International Energy Agency

Digitalisation and clean energy transitions

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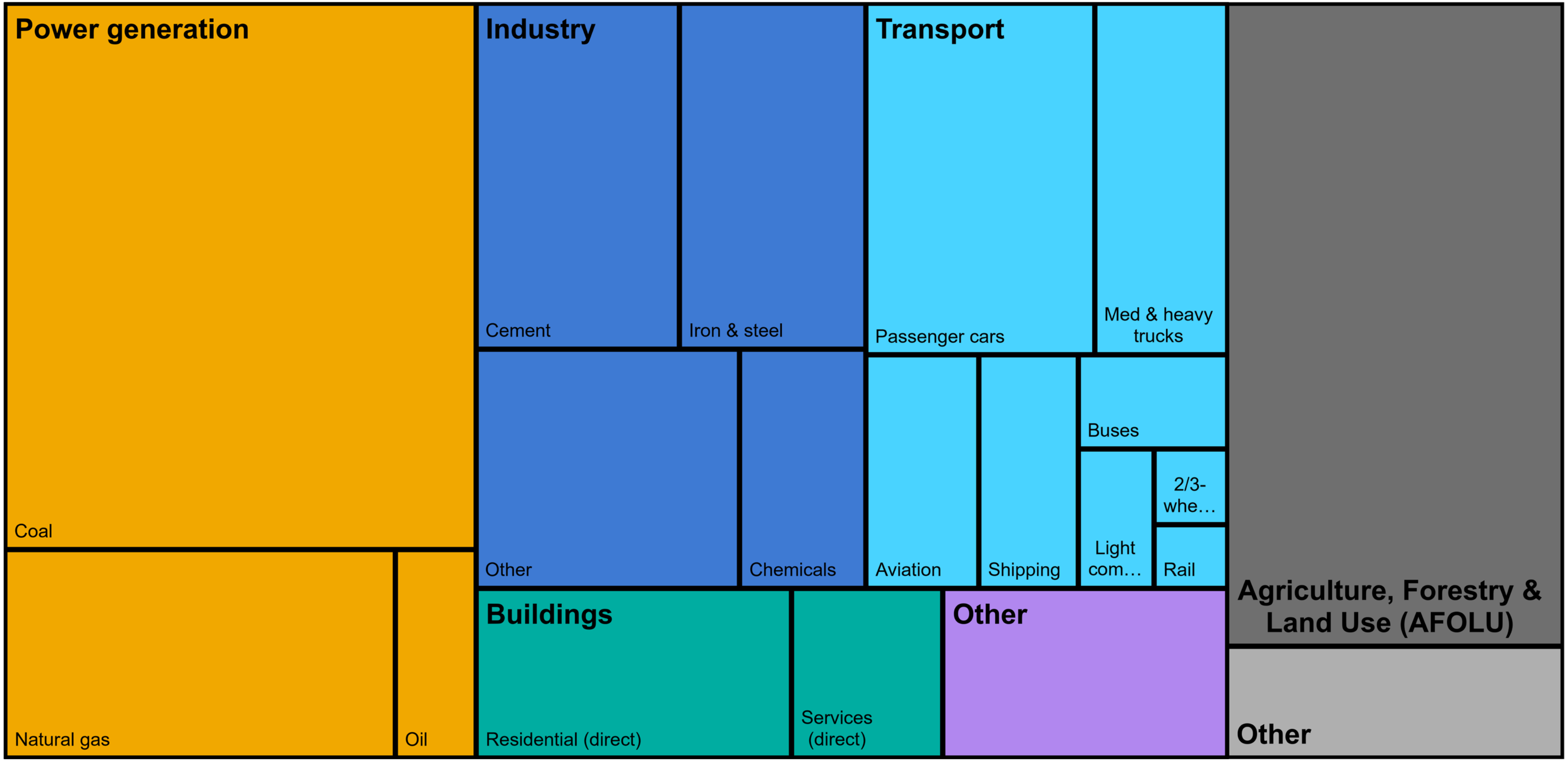
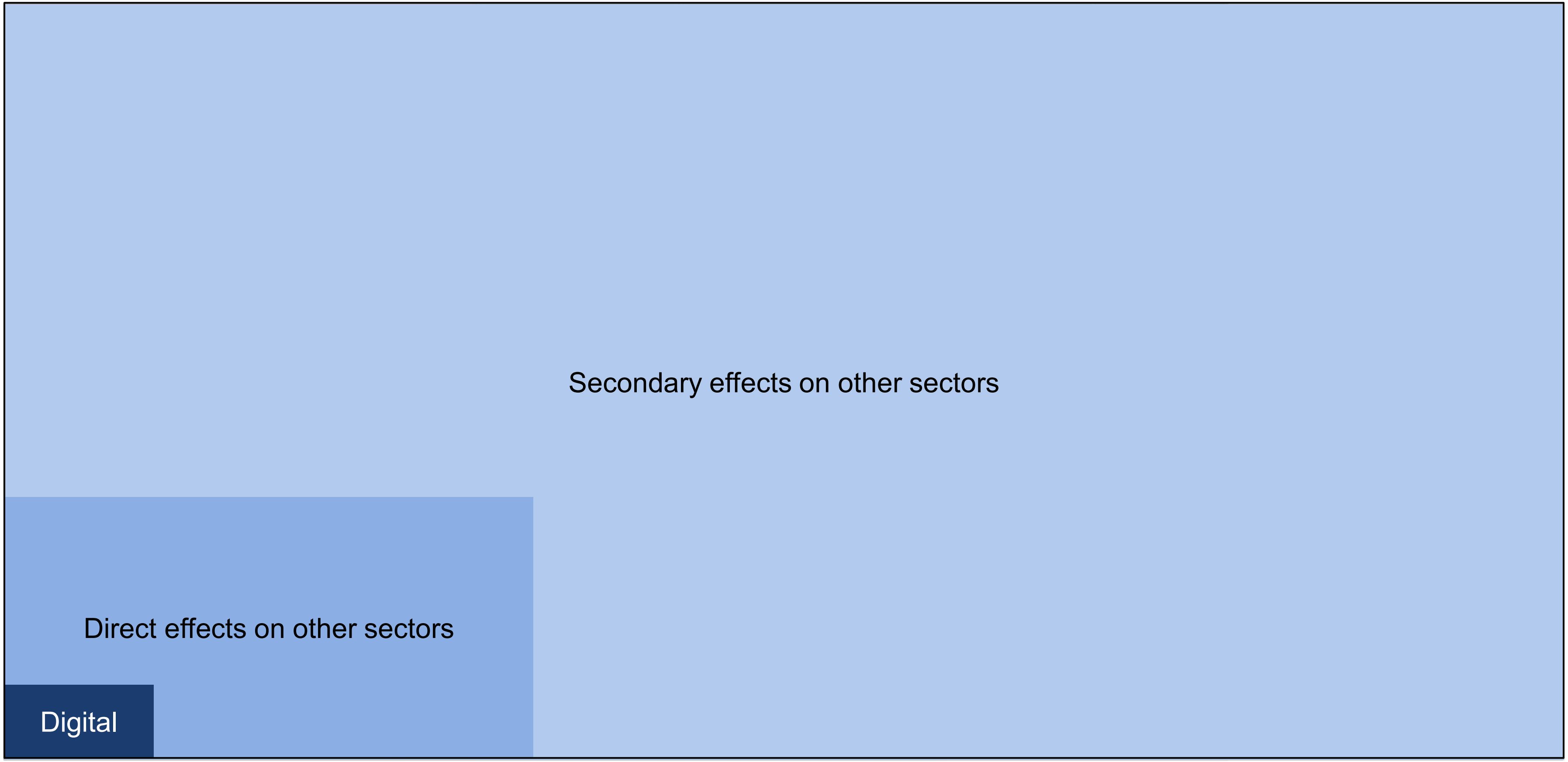
16 December 2021 • ITU Green Standards Week Day 3, Session 2

