Research brief

Simplified LCA - method to save time and resources

Performing a life cycle assessment (LCA) is a resource and time-consuming activity, especially for complex equipment like telecommunication equipment. As LCA is an important tool in the strive to minimize the environmental impact, there is a need for simplified LCA approaches. In the presented simplified LCA methodology, product parameters covering materials and processes are identified and grouped before multiplied by emission factors to estimate the total impact.

Simplified LCA — why and how?

Life cycle assessments (LCAs) are used to understand the main contributors to certain environmental impact categories like global warming potential, measuring the climate change. Conducting comprehensive LCA studies of Information and Communication Technology (ICT) products are challenging due to their complexity. These products consist of thousands of components, and collecting high-quality, up-to-date data across the full supply chain is difficult and time-consuming. Based on LCA practitioner experience, the largest contributors to the overall environmental impact can be identified. Grouping materials and processes, and focus on the main contributors, simplifies the approach and the life cycle impact can be calculated for more products with less resources. There is a clear need to simplify LCA methodologies in the ICT industry to ensure that practitioners can fully understand the data involved, enabling critical review and meaningful benchmarking. Having more LCA results, even if simplified, will ensure that decisions on material choices and processes can made on well-founded estimations.

LCAs include four life cycle stages: raw materials acquisition, production, use, and End of-Life Treatment (EoLT). For a simplified methodology the primary focus is on the so-called embodied emissions, excluding the use stage, as the use stage can be easily estimated based on electricity consumption during use.

Product parameterization leads to simplification

The presented simplified product parameterization methodology[1] can be summarized as a defined list of product parameters, covering main raw materials, mechanics, electro-mechanics, electronics and vendor/manufacturer activities. Each product parameter (PP) is multiplied with a corresponding emission factor (EF) to calculate the environmental impact of that part. The total environmental impact is then received by summing the individual impacts.

$$\Sigma\ [\text{Product parameter (PP)} \times \text{Emission factor (EF)}]$$

The simplified LCA methodology is presented with examples of estimating the greenhouse gas (GHG) emissions, giving examples of emission factors in the unit kilogram carbon dioxide equivalents (kg CO_2e) per kilogram material/processed part, etc.

Raw materials are grouped together

The total weight of each raw material is calculated prior to multiplying with a corresponding EF. The starting point is understanding the material used in the product through materials declaration or Bill of Materials (BOM) file listing included parts and electronic components. Based on the product content and manufacturing inputs the raw material cradle-to-gate impact is calculated per material. The total material-related environmental impact is calculated by adding the impact for each material. The impact results vary greatly depending on recycling rates, data sources, and allocation methods.

Production is grouped into five different parts

- **Mechanics** typically include the frame parts of the product such as racks and cabinets which need to be mechanically processed. One example is diecasting of aluminum frame parts. Examples of EFs for mechanics are 10 kg CO_2e/kg for small special parts, 4 kg CO_2e/kg for medium modules and 2 kg CO_2/kg for large cabinets.
- **Electro-mechanics** include cables, connectors, and fans, as well as active components like batteries. Examples of EFs for electromechanics (gate-to-gate) are 1 kg CO_2e/kg for power cables and 2 kg CO_2e/kg for a power supply unit.
- **Electronic production** is divided into the three main electronic components and standard components.
  - Integrated Circuits (IC) have an average EF of 2.6 kg CO_2e/cm^2 die area
  - Printed Circuit Boards (PCB) have an average EF of 3 kg CO_2e/dm^2
  - Displays have an average EF of 2.2 kg CO_2e/dm^2
  - Standard components like basic types of resistors, capacitors, transistors etc. are treated with one common EF.

[1] This methodology is called Product Parameter, PP, method in the ITU-T L.1411 Guidance on simplified life cycle assessments of Information and Communication Technologies.

- **Vendor/manufacturer own activities** include inbound and outbound transports, assembly and testing, and support activities which covers research and development, marketing, etc.
- **Infrastructure** includes production sites and network components like antenna towers, which can contribute significantly to GHG emissions (about 0.75 kg CO_2e per subscriber/year on average globally).

Use stage and end-of-life treatment are included for full lifecycle results

The electricity is key in the use stage GHG emission and greatly depend on the electricity mix used by the network equipment. In simplified LCAs, the operational electricity can be used as the only parameter to consider in the use stage. However, for more detailed assessments, in addition, the support activities of the network operator including offices, stores, business travel and transport can be added.

End-of-life treatment (EoLT) and recycling are essential for a full picture of the entire life cycle. As EoLT emissions happen in the future, they are difficult to quantify and therefore bring large uncertainties.

Example of GHG emissions from annual smart phone and network use

The presented simplified methodology is exemplified by providing results for a smartphone user with proportional use of mobile network equipment and infrastructure (per subscriber). The smartphone LCA uses data from a SONY/Ericsson LCA by Ercan et al.[2], while the simplified methodology explained in this document was applied on a RAN radio unit and a baseband. For GHG emissions, the network part is aligned with the global averages presented for networks in Malmodin et al. (2024)[3] by using a similar average electricity consumption and related GHG emissions, and nearly similar embodied GHG emissions per subscriber and year.

For an average smartphone user with an average use of mobile networks, the total GHG emissions are approximately 30 kg CO_2e per year. The two major GHG emission contributors relate to the mobile networks in the use stage using a global electricity mix and the electronics production for the smartphone. The global electricity grid emission factor was set at 0.54 kg CO_2e/kWh in these calculations. The total GHG emissions for a smartphone user with average usage of a mobile network are presented in the following graph and table.

