ICT energy

The energy use and enablement effect of the Information and Communication Technology industry

01 Introduction

This paper focuses on the overall energy consumption and greenhouse gas emissions from the Information and Communication Technology (ICT) sector including mobile networks such as 5G. Furthermore, the paper highlights the sustainability benefits that digitalization bring and why 5G is an important enabler of a low carbon future.

Cellular communication has, during the past decades, changed societies and people's lives. From 1G and 2G communication allowing us to make calls to people and not places, to today's high speed 5G networks. While 4G was a consumer centric technology, building the app-economy, the current 5G has an industry focus. With high data speeds, low latency, and the ability to create dedicated bandwidth for critical users – so called network slicing – the 5G technology has been tailored to fit the needs of various industries and societies.

The overall digitalization of industries and society is crucial to increase efficiency, competitiveness and to accelerate the transition towards a Net Zero future.

During the past years, the overall energy usage and life cycle greenhouse gas emissions of the ICT sector have been debated. The point has been raised that the digital economy would sharply increase its energy use as more amounts of data is transported through the communication networks. Our peer-reviewed research shows that the entire ICT industry uses approximately 4% of the world´s electricity for its operation, and represents 1,4% of the global green house gas emissions from a life cycle perspective.[1] It has also been found that even if data in the networks, during the past decade, has increased exponentially, energy consumption has remained at a quite stable level. Hence, data growth and energy consumption growth are not correlating[2].

1 Malmodin, Jens & Lundén, Dag. (2018). The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015. Sustainability, available at https://www.ericsson.com/en/reports-and-papers/research-papers/the-future-carbon-footprint-of-the-ict-and-em-sectors

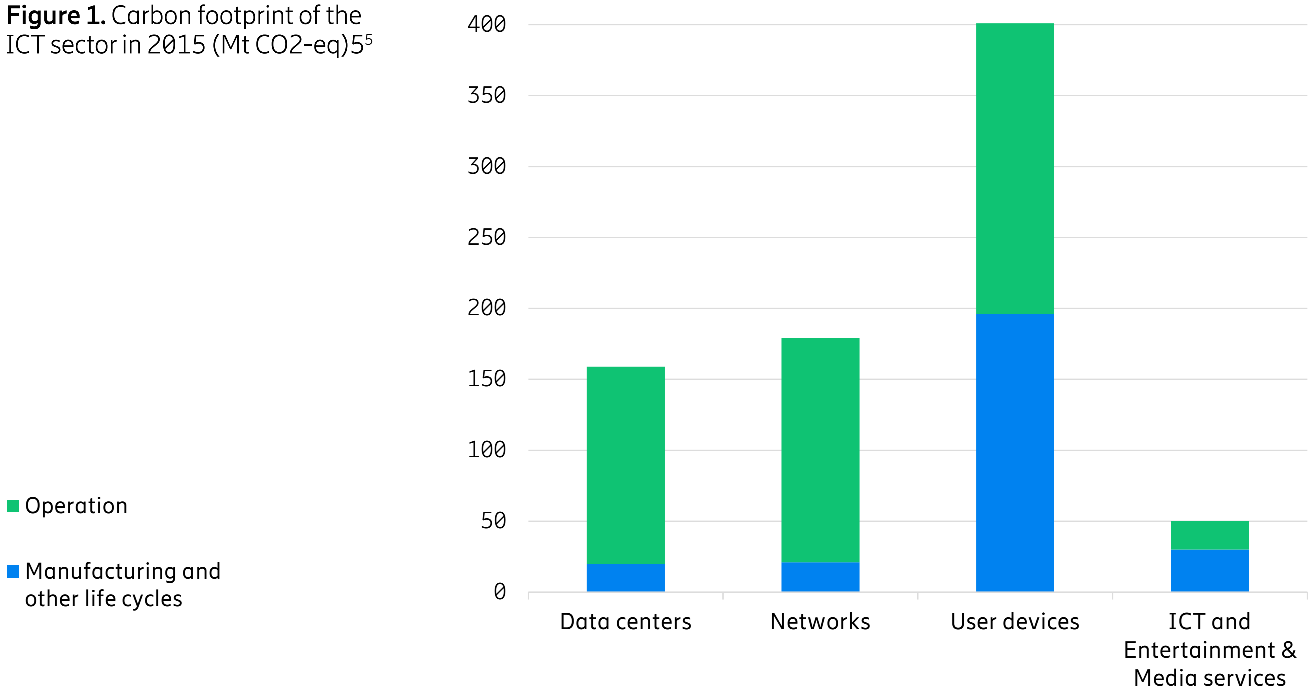
2 Lundén et. al., Dag. Electricity Consumption and Operational Carbon Emissions of European Telecom Network Operators. Sustainability (2022), available at https://www.mdpi.com/2071-1050/14/5/2637

02 Global and European ICT energy use and carbon emissions

The energy use, carbon footprint and the connection between data traffic and electricity consumption has been debated over the years and several projections have been published by different actors. In retrospect, many projections have turned out to overestimate the future electricity consumption and carbon footprint of ICT.