Greenhouse gas emissions come from many sectors and sources

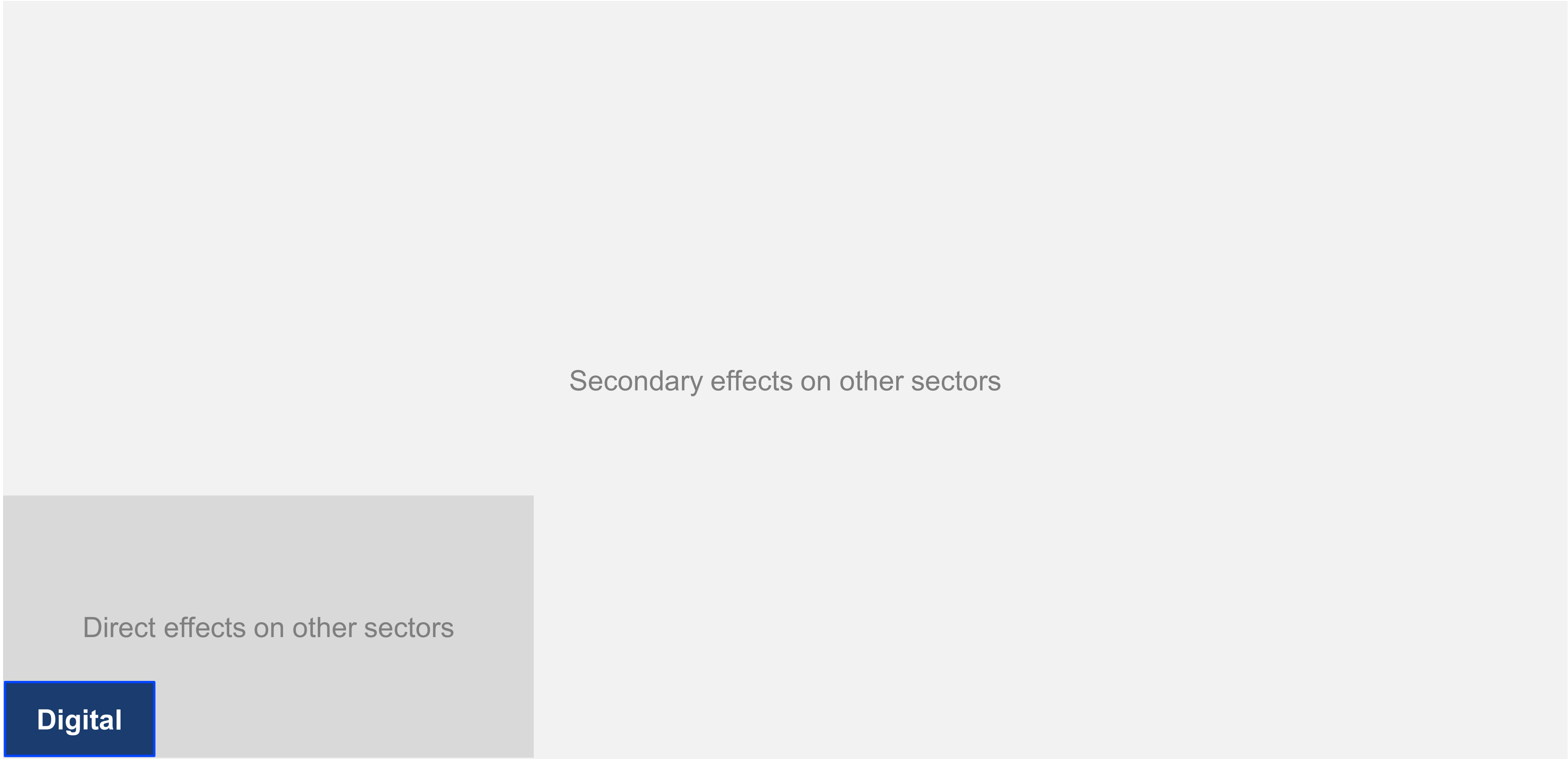


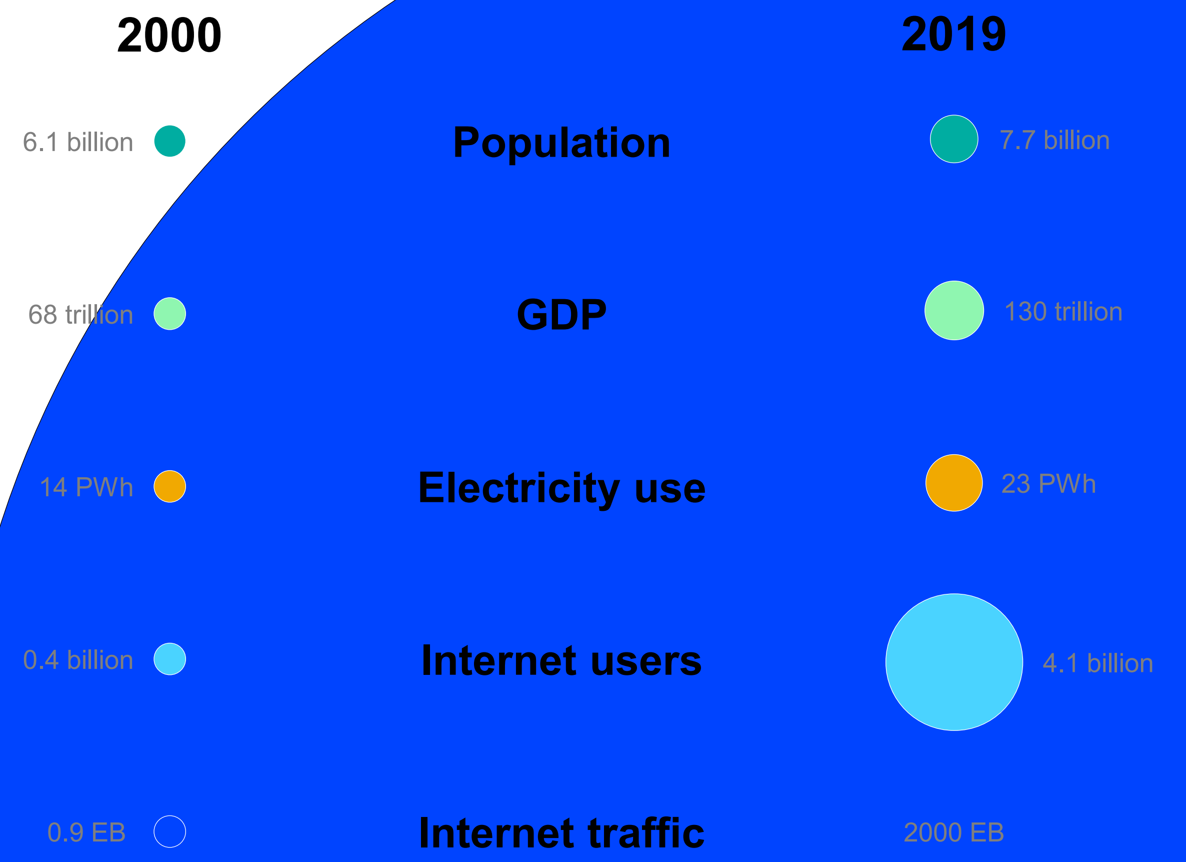
Source: Our World in Data (2020). Emissions by sector. IEA (2020), Energy Technology Perspectives.

Direct and indirect effects of digital technologies



Energy and carbon emissions from digital technologies





Sources: UN (2019), World Population Prospects 2019; World Bank (2020), Data Bank: GDP, PPP (Constant 2017 International $); IEA (2020), Data and statistics; ITU (2020), Statistics; Cisco (2015), The History and Future of Internet Traffic; Cisco (2018), Cisco Visual Networking Index: Forecast and Trends, 2017–2022

Forbes

May 30, 1999

Dig more coal -- the PCs are coming

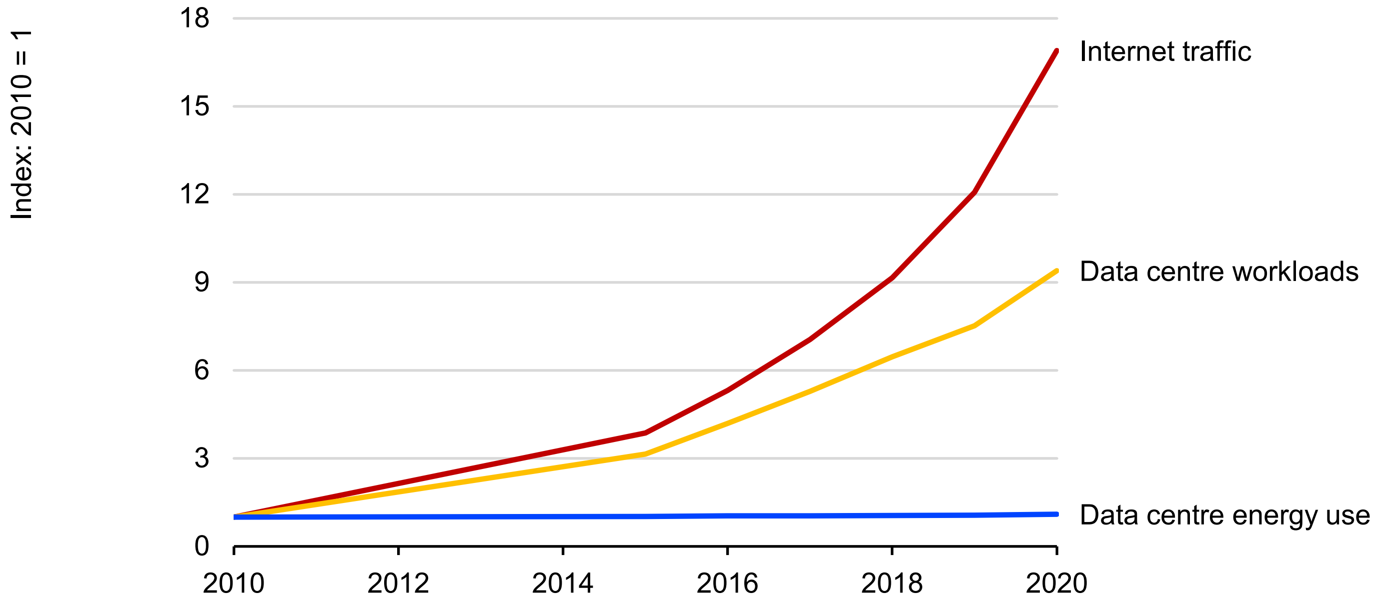
This article is more than 10 years old.

