Research brief

Embodied carbon emissions of ICT devices assessed by different approaches

The global embodied greenhouse gas emissions of mobile communication user devices, such as tablets, smartphones, feature phones, laptops, desktop PCs, PC displays, and customer premises equipment, were estimated to be 180 Mt CO_2e in 2020. The embodied emissions were studied by applying three different approaches using life cycle assessment/product carbon footprint data, supply chain data, or reported vendor data. The supply chain approach is considered to give a reasonable overall result, while the LCA/PCF approach helps in allocation of the total to the different equipment types. Representative values for embodied carbon emissions that can be applied in other studies are presented.

Embodied carbon emissions of user devices in 2020

The global embodied greenhouse gas (GHG) emissions of user devices associated with accessing mobile networks, hence tablets, smartphones and feature phones, laptop and desktop PCs, PC displays and customer premises equipment (CPEs) for 2020 were estimated to 180 Mt (million metric ton) carbon dioxide equivalents (CO_2e). The GHG emissions are referred to as carbon emissions and the embodied emissions in this study cover emissions upstream of usage, hence excluding use and end of life[1].

[1] Embodied emissions in this study refer to raw material acquisition, production/manufacturing and assembly, the upstream transportations as well as the distribution of the product. In the recommendation ITU-T L.1410 from International Telecommunications Union embodied emissions are defined to also include emissions related to end-of-life treatment.

Based on the total results in this study, global average values, or representative values, of embodied emissions for the investigated user devices were derived.

Representative embodied carbon emissions for 2020

User devices	Representative embodied carbon emissions (kg CO_2e)
Smartphone	50
Feature phone	20
Tablet	100
Laptop PC	200
Desktop PC	350
PC display	100
CPE	30

Three approaches used for the assessment

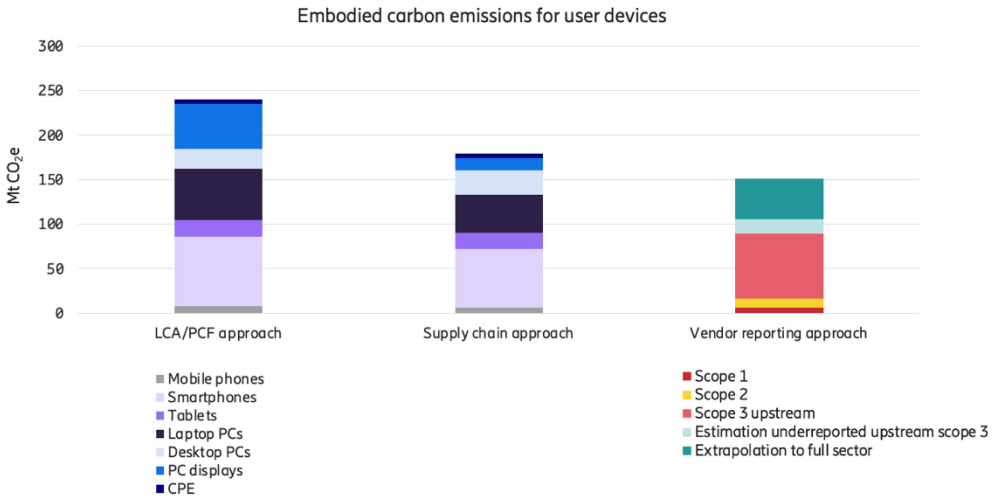
The purpose of the study was to investigate the embodied GHG emissions by applying three different approaches called: LCA/PCF, supply chain and vendor reporting based on the different data collected.

