Connecting a sustainable future

The power of Gigabit connectivity

How the telecommunications sector has a key enabling role to play in the transition to a more sustainable future

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Content

Executive Summary

The focus on immediate action to cut greenhouse gas emissions in line with the Paris Agreement to keep global temperature rises below 1.5°C has raised the stakes for energy-users worldwide. So many industries and activities crucial to our society are highly carbon-intensive. We all need to move quickly to further minimize energy consumption, reduce greenhouse gas emissions and meet our climate ambitions and responsibilities. **Today, 75% of the EU's greenhouse gas emissions come from energy consumption. This report shows that the key to enabling decarbonisation initiatives and innovations everywhere is Gigabit connectivity, e.g. high-speed Internet.** These are the fastest connections currently being provided by telecommunications providers - delivered using a range of advanced technologies from full fibre connections and hybrid fibre and coaxial broadband to 5G networks.

Scientific studies to date have not given us a clear enough view of the enabling potential of these ultra-fast, reliable connections. But new research commissioned from EY shows how Gigabit connections open the door to a raft of new applications which can gather, process and act on ever-changing real time data. These are delivering impressive results in lowering GHG emissions in carbon-intensive activities such as transport, building management, energy and agriculture. These account for the majority of global carbon emissions. **Gigabit connectivity has rapidly become an essential component for users in reducing emissions and delivering on sustainability goals.**

Here are some of the report's most notable findings:

- Energy supply must become more responsive. **Gigabit connectivity allows supply and demand data to be collected and analysed, enabling energy providers to make the best use of the smart grid.** This has the capability to reduce annual emissions by an amount larger than the UK's total CO_2 emissions in 2020.

- Smart buildings - and entire smart cities - are entering a new era of possibilities thanks to high-speed internet. This allows equipment to connect through the internet of things to collect and analyse real-time data to drive energy-saving. A range of leading edge transport innovations are showing promise in urban areas, where more than half of global greenhouse gas emissions are produced. **At a time when the EU is proposing a new emissions system for buildings, the use of connected devices in property management systems could reduce the energy consumption of a building by 20%.** These projects need to be scaled up.

- Agriculture is one of the largest contributors to global greenhouse gas emissions. But farmers are discovering they can use Gigabit connectivity to develop more climate-friendly practices. For example, **precision farming can target plants that require treatment – reducing the use of pesticides by more than 80% thanks to Cloud-based technologies and connected devices that allow real-time data tracking.** The European Commission is proposing to achieve climate neutrality in the combined land use, forestry and agriculture sector by 2035.

Executive summary

The telecommunications sector has set itself ambitious carbon reduction goals, such as science-based targets and net zero. It is constantly developing more energy efficient ways of working to reduce energy consumption in its infrastructure. Despite a large increase in data traffic in recent years, telecom operators achieved new levels of energy efficiency.

- **The 5G mobile network infrastructure is 85% more energy efficient** compared with 2G-4G networks.
- **The carbon footprint of the ICT sector could be reduced by more than 80%** if the sector and its clients used energy from renewables.
- **The consumption of refrigerants and energy can be reduced by using free air cooling in data centres.** These account for a large proportion of energy consumed. Data centres are "the factories of the digital world". Limiting their environmental impact will be key in the future low carbon world.

Large increases in data traffic are inevitable as society embraces 5G and internet of things solutions. Further research is needed to drive innovations and ensure the positive and energy-saving benefits created by new innovative solutions running on Gigabit connections will outperform any negative impacts. This research will require standardised impact method methodologies to deliver meaningful findings.

In conclusion, to achieve the ambitions of climate-neutrality in the EU and Net Zero in the UK 2050, the following is needed:

1. **A thorough impact assessment of the enabling effect of Gigabit connectivity** to ensure that policy makers and industry can make informed decisions about how to achieve a green and digital transition.

2. **Connectivity should be powered by renewable energy sources**, with support for the innovation measures taken by the telecommunications sector to run their networks at higher efficiency levels. Telecommunications industry collaboration and partnerships are key to the success of these initiatives.

3. **Support efforts from policy makers around energy efficiency:** "The best energy is that which is not consumed".

4. **Robust and clear measurement guidance to assess the environmental impact of Gigabit connectivity** to ensure that the green and digital transition is sustainable

What is clear is that the Gigabit technology the telecommunications sector provides has a central enabling role in supporting sectors way beyond its own boundaries and speeding their transition to sustainability.

Foreword

The world continues to face unprecedented challenges and businesses have a big role to play in changing the dynamics to help us thrive. As we face the challenges that come with a global pandemic, the critical role of digital technology and innovation is becoming more visible in keeping society moving. Yet, to fully activate the world-changing potential of digital technology, the information and communications technology sector (ICT) must lead the way by managing the responsible development, deployment and use of its products and services.

This report shows just how Gigabit connectivity is a fundamental catalyst, enabling other sectors to reduce their carbon footprints. It is at the heart of the digital transformation of businesses, cities, and public services. It is a catalyst for Industry 4.0 to bring sensibility, intelligence and automation to new generation production processes for greater competitiveness. It is the catalyst for the transformation of cities into smart and inclusive urban centres that improve the quality of life of their citizens. It is the catalyst for more efficient and comprehensive public services that educate us more effectively. It is the catalyst for offering better health to more people through delivering some everyday care remotely and conserving resources for more critical care. Gigabit technology will also be the catalyst for further accelerating transactions in the economy, maximising the use of resources and providing greater security for all.

Yet surely the greatest value of Gigabit connectivity is that it is an agent of transformation. For people, the immediate promise is greater speed and performance that will enable more immersive content. For companies and institutions, it will transform operating models, raising the quality of their products and services. The telecommunications industry believes not only in this transformative potential, but also in the responsible environmental transition that it enables. As this report shows through its varied case studies, technology is an essential condition for the energy efficiency of the productive sectors - boosting local food production, optimising logistical systems and opening the door to incremental efficiencies and benefits.

While we see those great enabling benefits to happen, the ICT sector also has a responsibility to ensure that what it is deploying is sustainable. We have seen the telecom sector becoming more efficient and adopting circular economy strategies and practices to control the growth of its own footprint. The ICT industry has taken great responsibility by enabling other industrial sectors to mitigate their emissions by the use of technology. On the other hand, it has also implemented tangible measures such as science-based targets and has committed to net zero. According to the International Energy Agency, the ICT sector had the highest uptake of sustainable energy in 2020[1].

To effectively tackle the health of our planet and inequality across society, it will take a big team effort. No one business or industry can go it alone. That is why telecom companies are working together, forming coalitions such as the European Green Digital Coalition and the Digital with Purpose Movement.

I would like to congratulate Liberty Global for producing a report showing us the enabling impact of Gigabit connectivity for society, as well as flagging the challenges ahead. Thank you for contributing in such a transparent and candid manner to better shape the debate and frame policy development across the industry.

Luis Neves
CEO of the Global Enabling Sustainability Initiative

1 IEA, "Data Centres and Data Transmission Networks", IEA, November,2021.

About the paper

This public policy paper aims to illuminate the debate around the sustainable potential of Gigabit connectivity - both within and way beyond the telecommunications sector. Scientific research to date does not give us a clear view on the total net environmental impact of the sector – or its crucially important enabling potential in the wider world. This report utilizes case studies to aid understanding and debate around the sustainable potential of Gigabit connectivity.

The findings showcased here were obtained through extensive interviews conducted by EY, and desktop research. Interviewees included Liberty Global and its partners, European policy makers, other telecom companies and key players in the sectors that can benefit from digitalisation to operate more sustainably. The research findings were compared and analysed by EY specialists on environmental impact, sustainable business, and the telecommunications sector. Ultimately, this paper highlights key topics for further discussion around nurturing the potential of Gigabit connectivity to increase energy efficiency in other sectors and activities.

This report mainly focuses on the impact on greenhouse gas emissions. Greenhouse gases keep the Earth warmer than it would be without them. Increasing emissions raises average global temperatures and contribute to climate change. Greenhouse gases include carbon dioxide (CO_2) as well as methane, nitrous oxide and others. The case studies all focus on innovations where connectivity is expected to have a large positive impact on energy usage reduction. Clearly telecommunication services and hardware in the hands of end users create other environmental impacts – such as e-waste generated by discarded electronic equipment. This includes phones, modems, cables and chargers, as well as the depletion of natural resources like gold, cobalt, lithium any many others used for their production. However, these impacts are not within the scope of this paper. Finally, this report does not investigate the social impact of connectivity.

Introduction

The ambition of the European Union and the United Kingdom is to become climate-neutral or reach Net Zero targets by 2050 and to cut net greenhouse gas emissions by 55% by 2030 compared to 1990 levels. Although 196 parties committed to reach net zero as soon as possible under the 2015 Paris Agreement, it now looks as though the efforts undertaken will not be enough to keep global temperatures below 1.5°C. Our ability to decarbonise appears to be the most urgent issue under global debate.

This task is challenging for sectors that are critical to our economy and society, yet also generate large emissions or are highly carbon intensive. Examples include the transport, building, energy, manufacturing and agricultural sectors[2].

Companies in these sectors can leverage the power of Gigabit connectivity which facilitates the use of vast amounts of data to drive efficiency and innovation in their operations, offering opportunities to enhance sustainability. As a provider of high-speed Gigabit connectivity[3], the telecommunications sector has a key enabling role to play in supporting the transition to sustainability, e.g. greening in other sectors, and to help address climate change.
However, even though Gigabit connectivity creates societal value for sustainable development in industry and consumers in their everyday lives, it also has an impact on the environment.

The European Commission has set extra ambitious targets for data centres to be carbon neutral by 2030 as well as transparency measures for telecommunication networks. For the European continent as a whole, the aim is to achieve the transition by 2050. Beyond the EU, the UK has launched a decarbonisation strategy for all sectors to reach net zero by 2050.
It is therefore important to better assess what drives the environmental footprint of the telecom sector.
This study takes a focused approach, only looking at energy consumption.

> “For the European continent as a whole, the aim is to achieve the energy transition by 2050.

2 Statista, Annual GHG emissions in the European Union from 1990 to 2019 by sector, 2021.

3 Gigabit connectivity refers connectivity providing speeds of 1 Gbps and includes both fixed and mobile networks. Such networks are characterized by their capability of providing a higher transmission of data at higher speeds such as fiber optic communication or 5G.

While there are few estimates for the telecom sector on its own, one study estimates its carbon footprint is around 0.7%[4] of global greenhouse gas emissions. When we broaden the scope however, and look at the ICT sector as a whole (the larger umbrella group that telecoms is included under) it was found that estimates can go as high as 3.7%[5] of global emissions. By way of comparison, the global share of the aviation sector is 1.9%[6].

Both studies measure the greenhouse gas emissions associated with energy and materials used throughout the lifecycle of the equipment. Where they diverge is what equipment they include: the first study only takes physical network infrastructure (fixed, mobile, and data centres) into account, while the second also looks at the end user devices that are enabled by network connections (computers, phones, television sets).

The more elements that have their impacts measured, the larger the footprint will be. So, the actual environmental impact of the telecommunications sector — including both the positive and negative impacts — is complex and near impossible to determine. Different studies apply different scopes.