"It's now reasonable to project that half of the electric grid will be powering the digital-Internet economy within the next decade."

Forbes (1999). https://www.forbes.com/forbes/1999/0531/6311070a.html#21a128aa2580.

Global data centre energy use trends

Internet traffic, data centre workloads and energy use, 2010-2020



Sources: Masanet et al. (2020). Recalibrating global data center energy-use estimates. IEA (2021). Data centres and data transmission networks; Cisco (2018). Global Cloud Index: Forecast and Methodology, 2016-2021; Cisco (2019). Visual Networking Index: Forecast and Trends, 2017-2022.

Note: Figures exclude cryptocurrency mining

Globally, data centres used an estimated 200-250 TWh in 2020, or around 1% of global electricity use

Newsroom

COVID-19 Network Traffic Surge Isn't Impacting Environment Confirm Telecom Operators

Friday 29 May, 2020

More Energy Efficient Networks and Renewable Energy Usage are Negating Negative Environmental Impacts

London: The energy consumption and carbon emissions of telecoms networks have remained mostly unchanged in recent weeks, despite significant increases in network traffic as a result of COVID-19 lockdown measures.

In most cases, network electricity usage has remained flat, even as voice and data traffic has spiked by 50% or more.

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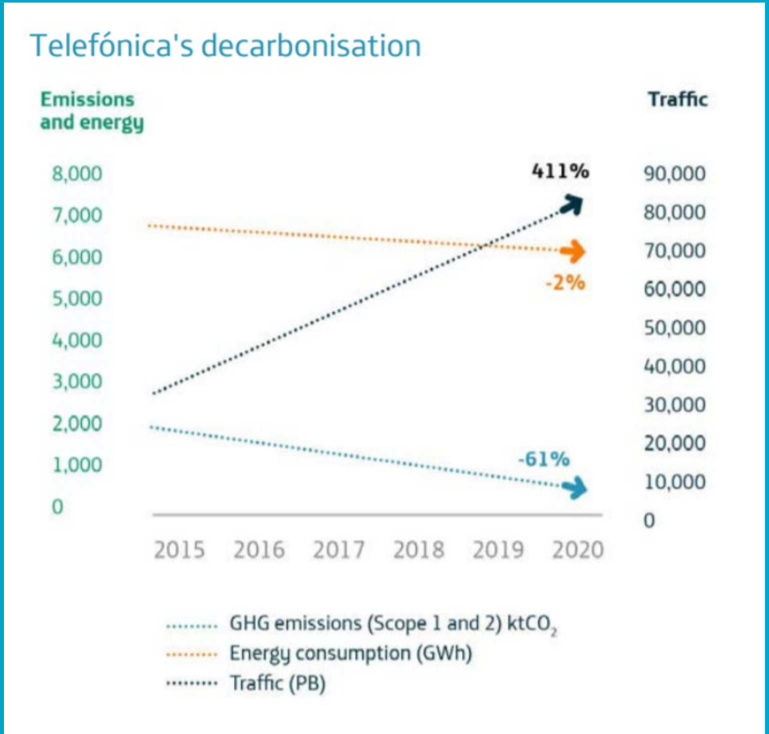
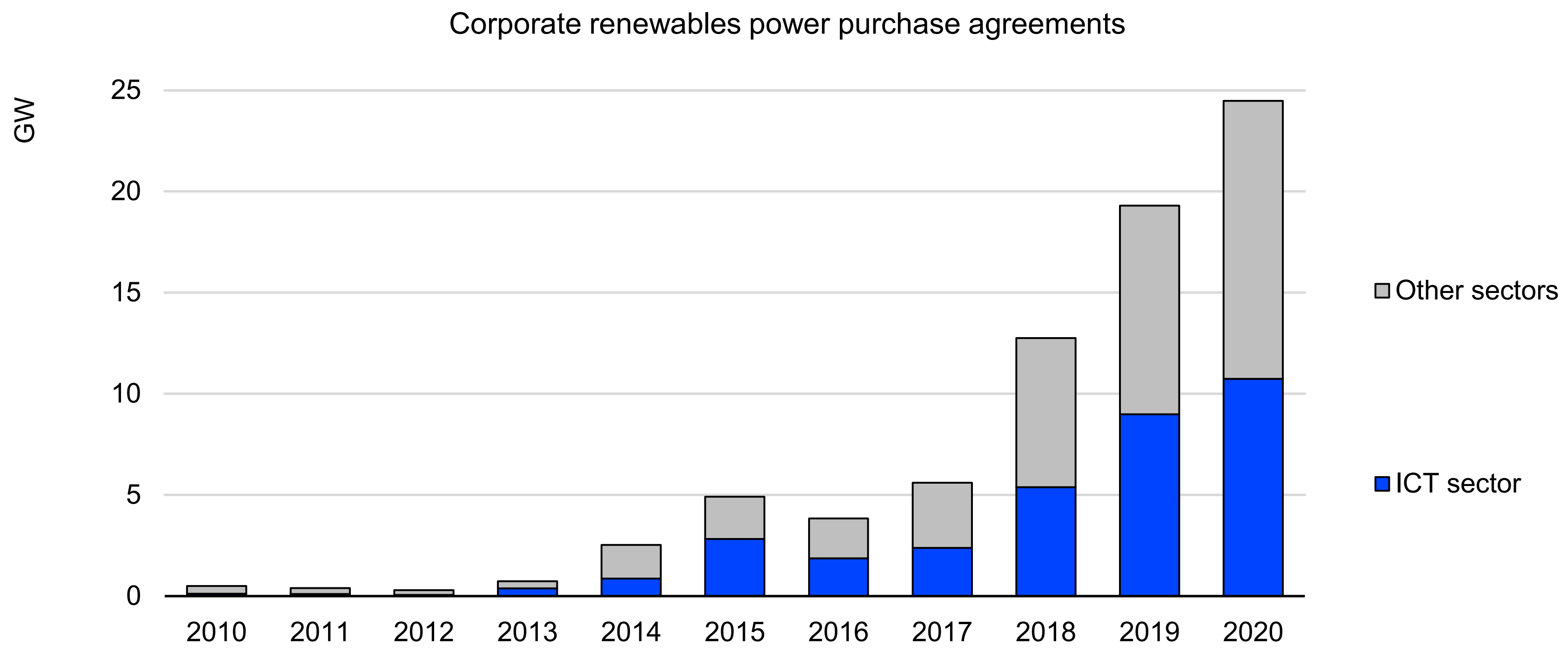


Telefonica: traffic up 45% in 2020, but energy use down 1.4%

GSMA (2020). https://www.gsma.com/newsroom/press-release/covid-19-network-traffic-surge-isnt-impacting-environment-confirm-telecom-operators/.

