Life cycle inventories of the ICT sector in the UVEK database

Report for deliverables D.H.a.2 and D.H.b.1

Lugas Raka Adrianto, Maulana Permana Ajie, Didier Beloin-Saint-Pierre*

Empa, St. Gallen, Switzerland

https://www.empa.ch/web/empa/

*Contact: dib@empa.ch

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Summary

This report presents the documentation for the update and creation of life cycle inventories (LCIs) in the UVEK database. The focus is on the ICT sector, starting from the production of: electronic components, devices, network infrastructure, and disposal of electronic equipment. For each dataset, modelling approaches, assumptions, and sources of data are explained. 197 datasets for the ICT sector have been checked, updated, or created in this project financed by the Swiss Federal Office for the Environment (FOEN). Specific life cycle impact assessment (LCIA) results are also presented for all datasets in chapters 8 and 9 (i.e. contribution analysis for selected impact indicators).

Overall about 40% of the updated datasets show significant changes (i.e. >10%) in their potential environmental impacts when compared to the results of the previous version. This does not mean that the other 60% did not change their flows substantially, but that the changes/improvements were compensated by the choices that were made in the scope definition of this work (see deliverable D.H.a.1). The two key modelling choices that have substantial effects on the results are the use of primary metals and global average electricity mixes instead of European metal stocks and European electricity mixes (i.e. ENTSO-E region) for the manufacturing of ICT components and devices.

The new ICT LCI datasets mainly inform us on the potential environmental impacts of devices and the use of internet and its infrastructure. In this case, we see that the environmental impacts of manufacturing the ICT device holds a substantial portion of their full life cycle (i.e. while considering usage and end of life). This follows the same conclusions as previous evaluations made at Empa, but a sensitivity analysis on varying data usage levels shows that this might not be the case with new levels of data transfer and computing (mainly in data center around the world). Indeed, the potential environmental impacts of data usage from internet could become a key source of impact in the future if we go beyond the level of 1 GB data download per hour with a laptop that has a lifetime expectancy of about 4 years and an average 5 hours of use per day (i.e. more than 5 GB use per day).

Project "LCI updates for the ICT sector in the UVEK database"

Commissioner:	Swiss Federal Office for the Environment (BAFU - FOEN)
Advisory Board Members:	Pierryves Padey, BAFU Katharina Meyer, BAFU Mischa Zschokke, Carbotech Tobias Welz, Seri Stefan Zweili, BIT René Itten, ZHAW Marius Schlegel, Swisscom
Validation:	Carbotech AG, Zürich
Project leader:	Didier Beloin-Saint-Pierre, Empa St. Gallen
Authors:	Lugas Raka Adrianto, Empa St. Gallen Maulana Permana Ajie, Empa St. Gallen Didier Beloin-Saint-Pierre, Empa St. Gallen
Deliverables and annex for this report:	Description of files:
• Deliverable_DHa2_DHb1_LCI_LCA_results.docx	• Main report entitled "Life cycle inventories of the ICT sector in the UVEK database".
• List_Excel_LCI_ICT_sector.xlsx	• Spreadsheet file containing the full list of updated and newly created ICT dataset.
• LCIAresults_Excel_LCI_ICT_sector.xlsx	• Spreadsheet file containing LCIA results and contribution analysis.
• Folder "UVEK Database for ICT"	• 197 datasets in XML, TXT, CSV formats (EcoSpold v1), and Simapro mapping files, representing the new unit processes in the ICT sector linked to the UVEK LCA database.
• Readme_UVEK_ICT.txt	• Readme for the general overview of the deliverables.

Abbreviations

ADSL	Asymmetric digital subscriber line
BOM	Bill of materials
CCFL	Cold cathode fluorescent lamp
CED	Cumulative energy demand, an LCIA method
CSTB	Complex set top boxes, one of the customer premise equipment options
CPE	Customer premise equipment
CPU	Central processing unit
DSLAM	Digital subscriber line access multiplexer, a network device
EPD	Environmental product declaration
ES	Ecological scarcity, an LCIA method
GWP	Global warming potential, an LCIA method
HDD	Hard disk drive
HDMI	High-Definition Multimedia Interface
IC	Integrated circuit or also known as chips
ICT	Information and communication technologies
IP	Internet protocol
LCD	Liquid crystal display
LED	Light-emitting diode
LCI	Life cycle inventory
LCIA	Life cycle impact assessment
NAND	"Not And" flash memory, a type of non-volatile storage that is widely used in consumer electronics devices
NAS	Network attached storage
NiMH	Nickel metal hydride, a type of rechargeable battery
NMC	Lithium nickel manganese cobalt oxides, commonly used in lithium ion batteries

MB/GB/TB/ZB	Megabyte, Gigabyte, Terabyte, Zetabyte – Unit for data storage capacity
oLED	Organic LED
PCI	Peripheral Component Interconnect
PCB/PWB	Printed circuit board/printed wiring board
PSU	Power supply units
RAM	Random access memory
SMD	Surface mounted device
SMT	Surface mount technology
SSD	Solid state drive
TFT LCD	Thin-film transistor LCD
THT	Through-hole technology
UBP	*Umweltbelastungspunkte* or eco points, an aggregated single score end point for the Swiss ecological scarcity LCIA method
UVEK	*Umwelt, Verkehr, Energie und Kommunikation*, Federal Department of Environment, Transport, Energy and Communications
WEEE	Waste Electrical and Electronic Equipment
WiFi	Wireless fidelity or sometimes known WLAN, wireless local area network
xDSL	Sum of digital subscriber line

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1 Introduction

This data gathering project, for the sector of Information & Communication Technology (ICT), aims at updating and creating life cycle inventory (LCI) datasets for the UVEK database. The project follows the requirements of the Swiss Federal Office for the Environment (FOEN) on the considered LCI datasets to provide an updated representation of potential environmental impacts for the ICT sector. This includes the review of existing datasets for the electronic components, ICT devices, accessories, use cases and end-of-life scenarios as well as for the creation of new datasets for networks, infrastructures, and data centres. This document provides the detailed LCIs and environmental assessments for each dataset in the appendixes of chapter 8 and 9. The LCI datasets and their metadata are also provided in separate files with the ecospold v1 format to ensure easy integration into the latest version of the UVEK database. The ecospold LCI datasets respect the Data Quality Requirements of UVEK (DQRv2:2018/21). After finalization and a review process, the data shall be published in UVEK 2023/2024 managed by BAFU/FOEN.

This final report is structured into nine chapters. Chapters 1 and 2 provide an introduction of the project and the general procedure of how ICT LCI datasets were updated or created with a summary of the data gathering activities. Chapter 3 presents the general results of the updated and created ICT datasets. Chapter 4 provides the essential interpretation and discussion from the environmental impact assessment step. Chapter 5 concludes the general overview with a recap of the modelling approach, main results, and recommendations for future studies in the context of LCA for the ICT sector. Chapter 6 provides the list of references. Chapters 7, 8 and 9 offer detailed descriptions of the considered ICT datasets as well as the general modelling assumptions behind all ICT LCI datasets for both existing and created unit processes. Key literature sources are cited for all the flows of the LCI datasets in Chapter 8 and 9. With that in mind, it is important to note that this project is mainly using public secondary data sources for the update and creation of LCI datasets.

1.1 Comparison with other ICT-related studies

- Recent comprehensive review papers that present summaries of carbon footprint values for ICT products and manufacturing activities, include the study of (Lövehagen et al., 2023) for the modern ICT devices and the study of (Teehan & Kandlikar, 2013) for the older ICT devices that were analysed a decade ago.
- For the use case of the ICT devices in section 4.3.4, the following studies are used as a basis of comparison: (Viana et al., 2022) and (Ruiz et al., 2022).
- The values that are used as a basis of comparison for electricity consumption and operational carbon emissions of large European telecom networks is mainly based on the study made by (Lundén et al., 2022).

2 Overview of ICT data update and creation workflow

2.1 Summary of life cycle inventory data updates and creation procedure

Figure 2.1-1 shows the general procedure that was followed to update or create LCI datasets for the ICT sector in the UVEK database. In this workflow, public documents published since 2008 (such as technical publications, articles, and product datasheets) are used as key information sources to complete the LCI datasets. Year 2008 is chosen as the temporal limit of our search since it is the year when the previous ICT LCI datasets were introduced in UVEK.

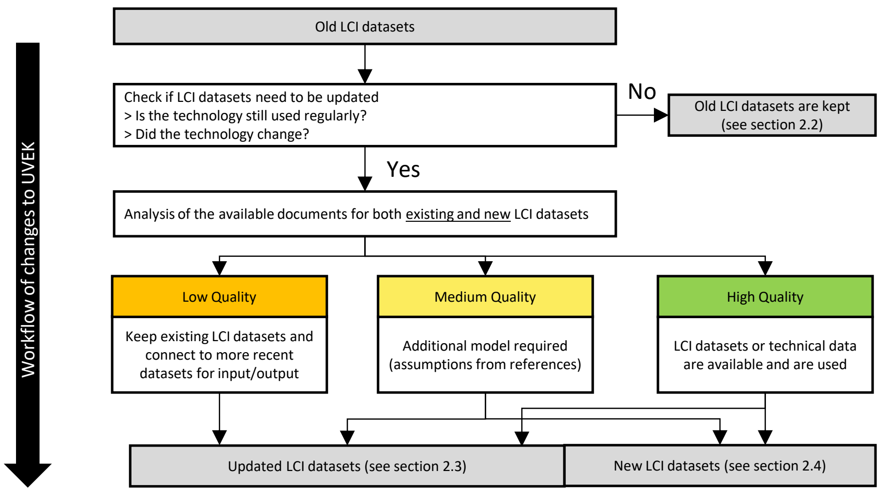

Figure 2.1-1. Summary of workflow to update the ICT sector in the UVEK database

The varying levels of availability and quality for recent public documents that describe the equipment, the devices, the infrastructure and the use scenarios of the ICT sector lead to 3 strategies when updating or creating LCI datasets. These strategies are listed and briefly explained in Table 2.1-1.

Table 2.1-1. Strategies for LCI dataset update of creation based on the quality and availability of information sources

LCI data (availability & quality)	LCI development strategies	Brief explanation of our work
High	Available LCIs & technical data are used	In some cases, the LCI data is presented in a transparent manner with clear links to the UVEK database. In other cases, the inventory data is available in multiple publications/references, which require averaging and data cleaning to define relevant levels of flows.
Medium	Additional models are proposed with assumptions based on existing references	Additional process modelling is sometimes necessary to fill the data gaps. If no recent literature is found, we use the existing references with potential modifications on the energy/resource efficiency according to other industry standards
Low (More research needed)	Use existing or similar datasets with connections to new datasets	Data is oftentimes limited and therefore, the current dataset is not updated extensively at the bill of materials level, except for the new connections to the other updated ICT LCI datasets

Table 2.1-2 and figure 2.1-2 present the proportions of LCI datasets that have been kept, updated or created as well as the LCI development strategies that have been used to support these changes. A total of 213 LCI datasets have been considered for this new representation of the ICT sector and its potential environmental impacts.

Table 2.1-2. Summary of the considered LCI datasets for the ICT sector

	Number of LCI datasets	LCIAs with contribution analysis
Existing ICT LCI datasets to be updated		
Updated LCI datasets	120 (+16*)	120
New ICT LCI datasets to be created		
Created and reviewed LCI datasets	77	77
Total	197 (+16*)	197

Note: *16 datasets are not updated and their LCIs already exist in the UVEK database (see section 2.2). For those datasets that do not need updating, LCIAs have not been performed since they are not expected to change in comparison to the results of the previous version.

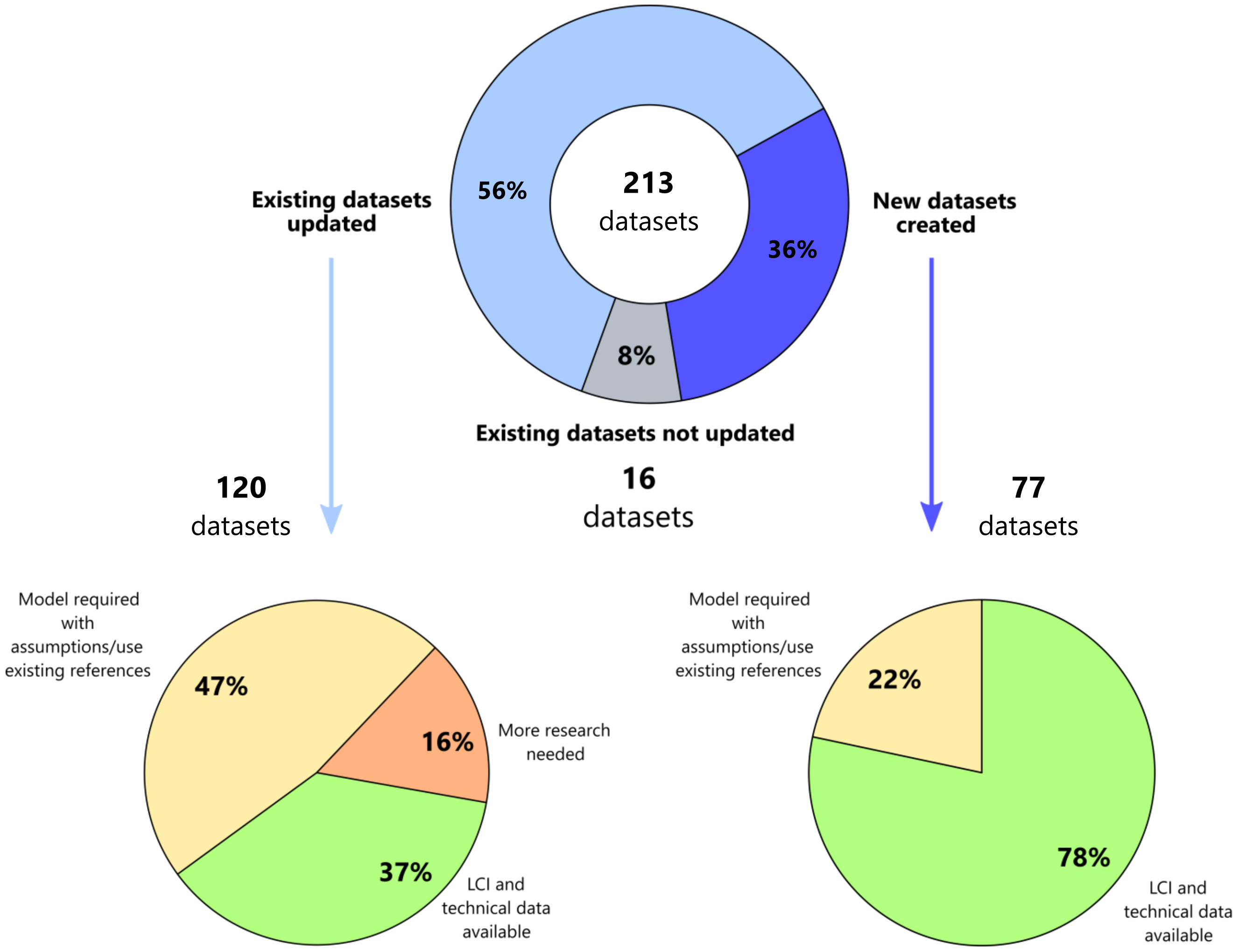

Figure 2.1-2. Summary of ICT dataset updates and creation: method and number of unit process

2.2 ICT datasets that have not been changed

There are sixteen existing LCI datasets in the UVEK database that were first considered in the project proposal but that do not need to be updated since they are either outdated technologies, equipment of low relevance in today's ICT context, or there is a lack of information on substantial changes that might have occurred in the last few decades. There is also no expected changes in the printed wiring board options that contain lead since such technology should no longer be used in new devices[1]. No LCI and LCIA results are presented for these datasets since they would not change when compared to the previous version of UVEK. These datasets are listed in Table 2.2-1.

Table 2.2-1. Investigated ICT LCI datasets of the UVEK database that are not changed

No	Unit process/dataset
1	Battery, LiIo, rechargeable, prismatic, at plant/GLO U
2	Battery, NiMH, rechargeable, prismatic, at plant/GLO U
3	CD-ROM/DVD-ROM drive, desktop computer, at plant/GLO U
4	CD-ROM/DVD-ROM drive, laptop computer, at plant/GLO U
5	Electronics scrap, for precious metal recovery, at preparation plant/GLO U
6	Mounting, surface mount technology, Pb-containing solder/GLO U
7	Mounting, through-hole technology, Pb-containing solder/GLO U
8	Printed wiring board, mounted, Desktop PC mainboard, Pb containing, at plant/GLO U
9	Printed wiring board, mounted, Laptop PC mainboard, Pb containing, at plant/GLO U
10	Printed wiring board, power supply unit desktop PC, Pb containing, at plant/GLO U
11	Printed wiring board, surface mount, lead-containing surface, at plant/GLO U
12	Printed wiring board, surface mounted, unspec., Pb containing, at plant/GLO U
13	Printed wiring board, through-hole mounted, unspec., Pb containing, at plant/GLO U
14	Printed wiring board, through-hole, lead-containing surface, at plant/GLO U
15	Printing colour, offset, 47.5% solvent, at plant/RER U
16	Printing colour, rotogravure, 55% toluene, at plant/RER U

[1] https://ec.europa.eu/commission/presscorner/detail/da/IP_06_903

2.3 Updates and modifications of existing ICT datasets

The general procedure to update the flows of the different updated LCI datasets has been presented in figure 2.1-1 and his based on the most relevant public documents that we could find. With that being said, we made other important changes to the connected unit processes that have been used as inputs or outputs. These changes are made to follow key choices that have been presented in the scope definition (deliverable D.H.a.1). They are:

- The use of global primary metals instead of European storage options when such datasets exist (e.g. copper)
- The use of international average electricity mixes instead of the European option to represent the production of equipment and devices with global supply chains.
- The connection to updated or created datasets to fully update the supply chains of ICT equipment & devices

These three changes in connected unit processes explain a substantial proportion of the changes in impacts that have been observed in the updated datasets (see section 3.1).

The Federal Office of Information Technology, Systems and Telecommunication (FOITT), in collaboration with GEWA, also supported this work with lab experiments where different ICT devices (e.g. notebooks) have been dismantled to collect statistics on the dimensions and masses of components. The collected information provides useful data to check and validate the flows that have been found in public documents, which serve as references.

Furthermore, the list of existing ICT LCI datasets that was defined in the proposal has been extended. This includes the background datasets required for the production of new hardware and components, e.g. lithium-ion batteries for portable devices. We have placed the datasets of batteries in the "updated" section, since they have been developed by Empa in other research projects. This means that we did not create them specifically for this project, but we added them in the UVEK database while respecting its requirements for dataset creation.

2.4 Creation of new datasets

The general procedure for collecting information and creating new dataset for the UVEK database follow the same choices as for the updated ICT LCI datasets (see section 2.3). The use of recent public data and parametric models allows for the development of average representations of the new ICT infrastructure, in particular for the Swiss transmission network and the Internet infrastructure. Furthermore, use case scenarios for specific devices such as smartphones and laptops can now be modelled using recent information and transparent bottom-up models to reflect ICT interconnectivity in the dataset. The work of FOITT and GEWA is also useful for the validation of new datasets since it gives information on the dimensions and masses of mobiles, notebooks & computers.

Two options to model the use of internet infrastructure have been used to create two types of datasets. The first type is using the hour of use as a reference flow and the second type is using the GB of transferred data. The former is seen as the most relevant representation since electricity consumption of network devices does not increase substantially with more data transfer. See section 4.3.4.2 for further explanation.

3 Results

The chapter provides an overview of the potential environmental impacts from all the updated (section 3.1) and new (section 3.2) LCI datasets in alphabetical order. This overview also offers links to the detailed LCI datasets and their contribution analyses, which is presented in the appendixes of chapters 8 (updated) and 9 (new).

3.1 Overview of potential environmental impacts for updated LCI datasets

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF]		Ecological Scarcity Total [UBP / RF]		CED Total [MJ primary / RF]		Main source of changes (for ecological scarcity)	Link to annex
		Old	**New**	**Old**	**New**	**Old**	**New**		
Aluminium collector foil production, for Li-ion battery {GLO} U	GLO	-	7.34E+00	-	1.43E+04	-	1.24E+02	From Empa datasets	8.5.20
Anode, graphite, for Li-ion battery {GLO} U	GLO	-	3.33E+00	-	1.74E+04	-	8.51E+01	From Empa datasets	8.5.20
Assembly, LCD module, at plant {GLO} U	GLO	3.79E+01	3.54E+01	7.10E+04	6.77E+04	4.74E+02	4.11E+02	Region of electricity	8.5.14
Backlight, LCD screen, at plant {GLO} U	GLO	1.07E+01	1.05E+01	1.94E+04	1.91E+04	1.69E+02	1.66E+02	Region of electricity	8.5.13
Battery cell, Li-ion, NMC111 {GLO} U	GLO	-	1.40E+01	-	4.44E+04	-	2.39E+02	From Empa datasets	8.5.20
Battery module packaging, Li-ion {GLO} U	GLO	-	1.17E+01	-	4.57E+04	-	2.00E+02	From Empa datasets	8.5.20
Battery, Li-ion, NMC111, rechargeable, prismatic {GLO} U	GLO	-	1.26E+01	-	3.96E+04	-	2.17E+02	From Empa datasets	8.5.20
Cable, connector for computer, without plugs, at plant {GLO} U	GLO	3.33E-01	3.69E-01	1.09E+03	2.25E+03	7.30E+00	7.63E+00	Use of global metal	8.5.3
Cable, data cable in infrastructure, at plant {GLO} U	GLO	1.69E-01	1.89E-01	6.20E+02	1.54E+03	4.40E+00	4.82E+00	Use of global metal	8.5.4
Cable, network cable, category 5, without plugs, at plant {GLO} U	GLO	4.16E-01	4.51E-01	1.88E+03	2.97E+03	7.70E+00	8.00E+00	Use of global metal	8.5.5
Cable, printer cable, without plugs, at plant {GLO} U	GLO	3.38E-01	3.74E-01	1.10E+03	2.27E+03	7.30E+00	7.65E+00	Use of global metal	8.5.6
Cable, ribbon cable, 20-pin, with plugs, at plant {GLO} U	GLO	8.73E+00	9.02E+00	3.13E+04	4.05E+04	1.84E+02	1.87E+02	Use of global metal	8.5.7
Cable, three-conductor cable, at plant {GLO} U	GLO	2.45E+00	3.07E+00	1.49E+04	4.40E+04	6.66E+01	7.93E+01	Use of global metal	8.5.8
Capacitor, electrolyte type, < 2cm height, at plant {GLO} U	GLO	4.53E+01	5.12E+01	1.21E+05	1.27E+05	8.86E+02	8.17E+02	Use of global metal	8.4.6
Capacitor, electrolyte type, > 2cm height, at plant {GLO} U	GLO	4.26E+01	4.86E+01	8.12E+04	8.78E+04	8.51E+02	7.82E+02	Use of global metal	8.4.7
Capacitor, film, through-hole mounting, at plant {GLO} U	GLO	4.51E+01	5.15E+01	1.54E+05	1.84E+05	8.67E+02	8.06E+02	Use of global metal	8.4.8
Capacitor, SMD type, surface-mounting, at plant {GLO} U	GLO	5.55E+01	6.15E+01	4.62E+05	4.69E+05	1.04E+03	9.73E+02	Use of global metal	8.4.9
Capacitor, Tantalum-, through-hole mounting, at plant {GLO} U	GLO	1.90E+02	1.96E+02	4.46E+05	4.52E+05	3.18E+03	3.11E+03	Production efforts	8.4.10
Capacitor, unspecified, at plant {GLO} U	GLO	7.58E+01	5.56E+01	2.53E+05	2.57E+05	1.37E+03	8.78E+02	Market shares	8.4.11
Cathode, lithium-ion battery, NMC111 {GLO} U	GLO	-	2.34E+01	-	5.53E+04	-	3.75E+02	From Empa datasets	8.5.20
Chassis, network main devices, at plant {GLO} U	GLO	4.45E+00	4.95E+00	1.18E+04	2.10E+04	6.50E+01	7.01E+01	Use of global metal	8.7.1
Connector, computer, peripherical type, at plant {GLO} U	GLO	6.80E+00	7.77E+00	1.46E+04	2.57E+04	1.27E+02	1.31E+02	Use of global metal	8.5.1

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF]		Ecological Scarcity Total [UBP / RF]		CED Total [MJ primary / RF]		Main source of changes (for ecological scarcity)	Link to annex
		Old	**New**	**Old**	**New**	**Old**	**New**		
Connector, PCI bus, at plant {GLO} U	GLO	3.95E+01	5.19E+01	4.12E+05	5.85E+05	6.44E+02	8.24E+02	Use of global metal	8.5.2
Copper collector foil production, for Li-ion battery {GLO} U	GLO	-	5.07E+00	-	8.76E+04	-	7.66E+01	From Empa datasets	8.5.20
Desktop computer, without screen, at plant {GLO} U	GLO	2.58E+02	2.18E+02	8.79E+05	9.74E+05	4.30E+03	3.40E+03	PWB input	8.6.1
Diode, glass-, SMD type, surface mounting, at plant {GLO} U	GLO	2.19E+02	2.43E+02	4.02E+05	4.38E+05	4.39E+03	3.98E+03	Use of global metal	8.4.12
Diode, glass-, through-hole mounting, at plant {GLO} U	GLO	2.19E+02	2.43E+02	3.88E+05	4.23E+05	4.38E+03	3.97E+03	Use of global metal	8.4.13
Diode, unspecified, at plant {GLO} U	GLO	2.19E+02	2.43E+02	3.93E+05	4.28E+05	4.38E+03	3.97E+03	All inputs equally	8.4.15
Dismantling, desktop computer, manually, at plant {CH} U	CH	4.18E-01	3.51E-01	4.95E+02	4.03E+02	1.17E+00	6.01E-01	Dismantling input	0
Dismantling, desktop computer, mechanically, at plant {CH} U	CH	3.60E-01	3.93E-01	4.16E+02	4.54E+02	7.45E-01	7.31E-01	Shredding input	8.8.12
Dismantling, IT accessories, mechanically, at plant {CH} U	CH	1.42E+00	1.40E+00	1.54E+03	1.50E+03	1.30E+00	8.63E-01	All inputs equally	8.8.8
Dismantling, laptop, manually, at plant {CH} U	CH	6.64E-01	6.58E-01	7.88E+02	7.78E+02	1.76E+00	1.67E+00	Dismantling input	8.8.16
Dismantling, laptop, mechanically, at plant {CH} U	CH	1.05E+00	1.03E+00	1.19E+03	1.16E+03	1.90E+00	1.57E+00	Shredding input	8.8.15
Dismantling, printer, laser, mechanically, at plant {CH} U	CH	2.09E+00	2.07E+00	2.21E+03	2.19E+03	9.36E-01	6.88E-01	Shredding input	8.8.5
Dismantling, shredder fraction from manual dismantling, mechanically, at plant {GLO} U	GLO	9.43E-01	9.13E-01	1.04E+03	9.88E+02	1.09E+00	5.67E-01	Shredding input	8.8.3
Disposal, desktop computer, to WEEE treatment {CH} U	CH	4.57E+00	3.37E+00	5.38E+03	3.89E+03	1.21E+01	6.17E+00	All inputs equally	8.8.14
Disposal, keyboard, standard version, to WEEE treatment {CH} U	CH	1.78E+00	1.12E+00	1.93E+03	1.20E+03	1.63E+00	6.91E-01	Dismantling input	8.8.10
Disposal, laptop computer, to WEEE treatment {CH} U	CH	3.00E+00	2.59E+00	3.43E+03	2.94E+03	5.82E+00	4.36E+00	All inputs equally	8.8.17
Disposal, mouse device, optical, with cable, to WEEE treatment {CH} U	CH	1.71E-01	1.40E-01	1.85E+02	1.50E+02	1.56E-01	8.63E-02	Dismantling input	8.8.11
Disposal, power adapter, external, for laptop, to WEEE treatment {CH} U	CH	7.54E-01	3.68E-01	8.18E+02	3.95E+02	6.90E-01	2.27E-01	Dismantling input	8.8.9
Disposal, printer, laser jet, b/w, to WEEE treatment {CH} U	CH	1.22E+01	1.22E+01	1.30E+04	1.28E+04	5.27E+00	4.15E+00	Shredding input	8.8.6
Disposal, printer, laser jet, colour, to WEEE treatment {CH} U	CH	1.22E+01	1.22E+01	1.30E+04	1.28E+04	5.27E+00	4.15E+00	Shredding input	8.8.7
Electronic component machinery, unspecified {GLO} U	GLO	1.96E+04	1.69E+04	6.17E+07	5.97E+07	3.09E+05	2.54E+05	Cable input	8.4.33
Electronic component production plant {GLO} U	GLO	2.75E+08	2.75E+08	5.97E+11	6.47E+11	3.26E+09	3.26E+09	-	8.4.34
Electronic component, active, unspecified, at plant {GLO} U	GLO	6.98E+02	4.71E+02	2.79E+06	2.92E+06	1.15E+04	7.77E+03	Changes in inputs	8.4.29
Electronic component, passive, unspecified, at plant {GLO} U	GLO	4.79E+01	5.24E+01	2.08E+05	2.55E+05	8.60E+02	8.12E+02	Changes in inputs	8.4.30
Electronic component, unspecified, at plant {GLO} U	GLO	2.62E+02	1.90E+02	1.06E+06	1.13E+06	4.38E+03	3.11E+03	Changes in inputs	8.4.31
Electronics for control units {RER} U	RER	2.50E+01	2.03E+01	8.99E+04	8.70E+04	4.31E+02	3.36E+02	Cable input	8.4.32
Facilities for mechanical treatment of WEEE scrap {GLO} U	GLO	1.67E+05	1.54E+05	4.51E+08	4.40E+08	2.48E+06	2.21E+06	PWB input	8.8.2
HDD, desktop computer, at plant {GLO} U	GLO	1.03E+01	5.29E+00	3.21E+04	1.57E+04	1.82E+02	8.59E+01	PWB input	8.5.31
HDD, laptop computer, at plant {GLO} U	GLO	2.91E+00	2.08E+00	8.10E+03	4.96E+03	5.41E+01	3.28E+01	PWB input	8.5.32

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF] Old	New	Ecological Scarcity Total [UBP / RF] Old	New	CED Total [MJ primary / RF] Old	New	Main source of changes (for ecological scarcity)	Link to annex
Hydroxide, for Li-ion NMC111 battery {GLO} U	GLO	-	1.54E+01	-	4.55E+04	-	2.60E+02	From Empa datasets	8.5.20
Inductor, low value multilayer chip type, LMCI, at plant {GLO} U	GLO	8.11E+01	8.73E+01	7.63E+05	7.69E+05	1.33E+03	1.27E+03	Production efforts	8.4.25
Inductor, miniature RF chip type, MRFI, at plant {GLO} U	GLO	5.13E+01	6.44E+01	2.96E+05	4.13E+05	9.39E+02	9.89E+02	Use of global metal	8.4.26
Inductor, ring core choke type, at plant {GLO} U	GLO	4.05E+01	4.68E+01	7.91E+04	9.17E+04	7.51E+02	6.91E+02	Use of global metal	8.4.27
Inductor, unspecified, at plant {GLO} U	GLO	5.76E+01	6.62E+01	3.80E+05	4.24E+05	1.01E+03	9.82E+02	Market shares	8.4.28
Integrated circuit, IC, logic type, at plant {GLO} U	GLO	9.66E+02	6.08E+02	4.38E+06	3.73E+06	15202.0	1.02E+04	Less energy uses	8.2.1
Integrated circuit, IC, memory type, at plant {GLO} U	GLO	4.78E+02	3.63E+02	1.11E+06	2.61E+06	8.98E+03	5.87E+03	Higher gold use	8.2.2
Keyboard, standard version, at plant {GLO} U	GLO	2.50E+01	1.00E+01	7.86E+04	2.89E+04	4.10E+02	1.62E+02	PWB input	8.5.33
Laptop computer, at plant {GLO} U	GLO	2.08E+02	1.39E+02	5.59E+05	5.56E+05	2.54E+03	2.13E+03	Input compensation	8.6.2
LCD flat screen, 17 inches, at plant {GLO} U	GLO	3.37E+02	1.74E+02	8.28E+05	4.62E+05	4.68E+03	2.43E+03	LCD module input	8.5.17
LCD glass, at plant {GLO} U	GLO	4.67E+00	3.57E+00	7.43E+03	5.91E+03	6.82E+01	5.50E+01	Less energy uses	8.5.12
LCD module, at plant {GLO} U	GLO	6.07E+01	5.33E+01	1.47E+05	1.37E+05	8.41E+02	7.01E+02	Assembly input	8.5.15
LCD screen, at plant {GLO} U	GLO	1.05E+01	8.28E+00	1.96E+04	1.67E+04	1.15E+02	1.01E+02	Region of electricity	8.5.16
Light emitting diode, LED, at plant {GLO} U	GLO	2.19E+02	2.43E+02	3.88E+05	4.22E+05	4.38E+03	3.97E+03	Use of global metal	8.4.14
Mechanical treatment plant, WEEE scrap {GLO} U	GLO	3.11E+06	3.08E+06	7.85E+09	7.82E+09	4.92E+07	4.85E+07	Facilities input	8.8.1
Mounting, surface mount technology, Pb-free solder {GLO} U	GLO	5.63E+00	6.29E+00	1.91E+04	1.98E+04	1.06E+02	1.02E+02	Region of electricity	8.3.1
Mounting, through-hole technology, Pb-free solder {GLO} U	GLO	4.36E+01	4.46E+01	1.24E+05	1.25E+05	9.05E+02	8.99E+02	Region of Nitrogen	8.3.2
Mouse device, optical, with cable, at plant {GLO} U	GLO	4.84E+00	2.97E+00	1.68E+04	1.13E+04	8.26E+01	4.68E+01	PWB input	8.5.34
Network access devices, internet, at user {GLO} U	GLO	6.26E+00	5.97E+00	1.41E+04	1.88E+04	1.11E+02	8.66E+01	Chassis input	0
Oxide, for Li-ion NMC111 battery {GLO} U	GLO	-	2.15E+01	-	5.41E+04	-	3.45E+02	From Empa datasets	8.5.20
Plugs, inlet and outlet, for computer cable, at plant {GLO} U	GLO	2.71E-01	2.76E-01	8.19E+02	1.01E+03	6.08E+00	6.17E+00	Use of global metal	8.5.9
Plugs, inlet and outlet, for network cable, at plant {GLO} U	GLO	4.33E-02	4.35E-02	1.32E+02	1.32E+02	9.30E-01	9.30E-01	-	8.5.10
Plugs, inlet and outlet, for printer cable, at plant {GLO} U	GLO	4.49E-01	4.52E-01	9.89E+02	1.13E+03	1.04E+01	1.04E+01	Use of global metal	8.5.11
Potentiometer, unspecified, at plant {GLO} U	GLO	3.34E+01	3.83E+01	6.08E+04	6.99E+04	5.99E+02	5.48E+02	Use of global metal	8.4.19
Power adapter, for laptop, at plant {GLO} U	GLO	3.77E+00	5.10E+00	9.45E+03	2.50E+04	5.81E+01	7.96E+01	Inductor input	8.5.29
Power supply unit, at plant {GLO} U	GLO	2.68E+01	2.75E+01	6.50E+04	6.96E+04	5.01E+02	4.40E+02	PWB input	8.5.30
Printed wiring board mounting facilities, SMT type {GLO} U	GLO	9.55E+04	9.56E+04	2.62E+08	2.63E+08	1.44E+06	1.44E+06	Cable input	8.3.18
Printed wiring board mounting facilities, THT type {GLO} U	GLO	1.64E+04	1.64E+04	5.51E+07	5.56E+07	2.63E+05	2.63E+05	Cable input	8.3.19
Printed wiring board mounting plant {GLO} U	GLO	6.78E+06	6.78E+06	1.81E+10	1.81E+10	1.09E+08	1.09E+08	-	8.3.20
Printed wiring board, mixed mounted, unspec., solder mix, at plant {GLO} U	GLO	1.47E+02	1.12E+02	5.63E+05	5.30E+05	2.47E+03	1.79E+03	PWB input	8.3.17
Printed wiring board, mounted, Desktop PC mainboard, at plant {GLO} U	GLO	1.53E+02	1.24E+02	6.03E+05	6.36E+05	2.60E+03	1.97E+03	Market shares	8.3.12

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF]		Ecological Scarcity Total [UBP / RF]		CED Total [MJ primary / RF]		Main source of changes (for ecological scarcity)	Link to annex
		Old	**New**	**Old**	**New**	**Old**	**New**		
Printed wiring board, mounted, Desktop PC mainboard, Pb free, at plant {GLO} U	GLO	1.53E+02	1.24E+02	6.04E+05	6.36E+05	2.60E+03	1.97E+03	IC input	8.3.11
Printed wiring board, mounted, Laptop PC mainboard, at plant {GLO} U	GLO	2.54E+02	1.87E+02	9.39E+05	1.05E+06	4.33E+03	3.00E+03	Market shares	8.3.14
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant {GLO} U	GLO	2.54E+02	1.87E+02	9.40E+05	1.05E+06	4.33E+03	3.00E+03	IC input	8.3.13
Printed wiring board, power supply unit desktop PC, Pb free, at plant {GLO} U	GLO	3.67E+01	3.85E+01	8.70E+04	9.34E+04	6.92E+02	6.06E+02	Inductor & IC inputs	8.3.15
Printed wiring board, power supply unit desktop PC, solder mix, at plant {GLO} U	GLO	3.72E+01	3.85E+01	8.76E+04	9.34E+04	7.03E+02	6.06E+02	Inductor & IC inputs	8.3.16
Printed wiring board, surface mount, at plant {GLO} U	GLO	2.71E+02	2.47E+02	5.86E+05	7.05E+05	5.01E+03	3.60E+03	Market shares	8.3.4
Printed wiring board, surface mount, lead-free surface, at plant {GLO} U	GLO	2.72E+02	2.47E+02	5.94E+05	7.05E+05	5.03E+03	3.60E+03	Use of global metal	8.3.3
Printed wiring board, surface mounted, unspec., Pb free, at plant {GLO} U	GLO	2.40E+02	1.74E+02	9.69E+05	9.04E+05	3.97E+03	2.78E+03	IC input	8.3.7
Printed wiring board, surface mounted, unspec., solder mix, at plant {GLO} U	GLO	2.40E+02	1.74E+02	9.67E+05	9.04E+05	3.97E+03	2.78E+03	Market shares	8.3.8
Printed wiring board, through-hole mounted, unspec., Pb free, at plant {GLO} U	GLO	5.28E+01	4.96E+01	1.57E+05	1.56E+05	9.48E+02	7.87E+02	IC input	8.3.9
Printed wiring board, through-hole mounted, unspec., solder mix, at plant {GLO} U	GLO	5.33E+01	4.96E+01	1.58E+05	1.56E+05	9.60E+02	7.87E+02	Market shares	8.3.10
Printed wiring board, through-hole, at plant {GLO} U	GLO	9.88E+01	9.11E+01	2.01E+05	2.19E+05	1.82E+03	1.40E+03	Market shares	8.3.6
Printed wiring board, through-hole, lead-free surface, at plant {GLO} U	GLO	9.88E+01	9.11E+01	1.95E+05	2.19E+05	1.82E+03	1.40E+03	Use of global metal	8.3.5
Printer, laser jet, b/w, at plant {GLO} U	GLO	6.75E+01	6.99E+01	1.04E+05	1.05E+05	8.34E+02	8.44E+02	No chromium steel	8.5.27
Printer, laser jet, colour, at plant {GLO} U	GLO	6.76E+01	7.00E+01	1.04E+05	1.05E+05	8.37E+02	8.47E+02	No chromium steel	8.5.28
Production efforts, capacitors {GLO} U	GLO	3.43E+01	4.02E+01	6.57E+04	7.15E+04	6.71E+02	6.01E+02	Region of electricity	8.4.1
Production efforts, diodes {GLO} U	GLO	2.16E+02	2.40E+02	3.76E+05	3.94E+05	4.33E+03	3.91E+03	Region of electricity	8.4.2
Production efforts, inductors {GLO} U	GLO	3.21E+01	3.82E+01	6.29E+04	6.90E+04	6.33E+02	5.70E+02	Region of electricity	8.4.3
Production efforts, resistors {GLO} U	GLO	2.54E+01	3.02E+01	4.72E+04	5.20E+04	4.89E+02	4.36E+02	Region of electricity	8.4.4
Production efforts, transistors {GLO} U	GLO	1.14E+02	1.40E+02	2.04E+05	2.27E+05	2.30E+03	2.04E+03	Region of electricity	8.4.5
Resistor, metal film type, through-hole mounting, at plant {GLO} U	GLO	2.92E+01	3.46E+01	6.56E+04	1.01E+05	5.55E+02	5.14E+02	Use of global metal	8.4.17
Resistor, SMD type, surface mounting, at plant {GLO} U	GLO	1.30E+02	1.70E+02	1.67E+06	2.21E+06	2.16E+03	2.69E+03	Use of global metal	8.4.16
Resistor, unspecified, at plant {GLO} U	GLO	5.49E+01	6.87E+01	4.63E+05	6.09E+05	9.58E+02	1.05E+03	Market shares	8.4.20
Resistor, wirewound, through-hole mounting, at plant {GLO} U	GLO	2.70E+01	3.18E+01	5.23E+04	5.98E+04	5.14E+02	4.62E+02	Use of global metal	8.4.18
Router, IP network, at server {GLO} U	GLO	2.94E+01	1.84E+01	6.72E+04	1.02E+05	5.09E+02	3.02E+02	PWB input	8.7.3
Shredding, electrical and electronic scrap {CH} U	CH	4.01E-02	1.00E-02	8.67E+01	3.87E+01	8.27E-01	3.04E-01	Swiss electricity input	8.8.4
Toner module, laser jet, b/w, at plant {GLO} U	GLO	9.22E+00	1.04E+01	1.61E+04	1.71E+04	2.04E+02	1.91E+02	Region of electricity	8.5.22
Toner module, laser jet, colour, at plant {GLO} U	GLO	9.29E+00	1.05E+01	1.62E+04	1.72E+04	2.06E+02	1.94E+02	Region of electricity	8.5.25
Toner, black, powder, at plant {GLO} U	GLO	5.27E+00	6.06E+00	9.31E+03	9.96E+03	1.37E+02	1.29E+02	Region of electricity	8.5.21
Toner, black, used for printing, at user {GLO} U	GLO	4.15E+01	4.67E+01	6.96E+04	7.39E+04	8.15E+02	7.63E+02	Region of electricity	8.5.23
Toner, colour, powder, at plant {GLO} U	GLO	5.55E+00	6.34E+00	9.75E+03	1.04E+04	1.48E+02	1.40E+02	Region of electricity	8.5.24
Toner, colour, used for printing, at user {GLO} U	GLO	3.88E+01	4.41E+01	6.71E+04	7.14E+04	8.26E+02	7.73E+02	Region of electricity	8.5.26
Transistor, SMD type, surface mounting, at plant {GLO} U	GLO	1.18E+02	1.86E+02	2.20E+05	8.31E+05	2.37E+03	2.78E+03	Amount of Nickel & Iron	8.4.21

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF]		Ecological Scarcity Total [UBP / RF]		CED Total [MJ primary / RF]		Main source of changes (for ecological scarcity)	Link to annex
		Old	**New**	**Old**	**New**	**Old**	**New**		
Transistor, unspecified, at plant {GLO} U	GLO	1.18E+02	1.58E+02	2.20E+05	4.55E+05	2.37E+03	2.34E+03	Market shares	8.4.24
Transistor, wired, big size, through-hole mounting, at plant {GLO} U	GLO	1.18E+02	1.44E+02	2.20E+05	2.67E+05	2.37E+03	2.12E+03	Use of global metal	8.4.22
Transistor, wired, small size, through-hole mounting, at plant {GLO} U	GLO	1.18E+02	1.44E+02	2.20E+05	2.68E+05	2.37E+03	2.12E+03	Use of global metal	8.4.23
Wafer, fabricated, for integrated circuit, at plant {GLO}	GLO	6.61E+04	-	1.31E+08	-	7.12E+05	-	Split in 2 below	8.1
Wafer, fabricated, for integrated circuit, logic type, at plant {GLO} U	GLO	-	1.80E+04	-	3.43E+07	-	3.10E+05	Error removed	8.1
Wafer, fabricated, for integrated circuit, memory type, at plant {GLO} U	GLO	-	9.26E+03	-	2.00E+07	-	1.51E+05	Error removed	8.1

3.2 Overview of potential environmental impacts for new LCI datasets

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF] New	Ecological Scarcity Total [UBP / RF] New	CED Total [MJ primary / RF] New	Link to annex
All-in-one printer (WiFi), at plant {GLO} U	GLO	8.53E+01	1.71E+05	1.48E+03	9.2.3
Assembly, OLED module, at plant {GLO} U	GLO	3.09E+01	6.14E+04	4.22E+02	9.5.3
Beamer, at plant {GLO} U	GLO	7.49E+01	3.00E+05	1.17E+03	9.2.5
Blade server, at data center {GLO} U	GLO	3.52E+02	1.57E+06	5.55E+03	9.7.4.1
Case, for smartphone, at plant {GLO} U	GLO	9.80E-01	1.66E+03	1.88E+01	9.3.4
Case, for tablet, at plant {GLO} U	GLO	7.44E+00	1.25E+04	1.47E+02	9.4.2
Charger, for smartphone, at plant {GLO} U	GLO	7.64E-01	3.75E+03	1.19E+01	9.3.5
Charger, for tablet, at plant {GLO} U	GLO	7.64E-01	3.75E+03	1.19E+01	9.4.3
Complex Set Top Boxes (CSTB), for customer premise equipment (CPE) {CH} U	CH	9.50E+00	2.80E+04	1.54E+02	0
CPU, network equipment, at plant {GLO} U	GLO	6.07E+01	5.03E+05	9.60E+02	9.7.5
Data center {GLO} U	GLO	7.08E+05	1.67E+09	9.03E+06	0
Docking station, at plant {GLO} U	GLO	3.39E+01	9.74E+04	5.63E+02	9.2.2
External drive, at plant {GLO} U	GLO	1.15E+01	2.62E+04	1.85E+02	9.1.2
Facility of data center {GLO} U	GLO	6.56E+05	1.43E+09	8.22E+06	9.7.1
HDMI cable, at plant {GLO} U	GLO	6.57E+00	8.96E+04	1.67E+02	9.2.1
Headset (bluetooth), for smartphone, at plant {GLO} U	GLO	6.03E+00	1.89E+04	1.28E+02	9.3.8
Headset (wired), for smartphone, at plant {GLO} U	GLO	1.85E+00	3.66E+03	3.69E+01	9.3.9
Heat sink for CPU, network equipment, at plant {GLO} U	GLO	3.28E+00	6.59E+04	5.54E+01	9.7.6
Inkjet cartridge, at plant {GLO} U	GLO	6.27E-01	1.35E+03	1.18E+01	9.2.4
Keyboard, wireless version, at plant {GLO} U	GLO	1.36E+01	4.45E+04	2.19E+02	9.2.6
LED module, at plant {GLO} U	GLO	8.42E+01	1.90E+05	1.21E+03	9.5.1
LED screen 23 inches, at plant {GLO} U	GLO	1.36E+02	3.15E+05	1.96E+03	9.5.2
Modem, for customer premise equipment (CPE) {CH} U	CH	2.43E+01	1.07E+05	4.00E+02	9.6.1.1
Mouse device, optical, wireless, at plant {GLO} U	GLO	4.35E+00	1.62E+04	6.79E+01	9.2.7
Multimedia gateway, for customer premise equipment (CPE) {CH} U	CH	8.10E+01	3.51E+05	1.33E+03	9.6.1.2
Network Attached Storage, NAS, at plant {GLO} U	GLO	6.91E+01	2.68E+05	1.13E+03	9.1.1
Network equipment, at data center {GLO} U	GLO	1.55E+02	6.96E+05	2.45E+03	9.7.3
OLED module, at plant {GLO} U	GLO	8.16E+01	2.03E+05	1.29E+03	9.5.4
OLED screen 43 inches, at plant {GLO} U	GLO	4.30E+02	1.15E+06	6.61E+03	9.5.5
Points of presence, network equipment {GLO} U	GLO	1.11E+01	4.14E+04	1.60E+02	9.6.1.4

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF] **New**	Ecological Scarcity Total [UBP / RF] **New**	CED Total [MJ primary / RF] **New**	Link to annex
Rack server, at data center {GLO} U	GLO	5.63E+02	2.67E+06	8.85E+03	9.7.4.3
Server, at data center {GLO} U	GLO	4.84E+02	2.26E+06	7.55E+03	9.7.4
Smartphone, high-tech phone, at plant {GLO} U	GLO	3.30E+01	9.85E+04	5.52E+02	9.3.1
Smartphone, mid-tier, average phone, at plant {GLO} U	GLO	2.72E+01	8.70E+04	4.55E+02	9.3.2
Smartphone, repairable type Fairphone, at plant {GLO} U	GLO	1.88E+01	4.69E+04	3.15E+02	9.3.3
Solid State Drive, SSD, at plant {GLO} U	GLO	1.78E+01	4.04E+04	2.86E+02	9.1.3
Spare batteries, for smartphone, at plant {GLO} U	GLO	4.92E-01	1.55E+03	8.46E+00	9.3.6
Spare batteries, for tablet, at plant {GLO} U	GLO	1.70E+00	5.35E+03	2.93E+01	9.4.4
Spare screen, for smartphone, at plant {GLO} U	GLO	2.53E+00	5.70E+03	3.63E+01	9.3.7
Spare screen, for tablet, at plant {GLO} U	GLO	1.23E+01	2.77E+04	1.77E+02	9.4.5
Storage array, at data center {GLO} U	GLO	5.42E+00	1.60E+04	8.79E+01	9.7.2
Switch, data center devices, at plant {GLO} U	GLO	4.11E+02	1.96E+06	6.50E+03	9.7.7
Tablet, average, at plant {GLO} U	GLO	5.44E+01	1.43E+05	8.79E+02	9.4.1
Tower server, at data center {GLO} U	GLO	5.37E+02	2.54E+06	8.27E+03	9.7.4.2
use of cable, fixed IP access network per GB {CH} U	CH	1.36E-01	5.73E+02	1.01E+01	9.6.4.1
use of cable, fixed IP access network per hour {CH} U	CH	1.32E-03	5.57E+00	9.81E-02	9.6.5.1
use of core national IP network per GB {CH} U	CH	4.58E-04	2.38E+00	2.48E-02	9.6.6
use of core national IP network per hour {CH} U	CH	3.92E-05	2.04E-01	2.12E-03	9.6.7
use of CPE, for transmission network per GB {CH} U	CH	4.39E-03	1.83E+01	3.04E-01	9.6.2
use of CPE, for transmission network per hour {CH} U	CH	1.70E-03	7.07E+00	1.03E-01	9.6.3
use of fixed IP access network per GB {CH} U	CH	6.58E-02	2.78E+02	4.81E+00	9.6.4.1
use of fixed IP access network per hour {CH} U	CH	9.90E-04	4.20E+00	7.18E-02	9.6.5.1
use of global transmission network per GB {GLO} U	CH	6.00E-02	9.48E+01	9.03E-01	9.6.8
use of IP access network, shares per GB {CH} U	CH	5.79E-02	2.46E+02	4.18E+00	9.6.4
use of IP access network, shares per hour {CH} U	CH	8.72E-04	3.72E+00	6.24E-02	9.6.5
use of optic fibre, fixed IP access network per GB {CH} U	CH	2.10E-03	9.38E+00	1.39E-01	9.6.4.1
use of optic fibre, fixed IP access network per hour {CH} U	CH	5.00E-05	2.24E-01	3.32E-03	9.6.5.1
use of wireless IP access network per GB {CH} U	CH	2.01E-02	9.20E+01	1.10+00	9.6.4.2
use of wireless IP access network per hour {CH} U	CH	3.08E-04	1.41E+00	1.68E-02	9.6.5.2
use of wireless IP access network, 2-4G per GB {CH} U	CH	1.81E-02	8.28E+01	9.89E-01	9.6.4.2
use of wireless IP access network, 2-4G per hour {CH} U	CH	2.77E-04	1.27E+00	1.51E-02	9.6.5.2
use of wireless IP access network, 5G per GB {CH} U	CH	2.41E-01	1.11E+03	1.30E+01	9.6.4.2
use of wireless IP access network, 5G per hour {CH} U	CH	3.69E-03	1.70E+01	1.99E-01	9.6.5.2

Activity	Region	IPCC 2021 GWP 100a [kg CO_2 eq / RF] **New**	Ecological Scarcity Total [UBP / RF] **New**	CED Total [MJ primary / RF] **New**	Link to annex
use of xDSL, fixed IP access network per GB {CH} U	CH	3.90E-02	1.66E+02	2.79E+00	9.6.4.1
use of xDSL, fixed IP access network per hour {CH} U	CH	9.59E-04	4.08E+00	6.85E-02	9.6.5.1
use, laptop, high intensity per GB {CH} U	CH	9.37E-01	2.85E+03	4.29E+01	9.8.6
use, laptop, high intensity per hour {CH} U	CH	4.46E-01	7.68E+02	7.09E+00	9.9.6
use, laptop, low intensity per GB {CH} U	CH	3.58E-02	1.30E+02	1.16E+00	9.8.4
use, laptop, low intensity per hour {CH} U	CH	3.14E-02	1.12E+02	8.20E-01	9.9.4
use, laptop, medium intensity per GB {CH} U	CH	1.53E-01	4.85E+02	6.60E+00	0
use, laptop, medium intensity per hour {CH} U	CH	8.54E-02	1.97E+02	1.63E+00	9.9.5
use, smartphone, high intensity per GB {CH} U	CH	5.76E-01	1.36E+03	1.44E+01	9.8.3
use, smartphone, high intensity per hour {CH} U	CH	4.32E-01	7.02E+02	6.59E+00	9.9.3
use, smartphone, low intensity per GB {CH} U	CH	2.01E-02	5.57E+01	4.41E-01	0
use, smartphone, low intensity per hour {CH} U	CH	1.84E-02	4.78E+01	3.48E-01	9.9.1
use, smartphone, medium intensity per GB {CH} U	CH	9.26E-02	2.26E+02	2.26E+00	9.8.2
use, smartphone, medium intensity per hour {CH} U	CH	7.24E-02	1.33E+02	1.16E+00	9.9.2

4 Discussion

This chapter provides a brief analysis of some key aspects of the changes that have been observed during the project for ICT LCI datasets that have been updated or created. It highlights the main trends explaining the changes, some aspects that might require further analyses and some key aspects of usage scenarios.

4.1 Key changes in the model of ICT LCI datasets

The list of "main source of changes" for updated LCI datasets (section 3.1) shows that most of the substantial changes in potential environmental impacts can be attributed to the use of primary metals and global average electricity mix to represent the supply chains of ICT components and devices. The environmental effects of these changes (i.e. increase in impacts) is sometimes compensated by a reduction of input flows because of lower material uses or higher energy efficiency of the production processes. For the new LCI datasets, it is interesting to see that devices are a key source of environmental impacts in ICT usage scenarios, which follows observations of previous work at Empa. Nevertheless, subsection 4.3.4.3 explains how this could change with higher data consumption levels in the future.

4.2 Overview of changes at database level

Figure 4.2-1 presents the observed relative differences between the ecological scarcity scores (UBP) of the old and new ICT LCI datasets that have been updated (see section 3.1 for the complete list). Each column represents 1 LCI dataset that was in the old version of the database. This overview shows that a substantial portion (~60%) of the LCI datasets have not changed their UBP score significantly (i.e. less than 10%). This does not means that values and flows have not changed in the new LCI datasets, but that the changes are minimal or that they counteract each other. Selected largest changes (i.e. top 7 increases and 7 reductions) are listed in table 4.2-1 to show the LCI datasets that have changed drastically in comparison with their previous version.

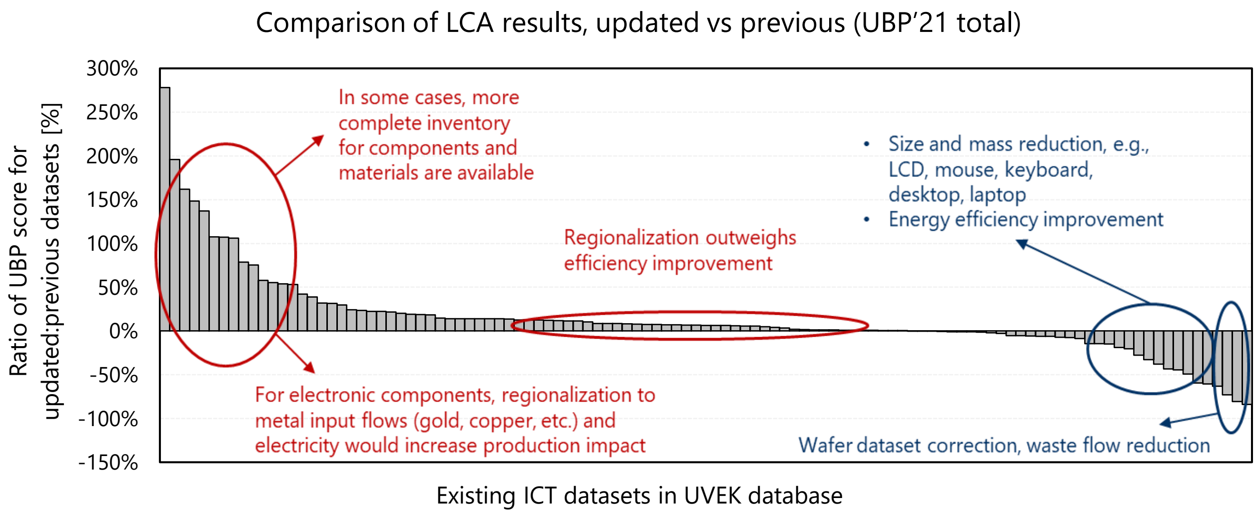

Figure 4.2-1. Comparison of LCA results (LCIA: single score UBP 2021) after and before the LCI update

Table 4.2-1. ICT datasets with large changes in LCA results using single score UBP 2021 method

Selected top 7 increase	Value (%)	Selected top 7 decrease	Value (%)
transistor, SMD type, surface mounting	278%	wafer, fabricated, for integrated circuit, memory	-85%
Cable, three-conductor cable	195%	wafer, fabricated, for integrated circuit, logic	-74%
Power adapter, for laptop	165%	Keyboard, standard version	-63%
Cable, data cable in infrastructure	148%	Shredding, electrical and electronic scrap	-55%
integrated circuit, IC, memory type	135%	HDD, desktop computer	-51%
Transistor, unspecified	107%	HDD, laptop computer	-39%
Cable, connector for computer	106%	Mouse device, optical, with cable	-33%

Detailed descriptions of the changes made during the update are provided in the appendix (section 8). This dataset information can help in understanding why such variations are observed. The hyperlink that is connected to each dataset in the table above (see section 3.1).

4.3 Further analysis for selected ICT LCI datasets

4.3.1 Wafer and integrated circuits

The environmental impacts of integrated circuits (ICs) for mobile devices may be underestimated in this update because there is a lack of available detailed descriptions of material content for new ICs. The technologies are nowadays mainly based on stacked ICs or package on package (PoP) technologies but we did not find reference that provided a detailed bill of materials for these recent technologies. With these new stacked options, mobile devices can deliver strong performance on a small surface (Apte et al., 2011; Pirson & Bol, 2021; Teehan, 2014), which might increase their environmental impacts per unit of surface.

4.3.2 Comparison of devices with the literature

Figure 4.3-1 presents a comparison of the carbon footprint from devices that have been modelled in this project and the carbon footprints of similar devices published by other organizations. The first models that we used presented much lower results than the other studies, which lead us to correct the impacts of ICs (see previous subsection). This assumption could be verified later with lab experiments on dismantled ICs.

4.3.3 Use of metals in ICT components

It is important to mention that the use of primary metals like copper, gold and silver can have a substantial effects on the potential environmental impacts of ICT components, mainly when considering all the categories of the ecological scarcity method. The previous version of the database was using a European market of primary and secondary metals, but this was changed to be representative of the global nature of the ICT supply chains.

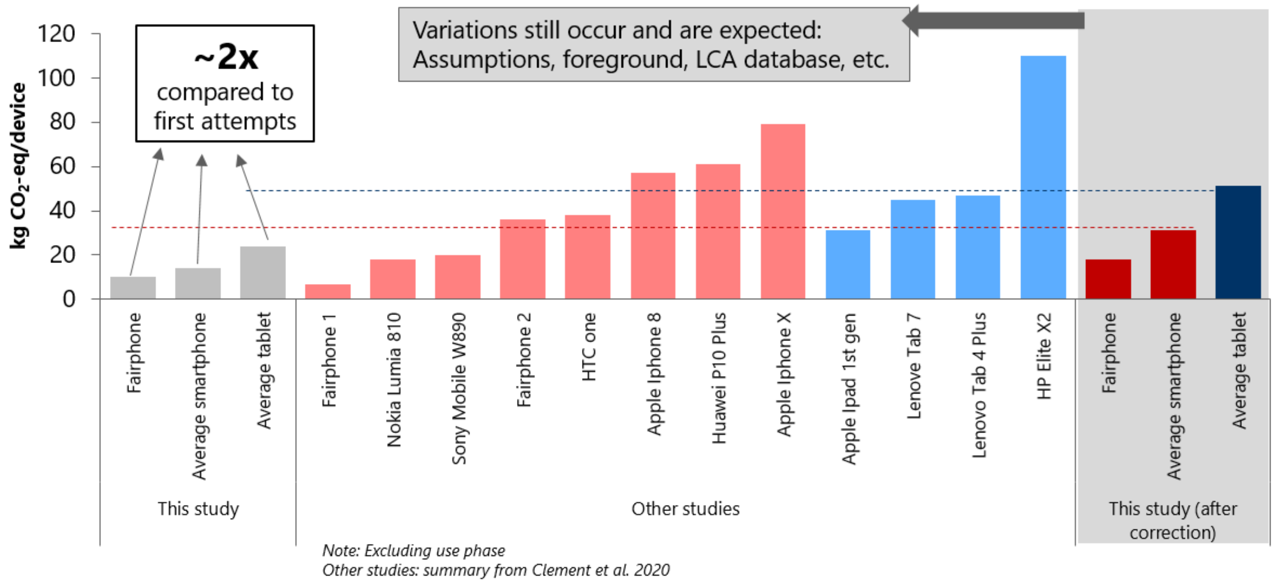

Figure 4.3-1. Carbon footprint of portable devices before and after modelling correction
*The Fairphone presented in this study are for Fairphone 1.

Figure 4.3-1 presents a comparison of carbon footprint values for ICT devices modelled in this study (before and after adaptation of the IC component) and in other public documents to provide some context. With that being said, we want to highlight that such a comparison is limited in its value since there is no verification that the scope and modelling assumptions of all studies are consistent. Some of the difference between devices could thus be explained by differences in the used background data and modelling assumptions.

4.3.4 Use case scenarios

4.3.4.1 Impact of smartphone use

Figure 4.3-2 presents the key sources of the carbon footprint for the average use of a smartphone in Switzerland under conditions that are specified below. This shows that much of the GHG emissions are linked to the use of energy sources, but that it is a connection that is mainly due to the use of energy for manufacturing the smartphone's components. The following subsection (4.3.4.3) provides a sensitivity analysis of varying data usage to put these results into perspective with the current increase in data usage on smartphones.

- Functional unit: the use of smartphone in Switzerland, with 2 years device lifetime
- Parameters: 4h active use/day; 7.2 kWh/year (5 W), 48 GB data consumption/year (Cordella et al., 2021)

Total GWP impacts according to IPCC 2021 = 41 kg CO_2-eq.

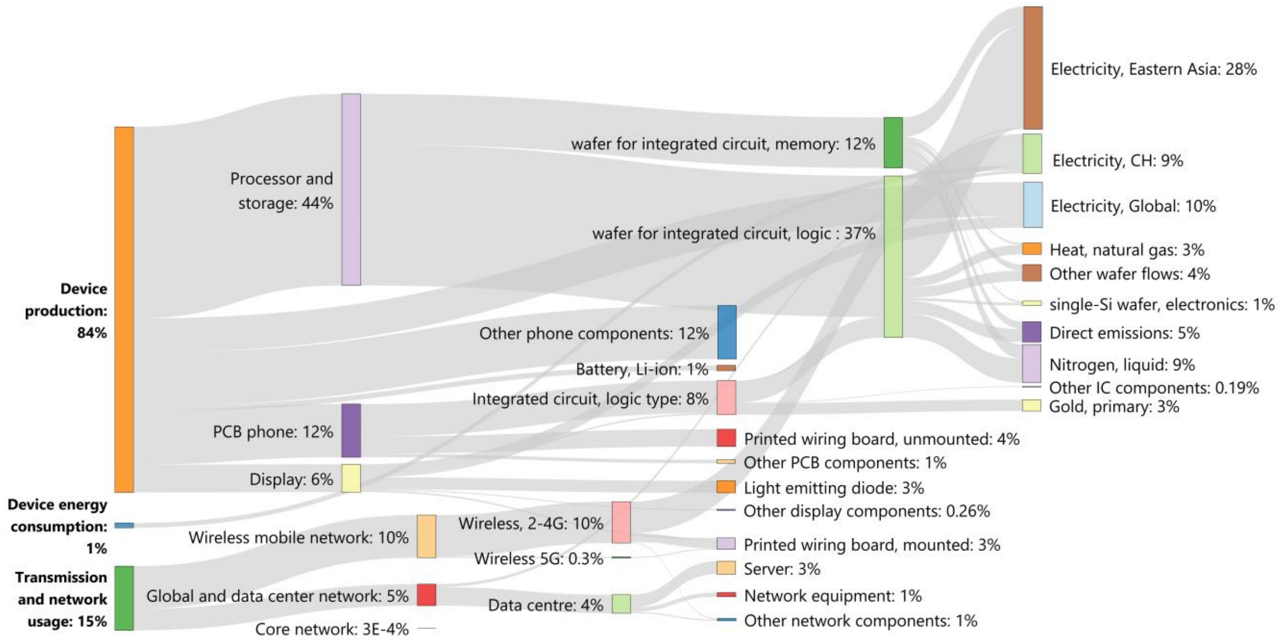

Figure 4.3-2. Hotspot analysis (Sankey diagram) for the use of smartphone in Switzerland for 2 years

4.3.4.2 Modelling the use of the internet infrastructure

After a few iterations to model the internet infrastructure and its use, it became clear that there would be conceptual challenges in defining a relevant reference flow. The preliminary choice was to use the amount of data transfer to describe the impacts of internet use (e.g. 1 GB of transferred data). This seems like a relevant choice since the final service of the internet is to transfer data to everyone. With that being said, choosing such a reference flow means that we often have to use top-down statistics on the annual use of electricity in relation to the total yearly data transfer. With such a modelling choice, we thus implicitly aggregate all electricity use of the network to the transferred data, which can raise concerns since much of the electricity is consumed to have the network ready to be used (i.e. the idle consumption of equipment is substantial). The input electricity flow values (in kWh/GB) are therefore sometimes very high in relation to hourly use scenarios that we have defined since they could represent power levels that cannot be managed by a house or the equipment. For example, the summed of electricity use for downloading an HD movie in 2 minutes with a high speed broadband connection would be linked to power consumption above 4 kW, which cannot be managed by the electronics of WiFi routers. The other option is to use reference flows that model the connection to the internet for a certain amount of time (e.g. 1 hour). Such a bottom-up approach allows for the use of power consumption levels from different devices, where the idle power consumption is similar to the power consumption when data is downloaded. Both options have their merits so we decided to present the models of the internet use with both perspectives to let the readers see the variations more clearly.

This was however not possible for the use of electricity in data centres at the global scale, which means that we have taken a conservative approach of aggregating all kWh use per transferred GB even if some electricity is for computation. More explanations on this choice are provided in section 9.6.8.

4.3.4.3 Impact of internet use per hour

Table 4.3-1. Sensitivity analysis for use phase and transmission networks

	Digital services	Carbon footprint ($kg\ CO_2$-eq./h)	Geographic validity, parameter changes
Viana et al. 2022	Video streaming = 0.3 – 0.9 GB/hr	0.003 – 0.94	Canada
Obringer et al. 2021	Streaming 480p = 0.2 GB/hr	0.07	Global, average
	Streaming ultra-HD or 4K = 7 GB/hr	0.44	
This study	Light data consumption = 0.1 GB/hr	0.0184-0.0201	Based on Swiss (CH) electricity mix Global data centre energy use 320 TWh/y ~ 17.1 ZB/y Consider wireless IP network only
	Moderate data consumption = 1 GB/hr	0.0724-0.0926	
	Heavy data consumption = 7 GB/hr	0.432-0.576	
3 sensitivity based on the moderate data consumption above	With higher power consumption of phone	0.206	Phone power = 10 W
	If data centre operations are more efficient	0.186	Data centre energy use = 220 TWh/y

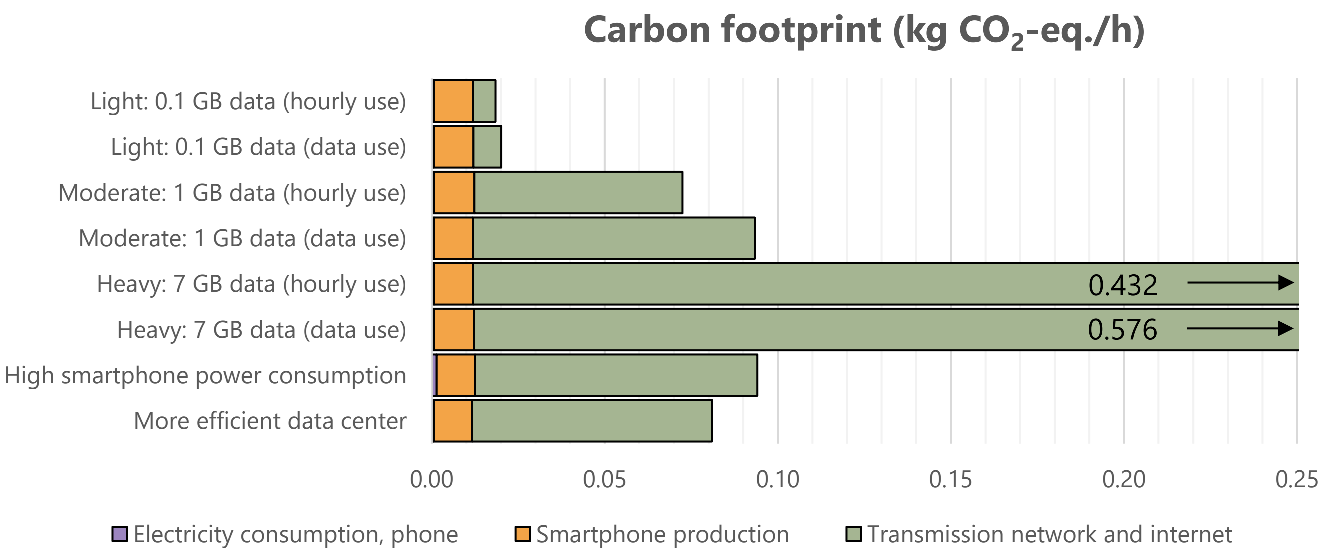

Figure 4.3-3. Hotspot analysis for the use of smartphone in Switzerland. FU = 1 hour use of device

From these sensitivity analyses (Figure 4.3-3), the following points can be made:

- Device manufacturing dominates the carbon footprint of using ICT devices when data usage intensity is low; the transmission network can become an environmental hotspot when Internet data consumption is high, i.e. above 1 GB/hr.
- The data transmission network and infrastructure systems can now be represented in the LCA database. This could allow future studies to parameterize network use under different ICT infrastructures and different conditions at other locations.

4.4 Uncertainties of flows in datasets

The uncertainties of the flows in the updated and created LCI datasets is still important. This can be explain in big part by the fact that we limited our data sources to publicly available documents. It is therefore difficult to say if they can be representative of the average flows for the ICT equipment, devices, infrastructures and usage scenarios or if they are the best estimates from experts. We would thus not recommend to make a comparison between these values and the potential environmental impacts that are published by manufacturers without further analyses.

With that being said, the uncertainty has been taken into account in the definition of the LCI datasets. Indeed, the Pedigree Matrix method has been used to make a semi-quantitative analysis of the representativeness of all flows in comparison to our goal of representing the average of the ICT sector for global supply chains and usage in Switzerland. We highly recommend to consider the range of uncertainties for all LCI datasets if you want to compare different equipment and devices of this update.

Furthermore, to limit the space for comments in the tables of sections 8 and 9, we did not include the information on the basic uncertainty (BU) parameter. They are nevertheless considered and presented in the description of the datasets in the UVEK database. The BU factors for all types of flows have been defined by following the typical methodological guidelines for uncertainties (Wernet et al. 2016).

5 Conclusion

In this study, a systematic approach is taken to (1) update existing ICT LCI datasets and (2) model new ICT LCI datasets in the UVEK LCA database. Secondary or public data found in literature or technical reports are the main sources for the dataset update/creation. The background datasets required for modelling the inventories are based on a recent version of the UVEK database (UVEK LCI Data DQRv2-2022). A total of 197 datasets have been made available and are accessible in a variety of LCA-readable formats for use in SimaPro or other life cycle assessment software options.

The current work offers updated/new ICT datasets with a high level of details. However, there are some aspects that can be further improved. These aspects are discussed below.

- Some of the background datasets that are not directly linked to the ICT sectors, such as heat and chemicals/materials, are only available in the RER or CH regions. This should be reviewed in the future as it may limit the representativeness of the global ICT supply chains. As an illustration, only the electricity mix datasets can be regionalized to the desired granularity of the model.
- The secondary share of key materials such as metals should be identified, ideally at the product level. While much of this information is not publicly available, efforts should be made to collect sufficient and accurate data from equipment manufacturers to achieve more representative product footprints. In addition, there is a need for more country- or region-specific key materials to improve the representativeness of the ICT datasets and their supply chains in the future.

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7 General Appendix

7.1 Other supporting files

The appendix files for the list of LCI datasets, LCIA results, and the transparent datasets that can be accessible using SimaPro software are provided in the supporting files. Readers should refer to these files for complete details of the project. These annex files are available with the main report folder and shown below. The related reports and previous deliverables are also presented for references.

!!! Please note that the naming convention of flows in dataset changed during the creation of this report. This is the reason why the names of flows in chapters 8 and 9 are not exactly the same as what is now found the database. With that being said, the equivalence between names is rather straightforward and the dataset names presented in section 3 are all following the format of the latest naming convention so the provided link can confirm the equivalences.

Table A-1. List of the entire project deliverables

Deliverables and annex	Description of files
• D.E.1	Documents and updated ICT datasets for UVEK
• D.F.1	Documents and new datasets for ICT
• D.G.1	Integration of ICT datasets in the UVEK database
• Report D.H.a.1 Scope Definition & Models	This report presents the scope definition and used models that are considered during the activities for updating existing datasets and creating new datasets for the description of the information & communication technology (ICT) sector in the UVEK database
• Report D.H.a.2 and D.H.b.1 LCI and LCIA for the ICT	This report presents the LCI and LCA of the updated and created datasets
• Report D.H.c.2 Examples of LCI Datasets	This report presents the procedure that will be followed to update or to create LCI datasets for the ICT sector in the UVEK database
• Report D.H.c.3 Discussions with links to D.H.a.2 and D.H.b.1 reports	This report presents the conversations, discussions, and email exchanges related to the development of ICT datasets during the project
• Progress Meeting Slides o 4 July 2023 o 27 April 2023 o 7 March 2023 o 16 December 2022	Slides presented during interim update meetings over the course of the ICT project

7.2 List of ICT datasets in the project

Table A-2. List of existing ICT datasets with updates

Dataset
aluminium collector foil production, for Li-ion battery, GLO
Anode, graphite, for Li-ion battery, RoW
Assembly, LCD module/GLO U
Assembly, LCD screen/GLO U
Backlight, LCD screen, at plant/GLO U
Battery cell, Li-ion, NMC 111
Battery module packaging, Li-ion, RoW
battery, Li-ion, NMC111, rechargeable, prismatic
Cable, connector for computer, without plugs, at plant/GLO U
Cable, data cable in infrastructure, at plant/GLO U
Cable, network cable, category 5, without plugs, at plant/GLO U
Cable, printer cable, without plugs, at plant/GLO U
Cable, ribbon cable, 20-pin, with plugs, at plant/GLO U
Cable, three-conductor cable, at plant/GLO U
Capacitor, electrolyte type, < 2cm height, at plant/GLO U
Capacitor, electrolyte type, > 2cm height, at plant/GLO U
Capacitor, film, through-hole mounting, at plant/GLO U
Capacitor, SMD type, surface-mounting, at plant/GLO U
Capacitor, Tantalum-, through-hole mounting, at plant/GLO U
Capacitor, unspecified, at plant/GLO U
cathode, lithium-ion battery, NMC111
Chassis, network main devices/RER U
Connector, computer, peripheral type, at plant/GLO U
Connector, PCI bus, at plant/GLO U
copper collector foil production
Desktop computer, without screen, at plant/GLO U
Diode, glass-, SMD type, surface mounting, at plant/GLO U
Diode, glass-, through-hole mounting, at plant/GLO U
Diode, unspecified, at plant/GLO U
Dismantling laptop computer, manually, at plant/GLO U
Dismantling laptop computer, mechanically, at plant/GLO U
Dismantling, desktop computer, manually, at plant/GLO U
Dismantling, desktop computer, mechanically, at plant/GLO U
Dismantling, IT accessories, mechanically, at plant/GLO U
Dismantling, printer, laser, mechanically, at plant/GLO U
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/GLO U
Disposal, desktop computer, to WEEE treatment/CH U
Disposal, keyboard, standard version, to WEEE treatment/CH U
Disposal, laptop computer, to WEEE treatment/CH U
Disposal, mouse device, optical, with cable, to WEEE treatment/CH U

Disposal, power adapter, external, for laptop, to WEEE treatment/CH U
Disposal, printer, laser jet, b/w, to WEEE treatment/CH U
Disposal, printer, laser jet, colour, to WEEE treatment/CH U
Electronic component machinery, unspecified/GLO/I U
Electronic component production plant/GLO/I U
Electronic component, active, unspecified, at plant/GLO U
Electronic component, passive, unspecified, at plant/GLO U
Electronic component, unspecified, at plant/GLO U
Electronics for control units/RER U
Facilities for mechanical treatment of WEEE scrap/GLO/I U
HDD, desktop computer, at plant/GLO U
HDD, laptop computer, at plant/GLO U
Hydroxide, for Li-ion NMC111 battery/GLO U
Inductor, low value multilayer chip type, LMCI, at plant/GLO U
Inductor, miniature RF chip type, MRFI, at plant/GLO U
Inductor, ring core choke type, at plant/GLO U
Inductor, unspecified, at plant/GLO U
Integrated circuit, IC, logic type, at plant/GLO U
Integrated circuit, IC, memory type, at plant/GLO U
Keyboard, standard version, at plant/GLO U
Laptop computer, at plant/GLO U
LCD flat screen, 17 inches, at plant/GLO U
LCD glass, at plant/GLO U
LCD module, at plant/GLO U
LCD screen, at plant {GLO} U
Light emitting diode, LED, at plant/GLO U
Mechanical treatment plant, WEEE scrap/GLO/I U
Mounting, surface mount technology, Pb-free solder/GLO U
Mounting, through-hole technology, Pb-free solder/GLO U
Mouse device, optical, with cable, at plant/GLO U
Network access devices, internet, at user/CH/I U
Oxide, for Li-ion NMC111 battery RoW
Plugs, inlet and outlet, for computer cable, at plant/GLO U
Plugs, inlet and outlet, for network cable, at plant/GLO U
Plugs, inlet and outlet, for printer cable, at plant/GLO U
Potentiometer, unspecified, at plant/GLO U
Power adapter, for laptop, at plant/GLO U
Power supply unit, at plant/CN U
Printed wiring board mounting facilities, SMT type/GLO/I U
Printed wiring board mounting facilities, THT type/GLO/I U
Printed wiring board mounting plant/GLO/I U
Printed wiring board, mixed mounted, unspec., solder mix, at plant/GLO U
Printed wiring board, mounted, Desktop PC mainboard, at plant/GLO U
Printed wiring board, mounted, Desktop PC mainboard, Pb free, at plant/GLO U
Printed wiring board, mounted, Laptop PC mainboard, at plant/GLO U

Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/GLO U
Printed wiring board, power supply unit desktop PC, Pb free, at plant/GLO U
Printed wiring board, power supply unit desktop PC, solder mix, at plant/GLO U
Printed wiring board, surface mount, at plant/GLO U
Printed wiring board, surface mount, lead-free surface, at plant/GLO U
Printed wiring board, surface mounted, unspec., Pb free, at plant/GLO U
Printed wiring board, surface mounted, unspec., solder mix, at plant/GLO U
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/GLO U
Printed wiring board, through-hole mounted, unspec., solder mix, at plant/GLO U
Printed wiring board, through-hole, at plant/GLO U
Printed wiring board, through-hole, lead-free surface, at plant/GLO U
Printer, laser jet, b/w, at plant/GLO U
Printer, laser jet, colour, at plant/GLO U
Production efforts, capacitors/GLO U
Production efforts, diodes/GLO U
Production efforts, inductors/GLO U
Production efforts, resistors/GLO U
Production efforts, transistors/GLO U
Resistor, metal film type, through-hole mounting, at plant/GLO U
Resistor, SMD type, surface mounting, at plant/GLO U
Resistor, unspecified, at plant/GLO U
Resistor, wirewound, through-hole mounting, at plant/GLO U
Router, IP network, at server/CH/I U
shredding, electrical and electronic scrap/kg/GLO
Toner module, laser jet, b/w, at plant/GLO U
Toner module, laser jet, colour, at plant/GLO U
Toner, black, powder, at plant/GLO U
Toner, black, used for printing/GLO U
Toner, colour, powder, at plant/GLO U
Toner, colour, used for printing/GLO U
Transistor, SMD type, surface mounting, at plant/kg/GLO U
Transistor, unspecified, at plant/GLO U
Transistor, wired, big size, through-hole mounting, at plant/kg/GLO U
Transistor, wired, small size, through-hole mounting, at plant/kg/GLO U
wafer, fabricated, for integrated circuit, at plant
wafer, fabricated, for integrated circuit, at plant, logic
wafer, fabricated, for integrated circuit, at plant, memory
Number of datasets = 120

Table A-3. List of existing ICT datasets without updates

Dataset
Battery, LiIo, rechargeable, prismatic, at plant/GLO U
Battery, NiMH, rechargeable, prismatic, at plant/GLO U
CD-ROM/DVD-ROM drive, desktop computer, at plant/GLO U
CD-ROM/DVD-ROM drive, laptop computer, at plant/GLO U
Electronics scrap, for precious metal recovery, at preparation plant/GLO U
Mounting, surface mount technology, Pb-containing solder/GLO U
Mounting, through-hole technology, Pb-containing solder/GLO U
Printed wiring board, mounted, Desktop PC mainboard, Pb containing, at plant/GLO U
Printed wiring board, mounted, Laptop PC mainboard, Pb containing, at plant/GLO U
Printed wiring board, power supply unit desktop PC, Pb containing, at plant/GLO U
Printed wiring board, surface mount, lead-containing surface, at plant/GLO U
Printed wiring board, surface mounted, unspec., Pb containing, at plant/GLO U
Printed wiring board, through-hole mounted, unspec., Pb containing, at plant/GLO U
Printed wiring board, through-hole, lead-containing surface, at plant/GLO U
Printing colour, offset, 47.5% solvent, at plant/RER U
Printing colour, rotogravure, 55% toluene, at plant/RER U
Number of datasets = 16

Table A-34 List of ICT datasets newly created

Dataset
All-in-one printer (WiFi), at plant {GLO} U
Assembly, OLED module, at plant {GLO} U
Beamer, at plant {GLO} U
Blade server, at data center {GLO} U
Case, for smartphone, at plant {GLO} U
Case, for tablet, at plant {GLO} U
Charger, for smartphone, at plant {GLO} U
Charger, for tablet, at plant {GLO} U
Complex Set Top Boxes (CSTB), for customer premise equipment (CPE) {CH} U
CPU, network equipment, at plant {GLO} U
Data center {GLO} U
Docking station, at plant {GLO} U
External drive, at plant {GLO} U
Facility of data center {GLO} U
HDMI cable, at plant {GLO} U
Headset (bluetooth), for smartphone, at plant {GLO} U
Headset (wired), for smartphone, at plant {GLO} U
Heat sink for CPU, network equipment, at plant {GLO} U
Inkjet cartridge, at plant {GLO} U
Keyboard, wireless version, at plant {GLO} U
LED module, at plant {GLO} U
LED screen 23 inches, at plant {GLO} U
Modem, for customer premise equipment (CPE) {CH} U
Mouse device, optical, wireless, at plant {GLO} U
Multimedia gateway, for customer premise equipment (CPE) {CH} U
Network Attached Storage, NAS, at plant {GLO} U
Network equipment, at data center {GLO} U
OLED module, at plant {GLO} U
OLED screen 43 inches, at plant {GLO} U
Points of presence, network equipment {GLO} U
Rack server, at data center {GLO} U
Server, at data center {GLO} U
Smartphone, high-tech phone, at plant {GLO} U
Smartphone, mid-tier, average phone, at plant {GLO} U
Smartphone, repairable type Fairphone, at plant {GLO} U
Solid State Drive, SSD, at plant {GLO} U
Spare batteries, for smartphone, at plant {GLO} U
Spare batteries, for tablet, at plant {GLO} U
Spare screen, for smartphone, at plant {GLO} U
Spare screen, for tablet, at plant {GLO} U
Storage array, at data center {GLO} U
Switch, data center devices, at plant {GLO} U

Tablet, average, at plant {GLO} U
Tower server, at data center {GLO} U
Use of cable, fixed IP access network per GB {CH} U
Use of cable, fixed IP access network per hour {CH} U
Use of core national IP network per GB {CH} U
Use of core national IP network per hour {CH} U
Use of CPE, for transmission network per GB {CH} U
Use of CPE, for transmission network per hour {CH} U
Use of fixed IP access network per GB {CH} U
Use of fixed IP access network per hour {CH} U
Use of global transmission network per GB {GLO} U
Use of IP access network, shares per GB {CH} U
Use of IP access network, shares per hour {CH} U
Use of optic fibre, fixed IP access network per GB {CH} U
Use of optic fibre, fixed IP access network per hour {CH} U
Use of wireless IP access network per GB {CH} U
Use of wireless IP access network per hour {CH} U
Use of wireless IP access network, 2-4G per GB {CH} U
Use of wireless IP access network, 2-4G per hour {CH} U
Use of wireless IP access network, 5G per GB {CH} U
Use of wireless IP access network, 5G per hour {CH} U
Use of xDSL, fixed IP access network per GB {CH} U
Use of xDSL, fixed IP access network per hour {CH} U
Use, laptop, high intensity per GB {CH} U
Use, laptop, high intensity per hour {CH} U
Use, laptop, low intensity per GB {CH} U
Use, laptop, low intensity per hour {CH} U
Use, laptop, medium intensity per GB {CH} U
Use, laptop, medium intensity per hour {CH} U
Use, smartphone, high intensity per GB {CH} U
Use, smartphone, high intensity per hour {CH} U
Use, smartphone, low intensity per GB {CH} U
Use, smartphone, low intensity per hour {CH} U
Use, smartphone, medium intensity per GB {CH} U
Use, smartphone, medium intensity per hour {CH} U
Number of datasets = 77

8 Appendix for life cycle inventories and impact assessments of updated ICT datasets

8.1 Wafer components, for integrated circuits, logic and memory types

- Dataset update and creation category: LCI and technical data available
- Unit process description:

This dataset can be applied to describe the processing of a wafer used for integrated circuit fabrication. The original input data for chemicals and elemental gases represents measures in grams per cm2 of input wafer. The information stems partly from an Intel fabrication site describing material input/output for a mid-sized, state-of-the art integrated circuit fabrication facility in Ireland in 2017. The infrastructure is calculated for a company producing 72'400 200-mm wafers per month, each weighing 1.68 kg/m^2. The life-span of the facility is assumed to be 25 years, a photovoltaic cell factory is taken as proxy. Transportation input data is based on ecoinvent standard distances for chemicals in Europe.

The input data is based on a chip factory in Ireland, which is used to represent a global average. Emissions and water inputs are retrieved from three different wafer fabrication sites in the USA and one company in Central Europe of an anonymous wafer fabrication company. Energy inputs have been adjusted to represent production in Asia since currently most wafer fabrication is conducted in Asia.

The wafer fabrication can include several thousand individual steps, which are grouped into the major operation classes called layering, patterning, doping and heat treatments. The technology applied during these operations is represented by the material input of chemicals and the energy used in these operations. Three input parameters have been identified as key hotspots in wafer fabrication: energy consumption, fabrication yield, and solid waste production. Latest literature suggests an increase in wafer fabrication efficiency from 55% to 75% (UBA 2021, Table 88). This change in efficiency leads to a change in the amount of silicon wafer needed for wafer fabrication, amount of chemicals consumed, and amount of solid waste produced. Energy consumption under current manufacturing practices have become more efficient, currently at around 2.5 - 7.7 MJ / cm^2 fabricated wafer, from the previous 15.8 MJ /cm2 (UBA 2021, Table 23). Since energy consumption is the key environmental hotspot, a fabricated wafer needs to be distinguished into wafers for memory ICs or logic ICs.

The resulting unit process for "wafer, fabricated, for integrated circuit, logic type" and "wafer, fabricated, for integrated circuit, memory type" are shown in Table 8.1-1 and Table 8.1-3, whereas the life cycle impact assessment results are presented in Figure 8.1-1 and Table 8.1-2, and Figure 8.1-2 and Table 8.1-4 respectively.

Table 8.1-1. Life cycle inventory for wafer, fabricated, for integrated circuit, logic type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Wafer, fabricated, for integrated circuit, logic type/m2/GLO U	1	m2				
Input						
Acetone, liquid, at plant/RER U	7.368	kg		Lognormal	1.25	(2,4,2,2,2,5)
Ammonia, liquid, at regional storehouse/RER U	3.049	kg		Lognormal	1.25	(2,4,2,2,2,5)
Ammonium carbonate, at plant/RER U	49.971	kg		Lognormal	1.25	(2,4,5,3,2,5)
Argon, liquid, at plant/RER U	22.61	kg		Lognormal	1.25	(2,4,2,2,2,5)
Arsine, at plant/GLO U	5.72E-05	kg		Lognormal	1.25	(2,4,2,2,2,5)
Chemicals inorganic, at plant/GLO U	0.994	kg		Lognormal	1.25	(2,4,2,2,2,5)
Chlorine, liquid, production mix, at plant/RER U	0.064	kg		Lognormal	1.25	(2,4,2,2,2,5)
Diborane, at plant/GLO U	5.72E-05	kg		Lognormal	1.25	(2,4,2,2,2,5)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	17500	kWh		Lognormal	1.23	(2,3,2,3,2,5)
heat, natural gas, at industrial furnace 1MW/MJ/CH U	14760	MJ		Lognormal	1.25	(2,4,2,2,2,5)
Helium, at plant/GLO U	2.261	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hexafluorethane, at plant/GLO U	0.665	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hexamethyldisilazane, at plant/GLO U	0.293	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrochloric acid, 30% in H2O, at plant/RER U	33.516	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrochloric acid, from the reaction of hydrogen with chlorine, at plant/RER U	2.115	kg		Lognormal	1.25	(2,4,2,2,2,5)
hydrogen fluoride, at plant/kg/GLO U	3.437	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrogen peroxide, 50% in H2O, at plant/RER U	24.164	kg		Lognormal	1.25	(2,4,5,3,2,5)
Hydrogen, liquid, at plant/RER U	4.2	kg		Lognormal	1.25	(2,4,5,3,2,5)
Isopropanol, at plant/RER U	26.866	kg		Lognormal	1.25	(2,4,2,2,2,5)
Methyl-3-methoxypropionate, at plant/GLO U	19.684	kg		Lognormal	1.25	(2,4,2,2,2,5)
Monoethanolamine, at plant/RER U	18.886	kg		Lognormal	1.25	(2,4,2,2,2,5)

Nitric acid, 50% in H2O, at plant/RER U	11.078	kg		Lognormal	1.25	(2,4,2,2,2,5)
Nitrogen, liquid, at plant/RER U	5060	kg		Lognormal	1.59	(2,4,5,3,2,5)
Oxygen, liquid, at plant/RER U	214	kg		Lognormal	1.59	(2,4,5,3,2,5)
Phosphane, at plant/GLO U	0.000226	kg		Lognormal	1.25	(2,4,2,2,2,5)
Phosphoric acid, industrial grade, 85% in H2O, at plant/RER U	27.566	kg		Lognormal	1.25	(2,4,2,2,2,5)
photovoltaic cell factory/p/DE/I U	1.46E-06	p		Lognormal	3.33	(2,4,5,3,3,5)
Silicone product, at plant/RER U	0.122	kg		Lognormal	1.25	(2,4,2,2,2,5)
single-Si wafer, electronics, at plant/m2/RER U	1.33	m2		Lognormal	1.25	(2,4,2,2,2,5)
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	109.739	kg		Lognormal	1.25	(2,4,2,2,2,5)
Sulphur hexafluoride, liquid, at plant/RER U	0.086	kg		Lognormal	1.25	(2,4,2,2,2,5)
Sulphuric acid, liquid, at plant/RER U	100.229	kg		Lognormal	1.25	(2,4,2,2,2,5)
tap water, at user/kg/RER U	84702	kg		Lognormal	1.59	(2,4,5,3,2,5)
tetrafluoroethylene, at plant/kg/RER U	0.399	kg		Lognormal	1.25	(2,4,2,2,2,5)
transport, freight, rail/tkm/RER U	1017.3	tkm		Lognormal	2.31	(3,4,5,3,2,5)
transport, freight, lorry, fleet average/tkm/RER U	357.33	tkm		Lognormal	2.31	(3,4,5,3,2,5)
Trichloromethane, at plant/RER U	0.116	kg		Lognormal	1.25	(2,4,2,2,2,5)
Trifluoromethane, at plant/GLO U	0.412	kg		Lognormal	1.25	(2,4,2,2,2,5)
Trimethylamine, at plant/RER U	57.323	kg		Lognormal	1.25	(2,4,2,2,2,5)
Water, ultrapure, at plant/GLO U	96509	kg		Lognormal	1.59	(2,4,5,3,2,5)
Zeolite, slurry, 50% in H2O, at plant/RER S	5.2	kg		Lognormal	1.59	(2,4,5,3,2,5)
Output						
Emissions to air						
Arsine	4.24E-07	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	0.001727	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Ethane, hexafluoro-, HFC-116	0.11902	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Hydrogen fluoride	0.49339	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Methanol	0.001667	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
NMVOC, non-methane volatile organic compounds, unspecified origin	4.1706	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Phosphine	3.15E-05	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)

Emissions to soil						
Sulfuric acid	4.72E-05	kg	agricultural	Lognormal	1.85	(2,4,5,3,2,5)
Waste to treatment						
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	413	kg		Lognormal	1.59	(3,3,5,3,2,5)
Treatment, wafer fabrication effluent, to wastewater treatment, class 2/CH U	96.509	m3		Lognormal	1.59	(2,4,5,3,2,5)

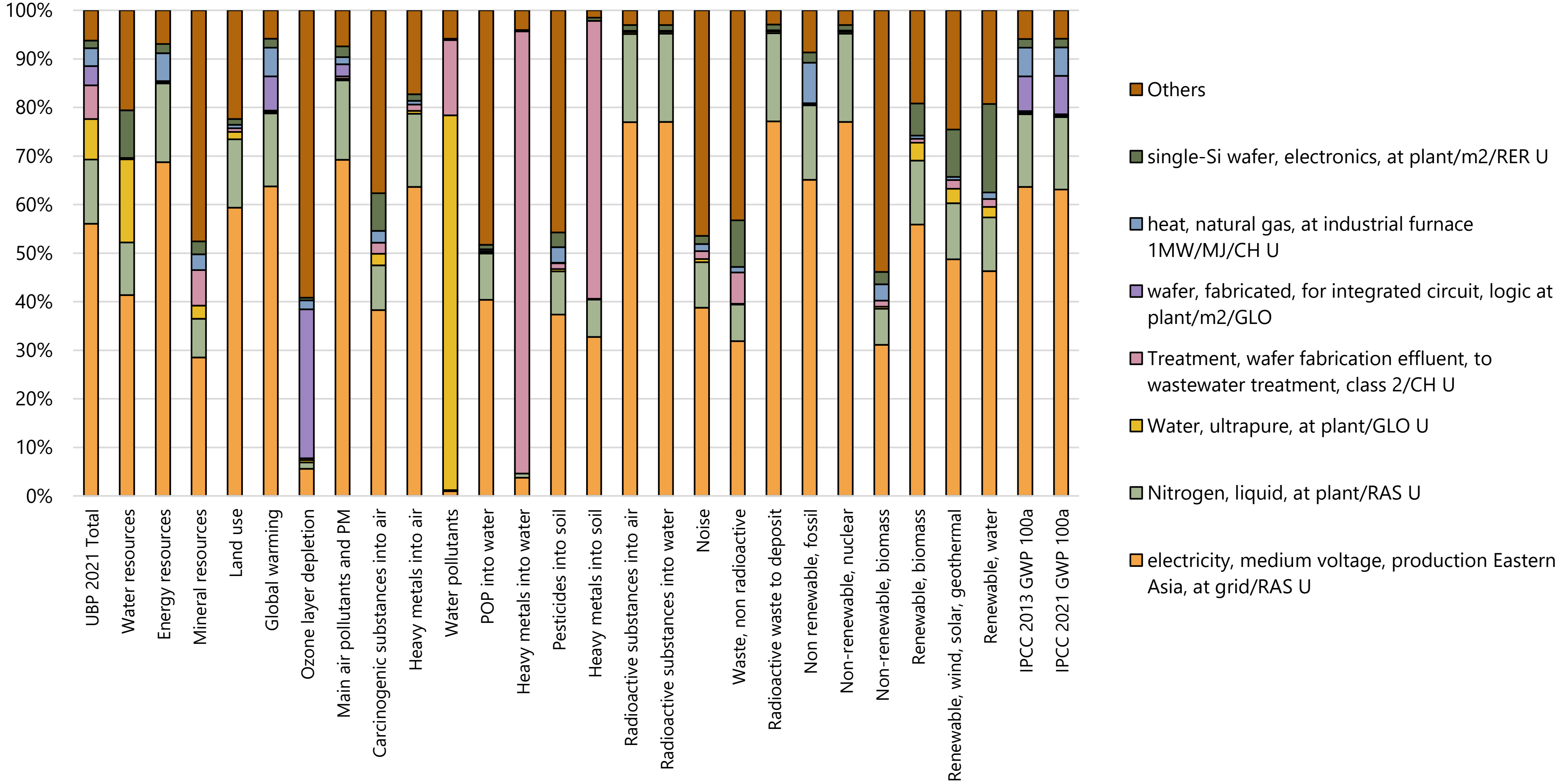

Figure 8.1-1. Contribution analysis presented in bar chart for wafer production, for IC logic type. FU = 1 m² wafer

Table 8.1-2. Contribution analysis presented in table for wafer production, for IC logic type. FU = 1 m^2 wafer

Contributors	UBP Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	56%	65%	64%	63%
Nitrogen, liquid, at plant/RER U	11%	12%	11%	11%
Water, ultrapure, at plant/GLO U	8%	0%	0%	0%
Treatment, wafer fabrication effluent, to wastewater treatment, class 2/CH U	7%	0%	0%	0%
wafer, fabricated, for integrated circuit, logic at plant/m2/GLO	4%	0%	7%	8%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	4%	8%	6%	6%
single-Si wafer, electronics, at plant/m2/RER U	2%	2%	2%	2%
Others	6%	9%	6%	6%
Total impact, in absolute value	**3.43E+07**	**2.07E+05**	**1.79E+04**	**1.80E+04**

Table 8.1-3. Life cycle inventory for wafer, fabricated, for integrated circuit, memory type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Wafer, fabricated, for integrated circuit, memory type/m2/GLO U	1	m2				
Input						
Acetone, liquid, at plant/RER U	7.368	kg		Lognormal	1.25	(2,4,2,2,2,5)
Ammonia, liquid, at regional storehouse/RER U	3.049	kg		Lognormal	1.25	(2,4,2,2,2,5)
Ammonium carbonate, at plant/RER U	49.971	kg		Lognormal	1.59	(2,4,5,3,2,5)
Argon, liquid, at plant/RER U	22.61	kg		Lognormal	1.25	(2,4,2,2,2,5)
Arsine, at plant/GLO U	5.72E-05	kg		Lognormal	1.25	(2,4,2,2,2,5)
Chemicals inorganic, at plant/GLO U	0.994	kg		Lognormal	1.25	(2,4,2,2,2,5)
Chlorine, liquid, production mix, at plant/RER U	0.064	kg		Lognormal	1.25	(2,4,2,2,2,5)
Diborane, at plant/GLO U	5.72E-05	kg		Lognormal	1.25	(2,4,2,2,2,5)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	5628	kWh		Lognormal	1.23	(2,3,2,3,2,5)
heat, natural gas, at industrial furnace 1MW/MJ/CH U	5166	MJ		Lognormal	1.23	(2,3,2,3,2,5)
Helium, at plant/GLO U	2.261	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hexafluorethane, at plant/GLO U	0.665	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hexamethyldisilazane, at plant/GLO U	0.293	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrochloric acid, 30% in H2O, at plant/RER U	33.516	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrochloric acid, from the reaction of hydrogen with chlorine, at plant/RER U	2.115	kg		Lognormal	1.25	(2,4,2,2,2,5)
hydrogen fluoride, at plant/kg/GLO U	3.437	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrogen peroxide, 50% in H2O, at plant/RER U	24.164	kg		Lognormal	1.25	(2,4,2,2,2,5)
Hydrogen, liquid, at plant/RER U	4.2	kg		Lognormal	1.25	(2,4,2,2,2,5)
Isopropanol, at plant/RER U	26.866	kg		Lognormal	1.25	(2,4,2,2,2,5)
Methyl-3-methoxypropionate, at plant/GLO U	19.684	kg		Lognormal	1.25	(2,4,2,2,2,5)
Monoethanolamine, at plant/RER U	18.886	kg		Lognormal	1.25	(2,4,2,2,2,5)
Nitric acid, 50% in H2O, at plant/RER U	11.078	kg		Lognormal	1.25	(2,4,2,2,2,5)
Nitrogen, liquid, at plant/RAS U	5060	kg		Lognormal	1.59	(2,4,5,3,2,5)

Oxygen, liquid, at plant/RER U	214	kg		Lognormal	1.59	(2,4,5,3,2,5)
Phosphane, at plant/GLO U	0.000226	kg		Lognormal	1.25	(2,4,2,2,2,5)
Phosphoric acid, industrial grade, 85% in H2O, at plant/RER U	27.566	kg		Lognormal	1.25	(2,4,2,2,2,5)
photovoltaic cell factory/p/DE/I U	1.46E-06	p		Lognormal	3.33	(2,4,5,3,3,5)
Silicone product, at plant/RER U	0.122	kg		Lognormal	1.25	(2,4,2,2,2,5)
single-Si wafer, electronics, at plant/m2/RER U	1.33	m2		Lognormal	1.25	(2,4,2,2,2,5)
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	109.739	kg		Lognormal	1.25	(2,4,2,2,2,5)
Sulphur hexafluoride, liquid, at plant/RER U	0.086	kg		Lognormal	1.25	(2,4,2,2,2,5)
Sulphuric acid, liquid, at plant/RER U	100.229	kg		Lognormal	1.25	(2,4,2,2,2,5)
tap water, at user/kg/RER U	84702	kg		Lognormal	1.59	(2,4,5,3,2,5)
tetrafluoroethylene, at plant/kg/RER U	0.399	kg		Lognormal	1.25	(2,4,2,2,2,5)
transport, freight, rail/tkm/RER U	1017.3	tkm		Lognormal	2.31	(3,4,5,3,2,5)
transport, freight, lorry, fleet average/tkm/RER U	357.33	tkm		Lognormal	2.31	(3,4,5,3,2,5)
Trichloromethane, at plant/RER U	0.116	kg		Lognormal	1.25	(2,4,2,2,2,5)
Trifluoromethane, at plant/GLO U	0.412	kg		Lognormal	1.25	(2,4,2,2,2,5)
Trimethylamine, at plant/RER U	57.323	kg		Lognormal	1.25	(2,4,2,2,2,5)
Water, ultrapure, at plant/GLO U	96509	kg		Lognormal	1.59	(2,4,5,3,2,5)
Zeolite, slurry, 50% in H2O, at plant/RER S	5.2	kg		Lognormal	1.59	(2,4,5,3,2,5)
Output						
Emissions to air						
Arsine	4.24E-07	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	0.001727	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Ethane, hexafluoro-, HFC-116	0.11902	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Hydrogen fluoride	0.49339	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Methanol	0.001667	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
NMVOC, non-methane volatile organic compounds, unspecified origin	4.1706	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)
Phosphine	3.15E-05	kg	high. pop.	Lognormal	1.85	(2,4,5,3,2,5)

Emissions to soil						
Sulfuric acid	4.72E-05	kg	agricultural	Lognormal	1.85	(2,4,5,3,2,5)
Waste to treatment						
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	413	kg		Lognormal	1.59	(3,3,5,3,2,5)
Treatment, wafer fabrication effluent, to wastewater treatment, class 2/CH U	96.509	m3		Lognormal	1.59	(2,4,5,3,2,5)

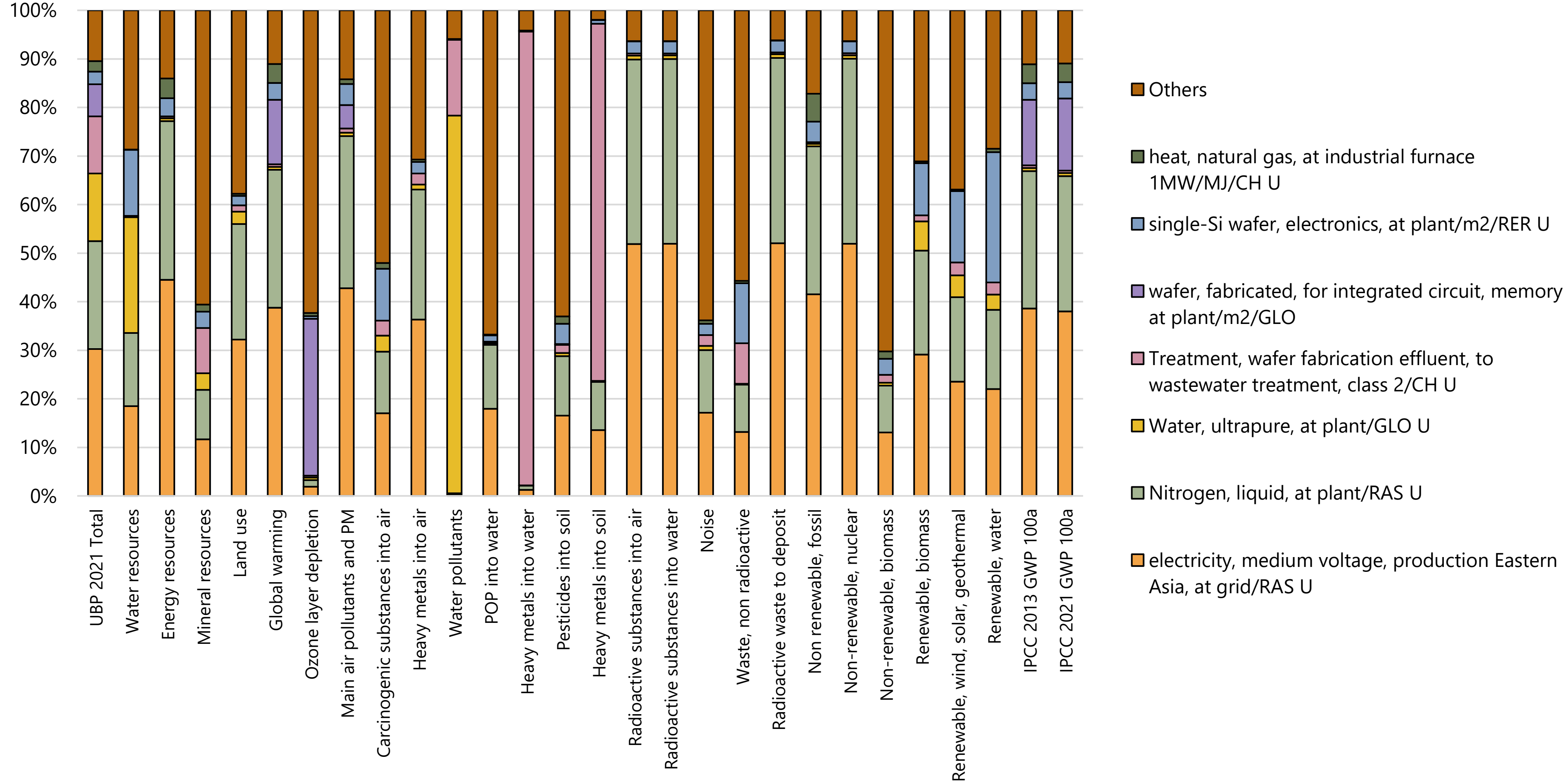

Figure 8.1-2. Contribution analysis presented in bar chart for: wafer production, for IC memory type. FU = 1 m² wafer

Table 8.1-4. Contribution analysis presented in table for: wafer production, for IC memory type. FU = 1 m² wafers

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	32%	45%	42%	41%
Nitrogen, liquid, at plant/RAS U	18%	25%	22%	22%
Water, ultrapure, at plant/GLO U	15%	1%	1%	1%
Treatment, wafer fabrication effluent, to wastewater treatment, class 2/CH U	12%	0%	1%	1%
wafer, fabricated, for integrated circuit, memory at plant/m2/GLO	7%	0%	15%	16%
single-Si wafer, electronics, at plant/m2/RER U	3%	5%	4%	4%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	2%	6%	4%	4%
Others	10%	17%	11%	11%
Total impact, in absolute value	**2.00E+07**	**1.01E+05**	**9.11E+03**	**9.26E+03**

8.2 Integrated circuits

8.2.1 Integrated circuits, logic types

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The integrated circuit, logic dataset is updated using the technical parameters found in the "Green Cloud Computing" report (Umweltbundesamt, 2021). This update mainly relates to energy and heat consumption, as well as the gold input for ICs. The mass flow of gold is conservatively unchanged (0.0108 kg gold/kg packaged IC) since we did not find a public document that clearly stated a new lower gold content for IC. The regionalization to the datasets is applied for the Eastern Asia electricity mix and global average, primary metal flows. The amount of wafer required (m^2) to produce 1 kg IC is taken from the empirical study found in literature (Teehan & Kandlikar, 2013), which is 0.02 m^2/kg packaged IC.

The resulting unit process for "integrated circuits, logic types" is shown in

Table 8.2-1, whereas the life cycle impact assessment results are presented in Figure 8.2-1 and Table 8.2-2.

Table 8.2-1. Life cycle inventory for integrated circuit, logic type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Integrated circuit, IC, logic type, at plant/kg/GLO U	1	kg				
Input						
Chemicals organic, at plant/GLO U	0.0086	kg		Lognormal	1.33	(2,4,2,3,3,5)
Copper, primary, at refinery/GLO U	0.082	kg		Lognormal	1.33	(2,4,2,3,3,5)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	36.75	kWh		Lognormal	1.35	(3,4,2,3,3,5)
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.11	(2,4,2,3,3,5)
Epoxy resin insulator (SiO2), at plant/RER U	0.4365	kg		Lognormal	1.33	(2,4,2,3,3,5)
Epoxy resin, liquid, at plant/RER U	0.0025	kg		Lognormal	1.33	(2,4,2,3,3,5)
Glass fibre reinforced plastic, polyamide, injection moulding, at plant/RER U	0.3169	kg		Lognormal	1.33	(2,4,2,3,3,5)
Gold, primary, at refinery/GLO U	0.0108	kg		Lognormal	1.33	(2,4,2,3,3,5)
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	27.1	MJ		Lognormal	1.35	(3,4,2,3,3,5)
Lead, primary, at plant/GLO U	0.037	kg		Lognormal	1.33	(2,4,2,3,3,5)
Nickel, 99.5%, at plant/GLO U	0.00328	kg		Lognormal	1.33	(2,4,2,3,3,5)
Silver, at regional storage/RER U	0.0075	kg		Lognormal	1.33	(2,4,2,3,3,5)
Tin, at regional storage/RER U	0.063	kg		Lognormal	1.33	(2,4,2,3,3,5)
transport, freight, rail/tkm/RER U	1.1948	tkm		Lognormal	2.08	(3,4,2,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.19913	tkm		Lognormal	2.08	(3,4,2,3,3,5)
transport, transoceanic freight ship/tkm/OCE U	20.538	tkm		Lognormal	2.12	(4,4,3,3,1,5)
Wafer, fabricated, for integrated circuit, logic type/m2/GLO U	0.02	m2		Lognormal	1.33	(2,4,2,3,3,5)
Zinc, primary, at regional storage/RER U	0.00756	kg		Lognormal	1.33	(2,4,2,3,3,5)

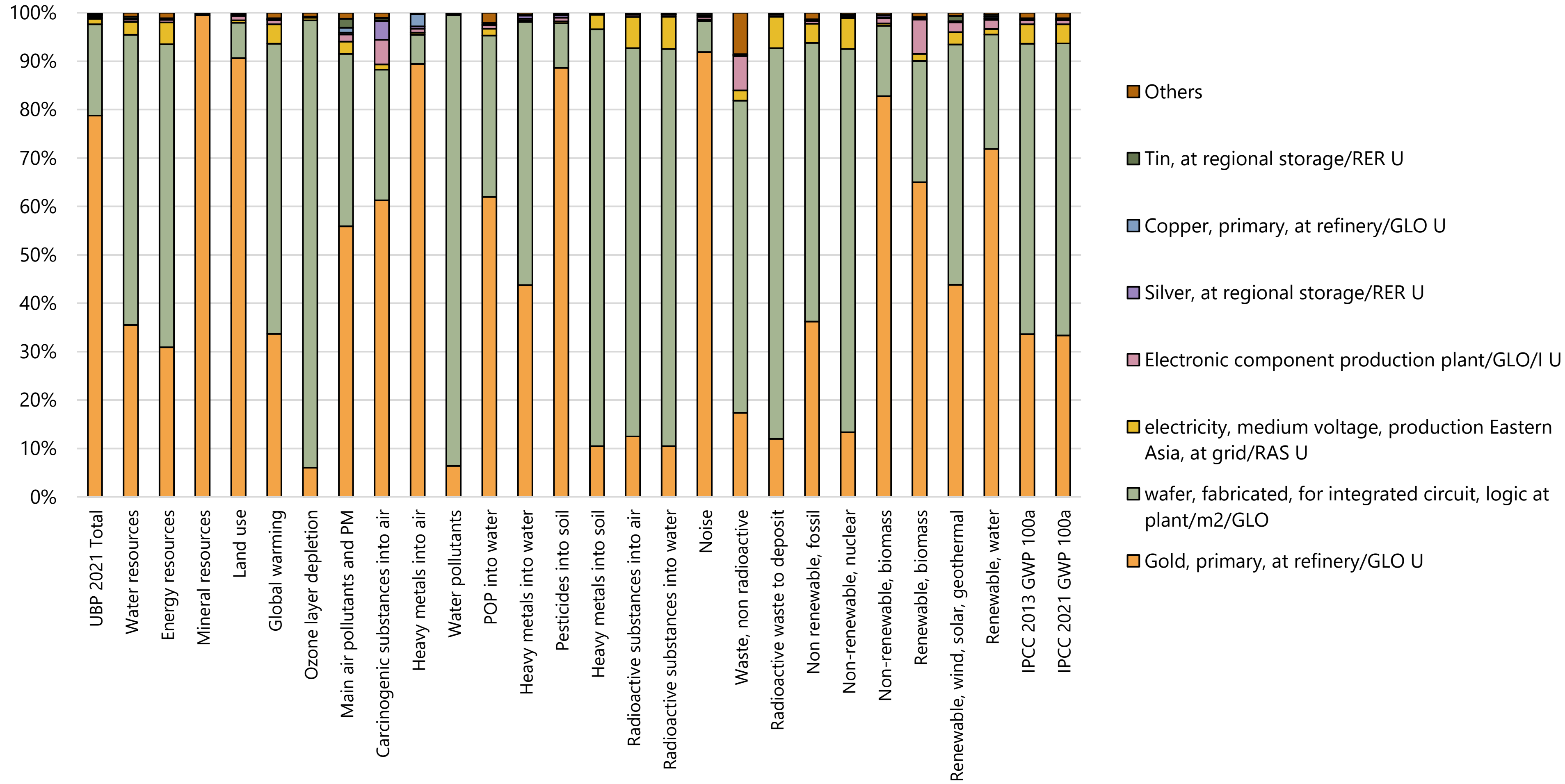

Figure 8.2-1. Contribution analysis presented in bar chart for: integrated circuit production, logic type. FU = 1 kg IC

Table 8.2-2. Contribution analysis presented in table for: integrated circuit production, logic type. FU = 1 kg IC

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, primary, at refinery/GLO U	79%	36%	34%	33%
wafer, fabricated, for integrated circuit, logic at plant/m2/GLO	19%	58%	60%	60%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	1%	4%	4%	4%
Electronic component production plant/GLO/I U	0%	1%	1%	1%
Silver, at regional storage/RER U	0%	0%	0%	0%
Copper, primary, at refinery/GLO U	0%	0%	0%	0%
Tin, at regional storage/RER U	0%	0%	0%	0%
Others	0%	1%	1%	1%
Total impact, in absolute value	**3.73E+06**	**7.33E+03**	**6.06E+02**	**6.08E+02**

8.2.2 Integrated circuits, memory types

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The integrated circuit, memory dataset is updated using the technical parameters found in the "Green Cloud Computing" report (Umweltbundesamt, 2021). This update mainly relates the energy and heat consumption, as well as the gold input for ICs. Specifically for the gold input, the mass of gold per kg IC is taken from the average values in the study of (C.-H. Kuo et al., 2020), 0.0078 kg gold/kg packaged IC. The regionalization to the datasets is applied for the Eastern Asia electricity mix and global average, primary metal flows. The amount of wafer required (m^2) to produce 1 kg IC is taken from the empirical study found in literature (Teehan & Kandlikar, 2013), which is 0.0191 m^2/kg packaged IC.

The resulting unit process for "integrated circuits, memory type" is shown in Table 8.2-3, whereas the life cycle impact assessment results are presented in Figure 8.2-2 and Table 8.2-4.

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Table 8.2-3. Life cycle inventory for integrated circuit, memory type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Integrated circuit, IC, memory type, at plant/kg/GLO U	1	kg				
Input						
Chemicals organic, at plant/GLO U	0.0066	kg		Lognormal	1.33	(2,4,2,3,3,5)
Copper, primary, at refinery/GLO U	0.31297	kg		Lognormal	1.33	(2,4,2,3,3,5)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	36.75	kWh		Lognormal	1.35	(3,4,2,3,3,5)
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.11	(2,4,2,3,3,5)
Epoxy resin insulator (SiO2), at plant/RER U	0.64147	kg		Lognormal	1.33	(2,4,2,3,3,5)
Epoxy resin, liquid, at plant/RER U	0.0007	kg		Lognormal	1.33	(2,4,2,3,3,5)
Gold, primary, at refinery/GLO U	0.0078	kg		Lognormal	1.33	(2,4,2,3,3,5)
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	27.1	MJ		Lognormal	1.35	(3,4,2,3,3,5)
Lead, primary, at plant/GLO U	0.00078	kg		Lognormal	1.33	(2,4,2,3,3,5)
Phosphorus, white, liquid, at plant/RER U	0.000321	kg		Lognormal	1.33	(2,4,2,3,3,5)
Pig iron, at plant/GLO U	0.007704	kg		Lognormal	1.33	(2,4,2,3,3,5)
Silver, at regional storage/RER U	0.0021	kg		Lognormal	1.33	(2,4,2,3,3,5)
Tin, at regional storage/RER U	0.00442	kg		Lognormal	1.33	(2,4,2,3,3,5)
transport, freight, rail/tkm/RER U	1.1976	tkm		Lognormal	2.08	(3,4,2,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.1996	tkm		Lognormal	2.09	(3,4,3,3,1,5)
transport, transoceanic freight ship/tkm/OCE U	21.264	tkm		Lognormal	2.12	(4,4,3,3,1,5)
Wafer, fabricated, for integrated circuit, memory type/m2/GLO U	0.0191	m2		Lognormal	1.33	(2,4,2,3,3,5)
Zinc, primary, at regional storage/RER U	0.01092	kg		Lognormal	1.33	(2,4,2,3,3,5)

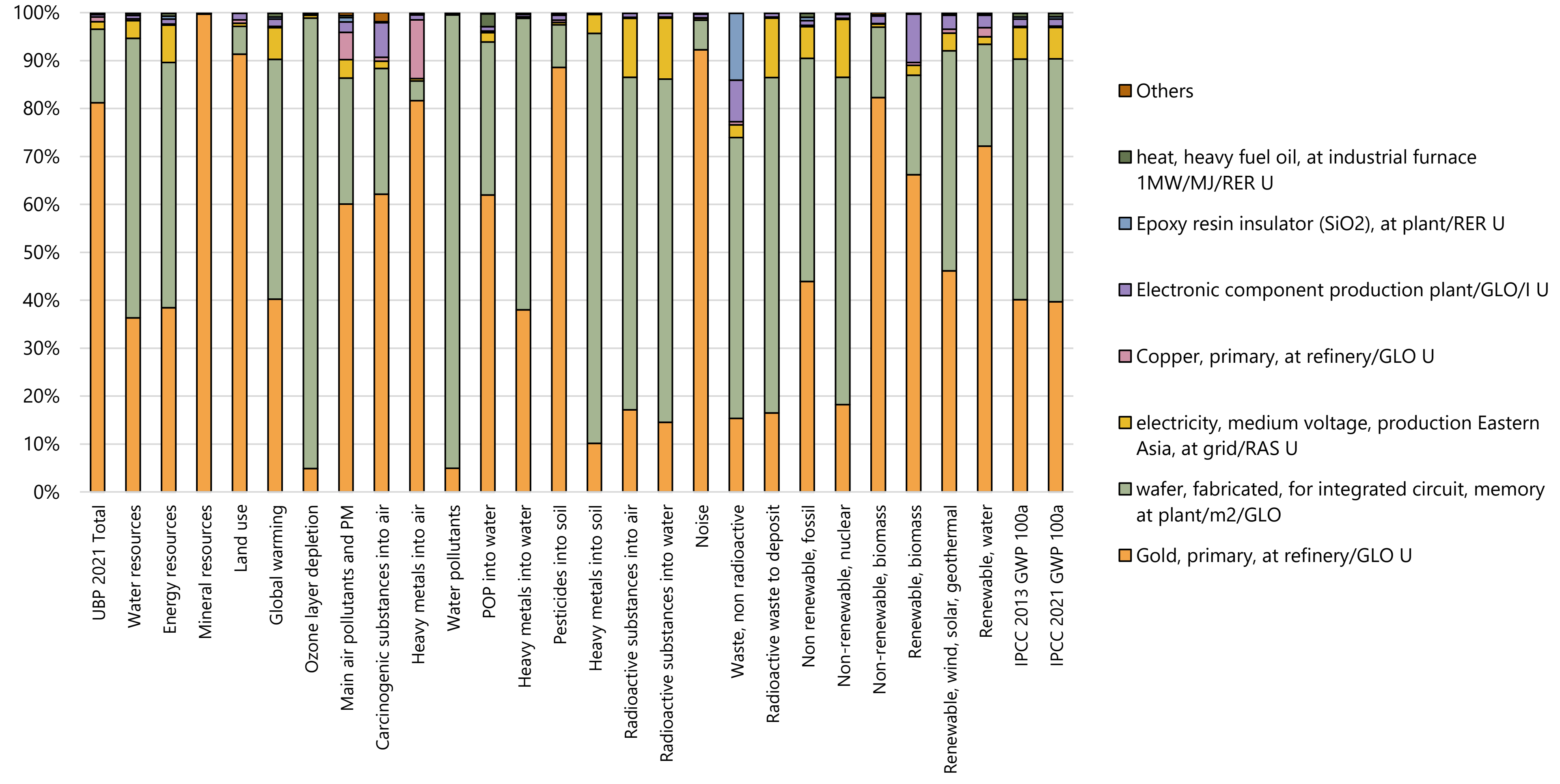

Figure 8.2-2. Contribution analysis presented in bar chart for: integrated circuit production, memory type. FU = 1 kg IC

Table 8.2-4. Contribution analysis presented in table for: integrated circuit production, memory type. FU = 1 kg IC

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, primary, at refinery/GLO U	82%	44%	40%	40%
wafer, fabricated, for integrated circuit, memory at plant/m2/GLO	15%	47%	50%	51%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	2%	7%	7%	7%
Copper, primary, at refinery/GLO U	1%	0%	0%	0%
Electronic component production plant/GLO/I U	0%	1%	1%	1%
Epoxy resin insulator (SiO2), at plant/RER U	0%	1%	0%	0%
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	0%	1%	1%	1%
Others	0%	0%	0%	0%
Total impact, in absolute value	**2.61E+06**	**4.30E+03**	**3.62E+02**	**3.63E+02**

8.3 Printed wiring boards

8.3.1 Mounting, surface mount technology (SMT), Pb-free solder

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The same inventory flows from the original "Mounting" datasets are used in the new dataset. However, energy consumption for the mounting of PWBs is adjusted using the energy efficiency factor due to improved process heating and cooling according to the industry best practice in European PCB manufacturing operations (Goosey & Kellner, 2010). The reduction percentage is assumed to be 17% from the original electricity consumption.

The resulting unit process for "Mounting, surface mount technology (SMT), Pb-free solder" is shown in

Table 8.3-1, whereas the life cycle impact assessment results are presented in Figure 8.3-1 and Table 8.3-2.

Table 8.3-1. Life cycle inventory for Mounting, surface mount technology, Pb-free solder and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Mounting, surface mount technology, Pb-free solder/m2/GLO U	1	m2				
Input						
electricity, medium voltage, production GLO, at grid/kWh/GLO U	3.587758	kWh		Lognormal	1.31	(2,3,4,3,1,5); data from literature
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Solder, paste, Sn95.5Ag3.9Cu0.6, for electronics industry, at plant/GLO U	0.080645	kg		Lognormal	1.31	(2,3,4,3,1,5); data from literature
transport, freight, rail/tkm/RER U	0.0080645	tkm		Lognormal	2.85	(4,5,4,3,5,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.016129	tkm		Lognormal	2.85	(4,5,4,3,5,5); standard distances
Output						
Emissions to air						
2-Propanol	0.003825	kg	high. pop.	Lognormal	2.85	(4,5,4,3,5,5); calculated from input of flux material
Formaldehyde	0.003825	kg	high. pop.	Lognormal	2.85	(4,5,4,3,5,5); calculated from input of flux material
Formic acid	0.000375	kg	high. pop.	Lognormal	2.85	(4,5,4,3,5,5); calculated from input of flux material
Heat, waste	15.561	MJ	high. pop.	Lognormal	1.63	(2,3,4,3,1,5); calculated from electricity input
Monoethanolamine	0.000225	kg	high. pop.	Lognormal	2.85	(4,5,4,3,5,5); calculated from input of flux material
Waste to treatment						
Disposal, tin sheet, 0% water, to sanitary landfill/CH U	0.0056452	kg		Lognormal	1.31	(2,3,4,3,1,5); data from literature

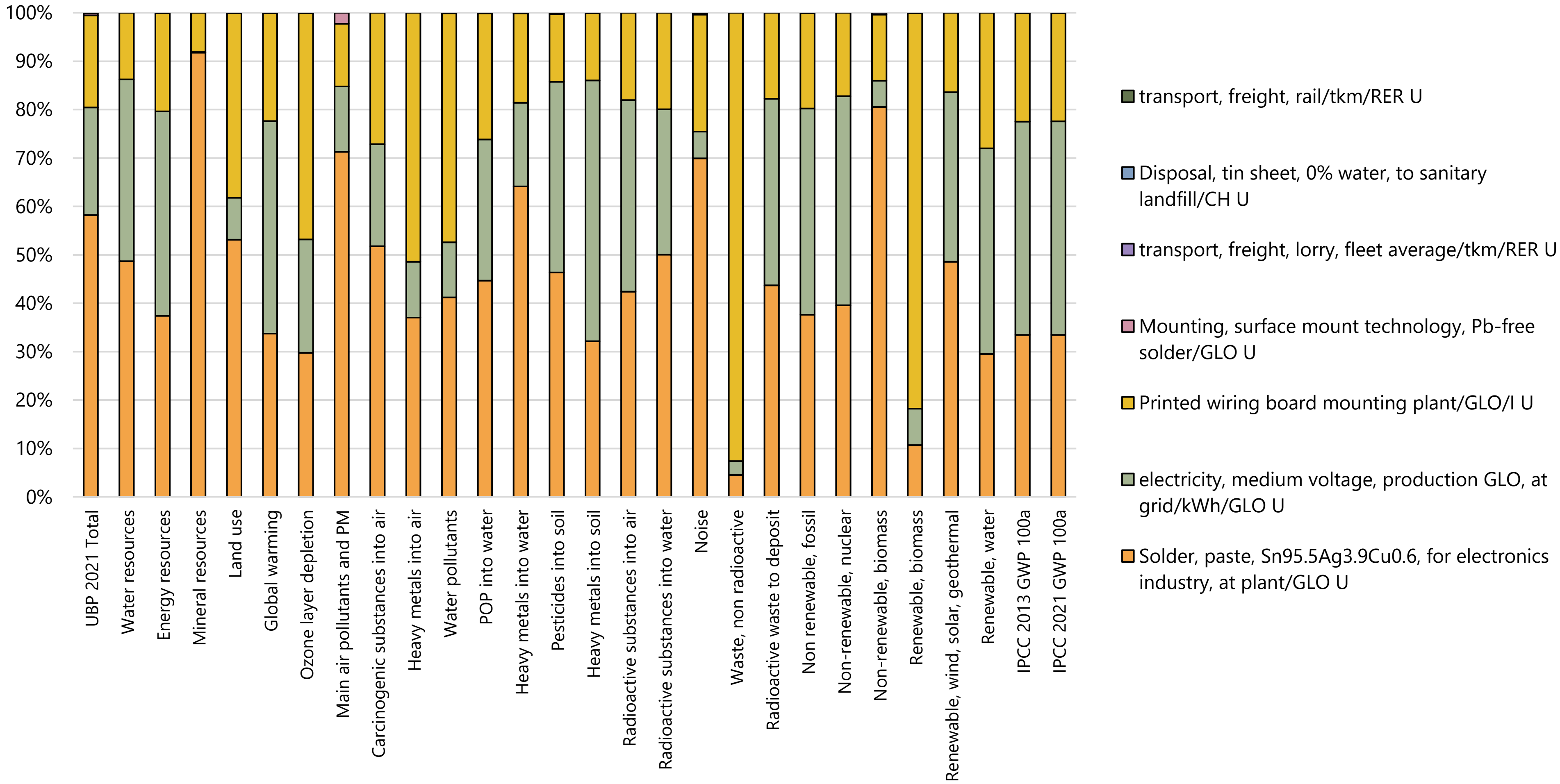

Figure 8.3-1. Contribution analysis presented in bar chart for: Mounting, surface mount technology, Pb-free solder. FU = 1 m²

Table 8.3-2. Contribution analysis presented in table for: Mounting, surface mount technology, Pb-free solder. FU = 1 m^2

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Solder, paste, Sn95.5Ag3.9Cu0.6, for electronics industry, at plant/GLO U	58%	38%	33%	33%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	22%	43%	44%	44%
Printed wiring board mounting plant/GLO/I U	19%	20%	22%	22%
Mounting, surface mount technology, Pb-free solder/GLO U	1%	0%	0%	0%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
Disposal, tin sheet, 0% water, to sanitary landfill/CH U	0%	0%	0%	0%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
Total impact, in absolute value	**1.98E+04**	**7.21E+01**	**6.32E+00**	**6.29E+00**

8.3.2 Mounting, through-hole technology (THT), Pb-free solder

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

Similar to the surface mounting technologies, here the energy consumption for the mounting of PWBs is adjusted using the energy efficiency factor due to improved process heating and cooling according to the industry best practice in European PCB manufacturing operations (Goosey & Kellner, 2010). The reduction percentage is assumed to be 17% from the original electricity consumption.

The resulting unit process for "Mounting, through-hole technology (THT), Pb-free solder" is shown in Table 8.3-3, whereas the life cycle impact assessment results are presented in Figure 8.3-2 and Table 8.3-4.

Table 8.3-3. Life cycle inventory for Mounting, through-hole technology, Pb-free solder and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Mounting, through-hole technology, Pb-free solder/m2/GLO U	1	m2				
Input						
electricity, medium voltage, production GLO, at grid/kWh/GLO U	5.611298	kWh		Lognormal	1.31	(2,3,4,3,1,5); data from literature
Flux, wave soldering, at plant/GLO U	0.2514	kg		Lognormal	1.31	(2,3,4,3,1,5); data from literature
Nitrogen, liquid, at plant/RAS U	74.338	kg		Lognormal	1.31	(2,3,4,3,1,5); data from literature
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Solder, bar, Sn95.5Ag3.9Cu0.6, for electronics industry, at plant/GLO U	0.42254	kg		Lognormal	1.31	(2,3,4,3,1,5); data from literature
transport, freight, rail/tkm/RER U	0.042254	tkm		Lognormal	2.85	(4,5,4,3,5,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.084507	tkm		Lognormal	2.85	(4,5,4,3,5,5); standard distances
Output						
Emissions to air						
2-Propanol	0.2514	kg	high. pop.	Lognormal	2.15	(4,3,4,3,1,5); calculated from input of flux material
Heat, waste	24.338	MJ	high. pop.	Lognormal	1.63	(2,3,4,3,1,5); calculated from electricity input
Waste to treatment						
Disposal, tin sheet, 0% water, to sanitary landfill/CH U	0.12254	kg		Lognormal	1.31	(2,3,4,3,1,5); data from literature

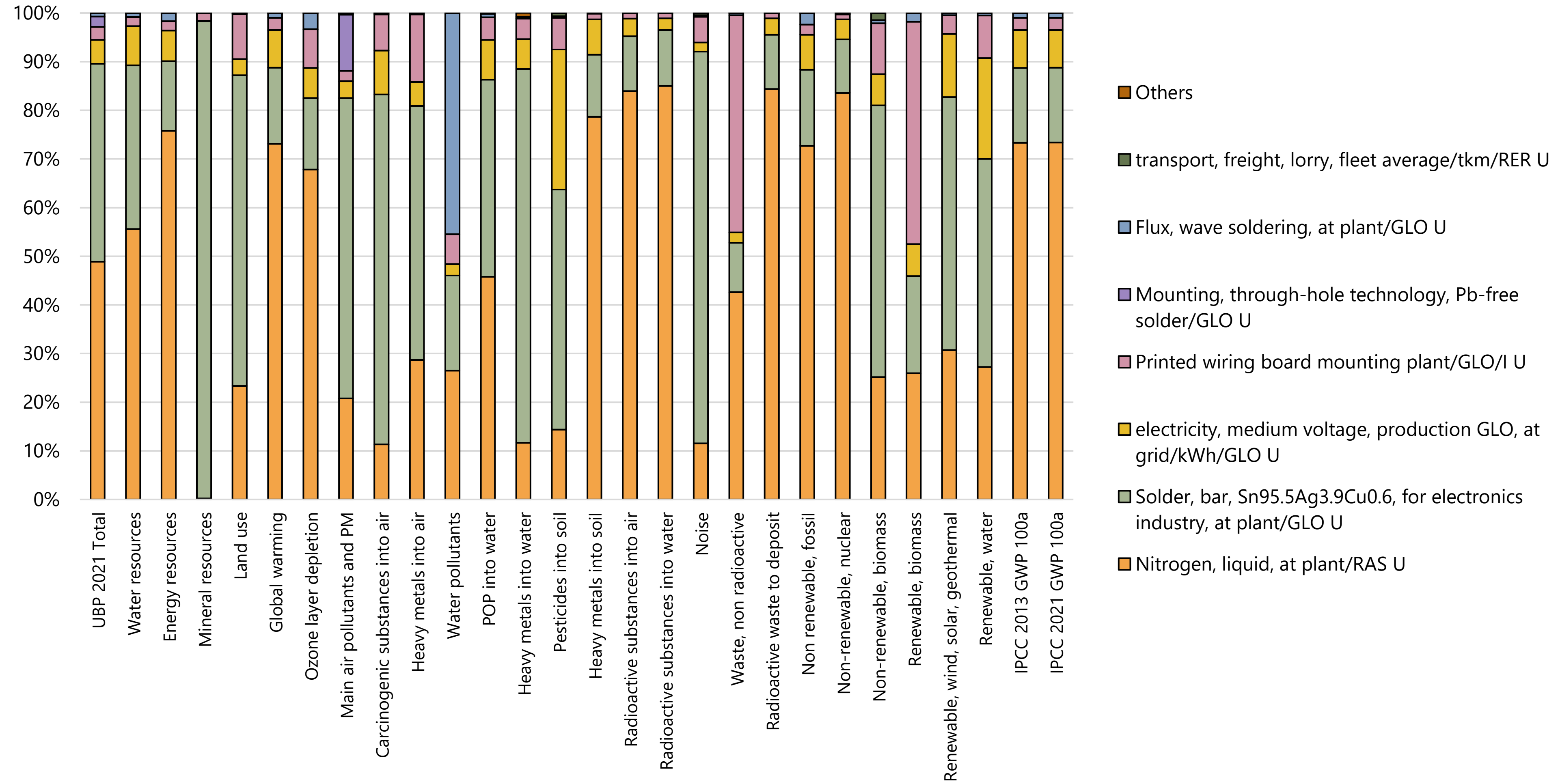

Figure 8.3-2. Contribution analysis presented in bar chart for: Mounting, through-hole technology, Pb-free solder. FU = 1 m²

Table 8.3-4. Contribution analysis presented in table for: Mounting, through-hole technology, Pb-free solder. FU = 1 m^2

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Nitrogen, liquid, at plant/RAS U	42%	67%	67%	67%
Solder, bar, Sn95.5Ag3.9Cu0.6, for electronics industry, at plant/GLO U	46%	19%	19%	19%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	6%	9%	10%	10%
Printed wiring board mounting plant/GLO/I U	3%	3%	3%	3%
Mounting, through-hole technology, Pb-free solder/GLO U	2%	0%	0%	0%
Flux, wave soldering, at plant/GLO U	1%	3%	1%	1%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**1.25E+05**	**5.49E+02**	**4.48E+01**	**4.46E+01**

8.3.3 Printed wiring board, surface mount, lead-free surface, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The energy consumption in the manufacturing of printed wiring board is updated using the recent PWB manufacturer's onsite measurement data found in the literature (Duque Ciceri et al., 2010; Kupka et al., 2018).

The resulting unit process for "Printed wiring board, surface mount, lead-free surface, at plant" is shown in Table 8.3-5, whereas the life cycle impact assessment results are presented in Figure 8.3-3 and Table 8.3-6.

