Data Centres and Data Transmission Networks

More efforts needed

Tracking report — November 2021

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Global internet traffic surged by more than 40% in 2020 as a result of increased video streaming, video conferenc

Rapid improvements in energy efficiency have, however, helped limit energy demand growth from data centres aı

Global trends in internet traffic, data centres workloads and data centre energy use, 2010-2020

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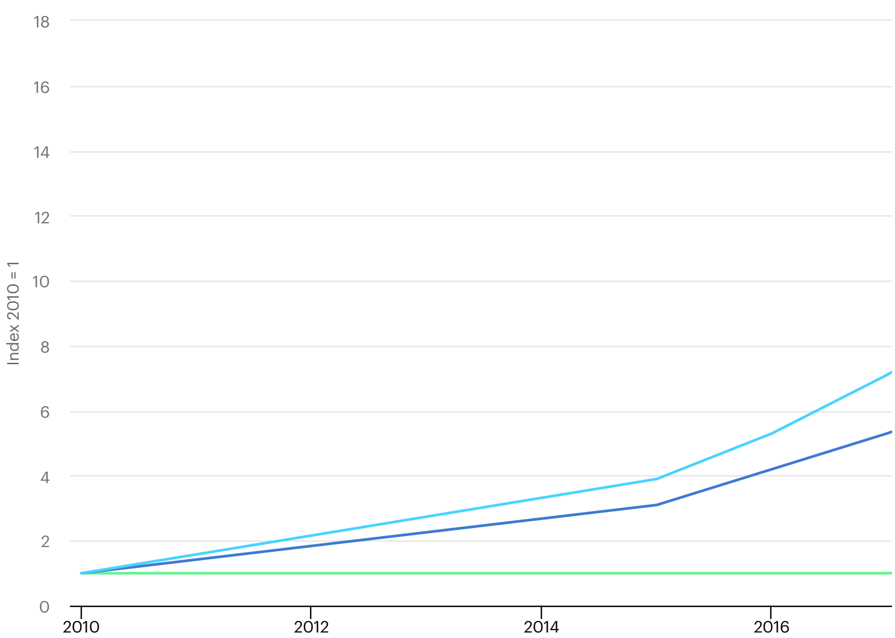


Internet traffic · Data centre workloads · Data centre energy use

Tracking progress

Demand for data services is rising exponentially

Global internet traffic surged by over 40% in 2020, driven by increased video streaming, video conferencing, online gaming and social networking. This growth comes on top of the past decade's already-rising demand for digital services: since 2010, the number of internet users worldwide has doubled, while global internet traffic has increased 15-fold, or ~30% per year.

Data centres account for around 1% of global electricity demand

Most of the world's Internet Protocol (IP) traffic goes through data centres. Greater connectivity is therefore propelling demand for data centre services and energy use (mostly electricity), with multiplying effects: for every bit of data that travels the network from data centres to end users, another five bits of data are transmitted within and among data centres.

Global data centre electricity use in 2020 was 200-250 TWh [1] , or around 1% of global final electricity demand. This excludes energy used for cryptocurrency mining, which was ~100 TWh in 2020. [2]

Strong efficiency improvements have helped to limit energy demand growth

Strong growth in demand for data centre services continues to be mostly offset by ongoing efficiency improvements for servers, storage devices, network switches and data centre infrastructure, as well as the high and growing share of services met by highly efficient cloud and hyperscale data centres.

Cloud and hyperscale data centres are run at high capacity, owing in part to virtualisation software that enables data centre operators to deliver greater work output with fewer servers. These large data centres also typically have very low power usage effectiveness (PUE), which is a measure of how efficiently a data centre uses energy. The most efficient hyperscale data centres can have PUE values of ~1.1 (meaning 0.1 kWh is used for cooling/power provision for every 1 kWh used for IT equipment).

Energy efficiency of data transmission networks has also improved rapidly

Globally, data transmission networks consumed 260-340 TWh in 2020 [3] , or 1.1-1.4% of global electricity use.

Data transmission network technologies are also rapidly becoming more efficient: fixed-line network energy intensity has halved every two years since 2000 in developed countries, and mobile-access network energy efficiency has improved 10-30% annually in recent years.

Data from several large network operators demonstrate how energy efficiency improvements have helped decouple data traffic from energy use. For instance, Sprint reduced its network energy intensity more than 80% between 2014 and 2019 to keep total network energy consumption flat, and data traffic through Telefónica's networks increased fivefold between 2015 and 2020 while electricity consumption fell 2% (this includes 45% traffic growth in 2020, with electricity use remaining at the 2019 level).

The nature of data transmission is changing rapidly as more traffic flows through mobile devices and networks

Several trends are shaping future data network electricity use. Global internet traffic more than doubled between 2017 and 2020, and could double again by 2023 if current trends are sustained. The nature of data transmission is changing rapidly, with mobile device traffic growing at triple the rate (+50%) of wired and Wi-Fi-only devices such as laptops and desktop computers (+17%).