Telefonica (2021). https://www.telefonica.com/documents/153952/13347920/2020-Telefonica-Consolidated-Management-Report.pdf/8e690923-f95f-4247-ed34-91c0ba0ff510

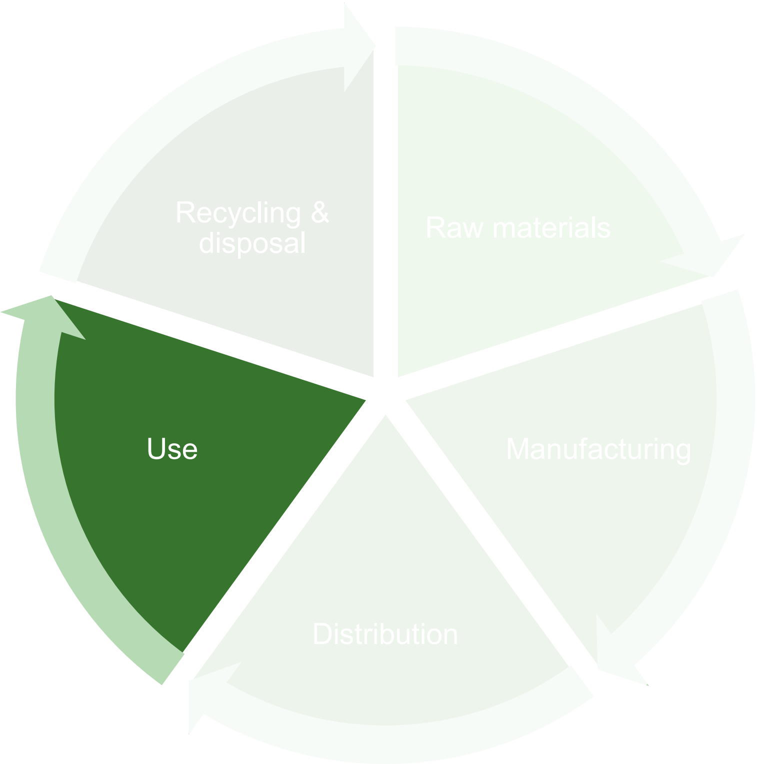
Renewable energy procurement

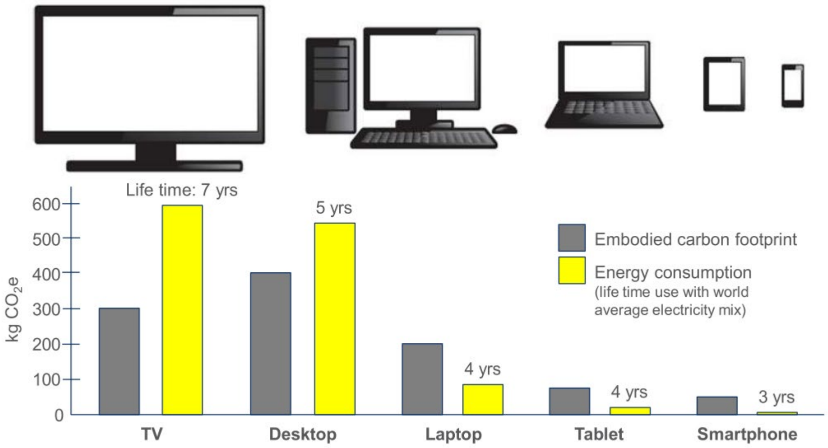


Source: BloombergNEF (2021), Corporate PPA Deal Tracker: January-February 2021.
ICT sectors include Technology and Telecommunications sectors.

ICT companies have accounted for around half of global corporate renewables procurement in recent years

Environmental impacts throughout the hardware lifecycle





Malmodin & Lunden (2018), The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015

There are environmental impacts beyond energy use and GHG emissions throughout the product lifecycle, including impacts on soil, air, water, biodiversity, and electronic waste.

The Guardian

News | Opinion | Sport | Culture | Lifestyle

Environment ▶ Climate change Wildlife Energy Pollution

Guardian Environment Network Environment

‘Tsunami of data’ could consume one fifth of global electricity by 2025

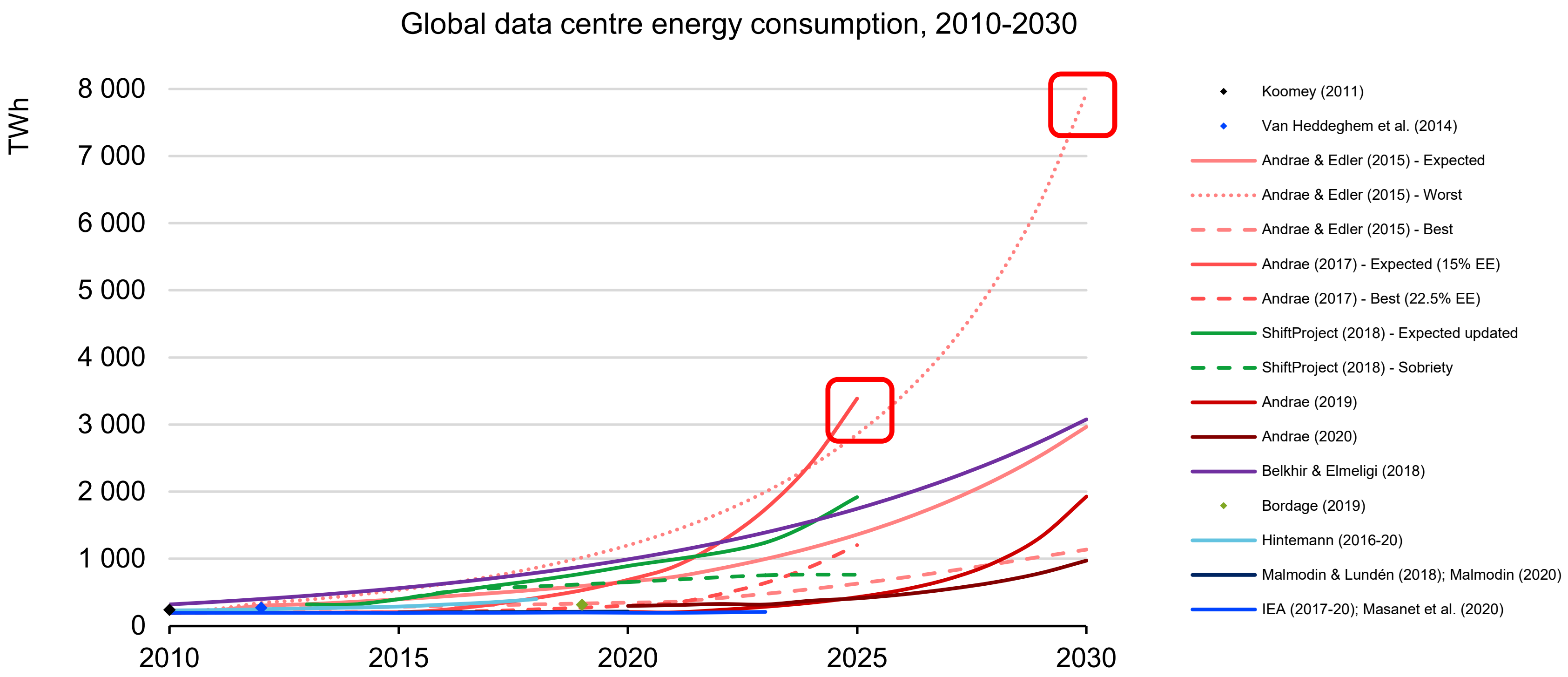
Billions of internet-connected devices could produce 3.5% of global emissions within 10 years and 14% by 2040, according to new research, reports Climate Home News