Table 8.3-5. Life cycle inventory for Printed wiring board, surface mount, lead-free surface and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, surface mount, lead-free surface, at plant/m2/GLO U	1	m2				
Input						
Water, unspecified natural origin/m3	5.5814	m3	in water	Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Copper, primary, at refinery/GLO U	2.8746	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Dipropylene glycol monomethyl ether, at plant/RER U	0.50069	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
electricity, medium voltage, production GLO, at grid/kWh/GLO U	185	kWh		Lognormal	1.27	(2,4,3,4,1,5); Updated data from literature
Electronic component production plant/GLO/I U	0.00000002	p		Lognormal	3.81	(4,5,1,3,5,5); rough assumption
Glass fibre reinforced plastic, polyester resin, hand lay-up, at plant/RER U	1.8897	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Gold, primary, at refinery/GLO U	0.00015474	kg		Lognormal	1.27	(2,4,3,4,1,5); average from several ZVEI umbrella specifications for PWB
heat, natural gas, at industrial furnace 1MW/MJ/CH U	213	MJ		Lognormal	1.27	(2,4,3,4,1,5); Updated data from literature
Hydrochloric acid, 30% in H2O, at plant/RER U	13.644	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Hydrogen peroxide, 50% in H2O, at plant/RER U	1.7693	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Iron (III) chloride, 40% in H2O, at plant/CH U	0.86093	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Nickel, 99.5%, at plant/GLO U	0.00077474	kg		Lognormal	1.27	(2,4,3,4,1,5); average from several ZVEI umbrella specifications for PWB
Phenolic resin, at plant/RER U	0.21332	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Sheet rolling, copper/RER U	1.8167	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Silver, at regional storage/RER U	0.00051474	kg		Lognormal	1.27	(2,4,3,4,1,5); average from several ZVEI umbrella specifications for PWB
Sodium chloride, powder, at plant/RER U	0.51072	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	6.9677	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer

Sulphuric acid, liquid, at plant/RER U	1.1674	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
tap water, at user/kg/RER U	23.967	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Tin, at regional storage/RER U	0.0027884	kg		Lognormal	1.27	(2,4,3,4,1,5); average from several ZVEI umbrella specifications for PWB
transport, freight, rail/tkm/RER U	19.303	tkm		Lognormal	2.08	(2,4,3,4,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	3.2172	tkm		Lognormal	2.08	(2,4,3,4,1,5); standard distances
Water, ultrapure, at plant/GLO U	1087.1	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 3 European PWB producer
Output						
Emissions to air						
Copper	0.00498	kg	high. pop.	Lognormal	3.08	(2,4,3,4,1,5); calculated from total release in USA
Heat, waste	1175.4	MJ	high. pop.	Lognormal	1.60	(2,4,3,4,1,5); calculated, from electricity input
Hydrogen chloride	0.0028564	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Hydrogen peroxide	0.00034474	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
NMVOC, non-methane volatile organic compounds, unspecified origin	0.042682	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Particulates, < 2.5 um	0.00033653	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Particulates, > 2.5 um, and < 10um	0.00011218	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Sodium hydroxide	0.0014774	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Sulfuric acid	0.00024624	kg	high. pop.	Lognormal	2.08	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Emissions to water						
AOX, Adsorbable Organic Halogen as Cl	0.00013352	kg	river	Lognormal	1.60	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Arsenic	2.1779E-06	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
BOD5, Biological Oxygen Demand	0.081715	kg	river	Lognormal	1.60	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer

Cadmium	1.8422E-05	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Chromium	5.2166E-05	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
COD, Chemical Oxygen Demand	0.081715	kg	river	Lognormal	1.60	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Copper	0.00017547	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Fluoride	0.00037574	kg	river	Lognormal	1.60	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Mercury	6.0922E-07	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Nickel	6.0922E-05	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Zinc	5.1437E-05	kg	river	Lognormal	5.09	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Waste to treatment						
disposal, emulsion paint, 0% water, to municipal incineration/kg/CH U	0.18204	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	13.899	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
disposal, municipal solid waste, 22.9% water, to municipal incineration/kg/CH U	0.052276	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer
Disposal, sludge, pig iron production, 8.6% water, to residual material landfill/CH U	4.1222	kg		Lognormal	1.27	(2,4,3,4,1,5); average data over 3 years from 1 European PWB producer

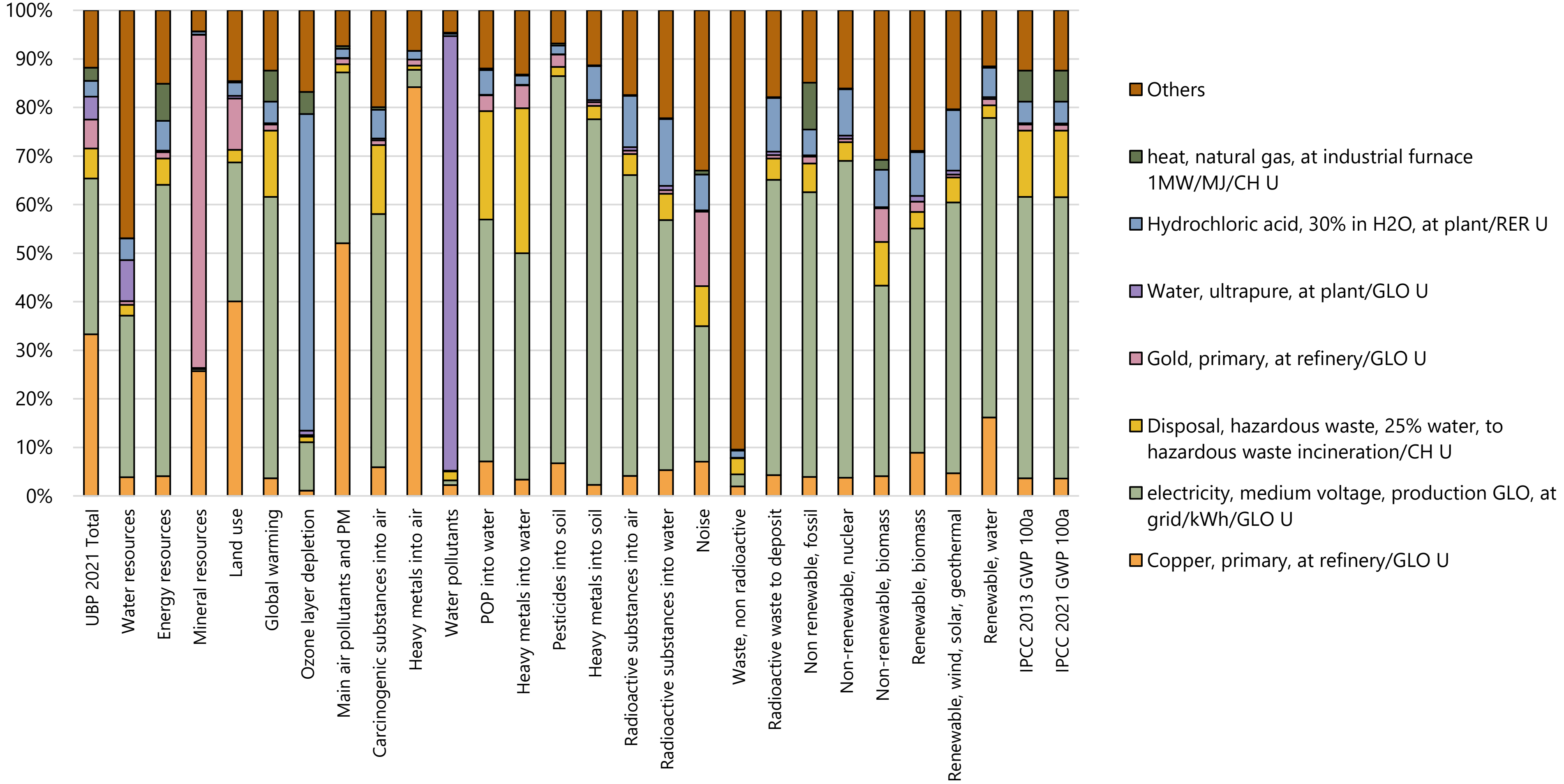

Figure 8.3-3. Contribution analysis presented in bar chart for: Printed wiring board, surface mount, lead-free surface. FU = 1 m^2

Table 8.3-6. Contribution analysis presented in table for: Printed wiring board, surface mount, lead-free surface. FU = 1 m²

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	33%	4%	4%	4%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	32%	59%	58%	58%
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	6%	6%	14%	14%
Gold, primary, at refinery/GLO U	6%	1%	1%	1%
Water, ultrapure, at plant/GLO U	5%	0%	0%	0%
Hydrochloric acid, 30% in H2O, at plant/RER U	3%	5%	4%	4%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	3%	10%	6%	6%
Others	12%	15%	12%	12%
Total impact, in absolute value	**7.05E+05**	**2.70E+03**	**2.48E+02**	**2.47E+02**

8.3.4 Printed wiring board, surface mount, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, surface mount, at plant" is shown in Table 8.3-7, whereas the life cycle impact assessment results are presented in Figure 8.3-4 and Table 8.3-8.

Table 8.3-7. Life cycle inventory for Printed wiring board, surface mount, at plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, surface mount, at plant/m2/GLO U	1	m2				
Input						
Printed wiring board, surface mount, lead-free surface, at plant/m2/GLO U	1	m2		Lognormal	1.33	(3,3,2,3,3,5) entirely Pb free

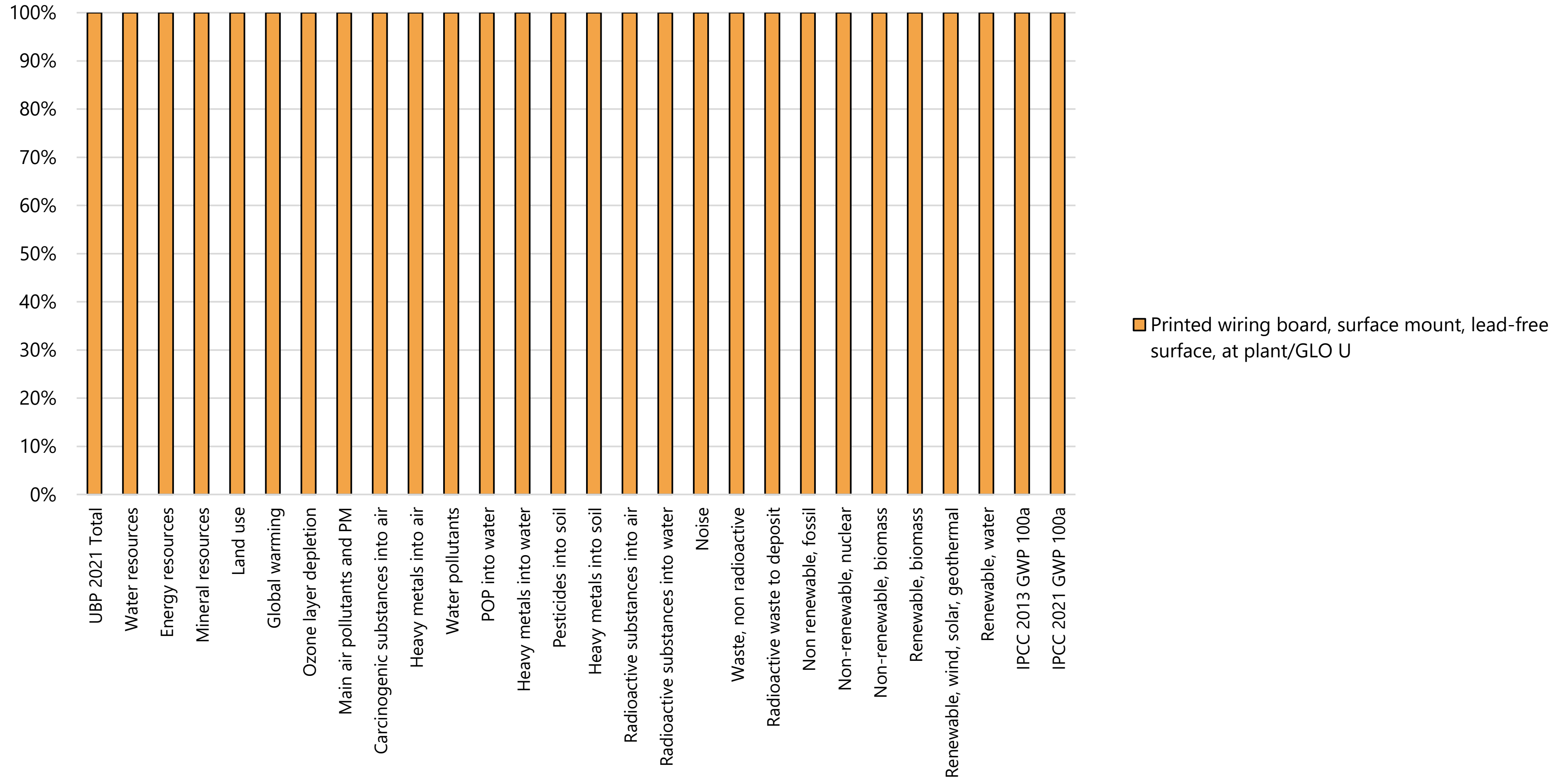

Figure 8.3-4. Contribution analysis presented in bar chart for: Printed wiring board, surface mount, at plant. FU = 1 m^2

Table 8.3-8. Contribution analysis presented in table for: Printed wiring board, surface mount, at plant. FU = 1 m^2

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mount, lead-free surface, at plant/m2/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**7.05E+05**	**2.70E+03**	**2.48E+02**	**2.47E+02**

8.3.5 Printed wiring board, through hole, lead-free surface, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The energy consumption in the manufacturing of printed wiring board is updated using the recent PWB manufacturer's onsite measurement data found in the literature (Duque Ciceri et al., 2010; Kupka et al., 2018).

The resulting unit process for "Printed wiring board, through hole, lead-free surface, at plant" is shown in

Table 8.3-9, whereas the life cycle impact assessment results are presented in Figure 8.3-5 and Table 8.3-10.

Table 8.3-9. Life cycle inventory for Printed wiring board, through-hole, lead-free surface and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, through-hole, lead-free surface, at plant/m2/GLO U	1	m2				
Input						
Acrylic varnish, 87.5% in H2O, at plant/RER U	0.137	kg		Lognormal	1.26	(2,3,3,4,1,5); approximation, based on average data over 3 years from 1 European PWB producer
Ammonium chloride, at plant/GLO U	1.868	kg		Lognormal	1.26	(2,3,3,4,1,5); assumption - based on data from 1 European producer
Copper, primary, at refinery/GLO U	0.75245	kg		Lognormal	1.26	(2,3,3,4,1,5); assumption - based on data from 1 European producer
Dipropylene glycol monomethyl ether, at plant/RER U	0.0546	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
electricity, medium voltage, production GLO, at grid/kWh/GLO U	54	kWh		Lognormal	1.26	(2,3,3,4,1,5); updated using recent literature data
Electronic component production plant/GLO/I U	0.00000002	p		Lognormal	3.07	(2,3,3,4,1,5); rough assumption
Ethanol from ethylene, at plant/RER U	0.02335	kg		Lognormal	1.26	(2,3,3,4,1,5); assumption - based on data from 1 European producer
Glass fibre reinforced plastic, polyester resin, hand lay-up, at plant/RER U	2.9916	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	0.755	MJ		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
heat, natural gas, at industrial furnace 1MW/MJ/CH U	70.9	MJ		Lognormal	1.26	(2,3,3,4,1,5); updated using recent literature data
Hydrochloric acid, 30% in H2O, at plant/RER U	1.61	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Hydrogen peroxide, 50% in H2O, at plant/RER U	0.239	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Iron (III) chloride, 40% in H2O, at plant/CH U	0.183	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Isopropanol, at plant/RER U	0.137	kg		Lognormal	1.26	(2,3,3,4,1,5); approximation, based on average data over 3 years from 1 European PWB producer
Phenolic resin, at plant/RER U	0.061989	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Polyethylene, LLDPE, granulate, at plant/RER U	0.02335	kg		Lognormal	1.26	(2,3,3,4,1,5); assumption - based on data from 1 European producer
Potassium carbonate, at plant/GLO U	3.7827	kg		Lognormal	1.26	(2,3,3,4,1,5); assumption - based on data from 1 European producer

Sheet rolling, copper/RER U	1.8167	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Silver, at regional storage/RER U	0.00081053	kg		Lognormal	1.26	(2,3,3,4,1,5); average from several ZVEI umbrella specifications for PWB
Sodium chloride, powder, at plant/RER U	0.327	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	0.434	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Sodium persulfate, at plant/GLO U	0.6538	kg		Lognormal	1.26	(2,3,3,4,1,5); assumption - based on data from 1 European producer
Sulphuric acid, liquid, at plant/RER U	0.239	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
tap water, at user/kg/RER U	308	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Tin, at regional storage/RER U	0.0035684	kg		Lognormal	1.26	(2,3,3,4,1,5); average from several ZVEI umbrella specifications for PWB
transport, freight, rail/tkm/RER U	9.177	tkm		Lognormal	2.07	(2,3,3,4,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	1.5295	tkm		Lognormal	2.07	(2,3,3,4,1,5); standard distances
Water, ultrapure, at plant/GLO U	0.205	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 3 European PWB producer
Output						
Emissions to air						
Copper	0.00498	kg	high. pop.	Lognormal	3.07	(2,3,3,4,1,5); calculated from total release in USA
Heat, waste	340.56	MJ	high. pop.	Lognormal	1.59	(2,3,3,4,1,5); calculated, from electricity input
Hydrogen chloride	0.002944	kg	high. pop.	Lognormal	2.07	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Hydrogen peroxide	0.000414	kg	high. pop.	Lognormal	2.07	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
NMVOC, non-methane volatile organic compounds, unspecified origin	0.00852	kg	high. pop.	Lognormal	2.07	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Sodium hydroxide	0.000782	kg	high. pop.	Lognormal	2.07	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Sulfuric acid	0.000414	kg	high. pop.	Lognormal	2.07	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Emissions to water						
AOX, Adsorbable Organic Halogen as Cl	0.00013352	kg	river	Lognormal	1.59	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer

Arsenic	2.1779E-06	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
BOD5, Biological Oxygen Demand	0.000084	kg	river	Lognormal	1.59	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Cadmium	1.8422E-05	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Chromium	5.2166E-05	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
COD, Chemical Oxygen Demand	0.000084	kg	river	Lognormal	1.59	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Copper	2.07E-08	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Fluoride	0.00037574	kg	river	Lognormal	1.59	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Mercury	6.0922E-07	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Nickel	8E-09	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Zinc	8.33E-09	kg	river	Lognormal	5.08	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Waste to treatment						
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	1.96	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
disposal, municipal solid waste, 22.9% water, to municipal incineration/kg/CH U	0.09414	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	0.227	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
disposal, sludge from steel rolling, 20% water, to residual material landfill/kg/CH U	0.743	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.109	kg		Lognormal	1.26	(2,3,3,4,1,5); average data over 3 years from 1 European PWB producer

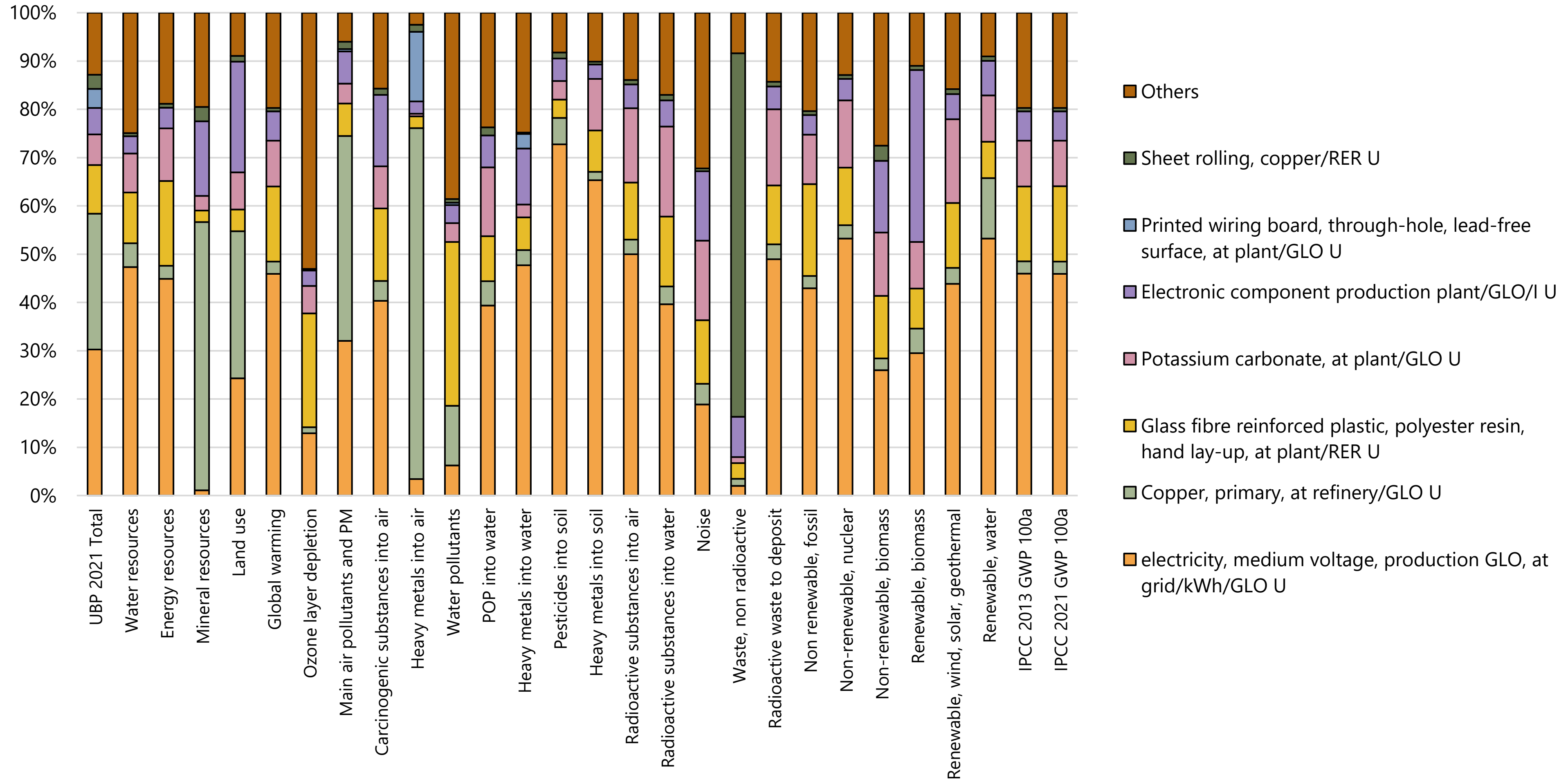

Figure 8.3-5. Contribution analysis presented in bar chart for: Printed wiring board, through hole, lead-free surface. FU = 1 m²

Table 8.3-10. Contribution analysis presented in table for: Printed wiring board, through hole, lead-free surface. FU = 1 m²

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	30%	43%	46%	46%
Copper, primary, at refinery/GLO U	28%	3%	3%	3%
Glass fibre reinforced plastic, polyester resin, hand lay-up, at plant/RER U	10%	19%	15%	16%
Potassium carbonate, at plant/GLO U	6%	10%	9%	9%
Electronic component production plant/GLO/I U	5%	4%	6%	6%
Printed wiring board, through-hole, lead-free surface, at plant/GLO U	4%	0%	0%	0%
Sheet rolling, copper/RER U	3%	1%	1%	1%
Others	13%	20%	20%	20%
Total impact, in absolute value	**2.19E+05**	**1.08E+03**	**9.13E+01**	**9.11E+01**

8.3.6 Printed wiring board, through hole, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, through hole, at plant" is shown in Table 8.3-11, whereas the life cycle impact assessment results are presented in Figure 8.3-6 and Table 8.3-12.

Table 8.3-11. Life cycle inventory for Printed wiring board, through-hole, at plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, through-hole, at plant/m2/GLO U	1	m2				
Input						
Printed wiring board, through-hole, lead-free surface, at plant/m2/GLO U	1	m2		Lognormal	1.33	(3,3,2,3,3,5). Update: entirely Pb free

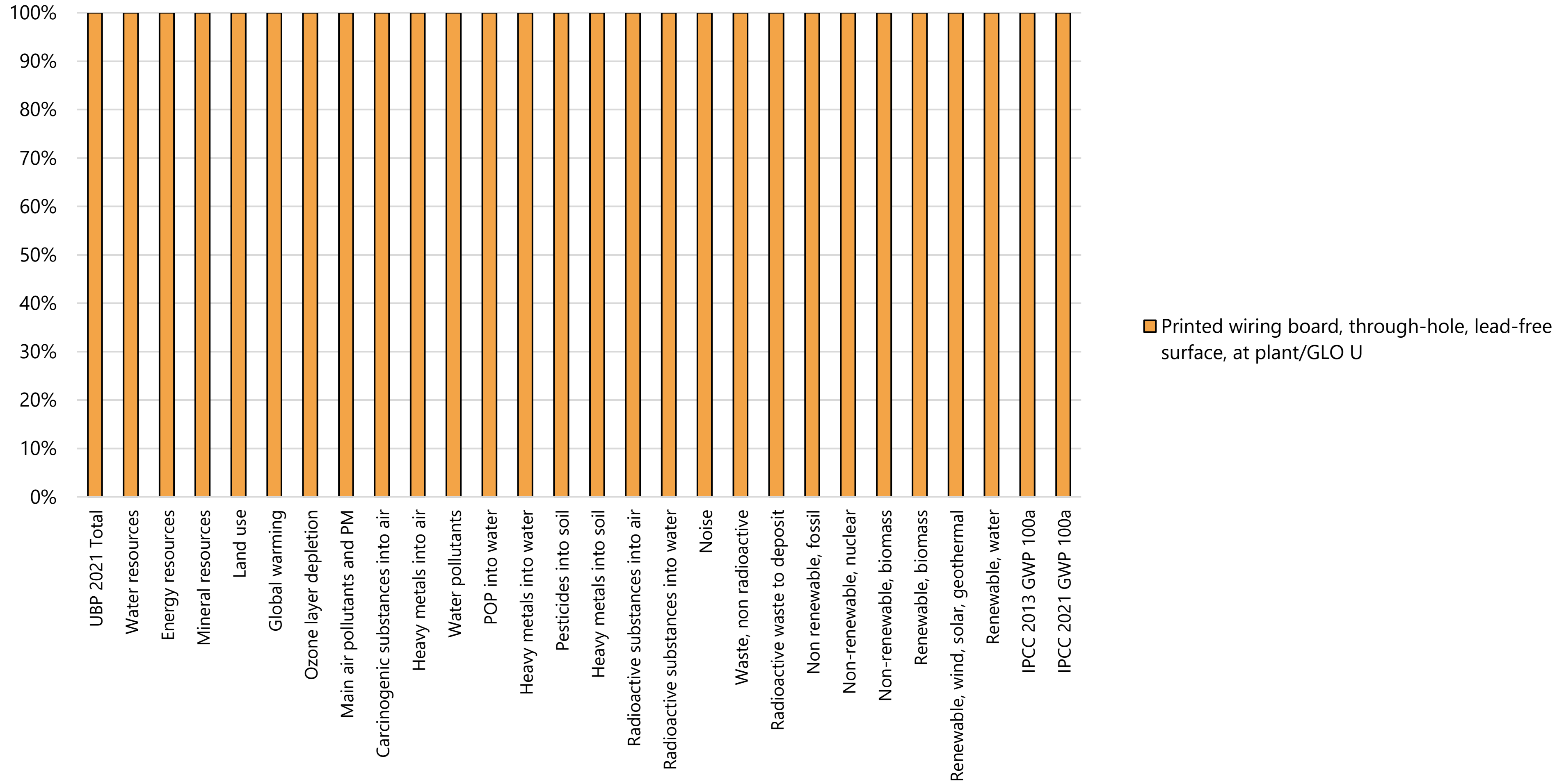

Figure 8.3-6. Contribution analysis presented in bar chart for: Printed wiring board, through hole, at plant. FU = 1 m²

Table 8.3-12. Contribution analysis presented in table for: Printed wiring board, through hole, at plant. FU = 1 m^2

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, through-hole, lead-free surface, at plant/m2/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**2.19E+05**	**1.08E+03**	**9.13E+01**	**9.11E+01**

8.3.7 Printed wiring board, surface mounted, unspec., Pb free

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In terms of bill of materials, PWB surface mounted and through hole mounted do not undergo significant changes according to the market data found in PWB design simulators (Leiton.de, 2023). Most of the updates and technology developments nevertheless occur in the upstream, i.e., manufacturing of chips/semiconductors and the basic electronic components. Therefore, we modified the foreground inventory of the PWBs in the updated UVEK LCA database using new ICT datasets described in the separate unit processes.

The resulting unit process for "Printed wiring board, surface mounted, unspec., Pb free" is shown in

Table 8.3-13, whereas the life cycle impact assessment results are presented in Figure 8.3-7 and Table 8.3-14.

Table 8.3-13. Life cycle inventory for Printed wiring board, surface mounted, unspec., Pb free and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	1	kg				
Input						
Capacitor, SMD type, surface-mounting, at plant/GLO U	0.032653	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Connector, PCI bus, at plant/GLO U	0.019388	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Diode, glass-, SMD type, surface mounting, at plant/GLO U	0.0040816	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Integrated circuit, IC, logic type, at plant/GLO U	0.17347	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Light emitting diode, LED, at plant/GLO U	0.0010204	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Mounting, surface mount technology, Pb-free solder/GLO U	0.23225	m2		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Printed wiring board, surface mount, lead-free surface, at plant/GLO U	0.23225	m2		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Resistor, SMD type, surface mounting, at plant/GLO U	0.023469	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
transistor, SMD type, surface mounting, at plant/GLO U	0.010204	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
transport, freight, rail/tkm/RER U	0.14286	tkm		Lognormal	2.16	(3,5,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.13265	tkm		Lognormal	2.16	(3,5,4,3,1,5); standard distances
transport, transoceanic freight ship/tkm/OCE U	0.80612	tkm		Lognormal	2.16	(3,5,4,3,1,5); standard distances
Output						
Waste to treatment						
Disposal, treatment of printed wiring boards/GLO U	0.020408	kg		Lognormal	1.40	(3,5,4,3,1,5); data from literature plus own assumptions

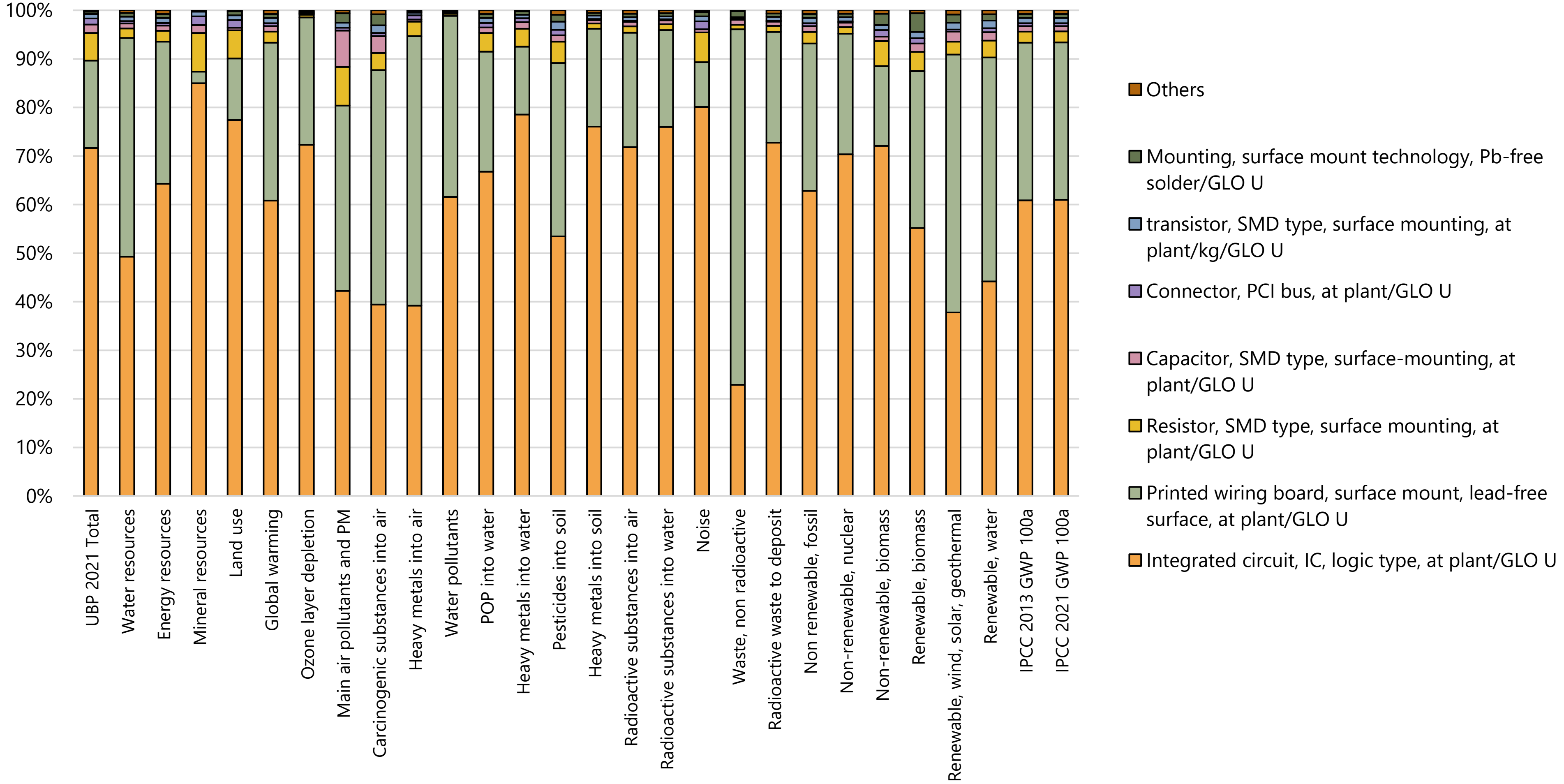

Figure 8.3-7. Contribution analysis presented in bar chart for: Printed wiring board, surface mounted, unspec., Pb free. FU = 1 kg

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Table 8.3-14. Contribution analysis presented in table for: Printed wiring board, surface mounted, unspec., Pb free. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/GLO U	72%	63%	61%	61%
Printed wiring board, surface mount, lead-free surface, at plant/GLO U	18%	30%	33%	32%
Resistor, SMD type, surface mounting, at plant/GLO U	6%	2%	2%	2%
Capacitor, SMD type, surface-mounting, at plant/GLO U	2%	1%	1%	1%
Connector, PCI bus, at plant/GLO U	1%	1%	1%	1%
transistor, SMD type, surface mounting, at plant/kg/GLO U	1%	1%	1%	1%
Mounting, surface mount technology, Pb-free solder/GLO U	1%	1%	1%	1%
Others	0%	1%	1%	1%
Total impact, in absolute value	**9.04E+05**	**2.04E+03**	**1.74E+02**	**1.74E+02**

8.3.8 Printed wiring board, surface mounted, unspec., solder mix

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, surface mounted, unspec., solder mix " is shown in Table 8.3-15, whereas the life cycle impact assessment results are presented in Figure 8.3-8 and Table 8.3-16.

Table 8.3-15. Life cycle inventory for Printed wiring board, surface mounted, unspec., solder mix and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	1	kg				
Input						
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	1	kg		Lognormal	1.42	(3,5,3,3,3,5); entirely Pb free

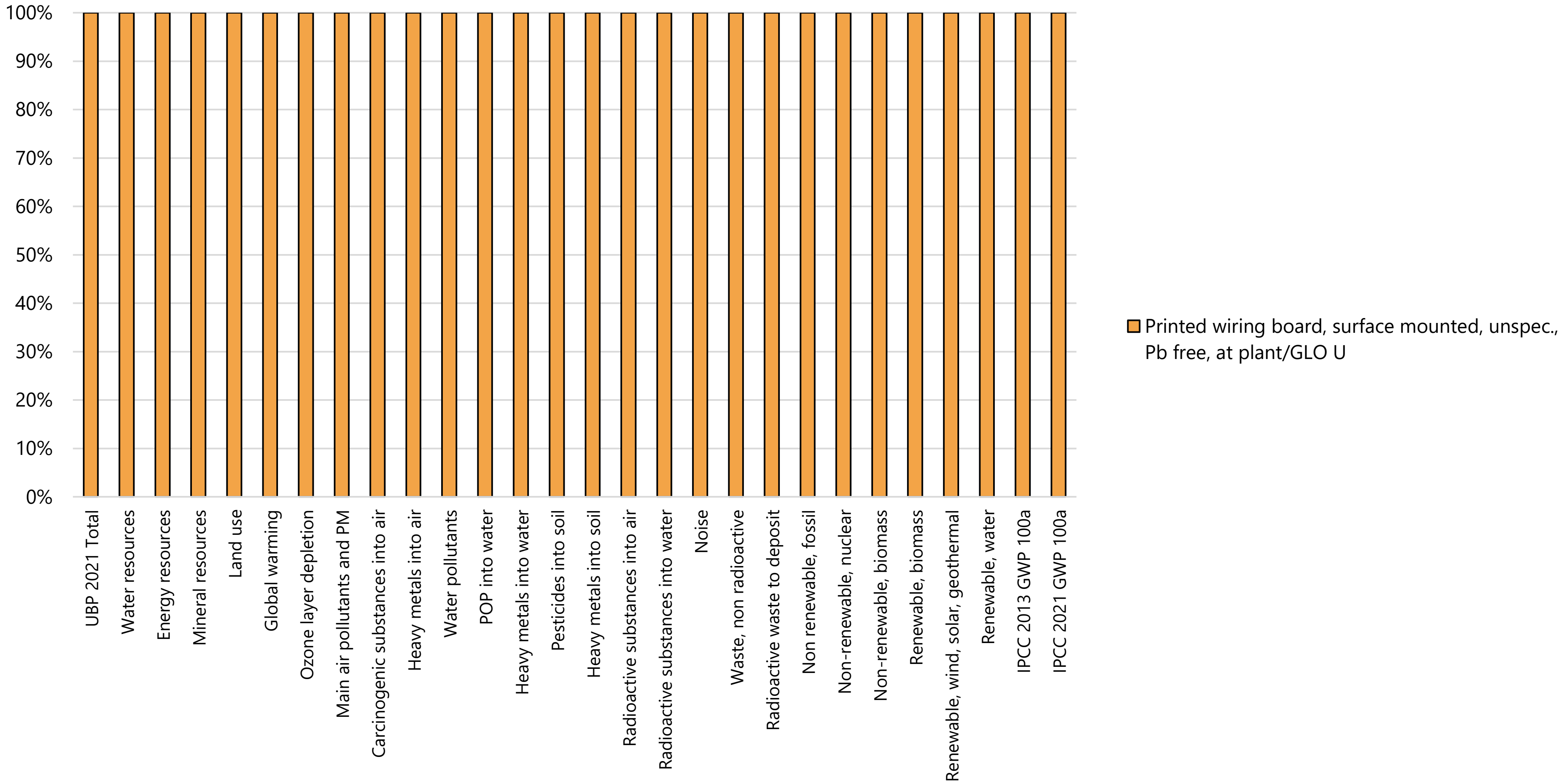

Figure 8.3-8. Contribution analysis presented in bar chart for: Printed wiring board, surface mounted, unspec., solder mix. FU = 1 kg

Table 8.3-16. Contribution analysis presented in table for: Printed wiring board, surface mounted, unspec., solder mix. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**9.04E+05**	**2.04E+03**	**1.74E+02**	**1.74E+02**

8.3.9 Printed wiring board, through-hole mounted, unspec., Pb free

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In terms of bill of materials, PWB surface mounted and through hole mounted do not undergo significant changes according to the market data found in PWB design simulators (Leiton.de, 2023). Most of the updates and technology developments nevertheless occur in the upstream, i.e., manufacturing of chips/semiconductors and the basic electronic components. Therefore, we modified the foreground inventory of the PWBs in the updated UVEK LCA database using new ICT datasets described in the separate unit processes.

The resulting unit process for "Printed wiring board, surface mounted, unspec., Pb free" is shown in Table 8.3-17, whereas the life cycle impact assessment results are presented in Figure 8.3-9 and Table 8.3-18.

Table 8.3-17. Life cycle inventory for Printed wiring board, through-hole mounted, unspec., Pb free and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	1	kg				
Input						
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.16	kg		Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling

Capacitor, electrolyte type, < 2cm height, at plant/GLO U	0.021837	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Capacitor, electrolyte type, > 2cm height, at plant/GLO U	0.036939	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Capacitor, film, through-hole mounting, at plant/GLO U	0.076429	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Capacitor, unspecified, at plant/GLO U	0.012551	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Diode, glass-, through-hole mounting, at plant/GLO U	0.0060816	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Inductor, ring core choke type, at plant/GLO U	0.33061	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Integrated circuit, IC, logic type, at plant/GLO U	0.017959	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Mounting, through-hole technology, Pb-free solder/GLO U	0.058367	m2	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Printed wiring board, through-hole, lead-free surface, at plant/GLO U	0.058367	m2	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Resistor, metal film type, through-hole mounting, at plant/GLO U	0.02051	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Section bar extrusion, aluminium/RER U	0.16	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Transformer, high voltage use, at plant/GLO U	0.096735	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
Transformer, low voltage use, at plant/GLO U	0.030714	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
transistor, wired, big size, through-hole mounting, at plant/GLO U	0.026224	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
transistor, wired, small size, through-hole mounting, at plant/GLO U	0.00089592	kg	Lognormal	1.40	(3,5,4,3,1,5); own assumptions - from literature & dismantling
transport, freight, rail/tkm/RER U	0.14286	tkm	Lognormal	2.16	(3,5,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.13265	tkm	Lognormal	2.16	(3,5,4,3,1,5); standard distances
transport, transoceanic freight ship/tkm/OCE U	0.80612	tkm	Lognormal	2.16	(3,5,4,3,1,5); standard distances
Output					
Waste to treatment					
Disposal, treatment of printed wiring boards/GLO U	0.020408	kg	Lognormal	1.40	(3,5,4,3,1,5); data from literature plus own assumptions

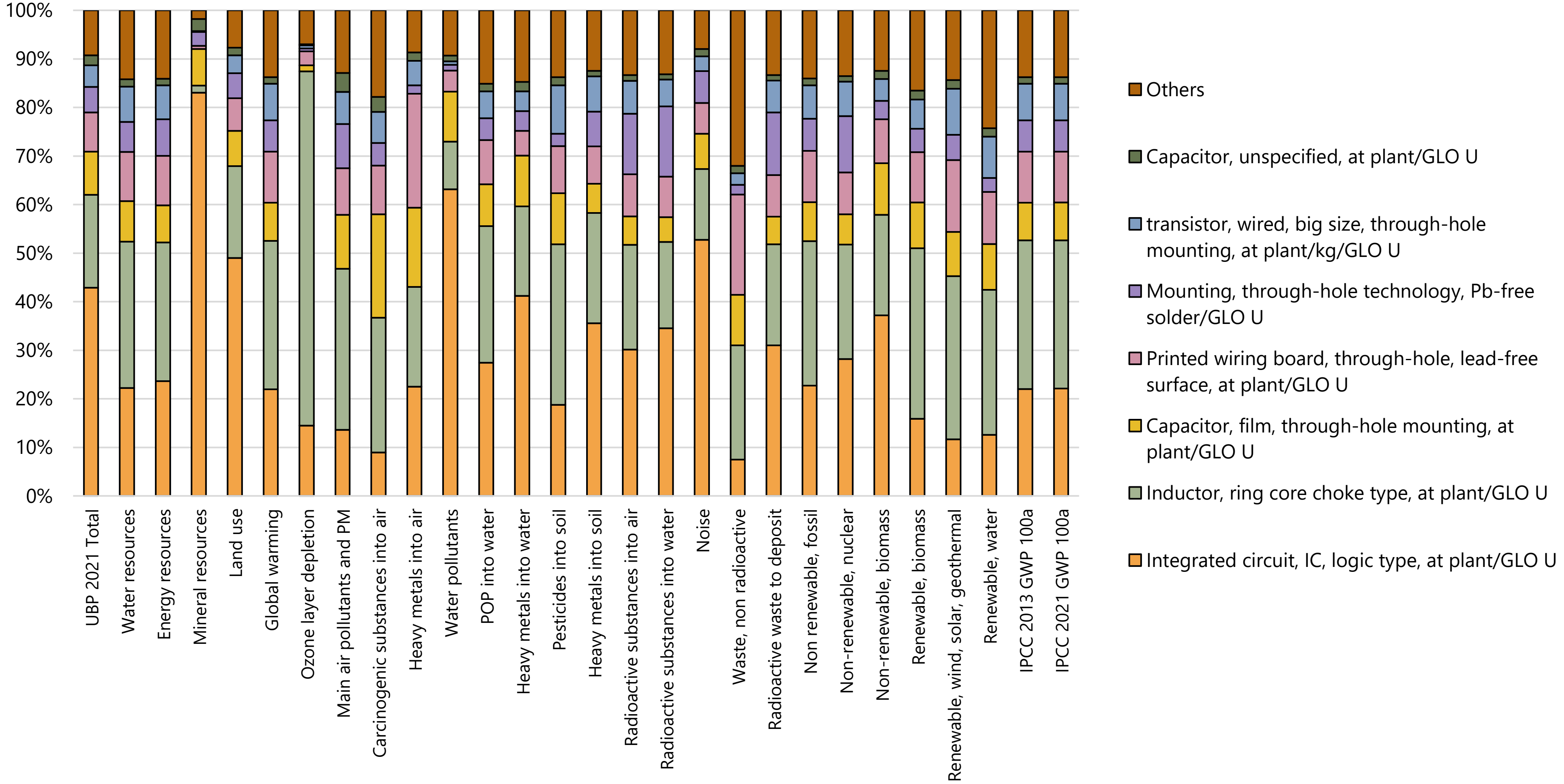

Figure 8.3-9. Contribution analysis presented in bar chart for: Printed wiring board, through-hole mounted, unspec., Pb free. FU = 1 kg

Table 8.3-18. Contribution analysis presented in table for: Printed wiring board, through-hole mounted, unspec., Pb free. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/GLO U	43%	23%	22%	22%
Inductor, ring core choke type, at plant/GLO U	19%	30%	31%	31%
Capacitor, film, through-hole mounting, at plant/GLO U	9%	8%	8%	8%
Printed wiring board, through-hole, lead-free surface, at plant/GLO U	8%	11%	10%	10%
Mounting, through-hole technology, Pb-free solder/GLO U	5%	7%	6%	6%
transistor, wired, big size, through-hole mounting, at plant/kg/GLO U	4%	7%	8%	8%
Capacitor, unspecified, at plant/GLO U	2%	1%	1%	1%
Others	9%	14%	14%	14%
Total impact, in absolute value	**1.56E+05**	**5.81E+02**	**4.97E+01**	**4.96E+01**

8.3.10 Printed wiring board, through-hole mounted, unspec., solder mix

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, through-hole mounted, unspec., solder mix " is shown in Table 8.3-19, whereas the life cycle impact assessment results are presented in Figure 8.3-10 and Table 8.3-20.

Table 8.3-19. Life cycle inventory for Printed wiring board, through-hole mounted, unspec., solder mix and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, through-hole mounted, unspec., solder mix, at plant/kg/GLO U	1	kg				
Input						
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	1	kg		Lognormal	1.42	(3,5,3,3,3,5); entirely Pb free

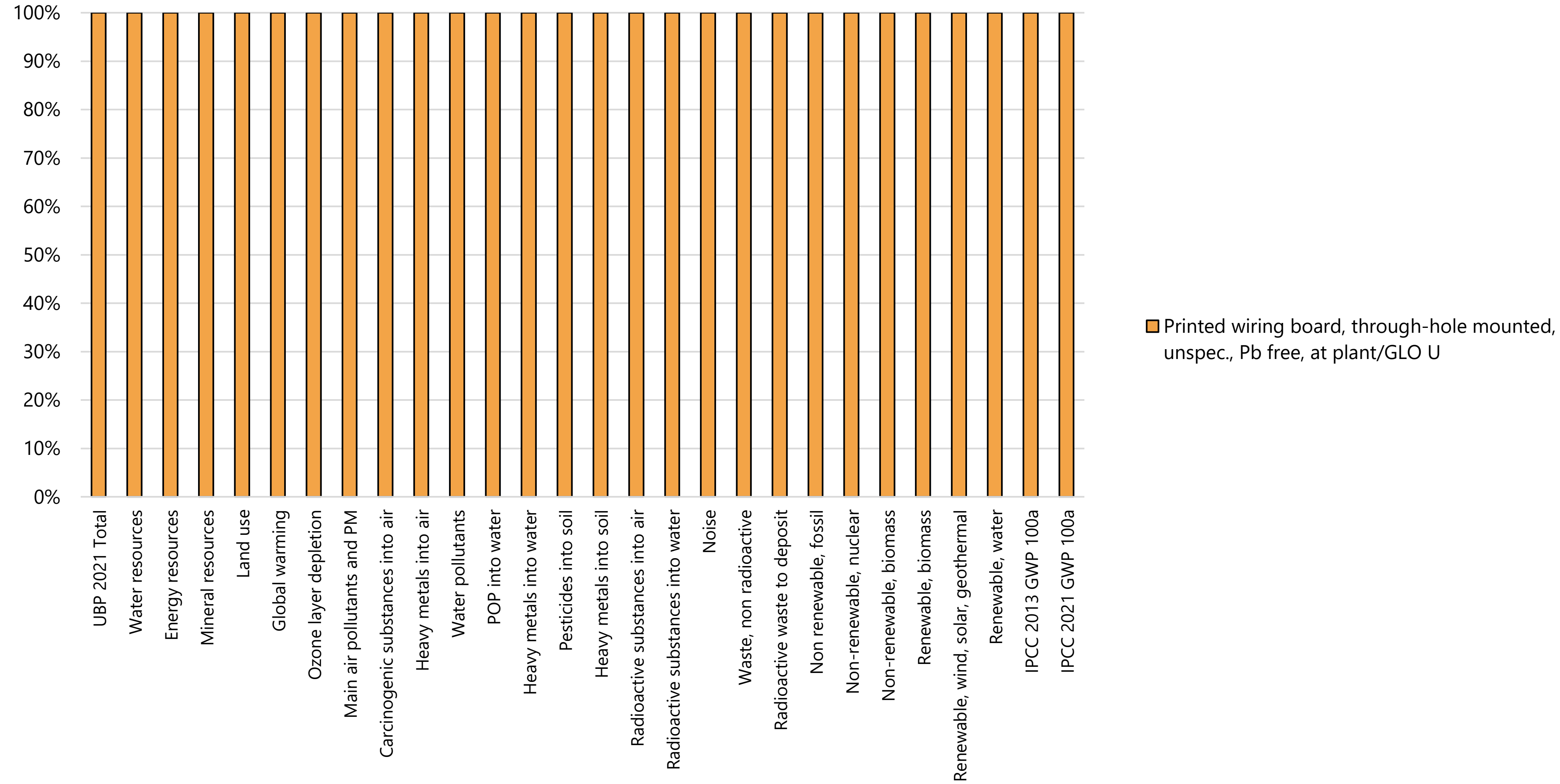

Figure 8.3-10. Contribution analysis presented in bar chart for: Printed wiring board, through-hole mounted, unspec., solder mix. FU = 1 kg

Table 8.3-20. Contribution analysis presented in table for: Printed wiring board, through-hole mounted, unspec., solder mix. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**1.56E+05**	**5.81E+02**	**4.97E+01**	**4.96E+01**

8.3.11 Printed wiring board, mounted, Desktop PC mainboard, Pb free

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In terms of bill of materials, PWB surface mounted and through hole mounted do not undergo significant changes according to the market data found in PWB design simulators (Leiton.de, 2023). Most of the updates and technology developments nevertheless occur in the upstream, i.e., manufacturing of chips/semiconductors and the basic electronic components. Therefore, we modified the foreground inventory of the PWBs in the updated UVEK LCA database using new ICT datasets described in the separate unit processes.

The resulting unit process for "Printed wiring board, mounted, Desktop PC mainboard, Pb free" is shown in

Table 8.3-21, whereas the life cycle impact assessment results are presented in Figure 8.3-11 and Table 8.3-22.

Table 8.3-21. Life cycle inventory for Printed wiring board, mounted, Desktop PC mainboard, Pb free and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, mounted, Desktop PC mainboard, Pb free, at plant/kg/GLO U	1	kg				
Input						
Capacitor, electrolyte type, < 2cm height, at plant/GLO U	0.18286	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Capacitor, SMD type, surface-mounting, at plant/GLO U	0.01102	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Capacitor, Tantalum-, through-hole mounting, at plant/GLO U	0.045714	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Connector, computer, peripherical type, at plant/GLO U	0.061224	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Connector, PCI bus, at plant/GLO U	0.18367	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Diode, glass-, SMD type, surface mounting, at plant/GLO U	0.0017143	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Inductor, ring core choke type, at plant/GLO U	0.011429	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Integrated circuit, IC, logic type, at plant/GLO U	0.081633	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Integrated circuit, IC, memory type, at plant/GLO U	0.020408	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Light emitting diode, LED, at plant/GLO U	0.00073469	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Mounting, surface mount technology, Pb-free solder/GLO U	0.09312	m2		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Mounting, through-hole technology, Pb-free solder/GLO U	0.016433	m2		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Printed wiring board, surface mount, lead-free surface, at plant/GLO U	0.10955	m2		Lognormal	1.33	(3,3,4,3,1,5); data from literature
Resistor, SMD type, surface mounting, at plant/GLO U	0.01102	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
transistor, wired, small size, through-hole mounting, at plant/GLO U	0.045714	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
transport, freight, rail/tkm/RER U	0.14286	tkm		Lognormal	2.11	(3,3,4,3,1,5); standard distances

transport, freight, lorry, fleet average/tkm/RER U	0.13265	tkm	Lognormal	2.11	(3,3,4,3,1,5); standard distances
transport, transoceanic freight ship/tkm/OCE U	0.80612	tkm	Lognormal	2.11	(3,3,4,3,1,5); standard distances
Output					
Waste to treatment					
Disposal, treatment of printed wiring boards/GLO U	0.020408	kg	Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions

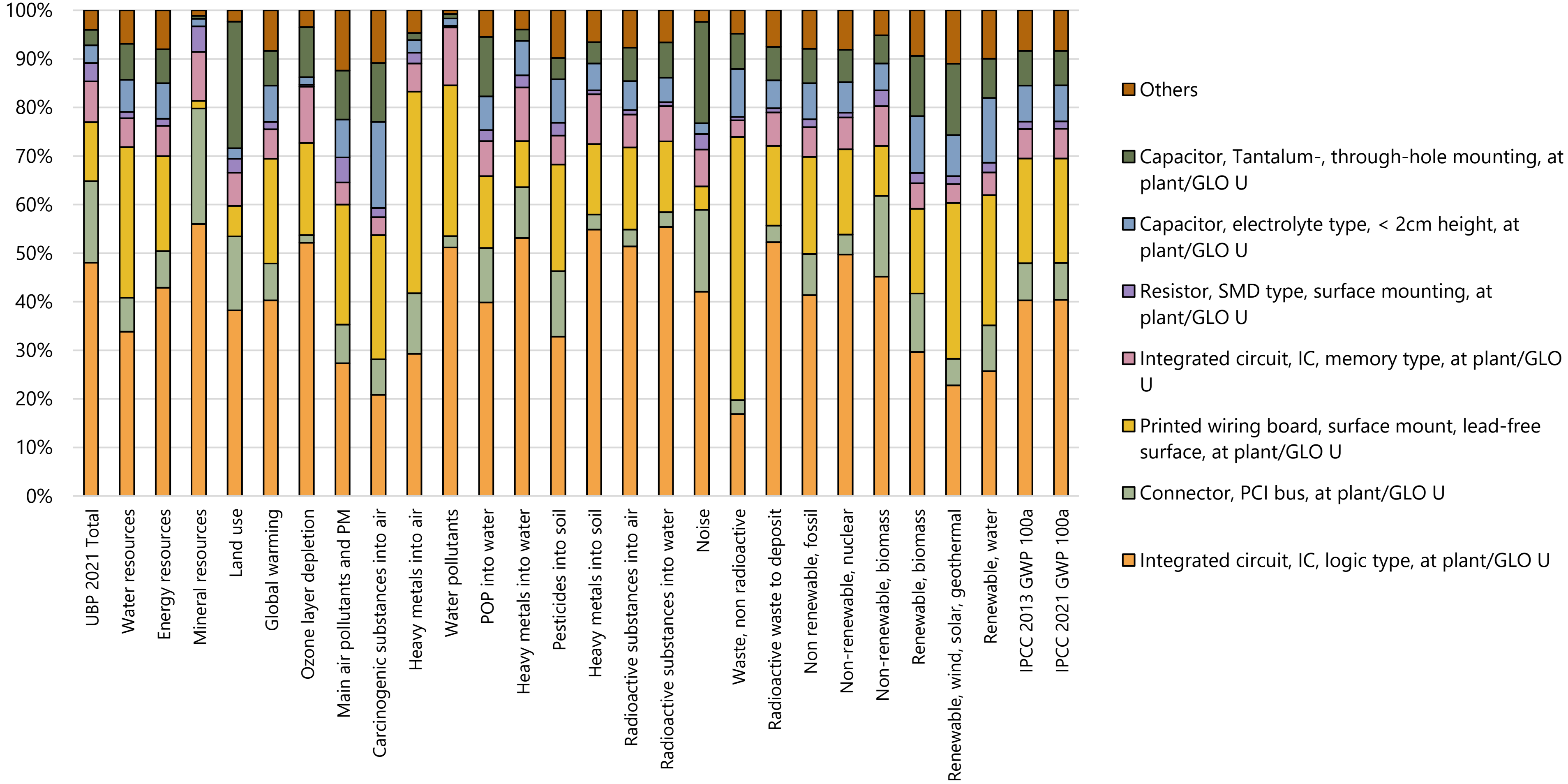

Figure 8.3-11. Contribution analysis presented in bar chart for: Printed wiring board, mounted, Desktop PC mainboard, Pb free. FU = 1 kg

Table 8.3-22. Contribution analysis presented in table for: Printed wiring board, mounted, Desktop PC mainboard, Pb free. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/GLO U	48%	41%	40%	40%
Connector, PCI bus, at plant/GLO U	17%	8%	8%	8%
Printed wiring board, surface mount, lead-free surface, at plant/GLO U	12%	20%	22%	22%
Integrated circuit, IC, memory type, at plant/GLO U	8%	6%	6%	6%
Resistor, SMD type, surface mounting, at plant/GLO U	4%	2%	1%	1%
Capacitor, electrolyte type, < 2cm height, at plant/GLO U	4%	7%	7%	7%
Capacitor, Tantalum-, through-hole mounting, at plant/GLO U	3%	7%	7%	7%
Others	4%	8%	8%	8%
Total impact, in absolute value	**6.36E+05**	**1.46E+03**	**1.24E+02**	**1.24E+02**

8.3.12 Printed wiring board, mounted, Desktop PC mainboard, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, mounted, Desktop PC mainboard, at plant" is shown in Table 8.3-23, whereas the life cycle impact assessment results are presented in Figure 8.3-12 and Table 8.3-24.

Table 8.3-23. Life cycle inventory for Printed wiring board, mounted, Desktop PC mainboard, at plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	1	kg				
Input						
Printed wiring board, mounted, Desktop PC mainboard, Pb free, at plant/kg/GLO U	1	kg		Lognormal	1.33	(3,3,2,3,3,5); competely Pb free

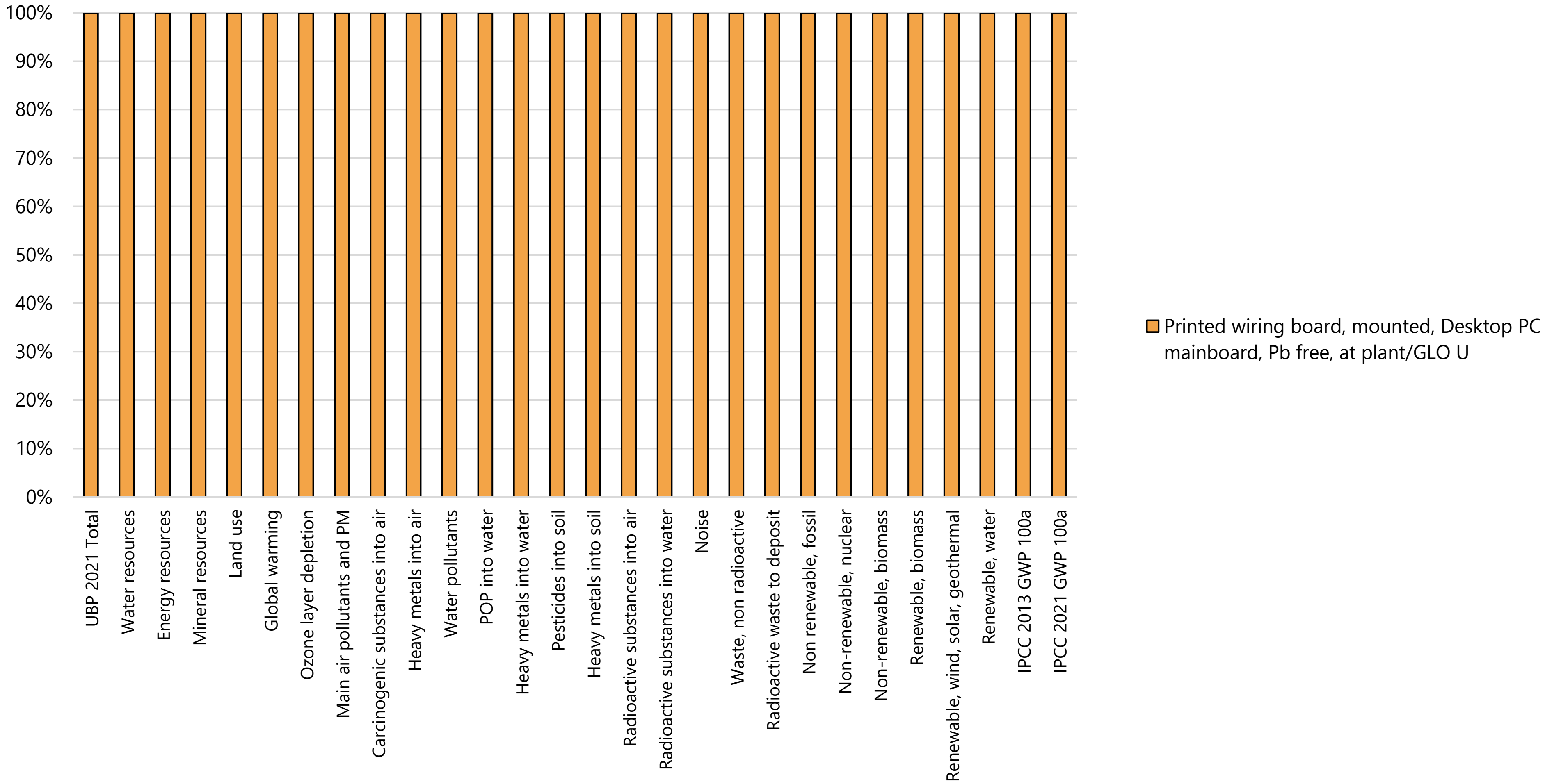

Figure 8.3-12. Contribution analysis presented in bar chart for: Printed wiring board, mounted, Desktop PC mainboard, at plant. FU = 1 kg

Table 8.3-24. Contribution analysis presented in table for: Printed wiring board, mounted, Desktop PC mainboard, at plant. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Desktop PC mainboard, Pb free, at plant/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**6.36E+05**	**1.46E+03**	**1.24E+02**	**1.24E+02**

8.3.13 Printed wiring board, mounted, Laptop PC mainboard, Pb free

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In terms of bill of materials, PWB surface mounted and through hole mounted do not undergo significant changes according to the market data found in PWB design simulators (Leiton.de, 2023). Most of the updates and technology developments nevertheless occur in the upstream, i.e., manufacturing of chips/semiconductors and the basic electronic components. Therefore, we modified the foreground inventory of the PWBs in the updated UVEK LCA database using new ICT datasets described in the separate unit processes.

The resulting unit process for "Printed wiring board, mounted, Desktop PC mainboard, Pb free" is shown in

Table 8.3-25, whereas the life cycle impact assessment results are presented in Figure 8.3-13 and Table 8.3-26.

Table 8.3-25. Life cycle inventory for Printed wiring board, mounted, Laptop PC mainboard, Pb free and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	1	kg				
Input						
Capacitor, SMD type, surface-mounting, at plant/GLO U	0.027551	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Connector, computer, peripherical type, at plant/GLO U	0.043878	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Connector, PCI bus, at plant/GLO U	0.032653	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Diode, glass-, SMD type, surface mounting, at plant/GLO U	0.0030612	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Integrated circuit, IC, logic type, at plant/GLO U	0.1449	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Integrated circuit, IC, memory type, at plant/GLO U	0.10816	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Light emitting diode, LED, at plant/GLO U	0.0010204	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Mounting, surface mount technology, Pb-free solder/GLO U	0.16496	m2		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Mounting, through-hole technology, Pb-free solder/GLO U	0.02911	m2		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
Printed wiring board, surface mount, lead-free surface, at plant/GLO U	0.19407	m2		Lognormal	1.33	(3,3,4,3,1,5); data from literature
Resistor, SMD type, surface mounting, at plant/GLO U	0.019388	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
transistor, SMD type, surface mounting, at plant/GLO U	0.0081633	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions
transport, freight, rail/tkm/RER U	0.14286	tkm		Lognormal	2.11	(3,3,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.13265	tkm		Lognormal	2.11	(3,3,4,3,1,5); standard distances
transport, transoceanic freight ship/tkm/OCE U	0.80612	tkm		Lognormal	2.11	(3,3,4,3,1,5); standard distances
Output						
Waste to treatment						
Disposal, treatment of printed wiring boards/GLO U	0.020408	kg		Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions

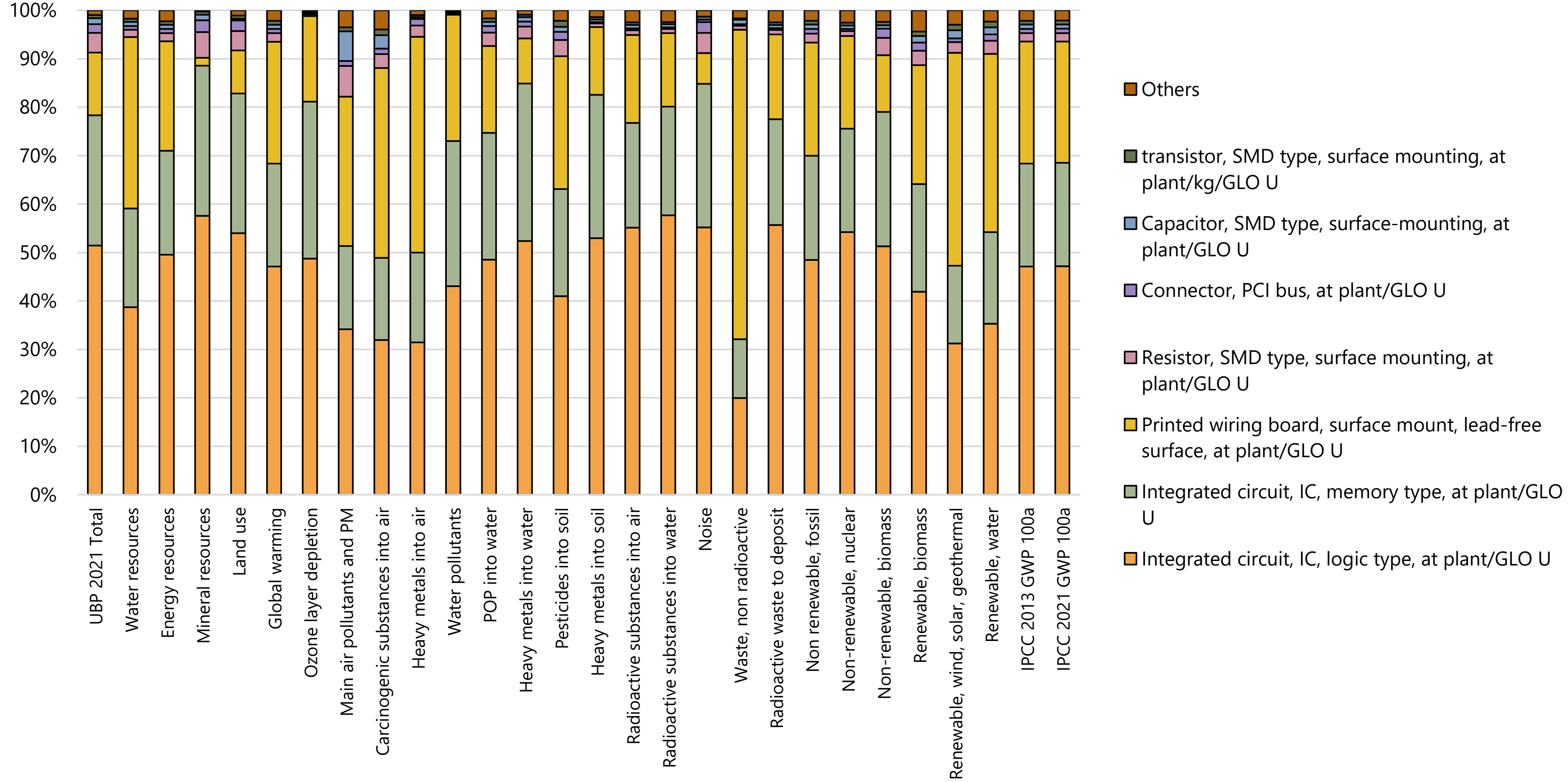

Figure 8.3-13. Contribution analysis presented in bar chart for: Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant. FU = 1 kg

Table 8.3-26. Contribution analysis presented in table for: Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/GLO U	51%	48%	47%	47%
Integrated circuit, IC, memory type, at plant/GLO U	27%	22%	21%	21%
Printed wiring board, surface mount, lead-free surface, at plant/GLO U	13%	23%	25%	25%
Resistor, SMD type, surface mounting, at plant/GLO U	4%	2%	2%	2%
Connector, PCI bus, at plant/GLO U	2%	1%	1%	1%
Capacitor, SMD type, surface-mounting, at plant/GLO U	1%	1%	1%	1%
transistor, SMD type, surface mounting, at plant/kg/GLO U	1%	1%	1%	1%
Others	1%	2%	2%	2%
Total impact, in absolute value	**1.05E+06**	**2.20E+03**	**1.87E+02**	**1.87E+02**

8.3.14 Printed wiring board, mounted, Laptop PC mainboard, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, mounted, Laptop PC mainboard, at plant" is shown in Table 8.3-27, whereas the life cycle impact assessment results are presented in Figure 8.3-14 and Table 8.3-28.

Table 8.3-27. Life cycle inventory for Printed wiring board, mounted, Laptop PC mainboard, at plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, mounted, Laptop PC mainboard, at plant/kg/GLO U	1	kg				
Input						
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	1	kg		Lognormal	1.33	(3,3,2,3,3,5); Only Pb free

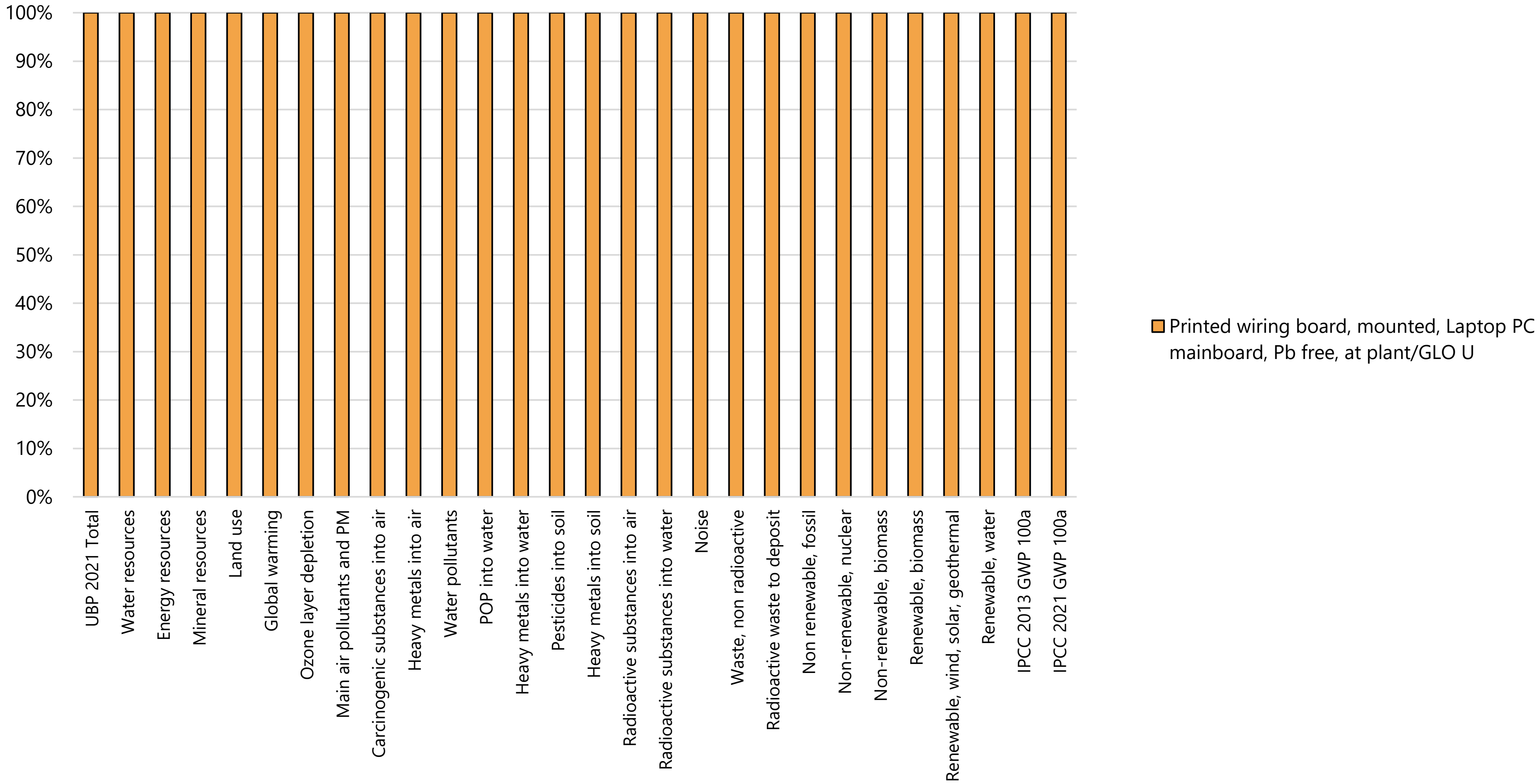

Figure 8.3-14. Contribution analysis presented in bar chart for: Printed wiring board, mounted, Laptop PC mainboard, at plant. FU = 1 kg

Table 8.3-28. Contribution analysis presented in table for: Printed wiring board, mounted, Laptop PC mainboard, at plant. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**1.05E+06**	**2.20E+03**	**1.87E+02**	**1.87E+02**

8.3.15 Printed wiring board, power supply unit desktop PC, Pb free

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In terms of bill of materials, PWB surface mounted and through hole mounted do not undergo significant changes according to the market data found in PWB design simulators (Leiton.de, 2023). Most of the updates and technology developments nevertheless occur in the upstream, i.e., manufacturing of chips/semiconductors and the basic electronic components. Therefore, we modified the foreground inventory of the PWBs in the updated UVEK LCA database using new ICT datasets described in the separate unit processes.

The resulting unit process for "Printed wiring board, mounted, power supply unit desktop PC, Pb free" is shown in Table 8.3-29, whereas the life cycle impact assessment results are presented in Figure 8.3-15 and Table 8.3-30.

Table 8.3-29. Life cycle inventory for Printed wiring board, power supply unit desktop PC, Pb free and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	1	kg				
Input						
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.13	kg		Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU

Capacitor, electrolyte type, < 2cm height, at plant/GLO U	0.043673	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Capacitor, electrolyte type, > 2cm height, at plant/GLO U	0.073878	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Capacitor, film, through-hole mounting, at plant/GLO U	0.022551	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Capacitor, unspecified, at plant/GLO U	0.025	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Diode, glass-, through-hole mounting, at plant/GLO U	0.0065	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Inductor, ring core choke type, at plant/GLO U	0.25612	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Integrated circuit, IC, logic type, at plant/GLO U	0.0030918	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Mounting, through-hole technology, Pb-free solder/GLO U	0.049184	m2	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Printed wiring board, through-hole, lead-free surface, at plant/GLO U	0.049184	m2	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Resistor, metal film type, through-hole mounting, at plant/GLO U	0.012143	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Section bar extrusion, aluminium/RER U	0.13	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Transformer, high voltage use, at plant/GLO U	0.19388	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
Transformer, low voltage use, at plant/GLO U	0.061531	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
transistor, wired, big size, through-hole mounting, at plant/GLO U	0.036122	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
transistor, wired, small size, through-hole mounting, at plant/GLO U	0.0017959	kg	Lognormal	1.38	(2,5,4,3,1,5); own dismantling activities of a Intel PII Desktop PC PSU
transport, freight, rail/tkm/RER U	0.14286	tkm	Lognormal	2.15	(2,5,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.13265	tkm	Lognormal	2.15	(2,5,4,3,1,5); standard distances
transport, transoceanic freight ship/tkm/OCE U	0.80612	tkm	Lognormal	2.15	(2,5,4,3,1,5); standard distances
Output					
Waste to treatment					
Disposal, treatment of printed wiring boards/GLO U	0.020408	kg	Lognormal	1.33	(3,3,4,3,1,5); data from literature plus own assumptions

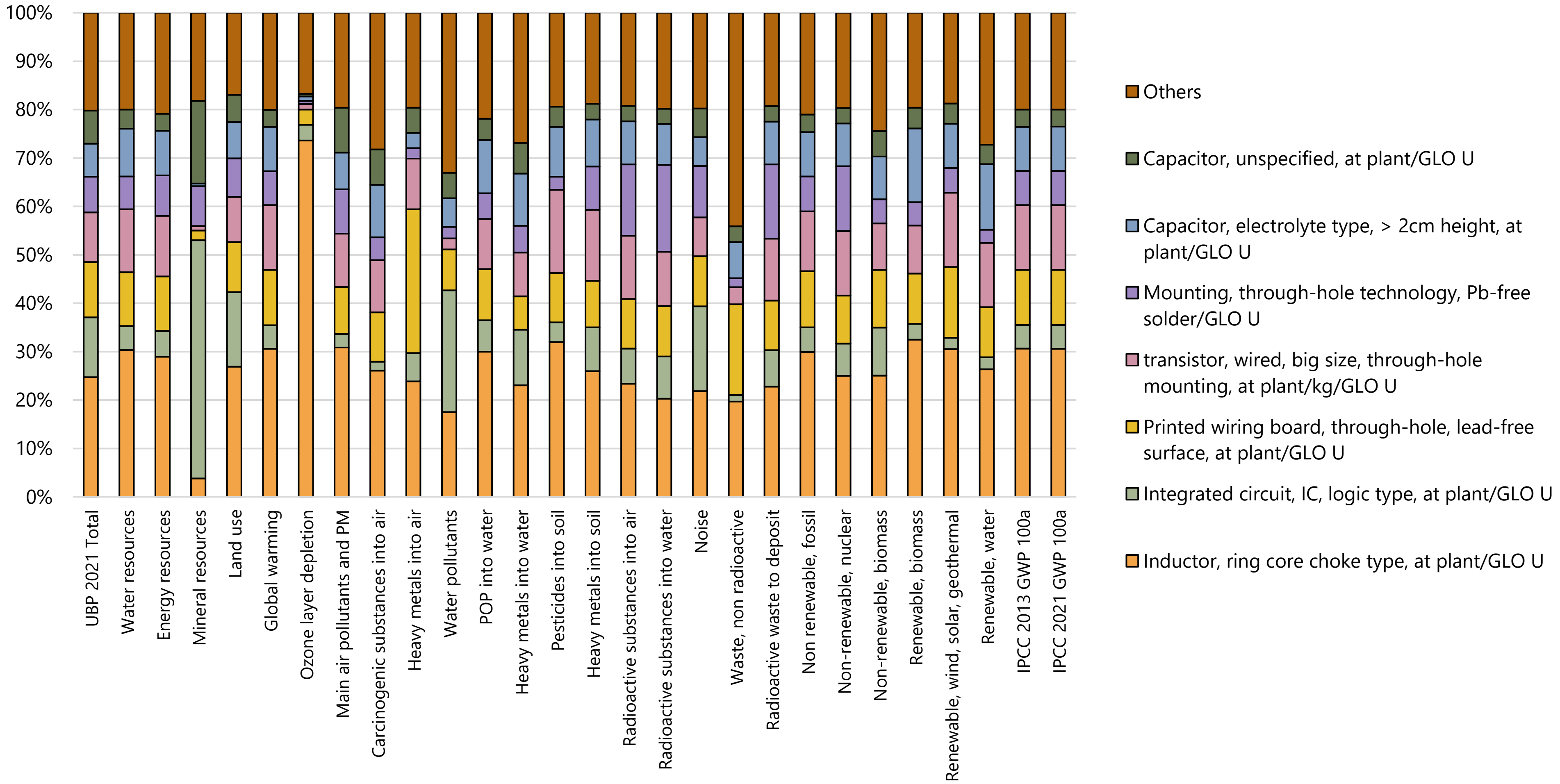

Figure 8.3-15. Contribution analysis presented in bar chart for: Printed wiring board, power supply unit desktop PC, Pb free. FU = 1 kg

Table 8.3-30. Contribution analysis presented in table for: Printed wiring board, power supply unit desktop PC, Pb free. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Inductor, ring core choke type, at plant/GLO U	25%	30%	31%	31%
Integrated circuit, IC, logic type, at plant/GLO U	12%	5%	5%	5%
Printed wiring board, through-hole, lead-free surface, at plant/GLO U	11%	12%	11%	11%
transistor, wired, big size, through-hole mounting, at plant/kg/GLO U	10%	12%	13%	13%
Mounting, through-hole technology, Pb-free solder/GLO U	7%	7%	7%	7%
Capacitor, electrolyte type, > 2cm height, at plant/GLO U	7%	9%	9%	9%
Capacitor, unspecified, at plant/GLO U	7%	4%	4%	4%
Others	20%	21%	20%	20%
Total impact, in absolute value	**9.34E+04**	**4.48E+02**	**3.86E+01**	**3.85E+01**

8.3.16 Printed wiring board, power supply unit desktop PC, solder mix, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder.

The resulting unit process for "Printed wiring board, power supply unit desktop PC, solder mix, at plant" is shown in Table 8.3-31, whereas the life cycle impact assessment results are presented in Figure 8.4-16 and Table 8.3-32.

Table 8.3-31. Life cycle inventory for Printed wiring board, power supply unit desktop PC, solder mix and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, power supply unit desktop PC, solder mix, at plant/kg/GLO U	1	kg				
Input						
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	1	kg		Lognormal	1.33	(3,3,2,3,3,5); Only Pb free

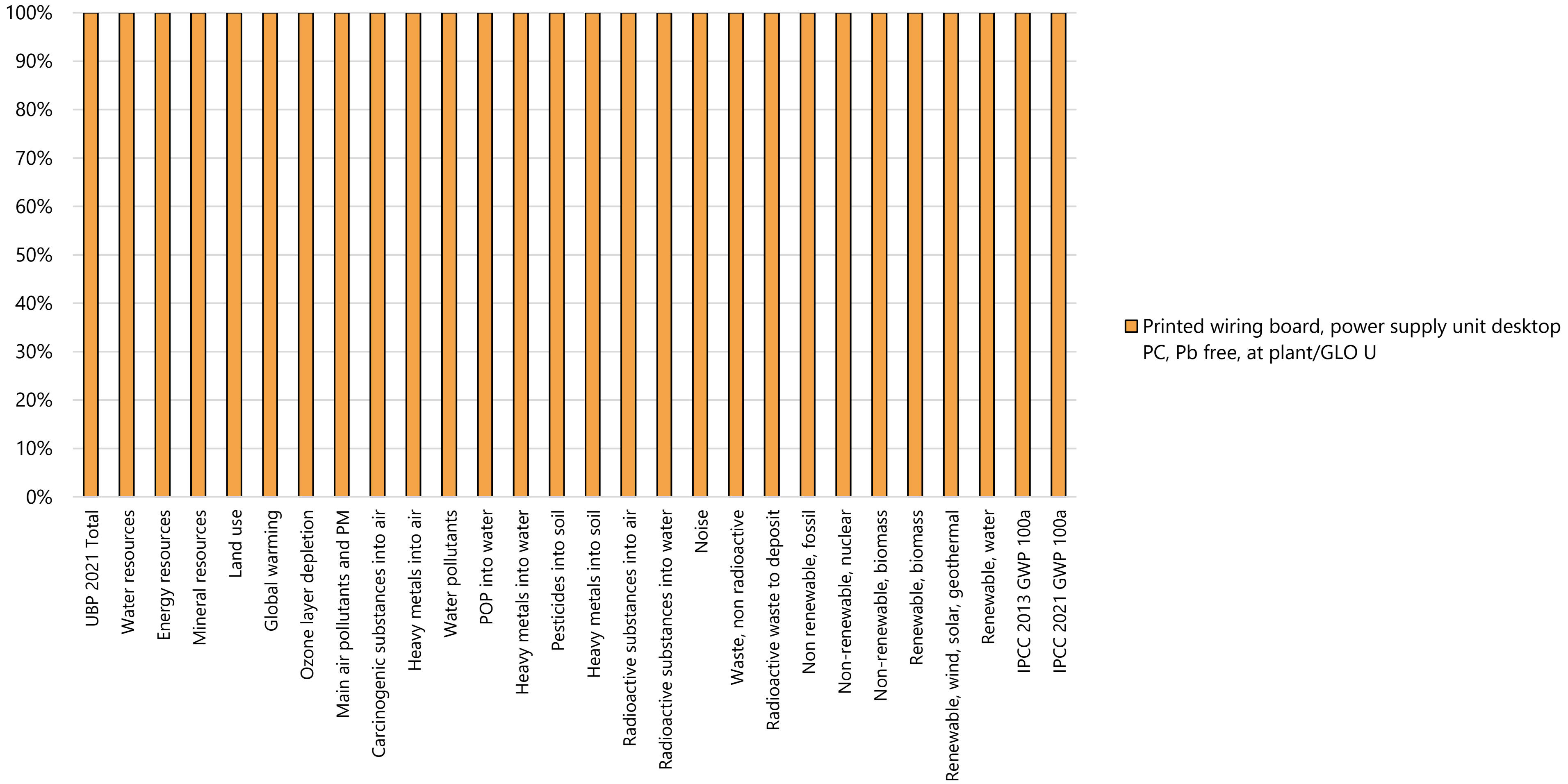

Figure 8.3-16. Contribution analysis presented in bar chart for: Printed wiring board, power supply unit desktop PC, solder mix, at plant. FU = 1 kg

Table 8.3-32. Contribution analysis presented in table for: Printed wiring board, power supply unit desktop PC, solder mix, at plant. FU = 1 kg

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
Printed wiring board, power supply unit desktop PC, solder mix, at plant/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**9.34E+04**	**4.48E+02**	**3.86E+01**	**3.85E+01**

8.3.17 Printed wiring board, mixed mounted, unspec., solder mix, at plant

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The regulations and Restrictions on Hazardous Substances (RoHS) Directive on the electrical and electronic products have banned the use of lead (Pb) and encouraged the use of lead-free materials (Andrae, 2010; European Union, 2003; Huang et al., 2020; Ma & Suhling, 2009; Zhou et al., 2011). For this reason, we modelled the market mix of all PWB datasets by assuming 100% lead free solder. It is also assumed that the SMT and THT shares are equal, i.e., 50:50.

The resulting unit process for "Printed wiring board, mixed mounted, unspec., solder mix, at plant" is shown in Table 8.3-33, whereas the life cycle impact assessment results are presented in Figure 8.3-17 and Table 8.3-34.

Table 8.3-33. Life cycle inventory for Printed wiring board, mixed mounted, unspec., solder mix and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	1	kg				
Input						
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.5	kg		Lognormal	1.45	(4,3,4,3,3,5); equal share
Printed wiring board, through-hole mounted, unspec., solder mix, at plant/kg/GLO U	0.5	kg		Lognormal	1.45	(4,3,4,3,3,5); equal share, assumed

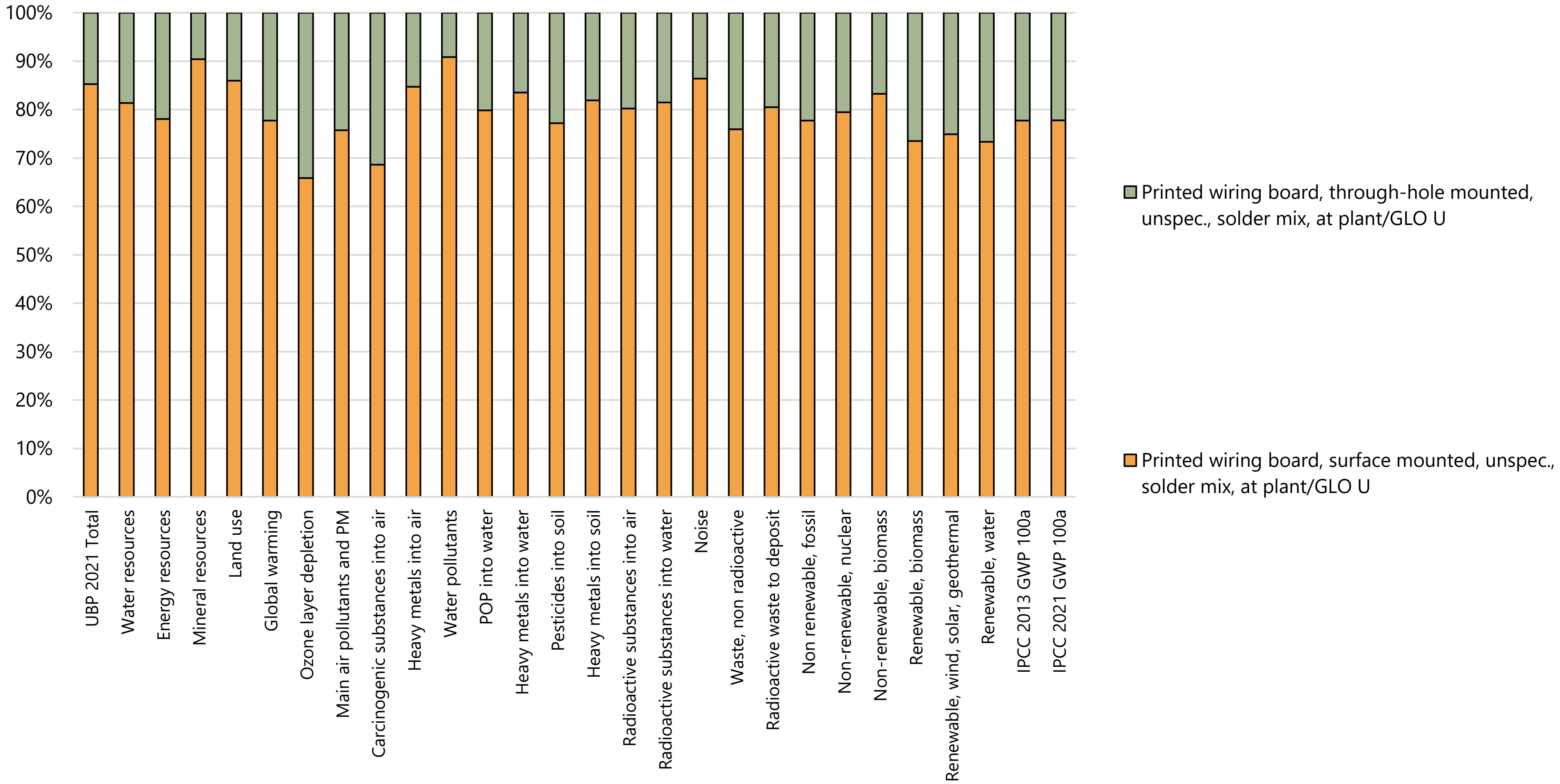

Figure 8.3-17. Contribution analysis presented in bar chart for: Printed wiring board, mixed mounted, unspec., solder mix, at plant. FU = 1 kg

Table 8.3-34. Contribution analysis presented in table for: Printed wiring board, mixed mounted, unspec., solder mix, at plant. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	85%	78%	78%	78%
Printed wiring board, through-hole mounted, unspec., solder mix, at plant/kg/GLO U	15%	22%	22%	22%
Total impact, in absolute value	**5.30E+05**	**1.31E+03**	**1.12E+02**	**1.12E+02**

8.3.18 Printed wiring board mounting facilities, SMT type

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The bill of materials for mounting facilities does not need to be updated because the facilities are assumed to remain the same since early installation. However, components are updated with the new datasets, discussed in separate unit processes.

The resulting unit process for "Printed wiring board, mounting facilities, SMT type" is shown in

Table 8.3-35, whereas the life cycle impact assessment results are presented in Figure 8.3-18 and Table 8.3-36.

Table 8.3-35. Life cycle inventory for Printed wiring board mounting facilities, SMT type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board mounting facilities, SMT type/p/GLO/I U	1	p				
Input						
Cable, network cable, category 5, without plugs, at plant/GLO U	1388.9	m		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Chromium steel 18/8, at plant/RER U	3400	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Flat glass, uncoated, at plant/RER U	500	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Injection moulding/RER U	1500	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Polyethylene, HDPE, granulate, at plant/RER U	1500	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	250	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Road vehicle plant/RER/I U	9.0909E-07	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Section bar rolling, steel/RER U	13600	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Sheet rolling, chromium steel/RER U	3400	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Steel, low-alloyed, at plant/RER U	13600	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
transport, freight, rail/tkm/RER U	3860	tkm		Lognormal	2.19	(4,2,4,1,3,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	1930	tkm		Lognormal	2.19	(4,2,4,1,3,5); standard distances

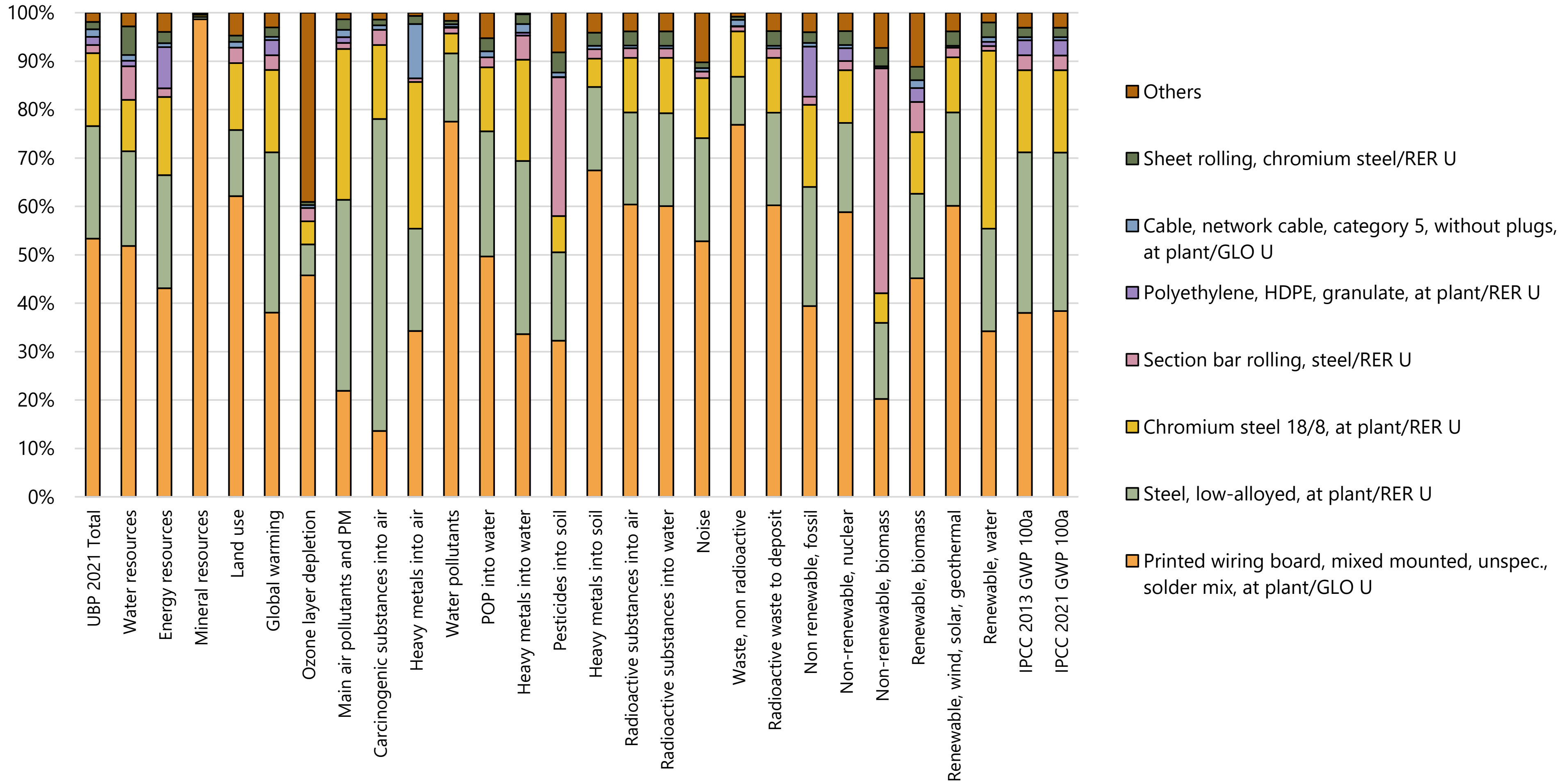

Figure 8.3-18. Contribution analysis presented in bar chart for: Printed wiring board mounting facilities, SMT type. FU = 1 unit

Table 8.3-36. Contribution analysis presented in table for: Printed wiring board mounting facilities, SMT type. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	53%	39%	38%	38%
Steel, low-alloyed, at plant/RER U	23%	25%	33%	33%
Chromium steel 18/8, at plant/RER U	15%	17%	17%	17%
Section bar rolling, steel/RER U	2%	2%	3%	3%
Polyethylene, HDPE, granulate, at plant/RER U	2%	10%	3%	3%
Cable, network cable, category 5, without plugs, at plant/GLO U	2%	1%	1%	1%
Sheet rolling, chromium steel/RER U	1%	2%	2%	2%
Others	2%	4%	3%	3%
Total impact, in absolute value	**2.63E+08**	**1.04E+06**	**9.66E+04**	**9.56E+04**

8.3.19 Printed wiring board mounting facilities, THT type

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The bill of materials for mounting facilities does not need to be updated because the facilities are assumed to remain the same since early installation. However, components are updated with the new datasets, discussed in separate unit processes.

The resulting unit process for "Printed wiring board, mounting facilities, THT type" is shown in Table 8.3-37, whereas the life cycle impact assessment results are presented in Figure 8.3-19 and Table 8.3-38.

Table 8.3-37. Life cycle inventory for Printed wiring board mounting facilities, THT type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board mounting facilities, THT type/p/GLO/I U	1	p				
Input						
Cable, network cable, category 5, without plugs, at plant/GLO U	555.56	m		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Chromium steel 18/8, at plant/RER U	240	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Flat glass, uncoated, at plant/RER U	200	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Injection moulding/RER U	100	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Polyethylene, HDPE, granulate, at plant/RER U	100	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	80	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Road vehicle plant/RER/I U	9.0909E-07	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Section bar rolling, steel/RER U	960	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Sheet rolling, chromium steel/RER U	240	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Steel, low-alloyed, at plant/RER U	960	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
transport, freight, rail/tkm/RER U	320	tkm		Lognormal	2.19	(4,2,4,1,3,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	160	tkm		Lognormal	2.19	(4,2,4,1,3,5); standard distances

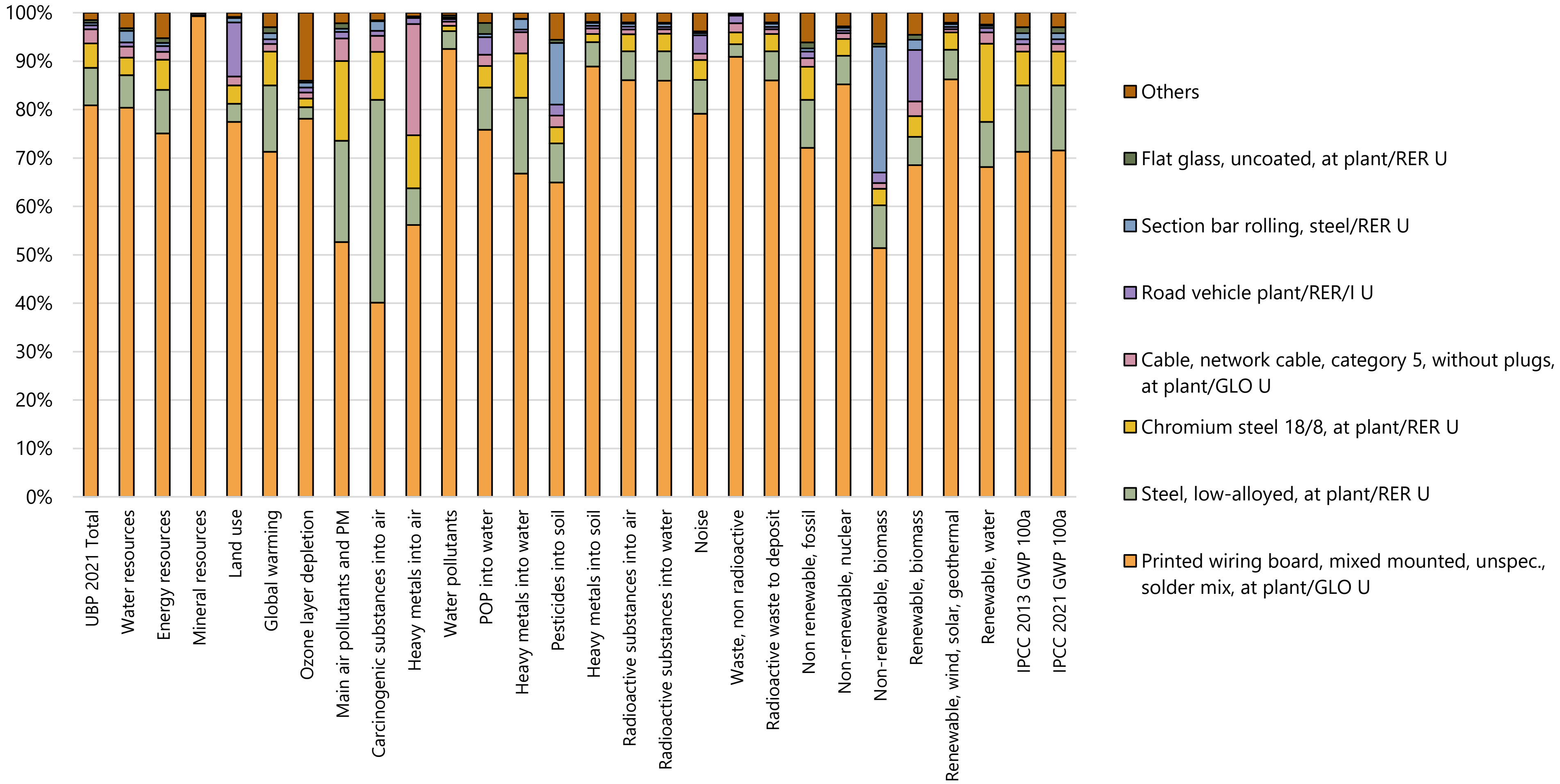

Figure 8.3-19. Contribution analysis presented in bar chart for: Printed wiring board mounting facilities, THT type. FU = 1 unit

Table 8.3-38. Contribution analysis presented in table for: Printed wiring board mounting facilities, THT type. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	81%	72%	71%	72%
Steel, low-alloyed, at plant/RER U	8%	10%	14%	13%
Chromium steel 18/8, at plant/RER U	5%	7%	7%	7%
Cable, network cable, category 5, without plugs, at plant/GLO U	3%	2%	2%	2%
Road vehicle plant/RER/I U	1%	1%	1%	1%
Section bar rolling, steel/RER U	1%	1%	1%	1%
Flat glass, uncoated, at plant/RER U	1%	1%	1%	1%
Others	2%	6%	3%	3%
Total impact, in absolute value	**5.56E+07**	**1.82E+05**	**1.65E+04**	**1.64E+04**

8.3.20 Printed wiring board mounting plant

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The bill of materials for mounting facilities does not need to be updated because the facilities are assumed to remain the same since early installation. However, components are updated with the new datasets, discussed in separate unit processes.

The resulting unit process for "Printed wiring board, mounting plant" is shown in Table 8.3-39, whereas the life cycle impact assessment results are presented in Figure 8.3-20 and Table 8.3-40.

Table 8.3-39. Life cycle inventory for Printed wiring board mounting plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printed wiring board mounting plant/p/GLO/I U	1	p				
Input						
Occupation, construction site	20000	m2a	land	Lognormal	1.73	(4,5,4,3,1,5); own estimation, based on overall information from several chinese producers
Occupation, industrial area, built up	225000	m2a	land	Lognormal	1.73	(4,5,4,3,1,5); own estimation, based on overall information from several chinese producers
Occupation, industrial area, vegetation	25000	m2a	land	Lognormal	1.73	(4,5,4,3,1,5); own estimation, based on overall information from several chinese producers
Transformation, from unknown	10000	m2	land	Lognormal	2.19	(4,5,4,3,1,5); own estimation, based on overall information from several chinese producers
Transformation, to industrial area, built up	9000	m2	land	Lognormal	2.19	(4,5,4,3,1,5); own estimation, based on overall information from several chinese producers
Transformation, to industrial area, vegetation	1000	m2	land	Lognormal	2.19	(4,5,4,3,1,5); own estimation, based on overall information from several chinese producers
Building, hall/CH/I U	5000	m2		Lognormal	3.18	(4,5,4,3,1,5); rough estimation
Building, multi-storey/RER/I U	20000	m3		Lognormal	3.18	(4,5,4,3,1,5); rough estimation
Printed wiring board mounting facilities, SMT type/p/GLO/I U	15	p		Lognormal	3.18	(4,5,4,3,1,5); estimation, based on Locascio (2000) and own plant visit
Printed wiring board mounting facilities, THT type/p/GLO/I U	12.5	p		Lognormal	3.18	(4,5,4,3,1,5); estimation, based on Locascio (2000) and own plant visit
Roads, company, internal/CH/I U	50000	m2a		Lognormal	3.18	(4,5,4,3,1,5); rough estimation
Output						
Waste to treatment						
Disposal, industrial devices, to WEEE treatment/CH U	309500	kg		Lognormal	1.45	(4,5,4,3,1,5); calculated from input of equipment

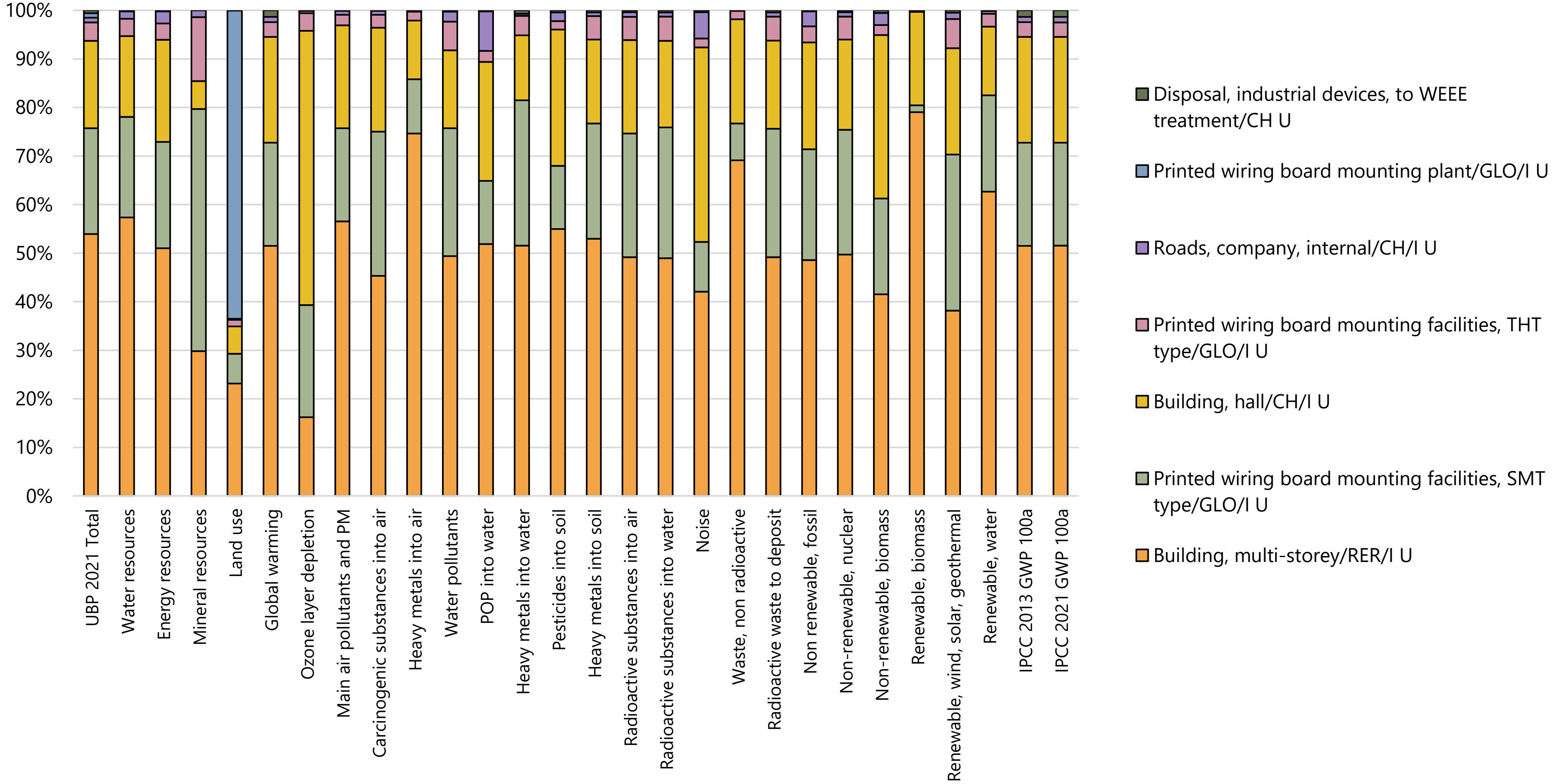

Figure 8.3-20. Contribution analysis presented in bar chart for: Printed wiring board mounting plant. FU = 1 unit

Table 8.3-40. Contribution analysis presented in table for: Printed wiring board mounting plant. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Building, multi-storey/RER/I U	54%	49%	51%	52%
Printed wiring board mounting facilities, SMT type/p/GLO/I U	22%	23%	21%	21%
Building, hall/CH/I U	18%	22%	22%	22%
Printed wiring board mounting facilities, THT type/p/GLO/I U	4%	3%	3%	3%
Roads, company, internal/CH/I U	1%	3%	1%	1%
Printed wiring board mounting plant/p/GLO/I U	1%	0%	0%	0%
Disposal, industrial devices, to WEEE treatment/CH U	1%	0%	1%	1%
Total impact, in absolute value	**1.81E+10**	**6.84E+07**	**6.82E+06**	**6.78E+06**

8.4 Electronic components

8.4.1 Production efforts, capacitors

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates are mostly related to the energy consumption, both concerning the electricity and heat consumption in the manufacturing stage. According to the recent information from electronics industry reports, 15 – 25% of energy efficiency increase is expected in the manufacturing of electronic components due to industry wide automation and improvements (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). The value of 20% energy reduction in electricity and heat is applied in the updated unit processes.

The resulting unit process for "production efforts, capacitors" is shown in Table 8.4-1, whereas the life cycle impact assessment results are presented in Figure 8.4-1 and Table 8.4-2.

Table 8.4-1. Life cycle inventory for production efforts, capacitors and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Production efforts, capacitors/kg/GLO U	1	kg				
Input						
Water, cooling, unspecified natural origin/m3	0.13	m3	in water	Lognormal	1.64	(2,4,4,3,1,5); average from literature & CER
Water, unspecified natural origin/m3	0.15	m3	in water	Lognormal	1.64	(2,4,4,3,1,5); average from literature & CER
Acetone, liquid, at plant/RER U	0.099	kg		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER
Chemicals organic, at plant/GLO U	0.099	kg		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER
electricity, medium voltage, production GLO, at grid/kWh/GLO U	38.96	kWh		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Ethyl acetate from butane, at plant/RER U	0.396	kg		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER

heat, natural gas, at industrial furnace 1MW/MJ/CH U	20.24	MJ		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER
Methyl ethyl ketone from butane, at plant/RER U	0.396	kg		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER
transport, freight, rail/tkm/RER U	1.482	tkm		Lognormal	2.11	(2,4,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.247	tkm		Lognormal	2.11	(2,4,4,3,1,5); standard distances
Output						
Emissions to air						
Acetone	0.034	kg	high. pop.	Lognormal	2.11	(2,4,4,3,1,5); calculated from input of auxillaries
Ethyl acetate	0.136	kg	high. pop.	Lognormal	2.11	(2,4,4,3,1,5); calculated from input of auxillaries
Heat, waste	175.32	MJ	high. pop.	Lognormal	2.11	(2,4,4,3,1,5); calculated from input of auxillaries
Methyl ethyl ketone	0.136	kg	high. pop.	Lognormal	2.11	(2,4,4,3,1,5); calculated from input of auxillaries
NMVOC, non-methane volatile organic compounds, unspecified origin	0.034	kg	high. pop.	Lognormal	2.11	(2,4,4,3,1,5); calculated from input of auxillaries
Waste to treatment						
Disposal, plastics, mixture, 15.3% water, to sanitary landfill/CH U	0.24	kg		Lognormal	1.33	(2,4,4,3,1,5); assumption, based on literature & CER
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.65	kg		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	0.24	kg		Lognormal	1.33	(2,4,4,3,1,5); assumption, based on literature & CER
Treatment, sewage, to wastewater treatment, class 2/CH U	0.15	m3		Lognormal	1.33	(2,4,4,3,1,5); average from literature & CER

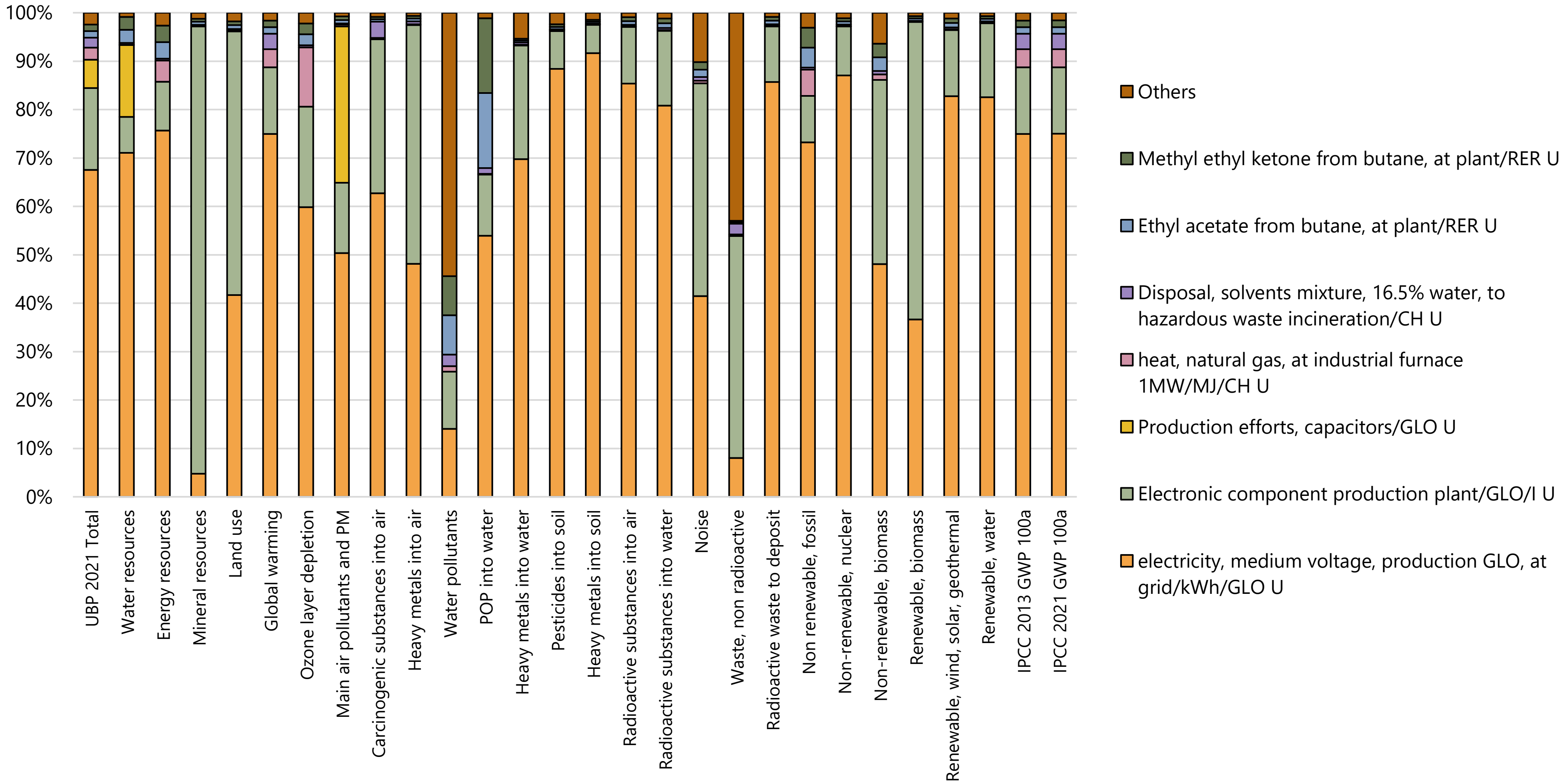

Figure 8.4-1. Contribution analysis presented in bar chart for: production efforts, capacitors. FU = 1 kg production efforts for capacitors

Table 8.4-2. Contribution analysis presented in table for: production efforts, capacitors. FU = 1 kg production efforts for capacitors

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	68%	73%	75%	75%
Electronic component production plant/p/GLO/I U	17%	10%	14%	14%
Production efforts, capacitors/kg/GLO U	6%	0%	0%	0%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	3%	5%	4%	4%
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	2%	0%	3%	3%
Ethyl acetate from butane, at plant/RER U	1%	4%	1%	1%
Methyl ethyl ketone from butane, at plant/RER U	1%	4%	1%	1%
Others	2%	3%	2%	2%
Total impact, in absolute value	**7.15E+04**	**4.55E+02**	**4.03E+01**	**4.02E+01**

8.4.2 Production efforts, diodes

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates are mostly related to the energy consumption, both concerning the electricity and heat consumption in the manufacturing stage. According to the recent information from electronics industry reports, 15 – 25% of energy efficiency increase is expected in the manufacturing of electronic components due to industry wide automation and improvements (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). The value of 20% energy reduction in electricity and heat is applied in the updated unit processes.

The resulting unit process for "production efforts, diodes" is shown in Table 8.4-3, whereas the life cycle impact assessment results are presented in Figure 8.4-2 and Table 8.4-4.

Table 8.4-3. Life cycle inventory for production efforts, diodes and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Production efforts, diodes/kg/GLO U	1	kg				
Input						
Chemicals organic, at plant/GLO U	0.871	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
electricity, medium voltage, production GLO, at grid/kWh/GLO U	195.2	kWh		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.85	(4,5,4,3,5,5); rough assumption
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	195.2	MJ		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
heat, natural gas, at industrial furnace 1MW/MJ/CH U	224	MJ		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Hydrochloric acid, 30% in H2O, at plant/RER U	0.099	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
hydrogen fluoride, at plant/kg/GLO U	0.62	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Hydrogen peroxide, 50% in H2O, at plant/RER U	0.22	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Hydrogen, liquid, at plant/RER U	0.09	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Methanol, at plant/GLO U	0.55	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Nitric acid, 50% in H2O, at plant/RER U	0.28	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Nitrogen, liquid, at plant/RAS U	92.6	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Oxygen, liquid, at plant/RER U	0.75	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Sulphuric acid, liquid, at plant/RER U	0.6	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
tap water, at user/kg/RER U	253	kg		Lognormal	1.68	(4,5,2,3,4,5); estimation - based on data for microchip production
transport, freight, rail/tkm/RER U	58.81	tkm		Lognormal	2.11	(2,4,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	9.8016	tkm		Lognormal	2.11	(2,4,4,3,1,5); standard distances
Water, ultrapure, at plant/GLO U	286	kg		Lognormal	1.68	(4,5,2,3,4,5); estimation - based on data for microchip production
Xylene, at plant/RER U	0.296	kg		Lognormal	1.33	(2,4,4,3,1,5); value from 1 literature source
Output						
Emissions to air						
Acetone	0.073	kg	high. pop.	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Ammonia	0.011	kg	high. pop.	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source

Carbon monoxide, fossil	0.042	kg	high. pop.	Lognormal	5.12	(2,4,4,3,1,5); value from 1 literature source
Heat, waste	867.6	MJ	high. pop.	Lognormal	1.64	(2,4,4,3,1,5); calculated, from electricity input
Hydrogen fluoride	0.015	kg	high. pop.	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Nitrogen oxides	0.073	kg	high. pop.	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Sulfur dioxide	0.025	kg	high. pop.	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Xylene	0.101	kg	high. pop.	Lognormal	2.11	(2,4,4,3,1,5); value from 1 literature source
Emissions to water						
BOD5, Biological Oxygen Demand	0.04	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Chloride	0.0039	kg	river	Lognormal	3.11	(2,4,4,3,1,5); value from 1 literature source
COD, Chemical Oxygen Demand	0.0036	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Fluoride	0.012	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Nitrite	0.064	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Phosphate	0.003	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Sulfate	0.013	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Suspended solids, unspecified	0.11	kg	river	Lognormal	1.64	(2,4,4,3,1,5); value from 1 literature source
Tin	0.00005	kg	river	Lognormal	5.12	(2,4,4,3,1,5); value from 1 literature source
Waste to treatment						
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.333	kg		Lognormal	1.33	(2,4,4,3,1,5); assumption, based on total waste information in 1 literature source
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	0.037	kg		Lognormal	1.33	(2,4,4,3,1,5); assumption, based on total waste information in 1 literature source
Treatment, sewage, to wastewater treatment, class 2/CH U	0.286	m3		Lognormal	1.33	(2,4,4,3,1,5); assumption, based on literature

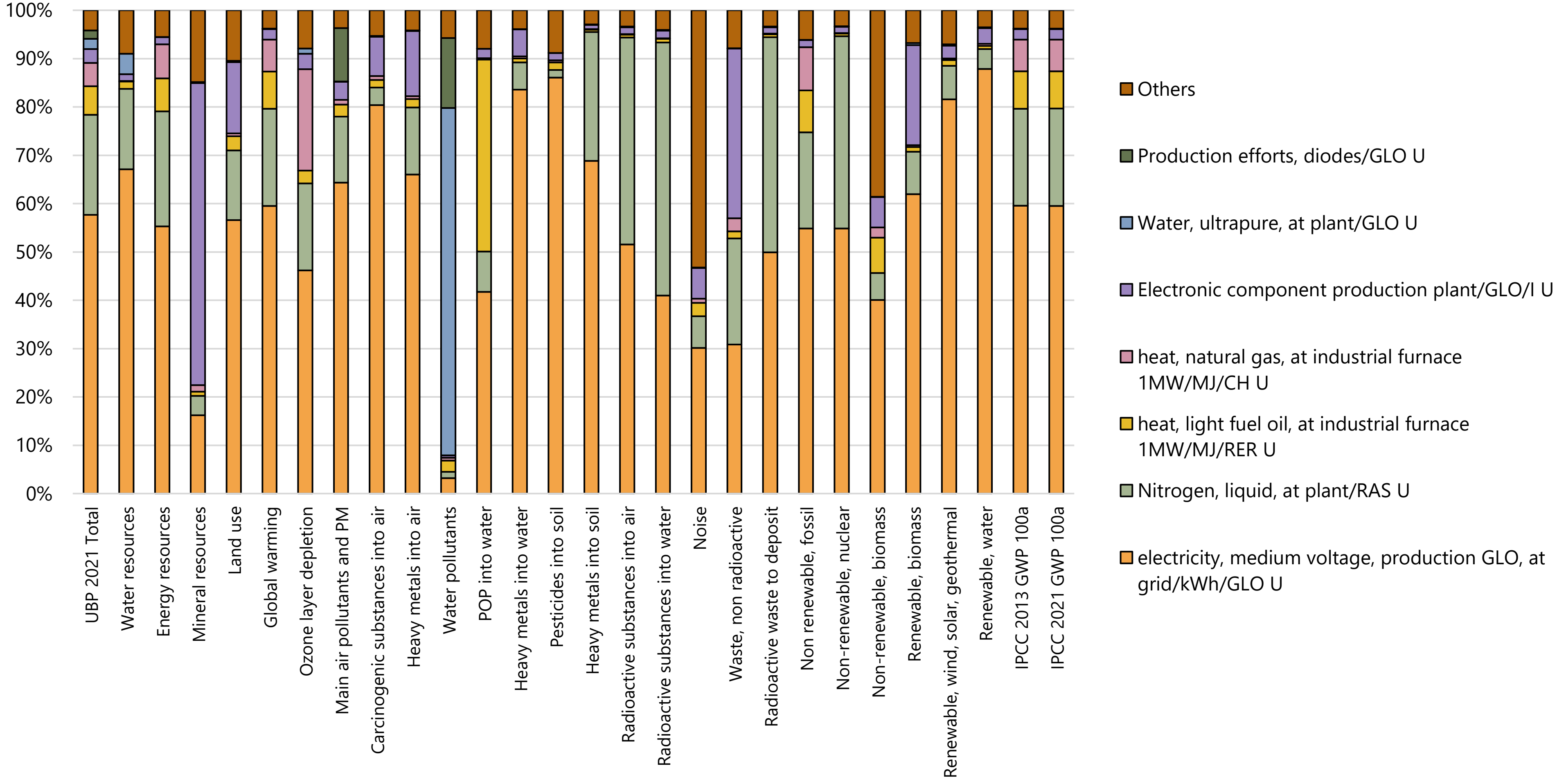

Figure 8.4-2. Contribution analysis presented in bar chart for: production efforts, diodes. FU = 1 kg production efforts for diodes

Table 8.4-4. Contribution analysis presented in table for: production efforts, diodes. FU = 1 kg production efforts for diodes

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	58%	55%	60%	60%
Nitrogen, liquid, at plant/RAS U	21%	20%	20%	20%
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	6%	9%	8%	8%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	5%	9%	7%	7%
Electronic component production plant/p/GLO/I U	3%	1%	2%	2%
Water, ultrapure, at plant/GLO U	2%	0%	0%	0%
Production efforts, diodes/kg/GLO U	2%	0%	0%	0%
Others	4%	6%	4%	4%
Total impact, in absolute value	**3.94E+05**	**2.90E+03**	**2.41E+02**	**2.40E+02**

8.4.3 Production efforts, inductors

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates are mostly related to the energy consumption, both concerning the electricity and heat consumption in the manufacturing stage. According to the recent information from electronics industry reports, 15 – 25% of energy efficiency increase is expected in the manufacturing of electronic components due to industry wide automation and improvements (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). The value of 20% energy reduction in electricity and heat is applied in the updated unit processes.

The resulting unit process for "production efforts, inductors" is shown in Table 8.4-5, whereas the life cycle impact assessment results are presented in Figure 8.4-3 and Table 8.4-6.

Table 8.4-5. Life cycle inventory for production efforts, inductors and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Production efforts, inductors/kg/GLO U	1	kg				
Input						
Water, cooling, unspecified natural origin/m3	0.13	m3	in water	Lognormal	1.9	(3,4,4,1,4,5); assumption from conclusion by analogy (using capacitors)
Water, unspecified natural origin/m3	0.15	m3	in water	Lognormal	1.9	(3,4,4,1,4,5); average from literature & CER
Acetone, liquid, at plant/RER U	0.099	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using capacitors)
Chemicals organic, at plant/GLO U	0.099	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using capacitors)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	38.4	kWh		Lognormal	1.65	(3,4,4,1,4,5); value from literature
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Ethyl acetate from butane, at plant/RER U	0.396	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using capacitors)
heat, natural gas, at industrial furnace 1MW/MJ/CH U	0.07	MJ		Lognormal	1.65	(3,4,4,1,4,5); calculated from value in liteerature
Methyl ethyl ketone from butane, at plant/RER U	0.396	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using capacitors)
transport, freight, rail/tkm/RER U	1.482	tkm		Lognormal	2.35	(3,4,4,1,4,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.247	tkm		Lognormal	2.35	(3,4,4,1,4,5); standard distances
Output						
Emissions to air						
Acetone	0.034	kg	high. pop.	Lognormal	2.35	(3,4,4,1,4,5); calculated from input of auxillaries
Ethyl acetate	0.136	kg	high. pop.	Lognormal	2.35	(3,4,4,1,4,5); calculated from input of auxillaries
Heat, waste	172.8	MJ	high. pop.	Lognormal	1.90	(3,4,4,1,4,5); calculated from electricity input
Methyl ethyl ketone	0.136	kg	high. pop.	Lognormal	2.35	(3,4,4,1,4,5); calculated from input of auxillaries
NMVOC, non-methane volatile organic compounds, unspecified origin	0.034	kg	high. pop.	Lognormal	1.90	(3,4,4,1,4,5); calculated from input of auxillaries
Waste to treatment						
Disposal, plastics, mixture, 15.3% water, to sanitary landfill/CH U	0.24	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption, based on literature & CER

Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.65	kg	Lognormal	1.65	(3,4,4,1,4,5); average from literature & CER
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	0.24	kg	Lognormal	1.65	(3,4,4,1,4,5); assumption, based on literature & CER
Treatment, sewage, to wastewater treatment, class 2/CH U	0.15	m3	Lognormal	1.65	(3,4,4,1,4,5); average from literature & CER

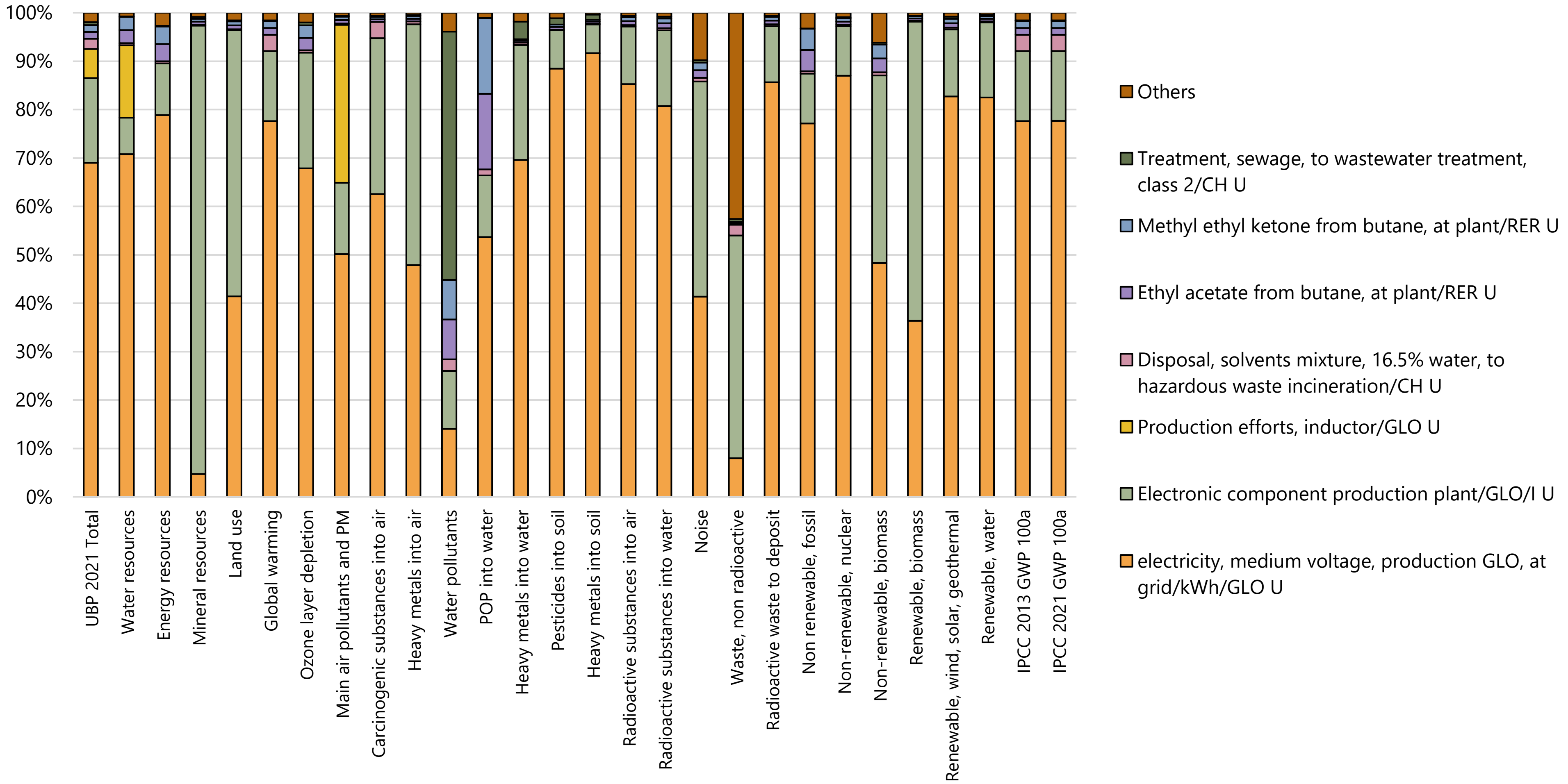

Figure 8.4-3. Contribution analysis presented in bar chart for: production efforts, inductors. FU = 1 kg production efforts for inductors

Table 8.4-6. Contribution analysis presented in table for: production efforts, inductors. FU = 1 kg production efforts for inductors

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	69%	77%	78%	78%
Electronic component production plant/p/GLO/I U	18%	10%	14%	14%
Production efforts, inductors/kg/GLO U	6%	0%	0%	0%
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	2%	0%	3%	3%
Ethyl acetate from butane, at plant/RER U	1%	4%	1%	1%
Methyl ethyl ketone from butane, at plant/RER U	1%	4%	1%	1%
Treatment, sewage, to wastewater treatment, class 2/CH U	1%	0%	0%	0%
Others	2%	3%	2%	2%
Total impact, in absolute value	**6.90E+04**	**4.26E+02**	**3.84E+01**	**3.82E+01**

8.4.4 Production efforts, resistors

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates are mostly related to the energy consumption, both concerning the electricity and heat consumption in the manufacturing stage. According to the recent information from electronics industry reports, 15 – 25% of energy efficiency increase is expected in the manufacturing of electronic components due to industry wide automation and improvements (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). The value of 20% energy reduction in electricity and heat is applied in the updated unit processes.

The resulting unit process for "production efforts, resistors" is shown in Table 8.4-7, whereas the life cycle impact assessment results are presented in Figure 8.4-4 and Table 8.4-8.

Table 8.4-7. Life cycle inventory for production efforts, resistors and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Production efforts, resistors/kg/GLO U	1	kg				
Input						
Water, cooling, unspecified natural origin/m3	0.0205	m3	in water	Lognormal	1.65	(3,4,4,1,1,5); assumption, based on literature
Water, unspecified natural origin/m3	0.0205	m3	in water	Lognormal	1.65	(3,4,4,1,1,5); assumption, based on literature
Carboxymethyl cellulose, powder, at plant/RER S	0.0032	kg		Lognormal	1.27	(2,4,3,3,1,5); average from literature
Chemicals organic, at plant/GLO U	0.0064	kg		Lognormal	1.27	(2,4,3,3,1,5); average from literature
electricity, medium voltage, production GLO, at grid/kWh/GLO U	30.64	kWh		Lognormal	1.27	(2,4,3,3,1,5); average from literature
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.85	(4,5,4,3,5,5); rough assumption
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	8.32	MJ		Lognormal	1.27	(2,4,3,3,1,5); average from literature
Solvents, organic, unspecified, at plant/GLO U	0.0064	kg		Lognormal	1.27	(2,4,3,3,1,5); average from literature
transport, freight, rail/tkm/RER U	0.7476	tkm		Lognormal	2.08	(2,4,3,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.1246	tkm		Lognormal	2.08	(2,4,3,3,1,5); standard distances
Output						
Emissions to air						
Ethyl cellulose	high. pop.	0.0032	kg	Lognormal	1.60	(2,4,3,3,1,5); calculated from input of auxillaries
Heat, waste	high. pop.	137.88	MJ	Lognormal	1.60	(2,4,3,3,1,5); calculated, from electricity input
NMVOC, non-methane volatile organic compounds, unspecified origin	high. pop.	0.0096	kg	Lognormal	1.60	(2,4,3,3,1,5); calculated from input of auxillaries
Waste to treatment						
Disposal, plastics, mixture, 15.3% water, to sanitary landfill/CH U	0.115	kg		Lognormal	1.27	(2,4,3,3,1,5); assumption, based on literature
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.0032	kg		Lognormal	1.27	(2,4,3,3,1,5); calculated from input of auxillaries
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	0.115	kg		Lognormal	1.27	(2,4,3,3,1,5); assumption, based on literature
Treatment, sewage, to wastewater treatment, class 2/CH U	0.0205	m3		Lognormal	1.27	(2,4,3,3,1,5); assumption, based on literature

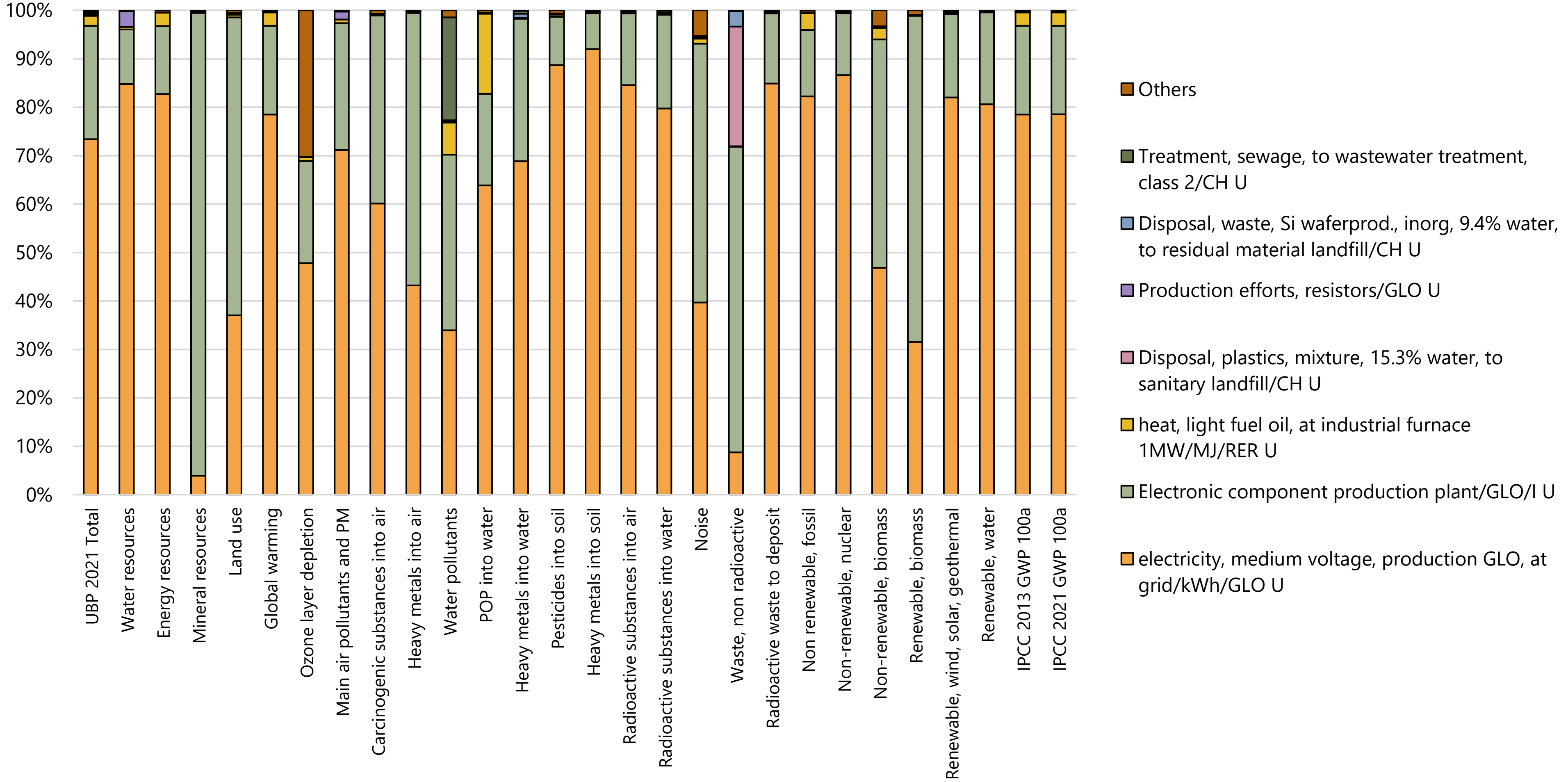

Figure 8.4-4. Contribution analysis presented in bar chart for: production efforts, resistors. FU = 1 kg production efforts for resistors

Table 8.4-8. Contribution analysis presented in table for: production efforts, resistors. FU = 1 kg production efforts for resistors

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	73%	82%	78%	79%
Electronic component production plant/p/GLO/I U	23%	14%	18%	18%
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	2%	4%	3%	3%
Disposal, plastics, mixture, 15.3% water, to sanitary landfill/CH U	0%	0%	0%	0%
Production efforts, resistors/kg/GLO U	0%	0%	0%	0%
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	0%	0%	0%	0%
Treatment, sewage, to wastewater treatment, class 2/CH U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**5.20E+04**	**3.19E+02**	**3.03E+01**	**3.02E+01**

8.4.5 Production efforts, transistors

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates are mostly related to the energy consumption, both concerning the electricity and heat consumption in the manufacturing stage. According to the recent information from electronics industry reports, 15 – 25% of energy efficiency increase is expected in the manufacturing of electronic components due to industry wide automation and improvements (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). The value of 20% energy reduction in electricity and heat is applied in the updated unit processes.

The resulting unit process for "production efforts, transistors" is shown in Table 8.4-9, whereas the life cycle impact assessment results are presented in Figure 8.4-5 and Table 8.4-10.