4 Jens Malmodin and Dag Lundén, "The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010-2015", Sustainability 10, no. 9 (2018): p. 3027.
5 The SHIFT project, "Lean ICT – Towards Digital Sobriety", The SHIFT Project, March 2019.
6 Hannah Ritchie, Max Roser, and Pablo Rosado, "Emissions by Sector," Our World in Data, May 11, 2020.

With the efforts undertaken by the telecommunications sector, Gigabit connectivity can lead the world's sustainable transformation.

In combination with its work to become carbon neutral by 2030, the telecommunications sector faces a window of opportunity to attract new "sustainable" investments by becoming an agent of change. It has been highlighted that the telecommunications sector has a key role in enabling its customers to green their activities while minimizing its own energy use[7].

Greening by: By providing Gigabit connectivity to drive innovative solutions, the telecommunications sector can enable positive environmental impacts beyond the boundaries of its own operations. The International Energy Agency has identified that digitalisation could enable important changes to global energy demand, especially in carbon-intensive sectors such as the energy sector but also transport (27% of the global emissions), buildings (25% of the global emissions), and industry (40% of the global emissions)[8].

This raises the first research question posed by this report:

- **What is the 'enabling' effect on the environmental impact of carbon-intensive sectors of new technology services enabled by Gigabit connectivity?**

Greening of: Even though operating connectivity networks is energy intensive, the telecommunications sector is seizing opportunities to increase its energy efficiency and operate more sustainably. However, as networks evolve to encompass the new demands of a large increase in data traffic, the future footprint of the sector is unclear.

This leads to a second research question:

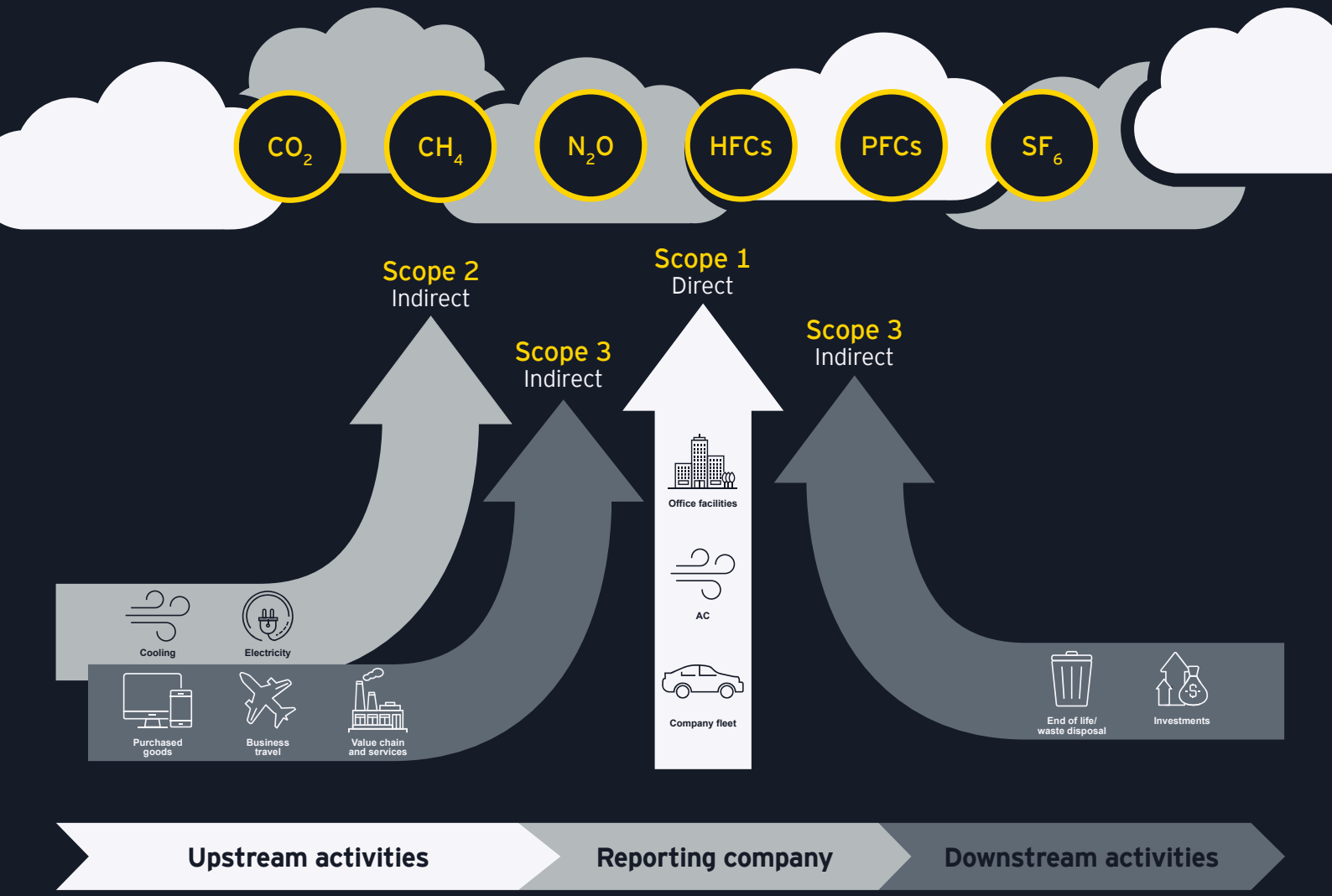
- **What is the environmental impact associated with energy efficiency initiatives undertaken by the telecommunications sector to address its own emissions from energy use? These are its Scope 1 and Scope 2[9] greenhouse gas emissions.**

7 ETNO: the European Telecommunications Network Operators' Association (ETNO) represents Europe's main telecom operators to advocate for the development of a favorable policy and regulatory environment.

8 IEA, "Emissions by sector", IEA, 2021.

9 Scope 1 emissions are direct emissions from owned or controlled operations from an organization. Scope 2 emissions are indirect emissions from the generation of purchased energy consumed by an organization (GHG Protocol Corporate Standards)

Defining the emissions scopes



Scope 1

Scope 1 emissions are direct emissions from owned or controlled operations from an organization

Scope 2

Scope 2 emissions are indirect emissions from the generation of purchased energy consumed by an organization

Scope 3

Scope 3 emissions are all indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions

Spotlight on the numbers

Greening by the telecom sector

How the telecommunications sector enables other industries to save energy

Adopting digital technologies

9%

Of projected world GHG emissions by 2030

Digital technologies have the potential to reduce global greenhouse gas emissions considerably. (GeSI, 2019)

5G Precision farming

Decrease total amount of pesticides

High-speed, 5G enabled, connecitivity allows farmers to precisely map weeds and target their use of pesticides in real time.

Smart Buildings

30%

Of green reduction in building energy use (EDGE Case Study)

Gigabit connectivity enables energy use reduction by connecting devices in smart buildings.

Greening of the telecom sector

How the telecommunications sector drives energy efficiency in its own operations

Change to renewable energy

Reduction of the ICT sector footprint

Considerable reductions can be gained if all electricity consumed by the ICT industry and its users came from renewable energy sources. (Ericsson, 2020)

Free air cooling technology

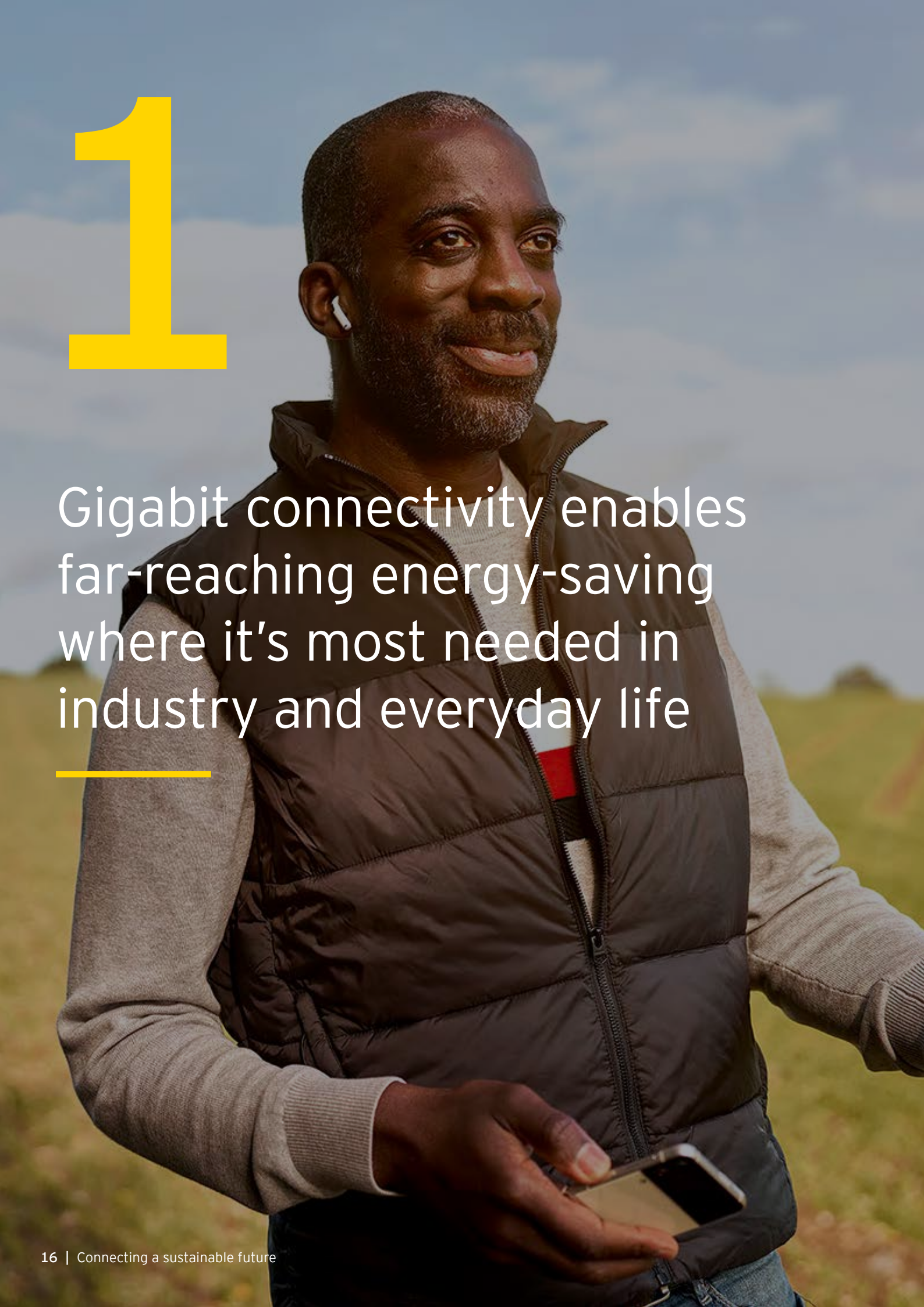
46 GWh

Energy saved at Virgin Media Ireland

Instead of relying on air conditioning, new systems use cool outdoor air to reduce temperatures at sites and server halls whenever outside temperatures are lower than those indoors.