Mon 11 Dec 2017 13.27 GMT

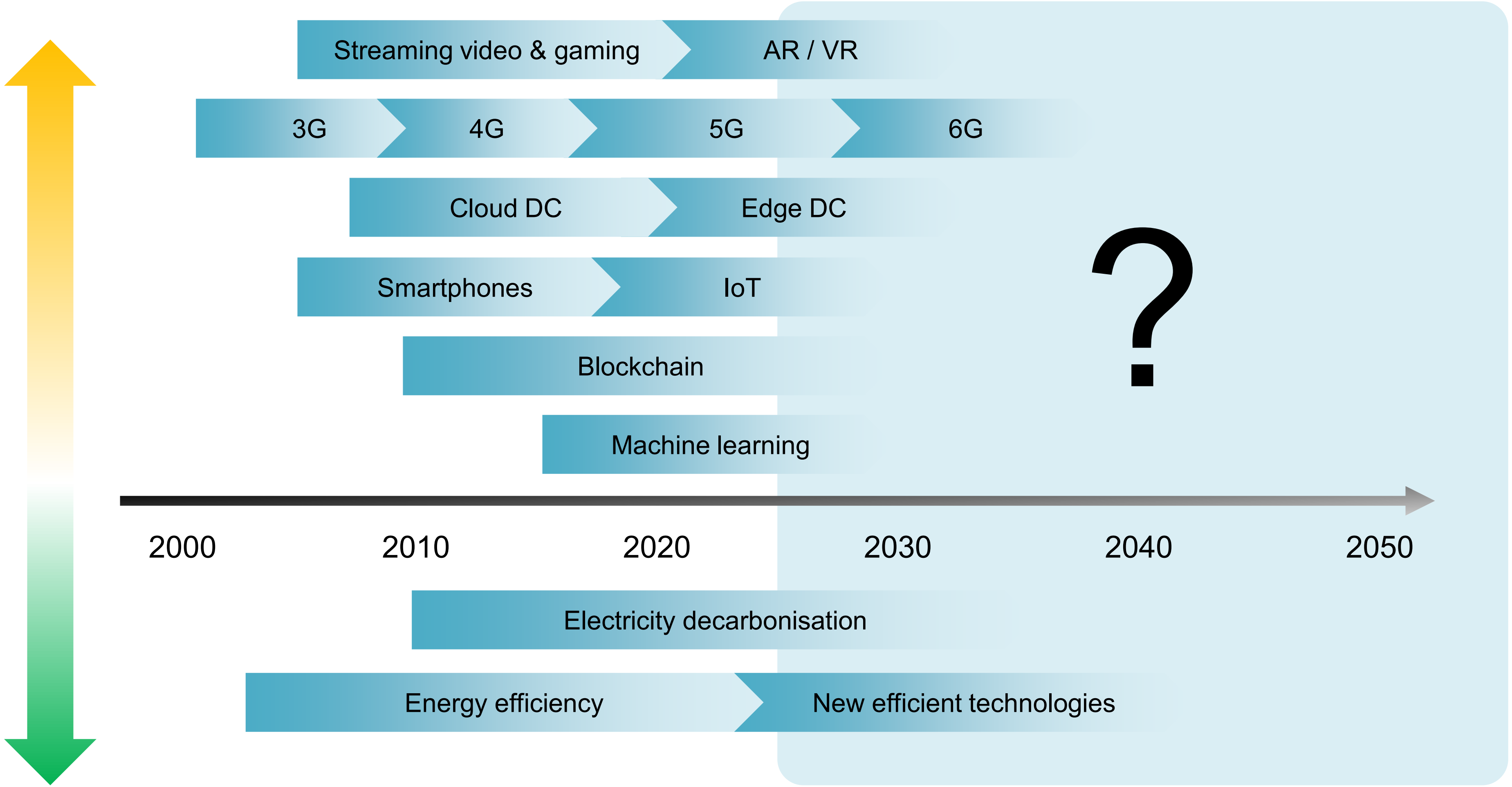
1,454 73

The Guardian (2017). https://www.theguardian.com/environment/2017/dec/11/tsunami-of-data-could-consume-fifth-global-electricity-by-2025.

Data centres: comparing global energy use estimates



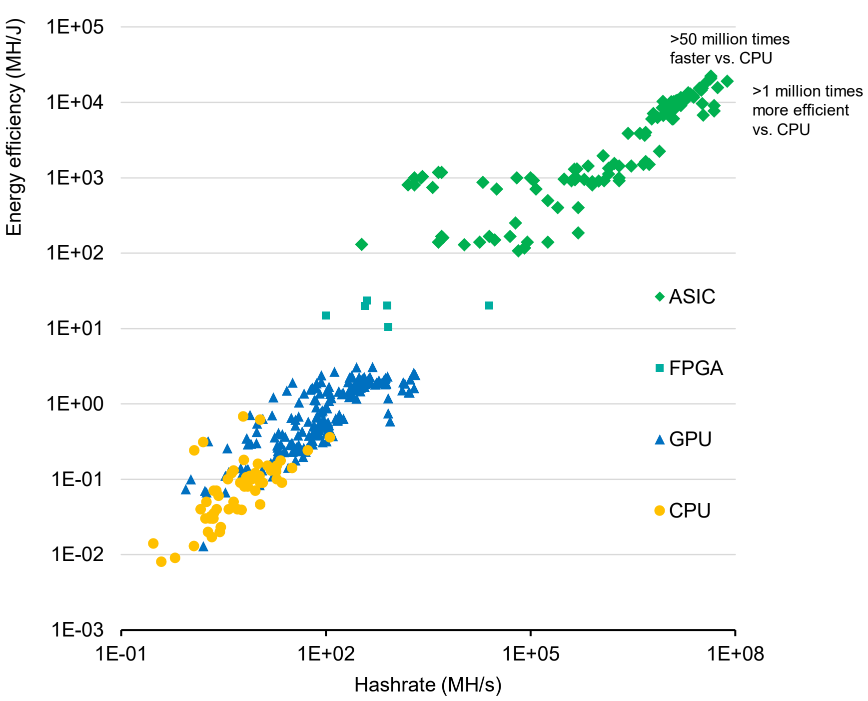
Sources: **Koomey (2011),** Growth in Data Center Electricity Use 2005 to 2010; **Van Heddeghem et al. (2014),** Trends in worldwide ICT electricity consumption from 2007 to 2012; **Andrae & Edler (2015),** On Global Electricity Usage of Communication Technology: Trends to 2030; **Andrae (2017),** Total Power Consumption Forecast; **The Shift Project (2018),** Lean ICT: Towards Digital Sobriety; **Andrae (2019),** Projecting the chiaroscuro of the electricity use of communication and computing from 2018 to 2030; **Andrae (2019),** Comparison of Several Simplistic High-Level Approaches for Estimating the Global Energy and Electricity Use of ICT Networks and Data Centers; **Andrae (2020),** New perspectives on internet electricity use in 2030; **Belkhir & Elmeligi (2018),** Assessing ICT global emissions footprint: Trends to 2040 & recommendations; **Bordage / GreenIT.fr (2019),** Environmental footprint of the digital world; **Hintemann & Claus (2016),** Green Cloud? The current and future development of energy consumption by data centers, networks and end-user devices; **Hintemann / Borderstep (2020),** Efficiency gains are not enough: Data center energy consumption continues to rise significantly; **Malmodin & Lunden (2018),** The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015; **Malmodin (2020)**, Energy consumption and carbon emissions in the ICT sector (presentation to TechUK); **IEA (2017),** Digitalization & Energy; **IEA (2018-20),** Tracking Clean Energy Progress: Data centres and data transmission networks; **Masanet et al. (2020),** Recalibrating global data center energy-use estimates.



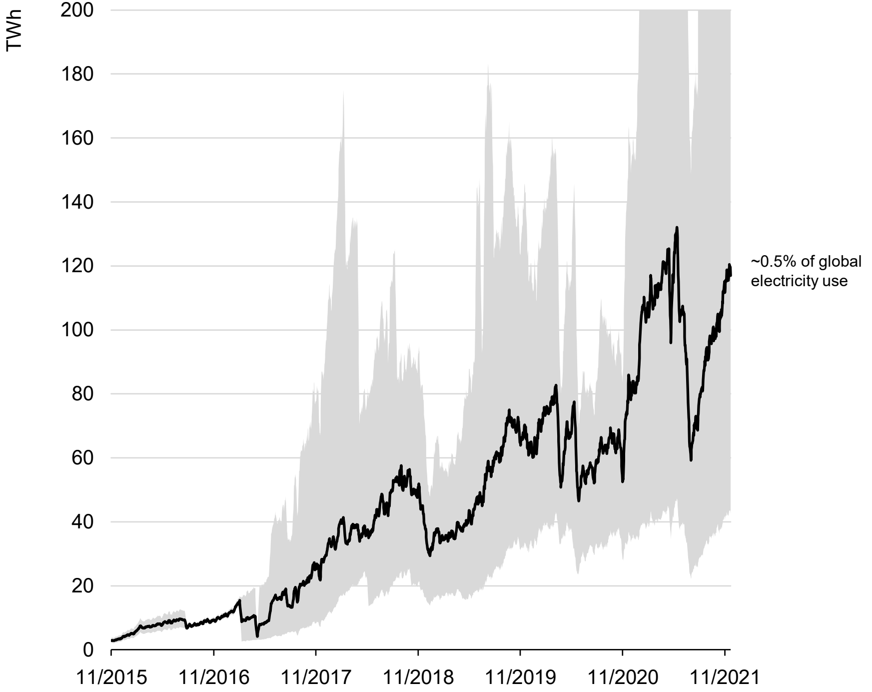
Streaming video & gaming
AR / VR
3G
4G
5G
6G
Cloud DC
Edge DC
Smartphones
IoT
Blockchain
Machine learning
?
2000
2010
2020
2030
2040
2050
Electricity decarbonisation
Energy efficiency
New efficient technologies