Table 8.4-9. Life cycle inventory for production efforts, transistors and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Production efforts, transistors/kg/GLO U	1	kg				
Input						
Water, cooling, unspecified natural origin/m3	0.00146	m3	in water	Lognormal	1.60	(2,4,3,3,1,5); estimation, based on total water amount from 1 literature source
Water, unspecified natural origin/m3	0.00584	m3	in water	Lognormal	1.60	(2,4,3,3,1,5); estimation, based on total water amount from 1 literature source
Chemicals organic, at plant/GLO U	0.38	kg		Lognormal	1.27	(2,4,3,3,1,5); value from 1 literature source
electricity, medium voltage, production GLO, at grid/kWh/GLO U	160	kWh		Lognormal	1.27	(2,4,3,3,1,5); value from 1 literature source. Energy consumption is updated to reflect improvement
Electronic component production plant/p/GLO/I U	2E-08	p		Lognormal	3.85	(4,5,4,3,5,5); rough assumption
Nitrogen, liquid, at plant/RAS U	8.3	kg		Lognormal	1.27	(2,4,3,3,1,5); value from 1 literature source
transport, freight, rail/tkm/RER U	8.688	tkm		Lognormal	2.08	(2,4,3,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	1.448	tkm		Lognormal	2.08	(2,4,3,3,1,5); standard distances
Output						
Emissions to air						
Heat, waste	720	MJ	high. pop.	Lognormal	1.60	(2,4,3,3,1,5); calculated, from electricity input
NMVOC, non-methane volatile organic compounds, unspecified origin	0.38	kg	high. pop.	Lognormal	1.60	(2,4,3,3,1,5); calculated from input of auxillaries
Waste to treatment						
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	2.42	kg		Lognormal	1.27	(2,4,3,3,1,5); calculated from input of auxillaries
Disposal, tin sheet, 0% water, to sanitary landfill/CH U	0.69	kg		Lognormal	1.27	(2,4,3,3,1,5); estimation, based on total waste amount from 1 literature source
Disposal, waste, Si waferprod., inorg, 9.4% water, to residual material landfill/CH U	0.01	kg		Lognormal	1.27	(2,4,3,3,1,5); estimation, based on total waste amount from 1 literature source
Treatment, sewage, to wastewater treatment, class 2/CH U	0.00584	m3		Lognormal	1.27	(2,4,3,3,1,5); estimation, based on total waste amount from 1 literature source

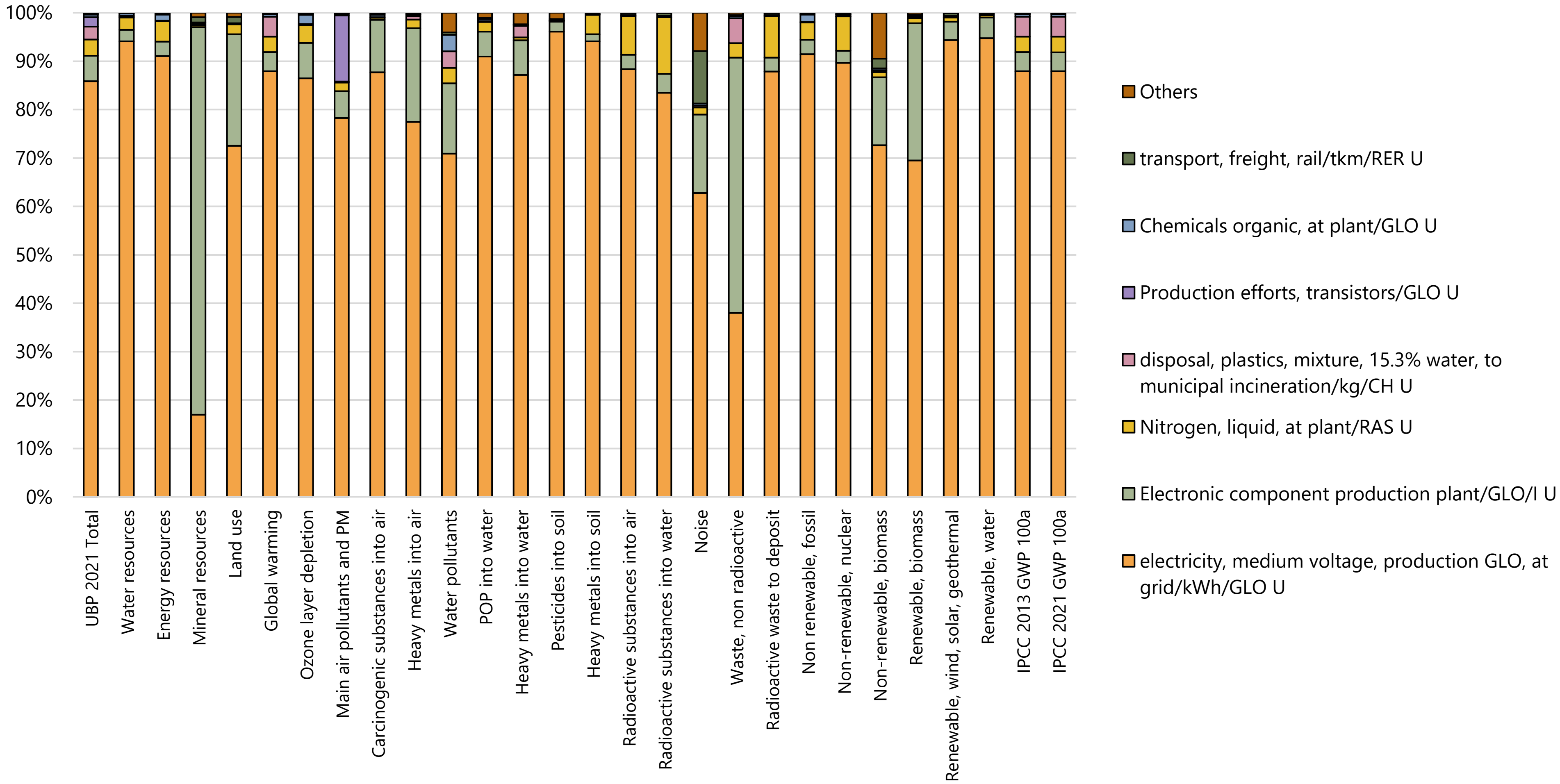

Figure 8.4-5. Contribution analysis presented in bar chart for: production efforts, transistors. FU = 1 kg production efforts for transistors

Table 8.4-10. Contribution analysis presented in table for: production efforts, transistors. FU = 1 kg production efforts for transistors

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
electricity, medium voltage, production GLO, at grid/kWh/GLO U	86%	91%	88%	88%
Electronic component production plant/p/GLO/I U	5%	3%	4%	4%
Nitrogen, liquid, at plant/RAS U	3%	4%	3%	3%
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	3%	0%	4%	4%
Production efforts, transistors/kg/GLO U	2%	0%	0%	0%
Chemicals organic, at plant/GLO U	1%	2%	1%	1%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**2.27E+05**	**1.48E+03**	**1.40E+02**	**1.40E+02**

8.4.6 Capacitor, electrolyte type, < 2 cm height

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

It was found that power electronics technologies have remained about the same since the 1980s for all capacitor types. As a result, the inventory data for the composition are identical to the original inventory already in the UVEK database. Other scientific studies also discussed that polypropylene – common materials used in today's capacitors – is a good base material to handle such a high temperature applications (Ho et al., 2010; Kartal, 2017). The grouping of the dielectric types remains the same as is. Nevertheless, the market share is adjusted in accordance with the most recent statistics in the literature (Group, 2020), namely: film capacitors (50%), SMD/ceramic capacitors (30%), electrolytic capacitors (19%) with an equal split for each type, and finally tantalum capacitors (1%).

The resulting unit process for "capacitor, electrolyte type, < 2 cm height" is shown in Table 8.4-11, whereas the life cycle impact assessment results are presented in Figure 8.4-6 and Table 8.4-12.

Table 8.4-11. Life cycle inventory for capacitor, electrolyte type, < 2 cm height and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Capacitor, electrolyte type, < 2cm height, at plant/GLO U	1	kg				
Input						
aluminium, primary, at plant/kg/RER U	0.69856	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.013616	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.08584	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Ethylene glycol, at plant/RER U	0.2738	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Kraft paper, unbleached, at plant/RER U	0.083546	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Lead, primary, at plant/GLO U	4.88E-05	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nylon 6, at plant/RER U	0.00037	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.08436	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.05476	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyphenylene sulfide, at plant/GLO U	0.023828	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyvinylchloride, at regional storage/RER U	0.06956	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, capacitors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silver, at regional storage/RER U	0.02516	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Synthetic rubber, at plant/RER U	0.065786	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.002072	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

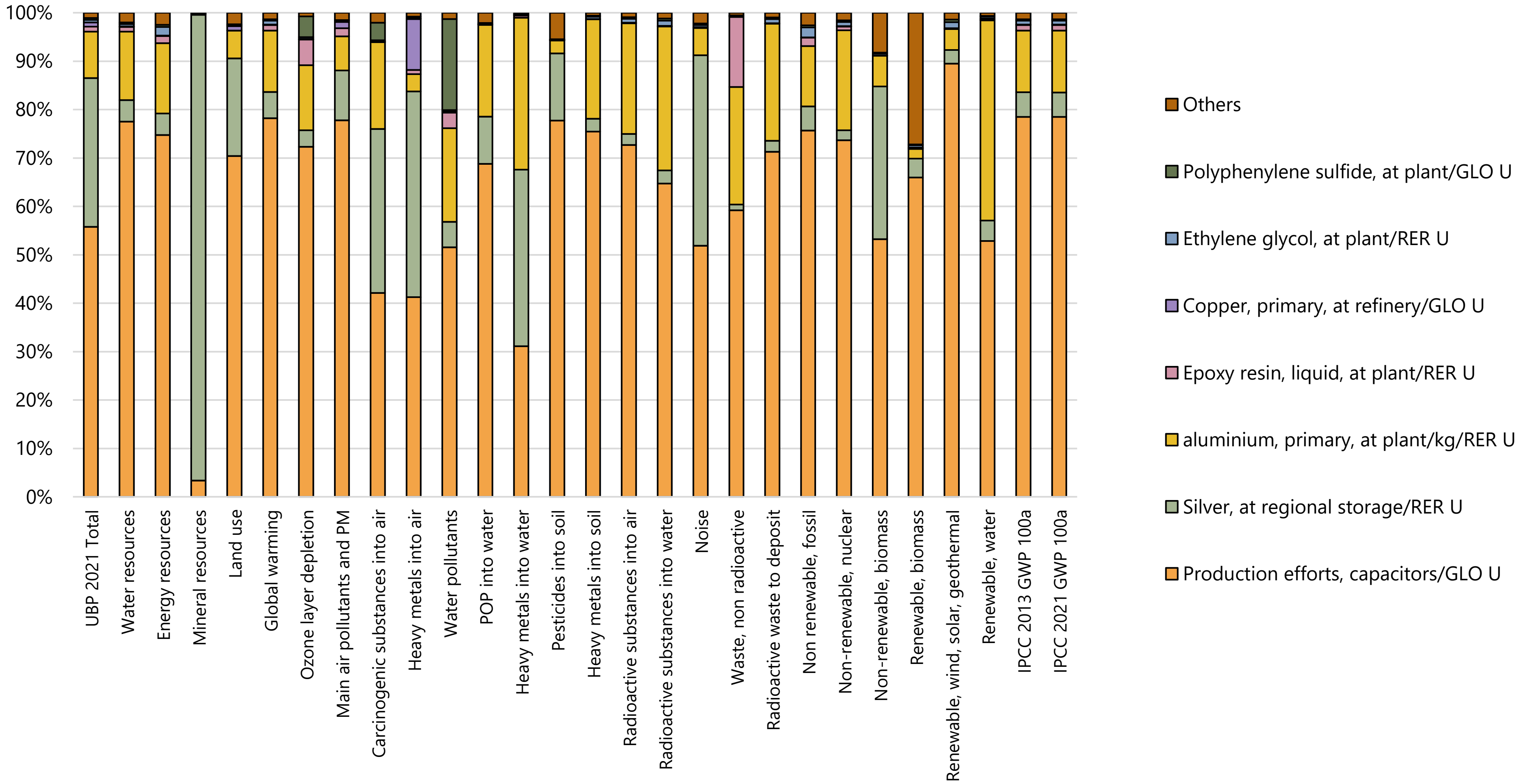

Figure 8.4-6. Contribution analysis presented in bar chart for: capacitor, electrolyte type, < 2cm height. FU = 1 kg capacitor, electrolyte type, < 2cm height

Table 8.4-12. Contribution analysis presented in table for: capacitor, electrolyte type, < 2 cm height. FU = 1 kg capacitor, electrolyte type, < 2cm height

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, capacitors/kg/GLO U	56%	76%	79%	78%
Silver, at regional storage/RER U	31%	5%	5%	5%
aluminium, primary, at plant/kg/RER U	10%	12%	13%	13%
Epoxy resin, liquid, at plant/RER U	1%	2%	1%	1%
Copper, primary, at refinery/GLO U	1%	0%	0%	0%
Ethylene glycol, at plant/RER U	1%	2%	1%	1%
Polyphenylene sulfide, at plant/GLO U	0%	0%	0%	0%
Others	1%	3%	1%	1%
Total impact, in absolute value	**1.27E+05**	**6.02E+02**	**5.14E+01**	**5.12E+01**

8.4.7 Capacitor, electrolyte type, > 2 cm height

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

It was found that power electronics technologies have remained about the same since the 1980s for all capacitor types. As a result, the inventory data for the composition are identical to the original inventory already in the UVEK database. Other scientific studies also discussed that polypropylene – common materials used in today's capacitors – is a good base material to handle such a high temperature applications (Ho et al., 2010; Kartal, 2017). The grouping of the dielectric types remains the same as is. Nevertheless, the market share is adjusted in accordance with the most recent statistics in the literature (Group, 2020), namely: film capacitors (50%), SMD/ceramic capacitors (30%), electrolytic capacitors (19%) with an equal split for each type, and finally tantalum capacitors (1%).

The resulting unit process for "capacitor, electrolyte type, > 2 cm height" is shown in Table 8.4-13, whereas the life cycle impact assessment results are presented in Figure 8.4-7 and Table 8.4-14.

Table 8.4-13. Life cycle inventory for capacitor, electrolyte type, > 2cm height and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Capacitor, electrolyte type, > 2cm height, at plant/kg/GLO U	1	kg				
Input						
aluminium, primary, at plant/kg/RER U	0.75332	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.013616	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Ethylene glycol, at plant/RER U	0.37	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Kraft paper, unbleached, at plant/RER U	0.13172	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nylon 6, at plant/RER U	0.00962	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Phenolic resin, at plant/RER U	0.00962	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.0296	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.05846	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyvinylchloride, at regional storage/RER U	0.07326	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, capacitors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Synthetic rubber, at plant/RER U	0.03256	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.00108	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

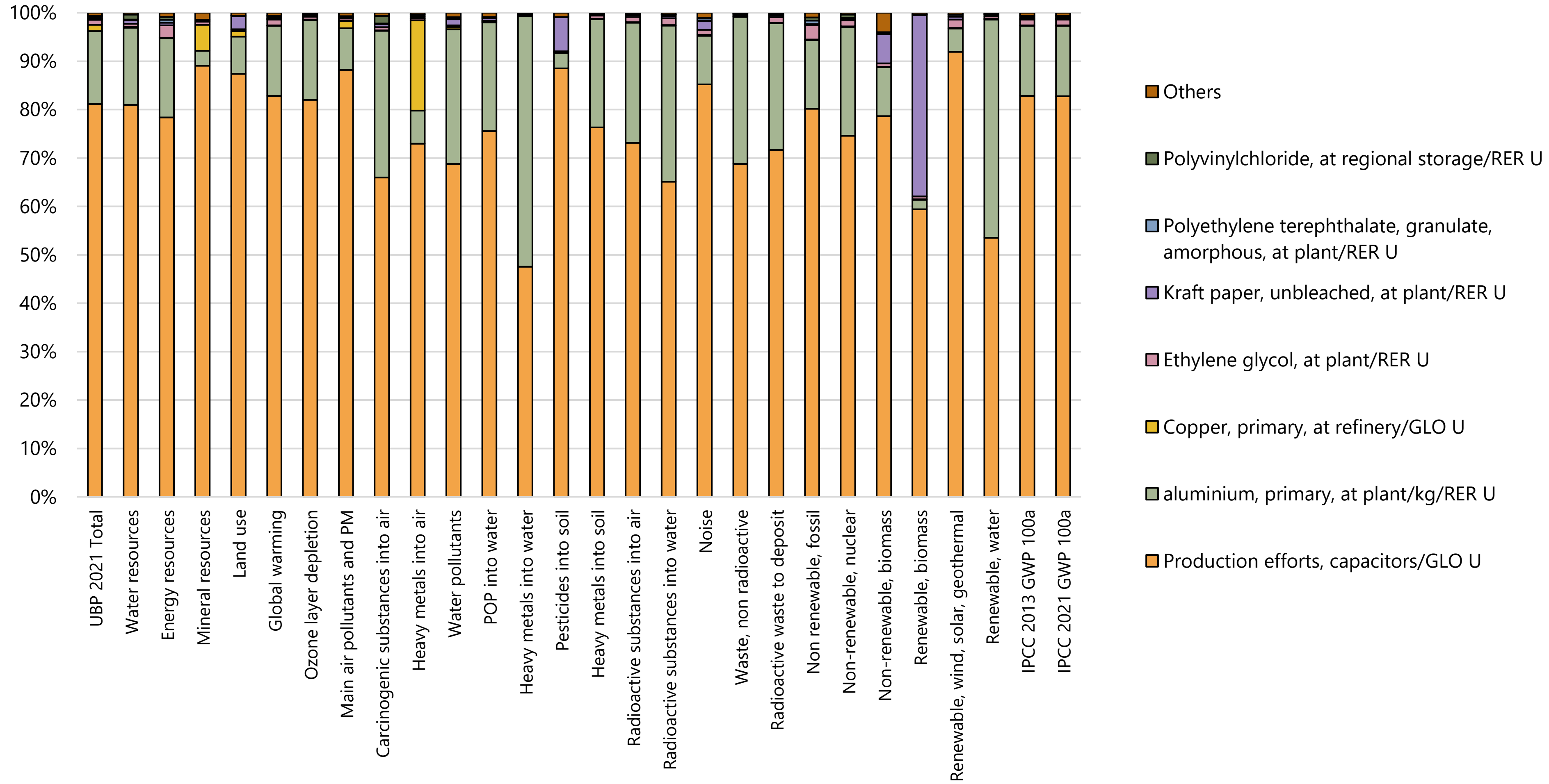

Figure 8.4-7. Contribution analysis presented in bar chart for: capacitor, electrolyte type, > 2cm height. FU = 1 kg capacitor, electrolyte type, > 2cm height

Table 8.4-14. Contribution analysis presented in table for: capacitor, electrolyte type, > 2cm height. FU = 1 kg capacitor, electrolyte type, > 2cm height

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, capacitors/kg/GLO U	81%	80%	83%	83%
aluminium, primary, at plant/kg/RER U	15%	14%	14%	15%
Copper, primary, at refinery/GLO U	1%	0%	0%	0%
Ethylene glycol, at plant/RER U	1%	3%	1%	1%
Kraft paper, unbleached, at plant/RER U	0%	0%	0%	0%
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0%	1%	0%	0%
Polyvinylchloride, at regional storage/RER U	0%	1%	0%	0%
Others	1%	1%	1%	1%
Total impact, in absolute value	**8.78E+04**	**5.68E+02**	**4.87E+01**	**4.86E+01**

8.4.8 Capacitor, film, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

It was found that power electronics technologies have remained about the same since the 1980s for all capacitor types. As a result, the inventory data for the composition are identical to the original inventory already in the UVEK database. Other scientific studies also discussed that polypropylene – common materials used in today's capacitors – is a good base material to handle such a high temperature applications (Ho et al., 2010; Kartal, 2017). The grouping of the dielectric types remains the same as is. Nevertheless, the market share is adjusted in accordance with the most recent statistics in the literature (Group, 2020), namely: film capacitors (50%), SMD/ceramic capacitors (30%), electrolytic capacitors (19%) with an equal split for each type, and finally tantalum capacitors (1%).

The resulting unit process for "capacitor, film, through-hole mounting" is shown in Table 8.4-15, whereas the life cycle impact assessment results are presented in Figure 8.4-8 and Table 8.4-16.

Table 8.4-15. Life cycle inventory for capacitor, film, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Capacitor, film, through-hole mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium, primary, at plant/kg/RER U	0.046472	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.36423	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.34477	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.006068	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.01332	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Phenolic resin, at plant/RER U	0.003552	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Phosphorus, white, liquid, at plant/RER U	0.01554	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.11692	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.03515	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyphenylene sulfide, at plant/GLO U	0.25996	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polypropylene, granulate, at plant/RER U	0.074074	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, capacitors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silver, at regional storage/RER U	0.041588	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.033892	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Zinc, primary, at regional storage/RER U	0.12432	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

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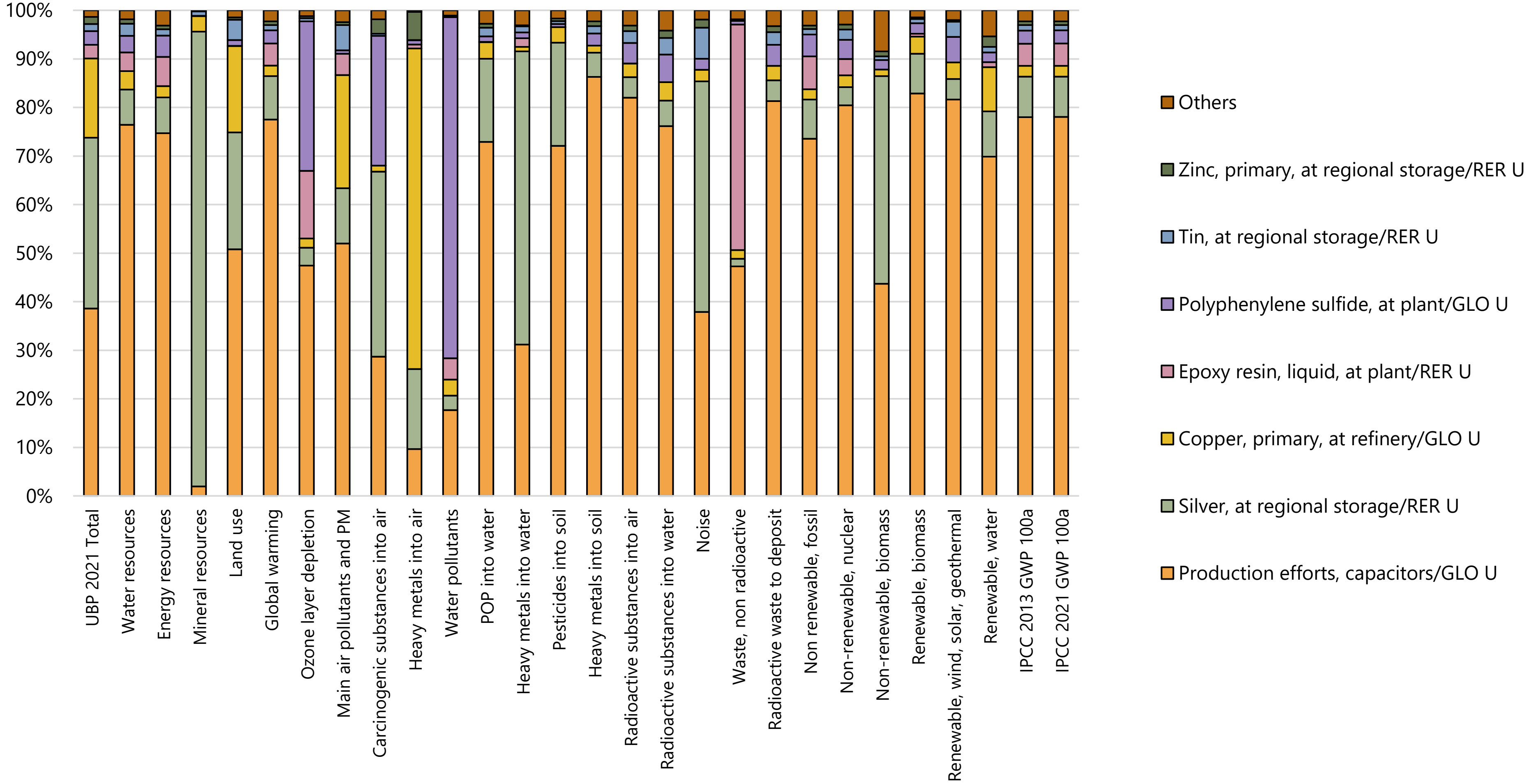

Figure 8.4-8. Contribution analysis presented in bar chart for: capacitor, film, through-hole mounting. FU = 1 kg capacitor, film, through-hole mounting

Table 8.4-16. Contribution analysis presented in table for: capacitor, film, through-hole mounting. FU = 1 kg capacitor, film, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, capacitors/kg/GLO U	39%	74%	78%	78%
Silver, at regional storage/RER U	35%	8%	8%	8%
Copper, primary, at refinery/GLO U	16%	2%	2%	2%
Epoxy resin, liquid, at plant/RER U	3%	7%	5%	5%
Polyphenylene sulfide, at plant/GLO U	3%	5%	3%	3%
Tin, at regional storage/RER U	1%	1%	1%	1%
Zinc, primary, at regional storage/RER U	1%	1%	1%	1%
Others	1%	3%	2%	2%
Total impact, in absolute value	**1.84E+05**	**6.19E+02**	**5.17E+01**	**5.15E+01**

8.4.9 Capacitor, SMD type, surface-mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

It was found that power electronics technologies have remained about the same since the 1980s for all capacitor types. As a result, the inventory data for the composition are identical to the original inventory already in the UVEK database. Other scientific studies also discussed that polypropylene – common materials used in today's capacitors – is a good base material to handle such a high temperature applications (Ho et al., 2010; Kartal, 2017). The grouping of the dielectric types remains the same as is. Nevertheless, the market share is adjusted in accordance with the most recent statistics in the literature (Group, 2020), namely: film capacitors (50%), SMD/ceramic capacitors (30%), electrolytic capacitors (19%) with an equal split for each type, and finally tantalum capacitors (1%).

The resulting unit process for "capacitor, SMD type, surface-mounting" is shown in Table 8.4-17, whereas the life cycle impact assessment results are presented in Figure 8.4-9 and Table 8.4-18.

Table 8.4-17. Life cycle inventory for capacitor, SMD type, surface-mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	1	kg				
Input						
Barite, at plant/RER U	0.79062	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.01406	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Flat glass, uncoated, at plant/RER U	0.00222	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.20084	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Palladium, at regional storage/RER U	0.001332	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, capacitors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silver, at regional storage/RER U	0.03922	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.02442	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Titanium dioxide, production mix, at plant/RER U	0.40729	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

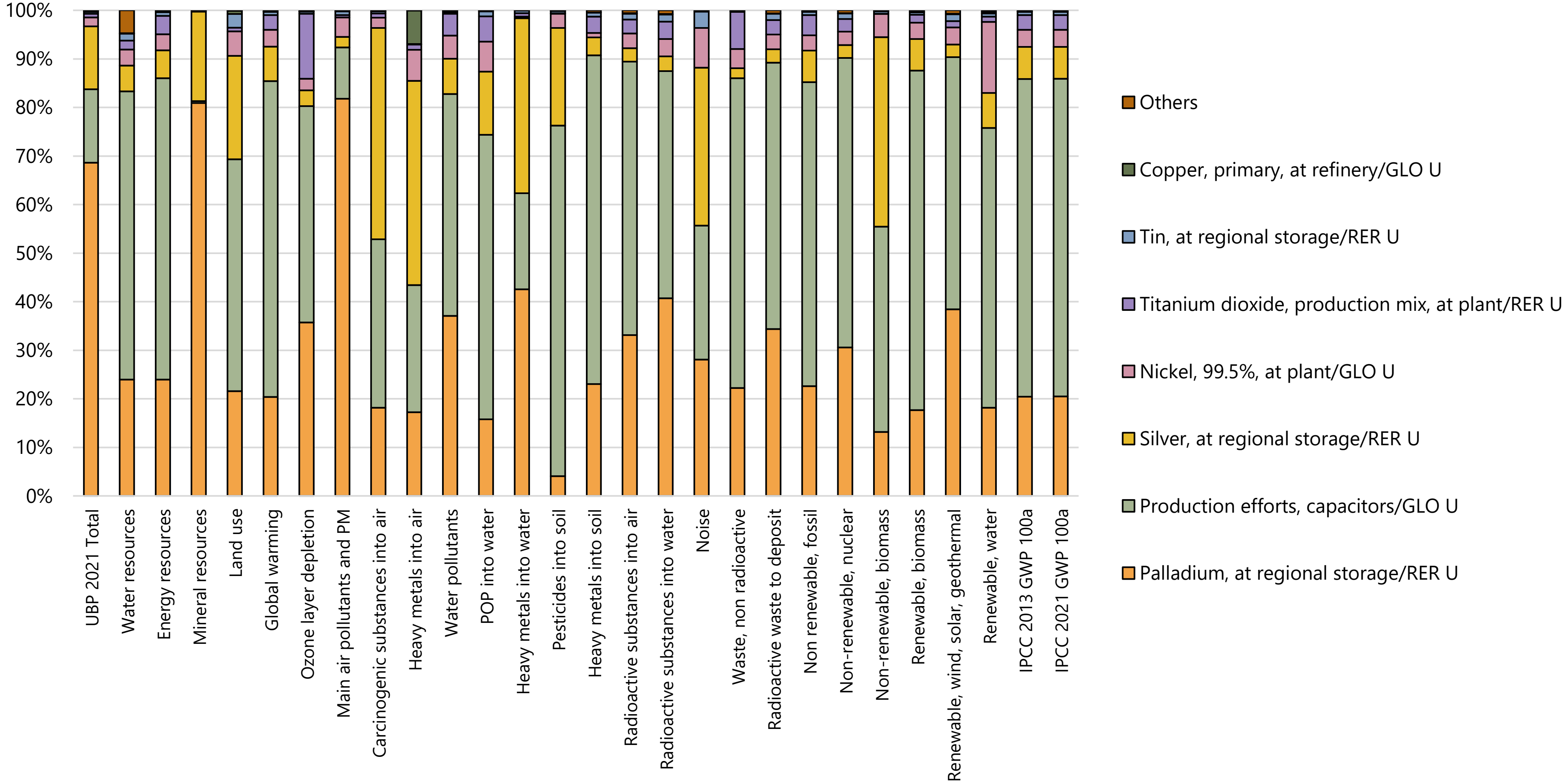

Figure 8.4-9. Contribution analysis presented in bar chart for: capacitor, SMD type, surface-mounting. FU = 1 kg capacitor, SMD type, surface-mounting

Table 8.4-18. Contribution analysis presented in table for: capacitor, SMD type, surface-mounting. FU = 1 kg capacitor, SMD type, surface-mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Palladium, at regional storage/RER U	69%	23%	20%	20%
Production efforts, capacitors/kg/GLO U	15%	63%	65%	65%
Silver, at regional storage/RER U	13%	6%	7%	7%
Nickel, 99.5%, at plant/GLO U	2%	3%	4%	4%
Titanium dioxide, production mix, at plant/RER U	1%	4%	3%	3%
Tin, at regional storage/RER U	0%	1%	1%	1%
Copper, primary, at refinery/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.69E+05**	**7.28E+02**	**6.17E+01**	**6.15E+01**

8.4.10 Capacitor, Tantalum-, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

It was found that power electronics technologies have remained about the same since the 1980s for all capacitor types. As a result, the inventory data for the composition are identical to the original inventory already in the UVEK database. Other scientific studies also discussed that polypropylene – common materials used in today's capacitors – is a good base material to handle such a high temperature applications (Ho et al., 2010; Kartal, 2017). The grouping of the dielectric types remains the same as is. Nevertheless, the market share is adjusted in accordance with the most recent statistics in the literature (Group, 2020), namely: film capacitors (50%), SMD/ceramic capacitors (30%), electrolytic capacitors (19%) with an equal split for each type, and finally tantalum capacitors (1%).

The resulting unit process for "capacitor, Tantalum-, through-hole mounting" is shown in Table 8.4-19, whereas the life cycle impact assessment results are presented in Figure 8.4-10 and Table 8.4-20.

Table 8.4-19. Life cycle inventory for capacitor, Tantalum-, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	1	kg				
Input						
Chemicals inorganic, at plant/GLO U	0.01628	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Epoxy resin, liquid, at plant/RER U	0.6068	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Manganese, at regional storage/RER U	0.053147	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Nickel, 99.5%, at plant/GLO U	0.062752	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Pig iron, at plant/GLO U	0.086728	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Production efforts, capacitors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silver, at regional storage/RER U	0.03848	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Tantalum, powder, capacitor-grade, at regional storage/GLO U	0.54316	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
tetrafluoroethylene, at plant/kg/RER U	0.0074	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Tin, at regional storage/RER U	0.03404	kg		Lognormal	1.32	(1,4,4,1,1,5); company information

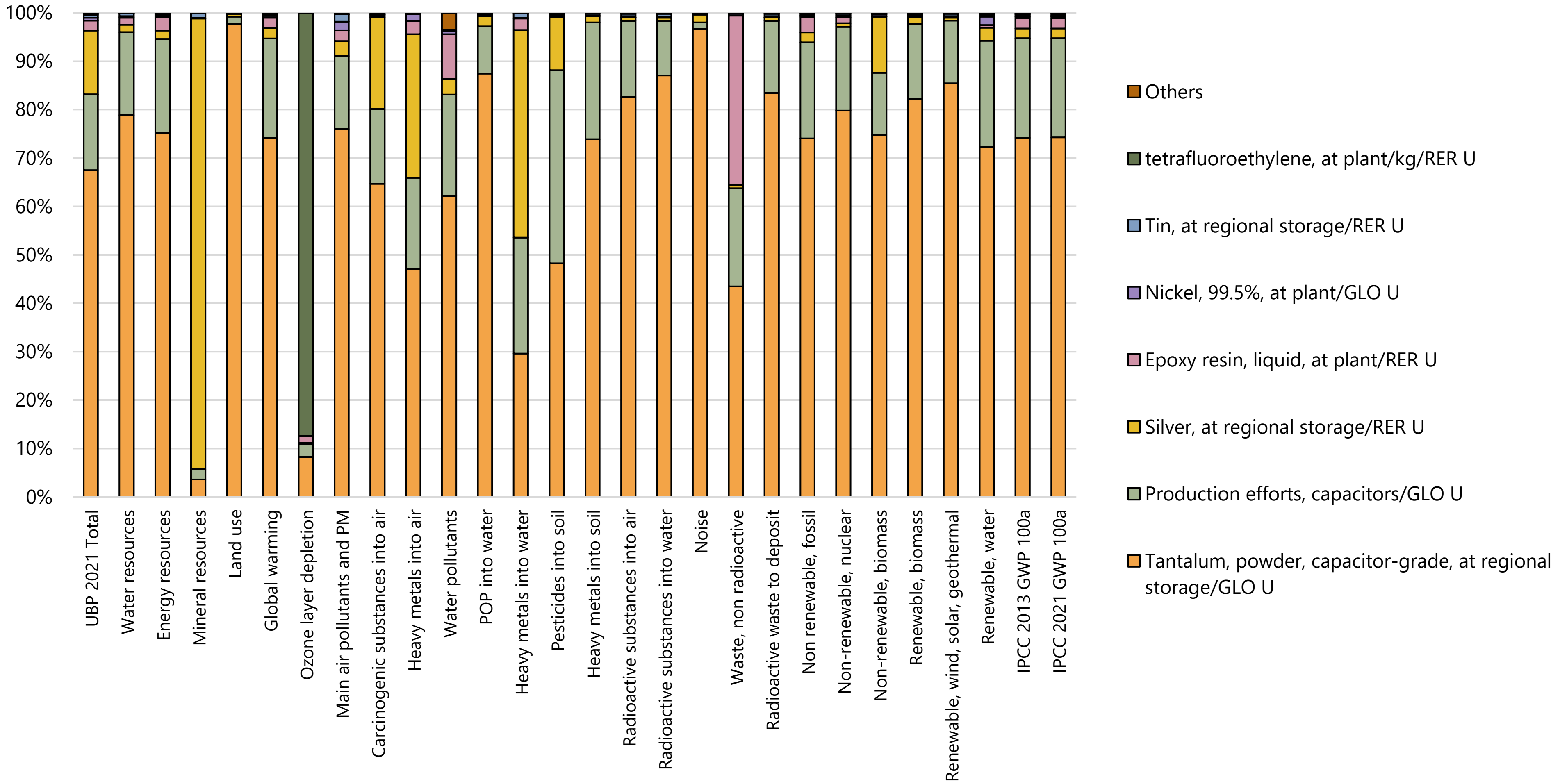

Figure 8.4-10. Contribution analysis presented in bar chart for: capacitor, Tantalum-, through-hole mounting. FU = 1 kg capacitor, Tantalum-, through-hole mounting

Table 8.4-20. Contribution analysis presented in table for: capacitor, Tantalum-, through-hole mounting. FU = 1 kg capacitor, Tantalum-, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Tantalum, powder, capacitor-grade, at regional storage/GLO U	67%	74%	74%	74%
Production efforts, capacitors/kg/GLO U	16%	20%	21%	20%
Silver, at regional storage/RER U	13%	2%	2%	2%
Epoxy resin, liquid, at plant/RER U	2%	3%	2%	2%
Nickel, 99.5%, at plant/GLO U	1%	0%	0%	0%
Tin, at regional storage/RER U	1%	0%	0%	0%
tetrafluoroethylene, at plant/kg/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.52E+05**	**2.29E+03**	**1.96E+02**	**1.96E+02**

8.4.11 Capacitor, unspecified

- Dataset update and creation category: LCI and technical data available
- Unit process description:

It was found that power electronics technologies have remained about the same since the 1980s for all capacitor types. As a result, the inventory data for the composition are identical to the original inventory already in the UVEK database. Other scientific studies also discussed that polypropylene – common materials used in today's capacitors – is a good base material to handle such a high temperature applications (Ho et al., 2010; Kartal, 2017). The grouping of the dielectric types remains the same as is. Nevertheless, the market share is adjusted in accordance with the most recent statistics in the literature (Group, 2020), namely: film capacitors (50%), SMD/ceramic capacitors (30%), electrolytic capacitors (19%) with an equal split for each type, and finally tantalum capacitors (1%).

The resulting unit process for "capacitor, unspecified" is shown in Table 8.4-21, whereas the life cycle impact assessment results are presented in Figure 8.4-11 and Table 8.4-22.

Table 8.4-21. Life cycle inventory for capacitor, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Capacitor, unspecified, at plant/kg/GLO U	1	kg				
Input						
Capacitor, electrolyte type, < 2cm height, at plant/kg/GLO U	0.095	kg		Lognormal	1.84	(5,4,2,1,4,5); assumption, based on specific data
Capacitor, electrolyte type, > 2cm height, at plant/kg/GLO U	0.095	kg		Lognormal	1.84	(5,4,2,1,4,5); assumption, based on specific data
Capacitor, film, through-hole mounting, at plant/kg/GLO U	0.5	kg		Lognormal	1.84	(5,4,2,1,4,5); assumption, based on specific data
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	0.3	kg		Lognormal	1.84	(5,4,2,1,4,5); assumption, based on specific data
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	0.01	kg		Lognormal	1.84	(5,4,2,1,4,5); assumption, based on specific data

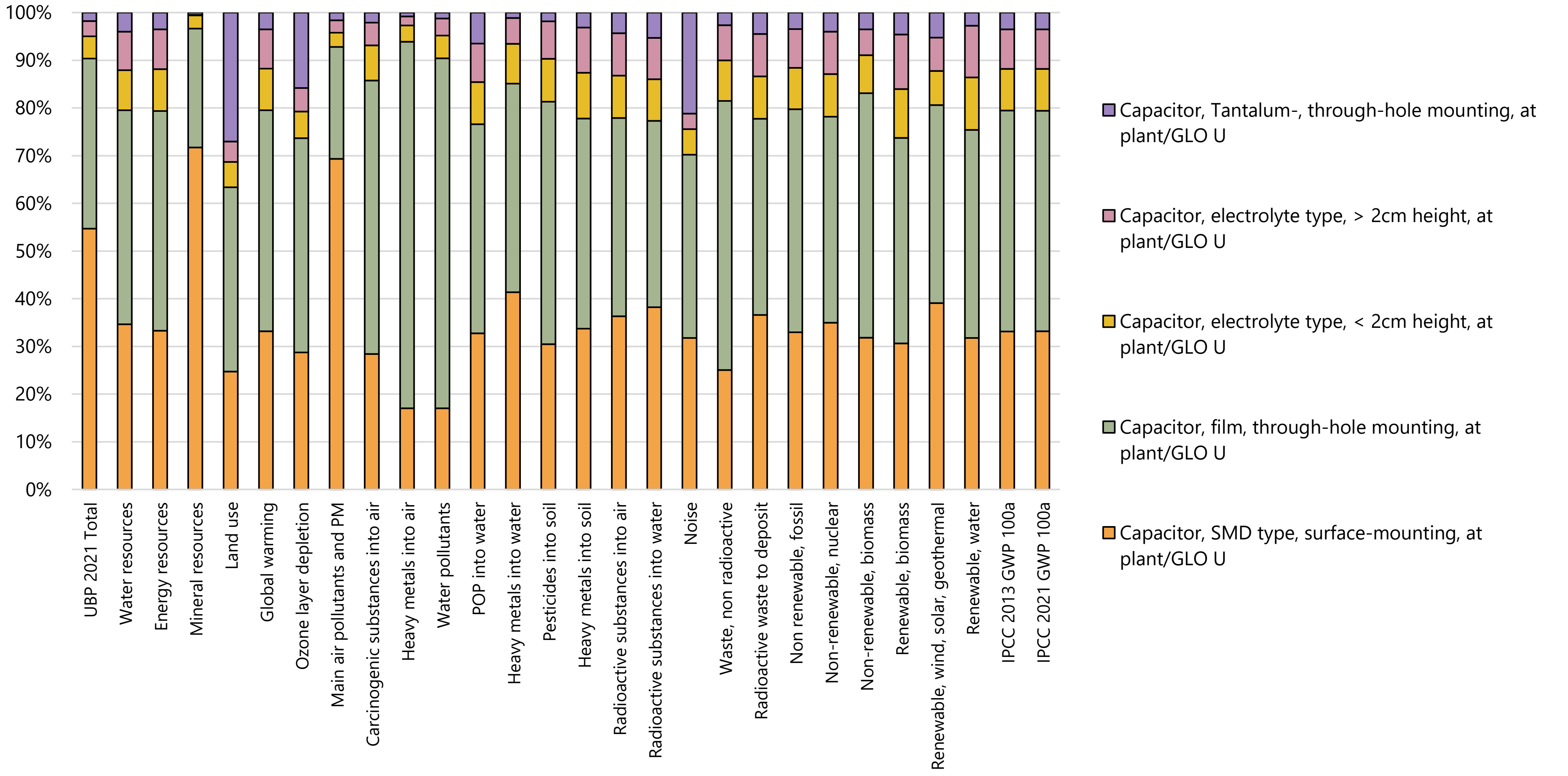

Figure 8.4-11. Contribution analysis presented in bar chart for: capacitor, unspecified. FU = 1 kg capacitor, unspecified

Table 8.4-22. Contribution analysis presented in table for: capacitor, unspecified. FU = 1 kg capacitor, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	55%	33%	33%	33%
Capacitor, film, through-hole mounting, at plant/kg/GLO U	36%	47%	46%	46%
Capacitor, electrolyte type, < 2cm height, at plant/kg/GLO U	5%	9%	9%	9%
Capacitor, electrolyte type, > 2cm height, at plant/kg/GLO U	3%	8%	8%	8%
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	2%	3%	4%	4%
Total impact, in absolute value	**2.57E+05**	**6.62E+02**	**5.58E+01**	**5.56E+01**

8.4.12 Diode, glass-, SMD type, surface mounting

- Dataset update and creation category: LCI and technical data available
- Unit process description:

Diode datasets retain the same three groupings from the original datasets: SMD, through-hole, and light emitting diodes. For the SMD type, according to an LCA study of diodes (Pina et al., 2021), it is assumed that the current dataset still reflects the material composition that is still available on the market. A similar update approach of maintaining the bill of materials as in the existing UVEK database is also followed for the other two types. However, no updates have been made to the material composition for the latter two types. The only exception is the production effort for diodes, which is explained in other unit processes. No statistics were found for diode market share by type. Thus, it is assumed that each diode type has a one-third market share of the total mix.

The resulting unit process for "diode, glass-, SMD type, surface mounting" is shown in Table 8.4-23, whereas the life cycle impact assessment results are presented in Figure 8.4-12 and Table 8.4-24.

Table 8.4-23. Life cycle inventory for diode, glass-, SMD type, surface mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Diode, glass-, SMD type, surface mounting, at plant/kg/GLO U	1	kg				
Materials/fuels						
aluminium oxide, at plant/kg/RER U	0.31876	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.24991	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.021944	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Funnel glass, CRT screen, at plant/GLO U	0.26104	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.008216	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Molybdenum, at regional storage/RER U	0.16068	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, diodes/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
silicon, electronic grade, at plant/kg/APAC U	0.004784	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.015288	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

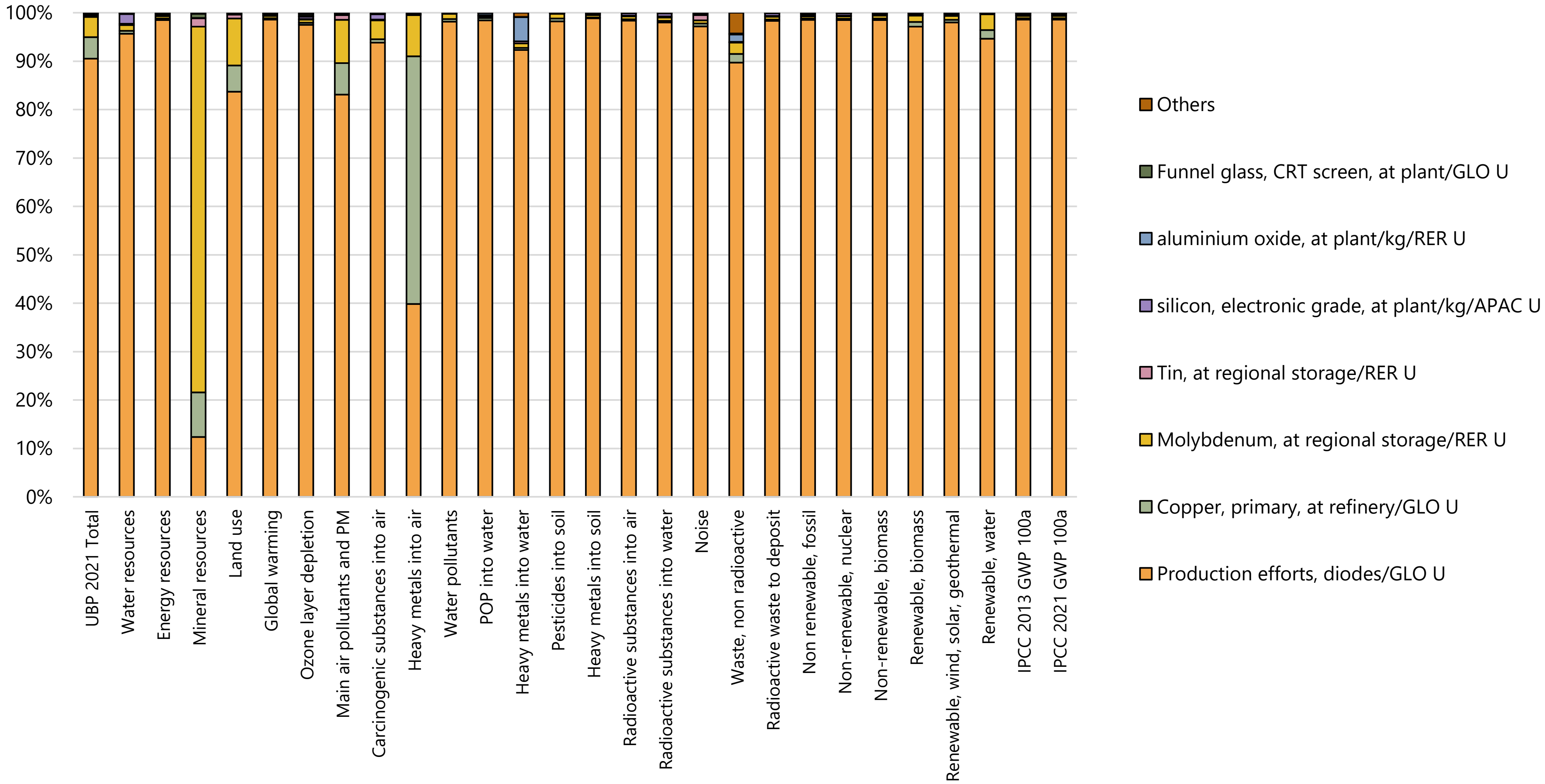

Figure 8.4-12. Contribution analysis presented in bar chart for: Diode, glass-, SMD type, surface mounting. FU = 1 kg diode, glass-, SMD type, surface mounting

Table 8.4-24. Contribution analysis presented in table for: Diode, glass-, SMD type, surface mounting. FU = 1 kg Diode, glass-, SMD type, surface mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, diodes/kg/GLO U	91%	99%	99%	99%
Copper, primary, at refinery/GLO U	4%	0%	0%	0%
Molybdenum, at regional storage/RER U	4%	0%	0%	0%
Tin, at regional storage/RER U	0%	0%	0%	0%
silicon, electronic grade, at plant/kg/APAC U	0%	0%	0%	0%
aluminium oxide, at plant/kg/RER U	0%	0%	0%	0%
Funnel glass, CRT screen, at plant/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.38E+05**	**2.94E+03**	**2.44E+02**	**2.43E+02**

8.4.13 Diode, glass-, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

Diode datasets retain the same three groupings from the original datasets: SMD, through-hole, and light emitting diodes. For the SMD type, according to an LCA study of diodes (Pina et al., 2021), it is assumed that the current dataset still reflects the material composition that is still available on the market. A similar update approach of maintaining the bill of materials as in the existing UVEK database is also followed for the other two types. However, no updates have been made to the material composition for the latter two types. The only exception is the production effort for diodes, which is explained in other unit processes. No statistics were found for diode market share by type. Thus, it is assumed that each diode type has a one-third market share of the total mix.

The resulting unit process for "diode, glass-, through-hole mounting" is shown in Table 8.4-25, whereas the life cycle impact assessment results are presented in Figure 8.4-13 and Table 8.4-26.

Table 8.4-25. Life cycle inventory for diode, glass-, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Diode, glass-, through-hole mounting, at plant/kg/GLO U	1	kg	100			
Input						
Copper, primary, at refinery/GLO U	0.23514	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.000104	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Funnel glass, CRT screen, at plant/GLO U	0.26146	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.016328	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Molybdenum, at regional storage/RER U	0.021008	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.003848	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.45074	kg		Lognormal	1.24	(1,4,2,1,1,5); average from literature & company informationv
Production efforts, diodes/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
silicon, electronic grade, at plant/kg/APAC U	0.00468	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.046488	kg		Lognormal	1.24	(1,4,2,1,1,5); average from literature & company informationv

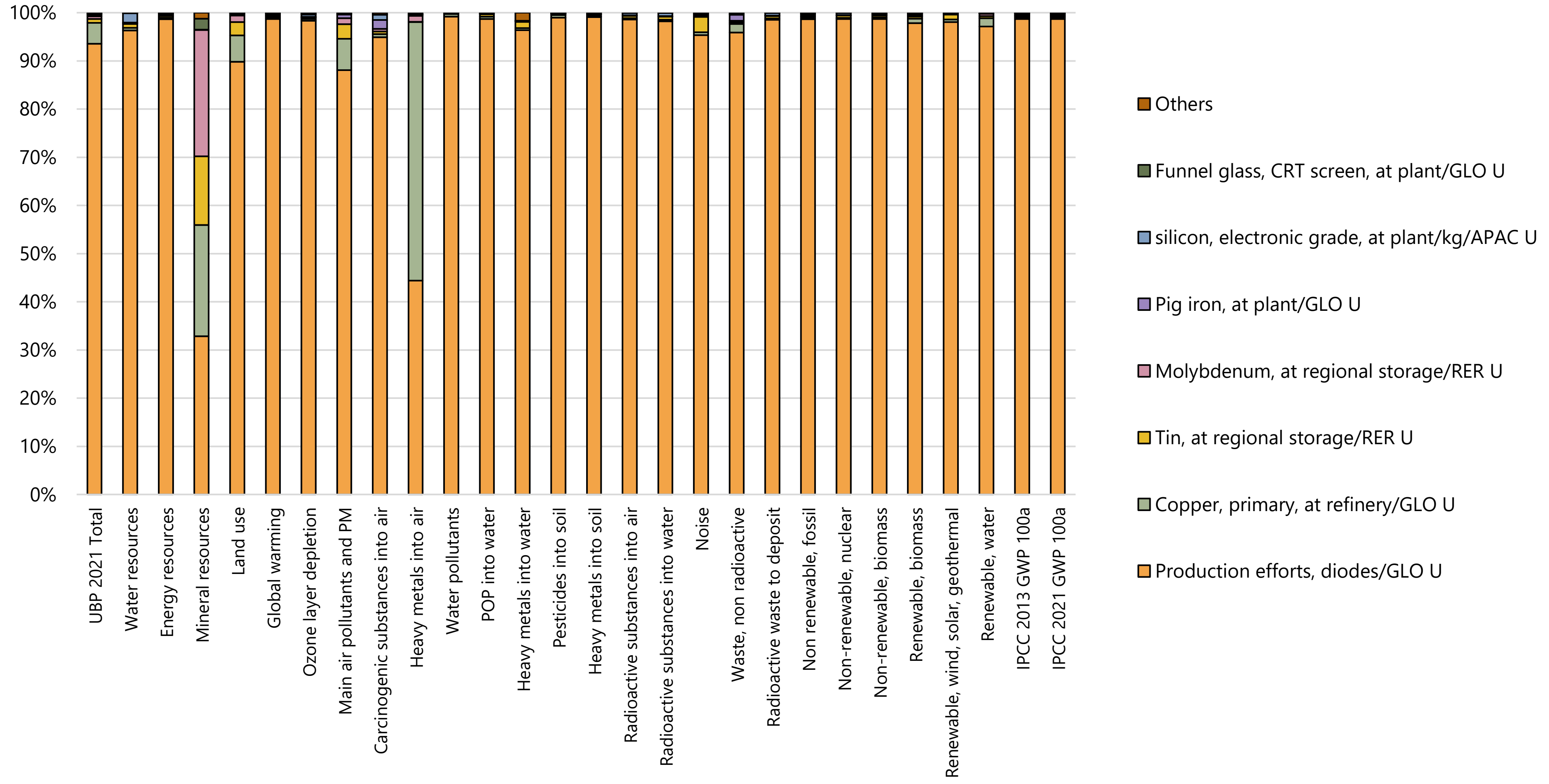

Figure 8.4-13. Contribution analysis presented in bar chart for: Diode, glass-, through-hole mounting. FU = 1 kg diode, glass-, through-hole mounting

Table 8.4-26. Contribution analysis presented in table for: Diode, glass-, through-hole mounting. FU = 1 kg Diode, glass-, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, diodes/kg/GLO U	94%	99%	99%	99%
Copper, primary, at refinery/GLO U	4%	0%	0%	0%
Tin, at regional storage/RER U	1%	0%	0%	0%
Molybdenum, at regional storage/RER U	1%	0%	0%	0%
Pig iron, at plant/GLO U	0%	0%	0%	0%
silicon, electronic grade, at plant/kg/APAC U	0%	0%	0%	0%
Funnel glass, CRT screen, at plant/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.23E+05**	**2.94E+03**	**2.44E+02**	**2.43E+02**

8.4.14 Light emitting diode, LED

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

Diode datasets retain the same three groupings from the original datasets: SMD, through-hole, and light emitting diodes. For the SMD type, according to an LCA study of diodes (Pina et al., 2021), it is assumed that the current dataset still reflects the material composition that is still available on the market. A similar update approach of maintaining the bill of materials as in the existing UVEK database is also followed for the other two types. However, no updates have been made to the material composition for the latter two types. The only exception is the production effort for diodes, which is explained in other unit processes. No statistics were found for diode market share by type. Thus, it is assumed that each diode type has a one-third market share of the total mix.

The resulting unit process for "Light emitting diode, LED" is shown in Table 8.4-27, whereas the life cycle impact assessment results are presented in Figure 8.4-14 and Table 8.4-28.

Table 8.4-27. Life cycle inventory for Light emitting diode, LED and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Light emitting diode, LED, at plant/kg/GLO U	1	kg				
Input						
Copper, primary, at refinery/GLO U	0.23514	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Epoxy resin, liquid, at plant/RER U	0.000104	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Funnel glass, CRT screen, at plant/GLO U	0.26146	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes) ---: funnel glass
Lead, primary, at plant/GLO U	0.016328	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Molybdenum, at regional storage/RER U	0.021008	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Nickel, 99.5%, at plant/GLO U	0.003848	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Pig iron, at plant/GLO U	0.45074	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Production efforts, diodes/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
silicon, electronic grade, at plant/kg/DE U	0.00468	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)
Tin, at regional storage/RER U	0.046488	kg		Lognormal	1.65	(3,4,4,1,4,5); assumption from conclusion by analogy (using through-hole mounted diodes)

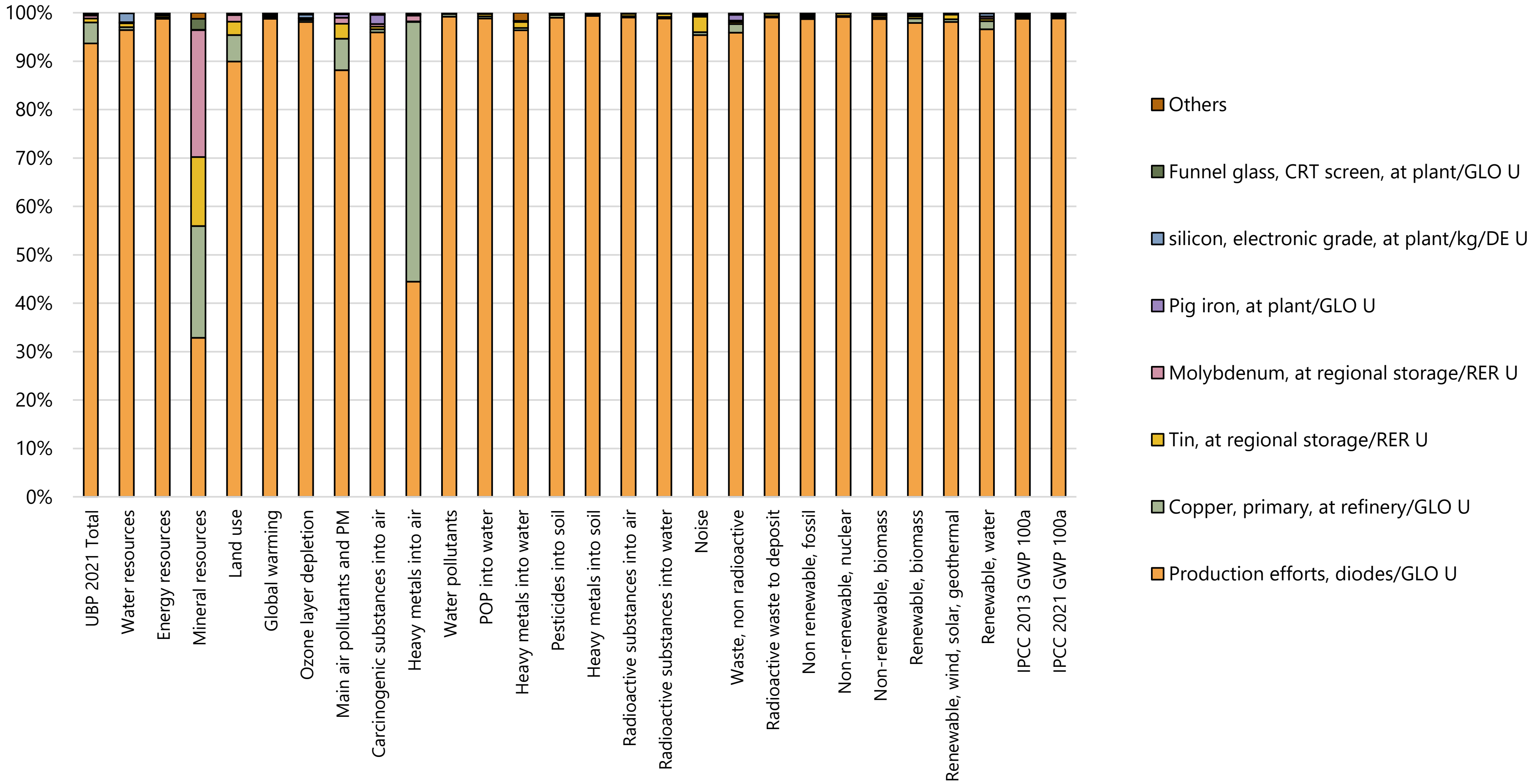

Figure 8.4-14. Contribution analysis presented in bar chart for: Light emitting diode, LED. FU = 1 kg light emitting diode, LED

Table 8.4-28. Contribution analysis presented in table for: Light emitting diode, LED. FU = 1 kg Light emitting diode, LED

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, diodes/kg/GLO U	94%	99%	99%	99%
Copper, primary, at refinery/GLO U	4%	0%	0%	0%
Tin, at regional storage/RER U	1%	0%	0%	0%
Molybdenum, at regional storage/RER U	1%	0%	0%	0%
Pig iron, at plant/GLO U	0%	0%	0%	0%
silicon, electronic grade, at plant/kg/DE U	0%	0%	0%	0%
Funnel glass, CRT screen, at plant/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.22E+05**	**2.94E+03**	**2.44E+02**	**2.43E+02**

8.4.15 Diode, unspecified

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

Diode datasets retain the same three groupings from the original datasets: SMD, through-hole, and light emitting diodes. For the SMD type, according to an LCA study of diodes (Pina et al., 2021), it is assumed that the current dataset still reflects the material composition that is still available on the market. A similar update approach of maintaining the bill of materials as in the existing UVEK database is also followed for the other two types. However, no updates have been made to the material composition for the latter two types. The only exception is the production effort for diodes, which is explained in other unit processes. No statistics were found for diode market share by type. Thus, it is assumed that each diode type has a one-third market share of the total mix.

The resulting unit process for "Diode, unspecified" is shown in Table 8.4-29, whereas the life cycle impact assessment results are presented in Figure 8.4-15 and Table 8.4-30.

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Table 8.4-29. Life cycle inventory for Diode, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Diode, unspecified, at plant/kg/GLO U	1	kg				
Input						
Diode, glass-, SMD type, surface mounting, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
Diode, glass-, through-hole mounting, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
Light emitting diode, LED, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data

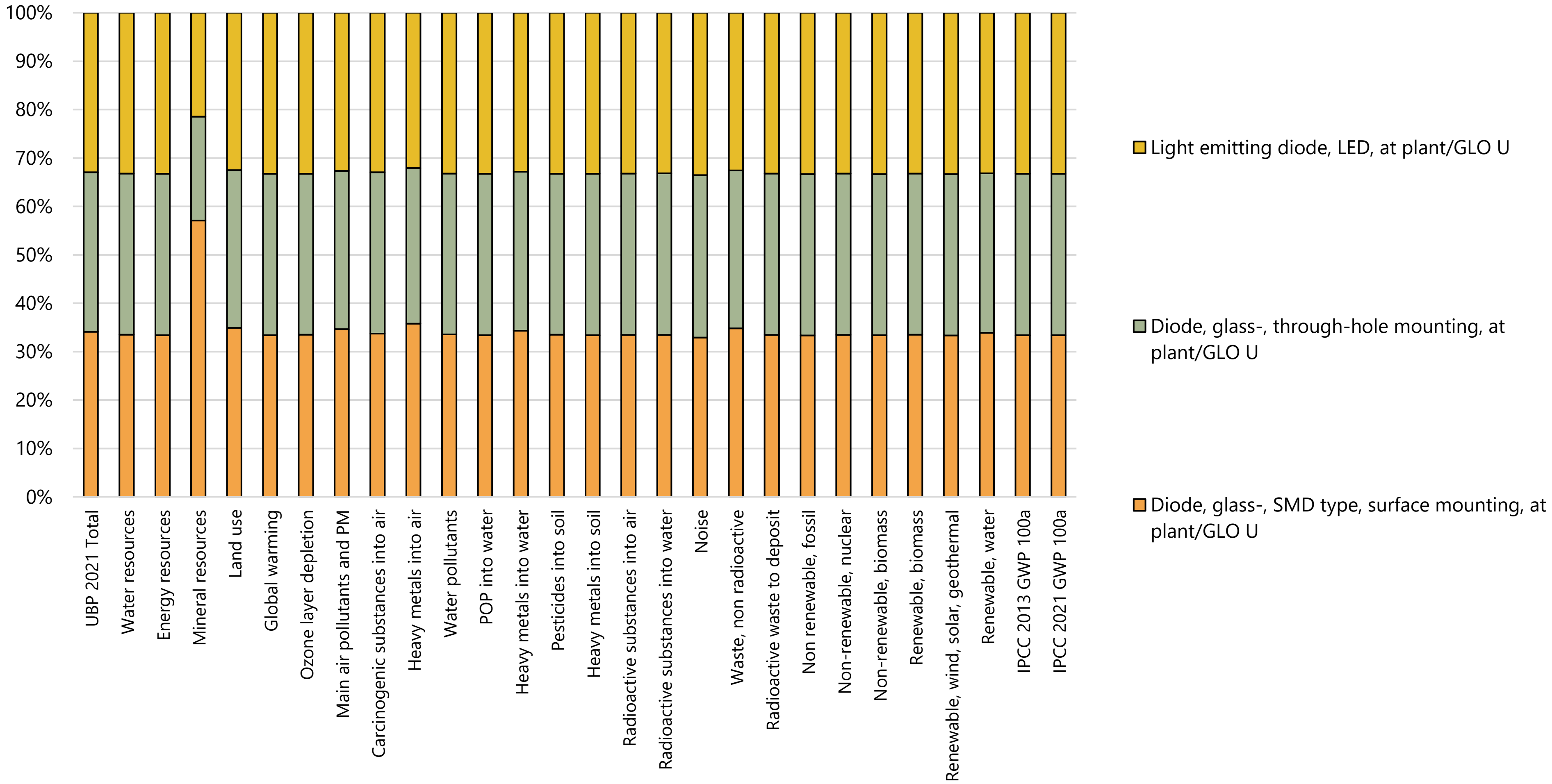

Figure 8.4-15. Contribution analysis presented in bar chart for: Diode, unspecified. FU = 1 kg diode, unspecified

Table 8.4-30. Contribution analysis presented in table for: Diode, unspecified. FU = 1 kg Diode, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Diode, glass-, SMD type, surface mounting, at plant/kg/GLO U	34%	33%	33%	33%
Diode, glass-, through-hole mounting, at plant/kg/GLO U	33%	33%	33%	33%
Light emitting diode, LED, at plant/kg/GLO U	33%	33%	33%	33%
Total impact, in absolute value	**4.28E+05**	**2.94E+03**	**2.44E+02**	**2.43E+02**

8.4.16 Resistor, SMD type, surface mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The datasets for resistors and potentiometers are verified by the understanding of the current trends of technologies as reviewed in the literature (Zedníček, 2022) and (Sumida, 2022). Resistor grouping in the updated database remains the same as in the original UVEK database: Resistor metal film type, SMD type, wirewound, and potentiometer. The literature review also confirms that the composition of each resistor in the original UVEK database remains unchanged. In addition, there are no statistics available on the market share of the individual types of resistors. Therefore, the assumption is that each type of resistor has a market share of one fourth of the total mix. The updates for the resistor components are mainly related to the manufacturing part, which is described in the other unit process "production, efforts".

The resulting unit process for "Resistor, SMD type, surface mounting" is shown inTable 8.4-31, whereas the life cycle impact assessment results are presented in Figure 8.4-16 and Table 8.4-32.

Table 8.4-31. Life cycle inventory for Resistor, SMD type, surface mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Resistor, SMD type, surface mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium oxide, at plant/kg/RER U	0.86038	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Chromium, at regional storage/RER U	0.001107	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.004551	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.011562	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Glass tube, borosilicate, at plant/DE U	0.008118	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Gold, primary, at refinery/GLO U	0.006273	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.005412	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Limestone, milled, packed, at plant/CH U	0.000615	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
MG-silicon, at plant/kg/APAC U	0.000123	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.020295	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Palladium, at regional storage/RER U	0.001722	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.028905	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polymethyl methacrylate, beads, at plant/RER U	0.007872	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, resistors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silica sand, at plant/DE U	0.24625	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Silver, at regional storage/RER U	0.0123	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.014391	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

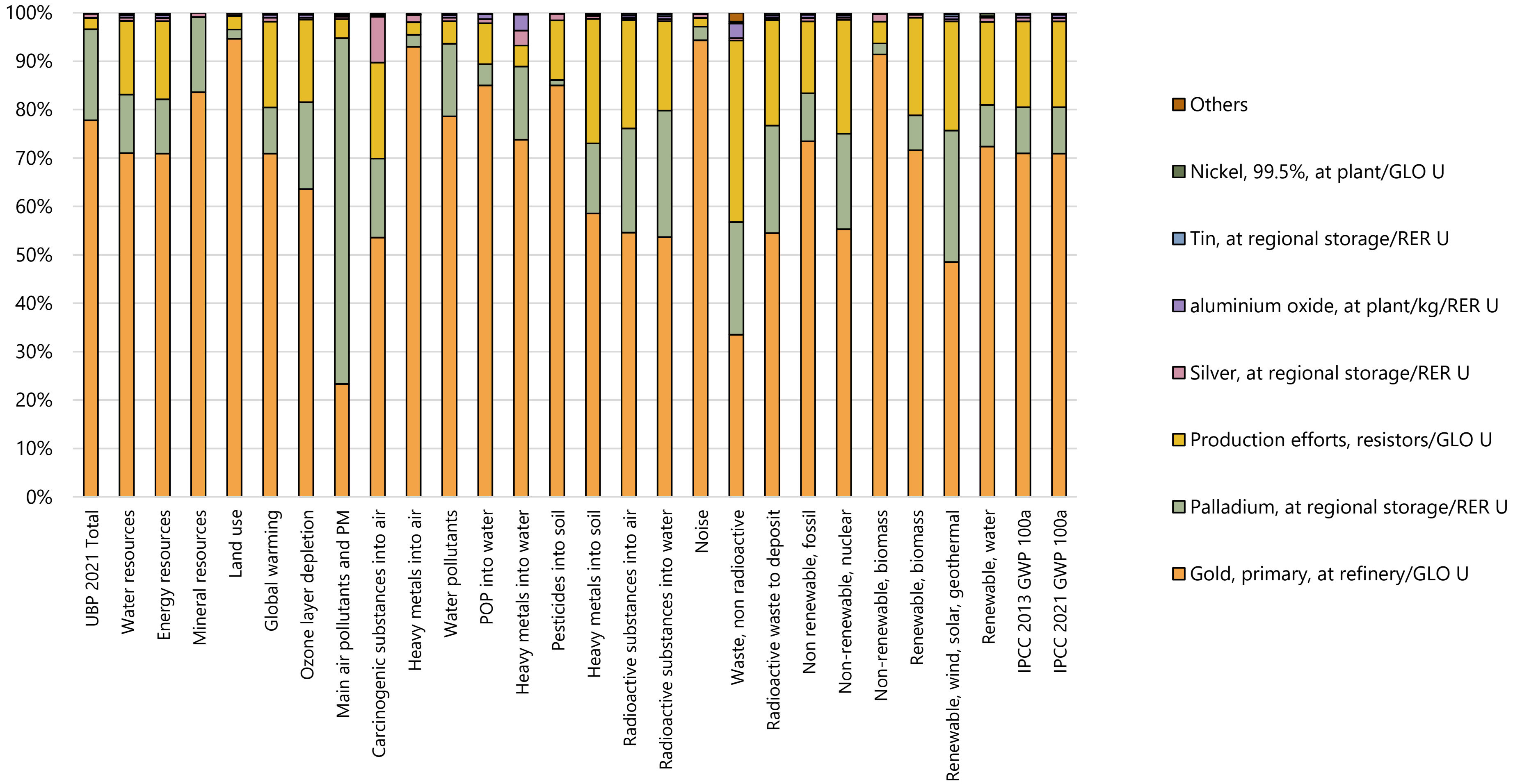

Figure 8.4-16. Contribution analysis presented in bar chart for: Resistor, SMD type, surface mounting. FU = 1 kg Resistor, SMD type, surface mounting

Table 8.4-32. Contribution analysis presented in table for: Resistor, SMD type, surface mounting. FU = 1 kg Resistor, SMD type, surface mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, primary, at refinery/GLO U	78%	73%	71%	71%
Palladium, at regional storage/RER U	19%	10%	10%	10%
Production efforts, resistors/kg/GLO U	2%	15%	18%	18%
Silver, at regional storage/RER U	1%	1%	1%	1%
aluminium oxide, at plant/kg/RER U	0%	1%	1%	1%
Tin, at regional storage/RER U	0%	0%	0%	0%
Nickel, 99.5%, at plant/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**2.21E+06**	**2.15E+03**	**1.71E+02**	**1.70E+02**

8.4.17 Resistor, metal film type, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The datasets for resistors and potentiometers are verified by the understanding of the current trends of technologies as reviewed in the literature (Zedníček, 2022) and (Sumida, 2022). Resistor grouping in the updated database remains the same as in the original UVEK database: Resistor metal film type, SMD type, wirewound, and potentiometer. The literature review also confirms that the composition of each resistor in the original UVEK database remains unchanged. In addition, there are no statistics available on the market share of the individual types of resistors. Therefore, the assumption is that each type of resistor has a market share of one fourth of the total mix. The updates for the resistor components are mainly related to the manufacturing part, which is described in the other unit process "production, efforts".

The resulting unit process for "Resistor, metal film type, through-hole mounting" is shown in Table 8.4-33, whereas the life cycle impact assessment results are presented in Figure 8.4-17 and Table 8.4-34.

Table 8.4-33. Life cycle inventory for Resistor, metal film type, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Resistor, metal film type, through-hole mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium oxide, at plant/kg/RER U	0.13481	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
aluminium, primary, at plant/kg/RER U	0.000369	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.45756	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.020664	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.061869	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Limestone, milled, packed, at plant/CH U	0.029643	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Magnesium oxide, at plant/RER U	0.005166	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Methyl acrylate, at plant/GLO U	0.000123	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.029028	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.12632	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.025215	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Polyurethane, flexible foam, at plant/RER U	0.001476	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Production efforts, resistors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silica sand, at plant/DE U	0.15375	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Silicone product, at plant/RER U	0.001968	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Steel, low-alloyed, at plant/RER U	0.0738	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Tin, at regional storage/RER U	0.10762	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information
Titanium dioxide, production mix, at plant/RER U	0.000738	kg		Lognormal	1.32	(1,4,4,1,1,5); average from literature & company information

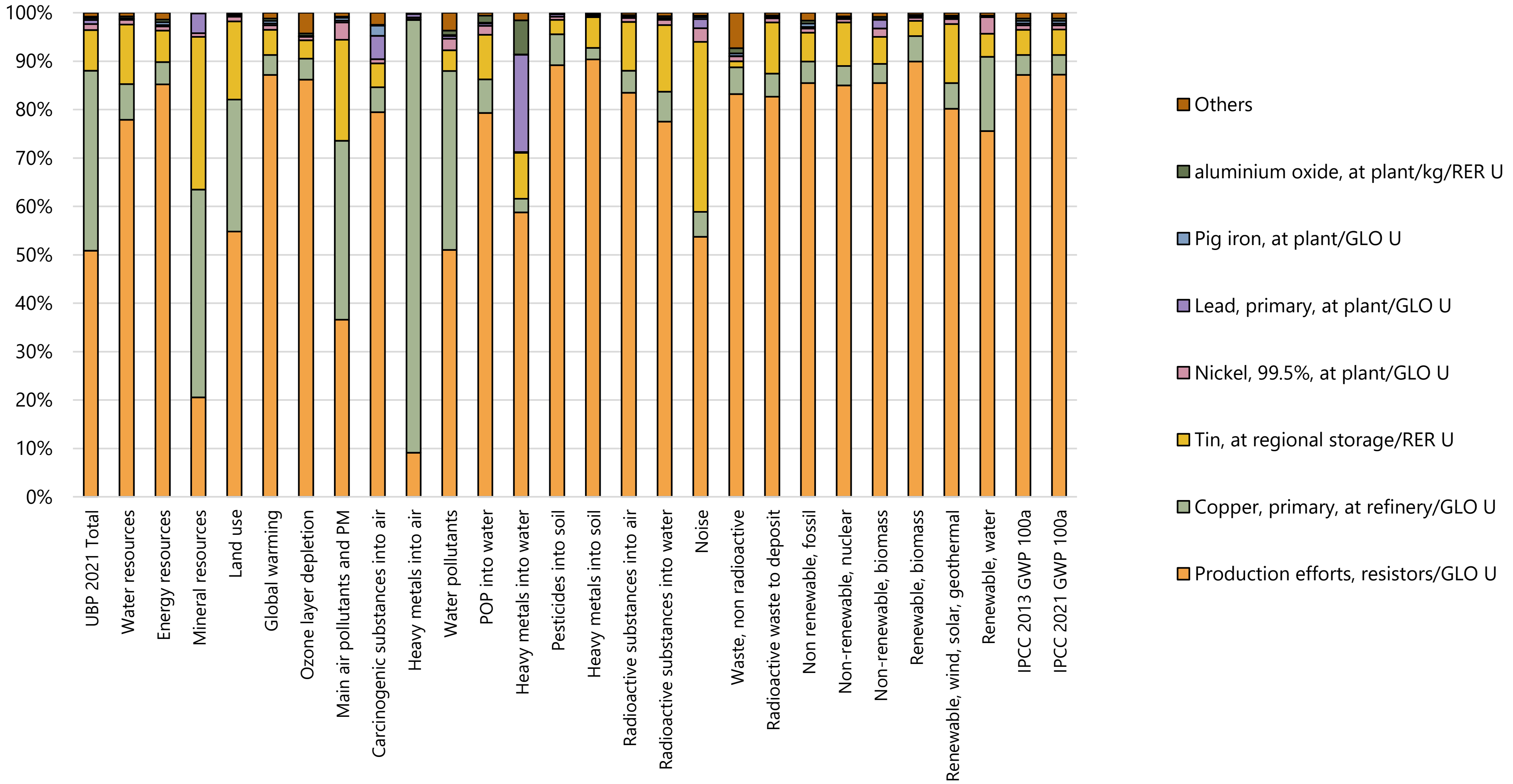

Figure 8.4-17. Contribution analysis presented in bar chart for: Resistor, metal film type, through-hole mounting. FU = 1 kg Resistor, metal film type, through-hole mounting

Table 8.4-34. Contribution analysis presented in table for: Resistor metal film type, through-hole mounting. FU = 1 kg Resistor, metal film type, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, resistors/kg/GLO U	51%	85%	87%	87%
Copper, primary, at refinery/GLO U	37%	4%	4%	4%
Tin, at regional storage/RER U	8%	6%	5%	5%
Nickel, 99.5%, at plant/GLO U	1%	1%	1%	1%
Lead, primary, at plant/GLO U	1%	0%	0%	0%
Pig iron, at plant/GLO U	0%	1%	1%	1%
aluminium oxide, at plant/kg/RER U	0%	1%	0%	0%
Others	1%	2%	1%	1%
Total impact, in absolute value	**1.01E+05**	**3.73E+02**	**3.48E+01**	**3.46E+01**

8.4.18 Resistor, wirewound, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The datasets for resistors and potentiometers are verified by the understanding of the current trends of technologies as reviewed in the literature (Zedníček, 2022) and (Sumida, 2022). Resistor grouping in the updated database remains the same as in the original UVEK database: Resistor metal film type, SMD type, wirewound, and potentiometer. The literature review also confirms that the composition of each resistor in the original UVEK database remains unchanged. In addition, there are no statistics available on the market share of the individual types of resistors. Therefore, the assumption is that each type of resistor has a market share of one fourth of the total mix. The updates for the resistor components are mainly related to the manufacturing part, which is described in the other unit process "production, efforts".

The resulting unit process for "Resistor, wirewound, through-hole mounting" is shown in Table 8.4-35, whereas the life cycle impact assessment results are presented in Figure 8.4-18 and Table 8.4-36.

Table 8.4-35. Life cycle inventory for Resistor, wirewound, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Resistor, wirewound, through-hole mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium oxide, at plant/kg/RER U	0.29581	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
aluminium, primary, at plant/kg/RER U	0.00492	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Copper, primary, at refinery/GLO U	0.04059	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Glass tube, borosilicate, at plant/DE U	0.01476	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Limestone, milled, packed, at plant/CH U	0.12091	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Nickel, 99.5%, at plant/GLO U	0.01353	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Pig iron, at plant/GLO U	0.06396	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Production efforts, resistors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation
Silica sand, at plant/DE U	0.50036	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Silicone product, at plant/RER U	0.011439	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Steel, low-alloyed, at plant/RER U	0.13653	kg		Lognormal	1.32	(1,4,4,1,1,5); company information
Tin, at regional storage/RER U	0.02706	kg		Lognormal	1.32	(1,4,4,1,1,5); company information

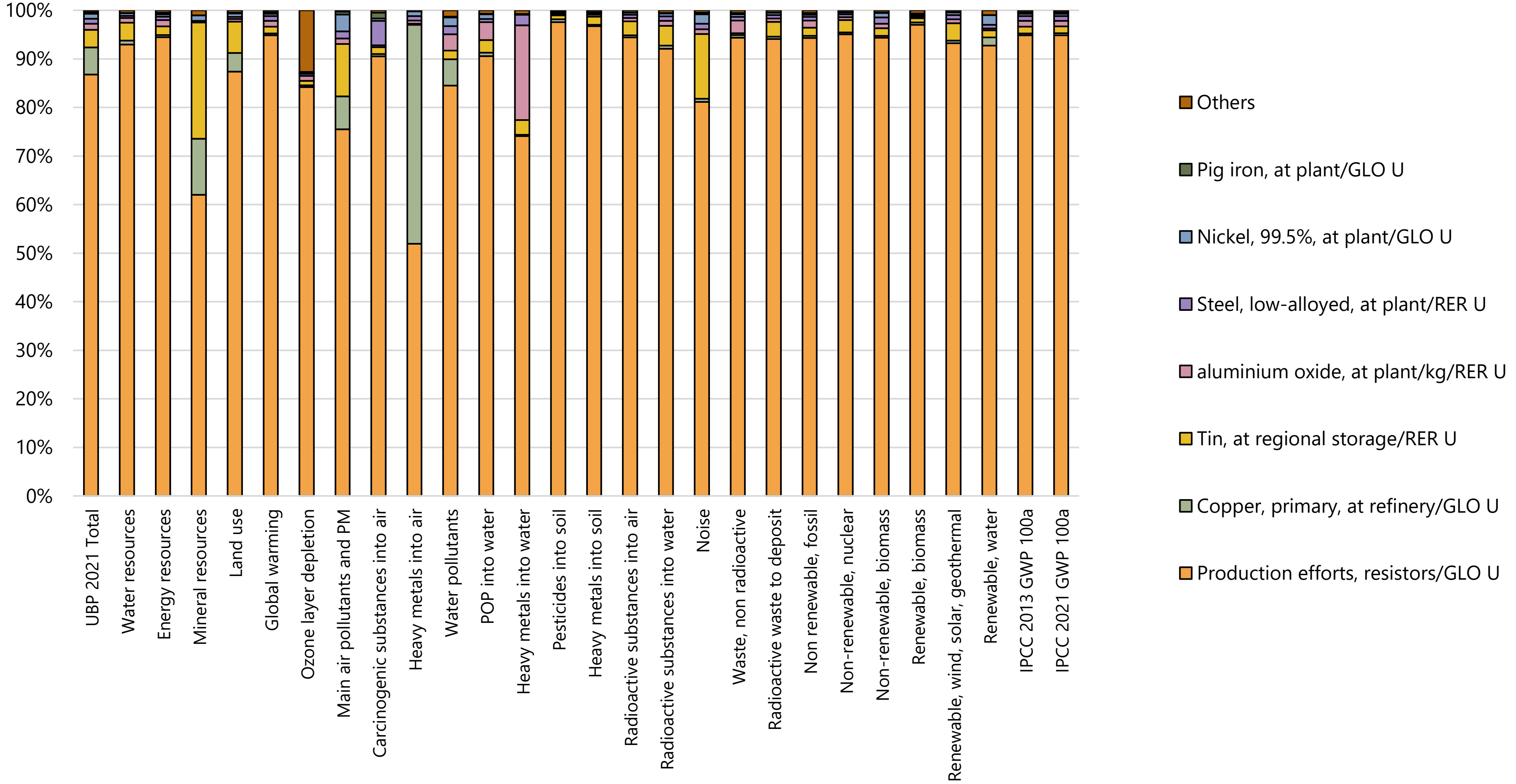

Figure 8.4-18. Contribution analysis presented in bar chart for: Resistor, wirewound, through-hole mounting. FU = 1 kg Resistor, wirewound, through-hole mounting

Table 8.4-36. Contribution analysis presented in table for: Resistor, wirewound, through-hole mounting. FU = 1 kg Resistor, wirewound, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, resistors/kg/GLO U	87%	94%	95%	95%
Copper, primary, at refinery/GLO U	6%	0%	0%	0%
Tin, at regional storage/RER U	4%	2%	1%	1%
aluminium oxide, at plant/kg/RER U	1%	1%	1%	1%
Steel, low-alloyed, at plant/RER U	1%	1%	1%	1%
Nickel, 99.5%, at plant/GLO U	1%	0%	0%	0%
Pig iron, at plant/GLO U	0%	0%	0%	0%
Others	0%	1%	0%	0%
Total impact, in absolute value	**5.98E+04**	**3.38E+02**	**3.20E+01**	**3.18E+01**

8.4.19 Potentiometer, unspecified

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The datasets for resistors and potentiometers are verified by the understanding of the current trends of technologies as reviewed in the literature (Zedníček, 2022) and (Sumida, 2022). Resistor grouping in the updated database remains the same as in the original UVEK database: Resistor metal film type, SMD type, wirewound, and potentiometer. The literature review also confirms that the composition of each resistor in the original UVEK database remains unchanged. In addition, there are no statistics available on the market share of the individual types of resistors. Therefore, the assumption is that each type of resistor has a market share of one fourth of the total mix. The updates for the resistor components are mainly related to the manufacturing part, which is described in the other unit process "production, efforts".

The resulting unit process for "Potentiometer, unspecified" is shown in Table 8.4-37, whereas the life cycle impact assessment results are presented in Figure 8.4-19 and Table 8.4-38.

Table 8.4-37. Life cycle inventory for Potentiometer, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Potentiometer, unspecified, at plant/kg/GLO U	1	kg				
Input						
aluminium oxide, at plant/kg/RER U	0.098523	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Copper, primary, at refinery/GLO U	0.064206	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Kraft paper, unbleached, at plant/RER U	0.027552	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Nickel, 99.5%, at plant/GLO U	0.005658	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Polycarbonate, at plant/RER U	0.89421	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.041451	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Production efforts, resistors/kg/GLO U	1	kg		Lognormal	1.60	(3,4,2,1,4,5); rough estimation
Steel, low-alloyed, at plant/RER U	0.084132	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Tin, at regional storage/RER U	0.005658	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data
Zinc, primary, at regional storage/RER U	0.008733	kg		Lognormal	1.32	(1,4,4,1,1,5); literature data

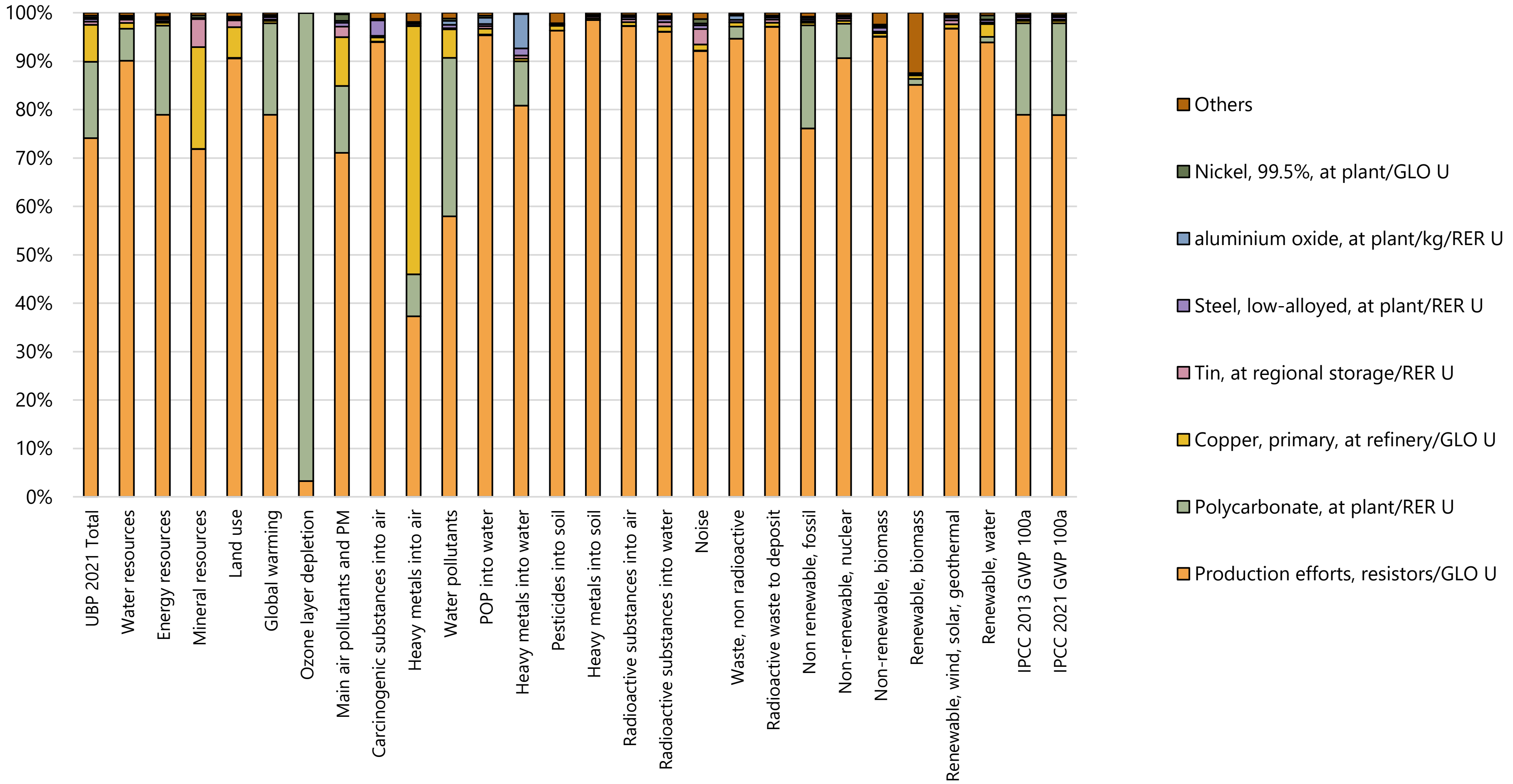

Figure 8.4-19. Contribution analysis presented in bar chart for: Potentiometer, unspecified. FU = 1 kg Potentiometer, unspecified

Table 8.4-38. Contribution analysis presented in table for: Potentiometer, unspecified. FU = 1 kg Potentiometer, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, resistors/kg/GLO U	74%	76%	79%	79%
Polycarbonate, at plant/RER U	16%	21%	19%	19%
Copper, primary, at refinery/GLO U	8%	1%	1%	1%
Tin, at regional storage/RER U	1%	0%	0%	0%
Steel, low-alloyed, at plant/RER U	1%	0%	1%	1%
aluminium oxide, at plant/kg/RER U	0%	0%	0%	0%
Nickel, 99.5%, at plant/GLO U	0%	0%	0%	0%
Others	1%	1%	0%	0%
Total impact, in absolute value	**6.99E+04**	**4.19E+02**	**3.84E+01**	**3.83E+01**

8.4.20 Resistor, unspecified

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The datasets for resistors and potentiometers are verified by the understanding of the current trends of technologies as reviewed in the literature (Zedníček, 2022) and (Sumida, 2022). Resistor grouping in the updated database remains the same as in the original UVEK database: Resistor metal film type, SMD type, wirewound, and potentiometer. The literature review also confirms that the composition of each resistor in the original UVEK database remains unchanged. In addition, there are no statistics available on the market share of the individual types of resistors. Therefore, the assumption is that each type of resistor has a market share of one fourth of the total mix. The updates for the resistor components are mainly related to the manufacturing part, which is described in the other unit process "production, efforts".

The resulting unit process for "Resistor, unspecified" is shown in Table 8.4-39, whereas the life cycle impact assessment results are presented in Figure 8.4-20 and Table 8.4-40.

Table 8.4-39. Life cycle inventory for Resistor, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Resistor, unspecified, at plant/kg/GLO U	1	kg				
Input						
Potentiometer, unspecified, at plant/kg/GLO U	0.25	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
Resistor, metal film type, through-hole mounting, at plant/kg/GLO U	0.25	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
Resistor, SMD type, surface mounting, at plant/kg/GLO U	0.25	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
Resistor, wirewound, through-hole mounting, at plant/kg/GLO U	0.25	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data

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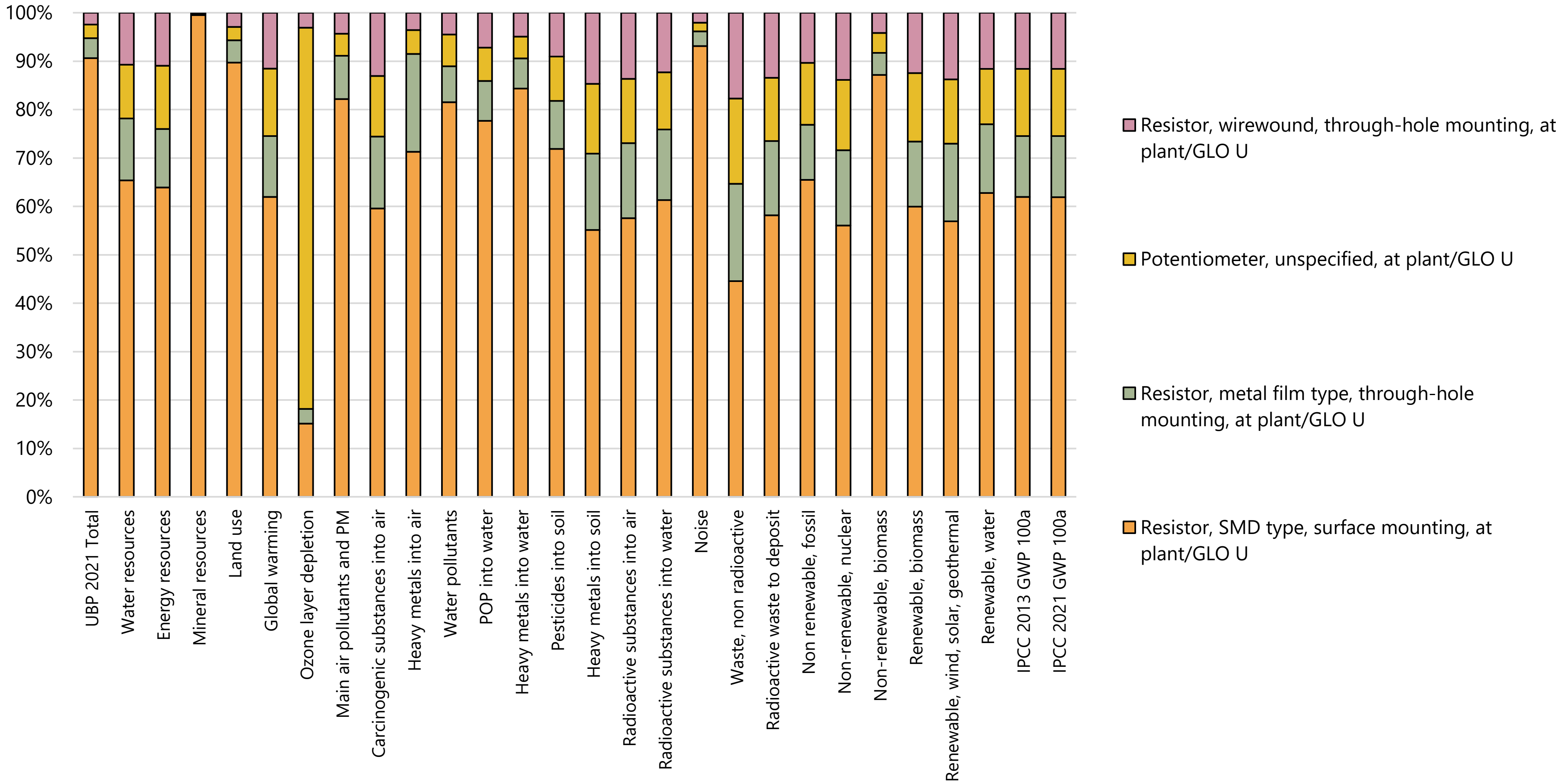

Figure 8.4-20. Contribution analysis presented in bar chart for: Resistor, unspecified. FU = 1 kg Resistor, unspecified

Table 8.4-40. Contribution analysis presented in table for: Resistor, unspecified. FU = 1 kg Resistor, unspecified

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
Resistor, SMD type, surface mounting, at plant/kg/GLO U	91%	65%	62%	62%
Resistor, metal film type, through-hole mounting, at plant/kg/GLO U	4%	11%	13%	13%
Potentiometer, unspecified, at plant/kg/GLO U	3%	13%	14%	14%
Resistor, wirewound, through-hole mounting, at plant/kg/GLO U	2%	10%	12%	12%
Total impact, in absolute value	**6.09E+05**	**8.19E+02**	**6.91E+01**	**6.87E+01**

8.4.21 Transistor, SMD type, surface mounting

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The same grouping as in the original UVEK database is still used for transistor datasets in the updated database: SMD type, wired large size and wired small size. Specifically for the SMD type transistors, the inventory data can be updated with reference to the scientific publication (Gómez et al., 2015). The selected transistor represents the composition closest to the average material composition of all the transistors studied, referred to as type "BC817-25" in the publication. Except for the update of the production effort, the other two generic transistor types (wired large and small size) remain the same at the inventory level. Finally, due to the lack of statistical data, the market share of the three transistor types is divided equally.

The resulting unit process for "transistor, SMD type, surface mounting" is shown in Table 8.4-41, whereas the life cycle impact assessment results are presented in Figure 8.4-21 and Table 8.4-42.

Table 8.4-41. Life cycle inventory for transistor, SMD type, surface mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Transistor, SMD type, surface mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium, primary, at plant/kg/RER U	0.0003	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Copper, primary, at refinery/GLO U	0.037	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Epoxy resin insulator (SiO2), at plant/RER U	0.45	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Nickel, 99.5%, at plant/GLO U	0.117	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Pig iron, at plant/GLO U	0.156	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
silicon, electronic grade, at plant/kg/APAC U	0.0106	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Tin, at regional storage/RER U	0.0279	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Production efforts, transistors/kg/GLO U	1	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Gold, primary, at refinery/GLO U	0.0021	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Chromium, at regional storage/RER U	0.0007	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
MG-silicon, at plant/kg/APAC U	0.0008	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Polyester resin, unsaturated, at plant/RER U	0.0001	kg		Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.

Carbon black, at plant/GLO U	0.002	kg	Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Silver, at regional storage/RER U	0.0084	kg	Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Cobalt, at plant/GLO U	0.0014	kg	Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Manganese, at regional storage/RER U	0.0028	kg	Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Formaldehyde, production mix, at plant/RER U	0.125	kg	Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.
Phenolic resin, at plant/RER U	0.0571	kg	Lognormal	1.27	(2,4,3,2,1,5); average from literature & company information. additional source: Gomez et al 2015.

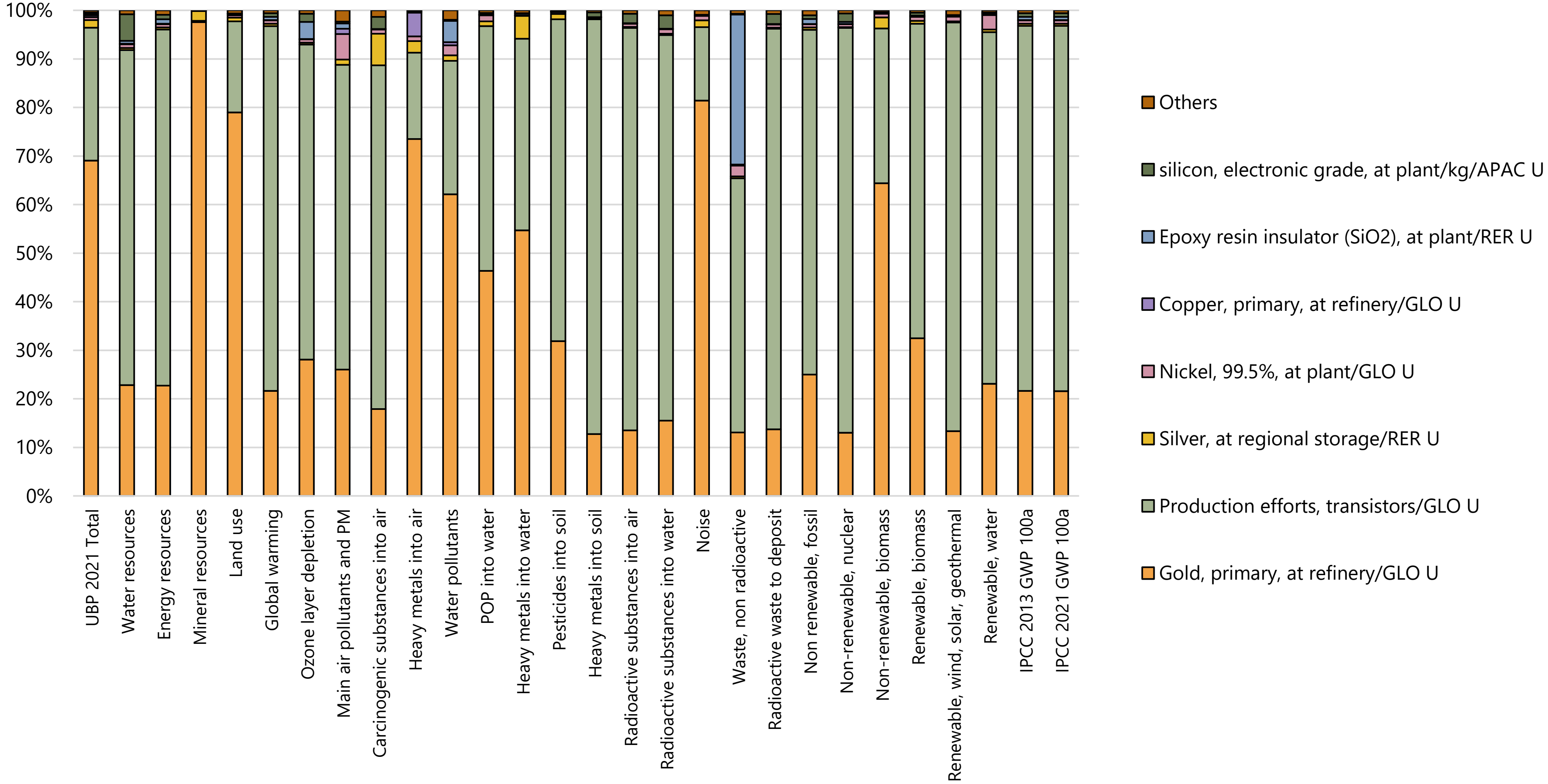

Figure 8.4-21. Contribution analysis presented in bar chart for: transistor, SMD type, surface mounting. FU = 1 kg transistor, SMD type, surface mounting

Table 8.4-42. Contribution analysis presented in table for: transistor, SMD type, surface mounting. FU = 1 kg transistor, SMD type, surface mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, primary, at refinery/GLO U	69%	25%	22%	22%
Production efforts, transistors/kg/GLO U	27%	71%	75%	75%
Silver, at regional storage/RER U	2%	0%	0%	0%
Nickel, 99.5%, at plant/GLO U	1%	1%	1%	1%
Copper, primary, at refinery/GLO U	0%	0%	0%	0%
Epoxy resin insulator (SiO2), at plant/RER U	0%	1%	1%	1%
silicon, electronic grade, at plant/kg/APAC U	0%	1%	1%	1%
Others	0%	1%	1%	1%
Total impact, in absolute value	**8.31E+05**	**2.10E+03**	**1.87E+02**	**1.86E+02**

8.4.22 Transistor wired, big size, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The same grouping as in the original UVEK database is still used for transistor datasets in the updated database: SMD type, wired large size and wired small size. Specifically for the SMD type transistors, the inventory data can be updated with reference to the scientific publication (Gómez et al., 2015). The selected transistor represents the composition closest to the average material composition of all the transistors studied, referred to as type "BC817-25" in the publication. Except for the update of the production effort, the other two generic transistor types (wired large and small size) remain the same at the inventory level. Finally, due to the lack of statistical data, the market share of the three transistor types is divided equally.

The resulting unit process for "transistor wired, big size, through-hole mounting" is shown in Table 8.4-43, whereas the life cycle impact assessment results are presented in Figure 8.4-22 and Table 8.4-44.

Table 8.4-43. Life cycle inventory for transistor wired, big size, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Transistor, wired, big size, through-hole mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium, primary, at plant/kg/RER U	0.0004	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.3541	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Epoxy resin insulator (SiO2), at plant/RER U	0.416	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.0369	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.0013	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.0235	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
silicon, electronic grade, at plant/kg/APAC U	0.0028	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Tin, at regional storage/RER U	0.0811	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
aluminium oxide, at plant/kg/RER U	0.0135	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Chemicals inorganic, at plant/GLO U	0.0164	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Glass tube, borosilicate, at plant/DE U	0.0129	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Nylon 6, at plant/RER U	0.0362	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Zinc, primary, at regional storage/RER U	0.0049	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Production efforts, transistors/kg/GLO U	1	kg		Lognormal	1.61	(3,4,3,2,4,5); rough estimation

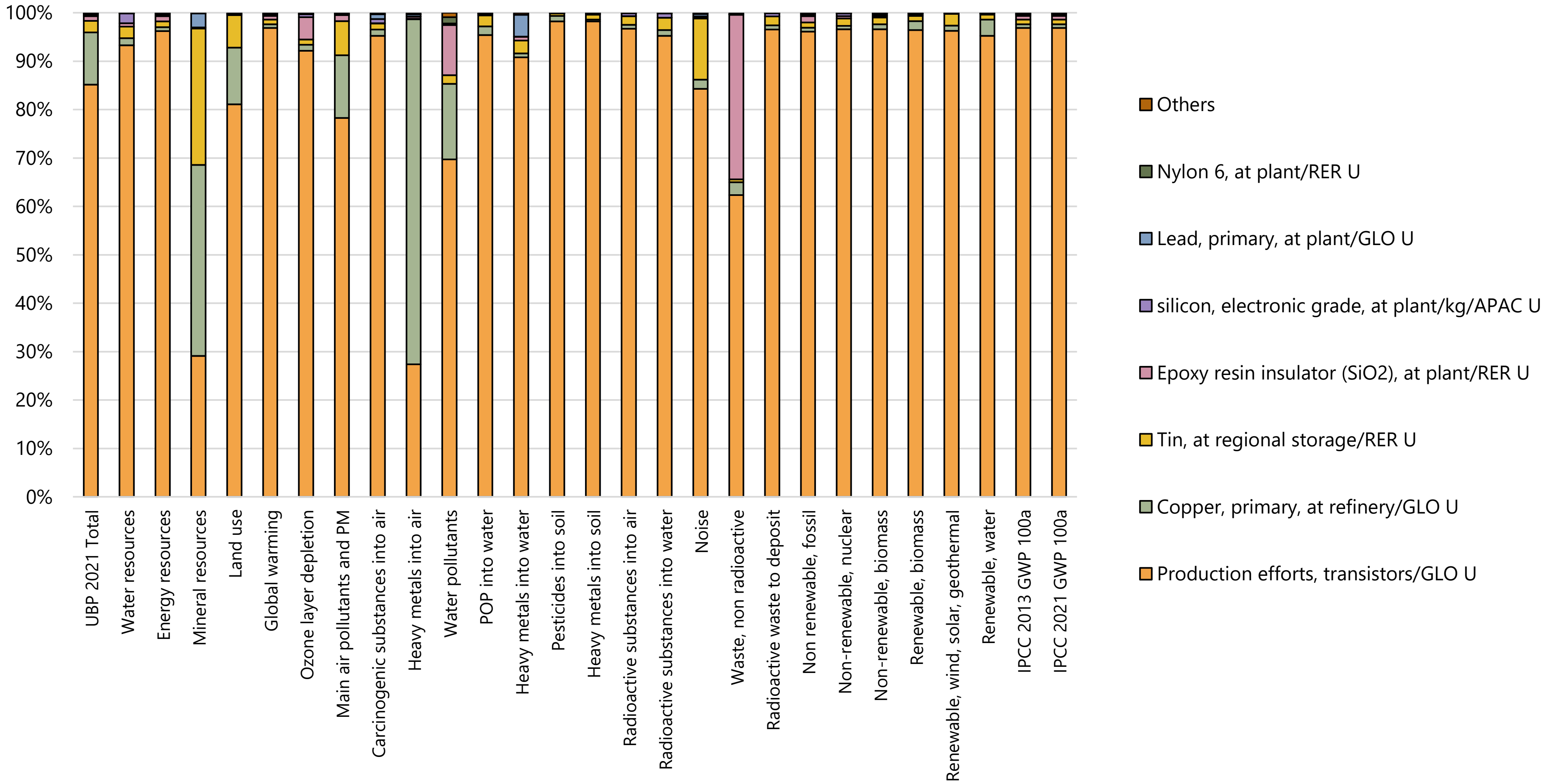

Figure 8.4-22. Contribution analysis presented in bar chart for: transistor, wired, big size, through-hole mounting. FU = 1 kg transistor, wired, big size, through-hole mounting

Table 8.4-44. Contribution analysis presented in table for: transistor, wired, big size, through-hole mounting. FU = 1 kg transistor, wired, big size, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, transistors/kg/GLO U	85%	96%	97%	97%
Copper, primary, at refinery/GLO U	11%	1%	1%	1%
Tin, at regional storage/RER U	2%	1%	1%	1%
Epoxy resin insulator (SiO2), at plant/RER U	1%	1%	1%	1%
silicon, electronic grade, at plant/kg/APAC U	0%	0%	0%	0%
Lead, primary, at plant/GLO U	0%	0%	0%	0%
Nylon 6, at plant/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**2.67E+05**	**1.54E+03**	**1.45E+02**	**1.44E+02**

8.4.23 Transistor wired, small size, through-hole mounting

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The same grouping as in the original UVEK database is still used for transistor datasets in the updated database: SMD type, wired large size and wired small size. Specifically for the SMD type transistors, the inventory data can be updated with reference to the scientific publication (Gómez et al., 2015). The selected transistor represents the composition closest to the average material composition of all the transistors studied, referred to as type "BC817-25" in the publication. Except for the update of the production effort, the other two generic transistor types (wired large and small size) remain the same at the inventory level. Finally, due to the lack of statistical data, the market share of the three transistor types is divided equally.

The resulting unit process for "transistor wired, small size, through-hole mounting" is shown in Table 8.4-45, whereas the life cycle impact assessment results are presented in Figure 8.4-23 and Table 8.4-46.

Table 8.4-45. Life cycle inventory for transistor wired, small size, through-hole mounting and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Transistor, wired, small size, through-hole mounting, at plant/kg/GLO U	1	kg				
Input						
aluminium, primary, at plant/kg/RER U	1E-04	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Copper, primary, at refinery/GLO U	0.37286	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Epoxy resin insulator (SiO2), at plant/RER U	0.46945	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Lead, primary, at plant/GLO U	0.043696	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Nickel, 99.5%, at plant/GLO U	0.013999	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Pig iron, at plant/GLO U	0.019098	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
silicon, electronic grade, at plant/kg/APAC U	0.0032	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Tin, at regional storage/RER U	0.074593	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Glass tube, borosilicate, at plant/DE U	0.0007	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Zinc, primary, at regional storage/RER U	0.0023	kg		Lognormal	1.24	(1,4,2,2,1,5); average from literature & company information
Production efforts, transistors/kg/GLO U	1	kg		Lognormal	1.61	(3,4,3,2,4,5); rough estimation

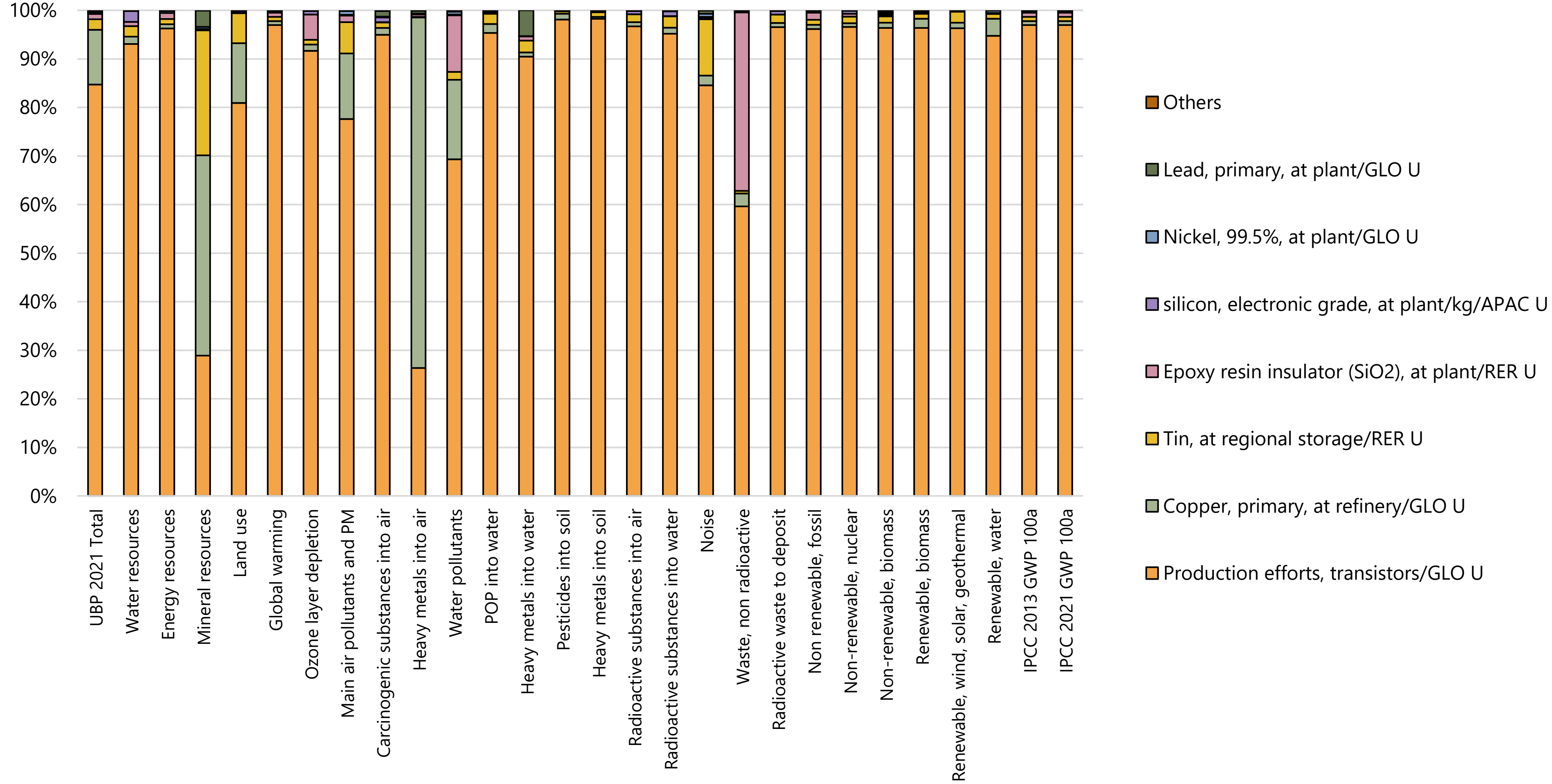

Figure 8.4-23. Contribution analysis presented in bar chart for: transistor, wired, small size, through-hole mounting. FU = 1 kg transistor, wired, small size, through-hole mounting

Table 8.4-46. Contribution analysis presented in table for: transistor, wired, small size, through-hole mounting. FU = 1 kg transistor, wired, small size, through-hole mounting

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, transistors/kg/GLO U	85%	96%	97%	97%
Copper, primary, at refinery/GLO U	11%	1%	1%	1%
Tin, at regional storage/RER U	2%	1%	1%	1%
Epoxy resin insulator (SiO2), at plant/RER U	1%	1%	1%	1%
silicon, electronic grade, at plant/kg/APAC U	0%	0%	0%	0%
Nickel, 99.5%, at plant/GLO U	0%	0%	0%	0%
Lead, primary, at plant/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**2.68E+05**	**1.54E+03**	**1.44E+02**	**1.44E+02**

8.4.24 Transistor, unspecified

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The same grouping as in the original UVEK database is still used for transistor datasets in the updated database: SMD type, wired large size and wired small size. Specifically for the SMD type transistors, the inventory data can be updated with reference to the scientific publication (Gómez et al., 2015). The selected transistor represents the composition closest to the average material composition of all the transistors studied, referred to as type "BC817-25" in the publication. Except for the update of the production effort, the other two generic transistor types (wired large and small size) remain the same at the inventory level. Finally, due to the lack of statistical data, the market share of the three transistor types is divided equally.

The resulting unit process for "Transistor, unspecified" is shown in Table 8.4-47, whereas the life cycle impact assessment results are presented in Figure 8.4-24 and Table 8.4-48.

Table 8.4-47. Life cycle inventory for Transistor, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Transistor, unspecified, at plant/kg/GLO U	1	kg				
Input						
transistor, SMD type, surface mounting, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
transistor, wired, big size, through-hole mounting, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data
transistor, wired, small size, through-hole mounting, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,1,4,5); assumption, based on specific data

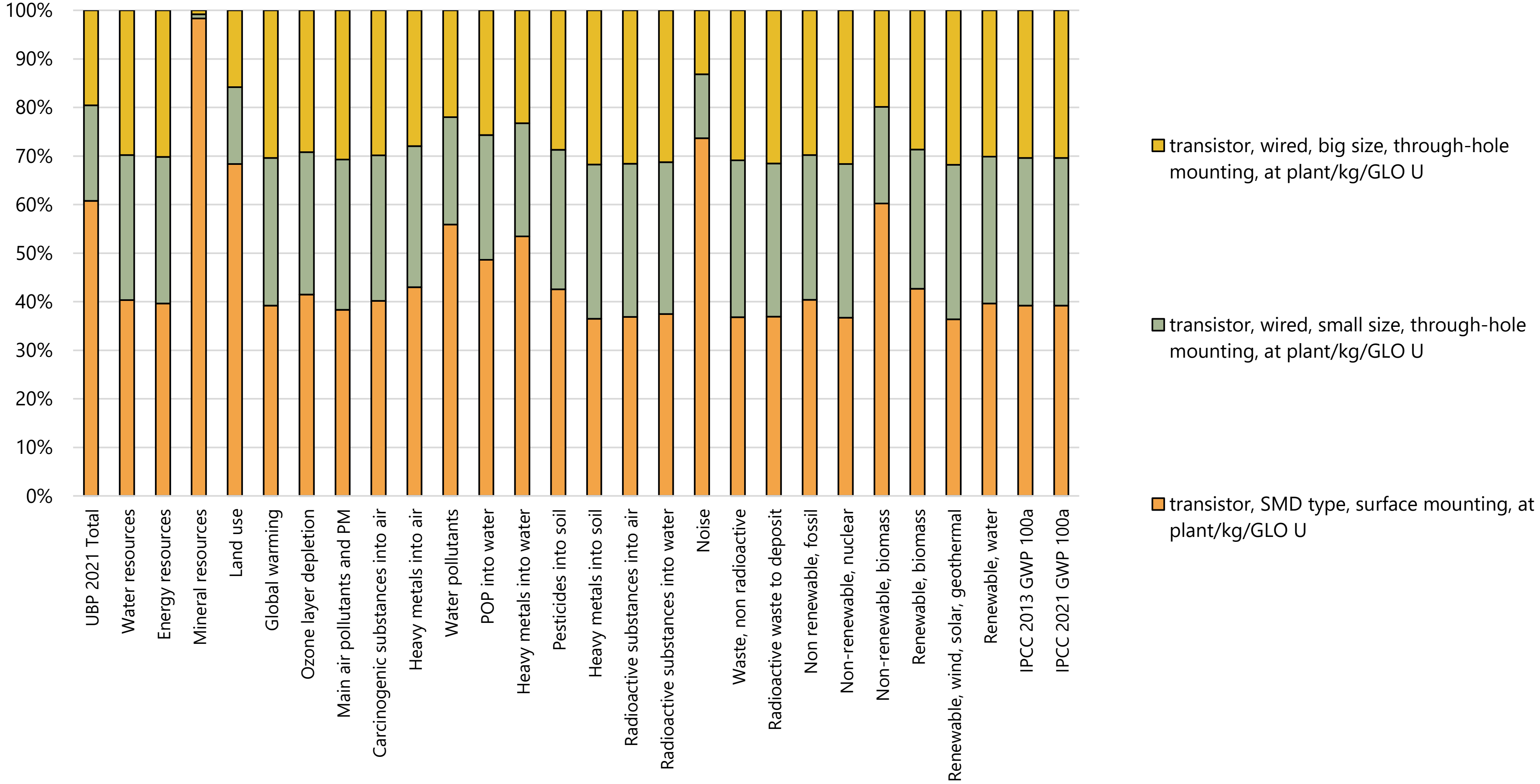

Figure 8.4-24. Contribution analysis presented in bar chart for: transistor, unspecified. FU = 1 kg transistor, unspecified

Table 8.4-48. Contribution analysis presented in table for: transistor, unspecified. FU = 1 kg transistor, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Transistor, SMD type, surface mounting, at plant/kg/GLO U	61%	40%	39%	39%
Transistor, wired, small size, through-hole mounting, at plant/kg/GLO U	20%	30%	30%	30%
Transistor, wired, big size, through-hole mounting, at plant/kg/GLO U	20%	30%	30%	30%
Total impact, in absolute value	**4.55E+05**	**1.73E+03**	**1.59E+02**	**1.58E+02**

8.4.25 Inductor, low value multilayer chip type, LMCI

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

There are three inductor types in the UVEK database: low-cost multilayer chip, miniature RF, and ring core choke. The composition of the inductors today is the same as that of the past decades, according to the latest information from a typical inductor manufacturer (Sunlord Inc., 2014). However, the manufacturing efforts for the inductors have been updated and are described in a separate unit process. The market share for the three types of inductors is divided equally due to the lack of statistical data.

The resulting unit process for "Inductor, low value multilayer chip type, LMCI" is shown in Table 8.4-49, whereas the life cycle impact assessment results are presented in Figure 8.4-25 and Table 8.4-50.

Table 8.4-49. Life cycle inventory for Inductor, low value multilayer chip type, LMCI and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Inductor, low value multilayer chip type, LMCI, at plant/GLO U	1	kg				
Input						
aluminium oxide, at plant/kg/RER U	0.41277	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Copper oxide, at plant/RER U	0.002072	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Funnel glass, CRT screen, at plant/GLO U	0.031228	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Glass tube, borosilicate, at plant/DE U	0.50453	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Nickel, 99.5%, at plant/GLO U	0.024568	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Production efforts, inductors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,3,4,5); rough estimation
Silver, at regional storage/RER U	0.44726	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Tin, at regional storage/RER U	0.057572	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information

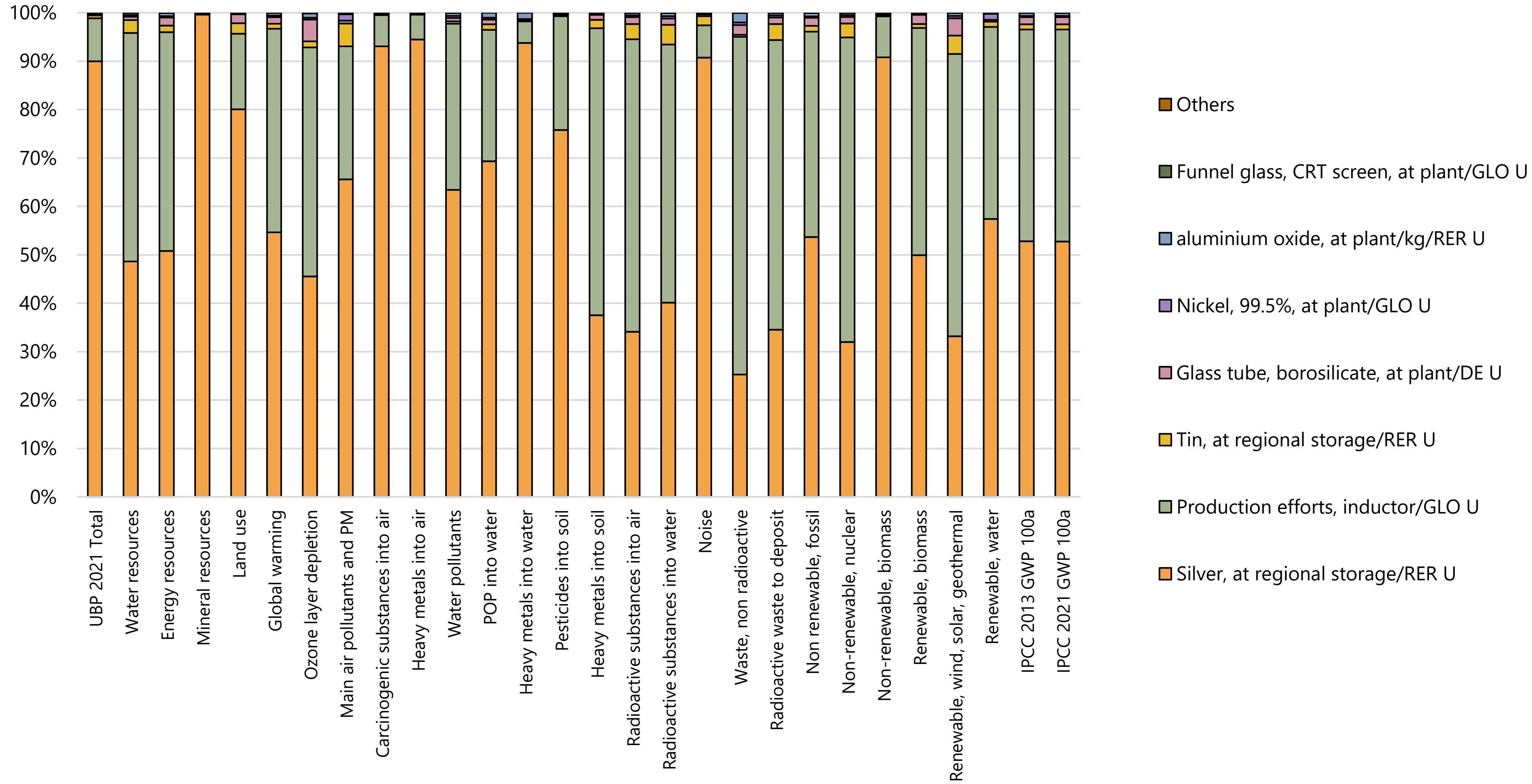

Figure 8.4-25. Contribution analysis presented in bar chart for: Inductor, low value multilayer chip type, LMCI. FU = 1 kg Inductor, low value multilayer chip type, LMCI

Table 8.4-50. Contribution analysis presented in table for: Inductor, low value multilayer chip type, LMCI. FU = 1 kg Inductor, low value multilayer chip type, LMCI

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Silver, at regional storage/RER U	90%	54%	53%	53%
Production efforts, inductors/kg/GLO U	9%	42%	44%	44%
Tin, at regional storage/RER U	1%	1%	1%	1%
Glass tube, borosilicate, at plant/DE U	0%	2%	1%	1%
Nickel, 99.5%, at plant/GLO U	0%	0%	0%	0%
aluminium oxide, at plant/kg/RER U	0%	1%	1%	1%
Funnel glass, CRT screen, at plant/GLO U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**7.69E+05**	**1.00E+03**	**8.78E+01**	**8.73E+01**

8.4.26 Inductor, miniature RF chip type, MRFI

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

There are three inductor types in the UVEK database: low-cost multilayer chip, miniature RF, and ring core choke. The composition of the inductors today is the same as that of the past decades, according to the latest information from a typical inductor manufacturer (Sunlord Inc., 2014). However, the manufacturing efforts for the inductors have been updated and are described in a separate unit process. The market share for the three types of inductors is divided equally due to the lack of statistical data.

The resulting unit process for "Inductor, miniature RF chip type, MRFI" is shown in Table 8.4-51, whereas the life cycle impact assessment results are presented in Figure 8.4-26 and Table 8.4-52.

Table 8.4-51. Life cycle inventory for Inductor, miniature RF chip type, MRFI and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Inductor, miniature RF chip type, MRFI, at plant/kg/GLO U	1	kg				
Input						
aluminium oxide, at plant/kg/RER U	0.99574	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Copper, primary, at refinery/GLO U	0.16102	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Epoxy resin, liquid, at plant/RER U	0.18737	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Gold, primary, at refinery/GLO U	0.001184	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Nickel, 99.5%, at plant/GLO U	0.032856	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Production efforts, inductors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,3,4,5); rough estimation
Quicklime, milled, packed, at plant/CH U	0.022644	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information
Silica sand, at plant/DE U	0.07918	kg		Lognormal	1.33	(1,4,4,4,2,5); average from company information

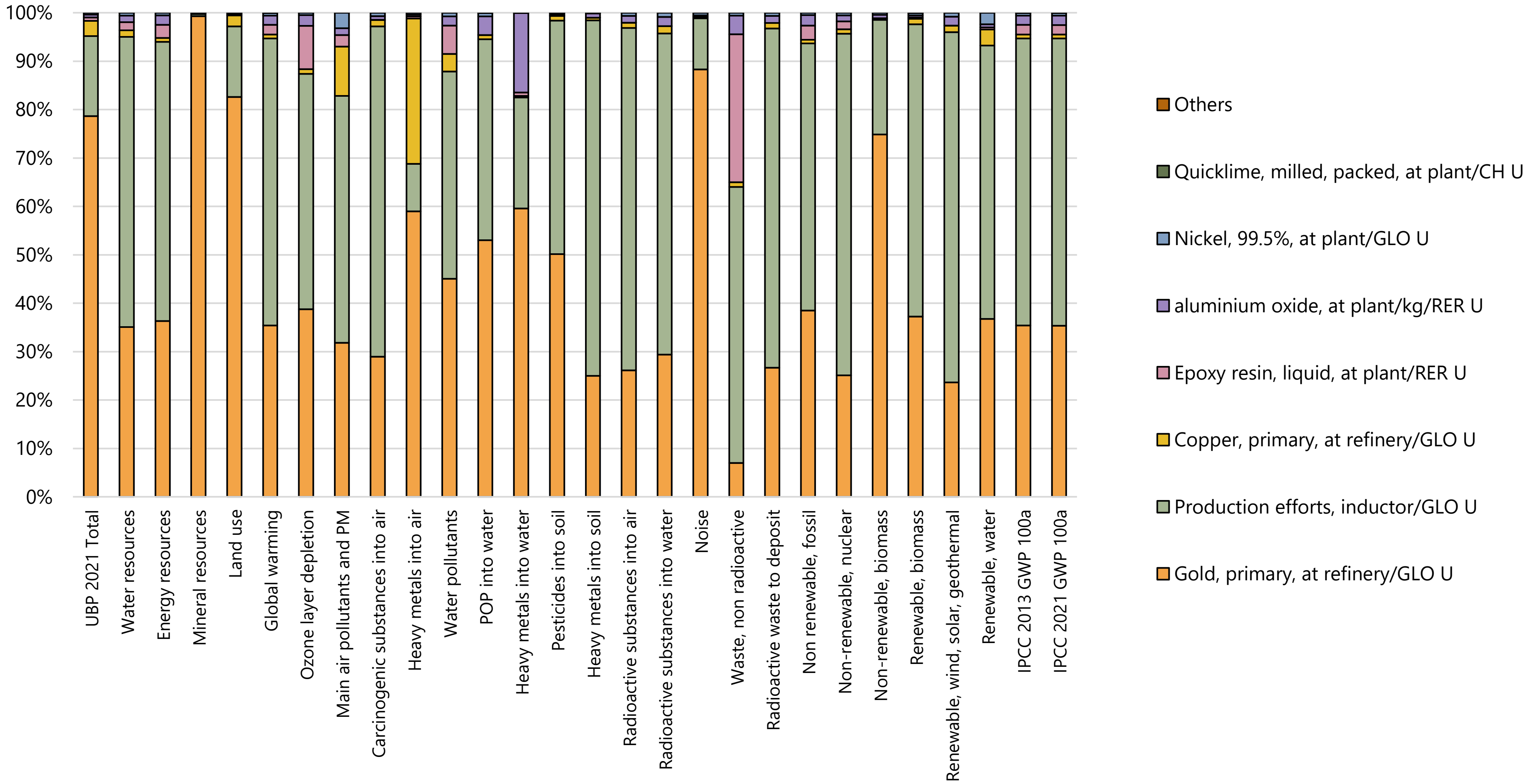

Figure 8.4-26. Contribution analysis presented in bar chart for: Inductor, miniature RF chip type, MRFI. FU = 1 kg Inductor, miniature RF chip type, MRFI

Table 8.4-52. Contribution analysis presented in table for: Inductor, miniature RF chip type, MRFI. FU = 1 kg Inductor, miniature RF chip type, MRFI

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, primary, at refinery/GLO U	79%	38%	35%	35%
Production efforts, inductors/kg/GLO U	17%	55%	59%	59%
Copper, primary, at refinery/GLO U	3%	1%	1%	1%
Epoxy resin, liquid, at plant/RER U	1%	3%	2%	2%
aluminium oxide, at plant/kg/RER U	1%	2%	2%	2%
Nickel, 99.5%, at plant/GLO U	0%	0%	1%	1%
Quicklime, milled, packed, at plant/CH U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.13E+05**	**7.72E+02**	**6.47E+01**	**6.44E+01**

8.4.27 Inductor, ring core choke type

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

There are three inductor types in the UVEK database: low-cost multilayer chip, miniature RF, and ring core choke. The composition of the inductors today is the same as that of the past decades, according to the latest information from a typical inductor manufacturer (Sunlord Inc., 2014). However, the manufacturing efforts for the inductors have been updated and are described in a separate unit process. The market share for the three types of inductors is divided equally due to the lack of statistical data.

The resulting unit process for "Inductor, ring core choke type" is shown in Table 8.4-53, whereas the life cycle impact assessment results are presented in Figure 8.4-27 and Table 8.4-54.

Table 8.4-53. Life cycle inventory for Inductor, ring core choke type and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Inductor, ring core choke type, at plant/kg/GLO U	1	kg				
Input						
Copper, primary, at refinery/GLO U	0.093092	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Epoxy resin, liquid, at plant/RER U	0.025012	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Funnel glass, CRT screen, at plant/GLO U	0.39856	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Lead, primary, at plant/GLO U	0.03774	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Pig iron, at plant/GLO U	0.010212	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Polycarbonate, at plant/RER U	0.8584	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Production efforts, inductors/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,3,4,5); rough estimation
Tin, at regional storage/RER U	0.03774	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information
Zircon, 50% zirconium, at plant/AU U	0.019092	kg		Lognormal	1.33	(1,4,4,4,2,5); average from literature & company information

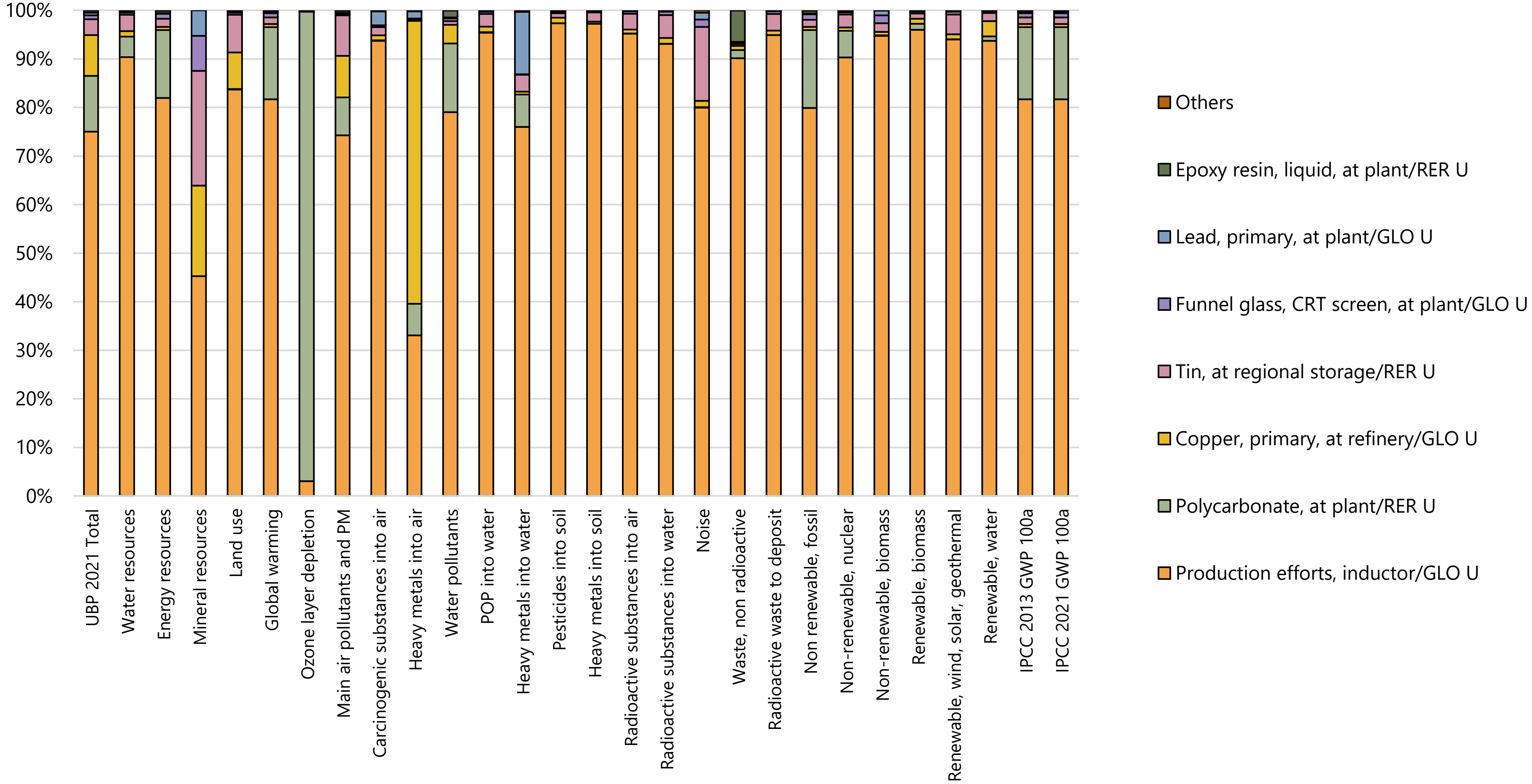

Figure 8.4-27. Contribution analysis presented in bar chart for: Inductor, ring core choke type. FU = 1 kg Inductor, ring core choke type

Table 8.4-54. Contribution analysis presented in table for: Inductor, ring core choke type. FU = 1 kg Inductor, ring core choke type

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Production efforts, inductors/kg/GLO U	75%	80%	82%	82%
Polycarbonate, at plant/RER U	12%	16%	15%	15%
Copper, primary, at refinery/GLO U	8%	1%	1%	1%
Tin, at regional storage/RER U	3%	1%	1%	1%
Funnel glass, CRT screen, at plant/GLO U	1%	1%	1%	1%
Lead, primary, at plant/GLO U	1%	0%	0%	0%
Epoxy resin, liquid, at plant/RER U	0%	1%	0%	0%
Total impact, in absolute value	**9.17E+04**	**5.33E+02**	**4.70E+01**	**4.68E+01**

8.4.28 Inductor, unspecified

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

There are three inductor types in the UVEK database: low-cost multilayer chip, miniature RF, and ring core choke. The composition of the inductors today is the same as that of the past decades, according to the latest information from a typical inductor manufacturer (Sunlord Inc., 2014). However, the manufacturing efforts for the inductors have been updated and are described in a separate unit process. The market share for the three types of inductors is divided equally due to the lack of statistical data.

The resulting unit process for "Inductor, ring core choke type" is shown in Table 8.4-55, whereas the life cycle impact assessment results are presented in Figure 8.4-28 and Table 8.4-56.

Table 8.4-55. Life cycle inventory for Inductor, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Inductor, unspecified, at plant/kg/GLO U	1	kg				
Input						
Inductor, low value multilayer chip type, LMCI, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,2,4,5); assumption, based on specific data
Inductor, miniature RF chip type, MRFI, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,2,4,5); assumption, based on specific data
Inductor, ring core choke type, at plant/kg/GLO U	0.33333	kg		Lognormal	1.89	(5,4,4,2,4,5); assumption, based on specific data

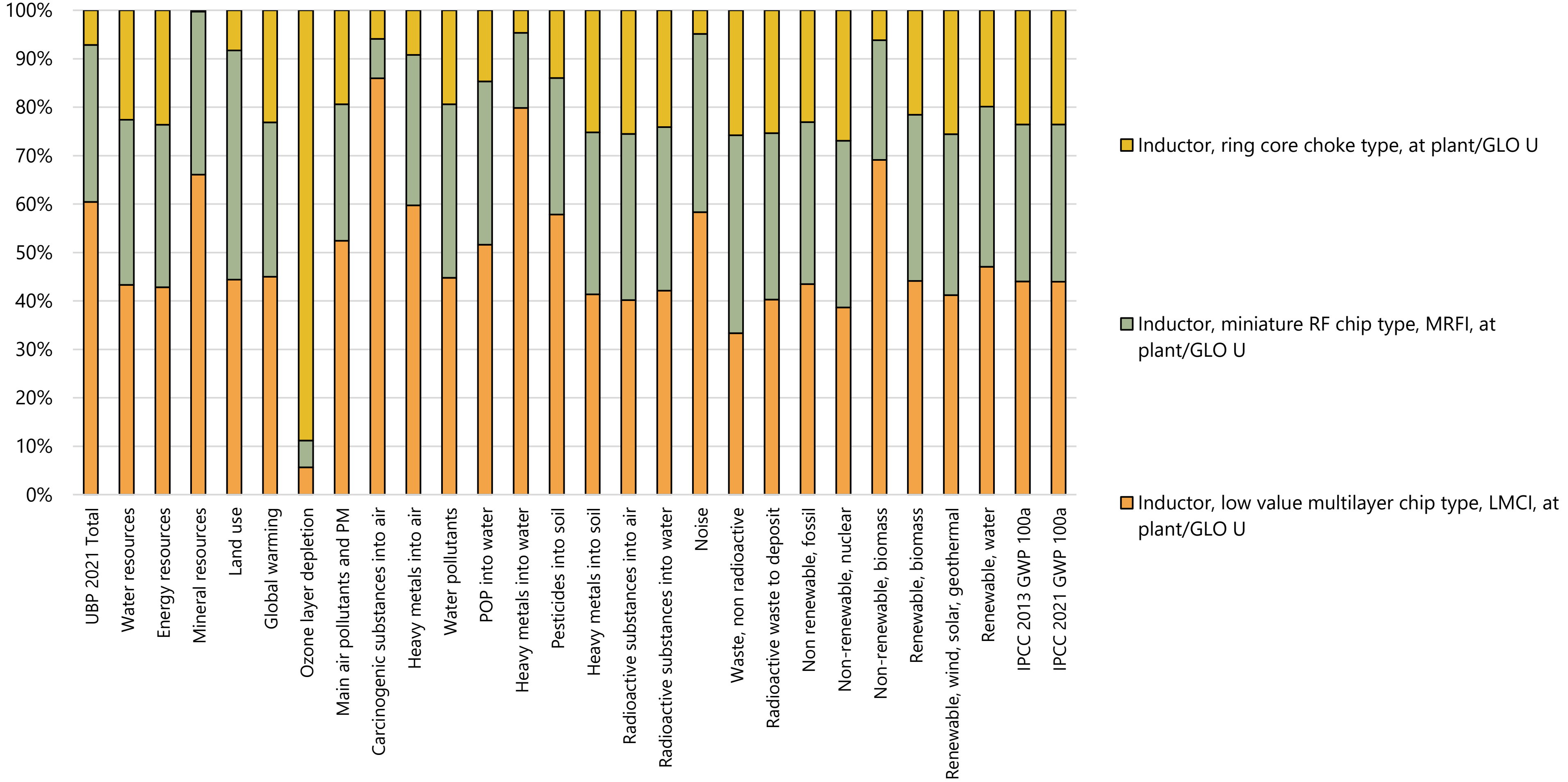

Figure 8.4-28. Contribution analysis presented in bar chart for: Inductor, unspecified. FU = 1 kg Inductor, unspecified

Table 8.4-56. Contribution analysis presented in table for: Inductor, unspecified. FU = 1 kg Inductor, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Inductor, low value multilayer chip type, LMCI, at plant/kg/GLO U	60%	43%	44%	44%
Inductor, miniature RF chip type, MRFI, at plant/kg/GLO U	32%	33%	32%	32%
Inductor, ring core choke type, at plant/kg/GLO U	7%	23%	24%	24%
Total impact, in absolute value	**4.24E+05**	**7.70E+02**	**6.65E+01**	**6.62E+01**

8.4.29 Electronic component, active, unspecified

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

There are three ICT data sets that are modified in this category: active electronic components, passive electronic components and unspecified electronic components. Due to the lack of more recent data, the composition of the materials in each of these datasets remains the same as that modeled in the UVEK database. In general, these values have been calculated by an average of the small electronic components from TVs, desktops and laptops. However, the life cycle inventories for the other ICT components have been updated and are described in the process descriptions for the other unit processes.