Switch to 5G

Increase in energy efficiency compared to previous generation mobile networks



1

Gigabit connectivity enables far-reaching energy-saving where it's most needed in industry and everyday life

With the production and consumption of energy responsible for more than 75% of the EU's total greenhouse gas emissions, companies' energy efficiency and consumption are critical in the race to achieve the 2030 climate objectives of the Green Deal[10]. The 26 member states of the EU, together with Norway and Iceland, have signed a declaration to stimulate green digital technologies to achieve a climate neutral economy[11]. What is the key to delivering the far-reaching energy efficiency measures the world desperately needs to meet demand as populations grow and human activity intensifies? And how can it be done without hurting economies already under pressure from fast rising food and energy prices?

Digital technologies, such as Gigabit connectivity, have gained importance as a solution providing resource efficiency and savings. As will be shown in this section, the telecommunications sector is at the heart of powering disruptive and innovative solutions to reduce global greenhouse gas emissions. It is already leading the way in sectors like building, manufacturing, transportation, and energy[12]. In Switzerland alone, it has been shown that 5G-powered pilot projects involving new flexible work arrangements, automated driving, smart grid, and precision farming solutions could avoid up to 2.1 Mt CO_2e[13]/year in 2030[14]. But this is just the start. Emerging digital solutions such as the internet of things[15], artificial intelligence and machine learning, could drive further improvements in mitigating the effects of climate change in different sectors by enabling real-time data collection and analysis.
A number of studies undertaken by the telecommunications sector also point to the potential for connectivity to drive sustainable transformation in other sectors. Ericsson estimates that digital technologies have the potential to reduce global greenhouse gas emissions by 15%, while only themselves being responsible for 1.6% of the total[16]. This is broadly in line with more conservative results from a study conducted by the Global Enabling Sustainability Initiative (GeSI), which estimates there is the potential to reduce global emissions by 9% between 2021 and 2030 or 3.6 Gt CO_2[17].

Research has shown that the main impact of such new digital solutions is through improved productivity and reduced work-related travel. Moreover, the use of ICT services is expected to increase production efficiency in manufacturing and consumption efficiency in the consumer sector. This means the intermediate inputs required per unit of production will be reduced. As an example, the deployment of artificial intelligence can improve productivity in most sectors through labour-saving. Increasing the efficiency of logistics and manufacturing has the potential to greatly reduce the input of oil and coal products, greatly contributing to greenhouse gas emission reduction[18].

10 "Energy and the Green Deal." European Commission. n.d

11 "EU Countries Commit to Leading the Green Digital Transformation," European Commission, March 19, 2021.

12 IEA, "Digitalisation & Energy", IEA, November 2017; MIT Technology Review Insights and Ericsson, "Decarbonizing industries with connectivity and 5G," MIT Technology Review, October 20, 2021.

13 CO_2e stands for Carbon Dioxide Equivalent including includes CO_2 and other greenhouse gases.

14 Jan Bieser, Beatrice Salieri, Roland Hischier, and Lorenz M. Hilty, "Next generation mobile networks – Problem or opportunity for climate protection?" University of Zurich and Empa, October, 2020.

15 The internet of things (IoT): refers to a network of devices (such as phones, smartwatches, connected home assistants, smart meters, as well as industrial devices like smart machines) that are connected to the internet and can "communicate" with each other but also gather, share, and analyze information and create actions accordingly (Statista, 2016).

16 GeSI, and Deloitte, "Digital with Purpose: Delivering a SMARTer2030", GeSI, 2019.

17 Ibid

18 Xiaoxi Zhang et. Al, "How ICT Can Contribute to Realize a Sustainable Society in the Future: A GCE approach", Environment, Development and Sustainability 24, no.4 (April 2022): pp. 5614-5640.

Looking specifically at the services provided by the telecom sector, higher speeds, ultra-low latency and reliability allow the wider use of services such as high-quality video conferencing. This in turn incentivizes users to commute less and reduce emissions from transportation. Such replacement effects are usually dependent on availability of high capacity networks, e.g. with a speed of at least 100 mbps. In addition, a study by GSMA (the global association of the mobile industry) showed that mobile connectivity often works as a catalyst for greater use of more environmentally friendly modes of transport through enabling route optimisation and vehicle fuel efficiency. An example that supports the above assumption that ICT services lead to production efficiency can be seen in the manufacturing sector. GSMA showed that the use of mobile connectivity for the management of storage and inventory helped to reduce the overall level of stock and storage space. This increases efficiency and cuts energy use for lighting and cooling[19]. In other words, the required input for production was reduced.

In addition, there seems to be a strong correlation with the general level of uptake of such services as well as the level of digital skills among the population. The uptake is a precondition for ICT services to have a positive impact on reducing greenhouse gas emissions in other sectors[20]. To support the development of these digital skills, the EU put forward the ambition of ensuring that 80% of adults have basic digital skills by 2030[21]. Similarly, the UK launched its Digital Strategy with a similar goal[22]. However, there are challenges in achieving this strengthening of digital skills and the consequent uptake of digital services. This is demonstrated by a Digital Economy and Society Index compiled by the European Commission, Figures showing levels of digitalisation, and adoption of cloud and AI technologies in small and medium sized enterprises in the 2021 report were 60%, 26% and 25% respectively. Hence, it can be concluded that the likely level of ICT services uptake is still limited. This is especially true of the fastest Gigabit network services. The uptake of fixed broadband with speeds of at least 100 Mbps was 34%, while the uptake of services of 1 Gbps speeds was only 1.3%. For very high speed mobile broadband, e.g. 5G, the coverage is currently

only 14%[23]. This suggests the positive effects of Gigabit technology in reducing can only grow. On the other hand, in the same study, the European Commission asked respondents how they saw their use of ICT services contributing to environmental sustainability. Here, an average of 66% of enterprises felt they had a medium or high intensity of green action through their use of ICT. The study found that the highest contribution came from staff teleworking (83%) and less business travel (78%). The authors point out the study was made during the COVID-19 pandemic when many firms were forced to adopt teleworking practices[24].

Gathered here are some current and innovative case studies. They come from four different sectors, all of which are in the vanguard of change. They are setting out in new directions on their own paths to sustainability. In each case, it is Gigabit connectivity which has helped them lower greenhouse gas emissions and cut their environmental footprint.

19 GSMA, and Carbon Trust, "The Enablement Effect – The impact of mobile communications technologies on carbon emission reductions", GSMA, 2019.
20 Xiaoxi Zhang et. al., "How ICT can contribute to realize a sustainable society in the future: a CGE approach", Environment, Development and Sustainability 24, no. 4 (2022): 5614-40
21 European Commission, "Europe's Digital Decade: digital targets for 2030," European Commission, March 9, 2021.
22 UK Government, "Executive Summary – UK Digital Strategy," UK Government, March 1, 2017.
23 European Commission, "Digital Economy and Society Index Report 2021," European Commission, November 12, 2021.
24 Ibid

Buildings: using connected devices in building management systems could cut energy use by 20%[25].

Energy-saving starts at home. Our daily use of houses, apartments, offices and commercial buildings accounts for a large portion of the world's total energy consumption.

- **In the European Union, energy consumption from buildings is estimated at around 40% of total energy use[26].**

So, what are the energy-saving benefits that building owners and operators are missing out on? Thanks to current technologies and faster speeds, data can be collected and analysed to transform environmental performance and cut operating costs. For example, smart thermostats connected to machine learning algorithms can anticipate likely building occupation based on past data. Weather forecast data can also be fed in to better predict heating and cooling needs[27]. Recent studies have estimated that building energy use could be cut by up to 20% with the use of technologies[28] representing a saving of 350Mt of global greenhouse gas emissions by 2050[29].

25 World Economic Forum (WEF), Global Internet of Things Council, and PwC, "State of the Connected World – 2020 Edition," World Economic Forum, December, 2020.
26 Ibid
27 IEA, "Digitalisation and Energy," IEA, November, 2017.
28 World Economic Forum et al., "State of the Connected World – 2020 Edition", December, 2020
29 IEA, "Empowering Cities for a Net Zero Future," IEA, July, 2021.

Case study - EDGE

Energy-saving building technology is already here

How can operators of buildings make the best use of fast connections to drive down their energy use? In its rethinking of the building of the future, the smart buildings specialist EDGE has developed a solution to give a sustainability boost to traditional building management systems. Using sensors and Gigabit connectivity, EDGE Next technology allows real-time data collection of trillions of data points on room temperatures, humidity, occupation and CO_2 levels. Scenarios and modelling are then used to manage and improve the building's energy efficiency. EDGE's building management systems can save up to 30% of energy consumed in old buildings, and 10% in new buildings. The company first piloted EDGE Next technology in 2018 at its Amsterdam headquarters, before the official launch two years later. That pilot shows savings of 16% of energy to date. This was the result of monitoring occupancy against energy consumption and making informed adjustments along the way.

Events continue to increase the pressure on carbon-intensive activities and sectors. For example, as part of its proposals to deliver on the European Green Deal ('Fit for 55' legislative package), the EU plans a separate new emissions trading system to cover emissions from fuels used in road transport and buildings. Operators will be looking for solutions like those being pioneered by EDGE Next. Leveraging the potential of connectivity could be essential for users affected by these new rules.

> "By focusing on sustainability, we inevitably found that digitalisation was going to be a driver for our innovations. Current building systems cover limited elements like weather temperature, but are not designed for sustainability or connected interactions that learn to understand the environmental performance of a building. Our solution monitors the CO_2 load or the virus load in the air of a room - and how air conditioning affects it. In this way we are able to reduce energy use.
>
> - Coen van Oostrom, Founder and CEO of EDGE

Smart cities needed: with half of greenhouse gas emissions coming from urban areas, new Gigabit-powered applications could cut emissions by up to 90% by 2050[30].

City living can be truly sustainable. As it is, about half the global population live in urban areas. By 2050 the UN expects this number to grow to 83% by 2050. What's more, 78% of the world's energy is consumed by cities[31], making it imperative for us to understand urban energy requirements, and how technology and digitalisation can help monitor and reduce energy consumption. Digital enablers like high-speed connectivity, cloud solutions, machine learning and AI are paving the way for the next phase of smart cities[32] by enabling real-time collection and analysis of data to inform city managers. For example, intelligent transport systems in smart cities could reduce carbon emissions by 0,39 gigatonnes of CO_2e by 2030[33]. This amount of carbon emissions is comparable to more than 40% of the annual emissions caused by the global maritime transport industry[34].

30 World Economic Forum, Financing climate change actions in cities, 2021

31 UN Habitat, "International Conference on Climate Change and Cities", UN Habitat, 2018.

32 A smart city is is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of the inhabitants and businesses.

33 GeSI, and Deloitte. "Digital with Purpose: Delivering a SMARTer 2030," GeSI, 2019.

34 Hanna Ritchie et al., "Emissions by Sector," Our World in Data, May 11, 2020.

> The role of Gigabit connectivity is crucial for the EU Strategy on Sustainable and Smart Mobility that aims to achieve a fully operational, multimodal trans-European transport network by 2050.
>
> - Charlotte Nørlund-Matthiessen, Policy Advisor in the Cabinet of Adina Vălean, European Commissioner for Transport

The latest solution promoted by the European Commission to drive the future of smart cities is to design a "digital twin". While the technology itself is not new, its use to manage city assets and resources is much more recent. A local "digital twin" is a virtual representation of a city's physical assets, processes and systems (i.e. street mapping, building heights) connected to real-time data collected by sensors all over the city. These need to be linked via high-speed networks to ensure the frictionless transmission of large amounts of data. Using AI and machine learning algorithms, digital twins help the modelling of scenarios that can be updated and changed in real time as their physical equivalents change. This risk-free testing environment increases the precision of long-term predictions and can support informed decision making to reduce energy consumption in areas such as transportation infrastructure.