Blockchain and cryptocurrencies

Efficiency of mining hardware



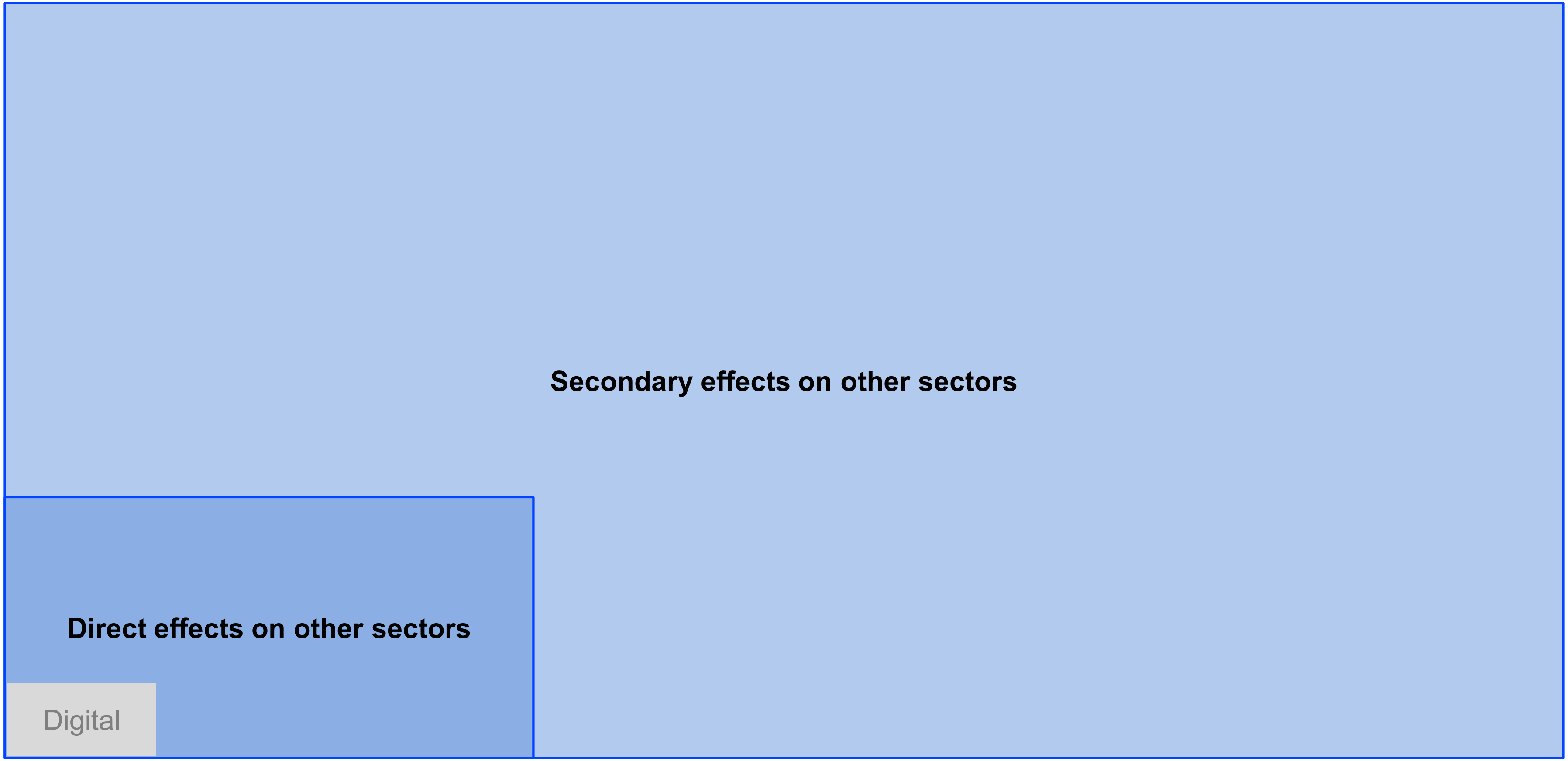
Bitcoin energy consumption



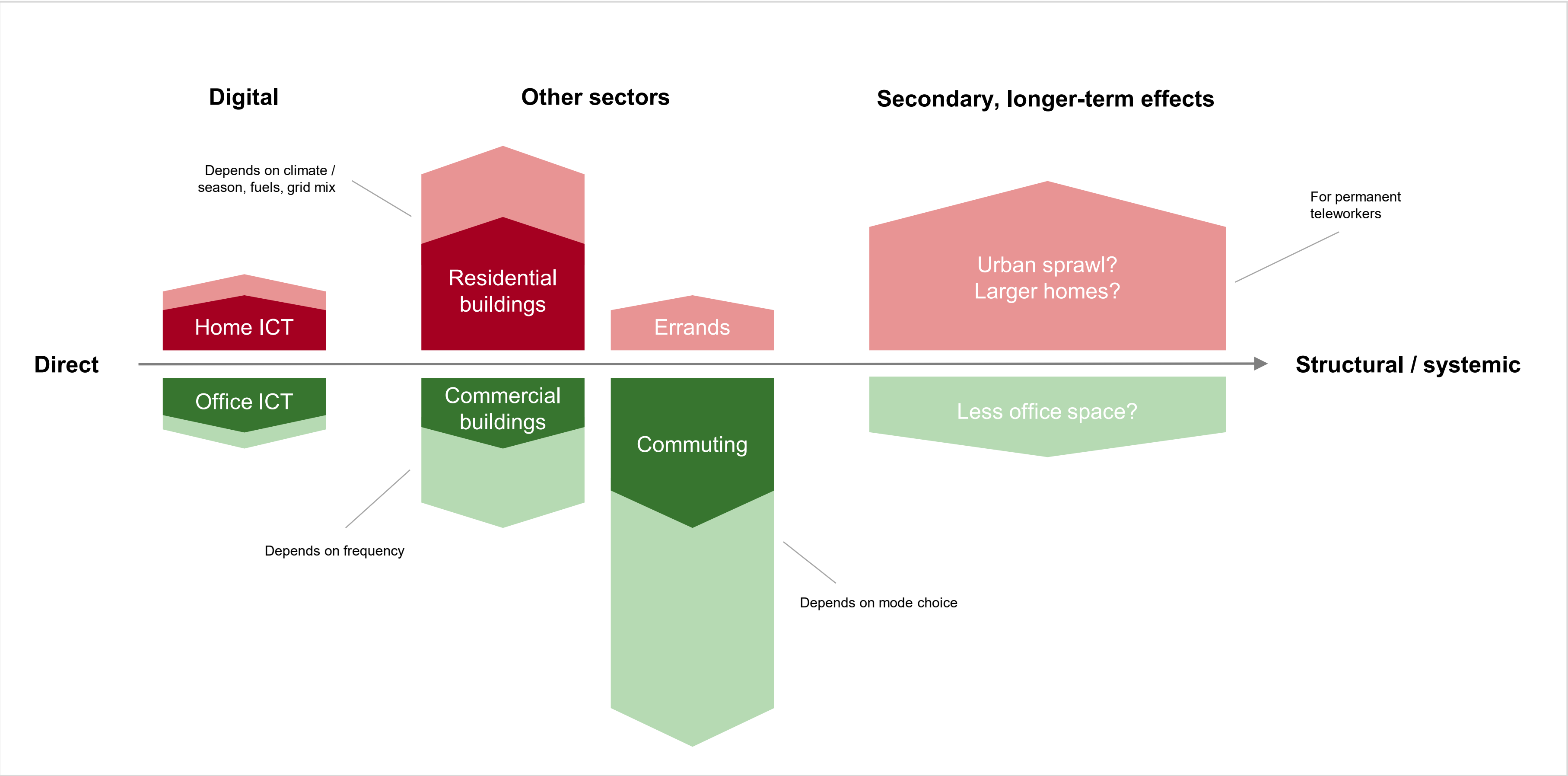
IEA (2019). Bitcoin energy use – mined the gap. https://www.iea.org/commentaries/bitcoin-energy-use-mined-the-gap.

Cambridge Centre for Alternative Finance (2020), Cambridge Bitcoin Electricity Consumption Index. https://www.cbeci.org/.

