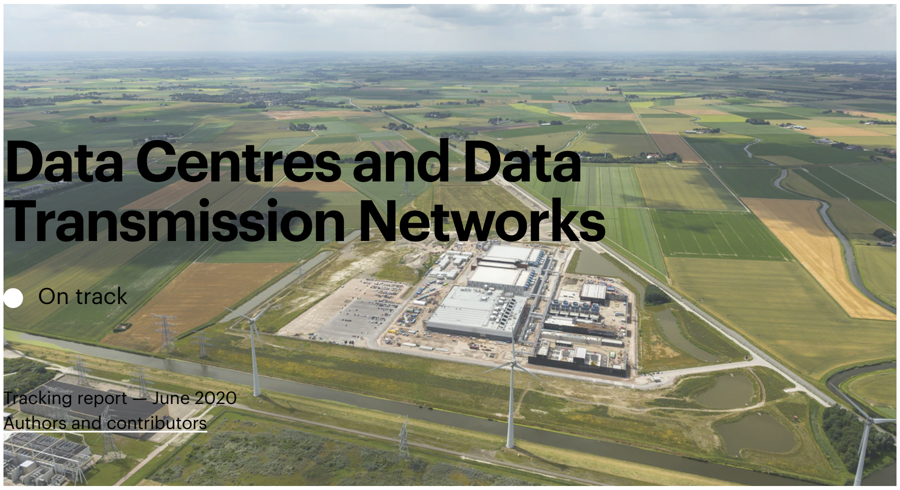


Data Centres and Data Transmission Networks

On track

Tracking report — June 2020

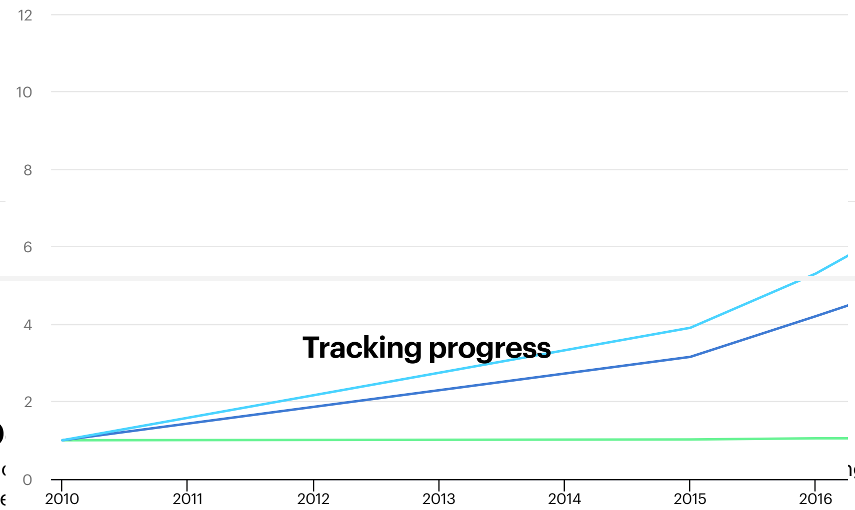
Authors and contributors

In this report

Global internet traffic surged by almost 40% between February and mid-April 2020, driven by growth in video streaming, video conferencing, online gaming, and social networking. This growth comes on top of rising demand for digital services over the past decade: since 2010, the number of internet users worldwide has doubled while global internet traffic has grown 12-fold. However, rapid improvements in energy efficiency have helped to limit energy demand growth from data centres and data transmission networks, which each accounted for around 1% of global electricity use in 2019. Strong government and industry efforts on energy efficiency, renewables procurement, and RD&D are necessary to limit growth in energy demand and emissions over the next decade.

Global trends in internet traffic, data centre workloads and data centre energy use, 2010-2019 **Open**

Index (2010 = 1)



Tracking progress

D

Gl ... ng
the
vic ... of
rising demand for digital services over the past decade: since 2010, the number of internet users worldwide has doubled while global internet traffic has grown 12-fold, or around 30% per year. [3] [6] [7]

Internet traffic · Data centre workloads · Data centre energy use

Demand for data and digital services is expected to continue its exponential growth over the coming years, with global internet traffic expected to double by 2022 to 4.2 zettabytes per year (4.2 trillion gigabytes). The number of mobile internet users is projected to increase from 3.8 billion in 2019 to 5 billion by 2025, while the number of Internet of Things (IoT) connections is expected to double from 12 billion to 25 billion. [8] These trends are driving exponential growth in demand for data centre and network services.