> Large scale digital twin applications need to run on 5G as a minimum to unlock the power of sensors and big data. However, these depend on fast connectivity, and large speed differences remain across Europe. A number of European research and innovation programmes (EU, Germany, Finland, Spain, Austria, France) are already working on 6G while many rural areas remain unconnected. There is a real need for connectivity services to unlock the power of smart cities.
>
> - Response from a European Commission official

Case study - Amsterdam

How a digital twin can make our cities smarter

In the Netherlands, the city of Amsterdam has spent 13 years developing and using smart solutions. There is already an impressive array of technologies in the mix – notably AI, robotics, big data, and sensors to improve data coverage and gain insights into the state of the urban environment. Crunching this data and using it to improve the quality of urban life is fundamental to Amsterdam's smart city ambitions. These already embrace projects for public good that include sustainable energy and climate resilience applications, smart mobility and food systems, and a high degree of City-wide digitisation.

As part of its sustainability goals, Amsterdam wanted to stimulate electric mobility. The Smart Mobility programme 2019-2025 aims to deliver a cleaner, smarter and more accessible system of urban mobility. A key part of this is the provision of "micro-mobility" modes of transport such as e-scooters and electric cargo bikes. Another is a string of eHUBS - offering clean electric, shared mobility options in different neighborhoods. Research suggests that a switch from conventional cars to e-scooters would result in five times less CO_2 grams equivalent per person per kilometre. To assist with peak load management on the electricity grid, a FlexPower project uses surplus renewable energy for fast charging of EV's by matching supply with demand. When the energy load on the grid is high, the EV will be charged more slowly, drawing less energy.

To optimize the use and quality monitoring of its water transport infrastructure, Amsterdam has developed a range of autonomous vehicles including its self-propelled, electric water transport - "Roboat". These carry people and goods, but also constantly monitor water quality. Amsterdam's ambition is to actively manage its entire transport system using digital technology. The city is also involved in connectivity-enabled data-related projects such as MobiLab or CDS-M. These retrieve information in cooperation with service providers. Live data is collated on traffic and parking, and the wider impact of a range of transport measures on urban areas can be considered and acted on.

> "The future of the smart city concept lies in understanding how to put digital enablers in place that are themselves green, but also contribute to the greening of a city. Cities are aware of the sustainability imperative and usually already have a sustainability agenda. The main challenge is to understand how to implement sustainability in a systemic way. For example, cities need to know if sensors are really going to help and what will be the associated rebound effect.
>
> - Response from a European Commission official

Energy: faster connectivity can aid smart demand response energy storage and reduce air pollution.

Changing the energy mix to renewable sources is crucial for the European Green Deal. This aims to reduce greenhouse gas emissions by at least 55% by 2030, with a 40% share of renewable energy. To achieve these ambitious goals, the energy grid needs to be upgraded, and new energy storage options will be needed. One of the challenges of using more renewable energy is being able to match demand with supply in real time. Too often, an unwanted oversupply of energy is fed onto the grid. Faster data transmission capabilities through Gigabit connectivity could significantly transform the energy network by allowing instant responses to change in energy usage. A smart grid allows communication between providers and consumers, minimizing differences in supply and demand through controls, computers, automation and network equipment[35].

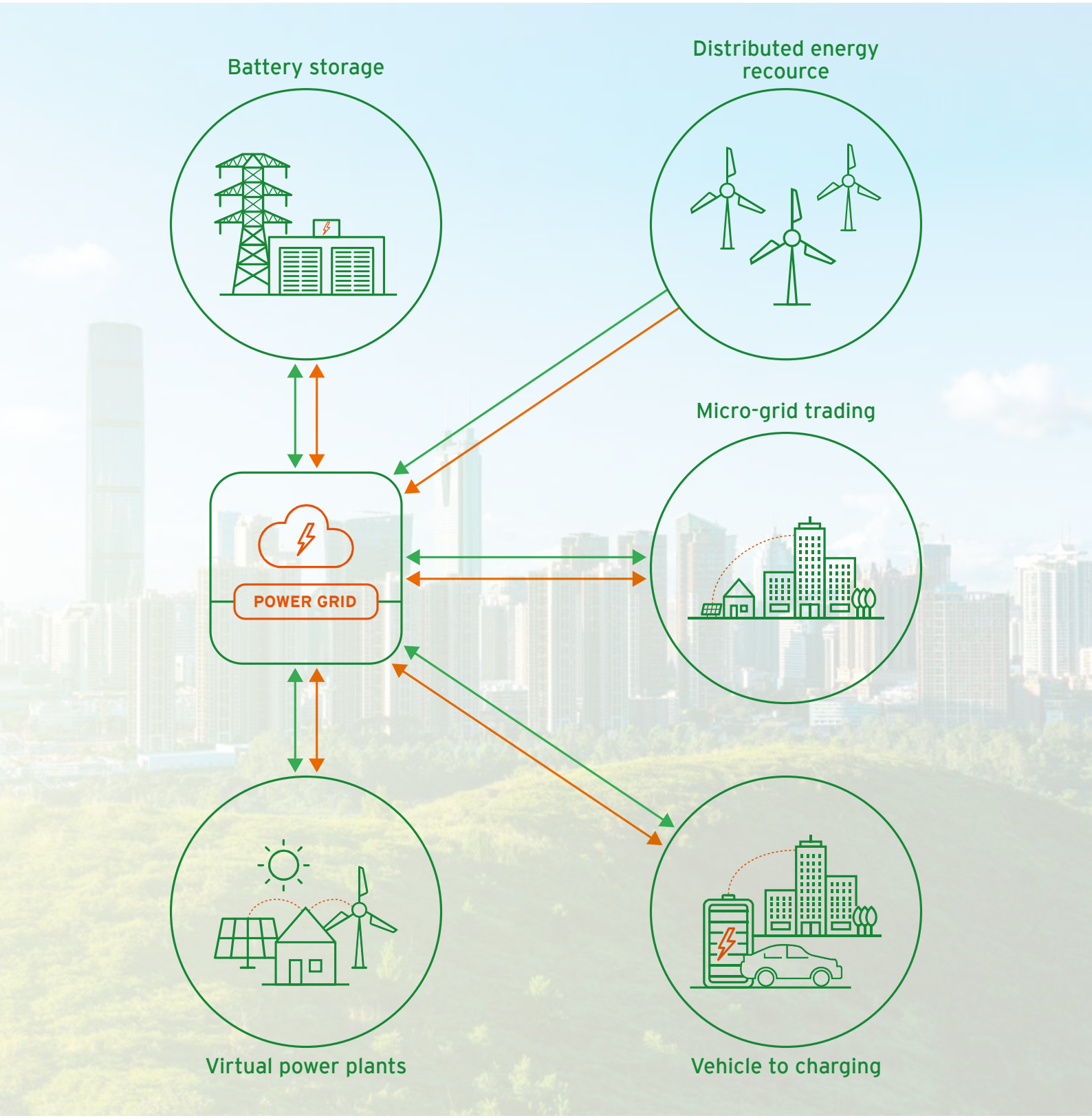
- **Smart grids could reduce annual emissions by 0,43 GT CO_2e[36] by 2030 compared to the business-as-usual scenario.**

Faster data transmission can also help energy providers to manage renewable energy allocation. For example, by integrating weather forecast data into predictive models of energy production, energy grids can better anticipate how much energy may be generated from renewable sources, and how much will need to be drawn from non-renewable sources. Better anticipation of energy demand and the ability to store energy as needed are two key elements to tip the balance in favour of renewable energy sources.

- **In the European Union increased storage and digitally enabled demand response could avoid 30 million tons of CO_2 by 2040[37].**

35 "The Smart Grid," U.S. Department of Energy, n.d.
36 GeSI, and Deloitte. "Digital with Purpose: Delivering a SMARTer 2030," GeSI, 2019.
37 IEA, "Digitalisation and Energy," IEA, 2017.

Picture: Smart Energy Systems



Case study - BMW

How electric vehicles can lead the charge towards smarter cities

BMW is working with the city of Rotterdam to study the use of electrical vehicles (EVs) for local energy storage. It is a pilot project on a major vehicle maintenance site in a part of the city with limited connection to the electric grid. The switch from combustion engines to EVs in the city's fleet required significant investment in the electricity infrastructure to supply the new fleet with the necessary charging power. To tackle the technical constraints and keep costs down, the city installed a large stationary battery equipped with BMW i3 battery packs. This allows energy to been drawn for storage at times of low demand. It can then be released when the grid supply is insufficient to provide the required charging capacity.

BMW Vehicle to Grid (V2G) enabled BMW i3 cars dock on the same site and can themselves provide additional energy storage. The vehicle's battery can be discharged when they are parked to charge other vehicles. Additionally, the batteries can store locally produced surplus renewable electricity and thus enable integration of onsite renewables like wind turbines and photovoltaic panels[38].

This project points the way to reducing the future cost of new charging infrastructure, where the energy not required by one electric vehicle can be used as aggregated storage in the wider energy system. This approach could boost the use of renewables and lower the need for physical extension of electricity grids. However, such a solution would require close working with stakeholders including construction partners, grid operators, energy providers and regulators to enable the efficient use of EV-batteries as low cost storage in energy markets.

> "One of the main challenges in taking this solution to the next level is to secure collaboration among all the stakeholders involved. That's energy providers, charging point operators, vehicle manufacturers, and municipalities - all will have to work closely together to figure out where the responsibility of each party lays and what it will mean in terms of financial and regulatory structure.
>
> - Dion van der Heijden, E-mobility Services Manager at BMW

38 Photovoltaic devices, commonly known as solar panels, generate electricity from sunlight through an electronic process by using semiconductors.

Manufacturing: faster data transmission allows companies to bring in leading edge digital solutions to reduce their carbon footprint and operate sustainably.

Manufacturing companies have long relied on technology and digitalisation to increase production while reducing operating costs. For example, factory operators use smart connected sensors together with the analytical power of machine learning and artificial intelligence to analyse and act on production events remotely and in real time. What companies are now exploring is the potential to cut their operational environmental footprint.

Case study - Nestlé

Augmented reality helps with site support and cuts business travel

A central team at Nestlé began using intensified reality technology during the Covid-19 pandemic to connect remotely to remote production shop floors, research and development sites and suppliers. By using smart glasses, 360-degree cameras, and 3D software, specialists are able to provide support on complex tasks without needing to travel long distances to sites. The technology also allows teams to be more efficient by supporting multiple projects at the same time, while contributing to the 2050 net zero strategy of the company. Augmented reality is both increasing speed and efficiency in facilities and reducing plane travel between Nestlé sites, helping the company reduce greenhouse gas emissions across its operations[39].

39 Nestlé, "Nestlé speeds up factory support with augmented reality", July 24, 2020.

Agriculture: new forms of connectivity show the way to improving farming practices – which are among the largest contributors to greenhouse gas emissions.

The agricultural sector is in the eye of the climate storm over the greenhouse gas emissions arising from its practices. The good news is that it is fast discovering the transformative potential of the internet of things, cloud technologies and AI, which are all enabled by Gigabit connectivity. New technological solutions can now help the agricultural industry turn itself into a more sustainable sector through better monitoring of fields and automation of processes.