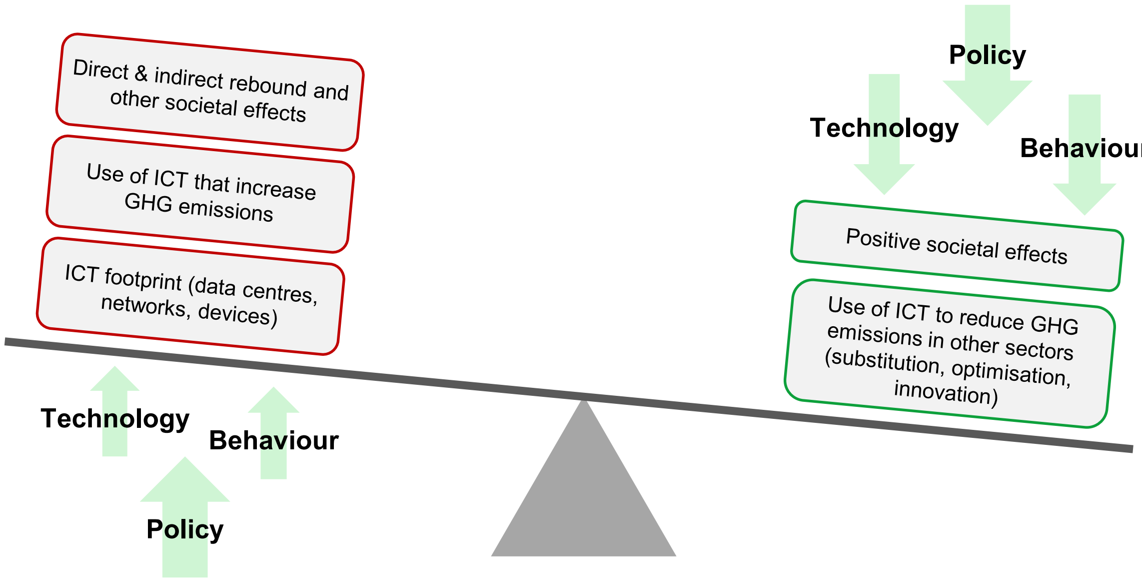
Effects on other sectors



Changes in energy use and emissions from teleworking



Influencing the net climate impacts of digitalisation



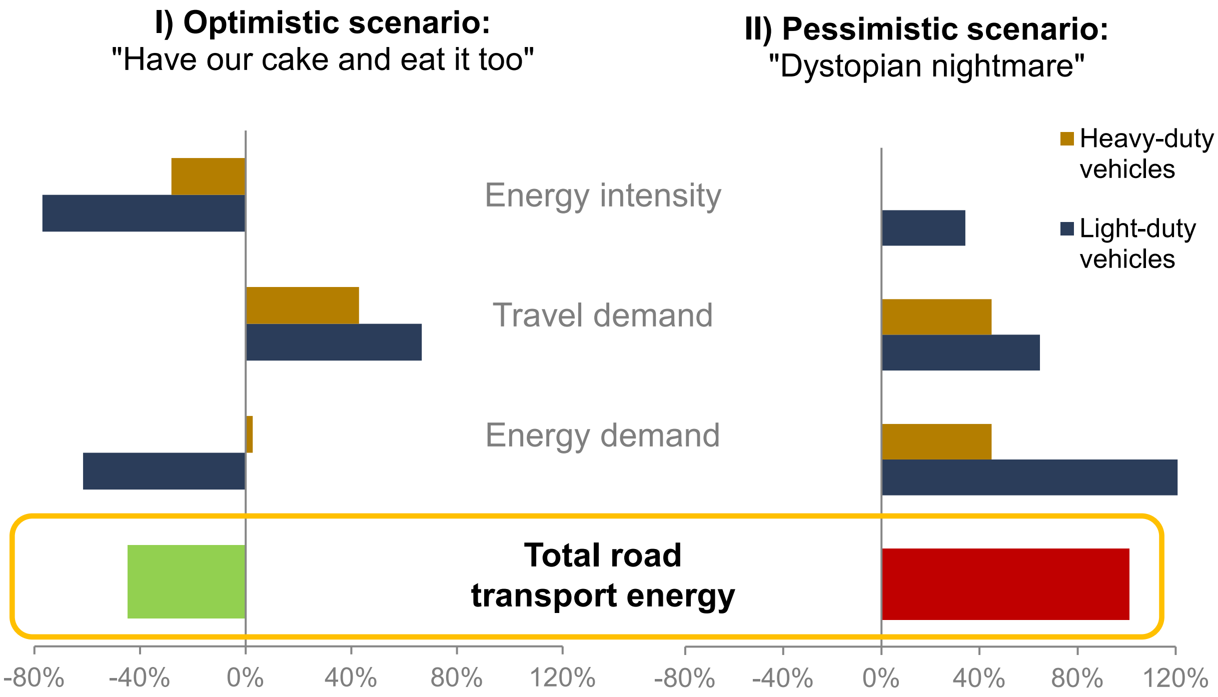
Adapted from Bergmark (2021), Assessing the net climate impact of digitalisation.

Policy choices will play a central role in shaping the net energy and emission impacts of digitalisation

Applying digital technologies in the energy sector

- **Buildings:** smart building controls & thermostats; connected appliances & lighting
- **Industry:** robotics; digital twins; 3D printing; machine learning
- **Transport:** shared mobility services; automated & connected vehicles; freight optimisation

Policies are critical: example of connected and automated vehicles



Source: Wadud, MacKenzie and Leiby (2016), "Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles".

Road transport energy demand could halve or double from automation and connectivity depending on how technology, behavior, and policy evolve

Applying digital technologies in the energy sector

- **Buildings:** smart building controls & thermostats; connected appliances & lighting
- **Industry:** robotics; digital twins; 3D printing; machine learning
- **Transport:** shared mobility services; automated & connected vehicles; freight optimisation
- **Electricity:** IoT and automation to improve efficiency and reduce maintenance costs; machine learning to improve solar and wind forecasts, and better match supply and demand from increasingly decentralised sources
- **Oil & gas:** machine learning to reduce costs of detecting methane leaks
- **Energy access:** mobile services and infrastructure to facilitate electricity access
- **Policy:** data collection; modelling; assessing policy options and effectiveness

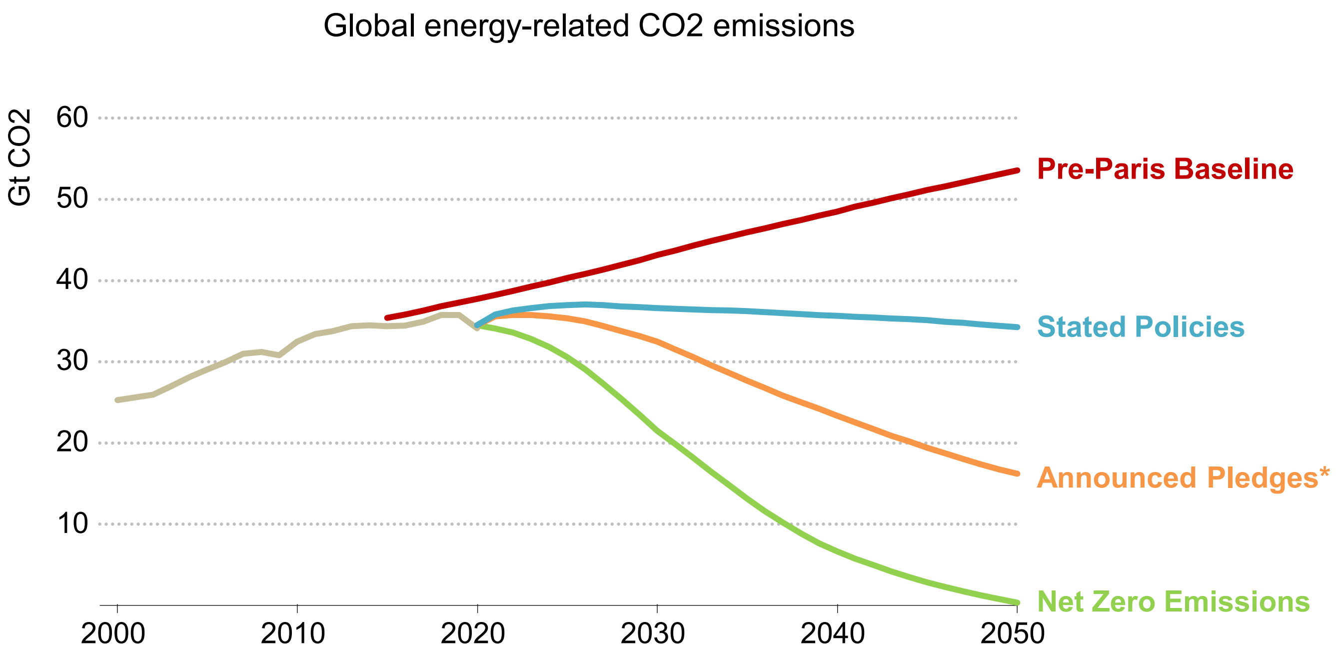
Net impacts on energy use and emissions will be shaped by climate policy

Managing emerging risks and challenges

- ICT energy consumption
- Potential rebound effects (e.g. autonomous vehicles, connected appliances, induced consumption)

- Cybersecurity and digital resilience
- Data privacy and ownership
- Jobs and skills

Keeping the door open to 1.5°C



* Including pledges announced at COP26

Despite some positive signs, there remains a significant gap to the Net Zero by 2050 Scenario – both in ambition and implementation