The resulting unit process for "Electronic component, active, unspecified" is shown in Table 8.4-57, whereas the life cycle impact assessment results are presented in Figure 8.4-29 and Table 8.4-58.

Table 8.4-57. Life cycle inventory for Electronic component, active, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Electronic component, active, unspecified, at plant/GLO U	1	kg				
Input						
Diode, unspecified, at plant/kg/GLO U	0.0196	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.55	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.309	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Light emitting diode, LED, at plant/kg/GLO U	0.00375	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Transistor, unspecified, at plant/kg/GLO U	0.117	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards

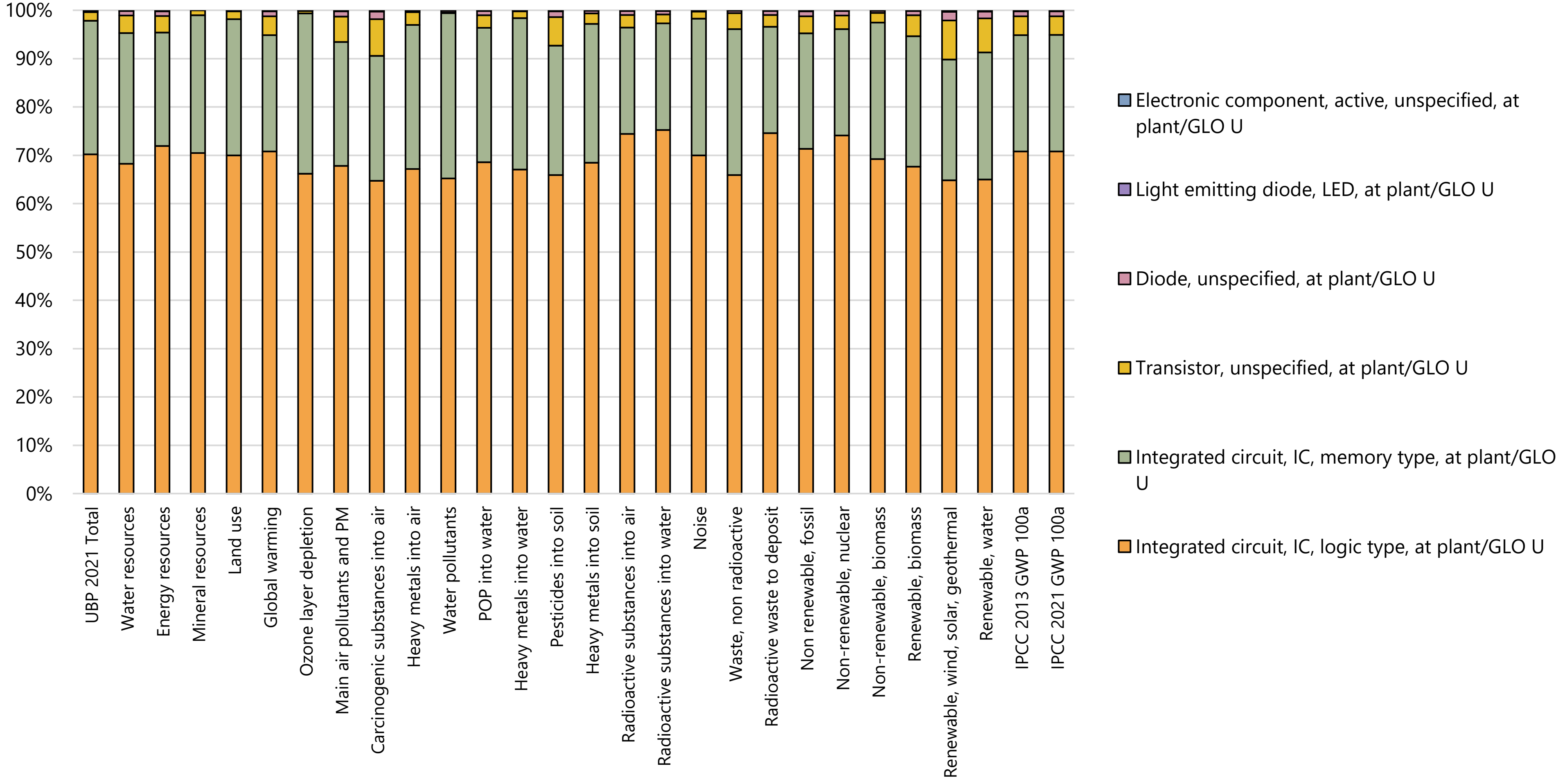

Figure 8.4-29. Contribution analysis presented in bar chart for: Electronic component, active, unspecified. FU = 1 kg Electronic component, active, unspecified

Table 8.4-58. Contribution analysis presented in table for: Electronic component, active, unspecified. FU = 1 kg Electronic component, active, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/kg/GLO U	70%	71%	71%	71%
Integrated circuit, IC, memory type, at plant/kg/GLO U	28%	24%	24%	24%
Transistor, unspecified, at plant/kg/GLO U	2%	4%	4%	4%
Diode, unspecified, at plant/kg/GLO U	0%	1%	1%	1%
Light emitting diode, LED, at plant/kg/GLO U	0%	0%	0%	0%
Electronic component, active, unspecified, at plant/kg/GLO U	0%	0%	0%	0%
Total impact, in absolute value	**2.92E+06**	**5.63E+03**	**4.69E+02**	**4.71E+02**

8.4.30 Electronic component, passive, unspecified

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

There are three ICT data sets that are modified in this category: active electronic components, passive electronic components and unspecified electronic components. Due to the lack of more recent data, the composition of the materials in each of these datasets remains the same as that modeled in the UVEK database. In general, these values have been calculated by an average of the small electronic components from TVs, desktops and laptops. However, the life cycle inventories for the other ICT components have been updated and are described in the process descriptions for the other unit processes.

The resulting unit process for "Electronic component, passive, unspecified" is shown in Table 8.4-59, whereas the life cycle impact assessment results are presented in Figure 8.4-30 and Table 8.4-60.

Table 8.4-59. Life cycle inventory for Electronic component, passive, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Electronic component, passive, unspecified, at plant/kg/GLO U	1	kg				
Input						
Capacitor, electrolyte type, < 2cm height, at plant/kg/GLO U	0.139	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	0.0438	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	0.0348	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Capacitor, unspecified, at plant/kg/GLO U	0.105	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Connector, computer, peripherical type, at plant/kg/GLO U	0.103	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Connector, PCI bus, at plant/kg/GLO U	0.182	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Inductor, ring core choke type, at plant/kg/GLO U	0.336	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Resistor, unspecified, at plant/kg/GLO U	0.0567	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards

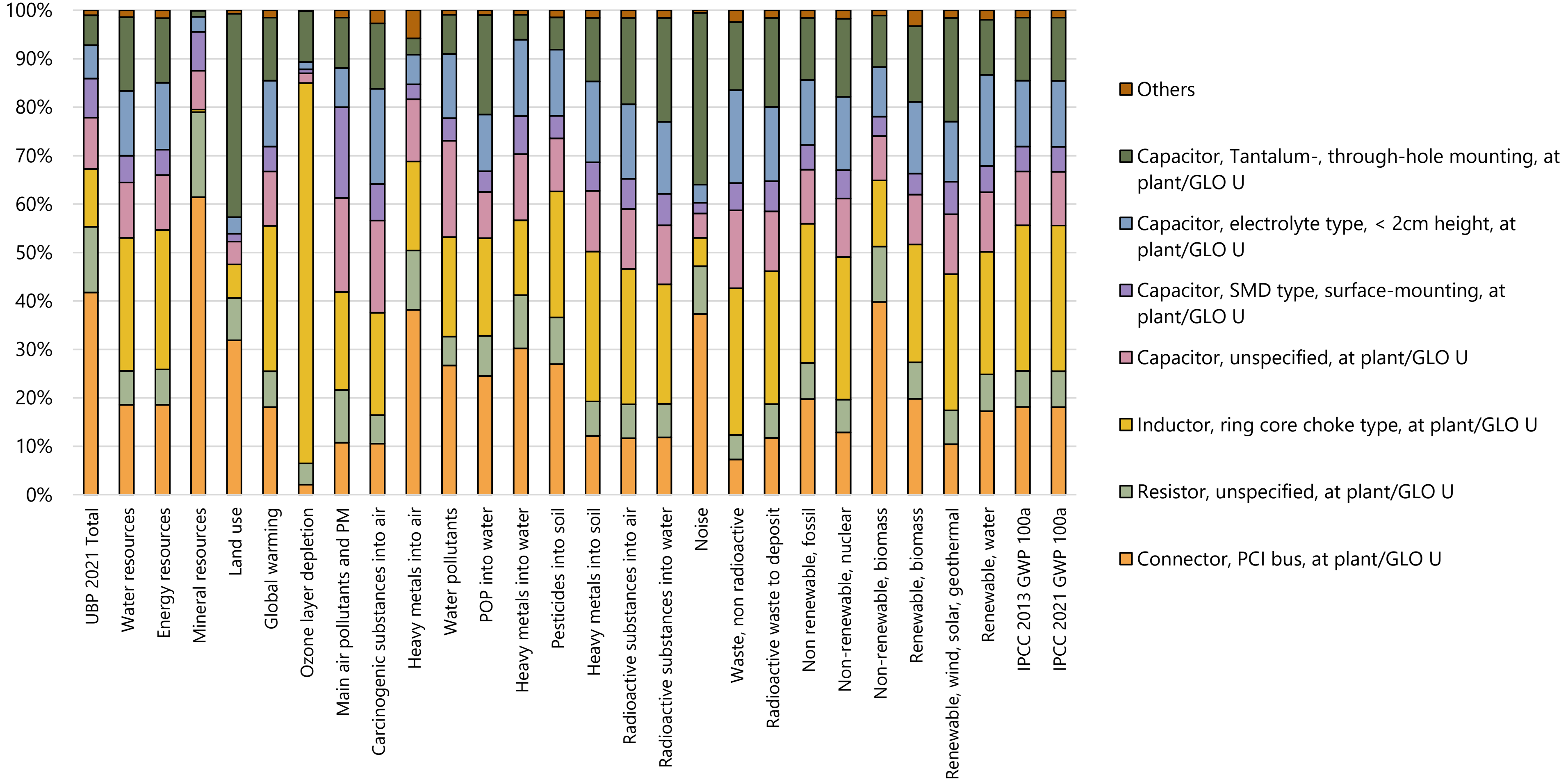

Figure 8.4-30. Contribution analysis presented in bar chart for: Electronic component, passive, unspecified. FU = 1 kg Electronic component, passive, unspecified

Table 8.4-60. Contribution analysis presented in table for: Electronic component, passive, unspecified. FU = 1 kg Electronic component, passive, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Connector, PCI bus, at plant/kg/GLO U	42%	20%	18%	18%
Resistor, unspecified, at plant/kg/GLO U	14%	7%	7%	7%
Inductor, ring core choke type, at plant/kg/GLO U	12%	29%	30%	30%
Capacitor, unspecified, at plant/kg/GLO U	11%	11%	11%	11%
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	8%	5%	5%	5%
Capacitor, electrolyte type, < 2cm height, at plant/kg/GLO U	7%	13%	14%	14%
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	6%	13%	13%	13%
Others	1%	2%	2%	2%
Total impact, in absolute value	**2.55E+05**	**6.23E+02**	**5.25E+01**	**5.24E+01**

8.4.31 Electronic component, unspecified

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

There are three ICT data sets that are modified in this category: active electronic components, passive electronic components and unspecified electronic components. Due to the lack of more recent data, the composition of the materials in each of these datasets remains the same as that modeled in the UVEK database. In general, these values have been calculated by an average of the small electronic components from TVs, desktops and laptops. However, the life cycle inventories for the other ICT components have been updated and are described in the process descriptions for the other unit processes.

The resulting unit process for "Electronic component, unspecified" is shown in Table 8.4-61, whereas the life cycle impact assessment results are presented in Figure 8.4-31 and Table 8.4-62.

Table 8.4-61. Life cycle inventory for Electronic component, unspecified and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Electronic component, unspecified, at plant/kg/GLO U	1	kg				
Input						
Electronic component, active, unspecified, at plant/kg/GLO U	0.33	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards
Electronic component, passive, unspecified, at plant/kg/GLO U	0.67	kg		Lognormal	2.33	(5,3,4,1,5,5); calculated from Desktop PC, Laptop and TV mainboards

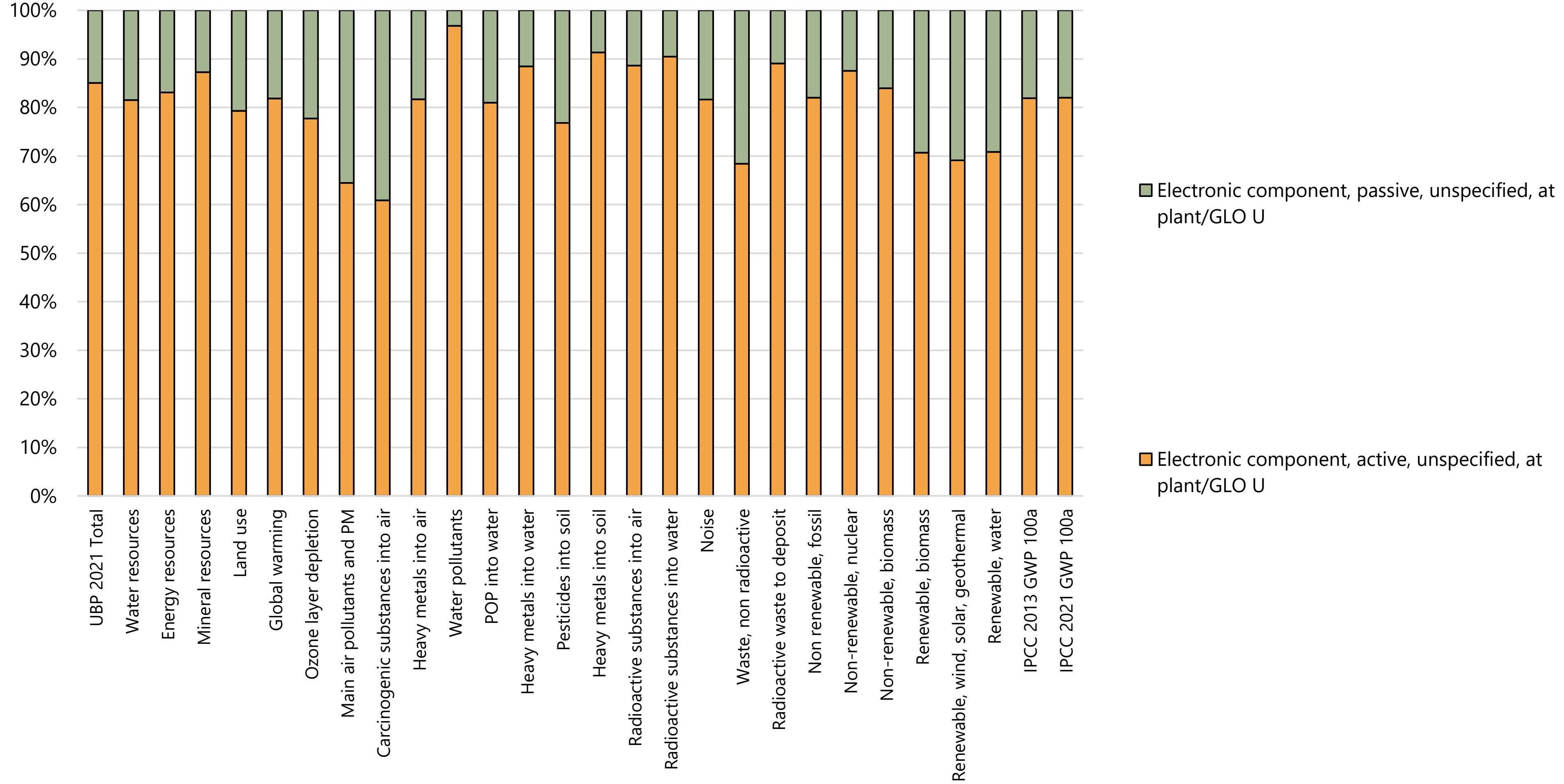

Figure 8.4-31. Contribution analysis presented in bar chart for: Electronic component, unspecified. FU = 1 kg Electronic component, unspecified

Table 8.4-62. Contribution analysis presented in table for: Electronic component, unspecified. FU = 1 kg Electronic component, unspecified

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Electronic component, active, unspecified, at plant/kg/GLO U	85%	82%	82%	82%
Electronic component, passive, unspecified, at plant/kg/GLO U	15%	18%	18%	18%
Total impact, in absolute value	**1.13E+06**	**2.28E+03**	**1.90E+02**	**1.90E+02**

8.4.32 Electronics for control units

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

No major updates are required for this dataset. However, new background datasets are updated individually in separate modules..

The resulting unit process for "Electronics for control units" is shown in Table 8.4-63, whereas the life cycle impact assessment results are presented in

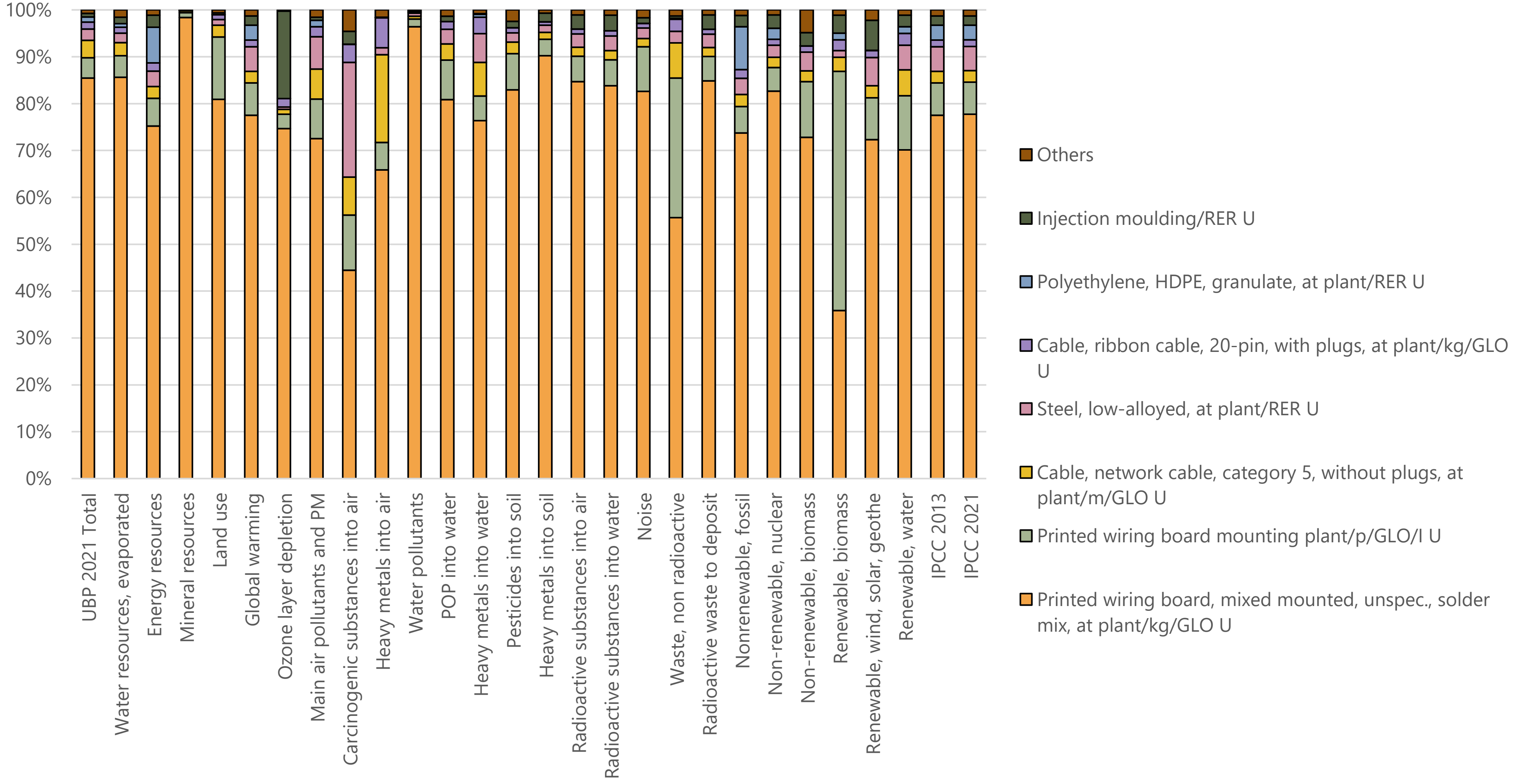

Figure 8.4-32 and Table 8.4-64.

Table 8.4-63. Life cycle inventory for Electronics for control units and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Electronics for control units/kg/RER U	1	kg				
Input						
Steel, low-alloyed, at plant/RER U	0.46	kg		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Sheet rolling, steel/RER U	0.46	kg		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Polyethylene, HDPE, granulate, at plant/RER U	0.32193	kg		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Injection moulding/RER U	0.32	kg		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.032	kg		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Cable, connector for computer, without plugs, at plant/m/GLO U	0.123	m		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Cable, network cable, category 5, without plugs, at plant/m/GLO U	1.11	m		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.14	kg		Lognormal	1.47	(3,5,4,4,3,5); approximation from 1 literature source
transport, freight, lorry, fleet average/tkm/RER U	0.10019	tkm		Lognormal	2.38	(4,4,4,2,4,5); standard distances
transport, freight, rail/tkm/RER U	0.20039	tkm		Lognormal	2.38	(4,4,4,2,4,5); standard distances
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.85	(4,5,4,3,5,5); rough assumption

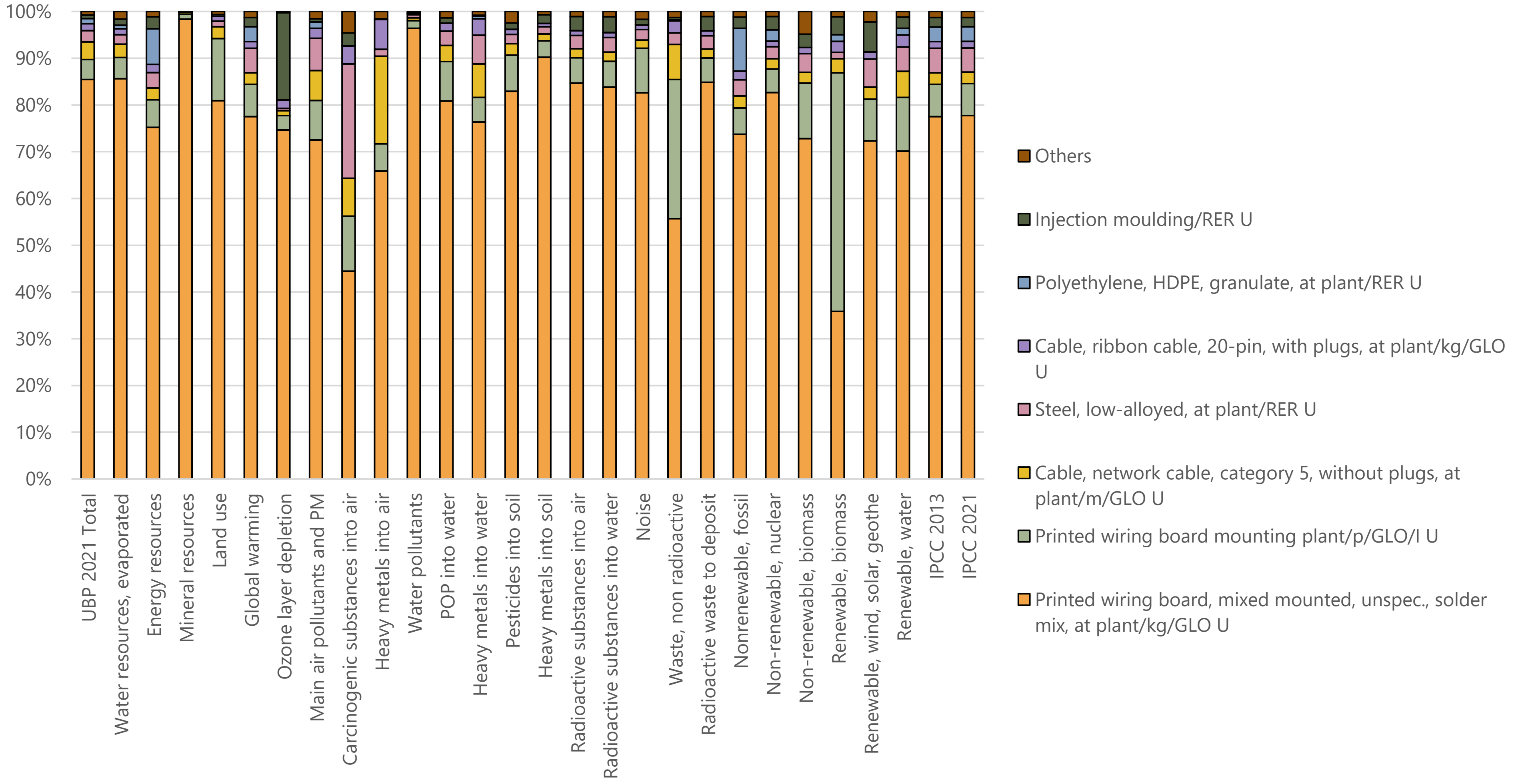

Figure 8.4-32. Contribution analysis presented in bar chart for: Electronics for control units. FU = 1 kg

Table 8.4-64. Contribution analysis presented in table for: Electronics for control units. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	85%	74%	78%	78%
Printed wiring board mounting plant/p/GLO/I U	4%	6%	7%	7%
Cable, network cable, category 5, without plugs, at plant/m/GLO U	4%	3%	2%	2%
Steel, low-alloyed, at plant/RER U	2%	3%	5%	5%
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	1%	2%	1%	1%
Polyethylene, HDPE, granulate, at plant/RER U	1%	9%	3%	3%
Injection moulding/RER U	1%	2%	2%	2%
Others	1%	1%	1%	1%
Total impact, in absolute value	**8.70E+04**	**2.50E+02**	**2.03E+01**	**2.03E+01**

8.4.33 Electronic component machinery, unspecified

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

No major updates are required for this dataset. However, new background datasets such as cables and printed wiring boards are updated individually in separate modules.

The resulting unit process for "Electronic component machinery, unspecified" is shown in Table 8.4-65, whereas the life cycle impact assessment results are presented in Figure 8.4-33 and Table 8.4-66.

Table 8.4-65. Life cycle inventory for Electronic component machinery and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Electronic component machinery, unspecified/p/GLO/I U	1	p				
Input						
Cable, network cable, category 5, without plugs, at plant/m/GLO U	555.56	m		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Chromium steel 18/8, at plant/RER U	440	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Injection moulding/RER U	200	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Polyethylene, HDPE, granulate, at plant/RER U	200	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	80	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Road vehicle plant/RER/I U	9.0909E-07	p		Lognormal	3.18	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Section bar rolling, steel/RER U	1760	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Sheet rolling, chromium steel/RER U	440	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
Steel, low-alloyed, at plant/RER U	1760	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on qualitative information from such kind of machines
transport, freight, rail/tkm/RER U	500	tkm		Lognormal	2.23	(4,5,4,1,3,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	250	tkm		Lognormal	2.23	(4,5,4,1,3,5); standard distances

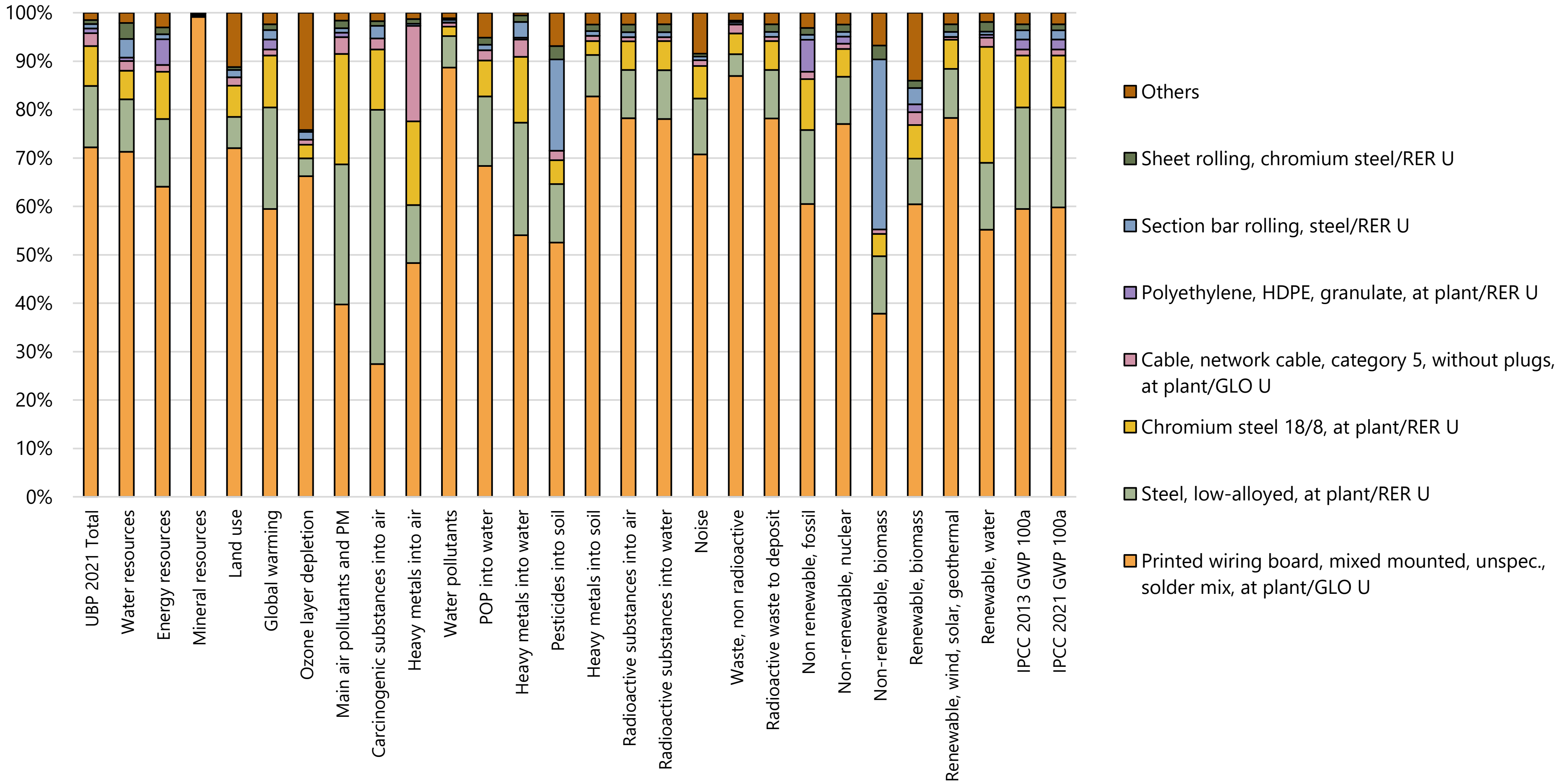

Figure 8.4-33. Contribution analysis presented in bar chart for: Electronic component machinery, unspecified. FU = 1 unit

Table 8.4-66. Contribution analysis presented in table for: Electronic component machinery, unspecified. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kgGLO U	72%	60%	59%	60%
Steel, low-alloyed, at plant/RER U	13%	15%	21%	21%
Chromium steel 18/8, at plant/RER U	8%	11%	11%	11%
Cable, network cable, category 5, without plugs, at plant/m/GLO U	3%	2%	1%	1%
Polyethylene, HDPE, granulate, at plant/RER U	1%	7%	2%	2%
Section bar rolling, steel/RER U	1%	1%	2%	2%
Sheet rolling, chromium steel/RER U	1%	1%	1%	1%
Others	2%	3%	2%	2%
Total impact, in absolute value	**5.97E+07**	**1.90E+05**	**1.70E+04**	**1.69E+04**

8.4.34 Electronic component production plant

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

No major updates are required for this dataset. However, new background datasets such as cables and electronic component machinery are updated individually in separate modules.

The resulting unit process for "Electronic component production plant" is shown in Table 8.4-67, whereas the life cycle impact assessment results are presented in Figure 8.4-34 and Table 8.4-68Table 8.4-66.

Table 8.4-67. Life cycle inventory for Electronic component production plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Electronic component production plant/p/GLO/I U	1	p				
Input						
Occupation, construction site	1092600	m2a	land	Lognormal	2.1	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Occupation, industrial area, built up	8194500	m2a	land	Lognormal	2.1	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Occupation, industrial area, vegetation	910500	m2a	land	Lognormal	2.1	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Transformation, from unknown	364200	m2	land	Lognormal	1.63	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Transformation, to industrial area, built up	327780	m2	land	Lognormal	1.63	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Transformation, to industrial area, vegetation	36420	m2	land	Lognormal	1.63	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Brick, at plant/RER U	680000	kg		Lognormal	1.31	(1,3,4,3,2,5); data from AMD Saxony site in Dresden
Building, hall/CH/I U	85587	m2		Lognormal	3.1	(1,3,4,3,2,5);
Building, multi-storey/RER/I U	327780	m3		Lognormal	3.1	(1,3,4,3,2,5);
Cable, data cable in infrastructure, at plant/m/GLO U	8750000	m		Lognormal	1.31	(1,3,4,3,2,5);
Cable, three-conductor cable, at plant/m/GLO U	1500000	m		Lognormal	1.31	(1,3,4,3,2,5);
Chromium steel 18/8, at plant/RER U	4428000	kg		Lognormal	1.31	(1,3,4,3,2,5);
Concrete, exacting, at plant/CH U	202800	m3		Lognormal	1.31	(1,3,4,3,2,5);
Concrete, sole plate and foundation, at plant/CH U	163000	m3		Lognormal	1.31	(1,3,4,3,2,5);
Drawing of pipes, steel/RER U	8364000	kg		Lognormal	1.31	(1,3,4,3,2,5);
Electronic component machinery, unspecified/p/GLO/I U	500	p		Lognormal	1.4	(4,4,4,3,1,5); estmation, based on literature information
reinforcing steel, at plant/kg/RER U	26000000	kg		Lognormal	1.31	(1,3,4,3,2,5);
Roads, company, internal/CH/I U	2048600	m2a		Lognormal	3.10	(1,3,4,3,2,5);
Steel, low-alloyed, at plant/RER U	3936000	kg		Lognormal	1.31	(1,3,4,3,2,5);
Wastewater treatment plant, class 5/CH/I U	1	p		Lognormal	3.14	(4,3,4,3,2,5); rough estimation
Output						
Waste to treatment						
Disposal, industrial devices, to WEEE treatment/CH U	1250000	kg		Lognormal	2.56	(5,5,5,5,5,5);
Disposal, treatment of cables/GLO U	1968800	kg		Lognormal	2.56	(5,5,5,5,5,5);

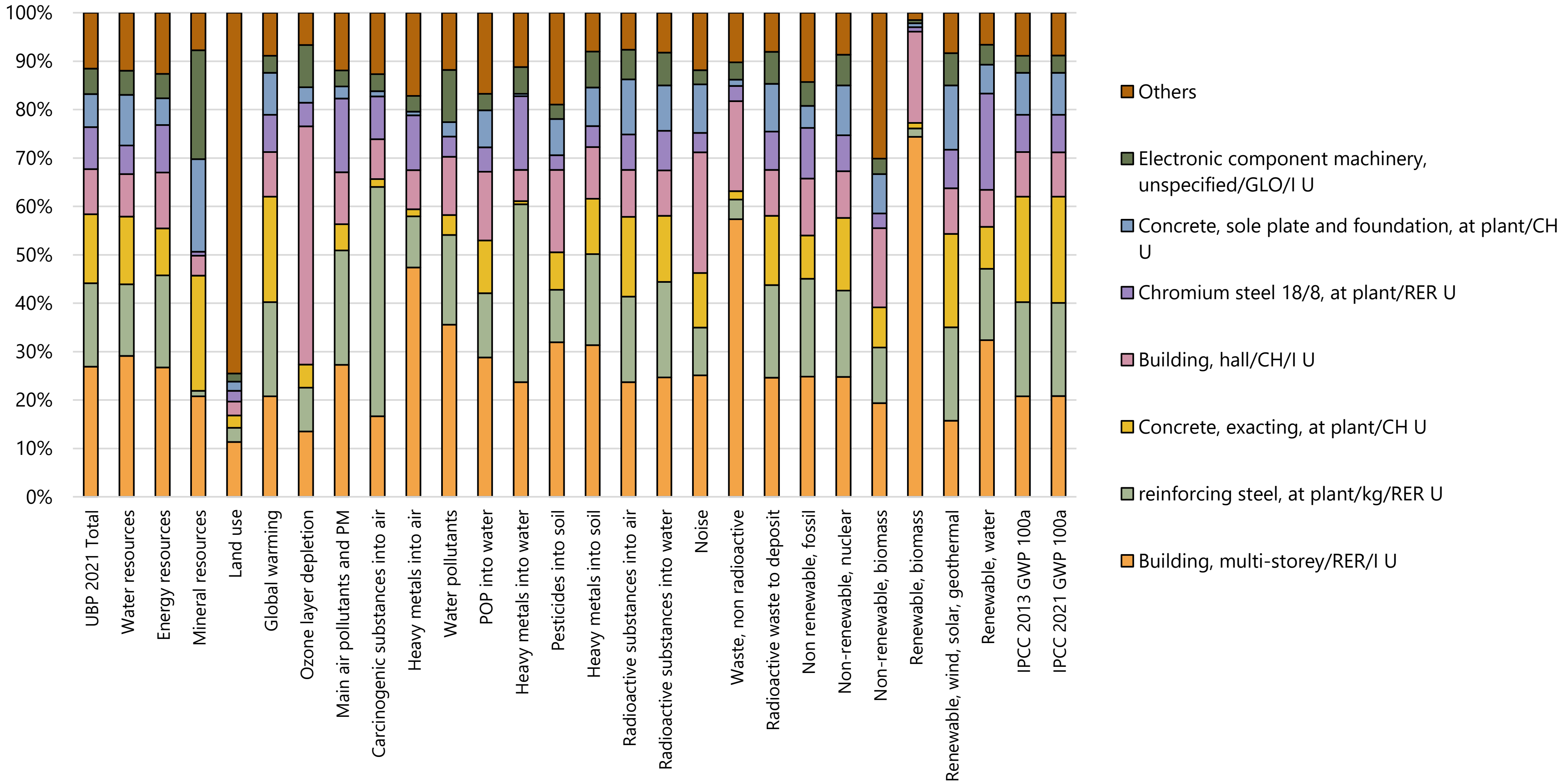

Figure 8.4-34. Contribution analysis presented in bar chart for: Electronic component production plant. FU = 1 unit

Table 8.4-68. Contribution analysis presented in table for: Electronic component production plant. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Building, multi-storey/RER/I U	27%	25%	21%	21%
reinforcing steel, at plant/kg/RER U	17%	20%	19%	19%
Concrete, exacting, at plant/CH U	14%	9%	22%	22%
Building, hall/CH/I U	9%	12%	9%	9%
Chromium steel 18/8, at plant/RER U	9%	10%	8%	8%
Concrete, sole plate and foundation, at plant/CH U	7%	5%	9%	9%
Electronic component machinery, unspecified/p/GLO/I U	5%	5%	4%	4%
Others	12%	14%	9%	9%
Total impact, in absolute value	**6.47E+11**	**2.19E+09**	**2.77E+08**	**2.75E+08**

8.5 Accessories

8.5.1 Connector, computer, peripheral type

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The connector dataset is updated using the secondary inventory data and material compositions from the study of consumer electronics that are found in the literature (Corcoran et al., 2014). For this purpose, USB type A is specifically modeled. In accordance with recent industry standards (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012), the electricity consumption for production is assumed to be reduced by 20% compared to the original dataset. The other input flows remain the same as in the original UVEK database, e.g. distance data for material transport.

The resulting unit process for "Connector, computer, peripheral type" is shown in

Table 8.5-1, whereas the life cycle impact assessment results are presented in Figure 8.5-1 and Table 8.5-2.

Table 8.5-1. Life cycle inventory for Connector, computer, peripherical type,and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Connector, computer, peripherical type, at plant/kg/GLO U	1	kg				
Input						
Copper, primary, at refinery/GLO U	0.075	kg		Lognormal	1.45	(4,5,4,3,1,5); estimation, calculated weight, based on qualitative information
electricity, medium voltage, production GLO, at grid/kWh/GLO U	5.208	kWh		Lognormal	1.65	(3,4,4,3,4,5); literature value as first approximation used
Polyethylene, HDPE, granulate, at plant/RER U	0.183	kg		Lognormal	1.45	(4,5,4,3,1,5); estimation, calculated weight, based on qualitative information
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.18	(4,5,4,3,1,5); rough estimation of infrastructure
Steel, low-alloyed, at plant/RER U	0.302	kg		Lognormal	1.45	(4,5,4,3,1,5); estimation, calculated weight, based on qualitative information
transport, freight, rail/tkm/RER U	0.6006	tkm		Lognormal	2.19	(4,5,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.1001	tkm		Lognormal	2.19	(4,5,4,3,1,5); standard distances
Brass, at plant/CH U	0.29	kg		Lognormal	2.19	(4,5,4,3,1,5); standard distances
Polyvinylchloride, at regional storage/RER U	0.162	kg		Lognormal	2.19	(4,5,4,3,1,5); standard distances
Output						
Emissions to air						
Heat, waste	23.436	MJ	high. pop.	Lognormal	1.73	(4,5,4,3,1,5); calculated from electricity input

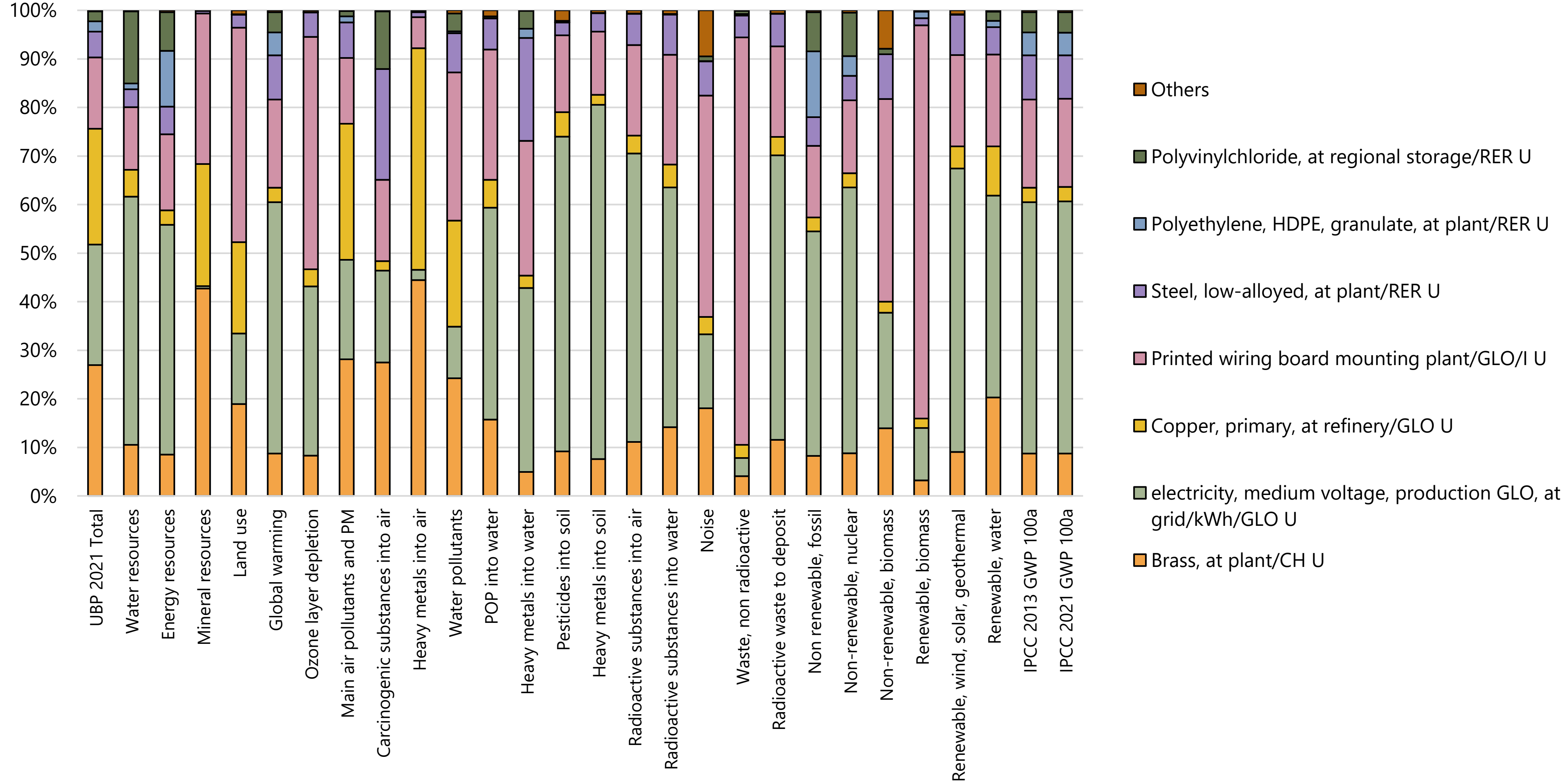

Figure 8.5-1. Contribution analysis presented in bar chart for: Connector, computer, peripherical type. FU = 1 kg Connector, computer, peripherical type

Table 8.5-2. Contribution analysis presented in table for: Connector, computer, peripherical type. FU = 1 kg Connector, computer, peripherical type

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Brass, at plant/CH U	27%	8%	9%	9%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	25%	46%	52%	52%
Copper, primary, at refinery/GLO U	24%	3%	3%	3%
Printed wiring board mounting plant/p/GLO/I U	15%	15%	18%	18%
Steel, low-alloyed, at plant/RER U	5%	6%	9%	9%
Polyethylene, HDPE, granulate, at plant/RER U	2%	14%	5%	5%
Polyvinylchloride, at regional storage/RER U	2%	8%	4%	4%
Others	0%	0%	0%	0%
Total impact, in absolute value	**2.57E+04**	**9.64E+01**	**7.82E+00**	**7.77E+00**

8.5.2 Connector, PCI Bus

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

No current data is found for PCI bus connectors. Only production effort data is updated in the new database, which is 20% less than the original dataset, assuming higher energy efficiency than decades ago (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012).

The resulting unit process for "Connector, PCI bus" is shown in Table 8.5-3, whereas the life cycle impact assessment results are presented in Figure 8.5-2 and Table 8.5-4Table 8.4-66.

Table 8.5-3. Life cycle inventory for Connector, PCI bus and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Connector, PCI bus, at plant/kg/GLO U	1	kg				
Input						
Brass, at plant/CH U	0.20295	kg		Lognormal	1.45	(4,5,4,3,1,5); estimation, calculated weight, based on qualitative information
electricity, medium voltage, production GLO, at grid/kWh/GLO U	5.208	kWh		Lognormal	1.66	(3,4,4,3,4,5); literature value as first approximation used
Gold, primary, at refinery/GLO U	0.00205	kg		Lognormal	1.45	(4,5,4,3,1,5); estimation, calculated weight, based on qualitative information
Nylon 66, at plant/RER U	0.795	kg		Lognormal	1.45	(4,5,4,3,1,5); estimation, calculated weight, based on qualitative information
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.18	(4,5,4,3,1,5); rough estimation of infrastructure
transport, freight, rail/tkm/RER U	0.6	tkm		Lognormal	2.19	(4,5,4,3,1,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.1	tkm		Lognormal	2.19	(4,5,4,3,1,5); standard distances
Output						
Emissions to air						
Heat, waste	23.436	MJ	high. pop.	Lognormal	1.73	(4,5,4,3,1,5); calculated from electricity input

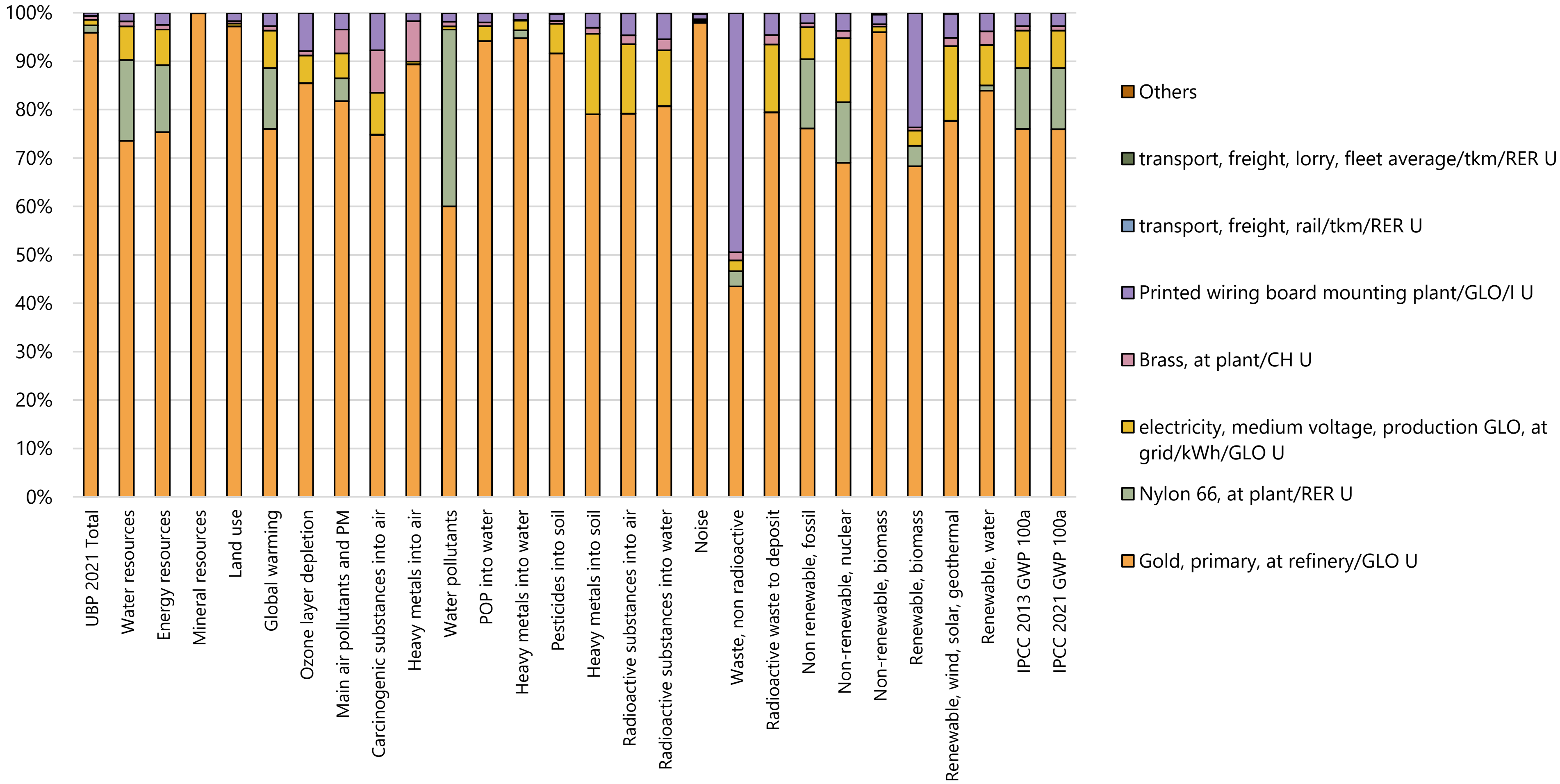

Figure 8.5-2. Contribution analysis presented in bar chart for: Connector, PCI bus. FU = 1 kg Connector, PCI bus

Table 8.5-4. Contribution analysis presented in table for: Connector, PCI bus. FU = 1 kg Connector, PCI bus

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, primary, at refinery/GLO U	96%	76%	76%	76%
Nylon 66, at plant/RER U	2%	14%	13%	13%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1%	7%	8%	8%
Brass, at plant/CH U	1%	1%	1%	1%
Printed wiring board mounting plant/p/GLO/I U	1%	2%	3%	3%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**5.85E+05**	**6.76E+02**	**5.22E+01**	**5.19E+01**

8.5.3 Cable, connector for computer, without plugs

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

Due to lacking relevant information, it is assumed that the composition remains the same as in the original dataset. However, it is assumed that the production effort for the cable is reduced by 20% in today's manufacturing plants due to energy efficiency and automation (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012).

The resulting unit process for "Cable, connector for computer, without plugs" is shown in Table 8.5-5, whereas the life cycle impact assessment results are presented in Figure 8.5-3 and Table 8.5-6.

Table 8.5-5. Life cycle inventory for Cable, connector for computer, without plugs and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cable, connector for computer, without plugs, at plant/m/GLO U	1	m				
Input						
Copper, primary, at refinery/GLO U	0.0195	kg		Lognormal	1.32	(1,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.07483	kWh		Lognormal	1.24	(2,4,1,3,1,5)
Extrusion, plastic pipes/RER U	0.0454	kg		Lognormal	1.24	(2,4,1,3,1,5)
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	0.0325416	MJ		Lognormal	1.24	(2,4,1,3,1,5)
Polyvinylchloride, at regional storage/RER U	0.0325	kg		Lognormal	1.24	(1,4,1,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	1.352E-08	p		Lognormal	3.11	(2,4,4,3,1,5)
propane/ butane, at refinery/kg/RER U	0.000012056	kg		Lognormal	1.24	(2,4,1,3,1,5)
tap water, at user/kg/RER U	1.3108	kg		Lognormal	1.24	(2,4,1,3,1,5)
transport, freight, rail/tkm/RER U	0.01298	tkm		Lognormal	2.12	(3,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.00649	tkm		Lognormal	2.07	(3,4,1,3,1,5)
Tube insulation, elastomere, at plant/DE U	0.0129	kg		Lognormal	1.32	(1,4,4,3,1,5)
Wire drawing, copper/RER U	0.0195	kg		Lognormal	1.32	(1,4,4,3,1,5)
Output						
Emissions to air						
Methanol	8.3871E-06	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
NMVOC, non-methane volatile organic compounds, unspecified origin	6.2903E-06	kg	low. pop.	Lognormal	1.63	(1,4,4,3,1,5)
Waste to treatment						
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	0.00019919	kg		Lognormal	1.33	(1,4,4,3,1,5)
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	0.0016425	kg		Lognormal	1.33	(2,4,4,3,1,5)

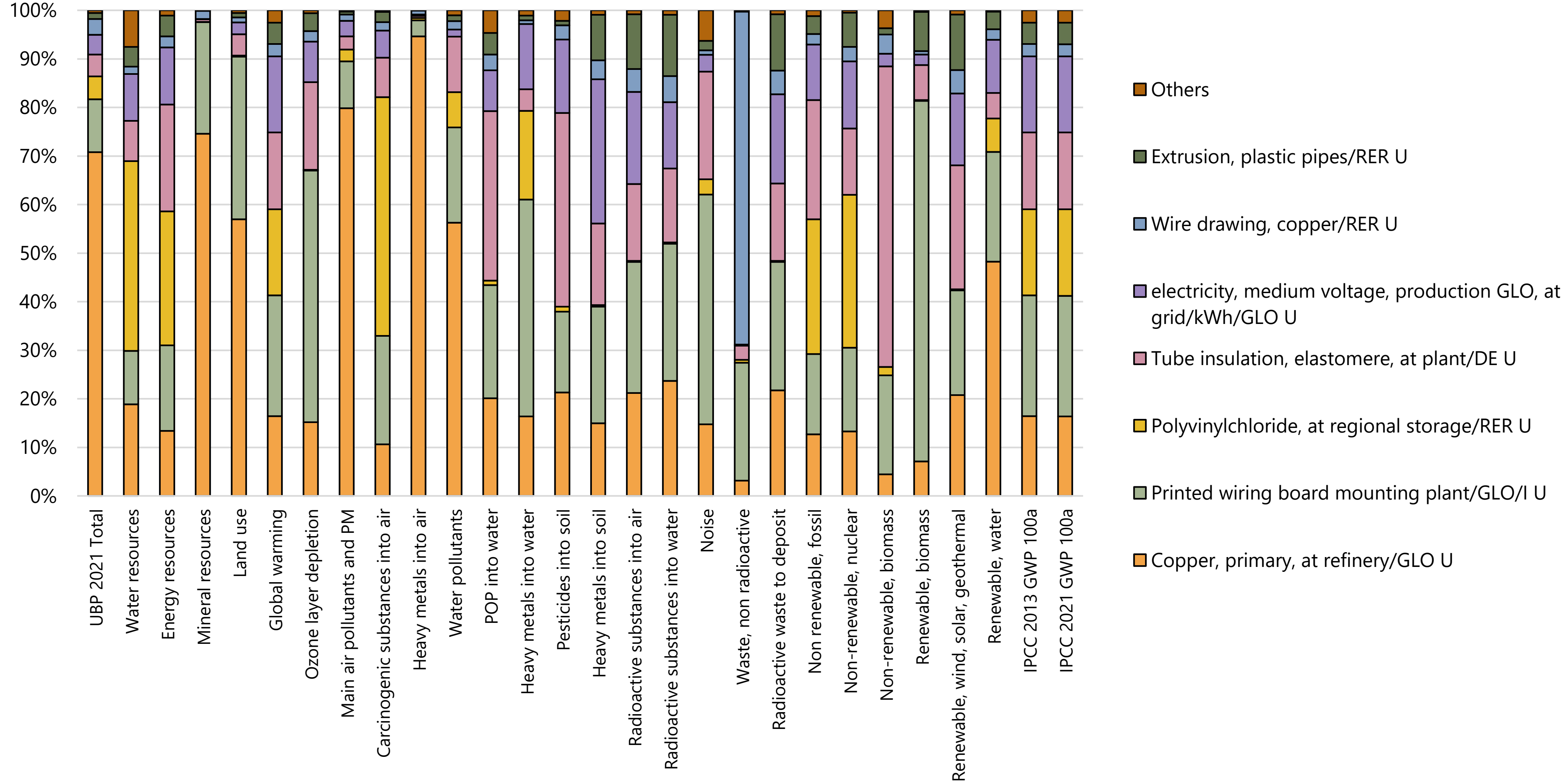

Figure 8.5-3. Contribution analysis presented in bar chart for: Cable, connector for computer. FU = 1 m Cable, connector for computer

Table 8.5-6. Contribution analysis presented in table for: Cable, connector for computer. FU = 1 m Cable, connector for computer

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	71%	13%	16%	16%
Printed wiring board mounting plant/p/GLO/I U	11%	17%	25%	25%
Polyvinylchloride, at regional storage/RER U	5%	28%	18%	18%
Tube insulation, elastomere, at plant/DE U	4%	25%	16%	16%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	4%	11%	16%	16%
Wire drawing, copper/RER U	3%	2%	3%	3%
Extrusion, plastic pipes/RER U	1%	4%	4%	4%
Others	1%	1%	3%	3%
Total impact, in absolute value	**2.25E+03**	**5.60E+00**	**3.71E-01**	**3.69E-01**

8.5.4 Cable, data cable in infrastructure

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In the absence of relevant information, it is assumed that the composition is the same as in the original data set. Major updates concern regionalization of primary metals used in cables.

The resulting unit process for "Cable, data cable in infrastructure" is shown in Table 8.5-7, whereas the life cycle impact assessment results are presented in Figure 8.5-4 and Table 8.5-8Table 8.4-66.

Table 8.5-7. Life cycle inventory for Cable, data cable in infrastructure and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cable, data cable in infrastructure, at plant/m/GLO U	1	m				
Input						
Copper, primary, at refinery/GLO U	0.01555	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Extrusion, plastic pipes/RER U	0.0342	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Glass fibre, at plant/RER U	0.01975	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Polyethylene, HDPE, granulate, at plant/RER U	0.0342	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Rolling mill/RER/I U	1.7695E-12	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
transport, freight, rail/tkm/RER U	0.0139	tkm		Lognormal	2.19	(4,3,4,3,3,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.00695	tkm		Lognormal	2.19	(4,3,4,3,3,5); standard distances
Wire drawing, copper/RER U	0.01555	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable

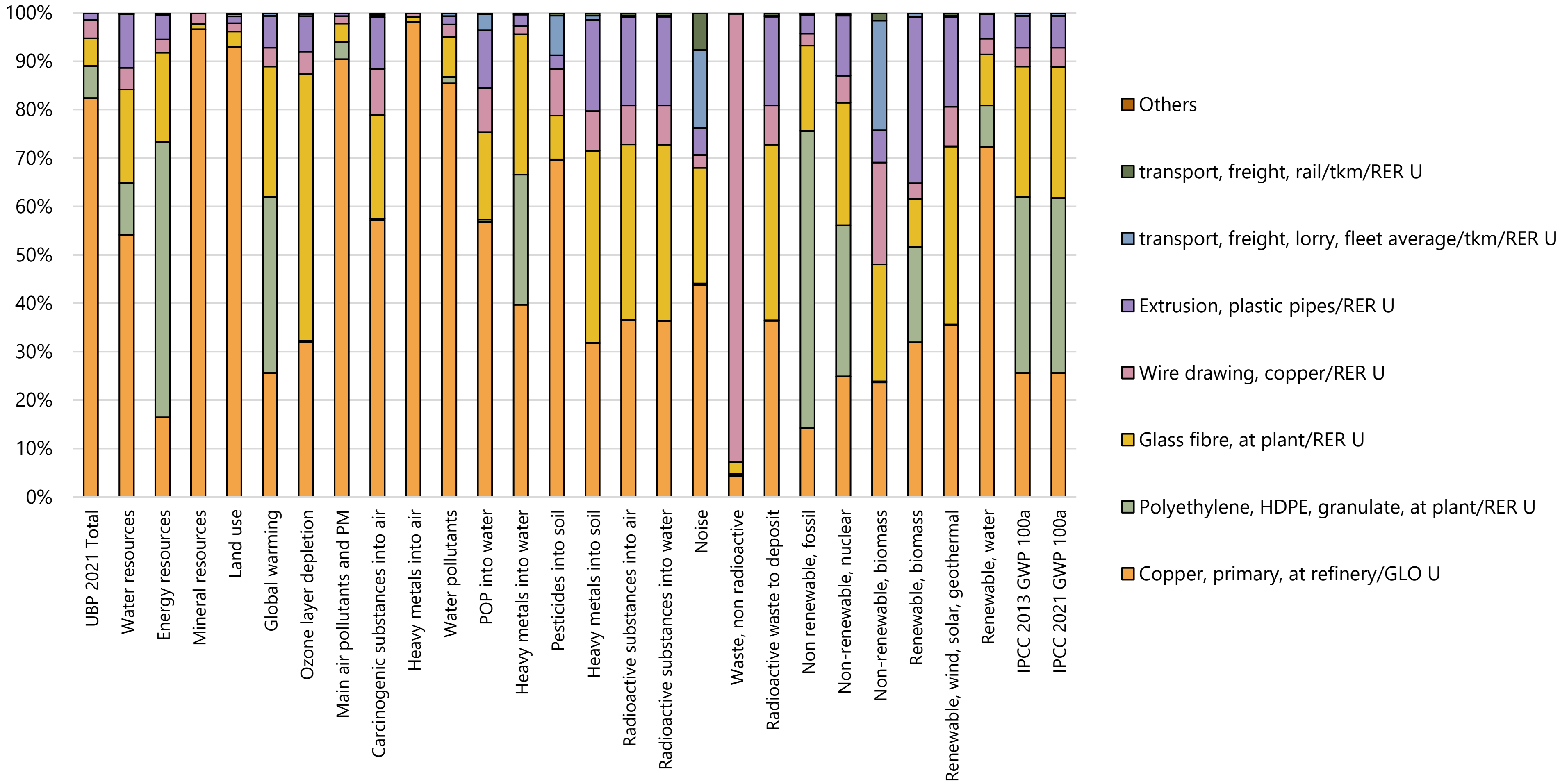

Figure 8.5-4. Contribution analysis presented in bar chart for: Cable, data cable in infrastructure. FU = 1 m Cable, data cable in infrastructure

Table 8.5-8. Contribution analysis presented in table for: Cable, data cable in infrastructure. FU = 1 m Cable, data cable in infrastructure

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	82%	14%	26%	26%
Polyethylene, HDPE, granulate, at plant/RER U	7%	61%	36%	36%
Glass fibre, at plant/RER U	6%	18%	27%	27%
Wire drawing, copper/RER U	4%	2%	4%	4%
Extrusion, plastic pipes/RER U	1%	4%	7%	7%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**1.54E+03**	**3.99E+00**	**1.90E-01**	**1.89E-01**

8.5.5 Cable, network cable, category 5, without plugs

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates to the dataset are applied to heat and electricity consumption, which is 20% less than the original datasets (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). The rest of the composition remains the same, as it is summarized in the environmental product declaration document of a supplier (Commscope, 2017).

The resulting unit process for "Cable, network cable, category 5, without plugs" is shown in Table 8.5-9, whereas the life cycle impact assessment results are presented in Figure 8.3-5 and Table 8.5-10Table 8.4-66.

Table 8.5-9. Life cycle inventory for Cable, network cable, category 5, without plugs and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cable, network cable, category 5, without plugs, at plant/m/GLO U	1	m				
Input						
Copper, primary, at refinery/GLO U	0.01825	kg		Lognormal	1.33	(2,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.074832	kWh		Lognormal	1.33	(1,4,4,3,1,5)
Extrusion, plastic film/RER U	0.001	kg		Lognormal	1.33	(1,4,4,3,1,5)
Extrusion, plastic pipes/RER U	0.01675	kg		Lognormal	1.33	(2,4,4,3,1,5)
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	0.0180232	MJ		Lognormal	1.33	(2,4,4,3,1,5)
Polyethylene, LDPE, granulate, at plant/RER U	0.001	kg		Lognormal	1.33	(1,4,4,3,1,5)
Polyvinylchloride, at regional storage/RER U	0.01675	kg		Lognormal	1.33	(2,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	7.488E-09	p		Lognormal	3.11	(2,4,4,3,1,5)
propane/ butane, at refinery/kg/RER U	6.6774E-06	kg		Lognormal	1.33	(2,4,4,3,1,5)
tap water, at user/kg/RER U	0.726	kg		Lognormal	1.33	(2,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.0072	tkm		Lognormal	2.11	(1,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.0036	tkm		Lognormal	2.11	(1,4,4,3,1,5)
Wire drawing, copper/RER U	0.01825	kg		Lognormal	1.33	(2,4,4,3,1,5)
Zinc coating, pieces/RER U	0.037699	m2		Lognormal	1.33	(2,4,4,3,1,5)
Output						
Emissions to air						
Methanol	4.6452E-06	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
NMVOC, non-methane volatile organic compounds, unspecified origin	3.4839E-06	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
Waste to treatment						
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	0.00011032	kg		Lognormal	1.33	(1,4,4,3,1,5)
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	0.00090968	kg		Lognormal	1.33	(2,4,4,3,1,5)

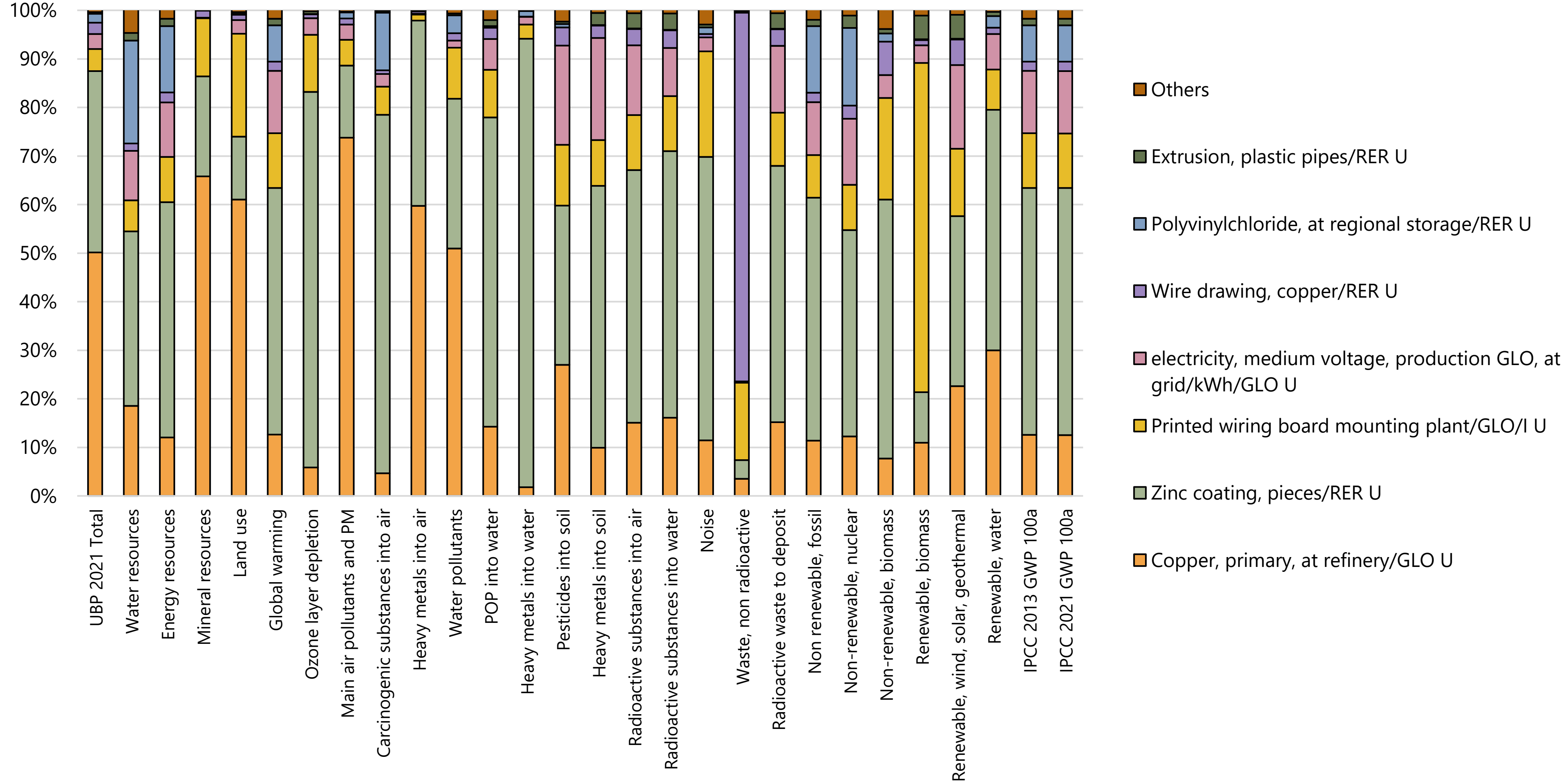

Figure 8.5-5. Contribution analysis presented in bar chart for: Cable, network cable, category 5. FU = 1 m Cable, network cable, category 5

Table 8.5-10. Contribution analysis presented in table for: Cable, network cable, category 5. FU = 1 m Cable, network cable, category 5

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	50%	11%	13%	13%
Zinc coating, pieces/RER U	37%	50%	51%	51%
Printed wiring board mounting plant/p/GLO/I U	5%	9%	11%	11%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	3%	11%	13%	13%
Wire drawing, copper/RER U	2%	2%	2%	2%
Polyvinylchloride, at regional storage/RER U	2%	14%	7%	8%
Extrusion, plastic pipes/RER U	0%	1%	1%	1%
Others	1%	3%	3%	3%
Total impact, in absolute value	**2.97E+03**	**5.86E+00**	**4.53E-01**	**4.51E-01**

8.5.6 Cable, printer cable, without plugs

- Dataset update and creation category: More research needed; use similar approach as the existing dataset with assumptions
- Unit process description:

The updates to the dataset are applied to heat and electricity consumption, which is 20% less than the original datasets (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012). However, as different types of cables, such as USB, may become more common in future printing technologies, this assumption may need to be re-examined in the future.

The resulting unit process for "Cable, printer cable, without plugs" is shown in Table 8.5-11, whereas the life cycle impact assessment results are presented in Figure 8.5-6 and Table 8.5-12Table 8.5-8Table 8.4-66.

Table 8.5-11. Life cycle inventory for Cable, printer cable, without plugs and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cable, printer cable, without plugs, at plant/m/GLO U	1	m				
Input						
aluminium, primary, at plant/kg/RER U	0.0009	kg		Lognormal	1.33	(1,4,4,3,1,5)
Copper, primary, at refinery/GLO U	0.0196	kg		Lognormal	1.33	(2,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.074832	kWh		Lognormal	1.33	(2,4,4,3,1,5)
Extrusion, plastic pipes/RER U	0.0525	kg		Lognormal	1.33	(2,4,4,3,1,5)
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	0.0360464	MJ		Lognormal	1.33	(2,4,4,3,1,5)
Polyvinylchloride, at regional storage/RER U	0.0525	kg		Lognormal	1.33	(2,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	1.4976E-08	p		Lognormal	3.11	(2,4,4,3,1,5)
propane/ butane, at refinery/kg/RER U	0.000013355	kg		Lognormal	1.33	(2,4,4,3,1,5)
Sheet rolling, aluminium/RER U	0.0009	kg		Lognormal	1.33	(1,4,4,3,1,5)
tap water, at user/kg/RER U	1.452	kg		Lognormal	1.33	(2,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.0146	tkm		Lognormal	2.12	(3,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.0073	tkm		Lognormal	2.12	(3,4,4,3,1,5)
Wire drawing, copper/RER U	0.0196	kg		Lognormal	1.33	(2,4,4,3,1,5)
Output						
Emissions to air						
Methanol	9.2903E-06	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
NMVOC, non-methane volatile organic compounds, unspecified origin	6.9677E-06	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
Waste to treatment						
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	0.00022065	kg		Lognormal	1.33	(1,4,4,3,1,5)
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	0.0018194	kg		Lognormal	1.33	(2,4,4,3,1,5)

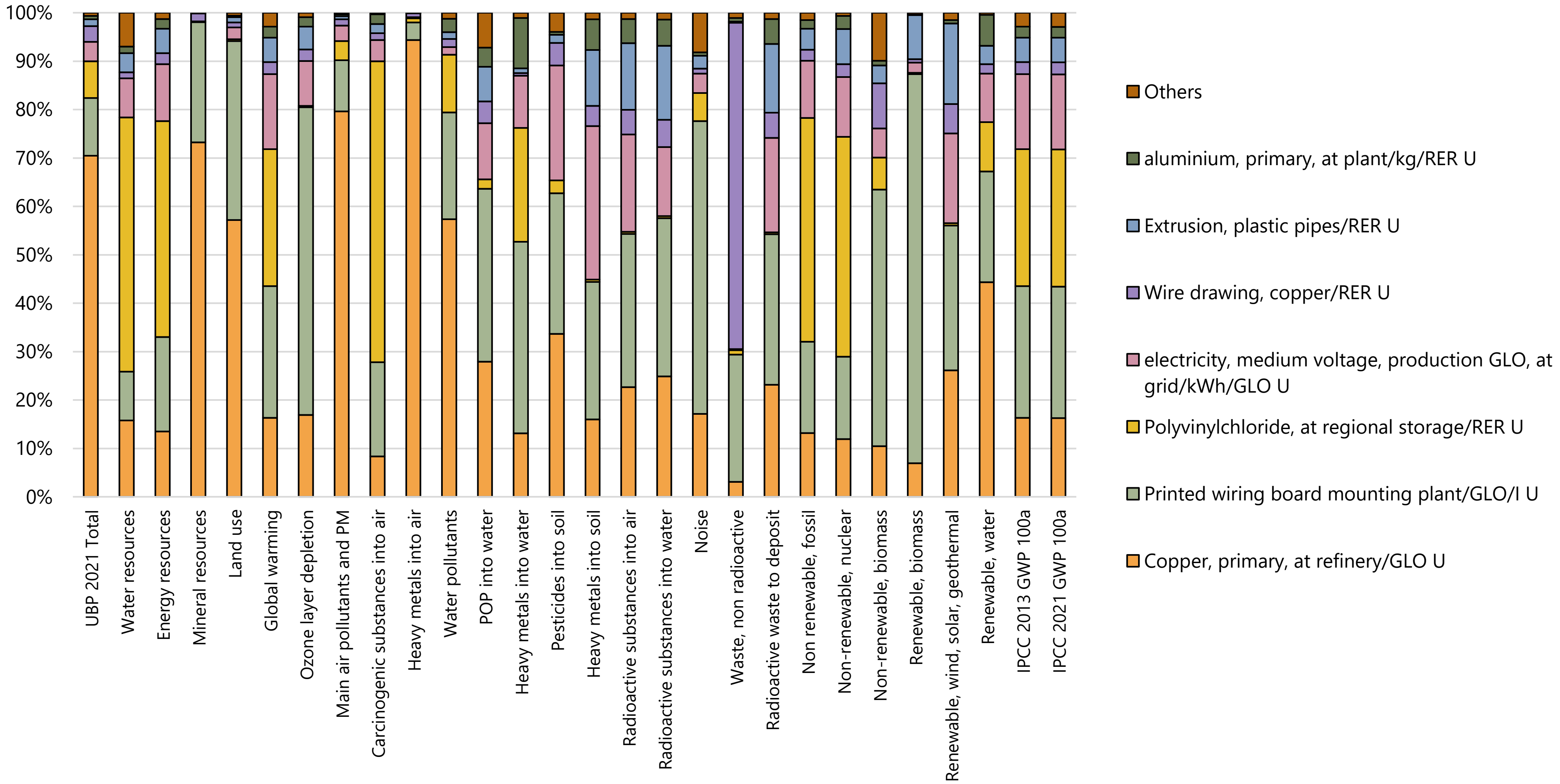

Figure 8.5-6. Contribution analysis presented in bar chart for: Cable, printer cable, without plugs. FU = 1 m Cable, printer cable, without plugs

Table 8.5-12. Contribution analysis presented in table for: Cable, printer cable, without plugs. FU = 1 m Cable, printer cable, without plugs

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	70%	13%	16%	16%
Printed wiring board mounting plant/p/GLO/I U	12%	19%	27%	27%
Polyvinylchloride, at regional storage/RER U	8%	46%	28%	28%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	4%	12%	15%	15%
Wire drawing, copper/RER U	3%	2%	2%	2%
Extrusion, plastic pipes/RER U	1%	4%	5%	5%
aluminium, primary, at plant/kg/RER U	1%	2%	2%	2%
Others	1%	2%	3%	3%
Total impact, in absolute value	**2.27E+03**	**5.43E+00**	**3.75E-01**	**3.74E-01**

8.5.7 Cable, ribbon cable, 20-pin, with plugs

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The updates to the dataset are applied to heat and electricity consumption, which is 20% less than the original datasets (Zentralverband Elektrotechnik- und Elektronikindustrie, 2012).

The resulting unit process for "Cable, ribbon cable, 20-pin, with plugs" is shown in Table 8.5-13, whereas the life cycle impact assessment results are presented in Figure 8.5-7Figure 8.3-5 and Table 8.5-14Table 8.4-66.

Table 8.5-13. Life cycle inventory for Cable, ribbon cable, 20-pin, with plugs and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	1	kg				
Output						
Brass, at plant/CH U	0.0033058	kg		Lognormal	1.33	(1,4,4,3,1,5)
Contour, brass/RER U	0.0033058	kg		Lognormal	1.33	(1,4,4,3,1,5)
Copper, primary, at refinery/GLO U	0.15496	kg		Lognormal	1.33	(1,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.618448	kWh		Lognormal	1.25	(2,4,1,3,1,5)
Extrusion, plastic pipes/RER U	0.15496	kg		Lognormal	1.33	(1,4,4,3,1,5)
heat, heavy fuel oil, at industrial furnace 1MW/MJ/RER U	0.50064	MJ		Lognormal	1.33	(2,4,4,3,1,5)
Injection moulding/RER U	0.68678	kg		Lognormal	1.33	(1,4,4,3,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.68678	kg		Lognormal	1.33	(1,4,4,3,1,5)
Polyvinylchloride, at regional storage/RER U	0.15496	kg		Lognormal	1.33	(1,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.11	(2,4,4,3,1,5)
propane/ butane, at refinery/kg/RER U	0.00018548	kg		Lognormal	1.33	(2,4,4,3,1,5)
tap water, at user/kg/RER U	20.167	kg		Lognormal	1.33	(2,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.2	tkm		Lognormal	2.12	(3,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.1	tkm		Lognormal	2.12	(3,4,4,3,1,5)
Wire drawing, copper/RER U	0.15496	kg		Lognormal	1.33	(1,4,4,3,1,5)
Zinc coating, pieces/RER U	0.62441	m2		Lognormal	1.33	(1,4,4,3,1,5)
Output						
Emissions to air						
Methanol	0.00012903	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
NMVOC, non-methane volatile organic compounds, unspecified origin	9.6774E-05	kg	low. pop.	Lognormal	2.11	(1,4,4,3,1,5)
Waste to treatment						
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	0.0030645	kg		Lognormal	1.33	(1,4,4,3,1,5)
disposal, plastics, mixture, 15.3% water, to municipal incineration/kg/CH U	0.025269	kg		Lognormal	1.33	(2,4,4,3,1,5)

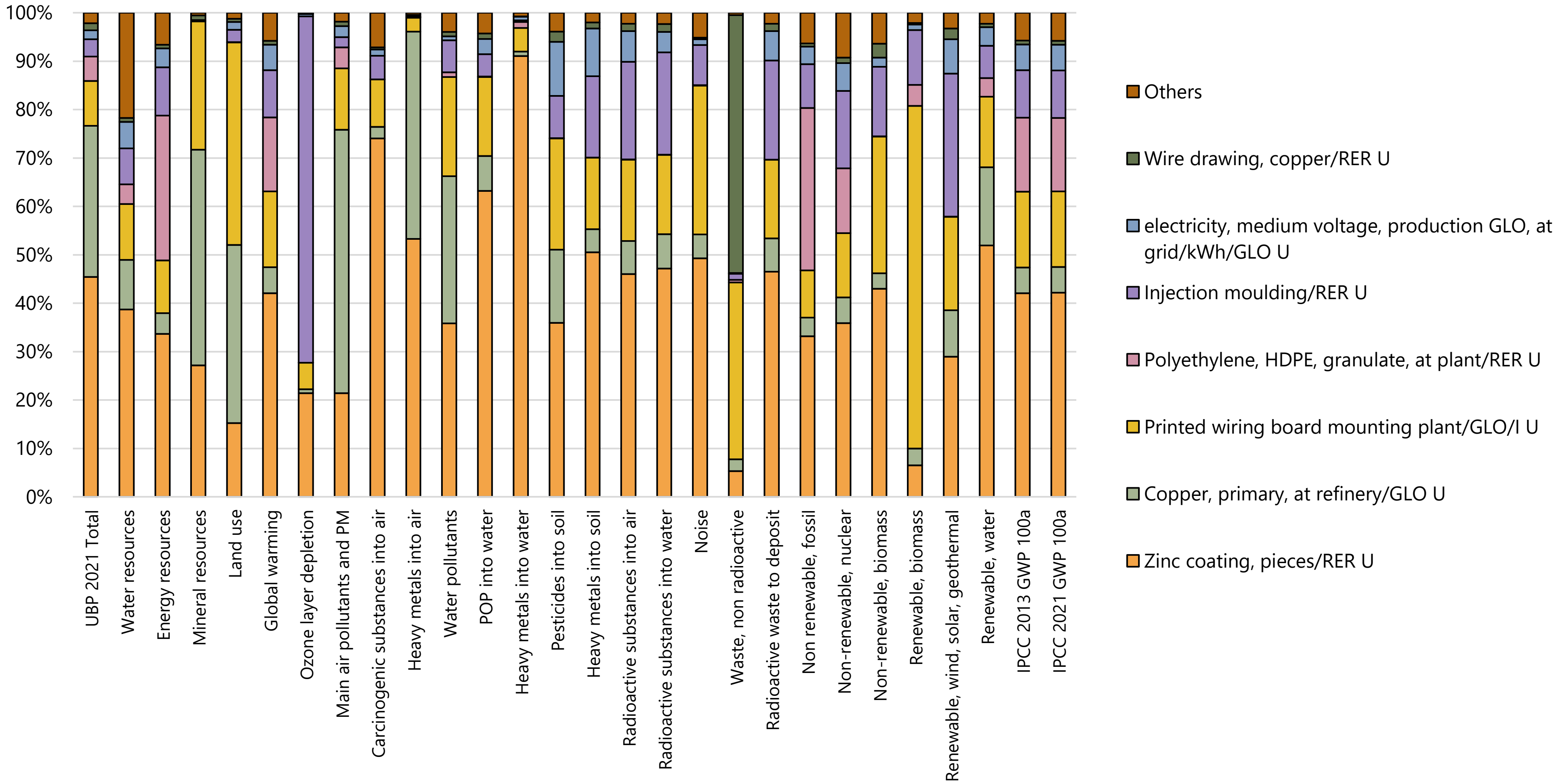

Figure 8.5-7. Contribution analysis presented in bar chart for: Cable, ribbon cable, 20-pin, with plugs. FU = 1 m Cable, ribbon cable, 20-pin, with plugs

Table 8.5-14. Contribution analysis presented in table for: Cable, ribbon cable, 20-pin, with plugs. FU = 1 kg of Cable, ribbon cable, 20-pin, with plugs

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Zinc coating, pieces/RER U	45%	33%	42%	42%
Copper, primary, at refinery/GLO U	31%	4%	5%	5%
Printed wiring board mounting plant/p/GLO/I U	9%	10%	16%	16%
Polyethylene, HDPE, granulate, at plant/RER U	5%	34%	15%	15%
Injection moulding/RER U	4%	9%	10%	10%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	2%	4%	5%	5%
Wire drawing, copper/RER U	1%	1%	1%	1%
Others	2%	6%	6%	6%
Total impact, in absolute value	**4.05E+04**	**1.46E+02**	**9.06E+00**	**9.02E+00**

8.5.8 Cable, three-conductor cable

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In the absence of relevant information, it is assumed that the composition is the same as in the original data set. Major updates concern regionalization of primary metals used in cables.

The resulting unit process for "Cable, three-conductor cable" is shown in Table 8.5-15, whereas the life cycle impact assessment results are presented in Figure 8.5-8Figure 8.5-7Figure 8.3-5 and Table 8.5-16Table 8.5-14Table 8.4-66.

Table 8.5-15. Life cycle inventory for Cable, three-conductor cable and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cable, three-conductor cable, at plant/m/GLO U	1	m				
Input						
Copper, primary, at refinery/GLO U	0.49238	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Extrusion, plastic pipes/RER U	0.54762	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Polyethylene, HDPE, granulate, at plant/RER U	0.54762	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable
Rolling mill/RER/I U	3.3766E-11	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
transport, freight, rail/tkm/RER U	0.208	tkm		Lognormal	2.85	(4,5,4,3,5,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	0.104	tkm		Lognormal	2.85	(4,5,4,3,5,5); standard distances
Wire drawing, copper/RER U	0.49238	kg		Lognormal	1.63	(1,3,4,3,4,5); data from composition of one such cable

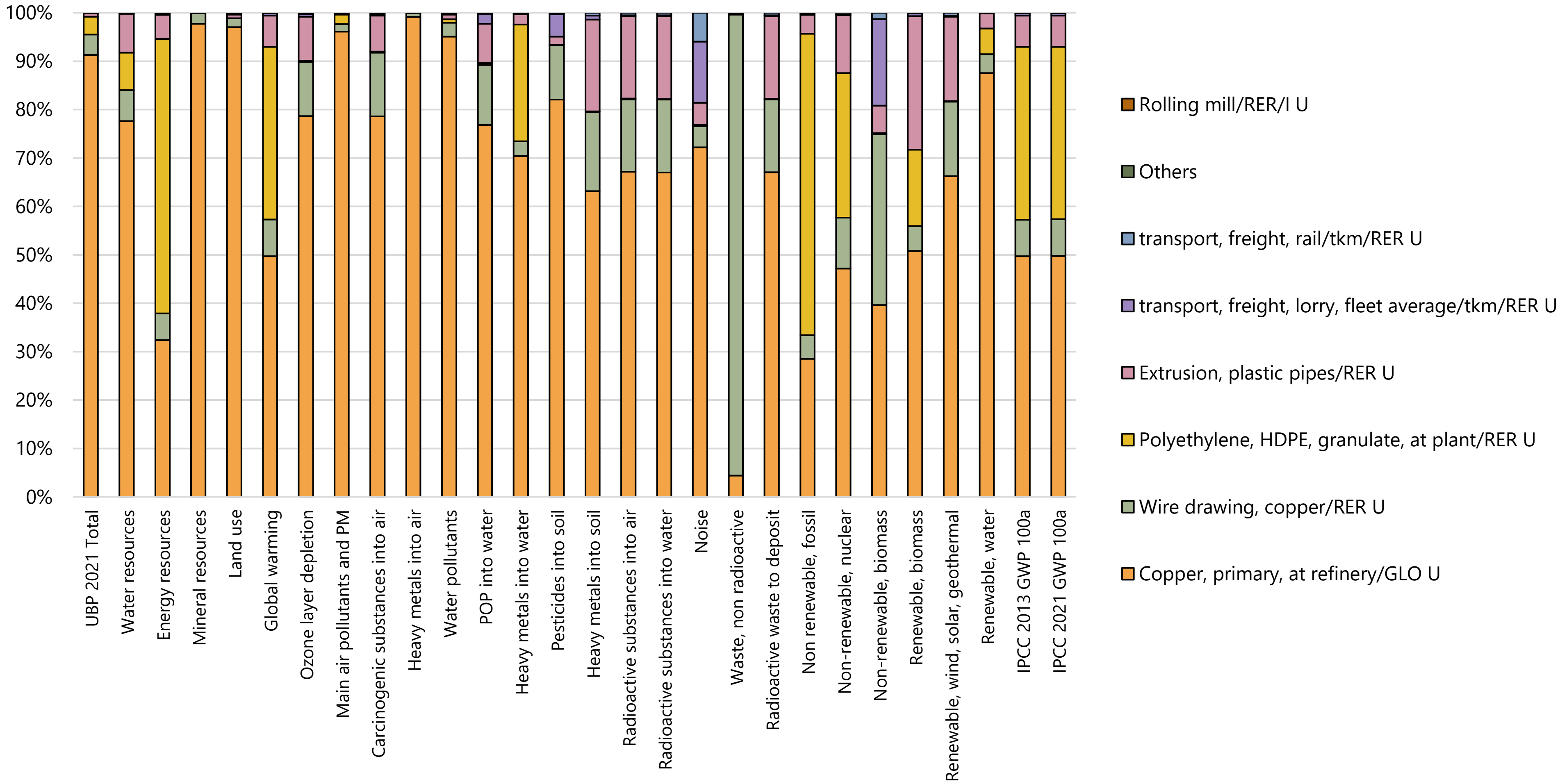

Figure 8.5-8. Contribution analysis presented in bar chart for: Cable, three-conductor cable. FU = 1 m Cable, three-conductor cable

Table 8.5-16. Contribution analysis presented in table for: Cable, three-conductor cable. FU = 1 m Cable, three-conductor cable

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	91%	29%	50%	50%
Wire drawing, copper/RER U	4%	5%	8%	8%
Polyethylene, HDPE, granulate, at plant/RER U	4%	62%	36%	36%
Extrusion, plastic pipes/RER U	1%	4%	6%	6%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.40E+04**	**6.30E+01**	**3.10E+00**	**3.07E+00**

8.5.9 Plugs, inlet and outlet, for computer cable

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In the absence of relevant information, it is assumed that the composition is the same as in the original data set. Major updates concern regionalization of primary metals used in plugs. Plugs are assumed to be manufactured in the same way, with minor/negligible changes.

The resulting unit process for "Plugs, inlet and outlet, for computer cable" is shown in Table 8.5-17, whereas the life cycle impact assessment results are presented in Figure 8.5-9 and Table 8.5-18.

Table 8.5-17. Life cycle inventory for Plugs, inlet and outlet, for computer cable and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p				
Input						
Brass, at plant/CH U	0.01015	kg		Lognormal	1.33	(2,4,4,3,1,5)
Contour, brass/RER U	0.01015	kg		Lognormal	1.33	(2,4,4,3,1,5)
Copper, primary, at refinery/GLO U	0.003225	kg		Lognormal	1.33	(1,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.0014755	kWh		Lognormal	1.33	(2,4,4,3,1,5)
Injection moulding/RER U	0.04512	kg		Lognormal	1.33	(2,4,4,3,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.00512	kg		Lognormal	1.33	(2,4,4,3,1,5)
Polyvinylchloride, at regional storage/RER U	0.04	kg		Lognormal	1.33	(2,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	1.2168E-08	p		Lognormal	3.11	(2,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.011699	tkm		Lognormal	2.12	(3,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.0058495	tkm		Lognormal	2.12	(3,4,4,3,1,5)
Wire drawing, copper/RER U	0.003225	kg		Lognormal	1.33	(1,4,4,3,1,5)
Zinc coating, pieces/RER U	0.00040211	m2		Lognormal	1.33	(1,4,4,3,1,5)

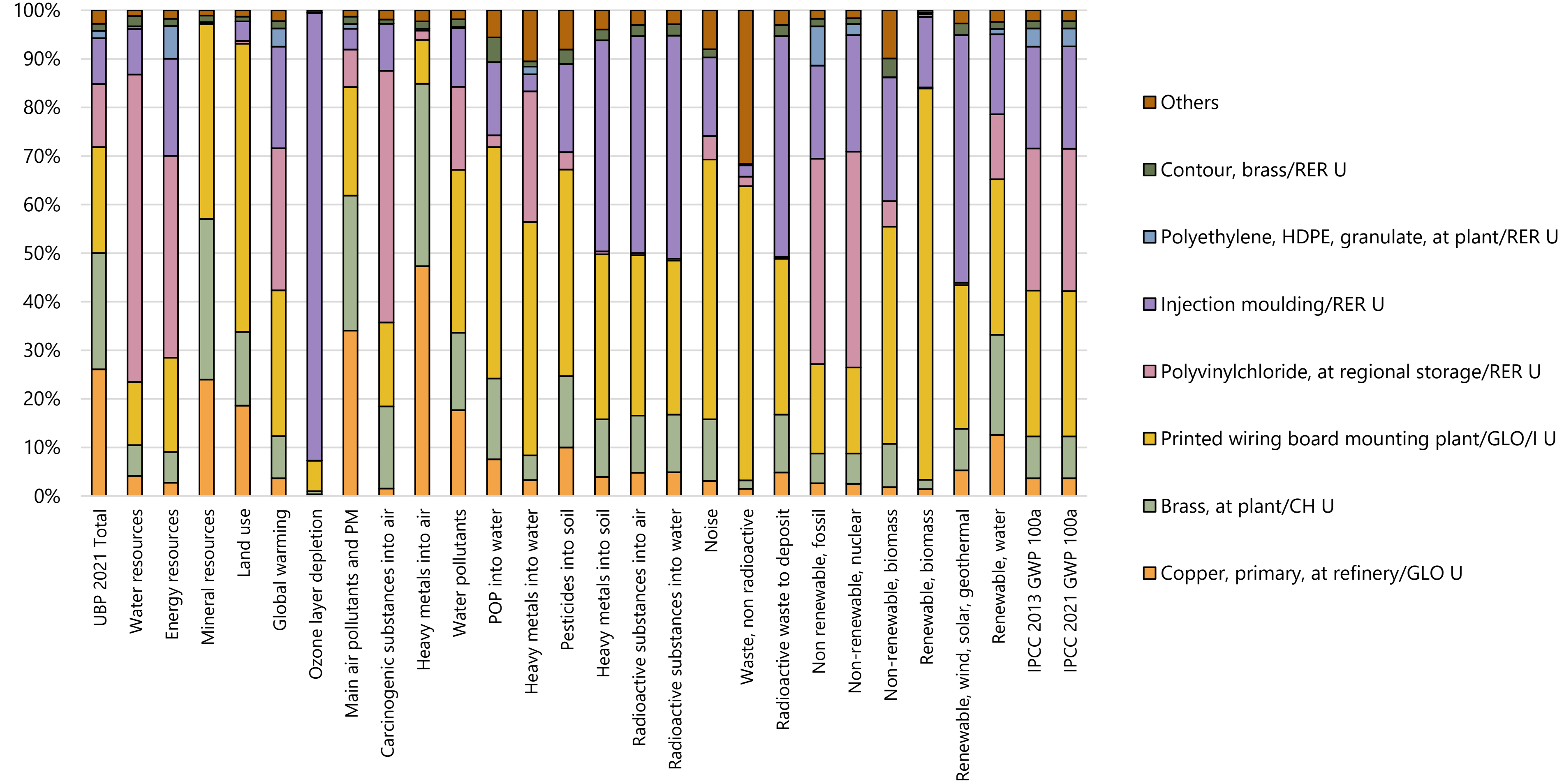

Figure 8.5-9. Contribution analysis presented in bar chart for: Plugs, inlet and outlet, for computer cable. FU = 1 unit

Table 8.5-18. Contribution analysis presented in table for: Plugs, inlet and outlet, for computer cable. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	26%	3%	4%	4%
Brass, at plant/CH U	24%	6%	9%	9%
Printed wiring board mounting plant/p/GLO/I U	22%	18%	30%	30%
Polyvinylchloride, at regional storage/RER U	13%	42%	29%	29%
Injection moulding/RER U	9%	19%	21%	21%
Polyethylene, HDPE, granulate, at plant/RER U	2%	8%	4%	4%
Contour, brass/RER U	1%	2%	1%	1%
Others	3%	2%	2%	2%
Total impact, in absolute value	**1.01E+03**	**4.53E+00**	**2.77E-01**	**2.76E-01**

8.5.10 Plugs, inlet and outlet, for network cable

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In the absence of relevant information, it is assumed that the composition is the same as in the original data set. Major updates concern regionalization of primary metals used in plugs. Plugs are assumed to be manufactured in the same way, with minor/negligible changes.

The resulting unit process for "Plugs, inlet and outlet, for network cable" is shown in Table 8.5-19, whereas the life cycle impact assessment results are presented in Figure 8.5-10 and Table 8.5-20.

Table 8.5-19. Life cycle inventory for Plugs, inlet and outlet, for network cable and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1	p				
Input						
Brass, at plant/CH U	0.002422	kg		Lognormal	1.33	(2,4,4,3,1,5)
Contour, brass/RER U	0.002422	kg		Lognormal	1.33	(2,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.0008853	kWh		Lognormal	1.33	(2,4,4,3,1,5)
Injection moulding/RER U	0.00618	kg		Lognormal	1.33	(2,4,4,3,1,5)
Polystyrene, high impact, HIPS, at plant/RER U	0.00218	kg		Lognormal	1.33	(1,4,4,3,1,5)
Polyvinylchloride, at regional storage/RER U	0.004	kg		Lognormal	1.33	(1,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	1.7888E-09	p		Lognormal	3.11	(2,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.0017204	tkm		Lognormal	2.12	(3,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.0008602	tkm		Lognormal	2.12	(3,4,4,3,1,5)

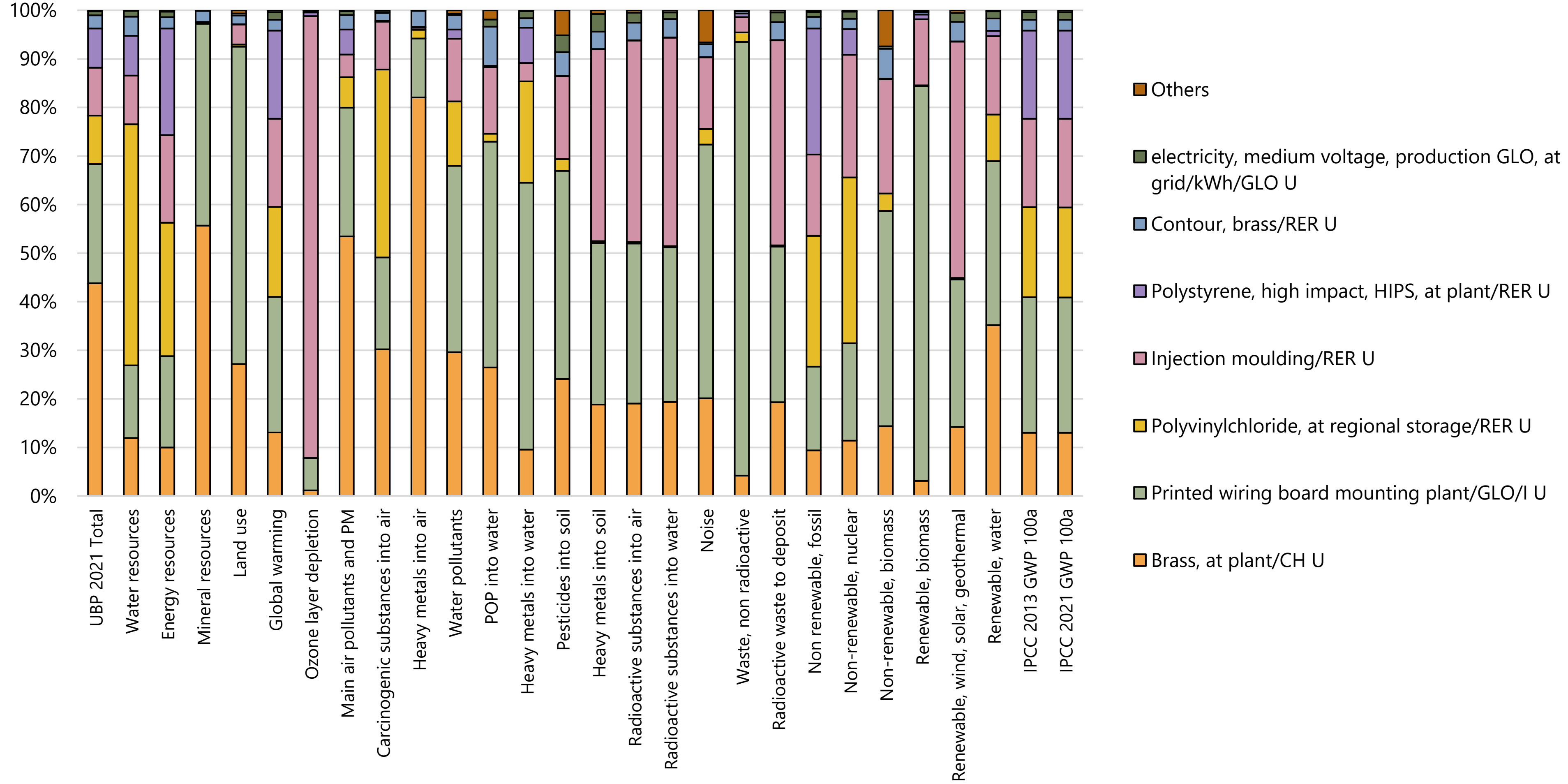

Figure 8.5-10. Contribution analysis presented in bar chart for: Plugs, inlet and outlet, for network cable. FU = 1 unit

Table 8.5-20. Contribution analysis presented in table for: Plugs, inlet and outlet, for network cable. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Brass, at plant/CH U	44%	9%	13%	13%
Printed wiring board mounting plant/p/GLO/I U	25%	17%	28%	28%
Polyvinylchloride, at regional storage/RER U	10%	27%	19%	19%
Injection moulding/RER U	10%	17%	18%	18%
Polystyrene, high impact, HIPS, at plant/RER U	8%	26%	18%	18%
Contour, brass/RER U	3%	2%	2%	2%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1%	1%	2%	2%
Others	0%	0%	0%	0%
Total impact, in absolute value	**1.32E+02**	**7.10E-01**	**4.37E-02**	**4.35E-02**

8.5.11 Plugs, inlet and outlet, for printer cable

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

In the absence of relevant information, it is assumed that the composition is the same as in the original data set. Major updates concern regionalization of primary metals used in plugs. Plugs are assumed to be manufactured in the same way, with minor/negligible changes.

The resulting unit process for "Plugs, inlet and outlet, for printer cable" is shown in Table 8.5-21, whereas the life cycle impact assessment results are presented in Figure 8.5-11Figure 8.5-10Figure 8.5-7Figure 8.3-5 and Table 8.5-22Table 8.5-16Table 8.5-14Table 8.4-66.

Table 8.5-21. Life cycle inventory for Plugs, inlet and outlet, for printer cable and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Plugs, inlet and outlet, for printer cable, at plant/p/GLO U	1	p				
Input						
Brass, at plant/CH U	0.0014	kg		Lognormal	1.32	(1,4,4,3,1,5)
Chromium steel 18/8, at plant/RER U	0.00261	kg		Lognormal	1.32	(1,4,4,3,1,5)
Contour, brass/RER U	0.0014	kg		Lognormal	1.32	(1,4,4,3,1,5)
Copper, primary, at refinery/GLO U	0.0023125	kg		Lognormal	1.32	(1,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.0014755	kWh		Lognormal	1.33	(2,4,4,3,1,5)
Hot rolling, steel/RER U	0.00261	kg		Lognormal	1.32	(1,4,4,3,1,5)
Injection moulding/RER U	0.07174	kg		Lognormal	1.33	(2,4,4,3,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.00681	kg		Lognormal	1.33	(2,4,4,3,1,5)
Polyethylene, LDPE, granulate, at plant/RER U	0.05273	kg		Lognormal	1.33	(2,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	1.8616E-08	p		Lognormal	3.11	(2,4,4,3,1,5)
Sheet rolling, steel/RER U	0.011537	kg		Lognormal	1.33	(2,4,4,3,1,5)
Silicone product, at plant/RER U	0.0122	kg		Lognormal	1.32	(1,4,4,3,1,5)
Steel, low-alloyed, at plant/RER U	0.011537	kg		Lognormal	1.33	(2,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.007898	tkm		Lognormal	2.12	(3,4,4,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.003949	tkm		Lognormal	2.12	(3,4,4,3,1,5)
Wire drawing, copper/RER U	0.0023125	kg		Lognormal	1.32	(1,4,4,3,1,5)
Zinc coating, pieces/RER U	0.0023	m2		Lognormal	1.33	(2,4,4,3,1,5)

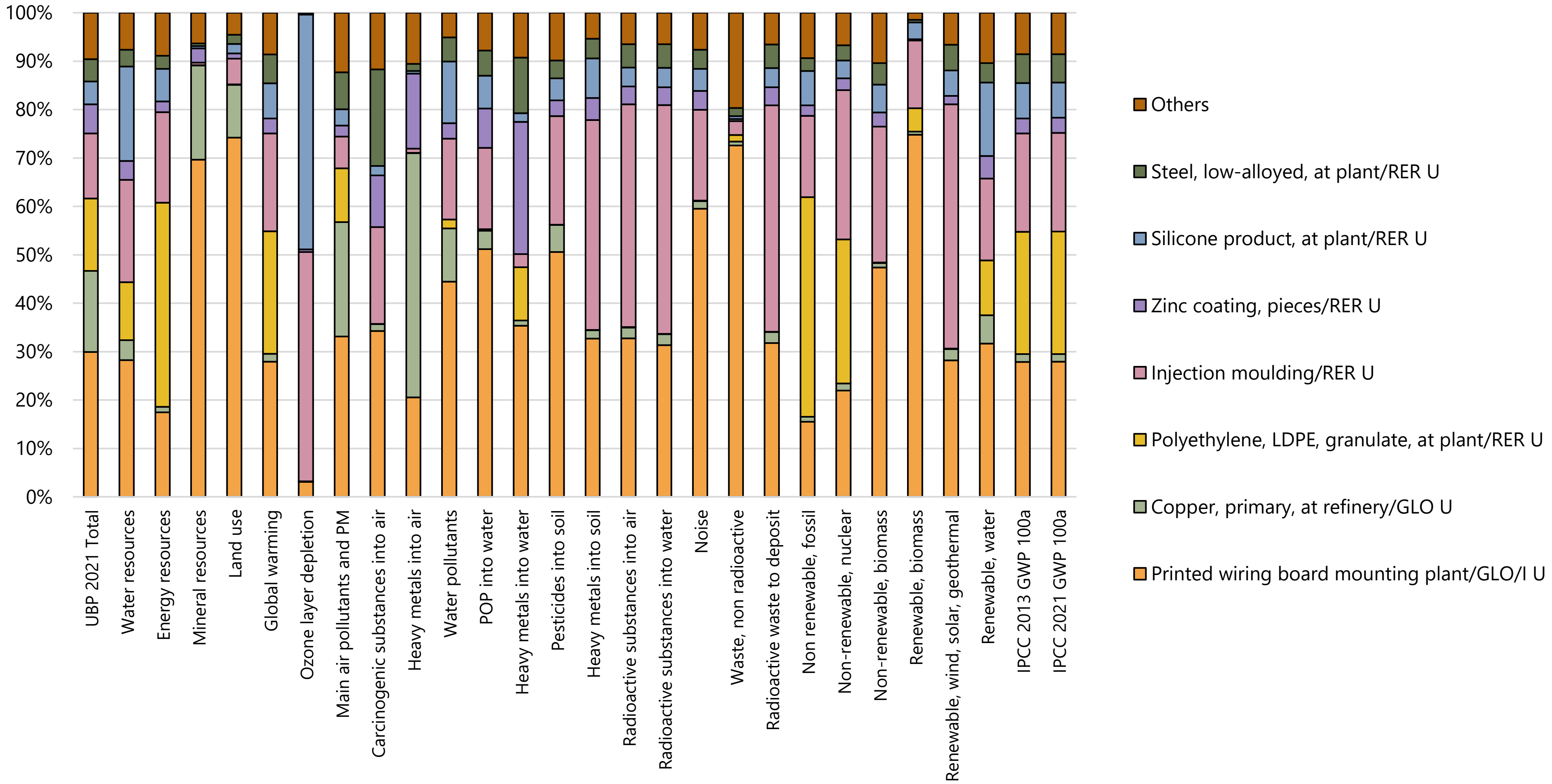

Figure 8.5-11. Contribution analysis presented in bar chart for: Plugs, inlet and outlet, for printer cable. FU = 1 unit

Table 8.5-22. Contribution analysis presented in table for: Plugs, inlet and outlet, for printer cable. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board mounting plant/p/GLO/I U	30%	16%	28%	28%
Copper, primary, at refinery/GLO U	17%	1%	2%	2%
Polyethylene, LDPE, granulate, at plant/RER U	15%	45%	25%	25%
Injection moulding/RER U	13%	17%	20%	20%
Zinc coating, pieces/RER U	6%	2%	3%	3%
Silicone product, at plant/RER U	5%	7%	7%	7%
Steel, low-alloyed, at plant/RER U	5%	3%	6%	6%
Others	10%	9%	9%	9%
Total impact, in absolute value	**1.13E+03**	**8.21E+00**	**4.55E-01**	**4.52E-01**

8.5.12 LCD glass

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

Except for the same LCA publication of the original dataset or the US-EPA LCA study that was the basis for the LCI in the original database (Socolof et al., 2005), no new information or LCA data are found for LCD glass production. It is assumed that glass production has technically improved over the years (Cantini et al., 2022), as the dataset is based on the last decades. In the new LCD dataset, this improvement translates into a 22.5% reduction in electricity and heat consumption.

The resulting unit process for "LCD glass" is shown in Table 8.5-23, whereas the life cycle impact assessment results are presented in Figure 8.5-12.

Table 8.5-23. Life cycle inventory for LCD glass and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
LCD glass, at plant/kg/GLO U	1	kg				
Input						
Water, unspecified natural origin/m3	0.0075	m3	in water	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
aluminium oxide, at plant/kg/RER U	0.005951	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia, liquid, at regional storehouse/RER U	0.002	kg		Lognormal	1.68	(4,3,4,3,4,5); estimation, based on CRT panel glass production
Barite, at plant/RER U	0.052585	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Cerium concentrate, 60% cerium oxide, at plant/CN U	0.00058428	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chemicals organic, at plant/GLO U	0.00297	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium oxide, flakes, at plant/RER U	0.00001082	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Copper carbonate, at plant/RER U	0.058753	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, production GLO, at grid/kWh/GLO U	2.193	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study, sum of electricity consumption in CN, JP, and US
Glass production site/RER/I U	1.25E-10	p		Lognormal	3.36	(1,5,4,3,4,5); Estimation from packaging glass production
Glass, from public collection, unsorted/RER U	0.0087642	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	8.223	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
heat, natural gas, at industrial furnace 1MW/MJ/CH U	7.75	MJ		Lognormal	2.12	(3,3,4,3,5,5); analogy conclusion - from CRT glass production data
hydrogen fluoride, at plant/kg/GLO U	0.016944	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Oxygen, liquid, at plant/RER U	0.0020055	kg		Lognormal	1.68	(4,3,4,3,4,5); estimation, based on CRT panel glass production
Potassium carbonate, at plant/GLO U	0.067192	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Silica sand, at plant/DE U	0.44273	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Soda, powder, at plant/RER U	0.086668	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Solvents, organic, unspecified, at plant/GLO U	0.00021	kg		Lognormal	1.68	(4,3,4,3,4,5); estimation, based on CRT panel glass production
transport, freight, lorry, fleet average/tkm/RER U	0.131	tkm		Lognormal	2.37	(1,5,4,3,4,5); Estimation from packaging glass production
transport, freight, lorry 7.5-16 metric ton, fleet average/tkm/RER U	0.000147	tkm		Lognormal	2.37	(1,5,4,3,4,5); Estimation from packaging glass production
Zirconium oxide, at plant/AU U	0.0096298	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Output						

Emissions to air						
Chromium	2.963E-08	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, waste	10.185	MJ	high. pop.	Lognormal	1.93	(4,3,4,3,4,5); Calculated from electricity input
Emissions to water						
BOD5, Biological Oxygen Demand	1.7593E-06	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Chloride	0.21667	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium	1.7593E-08	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
COD, Chemical Oxygen Demand	1.7593E-06	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Fluoride	0.00062963	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Iron	0.00059259	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Lead	9.3056E-06	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Nickel	1.7593E-08	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrate	8.4722E-07	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Oils, unspecified	0.0015463	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Solids, inorganic	0.77778	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Suspended solids, unspecified	0.0015509	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Waste to treatment						
disposal, glass, 0% water, to construction waste landfill/kg/CH U	0.0058551	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, inert waste, 5% water, to construction waste landfill/kg/CH U	0.0000775	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, lead in car shredder residue, 0% water, to municipal incineration/kg/CH U	0.00030324	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, municipal solid waste, 22.9% water, to sanitary landfill/CH U	0.0061883	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.0018192	kg		Lognormal	1.63	(1,3,4,3,1,5); data from an US-EPA LCA study

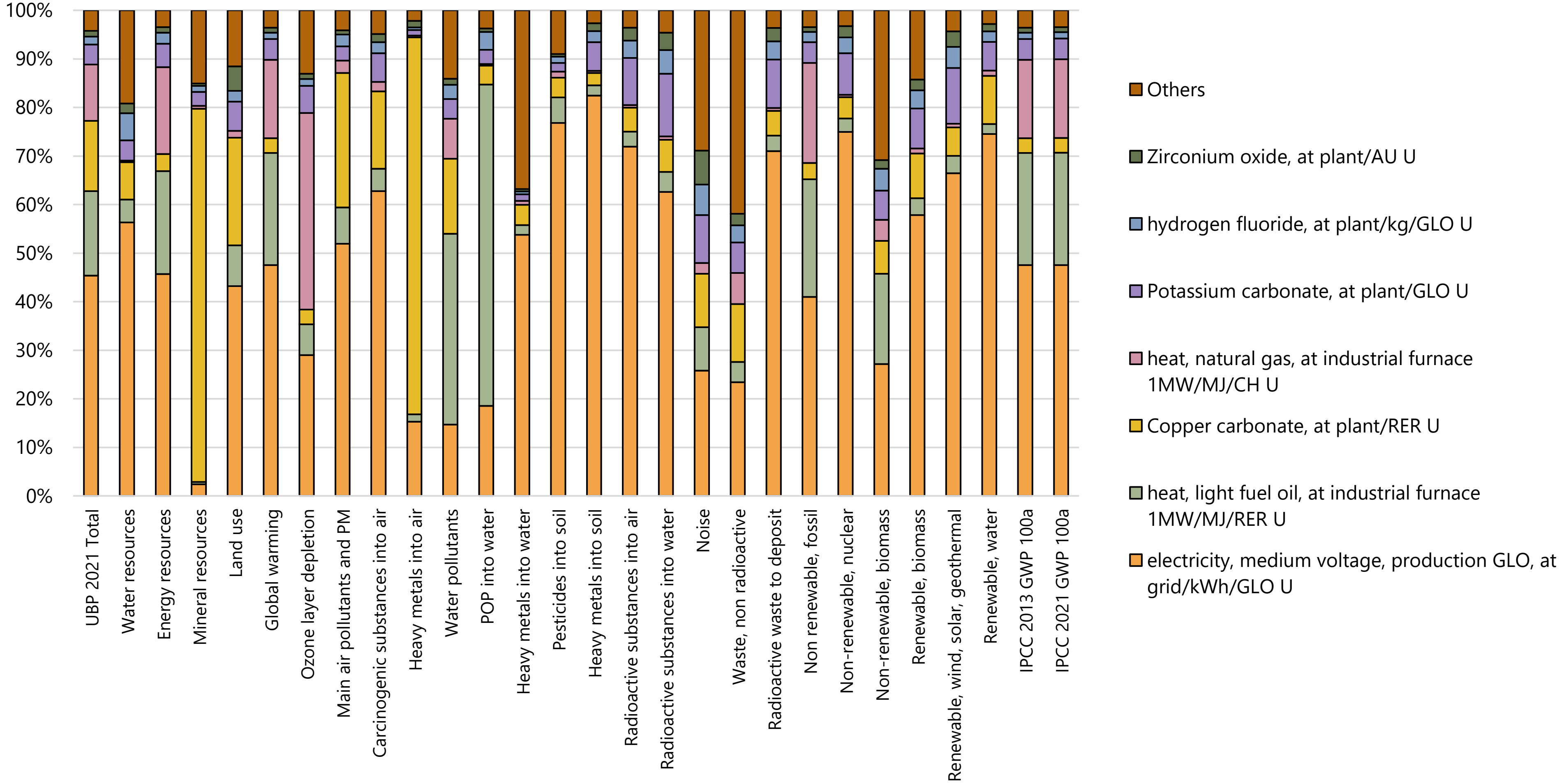

Figure 8.5-12. Contribution analysis presented in bar chart for: LCD glass. FU = 1 kg LCD glass

Table 8.5-24. Contribution analysis presented in table for: LCD glass. FU = 1 kg LCD glass

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	45%	41%	48%	48%
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	17%	24%	23%	23%
Copper carbonate, at plant/RER U	14%	3%	3%	3%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	12%	21%	16%	16%
Potassium carbonate, at plant/GLO U	4%	4%	4%	4%
hydrogen fluoride, at plant/kg/GLO U	2%	2%	1%	1%
Zirconium oxide, at plant/AU U	1%	1%	1%	1%
Others	4%	3%	4%	3%
Total impact, in absolute value	**5.91E+03**	**4.58E+01**	**3.58E+00**	**3.57E+00**

8.5.13 Backlight, LCD screen

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

Similar to the dataset for the LCD glass, the data set for the backlit LCD display is created using the same reference as the original dataset (Socolof et al., 2005). Based on the literature data (Cantini et al., 2022), the reduction in power and heat consumption is assumed to be 22.5%. However, the global electricity mix is used instead of a China-Japan mix, as the production of fluorescent lightings is now distributed worldwide, including the Americas, according to the latest market share data (MMR, 2022).

The resulting unit process for "Backlight, LCD screen" is shown in Table 8.5-25, whereas the life cycle impact assessment results are presented in Figure 8.5-13.

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Table 8.5-25. Life cycle inventory for Backlight, LCD screen and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Backlight, LCD screen, at plant/GLO U	1	kg				
Input						
Water, unspecified natural origin/m3	0.1901	m3	in water	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.033168	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Argon, liquid, at plant/RER U	0.00003495	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.003396	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chemicals inorganic, at plant/GLO U	0.00020743	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chemicals organic, at plant/GLO U	0.00027703	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium steel 18/8, at plant/RER U	0.02495	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Copper, primary, at refinery/GLO U	0.00067426	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Diethyl ether, at plant/RER U	0.000091881	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.9506305	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study == Updated due to efficiency improvements
Ethanol from ethylene, at plant/RER U	0.000045842	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Glass tube, borosilicate, at plant/DE U	0.04099	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
heat, natural gas, at industrial furnace 1MW/MJ/CH U	0.00029054	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Krypton, gaseous, at plant/RER U	0.000062475	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Lead concentrate, at beneficiation/GLO U	0.0019208	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Mercury, liquid, at plant/GLO U	3.9505E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Polycarbonate, at plant/RER U	0.11287	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.027129	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Polymethyl methacrylate, sheet, at plant/RER U	0.7495	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p		Lognormal	3.18	(4,5,4,3,1,5); Estimation, based on PWB mounting plant
Synthetic rubber, at plant/RER U	0.00059505	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
transport, freight, rail/tkm/RER U	0.59755	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard values
transport, freight, lorry, fleet average/tkm/RER U	0.099592	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard values

Output						
Emissions to air						
Diethyl ether	9.1683E-05	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethanol	4.5842E-05	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, waste	4.4158	MJ	high. pop.	Lognormal	1.93	(4,3,4,3,4,5); Calculated from electricity input
Nitrogen oxides	0.028911	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Waste to treatment						
Disposal, hazardous waste, 0% water, to underground deposit/DE U	2.6634E-07	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, hazardous waste, 25% water, to hazardous waste incineration/CH U	0.0067327	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, inert waste, 5% water, to construction waste landfill/kg/CH U	1.5076E-06	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, lead in car shredder residue, 0% water, to municipal incineration/kg/CH U	8.0891E-08	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, packaging cardboard, 19.6% water, to municipal incineration/kg/CH U	0.00001802	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, plastic, industr. electronics, 15.3% water, to municipal incineration/kg/CH U	0.0015194	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.00098911	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
disposal, polypropylene, 15.9% water, to municipal incineration/kg/CH U	0.0026931	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, spent activated carbon with mercury, 0% water, to underground deposit/DE U	9.1287E-10	kg		Lognormal	1.63	(1,3,4,3,1,5); data from an US-EPA LCA study
Treatment, LCD backlight production effluent, to wastewater treatment, class 2/CH U	0.09505	m3		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process

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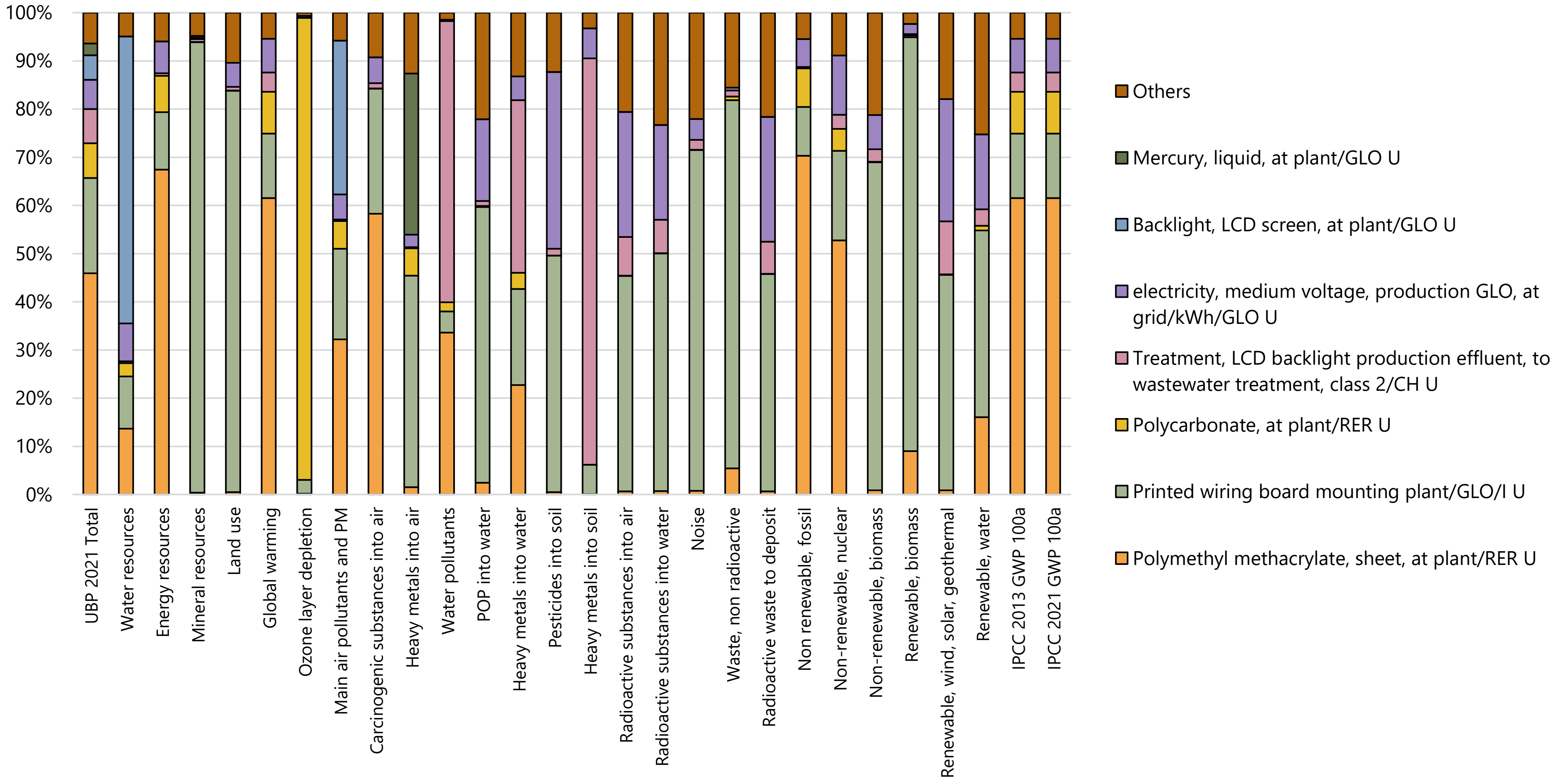

Figure 8.5-13. Contribution analysis presented in bar chart for: Backlight, LCD screen. FU = 1 kg

Table 8.5-26. Contribution analysis presented in table for: Backlight, LCD screen. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Polymethyl methacrylate, sheet, at plant/RER U	46%	70%	62%	62%
Printed wiring board mounting plant/p/GLO/I U	20%	10%	13%	13%
Polycarbonate, at plant/RER U	7%	8%	9%	9%
Treatment, LCD backlight production effluent, to wastewater treatment, class 2/CH U	7%	0%	4%	4%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	6%	6%	7%	7%
Backlight, LCD screen, at plant/GLO U	5%	0%	0%	0%
Mercury, liquid, at plant/GLO U	2%	0%	0%	0%
Others	6%	5%	5%	5%
Total impact, in absolute value	**1.91E+04**	**1.40E+02**	**1.06E+01**	**1.05E+01**

8.5.14 Assembly, LCD module

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

All materials and chemicals used in the assembly process are taken from the original technical study (Socolof et al., 2005). According to the most recent market statistics for TFT-LCD modules, the largest manufacturers in the world are as follows: BOE, LG Display, Innolyx Corp, AUO, Samsung, and China Star, all of which account for more than 80 % of the market share (Cision, 2010; Statista, 2020). However, electricity consumption is regionalized by market share and manufacturing region, namely China (40%), Japan (30%), and Taiwan (30%). The current version of the UVEK LCA database allows the inclusion of Taiwan's electricity mix in the updated dataset, in contrast to the previous version. Improved energy efficiency related to heat and electricity is also applied to module production (Cantini et al., 2022).

The resulting unit process for "Backlight, LCD screen" is shown in Table 8.5-27, whereas the life cycle impact assessment results are presented in Figure 8.5-14.

Table 8.5-27. Life cycle inventory for Assembly, LCD module and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Assembly, LCD module/kg/GLO U	1	kg				
Input						
Water, unspecified natural origin/m3	0.28125	m3	in water	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetic acid, 98% in H2O, at plant/RER U	0.0016667	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetone, liquid, at plant/RER U	0.0026823	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Aluminium sulphate, powder, at plant/RER U	0.027344	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia, liquid, at regional storehouse/RER U	0.0076211	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Argon, crude, liquid, at plant/RER U	0.0020495	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Carbon dioxide liquid, at plant/RER U	9.7396E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chemicals organic, at plant/GLO U	0.15699	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chlorine, liquid, production mix, at plant/RER U	0.0040365	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyclohexanol, at plant/RER U	5.2865E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Dimethyl sulfoxide, at plant/RER U	0.017266	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, at grid/kWh/CN U	5.808067	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, at grid/kWh/JP U	4.35605025	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, at grid/kWh/TW U	4.35605025	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Electronic component production plant/p/GLO/I U	0.00000002	p		Lognormal	3.18	(4,5,4,3,1,5); Estimation, based on electronic component production site
Ethanol from ethylene, at plant/RER U	0.0035156	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethylene glycol, at plant/RER U	0.00021146	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Glass fibre, at plant/RER U	3.8229E-07	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	9.38835	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
heat, natural gas, at industrial furnace 1MW/MJ/CH U	37.2744	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrochloric acid, 30% in H2O, at plant/RER U	0.011224	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
hydrogen fluoride, at plant/kg/GLO U	0.0010964	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen peroxide, 50% in H2O, at plant/RER U	0.000038281	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen, liquid, at plant/RER U	0.11562	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study

Isopropanol, at plant/RER U	0.090885	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Krypton, gaseous, at regional storage/CH U	6.7188E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Lime, hydrated, packed, at plant/CH U	0.036198	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA studyv
Methyl ethyl ketone, at plant/RER U	1.9141E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitric acid, 50% in H2O, at plant/RER U	0.0032292	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen, liquid, at plant/RER U	1.5365	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
N-methyl-2-pyrrolidone, at plant/RER U	0.00021146	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Oxygen, liquid, at plant/RER U	0.0020182	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Panel components, at plant/GLO U	0.021875	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphoric acid, industrial grade, 85% in H2O, at plant/RER U	0.010286	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Polycarbonate, at plant/RER U	0.00025312	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Propylene glycol, liquid, at plant/RER U	0.005224	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	0.09349	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sodium phosphate, at plant/RER U	0.048177	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sulphuric acid, liquid, at plant/RER U	0.059635	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Toluene diisocyanate, at plant/RER U	8.0208E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
transport, freight, rail/tkm/RER U	1.9405	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard values
transport, freight, lorry, fleet average/tkm/RER U	0.32341	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard values
Xylene, at plant/RER U	0.00040885	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Output						
Emissions to air						
Acetic acid	0.00035417	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetone	4.8437E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia	0.016224	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Tetramethyl ammonium hydroxide	0.16745	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Sulfur hexafluoride	2.7924E-05	kg	high. pop.	Lognormal	1.89	(3,3,4,1,4,5); tier 2b default emission factor according to IPCC guidelines
Sodium tetrahydroborate	0.0046354	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphoric acid	0.00001263	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study

Phosphine	0.016302	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
NMVOC, non-methane volatile organic compounds, unspecified origin	0.027813	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen oxides	7.0052E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen fluoride	6.9821E-06	kg	high. pop.	Lognormal	1.89	(3,3,4,1,4,5); tier 2b default emission factor according to IPCC guidelines
Hydrogen	3.4635E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen fluoride	0.013568	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen chloride	0.015781	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, waste	67.448	MJ	high. pop.	Lognormal	1.93	(4,3,4,3,4,5); Calculated from electricity input
Diethylene glycol	2.5234E-05	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyclohexane	0.00001263	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Boron trifluoride	0.0023906	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Boric acid	3.5677E-07	kg	high. pop.	Lognormal	2.10	(1,3,4,3,1,5); data from an US-EPA LCA study
Emissions to water						
Antimony	2.9688E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Arsenic	2.9688E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
BOD5, Biological Oxygen Demand	0.0045312	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Boron	1.1927E-06	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Cadmium	2.9688E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium VI	5.9635E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium	2.3021E-06	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
COD, Chemical Oxygen Demand	0.00069792	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Copper	2.3906E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyanide	9.5313E-07	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethane, 1,1,1-trichloro-, HCFC-140	5.9635E-09	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Fluoride	0.0033333	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrocarbons, aromatic	0.00015312	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Iron	6.849E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Lead	1.6068E-06	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study

Manganese	5.9635E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Mercury	2.5234E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Nickel	5.9635E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen	0.020651	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Oils, unspecified	5.2604E-05	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Phenol	5.9635E-08	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphate	5.9635E-08	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphorus	0.0011224	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Solids, inorganic	0.0019661	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Waste to treatment						
disposal, glass, 0% water, to construction waste landfill/kg/CH U	0.11995	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.2099	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, refinery sludge, 89.5% water, to hazardous waste incineration/CH U	0.0080469	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, sludge, NaCl electrolysis, 0% water, to residual material landfill/CH U	0.014922	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.87294	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH U	0.0041927	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Treatment, LCD module production effluent, to wastewater treatment, class 2/CH U	0.3737	m3		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study

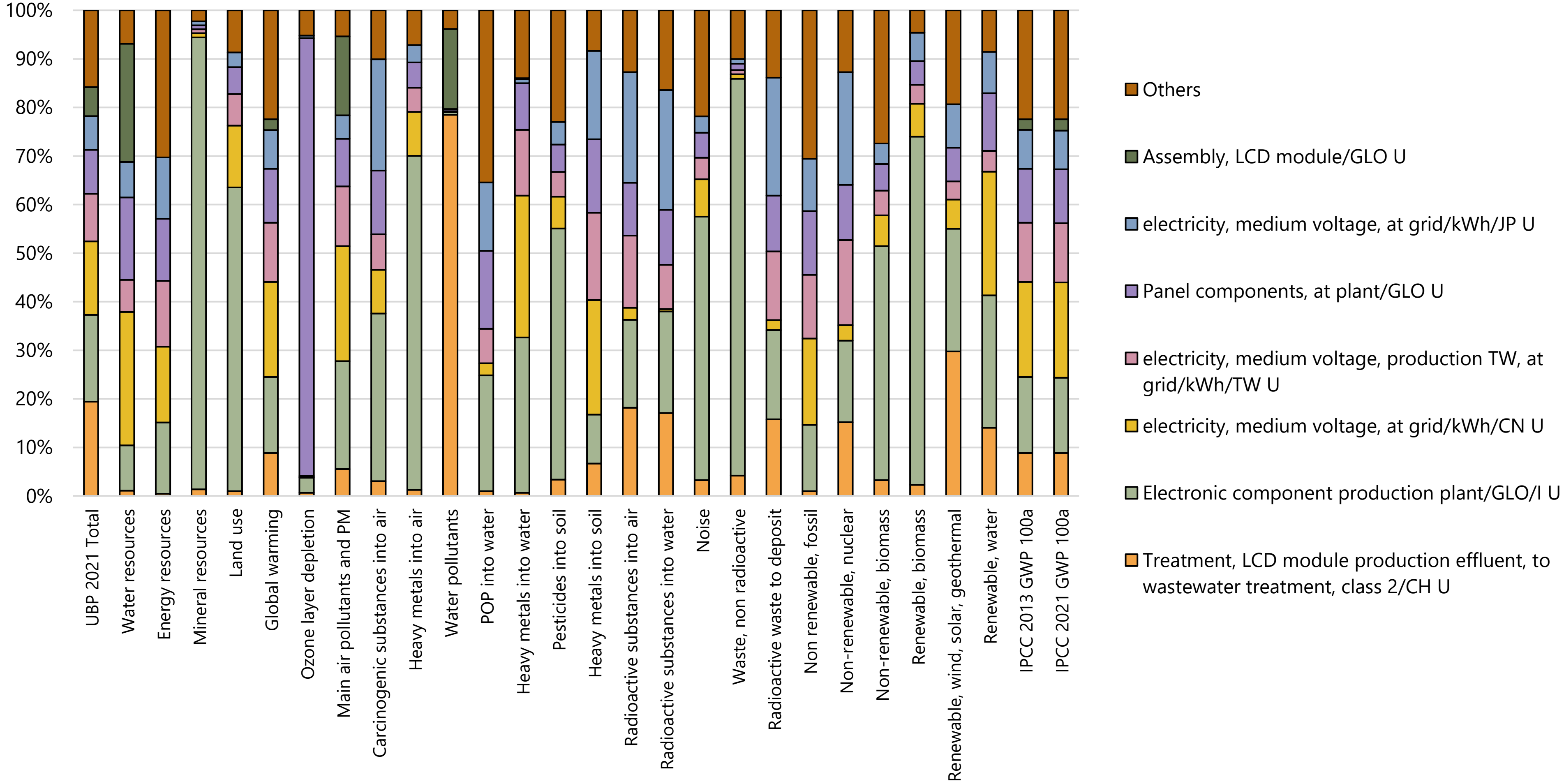

Figure 8.5-14. Contribution analysis presented in bar chart for: Assembly, LCD module. FU = 1 kg

Table 8.5-28. Contribution analysis presented in table for: Assembly, LCD module. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Treatment, LCD module production effluent, to wastewater treatment, class 2/CH U	19%	1%	9%	9%
Electronic component production plant/p/GLO/I U	19%	14%	16%	16%
electricity, medium voltage, at grid/kWh/CN U	15%	18%	20%	20%
electricity, medium voltage, at grid/kWh/TW U	10%	13%	12%	12%
Panel components, at plant/GLO U	9%	13%	11%	11%
electricity, medium voltage, at grid/kWh/JP U	7%	11%	8%	8%
Assembly, LCD module/kg/GLO U	6%	0%	2%	2%
Others	15%	31%	22%	22%
Total impact, in absolute value	**6.77E+04**	**3.22E+02**	**3.54E+01**	**3.54E+01**

8.5.15 LCD module

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

The bill of materials for LCD module production is derived from the original study (Socolof et al., 2005). The LCD module consists of various electronic parts such as integrated circuits, printed circuit boards, and backlight LCD screens. These parts are updated and described in the separate unit processes. The updated foreground datasets of the LCD module now include these electronics. Since these changes have been modeled in the respective background datasets, no compositional changes are assumed for the LCD module. For a particular metal, such as copper, a global primary copper dataset is selected instead of the European market mix to represent the global production of LCD modules.

The resulting unit process for "LCD module" is shown in Table 8.5-29, whereas the life cycle impact assessment results are presented in Figure 8.5-15Figure 8.5-10Figure 8.5-7Figure 8.3-5 and Table 8.5-30Table 8.5-28Table 8.5-24.