Data centres account for about 1% of global electricity demand

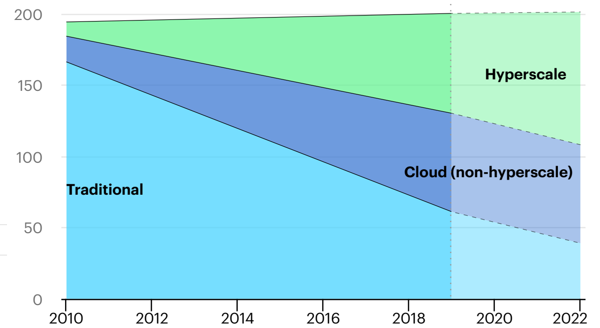
Most of the world's Internet Protocol (IP) traffic goes through data centres. Greater connectivity is therefore propelling demand for data centre services and energy use (mostly electricity), with multiplying effects: for every bit of data that travels the network from data centres to end users, another five bits of data are transmitted within and among data centres. [4]

Global data centre electricity demand in 2019 was around 200 TWh, or around 0.8% of global final electricity demand. [2]

If current trends in the efficiency of hardware and data centre infrastructure can be maintained, global data centre energy demand can remain nearly flat through 2022, despite a 60% increase in service demand. [2]

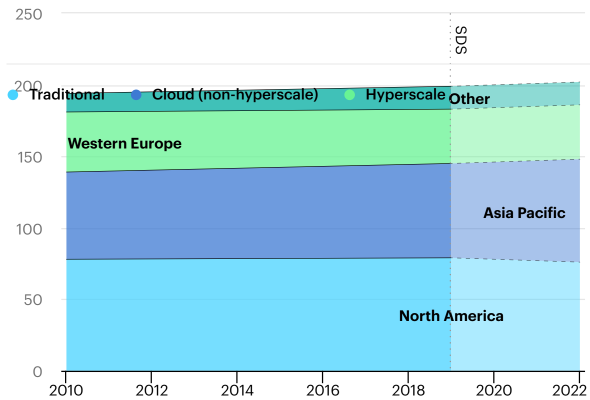
Global data centre energy demand by data centre type, 2010-2022 Open

TWh



Open

Traditional Cloud (non-hyperscale) Hyperscale



North America Asia Pacific Western Europe Other

Energy demand remains flat owing to strong efficiency improvements and a shift to cloud and hyperscale data centres

Strong growth in demand for data centre services continues to be offset by ongoing efficiency improvements for servers, storage devices, network switches and data centre infrastructure, as well as a shift to much greater shares of cloud and hyperscale data centres.

Hyperscale data centres are very efficient large-scale cloud data centres that run at high capacity, owing in part to virtualisation software that enables data centre operators to deliver greater work output with fewer servers.

The shift away from small, inefficient data centres towards much larger cloud and hyperscale data centres is evident in the shrinking share of data centre infrastructure in total energy demand, given the very low power usage effectiveness (PUE) of large data centres. PUE is a measure of how efficiently a data centre uses energy; the very best hyperscale data centres can have PUE values of around 1.1 (meaning 0.1 kWh used for cooling/power provision for every 1 kWh used for IT equipment).

Energy efficiency of data transmission networks has also improved rapidly

Data transmission network technologies are also rapidly becoming more efficient: fixed-line network energy intensity has halved every two years since 2000 in developed

Contents Cite Share

by more than 80% between 2014 and 2018, keeping total network energy consumption flat.

Data networks consumed around 250 TWh in 2019, or about 1% of global electricity use, with mobile networks accounting for two-thirds. Based on current efficiency improvement trends, electricity consumption is projected to rise to around 270 TWh in 2022.

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

Several trends are shaping the future of data network electricity use. Global IP traffic doubled between 2016 and 2019, and is projected to double again by 2022. [6] The nature of data transmission is changing rapidly, with traffic from wireless and mobile devices expected to make up more than 70% of total IP traffic by 2022, up from around 50% in 2019. [5]

This shift towards greater use of mobile networks may also have significant implications for the energy use of data transmission networks, given the considerably higher electricity intensities (kWh/GB) of mobile networks compared with fixed-line networks at current traffic rates.