Examples of such solutions include the use of internet of things devices to monitor humidity, acidification, and nutrients in soils, and the use of drones to identify weeds in fields. This is significant because farming, grazing and storage practices release methane and nitrous oxide, two powerful greenhouse gases. The agricultural sector is responsible for a large proportion of total greenhouse gas emissions (between 12% and 14%, excluding land use and forestry)[40].

More specifically, the increased and repetitive use of fertilisers and pesticides in modern crop agriculture is itself responsible for considerable greenhouse gas emissions. This is through both the production of such material and its use. It also leads to other environmental problems such as biodiversity loss, terrestrial acidification, loss of soil organic matter, salinisation and the accelerated erosion of soils.

40 Hanna Ritchie et al., "Emissions by Sector," Our World in Data, May 11, 2020.

Case study - Sunrise

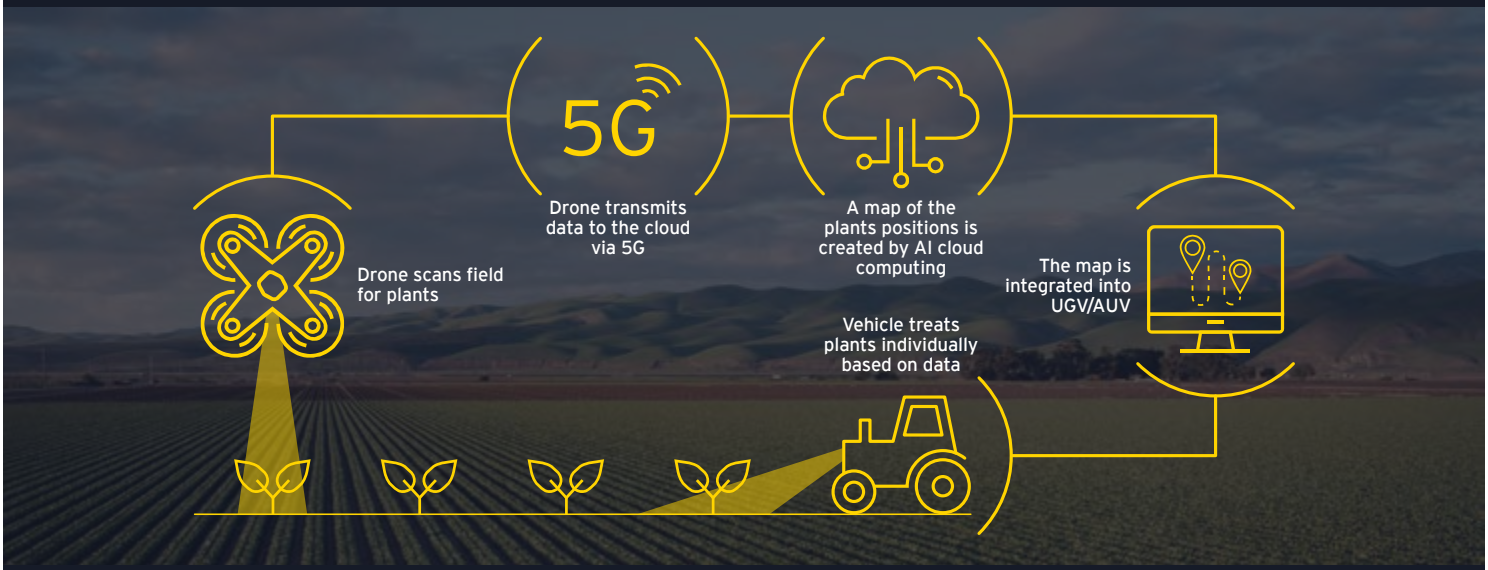
Using 5G to boost production and the environment

The environmental impact of pesticides is a concern for all society. Taking one example in Switzerland, in June 2021, the population was asked to vote on a pesticide-free farming proposal. Although it was not carried in a final vote, the issue of sustainable farming went to centre stage, where it remains.

This was the cue for Sunrise to embark on a research project, using 5G-driven solutions in collaboration with several partners - Agroscope, Fenaco, Huawei and the Eastern Switzerland University of Applied Sciences. A research team developed recognition system algorithms to spot crops from weeds by feeding the algorithm with trillions of plant pictures. By using drones, the research team captures photographs of the agricultural fields that are uploaded in real time into the cloud through 5G connectivity. The algorithm is then able to provide a map of the field indicating the precise position of the weed, which can in turn be isolated and treated (see picture below). High speed connectivity therefore allows farmers to better target their use of pesticides, decreasing the total amount required by 80%. The goal is to offer the algorithms as an open source for all Swiss farmers to use. The deployment of the 5G network remains crucial to provide this service to farmers.

> “We estimate that this solution could reduce the use of pesticides by 80%[41]. Additionally, we then realised that the amount of weed could easily be treated with hot water rather than pesticides because the location of the weeds was known to a very specific level.
>
> - Alexander Lehrmann, Innovation & Development at Sunrise

Picture: 5G Precision farming for greater production and ecology[42]



41 The reduction of pesticides is calculated by comparing the pesticides consumption in a business-as-usual scenario versus a scenario using precision farming.

42 Ioannis P. Chochliouros et al., “Energy Efficiency and Trends in Future 5G Network Infrastructures”, Energies 14, no. 17 (2021): p. 5392

All told, the range of solutions described here demonstrate the vast potential to make more efficient use of energy and cut greenhouse gas emissions in different sectors. In conclusion, however, the following was also noted from the interviews:

1. Gigabit connectivity makes data more actionable, allowing for informed adjustments after deployment of new solutions. It does so by allowing real-time data analysis that in turn allows for a better matching of resource availability and demand.

2. While it is clear that the solutions implemented have potential to reduce energy consumption and avoid emissions, only limited (or no) data can be found to confirm the environmental impact reduced or avoided. In most cases, the environmental impact is not measured.

3. Although many enterprises are working on their sustainability goals, many will be driven by cost optimization. However, either way, we observe that the process efficiency that Gigabit connectivity enables usually leads to energy efficiency.

4. Sustainability could be further enhanced if it was considered ahead of a solution's deployment, through detailed preliminary environmental impact assessments. The most effective way would be to leverage the green and digital transitions in a combination but this demands more knowledge and cooperation among various actors.

To assess the total environmental impact of Gigabit connectivity, it is also essential to look at how it is produced and the energy efficiency efforts undertaken by the telecommunications sector itself.

“The telecommunications sector is at the heart of powering disruptive and innovative solutions to reduce global greenhouse gas emissions.

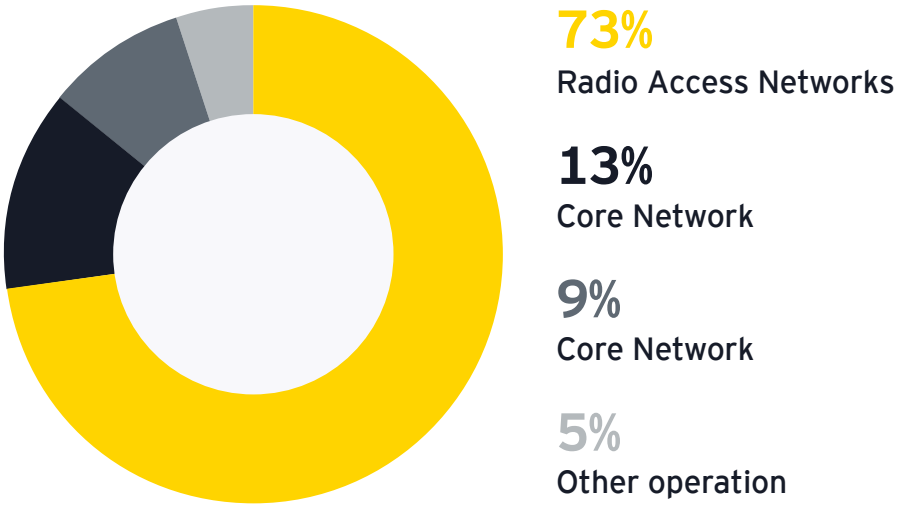
2

How the telecommunications sector drives energy efficiency in its own operations

The telecommunications sector is strongly aware of its own current and likely future energy needs as demand for the services it enables continues to rise. For the telecom sector, energy usage accounts for the biggest part of its greenhouse emissions. 3GPP, a partnership that unites seven telecommunications' standards development organizations, calls for a 90% reduction in energy use by mobile connectivity (5G networks) compared to 2010 levels[43].

The speed achieved by Gigabit connectivity in recent years has enabled a new range of digital services such as video streaming, video conferencing, online gaming, and social networks. As shown previously, such services bring quality of life to consumers while potentially reducing GHG emissions. The multitude of possibilities enabled by new digital solutions is feeding an ever-growing demand for connectivity. Network providers have worked tirelessly to develop a more energy efficient infrastructure to handle a larger bandwidth, while also expanding the network to connect more households and businesses. The figure on the right shows the composition of the energy consumption for a typical mobile network in 2021, indicating that radio access takes the largest share.

Figure 1. Breakdown of energy use per network element[44]



43 GSMA Future Networks, "Energy Efficiency: An Overview", GSMA, May 8, 2019.

44 GSMA Intelligence, "Going green: benchmarking the energy efficiency of mobile," GSMA, June, 2021.

Despite the large increase in data traffic in recent years, telecom operators achieved new levels of energy efficiency.

By constantly innovating, the telecommunications sector is able to develop new technology to boost network performance while using largely the same underpinning infrastructure.

A study by the Science Based Targets Initiative together with ITU, GSMA and GeSi showed that the sector was able to meet growing capacity demand through technological advancement and purchase of renewable electricity. However, as new technologies continue to increase in both size and complexity, more initiatives will be required[45]. Telecom operators are already addressing such challenges as they upgrade fixed and mobile networks. Virtualisation technologies will play a key role in the process. This enables a network to respond to demand by instantaneously creating the required functionality where and when it is needed. This process uses generic, physical devices, which can fulfil multiple roles and thereby reduce energy consumption and use of resources.

Fixed networks

The next generation of hybrid fibre and coaxial equipment will enable a higher bandwidth and data transmission while reusing most of the existing network infrastructure, with only a limited increase in energy. A 2018 paper by Nokia Bell Labs showed that the next generation of that equipment, i.e. more virtualised and distributed, could have a positive impact on both energy consumption and space utilization of network facilities[46]. It will entail full digitisation of the distribution network and migration to a new data transmission standard on the final segment of the networks to increase capacity to multiple Gigabits per second (Gbps). This also provides the pathway to the next generation. Speeds up to 10 Gigabits per second (10 Gbps) could become a reality in the near future, through upgrading existing infrastructure[47]. This process extends the life of the networks, reducing waste and avoiding large-scale environmental disruption during deployment.

Mobile networks

The next generation mobile network infrastructure, 5G, could result in an 85% reduction in CO_2 emissions per Gigabit by 2030, compared to today's 2G-4G mobile networks[48], as it is able to transfer a significantly higher amount of data with the same amount of energy. Beamforming or directional antennas (dynamic) will create a more efficient use of the infrastructure and simultaneously improve the quality of service.