Between 1995 and 2010 the operational electricity usage of the global ICT sector[3] is roughly estimated to have increased three times. However, it has been shown that, over the period 2010 to 2015, the energy consumption of ICT has remained at about the same level, despite a continuing growth in subscriptions and an exponential increase in data traffic. In 2015, the electricity use of the ICT sector was approximately 800TWh, corresponding to 3.6% of the world's electricity consumption and 1.4 % of the global carbon emissions[4]. During the same time period, data consumption increased by almost 400% and the number of internet users increased by more than one billion globally. The main part of electricity consumption is related to the operation of end user devices, such as laptops, smartphones etc.

Figure 1. Carbon footprint of the ICT sector in 2015 (Mt CO2-eq)5[5]



3 Including all user devices (PCs, mobile phones etc.), access networks, data centers and operating activities of the sector.
4 L.1470 : Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement available at www.itu.int.
5 https://www.ericsson.com/en/reports-and-papers/research-papers/the-future-carbon-footprint-of-the-ict-and-em-sectors

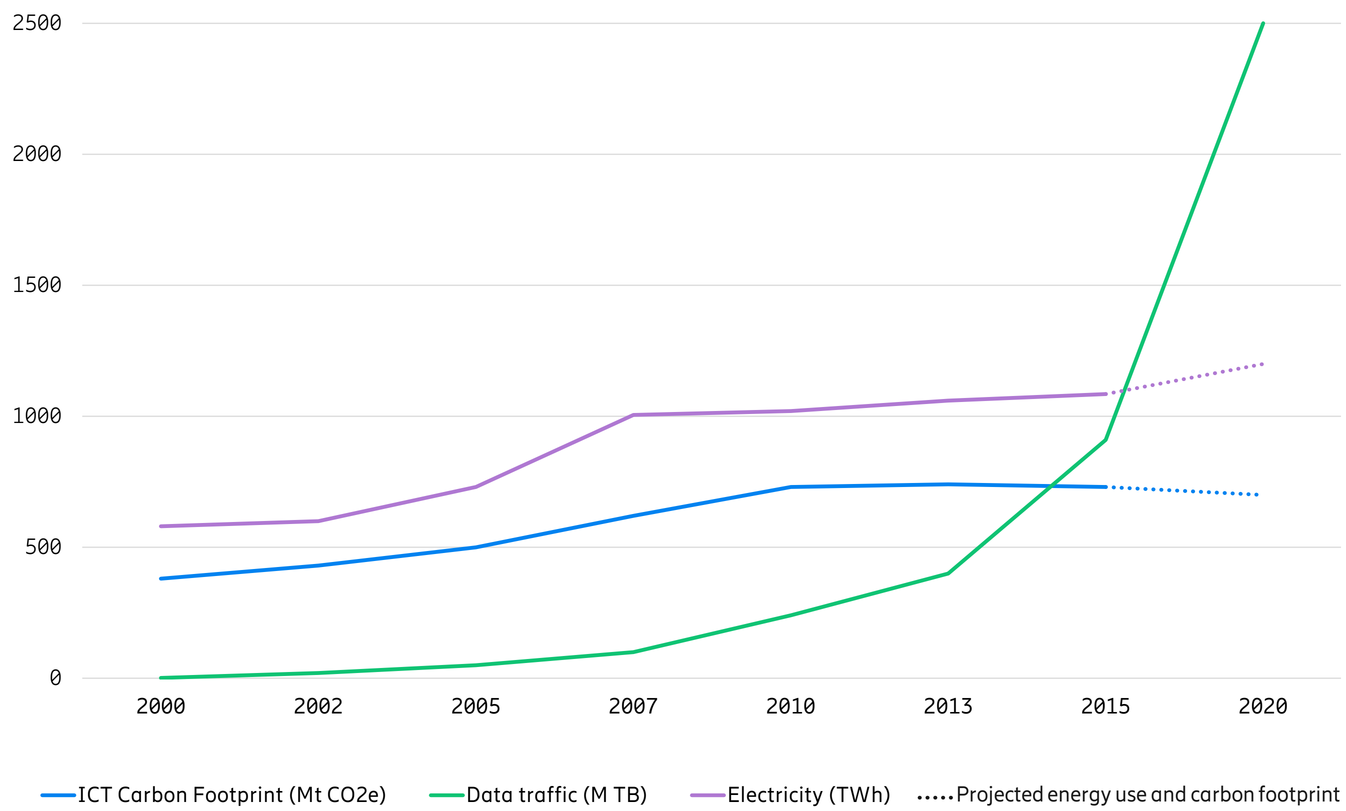
Estimations of the future energy consumption of the ICT sector have been conducted in several research studies, including studies published by Ericsson. The comparison of estimations with actual figures has shown that future estimates are often too high. This means that future estimates have overestimated the electricity consumption and greenhouse gas emissions of the ICT sector.