Mobile networks are rapidly shifting away from older 2G and 3G technology towards more efficient 4G and 5G. By 2022, 4G and 5G networks are expected to carry a combined 83% of mobile traffic, compared with less than 1% for 2G. [5]

4G networks are roughly five times more energy efficient than 3G and 50 times more efficient than 2G. The overall energy and emission impacts of 5G are still uncertain. 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. [12] [13] Network infrastructure providers and operators are projecting that 5G could be up to 10 to 20 times more energy-efficient than 4G by 2025-30.

Streaming video, online gaming and emerging digital technologies are likely to further boost demand for data centre and network services

Demand for data centre and network services will continue to grow strongly, driven in particular by rapidly growing demand from streaming video and gaming. Between 2019 and 2022, traffic from internet video is projected to more than double to 2.9 ZB, while online gaming is projected to quadruple to 180 EB. [6] Together, these streaming services are projected to account for 87% of consumer internet traffic in 2022.

Additionally, emerging digital technologies such as machine learning, blockchain, 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 50-70 TWh in 2019, or 0.2-0.3% of global electricity use. [15] [14] However, as blockchain applications become more widespread, understanding and managing their energy-use implications may become increasingly important for energy analysts and policy makers.

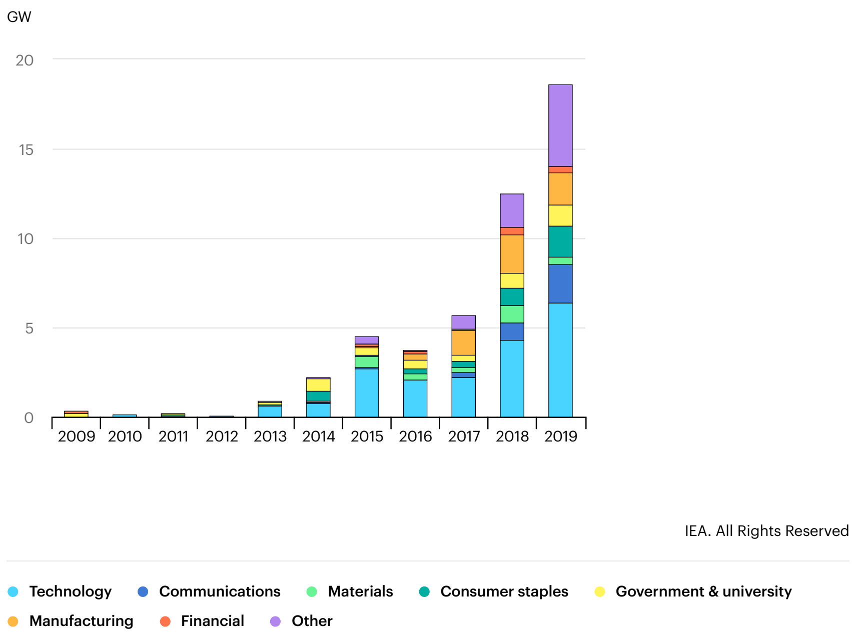
ICT companies are major investors in renewable energy

Information and communications technology (ICT) companies are major investors in renewable energy, protecting themselves from volatile power prices, reducing their environmental impact and improving brand reputation. In fact, ICT companies accounted for about half of global corporate renewables procurement in the past five years [16]

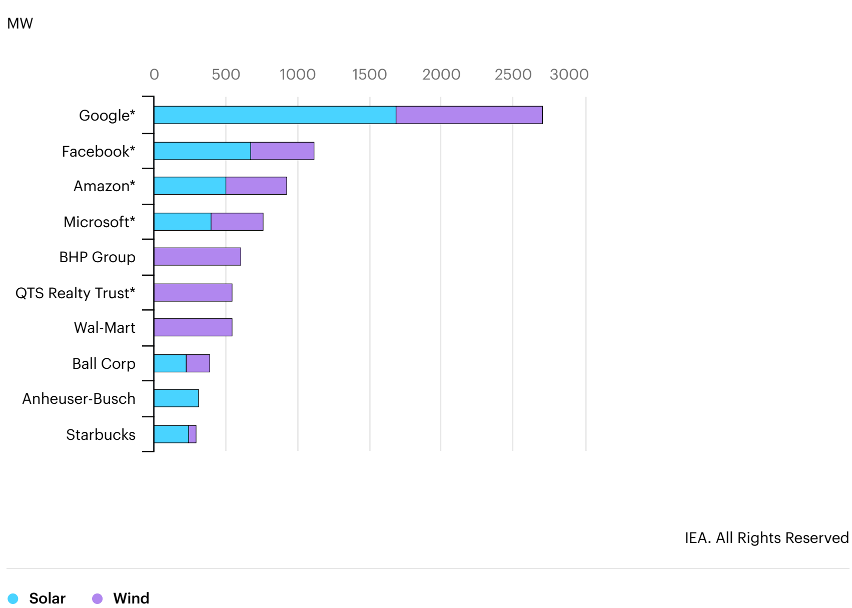
Hyperscale data centre operators in particular are leaders in corporate renewables