This shift towards greater mobile network use may also have significant implications for data transmission network energy usage, given that mobile networks have considerably higher electricity intensities (kWh/GB) than fixed-line networks at current traffic levels and network utilisation.

However, mobile networks are rapidly switching from older 2G and 3G technologies to more efficient 4G and 5G. By 2022, 4G and 5G networks together are expected to carry 83% of mobile traffic, compared with less than 1% for 2G.

4G networks are roughly five times more energy-efficient than 3G and 50 times more efficient than 2G.The overall energy and emissions impacts of 5G, however, are still uncertain, as studies carried out in Switzerland and France indicate. While a 5G antenna currently consumes around three times more electricity than a 4G antenna, power-saving features such as sleep mode could narrow the gap to 25% by 2022. Network infrastructure providers and operators are projecting that 5G networks could be 10 to 20 times more energy-efficient than 4G ones by 2025-2030.

Video streaming, online gaming and emerging digital technologies are likely to boost demand for data centre and network services even higher

Strong growth in demand for data centre and network services is expected to continue in the near term, particularly because of video streaming and gaming. In fact, these streaming services are projected to make up 87% of consumer internet traffic in 2022.

The average energy consumption of video streaming is fairly low compared with other everyday activities, with end-user devices such as televisions consuming the majority. Because streaming service usage tends to follow a “prime time” pattern (whereas other applications such as web browsing, file sharing and videoconferencing do not), further growth in this segment could increase peak internet traffic.

However, since data transmission networks generally have high fixed energy costs (even at low utilisation), the build-out of infrastructure to accommodate greater anticipated peak capacity could raise overall network energy use in the long run. Furthermore, emerging digital technologies such as blockchain, machine learning, 5G and virtual reality are also poised to raise demand for data services.

For example, electricity used by Bitcoin miners – one prominent example of emerging blockchain IT infrastructure – likely consumed 60-70 TWh in 2020 (~0.3% of global electricity usage). Surging Bitcoin prices have also led to increased energy use, with miners on track to consume around 100 TWh in 2021. As blockchain applications become more widespread, understanding and managing their energy-use implications may become increasingly important for energy analysts and policymakers.

Machine learning (ML) is another area of demand growth, with potentially significant implications for data centre energy use in upcoming years. While the amount of compute needed for each of the largest ML training runs is growing rapidly, it is unclear how quickly overall ML-related energy use in data centres is increasing. At Facebook, for example, compute demand for ML training (+150%/yr) and inference (+105%/yr) have outpaced overall data centre energy use (+40%/yr) in recent years.

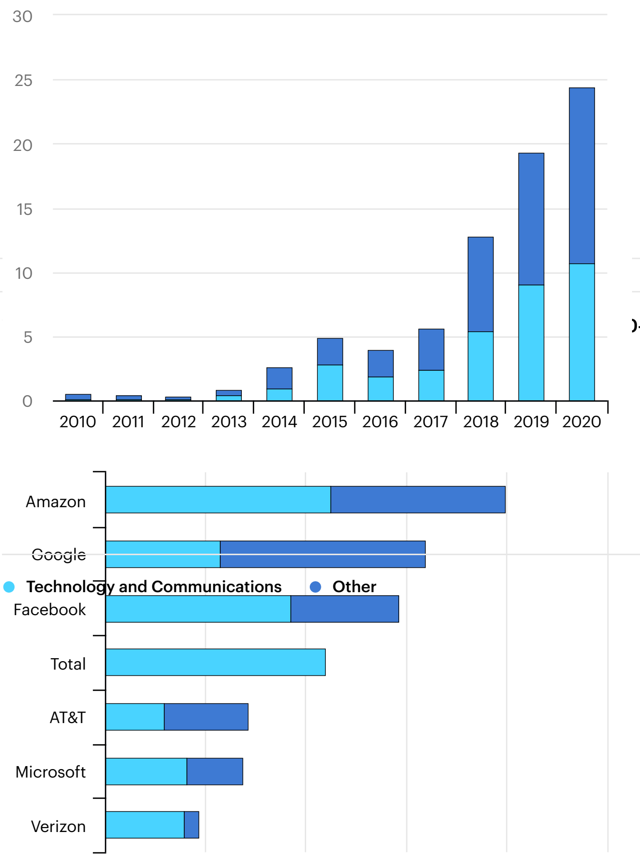
ICT companies are major purchasers of renewable energy

Information and communications technology (ICT) companies invest considerable sums in renewable energy to protect themselves from power price volatility, reduce their environmental impact and improve their brand reputation. In fact, ICT companies accounted for about half of global corporate renewable energy procurement in the past five years. [4]

Hyperscale data centre operators in particular lead in corporate renewable energy procurement, mainly through power purchase agreements (PPAs). Google (12 TWh in 2019), Apple (1.7 TWh in FY2020) and Facebook (7 TWh in 2020) purchased or generated enough renewable electricity to match 100% of their operational electricity consumption.