Table 8.5-29. Life cycle inventory for LCD module and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
LCD module, at plant/kg/GLO U	1	kg				
Input						
Backlight, LCD screen, at plant/kg/GLO U	0.4307	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Chromium steel 18/8, at plant/RER U	0.11345	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Copper, primary, at refinery/GLO U	0.0031	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Injection moulding/RER U	0.0938	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.0082	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
LCD glass, at plant/kg/GLO U	0.2965	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Assembly, LCD module/kg/GLO U	1	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nylon 6, at plant/RER U	0.0063	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Polycarbonate, at plant/RER U	0.0938	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.0438	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Section bar rolling, steel/RER U	0.1094	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Sheet rolling, copper/RER U	0.0031	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Sputtering, ITO, for LCD/RER U	5.5866E-08	m3		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study
Synthetic rubber, at plant/RER U	0.00405	kg		Lognormal	1.31	(1,3,4,3,1,5); calculated from an US-EPA study

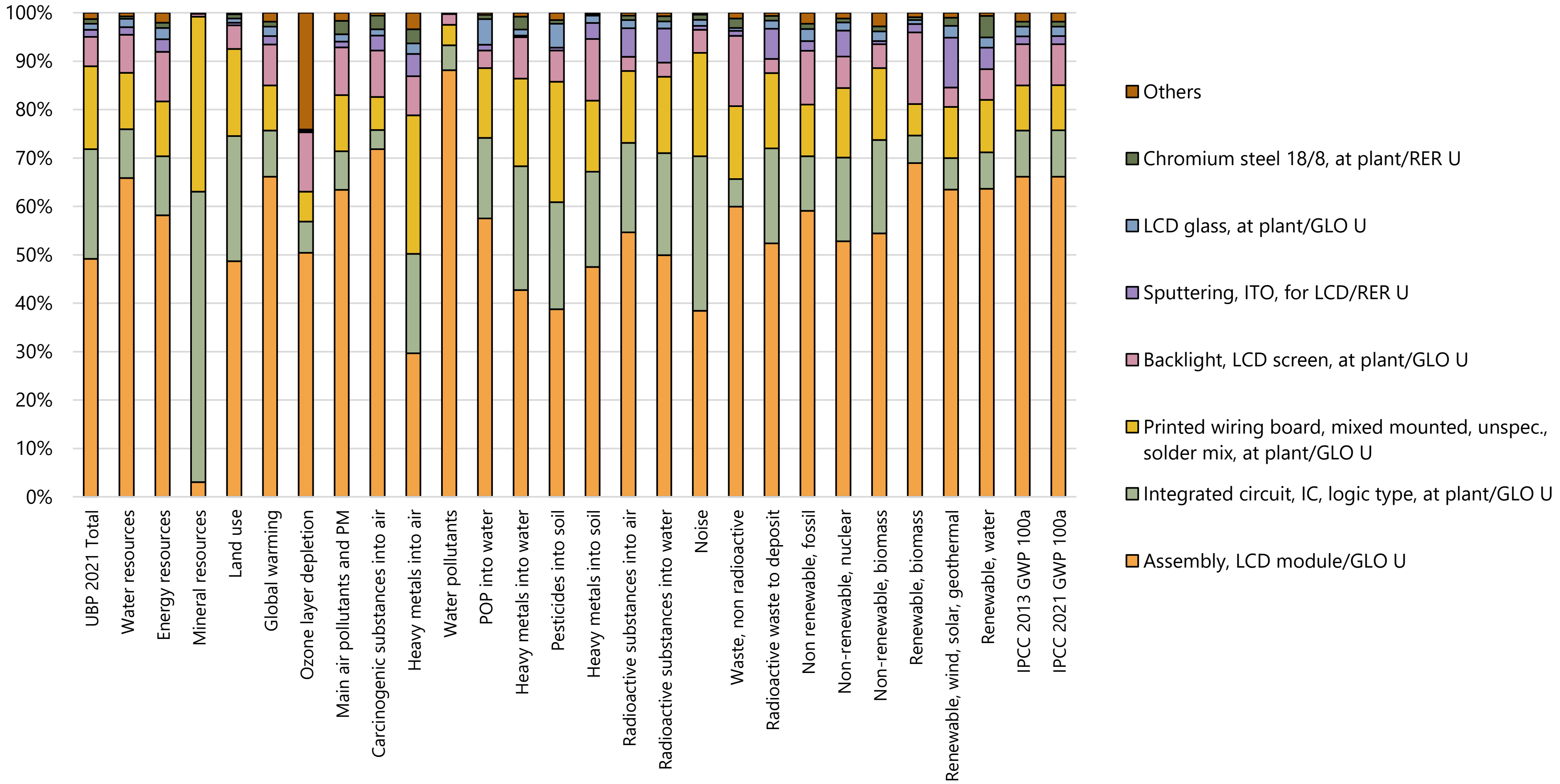

Figure 8.5-15. Contribution analysis presented in bar chart for: LCD module. FU = 1 kg

Table 8.5-30. Contribution analysis presented in table for: LCD module. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Assembly, LCD module/GLO U	50%	59%	66%	66%
Integrated circuit, IC, logic type, at plant/GLO U	22%	11%	10%	10%
Printed wiring board, mixed mounted, unspec., solder mix, at plant/GLO U	17%	11%	9%	9%
Backlight, LCD screen, at plant/GLO U	6%	11%	9%	8%
Sputtering, ITO, for LCD/RER U	1%	2%	2%	2%
LCD glass, at plant/GLO U	1%	2%	2%	2%
Chromium steel 18/8, at plant/RER U	1%	1%	1%	1%
Others	1%	2%	2%	2%
Total impact, in absolute value	1.37E+05	5.43E+02	5.33E+01	5.33E+01

8.5.16 LCD screen, at plant

- Dataset update and creation category: Additional model required with assumptions; alternatively, use existing references
- Unit process description:

All materials used to assemble LCD panels are derived from the original technical study (Socolof et al., 2005). According to recent LCD panel market statistics (TrendForce, 2020), the largest producers by global volume are China (50%), Taiwan (30%) and Korea (20%). As a result, the electricity mix will be adjusted with a more granular share according to the market share of the three manufacturing regions. The improvement of energy efficiency in terms of heat and electricity is also applied to LCD screen production (Cantini et al., 2022).

The resulting unit process for "Assembly, LCD screen" is shown in Table 8.5-31, whereas the life cycle impact assessment results are presented in Figure 8.5-16.

Table 8.5-31. Life cycle inventory for Assembly, LCD screen and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
LCD screen, at plant/kg/GLO U	1	kg				
Input						
Water, unspecified natural origin/m3	0.072	m3	in water	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetic acid, 98% in H2O, at plant/RER U	0.00042667	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetone, liquid, at plant/RER U	0.00068667	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Aluminium sulphate, powder, at plant/RER U	0.007	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia, liquid, at regional storehouse/RER U	0.001951	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Argon, crude, liquid, at plant/RER U	0.00052467	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Carbon dioxide liquid, at plant/RER U	2.4933E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chemicals organic, at plant/GLO U	0.040133	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chlorine, liquid, production mix, at plant/RER U	0.0010333	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyclohexanol, at plant/RER U	1.3533E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Dimethyl sulfoxide, at plant/RER U	0.00442	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, at grid/kWh/CN U	1.85856625	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, at grid/kWh/TW U	1.11513975	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
electricity, medium voltage, production KR, at grid/kWh/KR U	0.7434265	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethanol from ethylene, at plant/RER U	0.0009	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
heat, light fuel oil, at industrial furnace 1MW/MJ/RER U	2.4035075	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study

heat, natural gas, at industrial furnace 1MW/MJ/CH U	9.5418	MJ	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrochloric acid, 30% in H2O, at plant/RER U	0.0028733	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
hydrogen fluoride, at plant/kg/GLO U	0.00028067	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen peroxide, 50% in H2O, at plant/RER U	0.0000098	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen, liquid, at plant/RER U	0.0296	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Isopropanol, at plant/RER U	0.023267	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Krypton, gaseous, at regional storage/CH U	0.00000172	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Lime, hydrated, packed, at plant/CH U	0.0092667	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Methyl ethyl ketone, at plant/RER U	0.00000049	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitric acid, 50% in H2O, at plant/RER U	0.00082667	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen, liquid, at plant/RER U	0.39333	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Oxygen, liquid, at plant/RER U	0.00051667	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphoric acid, industrial grade, 85% in H2O, at plant/RER U	0.0026333	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Propylene glycol, liquid, at plant/RER U	0.0013373	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	0.023933	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sulphuric acid, liquid, at plant/RER U	0.015267	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
transport, freight, rail/tkm/RER U	0.3362	tkm	Lognormal	2.24	(4,5,4,4,3,5); standard values
transport, freight, lorry, fleet average/tkm/RER U	1.581	tkm	Lognormal	2.24	(4,5,4,4,3,5); standard values
Xylene, at plant/RER U	0.00010467	kg	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Printed wiring board mounting plant/p/GLO/I U	0.000000208	p	Lognormal	3.18	(4,5,4,3,1,5); Estimation, based on PWB mounting plant

transport, transoceanic freight ship/tkm/OCE U	0.78336	tkm		Lognormal	2.24	(4,5,4,4,3,5); rough estimation
Output						
Emissions to air						
Acetic acid	9.0667E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetone	0.0000124	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia	0.0041533	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Tetramethyl ammonium hydroxide	0.042867	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Sulfur hexafluoride	7.1485E-06	kg	high. pop.	Lognormal	1.89	(3,3,4,1,4,5); tier 2b default emission factor according to IPCC guidelines
Sodium tetrahydroborate	0.0011867	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphoric acid	3.2333E-06	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphine	0.0041733	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
NMVOC, non-methane volatile organic compounds, unspecified origin	0.00712	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen oxides	1.7933E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen fluoride	1.7874E-06	kg	high. pop.	Lognormal	1.89	(3,3,4,1,4,5); tier 2b default emission factor according to IPCC guidelines
Hydrogen	8.8667E-06	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen fluoride	0.0034733	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen chloride	0.00404	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, waste	17.267	MJ	high. pop.	Lognormal	1.93	(4,3,4,3,4,5); Calculated from electricity input
Diethylene glycol	0.00000646	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyclohexane	3.2333E-06	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study

Boron trifluoride	0.000612	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Boric acid	9.1333E-08	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Emissions to water						
Antimony	7.6E-09	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Arsenic	7.6E-09	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
BOD5, Biological Oxygen Demand	0.00116	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Boron	3.0533E-07	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Cadmium	7.6E-09	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium VI	1.5267E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium	5.8933E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
COD, Chemical Oxygen Demand	0.00017867	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Copper	6.12E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyanide	2.44E-07	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethane, 1,1,1-trichloro-, HCFC-140	1.5267E-09	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Fluoride	0.00085333	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrocarbons, aromatic	0.0000392	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Iron	1.7533E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Lead	4.1133E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Manganese	1.5267E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Mercury	6.46E-09	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study

Nickel	1.5267E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen	0.0052867	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Oils, unspecified	1.3467E-05	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Phenol	1.5267E-08	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphate	1.5267E-08	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphorus	0.00028733	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Solids, inorganic	0.00050333	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Waste to treatment						
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.0054	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, refinery sludge, 89.5% water, to hazardous waste incineration/CH U	0.00206	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, sludge, NaCl electrolysis, 0% water, to residual material landfill/CH U	0.00382	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.22347	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, used mineral oil, 10% water, to hazardous waste incineration/CH U	0.0010733	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Treatment, LCD module production effluent, to wastewater treatment, class 2/CH U	0.095667	m3		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study
Disposal, treatment of printed wiring boards/GLO U	0.001	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process

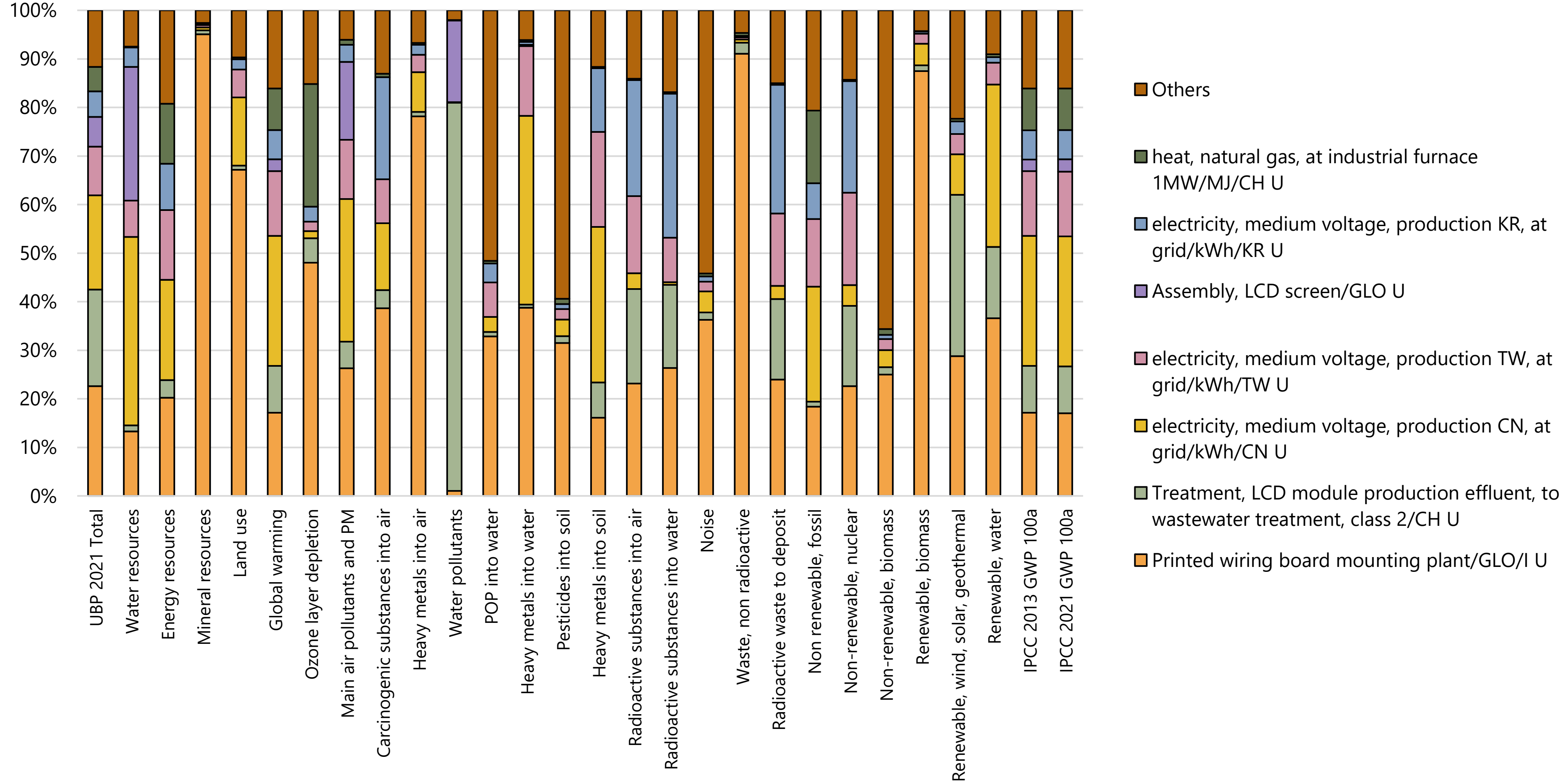

Figure 8.5-16. Contribution analysis presented in bar chart for: Assembly, LCD screen. FU = 1 kg

Table 8.5-32. Contribution analysis presented in table for: LCD screen, at plant. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board mounting plant/p/GLO/I U	23%	18%	17%	17%
Treatment, LCD module production effluent, to wastewater treatment, class 2/CH U	20%	1%	10%	10%
electricity, medium voltage, at grid/kWh/CN U	19%	24%	27%	27%
electricity, medium voltage, at grid/kWh/TW U	10%	14%	13%	13%
Assembly, LCD screen/kg/GLO U	6%	0%	2%	3%
electricity, medium voltage, production KR, at grid/kWh/KR U	5%	7%	6%	6%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	5%	15%	9%	9%
Others	12%	21%	16%	16%
Total impact, in absolute value	**1.67E+04**	**7.75E+01**	**8.29E+00**	**8.28E+00**

8.5.17 LCD flat screen, 17 inches

- Dataset update and creation category: LCI and technical data available
- Unit process description:

The bill of materials data is taken from two relevant technical publications for flat panel LCD monitors, consisting of electronics (circuit boards), chassis, and LCD modules (Babbitt et al., 2020; Teehan & Kandlikar, 2013). However, the input flows to the inventory are adjusted linearly for the 17-inch screen, as data are available in the literature for both smaller and larger screen sizes. The screen datasets also include the updated electronics datasets, such as LCD modules and PCBs, which are described separately in the other sections.

The resulting unit process for "LCD flat screen, 17 inches" is shown in Table 8.5-33, whereas the life cycle impact assessment results are presented in Figure 8.5-17 and Table 8.5-34.

Table 8.5-33. Life cycle inventory for LCD flat screen, 17 inches and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
LCD flat screen, 17 inches, at plant/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	1.34	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
aluminium, production mix, at plant/kg/RER U	0.29	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Assembly, LCD screen/kg/GLO U	4.711	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Chromium steel 18/8, at plant/RER U	0.0066	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Injection moulding/RER U	1.34	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
LCD module, at plant/kg/GLO U	1.858	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Polystyrene, expandable, at plant/RER U	0.675	kg		Lognormal	1.32	(4,4,2,1,1,5); own calculation, based on internet survey from current models
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.207	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Section bar extrusion, aluminium/RER U	0.145	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Sheet rolling, aluminium/RER U	0.145	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013
Synthetic rubber, at plant/RER U	0.0141	kg		Lognormal	1.22	(1,3,2,1,1,5); data from European Research project (about LCD disposal) & now updated using disassembly data from Babbit et al 2020 and Teehan 2013

Whitelined chipboard, WLC, at plant/RER U	0.825	kg	Lognormal	1.32	(4,4,2,1,1,5); own calculation, based on internet survey from current models

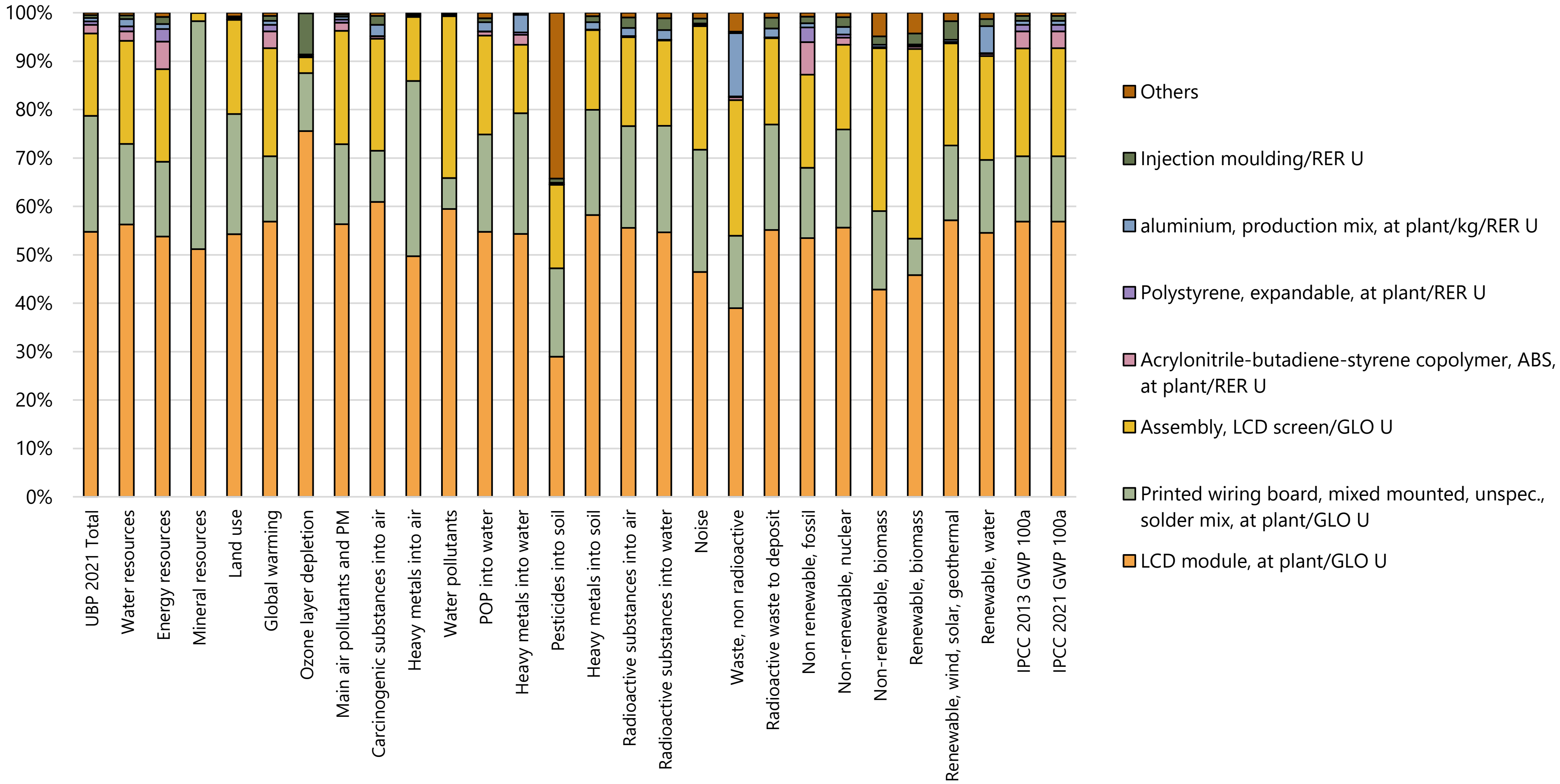

Figure 8.5-17. Contribution analysis presented in bar chart for: LCD flat screen, 17 inches. FU = 1 unit

Table 8.5-34. Contribution analysis presented in table for: LCD flat screen, 17 inches. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
LCD module, at plant/kg/GLO U	55%	53%	57%	57%
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	24%	15%	13%	13%
Assembly, LCD screen/kg/GLO U	17%	19%	22%	22%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	2%	7%	3%	3%
Polystyrene, expandable, at plant/RER U	1%	3%	1%	1%
aluminium, production mix, at plant/kg/RER U	1%	1%	1%	1%
Injection moulding/RER U	1%	1%	1%	1%
Others	0%	1%	1%	1%
Total impact, in absolute value	**4.62E+05**	**1.89E+03**	**1.74E+02**	**1.74E+02**

8.5.18 Battery, Li-Ion, $LiMn_2O_4$ (LMO), rechargeable, prismatic

Even though LMO batteries are an improvement of the previously known NiMH batteries (Notter et al., 2010), they are not very popular nowadays due to their durability and energy capacity characteristics (Crenna et al., 2021; Raugei & Winfield, 2019). It should be noted that batteries of the LMO or LiMn2O4 type are leaving the market and are being replaced by other types of batteries, such as batteries of the NMC type. Therefore, these most common Li-ion batteries are created instead to replace the original LMO battery. For these reasons, there will be no update of the LMO battery dataset.

8.5.19 Battery, NiMH, rechargeable, prismatic

It is observed that NiMH batteries, although rechargeable, are losing market competitiveness for small, highly portable devices according to battery market information (Analog Devices, 2006; CNET, 2008). One of the main reasons is that the battery can suffer significantly from the dreaded memory effect and has moderate self-discharging (Sasaki et al., 2013). NiMH batteries gradually lose usable capacity if they are repeatedly recharged after being partially discharged. For these reasons, there will be no update of the NiMH battery dataset.

8.5.20 Battery, Li-Ion, NMC111, rechargeable, prismatic and the associated battery components

In recent years, Nickel-Manganese-Cobalt or NMC type batteries are emerging and more popularly used not only for the electric vehicles application, but also for the portable electronic devices (Blomgren, 2016; dos Reis et al., 2021; Liang et al., 2019). Based on personal communications with internal Empa experts and recent disassembly activities of smartphones at the laboratory, NMC-111 batteries are identified to be commonly used in laptops and smartphones. Accordingly, the share of NMC-based batteries are found to be more common in both recent smartphones and tablets according to the JRC report on personal mobile devices, which was recorded to take more than 60% market shares (Tecchio et al., 2018).

Recently, a study was conducted by (Crenna et al., 2021) and (Ellingsen et al., 2014), which provided life cycle inventory for the NMC type batteries based on the studies of (Dai et al., 2018, 2019). The process-based inventory was also integrated in the ecoinvent 3.8 database (Wernet et al., 2016). It is important to note that the same collection of literature, specifically the study of (Dai et al., 2019), was used to develop life cycle inventory of batteries in electric vehicles in the recent study of (Sacchi et al., 2022). The other components are also created as 8 separate datasets, including: battery management system, cell, cathode, anode, foils, hydroxide, and oxide. Some datasets for batteries are already available in the UVEK LCA database and can be used to form the NMC111 battery.

Table 8.5-35. Life cycle inventory for battery, Li-ion, NMC111, rechargeable, prismatic and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	1	kg				
Input						
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.13653	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Battery cell, Li-ion, NMC111/GLO U	0.72591	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
battery-managment-system, at plant/RAS U	0.02424	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Battery module packaging, Li-ion/GLO U	0.0549	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Copper, primary, at refinery/GLO U	0.00055	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Electronic component, passive, unspecified, at plant/kg/GLO U	0.0043	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.00028	kWh		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Ethylene glycol, at plant/RER U	0.02151	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Glass fibre reinforced plastic, polyamide, injection moulding, at plant/RER U	0.00018	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Cold impact extrusion, aluminium, 1 stroke/RER U	0.135314883	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Injection moulding/RER U	0.00419	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Metal working factory/RER/I U	1.41414E-09	p		Lognormal	3.05	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Polyethylene, HDPE, granulate, at plant/RER U	0.00419	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
reinforcing steel, at plant/kg/RER U	0.00618	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Sheet rolling, aluminium/RER U	0.001215117	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Sheet rolling, copper/RER U	0.00055	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
Sheet rolling, steel/RER U	0.00618	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
tap water, at user/kg/RER U	0.02151	kg		Lognormal	1.23	(2,3,2,3,1,5) Literature, Crenna et al (2021).
transport, freight, rail/tkm/RER U	0.0153	tkm		Lognormal	2.06	(2,3,2,3,1,5) Literature, Crenna et al (2021).
transport, freight, light commercial vehicle/tkm/RER U	0.0096	tkm		Lognormal	2.06	(2,3,2,3,1,5) Literature, Crenna et al (2021).
transport, freight, lorry, fleet average/tkm/RER U	0.31	tkm		Lognormal	2.06	(2,3,2,3,1,5) Literature, Crenna et al (2021).
transport, transoceanic freight ship/tkm/OCE U	0.7368	tkm		Lognormal	2.06	(2,3,2,3,1,5) Literature, Crenna et al (2021).

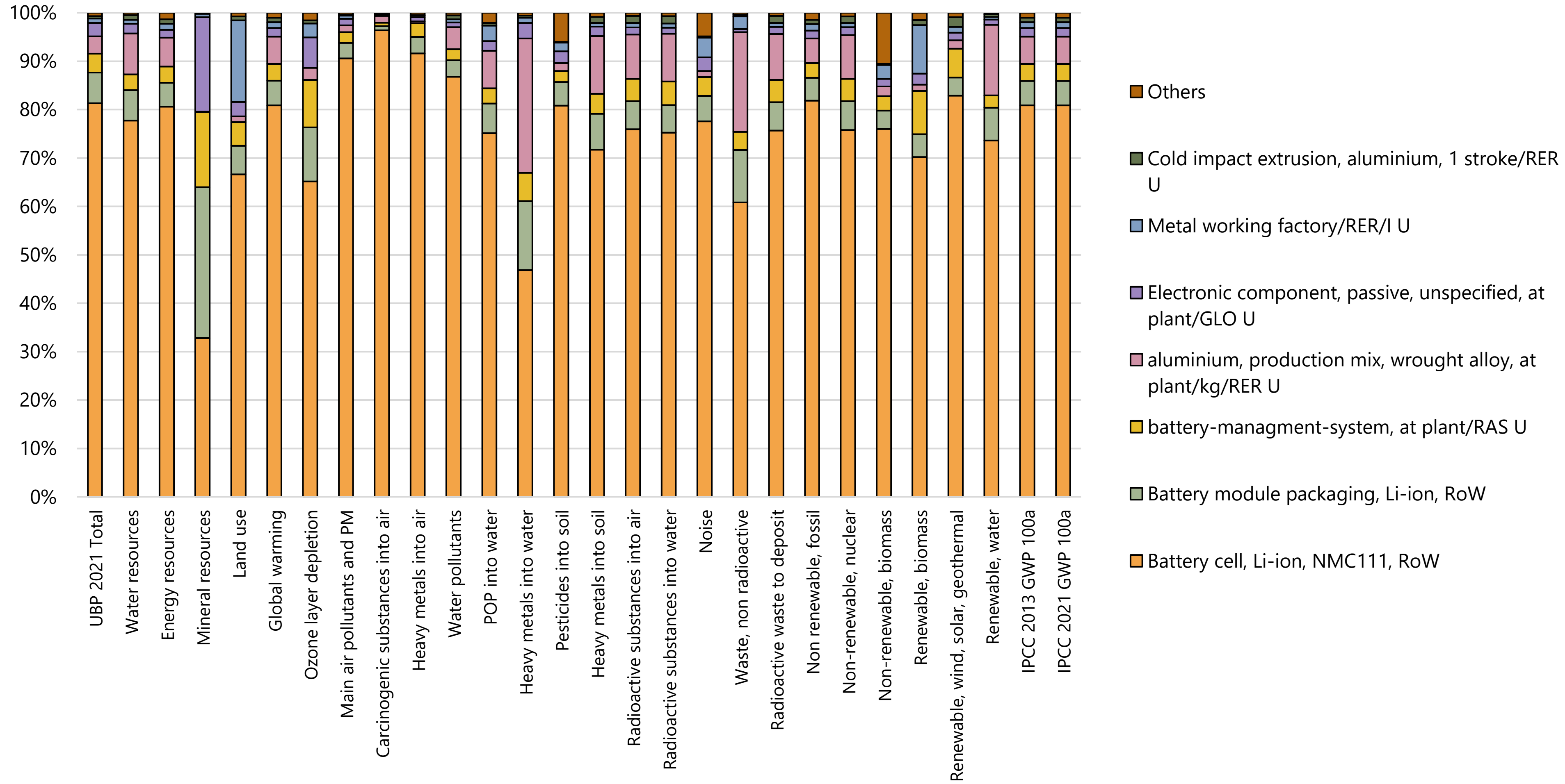

Figure 8.5-18. Contribution analysis presented in bar chart for: battery, Li-ion, NMC111, rechargeable, prismatic. FU = 1 kg

Table 8.5-36. Contribution analysis presented in table for: battery, Li-ion, NMC111, rechargeable, prismatic. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Battery cell, Li-ion, NMC111/kg/GLO U	81%	82%	81%	81%
Battery module packaging, Li-ion /kg/GLO U	6%	5%	5%	5%
battery-managment-system, at plant/RAS U	4%	3%	3%	3%
aluminium, production mix, wrought alloy, at plant/kg/RER U	4%	5%	6%	6%
Electronic component, passive, unspecified, at plant/kg/GLO U	3%	2%	2%	2%
Metal working factory/RER/I U	1%	1%	1%	1%
Cold impact extrusion, aluminium, 1 stroke/RER U	0%	1%	1%	1%
Others	1%	1%	1%	1%
Total impact, in absolute value	**3.96E+04**	**1.62E+02**	**1.26E+01**	**1.26E+01**

Table 8.5-37. Life cycle inventory for Battery cell, Li-ion, NMC111 and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Battery cell, Li-ion, NMC111/kg/GLO U	1	kg				
Input						
aluminium collector foil production, for Li-ion battery/GLO U	0.03	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.0283	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Anode, graphite, for Li-ion battery/GLO U	0.2	kg		Lognormal	1.26	(2,2,3,4,2,5); Ellingsen, 2014 supp. Info. and Crenna, 2021
separator, lithium-ion battery, at plant/RAS U	0.02	kg		Lognormal	1.26	(2,2,3,4,2,5); Ellingsen, 2014 supp. Info. and Crenna, 2021
cathode, lithium-ion battery, NMC111/GLO U	0.41	kg		Lognormal	1.26	(2,2,3,4,2,5); Ellingsen, 2014 supp. Info. and Crenna, 2021
Chemical plant, organics/RER/I U	4E-10	p		Lognormal	3.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
copper collector foil production, for Li-ion battery/GLO U	0.12	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Copper, primary, at refinery/GLO U	0.0335	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
district heat, at consumer, natural gas in industrial furnace 1MW/MJ/CH U	12.51	MJ		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
electrolyte, LiPF6, at plant/RAS U	0.146	kg		Lognormal	1.26	(2,2,3,4,2,5); Ellingsen, 2014 supporting information
electricity, medium voltage, production Eastern Asia, at grid/RAS U	1.1875	kWh		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Extrusion, plastic film/RER U	0.0041	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.00283	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Polypropylene, granulate, at plant/RER U	0.0013	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Sheet rolling, aluminium/RER U	0.0283	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Sheet rolling, copper/RER U	0.0335	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
transport, freight, rail/tkm/RER U	0.0153	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI
transport, freight, light commercial vehicle/tkm/RER U	0.0096	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI
transport, freight, lorry, fleet average/tkm/RER U	0.31	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI
transport, transoceanic container ship/OCE U	0.7368	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI
Output						
Emissions to air						
Heat, waste	100	MJ	high. pop.	Lognormal	1.26	(2,2,3,4,2,5); Ellingsen, 2014 supporting information

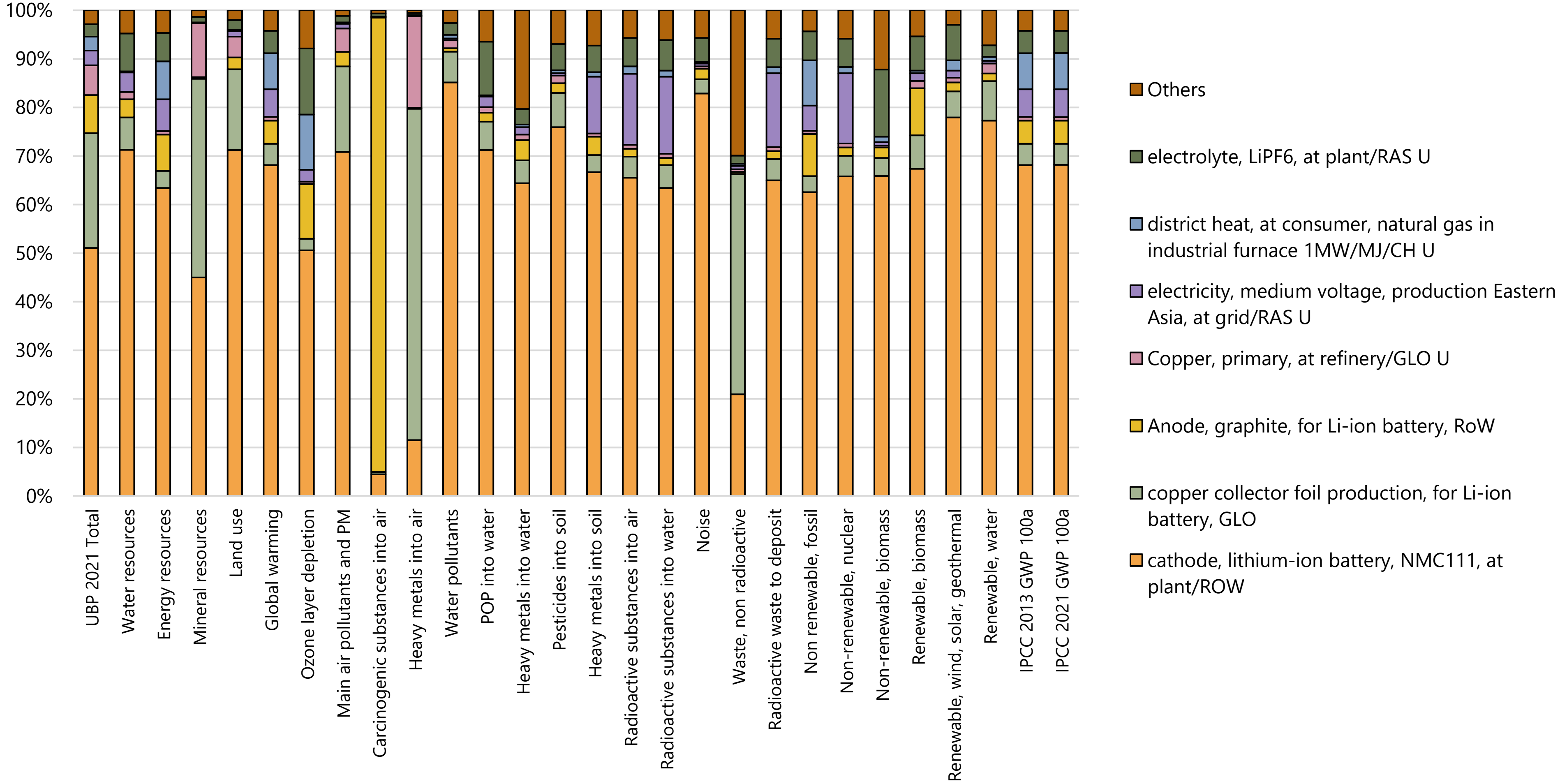

Figure 8.5-19. Contribution analysis presented in bar chart for: Battery cell, Li-ion, NMC111. FU = 1 kg

Table 8.5-38. Contribution analysis presented in table for: Battery cell, Li-ion, NMC111. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
cathode, lithium-ion battery, NMC111, at plant/ROW	51%	63%	68%	68%
copper collector foil production, for Li-ion battery, GLO	24%	3%	4%	4%
Anode, graphite, for Li-ion battery, RoW	8%	9%	5%	5%
Copper, primary, at refinery/GLO U	6%	1%	1%	1%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	3%	5%	6%	6%
district heat, at consumer, natural gas in industrial furnace 1MW/MJ/CH U	3%	9%	7%	7%
electrolyte, LiPF6, at plant/RAS U	3%	6%	5%	5%
Others	3%	4%	4%	4%
Total impact, in absolute value	**4.44E+04**	**1.83E+02**	**1.41E+01**	**1.40E+01**

Table 8.5-39. Life cycle inventory for aluminium collector foil production and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Aluminium collector foil production, for Li-ion battery/kg/GLO U	1	kg				
Input						
Aluminium casting, plant/RER/I U	1.5E-10	p		Lognormal	1.60	(2,4,3,4,4,5) Proxy for factory.
aluminium, production mix, wrought alloy, at plant/kg/RER U	1	kg		Lognormal	1.60	(2,4,3,4,4,5)
Sheet rolling, aluminium/RER U	1	kg		Lognormal	1.60	(2,4,3,4,4,5)
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	0.333333333	kg		Lognormal	1.60	(2,4,3,4,4,5)
Sulphuric acid, liquid, at plant/RER U	0.206666667	kg		Lognormal	1.60	(2,4,3,4,4,5)
transport, freight, rail/tkm/RER U	0.0153	tkm		Lognormal	2.34	(1,1,4,5,4,5)
transport, aircraft, freight/tkm/RER U	0.0623	tkm		Lognormal	2.34	(1,1,4,5,4,5)
transport, freight, light commercial vehicle/tkm/RER U	0.0096	tkm		Lognormal	2.34	(1,1,4,5,4,5)
transport, freight, lorry, fleet average/tkm/RER U	0.31	tkm		Lognormal	2.34	(1,1,4,5,4,5)
transport, transoceanic container ship/OCE U	1.112	tkm		Lognormal	2.34	(1,1,4,5,4,5)
Output						
Waste to treatment						
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.54	kg		Lognormal	1.60	(2,4,3,4,4,5)

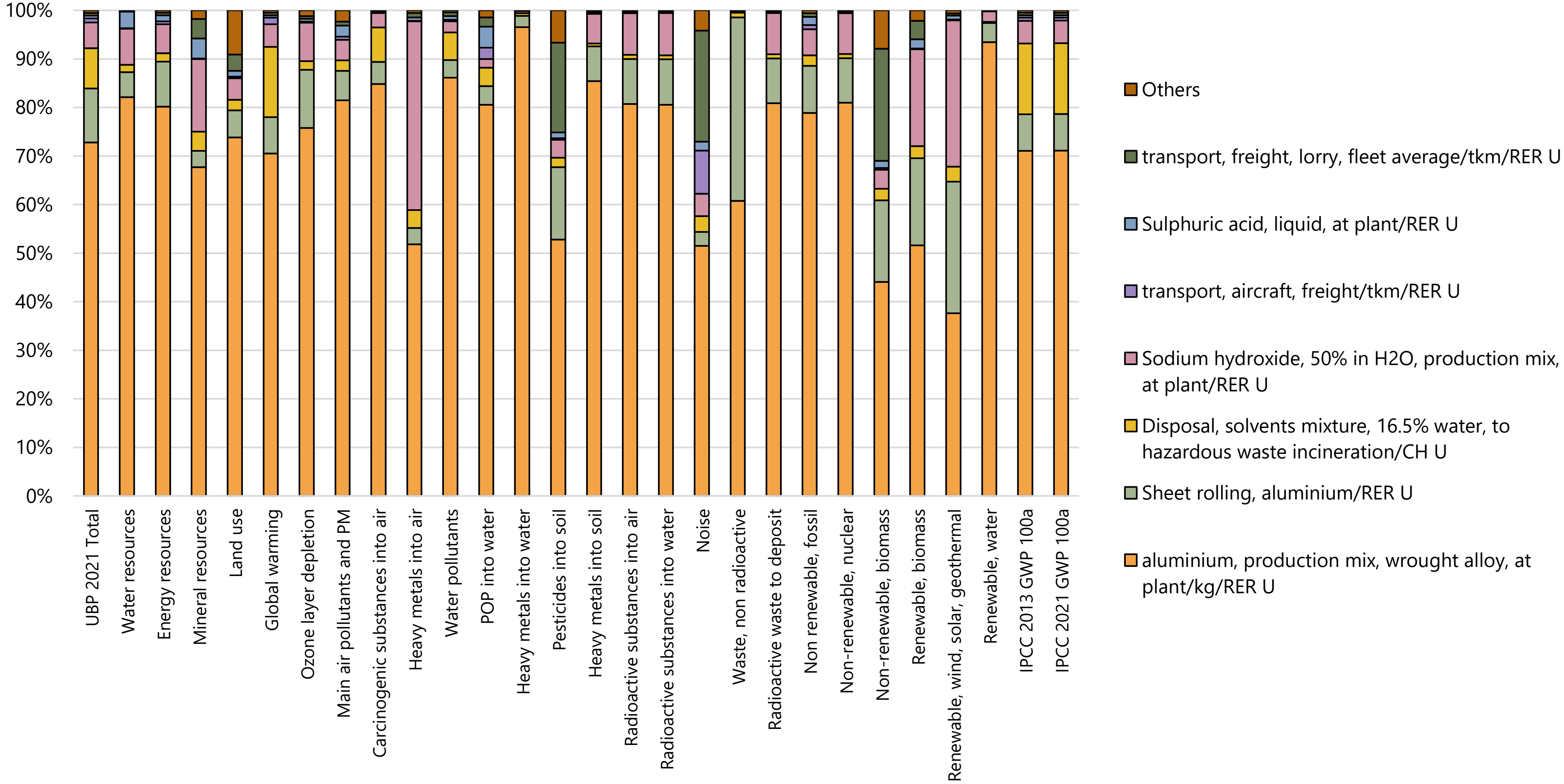

Figure 8.5-20. Contribution analysis presented in bar chart for: aluminium collector foil production, for Li-ion battery. FU = 1 kg

Table 8.5-40. Contribution analysis presented in table for: aluminium collector foil production, for Li-ion battery. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
aluminium, production mix, wrought alloy, at plant/kg/RER U	73%	79%	71%	71%
Sheet rolling, aluminium/RER U	11%	10%	8%	8%
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	8%	2%	15%	15%
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	5%	5%	5%	5%
transport, aircraft, freight/tkm/RER U	1%	1%	1%	1%
Sulphuric acid, liquid, at plant/RER U	1%	2%	0%	0%
transport, freight, lorry, fleet average/tkm/RER U	1%	1%	1%	1%
Others	1%	1%	0%	0%
Total impact, in absolute value	**1.43E+04**	**7.63E+01**	**7.34E+00**	**7.35E+00**

Table 8.5-41. Life cycle inventory for cathode, lithium-ion battery, NMC111 and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Cathode, lithium-ion battery, NMC111/kg/GLO U	1	kg				
Input						
Carbon black, at plant/GLO U	0.025	kg	Lognormal	1.23		(2,2,1,4,2,5); Literature Crenna et al. (2021).
Chemical plant, organics/RER/I U	4E-10	p	Lognormal	3.06		(2,2,1,4,2,5); Literature Crenna et al. (2021).
N-methyl-2-pyrrolidone, at plant/RER U	0.0056	kg	Lognormal	1.26		(2,2,3,4,2,5); Ellingsen, 2014 supporting information
oxide, for Li-ion NMC111 battery/GLO U	0.95	kg	Lognormal	1.23		(2,2,1,4,2,5); Literature Crenna et al. (2021).
polyvinylfluoride, at plant/kg/US U	0.025	kg	Lognormal	1.23		(2,2,1,4,2,5); Literature Crenna et al. (2021).
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.44058	kWh	Lognormal	1.23		(2,2,1,4,2,5); Literature Crenna et al. (2021).
heat, natural gas, at industrial furnace 1MW/MJ/CH U	25.864	MJ	Lognormal	1.23		(2,2,1,4,2,5); Literature Crenna et al. (2021).
transport, freight, rail/tkm/RER U	0.015	tkm	Lognormal	2.06		(2,2,1,4,2,5); Literature Crenna et al. (2021).
transport, freight, lorry, fleet average/tkm/RER U	0.32	tkm	Lognormal	2.06		(2,2,1,4,2,5); Literature Crenna et al. (2021).
transport, transoceanic container ship/OCE U	1.12	tkm	Lognormal	2.06		(2,2,1,4,2,5); Literature Crenna et al. (2021).
Output						
Emissions to air						
1-Methyl-2-pyrrolidinone		0.0056	kg	Lognormal	1.63	(2,3,1,4,3,5);

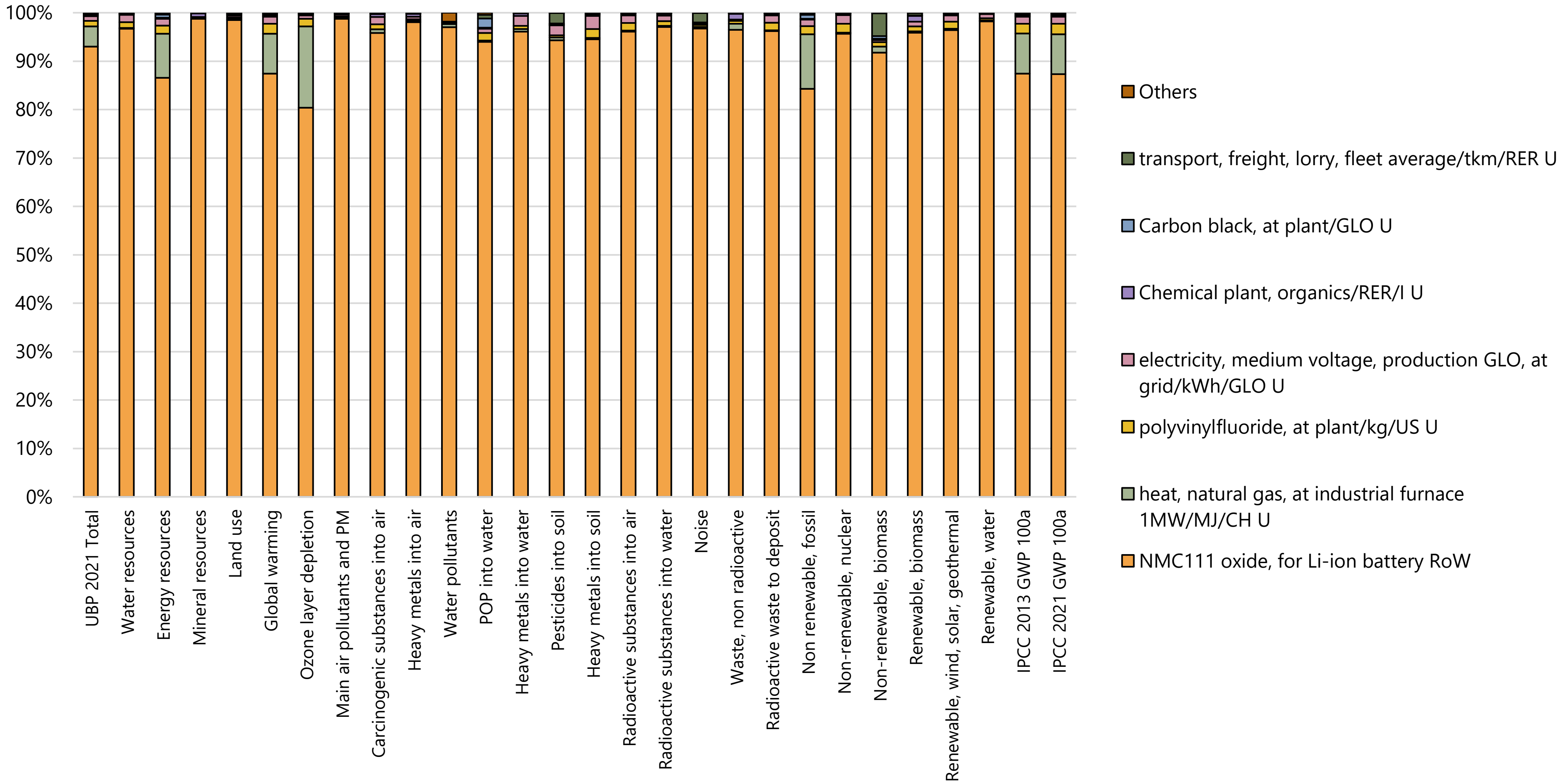

Figure 8.5-21. Contribution analysis presented in bar chart for: cathode, lithium-ion battery, NMC111. FU = 1 kg

Table 8.5-42. Contribution analysis presented in table for: cathode, lithium-ion battery, NMC111. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
NMC111 oxide, for Li-ion battery RoW	93%	84%	87%	87%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	4%	11%	8%	8%
polyvinylfluoride, at plant/kg/US U	1%	2%	2%	2%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1%	1%	1%	1%
Chemical plant, organics/RER/I U	0%	0%	0%	0%
Carbon black, at plant/GLO U	0%	1%	0%	0%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**5.53E+04**	**2.79E+02**	**2.34E+01**	**2.34E+01**

Table 8.5-43. Life cycle inventory for copper collector foil production, for Li-ion battery and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Copper collector foil production, for Li-ion battery/kg/GLO U	1	kg				
Input						
Copper, primary, at refinery/GLO U	1	kg		Lognormal	1.65	(3,4,4,4,4,5)
Metal working factory/RER/I U	4.58E-10	p		Lognormal	3.35	(3,4,4,4,4,5)Proxy for factory.
Sheet rolling, copper/RER U	1	kg		Lognormal	1.65	(3,4,4,4,4,5)
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	0.333333333	kg		Lognormal	1.65	(3,4,4,4,4,5)
Sulphuric acid, liquid, at plant/RER U	0.206666667	kg		Lognormal	1.65	(3,4,4,4,4,5)
transport, freight, rail/tkm/RER U	0.0153	tkm		Lognormal	2.34	(2,4,4,4,4,5)
transport, aircraft, freight/tkm/RER U	0.0623	tkm		Lognormal	2.34	(3,4,4,4,4,5)
transport, freight, light commercial vehicle/tkm/RER U	0.0096	tkm		Lognormal	2.34	(3,4,4,4,4,5)
transport, freight, lorry, fleet average/tkm/RER U	0.31	tkm		Lognormal	2.34	(3,4,4,4,4,5)
transport, transoceanic container ship/OCE U	1.112	tkm		Lognormal	2.34	(3,4,4,4,4,5)
Output						
Waste to treatment						
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	0.54	kg		Lognormal	1.65	(3,4,4,4,4,5)

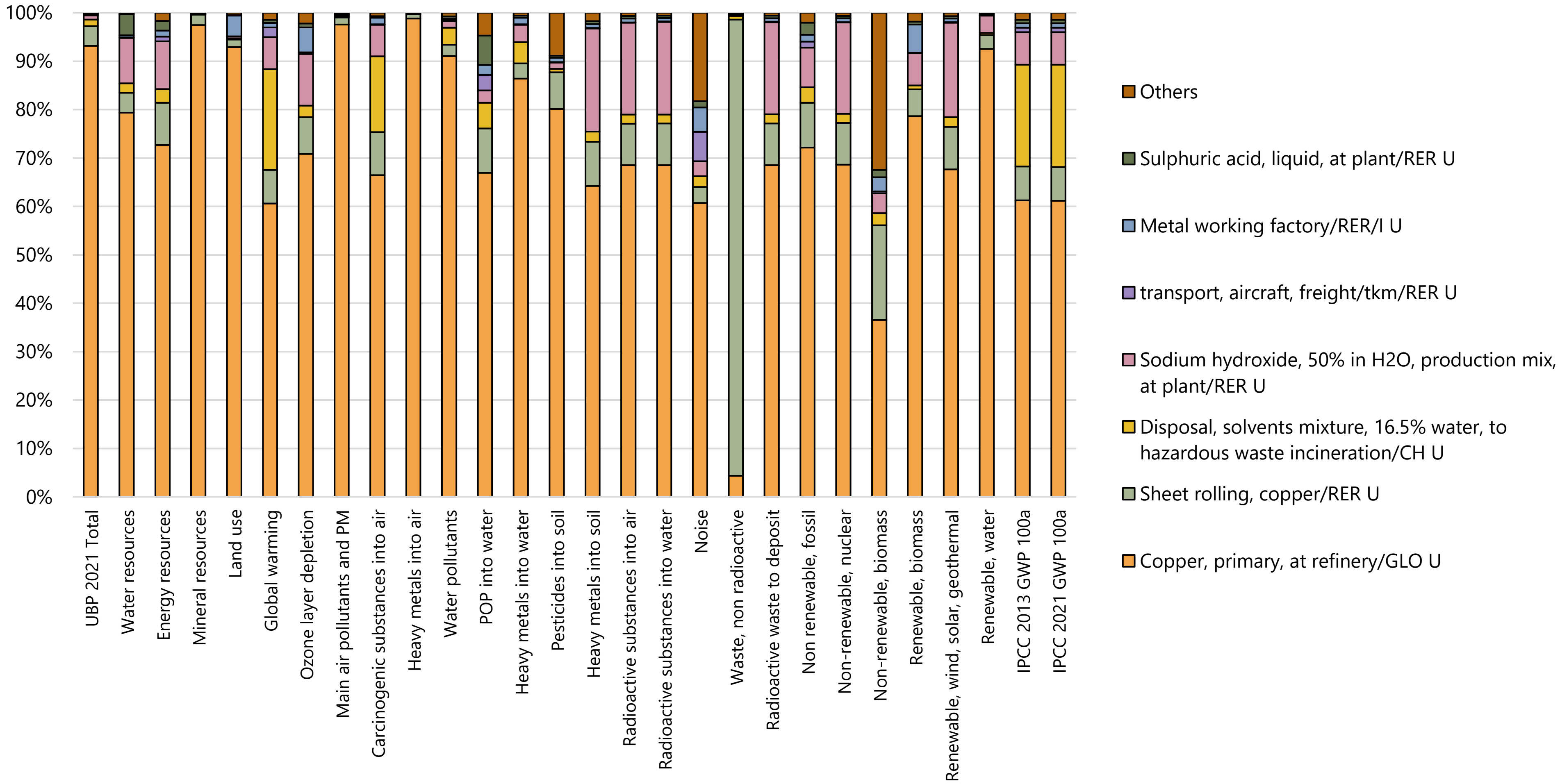

Figure 8.5-22. Contribution analysis presented in bar chart for: copper collector foil production. FU = 1 kg

Table 8.5-44. Contribution analysis presented in table for: oxide, for Li-ion NMC111 battery. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	93%	72%	61%	61%
Sheet rolling, copper/RER U	4%	9%	7%	7%
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration/CH U	1%	3%	21%	21%
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	1%	8%	7%	7%
transport, aircraft, freight/tkm/RER U	0%	1%	1%	1%
Metal working factory/RER/I U	0%	1%	1%	1%
Sulphuric acid, liquid, at plant/RER U	0%	3%	1%	1%
Others	0%	2%	1%	1%
Total impact, in absolute value	**8.76E+04**	**5.05E+01**	**5.10E+00**	**5.07E+00**

Table 8.5-45. Life cycle inventory for oxide, for Li-ion NMC111 battery and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Oxide, for Li-ion NMC111 battery/kg/GLO U	1	kg				
Input						
Chemical plant, organics/RER/I U	7.41E-10	p		Lognormal	3.06	(3,3,1,4,1,5); Literature. Crenna et al (2021).
Lithium carbonate, at plant/GLO U	0.383	kg		Lognormal	1.25	(3,3,1,4,1,5); Literature. Crenna et al (2021).
hydroxide, for Li-ion NMC111 battery/GLO U	0.949	kg		Lognormal	1.25	(3,3,1,4,1,5); Literature. Crenna et al (2021).
electricity, medium voltage, production GLO, at grid/kWh/GLO U	6.87369	kWh		Lognormal	1.25	(3,3,1,4,1,5); Literature. Crenna et al (2021).
transport, freight, rail/tkm/RER U	0.309	tkm		Lognormal	2.07	(3,3,1,4,1,5);
transport, freight, lorry, fleet average/tkm/RER U	0.025	tkm		Lognormal	2.07	(3,3,1,4,1,5);
transport, barge/tkm/RER U	0.209	tkm		Lognormal	2.07	(3,3,1,4,1,5);
transport, transoceanic container ship/OCE U	0.599	tkm		Lognormal	2.07	(3,3,1,4,1,5);
Output						
Emissions to air						
Carbon dioxide, fossil	0.207	kg		Lognormal	1.58	(3,3,1,4,1,5); Literature. Crenna et al (2021).
Water/m3	0.00012504	m3	low. pop.	Lognormal	2.79	(5,5,5,5,5,5); Literature. Crenna et al (2021).

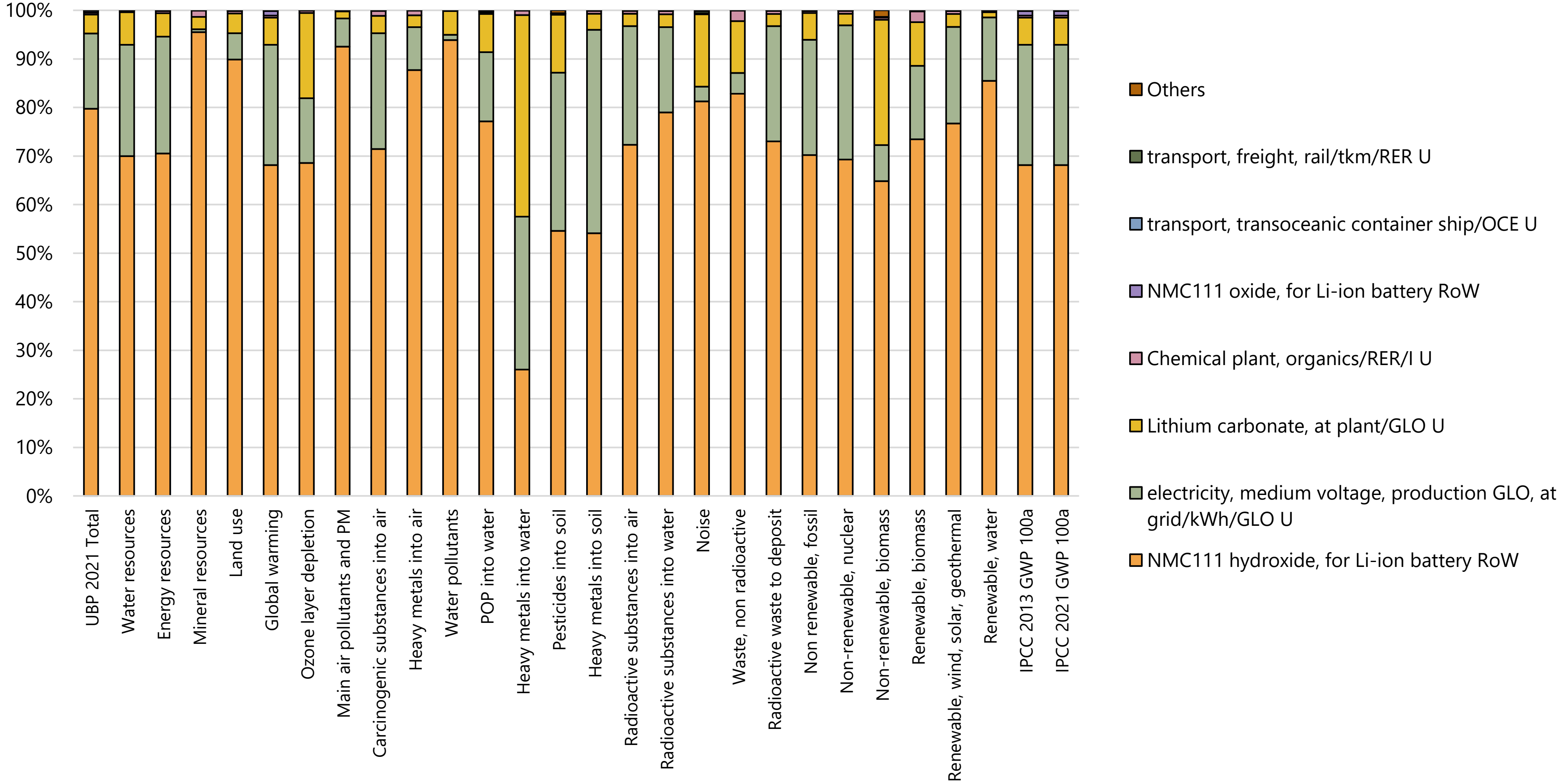

Figure 8.5-23. Contribution analysis presented in bar chart for: oxide, for Li-ion NMC111 battery. FU = 1 kg

Table 8.5-46. Contribution analysis presented in table for: oxide, for Li-ion NMC111 battery. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
NMC111 hydroxide, for Li-ion battery RoW	80%	70%	68%	68%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	16%	24%	25%	25%
Lithium carbonate, at plant/GLO U	4%	6%	6%	6%
Chemical plant, organics/RER/I U	0%	0%	0%	0%
Oxide, for Li-ion NMC111 battery/kg/GLO U	0%	0%	1%	1%
transport, transoceanic container ship/OCE U	0%	0%	0%	0%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
Others	0%	0%	0%	0%
Total impact, in absolute value	**5.41E+04**	**2.48E+02**	**2.16E+01**	**2.15E+01**

Table 8.5-47. Life cycle inventory for hydroxide, for Li-ion NMC111 battery and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Hydroxide, for Li-ion NMC111 battery/kg/GLO U	1	kg				
Input						
Water, cooling, unspecified natural origin, RoW	0.00061963	m3		Lognormal	1.16	
Ammonia, liquid, at regional storehouse/RER U	0.0058765	kg		Lognormal	1.14	(3,3,1,4,1,5); Literature, Crenna et al. (2021)
Chemical plant, organics/RER/I U	7.194E-10	p		Lognormal	3.02	(3,3,1,4,1,5); Literature, Crenna et al. (2021)
Cobalt, at plant/GLO U	0.547928333	kg		Lognormal	1.14	(3,3,1,4,1,5); Literature, Crenna et al. (2021) - proxy to cobalt sulfate
Manganese, at regional storage/RER U	0.533822687	kg		Lognormal	1.14	(3,3,1,4,1,5); Literature, Crenna et al. (2021) - proxy to manganese sulfate
Nickel, 99.5%, at plant/GLO U	0.547079873	kg		Lognormal	1.14	(3,3,1,4,1,5); Literature, Crenna et al. (2021) - proxy to nickel sulfate
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	0.86360624	kg		Lognormal	1.14	(3,3,1,4,1,5); Literature, Crenna et al. (2021)
heat, natural gas, at industrial furnace 1MW/MJ/CH U	37.97307113	MJ		Lognormal	1.14	(3,3,1,4,1,5); Literature, Crenna et al. (2021)
transport, barge/tkm/RER U	0.025	tkm		Lognormal	2.02	(3,3,1,4,1,5);
transport, freight, rail/tkm/RER U	0.309	tkm		Lognormal	2.02	(3,3,1,4,1,5);
transport, freight, lorry, fleet average/tkm/RER U	0.209	tkm		Lognormal	2.02	(3,3,1,4,1,5);
transport, transoceanic container ship/OCE U	0.599	tkm		Lognormal	2.02	(3,3,1,4,1,5);
Output						
Emissions to air						
Ammonia	0.0058765	kg		Lognormal	1.58	(3,3,1,4,1,5)
Waste to treatment						
Treatment, sewage, to wastewater treatment, class 3/CH U	0.000619	m3		Lognormal	1.25	(3,3,1,4,1,5); Literature, Crenna et al. (2021)

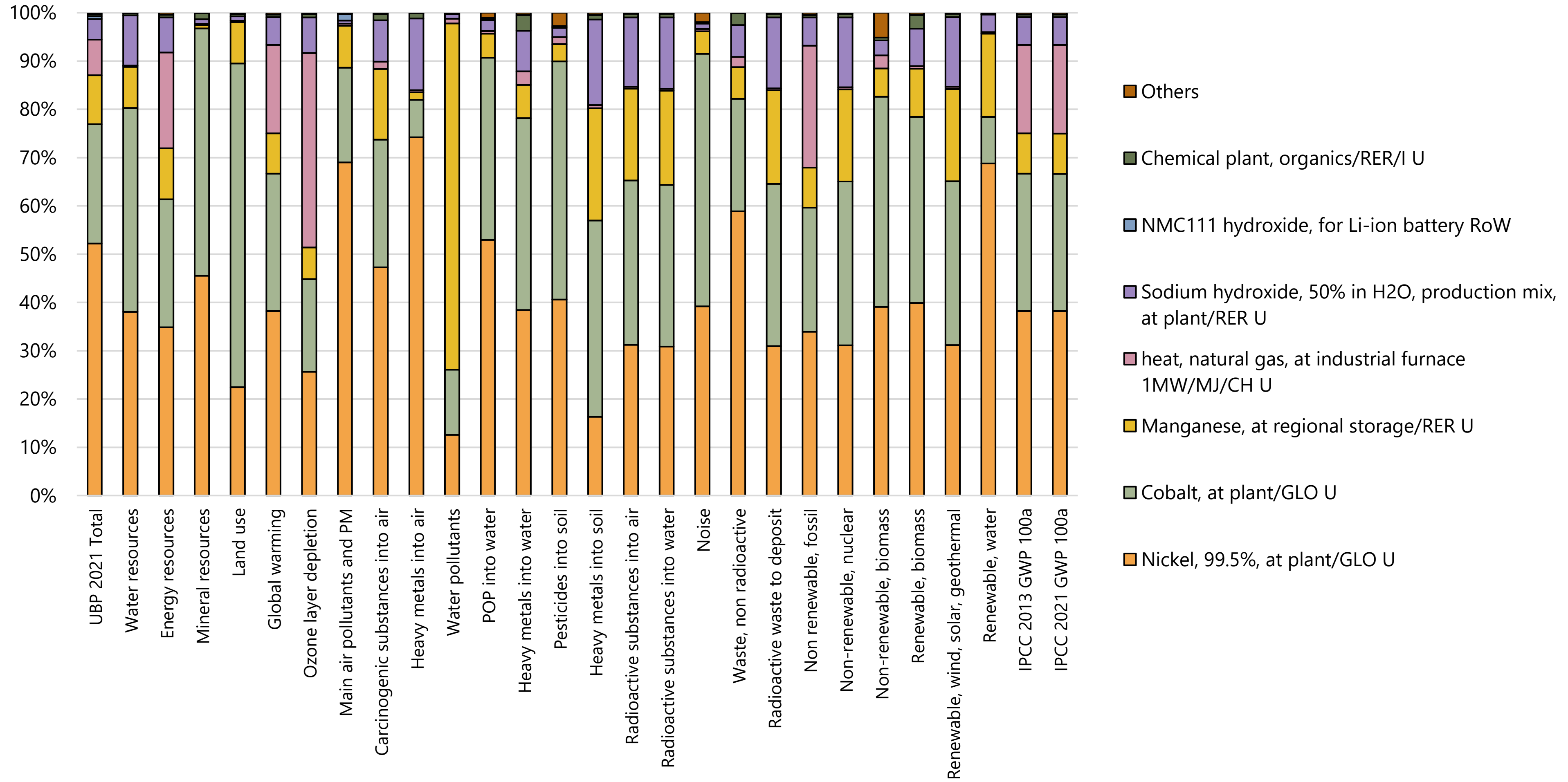

Figure 8.5-24. Contribution analysis presented in bar chart for: hydroxide, for Li-ion NMC111 battery. FU = 1 kg

Table 8.5-48. Contribution analysis presented in table for: hydroxide, for Li-ion NMC111 battery. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Nickel, 99.5%, at plant/GLO U	52%	34%	38%	38%
Cobalt, at plant/GLO U	25%	26%	28%	28%
Manganese, at regional storage/RER U	10%	8%	8%	8%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	7%	25%	18%	18%
Sodium hydroxide, 50% in H2O, production mix, at plant/RER U	4%	6%	6%	6%
Hydroxide, for Li-ion NMC111 battery/kg/GLO U	1%	0%	0%	0%
Chemical plant, organics/RER/I U	0%	1%	1%	1%
Others	0%	0%	0%	0%
Total impact, in absolute value	**4.55E+04**	**1.83E+02**	**1.55E+01**	**1.54E+01**

Table 8.5-49. Life cycle inventory for Battery module packaging, Li-ion and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Battery module packaging, Li-ion/kg/GLO U	1	kg				
Input						
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.796909492	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Copper, primary, at refinery/GLO U	0.047461369	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Electronic component, passive, unspecified, at plant/kg/GLO U	0.123620309	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Extrusion, plastic film/RER U	0.01986755	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Glass fibre reinforced plastic, polyamide, injection moulding, at plant/RER U	0.01214128	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Cold impact extrusion, aluminium, 1 stroke/RER U	0.3598234	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Metal working factory/RER/I U	4.58E-10	p		Lognormal	3.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Polyethylene, HDPE, granulate, at plant/RER U	0.01986755	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
Sheet rolling, aluminium/RER U	0.437086093	kg		Lognormal	1.26	(2,2,3,4,2,5); Ellingsen, 2014 supporting information and Crenna, 2021
Sheet rolling, copper/RER U	0.047461369	kg		Lognormal	1.23	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
transport, freight, rail/tkm/RER U	0.0153	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
transport, freight, lorry 32-40 metric ton, EURO 3/tkm/RER U	0.31	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
transport, aircraft, freight/tkm/RER U	0.0623	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.
transport, transoceanic container ship/OCE U	0.7368	tkm		Lognormal	2.06	(2,2,1,4,2,5); Literature. Crenna, 2021 and SI.

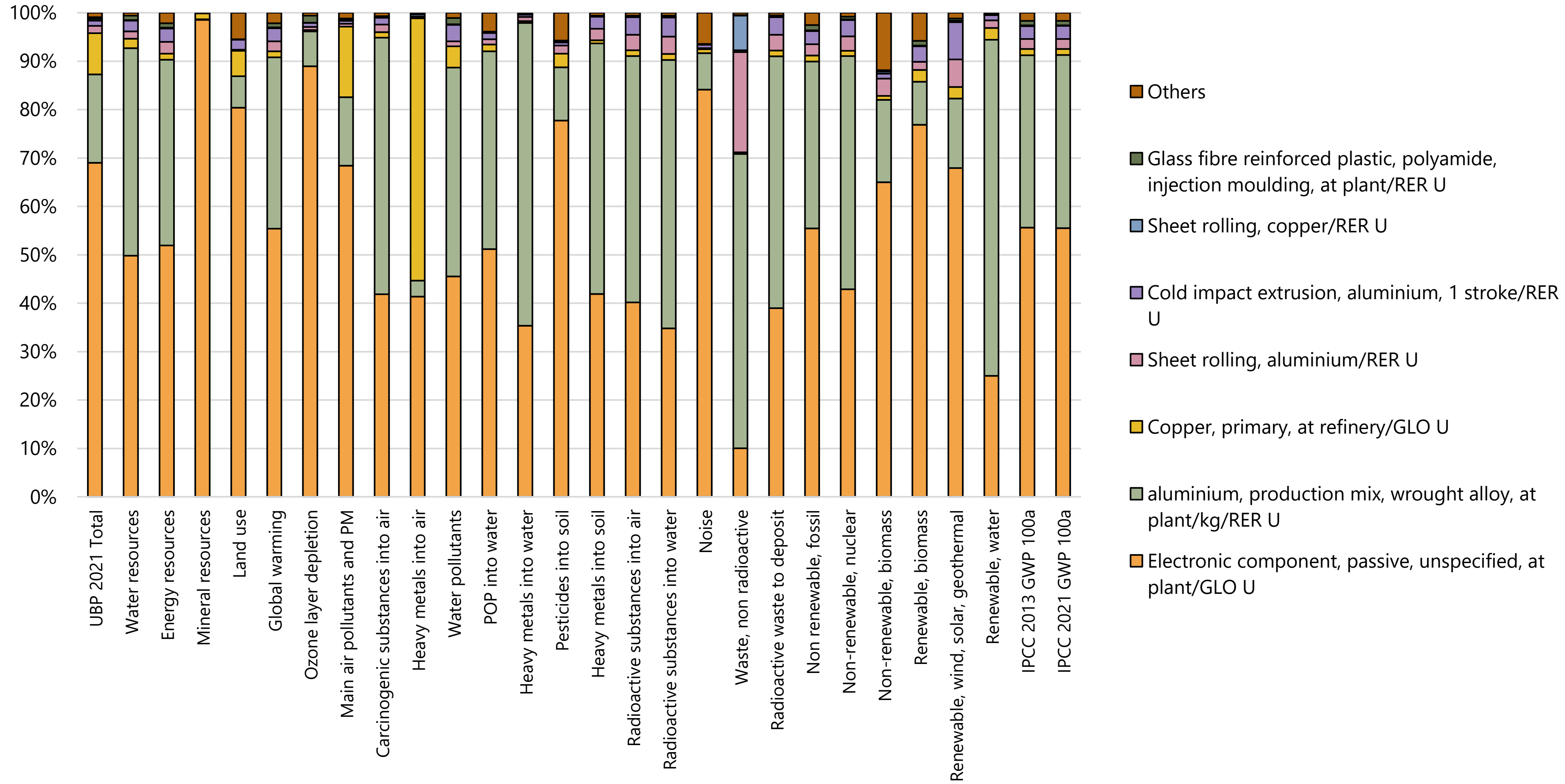

Figure 8.5-25. Contribution analysis presented in bar chart for: Battery module packaging, Li-ion. FU = 1 kg

Table 8.5-50. Contribution analysis presented in table for: Battery module packaging, Li-ion. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Electronic component, passive, unspecified, at plant/kg/GLO U	69%	55%	56%	56%
aluminium, production mix, wrought alloy, at plant/kg/RER U	18%	34%	36%	36%
Copper, primary, at refinery/GLO U	8%	1%	1%	1%
Sheet rolling, aluminium/RER U	2%	2%	2%	2%
Cold impact extrusion, aluminium, 1 stroke/RER U	1%	3%	3%	3%
Sheet rolling, copper/RER U	0%	0%	0%	0%
Glass fibre reinforced plastic, polyamide, injection moulding, at plant/RER U	0%	1%	1%	1%
Others	1%	3%	2%	2%
Total impact, in absolute value	**4.57E+04**	**1.39E+02**	**1.17E+01**	**1.17E+01**

Table 8.5-51. Life cycle inventory for Anode, graphite, for Li-ion battery and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Anode, graphite, for Li-ion battery/kg/GLO U	1	kg				
Input						
Carbon black, at plant/GLO U	0.01	kg		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
Carboxymethyl cellulose, powder, at plant/RER S	0.03	kg		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
Chemical plant, organics/RER/I U	4E-10	p		Lognormal	3.02	(2,2,1,4,2,4); Crenna et al, 2021, Literature
Latex, at plant/RER S	0.02	kg		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
Graphite, battery grade, at plant/CN U	0.94	kg		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
Water, deionised, at plant/CH U	1	kg		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.44058	kWh		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
heat, natural gas, at industrial furnace 1MW/MJ/CH U	7.7593	MJ		Lognormal	1.15	(2,2,1,4,2,4); Crenna et al, 2021, Literature
transport, freight, rail/tkm/RER U	0.98658	tkm		Lognormal	2.07	(2,2,3,4,2,4); Ellingsen, 2014 supporting information
transport, freight, lorry 32-40 metric ton, EURO 3/tkm/RER U	0.24048	tkm		Lognormal	2.07	(2,2,3,4,2,4); Ellingsen, 2014 supporting information
Output						
Waste to treatment						
Treatment, sewage, to wastewater treatment, class 3/CH U	0.001	m3		Lognormal	1.33	(2,2,3,4,3,5); Literature, Crenna et al (2021).

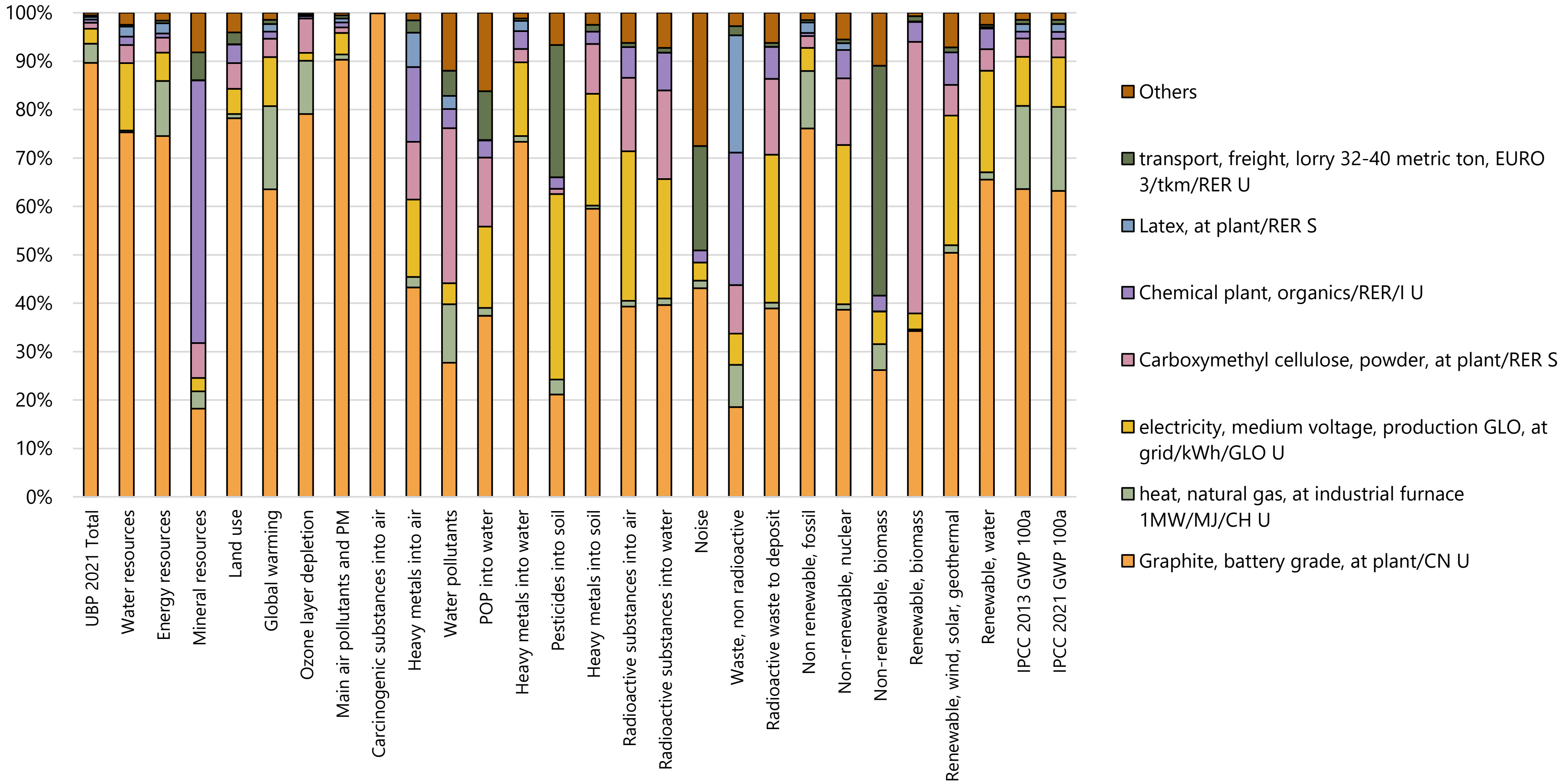

Figure 8.5-26. Contribution analysis presented in bar chart for: Anode, graphite, for Li-ion battery. FU = 1 kg

Table 8.5-52. Contribution analysis presented in table for: Anode, graphite, for Li-ion battery. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Graphite, battery grade, at plant/CN U	90%	76%	64%	63%
heat, natural gas, at industrial furnace 1MW/MJ/CH U	4%	12%	17%	17%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	3%	5%	10%	10%
Carboxymethyl cellulose, powder, at plant/RER S	1%	2%	4%	4%
Chemical plant, organics/RER/I U	1%	1%	1%	1%
Latex, at plant/RER S	1%	2%	2%	2%
transport, freight, lorry 32-40 metric ton, EURO 3/tkm/RER U	0%	1%	1%	1%
Others	1%	1%	1%	1%
Total impact, in absolute value	**1.74E+04**	**7.93E+01**	**3.37E+00**	**3.33E+00**

8.5.21 Toner, black, powder

The key inventory flows for toner module, powder, and cartridge manufacturing of black and color printing were taken from the study of (Ahmadi et al., 2003). While the study was rather outdated, the production process remains the same, except that for the energy use in the manufacturing, a potential reduction of energy intensity up to 20% is assumed in all printing equipment datasets (Shihata et al., 2022). Regionalization of electricity input is also performed to reflect global printing equipment datasets.

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Table 8.5-53. Life cycle inventory for Toner, black, powder and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Toner, black, powder, at plant/kg/GLO U	1	kg				
Input						
Carbon black, at plant/GLO U	0.05	kg		Lognormal	1.31	(2,3,4,2,1,5)
Chemicals inorganic, at plant/GLO U	0.045	kg		Lognormal	1.31	(2,3,4,2,1,5)
Chemicals organic, at plant/GLO U	0.03	kg		Lognormal	1.31	(2,3,4,2,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	4.888	kWh		Lognormal	1.31	(2,3,4,2,1,5)
Latex, at plant/RER S	0.7	kg		Lognormal	1.31	(2,3,4,2,1,5)
Magnetite, at plant/GLO U	0.175	kg		Lognormal	1.31	(2,3,4,2,1,5)
transport, freight, rail/tkm/RER U	0.2	tkm		Lognormal	2.10	(2,3,4,2,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.1	tkm		Lognormal	2.10	(2,3,4,2,1,5)
Output						
Emissions to air						
Heat, waste	22	MJ	high. pop.	Lognormal	1.63	(2,3,4,2,1,5);

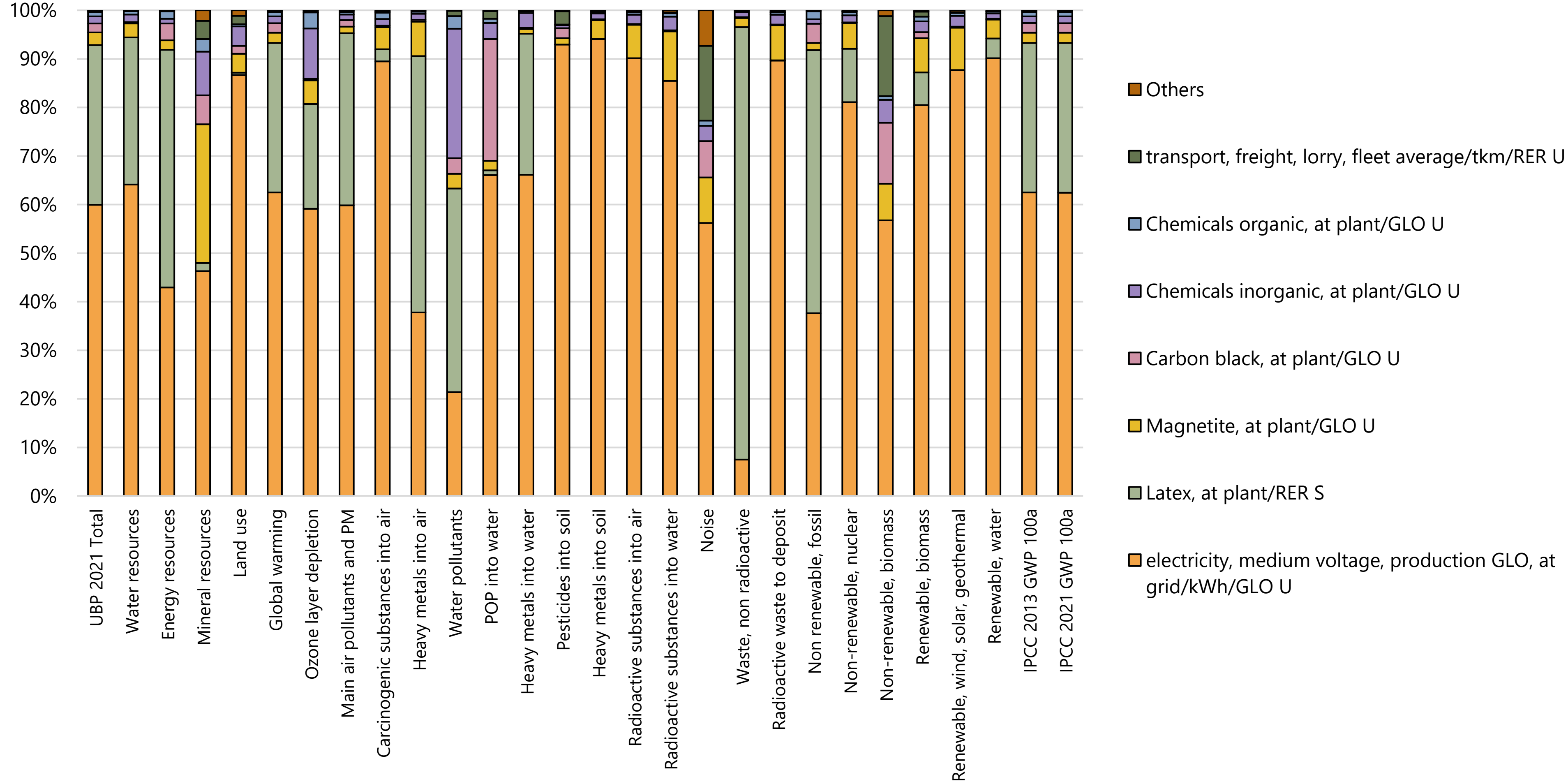

Figure 8.5-27. Contribution analysis presented in bar chart for: Toner, black, powder. FU = 1 kg

Table 8.5-54. Contribution analysis presented in table for: Toner, black, powder. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	60%	38%	62%	62%
Latex, at plant/RER S	33%	54%	31%	31%
Magnetite, at plant/GLO U	3%	1%	2%	2%
Carbon black, at plant/GLO U	2%	4%	2%	2%
Chemicals inorganic, at plant/GLO U	1%	1%	1%	1%
Chemicals organic, at plant/GLO U	1%	2%	1%	1%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
Total impact, in absolute value	**9.96E+03**	**1.11E+02**	**6.08E+00**	**6.06E+00**

8.5.22 Toner module, laser jet, b/w

The key inventory flows for toner module, powder, and cartridge manufacturing of black and color printing were taken from the study of (Ahmadi et al., 2003). While the study was rather outdated, the production process remains the same, except that for the energy use in the manufacturing, a potential reduction of energy intensity up to 20% is assumed in all printing equipment datasets (Shihata et al., 2022). Regionalization of electricity input is also performed to reflect global printing equipment datasets.

Table 8.5-55. Life cycle inventory for Toner module, laser jet, b/w and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Toner module, laser jet, b/w, at plant/p/GLO U	1	p				
Input						
aluminium, primary, at plant/kg/RER U	0.1434	kg		Lognormal	1.40	(2,4,4,2,3,5)
Building, hall/CH/I U	4.8611E-06	m2		Lognormal	3.15	(2,4,4,2,3,5)
Corrugated board, recycling fibre, double wall, at plant/RER U	0.404	kg		Lognormal	1.40	(2,4,4,2,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	6.3448	kWh		Lognormal	1.40	(2,4,1,2,3,5); Updated to reflect efficient manufacturing
Extrusion, plastic film/RER U	0.086981	kg		Lognormal	1.40	(2,4,4,2,3,5)
Glass fibre, at plant/RER U	0.010566	kg		Lognormal	1.40	(2,4,4,2,3,5)
Injection moulding/RER U	0.26943	kg		Lognormal	1.40	(2,4,4,2,3,5)
Magnetite, at plant/GLO U	0.036981	kg		Normal	1.40	(2,4,4,2,3,5)
Polyethylene, LDPE, granulate, at plant/RER U	0.05	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polystyrene, general purpose, GPPS, at plant/RER U	0.21132	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polyurethane, rigid foam, at plant/RER U	0.095094	kg		Lognormal	1.40	(2,4,1,2,3,5)
Section bar extrusion, aluminium/RER U	0.1434	kg		Lognormal	1.40	(2,4,4,2,3,5)
Sheet rolling, steel/RER U	0.25358	kg		Lognormal	1.40	(2,4,4,2,3,5)
steel, electric, un- and low-alloyed, at plant/kg/RER U	0.25358	kg		Lognormal	1.40	(2,4,4,2,3,5)
Toner, black, powder, at plant/GLO U	0.26	kg		Normal	1.40	(2,4,4,2,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.50211	tkm		Lognormal	2.16	(2,4,4,2,3,5)
Output						
Emissions to air						
Heat, waste	28.552	MJ	high. pop.	Lognormal	1.69	(2,4,4,2,3,5)

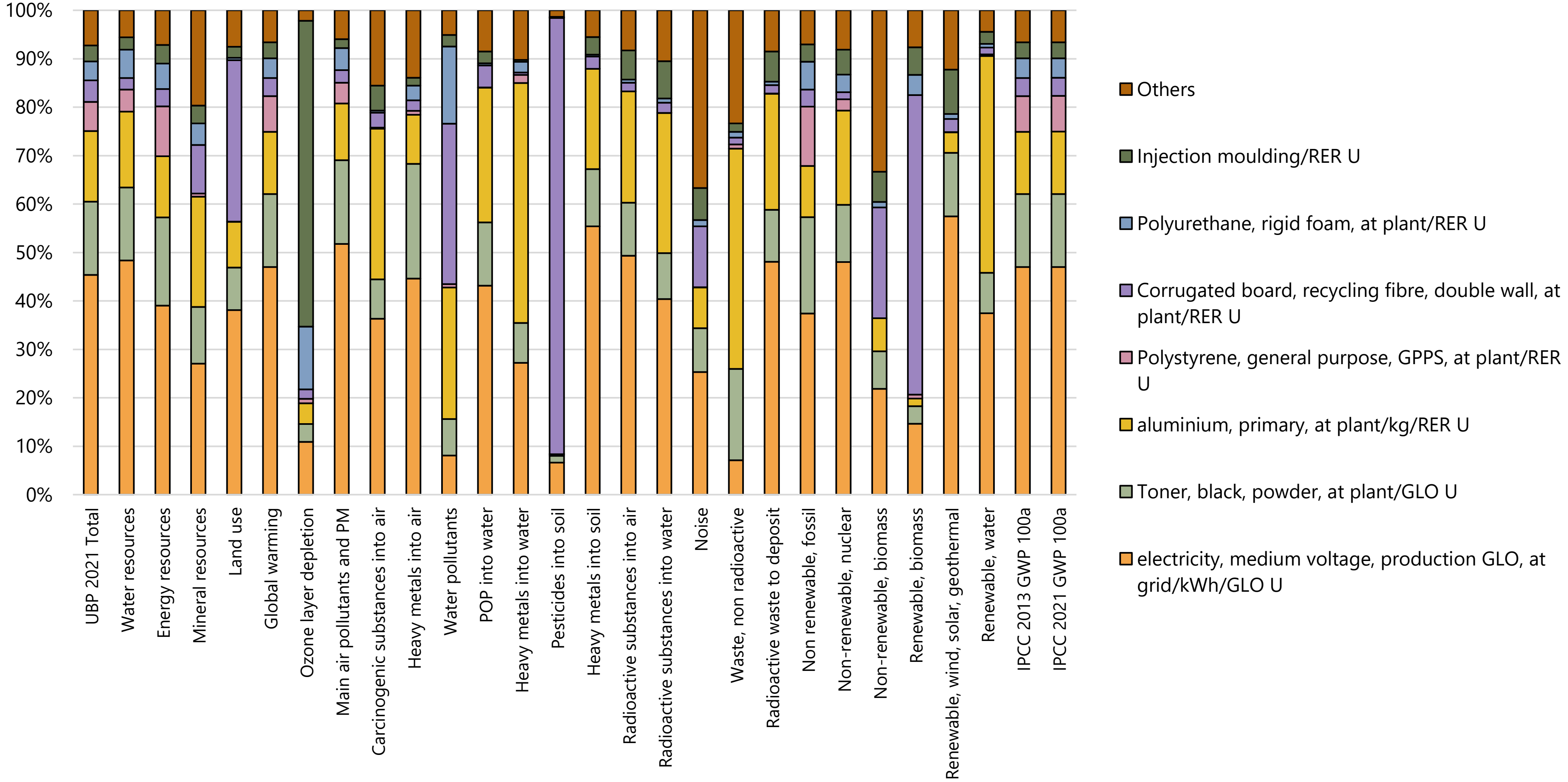

Figure 8.5-28. Contribution analysis presented in bar chart for: Toner module, laser jet, b/w. FU = 1 unit

Table 8.5-56. Contribution analysis presented in table for: Toner module, laser jet, b/w. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	45%	37%	47%	47%
Toner, black, powder, at plant/kg/GLO U	15%	20%	15%	15%
aluminium, primary, at plant/kg/RER U	15%	11%	13%	13%
Polystyrene, general purpose, GPPS, at plant/RER U	6%	12%	7%	7%
Corrugated board, recycling fibre, double wall, at plant/RER U	4%	4%	4%	4%
Polyurethane, rigid foam, at plant/RER U	4%	6%	4%	4%
Injection moulding/RER U	3%	4%	3%	3%
Others	7%	7%	7%	7%
Total impact, in absolute value	**1.71E+04**	**1.45E+02**	**1.05E+01**	**1.04E+01**

8.5.23 Toner, black, used for printing

The key inventory flows for toner module, powder, and cartridge manufacturing of black and color printing were taken from the study of (Ahmadi et al., 2003). While the study was rather outdated, the production process remains the same, except that for the energy use in the manufacturing, a potential reduction of energy intensity up to 20% is assumed in all printing equipment datasets (Shihata et al., 2022). Regionalization of electricity input is also performed to reflect global printing equipment datasets.

Table 8.5-57. Life cycle inventory for Toner, black, used for printing and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Toner, black, used for printing/kg/GLO U	1	kg				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.23867	kg		Lognormal	1.40	(2,4,4,2,3,5)
aluminium, primary, at plant/kg/RER U	0.26125	kg		Lognormal	1.40	(2,4,4,2,3,5)
Building, hall/CH/I U	0.000020774	m2		Lognormal	3.15	(2,4,4,2,3,5)
Corrugated board, recycling fibre, double wall, at plant/RER U	0.86325	kg		Lognormal	1.40	(2,4,4,2,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	13.56	kWh		Lognormal	1.46	(4,4,4,2,3,5); Updated to reflect efficient manufacturing
Extrusion, plastic film/RER U	0.10684	kg		Lognormal	1.40	(2,4,4,2,3,5)
Injection moulding/RER U	0.28383	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polyethylene, LDPE, granulate, at plant/RER U	0.12296	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polypropylene, granulate, at plant/RER U	0.029028	kg		Lognormal	1.40	(2,4,4,2,3,5)
Section bar extrusion, aluminium/RER U	0.26125	kg		Lognormal	1.40	(2,4,4,2,3,5)
Sheet rolling, steel/RER U	0.19997	kg		Lognormal	1.40	(2,4,4,2,3,5)
steel, electric, un- and low-alloyed, at plant/kg/RER U	0.19997	kg		Lognormal	1.40	(2,4,4,2,3,5)
Toner module, laser jet, b/w, at plant/p/GLO U	2.1368	p		Lognormal	1.40	(2,4,4,2,3,5)
Toner, black, powder, at plant/kg/GLO U	0.51889	kg		Lognormal	1.40	(2,4,4,2,3,5)
transport, freight, lorry, fleet average/tkm/RER U	3.8012	tkm		Lognormal	2.16	(2,4,4,2,3,5)
transport, transoceanic freight ship/tkm/OCE U	18.733	tkm		Lognormal	2.16	(2,4,4,2,3,5)
Output						
Emissions to air						
Heat, waste	61.008	MJ	high. pop.	Lognormal	1.69	(2,4,4,2,3,5)
disposal, packaging cardboard, 19.6% water, to municipal incineration/kg/CH U	1.7265	kg		Lognormal	1.40	(2,4,4,2,3,5)
disposal, plastic, industr. electronics, 15.3% water, to municipal incineration/kg/CH U	0.28383	kg		Lognormal	1.40	(2,4,4,2,3,5)
disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.21368	kg		Lognormal	1.40	(2,4,4,2,3,5)
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	0.91484	kg		Lognormal	1.40	(2,4,4,2,3,5)

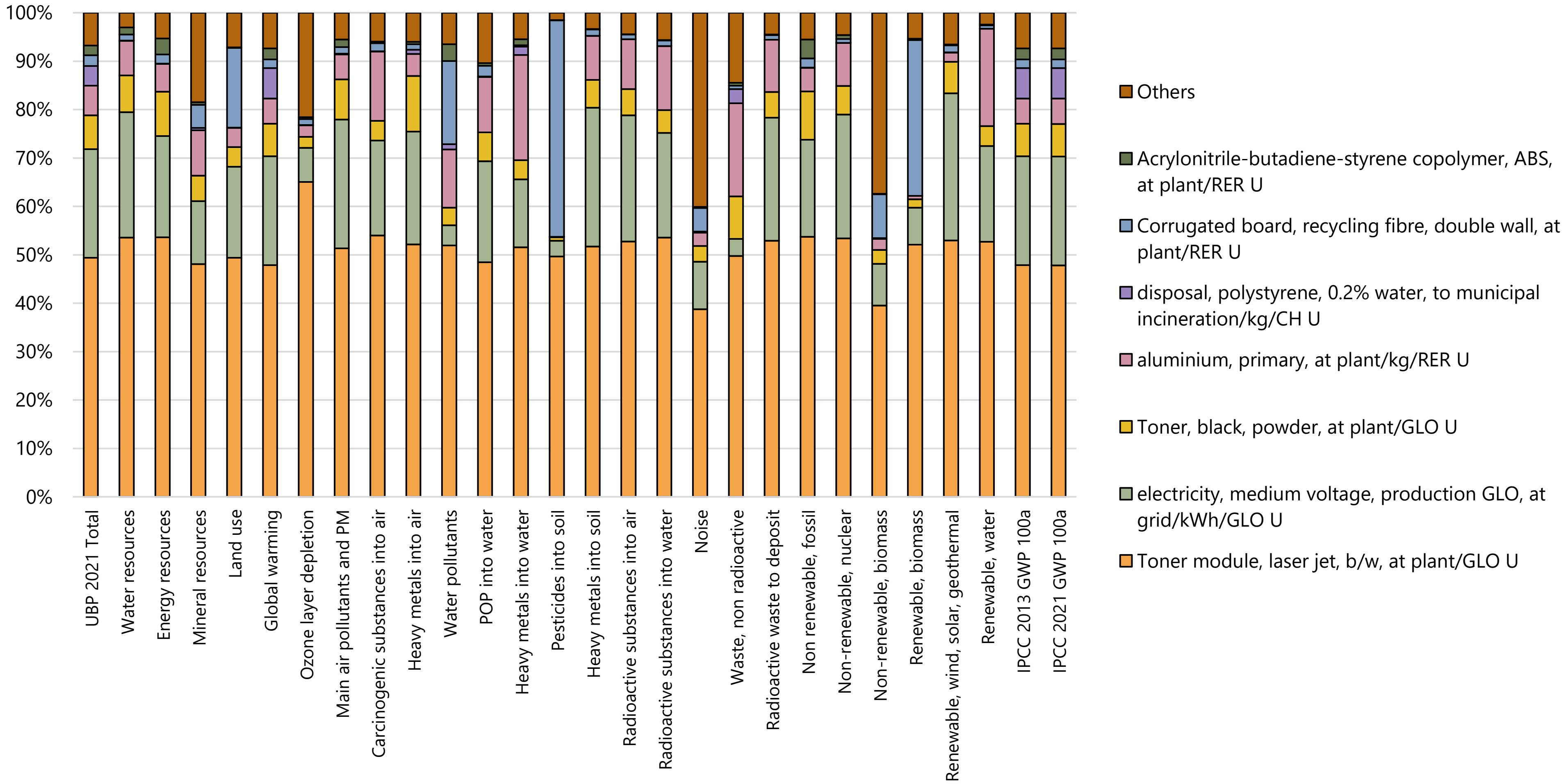

Figure 8.5-29. Contribution analysis presented in bar chart for: Toner, black, used for printing. FU = 1 kg

Table 8.5-58. Contribution analysis presented in table for: Toner, black, used for printing. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Toner module, laser jet, b/w, at plant/p/GLO U	49%	54%	48%	48%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	22%	20%	22%	22%
Toner, black, powder, at plant/kg/GLO U	7%	10%	7%	7%
aluminium, primary, at plant/kg/RER U	6%	5%	5%	5%
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	4%	0%	6%	6%
Corrugated board, recycling fibre, double wall, at plant/RER U	2%	2%	2%	2%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	2%	4%	2%	2%
Others	7%	6%	7%	7%
Total impact, in absolute value	**7.39E+04**	**5.78E+02**	**4.68E+01**	**4.67E+01**

8.5.24 Toner, colour, powder

The key inventory flows for toner module, powder, and cartridge manufacturing of black and color printing were taken from the study of (Ahmadi et al., 2003). While the study was rather outdated, the production process remains the same, except that for the energy use in the manufacturing, a potential reduction of energy intensity up to 20% is assumed in all printing equipment datasets (Shihata et al., 2022). Regionalization of electricity input is also performed to reflect global printing equipment datasets.

Table 8.5-59. Life cycle inventory for Toner, colour, powder and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Toner, colour, powder, at plant/kg/GLO U	1	kg				
Input						
Chemicals inorganic, at plant/GLO U	0.045	kg		Lognormal	1.31	(2,3,4,2,1,5)
Chemicals organic, at plant/GLO U	0.13	kg		Lognormal	1.31	(2,3,4,2,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	4.888	kWh		Lognormal	1.31	(2,3,4,2,1,5)
Latex, at plant/RER S	0.825	kg		Lognormal	1.31	(2,3,4,2,1,5)
transport, freight, rail/tkm/RER U	0.2	tkm		Lognormal	2.10	(2,3,4,2,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.1	tkm		Lognormal	2.10	(2,3,4,2,1,5)
Output						
Emissions to air						
Heat, waste	22	MJ	high. pop.	Lognormal	1.63	(2,3,4,2,1,5); calculation

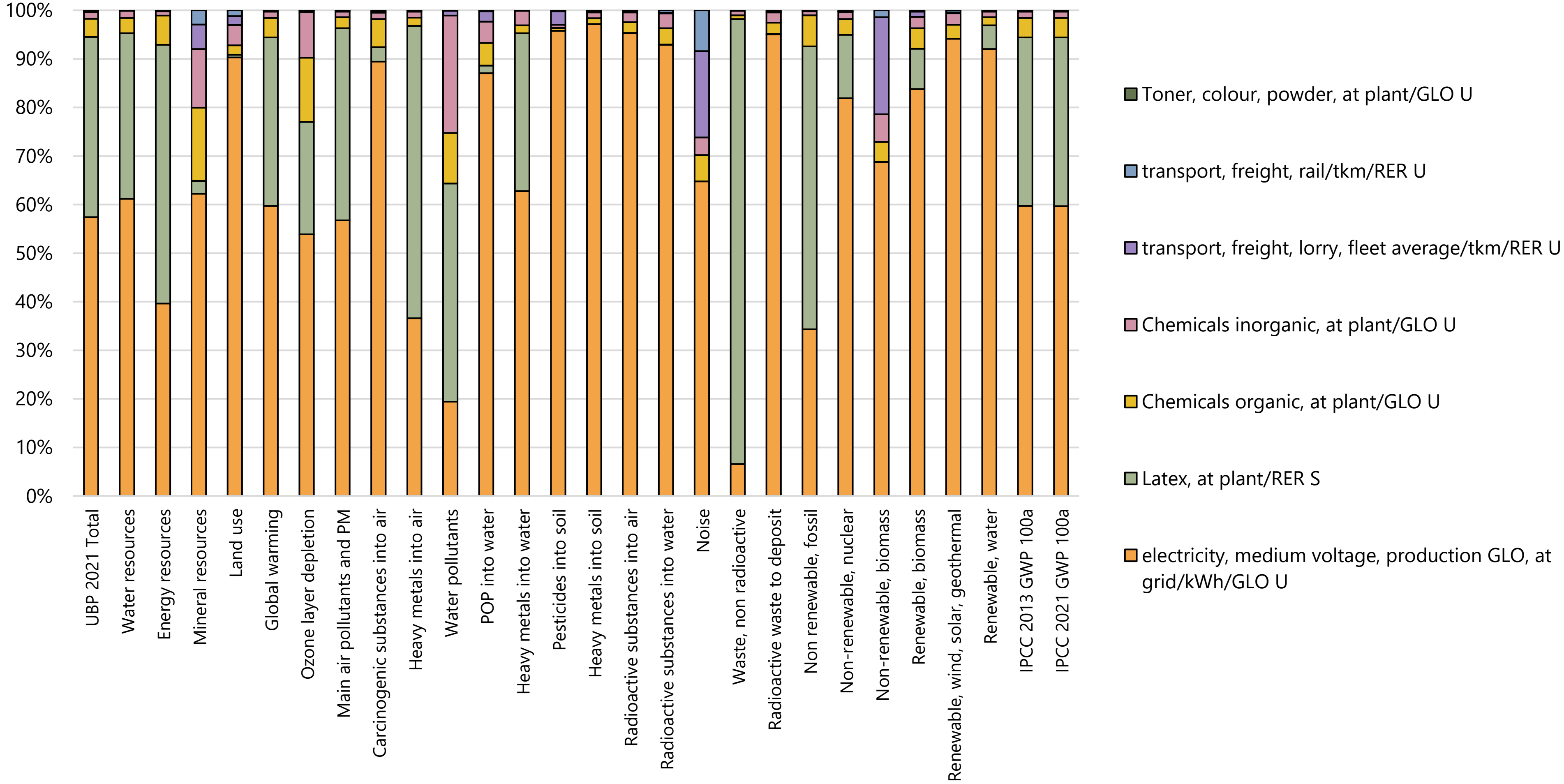

Figure 8.5-30. Contribution analysis presented in bar chart for: Toner, colour, powder. FU = 1 kg

Table 8.5-60. Contribution analysis presented in table for: Toner, colour, powder. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	57%	34%	60%	60%
Latex, at plant/RER S	37%	58%	35%	35%
Chemicals organic, at plant/GLO U	4%	6%	4%	4%
Chemicals inorganic, at plant/GLO U	1%	1%	1%	1%
transport, freight, lorry, fleet average/tkm/RER U	0%	0%	0%	0%
transport, freight, rail/tkm/RER U	0%	0%	0%	0%
Toner, colour, powder, at plant/kg/GLO U	0%	0%	0%	0%
Total impact, in absolute value	**1.04E+04**	**1.22E+02**	**6.36E+00**	**6.34E+00**

8.5.25 Toner module, laser jet, colour

The key inventory flows for toner module, powder, and cartridge manufacturing of black and color printing were taken from the study of (Ahmadi et al., 2003). While the study was rather outdated, the production process remains the same, except that for the energy use in the manufacturing, a potential reduction of energy intensity up to 20% is assumed in all printing equipment datasets (Shihata et al., 2022). Regionalization of electricity input is also performed to reflect global printing equipment datasets.

Table 8.5-61. Life cycle inventory for Toner module, laser jet, colour and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Toner module, laser jet, colour, at plant/p/GLO U	1	p				
Input						
aluminium, primary, at plant/kg/RER U	0.1434	kg		Lognormal	1.40	(2,4,4,2,3,5)
Building, hall/CH/I U	4.8611E-06	m2		Lognormal	3.15	(2,4,4,2,3,5)
Corrugated board, recycling fibre, double wall, at plant/RER U	0.404	kg		Lognormal	1.40	(2,4,4,2,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	6.3448	kWh		Lognormal	1.40	(2,4,1,2,3,5); Updated to reflect efficient manufacturing
Extrusion, plastic film/RER U	0.086981	kg		Lognormal	1.40	(2,4,4,2,3,5)
Glass fibre, at plant/RER U	0.010566	kg		Lognormal	1.40	(2,4,4,2,3,5)
Injection moulding/RER U	0.26943	kg		Lognormal	1.40	(2,4,4,2,3,5)
Magnetite, at plant/GLO U	0.036981	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polyethylene, LDPE, granulate, at plant/RER U	0.05	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polystyrene, general purpose, GPPS, at plant/RER U	0.21132	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polyurethane, rigid foam, at plant/RER U	0.095094	kg		Lognormal	1.40	(2,4,4,2,3,5)
Section bar extrusion, aluminium/RER U	0.1434	kg		Lognormal	1.40	(2,4,4,2,3,5)
Sheet rolling, steel/RER U	0.25358	kg		Lognormal	1.40	(2,4,4,2,3,5)
steel, electric, un- and low-alloyed, at plant/kg/RER U	0.25358	kg		Lognormal	1.40	(2,4,4,2,3,5)
Toner, colour, powder, at plant/kg/GLO U	0.26	kg		Lognormal	1.40	(2,4,4,2,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.50211	tkm		Lognormal	2.16	(2,4,4,2,3,5)
Output						
Emissions to air						
Heat, waste	28.552	MJ	high. pop.	Lognormal	1.69	(2,4,4,2,3,5)

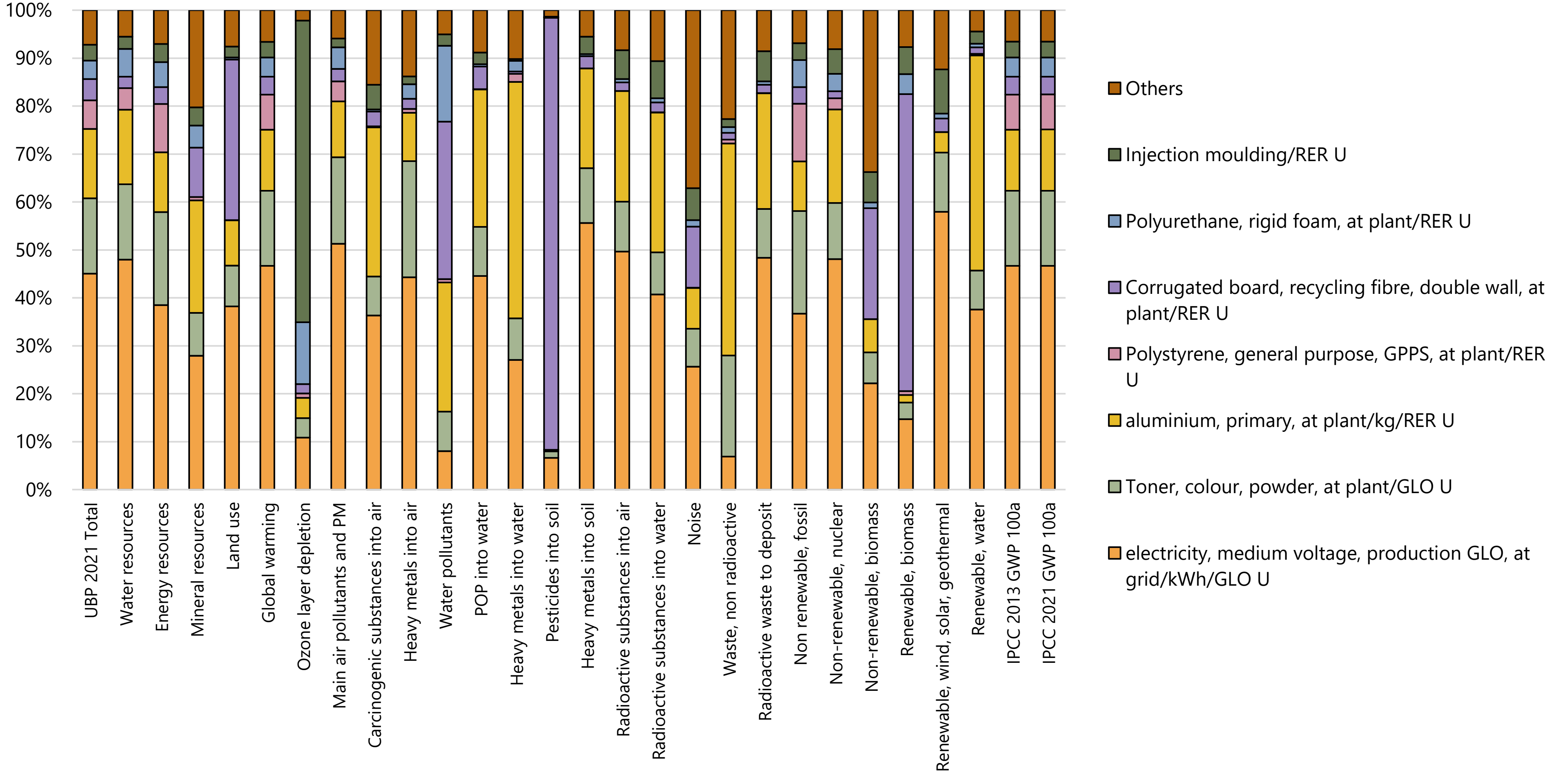

Figure 8.5-31. Contribution analysis presented in bar chart for: Toner module, laser jet, colour. FU = 1 unit

Table 8.5-62. Contribution analysis presented in table for: Toner module, laser jet, colour. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	45%	37%	47%	47%
Toner, colour, powder, at plant/kg/GLO U	16%	21%	16%	16%
aluminium, primary, at plant/kg/RER U	14%	10%	13%	13%
Polystyrene, general purpose, GPPS, at plant/RER U	6%	12%	7%	7%
Corrugated board, recycling fibre, double wall, at plant/RER U	4%	3%	4%	4%
Polyurethane, rigid foam, at plant/RER U	4%	6%	4%	4%
Injection moulding/RER U	3%	4%	3%	3%
Others	7%	7%	7%	7%
Total impact, in absolute value	**1.72E+04**	**1.48E+02**	**1.06E+01**	**1.05E+01**

8.5.26 Toner, colour, used for printing

The key inventory flows for toner module, powder, and cartridge manufacturing of black and color printing were taken from the study of (Ahmadi et al., 2003). While the study was rather outdated, the production process remains the same, except that for the energy use in the manufacturing, a potential reduction of energy intensity up to 20% is assumed in all printing equipment datasets (Shihata et al., 2022). Regionalization of electricity input is also performed to reflect global printing equipment datasets.

Table 8.5-63. Life cycle inventory for Toner, colour, used for printing and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Toner, colour, used for printing/GLO U	1	kg				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.23867	kg		Lognormal	1.40	(2,4,4,2,3,5)
aluminium, primary, at plant/kg/RER U	0.26125	kg		Lognormal	1.40	(2,4,4,2,3,5)
Building, hall/CH/I U	0.000020774	m2		Lognormal	3.15	(2,4,4,2,3,5)
Corrugated board, recycling fibre, double wall, at plant/RER U	0.86325	kg		Lognormal	1.40	(2,4,4,2,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	13.56	kWh		Lognormal	1.46	(4,4,4,2,3,5); Updated to reflect efficient manufacturing
Extrusion, plastic film/RER U	0.10684	kg		Lognormal	1.40	(2,4,4,2,3,5)
Injection moulding/RER U	0.28383	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polyethylene, LDPE, granulate, at plant/RER U	0.12296	kg		Lognormal	1.40	(2,4,4,2,3,5)
Polypropylene, granulate, at plant/RER U	0.029028	kg		Lognormal	1.40	(2,4,4,2,3,5)
Section bar extrusion, aluminium/RER U	0.26125	kg		Lognormal	1.40	(2,4,4,2,3,5)
Sheet rolling, steel/RER U	0.19997	kg		Lognormal	1.40	(2,4,4,2,3,5)
steel, electric, un- and low-alloyed, at plant/kg/RER U	0.19997	kg		Lognormal	1.40	(2,4,4,2,3,5)
Toner module, laser jet, colour, at plant/p/GLO U	2.1368	p		Lognormal	1.40	(2,4,4,2,3,5)
Toner, colour, powder, at plant/kg/GLO U	0.51889	kg		Lognormal	1.40	(2,4,4,2,3,5)
transport, freight, lorry, fleet average/tkm/RER U	3.8012	tkm		Lognormal	2.16	(2,4,4,2,3,5)
transport, transoceanic freight ship/tkm/OCE U	18.733	tkm		Lognormal	2.16	(2,4,4,2,3,5)
Output						
Waste to treatment						
disposal, packaging cardboard, 19.6% water, to municipal incineration/kg/CH U	1.7265	kg		Lognormal	1.40	(4,4,4,2,1,5)
disposal, plastic, industr. electronics, 15.3% water, to municipal incineration/kg/CH U	0.28383	kg		Lognormal	1.40	(4,4,4,2,1,5)
disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.21368	kg		Lognormal	1.40	(4,4,4,2,1,5)

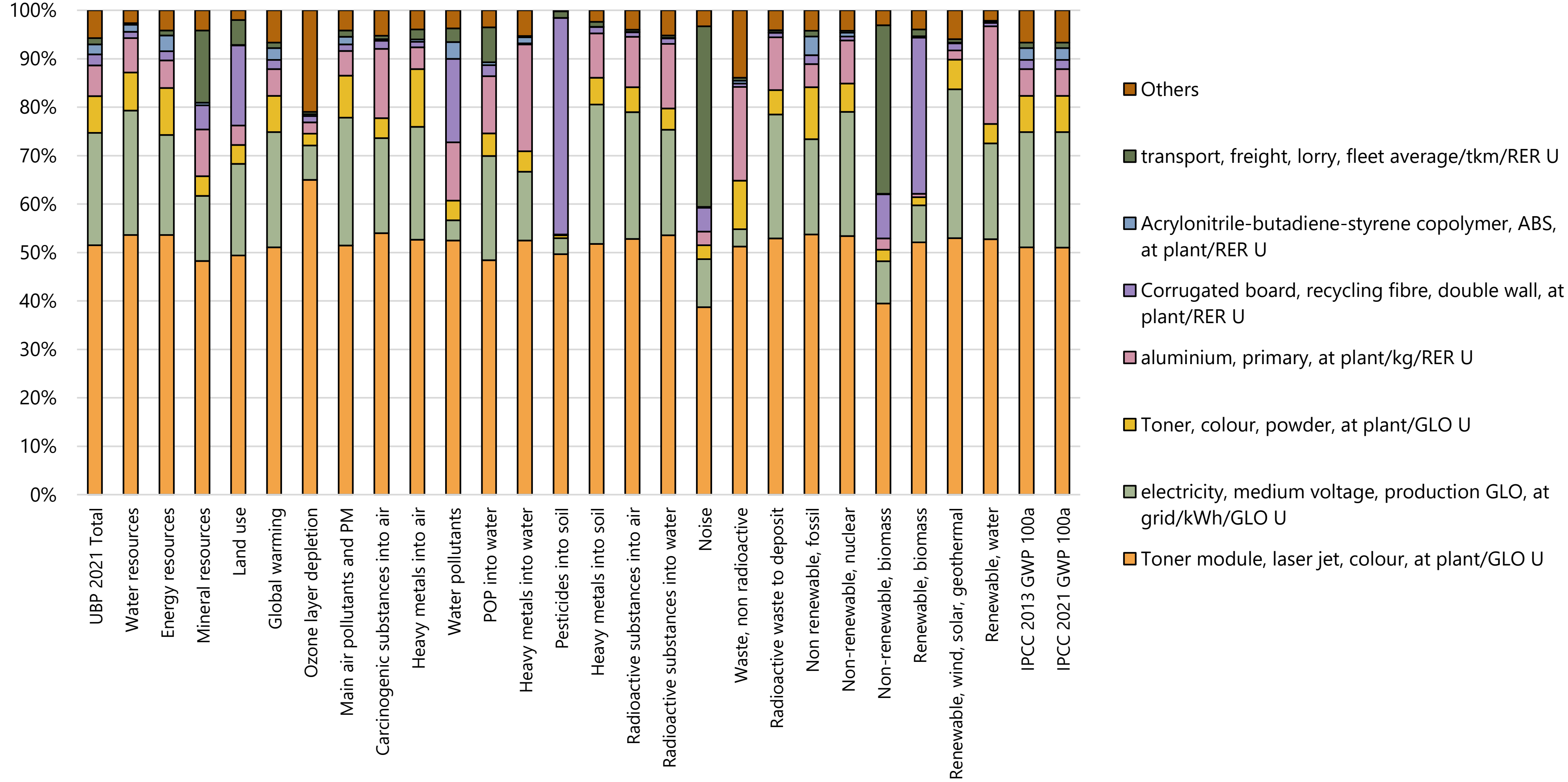

Figure 8.5-32. Contribution analysis presented in bar chart for: Toner, colour, used for printing. FU = 1 unit

Table 8.5-64. Contribution analysis presented in table for: Toner, colour, used for printing. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Toner module, laser jet, colour, at plant/p/GLO U	51%	54%	51%	51%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	23%	20%	24%	24%
Toner, colour, powder, at plant/kg/GLO U	8%	11%	7%	7%
aluminium, primary, at plant/kg/RER U	6%	5%	6%	6%
Corrugated board, recycling fibre, double wall, at plant/RER U	2%	2%	2%	2%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	2%	4%	2%	2%
transport, freight, lorry, fleet average/tkm/RER U	1%	1%	1%	1%
Others	6%	4%	7%	7%
Total impact, in absolute value	**7.14E+04**	**5.89E+02**	**4.42E+01**	**4.41E+01**

8.5.27 Printer, laser jet, b/w, at plant

For the two printers (b/w and color), the inventory flows from the disassembly data for consumer electronic products from (Babbitt et al., 2020) is used to update the key input flows such as steel, plastic, aluminum, and copper. The electricity consumption for the manufacturing of both printers are assumed to decrease by 20% according to energy efficiency improvement potential (Shihata et al., 2022).

Table 8.5-65. Life cycle inventory for Printer, laser jet, b/w and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printer, laser jet, b/w, at plant/p/GLO U	1	p				
Input						
Water, well	0.0227	m3	in water	Lognormal	1.32	(1,4,1,3,3,5)
aluminium, production mix, at plant/kg/RER U	0.015	kg		Lognormal	1.32	(1,4,1,3,3,5). Literature: the entire dataset is updated using average printers bill of materials from Babbit et al 2020
Cable, connector for computer, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.32	(1,4,1,3,3,5)
Cable, printer cable, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.32	(1,4,1,3,3,5)
Copper, primary, at refinery/GLO U	0.035	kg		Lognormal	1.32	(1,4,1,3,3,5)
Corrugated board, recycling fibre, double wall, at plant/RER U	1.304	kg		Lognormal	1.32	(1,4,1,3,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.3336	kWh		Lognormal	1.32	(2,4,3,3,3,5)
Epoxy resin, liquid, at plant/RER U	0.0202	kg		Lognormal	1.32	(1,4,1,3,3,5)
Flat glass, uncoated, at plant/RER U	0.005	kg		Lognormal	1.32	(1,4,1,3,3,5)
Injection moulding/RER U	2.8673	kg		Lognormal	1.32	(1,4,1,3,3,5)
Magnesium, at plant/RER U	0.0774	kg		Lognormal	1.32	(1,4,1,3,3,5)
Magnesium-alloy, AZ91, diecasting, at plant/RER U	0.0774	kg		Lognormal	1.32	(1,4,1,3,3,5)
Packaging film, LDPE, at plant/RER U	0.0352	kg		Lognormal	1.32	(1,4,1,3,3,5)
photovoltaic cell factory/p/DE/I U	1.3333E-08	p		Lognormal	3.12	(1,4,3,3,3,5)
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.32	(1,4,1,3,3,5)
Plugs, inlet and outlet, for printer cable, at plant/p/GLO U	1	p		Lognormal	1.32	(1,4,1,3,3,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.0626	kg		Lognormal	1.32	(1,4,1,3,3,5)
Polystyrene foam slab, at plant/RER U	0.2608	kg		Lognormal	1.32	(1,4,1,3,3,5)
Polystyrene, high impact, HIPS, at plant/RER U	3.731	kg		Lognormal	1.32	(1,4,1,3,3,5)
Section bar extrusion, aluminium/RER U	0.015	kg		Lognormal	1.32	(1,4,1,3,3,5)
Sheet rolling, copper/RER U	0.035	kg		Lognormal	1.32	(1,4,1,3,3,5)
Sheet rolling, steel/RER U	0.1199	kg		Lognormal	1.32	(1,4,1,3,3,5)
Steel, low-alloyed, at plant/RER U	1.843	kg		Lognormal	1.32	(1,4,1,3,3,5)

Stretch blow moulding/RER U	0.0626	kg		Lognormal	1.32	(1,4,1,3,3,5)
Synthetic rubber, at plant/RER U	0.0171	kg		Lognormal	1.32	(1,4,1,3,3,5)
tap water, at user/kg/RER U	24.8	kg		Lognormal	1.32	(1,4,1,3,3,5)
Toner module, laser jet, b/w, at plant/p/GLO U	1	p		Lognormal	1.32	(1,4,1,3,3,5)
transport, freight, rail/tkm/RER U	0.99705	tkm		Lognormal	2.11	(1,4,1,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.49852	tkm		Lognormal	2.11	(1,4,1,3,3,5)
transport, transoceanic freight ship/tkm/OCE U	106.19	tkm		Lognormal	2.11	(1,4,1,3,3,5)
Wire drawing, copper/RER U	0.1565	kg		Lognormal	1.32	(1,4,1,3,3,5)
Output						
Waste to treatment						
disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.0352	kg		Lognormal	1.32	(1,4,1,3,3,5)
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	0.2608	kg		Lognormal	1.32	(1,4,1,3,3,5)
Disposal, printer, laser jet, b/w, to WEEE treatment/CH old	1	p		Lognormal	1.32	(1,4,1,3,3,5)
Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U	0.0474	m3		Lognormal	1.32	(1,4,1,3,3,5)

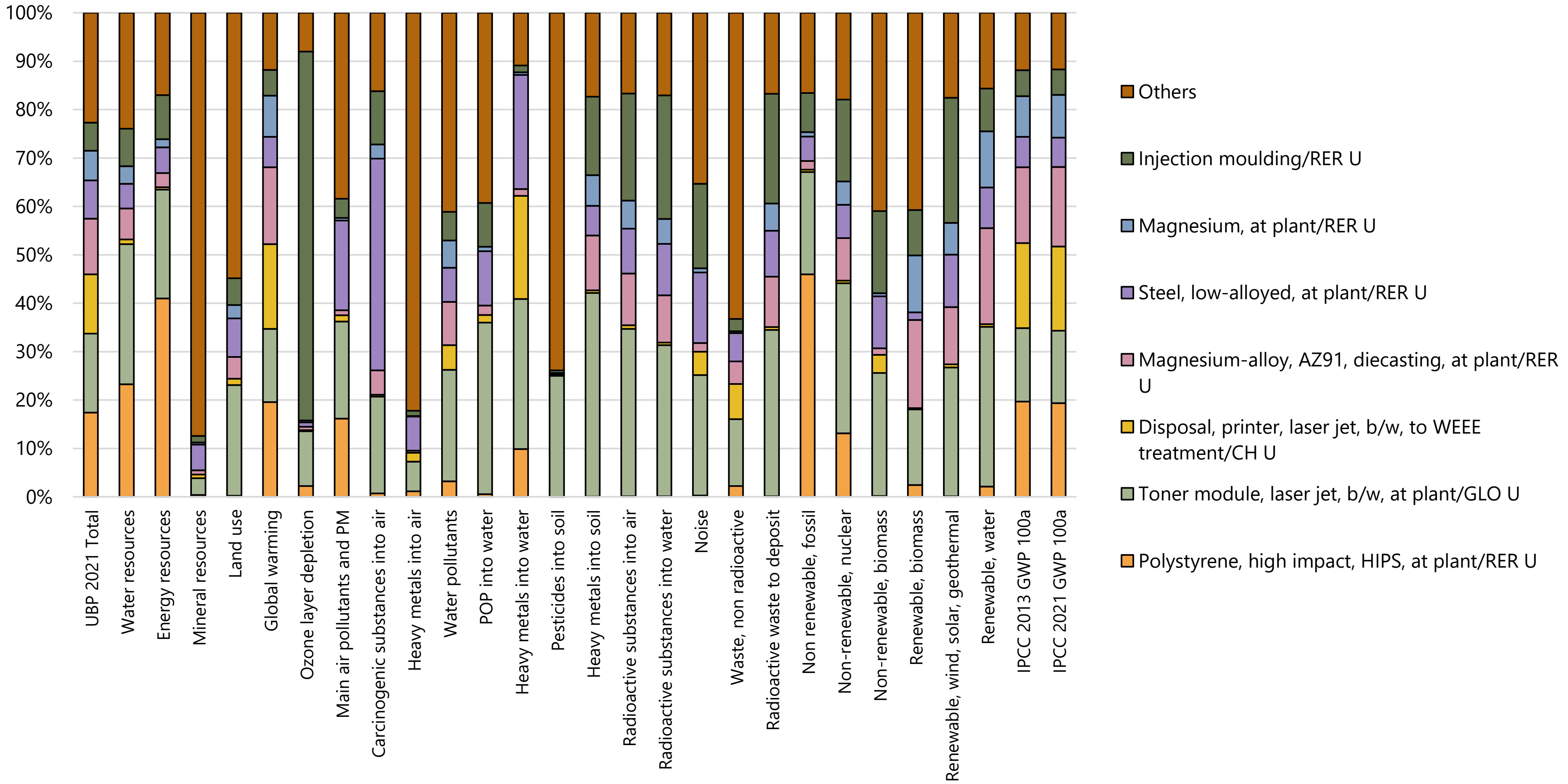

Figure 8.5-33. Contribution analysis presented in bar chart for: Printer, laser jet, b/w. FU = 1 unit

Table 8.5-66. Contribution analysis presented in table for: Printer, laser jet, b/w. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Polystyrene, high impact, HIPS, at plant/RER U	17%	46%	20%	19%
Toner module, laser jet, b/w, at plant/p/GLO U	16%	21%	15%	15%
Disposal, printer, laser jet, b/w, to WEEE treatment/CH U	12%	0%	18%	17%
Magnesium-alloy, AZ91, diecasting, at plant/RER U	11%	2%	16%	16%
Steel, low-alloyed, at plant/RER U	8%	5%	6%	6%
Magnesium, at plant/RER U	6%	1%	8%	9%
Injection moulding/RER U	6%	8%	5%	5%
Others	23%	17%	12%	12%
Total impact, in absolute value	**1.05E+05**	**6.86E+02**	**6.91E+01**	**6.99E+01**

8.5.28 Printer, laser jet, colour, at plant

For the two printers (b/w and color), the inventory flows from the disassembly data for consumer electronic products from (Babbitt et al., 2020) is used to update the key input flows such as steel, plastic, aluminum, and copper. The electricity consumption for the manufacturing of both printers are assumed to decrease by 20% according to energy efficiency improvement potential (Shihata et al., 2022).

Table 8.5-67. Life cycle inventory for Printer, laser jet, colour and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Printer, laser jet, colour, at plant/p/GLO U	1	p				
Input						
Water, well	0.0227	m3	in water	Lognormal	1.32	(1,4,1,3,3,5)
aluminium, production mix, at plant/kg/RER U	0.015	kg		Lognormal	1.32	(1,4,1,3,3,5). Literature: the entire dataset is updated using average printers bill of materials from Babbit et al 2020
Cable, connector for computer, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.32	(1,4,1,3,3,5)
Cable, printer cable, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.32	(1,4,1,3,3,5)
Copper, primary, at refinery/GLO U	0.035	kg		Lognormal	1.32	(1,4,1,3,3,5)
Corrugated board, recycling fibre, double wall, at plant/RER U	1.304	kg		Lognormal	1.32	(1,4,1,3,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.3336	kWh		Lognormal	1.35	(2,4,3,3,3,5)
Epoxy resin, liquid, at plant/RER U	0.0202	kg		Lognormal	1.32	(1,4,1,3,3,5)
Flat glass, uncoated, at plant/RER U	0.005	kg		Lognormal	1.32	(1,4,1,3,3,5)
Injection moulding/RER U	2.8673	kg		Lognormal	1.32	(1,4,1,3,3,5)
Magnesium, at plant/RER U	0.0774	kg		Lognormal	1.32	(1,4,1,3,3,5)
Magnesium-alloy, AZ91, diecasting, at plant/RER U	0.0774	kg		Lognormal	1.32	(1,4,1,3,3,5)
Packaging film, LDPE, at plant/RER U	0.0352	kg		Lognormal	1.32	(1,4,1,3,3,5)
photovoltaic cell factory/p/DE/I U	1.3333E-08	p		Lognormal	3.10	(1,4,3,3,3,5)
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.32	(1,4,1,3,3,5)
Plugs, inlet and outlet, for printer cable, at plant/p/GLO U	1	p		Lognormal	1.32	(1,4,1,3,3,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.0626	kg		Lognormal	1.32	(1,4,1,3,3,5)
Polystyrene foam slab, at plant/RER U	0.2608	kg		Lognormal	1.32	(1,4,1,3,3,5)
Polystyrene, high impact, HIPS, at plant/RER U	3.731	kg		Lognormal	1.32	(1,4,1,3,3,5)
Section bar extrusion, aluminium/RER U	0.0199	kg		Lognormal	1.32	(1,4,1,3,3,5)
Sheet rolling, copper/RER U	0.0516	kg		Lognormal	1.32	(1,4,1,3,3,5)
Sheet rolling, steel/RER U	0.1199	kg		Lognormal	1.32	(1,4,1,3,3,5)
Steel, low-alloyed, at plant/RER U	1.843	kg		Lognormal	1.32	(1,4,1,3,3,5)
Stretch blow moulding/RER U	0.0626	kg		Lognormal	1.32	(1,4,1,3,3,5)

Synthetic rubber, at plant/RER U	0.0171	kg	Lognormal	1.32	(1,4,1,3,3,5)
tap water, at user/kg/RER U	24.8	kg	Lognormal	1.32	(1,4,1,3,3,5)
Toner module, laser jet, colour, at plant/p/GLO U	1	p	Lognormal	1.32	(1,4,1,3,3,5)
transport, freight, rail/tkm/RER U	0.99705	tkm	Lognormal	2.11	(1,4,1,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.49852	tkm	Lognormal	2.11	(1,4,1,3,3,5)
transport, transoceanic freight ship/tkm/OCE U	106.19	tkm	Lognormal	2.11	(1,4,1,3,3,5)
Wire drawing, copper/RER U	0.1565	kg	Lognormal	1.32	(1,4,1,3,3,5)
Output					
Waste to treatment					
disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.0352	kg	Lognormal	1.32	(1,4,1,3,3,5)
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	0.2608	kg	Lognormal	1.32	(1,4,1,3,3,5)
Disposal, printer, laser jet, colour, to WEEE treatment/CH U	1	p	Lognormal	1.32	(1,4,1,3,3,5)
Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U	0.0474	m3	Lognormal	1.32	(1,4,1,3,3,5)

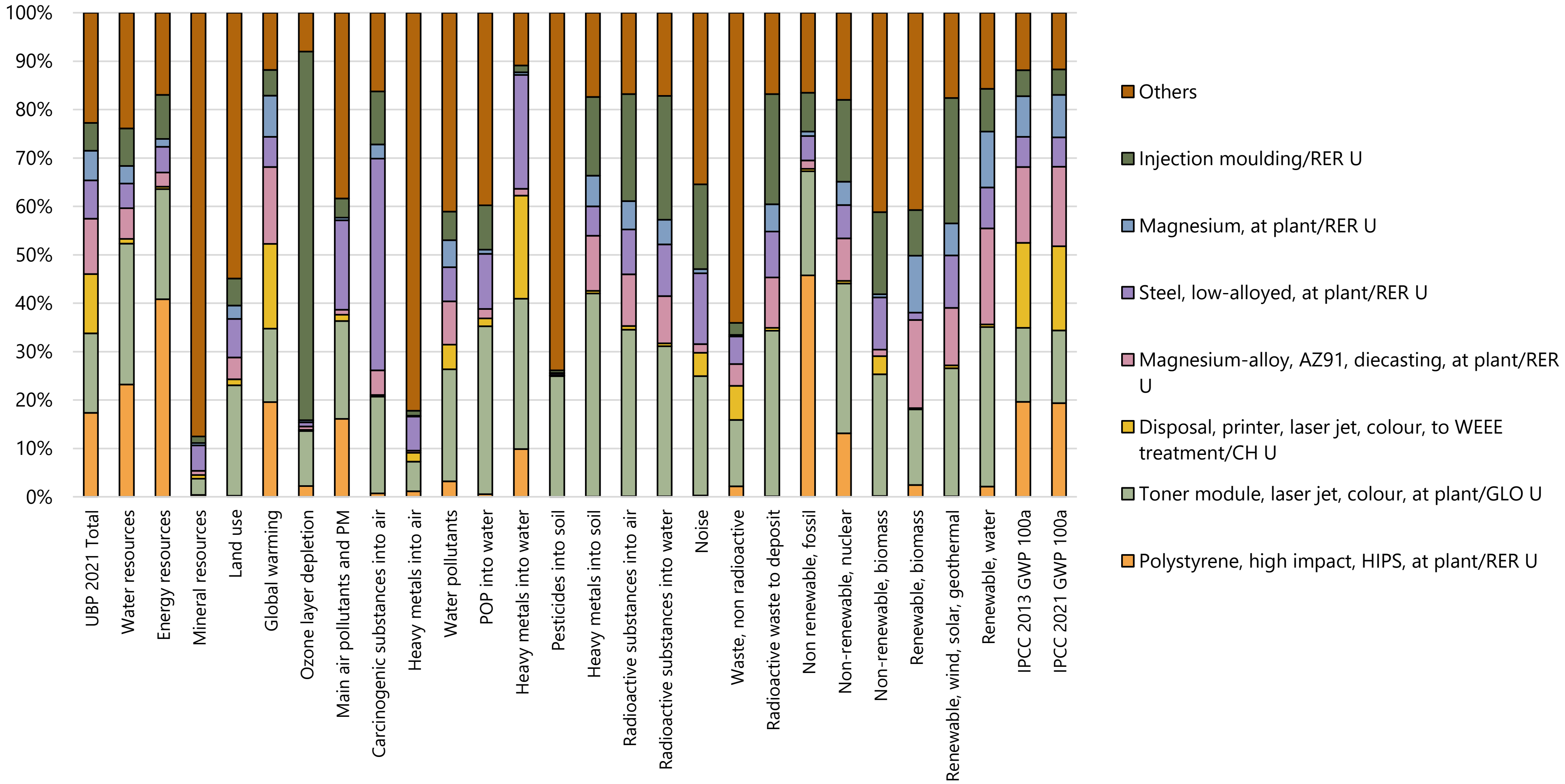

Figure 8.5-34. Contribution analysis presented in bar chart for: Printer, laser jet, colour. FU = 1 unit

Table 8.5-68. Contribution analysis presented in table for: Printer, laser jet, colour. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Polystyrene, high impact, HIPS, at plant/RER U	17%	46%	20%	19%
Toner module, laser jet, colour, at plant/p/GLO U	16%	21%	15%	15%
Disposal, printer, laser jet, colour, to WEEE treatment/CH U	12%	0%	18%	17%
Magnesium-alloy, AZ91, diecasting, at plant/RER U	11%	2%	16%	16%
Steel, low-alloyed, at plant/RER U	8%	5%	6%	6%
Magnesium, at plant/RER U	6%	1%	8%	9%
Injection moulding/RER U	6%	8%	5%	5%
Others	23%	17%	12%	12%
Total impact, in absolute value	**1.05E+05**	**6.89E+02**	**6.92E+01**	**7.00E+01**

8.5.29 Power adaptor, for laptop

The inventory for notebook adapters are modified using the secondary data from the study of personal electronics/computers of (Tecchio et al., 2018). In case some missing information for electronic components are still present, the gaps are filled by consulting comprehensive bill of materials data from (Teehan & Kandlikar, 2013). The input flows for electronics were not included in the existing adaptor dataset and become one of the main changes at the inventory level. A standard 60W unit adaptor is taken as the average size for a standard notebook in the database. Besides adapting the inventory amounts, in the new dataset we also introduced the addition of electronics input flows, which were not considered in the existing dataset. Furthermore, in the updated dataset, the mass flow of adapter has been reduced to nearly half, after which the data from literature is also adjusted according to this assumption. This will also reflect on the disposal of notebook adaptor, which is explained in the other section.