2018, Google (10 TWh) and Apple (1.3 TWh) purchased or generated enough renewable electricity to match 100% of their data centre energy consumption. Equinix consumed 5.2 TWh in 2018 (92% renewables) while Facebook data centres consumed 3.2 TWh (75% renewables). Amazon and Microsoft sourced about half of the data centre electricity from renewables.

Global PPA volumes by sector, 2009-2019 Open



Top corporate off-takers, 2019 Open



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*. Wind and solar are variable sources that may not match the demand profile of a data centre, and renewable energy purchases might even be for a different grid or region.

More ambitious approaches to carbon-free procurement and generation can have an even greater environmental benefit, specifically by accounting for both location and time. Google, for instance, has set a long-term goal to source carbon-free energy on a "truly 24x7 basis". In April 2020, it announced a new computing platform to shift computing tasks to times when low-carbon sources are plentiful.

Data centres operators investing in renewable energy, working with electricity utilities, regulators and project developers, should seek to 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 to grow strongly, but how this affects 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 commit to efficiency and climate targets

Improving data collection 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).

In its digital strategy released in February 2020, the European Commission included a key action for the ICT sector to achieve climate neutrality by 2030 while improving data collection and transparency: "Initiatives to achieve climate-neutral, highly energy-efficient and sustainable data centres by no later than 2030 and transparency measures for telecoms operators on their environmental footprint".

Companies and industries are increasingly setting voluntary efficiency and CO_2 emissions targets. In February 2020, the ICT industry agreed on a science-based target to reduce GHG emissions by 45% between 2020 and 2030. In the European Union and the United States, companies have adopted voluntary agreements to improve the efficiency of connected set-top boxes.

Encourage energy efficiency and flexibility in data centre operations

Data centres can be a more efficient and flexible resource in the grid than they are today. Governments can encourage further energy efficiency through guidance, incentives and standards, while regulations and price signals could help incentivise demand-side

Use data centres as drivers for 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 contribute towards national energy and climate targets. Investment in energy storage and other demand-side response capacity can also be encouraged as a complement to more renewable capacity.

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 phase-out 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 trends of current technologies slow (or even stall) in upcoming years, new, more efficient technologies will be needed to keep pace with growing data demand.

Resources

This IEA commentary explores the global and local energy implications of data centres and discusses how energy policy makers can help ensure that data centre developments contribute to broader energy policy goals.

Data centres and energy – from global headlines to local headaches?

This IEA commentary analyses the electricity consumption and carbon emissions associated with video streaming.

The carbon footprint of streaming video: Fact-checking the headlines

This IEA commentary explains why and how bitcoin technology uses energy; reviews published estimates of bitcoin energy use; and explores how these trends might evolve.

Bitcoin energy use

This report is the IEA's first comprehensive effort to depict how digitalisation could transform the world's energy systems. It examines the impact of digital technologies on energy demand and supply and explores the transformational potential of

Contents

Cite Share

Electronic Devices and Networks Annex (EDNA) is a project under the framework of the IEA Energy Efficient End-Use Equipment Technology Collaboration Programme (4E TCP). It aims to ensure that the next generation of network-connected devices uses electricity as efficiently as possible.

4E TCP EDNA

Acknowledgements

Many thanks to Eric Masanet (University of California, Santa Barbara) for his ongoing support of this analysis.

References

1 Sandvine (2020). The Global Internet Phenomena Report. https://www.sandvine.com/hubfs/Sandvine_Redesign_2019/Downloads/2020/Phenomena/COVID%20Internet%20Phenomena%20Report%2020200507.pdf.