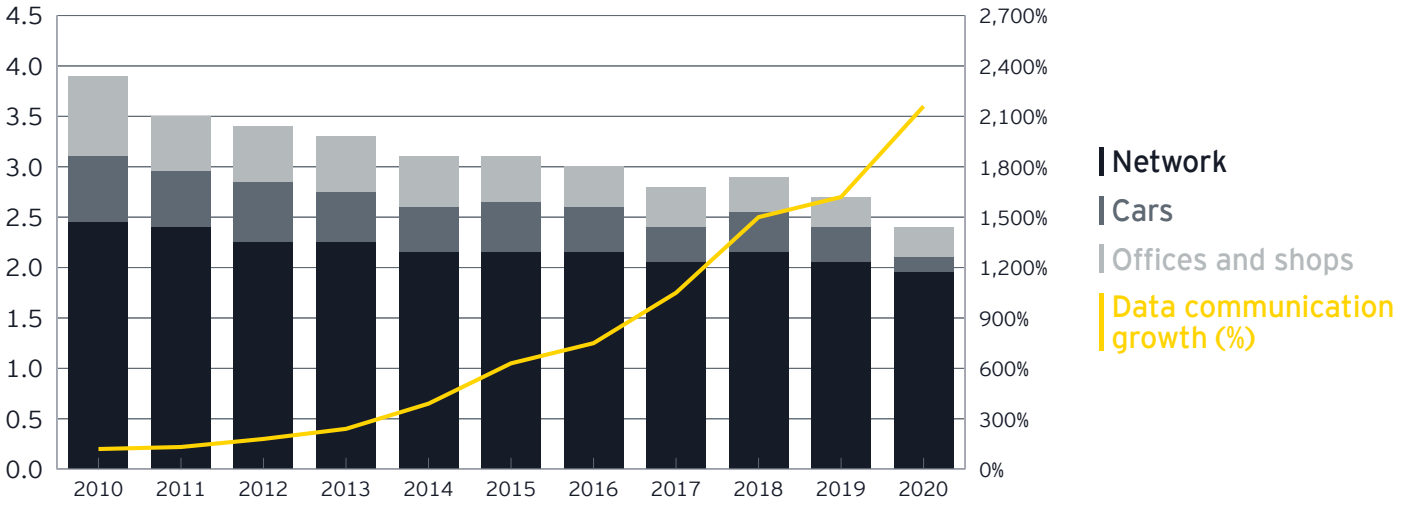
45 ITU et al., "Guidance for ICT Companies Setting Science Based Targets," ITU, 2020.
46 R. J. Vale, Martin J. Glapa, & Jean-Philippe Joseph, "Achieving Significant Space, Energy, And Cost Reductions With Future Virtualized Distributed Access RPD and RMD Architectures for MSOs", SCTE ISBE Cable Tec Expo 2018, 2018.
47 CableLabs, "DOCSIS 4.0 Technology," CableLabs, January 19, 2022.
48 Jan Bieser et al., "Next generation mobile networks – Problem or opportunity for climate protection?", October, 2020.

A key forum for coordination of the sector's work is the European Green Digital Coalition, which was formed in March 2021, established jointly by the European Commission and ICT companies. This body acknowledges the ICT sector's role in the fight against climate change. Out of the 26 founding members, half were CEOs from telecom companies (including Liberty Global's CEO Mike Fries). The companies they represent have committed to becoming carbon neutral by 2040[49]. Telecommunications companies are undertaking many energy efficiency initiatives to "greenify" their operations. These include the use of new cooling methods like free air cooling, suppressing redundant energy intensive functions (e.g. lighting in server rooms), and updating power supplies so that they are more energy efficient. This can result in lower greenhouse gas emissions and costs.

- **Free air cooling systems have the potential to save around 30% on operational expenses[50].**

Some companies like KPN have managed to keep their network's energy consumption steady over the last decade (see Figure 2) despite data communication growth. This is due to fixed network rationalisation and the migration of mobile network equipment to next-generation upgrades. Other network operators like Telefónica have maintained their energy efficiency by: switching off 3G and legacy infrastructure and powering a smaller part of the network; implementing power-saving features (PSF) in the access network; modernising their network and equipment; and implementing renewable energy plans.

Figure 2. KPN's energy consumption (PJ)[51] compared to data communication growth[52]



49 "European Green Digital Coalition," European Commission, November 12, 2021.

50 Maurizio Frizziero, "Global Trends Drive the Need to Rethink Data Center Cooling for Long-term Cost Savings," Schneider Electric, December 3, 2019.

51 Petajoule is a petajoule is a standard unit of energy. One petajoule equals 1 000 000 000 000 000 joules (10 to the power 15), or 278 gigawatt hours.

52 KPN, "KPN Integrated Annual Report 2020", KPN, February 21, 2021.

Case study - Liberty Global

Liberty Global's energy efficiency initiatives

Paris Agreement[53]. Although Liberty Global relies on renewable electricity in almost all of its operations, the company has undertaken several initiatives to enhance the energy efficiency of its networks and reduce Scope 1 and 2 emissions:

Cooling technical sites without air conditioning

To reduce energy use, Liberty Global has updated old cooling systems in its operational sites with modern ones that utilize free air cooling technology. Instead of relying on air conditioning to reduce temperatures at its sites, new systems use cool outdoor air whenever outside temperatures are lower than those indoors. This "free" air can also be used to assist in chilling water used for air conditioning.

Relying on a more modern power supply infrastructure

In Switzerland, Liberty Global updated its power supply infrastructure to one that is more modern and efficient. The latest power supply is modular and includes a hot-swappable system with high yield. This is a system which allows components to be plugged into a computer or removed while the power remains switched on, making it significantly more efficient. As well as making the associated network and services more reliable, when complete this system will result in:

- 1GWh of energy saved from raising temperature set points in 2020
- €625,000 in cost savings in Belgium since the installation of free air cooling in 2013

53 Liberty Global, "Liberty Global commits to Net Zero targets by 2030," Liberty Global, November 8, 2021.

Liberty Global has adopted other measures to reduce the energy required in its network operations in different countries:

- Raising temperature set points to reduce the amount of cool air required to reach the desired temperature in technical sites. This in turn reduces the energy required to power air conditioning.
- Using phase-change material (PCM) in the fabric of new technical buildings in the Netherlands and Ireland. A PCM heat exchanger acts like a temperature regulator by absorbing heat from the air during the day and releasing it during the night, minimizing the use of refrigerants. This process has resulted in 4.7 GWh of yearly energy savings - enough to power 1,000 homes for a year. In addition, the PCM itself is made from a residual product collected in Dutch salt mines which has a relatively low environmental impact.
- Even though some sites still need to use air conditioning in warmer locations, or on warmer days, these initiatives have cut energy consumption, and contributed to cost savings. The following impact was seen in two countries where Liberty Global has operations[54]:

In Ireland

- 46 GWh energy saved in technical sites in Ireland since the installation of free air cooling systems in 2014.
- €6 million in cost savings in Ireland since the installation of free air cooling in 2014.

In Switzerland:

- 1GWh of energy saved from raising temperature set points in 2020.
- €625,000 in cost savings in Belgium since the installation of free air cooling in 2013.

The ICT sector's carbon footprint could be reduced by over 80%[55] if all electricity consumed (by itself and its users) came from renewable energy sources.

54 Liberty Global currently has operations in Belgium, the Netherlands, Ireland, Poland, Slovakia, Switzerland and the United Kingdom.

55 Ericsson, "A quick guide to your digital carbon footprint", Ericsson, February, 2020.

Case study - Telefónica

The roadmap to reduce Scope 3 emissions

Telefónica has set a goal of reducing emissions by 90% to reach net zero emissions by 2040. It then plans to neutralize the remaining 10%. It will do this following an environmental policy developed over several years. It recently set internal emission reduction targets which were validated by the Science-Based Target Initiative (SBTi): In 2025, Scopes 1 and 2 emissions will be reduced by 90% in main markets and Scope 3 emissions will be cut by 39%[56] (compared to 2015 and 2016, respectively).

Like many other telecommunications operators, it has undertaken several energy efficiency measures within its own network, and committed to an ambitious renewable energy strategy (using 100% renewable energy by 2030). By far the largest contributor to emissions for network operators like Telefónica arises elsewhere in the value chain - either from suppliers of goods and services, or from the subsequent use of the products sold. So as to achieve its value chain ambitions, Telefónica intends to support its suppliers on their decarbonisation journey through a supplier engagement programme. Over 500 will be helped to disclose their climate strategy to CDP (a global not for profit body that operates a disclosure programme) and then develop climate-related projects through initiatives such as Joint Audit Cooperation (JAC). This allows leader telecom companies to work closely with key suppliers. In 2020, Telefónica had already reduced its value chain emissions by 26,8%[57].

Together with GSMA, Telefónica is also leading a focus group on how to reduce Scope 3 emissions in the telecommunications sector. It wants to encourage suppliers to commit to net zero, providing them with the necessary support to do so. The suppliers will be helped to:

- Calculate their own emissions
- Pursue the right initiatives to reduce their emissions from an established baseline
- Take advantage of prices negotiated by network operators with renewable energy suppliers
- Telefónica also promotes the eco-design of its own products, integrating energy efficiency into their use.

56 GMSA, "Mobile Net Zero," GSMA, 2021.
57 Ibid.

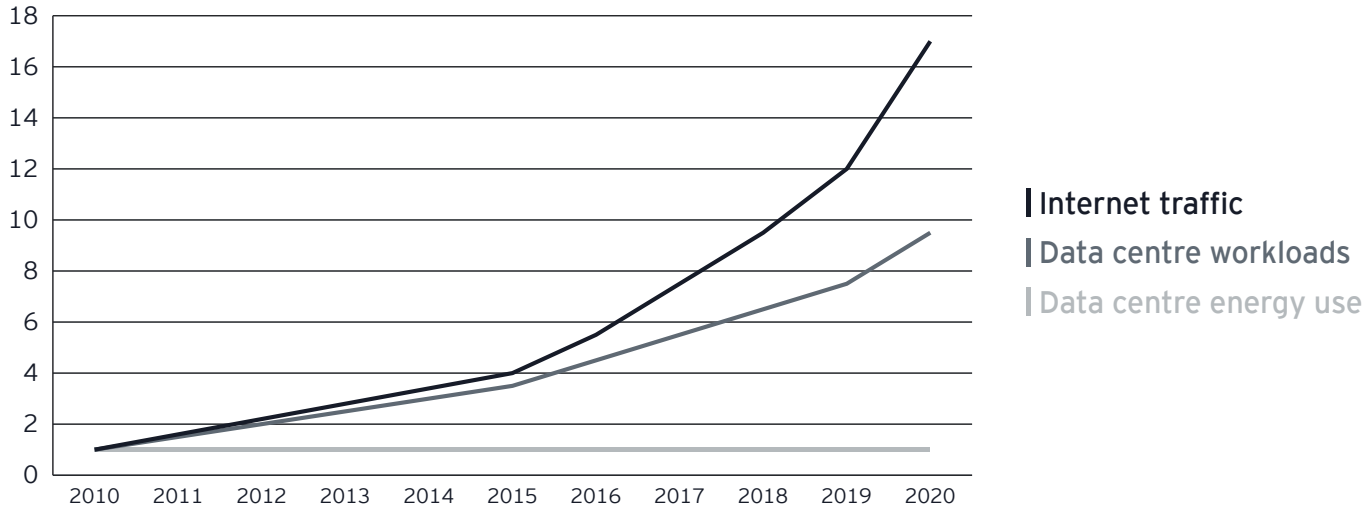
Data centres are the "factories of the digital world" - under scrutiny for their energy consumption. As a truly connected and automated world becomes reality, limiting their environmental impact will be key.