To understand the latest trends, Ericsson is conducting research to update the global ICT usage figures from 2015 onwards to assess the energy consumption and carbon footprint measures.

The energy use in fixed and mobile networks has been assessed in several studies. In 2015, the global electricity consumption of fixed and mobile network operations was 242 TWh, which corresponded to about 1% of the total global electricity supply. Updated figures for European-based telecom operators[6], shows a slight increase in energy use from 2015 to 2018, while data traffic increased threefold. Furthermore, within the European part of the data set, consisting of countries within EU, UK, Norway and Switzerland, the share of renewable energy was 71% in 2018.

Overall, research based on extensive collection of operational data shows that the operational electricity consumption of the ICT sector is not increasing substantially.Though data traffic has risen exponentially during the past decades, energy consumption has not increased at the same pace. In the past, assumed correlation between data traffic and electricity usage has resulted in exaggerated forecasts of the future. Our data shows that when collecting operational data independently, no such correlation can be found. Thus, expected data growth in society due to increased digitalization does not mean sharp increase in future electricity consumption.

Figure 2. ICT sector electricity and carbon footprint, global figures



6 Europe-based operators, means members of the European Telecommunication Network Operators Association (ETNO), with headquarters in Europe, serving more than 800 million customers worldwide, with approximately 400 million in Europe.

03 Product energy performance

Global mobile network subscriptions have grown from 6 billion in 2011 to 8.1 billion in 2021. Whilst mobile data traffic has grown almost 300 times[7] over the last 10 years, mobile network operators' global network energy consumption has risen by just 64 percent, from 91TWh to about 150TWh. The main driver of the energy increase is due to a larger surface and population coverage and deployment of additional equipment supporting newer mobile generations, rather than the increase in the traffic.

Nevertheless, energy use and energy performance for networks is a topic of importance both for vendors, such as Ericsson, and the users, such as the mobile network operators. The importance comes from both a climate perspective, and from a business perspective to minimize operational costs. Limiting energy input and output from network equipment (e.g., base stations) is not an efficient way to reduce the overall energy consumption of the entire network. Such reductions would, on the contrary, result in reduced surface and population coverage, where a more densified network would have to be built, potentially resulting in increased energy use.

A solution to improve environmental performance in general and particularly energy consumption, is to upgrade older equipment. As an example, newer multiband radios can simultaneously handle many frequency bands[8]. This means that several older single band radios can be replaced by one radio, resulting in up to 50% energy savings[9].

Over the years, major technological innovations have enabled mobile networks to support significantly more data traffic while consuming only marginally more energy. One example of such innovations is sleep mode, where components in the network idle in between data transmissions. In the 4G standard, the sleep mode intervals are quite short – maximum 0.2 ms – while the 5G standard has been designed based on knowledge of typical traffic activity in radio networks, and thus provides much better support for implementing energy-saving features. In the 5G standard, sleep mode intervals are up to 800 times longer than in the 4G standard, resulting in significantly lower energy consumption. Hence, improved energy performance can be obtained with various software solutions and by upgrading older equipment to modern high-performing products.

> All-in-all, the 5G standard is a much more energy efficient technology than the previous generations (i.e., 2G, 3G and 4G).