Table 8.5-69. Life cycle inventory for Power adapter, for laptop and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Power adapter, for laptop, at plant/p/GLO U	1	p				
Input						
Polycarbonate, at plant/RER U	0.048	kg		Lognormal	1.31	(2,2,2,3,3,5)
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.037	kg		Lognormal	1.31	(2,2,2,3,3,5)
Cable, connector for computer, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.24	(1,4,2,3,1,5)
Copper, primary, at refinery/GLO U	0.04	kg		Lognormal	1.24	(1,4,2,3,1,5) non ferrous fraction, from Tecchio et al 2018
aluminium, production mix, at plant/kg/RER U	0.04	kg		Lognormal	1.24	(1,4,2,3,1,5) non ferrous fraction, from Tecchio et al 2018
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.22224	kWh		Lognormal	1.24	(1,4,2,3,1,5)
Extrusion, plastic pipes/RER U	0.085	kg		Lognormal	1.24	(1,4,2,3,1,5)
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.24	(1,4,2,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	7.4256E-08	p		Lognormal	3.06	(1,4,2,3,1,5)
Sheet rolling, steel/RER U	0.002	kg		Lognormal	1.24	(1,4,2,3,1,5)
transport, freight, rail/tkm/RER U	0.10622	tkm		Lognormal	1.31	(2,2,2,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.05231	tkm		Lognormal	1.31	(2,2,2,3,3,5)
Wire drawing, copper/RER U	0.04	kg		Lognormal	1.24	(1,4,2,3,1,5)
Inductor, unspecified, at plant/kg/GLO U	0.0265	kg		Lognormal	1.31	(2,2,2,3,3,5)
Capacitor, unspecified, at plant/kg/GLO U	0.0075	kg		Lognormal	1.31	(2,2,2,3,3,5)
Output						
Waste to treatment						
Disposal, power adapter, external, for laptop, to WEEE treatment/CH U	1	p		Lognormal	1.40	(1,4,4,3,3,5)

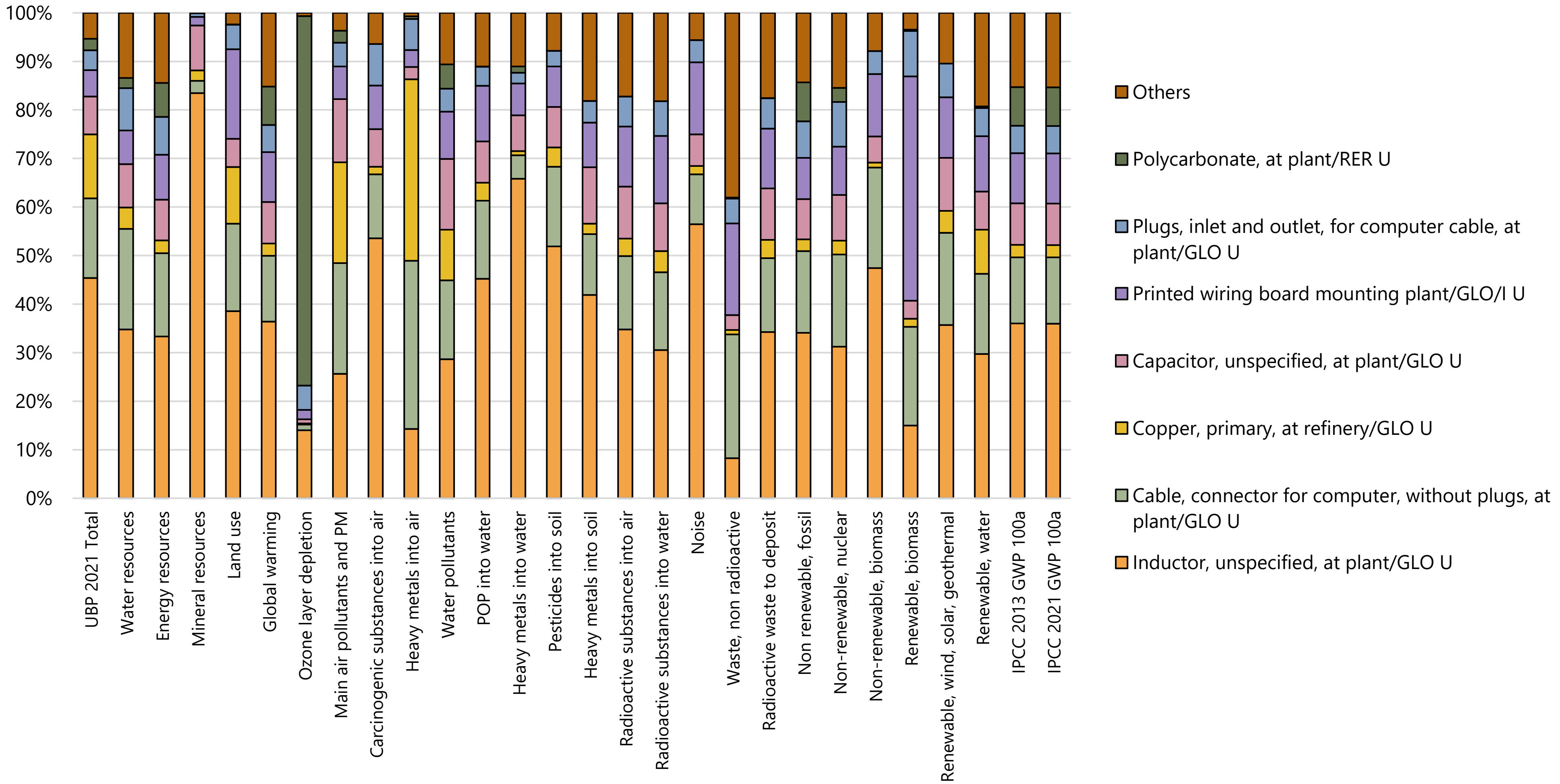

Figure 8.5-35. Contribution analysis presented in bar chart for: Power adapter, for laptop. FU = 1 unit

Table 8.5-70. Contribution analysis presented in table for: Power adapter, for laptop. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Inductor, unspecified, at plant/kgGLO U	45%	34%	34%	34%
Cable, connector for computer, without plugs, at plant/m/GLO U	16%	17%	13%	13%
Copper, primary, at refinery/GLO U	13%	2%	2%	2%
Capacitor, unspecified, at plant/kg/GLO U	8%	8%	8%	8%
Printed wiring board mounting plant/p/GLO/I U	5%	8%	10%	10%
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	4%	8%	5%	5%
Polycarbonate, at plant/RER U	2%	8%	8%	8%
Others	5%	14%	15%	15%
Total impact, in absolute value	**2.50E+04**	**6.00E+02**	**5.12E+00**	**5.10E+00**

8.5.30 Power supply unit, at plant

The original dataset for power supply unit was generated using dismantling of PSU in the laboratory. To update this dataset, we consult an LCA study from (Teehan & Kandlikar, 2013) and extract relevant input flows data that have connections with the existing dataset. This includes the quantities of cables, fan, and metals. However the mass of electronics or PWB is not modified in the new dataset since the quantity is similar to the study of Teehan et al. 2013 when all electronics components mass are aggregated. The new PWB dataset for a PSU unit is nevertheless used and described in the other section.

Table 8.5-71. Life cycle inventory for Power supply unit, at plant and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Power supply unit, at plant/p/GLO U	1	p				
Input						
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.158	kg		Lognormal	1.35	(3,3,3,4,3,5) Update 2023: new inventory taken from Teehan 2013
Fan, at plant/GLO U	0.0914	kg		Lognormal	1.35	(3,3,3,4,3,5)
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.35	(3,3,3,4,3,5)
Printed wiring board, power supply unit desktop PC, solder mix, at plant/kg/GLO U	0.6038	kg		Lognormal	1.35	(3,3,3,4,3,5)
Sheet rolling, steel/RER U	0.56	kg		Lognormal	1.35	(3,3,3,4,3,5)
Steel, low-alloyed, at plant/RER U	0.56	kg		Lognormal	1.35	(3,3,3,4,3,5)

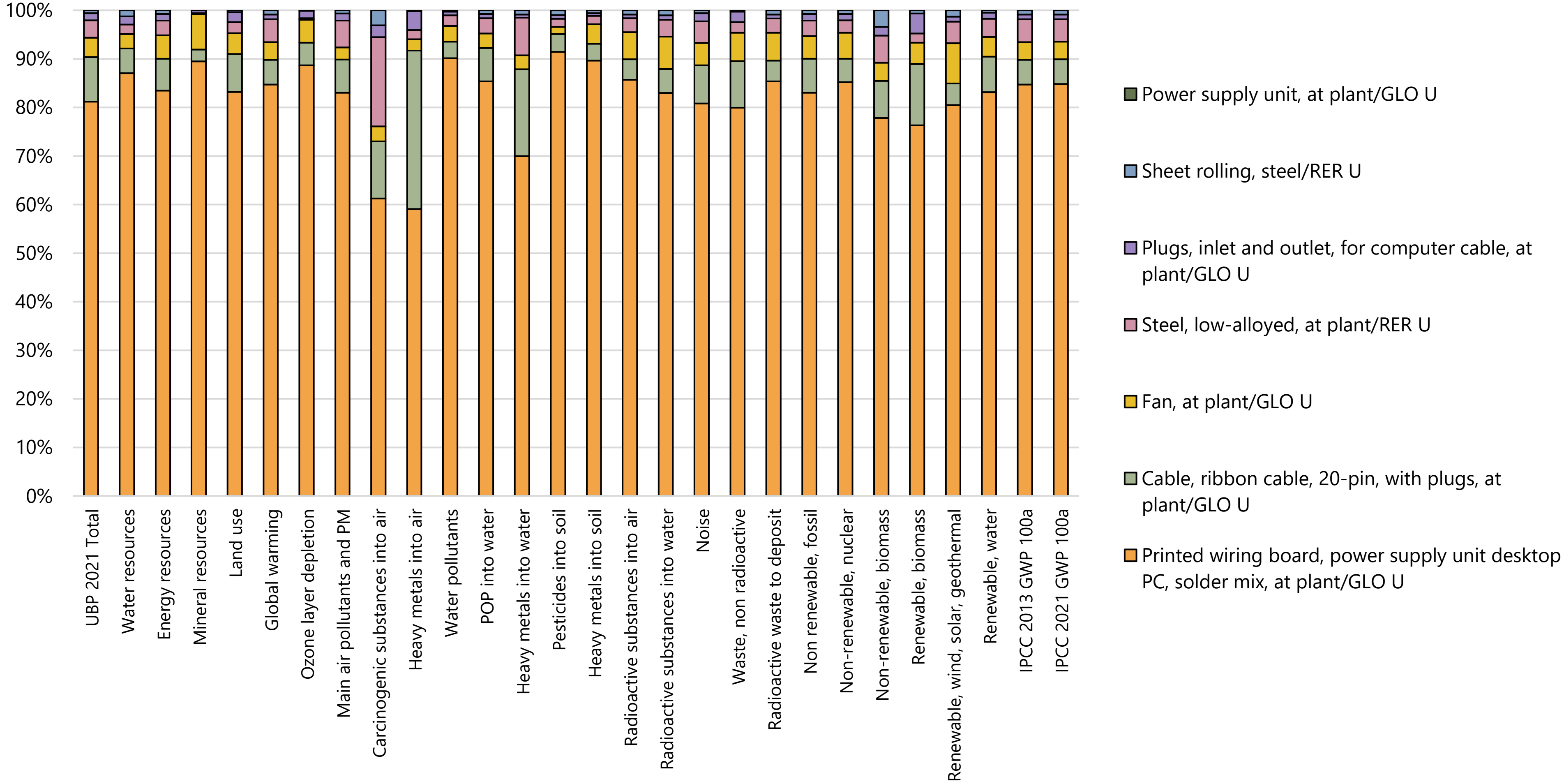

Figure 8.5-36. Contribution analysis presented in bar chart for: Power supply unit, at plant. FU = 1 unit

Table 8.5-72. Contribution analysis presented in table for: Power supply unit, at plant. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, power supply unit desktop PC, solder mix, at plant/kg/GLO U	81%	83%	85%	85%
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	9%	7%	5%	5%
Fan, at plant/GLO U	4%	5%	4%	4%
Steel, low-alloyed, at plant/RER U	4%	3%	5%	5%
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1%	1%	1%	1%
Sheet rolling, steel/RER U	1%	1%	1%	1%
Power supply unit, at plant/p/GLO U	0%	0%	0%	0%
Total impact, in absolute value	**6.96E+04**	**3.27E+02**	**2.76E+01**	**2.75E+01**

8.5.31 HDD, desktop computer

The dataset is updated using recent technical data from JRC technical report (Talens Peiró & Ardente, 2015; Tecchio et al., 2018) and also by consulting product sheet of storage device manufacturers, i.e., WD (WD, 2022). This information is based on 3.5 inch HDD desktop, with a storage capacity of 1 TB. The weight of such HDD is 450 gr. The material composition of this HDD is updated using JRC report.

Table 8.5-73. Life cycle inventory for HDD, desktop computer and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
HDD, desktop computer, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.01755	kg		Lognormal	1.24	(1,4,2,3,1,5)
Polycarbonate, at plant/RER U	0.0135	kg		Lognormal	1.24	(1,4,2,3,1,5)
aluminium, production mix, at plant/kg/RER U	0.2025	kg		Lognormal	1.24	(1,4,2,3,1,5)
Chromium steel 18/8, at plant/RER U	0.03915	kg		Lognormal	1.24	(1,4,2,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.37	kWh		Lognormal	1.24	(1,4,2,3,1,5)
Hot rolling, steel/RER U	0.03915	kg		Lognormal	1.24	(1,4,2,3,1,5)
Powder coating, aluminium sheet/RER U	0.0112	m2		Lognormal	1.35	(3,4,2,3,3,5)
Printed wiring board mounting plant/p/GLO/I U	3.3333E-08	p		Lognormal	3.11	(2,4,2,3,3,5)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.01755	kg		Lognormal	1.24	(1,4,2,3,1,5)
Section bar extrusion, aluminium/RER U	0.2025	kg		Lognormal	1.24	(1,4,2,3,1,5)
Sheet rolling, aluminium/RER U	0.008	kg		Lognormal	1.24	(1,4,2,3,1,5)
Sheet rolling, steel/RER U	0.1404	kg		Lognormal	1.24	(1,4,2,3,1,5)
Steel, low-alloyed, at plant/RER U	0.1404	kg		Lognormal	1.24	(1,4,2,3,1,5)
Stretch blow moulding/RER U	0.001	kg		Lognormal	1.24	(1,4,2,3,1,5)
transport, freight, rail/tkm/RER U	0.115	tkm		Lognormal	2.10	(2,3,2,1,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.0575	tkm		Lognormal	2.10	(2,3,2,1,3,5)
Output						
Emissions to air						
Heat, waste	6.165	MJ	low. pop.	Lognormal	1.58	(1,4,2,3,1,5)

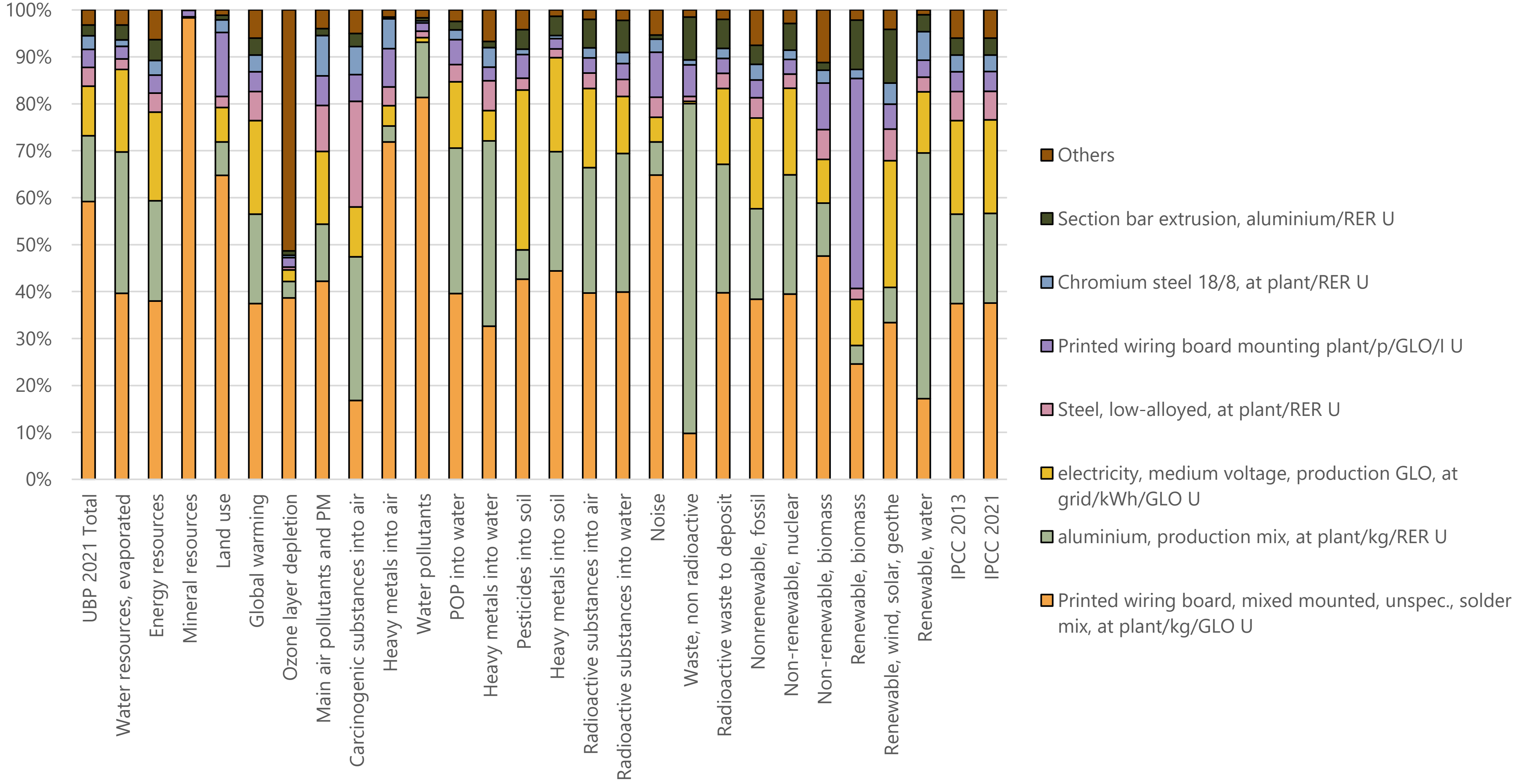

Figure 8.5-37. Contribution analysis presented in bar chart for: HDD, desktop computer. FU = 1 unit

Table 8.5-74. Contribution analysis presented in table for: HDD, desktop computer. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	59%	38%	37%	38%
aluminium, production mix, at plant/kg/RER U	14%	19%	19%	19%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	11%	19%	20%	20%
Steel, low-alloyed, at plant/RER U	4%	4%	6%	6%
Printed wiring board mounting plant/p/GLO/I U	4%	4%	4%	4%
Chromium steel 18/8, at plant/RER U	3%	3%	4%	4%
Section bar extrusion, aluminium/RER U	2%	4%	4%	4%
Others	3%	7%	5%	5%
Total impact, in absolute value	**1.57E+04**	**6.04E+01**	**5.31E+00**	**5.29E+00**

8.5.32 HDD, laptop computer

The dataset is updated using recent technical data from JRC technical report (Talens Peiró & Ardente, 2015; Tecchio et al., 2018) and also by consulting product sheet of storage device manufacturers, i.e., WD (WD, 2019). This information is based on 2.5 inch HDD notebook, with a storage capacity of 1 TB. The weight of such HDD is 90 gr. The material composition of this HDD is updated using JRC report. It is assumed that the share of bill of materials for HDD size used in desktops and laptops are the same in both sizes.

Table 8.5-75. Life cycle inventory for HDD, laptop computer and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
HDD, laptop computer, at plant/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.00351	kg		Lognormal	1.24	(1,4,2,3,1,5)
Polycarbonate, at plant/RER U	0.0027	kg		Lognormal	1.24	(1,4,2,3,1,5)
aluminium, production mix, at plant/kg/RER U	0.0405	kg		Lognormal	1.24	(1,4,2,3,1,5)
Chromium steel 18/8, at plant/RER U	0.00783	kg		Lognormal	1.24	(1,4,2,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.37	kWh		Lognormal	1.24	(1,4,2,3,1,5)
Hot rolling, steel/RER U	0.00783	kg		Lognormal	1.24	(1,4,2,3,1,5)
Powder coating, aluminium sheet/RER U	0.000028	m2		Lognormal	1.35	(3,4,2,3,3,5)
Printed wiring board mounting plant/p/GLO/I U	3.3333E-08	p		Lognormal	3.11	(2,4,2,3,3,5)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kgGLO U	0.00351	kg		Lognormal	1.24	(1,4,2,3,1,5)
Section bar extrusion, aluminium/RER U	0.0405	kg		Lognormal	1.24	(1,4,2,3,1,5)
Sheet rolling, aluminium/RER U	0.0040816	kg		Lognormal	1.24	(1,4,2,3,1,5)
Sheet rolling, steel/RER U	0.02808	kg		Lognormal	1.24	(1,4,2,3,1,5)
Steel, low-alloyed, at plant/RER U	0.02808	kg		Lognormal	1.24	(1,4,2,3,1,5)
Stretch blow moulding/RER U	0.0005102	kg		Lognormal	1.24	(1,4,2,3,1,5)
transport, freight, rail/tkm/RER U	0.024816	tkm		Lognormal	2.10	(2,3,2,1,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.012408	tkm		Lognormal	2.10	(2,3,2,1,3,5)
Output						
Emissions to air						
Heat, waste	6.165	MJ	low. pop.	Lognormal	1.58	(1,4,2,3,1,5)

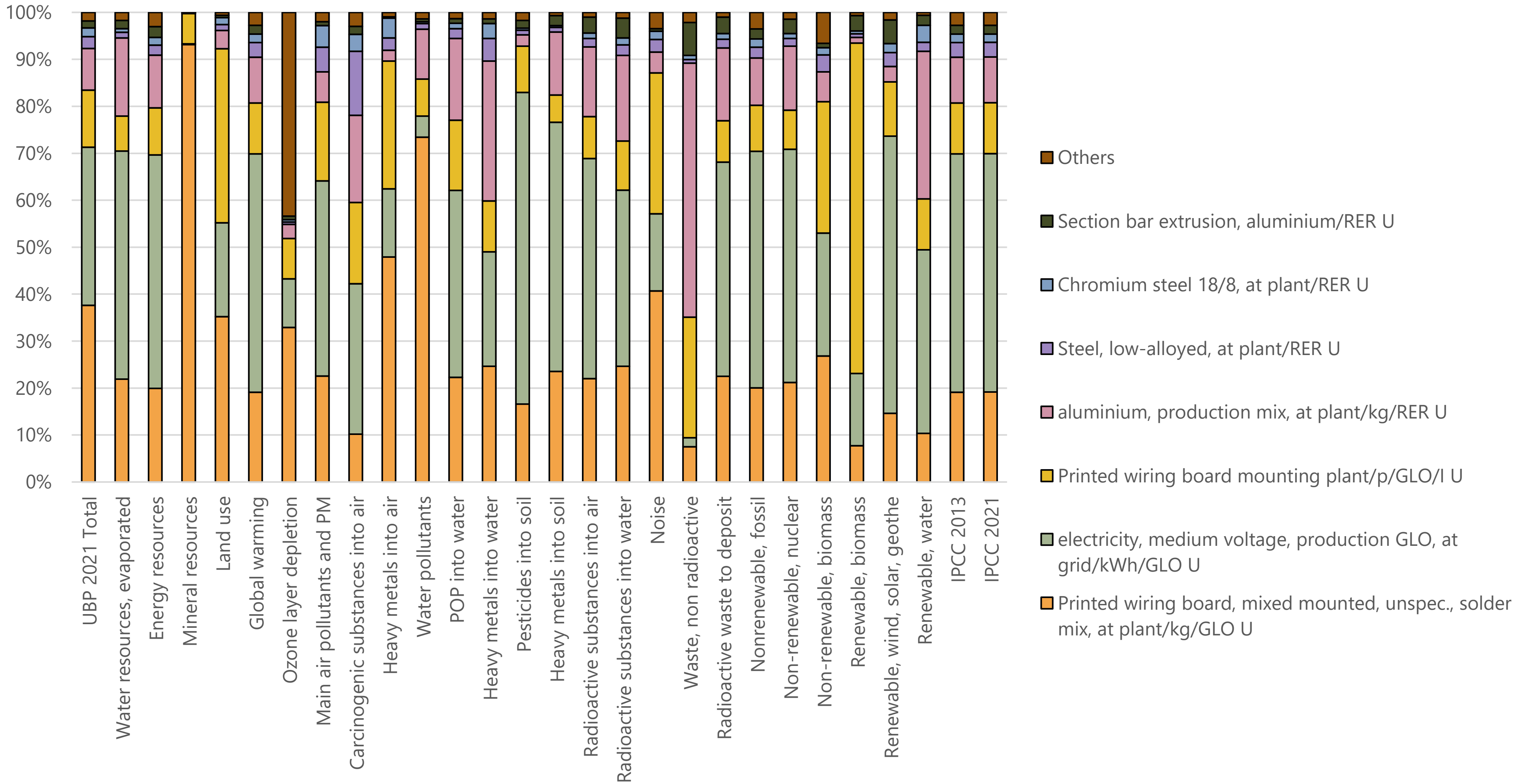

Figure 8.5-38. Contribution analysis presented in bar chart for: HDD, laptop computer. FU = 1 unit

Table 8.5-76. Contribution analysis presented in table for: HDD, laptop computer. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	38%	20%	19%	19%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	34%	50%	51%	51%
Printed wiring board mounting plant/p/GLO/I U	12%	10%	11%	11%
aluminium, production mix, at plant/kg/RER U	9%	10%	10%	10%
Steel, low-alloyed, at plant/RER U	3%	2%	3%	3%
Chromium steel 18/8, at plant/RER U	2%	2%	2%	2%
Section bar extrusion, aluminium/RER U	1%	2%	2%	2%
Others	1%	4%	2%	2%
Total impact, in absolute value	**4.96E+03**	**2.32E+01**	**2.09E+00**	**2.08E+00**

8.5.33 Keyboard, standard version

The inventory flows for keyboard uses the same reference as in the original datasets, with supplements for some flows from the LCA study of personal computers (Hikwama, 2005). Since data for recent keyboards are not available, we assumed that today's keyboards design are optimized such that environmental impacts can be reduced. For this assumption, we obtained the data of optimized eco-design, we took the reference from a manufacturer, Logitech from the sustainability report (Logitech, 2022). In summary, the main reduction in materials consumption concerns electronics (PCB), metals, and plastics, each with the reduction value of 6%, 29%, and 20% respectively. Besides composition, it is assumed that energy consumption during manufacturing will decrease by 20% (Shihata et al., 2022).

Table 8.5-77. Life cycle inventory for Keyboard, standard version and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Keyboard, standard version, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.536	kg		Lognormal	1.34	(1,4,3,3,3,5)
Steel, low-alloyed, at plant/RER U	0.0426	kg		Lognormal	1.34	(1,4,3,3,3,5)
Copper, primary, at refinery/GLO U	0.0329	kg		Lognormal	1.34	(1,4,3,3,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.888	kWh		Lognormal	1.34	(1,4,3,3,3,5)
Extrusion, plastic pipes/RER U	0.0371	kg		Lognormal	1.34	(1,4,3,3,3,5)
Injection moulding/RER U	0.77	kg		Lognormal	1.34	(1,4,3,3,3,5)
Polyvinylchloride, at regional storage/RER U	0.0371	kg		Lognormal	1.34	(1,4,3,3,3,5)
Printed wiring board mounting plant/p/GLO/I U	2.4544E-07	p		Lognormal	3.12	(1,4,3,3,3,5)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.015	kg		Lognormal	1.34	(1,4,3,3,3,5)
transport, freight, rail/tkm/RER U	0.236	tkm		Lognormal	2.12	(2,4,3,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.118	tkm		Lognormal	2.12	(2,4,3,3,3,5)
transport, transoceanic freight ship/tkm/OCE U	25.134	tkm		Lognormal	2.12	(2,4,3,3,3,5)
Wire drawing, copper/RER U	0.0329	kg		Lognormal	1.34	(1,4,3,3,3,5)
Output						
Waste to treatment						
Disposal, keyboard, standard version, to WEEE treatment/CH U	1	p		Lognormal	1.34	(1,4,3,3,3,5)

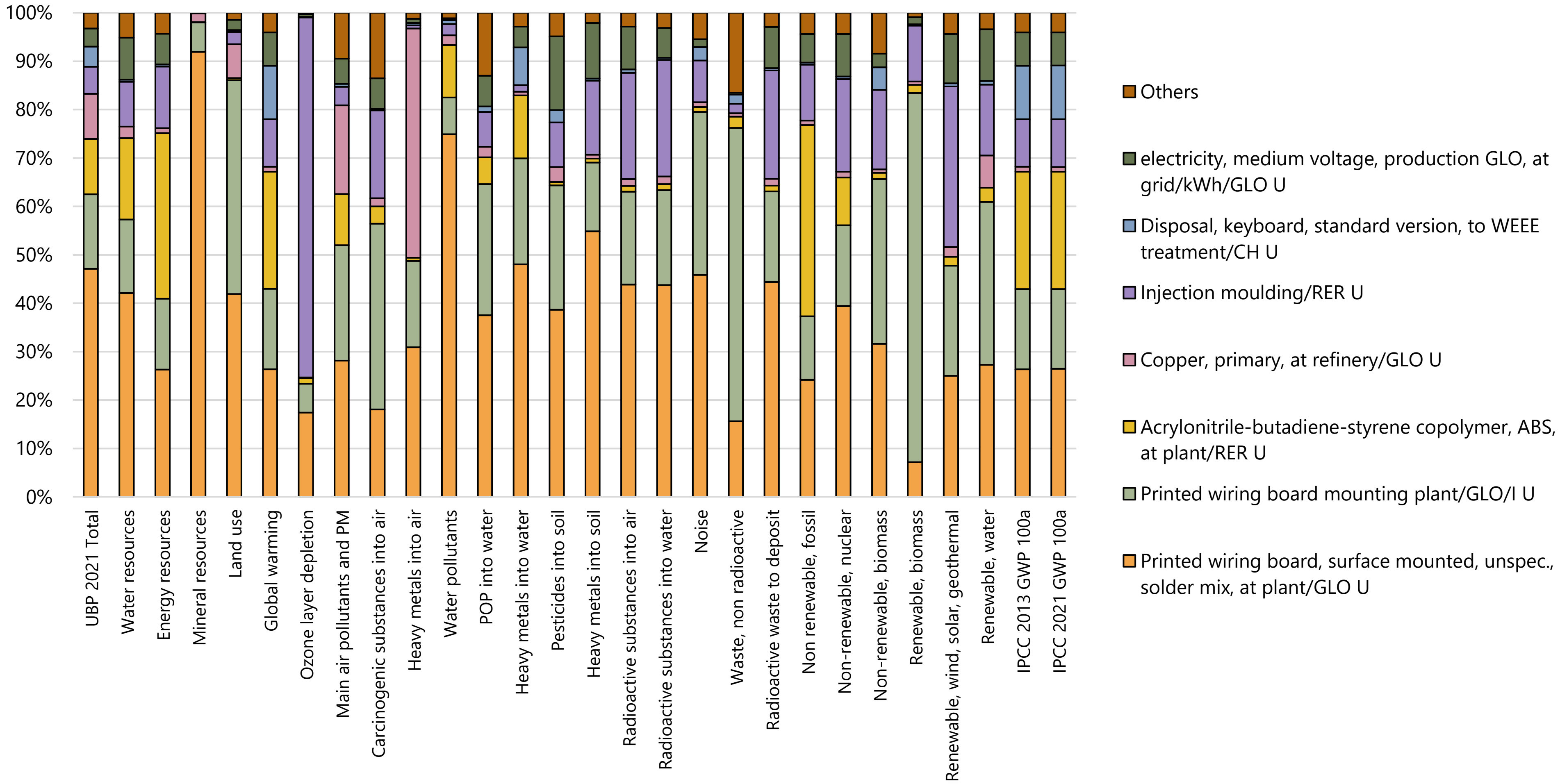

Figure 8.5-39. Contribution analysis presented in bar chart for: Keyboard, standard version. FU = 1 unit

Table 8.5-78. Contribution analysis presented in table for: Keyboard, standard version. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	47%	24%	26%	26%
Printed wiring board mounting plant/p/GLO/I U	15%	13%	17%	17%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	11%	39%	24%	24%
Copper, primary, at refinery/GLO U	9%	1%	1%	1%
Injection moulding/RER U	6%	12%	10%	10%
Disposal, keyboard, standard version, to WEEE treatment/CH U	4%	0%	11%	11%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	4%	6%	7%	7%
Others	3%	4%	4%	4%
Total impact, in absolute value	**2.89E+04**	**1.28E+02**	**1.00E+01**	**1.00E+01**

8.5.34 Mouse device, optical, with cable

The inventory flows for keyboard uses the same reference as in the original datasets, with supplements for some flows from the LCA study of personal computers (Hikwama, 2005). Since data for recent keyboards are not available, we assumed that today's mice design are optimized such that environmental impacts can be reduced. For this assumption, we obtained the data of optimized eco-design, we took the reference from a manufacturer, Logitech from the sustainability report (Logitech, 2022). In summary, the main reduction in materials consumption concerns electronics (PCB), metals, and plastics, each with the reduction value of 13%, 58%, and 40% respectively. Certain materials such as rubber are no longer used in the market today, and hence were not considered in the updated dataset. Besides composition, it is assumed that energy consumption during manufacturing will decrease by 20% (Shihata et al., 2022).

Table 8.5-79. Life cycle inventory for Mouse device, optical, with cable and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Mouse device, optical, with cable, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.0408	kg		Lognormal	1.33	(1,4,4,3,1,5)
Cable, network cable, category 5, without plugs, at plant/m/GLO U	0.9	m		Lognormal	1.33	(1,4,4,3,1,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.888	kWh		Lognormal	1.33	(1,4,4,3,1,5)
Extrusion, plastic pipes/RER U	0.00245	kg		Lognormal	1.33	(1,4,4,3,1,5)
Hot rolling, steel/RER U	0.0022	kg		Lognormal	1.33	(1,4,4,3,1,5)
Injection moulding/RER U	0.0513	kg		Lognormal	1.33	(1,4,4,3,1,5)
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1	p		Lognormal	1.33	(1,4,4,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	2.496E-08	p		Lognormal	3.10	(1,4,4,3,1,5)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.007	kg		Lognormal	1.33	(1,4,4,3,1,5)
Sheet rolling, steel/RER U	0.01085	kg		Lognormal	1.33	(1,4,4,3,1,5)
Steel, low-alloyed, at plant/RER U	0.01085	kg		Lognormal	1.33	(1,4,4,3,1,5)
transport, freight, rail/tkm/RER U	0.01951	tkm		Lognormal	2.16	(2,4,4,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.009755	tkm		Lognormal	2.16	(2,4,4,3,3,5)
transport, transoceanic freight ship/tkm/OCE U	2.0778	tkm		Lognormal	2.16	(2,4,4,3,3,5)
Output						
Waste to treatment						
Disposal, mouse device, optical, with cable, to WEEE treatment/CH U	1	p		Lognormal	1.33	(1,4,4,3,1,5)

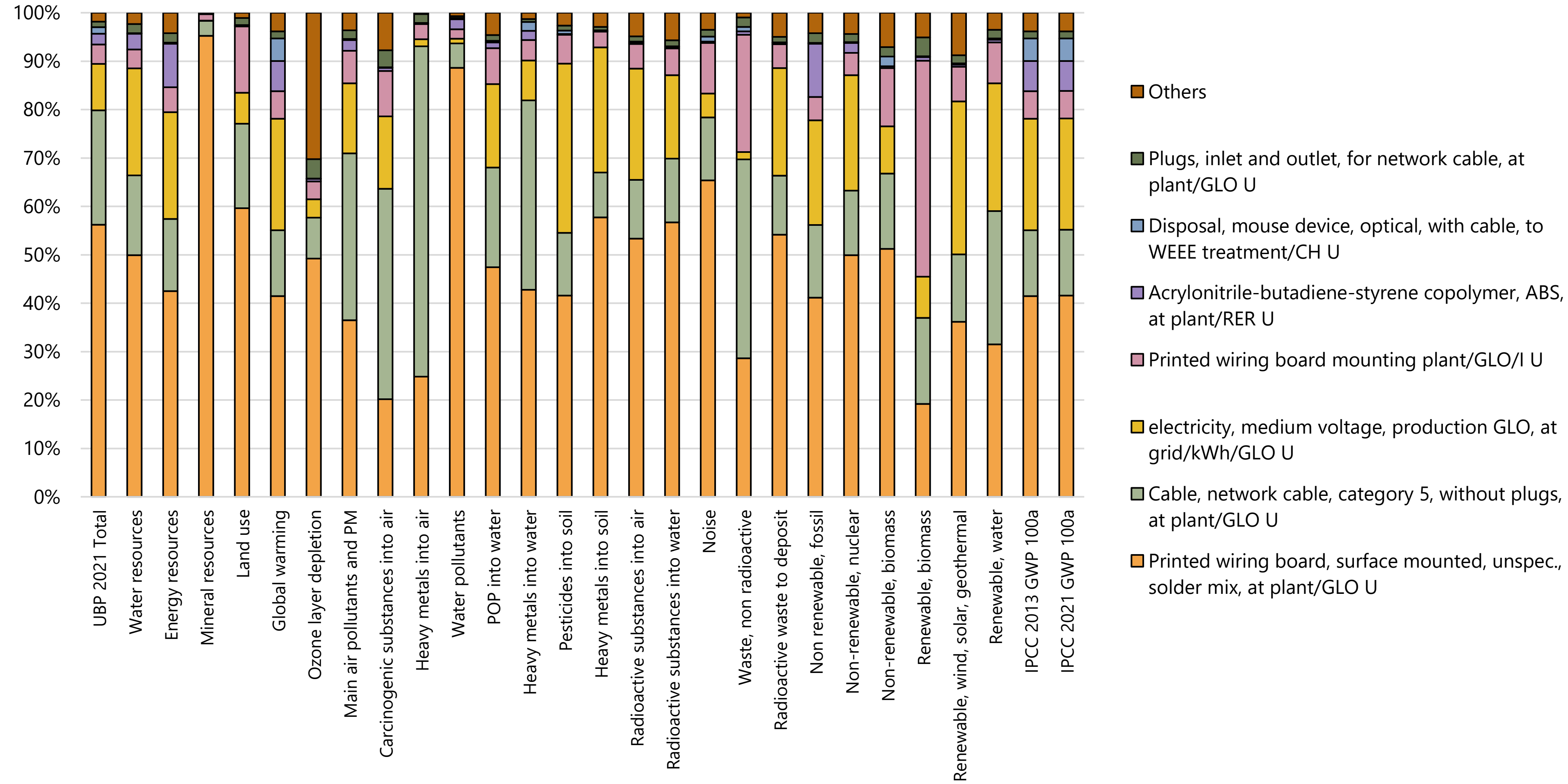

Figure 8.5-40. Contribution analysis presented in bar chart for: Mouse device, optical, with cable. FU = 1 unit

Table 8.5-80. Contribution analysis presented in table for: Mouse device, optical, with cable. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	56%	41%	41%	42%
Cable, network cable, category 5, without plugs, at plant/m/GLO U	24%	15%	14%	14%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	10%	22%	23%	23%
Printed wiring board mounting plant/p/GLO/I U	4%	5%	6%	6%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	2%	11%	6%	6%
Disposal, mouse device, optical, with cable, to WEEE treatment/CH U	1%	0%	5%	5%
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1%	2%	1%	1%
Others	2%	4%	4%	4%
Total impact, in absolute value	**1.13E+04**	**3.50E+01**	**2.97E+00**	**2.97E+00**

8.6 Terminals

8.6.1 Desktop computer

Some datasets are removed: CD-Drive and Batteries in the desktop computers – they are no longer relevant for the integrated desktop unit. Many data are taken from the recent bill of materials data from the dismantling study of (Babbitt et al., 2020) and some specific data gaps are supplemented with data from (Teehan & Kandlikar, 2013). Both sources contain data for computer units released in the year 2011 – 2015, with the average specification as follows: Intel® Core™ i5-8500, 6 Cores/9MB/6T/up to 4.1GHz, 500 GB RAM HDD, 8 GB working memory, total weight without screen and cardboard packaging 8.8 kg. Transport efforts are adjusted according to the new total mass of the modeled desktop computer.

Table 8.6-1. Life cycle inventory for Desktop computer, without screen and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Desktop computer, without screen, at plant/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.158	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
aluminium, production mix, at plant/kg/RER U	0.766	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Cable, connector for computer, without plugs, at plant/m/GLO U	2.5	m		Lognormal	1.33	(1,4,2,3,3,5)
Cable, network cable, category 5, without plugs, at plant/m/GLO U	3	m		Lognormal	1.33	(1,4,2,3,3,5)
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.0506	kg		Lognormal	1.33	(1,4,2,3,3,5)
Chromium steel 18/8, at plant/RER U	0.0237	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Copper, primary, at refinery/GLO U	0.344	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Corrugated board, recycling fibre, double wall, at plant/RER U	1.84	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
electricity, medium voltage, production GLO, at grid/kWh/GLO U	7.0277	kWh		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Foaming, expanding/RER U	0.16	kg		Lognormal	1.33	(1,4,2,3,3,5) Adjuster after mass
HDD, desktop computer, at plant/p/GLO U	1	p		Lognormal	1.33	(1,4,2,3,3,5)
Hot rolling, steel/RER U	0.0237	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.04	kg		Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
photovoltaic cell factory/p/DE/I U	1.3333E-08	p		Lognormal	3.11	(1,4,2,3,3,5)
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.33	(1,4,2,3,3,5)
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1	p		Lognormal	1.33	(1,4,2,3,3,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.0195	kg		Lognormal	1.33	(1,4,2,3,3,5) Adjusted after mass
Polypropylene, granulate, at plant/RER U	0.16	kg		Lognormal	1.33	(1,4,2,3,3,5) Adjusted after mass
Powder coating, steel/RER U	0.294	m2		Lognormal	1.33	(1,4,2,3,3,5) Adjusted after mass
Power supply unit, at plant/p/GLO U	1	p		Lognormal	1.33	(1,4,2,3,3,5)

Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	0.757	kg	Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Printed wiring board, surface mount, at plant/m2/GLO U	0.00809	m2	Lognormal	1.33	(1,4,2,3,3,5)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.212	kg	Lognormal	1.33	(1,4,2,3,3,5) Adjusted according to PWB mass
Section bar extrusion, aluminium/RER U	0.766	kg	Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Sheet rolling, steel/RER U	4.59	kg	Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Steel, low-alloyed, at plant/RER U	4.59	kg	Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Stretch blow moulding/RER U	0.0751	kg	Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
tap water, at user/kg/RER U	1620	kg	Lognormal	1.33	(1,4,2,3,3,5)
transport, freight, rail/tkm/RER U	1.69	tkm	Lognormal	2.10	(2,2,2,1,3,5) Adjusted from 11.3 kg to 8.8 kg total mass
transport, freight, lorry, fleet average/tkm/RER U	0.847	tkm	Lognormal	2.10	(2,2,2,1,3,5) Adjusted from 11.3 kg to 8.8 kg total mass
transport, transoceanic freight ship/tkm/OCE U	180	tkm	Lognormal	2.10	(2,2,2,1,3,5) Adjusted from 11.3 kg to 8.8 kg total mass
Wire drawing, copper/RER U	0.0487	kg	Lognormal	1.33	(1,4,2,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Output					
Waste to treatment					
Disposal, desktop computer, to WEEE treatment/CH U	1	p	Lognormal	1.33	(1,4,2,3,3,5)
disposal, polypropylene, 15.9% water, to municipal incineration/kg/CH U	0.128	kg	Lognormal	1.33	(1,4,2,3,3,5) Adjusted according to PP fraction
Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U	1.62	m3	Lognormal	1.33	(1,4,2,3,3,5)

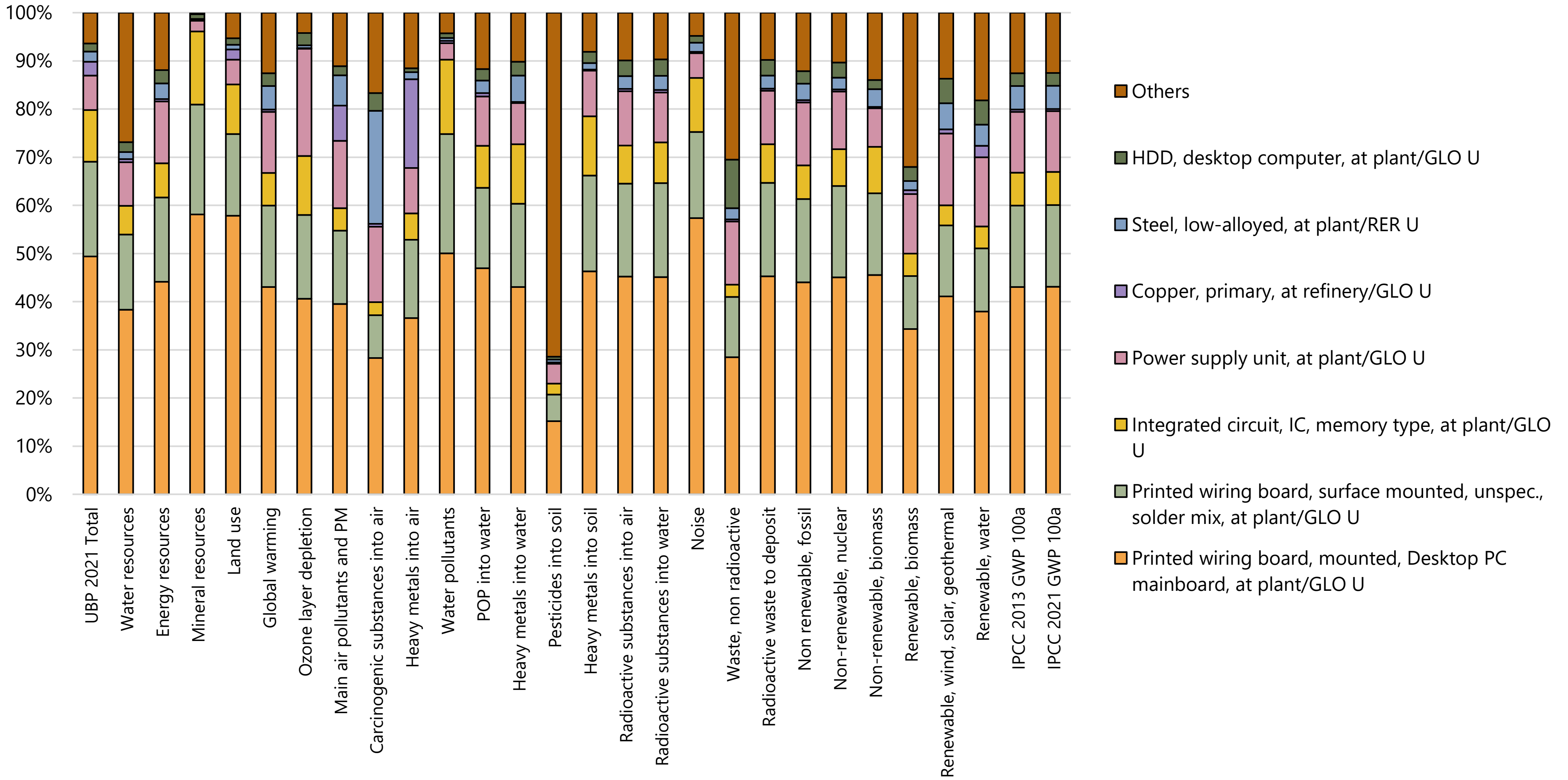

Figure 8.6-1. Contribution analysis presented in bar chart for: Desktop computer, without screen. FU = 1 unit

Table 8.6-2. Contribution analysis presented in table for: Desktop computer, without screen. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	49%	44%	43%	43%
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	20%	17%	17%	17%
Integrated circuit, IC, memory type, at plant/kg/GLO U	11%	7%	7%	7%
Power supply unit, at plant/p/GLO U	7%	13%	13%	13%
Copper, primary, at refinery/GLO U	3%	0%	0%	0%
Steel, low-alloyed, at plant/RER U	2%	3%	5%	5%
HDD, desktop computer, at plant/p/GLO U	2%	3%	3%	3%
Others	6%	12%	13%	13%
Total impact, in absolute value	**9.74E+05**	**2.50E+03**	**2.18E+02**	**2.18E+02**

8.6.2 Laptop computer

Some datasets are removed: CD-drive, NIMH batteries, and magnesium allow for casing, since they are no longer relevant for the laptop computer. The update values were taken from the bill of materials data from the dismantling study of (Babbitt et al., 2020) and the rest of the data gaps were supplemented with data from (Teehan & Kandlikar, 2013). The specification of reference laptop, i.e, HP 530, is the following: Intel® Celeron® M, 4 GB RAM, 500 GB HDD, 15.4 inch screen, total weight with expansion base 2.77 kg. Transport efforts are adjusted according to the new total mass of the modeled desktop computer.

Table 8.6-3. Life cycle inventory for Laptop computer and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Laptop computer, at plant/GLO U	1	p				
Input						
aluminium, production mix, at plant/kg/RER U	0.418	kg		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.244	kg		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Cable, network cable, category 5, without plugs, at plant/m/GLO U	0.156	m		Lognormal	1.34	(1,4,3,3,3,5)
Steel, low-alloyed, at plant/RER U	0.313	kg		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Copper, primary, at refinery/GLO U	0.048	kg		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Corrugated board, recycling fibre, double wall, at plant/RER U	0.737	kg		Lognormal	1.34	(1,4,3,3,3,5) Adjusted according to laptop mass
electricity, medium voltage, production GLO, at grid/kWh/GLO U	5.27778	kWh		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Extrusion, plastic pipes/RER U	0.368	kg		Lognormal	1.34	(1,4,3,3,3,5) Adjusted according to laptop mass
HDD, laptop computer, at plant/p/GLO U	1	p		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.021	kg		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
LED module, at plant/kg/GLO U	0.54	kg		Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Packaging film, LDPE, at plant/RER U	0.044	kg		Lognormal	1.34	(1,4,3,3,3,5) Adjusted according to laptop mass
photovoltaic cell factory/p/DE/I U	3.038E-08	p		Lognormal	3.12	(1,4,3,3,3,5)
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1	p		Lognormal	1.34	(1,4,3,3,3,5)
Polystyrene foam slab, at plant/RER U	0.0781	kg		Lognormal	1.34	(1,4,3,3,3,5) Adjusted according to laptop mass
Polystyrene, high impact, HIPS, at plant/RER U	0.372	kg		Lognormal	1.34	(1,4,3,3,3,5) Adjusted according to laptop mass
Power adapter, for laptop, at plant/p/GLO U	1	p		Lognormal	1.34	(1,4,3,3,3,5)
Printed wiring board, mounted, Laptop PC mainboard, at plant/kg/GLO U	0.171	kg		Lognormal	1.34	(1,4,3,3,3,5) Total PWB = 0.337 kg, Data from Babbit et al 2020 and Teehan et al 2013
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.166	kg		Lognormal	1.34	(1,4,3,3,3,5) Total PWB = 0.337 kg, Data from Babbit et al 2020 and Teehan et al 2013

Section bar extrusion, aluminium/RER U	0.418	kg	Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Sheet rolling, aluminium/RER U	0.418	kg	Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Sheet rolling, copper/RER U	0.048	kg	Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
Sheet rolling, steel/RER U	0.313	kg	Lognormal	1.34	(1,4,3,3,3,5) Data from Babbit et al 2020 and Teehan et al 2013
tap water, at user/kg/RER U	1620	kg	Lognormal	1.34	(1,4,3,3,3,5)
transport, freight, rail/tkm/RER U	0.559	tkm	Lognormal	2.12	(1,4,3,3,3,5) Adjusted according to laptop mass
transport, freight, lorry, fleet average/tkm/RER U	0.28	tkm	Lognormal	2.12	(1,4,3,3,3,5) Adjusted according to laptop mass
transport, transoceanic freight ship/tkm/OCE U	59.5	tkm	Lognormal	2.12	(1,4,3,3,3,5) Adjusted according to laptop mass
Output					
Waste to treatment					
Disposal, laptop computer, to WEEE treatment/CH U	1	p	Lognormal	1.34	(1,4,3,3,3,5)
disposal, polyethylene, 0.4% water, to municipal incineration/kg/CH U	0.044	kg	Lognormal	1.34	(1,4,3,3,3,5)
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	0.089	kg	Lognormal	1.34	(1,4,3,3,3,5)
Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U	1.62	m3	Lognormal	1.34	(1,4,3,3,3,5)

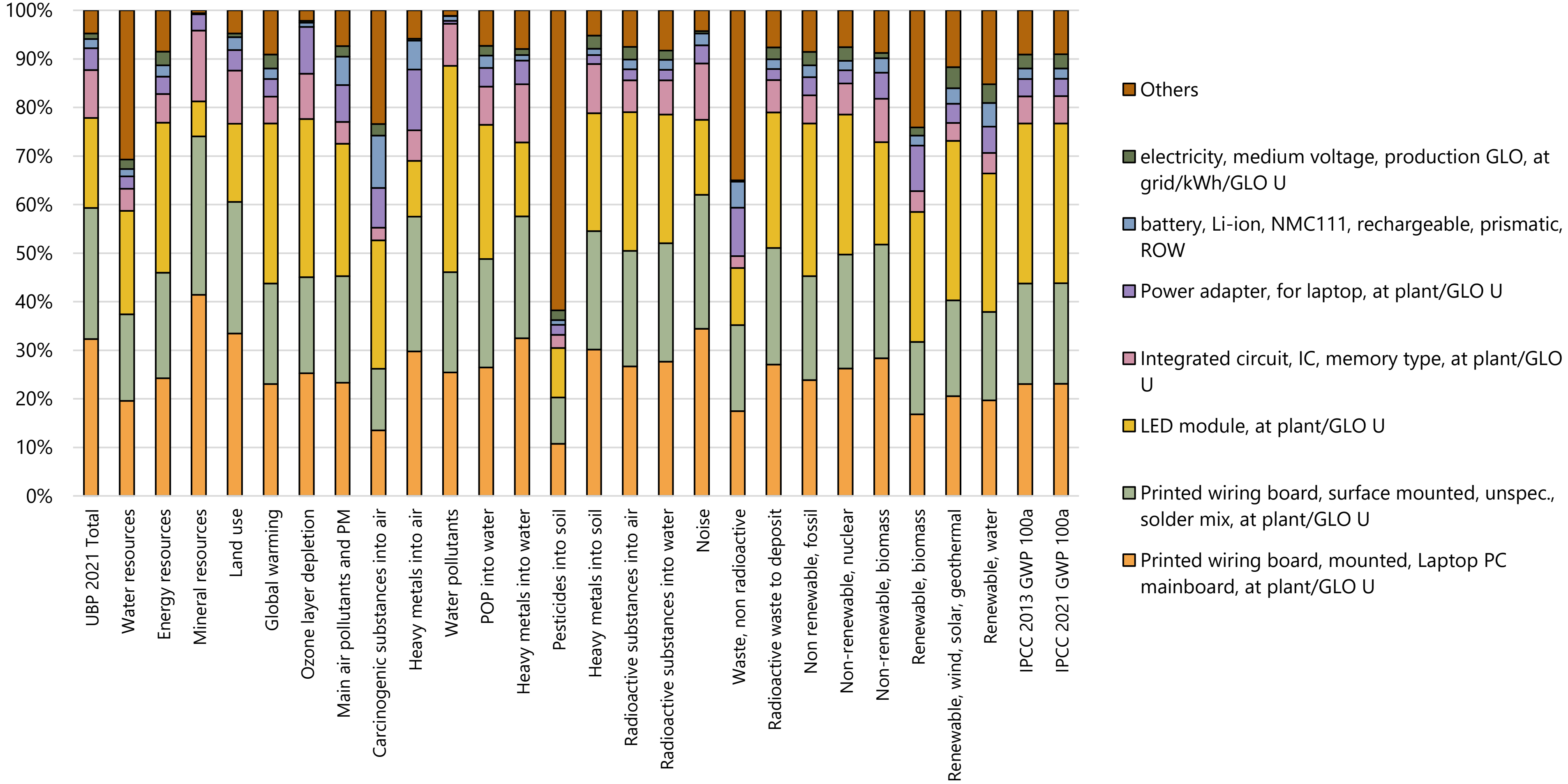

Figure 8.6-2. Contribution analysis presented in bar chart for: Laptop computer. FU = 1 unit

Table 8.6-4. Contribution analysis presented in table for: Laptop computer. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Laptop PC mainboard, at plant/kg/GLO U	32%	24%	23%	23%
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	27%	21%	21%	21%
LED module, at plant/kg/GLO U	19%	31%	33%	33%
Integrated circuit, IC, memory type, at plant/kg/GLO U	10%	6%	6%	6%
Power adapter, for laptop, at plant/p/GLO U	4%	4%	4%	4%
battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	2%	2%	2%	2%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1%	3%	3%	3%
Others	5%	9%	9%	9%
Total impact, in absolute value	**5.56E+05**	**1.58E+03**	**1.40E+02**	**1.39E+02**

8.7 Network and Infrastructure

8.7.1 Chassis, network main devices

Recently updated based on Swiss telecom and personal communication in 2017. No need for updates in the new database. These changes were not linked to an updated report so the reference is still the same.

Table 8.7-1. Life cycle inventory for Chassis, network main devices and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Chassis, network main devices/kg/GLO U	1	kg				
Output						
electricity, low voltage, production GLO, at grid/kWh/GLO U	1	kWh		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
aluminium, production mix, cast alloy, at plant/kg/RER U	0.025	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
aluminium, production mix, at plant/kg/RER U	0.025	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Cast iron, at plant/RER U	0.05	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Copper, primary, at refinery/GLO U	0.15	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Steel, low-alloyed, at plant/RER U	0.622	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Tin, at regional storage/RER U	0.002	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Brass, at plant/CH U	0.01	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Zinc, primary, at regional storage/RER U	0.001	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Epoxy resin, liquid, at plant/RER U	0.02	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Polyethylene, HDPE, granulate, at plant/RER U	0.01	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Polyvinylchloride, bulk polymerised, at plant/RER U	0.01	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices

Polypropylene, granulate, at plant/RER U	0.05	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Flat glass, coated, at plant/RER U	0.02	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Silicone product, at plant/RER U	0.001	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Corrugated board, mixed fibre, single wall, at plant/RER U	0.004	kg		Lognormal	1.68	(5,5,2,3,3,5); packaging
transport, freight, lorry, fleet average/tkm/RER U	0.1	tkm		Lognormal	2.37	(5,5,2,3,3,5); standard distance 100km
transport, freight, rail/tkm/RER U	0.2	tkm		Lognormal	2.37	(5,5,2,3,3,5); standard distance 200km
transport, freight, lorry 7.5-16 metric ton, fleet average/tkm/RER U	0.5	tkm		Lognormal	2.37	(5,5,2,3,3,5); delivery to storage 500km
transport, freight, light commercial vehicle/tkm/RER U	0.3	tkm		Lognormal	2.37	(5,5,2,3,3,5); installation, service, deinstallation 300km
Sheet rolling, steel/RER U	0.622	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Powder coating, steel/RER U	0.05	m2		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Wire drawing, copper/RER U	0.15	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
Output						
Emissions to air						
Heat, waste	3.6	MJ	high. pop.	Lognormal	1.63	(3,5,1,1,1,5); calculation
Waste to treatment						
Disposal, building, bulk iron (excluding reinforcement), to sorting plant/CH U	0.672	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
disposal, packaging cardboard, 19.6% water, to municipal incineration/kg/CH U	0.004	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices
disposal, plastic, industr. electronics, 15.3% water, to municipal incineration/kg/CH U	0.11	kg		Lognormal	1.68	(5,5,2,3,3,5); assumption according to factsheets of network devices

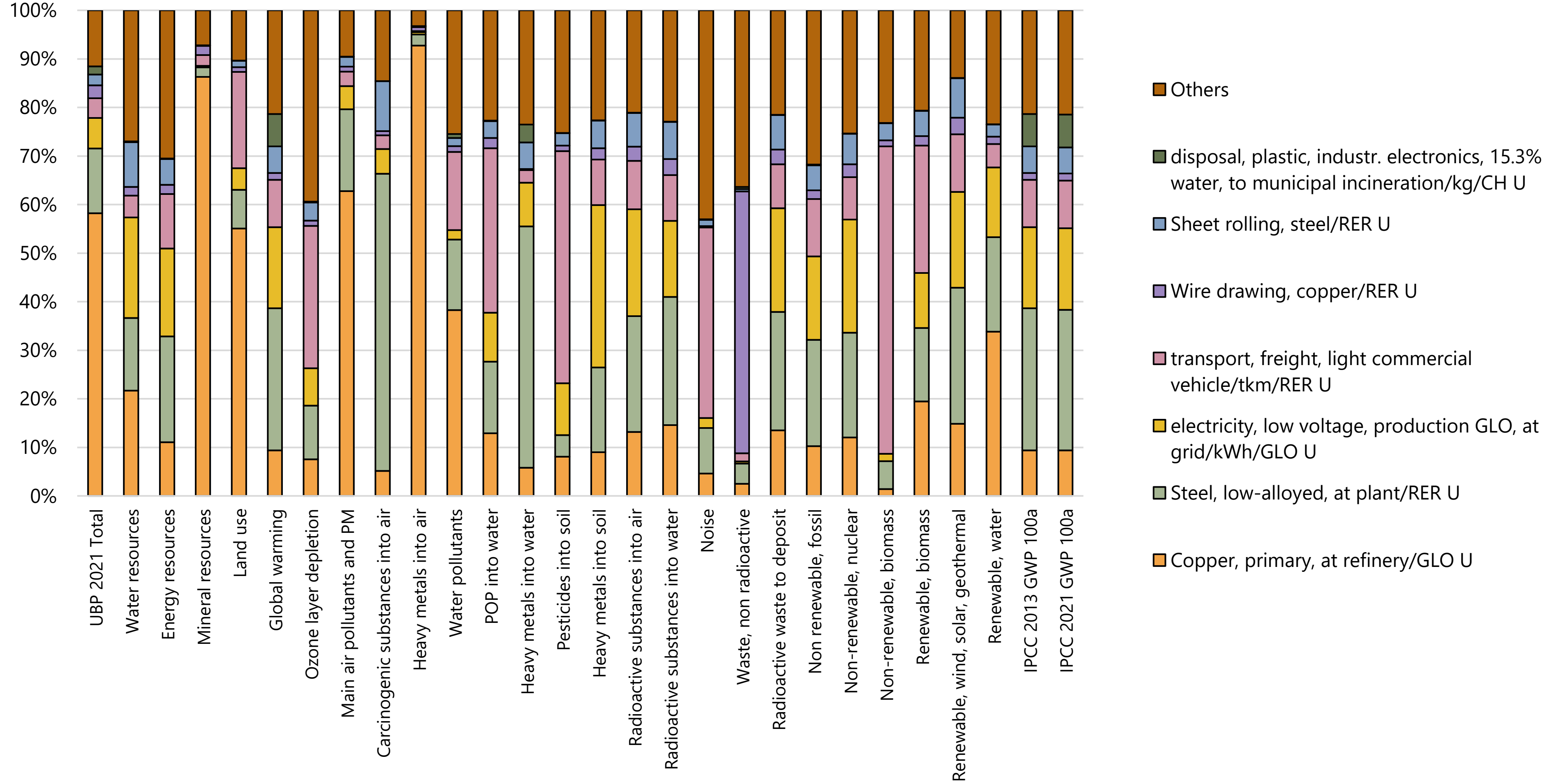

Figure 8.7-1. Contribution analysis presented in bar chart for: chassis, network main devices. FU = 1 kg

Table 8.7-2. Contribution analysis presented in table for: chassis, network main devices. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Copper, primary, at refinery/GLO U	58%	10%	9%	9%
Steel, low-alloyed, at plant/RER U	13%	22%	29%	29%
electricity, low voltage, production GLO, at grid/kWh/GLO U	6%	17%	17%	17%
transport, freight, light commercial vehicle/tkm/RER U	4%	12%	10%	10%
Wire drawing, copper/RER U	3%	2%	1%	1%
Sheet rolling, steel/RER U	2%	5%	5%	5%
disposal, plastic, industr. electronics, 15.3% water, to municipal incineration/kg/CH U	2%	0%	7%	7%
Others	12%	32%	21%	21%
Total impact, in absolute value	**2.10E+04**	**5.35E+01**	**5.00E+00**	**4.95E+00**

8.7.2 Network access device

Based on the review, the previous dataset still represents recent equipment so the input values have not been changed.

Table 8.7-3. Life cycle inventory for Network access devices, internet, at user and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Network access devices, internet, at user/p/GLO/I U	1	p				
Input						
Chassis, network main devices/kg/GLO U	0.27906	kg		Lognormal	1.64	(4,3,3,1,4,5); Estimation, total weight from factssheet Zyxel; Factssheet Zyxel IES-6000 Series: 15 kg / 768 ports, 50% utilisation; Cisco router factssheet: 3.63 kg, assumption PWB=50% of weight
Printed wiring board, surface mount, at plant/m2/GLO U	0.01796	m2		Lognormal	1.64	(4,3,3,1,4,5); Estimation; Factssheet Zyxel IES-6000 Series: 39.6x24cm per 48 ports, 50% utilisation; Cisco router factssheet: area 26.67cmx28.07cm
transport, transoceanic freight ship/tkm/OCE U	6.696	tkm		Lognormal	2.12	(2,3,3,3,3,5); Over all weight of device = 2* chassis weight, transport from Asia: 12000km
transport, freight, lorry 7.5-16 metric ton, fleet average/tkm/RER U	0.4465	tkm		Lognormal	2.12	(2,3,3,3,3,5); Over all weight of device = 2* chassis weight, transport from Rotterdam: 800km

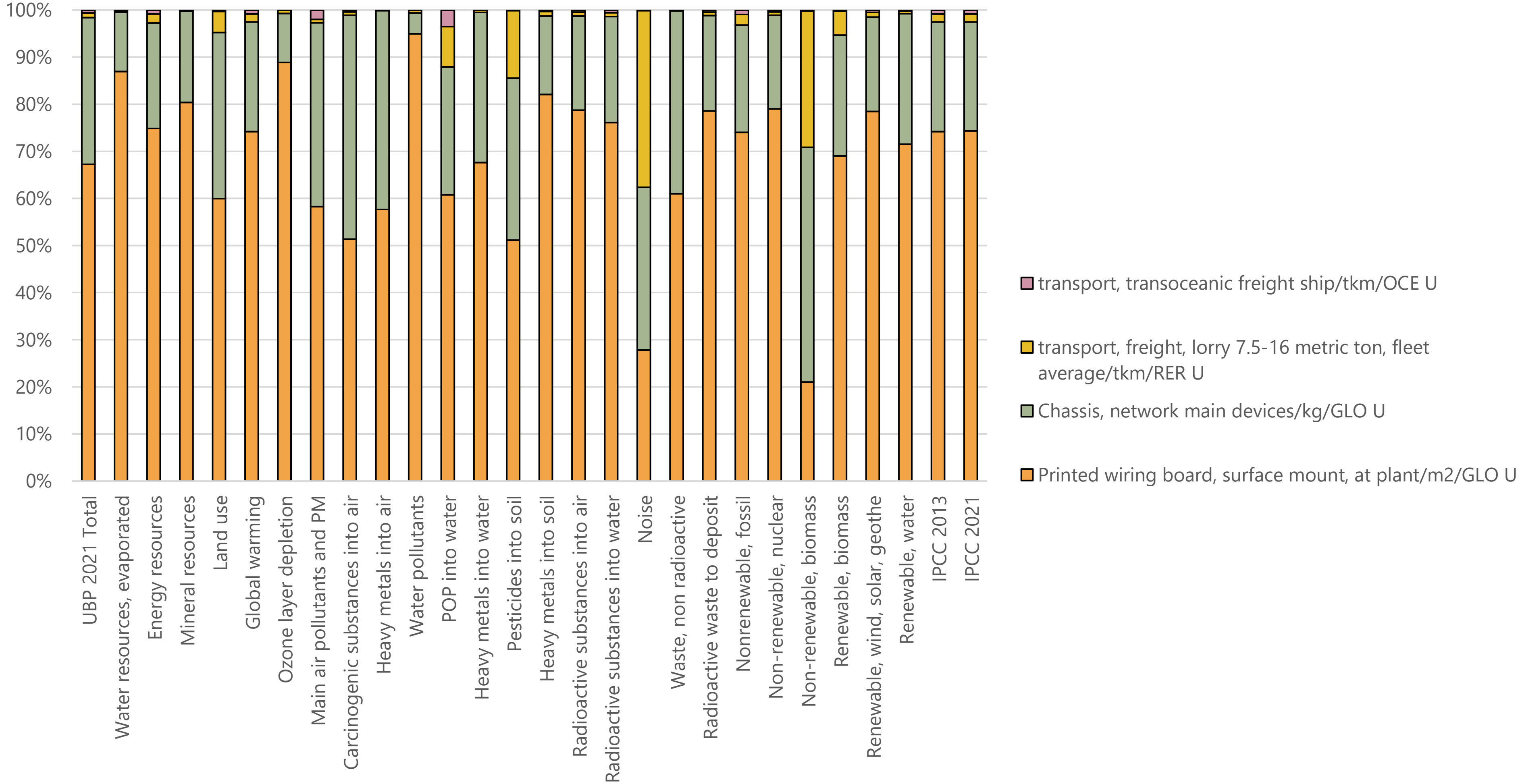

Figure 8.7-2. Contribution analysis presented in bar chart for: network access devices, internet. FU = 1 unit

Table 8.7-4. Contribution analysis presented in table for: network access devices, internet. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mount, at plant/m2/GLO U	67%	74%	74%	74%
Chassis, network main devices/kg/GLO U	31%	23%	23%	23%
transport, freight, lorry 7.5-16 metric ton, fleet average/tkm/RER U	1%	2%	2%	2%
transport, transoceanic freight ship/tkm/OCE U	1%	1%	1%	1%
Network access devices, internet, at user/p/GLO/I U	0%	0%	0%	0%
Total impact, in absolute value	**1.88E+04**	**6.55E+01**	**6.00E+00**	**5.97E+00**

8.7.3 Router, IP network

The dataset is updated using the average of recent router equipment found in the literature by (Kübler, 2022) and (T.-C. Kuo et al., 2016). Chassis used is a mixture of steel based chassis and ABS. The IC types (logic and memory) are divided equally, as both ICs can be used in the router. This is based on the assumption found in the work of Kubler 2022, in which the IC types are not specified.

Table 8.7-5. Life cycle inventory for Router, IP network and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Router, IP network, at server/p/GLO/I U	1	p				
Input						
Cable, connector for computer, without plugs, at plant/m/GLO U	0.306	m	Lognormal	1.23		(2,3,2,3,2,5);
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.0103	kg	Lognormal	1.23		(2,3,2,3,2,5);
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.0103	kg	Lognormal	1.23		(2,3,2,3,2,5);
Diode, unspecified, at plant/kg/GLO U	0.00025	kg	Lognormal	1.23		(2,3,2,3,2,5);
Transistor, unspecified, at plant/kg/GLO U	0.00185	kg	Lognormal	1.23		(2,3,2,3,2,5);
Solder, bar, Sn63Pb37, for electronics industry, at plant/GLO U	0.0925	kg	Lognormal	1.23		(2,3,2,3,2,5);
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.0845	kg	Lognormal	1.23		(2,3,2,3,2,5);
Chassis, network main devices/kg/GLO U	0.0845	kg	Lognormal	1.23		(2,3,2,3,2,5);
Steel, low-alloyed, at plant/RER U	0.00415	kg	Lognormal	1.23		(2,3,2,3,2,5);
Capacitor, unspecified, at plant/kg/GLO U	0.005	kg	Lognormal	1.23		(2,3,2,3,2,5);
Light emitting diode, LED, at plant/kg/GLO U	0.0005	kg	Lognormal	1.23		(2,3,2,3,2,5);
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.0474	kg	Lognormal	1.23		(2,3,2,3,2,5);
Resistor, unspecified, at plant/kg/GLO U	0.0017	kg	Lognormal	1.23		(2,3,2,3,2,5);
Switch, toggle type, at plant/GLO U	0.00005	kg	Lognormal	1.23		(2,3,2,3,2,5);
Inductor, unspecified, at plant/kg/GLO U	0.00002	kg	Lognormal	1.23		(2,3,2,3,2,5);
Transformer, low voltage use, at plant/GLO U	0.00445	kg	Lognormal	1.23		(2,3,2,3,2,5);
transport, transoceanic freight ship/tkm/OCE U	8.8368	tkm	Lognormal	2.06		(2,3,2,3,2,5); Over all weight of device = 2* router weight, transport from Asia: 12000km
transport, freight, lorry 7.5-16 metric ton, fleet average/tkm/RER U	0.58912	tkm	Lognormal	2.06		(2,3,2,3,2,5); Over all weight of device = 2* router weight, transport from Rotterdam: 800km

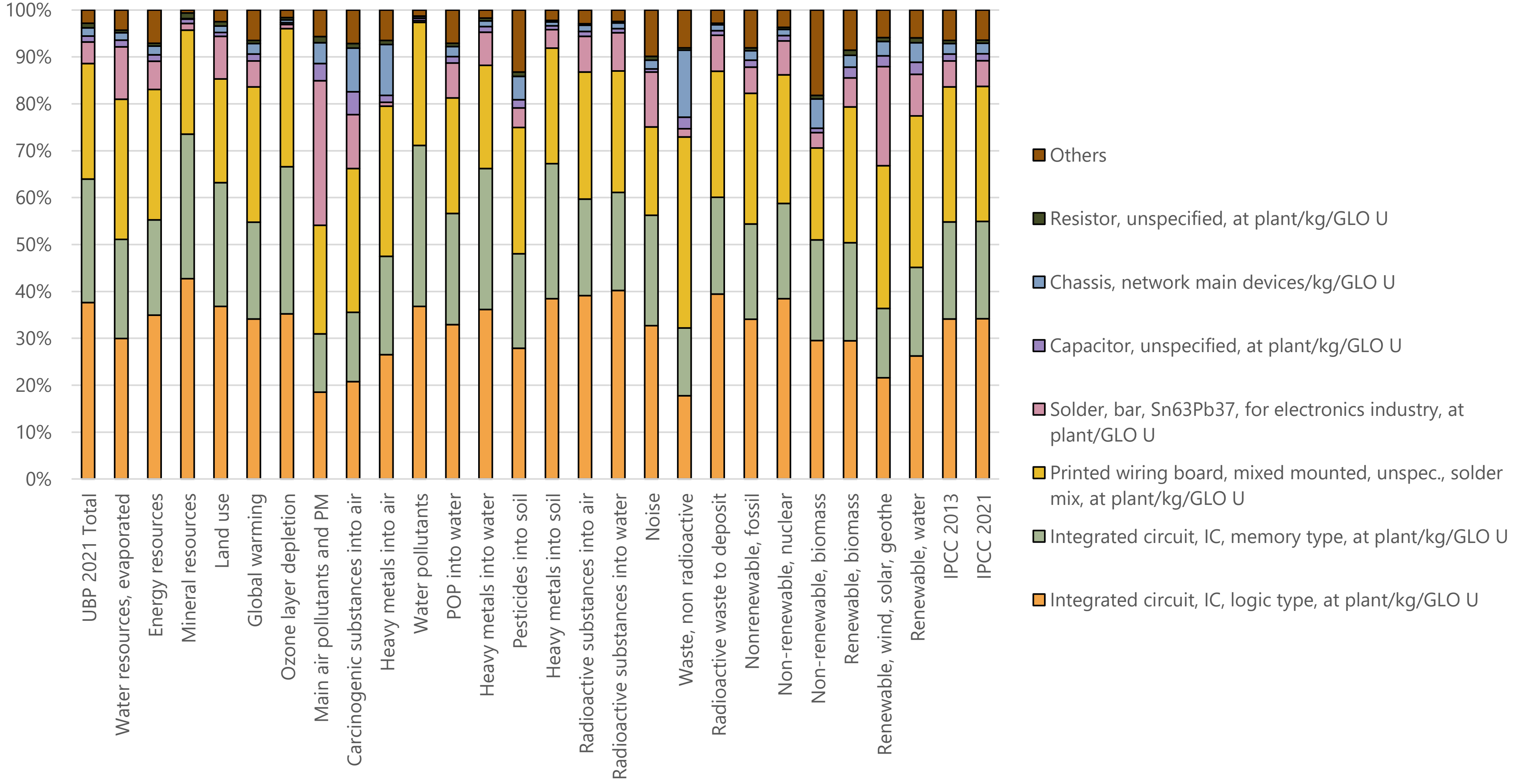

Figure 8.7-3. Contribution analysis presented in bar chart for: Router, IP network. FU = 1 unit

Table 8.7-6. Contribution analysis presented in table for: Router, IP network. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/kg/GLO U	38%	34%	34%	34%
Integrated circuit, IC, memory type, at plant/kg/GLO U	26%	20%	21%	21%
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	25%	28%	29%	29%
Solder, bar, Sn63Pb37, for electronics industry, at plant/GLO U	5%	6%	6%	6%
Capacitor, unspecified, at plant/kg/GLO U	1%	1%	1%	1%
Chassis, network main devices/kg/GLO U	2%	2%	2%	2%
Resistor, unspecified, at plant/kg/GLO U	1%	1%	1%	1%
Others	2%	8%	6%	6%
Total impact, in absolute value	**1.02E+05**	**2.22E+02**	**1.83E+01**	**1.84E+01**

8.8 End of life

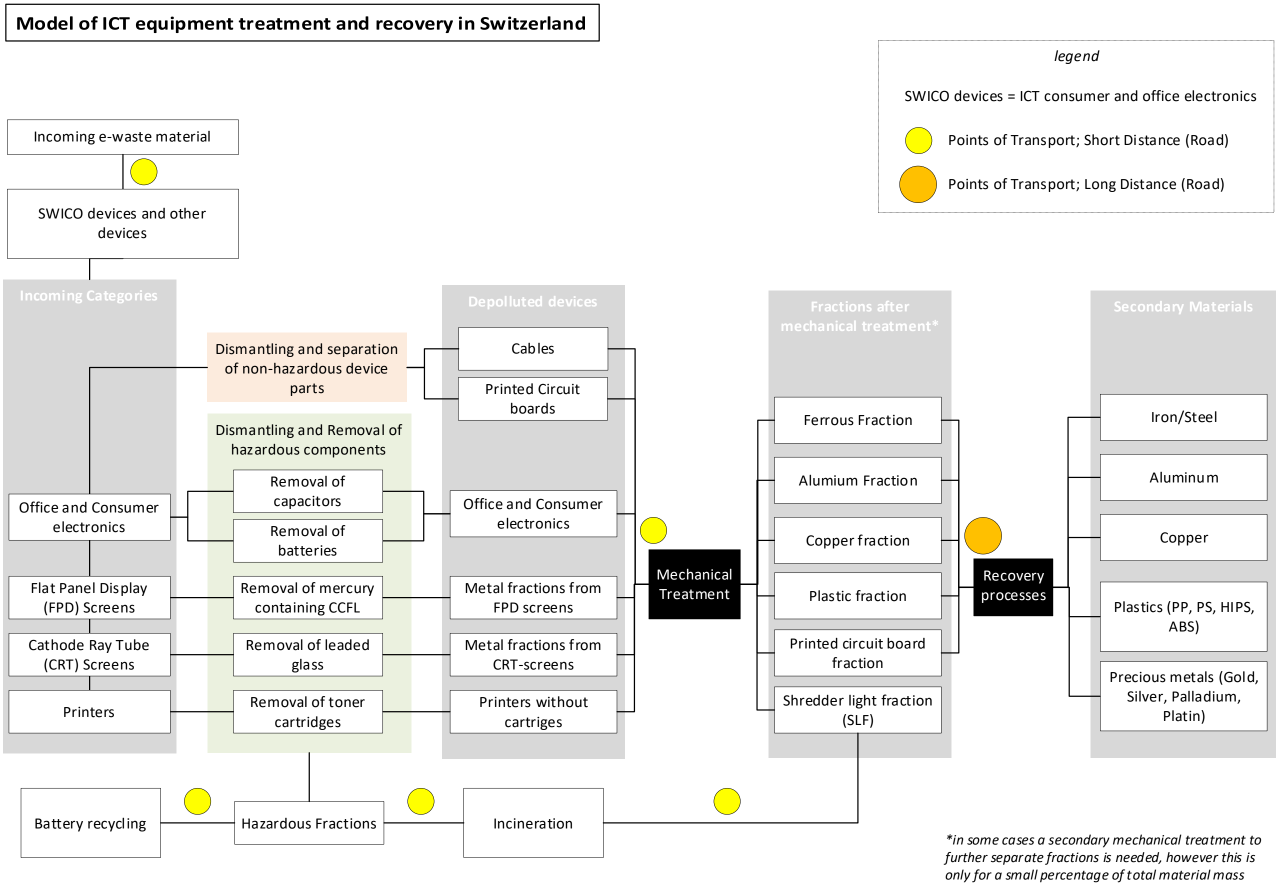

Figure 8.8-1. The flowchart for the treatment of e-waste in Switzerland

Ecoinvent documentation Chapter V – Electronics disposal page 22:

Based on this research and to keep the same structure defined in the UVEK/Ecoinvent database, we will create the following dataset (see the structure) – 4 step procedure: shredder, separation, shredder, separation:

- Disposal, device X, to WEEE treatment
  - Dismantling, device X, manually
    - Disposal of a, b, c, d…
    - Transport of WEEE to recycling facilities also contribute to environmental impacts. However, the transport modes have been updated to reflect the current transportation means (EURO5-6 in Switzerland) average in the country
    - Energy mix in the electricity mix use also has been updated for the recent years for the case of Switzerland
  - Dismantling, device X, mechanically
    - Disposal of a, b, c…
    - Shredding process, electrical and electronic scrap

8.8.1 Mechanical treatment plant, WEEE scrap

Since the building facilities are constructed with long service life, it is assumed that the material requirement remains the same. However, if new ICT components/datasets exist, the inventory flows are reconnected with the most recent corresponding option in the UVEK LCA database. The manual treatment plant datasets are not updated after the discussion and personal communication with a WEEE recycling expert (i.e.., Manuele Capelli) at Empa St. Gallen.

Table 8.8-1. Life cycle inventory for Mechanical treatment plant, WEEE scrap and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Mechanical treatment plant, WEEE scrap/p/GLO/I U	1	p				
Input						
Occupation, construction site	13333	m2a	land	Lognormal	1.69	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Occupation, industrial area, built up	158330	m2a	land	Lognormal	1.69	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Occupation, industrial area, vegetation	8333.3	m2a	land	Lognormal	1.69	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Transformation, from unknown	6666.7	m2	land	Lognormal	2.16	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Transformation, to industrial area, built up	6333.3	m2	land	Lognormal	2.16	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Transformation, to industrial area, vegetation	333.33	m2	land	Lognormal	2.16	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Building, hall/CH/I U	5000	m2		Lognormal	3.15	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Building, multi-storey/RER/I U	6670	m3		Lognormal	3.15	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Roads, company, internal/CH/I U	16667	m2a		Lognormal	3.15	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Facilities for mechanical treatment of WEEE scrap/GLO/I U	2.5	p		Lognormal	3.15	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites
Output						
Waste to treatment						
Disposal, industrial devices, to WEEE treatment/CH U	87500	kg		Lognormal	1.4	(3,5,4,3,1,5); own estimation, based on proper knowledge of Swiss recycling sites

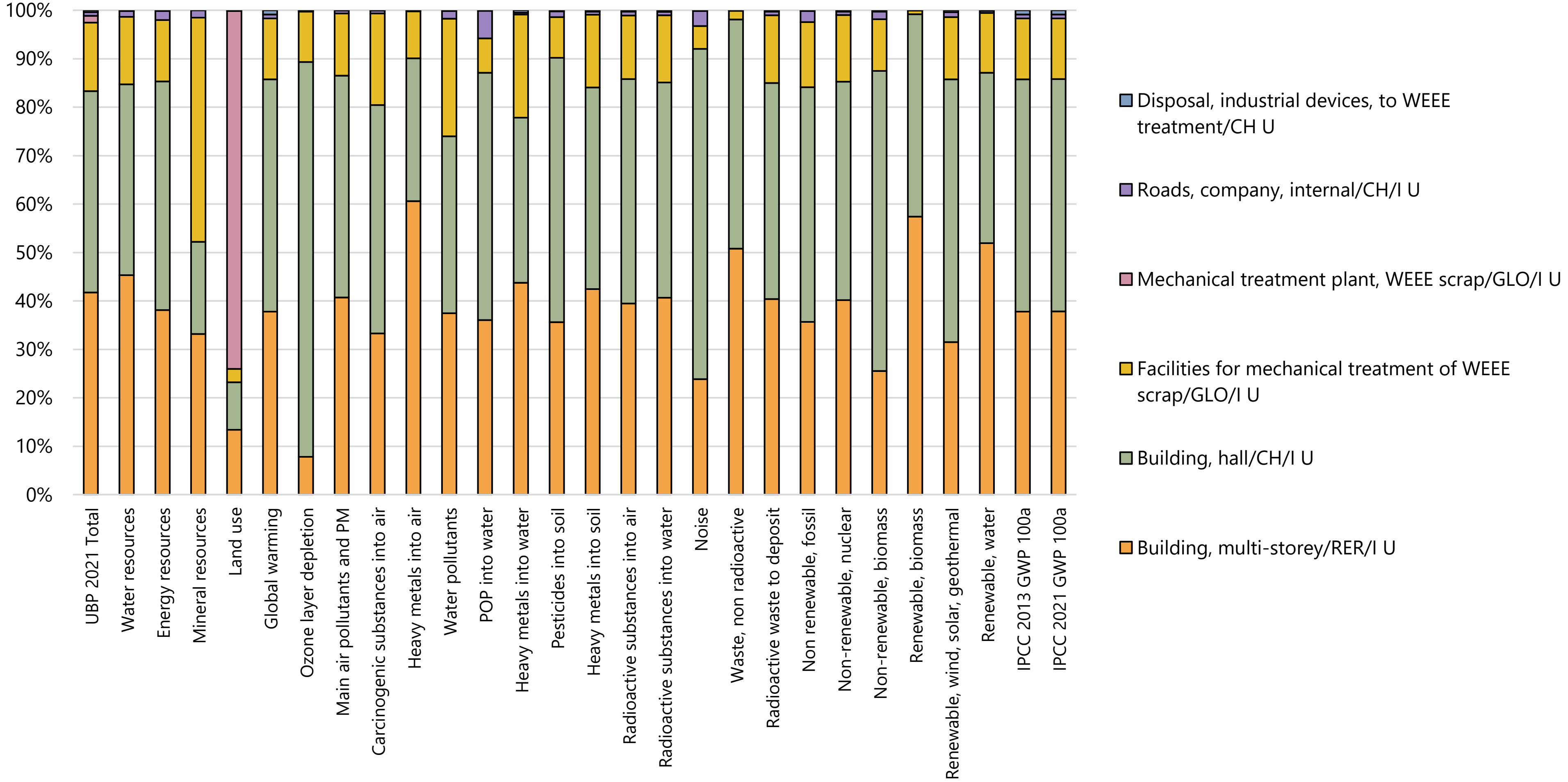

Figure 8.8-2. Contribution analysis presented in bar chart for: Mechanical treatment plant, WEEE scrap. FU = 1 unit

Table 8.8-2. Contribution analysis presented in table for: Mechanical treatment plant, WEEE scrap. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Building, multi-storey/RER/I U	42%	36%	38%	38%
Building, hall/CH/I U	42%	48%	48%	48%
Facilities for mechanical treatment of WEEE scrap/GLO/I U	14%	13%	13%	13%
Mechanical treatment plant, WEEE scrap/GLO/I U	1%	0%	0%	0%
Roads, company, internal/CH/I U	1%	2%	1%	1%
Disposal, industrial devices, to WEEE treatment/CH U	0%	0%	1%	1%
Total impact, in absolute value	**7.82E+09**	**3.10E+07**	**3.10E+06**	**3.08E+06**

8.8.2 Facilities for mechanical treatment of WEEE scrap

Since the building facilities are constructed with long service life, it is assumed that the material requirement remains the same. However, if new ICT components/datasets exist, the inventory flows are reconnected with the most recent corresponding option in the UVEK LCA database. The manual treatment plant datasets are not updated after the discussion and personal communication with a WEEE recycling expert (i.e.., Manuele Capelli) at Empa St. Gallen.

Table 8.8-3. Life cycle inventory for Facilities for mechanical treatment of WEEE scrap and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Facilities for mechanical treatment of WEEE scrap/GLO/I U	1	p				
Input						
Cable, network cable, category 5, without plugs, at plant/m/GLO U	2777.8	m		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Chromium steel 18/8, at plant/RER U	6400	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Injection moulding/RER U	2500	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Polyethylene, HDPE, granulate, at plant/RER U	2500	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	400	kg		Lognormal	1.45	(4,2,4,1,3,5); estimation, based on partial information from a similar machine
Road vehicle plant/RER/I U	9.0909E-07	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Section bar rolling, steel/RER U	25600	kg		Lognormal	1.38	(4,2,1,1,3,5); estimation, based on partial information from a similar machine
Sheet rolling, chromium steel/RER U	6400	kg		Lognormal	1.38	(4,2,1,1,3,5); estimation, based on partial information from a similar machine
Steel, low-alloyed, at plant/RER U	25600	kg		Lognormal	1.38	(4,2,1,1,3,5); estimation, based on partial information from a similar machine
transport, freight, rail/tkm/RER U	7000	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard distances
transport, freight, lorry, fleet average/tkm/RER U	3500	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard distances

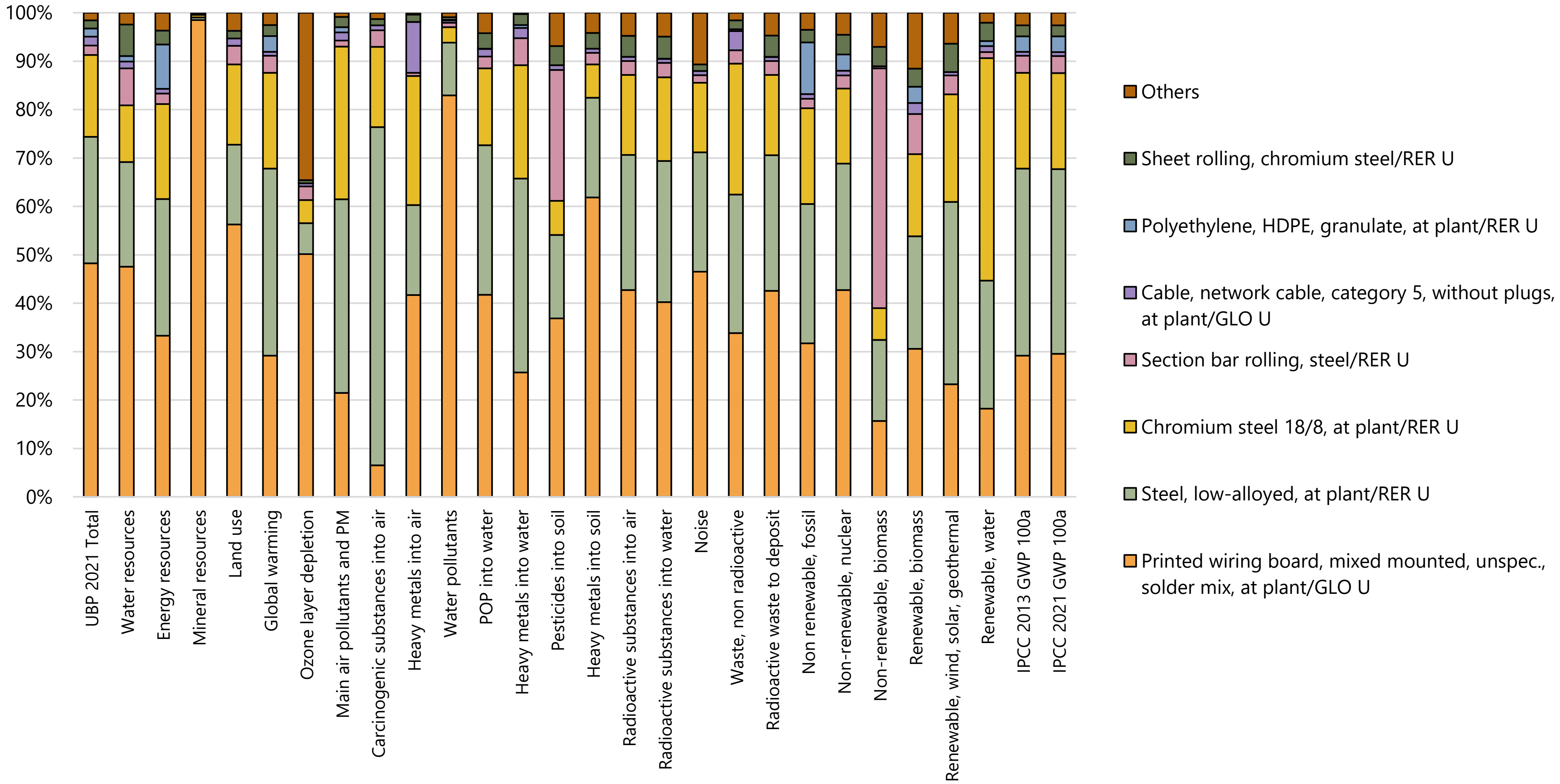

Figure 8.8-3. Contribution analysis presented in bar chart for: Facilities for mechanical treatment of WEEE scrap. FU = 1 unit

Table 8.8-4. Contribution analysis presented in table for: Facilities for mechanical treatment of WEEE scrap. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	48%	32%	29%	30%
Steel, low-alloyed, at plant/RER U	26%	29%	39%	38%
Chromium steel 18/8, at plant/RER U	17%	20%	20%	20%
Section bar rolling, steel/RER U	2%	2%	4%	4%
Cable, network cable, category 5, without plugs, at plant/m/GLO U	2%	1%	1%	1%
Polyethylene, HDPE, granulate, at plant/RER U	2%	11%	3%	3%
Sheet rolling, chromium steel/RER U	2%	3%	2%	2%
Others	2%	4%	3%	3%
Total impact, in absolute value	4.40E+08	1.67E+06	1.55E+05	1.54E+05

8.8.3 Dismantling, shredder fraction from manual dismantling, mechanically

The fraction for residues remains the same. However, the background dataset for shredder equipment is replaced with the new dataset.

Table 8.8-5. Life cycle inventory for Dismantling, shredder fraction from manual dismantling, mechanically and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/GLO U	1	kg				
Output						
Waste to treatment						
disposal, residues, shredder fraction from manual dismantling, in MSWI/kg/CH U	0.365	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Shredding, electrical and electronic scrap/kg/GLO U	1	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation

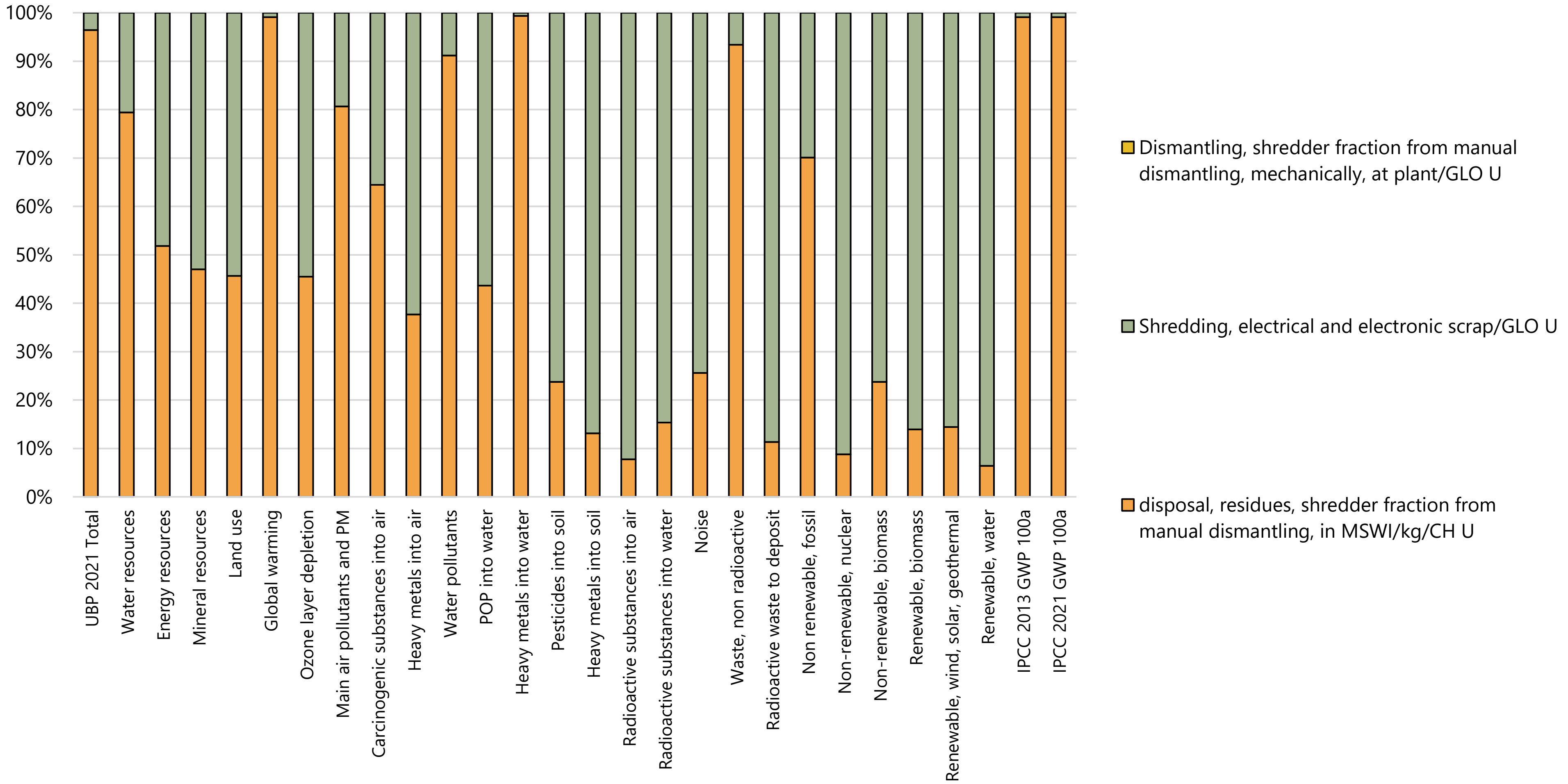

Figure 8.8-4. Contribution analysis presented in bar chart for: Dismantling, shredder fraction from manual dismantling, mechanically. FU = 1 kg

Table 8.8-6. Contribution analysis presented in table for: Dismantling, shredder fraction from manual dismantling, mechanically. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
disposal, residues, shredder fraction from manual dismantling, in MSWI/kg/CH U	96%	70%	99%	99%
Shredding, electrical and electronic scrap/kg/GLO U	4%	30%	1%	1%
Total impact, in absolute value	**9.88E+02**	**3.72E-01**	**9.13E-01**	**9.13E-01**

8.8.4 Shredding, electrical and electronic scrap

Compared to the previous version of this dataset, mechanical treatment process or dismantling of WEEE requires a series of milling, shredding, and separation processes. According to the literature data (Lassesson, 2008; Yoo et al., 2021), the energy (electricity) consumption value is in the range of 15 – 20 kWh/ton electronic waste treated. In the update, we applied a conservative approach by selecting the higher value in the range, i.e., 20 kWh/ton treated waste. The electricity source is also now regionalized to Swiss production mix in the updated dataset. The other input flows in this dataset are updated using the new ICT datasets whenever available. No major improvements are expected in the dust filtering mechanisms, as the existing technology in the model could already eliminate 99.9% of the dust generated from the shredder equipment.

Table 8.8-7. Life cycle inventory for Shredding, electrical and electronic scrap and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Shredding, electrical and electronic scrap/kg/CH U	1	kg				
Input						
electricity, medium voltage, at grid/kWh/CH U	0.02	kWh		Lognormal	1.23	(2,3,2,3,1,5); literature values - based on recent energy consumption data 2020
transport, freight, rail, electricity with shunting/tkm/CH U	0.014535	tkm		Lognormal	2.06	(3,1,2,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
transport, freight, lorry 16-32 metric ton, fleet average/tkm/CH U	0.028215	tkm		Lognormal	2.06	(3,1,2,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
Mechanical treatment plant, WEEE scrap/p/GLO/I U	8E-10	p		Lognormal	2.15	(4,5,2,3,5,5); rough estimation of infrastructure
Output						
Emissions to air						
Aluminium	0.0000014	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Antimony	1.19E-07	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Bromine	2.38E-07	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Cadmium	2.38E-08	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Chlorine	3.22E-07	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Chromium	5.18E-08	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Copper	0.00000042	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Heat, waste	0.2376	MJ	high. pop.	Lognormal	1.69	(2,3,4,3,1,5); calculated from eletricity input
Iron	0.00000483	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Lead	4.13E-07	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Mercury	1.19E-10	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Nickel	1.61E-07	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Phosphorus	1.4E-08	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Polychlorinated biphenyls	1.89E-09	kg	high. pop.	Lognormal	2.16	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Tin	3.01E-07	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)
Zinc	1.309E-06	kg	high. pop.	Lognormal	1.69	(1,4,4,3,3,5); values from Swiss Recycling company in Morf (2004)

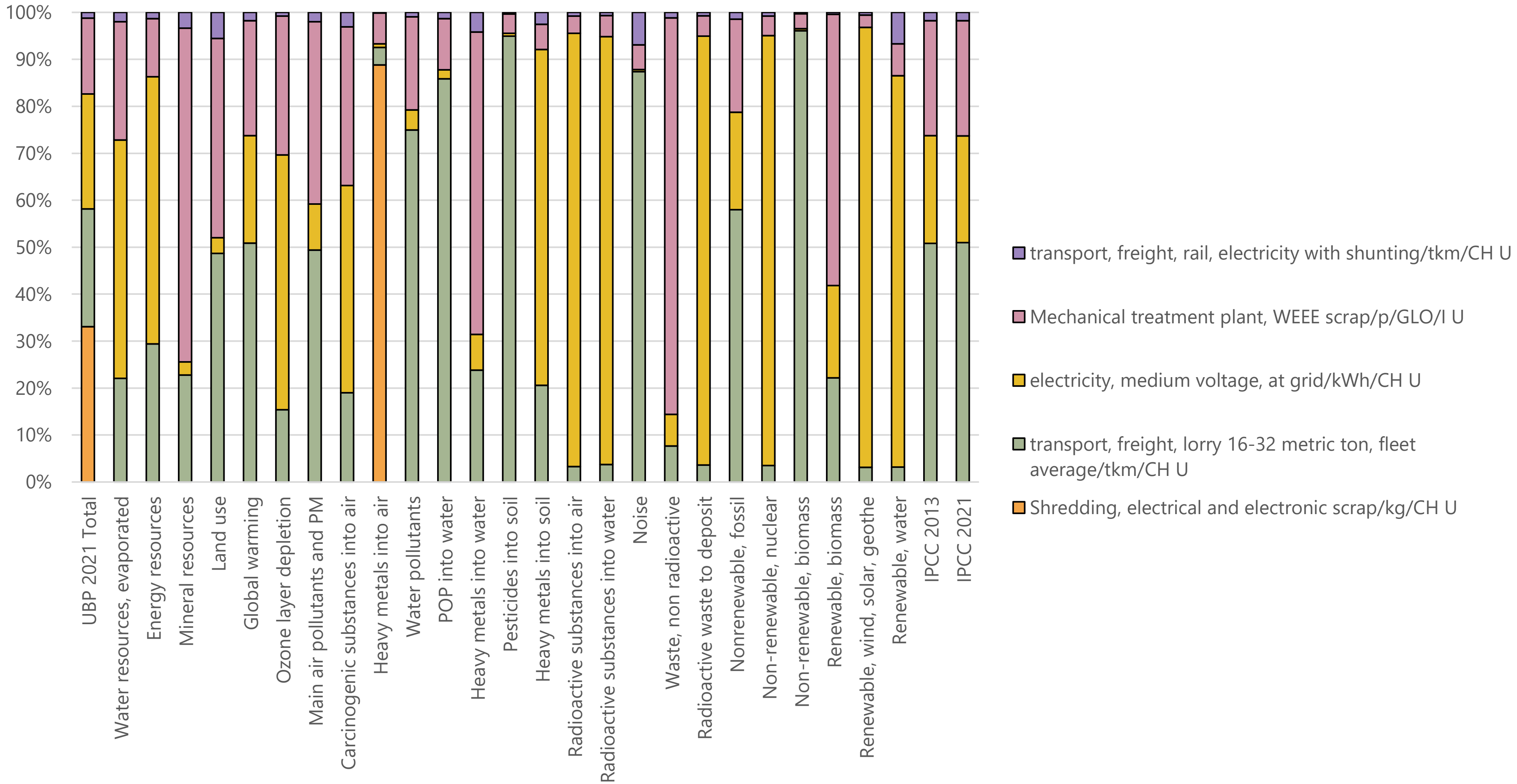

Figure 8.8-5. Contribution analysis presented in bar chart for: Shredding, electrical and electronic scrap. FU = 1 kg

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Table 8.8-8. Contribution analysis presented in table for: Shredding, electrical and electronic scrap. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Shredding, electrical and electronic scrap/kg/CH U	33%	0%	0%	0%
transport, freight, lorry 16-32 metric ton, fleet average/tkm/CH U	25%	58%	51%	51%
electricity, medium voltage, at grid/kWh/CH U	24%	21%	23%	23%
Mechanical treatment plant, WEEE scrap/p/GLO/I U	16%	20%	24%	25%
transport, freight, rail, electricity with shunting/tkm/CH U	1%	1%	2%	2%
Total impact, in absolute value	**3.87E+01**	**1.25E-01**	**1.01E-02**	**1.00E-02**

8.8.5 Dismantling, printer, laser, mechanically

The transfer coefficients to the ultimate end of life options remain the same. However, the shredding, milling, and separation datasets are updated using the new ICT dataset for waste treatment.

Table 8.8-9. Life cycle inventory for Dismantling, printer, laser, mechanically and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, printer, laser, mechanically, at plant/kg/CH U	1	kg				
Output						
Waste to treatment						
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.2411	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	0.1551	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, residues, mechanical treatment, laser printer, in MSWI/kg/CH U	0.27183	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of cables/kg/GLO U	0.0199	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Shredding, electrical and electronic scrap/kg/CH U	0.4744	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation

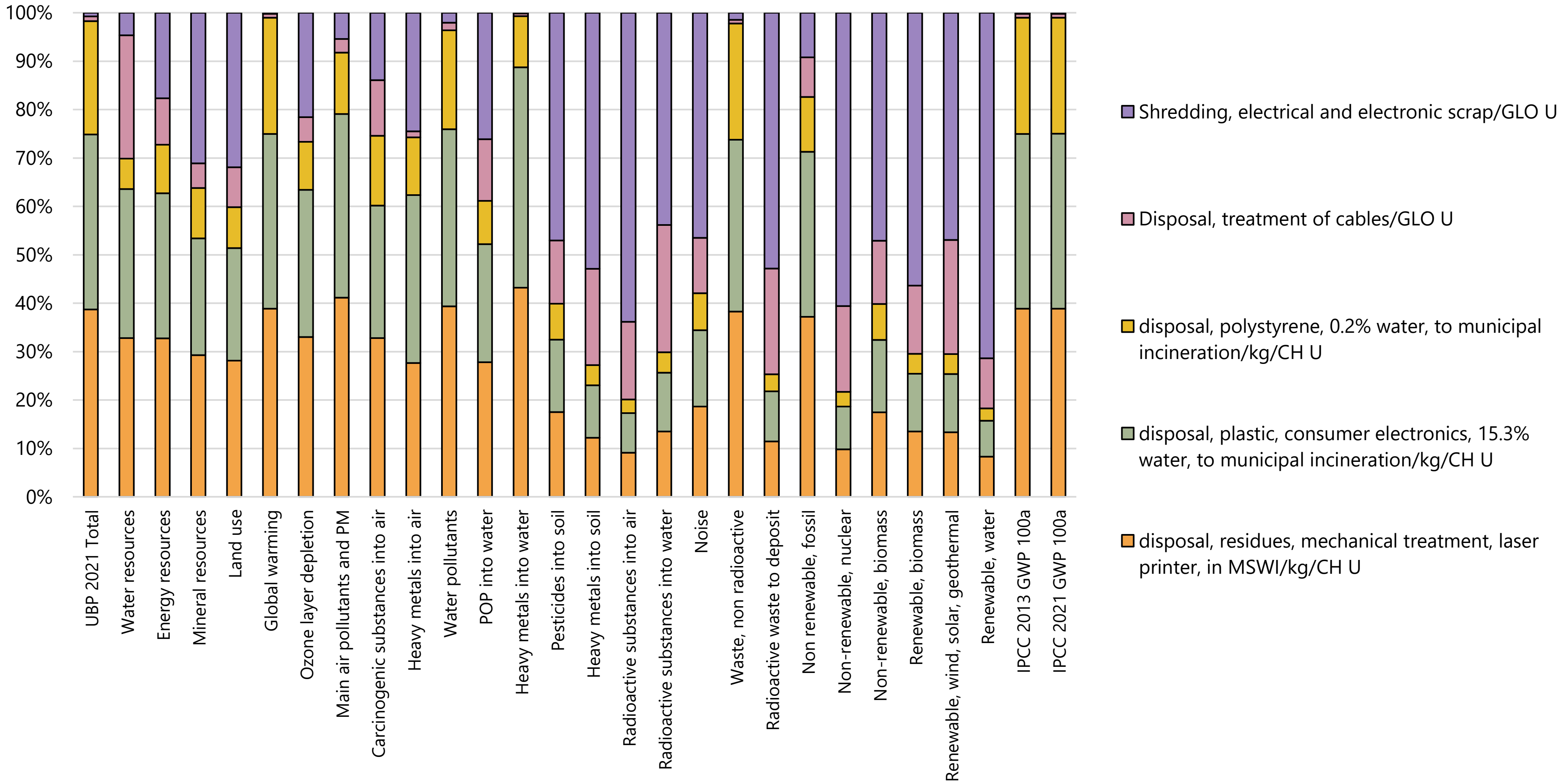

Figure 8.8-6. Contribution analysis presented in bar chart for: Dismantling, printer, laser, mechanically. FU = 1 kg

Table 8.8-10. Contribution analysis presented in table for: Dismantling, printer, laser, mechanically. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
disposal, residues, mechanical treatment, laser printer, in MSWI/kg/CH U	39%	37%	39%	39%
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	36%	34%	36%	36%
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	23%	11%	24%	24%
Disposal, treatment of cables/kg/GLO U	1%	8%	1%	1%
Shredding, electrical and electronic scrap/kg/CH U	1%	9%	0%	0%
Total impact, in absolute value	**2.19E+03**	**5.52E-01**	**2.07E+00**	**2.07E+00**

8.8.6 Disposal, printer, laser jet, b/w, to WEEE treatment

The split of manual and mechanical treatment for waste printers is taken from the recent data of SWICO and SENS technical report (SWICO & SENS, 2022).

The two datasets are updated mainly in the mechanical treatment or dismantling processes (shredding, milling, and separation). The share of manual and mechanical treatment flows is kept the same as the existing estimation in the UVEK database. This has been confirmed by comparing the current printers with the other average printers from the electronic devices dismantling study of (Babbitt et al., 2020).

Table 8.8-11. Life cycle inventory for Disposal, printer, laser jet, b/w, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, printer, laser jet, b/w, to WEEE treatment/p/CH U	1	p				
Output						
Waste to treatment						
Dismantling, printer, laser, manually, at plant/CH U	1.3501	kg	Lognormal	1.21		(1,1,1,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005), with updates SWICO and SENS technical report (SWICO & SENS, 2022).
Dismantling, printer, laser, mechanically, at plant/kg/CH U	4.5199	kg	Lognormal	1.21		(1,1,1,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005), with updates SWICO and SENS technical report (SWICO & SENS, 2022).

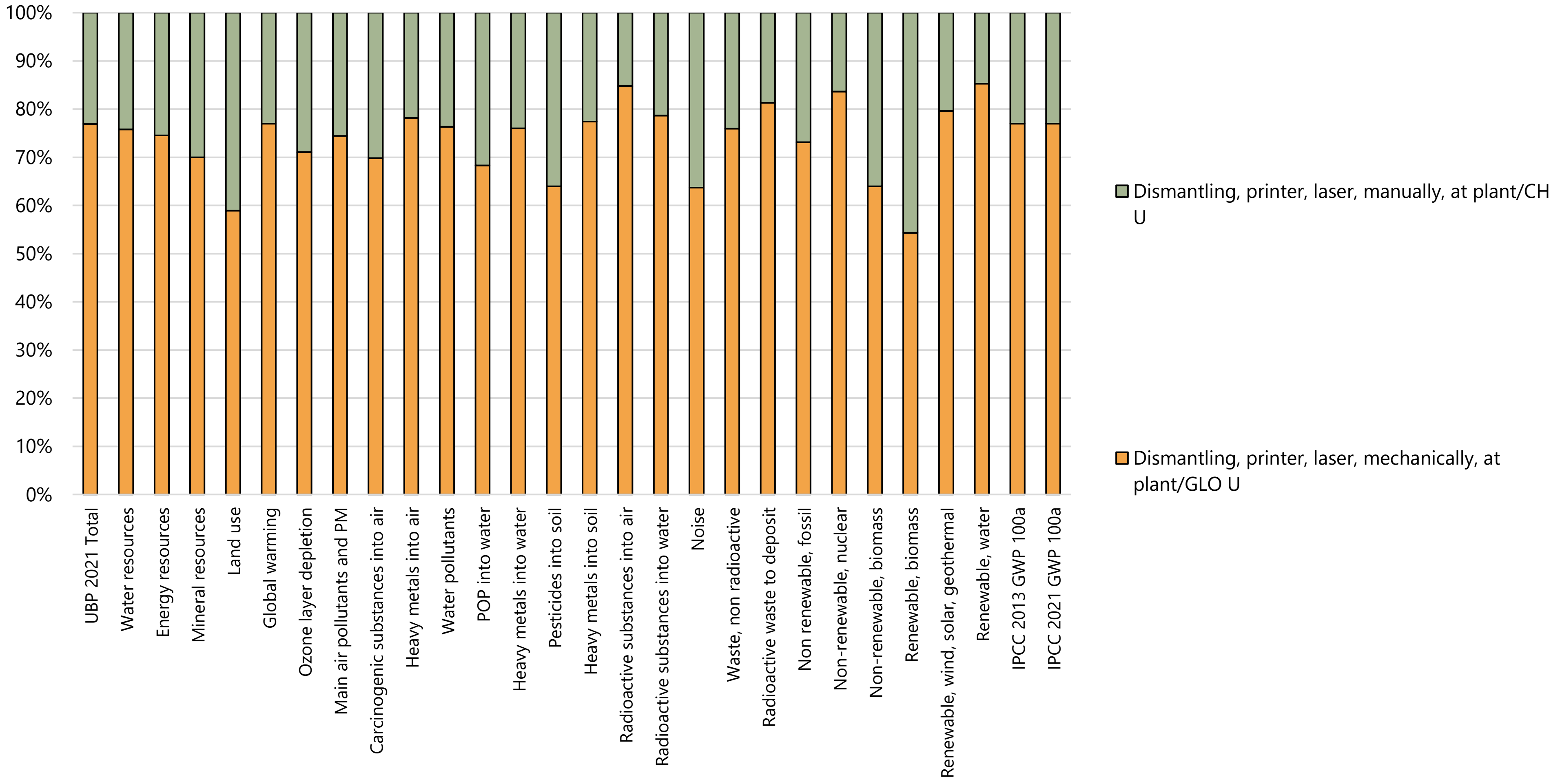

Figure 8.8-7. Contribution analysis presented in bar chart for: Disposal, printer, laser jet, b/w, to WEEE treatment. FU = 1 kg

Table 8.8-12. Contribution analysis presented in table for: Disposal, printer, laser jet, b/w, to WEEE treatment. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, printer, laser, mechanically, at plant/kg/CH U	77%	73%	77%	77%
Dismantling, printer, laser, manually, at plant/CH U	23%	27%	23%	23%
Total impact, in absolute value	**1.28E+04**	**3.39E+00**	**1.22E+01**	**1.22E+01**

8.8.7 Disposal, printer, laser jet, colour, to WEEE treatment

The split of manual and mechanical treatment for waste printers is taken from the recent data of SWICO and SENS technical report (SWICO & SENS, 2022).

The two datasets are updated mainly in the mechanical treatment or dismantling processes (shredding, milling, and separation). The share of manual and mechanical treatment flows is kept the same as the existing estimation in the UVEK database. This has been confirmed by comparing the current printers with the other average printers from the electronic devices dismantling study of (Babbitt et al., 2020).

Table 8.8-13. Life cycle inventory for Disposal, printer, laser jet, colour, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, printer, laser jet, colour, to WEEE treatment/p/CH U	1	p				
Output						
Waste to treatment						
Dismantling, printer, laser, manually, at plant/CH U	1.3501	kg	Lognormal	1.21		(1,1,1,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005), with updates SWICO and SENS technical report (SWICO & SENS, 2022).
Dismantling, printer, laser, mechanically, at plant/kg/CH U	4.5199	kg	Lognormal	1.21		(1,1,1,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005), with updates SWICO and SENS technical report (SWICO & SENS, 2022).

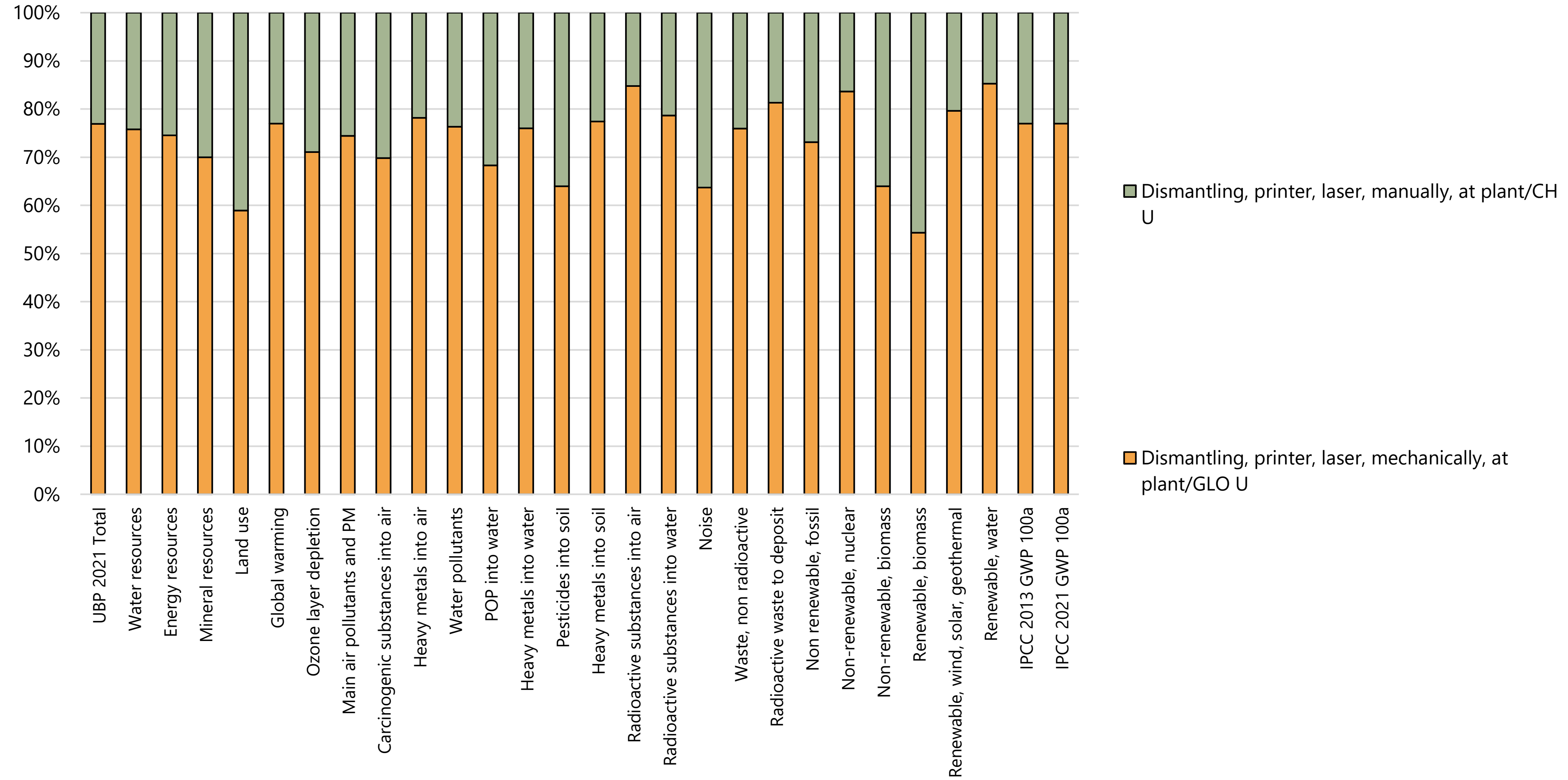

Figure 8.8-8. Contribution analysis presented in bar chart for: Disposal, printer, laser jet, colour, to WEEE treatment. FU = 1 kg

Table 8.8-14. Contribution analysis presented in table for: Disposal, printer, laser jet, colour, to WEEE treatment. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, printer, laser, mechanically, at plant/kg/CH U	77%	73%	77%	77%
Dismantling, printer, laser, manually, at plant/CH U	23%	27%	23%	23%
Total impact, in absolute value	**1.28E+04**	**3.39E+00**	**1.22E+01**	**1.22E+01**

8.8.8 Dismantling, IT accessoires, mechanically

The update to this dataset concerns mainly the quantity/mass of WEEE to be treated in the mechanical separation plant. Instead of using the same mass flow as in the existing dataset, the updated dataset now reflects the mass of power adaptor, keyboard, and mouse in the new datasets, which are the aggregation of all input materials described in the other section.

Table 8.8-15. Life cycle inventory for Dismantling, IT accessoires, mechanically and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, IT accessoires, mechanically, at plant/kg/GLO U	1	kg				
Output						
Waste to treatment						
disposal, residues, mechanical treatment, IT accessoires, in MSWI/kg/CH U	0.47	kg	Lognormal	1.34		(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of printed wiring boards/GLO U	0.162	kg	Lognormal	1.34		(3,4,4,1,1,5); calculated - based on composition data
Shredding, electrical and electronic scrap/kg/CH U	0.8375	kg	Lognormal	1.65		(3,4,4,1,4,5); rough estimation

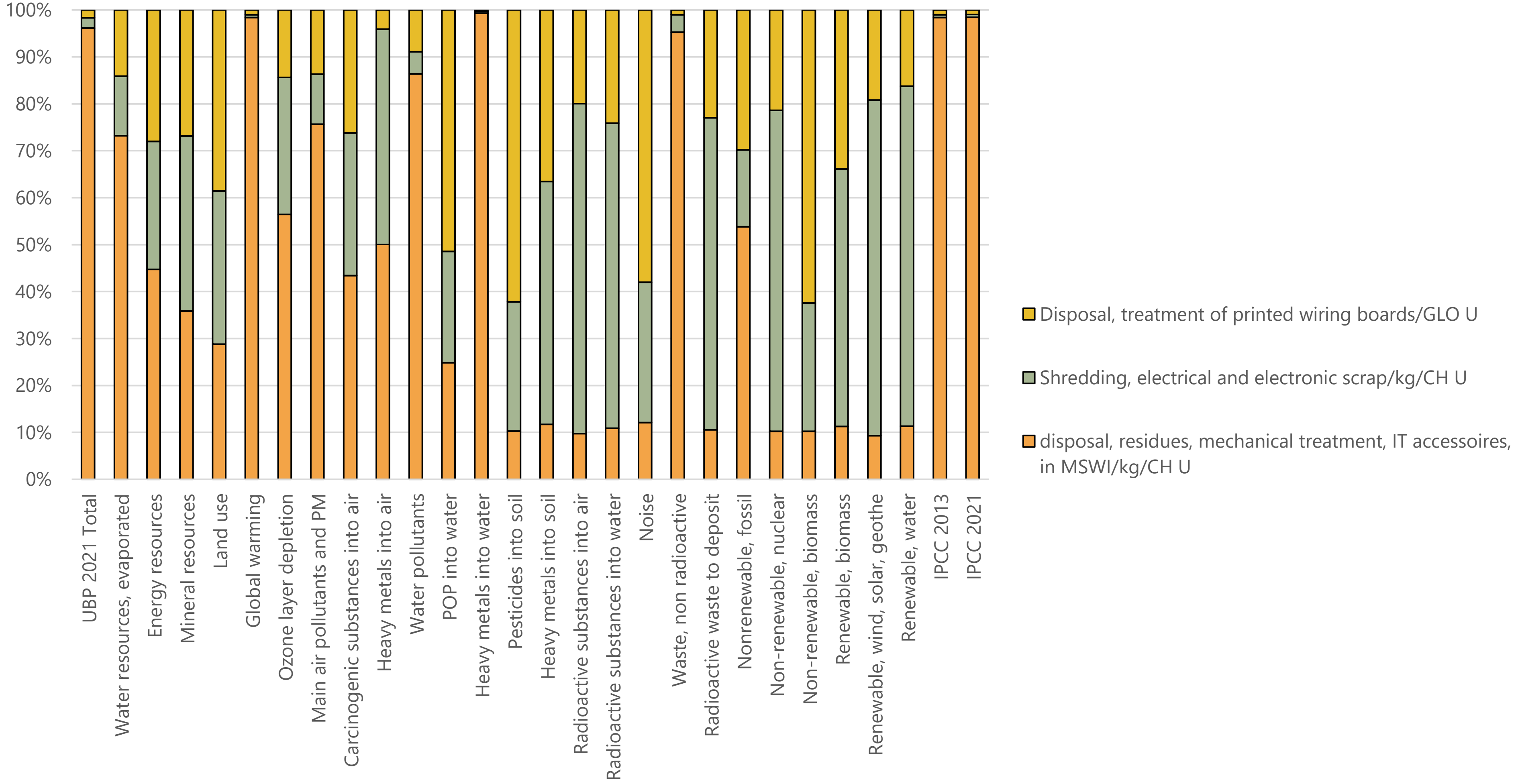

Figure 8.8-9. Contribution analysis presented in bar chart for: Dismantling, IT accessoires, mechanically. FU = 1 kg

Table 8.8-16. Contribution analysis presented in table for: Dismantling, IT accessoires, mechanically. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
disposal, residues, mechanical treatment, IT accessoires, in MSWI/kg/CH U	96%	54%	98%	98%
Shredding, electrical and electronic scrap/kg/CH U	2%	16%	1%	1%
Disposal, treatment of printed wiring boards/GLO U	2%	30%	1%	1%
Dismantling, IT accessoires, mechanically, at plant/kg/CH U	0%	0%	0%	0%
Total impact, in absolute value	**1.50E+03**	**6.44E-01**	**1.40E+00**	**1.40E+00**

8.8.9 Disposal, power adapter, external, for laptop, to WEEE treatment

The update to this dataset concerns mainly the quantity/mass of WEEE to be treated in the mechanical separation plant. Instead of using the same mass flow as in the existing dataset, the updated dataset now reflects the mass of power adaptor, keyboard, and mouse in the new datasets, which are the aggregation of all input materials described in the other section.

Table 8.8-17. Life cycle inventory for Disposal, power adapter, external, for laptop, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, power adapter, external, for laptop, to WEEE treatment/p/CH U	1	p				
Output						
Waste to treatment						
Dismantling, IT accessoires, mechanically, at plant/kg/CH U	0.263	kg		Lognormal	1.26	(3,4,1,1,1,5); estimation, based on own experiences, updated massflow of IT accessories

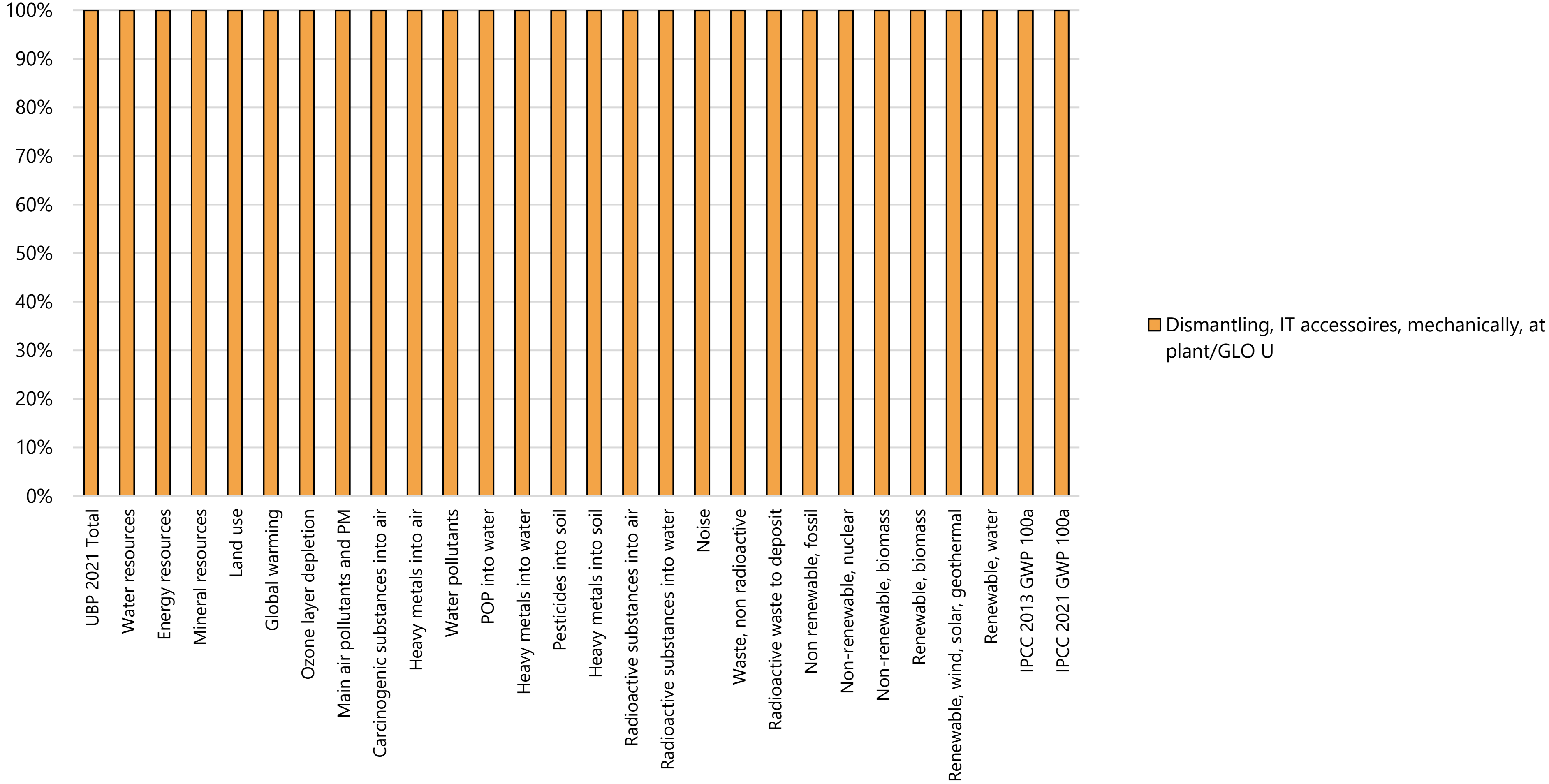

Figure 8.8-10. Contribution analysis presented in bar chart for: Disposal, power adapter, external, for laptop, to WEEE treatment. FU = 1 unit

Table 8.8-18. Contribution analysis presented in table for: Disposal, power adapter, external, for laptop, to WEEE treatment. FU = 1 unit

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
Dismantling, IT accessoires, mechanically, at plant/kg/CH U	100%	100%	100%	100%
Total impact, in absolute value	3.95E+02	1.69E-01	3.68E-01	3.68E-01

8.8.10 Disposal, keyboard, standard version, to WEEE treatment

The update to this dataset concerns mainly the quantity/mass of WEEE to be treated in the mechanical separation plant. Instead of using the same mass flow as in the existing dataset, the updated dataset now reflects the mass of power adaptor, keyboard, and mouse in the new datasets, which are the aggregation of all input materials described in the other section.

Table 8.8-19. Life cycle inventory for Disposal, keyboard, standard version, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, keyboard, standard version, to WEEE treatment/CH U	1	p				
Output						
Waste to treatment						
Dismantling, IT accessoires, mechanically, at plant/kg/CH U	0.8	kg	Lognormal	1.26		(3,4,1,1,1,5); estimation, based on own experiences, updated massflow of IT accessories

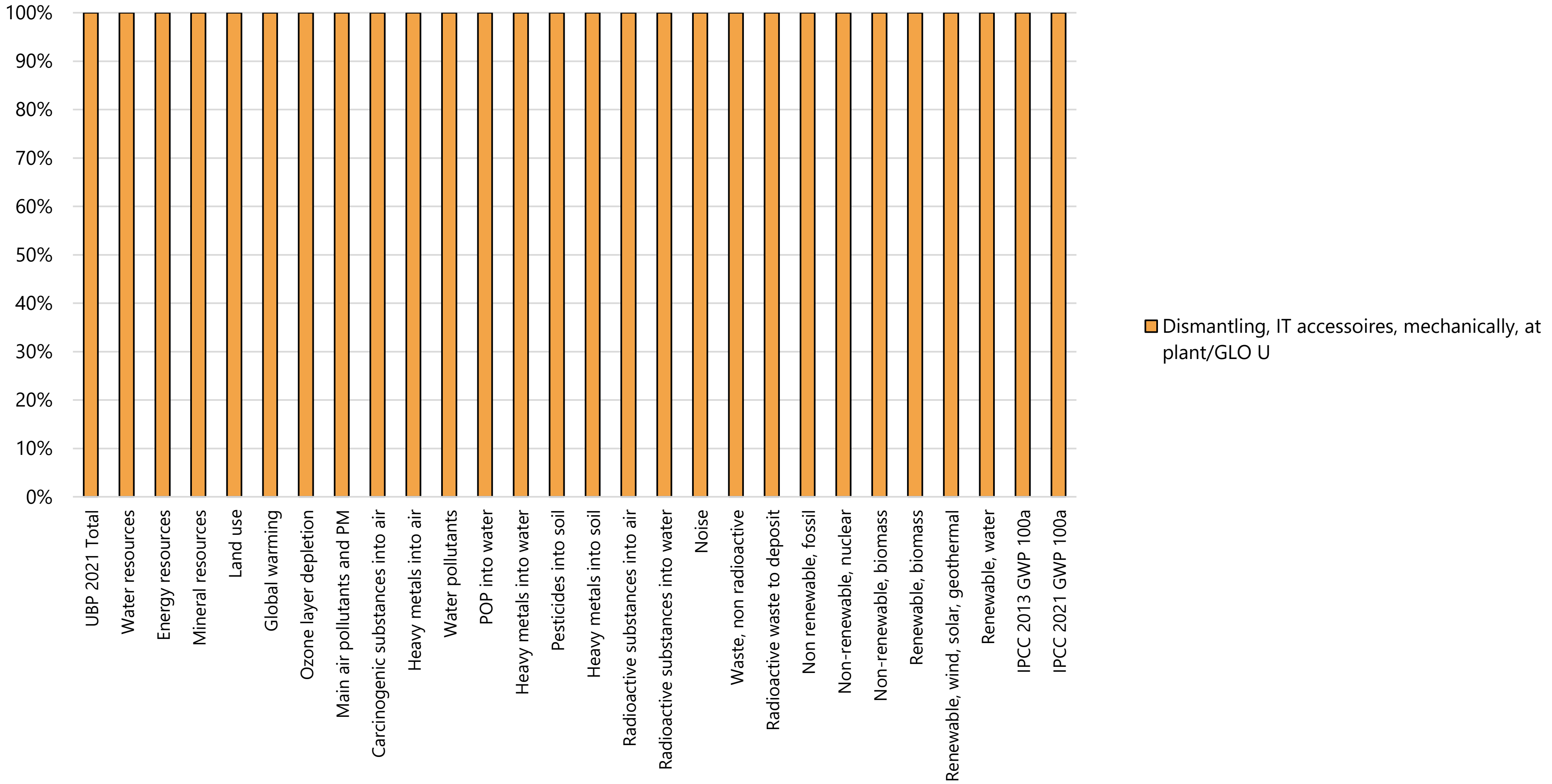

Figure 8.8-11. Contribution analysis presented in bar chart for: Disposal, keyboard, standard version, to WEEE treatment. FU = 1 unit

Table 8.8-20. Contribution analysis presented in table for: Disposal, keyboard, standard version, to WEEE treatment. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, IT accessoires, mechanically, at plant/kg/CH U	100%	100%	100%	100%
Total impact, in absolute value	**1.20E+03**	**5.15E-01**	**1.12E+00**	**1.12E+00**

8.8.11 Disposal, mouse device, optical, with cable, to WEEE treatment

The update to this dataset concerns mainly the quantity/mass of WEEE to be treated in the mechanical separation plant. Instead of using the same mass flow as in the existing dataset, the updated dataset now reflects the mass of power adaptor, keyboard, and mouse in the new datasets, which are the aggregation of all input materials described in the other section.

Table 8.8-21. Life cycle inventory for Disposal, mouse device, optical, with cable, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, mouse device, optical, with cable, to WEEE treatment/p/CH U	1	p				
Output						
Waste to treatment						
Dismantling, IT accessoires, mechanically, at plant/kg/CH U	0.1	kg	Lognormal	1.26		(3,4,1,1,1,5); estimation, based on own experiences, updated massflow of IT accessories

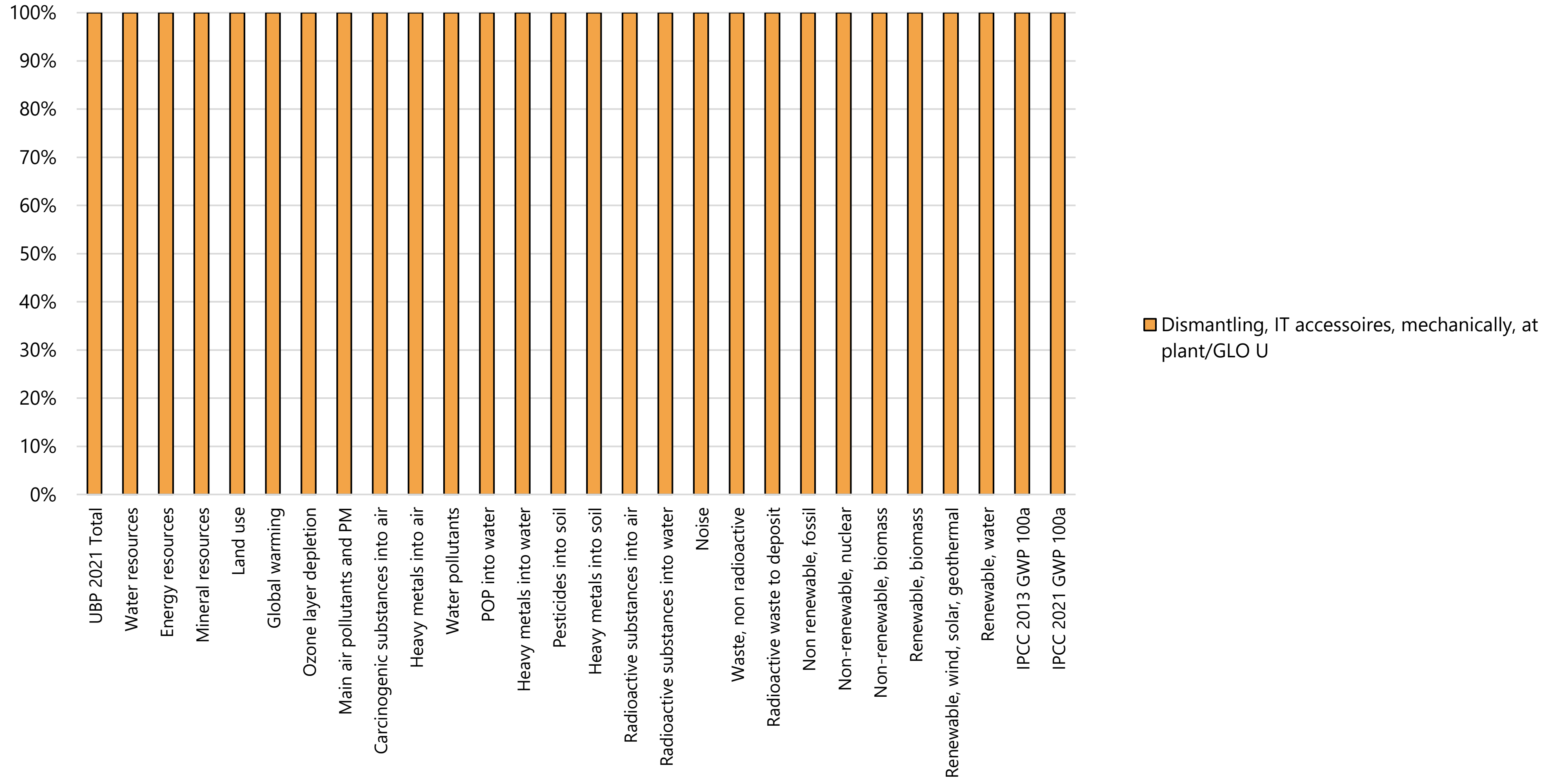

Figure 8.8-12. Contribution analysis presented in bar chart for: Disposal, mouse device, optical, with cable, to WEEE treatment. FU = 1 unit

Table 8.8-22. Contribution analysis presented in table for: Disposal, mouse device, optical, with cable, to WEEE treatment. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, IT accessoires, mechanically, at plant/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**1.50E+02**	**6.44E-02**	**1.40E-01**	**1.40E-01**

8.8.12 Dismantling, desktop computer, mechanically

The transfer coefficients to the ultimate end of life options remain the same. However, the shredding, milling, and separation datasets are updated using the new ICT dataset for waste treatment.