Global power purchase agreements volumes by sector, 2010-2020 Open

GW



)-2020 Open

Technology and Communications   Other

Solar   Wind

Further company and regulator efforts could maximise system-wide benefits and reduce emissions

While these achievements are impressive, matching 100% of annual demand with renewable energy purchases or certificates does not guarantee that data centres are actually 100% powered by renewable sources *all the time*. The variability of wind and solar sources may not match a data centre's demand profile, and renewable energy purchases might even be for a different grid or region.

More ambitious approaches to carbon-free procurement and generation can have even greater environmental benefits, specifically by accounting for both location and time. Google and Microsoft have announced 2030 targets to source and match zero-carbon electricity on a 24/7 basis. Machine learning and other digital technologies can help achieve such goals by actively shifting computing tasks to times and regions for which low-carbon sources are plentiful.

In co-operation with electricity utilities, regulators and project developers, data centre operators investing in renewable energy should identify projects that maximise benefits for the local grid and also reduce overall GHG emissions.

Recommended actions

Demand for data centre and network services is expected to continue growing strongly, but how this affects overall energy use will still be determined largely by the pace of energy efficiency gains.

Government policies, as well as data centre and network operator actions and commitments, will be essential to support further efficiency improvements to moderate overall ICT energy use. The incentive to reduce energy use is strong, as energy costs make up a significant share of ICT companies' operational expenditures (e.g. 20-40% for network operators).

Improve data collection and transparency

Improving data collection and sharing on ICTs and their energy-use characteristics can help inform energy analysis and policymaking. For example, the US Energy Information Administration collects data on connected devices in homes (RECS) and commercial buildings (CBECS), as well as on servers in data centres (CBECS).

The US Energy Act of 2020, introduced in December of that year, calls for an updated study on data centre energy use (following the 2016 report), an open data initiative on energy use for federally owned and operated data centres, as well as the development of a new efficiency metric.

Commit to efficiency and climate targets and implement measures to achieve them

ICT companies are setting increasingly ambitious efficiency and CO_2 emissions targets, including for net zero emissions. In February 2020, the ICT industry agreed on a science-based target to reduce GHG emissions 45% between 2020 and 2030.

In January 2021, data centre operators and industry associations in Europe launched the Climate Neutral Data Centre Pact, which includes a pledge to make data centres climate-neutral by 2030 and has intermediate (2025) targets for power usage effectiveness and carbon-free energy. The 2030 target appears to be in line with the European Commission's digital strategy, which was released in February 2020 and includes a key action on "[i]nitiatives to achieve climate-neutral, highly energy-efficient and sustainable data centres by no later than 2030".

Increase the energy efficiency and flexibility of data centre operations

Data centres could become even more energy efficient, while providing flexibility to the grid. Governments can offer guidance, incentives and standards to encourage further energy efficiency, while regulations and price signals could help incentivise demand-side flexibility. Huang and Masanet (2015) offer a summary of best practices and how to calculate savings for incentive programmes.

Use data centres to drive renewable energy use

Governments and grid operators can work with data centre operators to determine how renewable energy investments can most optimally benefit the whole system as well as help meet national energy and climate targets. Governments can also encourage data centres to invest in energy storage and other demand-side response capacity to complement renewable energy generation.

Enact policies for more efficient data transmission networks

Governments and network operators could be instrumental in implementing policies and programmes to improve the energy efficiency of data transmission networks.

Actions could include accelerating the phaseout of energy-intensive legacy networks, implementing network device energy efficiency standards, improving metrics and incentives for efficient network operations, and supporting international technology protocols.

Invest in RD&D for efficient next-generation computing and communications technologies

Demand for data centre services will continue to grow strongly, driven by media streaming and emerging technologies such as AI, virtual reality, 5G and blockchain. As efficiency gains of current technologies decelerate (or even stall) in upcoming years, more efficient new technologies will be needed to keep pace with growing data demand.

Reduce lifecycle environmental impacts

In addition to their operational energy use and emissions, data centres and data transmission networks are also responsible for “embodied” lifecycle emissions and other environmental impacts, including from raw material extraction, manufacturing, transportation and end-of-life disposal/recycling.

As data centres and networks become increasingly efficient and powered by clean electricity, non-operational lifecycle emissions will become relatively more important. Companies and governments should therefore ramp up efforts to reduce embodied emissions all across data centre and network supply chains.

Resources

The IEA-4E EDNA project aims to ensure that the next generation of network-connected devices uses electricity as efficiently as possible.

IEA Energy Efficient End-use Equipment Technology Collaboration Programme – Electronic Devices and Networks Annex

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Acknowledgements

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