The European Union has introduced a more ambitious carbon neutrality target for 2030 for data centres, which are an important part of the ICT eco-system. Data centres and other technical facilities need to maintain stable low temperatures to achieve peak performance, and this requires the constant consumption of energy.

The workload of data centres has risen significantly in the last decade in tandem with internet traffic. This trend is expected to continue with the increased use of applications like augmented and virtual reality, blockchain, crypto currencies and the internet of things.

Data centres and telecommunication networks account for a large part of the energy consumed by the internet. Available information on their energy use shows these have managed to keep their power usage flat over the last decade, in spite of the significant increase in data traffic: see Figure 3.

Figure 3. Data Centres and Data Transmission Networks[58]



58 IEA, "Data Centres and Data Transmission Networks," IEA, November, 2021.

Case study - AtlasEdge

The rollout of smaller, localized and more sustainable data centres

As the number of connected devices continues to grow, centralized Cloud data centers may struggle to handle the future amount of data. AtlasEdge is a joint venture between Liberty Global and DigitalBridge. It was established in 2021 with plans to operate more than 100 Edge data centres across 11 European countries. These are smaller and more localised than traditional data centres, hence their name which highlights how they are placed on the 'edge' of the network. By enabling the storage and processing of data closer to the end consumer they can help reduce latency and improve connectivity on a local scale.

AtlasEdge will sign up to the 'EU Climate Change Data Centre Pact'. This is a voluntary alliance of data centre operators and trade associations who are committed to the European Green Deal, achieving the greenhouse gas reductions set out in climate laws, and leveraging technology and digitalisation to achieve the goal of making Europe climate neutral by 2050.

1

The deployment of Gigabit connectivity has led to a multitude of innovative features which also help consumers reduce their environmental footprints. Simultaneously, the industry is mitigating the potentially higher energy demand by deploying more energy efficient network architectures and employing more sustainable cooling systems in their data centres.

2

The European Green Deal and the carbon-neutrality targets of policy-makers in the EU and UK provides an opportunity for telecommunications operators to both contribute to, and facilitate the transition to a carbon-neutral economy through their corporate activities. However, it is acknowledged that data on the environmental impact of initiatives by the telecommunications sector is currently limited.

3

Measuring how Gigabit connectivity can enable emission reduction

As previously indicated, there are two distinct aspects of the environmental impact of Gigabit connectivity: **greening by** and **greening of** the telecom sector.

With regard to greening by the case studies here illustrate some of the many ways Gigabit technology will enable the sustainable transformation needed to meet the EU and UK's commitments to become carbon neutral economies.

Gigabit connectivity enables real-time data analytics which in turn make it possible for carbon-intensive sectors to adjust their activities to reduce GHG emissions. As the case studies demonstrate, such emissions are reduced through lowering production input and by increasing the efficiency of the resources used. For many of the case studies, normal connectivity would have been insufficient to drive the change. As was seen in the case of "digital twins", very high capacity networks such as 5G are a minimum requirement to unlock the use of sensors and big data in smart cities. Another key element is the matching of supply and demand. The BMW case study on EV charging shows one way of achieving a wider switch to sustainable electrical vehicle charging. The more data that is produced from projects such as this, the easier it will be to maximise the use of available renewable energy and EV charging facilities.

Perhaps the biggest positive impact of such initiatives to date has been seen in building management. Here it was shown that smart solutions can render impressive results – saving up to 30% of energy consumed in old buildings, and 10% in new ones. At the same time, this study has shown the big strides being taken in telecommunications to ensure that even with increased data traffic, there is a shift towards reducing the GHG emissions through boosting the energy efficiency of the networks by switching to renewable energy and modern cooling technologies.However, the case studies do show that a more complete framework and methodology is needed to measure the positive contributions of enabling effects, while also taking the environmental footprint of the telecom sector itself into account.

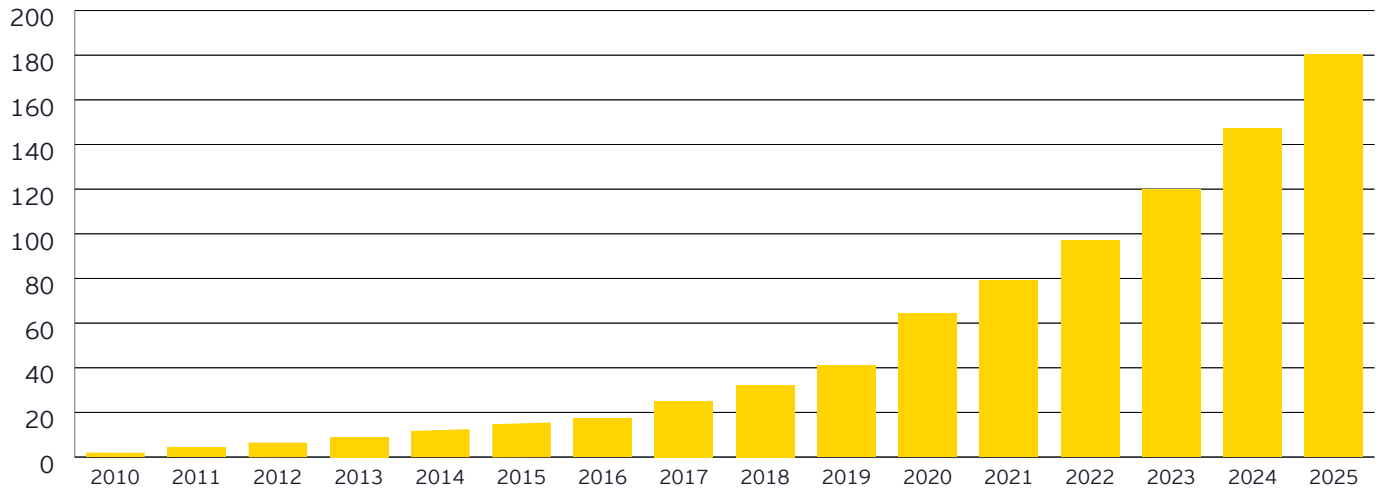
In absolute values, 5G is said to be 85%[59] to 90%[60] more energy efficient than previous mobile technologies. Additionally, the increased use of virtualisation will make the networks smarter and more efficient. One component can be used for several purposes, limiting both energy usage and waste.

59 Jan Bieser, et al., "Next generation mobile networks - problem or opportunity for climate protection?", University of Zurich and Empa, October, 2020.
60 GSMA, "Mobile Net Zero", GSMA, 2021.

But what impact might network upgrades have on an operator's greenhouse gas emissions? If the amount of data traffic increases further, could this impact future Scope 1 and 2 emissions due to the higher future energy use?

As we march towards a fully connected and automated world, the volume of data that will be generated is expected to increase significantly. Some sources expect it to triple by 2025, see Figure 4, while others estimate the potential increase in data traffic could be up to 1,000 times.

Figure 4. Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2025[57].



Some suggest that this could lead to a two- or three-fold increase in energy consumption[61]. This is a so called "rebound effect", where due to energy efficiencies consequential human behaviour, which may use more of it, actually cancels out associated energy savings.

> "This large future rise in data traffic is often described as the "rebound effect". It can be expected once society exploits the full potential of 5G and internet of things solutions.

61 Ioannis P. Chochliouros, et al., "Energy Efficiency Concerns and Trends in Future 5G Network Infrastructures," 2021.

Such a rise may have multiple and unintended causes, and will most likely be related to changes in human behaviour. Rebound effects may be short or long term, so is hard to estimate them fully[62]. Moreover, research findings in this area differ. So far, the telecom sector has proved able to keep its energy use growth small or even see it drop - while bandwidth has simultaneously increased exponentially. It seems that energy efficiency gains in infrastructure stemming from environmental initiatives and technological innovations could keep energy use at a constant level, even with the current increase in data traffic.

A recent study by the European telecom regulators body, BEREC, shows the importance of clarity in identifying which part of the industry's value chain is being assessed for environmental impact. While the ICT sector as a whole represents an estimated share of 2–4% of total global GHG emissions, devices account for a high proportion of the total - 60 to 80%. In comparison, networks account for 12-24% and data centres account for 15%. Hence, the impact of the energy consumption of ICT equipment as a whole needs to be taken into account.

Another recent study showed that if the number of ICT equipment installations remains much the same, the actual change in each's energy use will be key to assessing total energy consumption in the next decade. With an assumed increase in energy consumption of each device of 2% per year, the total energy consumption for the ICT sector in 2030 will be 1.5 times that in 2020[63]. To conclude, in-depth studies are needed.

62 GeSi, "ICT Sector Guidance built on the GHG Protocol Product Life Cycle Accounting and Reporting Standard", GeSI, July 21, 2017.

63 Xiaoxi Zhang et. al., "How ICT can contribute to realize a sustainable society in the future: a CGE approach", Environment, Development and Sustainability 24, no. 4 (2022): 5614-40

Further research is also required to highlight the positive impact enabled by Gigabit connectivity. **Standardised impact measurements** will be essential if this research is to reach useful conclusions.

As has been described here, there are challenges inherent in measuring the greening of the ICT sector and its impact on Scope 3 emissions. As noted at the start, we found that estimates can go as high as 3.7%[64] of global emissions. However, the studies with higher percentages do have a larger scope, looking way beyond the physical network infrastructure to the impact of end user devices. This is work in progress. Current estimations should not be seen as comparable or indicating absolute truths.

Well-established measurement through platforms such as those supervised by CDP have helped the telecom sector track its progress towards meeting Scopes 1 and 2 requirements through public disclosure. The data and case studies presented in this report do show that the sector is on a good trajectory - bringing down its footprint, while simultaneously providing higher speeds and more bandwidth to carry ever-increasing data loads. Efforts are now underway to develop similar performance monitoring measures for Scope 3. Meanwhile, a drive is on at a European and international level to find better ways to assess the environmental footprint of the ICT sector (and thereby indirectly the telecommunications sector).

These are some of the aspects to consider when looking at improving the measurement of Scope 3 emissions.

1. The methodology

When it comes to measuring carbon emissions, waste or energy efficiency generated by an organisation, there are various standards in use i.e. Greenhouse Gas Protocol accounting and reporting standards[65], Sustainability Accounting Standards Board (SASB)[66], the Global Reporting Initiative (GRI)[67] and ISO[68]. Generally, those standards tend to take similar measures and lead to produce comparable results.

However, the guidance available to measure the impact of an organization, a product, or a service is not standardised. Several governmental and organizational initiatives have therefore been established to harmonise methodologies on impact measurement. For example, the Value Balancing Alliance (VBA)[69] aims to create a global impact measurement and valuation standard (IMV) for monetising and disclosing the positive and negative impacts of corporate activities. It also aims to provide guidance on how these impacts can be integrated into business decisions. At product-level, the Product Environmental Footprint (PEF) quantifies all environmental impacts over the lifecycle of a product. This is especially helpful in evaluating the impact created by internet of things equipment that may be used in the future.