Approach	Data and method
LCA/PCF	Data from published life cycle assessment (LCA) studies, typical values in accessible studies, and vendors' product carbon footprint (PCF) documentation were collected. Representative values (one per user device type) were derived and combined with sales statistics to create the total embodied carbon emissions of the investigated user devices at a sector level.
Supply Chain	Company data collected from device manufacturers and other actors of the electronics industry were aggregated and used together with previously estimated materials acquisition carbon emissions to derive a total value for embodied emissions of all electronics. The value was then allocated to different industry sectors using electronics, to parts of the ICT sector, and to the specific user devices.
Vendor Reporting	Supply chain data collected from device vendors' annual environmental reporting were multiplied by sales values for user devices. The outcome was then extrapolated by market shares to estimate the total embodied carbon emissions of chosen user devices at a sector level.

Total results depended on approach

The supply chain approach is arguably a more comprehensive approach for estimating the entire electronics sector due to high data coverage. However, the allocation to different industry sectors is a challenge as each supply chain category also produces electronics to other sectors.

The vendor reporting approach could also, in principle, be seen as comprehensive. However, the approach to a large extent relies on scope 3 reporting[2] which is both underreported and highly uncertain due to the complexities of the supply chain. The supply chain approach differs in that it only relies to a limited extent on scope 3 reporting as data is collected for the different suppliers. The LCA/PCF approach is useful to estimate good representative values for specific or typical user devices, however when calculating a total value, the approach overestimates the GHG emissions.



The supply chain approach gives the best estimate of the total GHG emissions from the investigated user devices due to the use of reported data in the supply chain. As seen in the graph above the LCA/PCF approach estimates 35% higher embodied carbon emissions than the supply chain approach, while the vendor reporting approach is 16% lower, although estimations and extrapolations have been made to cover data gaps.

For typical values per user device type, comparing and combining the results of the supply chain approach and the LCA/PCF approach, is considered to give the best estimates.

[2] Scope 3 relates to the terminology in the reporting standard by GHG Protocol https://ghgprotocol.org/. Whereas scope 1 and scope 2 GHG emissions relate to a company's direct and purchased electricity use emissions, respectively, scope 3 emissions cover other indirect GHG emissions from sources in the reporting organization's value chain. In this study the upstream scope 3 emissions e.g. related to the entire supply chain, but also emissions related to e.g. business travel and commuting are collected.

Comparing the results to ITU trajectory and development since 2015

In the decarbonization trajectory of the ICT sector by ITU and partners (ITU-T L.1470[3]), the upper band for total carbon emissions of user devices, including the use stage, are 379 Mt CO_2e for 2020. The embodied carbon emissions of all user devices are about 180 Mt CO_2e, hence including Internet of Things (IoT) and other user devices that were not investigated in this study.
Comparing to 2015, the 180 Mt CO_2e resulting for the user devices included in this study is an increase of about 2.4%. For 2015 the embodied carbon emissions for the ICT user devices included in this study were estimated to 175.3 Mt CO_2e[4].

Data quality

The ITU standard's data quality requirements, such as evaluating different sources to create the best possible estimate and using the most recognized, representative, high-quality data available, were considered when scoping this study. Primary company data in the entire electronics sector and device vendor data were collected. This was complemented by academic articles and a large number of companies' product carbon footprint reports. Moreover, the study has noted the principles of timeliness, accuracy and accessibility to the extent possible while respecting the completeness principle by allowing unpublished data to avoid cut-off in some cases. The study highlights major gaps in scope 3 emissions reporting, particularly in the vendor reporting approach.

Reference to full paper:

Lövehagen N, Malmodin J, Bergmark P, Matinfar S. Assessing embodied carbon emissions of communication user devices by combining approaches. 2023. *Renewable and Sustainable Energy Reviews*, Volume 183, September 2023, 113422.
https://doi.org/10.1016/j.rser.2023.113422

[3] International Telecommunication Union (ITU-T), Greenhouse gas emissions trajectories for the information and communication technology sector compatible with the UNFCCC Paris Agreement. Recommendation ITU-T L.1470 (01/2020).

[4] Malmodin J and Lundén D. The energy and carbon footprint of the global ICT and E&M sectors 2010-2015. Sustainability 2018;10(9):3027.