7 Ericsson Mobility Report, June 2022, available at Ericsson.com

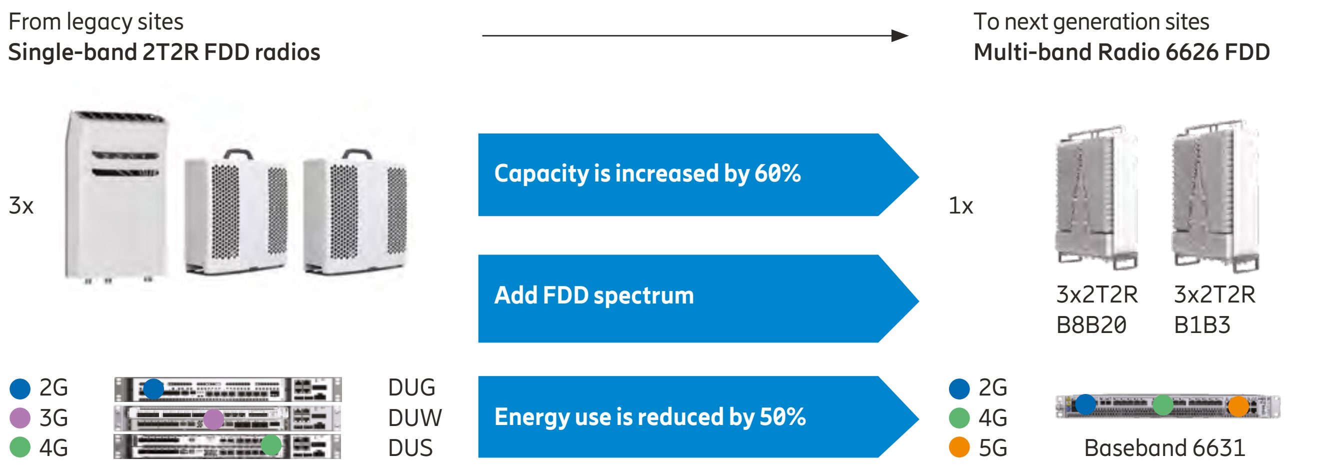
8 In telecommunications, different frequency bands are used to transport the data over the air in the network. Larger frequency bandwidth allows more data to be transported at higher speeds. In general, larger contingent bandwidth of 100MHz or more is available on higher frequency bands – e.g. 3500 MHz or 28 000 MHz. At the same time, higher frequencies have lower coverage and lower signal penetration, for example in buildings. Frequency bands are regulated by national authorities, where network operators have licenses to operate certain frequency bands to provide services to their customers.

9 More information can be obtained in the Ericsson "On the road to breaking the energy curve – A key building block for a Net Zero future" report, available at Ericsson.com.

Research has shown that 5G is much more efficient than 4G both in rural environments, where there is little traffic, as well as in urban areas with high traffic and many users. In rural areas, due to sleep mode solutions, the energy consumption can be up to nine times lower for 5G than for 4G. In urban areas, it has been shown that if capacity is increased in an existing 4G network with additional 5G micro cells, compared to using additional 4G cells, the reduction in network energy consumption is close to 50 percent. Furthermore, if the entire network would be upgraded to 5G, a total energy reduction of up to 70 percent is achievable[10].

The deployment of every new mobile generation since 3G has led to concerns about increasing mobile network energy consumption. However, while historic figures show a rise in global energy consumption over time, it is not as significant as some early expectations. Utilizing efficiency gains from new mobile generations, combined with new innovative operational approaches, has been critical for keeping network energy consumption at a manageable level. To meet the industry aspiration for Net Zero carbon emissions, an approach that breaks the historic upward trajectory of global network energy consumption is required. This challenge can be addressed by applying a holistic network approach that will gradually reduce energy consumption. Where building the networks with precision, implementing various energy saving software and remove and retire older generations of technology (e.g., 2G and 3G) from the network, are key to lowering the overall energy consumption for mobile networks.

Figure 3. Mobile site expansion and modernization, resulting in higher capacity and lowered energy consumption.



Capacity	1
Energy consumption (kWh)	100%
Spectrum [MHz]	900, 1800, 2100

Capacity	x1.6
Energy consumption (kWh)	50%
Spectrum [MHz]	800, 900, 1800, 2100

10 Frenger et al. More Capacity and Less Power: How 5G NR Can Reduce Network Energy Consumption | IEEE Conference Publication | IEEE Xplore, available at www.ieeexplore.ieee.org/document/8746600

04 Digital solutions enabling an energy efficient low carbon future

ICT has a unique potential to enable other industrial sectors to move towards a low-carbon economy that will be central to meeting climate goals and Net Zero ambitions. Estimates suggests that selected ICT solutions can enable up to 15% reduction of green house gas emissions in other industries. Digitalization is a unique and powerful enabler for decarbonization transformation. This can be done through efficiency and optimization, saving energy and materials, utilizing analytics and insight.