Table 8.8-23. Life cycle inventory for Dismantling, desktop computer, mechanically and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, desktop computer, mechanically, at plant/kg/CH U	1	kg				
Output (Waste to treatment)						
Disposal, capacitors, 0% water, to hazardous waste incineration {CH} U	0.00972	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, plastic, consumer electronics, 15.3% water, to municipal incineration {CH} U	0.0013	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, residues, mechanical treatment, desktop computer, in MSWI {CH} U	0.14352	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of cables {GLO} U	0.026	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of printed wiring boards {GLO} U	0.0405	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Shredding, electrical and electronic scrap {CH} U	0.8296	kg		Lognormal	1.65	(3,4,4,1,4,5); calculated - based on composition data

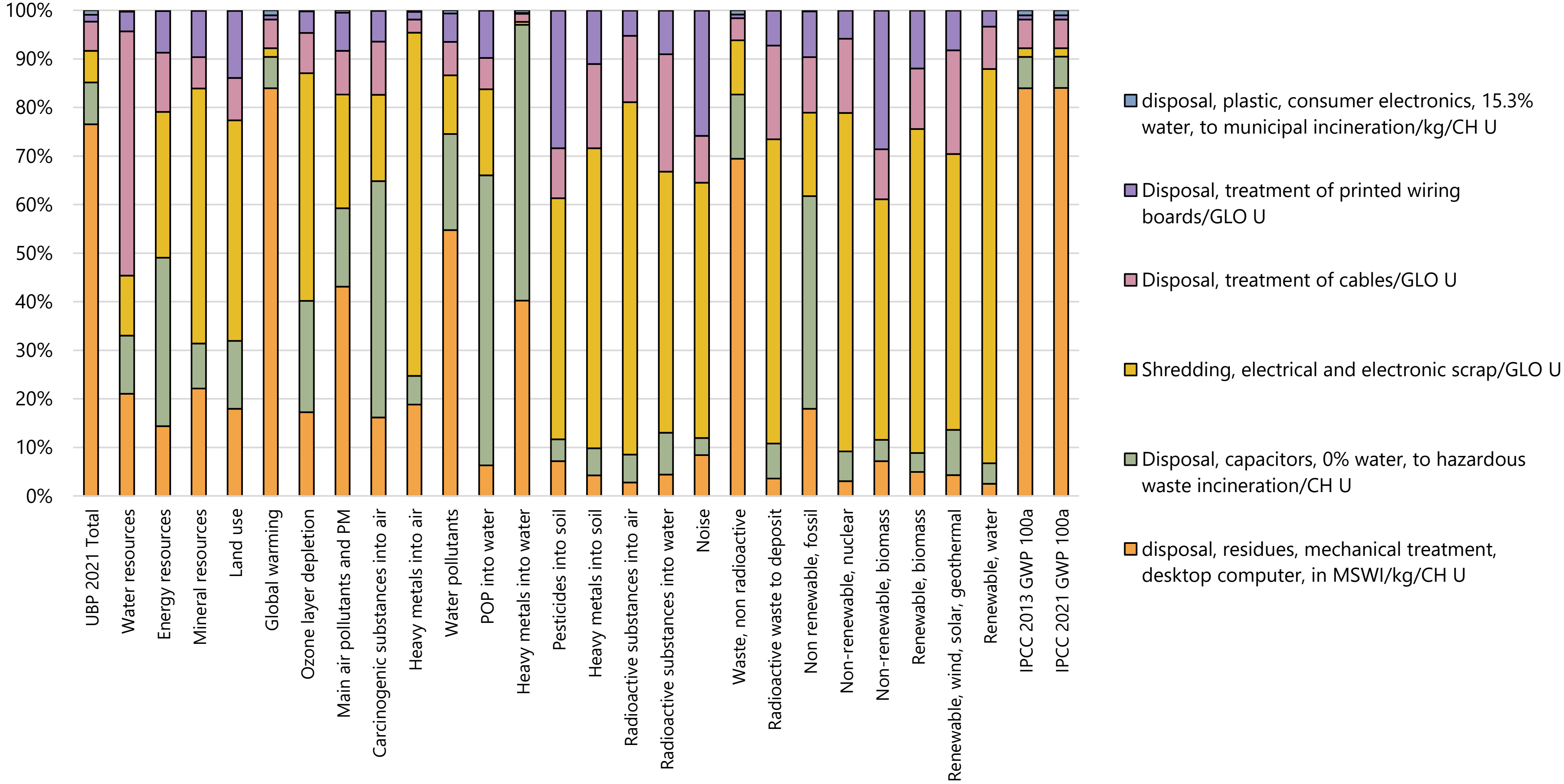

Figure 8.8-13. Contribution analysis presented in bar chart for: Dismantling, desktop computer, mechanically. FU = 1 kg

Table 8.8-24. Contribution analysis presented in table for: Dismantling, desktop computer, mechanically. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/kg/GLO U	76%	17%	84%	84%
Disposal, capacitors, 0% water, to hazardous waste incineration/CH U	9%	42%	6%	6%
Shredding, electrical and electronic scrap/kg/CH U	7%	20%	2%	2%
Disposal, treatment of cables/GLO U	6%	11%	6%	6%
Disposal, treatment of printed wiring boards/GLO U	1%	9%	1%	1%
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	1%	0%	1%	1%
Dismantling, desktop computer, mechanically, at plant/kg/CH U	0%	0%	0%	0%
Total impact, in absolute value	**4.54E+02**	**5.24E-01**	**3.93E-01**	**3.93E-01**

8.8.13 Dismantling, desktop computer, manually

The transfer coefficients to the ultimate end of life options remain the same. However, the shredding, milling, and separation datasets are updated using the new ICT dataset for waste treatment. The battery treatment was also removed from the end of life options because desktop no longer uses NiMh batteries.

Table 8.8-25. Life cycle inventory for Dismantling, desktop computer, manually and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, desktop computer, manually, at plant/kg/CH U	1	kg				
Input						
transport, freight, rail, electricity with shunting/tkm/CH U	0.014535	tkm		Lognormal	2.11	(3,1,4,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
transport, freight, lorry 16-32 metric ton, fleet average/tkm/CH U	0.028215	tkm		Lognormal	2.11	(3,1,4,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
Manual treatment plant, WEEE scrap/GLO/I U	0.000000016	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Output						
Waste to treatment						
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/kg/GLO U	0.272	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, capacitors, 0% water, to hazardous waste incineration/CH U	0.00972	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.021	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data

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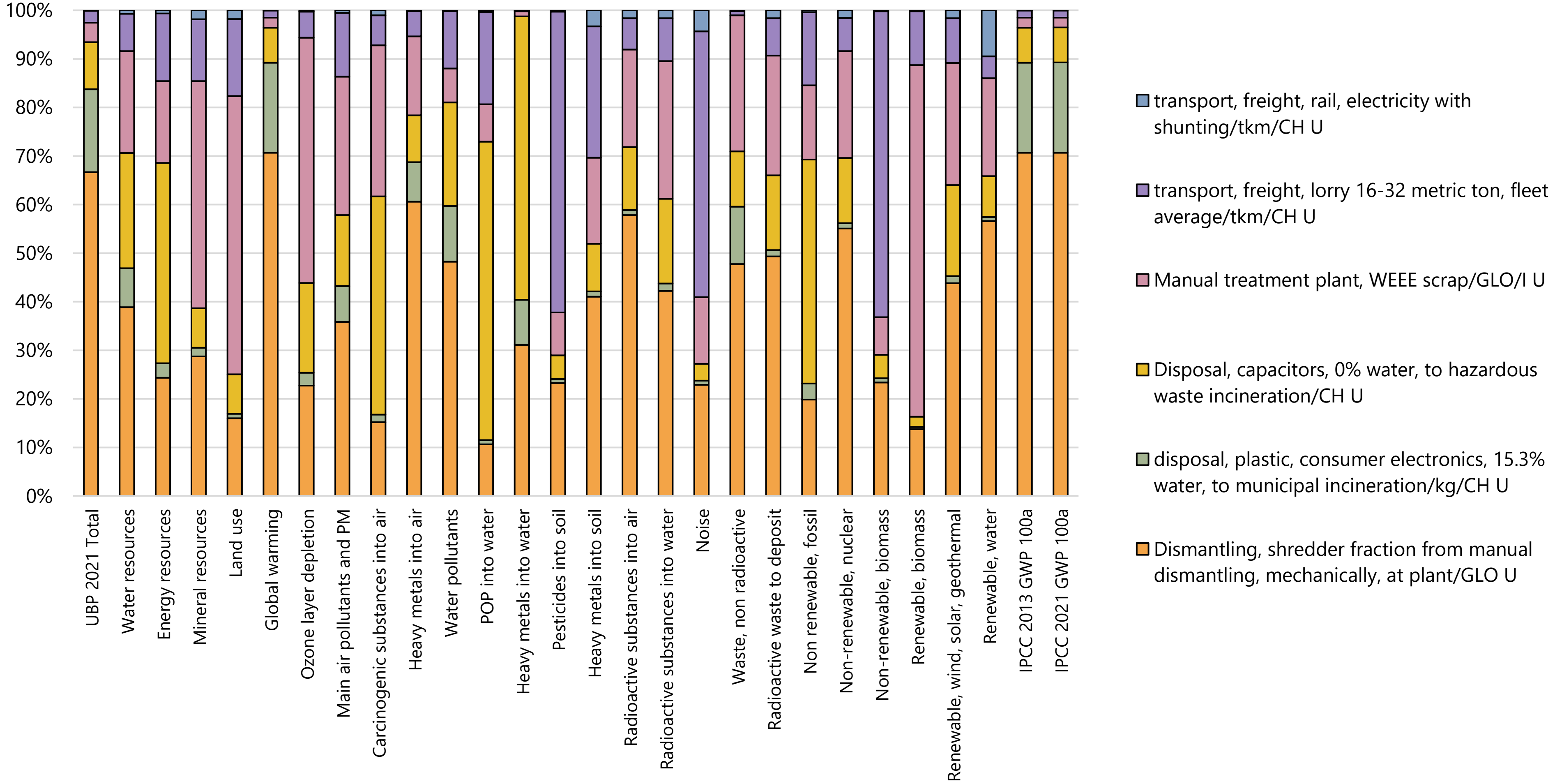

Figure 8.8-14. Contribution analysis presented in bar chart for: Dismantling, desktop computer, manually. FU = 1 kg

Table 8.8-26. Contribution analysis presented in table for: Dismantling, desktop computer, manually. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/kg/GLO U	67%	20%	71%	71%
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	17%	3%	19%	19%
Disposal, capacitors, 0% water, to hazardous waste incineration/CH U	10%	46%	7%	7%
Manual treatment plant, WEEE scrap/GLO/I U	4%	15%	2%	2%
transport, freight, lorry 16-32 metric ton, fleet average/tkm/CH U	2%	15%	1%	1%
transport, freight, rail, electricity with shunting/tkm/CH U	0%	0%	0%	0%
Total impact, in absolute value	**4.03E+02**	**4.88E-01**	**3.51E-01**	**3.51E-01**

8.8.14 Disposal, desktop computer, to WEEE treatment

The update to this dataset concerns mainly the mass of desktop computers waste to be treated in the mechanical and manual separation plant. The average mass of 8.8 kg is used as in the dataset for desktop computer, where the split to manual and mechanical treatment is assumed to be the same as in the original dataset. Another change is that the batteries flows are now removed since desktop computers do not contain lithium ion batteries.

Table 8.8-27. Life cycle inventory for Disposal, desktop computer, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, desktop computer, to WEEE treatment/p/CH U	1	p				
Output						
Waste to treatment						
Dismantling, desktop computer, manually, at plant/kg/CH U	2.024	kg		Lognormal	1.21	(1,1,1,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
Dismantling, desktop computer, mechanically, at plant/kg/CH U	6.776	kg		Lognormal	1.21	(1,1,1,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)

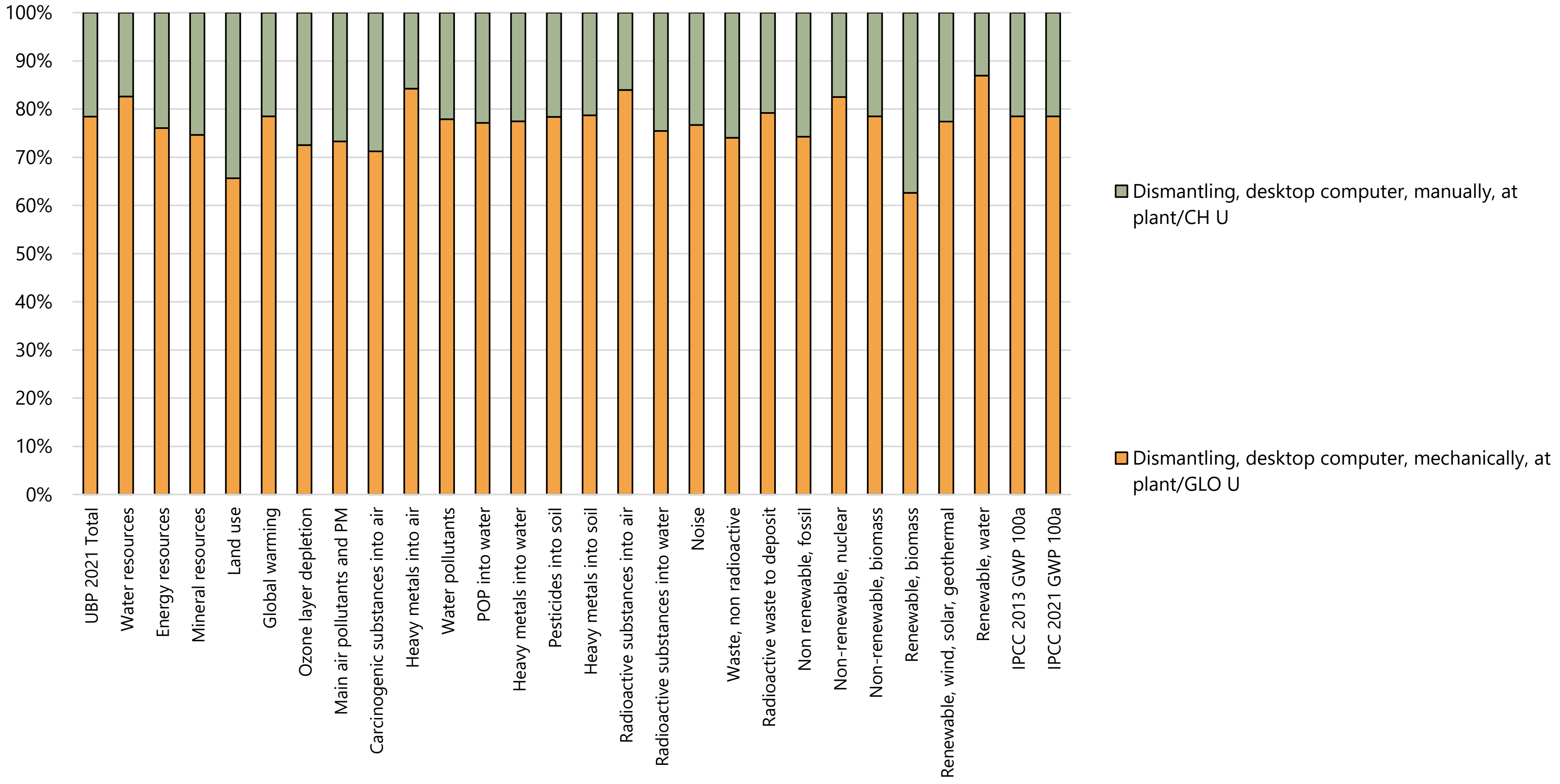

Figure 8.8-15. Contribution analysis presented in bar chart for: Disposal, desktop computer, to WEEE treatment. FU = 1 unit

Table 8.8-28. Contribution analysis presented in table for: Disposal, desktop computer, to WEEE treatment. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Dismantling, desktop computer, mechanically, at plant/kg/CH U	79%	78%	79%	79%
Dismantling, desktop computer, manually, at plant/kg/CH U	21%	22%	21%	21%
Total impact, in absolute value	**3.89E+03**	**4.54E+00**	**3.37E+00**	**3.37E+00**

8.8.15 Dismantling, laptop computer, mechanically

The transfer coefficients to the ultimate end of life options remain the same. However, the shredding, milling, and separation datasets are updated using the new ICT dataset for waste treatment.

Table 8.8-29. Life cycle inventory for Dismantling, laptop computer, mechanically and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, laptop, mechanically, at plant/kg/CH U	1	kg				
Output						
Waste to treatment						
Disposal, Li-ions batteries, mixed technology/GLO U	0.0876	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, fluorescent lamps/GLO U	0.0186	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, LCD module, to municipal waste incineration/kg/CH U	0.0866	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.0649	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, residues, mechanical treatment, laptop computer, in MSWI/kg/CH U	0.25183	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of printed wiring boards/GLO U	0.0327	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Shredding, electrical and electronic scrap/kg/CH U	0.5816	kg		Lognormal	1.65	(3,4,4,1,4,5); rough estimation

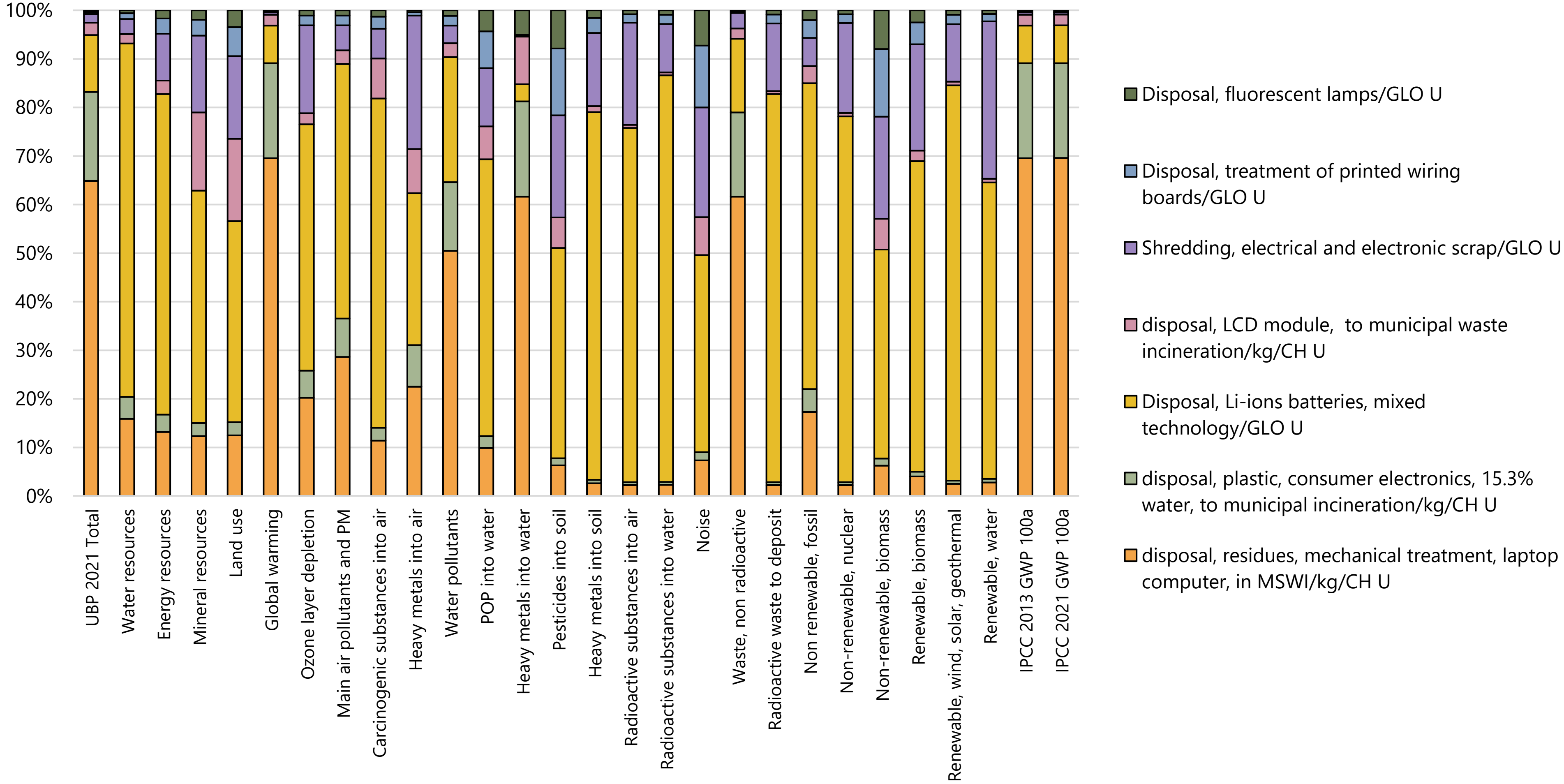

Figure 8.8-16. Contribution analysis presented in bar chart for: Dismantling, laptop computer, mechanically. FU = 1 kg

Table 8.8-30. Contribution analysis presented in table for: Dismantling, laptop computer, mechanically. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
disposal, residues, mechanical treatment, laptop computer, in MSWI/kg/CH U	65%	17%	70%	70%
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	18%	5%	20%	20%
Disposal, Li-ions batteries, mixed technology/GLO U	12%	63%	8%	8%
disposal, LCD module, to municipal waste incineration/kg/CH U	3%	4%	2%	2%
Shredding, electrical and electronic scrap/kg/CH U	2%	6%	0%	0%
Disposal, treatment of printed wiring boards/GLO U	0%	4%	0%	0%
Disposal, fluorescent lamps/GLO U	0%	2%	0%	0%
Total impact, in absolute value	**1.16E+03**	**1.07E+00**	**1.03E+00**	**1.03E+00**

8.8.16 Dismantling, laptop computer, manually

The transfer coefficients to the ultimate end of life options remain the same. However, the shredding, milling, and separation datasets are updated using the new ICT dataset for waste treatment. The battery treatment was also removed from the end of life options because desktop no longer uses NiMh batteries.

Table 8.8-31. Life cycle inventory for Dismantling, laptop computer, manually and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Dismantling, laptop, manually, at plant/kg/CH U	1	kg				
Input						
transport, freight, rail, electricity with shunting/tkm/CH U	0.014535	tkm		Lognormal	2.11	(3,1,4,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
transport, freight, lorry 16-32 metric ton, fleet average/tkm/CH U	0.028215	tkm		Lognormal	2.11	(3,1,4,1,1,5); data from Swiss WEEE systems - reported in Hischier (2005)
Manual treatment plant, WEEE scrap/GLO/I U	0.000000016	p		Lognormal	3.85	(4,5,4,3,5,5); rough estimation of infrastructure
Output						
Waste to treatment						
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/GLO U	0.1168	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, Li-ions batteries, mixed technology/GLO U	0.0876	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, fluorescent lamps/GLO U	0.0186	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, LCD module, to municipal waste incineration/kg/CH U	0.0866	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.136	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of cables/GLO U	0.0018	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data
Disposal, treatment of printed wiring boards/GLO U	0.1317	kg		Lognormal	1.34	(3,4,4,1,1,5); calculated - based on composition data

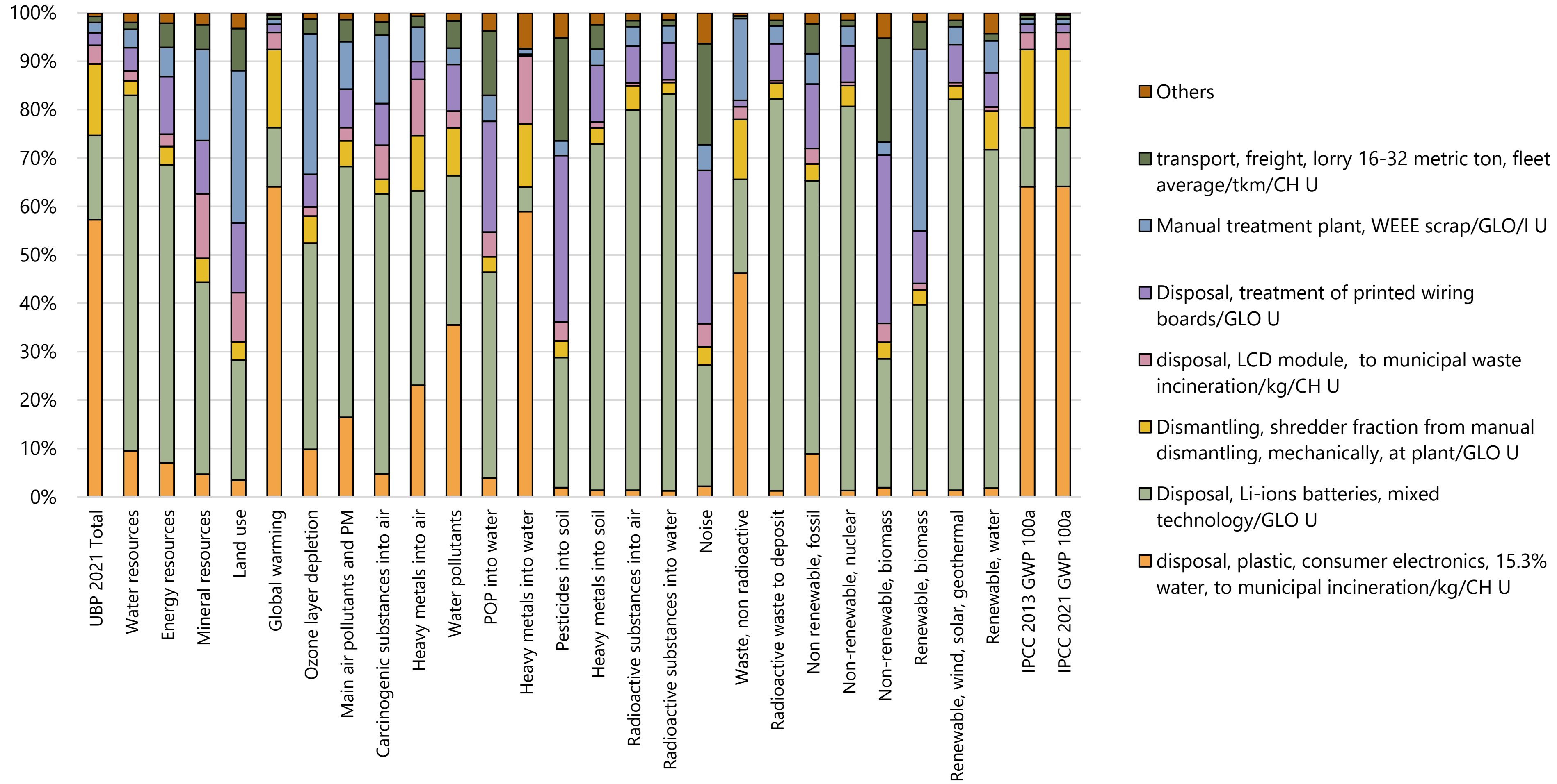

Figure 8.8-17. Contribution analysis presented in bar chart for: Dismantling, laptop computer, manually. FU = 1 kg

Table 8.8-32. Contribution analysis presented in table for: Dismantling, laptop computer, manually. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	57%	9%	64%	64%
Disposal, Li-ions batteries, mixed technology/GLO U	17%	56%	12%	12%
Dismantling, shredder fraction from manual dismantling, mechanically, at plant/GLO U	15%	3%	16%	16%
disposal, LCD module, to municipal waste incineration/kg/CH U	4%	3%	3%	3%
Disposal, treatment of printed wiring boards/GLO U	3%	13%	2%	2%
Manual treatment plant, WEEE scrap/GLO/I U	2%	6%	1%	1%
transport, freight, lorry 16-32 metric ton, fleet average/tkm/CH U	1%	6%	1%	1%
Others	1%	2%	0%	0%
Total impact, in absolute value	**7.78E+02**	**1.18E+00**	**6.58E-01**	**6.58E-01**

8.8.17 Disposal, laptop computer, to WEEE treatment

The update to this dataset concerns mainly the mass of desktop computers waste to be treated in the mechanical and manual separation plant. The average mass of 2.77 kg is used as in the dataset for laptop computer, where the split to manual and mechanical treatment is assumed to be the same as in the original dataset. Another change is that the batteries flows are now removed since desktop computers do not contain lithium ion batteries.

Table 8.8-33. Life cycle inventory for Disposal, laptop computer, to WEEE treatment and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Disposal, laptop computer, to WEEE treatment/p/CH U	1	p				
Output						
Waste to treatment						
Dismantling, laptop, manually, at plant/kg/CH U	0.631	kg	Lognormal	1.21		(1,1,1,1,1,5); data from Swiss WEEE systems - updated using data from SWICO report 2022
Dismantling, laptop, mechanically, at plant/kg/CH U	2.11	kg	Lognormal	1.21		(1,1,1,1,1,5); data from Swiss WEEE systems - updated using data from SWICO report 2022

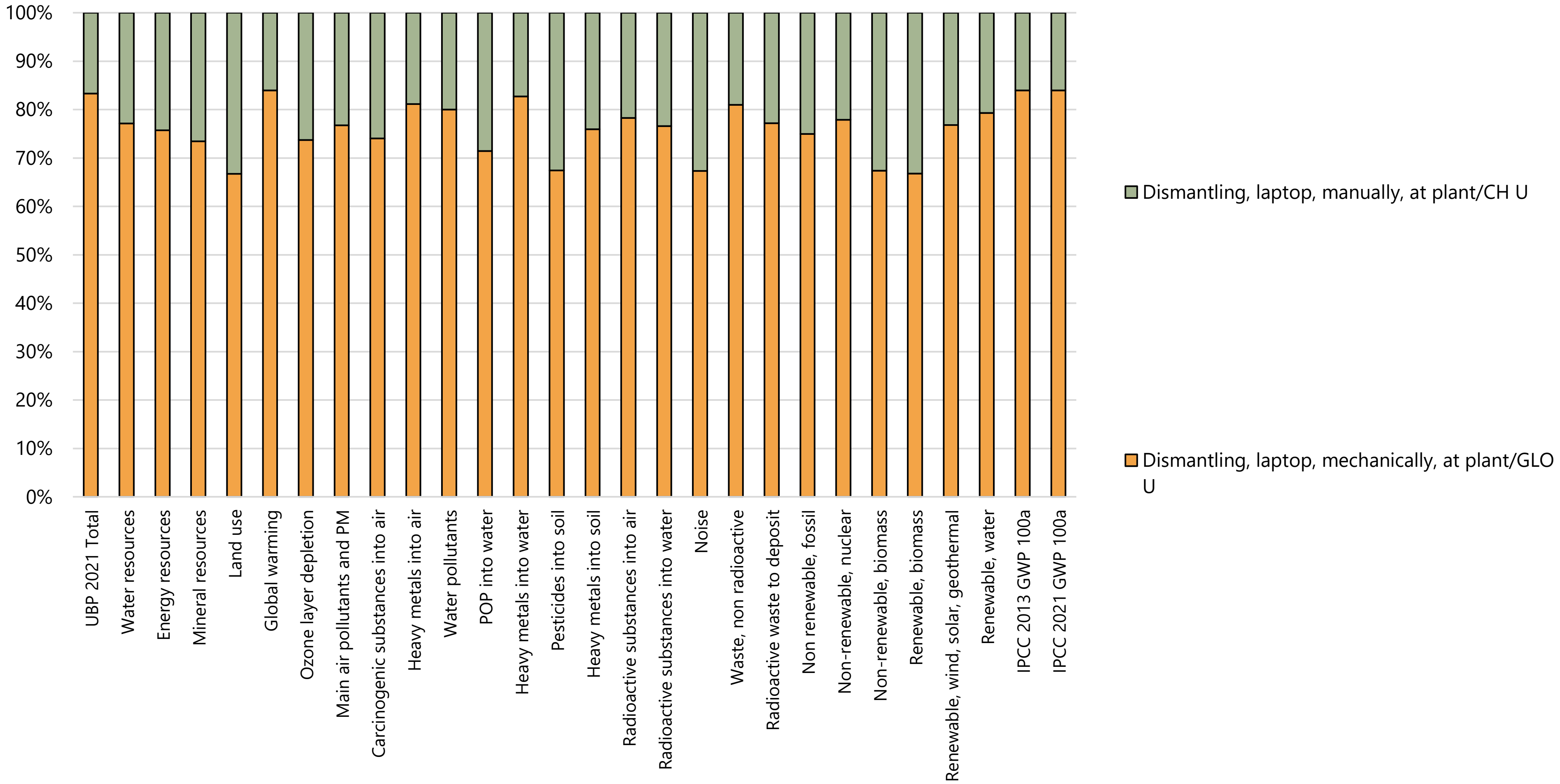

Figure 8.8-18. Contribution analysis presented in bar chart for: Disposal, laptop computer, to WEEE treatment. FU = 1 unit

Table 8.8-34. Contribution analysis presented in table for: Disposal, laptop computer, to WEEE treatment. FU = 1 unit

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
Dismantling, laptop, mechanically, at plant/GLO U	83%	75%	84%	84%
Dismantling, laptop, manually, at plant/CH U	17%	25%	16%	16%
Total impact, in absolute value	**2.94E+03**	**2.99E+00**	**2.59E+00**	**2.59E+00**

9 Appendix for life cycle inventories and impact assessments of new ICT datasets

9.1 Computer subcomponent

9.1.1 Network attached storage/NAS

Network attached storage (NAS) is modeled as a small desktop with defined technical specifications of a Synology DS220+ (Synology, 2023). When needed, the missing inventory flows for processing units and other auxiliary components are taken from the study of (Teehan & Kandlikar, 2013). The key technical specifications, which are available in the product datasheet of Synology DS220+, include: CPU Intel Celeron J4025 2-core 2.0 GHz, 2 GB RAM capacity, 2 x 4 TB 2.5" HDD storage capacity, system fan, cables, 1 power adaptor, and packaging. The total weight of the modeled NAS is 1.30 kg.

Table 9.1-1

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
Network Attached Storage, NAS, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.4	kg		Lognormal	1.23	(2,3,2,3,2,5); Casing. Literature: Teehan and Kandikar 2013.
aluminium, production mix, at plant/kg/RER U	0.45	kg		Lognormal	1.23	(2,3,2,3,2,5); Casing. Literature: Teehan and Kandikar 2013.
electricity, medium voltage, production GLO, at grid/kWh/GLO U	5.278	kWh		Lognormal	1.23	(2,3,2,3,2,5); Assembly. Literature: Teehan and Kandikar 2013.
Fan, at plant/GLO U	0.02	kg		Lognormal	1.23	(2,3,2,3,2,5); Data sheet NAS Synology DS220+
HDD, desktop computer, at plant/p/GLO U	4	p		Lognormal	1.23	(2,3,2,3,2,5); Data sheet NAS Synology DS220+
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.0084	kg		Lognormal	1.23	(2,3,2,3,2,5); IC, PWB. Literature: Teehan and Kandikar 2013.
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	2	p		Lognormal	1.23	(2,3,2,3,2,5); Data sheet NAS Synology DS220+
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	2	p		Lognormal	1.23	(2,3,2,3,2,5); Data sheet NAS Synology DS220+
Power supply unit, at plant/p/GLO U	0.15	p		Lognormal	1.23	(2,3,2,3,2,5); Power supply. Literature: Teehan and Kandikar 2013.
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	0.227	kg		Lognormal	1.23	(2,3,2,3,2,5); IC, PWB. Literature: Teehan and Kandikar 2013.
Sheet rolling, aluminium/RER U	0.45	kg		Lognormal	1.23	(2,3,2,3,2,5); Casing. Literature: Teehan and Kandikar 2013.
Stretch blow moulding/RER U	0.4	kg		Lognormal	1.23	(2,3,2,3,2,5); Casing. Literature: Teehan and Kandikar 2013.
transport, freight, lorry, fleet average/tkm/RER U	0.126	tkm		Lognormal	2.06	(2,3,2,3,2,5);
transport, freight, rail/tkm/RER U	0.252	tkm		Lognormal	2.06	(2,3,2,3,2,5);
transport, transoceanic freight ship/tkm/OCE U	26.9	tkm		Lognormal	2.06	(2,3,2,3,2,5);
Output						
Waste to treatment						
Disposal, desktop computer, to WEEE treatment/p/CH U	0.15	p		Lognormal	1.34	(2,3,3,4,3,5); Proxy for a small desktop computer/NAS

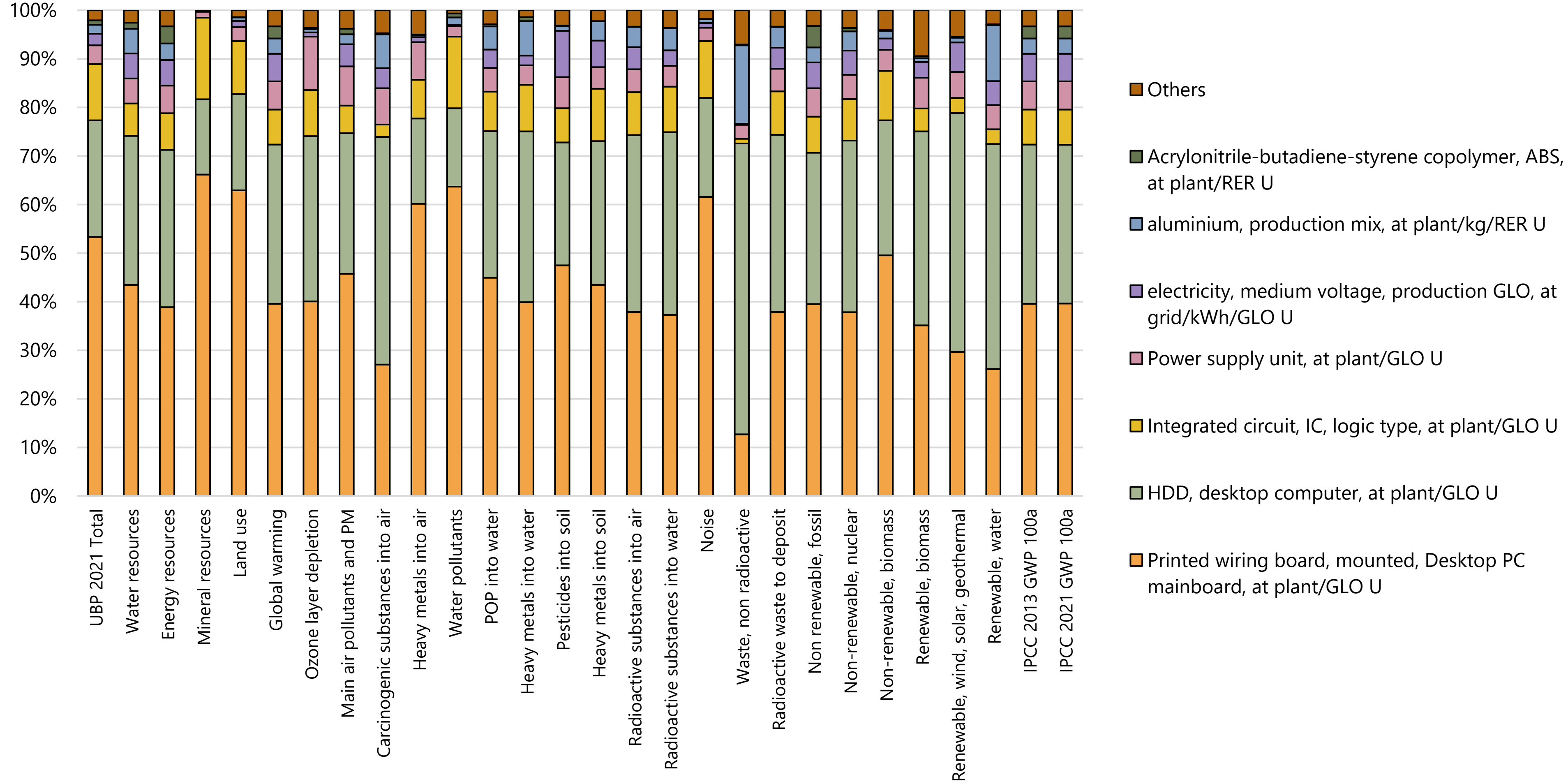

Figure 9.1-1. Contribution analysis presented in bar chart for: Network attached storage/NAS. FU = 1 unit

Table 9.1-2. Contribution analysis presented in table for: Network attached storage/NAS. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	54%	41%	41%	41%
HDD, desktop computer, at plant/p/GLO U	23%	29%	31%	31%
Integrated circuit, IC, logic type, at plant/kg/GLO U	12%	8%	7%	7%
Power supply unit, at plant/p/GLO U	4%	6%	6%	6%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	2%	5%	6%	6%
aluminium, production mix, at plant/kg/RER U	2%	3%	3%	3%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	1%	5%	3%	3%
Others	2%	3%	3%	3%
Total impact, in absolute value	**2.68E+05**	**8.20E+02**	**6.92E+01**	**6.91E+01**

9.1.2 External drive

There are two types of external drives, hard disk drives (HDDs) and solid state drives (SSDs). In the past, external drives are dominated mostly by the HDDs type of storage: spinning hard drives consisting of a metal platter with a magnetic coating on which a read/write head gets access to the data while the platter is spinning. Recently, SSDs, instead, store data on interconnected flash memory chips (Tecchio et al., 2018). There has been a shift in market share since 2012 when the usage of external SSDs are more widely available for personal computers, due to significant price drops over the years (Sprecher et al., 2014). The dataset is modeled as a mix of SSD and HDD, with a ratio of 60:40 according to the market projection (Statista, 2017). The standard capacity of 500 – 1 TB external drives is defined.

Table 9.1-3. Life cycle inventory for Computer subcomponents, external drive and the representation in the UVEK database

Unit process	Value	Unit	Sub category	Distribution	SD 95%	Comment
External drive, at plant/p/GLO U	1	p				
Input						
Computer subcomponent, SSD, at plant/p/GLO U	0.6	p		Lognormal	1.23	(2,2,2,2,2,5); HDD for laptops + SSD, with a share of 40:60 (Statista, 2017).
HDD, laptop computer, at plant/p/GLO U	0.4	p		Lognormal	1.23	(2,2,2,2,2,5); HDD for laptops + SSD, with a share of 40:60 (Statista, 2017).

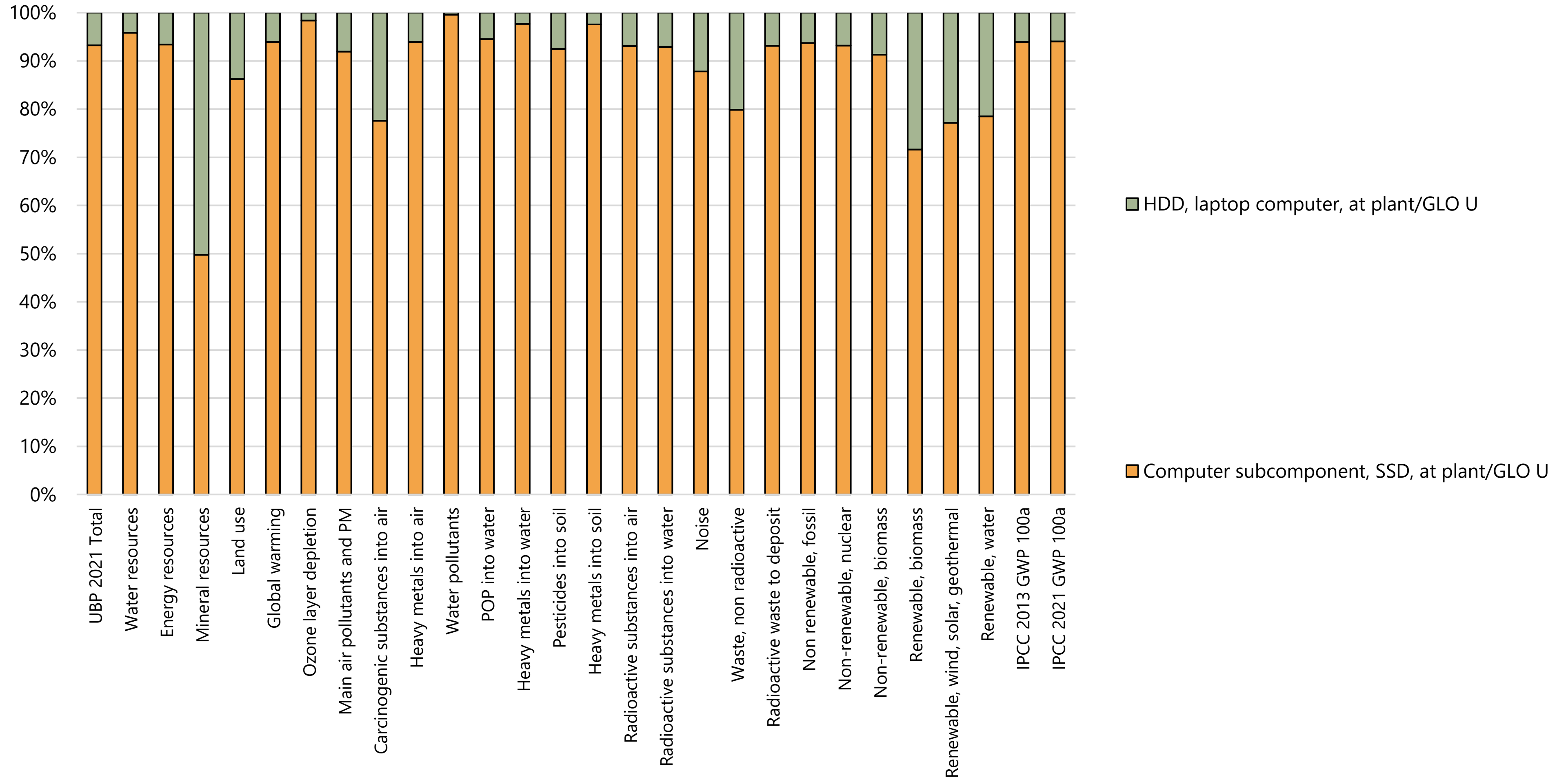

Figure 9.1-2. Contribution analysis presented in bar chart for: Computer subcomponents, external drive. FU = 1 unit

Table 9.1-4. Contribution analysis presented in table for: Computer subcomponents, external drive. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Computer subcomponent, SSD, at plant/p/GLO U	92%	93%	93%	93%
HDD, laptop computer, at plant/p/GLO U	8%	7%	7%	7%
Total impact, in absolute value	2.62E+04	1.26E+02	1.14E+01	1.15E+01

9.1.3 Solid state drive or SSD

The specification is: 2.5 SSD of 50 gram, with a storage capacity of 800 GB, according to an SSD manufacturer (WD, 2020). The components for a standard SSD are taken from the study of (Schödwell et al., 2018; Umweltbundesamt, 2021). Among the essential electronics are wafer (chips) and printed wiring boards areas, which are calculated based on the capacity of SSD. It is assumed that the storage capacity per area or NANDproDIE is 49.8 GB/cm2. It is also assumed that there are 2 PCBS per unpopulated board each having an area of 54.2 cm2 / PCB. The weight of SSD is defined according the standard SSD weights in the market: 64 g/SSD.

Table 9.1-5. Life cycle inventory for Computer subcomponent, SSD and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Solide State Drive (SSD), at plant/p/GLO U	1	p				
Input						
Printed wiring board, surface mount, lead-free surface, at plant/m2/GLO U	0.0108	m2		Lognormal	1.23	(2,3,1,3,2,5)
Mounting, surface mount technology, Pb-free solder/m2/GLO U	0.0108	m2		Lognormal	1.23	(2,3,1,3,2,5)
wafer, fabricated, for integrated circuit, memory at plant/m2/GLO U	0.001606	m2		Lognormal	1.23	(2,3,1,3,2,5)
aluminium, production mix, at plant/kg/RER U	0.0384	kg		Lognormal	1.23	(2,3,1,3,2,5); Schödwell 2018, 60% of SSD weight
Sheet rolling, aluminium/RER U	0.0384	kg		Lognormal	1.23	(2,3,1,3,2,5); Schödwell 2018, 60% of SSD weight
transport, freight, rail/tkm/RER U	0.0164	tkm		Lognormal	2.06	(2,3,1,3,2,5)
transport, freight, lorry, fleet average/tkm/RER U	0.00821	tkm		Lognormal	2.06	(2,3,1,3,2,5)

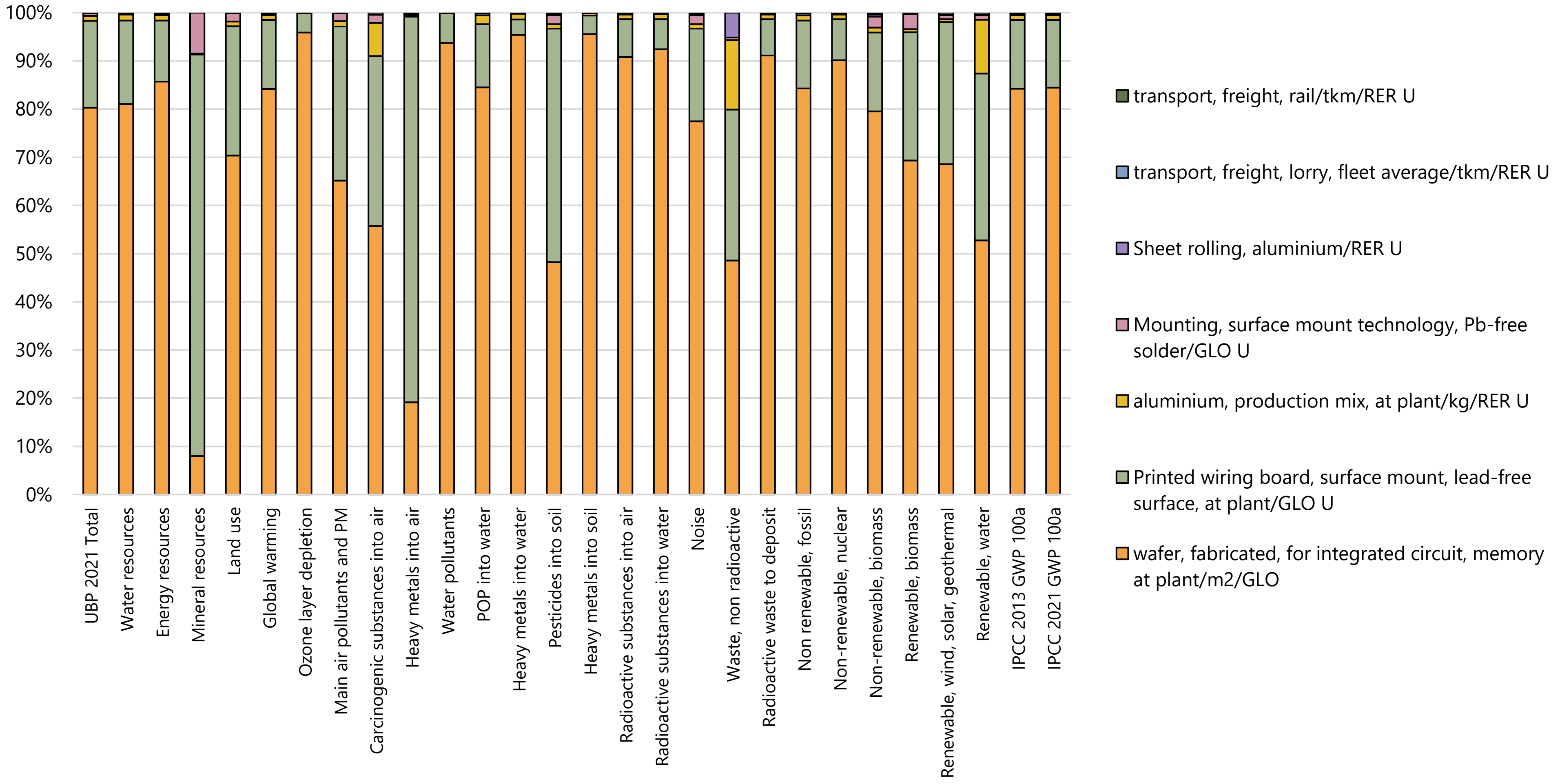

Figure 9.1-3. Contribution analysis presented in bar chart for: Computer subcomponent, SSD. FU = 1 unit

Table 9.1-6. Contribution analysis presented in table for: Computer subcomponent, SSD. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO	80%	83%	83%	83%
Printed wiring board, surface mount, lead-free surface, at plant/m2/GLO U	19%	15%	15%	15%
aluminium, production mix, at plant/kg/RER U	1%	1%	1%	1%
Mounting, surface mount technology, Pb-free solder/m2/GLO U	>0%	>0%	>0%	>0%
Sheet rolling, aluminium/RER U	>0%	>0%	>0%	>0%
transport, freight, lorry, fleet average/tkm/RER U	>0%	>0%	>0%	>0%
transport, freight, rail/tkm/RER U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**4.04E+04**	**1.94E+02**	**1.76E+01**	**1.78E+01**

9.2 Auxiliary equipment

9.2.1 HDMI cable

The datasets for HDMI cables are developed by combining other component datasets already available in the UVEK, namely cables and plugs. The total length of the cable is 2 m. The presence of copper as conductor wires and PVC as the cable jacket type is in accordance with the material datasheet of common HDMI cables from the manufacturers (Aten, 2018).

Table 9.2-1. Life cycle inventory for HDMI, cable and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
HDMI cable, at plant/p/GLO U	1	p				
Input						
Cable, three-conductor cable, at plant/m/GLO U	2	m		Lognormal	1.33	(3,3,1,3,3,5); Defined length = 2m
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.33	(3,3,1,3,3,5); For inlet and outlet
Connector, computer, peripherical type, at plant/kg/GLO U	0.02	kg		Lognormal	1.33	(3,3,1,3,3,5); 2 connectors

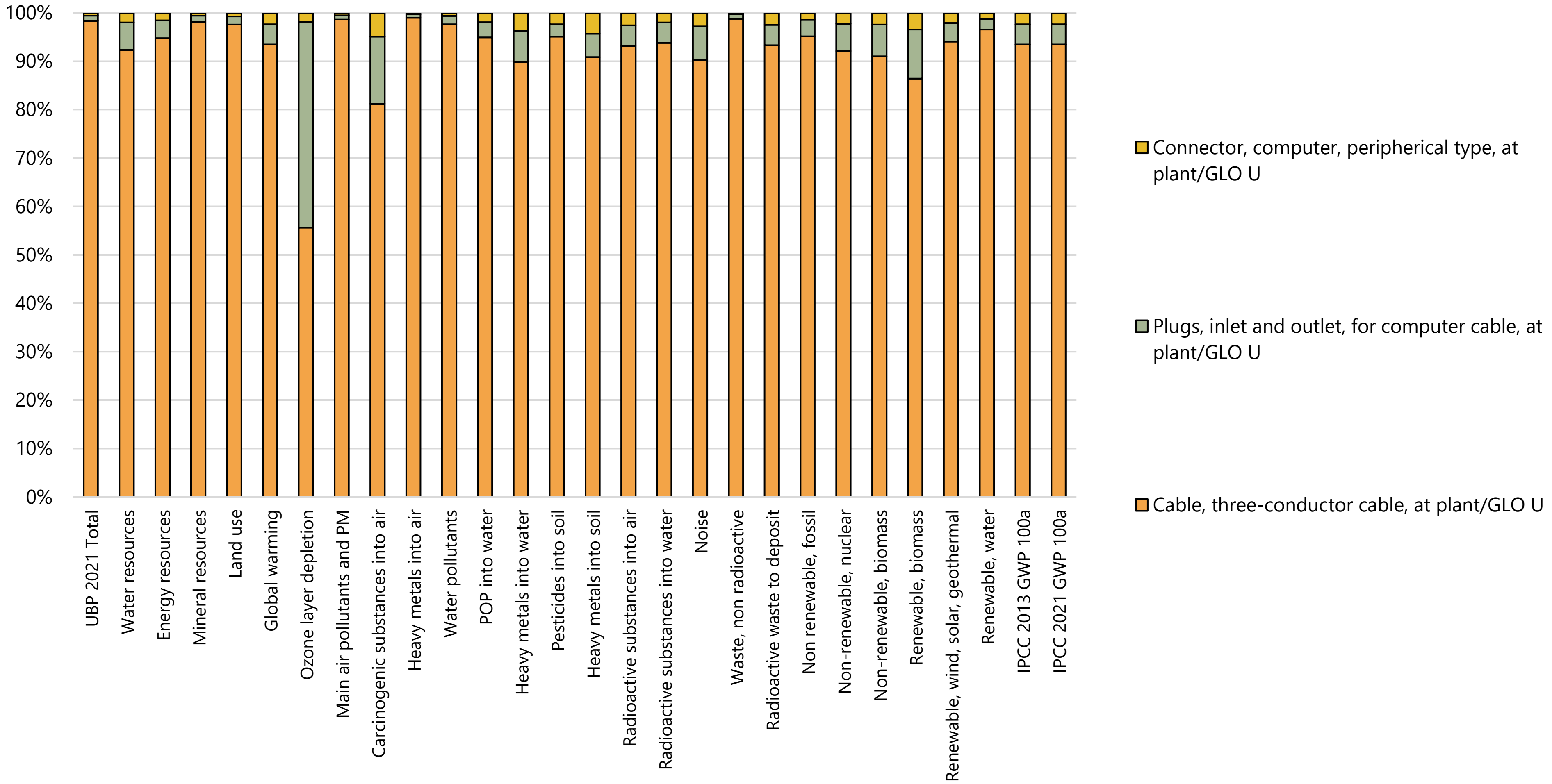

Figure 9.2-1. Contribution analysis presented in bar chart for: HDMI, cable. FU = 1 unit

Table 9.2-2. Contribution analysis presented in table for: HDMI, cable. FU = 1 unit (2 m long)

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Cable, three-conductor cable, at plant/m/GLO U	98%	95%	93%	93%
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1%	3%	4%	4%
Connector, computer, peripherical type, at plant/kg/GLO U	1%	1%	2%	2%
Total impact, in absolute value	**8.96E+04**	**1.32E+02**	**6.63E+00**	**6.57E+00**

9.2.2 Docking station

The LCA of docking station is developed using modeling parameters from the LCA study of Dell docking stations family (Dell, 2022a). The total mass of the docking station is 0.6 kg. The docking comprises a power supply unit 180W, power adapter, aluminum and plastics casing, plugs, ports and cables. The bill of materials are taken from the manufacturers' datasheets (Dell, 2022b; Lenovo, 2022).

Table 9.2-3. Life cycle inventory for Docking station and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Docking station, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.15	kg		Lognormal	1.23	(2,3,1,3,2,5)
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.3	kg		Lognormal	1.23	(2,3,1,3,2,5)
Cable, connector for computer, without plugs, at plant/m/GLO U	2	m		Lognormal	1.23	(2,3,1,3,2,5)
Connector, computer, peripherical type, at plant/kg/GLO U	0.05	kg		Lognormal	1.23	(2,3,1,3,2,5); 5 ports USB type A and C
Corrugated board, mixed fibre, single wall, at plant/RER U	0.9	kg		Lognormal	1.23	(2,3,1,3,2,5)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	0.22224	kWh		Lognormal	1.23	(2,3,1,3,2,5)
Extrusion, plastic pipes/RER U	0.3	kg		Lognormal	1.23	(2,3,1,3,2,5)
Packaging film, LDPE, at plant/RER U	0.045	kg		Lognormal	1.23	(2,3,1,3,2,5)
Packaging, corrugated board, mixed fibre, single wall, at plant/RER U	0.045	kg		Lognormal	1.23	(2,3,1,3,2,5)
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.23	(2,3,1,3,2,5)
Polycarbonate, at plant/RER U	0.15	kg		Lognormal	1.23	(2,3,1,3,2,5)
Power adapter, for laptop, at plant/p/GLO U	1	p		Lognormal	1.23	(2,3,1,3,2,5)
Power supply unit, at plant/p/GLO U	0.8	p		Lognormal	1.23	(2,3,1,3,2,5); 1 PSU with power of 180W ~ 0.8x capacity of the original dataset
Sheet rolling, aluminium/RER U	0.3	kg		Lognormal	1.23	(2,3,1,3,2,5)
transport, freight, lorry, fleet average/tkm/RER U	0.14	tkm		Lognormal	2.06	(2,3,1,3,2,5)
transport, transoceanic container ship/OCE U	29.8	tkm		Lognormal	2.06	(2,3,1,3,2,5)

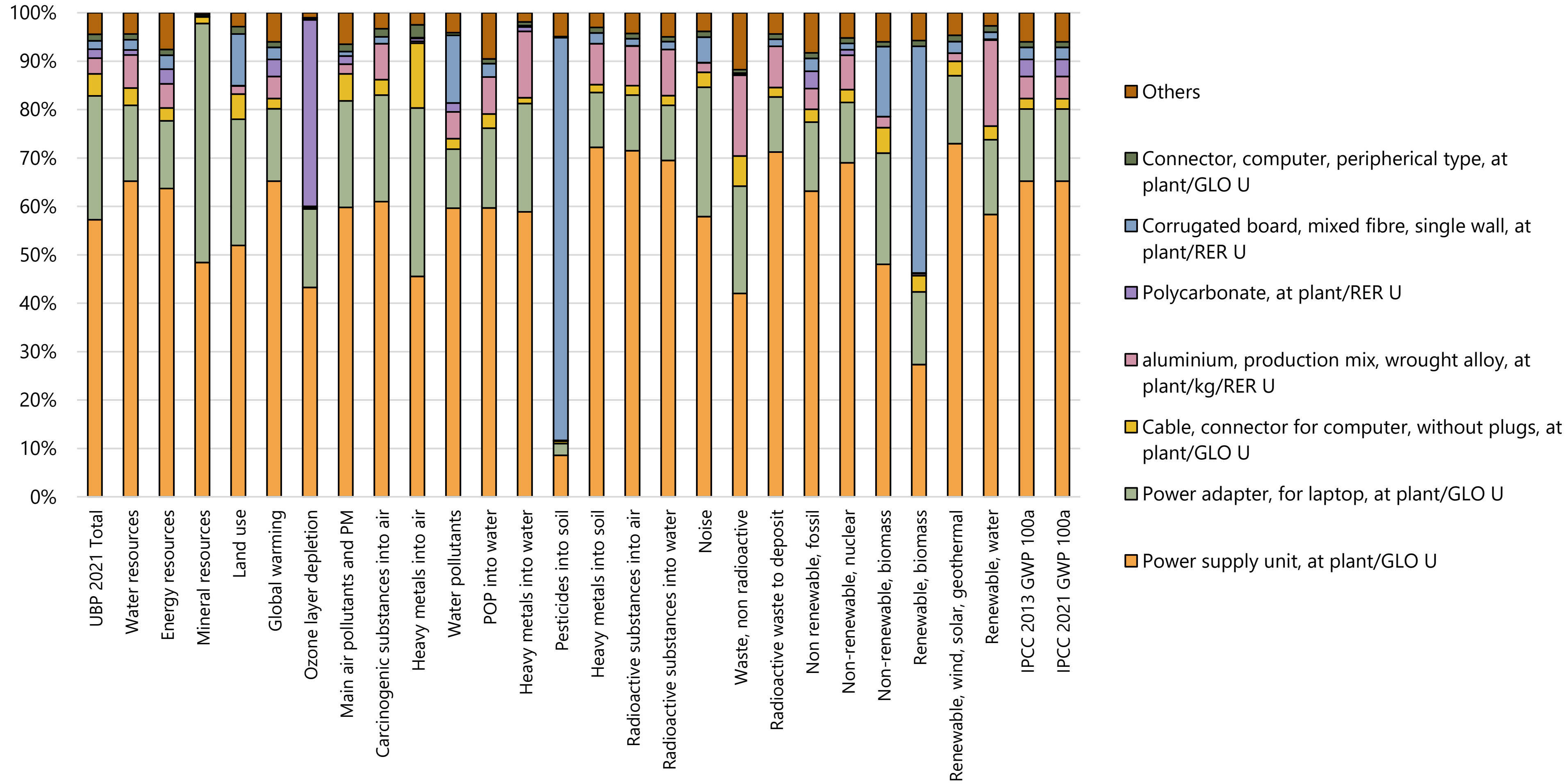

Figure 9.2-2. Contribution analysis presented in bar chart for: Docking station. FU = 1 unit

Table 9.2-4. Contribution analysis presented in table for: Docking station. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Power supply unit, at plant/p/GLO U	57%	63%	65%	65%
Power adapter, for laptop, at plant/p/GLO U	26%	14%	15%	15%
Cable, connector for computer, without plugs, at plant/m/GLO U	5%	3%	2%	2%
aluminium, production mix, wrought alloy, at plant/kg/RER U	3%	4%	5%	5%
Polycarbonate, at plant/RER U	2%	4%	4%	4%
Corrugated board, mixed fibre, single wall, at plant/RER U	2%	3%	2%	2%
Connector, computer, peripherical type, at plant/kg/GLO U	1%	1%	1%	1%
Others	4%	8%	6%	6%
Total impact, in absolute value	**9.74E+04**	**4.17E+02**	**3.40E+01**	**3.39E+01**

9.2.3 All-in-one printer - Wi-Fi

The bill of materials for this average inkjet printer are taken from the disassembly data from the inkjet all in one printer Kodak printer ESP7 (Babbitt et al., 2020) and complemented with the product sheets of printer manufacturers, i.e., HP, specifically HP OfficeJet Pro 9022e All-in-One Printer (HP, 2023). The key technical specifications are built-in WiFi connectivity, 1 GHz processor, 512 MB memory, and 4 inkjet cartridges. The total weight of the printer is approximately 11.6 kg, which includes the casing materials (plastics, aluminum, steel, and glass), cartridges, and electronics such as printed circuit boards.

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Table 9.2-5. Life cycle inventory for all-in-one printer (WiFi) and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
All-in-one printer (WiFi), at plant/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	1.889	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature for the materials: Average all in one printers bill of materials from Babbit et al 2020 and HP 2023 product sheet
aluminium, production mix, at plant/kg/RER U	0.003	kg		Lognormal	1.24	(2,3,2,4,2,5); Metal parts.
Auxiliary equipment, inkjet cartridge/p/GLO U	4	p		Lognormal	1.24	(2,3,2,4,2,5); 4 cartridges of different colors according to the product sheet
Cable, connector for computer, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.24	(2,3,2,4,2,5); Internal parts.
Cable, printer cable, without plugs, at plant/m/GLO U	1.8	m		Lognormal	1.24	(2,3,2,4,2,5); Internal parts.
Copper, primary, at refinery/GLO U	0.055	kg		Lognormal	1.24	(2,3,2,4,2,5); Metal parts.
Corrugated board, recycling fibre, double wall, at plant/RER U	2.32	kg		Lognormal	1.24	(2,3,2,4,2,5); Housing.
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.333 6	kWh		Lognormal	1.24	(2,3,2,4,2,5); Assumed to be the same as the average laser jet printers
Flat glass, uncoated, at plant/RER U	1.129	kg		Lognormal	1.24	(2,3,2,4,2,5); Flat panel glass + other glass
Injection moulding/RER U	7.556	kg		Lognormal	1.24	(2,3,2,4,2,5);
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.24	(2,3,2,4,2,5); Internal parts.
Plugs, inlet and outlet, for printer cable, at plant/p/GLO U	1	p		Lognormal	1.24	(2,3,2,4,2,5); Internal parts.
Polystyrene foam slab, at plant/RER U	0.569	kg		Lognormal	1.24	(2,3,2,4,2,5); Housing.
Polystyrene, high impact, HIPS, at plant/RER U	5.1	kg		Lognormal	1.24	(2,3,2,4,2,5); Housing.
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	0.385	kg		Lognormal	1.24	(2,3,2,4,2,5);
Section bar extrusion, aluminium/RER U	0.003	kg		Lognormal	1.24	(2,3,2,4,2,5);
Sheet rolling, copper/RER U	0.055	kg		Lognormal	1.24	(2,3,2,4,2,5);
Sheet rolling, steel/RER U	2.318	kg		Lognormal	1.24	(2,3,2,4,2,5);
Steel, low-alloyed, at plant/RER U	2.318	kg		Lognormal	1.24	(2,3,2,4,2,5); Metal parts.
transport, freight, lorry, fleet average/tkm/RER U	0.997	tkm		Lognormal	2.06	(2,3,2,4,2,5);
transport, freight, rail/tkm/RER U	1.99	tkm		Lognormal	2.06	(2,3,2,4,2,5);

transport, transoceanic freight ship/tkm/OCE U	212	tkm	Lognormal	2.06	(2,3,2,4,2,5);
Output					
Waste to treatment					
disposal, plastic, consumer electronics, 15.3% water, to municipal incineration/kg/CH U	0.755 6	kg	Lognormal	1.25	(3,3,2,2,2,5)
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	2.267	kg	Lognormal	1.25	(3,3,2,2,2,5)
Disposal, treatment of cables/GLO U	0.02	kg	Lognormal	1.25	(3,3,2,2,2,5)
Shredding, electrical and electronic scrap/kg/CH U	6.996	kg	Lognormal	1.25	(3,3,2,2,2,5); Assuming 60% parts are recycled, Literature: Bousquin 2011.

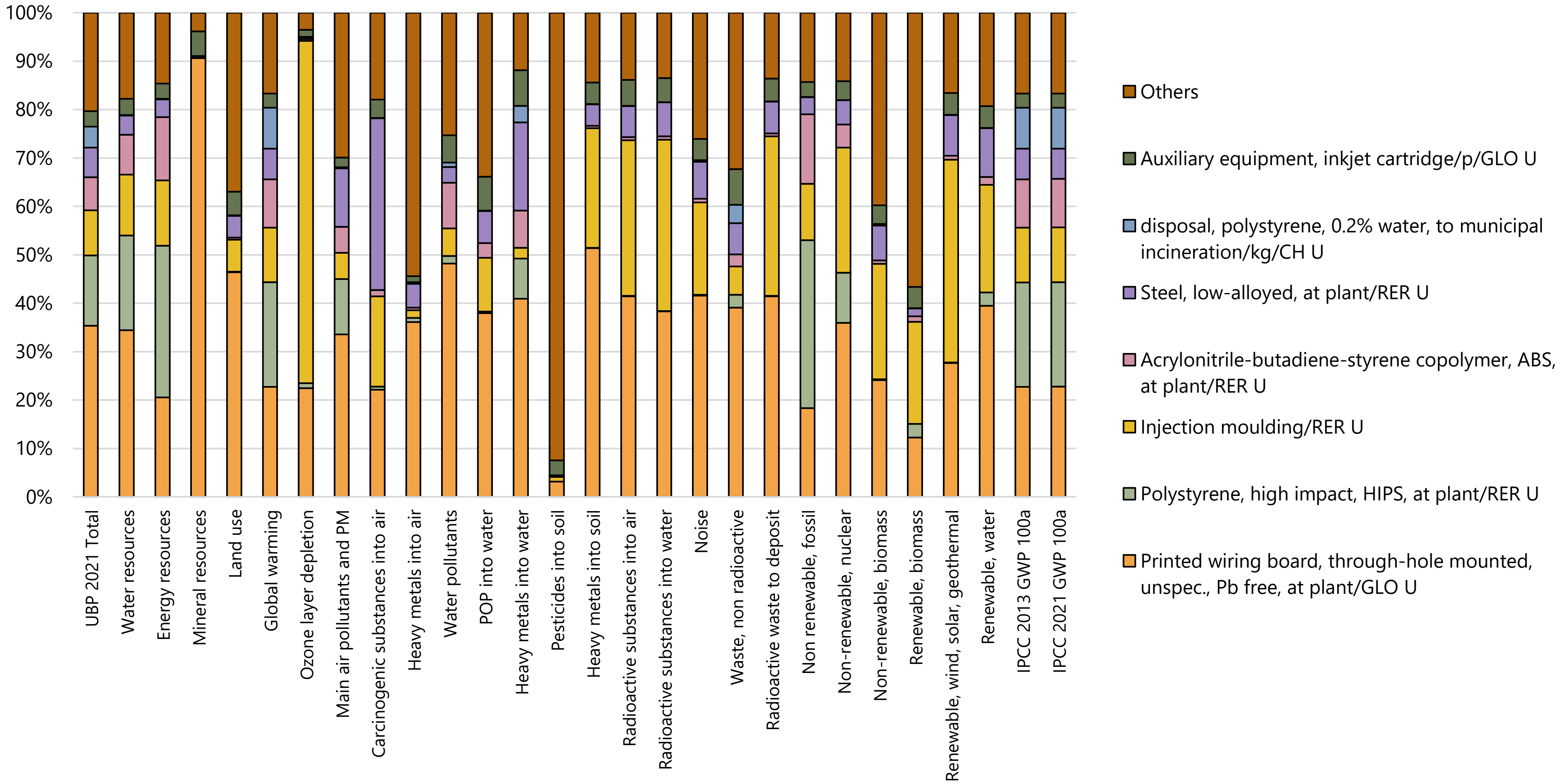

Figure 9.2-3. Contribution analysis presented in bar chart for: all-in-one printer (WiFi). FU = 1 unit

Table 9.2-6. Contribution analysis presented in table for: all-in-one printer (WiFi). FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	35%	18%	23%	23%
Polystyrene, high impact, HIPS, at plant/RER U	15%	35%	22%	22%
Injection moulding/RER U	9%	12%	11%	11%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	7%	14%	10%	10%
Steel, low-alloyed, at plant/RER U	6%	4%	6%	6%
disposal, polystyrene, 0.2% water, to municipal incineration/kg/CH U	4%	>0%	8%	8%
Auxiliary equipment, inkjet cartridge/p/GLO U	3%	3%	3%	3%
Others	20%	14%	17%	17%
Total impact, in absolute value	**1.71E+05**	**1.24E+03**	**8.57E+01**	**8.53E+01**

9.2.4 Inkjet cartridge

One of the essential consumables for new printing technologies is the inkjet cartridge (Bousquin et al., 2011; Grzesik & Terefeńko, 2012). The bill of materials for the manufacturing of one piece standard inkjet cartridge are retrieved from the detailed LCA study of (Krystofik et al., 2014), in which the authors break down the assembly of cartridge components at the material level. The cartridge assembly is categorized into several subparts, namely housing, circuitry/flexible printed circuit board, cartridge label, ink/solvent-based ink, and other materials. The production is assumed to occur globally as the production origin of each material/component location could not be identified as described in the original study.

Table 9.2-7. Life cycle inventory for inkjet cartridge and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Inkjet cartridge, at plant/p/GLO U	1	p				
Input						
Adhesive for metals, at plant/DE U	0.005	g		Lognormal	1.26	(2,3,3,3,2,5); Cartridge label. Literature: Krystofik et al 2014.
Butane-1,4-diol, at plant/RER U	0.15	g		Lognormal	1.26	(2,3,3,3,2,5); Ink/solvent-based ink. Literature: Krystofik et al 2014.
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.02	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet circuitry. Literature: Krystofik et al 2014.
Carbon black, at plant/GLO U	1.05	g		Lognormal	1.26	(2,3,3,3,2,5); Ink/solvent-based ink. Literature: Krystofik et al 2014.
Copper, secondary, at refinery/RER U	0.015	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet circuitry. Literature: Krystofik et al 2014.
Corrugated board base paper, wellenstoff, at plant/RER U	24.58	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Corrugated board, recycling fibre, double wall, at plant/RER U	1.76	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Ethylvinylacetate, foil, at plant/RER U	0.03	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet circuitry. Literature: Krystofik et al 2014.
Glass fibre, at plant/RER U	3.55	g		Lognormal	1.26	(2,3,3,3,2,5); Housing. Literature: Krystofik et al 2014.
Gold, secondary, at precious metal refinery/SE U	0.001	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet circuitry. Literature: Krystofik et al 2014.
Injection moulding/RER U	23.64	g		Lognormal	1.26	(2,3,3,3,2,5); Housing. Literature: Krystofik et al 2014.
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.114	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet circuitry. Literature: Krystofik et al 2014.
N-methyl-2-pyrrolidone, at plant/RER U	1.05	g		Lognormal	1.26	(2,3,3,3,2,5); Ink/solvent-based ink. Literature: Krystofik et al 2014.
Packaging film, LDPE, at plant/RER U	0.045	g		Lognormal	1.26	(2,3,3,3,2,5); Cartridge label. Literature: Krystofik et al 2014.
Packaging film, LDPE, at plant/RER U	0.19	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Paper, woodfree, coated, at integrated mill/RER U	5.63	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Pentane, at plant/RER U	1.05	g		Lognormal	1.26	(2,3,3,3,2,5); Ink/solvent-based ink. Literature: Krystofik et al 2014.
Pigments, paper production, unspecified, at plant/RER U	1.8	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Polyethylene terephthalate, granulate, bottle grade, at plant/RER U	20.09	g		Lognormal	1.26	(2,3,3,3,2,5); Housing. Literature: Krystofik et al 2014.
Polyurethane, rigid foam, at plant/RER U	1.34	g		Lognormal	1.26	(2,3,3,3,2,5); Ink delivery system. Literature: Krystofik et al 2014.
Production efforts, transistors/kg/GLO U	0.1	g		Lognormal	1.26	(2,3,3,3,2,5); Inkjet circuitry. Literature: Krystofik et al 2014.

Production of carton board boxes, offset printing, at plant/CH U	0.05	g	Lognormal	1.26	(2,3,3,3,2,5); Cartridge label. Literature: Krystofik et al 2014.
Sealing tape, aluminum/PE, 50 mm wide, at plant/RER U	1.16	m	Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Steel product manufacturing, average metal working/RER U	75.36	g	Lognormal	1.26	(2,3,3,3,2,5); Inkjet packaging/multiple materials. Literature: Krystofik et al 2014.
Water, deionised, at plant/CH U	11.7	g	Lognormal	1.26	(2,3,3,3,2,5); Ink/solvent-based ink. Literature: Krystofik et al 2014.

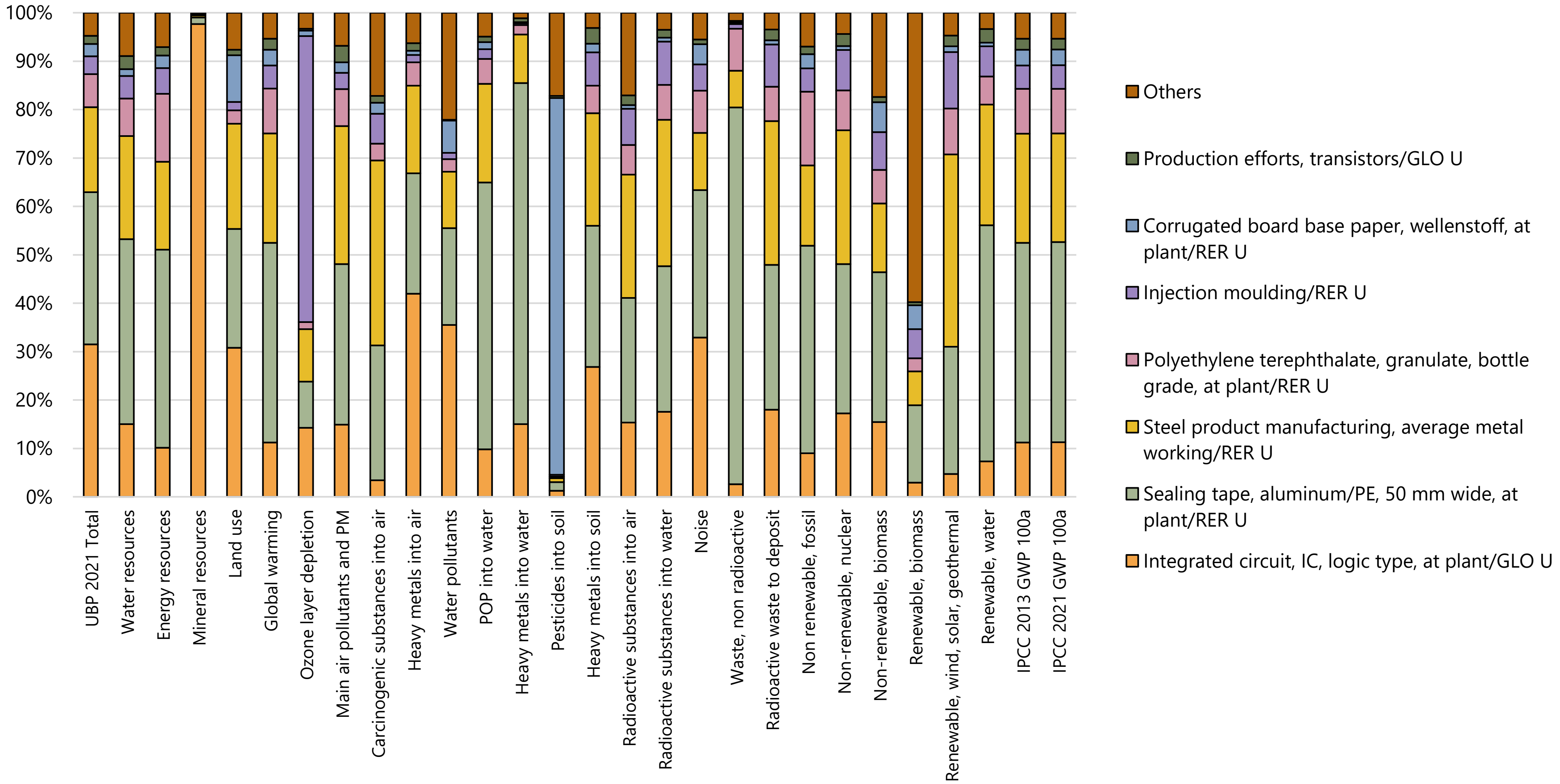

Figure 9.2-4. Contribution analysis presented in bar chart for: inkjet cartridge. FU = 1 unit

Table 9.2-8. Contribution analysis presented in table for: inkjet cartridge. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Integrated circuit, IC, logic type, at plant/kg/GLO U	32%	9%	11%	11%
Sealing tape, aluminum/PE, 50 mm wide, at plant/RER U	31%	43%	41%	41%
Steel product manufacturing, average metal working/RER U	18%	17%	23%	22%
Polyethylene terephthalate, granulate, bottle grade, at plant/RER U	7%	15%	9%	9%
Injection moulding/RER U	4%	5%	5%	5%
Corrugated board base paper, wellenstoff, at plant/RER U	3%	3%	3%	3%
Production efforts, transistors/kg/GLO U	2%	2%	2%	2%
Others	5%	7%	5%	5%
Total impact, in absolute value	**1.35E+03**	**9.44E+00**	**6.29E-01**	**6.27E-01**

9.2.5 Beamer/projector

The bill of materials for standard beamers/projectors are taken from the LCA study of (Cheung et al., 2018). The total weight of the projector is on average 2.8 kg, including casing, inner chassis, printed wiring boards, and electronic components.

Table 9.2-9. Life cycle inventory for Beamer/projector and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Beamer, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.114	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis+casing. Literature: Cheung et al 2018
aluminium, production mix, at plant/kg/RER U	0.162	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.024	kg		Lognormal	1.31	(2,2,2,3,3,5); Electronic components. Literature: Cheung
Diethyl ether, at plant/RER U	0.114	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.89	kWh		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis+casing. Literature: Cheung et al 2018
Fan, at plant/GLO U	0.255	kg		Lognormal	1.31	(2,2,2,3,3,5); Electronic components. Literature: Cheung et al 2018
float glass, at plant/RER U	0.194	kg		Lognormal	1.31	(2,2,2,3,3,5); Optical components. Literature: Cheung et al 2018
Glass fibre reinforced plastic, polyamide, injection moulding, at plant/RER U	0.02	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
Glass fibre reinforced plastic, polyester resin, hand lay-up, at plant/RER U	0.166	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
Glass fibre, at plant/RER U	0.0311	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
heat, natural gas, at industrial furnace 1MW/MJ/CH U	5.36	MJ		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis+casing. Literature: Cheung et al 2018
LCD module, at plant/kg/GLO U	0.012	kg		Lognormal	1.31	(2,2,2,3,3,5); Electronic components. Literature: Cheung
Magnetite, at plant/GLO U	0.04	kg		Lognormal	1.31	(2,2,2,3,3,5); Electronic components. Literature: Cheung
Paper, woodfree, coated, at regional storage/RER U	0.0006	kg		Lognormal	1.31	(2,2,2,3,3,5); Electronic components. Literature: Cheung
Plugs, inlet and outlet, for computer cable, at plant/p/GLO U	1	p		Lognormal	1.31	(2,2,2,3,3,5); Electronic components. Literature: Cheung
Polycarbonate, at plant/RER U	0.754	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis+casing. Literature: Cheung et al 2018
Polyphenylene sulfide, at plant/GLO U	0.173	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
Polypropylene, granulate, at plant/RER U	0.0335	kg		Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.495	kg		Lognormal	1.31	(2,2,2,3,3,5); PWB part. Literature: Cheung et al 2018

Sheet rolling, aluminium/RER U	0.162	kg	Lognormal	1.31	(2,2,2,3,3,5); Inner chassis. Literature: Cheung et al 2018
transport, transoceanic container ship/OCE U	60.1	tkm	Lognormal	2.10	(2,2,2,3,3,5);
transport, freight, lorry, fleet average/tkm/RER U	0.283	tkm	Lognormal	2.10	(2,2,2,3,3,5);
Output					
Waste to treatment					
Disposal, laptop computer, to WEEE treatment/p/CH U	1.01	p	Lognormal	1.14	(3,3,2,2,2,5); Proxy for beamer. Literature: Cheung et al 2018

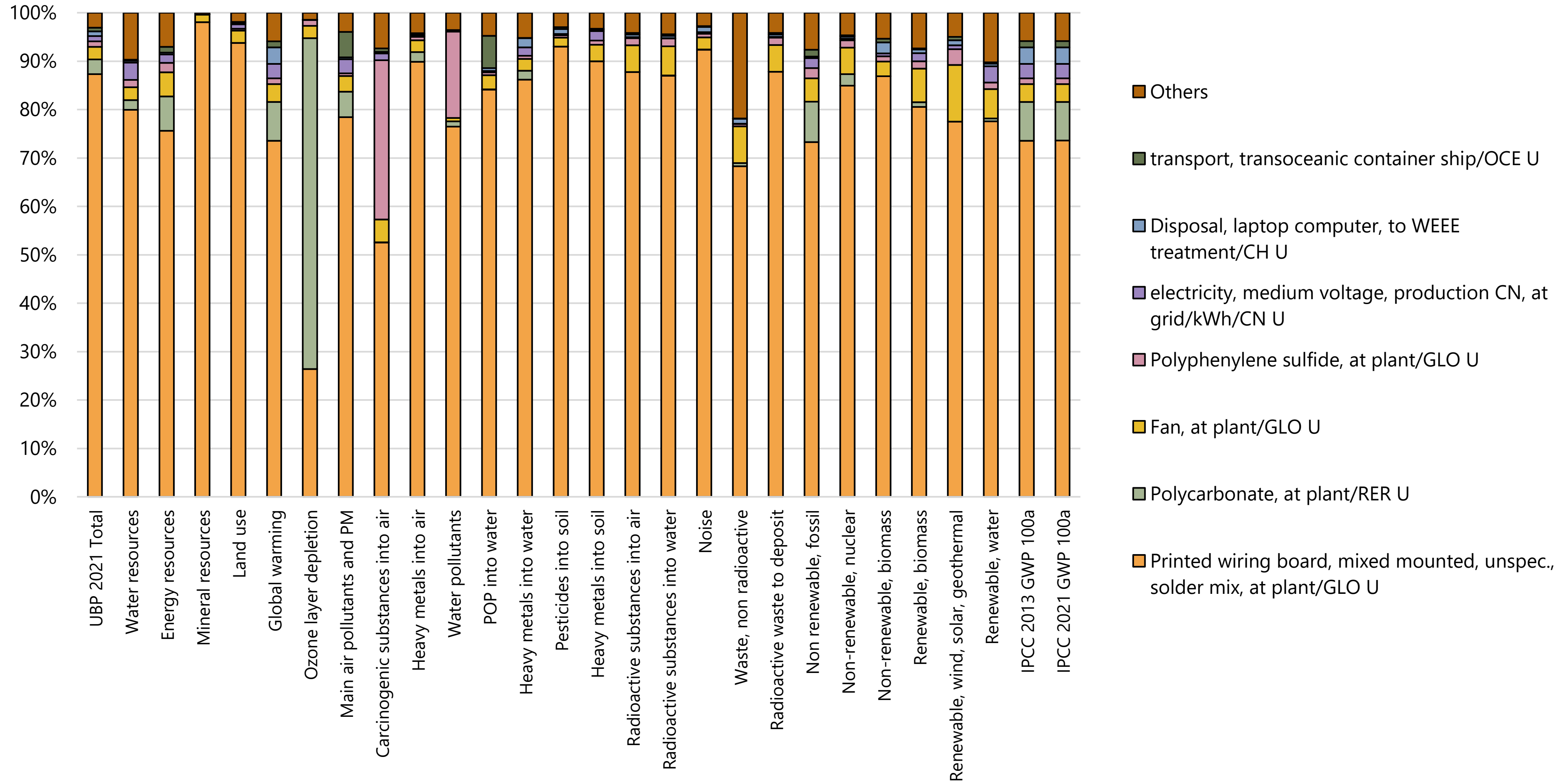

Figure 9.2-5. Contribution analysis presented in bar chart for: Beamer/projector. FU = 1 unit

Table 9.2-10. Contribution analysis presented in table for: Beamer/projector. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	88%	73%	74%	74%
Polycarbonate, at plant/RER U	3%	8%	8%	8%
Fan, at plant/GLO U	3%	5%	4%	4%
Polyphenylene sulfide, at plant/GLO U	1%	2%	1%	1%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1%	2%	2%	2%
Disposal, laptop computer, to WEEE treatment/p/CH U	1%	>0%	3%	3%
transport, transoceanic container ship/OCE U	1%	1%	1%	1%
Others	2%	8%	7%	7%
Total impact, in absolute value	**3.00E+05**	**8.86E+02**	**7.49E+01**	**7.49E+01**

9.2.6 Keyboard, Wireless version

The wireless keyboard is modeled using the existing wired keyboard dataset. The modifications to the existing keyboards are: the addition of a pair NiMh batteries (50 grams), the removal of wired cable, and lastly the increased mass of PCB components (Babbitt et al., 2020). The rest of other inventory flows are assumed to be the same as optimized wired keyboards.

Table 9.2-11. Life cycle inventory for Keyboard, Wireless version and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Keyboard, wireless version, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.536	kg		Lognormal	1.34	(1,4,3,3,3,5)
Battery, NiMH, rechargeable, prismatic, at plant/GLO U	0.05	kg		Lognormal	1.34	(1,4,3,3,3,5); A pair of AA batteries.
Copper, primary, at refinery/GLO U	0.0329	kg		Lognormal	1.34	(1,4,3,3,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.1111	kWh		Lognormal	1.34	(1,4,3,3,3,5)
Extrusion, plastic pipes/RER U	0.0371	kg		Lognormal	1.34	(1,4,3,3,3,5)
Injection moulding/RER U	0.77	kg		Lognormal	1.34	(1,4,3,3,3,5)
Polyvinylchloride, at regional storage/RER U	0.0371	kg		Lognormal	1.34	(1,4,3,3,3,5)
Printed wiring board mounting plant/p/GLO/I U	2.4544E-07	p		Lognormal	1.34	(1,4,3,3,3,5)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.03	kg		Lognormal	1.34	(1,4,3,3,3,5); Assumed to be 2x PCB of standard keyboard, Literature: Babbit et al 2020.
Steel, low-alloyed, at plant/RER U	0.0426	kg		Lognormal	1.34	(1,4,3,3,3,5)
transport, freight, lorry, fleet average/tkm/RER U	0.118	tkm		Lognormal	2.12	(1,4,3,3,3,5)
transport, freight, rail/tkm/RER U	0.236	tkm		Lognormal	2.12	(1,4,3,3,3,5)
transport, transoceanic freight ship/tkm/OCE U	25.134	tkm		Lognormal	2.12	(1,4,3,3,3,5)
Output						
Waste to treatment						
Disposal, keyboard, standard version, to WEEE treatment/p/CH U	1	p		Lognormal	1.34	(1,4,3,3,3,5)

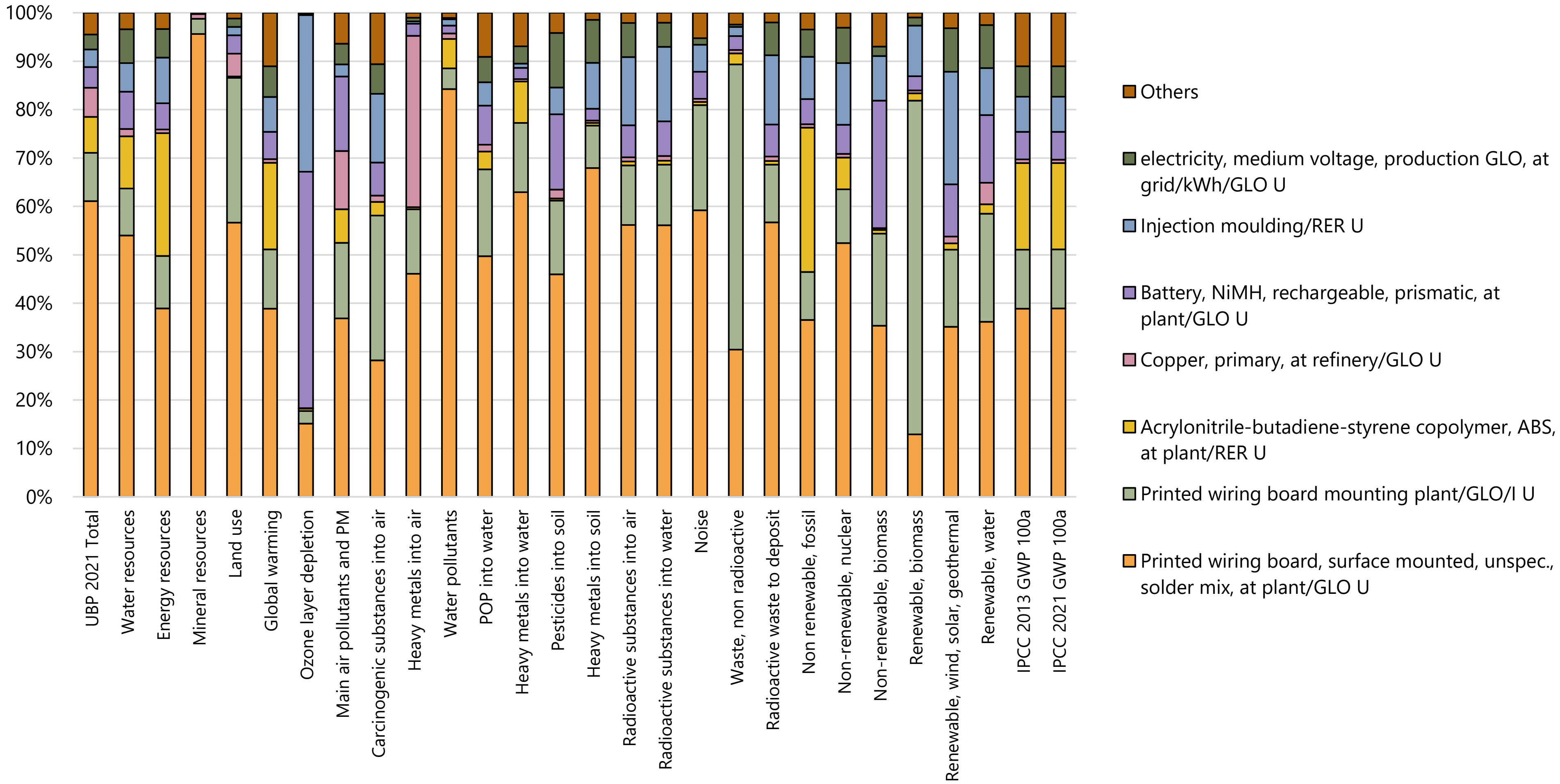

Figure 9.2-6. Contribution analysis presented in bar chart for: Keyboard, wireless version. FU = 1 unit

Table 9.2-12. Contribution analysis presented in table for: Keyboard, wireless version. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	61%	37%	39%	39%
Printed wiring board mounting plant/p/GLO/I U	10%	10%	12%	12%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	7%	30%	18%	18%
Copper, primary, at refinery/GLO U	6%	1%	1%	1%
Battery, NiMH, rechargeable, prismatic, at plant/GLO U	4%	5%	6%	6%
Injection moulding/RER U	4%	9%	7%	7%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	3%	6%	6%	6%
Others	5%	3%	11%	11%
Total impact, in absolute value	**4.45E+04**	**1.69E+02**	**1.36E+01**	**1.36E+01**

9.2.7 Mouse device, optical, wireless

The wireless keyboard is modeled using the existing wired mouse dataset. The modifications to the existing mice are: the addition of a single NiMh battery (25 grams), the removal of wired cable, and lastly the increased mass of PCB components (Babbitt et al., 2020). The rest of other inventory flows are assumed to be the same as optimized wired mice.

Table 9.2-13. Life cycle inventory for Mouse device, optical, wireless and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Mouse device, optical, wireless, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.0408	kg		Lognormal	1.25	(2,4,1,3,1,5)
Battery, NiMH, rechargeable, prismatic, at plant/GLO U	0.025	kg		Lognormal	1.25	(2,4,1,3,1,5); A single AA battery.
electricity, medium voltage, production GLO, at grid/kWh/GLO U	1.111	kWh		Lognormal	1.25	(2,4,1,3,1,5)
Extrusion, plastic pipes/RER U	0.00245	kg		Lognormal	1.25	(2,4,1,3,1,5)
Hot rolling, steel/RER U	0.0022	kg		Lognormal	1.25	(2,4,1,3,1,5)
Injection moulding/RER U	0.0513	kg		Lognormal	1.25	(2,4,1,3,1,5)
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1	p		Lognormal	1.25	(2,4,1,3,1,5)
Printed wiring board mounting plant/p/GLO/I U	2.496E-08	p		Lognormal	1.25	(2,4,1,3,1,5)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	0.014	kg		Lognormal	1.25	(2,4,1,3,1,5); Assumed to be 2x PCB of standard mouse. Literature: Babbit et al 2020.
Sheet rolling, steel/RER U	0.01085	kg		Lognormal	1.25	(2,4,1,3,1,5)
Steel, low-alloyed, at plant/RER U	0.01085	kg		Lognormal	1.25	(2,4,1,3,1,5)
transport, freight, lorry, fleet average/tkm/RER U	0.009755	tkm		Lognormal	2.06	(2,4,1,3,1,5)
transport, freight, rail/tkm/RER U	0.01951	tkm		Lognormal	2.06	(2,4,1,3,1,5)
transport, transoceanic freight ship/tkm/OCE U	2.0778	tkm		Lognormal	2.06	(2,4,1,3,1,5)
Output						
Waste to treatment						
Disposal, mouse device, optical, with cable, to WEEE treatment/p/CH U	1	p		Lognormal	1.34	(1,4,3,3,3,5)

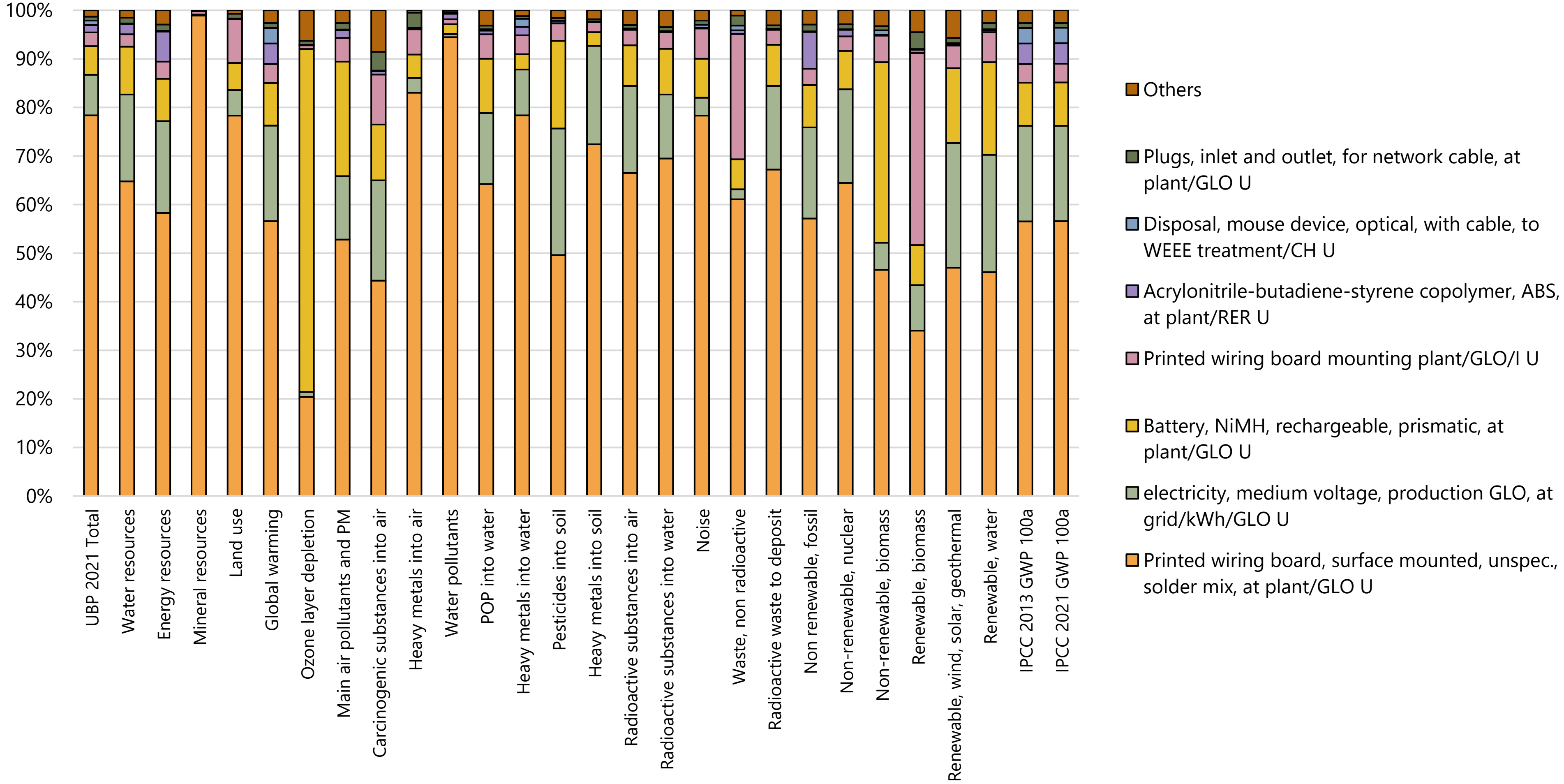

Figure 9.2-7. Contribution analysis presented in bar chart for: Mouse device, optical, wireless. FU = 1 unit

Table 9.2-14. Contribution analysis presented in table for: Mouse device, optical, wireless. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., solder mix, at plant/kg/GLO U	78%	57%	57%	57%
electricity, medium voltage, production GLO, at grid/kWh/GLO U	8%	19%	20%	20%
Battery, NiMH, rechargeable, prismatic, at plant/GLO U	6%	9%	9%	9%
Printed wiring board mounting plant/p/GLO/I U	3%	3%	4%	4%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	2%	8%	4%	4%
Disposal, mouse device, optical, with cable, to WEEE treatment/p/CH U	1%	>0%	3%	3%
Plugs, inlet and outlet, for network cable, at plant/p/GLO U	1%	1%	1%	1%
Others	1%	3%	3%	3%
Total impact, in absolute value	**1.62E+04**	**5.03E+01**	**4.35E+00**	**4.35E+00**

9.3 Smartphone

9.3.1 Smartphone, high-tech phone

Compiling an accurate list of components contained in a smartphone is difficult due to tightly confidential data and variations between devices/manufacturers. Nevertheless, this dataset focuses on the average smartphones with the specification as follows: 4 – 6.5 inch screen size. The weight of the smartphone is defined to be about 160 grams. The data for average smartphones are mainly taken from the JRC technical report and other published articles (Andrae, 2016; Cordella et al., 2021, 2020; Ercan et al., 2016; Manhart et al., 2016). The data is also compared with the bill of materials information from the study of (Babbitt et al., 2020).

Memory and RAM are defined separately using the calculation parameter from (Umweltbundesamt, 2021). It is assumed that the storage capacity and RAM per wafer area or NANDproDIE are 49.8 GB/cm2 and 1.1725 GB/cm2. The modeled smartphone has a storage capacity of 64 GB and RAM capacity of 4 GB. According to the industry information (IBM research), up to 6 stacked dies can be integrated in a single package to optimize density and performance (Sakuma et al., 2008). In the modeling, we increased the area of wafer/die to represent ~7 cm2 total wafer logic area (Clément et al., 2020).

Table 9.3-1. Life cycle inventory for Smartphone, high-tech phone and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Smartphone, high-tech phone, at plant/GLO U	1	p				
Input						
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.022	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.039	kg		Lognormal	1.31	(2,2,1,3,3,5); Battery. Literature: Cordella et al. 2020, JRC report
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	0.0007	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Cold impact extrusion, aluminium, 2 strokes/RER U	0.022	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Cold impact extrusion, steel, 2 strokes/RER U	0.0065	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Connector, computer, peripherical type, at plant/kg/GLO U	0.00025	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Connector, computer, peripherical type, at plant/kg/GLO U	0.00025	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
electricity, medium voltage, production Eastern Asia, at grid/RAS U	4.698	kWh		Lognormal	1.31	(2,2,1,3,3,5); Manufacturing and assembly. Literature: Cordella et al. 2020, JRC report
Electronic component, active, unspecified, at plant/kg/GLO U	0.0019	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Electronic component, passive, unspecified, at plant/kg/GLO U	0.0009	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Electronic component, passive, unspecified, at plant/kg/GLO U	0.016	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Extrusion, plastic film/RER U	0.02	kg		Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
Folding boxboard, FBB, at plant/RER U	0.11	kg		Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
Inductor, ring core choke type, at plant/kg/GLO U	0.0002	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Injection moulding/RER U	0.0095	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.002	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report

LED module, at plant/kg/GLO U	0.03	kg	Lognormal	1.31	(2,2,1,3,3,5); Screen/Display. Literature: Cordella et al. 2020, JRC report
Paper, newsprint, at plant/CH U	0.05	kg	Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
permanent magnet, for electric motor/RER U	0.001	kg	Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Polycarbonate, at plant/RER U	0.0095	kg	Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Polyethylene, LDPE, granulate, at plant/RER U	0.02	kg	Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.028	kg	Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Resistor, SMD type, surface mounting, at plant/kg/GLO U	0.002	kg	Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Smartphone, charger/p/GLO U	1	p	Lognormal	1.31	(2,2,3,3,3,5); Literature: Hischier et al 2014.
Steel, low-alloyed, at plant/RER U	0.0065	kg	Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Transistor, SMD type, surface mounting, at plant/kg/GLO U	0.0001	kg	Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
transport, freight, lorry, fleet average/tkm/RER U	0.0162	tkm	Lognormal	2.10	(2,2,1,3,3,5); According to smartphone mass.
transport, freight, rail/tkm/RER U	0.0323	tkm	Lognormal	2.10	(2,2,1,3,3,5); According to smartphone mass.
transport, transoceanic container ship/OCE U	3.4	tkm	Lognormal	2.10	(2,2,1,3,3,5); According to smartphone mass.
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO U	0.0007	m2	Lognormal	1.31	(2,2,1,3,3,5); Total die area = 7 cm2 wafer logic. Literature: Codella et al. 2020, JRC report
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO U	0.00047	m2	Lognormal	1.31	(2,2,1,3,3,5); For memory of 64 GB, flash type + 4 GB RAM. Literature: UBA report, 2021
Output					
Waste to treatment					
Disposal, laptop computer, to WEEE treatment/p/CH U	0.06	p	Lognormal	1.31	(3,4,3,3,3,5); Proxy, adjusted using weight

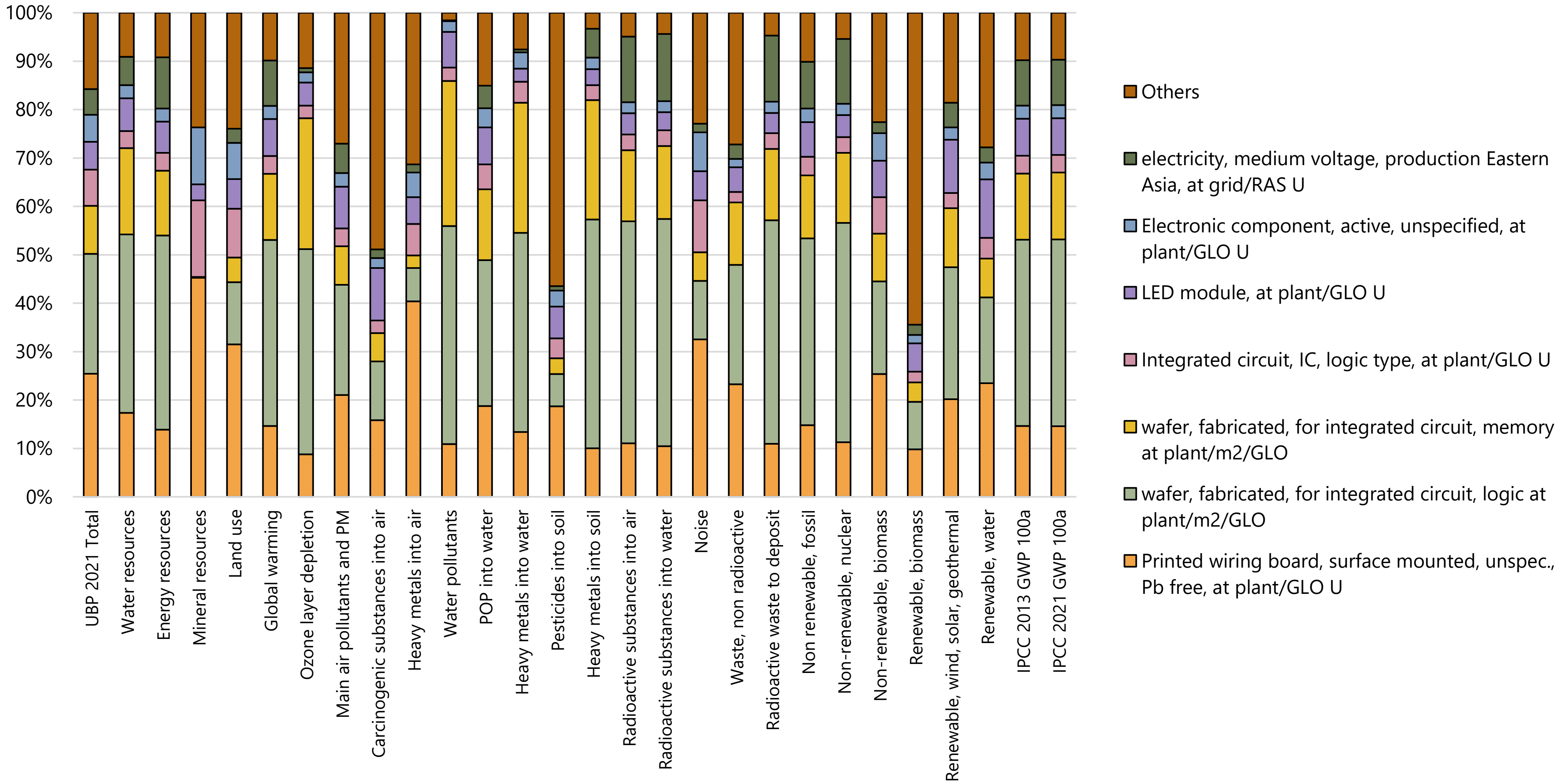

Figure 9.3-1. Contribution analysis presented in bar chart for: Smartphone, high-tech phone. FU = 1 unit

Table 9.3-2. Contribution analysis presented in table for: Smartphone, high-tech phone. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	26%	15%	15%	15%
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO	24%	38%	38%	38%
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO	10%	12%	13%	13%
Integrated circuit, IC, logic type, at plant/kg/GLO U	8%	4%	4%	4%
LED module, at plant/kg/GLO U	6%	7%	8%	8%
Electronic component, active, unspecified, at plant/kg/GLO U	6%	3%	3%	3%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	5%	10%	9%	9%
Others	15%	11%	10%	10%
Total impact, in absolute value	**9.85E+04**	**3.80E+02**	**3.28E+01**	**3.30E+01**

9.3.2 Smartphone, mid-tier, average phone

This dataset is modelled using the same approach as the high-tech smartphone concepts. However, certain technical specifications are used as parameters to scale the model for average/mid-tier smartphones, namely the storage and RAM capacity. Memory and RAM are defined separately using the calculation parameter from (Umweltbundesamt, 2021). It is assumed that the storage capacity and RAM per wafer area or NANDproDIE are 49.8 GB/cm2 and 1.1725 GB/cm2. The modeled smartphone has a storage capacity of 32 GB and RAM capacity of 2 GB. According to the industry information (IBM research), up to 6 stacked dies can be integrated in a single package to optimize density and performance (Sakuma et al., 2008). In the modeling, we increased the area of wafer/die to represent ~5.5 cm2 total wafer logic area (Clément et al., 2020).

Table 9.3-3. Life cycle inventory for Smartphone, mid-tier, average phone and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Smartphone, mid-tier, average phone, at plant/p/GLO U	1	p				
Input						
aluminium, production mix, wrought alloy, at plant/kg/RER U	0.022	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.039	kg		Lognormal	1.31	(2,2,1,3,3,5); Battery. Literature: Cordella et al. 2020, JRC report
Capacitor, SMD type, surface-mounting, at plant/kg/GLO U	0.0007	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Cold impact extrusion, aluminium, 2 strokes/RER U	0.022	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Cold impact extrusion, steel, 2 strokes/RER U	0.0065	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Connector, computer, peripherical type, at plant/kg/GLO U	0.00025	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Connector, computer, peripherical type, at plant/kg/GLO U	0.00025	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
electricity, medium voltage, production Eastern Asia, at grid/RAS U	4.698	kWh		Lognormal	1.31	(2,2,1,3,3,5); Manufacturing and assembly. Literature: Cordella et al. 2020, JRC report
Electronic component, active, unspecified, at plant/kg/GLO U	0.0019	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Electronic component, passive, unspecified, at plant/kg/GLO U	0.0009	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Electronic component, passive, unspecified, at plant/kg/GLO U	0.016	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Extrusion, plastic film/RER U	0.02	kg		Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
Folding boxboard, FBB, at plant/RER U	0.11	kg		Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
Inductor, ring core choke type, at plant/kg/GLO U	0.0002	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Injection moulding/RER U	0.0095	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.002	kg		Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
LED module, at plant/kg/GLO U	0.03	kg		Lognormal	1.31	(2,2,1,3,3,5); Screen/Display. Literature: Cordella et al. 2020, JRC report
Paper, newsprint, at plant/CH U	0.05	kg		Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
permanent magnet, for electric motor/RER U	0.001	kg		Lognormal	1.31	(2,2,1,3,3,5); Others (camera, speakers, buttons). Literature: Cordella et al. 2020, JRC report
Polycarbonate, at plant/RER U	0.0095	kg		Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report

Polyethylene, LDPE, granulate, at plant/RER U	0.02	kg	Lognormal	1.31	(2,2,1,3,3,5); Packaging and documentation. Literature: Cordella et al. 2020, JRC report
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.028	kg	Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Resistor, SMD type, surface mounting, at plant/kg/GLO U	0.002	kg	Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
Smartphone, charger/p/GLO U	1	p	Lognormal	1.31	(2,2,3,3,3,5); Literature: Hischier et al 2014.
Steel, low-alloyed, at plant/RER U	0.0065	kg	Lognormal	1.31	(2,2,1,3,3,5); Housing. Literature: Cordella et al. 2020, JRC report
Transistor, SMD type, surface mounting, at plant/kg/GLO U	0.0001	kg	Lognormal	1.31	(2,2,1,3,3,5); Electronics. Literature: Cordella et al. 2020, JRC report
transport, freight, lorry, fleet average/tkm/RER U	0.0162	tkm	Lognormal	2.10	(2,2,1,3,3,5); According to smartphone mass.
transport, freight, rail/tkm/RER U	0.0323	tkm	Lognormal	2.10	(2,2,1,3,3,5); According to smartphone mass.
transport, transoceanic container ship/OCE U	3.4	tkm	Lognormal	2.10	(2,2,1,3,3,5); According to smartphone mass.
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO U	0.0005	m2	Lognormal	1.31	(2,2,1,3,3,5); Total die area = 5.cm2 wafer logic. Literature: Codella et al. 2020, JRC report
Wafer, fabricated, for integrated circuit, memory at plant/mGLO U	0.000235	m2	Lognormal	1.31	(2,2,1,3,3,5); For memory of 32 GB, flash type + 2 GB RAM. Literature: UBA report, 2021
Output/					
Waste to treatment					
Disposal, laptop computer, to WEEE treatment/p/CH U	0.06	p	Lognormal	1.31	(3,4,3,3,3,5); Proxy, adjusted using weight

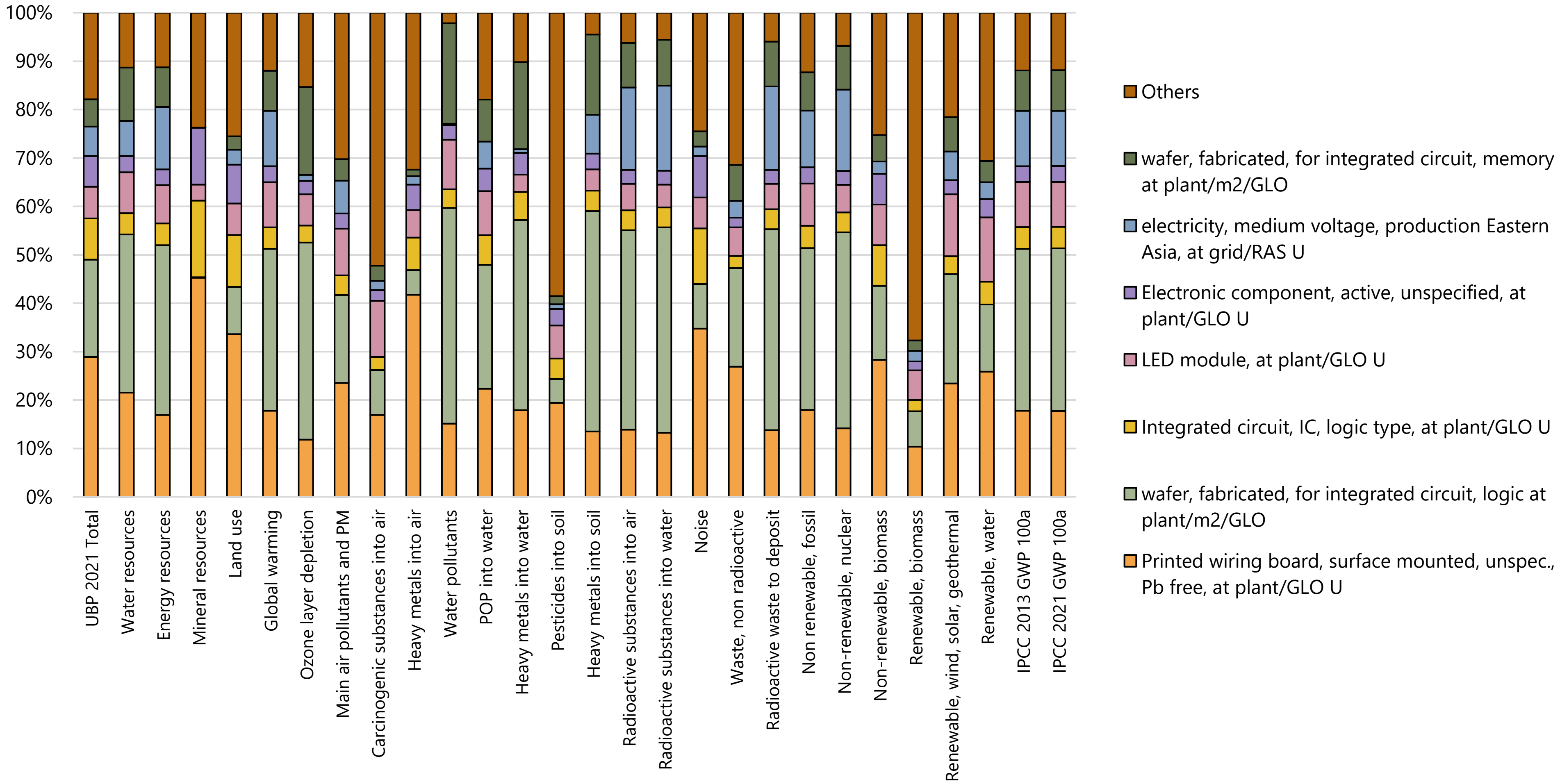

Figure 9.3-2. Contribution analysis presented in bar chart for: Smartphone, mid-tier, average phone. FU = 1 unit

Table 9.3-4. Contribution analysis presented in table for: Smartphone, mid-tier, average phone. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	29%	18%	18%	18%
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO	20%	33%	33%	34%
Integrated circuit, IC, logic type, at plant/kg/GLO U	9%	5%	4%	4%
LED module, at plant/kg/GLO U	7%	9%	9%	9%
Electronic component, active, unspecified, at plant/kg/GLO U	6%	3%	3%	3%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	6%	12%	11%	11%
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO	6%	8%	8%	8%
Others	18%	12%	12%	12%
Total impact, in absolute value	**8.70E+04**	**3.15E+02**	**2.71E+01**	**2.72E+01**

9.3.3 Smartphone, repairable type Fairphone

The data for Fairphone was taken from the complete inventory information from the thesis project of (Güvendik, 2014), which analyzes the bill of materials and components of Fairphone 1st gen. It is acknowledged that the recent model of Fairphone 4 is currently sold in the market, yet the transparent inventory data is kept confidential in the LCA report of Fraunhofer IZM (Sánchez et al., 2022) due to intellectual property. Therefore, the latter technical report was only used to validate the LCIA results of the cited literature.

Memory and RAM are defined separately using the calculation parameter from (Umweltbundesamt, 2021). It is assumed that the storage capacity and RAM per wafer area or NANDproDIE are 49.8 GB/cm2 and 1.1725 GB/cm2. The modeled smartphone has a storage capacity of 16 GB and RAM capacity of 1 GB. In the modeling, we increased the area of wafer/die to represent 4 cm2 total wafer logic area (Clément et al., 2020).

Table 9.3-5. Life cycle inventory for Smartphone, repairable type Fairphone and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Smartphone, repairable type Fairphone, at plant/p/GLO U	1	p				
Input						
battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.0386	kg		Lognormal	1.25	(2,3,3,2,1,5); Battery. Literature: Guvendik 2014.
Brass, at plant/CH U	0.00014	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Cable, ribbon cable, 20-pin, with plugs, at plant/kg/GLO U	0.00019	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Capacitor, unspecified, at plant/kg/GLO U	0.00052	kg		Lognormal	1.25	(2,3,3,2,1,5);Electronics. Literature: Guvendik 2014.
Chromium steel 18/8, at plant/RER U	0.05482	kg		Lognormal	1.25	(2,3,3,2,1,5);LCD screen and housing. Literature: Guvendik 2014.
Connector, computer, peripherical type, at plant/kg/GLO U	0.00191	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Copper, primary, at refinery/GLO U	0.00419	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Diode, glass-, SMD type, surface mounting, at plant/kg/GLO U	0.00052	kg		Lognormal	1.25	(2,3,3,2,1,5);Electronics. Literature: Guvendik 2014.
electricity, medium voltage, production Eastern Asia, at grid/RAS U	4.698	kWh		Lognormal	1.25	(2,3,3,2,1,5);Assembly. Literature: Cordella et al 2020.
Electronic component, passive, unspecified, at plant/kg/GLO U	0.00501	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Extrusion, plastic film/RER U	0.00055	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Ferrite, at plant/GLO U	0.00002	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Glass fibre reinforced plastic, polyester resin, hand lay-up, at plant/RER U	0.00078	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Inductor, miniature RF chip type, MRFI, at plant/kg/GLO U	0.00006	kg		Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Injection moulding/RER U	0.0202	kg		Lognormal	1.25	(2,3,3,2,1,5);LCD screen and housing. Literature: Guvendik 2014.
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.00042	kg		Lognormal	1.25	(2,3,3,2,1,5);ICs. Literature: Guvendik 2014.
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.00065	kg		Lognormal	1.25	(2,3,3,2,1,5);ICs. Literature: Guvendik 2014.
Kraft paper, unbleached, at plant/RER U	0.054	kg		Lognormal	1.25	(2,3,3,2,1,5);Packaging. Literature: Guvendik 2014.
LED module, at plant/kg/GLO U	0.034	kg		Lognormal	1.25	(2,3,3,2,1,5);LCD screen and housing. Literature: Guvendik 2014.
Light emitting diode, LED, at plant/kg/GLO U	0.00041	kg		Lognormal	1.25	(2,3,3,2,1,5);LCD screen and housing. Literature: Guvendik 2014.
Packaging film, LDPE, at plant/RER U	0.0071	kg		Lognormal	1.25	(2,3,3,2,1,5);Packaging. Literature: Guvendik 2014.
Packaging, corrugated board, mixed fibre, single wall, at plant/RER U	0.0361	kg		Lognormal	1.25	(2,3,3,2,1,5);Packaging. Literature: Guvendik 2014.

Paper, woodcontaining, LWC, at plant/RER U	0.068	kg	Lognormal	1.25	(2,3,3,2,1,5);Packaging. Literature: Guvendik 2014.
Polycarbonate, at plant/RER U	0.01314	kg	Lognormal	1.25	(2,3,3,2,1,5);LCD screen and housing. Literature: Guvendik 2014.
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	0.00055	kg	Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.00732	kg	Lognormal	1.25	(2,3,3,2,1,5);Printed circuit boards. Literature: Guvendik 2014.
Sheet rolling, chromium steel/RER U	0.05482	kg	Lognormal	1.25	(2,3,3,2,1,5);LCD screen and housing. Literature: Guvendik 2014.
Sheet rolling, copper/RER U	0.00419	kg	Lognormal	1.25	(2,3,3,2,1,5);Others. Literature: Guvendik 2014.
Smartphone, charger/p/GLO U	1	p	Lognormal	1.25	(2,3,3,2,1,5);Literature: Hischier et al 2014.
Transistor, SMD type, surface mounting, at plant/kg/GLO U	0.00002	kg	Lognormal	1.25	(2,3,3,2,1,5);Electronics. Literature: Guvendik 2014.
transport, freight, lorry, fleet average/tkm/RER U	0.0165	tkm	Lognormal	2.07	(2,3,3,2,1,5);Transport, adjusted using mass.
transport, freight, rail/tkm/RER U	0.033	tkm	Lognormal	2.07	(2,3,3,2,1,5);Transport, adjusted using mass.
transport, transoceanic container ship/OCE U	3.47	tkm	Lognormal	2.07	(2,3,3,2,1,5);Transport, adjusted using mass.
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO U	0.0004	m2	Lognormal	1.25	(2,3,3,2,1,5);Total die area = 4cm2 wafer logic. Literature: Clement et al. 2020
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO U	0.000117	m2	Lognormal	1.25	(2,3,3,2,1,5);Memory = 16 GB and RAM = 1 GB. Literature: UBA report, 2021.
Output					
Waste to treatment					
Disposal, laptop computer, to WEEE treatment/p/CH U	0.06	p	Lognormal	1.36	(3,4,3,3,3,5); Proxy, adjusted using weight

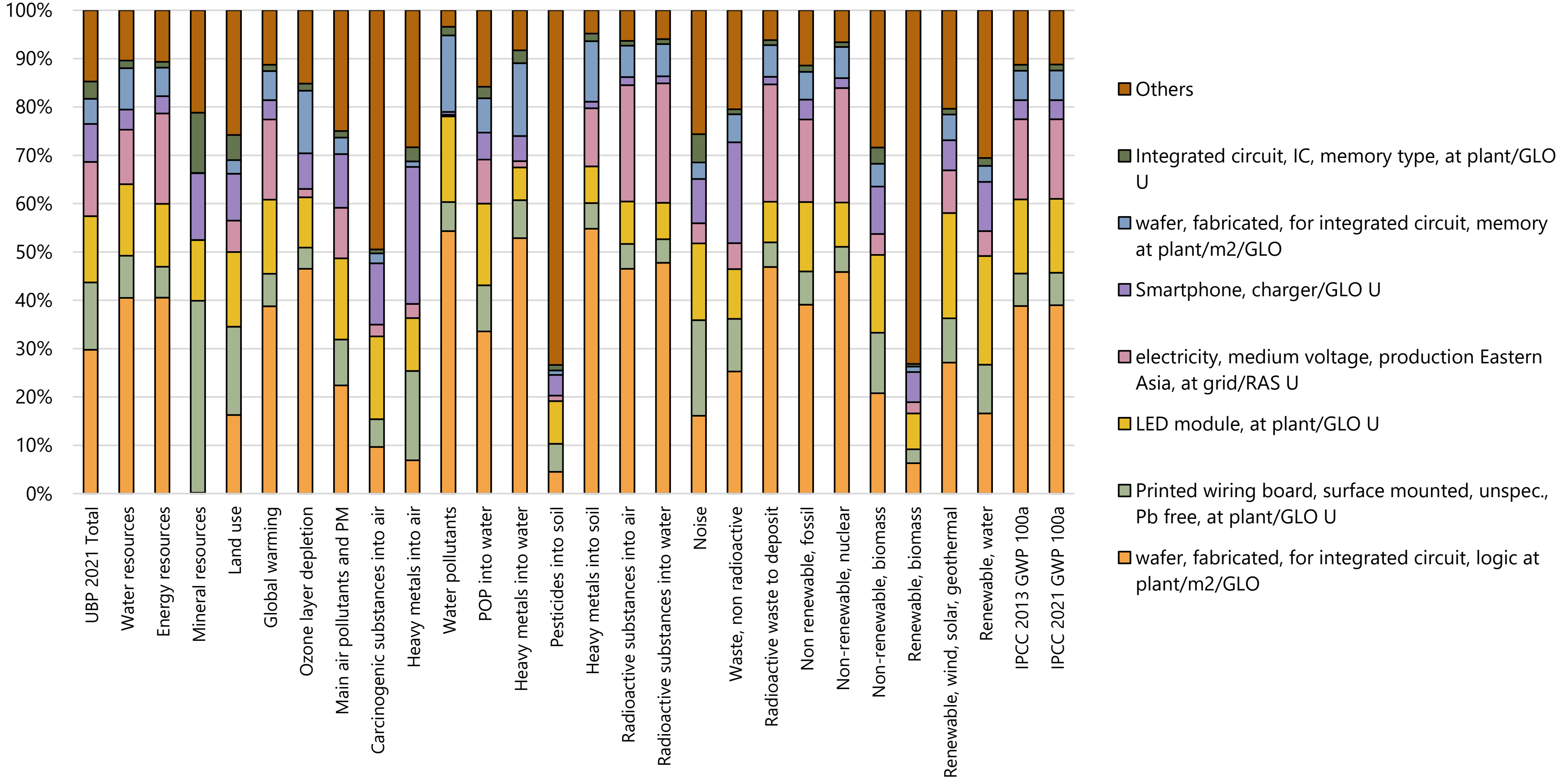

Figure 9.3-3. Contribution analysis presented in bar chart for: Smartphone, repairable type Fairphone. FU = 1 unit

Table 9.3-6. Contribution analysis presented in table for: Smartphone, repairable type Fairphone. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO U	30%	39%	39%	39%
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	14%	7%	7%	7%
LED module, at plant/kg/GLO U	14%	14%	15%	15%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	11%	17%	17%	17%
Smartphone, charger/p/GLO U	8%	4%	4%	4%
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO U	5%	6%	6%	6%
Integrated circuit, IC, memory type, at plant/kg/GLO U	4%	1%	1%	1%
Others	15%	11%	11%	11%
Total impact, in absolute value	**4.69E+04**	**2.15E+02**	**1.87E+01**	**1.88E+01**

9.3.4 Smartphone, case

The dataset is modelled as a pure silicone based case. The assembly energy requirement is assumed to be linearly adjusted using the energy consumption of smartphone production (Cordella et al., 2020). The packaging and case weight are 48 and 40 grams, respectively. Silicone cases are assumed to be made of 100% silicone materials according to the average cases found in the digital marketplace (Galaxus, 2023b).

Table 9.3-7. Life cycle inventory for Smartphone, case and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Case, for smartphone, at plant/p/GLO U	1	p				
Input						
Silicone product, at plant/RER U	0.04	kg		Lognormal	1.33	(3,3,1,4,3,5); Source: average mass of cases for backcover, on Digitec 2023
electricity, medium voltage, production Eastern Asia, at grid/RAS U	1.17	kWh		Lognormal	1.35	(3,3,3,4,3,5); Literature: Cordella et al 2020.
Packaging, corrugated board, mixed fibre, single wall, at plant/RER U	0.048	kg		Lognormal	1.35	(3,3,3,4,3,5); Literature: Guvendik 2014.
Packaging film, LDPE, at plant/RER U	0.0024	kg		Lognormal	1.35	(3,3,3,4,3,5); Literature: Guvendik 2014.
Injection moulding/RER U	0.0024	kg		Lognormal	1.35	(3,3,3,4,3,5); Literature: Guvendik 2014.
transport, freight, lorry, fleet average/tkm/RER U	0.00405	tkm		Lognormal	2.06	(2,3,2,4,2,5)
transport, freight, rail/tkm/RER U	0.00808	tkm		Lognormal	2.06	(2,3,2,4,2,5)
transport, transoceanic container ship/OCE U	0.85	tkm		Lognormal	2.06	(2,3,2,4,2,5)

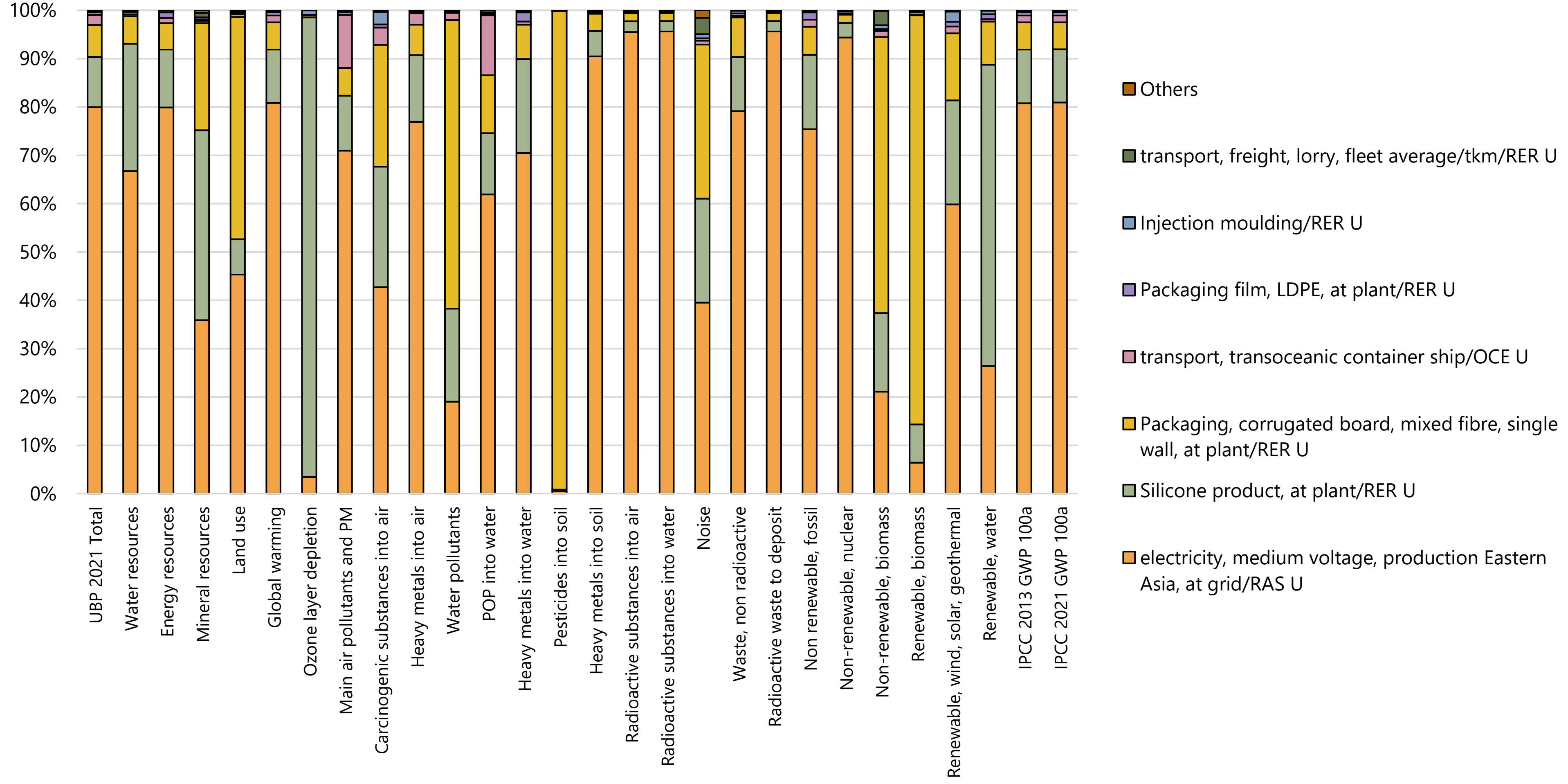

Figure 9.3-4. Contribution analysis presented in bar chart for: Smartphone, case. FU = 1 unit

Table 9.3-8. Contribution analysis presented in table for: Smartphone, case. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	80%	75%	81%	81%
Silicone product, at plant/RER U	10%	15%	11%	11%
Packaging, corrugated board, mixed fibre, single wall, at plant/RER U	7%	6%	6%	6%
transport, transoceanic container ship/OCE U	2%	1%	1%	1%
Packaging film, LDPE, at plant/RER U	1%	2%	1%	1%
Injection moulding/RER U	>0%	>0%	>0%	>0%
transport, freight, lorry, fleet average/tkm/RER U	>0%	>0%	>0%	>0%
Others	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.66E+03**	**1.24E+01**	**9.81E-01**	**9.80E-01**

9.3.5 Smartphone, charger

The dataset is modelled as a smaller version of power adapter for laptops, which is already updated and described in the other dataset. The weight of charger is approximately 50 grams. This modeling approach follows the LCA data collection strategy of (Hischier et al., 2014).

Table 9.3-9. Life cycle inventory for Smartphone, charger and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Charger, for smartphone, at plant/p/GLO U	1	p				
Input						
Power adapter, for laptop, at plant/p/GLO U	0.15	p		Lognormal	1.26	(2,3,3,3,2,5); Approximately 50 grams of charger; Adaptation following Hischier et al 2014.

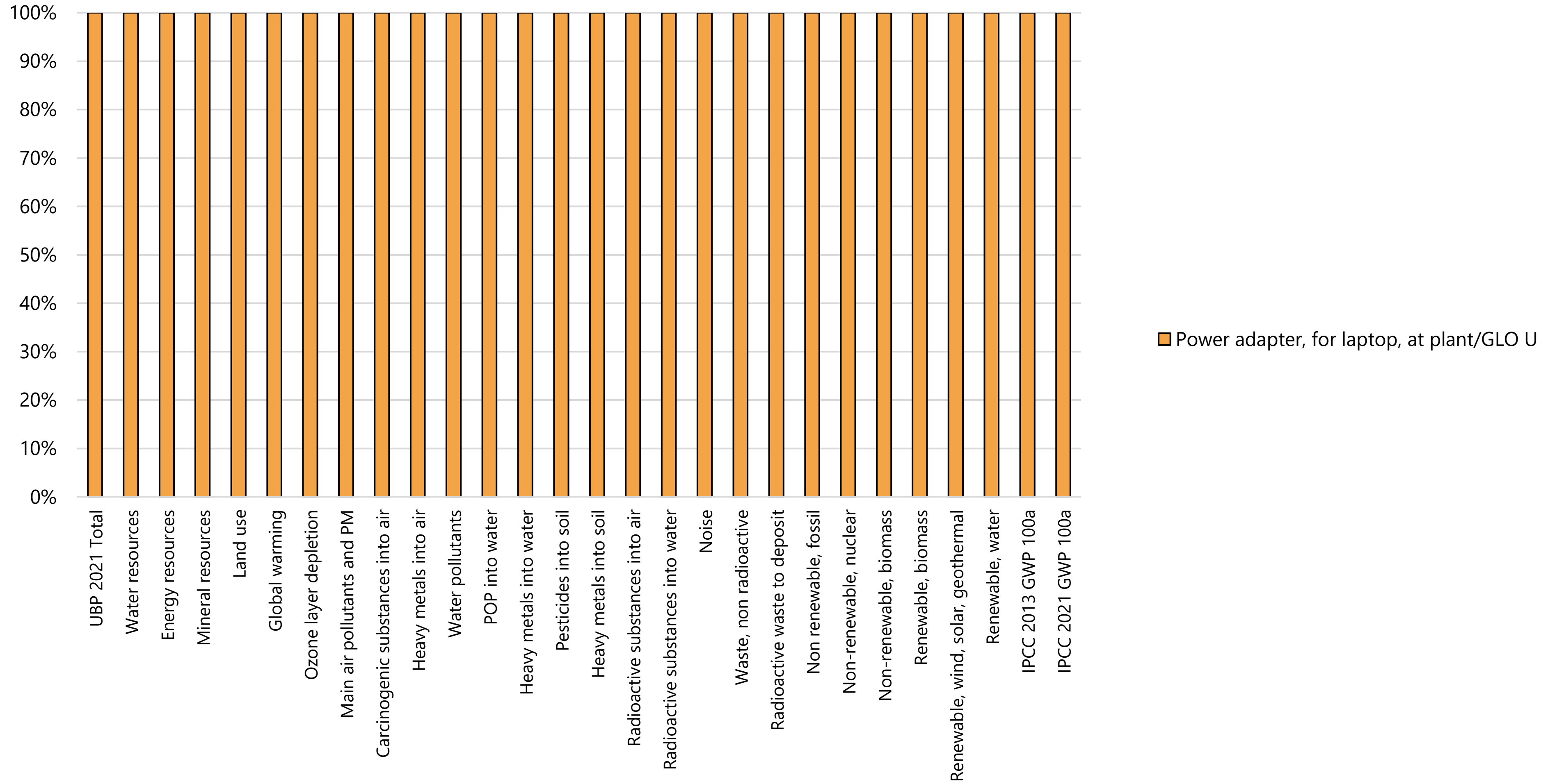

Figure 9.3-5. Contribution analysis presented in bar chart for: Smartphone, charger. FU = 1 unit

Table 9.3-10. Contribution analysis presented in table for: Smartphone, charger. FU = 1 unit

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
Power adapter, for laptop, at plant/p/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**3.75E+03**	**9.00E+00**	**7.68E-01**	**7.64E-01**

9.3.6 Smartphone, spare batteries

The dataset comprises the lithium ion battery, adjusted to the mass of average tablets (0.16 kg). Inventory data is taken from (Cordella et al., 2020).