Tracking Clean Energy Progress 2021

Power

- Renewable power
  - Solar PV
  - Wind
  - Hydropower
  - Bioenergy
  - Geothermal
  - CSP
  - Ocean
- Nuclear power
- Gas-fired power
- Coal-fired power
- CCUS in power

Industry

- Chemicals
- Iron and steel
- Cement
- Pulp and paper
- Aluminium
- CCUS in industry & transformation

Transport

- Electric vehicles
- Fuel economy
- Trucks & buses
- Transport biofuels
- Aviation
- Shipping
- Rail

Buildings

- Building envelopes
- Heating
- Heat pumps
- District heating
- Cooling
- Lighting
- Appliances & equipment
- Data centres & networks

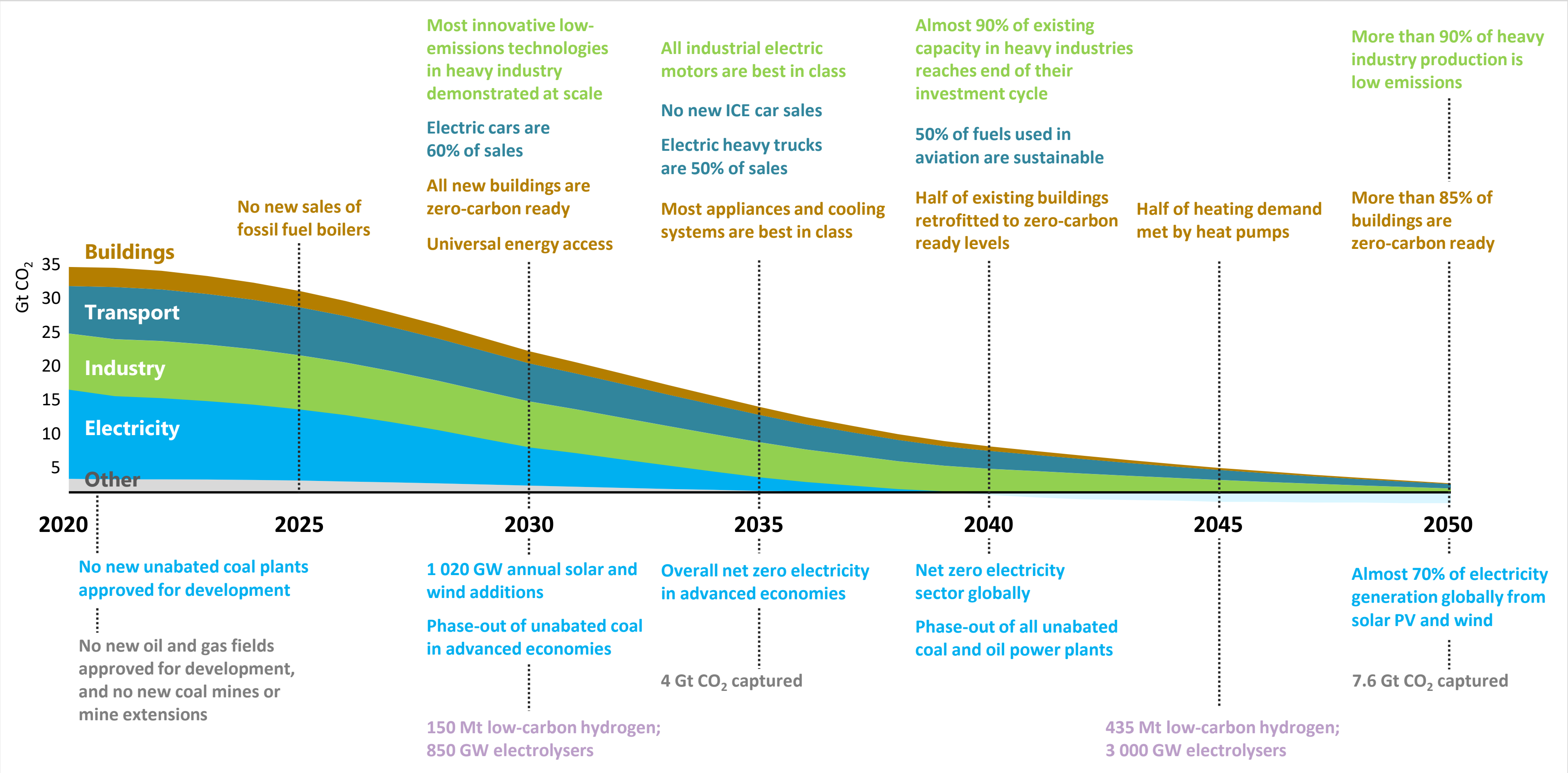
Fuel supply

- Methane emissions from oil and gas
- Flaring emissions

Energy integration

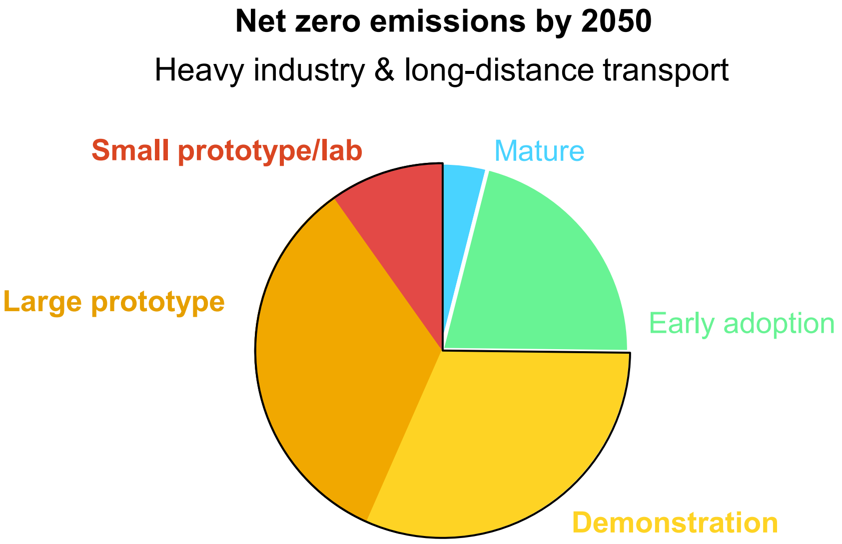
- Energy storage
- Hydrogen
- Smart grids
- Demand response
- Direct air capture

Set near-term milestones to get on track for long-term targets



Clean energy technology progress hinges on innovation

Cumulative emissions reductions by technology maturity relative to baseline trends



Source: IEA (2020). Energy Technology Perspectives 2020.

In the Faster Innovation Case, almost half of the emissions reductions for reaching net-zero by 2050 rely on technologies that are not yet commercial today. The share is higher in heavy industry & long-distance transport.

Key takeaways

- Understanding the effects of digitalisation on climate change requires a comprehensive, systems-level perspective.
- Given the growth in demand for digital technologies, policies and actions are needed to mitigate energy and emissions growth from the sector in three areas:
    1. energy efficiency, incl. RD&D into next-generation tech;
    2. zero-carbon electricity;
    3. decarbonising supply chains.
- The direct GHG “footprint” is relatively small compared to the direct and indirect effects of digitalisation on other sectors and activities (“handprint”).
- Digital technologies can have both positive and negative effects on climate change. They are NOT a silver bullet to tackle climate change, but can be an important tool.
- Strong climate policies are critical to ensure that digital technologies are applied in areas that help reduce emissions.

Further reading

- **IEA analysis:**
  - **Direct footprint of ICT:** Tracking Clean Energy Progress: Data centres & networks (2021); Bitcoin energy use (2019); Data centres: global and local impacts (2019); Carbon footprint of streaming video (2020).
  - **Effects on energy systems and other sectors:** Digitalization & Energy (2017); Energy and emissions savings from working from home (June 2020); 5 ways Big Tech could have big impacts on clean energy transitions (2021).
- **Other key papers:**
  - **Comprehensive reviews of digitalisation and climate:** Royal Society (2020), Digital technology and the planet: harnessing computing to achieve net zero. Freitag et al. (2020), The climate impact of ICT: A review of estimates, trends and regulations. Hook et al. (2020), A systematic review of the energy and climate impacts of teleworking. Rolnick et al. (2019), Tackling Climate Change with Machine Learning.
  - **Frameworks and methodologies to consider direct and indirect effects:** Horner et al. (2016), Known unknowns: indirect energy effects of ICT; Pohl et al. (2020), How LCA contributes to the environmental assessment of higher order effects of ICT application: A review of different approaches; Coroamă et al. (2020) and Bergmark et al. (2020), A Methodology for Assessing the Environmental Effects Induced by ICT Services.

Questions?

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