGVs multiplies the average annual emissions per vehicle by the percentage fuel savings for those HGVs equipped with IoT telematics. Meanwhile, the abatement factor for smart factories multiplies the average annual energy consumption per factory by an estimated energy saving for connected factories (driven by digitisation), multiplied by the EEF. Abatement factors are calculated for a selection of countries and then extrapolated to a regional level annually from 2020 to 2030.

4. **Forecast the technology adoption rate –** We then make assumptions on the forecast outlook for a given mobile or digital technology that forms the basis for each of the modelled use cases. For metrics that we model in GSMA Intelligence (cellular IoT connections in different industry verticals, and LTE and 5G subscribers), we have adapted our forecasts out to 2030. For metrics outside of the GSMA Intelligence database (such as the home-working population or electric-vehicle charging points), we have incorporated external data sources and overlaid our own assumptions where relevant. The result is an annual dataset to 2030 of the adoption level for each of the profiled use cases on a regional basis that can be combined with the abatement factors from step 3.

5. **Calculate CO_2 savings –** This refers to the projected level of CO_2 savings as a result of deploying our profiled mobile and digital technologies. The figures are calculated by multiplying the level of adoption (step 4) by the abatement factor for a given technology (step 3). The resulting number is expressed as CO_2e per year. We express CO_2 savings in megatonnes (1 million tonnes) or gigatonnes (1 billion tonnes) of CO_2e.

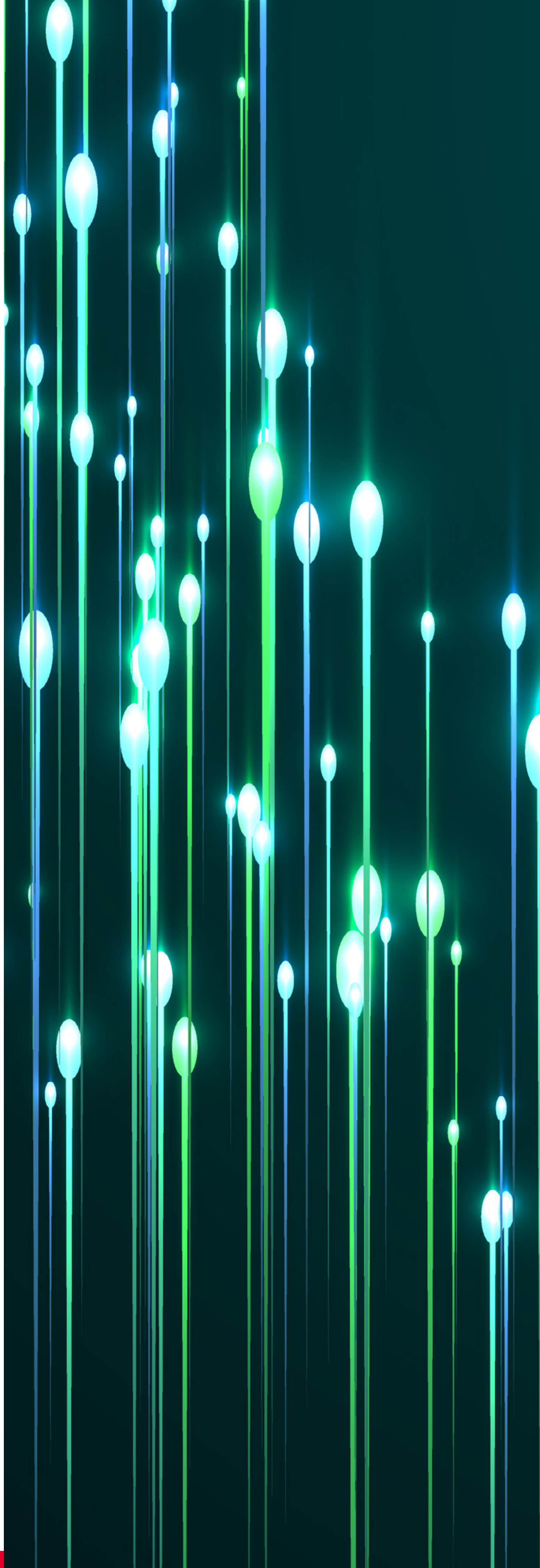
   While large, these savings can sometimes seem abstract. After all, how can you accurately gauge how much 20 million of tonnes of CO_2e really is? We have therefore included contextual statistics in the Executive Summary and other parts of the report to give a sense of the relative size of an impact (e.g. number of round-trip flights, or homes heated per year).

6. **Calculate contribution levels to sector reductions –** The final step is to express the CO_2 savings from step 5 as a share of the overall reduction in CO_2 emissions for a given industry over the 10 years to 2030. The overall sector decline is based on data from Exponential Roadmap and assumes a 50% reduction in CO_2 levels by 2030, which is the approximate level needed to stay on a trajectory to achieve net zero by 2050.

   For example, the CO_2 savings as a result of working from home are projected at 377 megatonnes over the 2020–2030 period. Given that a 50% reduction in overall transport-sector CO_2 emissions over the same period equates to 4,350 megatonnes, the impact of working from home is calculated as 377/4,350 = 9%. In other words, we estimate that the working-from-home shift – enabled by high-speed broadband and leading to reductions in commuting journeys – could drive just under 10% of the overall CO_2 savings needed from the transport sector over the next 10 years if it is to remain on course for net zero by 2050.

Assumptions and projections are subject to uncertainty from a number of factors. These include economic health and the risk of shocks, business investment, consumer willingness to change, political priorities and regulation. We have expressed the CO_2 impact savings in each sector as a set of scenarios less optimistic (20% below) and more optimistic (20% above) than our base-case projections. This approach gives higher confidence that the actual result will fall within a range. This gives industry players and governments a common ground for understanding the overall magnitude of potential impact rather than a specific point estimate.

GSMA Intelligence



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