2 IEA analysis based on Masanet, E. et al. (2020). Recalibrating global data center energy-use estimates, *Science*, 367(6481), 984-986, https://doi.org/10.1126/science.aba3758.

3 Cisco (2015). The History and Future of Internet Traffic, https://blogs.cisco.com/sp/the-history-and-future-of-internet-traffic.

4 Cisco (2018). Cisco Global Cloud Index: Forecast and Methodology, 2016-2021, https://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-gci/white-paper-c11-738085.pdf.

5 Cisco (2019a). Cisco Visual Networking Index : Global Mobile Data Traffic Forecast Update, 2017-2022, https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-738429.pdf.

6 Cisco (2019b). Cisco Visual Networking Index: Forecast and Trends, 2017-2022 White Paper, Cisco Forecast and Methodology, http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-481360_ns827_Networking_Solutions_White_Paper.html.

7 ITU (International Telecommunications Union) (2020). ICT Statistics, https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.

8 GSMA (2020). The Mobile Economy, https://www.gsma.com/mobileeconomy/wp-content/uploads/2020/03/GSMA_MobileEconomy2020_Global.pdf.

9 Aslan, J. et al. (2018). Electricity intensity of internet data transmission: Untangling the estimates, *Journal of Industrial Ecology*, 22(4), 785-798, https://doi.org/10.1111/jiec.12630.

10 Fehske, A. et al. (2011). The Global Footprint of Mobile Communications: The ecological and economic perspective, *IEEE Communications Magazine*, 49(8), 55-62, https://doi.org/10.1109/MCOM.2011.5978416.

11 Pihkola, H. et al. (2018). Evaluating the energy consumption of mobile data transfer: From technology development to consumer behaviour and life cycle thinking, *Sustainability*, 10(7), 2494, https://doi.org/10.3390/su10072494.

12 Johnson, D. (2018). The 5G dilemma: More base stations, more antennas – less energy? IEEE Spectrum, https://spectrum.ieee.org/energywise/telecom/wireless/will-increased-energy-consumption-be-the-achilles-heel-of-5g-networks.

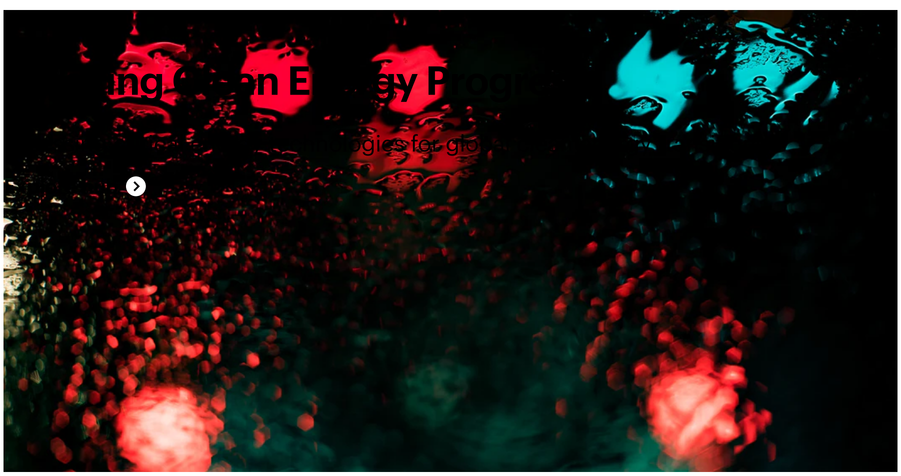
13 Huawei (2019). 5G Telecom Power Target Network White Paper, https://carrier.huawei.com/~/media/CNBGV2/download/products/network-energy/5G-Telecom-Energy-Target-Network-White-Paper.pdf.

14 Cambridge Centre for Alternative Finance (2020). Cambridge Bitcoin Electricity Consumption Index

/commentaries/bitcoin-energy-use-mined-the-gap.

16 BloombergNEF (2020). Corporate PPA Deal Tracker: March 2020, https://www.bnef.com/core/insights/22615.

17 4E EDNA (2019). Intelligent Efficiency for Data Centres and Wide Area Networks, https://www.iea-4e.org/document/428/intelligent-efficiency-for-data-centres-and-wide-area-networks.



Contents Cite Share

Countries
Fuels and technologies
Topics

Explore
Analysis
Data and statistics

About
Contact
Areas of work
Jobs
News and events
Delegates

ternational
iergy Agency

Follow

Terms Privacy