64 The Shift Project, "Lean ICT – Towards Digital Sobriety," The SHIFT Project, March, 2019.

65 The Greenhouse Gas Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas emissions from private and public sector operations, value chains and mitigation actions.

66 The Sustainability Accounting Standards Board (SASB) aims to develop sustainability accounting standards and drive the need for standardized reporting of ESG data.

67 The Global Reporting Initiative is an international independent standards organization that helps businesses, governments and other organizations understand and communicate their impacts on issues such as climate change, human rights and corruption.

68 The International Organization for Standardization is an international standard-setting body composed of representatives from various national standards organizations.

69 The Value Balancing Alliance (VBA) is founded in 2019 representing 15 multinationals, the four largest services networks, OECD, and the leading academic institutions.

A global standard is required - not only to foster long-term thinking and understand comparative performance, but also to consolidate existing knowledge around impact measurement. According to the European Commission, Life Cycle Assessment (LCA) is the best framework for assessing the environmental impacts of products and services.

However, the European Commission also highlights the need for more consistent data and consensus on LCA methodologies[70]. The European Commission intends to keep working on this topic and will release a European Platform of Life Cycle to tackle these challenges[71].

2. The lack and quality of data

Both the case studies and research findings in this report indicate that relevant data is often outdated or simply unavailable. Few regular studies are being conducted on the environmental impact of connectivity, and many organisations and studies draw conclusions based on scientific papers from three or even four years ago.

Planning mitigation to Scope 3 emissions is especially difficult because of the lack of relevant and accurate data. For example, there is little data on the end-of-life phase of electronic equipment, including the handling of waste. The rapid pace at which technologies being investigated evolve makes it hard to estimate their environmental footprint, rendering data collection less useful in the longer term.

The European Single Access Point (ESAP)[72] may be a step in the right direction as it will potentially offer a single source for public financial and sustainability-related information about EU companies and EU investment products. It will contain sustainability-related information published by companies, which will support the objectives of the EU Green Deal. However, it is unclear when this platform will be accessible.

70 Communication on Integrated Product Policy, (COM (2003)302)

71 "Implementation of the IPP communication – European Platform on Life Cycle Assessment", European Commission, n.d.

72 European Commission, "Capital Markets Union: Commission proposes new measures to boost Europe's capital markets", European Commission, 2021.

The biggest remaining challenge however is measuring the greening by of digital technologies, notably Gigabit connectivity. Joint public-private initiatives such as the European Green Digital Coalition are attempting to address these issues by developing a methodology to measure this impact. The coalition started its work in 2021 and will take action on:

- Investments in green and sustainable technologies and energy efficiencies in its operation;
- the development of tools to estimate the environmental impact of these green and digital technologies in collaboration with NGOs and other expert organisations;
- the formulation of recommendations and guidelines for a green and digital transformation encompassing other relevant sectors.

Such a coalition should not only help to develop the tech sector in a sustainable manner, but also assist other carbon-intensive sectors such as energy, transport, agriculture, and construction to reach their own sustainability goals[73]. It recognises the positive impact of digital technologies in other sectors. The coalition is a great step forward towards the Green Deal and measuring the environmental impact.

The ultimate goal should be to enhance the positive impacts brought by digital technologies while minimizing their negative impacts. To sum up, the key aspects that must be considered to better measure the impact of Gigabit connectivity are:

1 The rebound effect of the new solutions enabled by connectivity, such as efficiency gains, tend to be counteracted by increased consumption. Consequently, the rebound effect may make it harder to estimate the reduction in greenhouse gas emissions from energy efficiency improvements.

2 The lack of standardised methodologies to measure the environmental impact of connectivity applications. This prevents accurate analysis and comparisons to inform decision making.

73 European Commission, "Companies take action to support the green and digital transformation of the EU," European Commission, March 19, 2021.

“Ultimately, the degree of digitisation and deployment of Gigabit connectivity will determine the extent to which such technologies can reduce GHG emissions in the wider world.

4

Conclusion and recommendations

Gigabit connectivity is an essential component to drive the European Union's and UK's transition to sustainability.

Policy-makers in the EU and the UK expect the telecommunications sector to deliver on ambitious connectivity targets. It is these which will drive sustainable transformation in many other sectors. Coming back to our research questions and key insights of this report we can conclude the following.

> "The telecoms industry is making a vast collective effort to address both its direct emissions and those that come from the consumption of purchased electricity or other forms of energy. This is the "greening of" the sector with regard to its Scope 1 and Scope 2 emissions.

As previously indicated, the telecommunications sector already has the potential to enable more positive impact by 2030. This is as long as the sector maintains its decarbonisation effort to manage the energy consumption of its network infrastructure. It will also need to manage the emissions arising from the construction of equipment in order to fully deploy the Gigabit connectivity infrastructure.

In recent years, the telecommunications sector has taken huge steps forward to address its Scope 1 and 2 emissions by improving the energy efficiency of its technology (e.g. 5G, fibre), but also in its operations, extending the use of free air cooling, shutting off dormant equipment, managing legacy network, and increasing investments in renewable energy. This is in line with the EU's most recent regulations for a green and digital transformation that will benefit European citizens, businesses and the environment[74]. Upgrades to new forms of network infrastructure will be key to ensure that the trajectory of growing energy efficiency is kept. The examples quoted in this report show that 5G networks are around 85% more energy efficient than previous generations[75]. This is of paramount importance, since the ever-growing data traffic could otherwise lead to an exponential growth in energy consumption. In addition, the use of renewable energy by the ICT sector could cut its emissions by 80%[76]. Meanwhile, efforts are underway to address emissions from the supply chain and the use of products provided for customers by the telecom sector. Such emissions are included in Scope 3. Here, the sector is now working collectively to assist suppliers on their own decarbonisation programmes. It is also investing heavily in renewable energies.

74 European Commission, "Shaping Europe's Digital Future," European Commission, n.d.
75 Jan Bieser et al., "Next generation mobile networks – Problem or opportunity for climate protection?", University of Zurich and Empa, October, 2020.
76 Ericsson, "A quick guide to your digital carbon footprint," Ericsson, February, 2020.

> “The ability of the Gigabit technology delivered by the telecoms industry to drive sustainable decarbonisation in other sectors is not in doubt. What is lacking is comprehensive and comparable science-based data to guide the assessment and implementation of the best technologies to maximise this “greening by” impact of the industry.

This problem is being addressed by policy-makers and the telecoms industry. The telecom and wider ICT industry are currently partnering with the European Commission to develop a methodology for measuring the effectiveness of different digital technologies in reducing GHG emissions in the sectors in which they are deployed.

This is as distinct from their impact on Scope 1, 2 and 3 emissions in the telecommunications sector itself. In order to fully assess the net positive impact of digital technologies, there is a need to define science-based methods to make reliable comparisons between different solutions in reducing GHG emissions. Initiatives like the European Green and Digital Coalition are actively trying to support a green digital transformation of sectors such as energy, transport, agriculture, and construction. In this way, the path towards a sustainable future in the economy and society as a whole can be accelerated. The case studies outlined here show the extent to which the use of Gigabit connectivity is an essential enabler for companies to progress their drive towards sustainable decarbonisation. Ultimately, it is the degree of digitisation and the deployment of Gigabit connectivity which will determine the extent to which such technologies can reduce GHG emissions in other sectors. Beyond that, the motivations behind technology deployment, and the extent of whether these are sustainability-driven from the start may shape outcomes. The use of detailed preliminary environmental impact assessments and then leveraging green and digital transitions together in a combination looks likely to be most effective strategy.

High-level recommendations

1

More and deeper insights are needed into the energy-saving and emission-reducing benefits of a wide range of solutions that run on Gigabit connectivity. A thorough impact assessment would inform policy makers about how Gigabit connectivity can drive the carbon neutrality targets of society as a whole in Europe and the UK. They should study and learn from best practice, well illustrated by the case studies described in this report.

2

Gigabit connectivity will only be sustainable and open the door to carbon-saving opportunities everywhere if it makes use of renewable energy. Policy makers should strongly support the sector's transition towards renewable energy sources. The sector should proactively invest in renewable energy solutions.

3

"The best energy is energy that is not consumed". Network operators have demonstrated that the latest connectivity is faster and significantly more energy efficient. They should ensure that the current level of progress is maintained as networks are upgraded and adapted to meet future connectivity needs.

4

Robust and clear measurement guidance is required to assess the environmental impact generated by Gigabit connectivity. Currently, there are too many frameworks, with only limited agreement on methods and scope. Guidance should be provided on which impacts are most important for the sector to measure.

A vision of the future from Liberty Global

The world today shares its most urgent imperative: to create a sustainable future.

As a pioneer in the industry that has revolutionised our era, Liberty Global sees it as incumbent on the telecommunications sector to do all it can to spearhead a greener, more energy-efficient agenda.

As laid out in this report, gigabit connectivity is daily creating new possibilities for how we innovate, become more agile and efficient, powering the rapid scaling of solutions to the environment and climate crisis of our times.

Next-generation connectivity is now enabling innovations across a multitude of sectors, including manufacturing, agriculture and transport, delivering critical reductions in carbon emissions. These examples, from precision farming with 5G to smart buildings and digital twins, each rely on a winning combination of machine learning, automation, and real-time data monitoring and analysis. In short, smart innovations come from smart interactions—requiring fast, reliable connectivity and bandwidth to support big data, cloud solutions and AI capabilities. The role and purpose of telecommunications in our world has never been clearer. The industry just needs to stay ahead of connectivity demands – upgrading its networks responsibly and strategically and continuing to invest at scale.

> “Our priorities are grounded in being a responsible, sustainable and inclusive company. We are excited for the innovations and efficiencies that gigabit connectivity can support, and are fully committed to our roadmap to 10Gig speeds over the coming years. We hold ourselves to being an active force for good in creating a bright and connected future.
>
> - Molly Bruce, Vice President, Corporate Responsibility and ESG Communications at Liberty Global

As this report also details, the role of telecommunications is not solely that of an enabler to customers, businesses and other industries. The sector also has a responsibility to optimise its own operations and practices.

Liberty Global's own environmental, social and governance ambitions are informing energy-saving decisions, smarter models, responsible partnerships, and greener practices across the business. In the last two years, Liberty Global became one of the world's first 500 companies to develop and receive approval for science-based targets to reduce carbon emissions in line with the 2015 Paris Agreement. It became a founding member of the European Green Digital Coalition, and has announced its commitment to become net zero across its own operations within Scopes 1 and 2 by 2030.

Recently, the company re-engineered its internet modem, the Mercury V2+, with a case made of 100% recycled plastic and delivered to customers in 100% recycled packaging. It is already actively planning to meet its Scope 3 ambition - working extensively with suppliers to validate green practices throughout its value chain. The company also continues to examine ways to increase renewable energy sources and modernise networks that are already providing speeds upwards of 1Gig.

Liberty Global also greatly values partnerships, well-constructed policies that support fair investment, disruptive innovations and broad co-operation towards a shared agenda. The company stands behind increasing transparency and standardising methodologies to measure the environmental impacts of growing connectivity applications.
The telecommunications sector has an incredible opportunity to be more impactful together than it ever could be as a sum of its parts. It is an industry defined from the start by innovation, agility and efficiency.

This is the time for everyone involved in it to truly come together to tackle the world's most important issue.
It's today that we should connect - for a sustainable future for us all tomorrow.

5

Appendix

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