The advantages of 5G network capabilities include ultra-low latency, real-time and predictive analytics, and increased transmission speeds. For businesses this can create new opportunities to advance digital transformation efforts, improve efficiencies and create entirely new use cases for different industry sectors. Large greenhouse gas-emitting sectors like energy, manufacturing, and transport could have the biggest impact on decarbonization efforts through digitalization in general and the use of 5G in particular.

Cellular network infrastructure is a unique and fundamental enabler of decarbonization efforts. The intelligent systems digital mobile networks support is increasingly used to closely monitor, manage, and lower their energy and resource consumption levels. Mobile broadband infrastructure will specifically facilitate the decarbonization efforts among energy, industry, and transportation sector participants through:

- remote intelligence enabled by cellular connectivity
- new ecosystems and platforms driven by rapid transformation
- new business models, from the bottom to the top

To achieve the transition to a sustainable and low carbon society, access to high-speed 5G networks and digitalization of all sectors needs to be accelerated. As we have seen with previous generations of technologies (such as 4G), access to infrastructure will enable industries to innovate and develop solutions that will benefit societies. As mentioned in the introduction to this paper, 4G enabled the consumer centric industry with smartphones and applications such as Spotify and Netflix. With 5G, it is now the society's turn to move into a new phase, changing how electricity is generated and consumed, how transports are shifted to become sustainable and manufacturing industries to increase their efficiencies and minimize their negative environmental impacts.

The communication networks are the enablers of digitalization, where the rapid build out of 5G is crucial to speed up the transition for a sustainable world and to achieve the objectives in the Paris agreement on climate change.

Electricity generation and utilities [11]

The electricity demand is expected to grow steadily in the coming two decades, where renewables, such as solar and wind, will grow from 29% of energy generation to 45%. Since the energy utility sector is becoming more and more dependent on renewable energy sources, it will create management and operational challenges for electricity producers. Volatility in the energy production, the fact that many renewable power sources are small and widely dispersed and grid capacity limitations, puts pressure on load balancing and energy planning efforts. Furthermore, as more households install solar panels, the value chain for electricity becomes more circular, where individuals can be both consumers and producers at the same time, so called prosumers. The new circular value chains cause challenges for utilities and for regulators.

5G will be critical for the future of renewable energy, as it provides higher levels of reconfigurability for power grids, which may allow local networks to work separately from the main network, helping renewable energy installations operate more dynamically and efficiently.

The connected and automated smart grid supported by digital technologies will be crucial for handling the bi-directional energy flow from prosumers as well as greater fluctuation in power production from less predictable renewable generations. In the automated, connected smart grid, large data volumes and real-time data flow from smart meters and sensors, which is critical for managing a bi-directional value chain. 5G is an enabling technology to address these challenges. It can support near real-time power distribution automation services and reliable sharing of power grid-related information, automation, remote monitoring and control.

Transports [12]

The synergies that result from collectively and systematically integrating transportation and communication networks—such as telematics, smart city analytics, and traffic management solutions—can quickly lead to efficiencies that educe emissions.

A key challenge to accelerating decarbonization through connectivity, however, is that currently most transportation "systems" are still largely siloed. Fleets of trucks operated by logistics firms, public subway operators, or individual drivers of vehicles largely exist in separate parallel data universes. The transportation sector will need to become connected and electrified, and equally important, to be digitally integrated cross sectorial. To utilize the potential of all the collected data within each individual transport management system and to connect each one to every other, data must be shared between public and private transportation network platforms, as well with other industry platforms.

One example can be route optimization for electrical vehicles, where data on road topography, traffic patterns, congestion, charging infrastructure, electrical grid utilization and the position of the vehicle needs to be collected and analyzed. The flow of all this data needs cellular communications, where 5G is a crucial enabler of a fossil free transportation sector.

11 References: MIT Technology Review Insights, Decarbonizing industries with connectivity & 5G, October 2021; Ericsson, Connected Energy Utilities, September 2022

12 MIT Technology Review Insights, Decarbonizing industries with connectivity & 5G, October 2021

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