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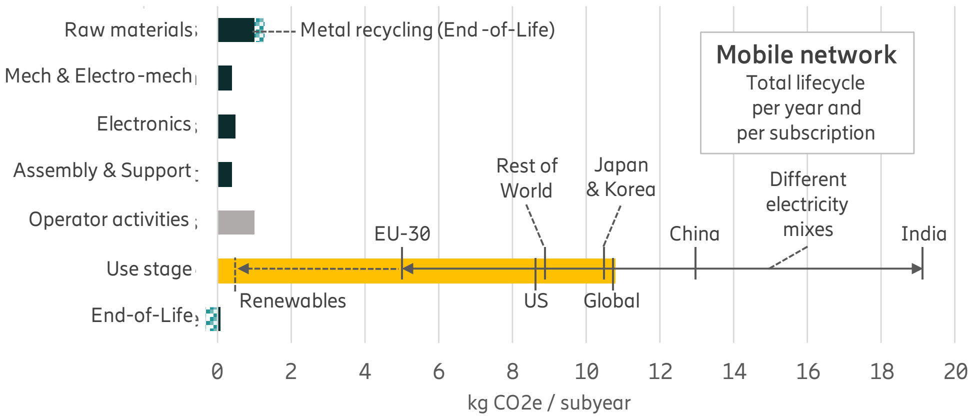
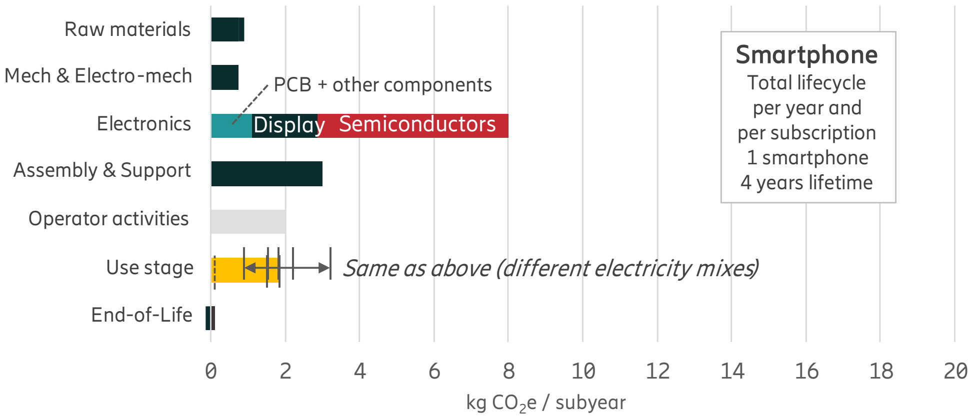
[2] Ercan M, Malmodin J, Bergmark P, Kimfalk E, Nilsson E. Life cycle assessment of a smartphone. In: Proceedings of the ICT for sustainability (ICT4S); 2016. doi: 10.2991/ict4s-16.2016.15.

[3] Malmodin J, Lövehagen N, Bergmark P, Lundén D. ICT sector electricity consumption and greenhouse gas emissions—2020 outcome. Telecommunications Policy. 2024 Apr 1;48(3):102701 doi: 10.1016/j.telpol.2023.102701.





Smartphone and mobile network		
Embodied GHG	**Lifetime**	**CO_2e /subyear**
Smartphone (1 sub)	4 years	12.5 kg
… peripherals/repair	(4 years)	1.6 kg
Radio (100 subs)	8 years	0.81 kg
Baseband (600 subs)	8 years	0.11 kg
Antenna towers	20+ years	0.85 kg
Other site materials	3–20 yrs.	~0.8 kg
Use/operation GHG	**Electricity**	**CO_2/subyear**
Smartphone (1 sub)	4 kWh	2.1 kg
Radio(s) (per sub)	13.5 kWh	7.3 kg
Baseband (per sub)	2.6 kWh	1.4 kg
Other site (per sub)	2.5 kWh	1.3 kg
Core network, operator activities	1.4 kWh	1.7 kg
Total		**~30 kg**

Dealing with uncertainties

LCA results are associated with large uncertainties and comparisons of LCA studies cannot be made with enough accuracy if coming from different sources even though the products are very similar. Important aspects to consider:

- Defining scope is crucial in any LCA. It is important to clearly state what is included, as this significantly affects the results and their interpretation.
- Complex, multiple, and variable supply chains with ever changing electricity mixes are reasons that the same product can have very different environmental impacts. It is recommended to start with representative general averages that can later be refined as more specific, updated data are collected.
- Support activities, such as office work, business travel, and services like R&D or marketing, are often inconsistently included in LCAs and EFs, but should be estimated and transparently reported in the scope.
- For complex electronic products, aggregated emission factors are often created for specific parts. These become mini-LCAs with the same challenges as above. It is recommended to collect specific data on the most important parts and clearly state scope and assumptions in aggregated emission factors.
- Handling of future potential impacts relates to scenarios for future use and end-of-life treatment but are also built into the impact assessment categorization systems used in LCAs. Results should be compared across different impact assessment models to understand the variations from the models.
- LCAs are often simplified using assumptions and existing databases where e.g. the data age and covered scope are not clearly stated. This increases the uncertainty in general, but especially for equipment in fast-evolving sectors like ICT.

Improving the simplified LCA results

A key challenge for continued development and application of this methodology is to get more suppliers involved and make sure they use the same holistic life cycle thinking when establishing their EFs. Two other challenges that have emerged are (i) to avoid overcomplicating part/component models and stay at a relatively manageable level of data and models and (ii) to continuously review and update the included EFs to stay up to date.

Reference to full paper:

Malmodin J & Lövehagen N. A methodology for simplified LCAs of electronic products. 2024. *Electronics Goes Green 2024+ (EGG)*, Berlin, Germany, 2024, pp. 1-12, doi: 10.23919/EGG62010.2024.10631258.