Table 9.3-11. Life cycle inventory for Smartphone, spare batteries and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Spare batteries, for smartphone, at plant/GLO U	1	p				
Input						
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.039	kg		Lognormal	1.35	(3,3,3,4,3,5); Literature: JRC report, Cordella et al 2020

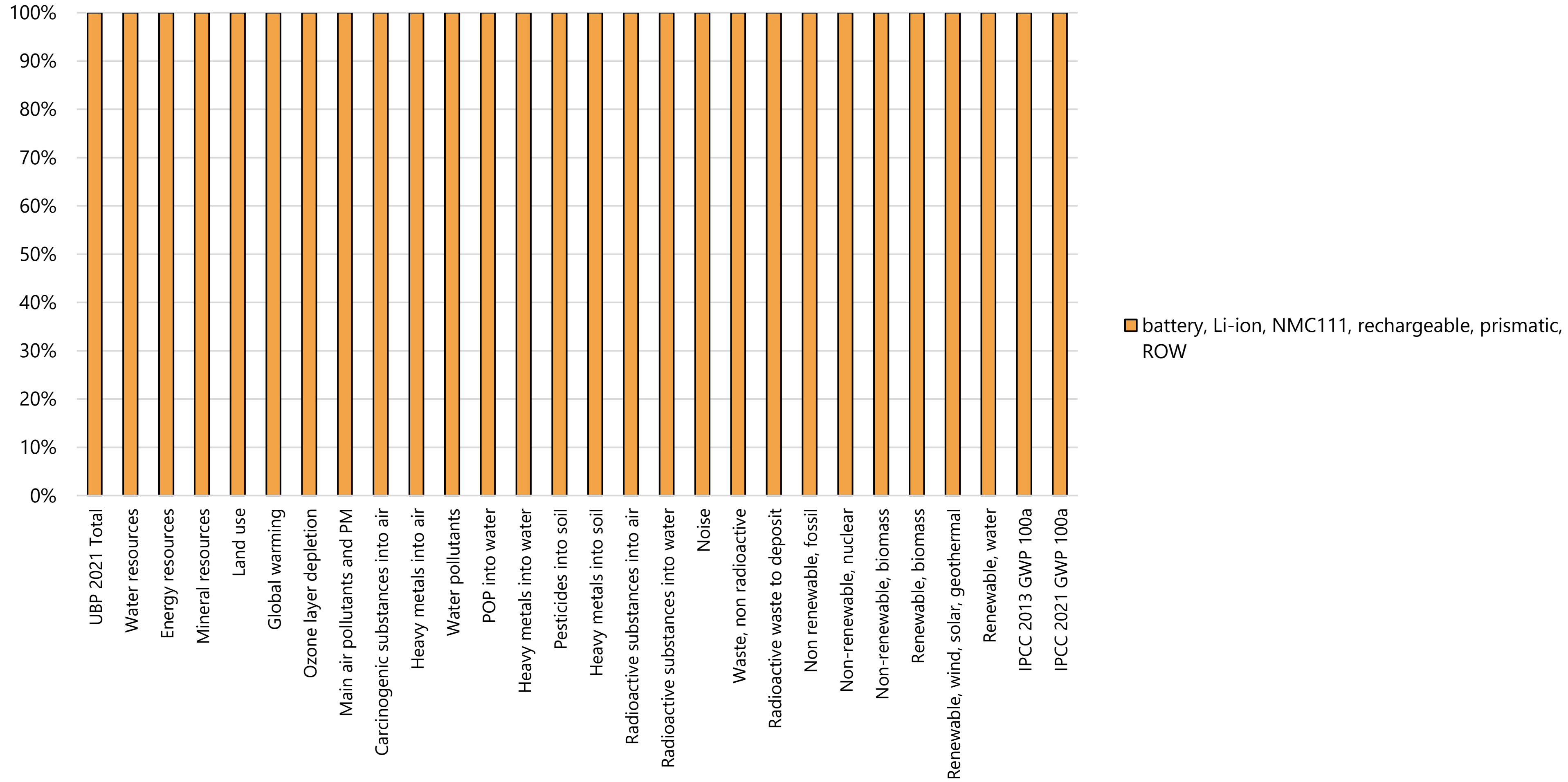

Figure 9.3-6. Contribution analysis presented in bar chart for: Smartphone, spare batteries. FU = 1 unit

Table 9.3-12. Contribution analysis presented in table for: Smartphone, spare batteries. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**1.55E+03**	**6.33E+00**	**4.93E-01**	**4.92E-01**

9.3.7 Smartphone, spare screen

The dataset for smartphone spare screen is modeled as a separate LCD display with the size of 75.5 cm2, equivalent to 30 grams of LCD module. Inventory data is taken from (Cordella et al., 2020).

Table 9.3-13. Life cycle inventory for Smartphone, spare batteries and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Spare screen, for smartphone, at plant/GLO U	1	p				
Input						
LED module, at plant/kg/GLO U	0.03	kg		Lognormal	1.31	(2,3,2,3,3,5); Screen/display. Literature: JRC report, Cordella et al 2020.

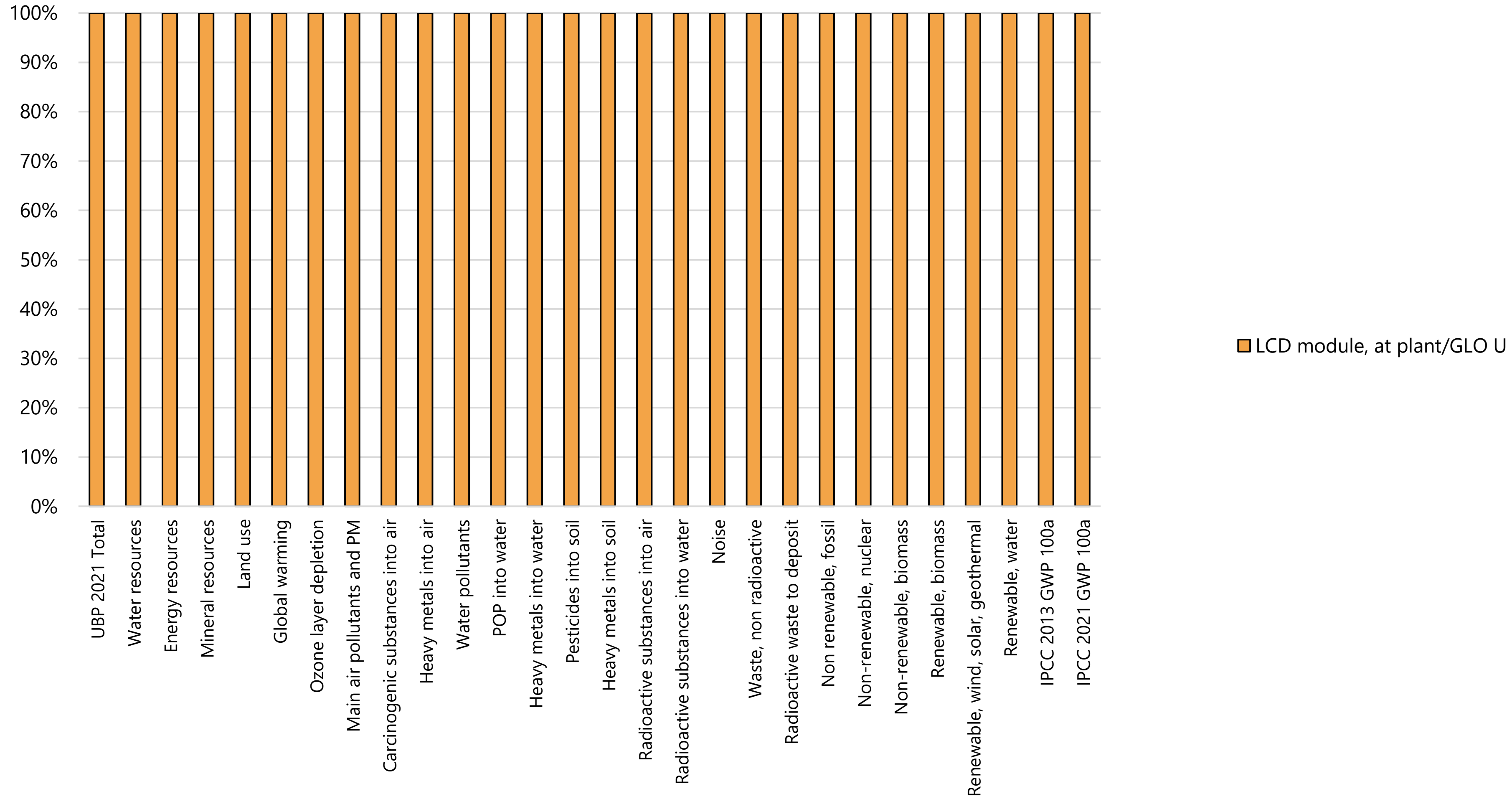

Figure 9.3-7. Contribution analysis presented in bar chart for: Smartphone, spare screen. FU = 1 unit

Table 9.3-14. Contribution analysis presented in table for: Smartphone, spare screen. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
LED module, at plant/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**5.70E+03**	**2.73E+01**	**2.53E+00**	**2.53E+00**

9.3.8 Smartphone, headset (Bluetooth)

The dataset for wired headset is taken from the inventory data of average smartphones in the LCA study of (Andrae, 2017). It comprises of high density polyethylene, battery, circuit boards, USB cables, and passive electronic components, all summing up to approximately 200 grams of headset weight. The weight of the circuit boards is obtained specifically from a customizable PWB manufacturer (PCBA, 2023). The product is a representation of standard Bluetooth headphones, i.e., Logitech devices in the market. Additionally, The manufacturing electricity energy is assumed to be similar with the other headsets according to (Andrae, 2017), which is ~ 2 kWh per device. The packaging materials are modeled as corrugated board and printed papers with a total weight of 400 grams (Galaxus, 2023c).

Table 9.3-15. Life cycle inventory for Smartphone, headset (bluetooth) and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Headset (bluetooth), for smartphone, at plant/p/GLO U	1	p				
Materials/fuels						
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.025	kg		Lognormal	1.35	(3,3,3,3,3,5); BOM: 25 gr battery for wireless headset.
Connector, computer, peripherical type, at plant/kg/GLO U	0.03	kg		Lognormal	1.35	(3,3,3,3,3,5); 30gr per 1 m.
electricity, medium voltage, production Eastern Asia, at grid/RAS U	2	kWh		Lognormal	1.35	(3,3,3,3,3,5); Literature: Andrae 2017.
Electronic component, passive, unspecified, at plant/kg/GLO U	0.01	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020
Extrusion, plastic film/RER U	0.08	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020
Folding boxboard, FBB, at plant/RER U	0.4	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020
Injection moulding/RER U	0.16	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020
Packaging film, LDPE, at plant/RER U	0.08	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020
Paper, newsprint, at regional storage/RER U	0.2	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020
Polypropylene, granulate, at plant/RER U	0.08	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020. Adapted using PP, with 50:50 split with other plastics
Polyurethane, flexible foam, at plant/RER U	0.08	kg		Lognormal	1.33	(3,3,1,3,3,5); Literature: Cordella et al 2020. Adapted using PP, with 50:50 split with other plastics
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.01	kg		Lognormal	1.33	(3,3,1,3,3,5); Max weight from a customizes PWB weight
transport, freight, lorry, fleet average/tkm/RER U	0.0202	tkm		Lognormal	2.11	(3,3,1,3,3,5); According to headset mass.
transport, freight, rail/tkm/RER U	0.004	tkm		Lognormal	2.11	(3,3,1,3,3,5); According to headset mass.
transport, transoceanic container ship/OCE U	4.25	tkm		Lognormal	2.11	(3,3,1,3,3,5); According to headset mass.

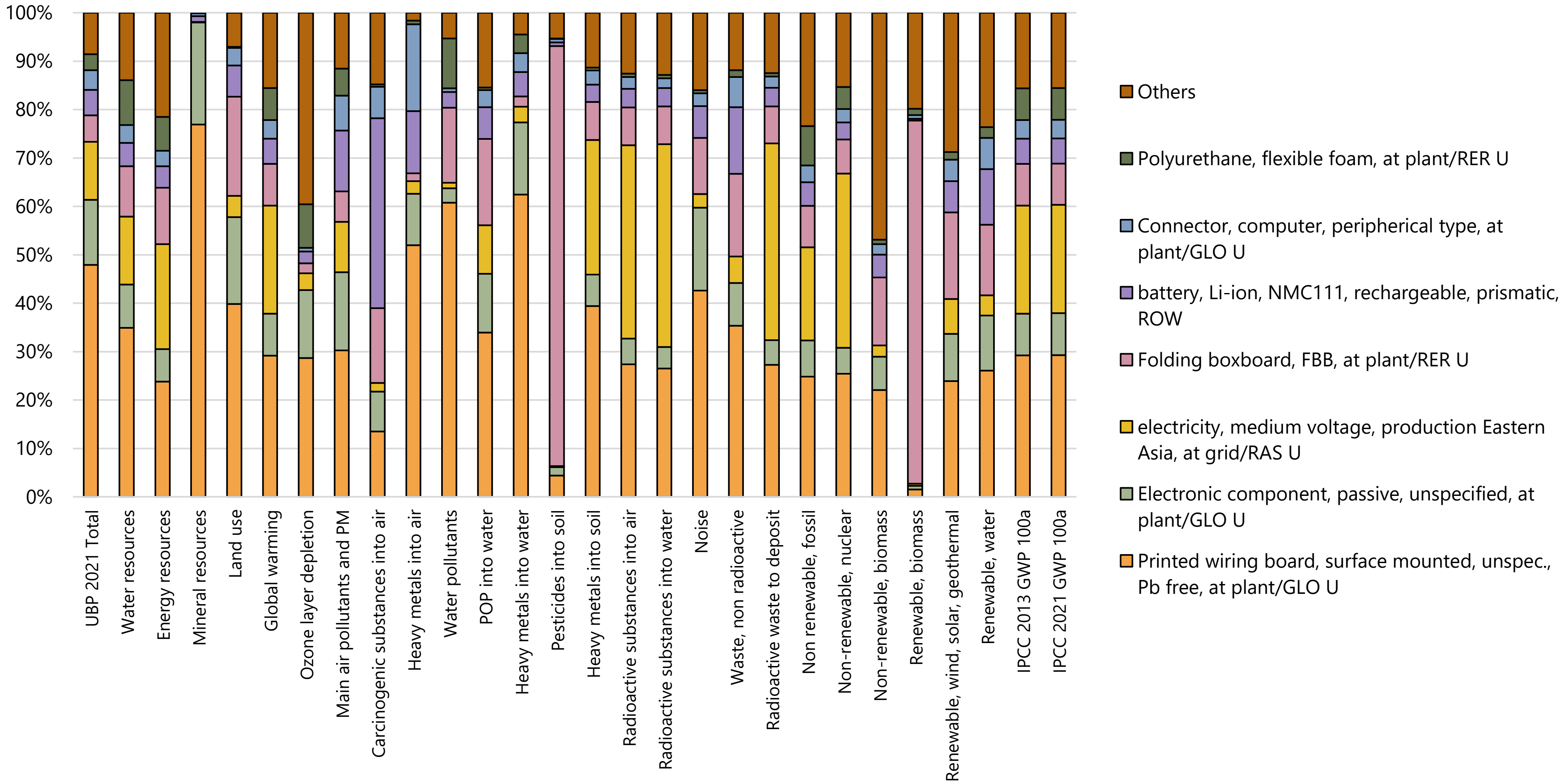

Figure 9.3-8. Contribution analysis presented in bar chart for: Smartphone, headset (bluetooth). FU = 1 unit

Table 9.3-16. Contribution analysis presented in table for: Smartphone, headset (bluetooth). FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	48%	25%	29%	29%
Electronic component, passive, unspecified, at plant/kg/GLO U	13%	7%	9%	9%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	12%	19%	22%	22%
Folding boxboard, FBB, at plant/RER U	6%	9%	9%	9%
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	5%	5%	5%	5%
Connector, computer, peripherical type, at plant/kg/GLO U	4%	3%	4%	4%
Polyurethane, flexible foam, at plant/RER U	3%	8%	7%	7%
Others	9%	23%	16%	16%
Total impact, in absolute value	**1.89E+04**	**8.30E+01**	**6.04E+00**	**6.03E+00**

9.3.9 Smartphone, headset (wired)

The dataset for wired headset is taken from the inventory data of average smartphones in the JRC technical report (Cordella et al., 2020). It comprises of high density polyethylene, cables, and passive electronic components, all summing up to approximately 20 grams of headset weight. The product is a representation of conventional wired earpods in the market. Additionally, The manufacturing electricity energy is assumed to be similar with the other headsets according to (Andrae, 2017), which is ~ 2 kWh per device. The packaging materials are modeled as corrugated board and printed papers with a total weight of 50 grams (Galaxus, 2023a).

Table 9.3-17. Life cycle inventory for Smartphone, headset (wired) and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Headset (wired), for smartphone, at plant/p/GLO U	1	p				
Input						
Connector, computer, peripherical type, at plant/kg/GLO U	0.03	kg	Lognormal	1.35		(3,3,3,3,3,5); 30gr per 1 m.
electricity, medium voltage, production Eastern Asia, at grid/RAS U	2	kWh	Lognormal	1.35		(3,3,3,3,3,5); Literature: Andrae 2017.
Electronic component, passive, unspecified, at plant/kg/GLO U	0.001	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
Extrusion, plastic film/RER U	0.01	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
Folding boxboard, FBB, at plant/RER U	0.05	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
Injection moulding/RER U	0.022	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
Packaging film, LDPE, at plant/RER U	0.01	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
Paper, newsprint, at regional storage/RER U	0.025	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
Polyethylene, HDPE, granulate, at plant/RER U	0.022	kg	Lognormal	1.33		(3,3,1,3,3,5); Literature: Cordella et al 2020
transport, freight, lorry, fleet average/tkm/RER U	0.00202	tkm	Lognormal	2.11		(3,3,1,3,3,5); According to wired headset mass.
transport, freight, rail/tkm/RER U	0.00404	tkm	Lognormal	2.11		(3,3,1,3,3,5); According to wired headset mass.
transport, transoceanic container ship/OCE U	0.425	tkm	Lognormal	2.11		(3,3,1,3,3,5); According to wired headset mass.

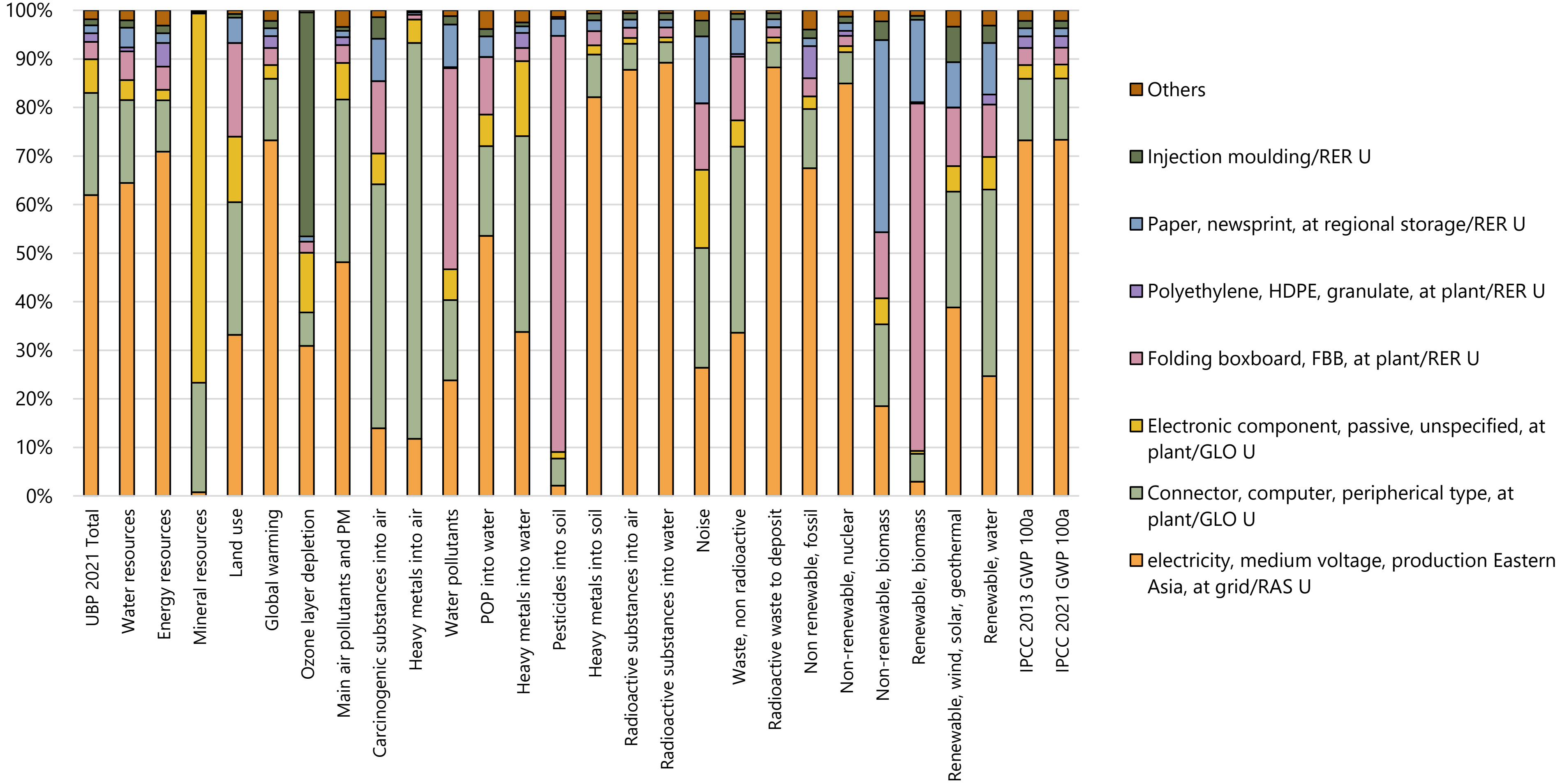

Figure 9.3-9. Contribution analysis presented in bar chart for: Smartphone, headset (wired). FU = 1 unit

Table 9.3-18. Contribution analysis presented in table for: Smartphone, headset (wired). FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	62%	67%	73%	73%
Connector, computer, peripherical type, at plant/kg/GLO U	21%	12%	13%	13%
Electronic component, passive, unspecified, at plant/kg/GLO U	7%	3%	3%	3%
Folding boxboard, FBB, at plant/RER U	4%	4%	4%	3%
Polyethylene, HDPE, granulate, at plant/RER U	2%	7%	2%	2%
Paper, newsprint, at regional storage/RER U	2%	2%	2%	2%
Injection moulding/RER U	1%	2%	2%	2%
Others	2%	4%	2%	2%
Total impact, in absolute value	**3.66E+03**	**2.38E+01**	**1.85E+00**	**1.85E+00**

9.4 Tablet

9.4.1 Average tablet

The data for Tablet, represented here as iPad Gen 2 with the weight of ~500 gr, is obtained from the studies of (Ahmadi Achachlouei et al., 2015; Hischier et al., 2014, 2015). The referred studies connect the lab-based data with the LCA database, i.e., Ecoinvent. This means that inventory data is performed on the level of individual components (i.e., on the level of ICs, resistors, etc.) to build more precise inventory models for the device.

After conducting the LCIA, it is found that the GPW is around 22 kg CO2-eq/tablet, which is in the range of the results from other studies (Ahmadi Achachlouei et al., 2015; Suksuwan et al., 2020; Teehan & Kandlikar, 2013). As a comparison, recent iPad devices have embodied carbon footprint of approximately 58 kg CO2-eq/table (Apple, 2021). According to the previous studies, the variations in results are due to the difference of LCA databases and lack of specific details of casing materials, which are especially important for lighter products (Teehan & Kandlikar, 2013). Another study by (Clément et al., 2020), (Clemm et al., 2019), and recent JRC technical report (Alfieri & Spiliotopoulos, 2023) also stresses consistent lack of transparent LCI data on IC chips by technology manufacturers. Many parameters are only known by the manufacturer, which are difficult to obtain, leading to uncertainties and a wide range of results (Pirson et al., 2023).

Memory and RAM are defined separately using the calculation parameter from (Umweltbundesamt, 2021). It is assumed that the storage capacity and RAM per wafer area or NANDproDIE are 49.8 GB/cm2 and 1.1725 GB/cm2. The modeled tablet has a storage capacity of 256 GB and RAM capacity of 3 GB. In the modeling, we increased the area of wafer/die to represent ~10,2 cm2 total wafer logic area (Clément et al., 2020; Teehan & Kandlikar, 2013).

Table 9.4-1. Life cycle inventory for Tablet, average and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Tablet, average, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.009	kg		Lognormal	1.25	(2,3,3,3,1,5); Housing, plastics. Literature: Hischer et al 2015.
aluminium, production mix, at plant/kg/RER U	0.14	kg		Lognormal	1.25	(2,3,3,3,1,5); Housing, black panel. Literature: Hischer et al 2015.
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.135	kg		Lognormal	1.25	(2,3,3,3,1,5); Battery. Literature: Hischer et al 2015.
Copper, primary, at refinery/GLO U	0.013	kg		Lognormal	1.25	(2,3,3,3,1,5); Others. Literature: Hischer et al 2015.
electricity, medium voltage, production Eastern Asia, at grid/RAS U	3.5278	kWh		Lognormal	1.25	(2,3,3,3,1,5); Literature: Teehan and Kandikar 2013.
Flat glass, coated, at plant/RER U	0.109	kg		Lognormal	1.25	(2,3,3,3,1,5); Glass. Literature: Hischer et al 2015.
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.001	kg		Lognormal	1.25	(2,3,3,3,1,5); Literature: Teehan and Kandikar 2013.
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.001	kg		Lognormal	1.25	(2,3,3,3,1,5); Literature: Teehan and Kandikar 2013.
LED module, at plant/kg/GLO U	0.145	kg		Lognormal	1.25	(2,3,3,3,1,5); Display. Literature: Hischer et al 2015.
Polyurethane, rigid foam, at plant/RER U	0.009	kg		Lognormal	1.25	(2,3,3,3,1,5); Housing, plastics. Literature: Hischer et al 2015.
Power supply unit, at plantp//GLO U	0.09	p		Lognormal	1.25	(2,3,3,3,1,5); Literature: Teehan and Kandikar 2013.
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.039	kg		Lognormal	1.25	(2,3,3,3,1,5); Circuit boards. Literature: Hischer et al 2015.
Sheet rolling, aluminium/RER U	0.14	kg		Lognormal	1.25	(2,3,3,3,1,5); Housing, black panel. Literature: Hischer et al 2015.
Sheet rolling, copper/RER U	0.013	kg		Lognormal	1.25	(2,3,3,3,1,5); Others. Literature: Hischer et al 2015.

Sheet rolling, steel/RER U	0.013	kg	Lognormal	1.25	(2,3,3,3,1,5); Others. Literature: Hischer et al 2015.
Steel, low-alloyed, at plant/RER U	0.013	kg	Lognormal	1.25	(2,3,3,3,1,5); Others. Literature: Hischer et al 2015.
Tablet, charger/p/GLO U	1	p	Lognormal	1.25	(2,3,3,3,1,5); Literature: Hischier et al 2014.
transport, freight, lorry, fleet average/tkm/RER U	0.0505	tkm	Lognormal	2.07	(2,3,3,3,1,5); According to tablet mass
transport, freight, rail/tkm/RER U	0.101	tkm	Lognormal	2.07	(2,3,3,3,1,5); According to tablet mass
transport, transoceanic freight ship/tkm/OCE U	10.7	tkm	Lognormal	2.07	(2,3,3,3,1,5); According to tablet mass
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO U	0.00102	m2	Lognormal	1.25	(2,3,3,3,1,5); Total die area = 10.2 cm2 wafer logic. Literature: Clement et al. 2020 and Teehan et al 2013.
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO U	0.00077	m2	Lognormal	1.25	(2,3,3,3,1,5); Memory = 256 GB and RAM = 3 GB. Literature: UBA report, 2021.
Output					
Waste to treatment					
Disposal, laptop computer, to WEEE treatment/p/CH U	0.18	p	Lognormal	1.36	(3,4,3,3,3,5); Proxy, adusted using weight

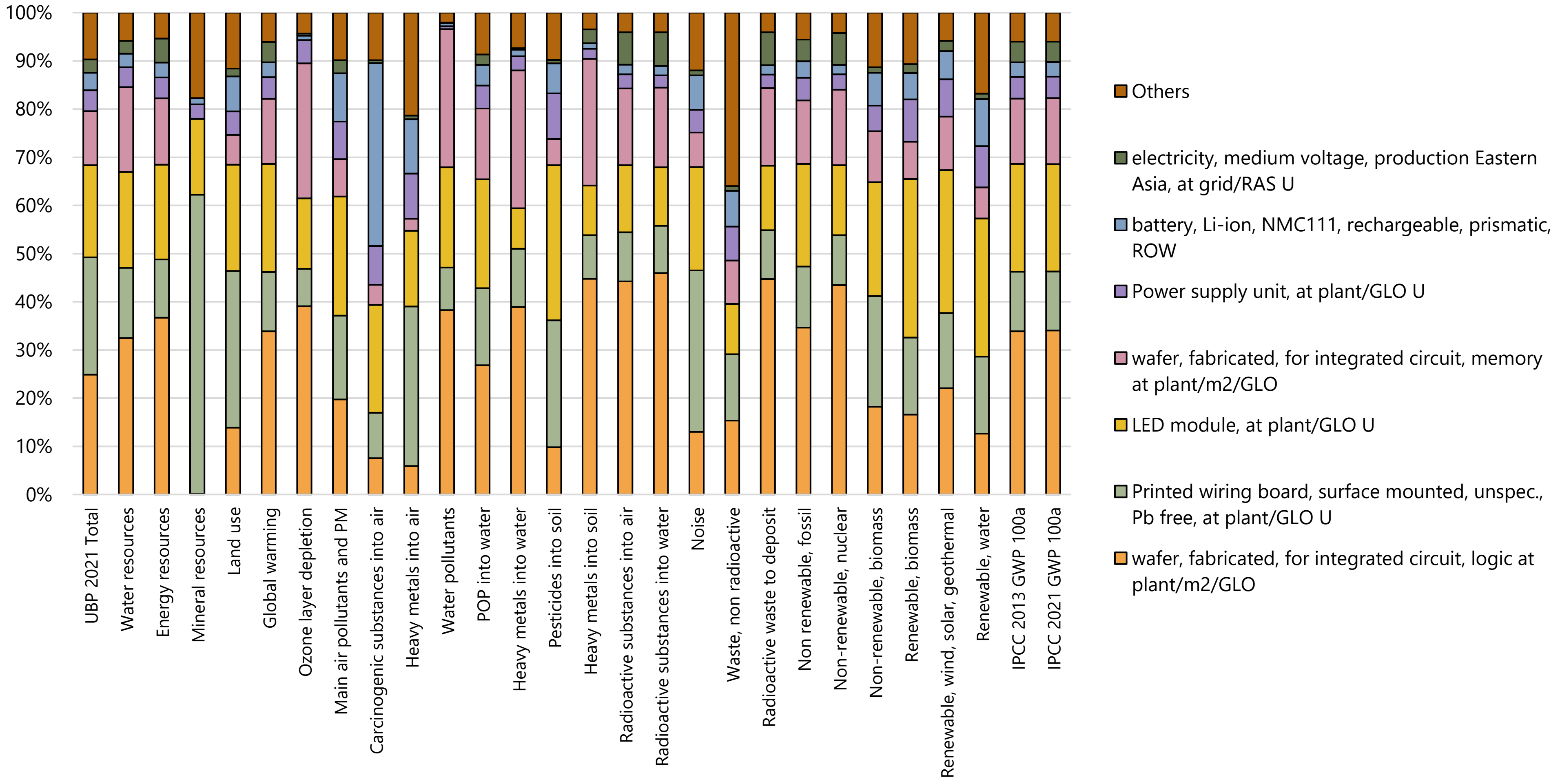

Figure 9.4-1. Contribution analysis presented in bar chart for: Tablet, average. FU = 1 unit

Table 9.4-2. Contribution analysis presented in table for: Tablet, average. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Wafer, fabricated, for integrated circuit, logic at plant/m2/GLO	25%	34%	34%	34%
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	25%	13%	13%	13%
LED module, at plant/kg/GLO U	19%	22%	23%	22%
Wafer, fabricated, for integrated circuit, memory at plant/m2/GLO	11%	13%	13%	13%
Power supply unit, at plant/p/GLO U	4%	5%	5%	5%
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	4%	4%	3%	3%
electricity, medium voltage, production Eastern Asia, at grid/RAS U	3%	5%	4%	4%
Others	9%	4%	5%	6%
Total impact, in absolute value	**1.43E+05**	**6.16E+02**	**5.42E+01**	**5.44E+01**

9.4.2 Tablet, case

The dataset is modelled as a pure polyurethane based case. The assembly energy requirement is assumed to be linearly adjusted using the energy consumption of smartphone production (Cordella et al., 2020). The packaging and case weight are 480 and 450 grams, respectively. Polyurethane cases are assumed to be made of 100% silicone materials according to the average cases found in the digital marketplace (Galaxus, 2023b).

Table 9.4-3. Life cycle inventory for Tablet, case and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Case, for tablet, at plant/p/GLO U	1	p				
Input						
Polyurethane, flexible foam, at plant/RER U	0.45	kg		Lognormal	1.60	(3,4,1,3,4,5); Source: average mass of cases for backcover, on Digitec 2023
Injection moulding/RER U	0.45	kg		Lognormal	1.60	(3,4,1,3,4,5); Source: average mass of cases for backcover, on Digitec 2023
electricity, medium voltage, production Eastern Asia, at grid/RAS U	5.64	kWh		Lognormal	1.58	(2,3,1,3,4,5); Literature: Cordella et al 2020.
Packaging, corrugated board, mixed fibre, single wall, at plant/RER U	0.48	kg		Lognormal	1.58	(2,3,1,3,4,5);
Packaging film, LDPE, at plant/RER U	0.024	kg		Lognormal	1.58	(2,3,1,3,4,5);
Injection moulding/RER U	0.024	kg		Lognormal	1.58	(2,3,1,3,4,5);
transport, freight, lorry, fleet average/tkm/RER U	0.0446	tkm		Lognormal	2.29	(2,3,1,3,4,5);
transport, freight, rail/tkm/RER U	0.0889	tkm		Lognormal	2.29	(2,3,1,3,4,5);
transport, transoceanic container ship/OCE U	9.35	tkm		Lognormal	2.29	(2,3,1,3,4,5);

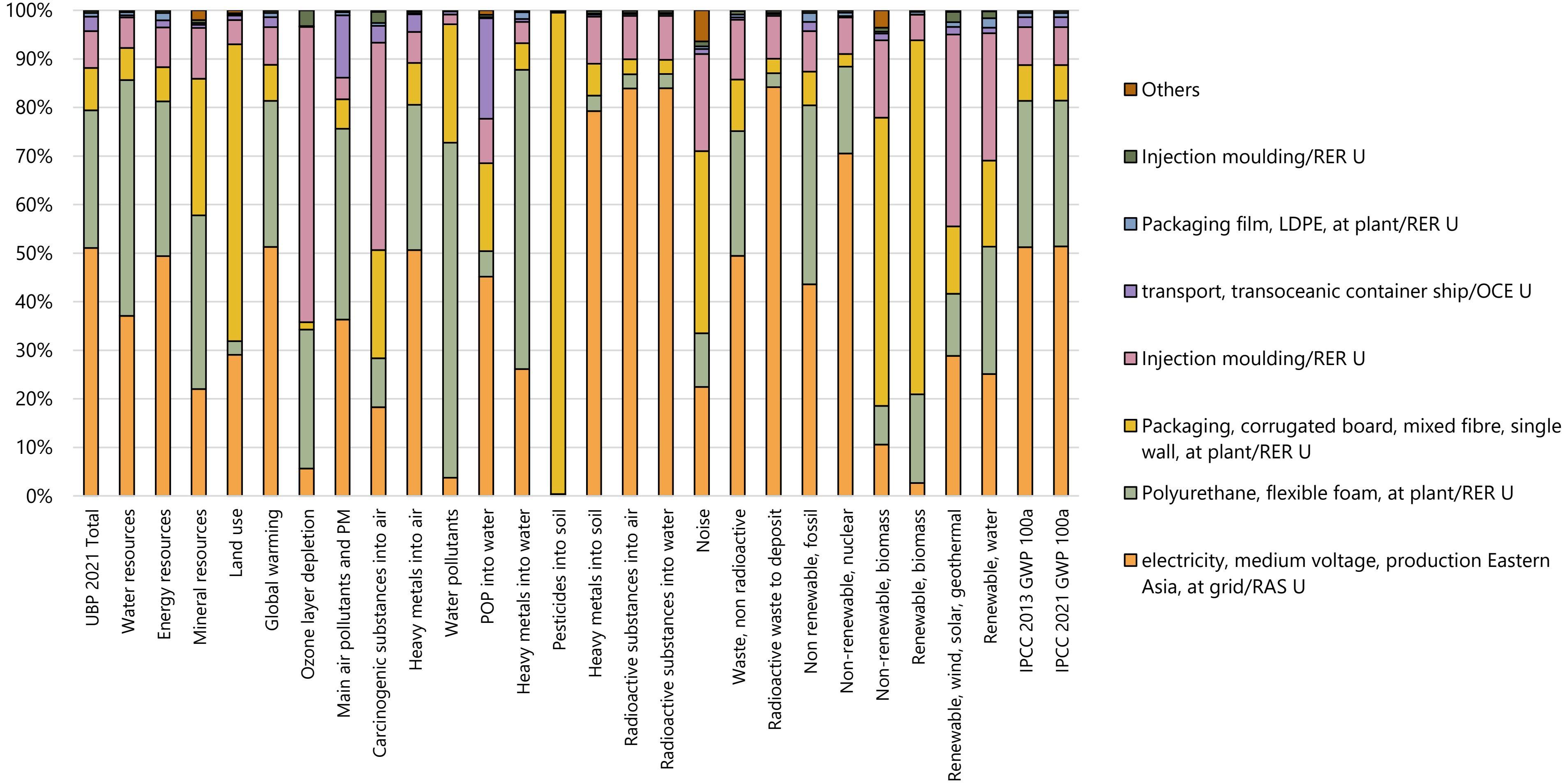

Figure 9.4-2. Contribution analysis presented in bar chart for: Tablet, case. FU = 1 unit

Table 9.4-4. Contribution analysis presented in table for: Tablet, case. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, medium voltage, production Eastern Asia, at grid/RAS U	51%	44%	51%	51%
Polyurethane, flexible foam, at plant/RER U	28%	37%	30%	30%
Packaging, corrugated board, mixed fibre, single wall, at plant/RER U	9%	7%	7%	7%
Injection moulding/RER U	8%	8%	8%	8%
transport, transoceanic container ship/OCE U	3%	2%	2%	2%
Packaging film, LDPE, at plant/RER U	1%	2%	1%	1%
Injection moulding/RER U	>0%	>0%	>0%	>0%
Others	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.25E+04**	**1.04E+02**	**7.46E+00**	**7.44E+00**

9.4.3 Tablet, charger

The dataset is modelled as a smaller version of power adapter for laptops, which is already updated and described in the other dataset. The weight of charger is approximately 50 grams. This modeling approach follows the LCA data collection strategy of (Hischier et al., 2014).

Table 9.4-5. Life cycle inventory for Tablet, charger and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Charger, for tablet, at plant/p/GLO U	1	p				
Input						
Power adapter, for laptop, at plant/p/GLO U	0.15	p		Lognormal	1.26	(2,3,3,3,2,5); Approximately 50 grams of charger; Adaptation following Hischier et al 2014.

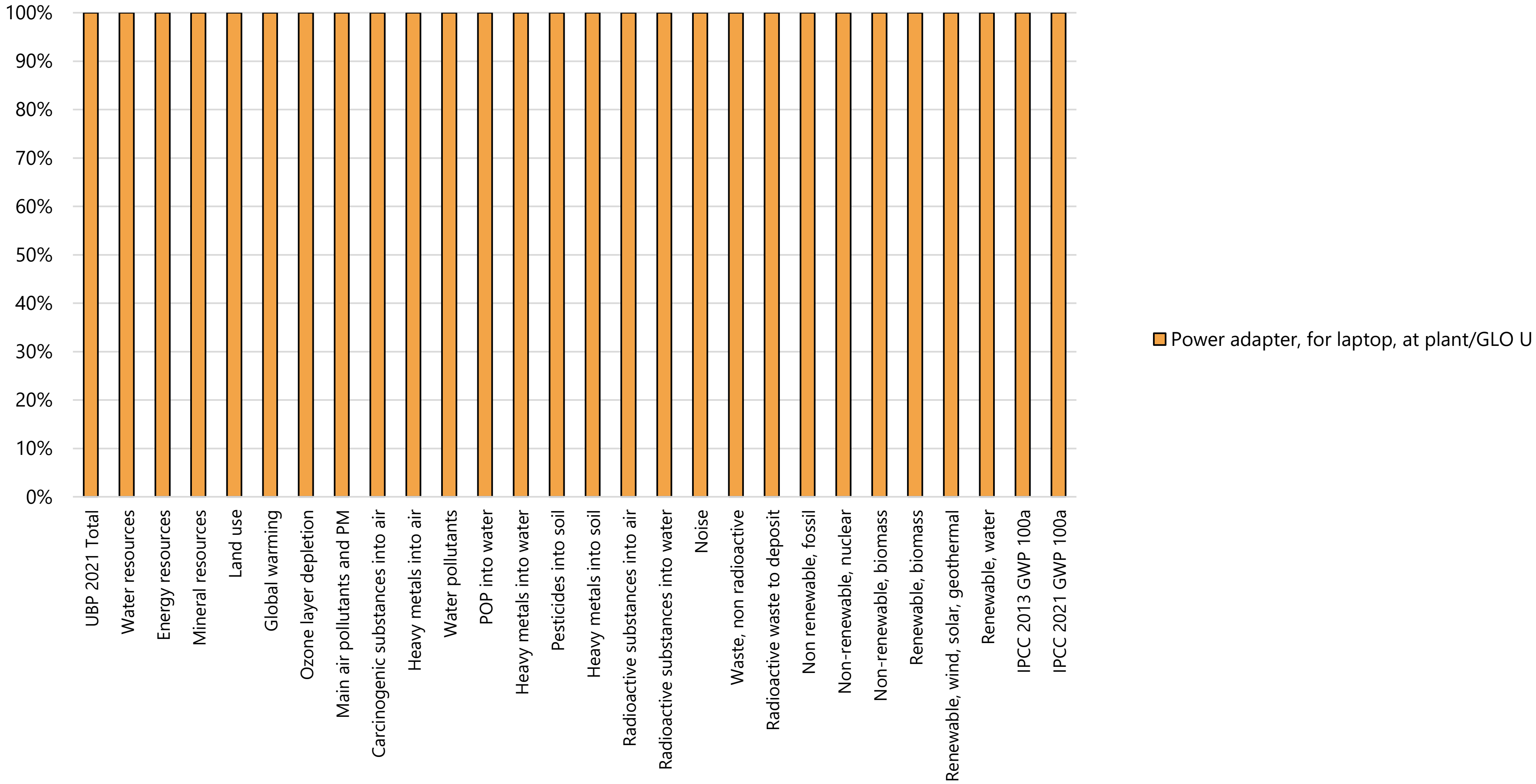

Figure 9.4-3. Contribution analysis presented in bar chart for: Tablet, charger. FU = 1 unit

Table 9.4-6. Contribution analysis presented in table for: Tablet, charger. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Power adapter, for laptop, at plant/p/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**3.75E+03**	**9.00E+00**	**7.68E-01**	**7.64E-01**

9.4.4 Tablet, spare batteries

The spare batteries for tablet is modelled using the Li-ion battery NMC-111 datasets, which is newly created in the UVEK LCA database. The mass of 0.135 kg is defined as the average weight of batteries in tablets, according to the LCA study of (Hischier et al., 2015).

Table 9.4-7. Life cycle inventory for Tablet, spare batteries and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Spare batteries, for tablet, at plant/p/GLO U	1	p				
Input						
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	0.135	kg	Lognormal	1.35		(3,3,3,4,3,5); The same amount as average batter mass in tablets. Literature: Hischer et al 2015

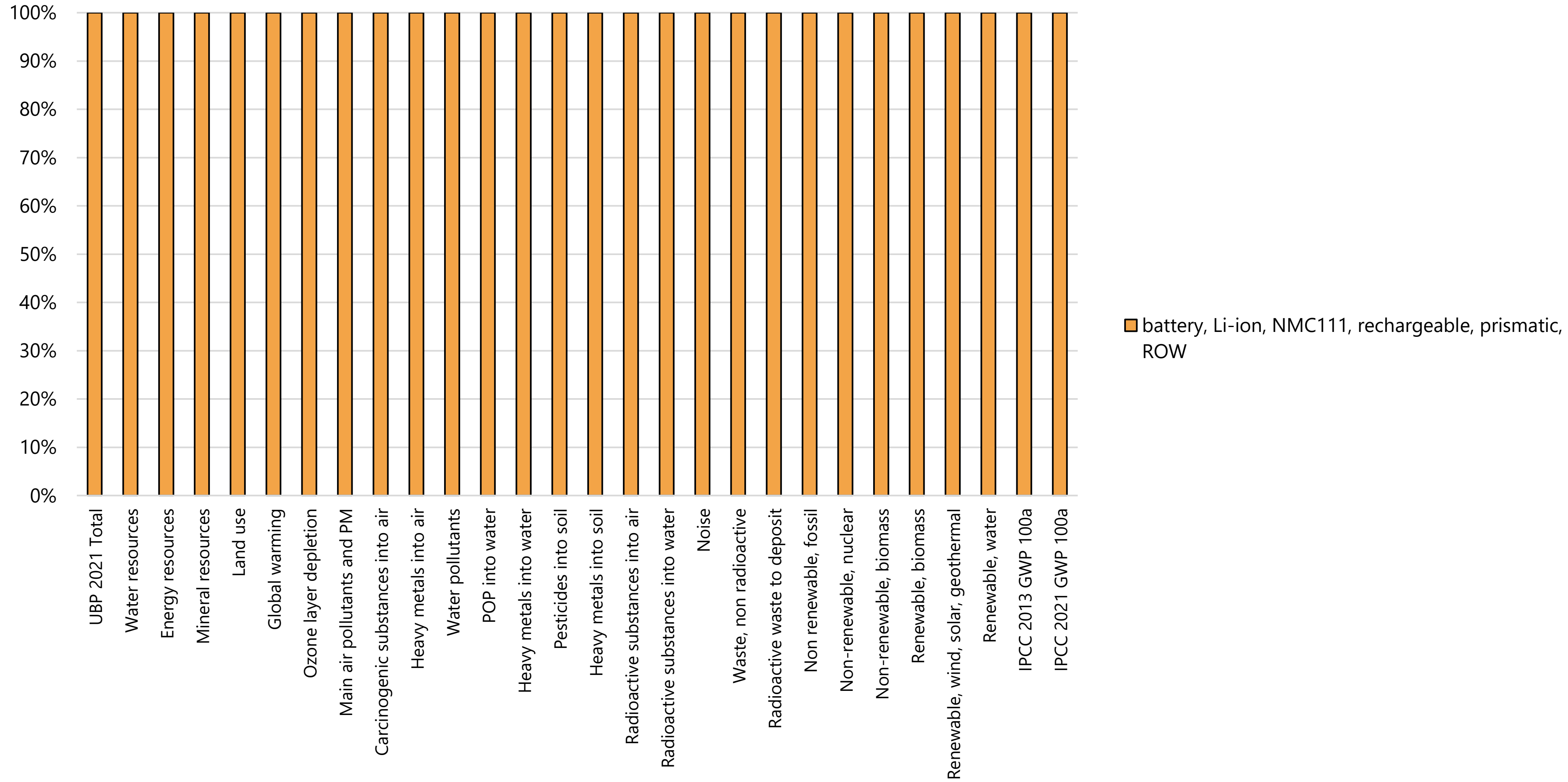

Figure 9.4-4. Contribution analysis presented in bar chart for: Tablet, spare batteries. FU = 1 unit

Table 9.4-8. Contribution analysis presented in table for: Tablet, spare batteries. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Battery, Li-ion, NMC111, rechargeable, prismatic/kg/GLO U	100%	100%	100%	100%
Total impact, in absolute value	**5.35E+03**	**2.19E+01**	**1.71E+00**	**1.70E+00**

9.4.5 Tablet, spare screen

The dataset for tablet spare screen is modeled as a separate LCD display with the size of 238 x 183 mm2, equivalent to 140 grams of LCD module and a coated glass. Inventory data is taken from (Hischier et al., 2015).

Table 9.4-9. Life cycle inventory for Tablet, spare screen and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Spare screen, for tablet, at plant/p/GLO U	1	p				
Input						
LED module, at plant/kg/GLO U	0.145	kg	Lognormal	1.31		(2,3,2,3,3,5); Display and glass. Literature: Hischier et al 2015
Flat glass, coated, at plant/RER U	0.109	kg	Lognormal	1.31		(2,3,2,3,3,5); Display and glass. Literature: Hischier et al 2015

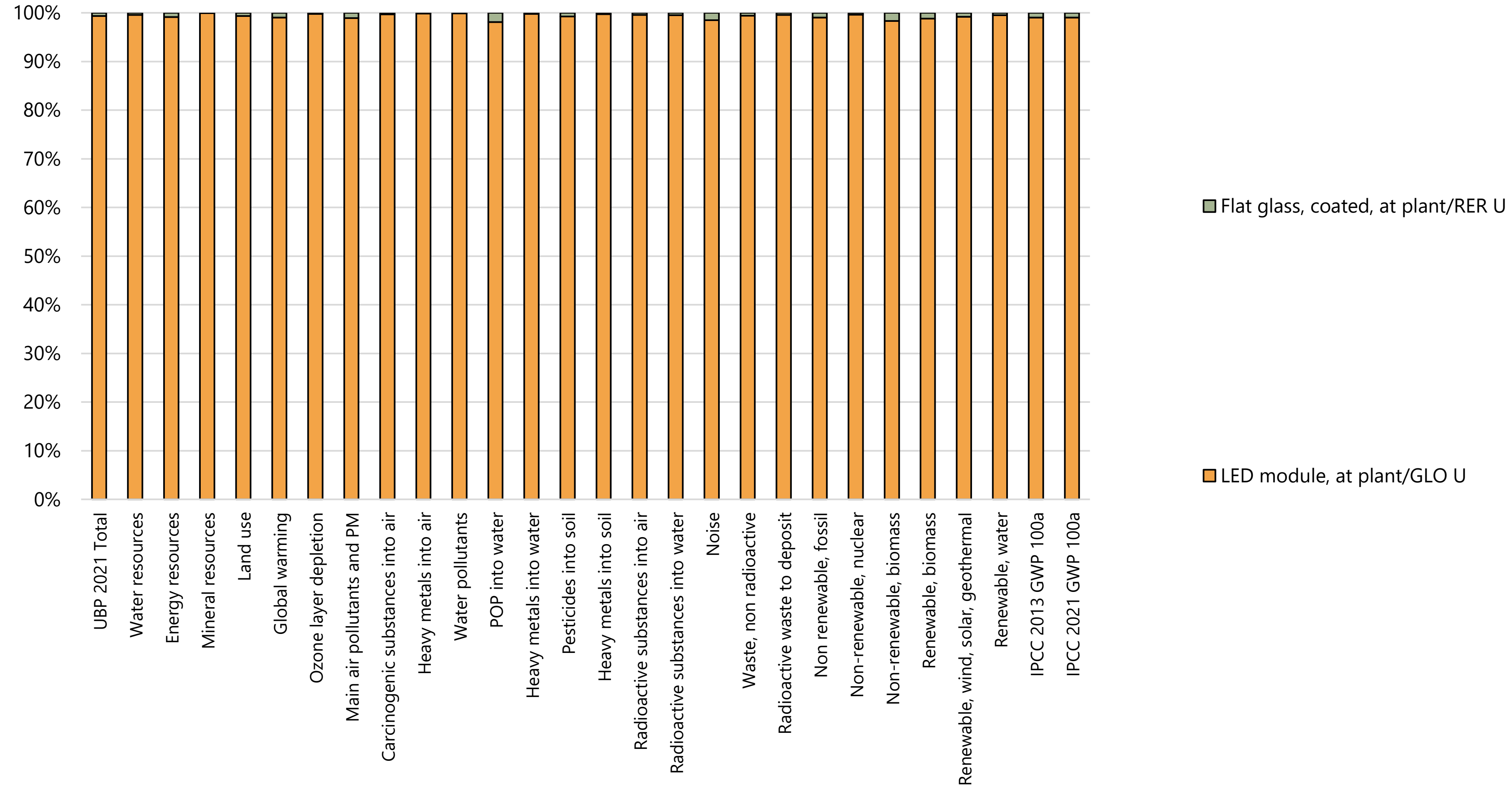

Figure 9.4-5. Contribution analysis presented in bar chart for: Tablet, spare screen. FU = 1 unit

Table 9.4-10. Contribution analysis presented in table for: Tablet, spare screen. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
LED module, at plant/kg/GLO U	99%	99%	99%	99%
Flat glass, coated, at plant/RER U	1%	1%	1%	1%
Total impact, in absolute value	**2.77E+04**	**1.33E+02**	**1.24E+01**	**1.23E+01**

9.5 Display technologies

9.5.1 LED module

The LED module is modeled by changing the backlight sources technology from the cold cathode fluorescent lamp (CCFL) to light emitting diode, according to the recent backlight technologies (Park & Lim, 2007). In order to calculate the amount of LED required to replace the CCFL backlighting technologies, the luminous efficacy is used as a proxy to scale the mass of LED with the same performance as its CCFL backlight. According to the (Morgan Pattison et al., 2018), a modern LED technology has up to 160 lumens/W whereas the conventional CCFL has on average 55 lumens/W. Therefore, a factor of 34% is used as the conversion factor for calculating the LED mass in the LED module for the same performance of CCFL backlit screen. The other materials required to manufacture an LED module is assumed to be the same as the LCD module, as inventoried in (Socolof et al., 2005).

Table 9.5-1. Life cycle inventory for LED module and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
LED module, at plant/GLO U	1	kg				
Input						
Light emitting diode, LED, at plant/kg/GLO U	0.146	kg		Lognormal	1.57	(1,3,5,3,1,5); Adaptation is made to reflect LED backlighting; calculated from an US-EPA study
Chromium steel 18/8, at plant/RER U	0.11345	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Copper, primary, at refinery/GLO U	0.0031	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Injection moulding/RER U	0.0938	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.0082	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
LCD glass, at plant/kg/GLO U	0.2965	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Assembly, LCD module/kg/GLO U	1	kg		Lognormal	1.57	(1,3,5,3,1,5); data from an US-EPA LCA study
Nylon 6, at plant/RER U	0.0063	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Polycarbonate, at plant/RER U	0.0938	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.0438	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Section bar rolling, steel/RER U	0.1094	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Sheet rolling, copper/RER U	0.0031	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Sputtering, ITO, for LCD/RER U	5.5866E-08	m3		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study
Synthetic rubber, at plant/RER U	0.00405	kg		Lognormal	1.57	(1,3,5,3,1,5); calculated from an US-EPA study

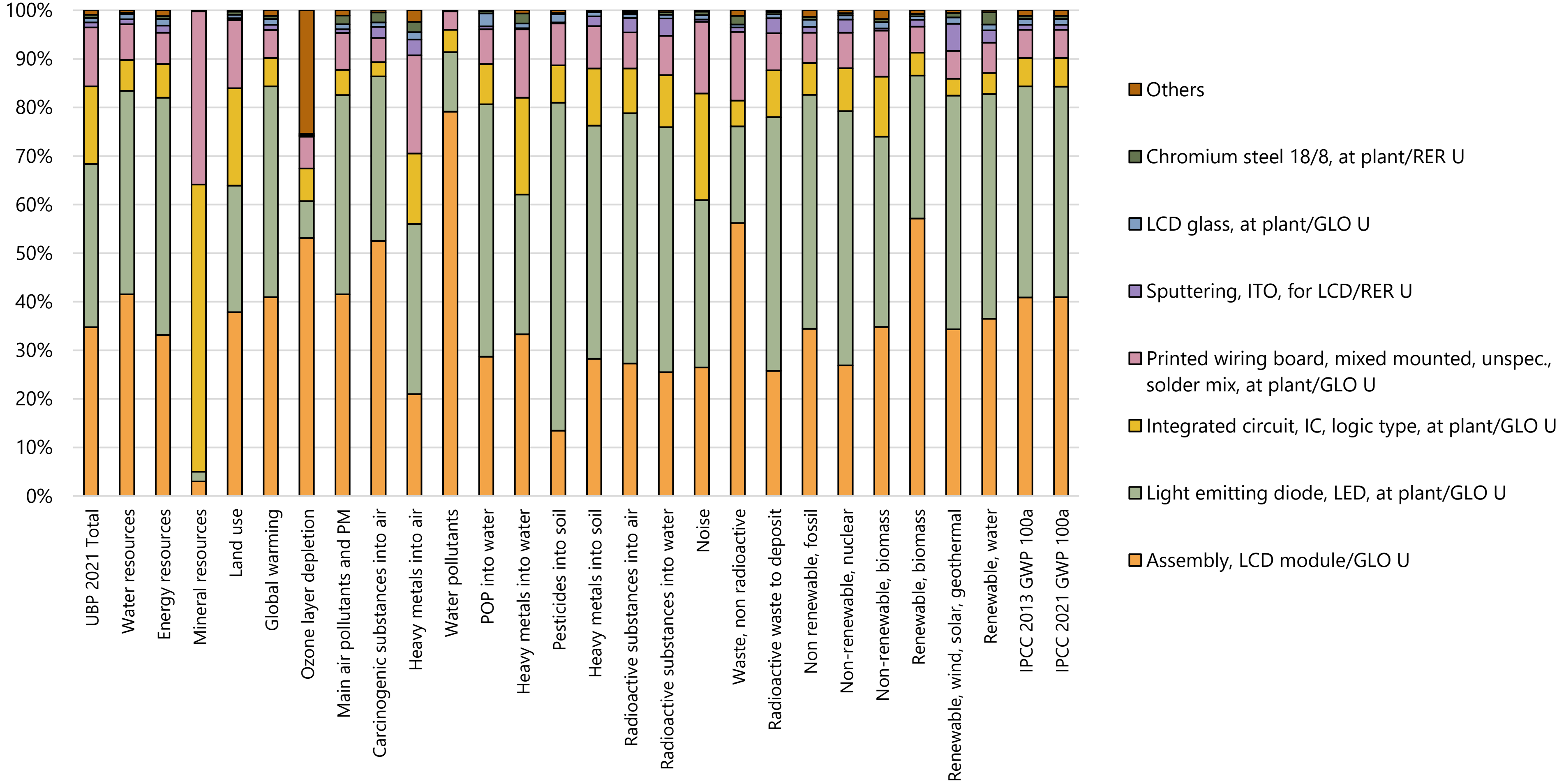

Figure 9.5-1. Contribution analysis presented in bar chart for: LED module. FU = 1 kg

Table 9.5-2. Contribution analysis presented in table for: LED module. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Assembly, LCD module/kg/GLO U	35%	34%	41%	41%
Light emitting diode, LED, at plant/kg/GLO U	34%	48%	43%	43%
Integrated circuit, IC, logic type, at plant/kg/GLO U	16%	7%	6%	6%
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	12%	6%	6%	6%
Sputtering, ITO, for LCD/RER U	1%	1%	1%	1%
LCD glass, at plant/kg/GLO U	1%	1%	1%	1%
Chromium steel 18/8, at plant/RER U	1%	1%	1%	1%
Others	1%	1%	1%	1%
Total impact, in absolute value	**1.90E+05**	**9.11E+02**	**8.44E+01**	**8.42E+01**

9.5.2 LED screen 23 inches, at plant

The bill of materials for LED screen monitors are taken from the other dismantling studies (Babbitt et al., 2020; Peeters et al., 2012) and an EPD report from a monitor manufacturer, i.e., LG electronics (LG, 2018). Unlike the LCD-CCFL backlit monitors, the LED monitor uses LCD module with LED as the backlighting technologies (Osmani & Wolf, 2013). The average size of the modeled LED monitor is 23 inches, with a total weight of approximately 3.2 kg. The monitor comprises metals (copper, steel), plastics (ABS), PCB, and flat panel glass, whose weight shares are defined from the bill of materials data from (Babbitt et al., 2020). The environmental footprint results are comparable with those of (Bhakar et al., 2015).

Table 9.5-3. Life cycle inventory for Display, LED screen 23 inches and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
LED screen 23 inches, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	1.382	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
aluminium, production mix, at plant/kg/RER U	0.0085	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Assembly, LCD screen/kg/GLO U	3.112	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Chromium steel 18/8, at plant/RER U	0.0117	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Copper, primary, at refinery/GLO U	0.0014	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Injection moulding/RER U	1.382	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
LED module, at plant/kg/GLO U	1.055	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.08	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Section bar extrusion, aluminium/RER U	0.00425	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Sheet rolling, aluminium/RER U	0.00425	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Steel, converter, low-alloyed, at plant/RER U	1.175	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Sheet rolling, steel/RER U	1.175	kg		Lognormal	1.24	(2,3,2,4,2,5); Literature: Babbit et al 2020, Bill of materials
Whitelined chipboard, WLC, at plant/RER U	0.62	kg		Lognormal	1.26	(3,3,2,4,2,5); Own calculations, assumed = 1/5 of the total monitor mass

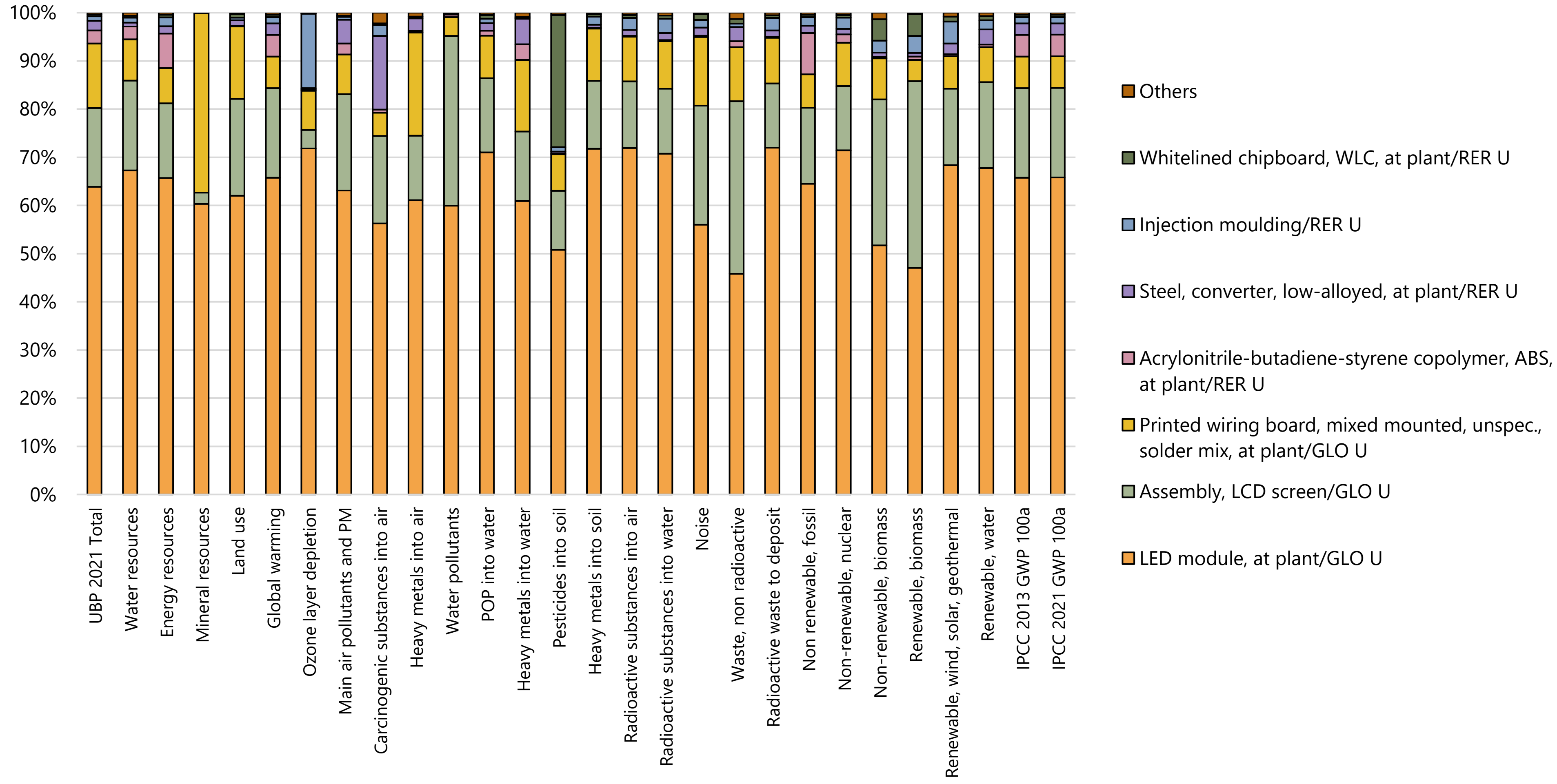

Figure 9.5-2. Contribution analysis presented in bar chart for: Display, LED screen 23 inches. FU = 1 unit

Table 9.5-4. Contribution analysis presented in table for: Display, LED screen 23 inches. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
LED module, at plant/kg/GLO U	64%	65%	66%	66%
Assembly, LCD screen/kg/GLO U	16%	16%	19%	19%
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	13%	7%	7%	7%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	3%	9%	5%	5%
Steel, converter, low-alloyed, at plant/RER U	2%	2%	2%	2%
Injection moulding/RER U	1%	2%	1%	1%
Whitelined chipboard, WLC, at plant/RER U	>0%	1%	>0%	>0%
Others	>0%	>0%	>0%	>0%
Total impact, in absolute value	**3.15E+05**	**1.50E+03**	**1.36E+02**	**1.36E+02**

9.5.3 Assembly, OLED module

This module includes the auxiliaries and energy efforts as well as the related emissions (air/water) and waste amounts for the assembly of the complete oLED module. Estimations for infrastructure and the overall transport amounts (incl. for the materials in the LCD module) are included as well.

Remark: 2023 updates: this dataset is used to represent oLED module that is made entirely in South Korea. It is built on inventory data based on information in a US-EPA LCA study about LCD and CRT production. (see also Assembly, LCD module).

Table 9.5-5. Life cycle inventory for Assembly, OLED module and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Assembly, OLED module/kg/GLO U	1	kg				
Input						
Water, unspecified natural origin/m3	0.28125	m^3	In water	Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetic acid, 98% in H2O, at plant {RER} U	0.0016667	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetone, liquid, at plant {RER} U	0.0026823	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Aluminium sulphate, powder, at plant {RER} U	0.027344	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia, liquid, at regional storehouse {RER} U	0.0076211	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Argon, crude, liquid, at plant {RER} U	0.0020495	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Carbon dioxide liquid, at plant {RER} U	9.7396E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chemicals organic, at plant {GLO} U	0.15699	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Chlorine, liquid, production mix, at plant {RER} U	0.0040365	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyclohexanol, at plant {RER} U	5.2865E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Dimethyl sulfoxide, at plant {RER} U	0.017266	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Electricity, medium voltage, production Eastern Asia, at grid {RAS} U	14.5	kWh		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Electronic component production plant {GLO} U	0.00000002	p		Lognormal	3.18	(4,5,4,3,1,5); Estimation, based on production site
Ethanol from ethylene, at plant {RER} U	0.0035156	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethylene glycol, at plant {RER} U	0.00021146	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Glass fibre, at plant {RER} U	3.8229E-07	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, light fuel oil, at industrial furnace 1MW {RER} U	9.38835	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, natural gas, at industrial furnace 1MW {CH} U	37.2744	MJ		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrochloric acid, 30% in H2O, at plant {RER} U	0.011224	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen fluoride, at plant {GLO} U	0.0010964	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen peroxide, 50% in H2O, at plant {RER} U	3.8281E-05	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen, liquid, at plant {RER} U	0.11562	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Isopropanol, at plant {RER} U	0.090885	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Krypton, gaseous, at regional storage {CH} U	6.7188E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study

Lime, hydrated, packed, at plant {CH} U	0.036198	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Methyl ethyl ketone, at plant {RER} U	1.9141E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitric acid, 50% in H2O, at plant {RER} U	0.0032292	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen, liquid, at plant {RER} U	1.5365	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
N-methyl-2-pyrrolidone, at plant {RER} U	0.00021146	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Oxygen, liquid, at plant {RER} U	0.0020182	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Panel components, at plant {GLO} U	0.021875	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphoric acid, industrial grade, 85% in H2O, at plant {RER} U	0.010286	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Polycarbonate, at plant {RER} U	0.00025312	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Propylene glycol, liquid, at plant {RER} U	0.005224	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sodium hydroxide, 50% in H2O, production mix, at plant {RER} U	0.09349	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sodium phosphate, at plant {RER} U	0.048177	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Sulphuric acid, liquid, at plant {RER} U	0.059635	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Toluene diisocyanate, at plant {RER} U	8.0208E-06	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Transport, freight, rail {RER} U	1.9405	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard values
Transport, freight, lorry, fleet average {RER} U	0.32341	tkm		Lognormal	2.24	(4,5,4,3,3,5); standard values
Xylene, at plant {RER} U	0.00040885	kg		Lognormal	1.31	(1,3,4,3,1,5); data from an US-EPA LCA study
Output						
Emissions to air						
Acetic acid	0.00035417	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Acetone	4.8437E-05	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Ammonia	0.016224	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Tetramethyl ammonium hydroxide	0.16745	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Sulfur hexafluoride	2.7924E-05	kg	high. pop.	Lognormal	2.34	(3,3,4,1,4,5); tier 2b default emission factor of IPCC guidelines
Sodium tetrahydroborate	0.0046354	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphoric acid	0.00001263	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphine	0.016302	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
NMVOC, non-methane volatile organic compounds, unspecified origin	0.027813	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study

Nitrogen oxides	7.0052E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Nitrogen fluoride	6.9821E-06	kg	high. pop.	Lognormal	1.89	(3,3,4,1,4,5); tier 2b default emission factor of IPCC guidelines
Hydrogen	3.4635E-05	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen fluoride	0.013568	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrogen chloride	0.015781	kg	high. pop.	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Heat, waste	67.448	MJ	high. pop.	Lognormal	1.93	(4,3,4,3,4,5); Calculated from electricity input
Diethylene glycol	2.5234E-05	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyclohexane	0.00001263	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Boron trifluoride	0.0023906	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Boric acid	3.5677E-07	kg	high. pop.	Lognormal	2.1	(1,3,4,3,1,5); data from an US-EPA LCA study
Emissions to water						
Antimony	2.9688E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Arsenic	2.9688E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
BOD5, Biological Oxygen Demand	0.0045312	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Boron	1.1927E-06	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Cadmium	2.9688E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium VI	5.9635E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Chromium	2.3021E-06	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
COD, Chemical Oxygen Demand	0.00069792	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Copper	2.3906E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Cyanide	9.5313E-07	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Ethane, 1,1,1-trichloro-, HCFC-140	5.9635E-09	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Fluoride	0.0033333	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Hydrocarbons, aromatic	0.00015312	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Iron	6.849E-07	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Lead	1.6068E-06	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Manganese	5.9635E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Mercury	2.5234E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study
Nickel	5.9635E-08	kg	river	Lognormal	5.11	(1,3,4,3,1,5); data from an US-EPA LCA study

Nitrogen	0.020651	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Oils, unspecified	0.00005260 4	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Phenol	5.9635E-08	kg	river	Lognormal	3.09	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphate	5.9635E-08	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Phosphorus	0.0011224	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Solids, inorganic	0.0019661	kg	river	Lognormal	1.62	(1,3,4,3,1,5); data from an US-EPA LCA study
Waste to treatment						
Disposal, glass, 0% water, to construction waste landfill {CH} U	0.11995	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study
Disposal, plastic, consumer electronics, 15.3% water, to municipal incineration {CH} U	0.2099	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, refinery sludge, 89.5% water, to hazardous waste incineration {CH} U	0.0080469	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, sludge, NaCl electrolysis, 0% water, to residual material landfill {CH} U	0.014922	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration {CH} U	0.87294	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Disposal, used mineral oil, 10% water, to hazardous waste incineration {CH} U	0.0041927	kg		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study - approximated with existing waste process
Treatment, LCD module production effluent, to wastewater treatment, class 2 {CH} U	0.3737	m3		Lognormal	1.63	(1,3,4,3,4,5); data from an US-EPA LCA study

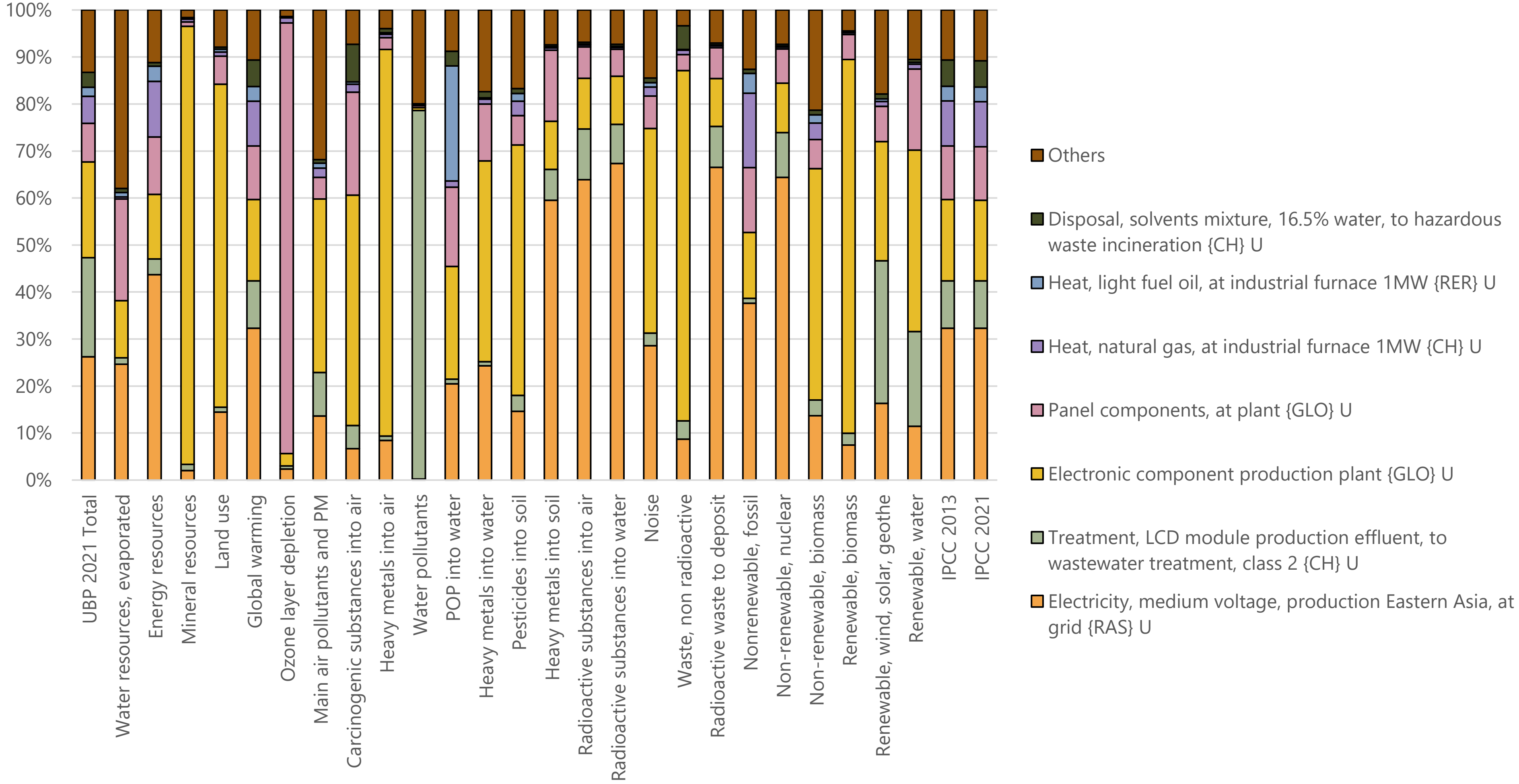

Figure 9.5-3. Contribution analysis presented in bar chart for: Assembly, OLED module. FU = 1 kg

Table 9.5-6. Contribution analysis presented in table for: Assembly, OLED module. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Electricity, medium voltage, production Eastern Asia, at grid {RAS} U	26%	38%	32%	32%
Treatment, LCD module production effluent, to wastewater treatment, class 2 {CH} U	21%	1%	10%	10%
Electronic component production plant {GLO} U	20%	14%	17%	17%
Panel components, at plant {GLO} U	8%	14%	11%	11%
Heat, natural gas, at industrial furnace 1MW {CH} U	6%	16%	10%	10%
Heat, light fuel oil, at industrial furnace 1MW {RER} U	2%	4%	3%	3%
Disposal, solvents mixture, 16.5% water, to hazardous waste incineration {CH} U	3%	1%	6%	6%
Others	13%	13%	11%	11%
Total impact, in absolute value	**6.14E+04**	**2.98E+02**	**3.09E+01**	**3.09E+01**

9.5.4 OLED module

The source of life cycle inventory for organic light emitting diode (OLED) is the LCA study of (Amasawa et al., 2016). Overall, the approaches for constructing inventories of fine specialty chemicals and fabrication process in the OLED for smartphones or other smart devices involve creation of inventory with stoichiometry and application of observed correlation between display area and production cost in the display industry. From this study, four specialty chemicals/ingredients are chosen for organic and metal layer depositions, namely bisphenol-A, phtalic anhydride, magnesium, and silver. The geographical specificity is set to be in South Korea, because the majority of active matrix OLED display productions (>90% of production share) occur in the country (Semenza, 2013). For such reason, all electricity input reflects the electricity mix of South Korean grid.

Table 9.5-7. Life cycle inventory for OLED module and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
OLED module, at plant/kg/GLO U	1	kg				
Input						
Assembly, OLED module/kg/GLO U	1	kg	Lognormal	1.24		(1,3,3,3,1,5); data from an US-EPA LCA study. Adapted to SK electricity mix
Bisphenol A, powder, at plant/RER U	0.55	kg	Lognormal	1.28		(3,4,2,4,2,5); Proxy for speciality chemicals. Literature: Amasawa et al 2016
Chromium steel 18/8, at plant/RER U	0.11345	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Copper, primary, at refinery/GLO U	0.0031	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Injection moulding/RER U	0.0938	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Integrated circuit, IC, logic type, at plant/kg/GLO U	0.0082	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
LCD glass, at plant/kg/GLO U	0.2965	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Light emitting diode, LED, at plant/kg/GLO U	0.127	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Magnesium, at plant/RER U	0.0045	kg	Lognormal	1.28		(3,4,2,4,2,5); Proxy for speciality chemicals. Literature: Amasawa et al 2016
Phthalic anhydride, at plant/RER U	0.55	kg	Lognormal	1.28		(3,4,2,4,2,5); Proxy for speciality chemicals. Literature: Amasawa et al 2016
Polycarbonate, at plant/RER U	0.0938	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.0415	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Section bar rolling, steel/RER U	0.1094	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Sheet rolling, copper/RER U	0.0031	kg	Lognormal	1.24		(1,3,3,3,1,5); calculated from an US-EPA study
Silver, at regional storage/RER U	0.0045	kg	Lognormal	1.28		(3,4,2,4,2,5); Proxy for speciality chemicals. Literature: Amasawa et al 2016

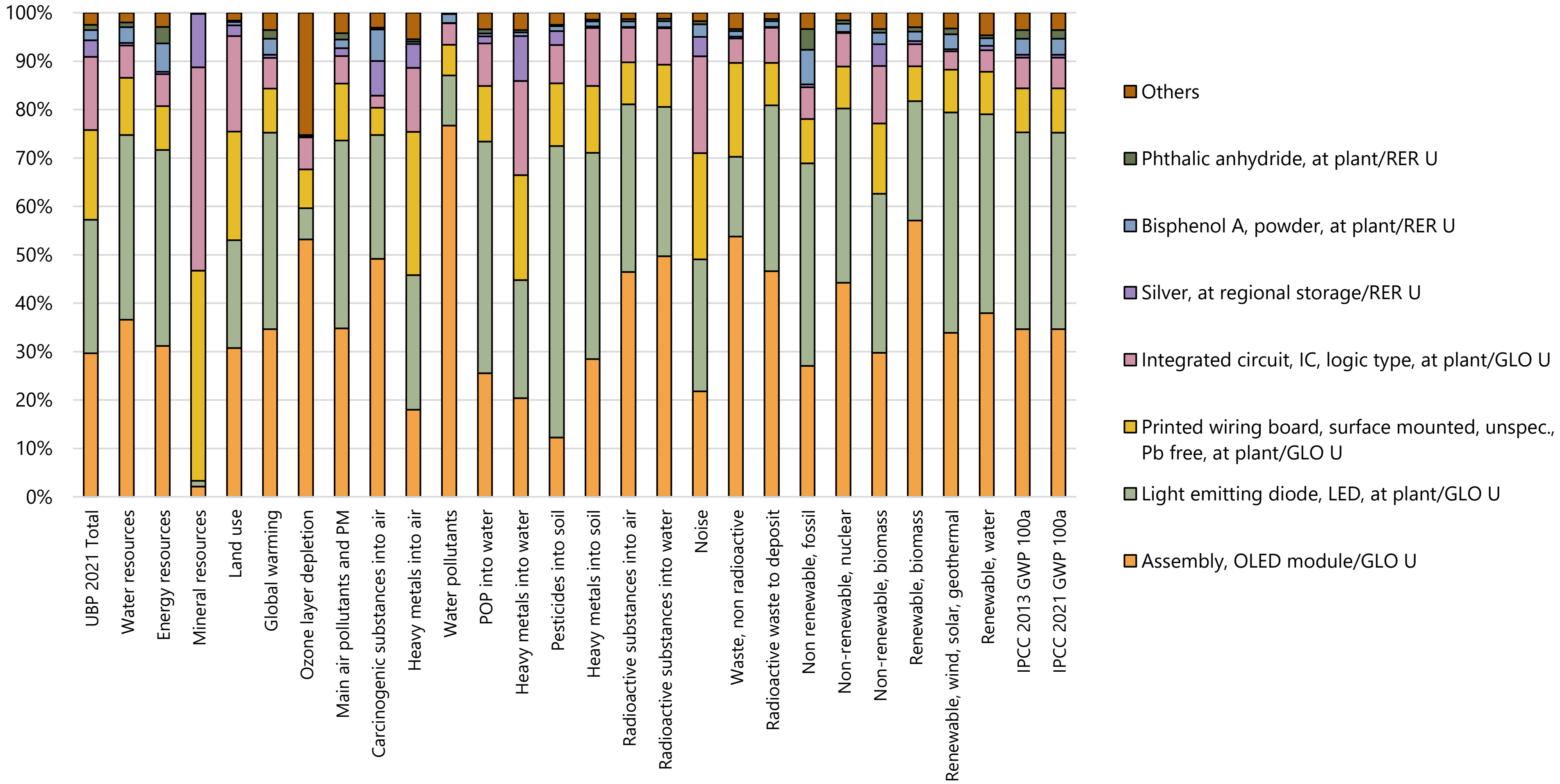

Figure 9.5-4. Contribution analysis presented in bar chart for: OLED module. FU = 1 kg

Table 9.5-8. Contribution analysis presented in table for: OLED module. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Assembly, OLED module/kg/GLO U	31%	31%	37%	37%
Light emitting diode, LED, at plant/kg/GLO U	27%	40%	39%	39%
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	18%	9%	9%	9%
Integrated circuit, IC, logic type, at plant/kg/GLO U	15%	6%	6%	6%
Silver, at regional storage/RER U	3%	1%	1%	1%
Bisphenol A, powder, at plant/RER U	2%	7%	3%	3%
Phthalic anhydride, at plant/RER U	1%	4%	2%	2%
Others	3%	2%	4%	4%
Total impact, in absolute value	**2.03E+05**	**9.66E+02**	**8.18E+01**	**8.16E+01**

9.5.5 OLED screen 43 inches, at plant

For the OLED screen, it is assumed that the bill of materials for LED screen monitors from the other dismantling studies (Babbitt et al., 2020; Peeters et al., 2012) can be used to model OLED monitors. However, the module type is specifically adapted using OLED based modules. The average size of the modeled OLED monitor is 43 inches, with a total weight of approximately 9.3 kg. The model is based on the actual product LG smart TV 43" 43UH610A-UJ (LG, 2016). The monitor comprises metals (copper, steel), plastics (ABS), PCB, and flat panel glass, whose weight shares are defined from the bill of materials data from (Babbitt et al., 2020).

Table 9.5-9. Life cycle inventory for Display, OLED screen and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
OLED screen 43 inches, at plant/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	4.314	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Assembly, LCD screen/kg/GLO U	9.277	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Chromium steel 18/8, at plant/RER U	0.3	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Injection moulding/RER U	4.314	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
OLED module, at plant/kg/GLO U	3.06	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	0.586	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Steel, converter, low-alloyed, at plant/RER U	2.889	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Sheet rolling, steel/RER U	2.889	kg		Lognormal	1.34	(3,3,2,4,3,5); Literature: Babbit et al 2020, Bill of materials
Whitelined chipboard, WLC, at plant/RER U	1.87	kg		Lognormal	1.39	(4,3,2,4,3,5); Own estimations; Assumed = 1/5 of the total monitor mass

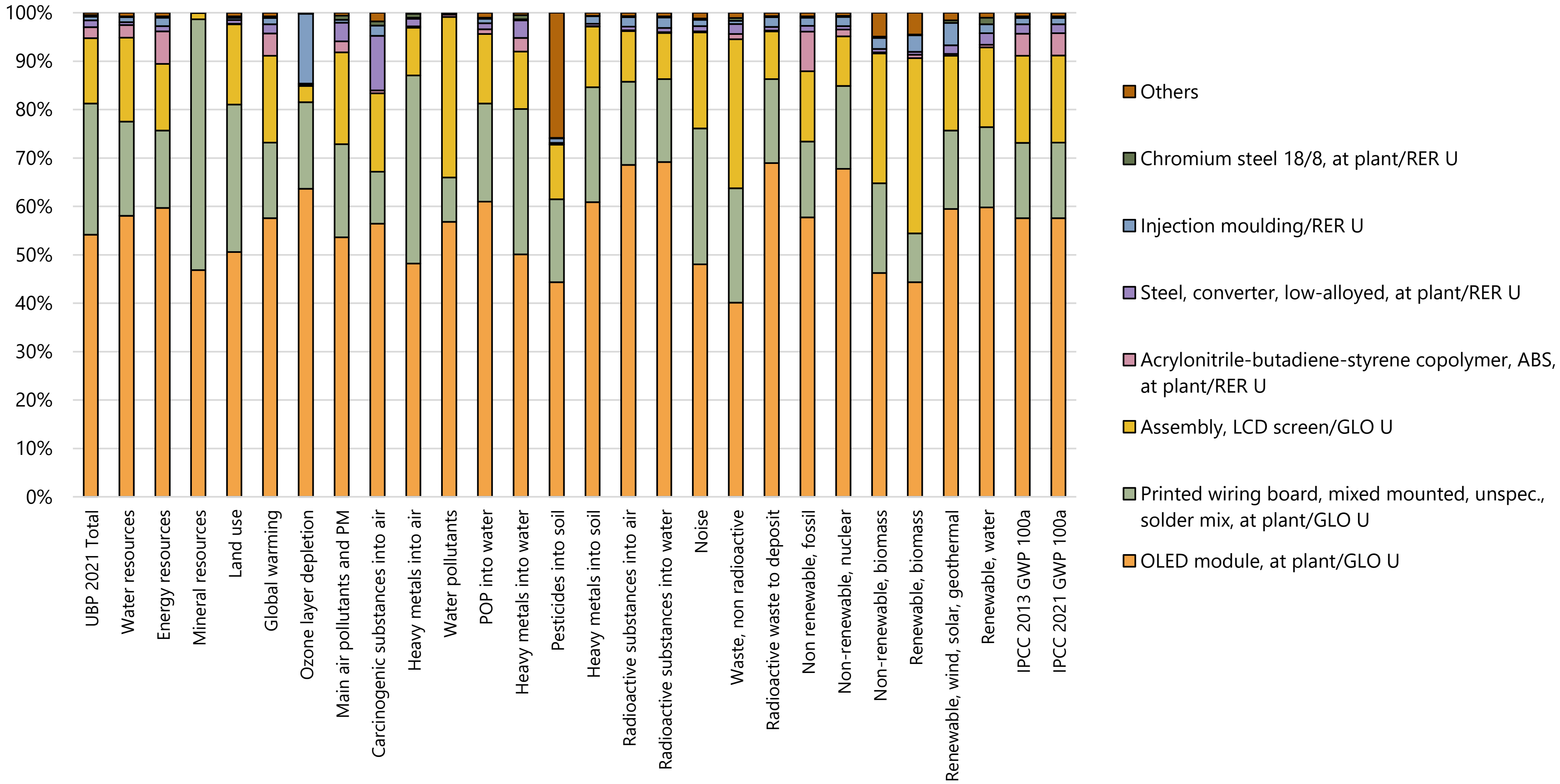

Figure 9.5-5. Contribution analysis presented in bar chart for: Display, OLED screen 43 inches. FU = 1 unit

Table 9.5-10. Contribution analysis presented in table for: Display, OLED screen 43 inches. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
OLED module, at plant/kg/GLO U	54%	59%	59%	59%
Printed wiring board, mixed mounted, unspec., solder mix, at plant/kg/GLO U	27%	15%	15%	15%
Assembly, LCD screen/kg/GLO U	13%	14%	18%	18%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	2%	8%	4%	4%
Steel, converter, low-alloyed, at plant/RER U	1%	1%	2%	2%
Injection moulding/RER U	1%	2%	1%	1%
Chromium steel 18/8, at plant/RER U	>0%	>0%	>0%	>0%
Others	>0%	1%	1%	1%
Total impact, in absolute value	**1.15E+06**	**5.04E+03**	**4.31E+02**	**4.30E+02**

9.6 Transmission network

9.6.1 Equipment for the different parts of the internet network

This sub-section presents the various equipment devices that are necessary in the use of the internet network at the local, national and global levels.

9.6.1.1 Modem for customer premise equipment (CPE)

The dataset is based on average of Scientific Atlanta EPC2203 & Thomson TWG870. Thomson TWG870 and Scientific Atlanta EPC2203 constitute the largest proportion of the category modems (SFOE, 2015). The power supply unit is assumed to be 1.5019 kg per modem (UVEK), router to be 0.58 kg/pcs (UVEK), and cable to be 1.04 kg/m (UVEK). Wiring assumed to be copper, based on existing chassis and router datasets. Type of polymers used taken from those found in existing chassis and router datasets. Proportion 1:1:1 for HDPE:PVC:PP. No information from main literature or dataset regarding type of steel used, hence it is assumed to be low-alloyed. Total mass = 0.665 kg.

Table 9.6-1. Life cycle inventory for a Modem

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Modem, for customer premise equipment (CPE)/p/CH U	1	unit				
Input						
Power supply unit, at plant/p/GLO U	0.13	p		Lognormal	1.26	(2,3,3,1,2,5)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.0884	kg		Lognormal	1.26	(2,3,3,1,2,5)
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	0.0884	kg		Lognormal	1.26	(2,3,3,1,2,5)
Cable, three-conductor cable, at plant/m/GLO U	0.0654	m		Lognormal	1.26	(2,3,3,1,2,5)
Steel, low-alloyed, at plant/RER U	0.0025	kg		Lognormal	1.26	(2,3,3,1,2,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.0741	kg		Lognormal	1.26	(2,3,3,1,2,5)
Polypropylene, granulate, at plant/RER U	0.0741	kg		Lognormal	1.26	(2,3,3,1,2,5)
Polyvinylchloride, at regional storage/RER U	0.0741	kg		Lognormal	1.26	(2,3,3,1,2,5)
Injection moulding/RER U	0.222	kg		Lognormal	1.26	(2,3,3,1,2,5)
Hot rolling, steel/RER U	0.0025	kg		Lognormal	1.26	(2,3,3,1,2,5)

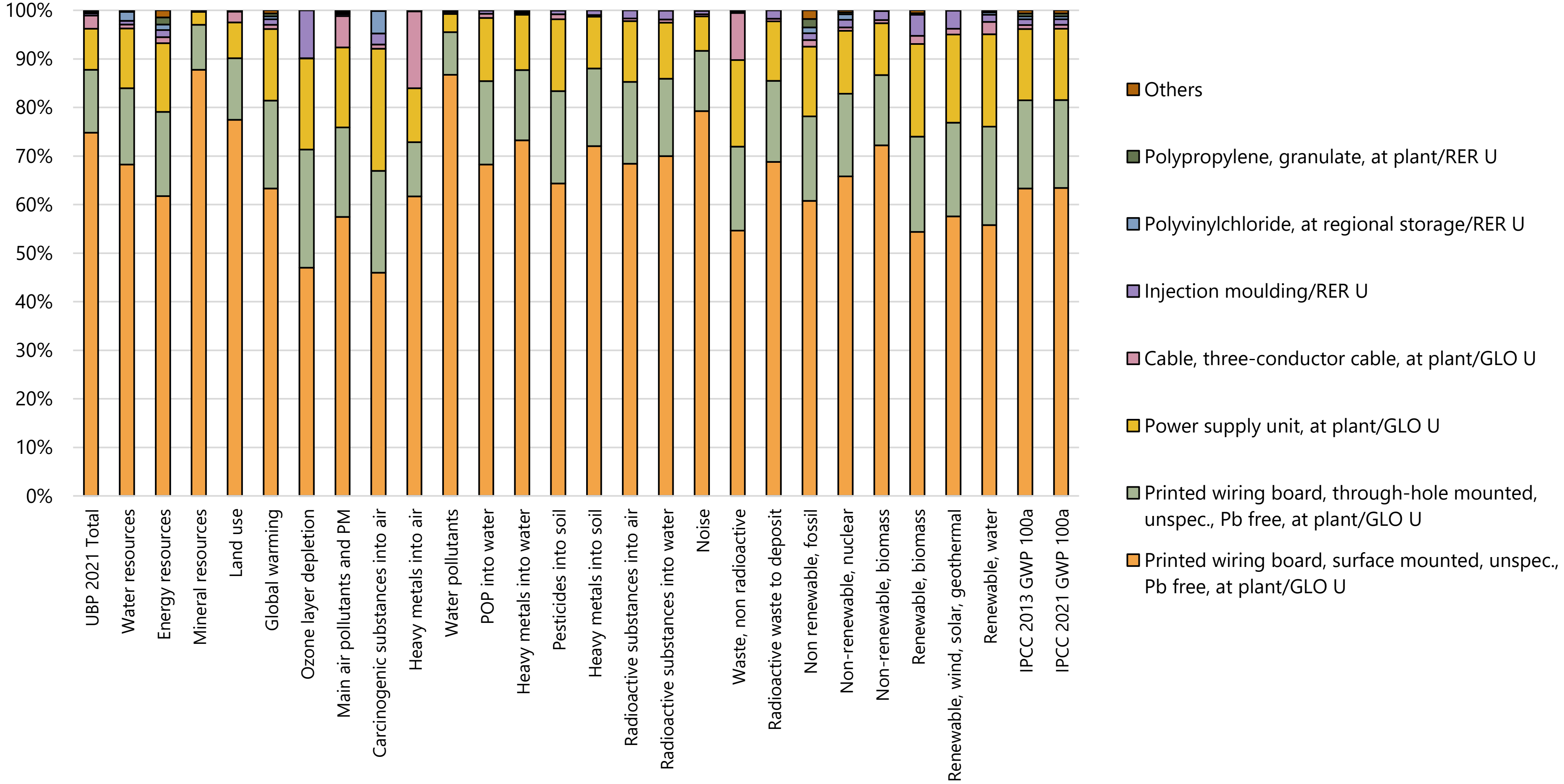

Figure 9.6-1. Contribution analysis presented in bar chart for: Modem. FU = 1 p

Table 9.6-2. Contribution analysis presented in table for: Modem. FU = 1 p

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	75%	61%	63%	63%
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	13%	17%	18%	18%
Power supply unit, at plant/p/GLO U	8%	14%	15%	15%
Cable, three-conductor cable, at plant/m/GLO U	3%	1%	1%	1%
Injection moulding/RER U	>0%	1%	1%	1%
Polyvinylchloride, at regional storage/RER U	>0%	1%	1%	1%
Polypropylene, granulate, at plant/RER U	>0%	2%	1%	1%
Others	>0%	2%	1%	1%
Total impact, in absolute value	**1.07E+05**	**2.97E+02**	**2.43E+01**	**2.43E+01**

9.6.1.2 Multimedia gateway for customer premise equipment (CPE)

The dataset is based on the Samsung SMT-G7400 (SFOE, 2015). The conversion of weights to pieces for power supply units and HDDs are based on existing UVEK datasets. The types of polymers used are taken from the polymers currently in use within existing chassis and router datasets. The proportion is 1:1:1 for HDPE:PVC:PP. No information from the literature regarding type of steel was found. Hence it was assumed that low-alloyed steel was used. The total mass of the equipment is 3.79 kg.

Table 9.6-3. Life cycle inventory for a Multimedia gateway

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Multimedia gateway, for customer premise equipment (CPE)/p/CH U	1	unit				
Input						
Power supply unit, at plant/p/GLO U	0.25	p		Lognormal	1.26	(2,3,3,1,2,5)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.286	kg		Lognormal	1.26	(2,3,3,1,2,5)
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	0.286	kg		Lognormal	1.26	(2,3,3,1,2,5)
Cable, three-conductor cable, at plant/m/GLO U	0.226	m		Lognormal	1.26	(2,3,3,1,2,5)
Steel, low-alloyed, at plant/RER U	1	kg		Lognormal	1.26	(2,3,3,1,2,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.304	kg		Lognormal	1.26	(2,3,3,1,2,5)
Polypropylene, granulate, at plant/RER U	0.304	kg		Lognormal	1.26	(2,3,3,1,2,5)
Polyvinylchloride, at regional storage/RER U	0.304	kg		Lognormal	1.26	(2,3,3,1,2,5)
Injection moulding/RER U	0.912	kg		Lognormal	1.26	(2,3,3,1,2,5)
Hot rolling, steel/RER U	1	kg		Lognormal	1.26	(2,3,3,1,2,5)
HDD, desktop computer, at plant/p/GLO U	0.695	p		Lognormal	1.26	(2,3,3,1,2,5)

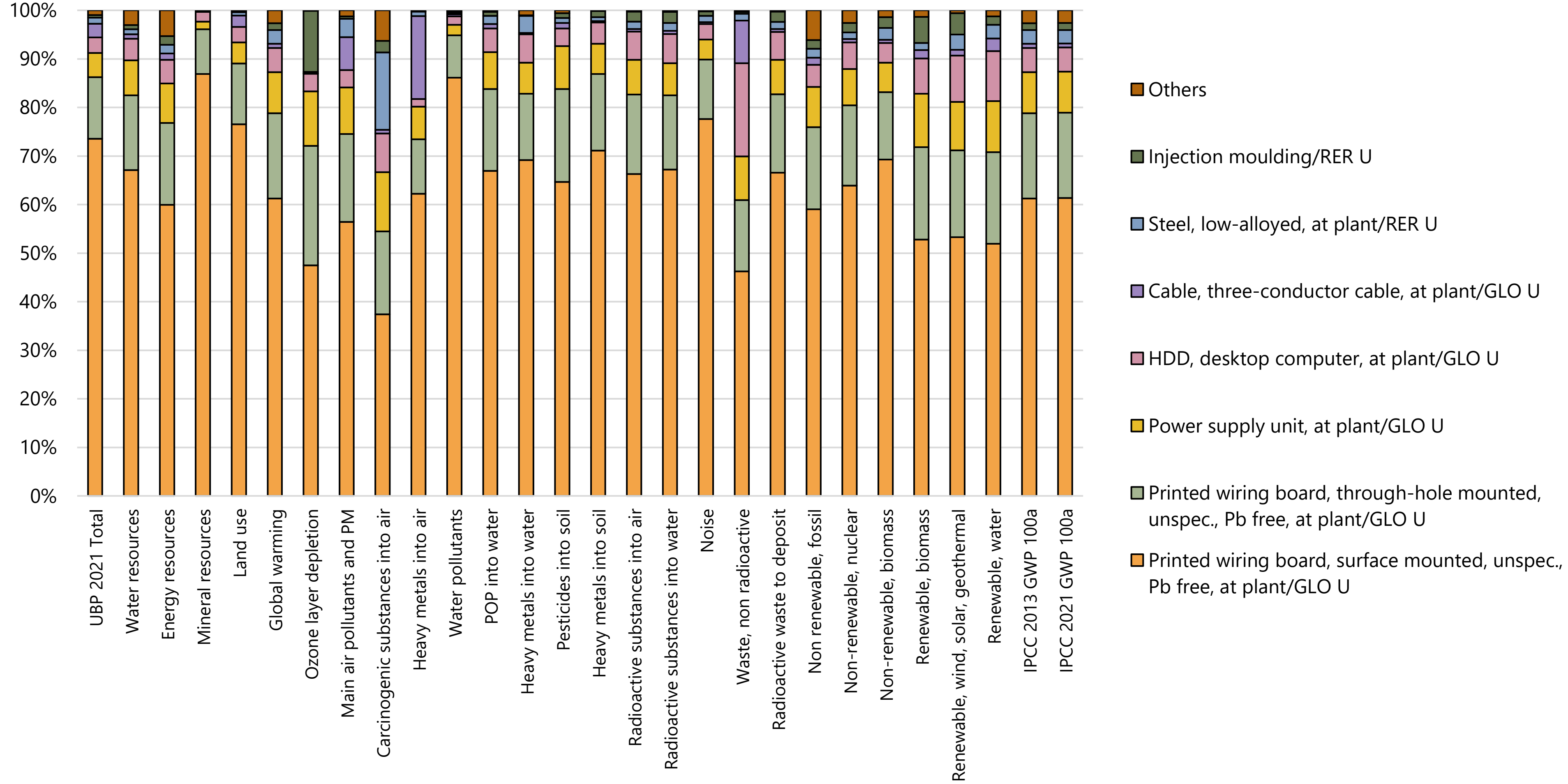

Figure 9.6-2. Contribution analysis presented in bar chart for: Multimedia gateway. FU = 1 p

Table 9.6-4. Contribution analysis presented in table for: Multimedia gateway. FU = 1 p

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	74%	59%	62%	62%
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	13%	17%	18%	18%
Power supply unit, at plant/p/GLO U	5%	8%	9%	8%
HDD, desktop computer, at plant/p/GLO U	3%	4%	5%	5%
Cable, three-conductor cable, at plant/m/GLO U	3%	1%	1%	1%
Steel, low-alloyed, at plant/RER U	1%	2%	3%	3%
Injection moulding/RER U	1%	2%	1%	1%
Others	>0%	7%	1%	2%
Total impact, in absolute value	**3.51E+05**	**9.85E+02**	**8.11E+01**	**8.10E+01**

9.6.1.3 Complex Set Top Boxes (CSTB) for customer premise equipment (CPE)

Dataset is based on an average of 6 different CSTB types (SFOE, 2015). Power supply unit assumed to be 1.5019 kg/p (UVEK) and router to be 0.58 kg/pcs (UVEK). HDD weight is assumed to be 0.45 kg/p (UVEK). Total weight is therefore 1.42 kg.

Table 9.6-5. Life cycle inventory for Complex Set Top Boxes (CSTB)

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Complex Set Top Boxes (CSTB), for customer premise equipment (CPE)/p/CH U	1	unit				
Input						
Power supply unit, at plant/p/GLO U	0.0803	p		Lognormal	1.26	(2,3,3,2,2,5)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.00176	kg		Lognormal	1.26	(2,3,3,2,2,5)
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	0.00176	kg		Lognormal	1.26	(2,3,3,2,2,5)
Cable, three-conductor cable, at plant/m/GLO U	0.00148	m		Lognormal	1.26	(2,3,3,2,2,5)
Steel, low-alloyed, at plant/RER U	0.00526	kg		Lognormal	1.26	(2,3,3,2,2,5)
Polyethylene, HDPE, granulate, at plant/RER U	0.00045	kg		Lognormal	1.26	(2,3,3,2,2,5)
Polypropylene, granulate, at plant/RER U	0.00045	kg		Lognormal	1.26	(2,3,3,2,2,5)
Polyvinylchloride, at regional storage/RER U	0.00045	kg		Lognormal	1.26	(2,3,3,2,2,5)
Injection moulding/RER U	0.00135	kg		Lognormal	1.26	(2,3,3,2,2,5)
Hot rolling, steel/RER U	0.00526	kg		Lognormal	1.26	(2,3,3,2,2,5)
HDD, desktop computer, at plant/p/GLO U	1.3	p		Lognormal	1.26	(2,3,3,2,2,5)

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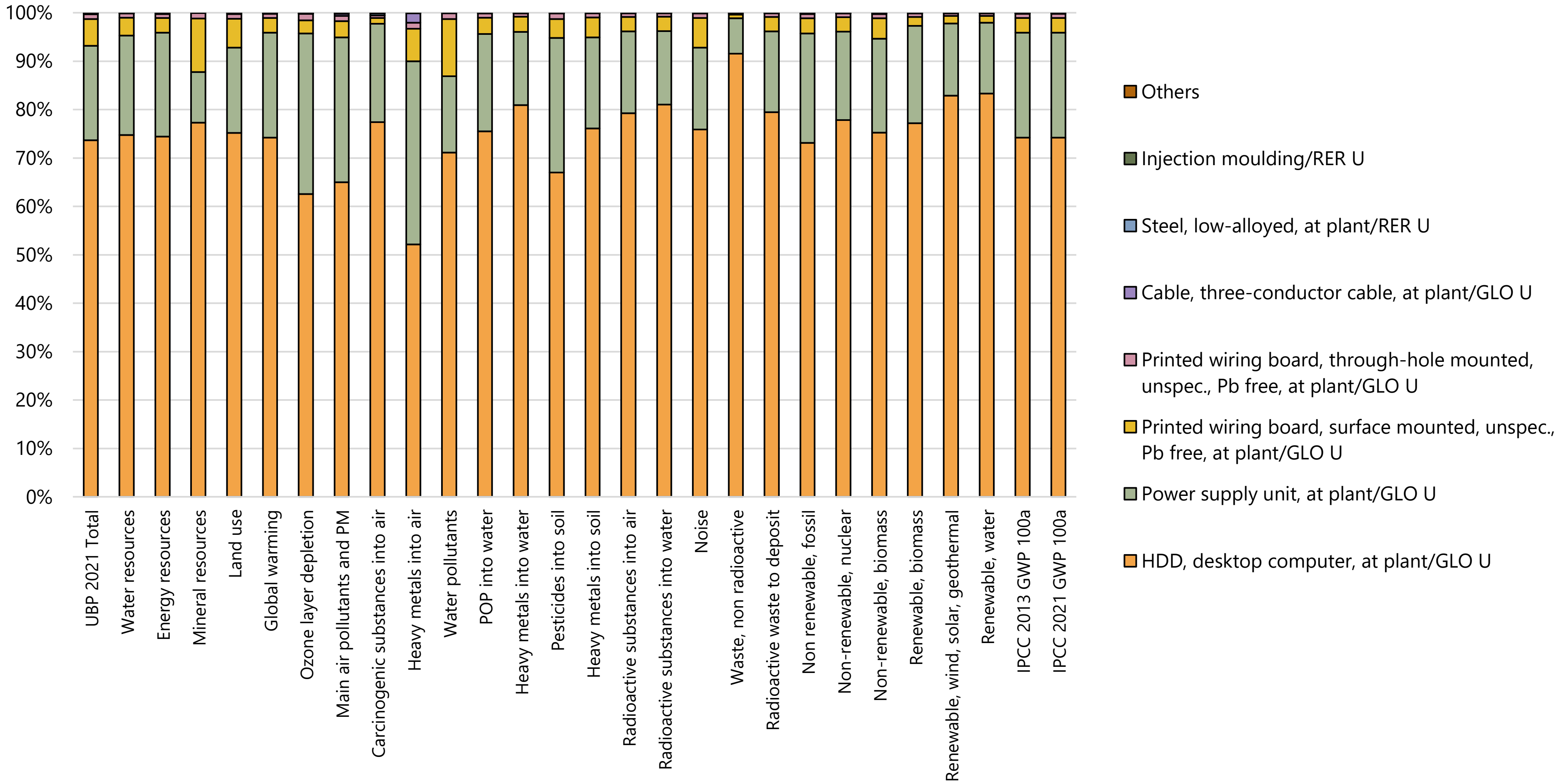

Figure 9.6-3. Contribution analysis presented in bar chart for: Complex Set Top Boxes (CSTB). FU = 1 p

Table 9.6-6. Contribution analysis presented in table for: Complex Set Top Boxes (CSTB). FU = 1 p

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
HDD, desktop computer, at plant/p/GLO U	73%	71%	72%	72%
Power supply unit, at plant/p/GLO U	20%	24%	23%	23%
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	6%	3%	3%	3%
Printed wiring board, through-hole mounted, unspec., Pb free, at plant/kg/GLO U	1%	1%	1%	1%
Cable, three-conductor cable, at plant/m/GLO U	>0%	>0%	>0%	>0%
Steel, low-alloyed, at plant/RER U	>0%	>0%	>0%	>0%
Injection moulding/RER U	>0%	>0%	>0%	>0%
Others	>0%	1%	1%	1%
Total impact, in absolute value	**2.80E+04**	**1.11E+02**	**9.54E+00**	**9.50E+00**

9.6.1.4 Points of presence (PoP), network equipment

PoP is 3% router, 91% network access device, and 6% chassis. Average chassis weight found for three servers is 19 Kg (SFOE, 2015).

Table 9.6-7. Life cycle inventory for Points of presence (PoP), network equipment

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Points of presence, network equipment/kg/GLO U	1	p				
Input						
Router, IP network, at server/p/GLO U	0.03	p		Lognormal	1.26	(2,3,3,2,2,5)
Network access devices, internet, at user/p/GLO/I U	0.91	p		Lognormal	1.26	(2,3,3,2,2,5)
Chassis, network main devices/kg/GLO U	1.14	kg		Lognormal	1.26	(2,3,3,2,2,5)

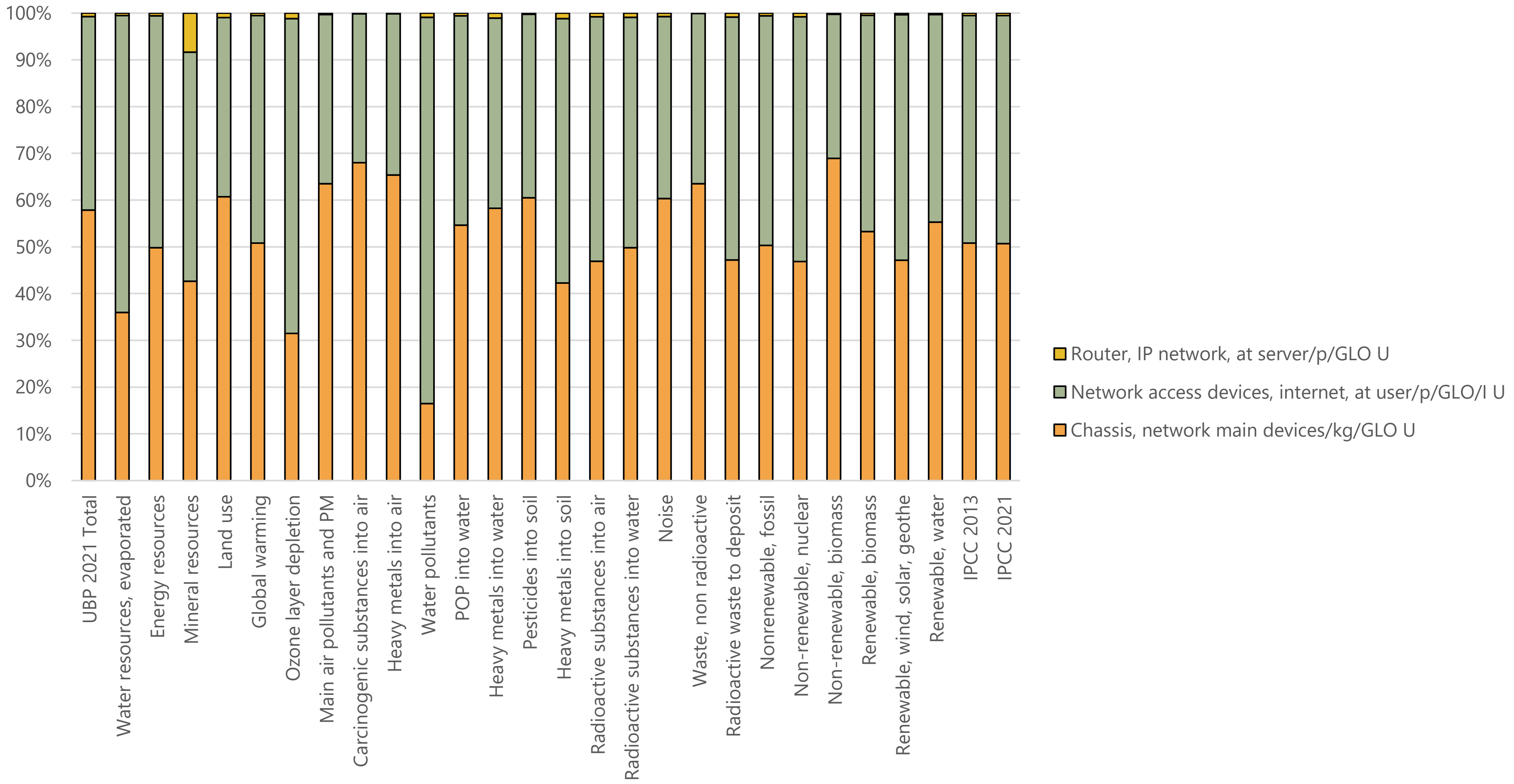

Figure 9.6-4. Contribution analysis presented in bar chart for: Points of presence (PoP), network equipment. FU = 1 kg

Table 9.6-8. Contribution analysis presented in table for: Points of presence (PoP), network equipment. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Chassis, network main devices/kg/GLO U	58%	50%	51%	51%
Network access devices, internet, at user/p/GLO/I U	41%	49%	49%	49%
Router, IP network, at server/p/GLO/I U	1%	1%	1%	1%
Total impact, in absolute value	**4.14E+04**	**1.21E+02**	**1.12E+01**	**1.11E+01**

9.6.2 Use of customer premise equipment (CPE) for transmission network per GB

The dataset corresponds to the amount of equipment and electricity consumed to support a certain amount of network traffic (in GB of data). In literature, they are also often termed as CPE or Customer Premise Equipment. The dataset is based on the number of modems, multimedia gateways, and CSTBs needed to support a certain amount of network traffic in Switzerland for the year 2013 (SFOE, 2015). Total amount of network traffic is based on measured traffic for internet, phone and television broadcast. For television broadcast, data volumes are calculated by multiplying the average television use in minutes with the channel and transmission rates of a specific television channel. The amount of electricity consumed is calculated by multiplying the energy intensity of customer premise equipment (modems, multimedia gateways, and CSTBs) with the number of customer premise equipment (Breide & Helleberg, 2022). The dataset assumes a lifetime of 6 years for all devices (Hischier et al., 2015). Each customer premise equipment is described in section 9.6.1.

Table 9.6-9. Life cycle inventory for Transmission network, CPE use and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of CPE, for transmission network/GB/CH U	1	unit				1 Unit = 1 GB of data
Input						
Multimedia gateway, for customer premise equipment (CPE)/p/CH U	2.64E-6	p		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015
Modem, for customer premise equipment (CPE)/p/CH U	1.13E-5	P		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015
Complex Set Top Boxes (CSTB), for customer premise equipment (CPE)/p/CH U	9.54E-6	p		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015
electricity, low voltage, at grid/kWh/CH U	3.11E-2	kWh		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015

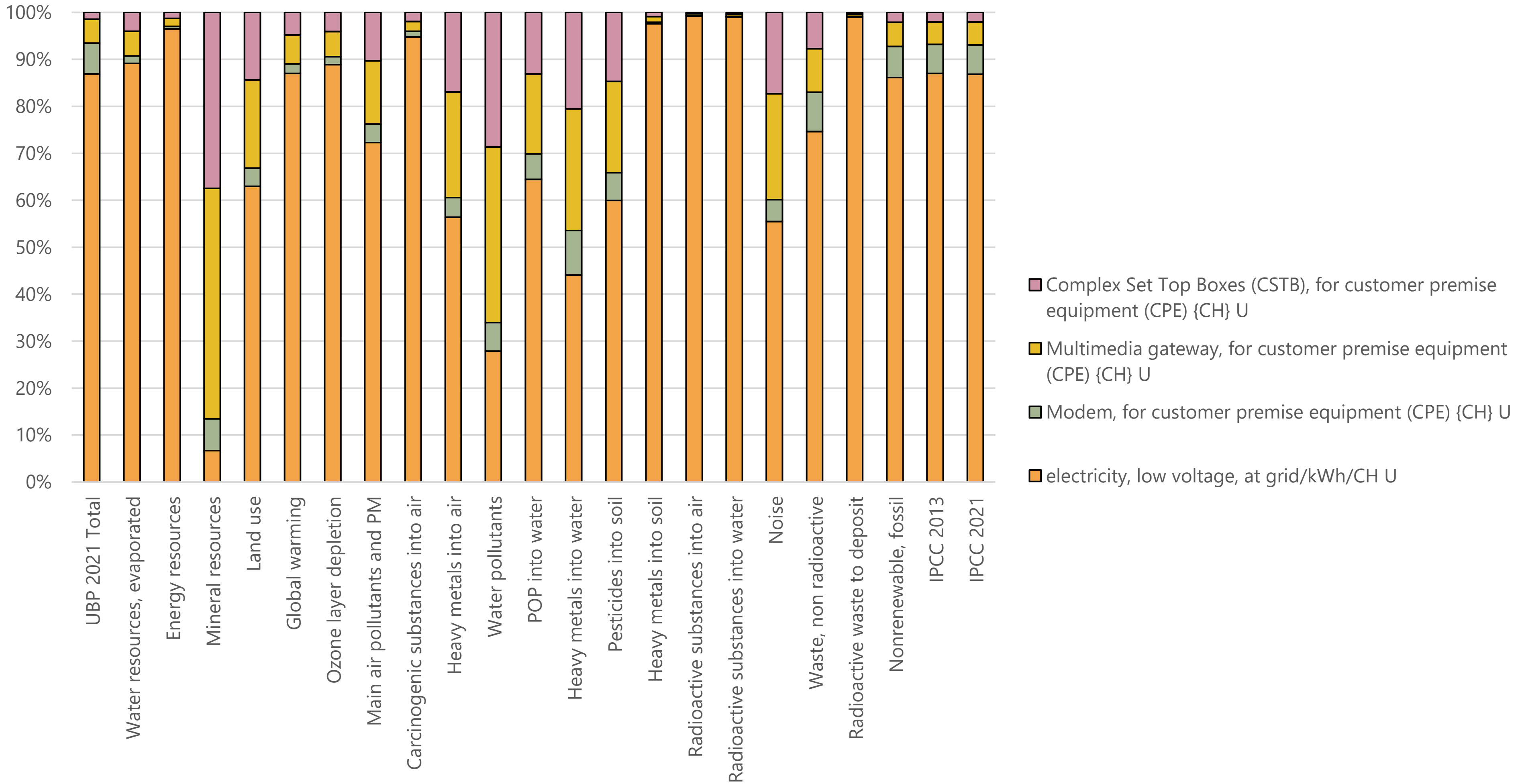

Figure 9.6-5. Contribution analysis presented in bar chart for: Transmission network, CPE use. FU = 1 GB

Table 9.6-10. Contribution analysis presented in table for: Transmission network, CPE use. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	87%	86%	87%	87%
Transmission network, modem/p/CH U	7%	7%	6%	6%
Transmission network, multimedia gateway/p/CH U	5%	5%	5%	5%
Transmission network, CSTB/p/CH U	1%	2%	2%	2%
Total impact, in absolute value	**1.83E+01**	**5.05E-02**	**4.46E-03**	**4.39E-03**

9.6.3 Use of customer premise equipment (CPE) for transmission network per hour

The dataset corresponds to the amount of equipment and electricity for the use of the premise equipment during 1 hour. In literature, they are also often termed as CPE or Customer Premise Equipment. The dataset is based on the share of modems, multimedia gateways, and CSTBs that would be used during 1 hour in Switzerland for the year 2013 (SFOE, 2015). Total amount of network traffic is based on measured traffic for internet, phone and television broadcast. For television broadcast, data volumes are calculated by multiplying the average television use in minutes with the channel and transmission rates of a specific television channel. The amount of electricity consumed is defined by average electricity use of different CPE devices in the US (NRDC, 2013). The dataset assumes a lifetime of 6 years for all devices (Hischier et al., 2015). Each customer premise equipment is described in section 9.6.1.

Table 9.6-11. Life cycle inventory for Use of CPE in transmission network per hour

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of CPE, for transmission network/hr/CH U	1	hr				
Input						
Multimedia gateway, for customer premise equipment (CPE)/p/CH U	2.14E-6	P		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015
Modem, for customer premise equipment (CPE)/p/CH U	9.15E-6	P		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015
Complex Set Top Boxes (CSTB), for customer premise equipment (CPE)/p/CH U	7.72E-6	p		Lognormal	1.23	(2,3,2,2,2,5) Based on SFOE 2015
electricity, low voltage, at grid/kWh/CH U	0.01E-2	kWh		Lognormal	1.23	(2,3,2,2,2,5) Based on NRDC 2013

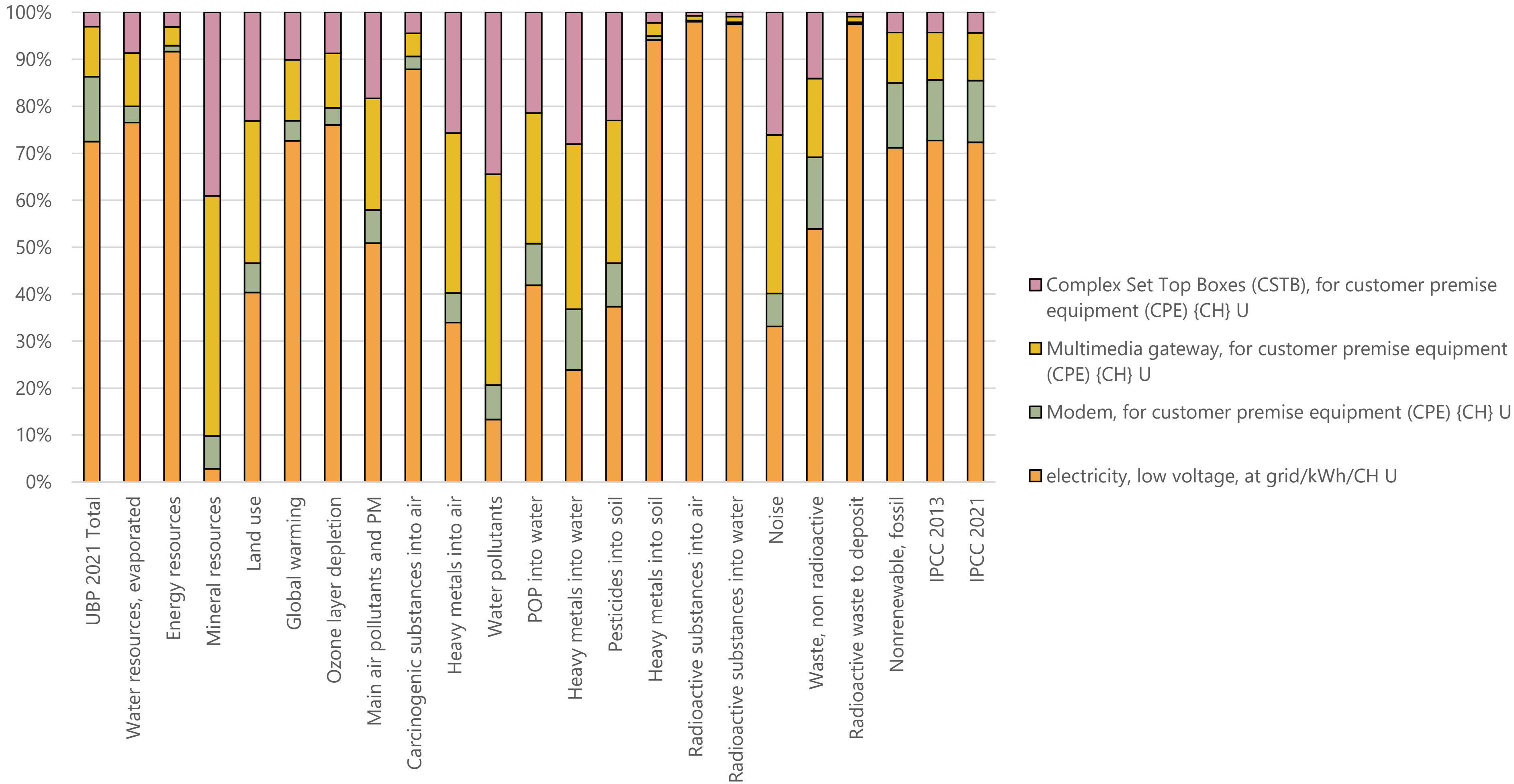

Figure 9.6-6. Contribution analysis presented in bar chart for: Transmission network, CPE use. FU = 1 hr

Table 9.6-12. Contribution analysis presented in table for: Transmission network, CPE use. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	72%	71%	73%	72%
Transmission network, modem/p/CH U	14%	14%	13%	13%
Transmission network, multimedia gateway/p/CH U	11%	11%	10%	10%
Transmission network, CSTB/p/CH U	3%	4%	4%	4%
Total impact, in absolute value	**7.07E+00**	**1.97E-02**	**1.72E-03**	**1.70E-03**

9.6.4 Use of access network from internet providers per GB (IP)

The datasets represents the share of fixed and mobile data transfer on the access network of Switzerland for the year 2020. The total amount of network traffic is based on information from the ITU (ITU, 2020).

Table 9.6-13. Life cycle inventory for the Use of the IP access network, current shares

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of IP access network, shares/GB/CH U	1	Unit				1 Unit = 1 GB of data transfer
Input						
Use of fixed IP access network/GB/CH U	0.82876	Unit		Lognormal	1.23	(2,3,1,2,2,5)
Use of wireless IP access network/GB/CH U	0.16986	Unit		Lognormal	1.23	(2,3,1,2,2,5)

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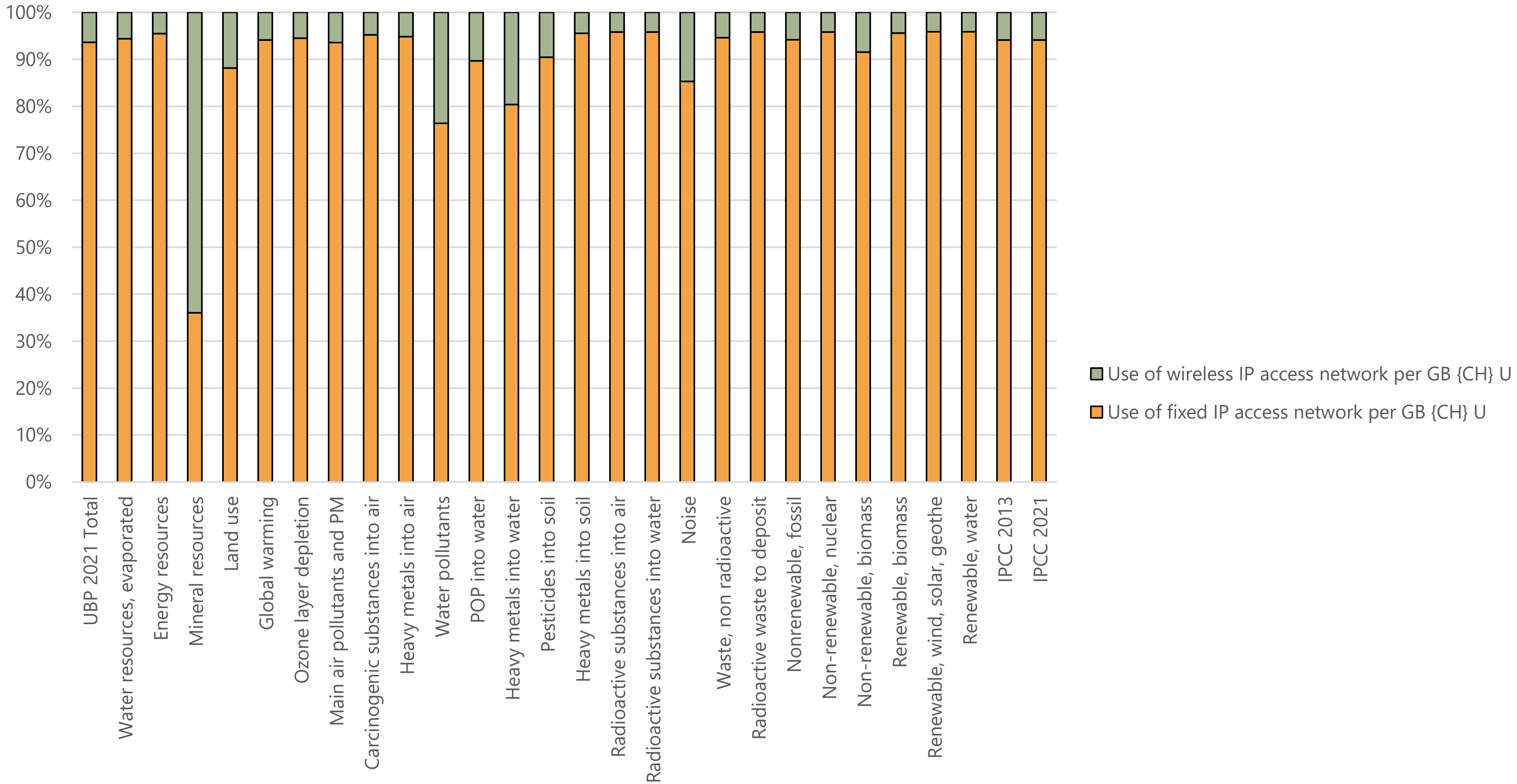

Figure 9.6-7. Contribution analysis presented in bar chart for: Use of IP access network, current shares. FU = 1 GB

Table 9.6-14. Contribution analysis presented in table for: Use of IP access network, current shares. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of fixed IP access network, CH	94%	94%	94%	94%
Use of wireless IP access network, CH	6%	6%	6%	6%
Total impact, in absolute value	**2.46E+02**	**6.72E-01**	**5.9E-02**	**5.79E-02**

9.6.4.1 Use of the fixed IP access network per GB (cable, optic fiber, and xDSL)

The datasets represents the split of fixed IP access network (cable, optic fibre, xDSL) in Switzerland for the reference year of 2014. Each transmission network type will be explained separately below. The share is based on statistics of OECD (https://www.oecd.org/digital/broadband/broadband-statistics/)

Table 9.6-15. Life cycle inventory for the Use of the fixed IP access network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of fixed IP access network/GB/CH U	1	Unit				1 Unit = 1 GB of data transfer
Input						
Use of cable, fixed IP access network/GB/CH U	0.31	Unit		Lognormal	1.23	(2,3,1,2,2,5)
Use of optic fibre, fixed IP access network/GB/CH U	0.09	Unit		Lognormal	1.23	(2,3,1,2,2,5)
Use of xDSL, fixed IP access network/GB/CH U	0.6	Unit		Lognormal	1.23	(2,3,1,2,2,5)

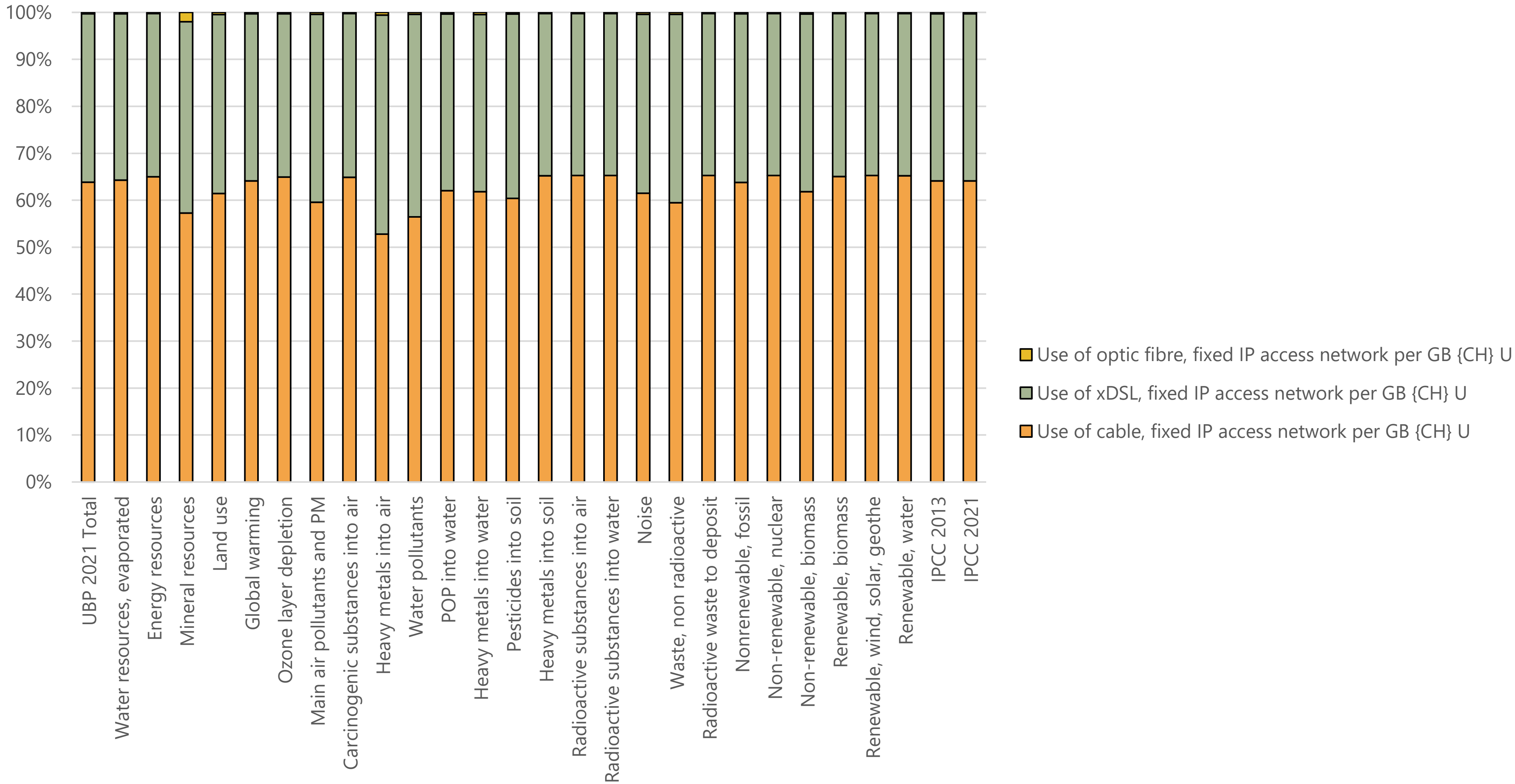

Figure 9.6-8. Contribution analysis presented in bar chart for: Use of the fixed IP access network. FU = 1 GB

Table 9.6-16. Contribution analysis presented in table for:Use of the fixed IP access network. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of cable, fixed IP access network/GB/CH U	64%	64%	64%	64%
Use of xDSL, fixed IP access network/GB/CH U	36%	36%	36%	36%
Use of optic fibre, fixed IP access network/GB/CH U	>1%	>1%	>1%	>1%
Total impact, in absolute value	**2.78E+02**	**7.64E-01**	**6.70E-02**	**6.58E-02**

A. Use of cable, fixed IP access network per GB

The dataset represents the copper cable network in Switzerland. The reference year for network traffic is 2014. The equipment and electricity use is based on information from 2013, but is deemed the most recent publicly available information (SFOE, 2015).

Table 9.6-17. Life cycle inventory for the Use of cable, fixed IP access network per GB

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of cable, fixed IP access network/GB/CH U	1	Unit				1 Unit = 1 GB
Input						
Network access devices, internet, at user/p/CH/I U	7.53E-04	p		Lognormal	1.33	(2,3,3,2,3,5)
Router, IP network, at server/p/CH/I U	6.39E-06	p		Lognormal	1.33	(2,3,3,2,3,5)
Cable, data cable in infrastructure, at plant/m/GLO U	1.23E-02	m		Lognormal	1.33	(2,3,3,2,3,5)
Points of presence (PoP), network equipment/p/GLO U	1.89E-05	p		Lognormal	1.33	(2,3,3,2,3,5)
Electricity/heat						
electricity, low voltage, at grid/kWh/CH U	1.05E+00	kWh		Lognormal	1.33	(2,3,3,2,3,5)

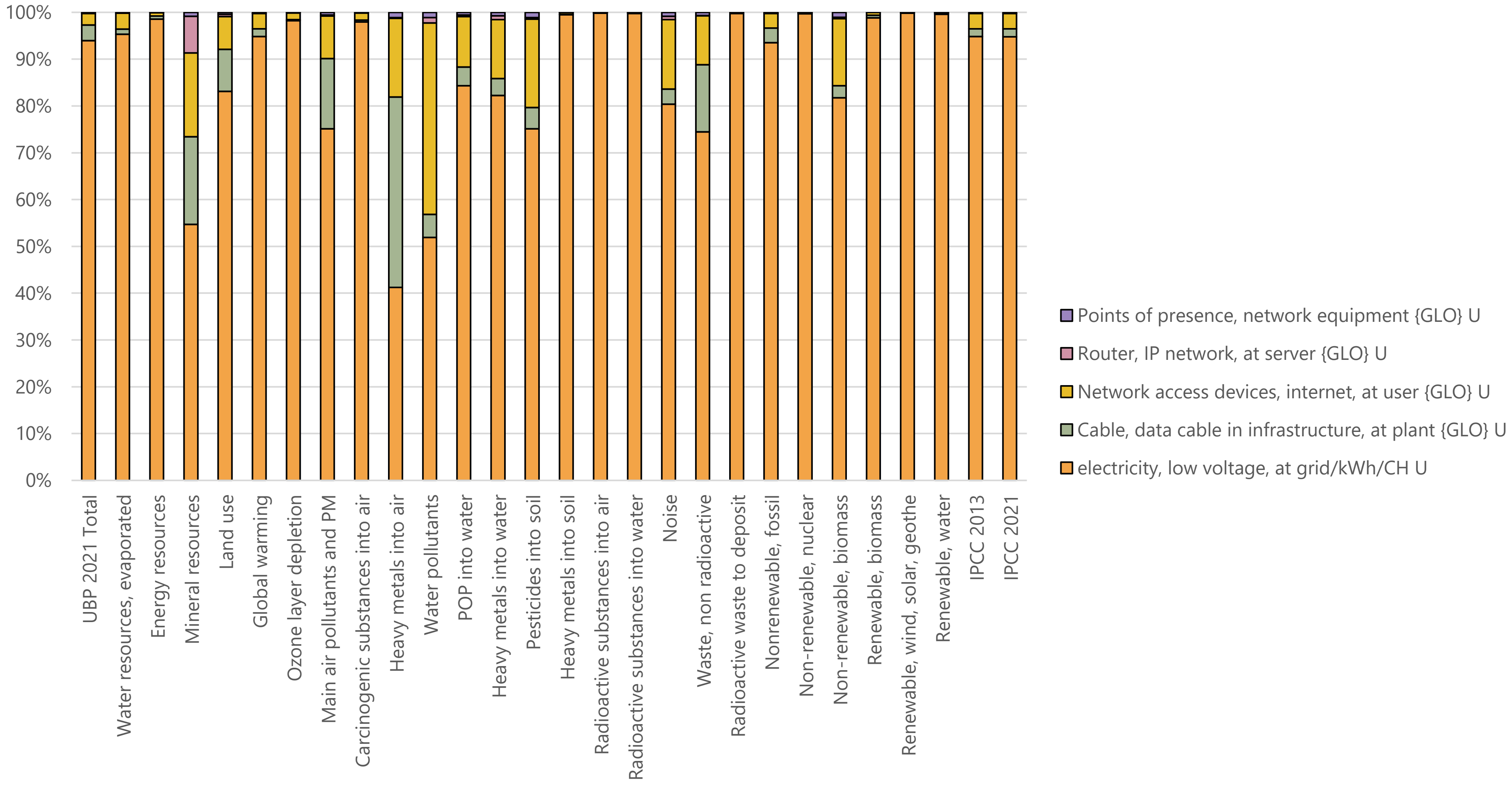

Figure 9.6-9. Contribution analysis presented in bar chart for: Use of cable, fixed IP access network. FU = 1 GB

Table 9.6-18. Contribution analysis presented in table for: Use of cable, fixed IP access network. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	94%	94%	95%	95%
Cable, data cable in infrastructure, at plant/m/GLO U	3%	3%	2%	2%
Network access devices, internet, at user/p/GLO/I U	2%	3%	3%	3%
Router, IP network, at server/p/GLO/I U	>0%	>0%	>0%	>0%
Points of presence (PoP), network equipment/kg/GLO/U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**5.73E+02**	**1.57E+00**	**1.39E-01**	**1.36E-01**

B. Use of optic fiber, fixed IP access network per GB

The dataset represents the use of the optic fiber network in Switzerland. The reference year for network traffic is 2014. The equipment is based on information from 2010 but is deemed the most actual. A lifetime of 6 years is assumed (Müller et al., 2013).

Table 9.6-19. Life cycle inventory for Use of optic fibre, fixed IP access network per GB

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of optic fibre, fixed IP access network/GB/CH U	1	unit				1 Unit = 1 GB of data transfer
Input						
Router, IP network, at server/p/GLO/I U	1.32E-07	p		Lognormal	1.39	(2,3,4,2,3,5)
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	1.41E-09	p		Lognormal	1.39	(2,3,4,2,3,5)
Cable, data cable in infrastructure, at plant/m/GLO U	7.03E-04	m		Lognormal	1.39	(2,3,4,2,3,5)
Server, in data center/p/GLO U	4.92E-07	p		Lognormal	1.39	(2,3,4,2,3,5)
electricity, low voltage, at grid/kWh/CH U	1.39E-02	kWh		Lognormal	1.39	(2,3,4,2,3,5)

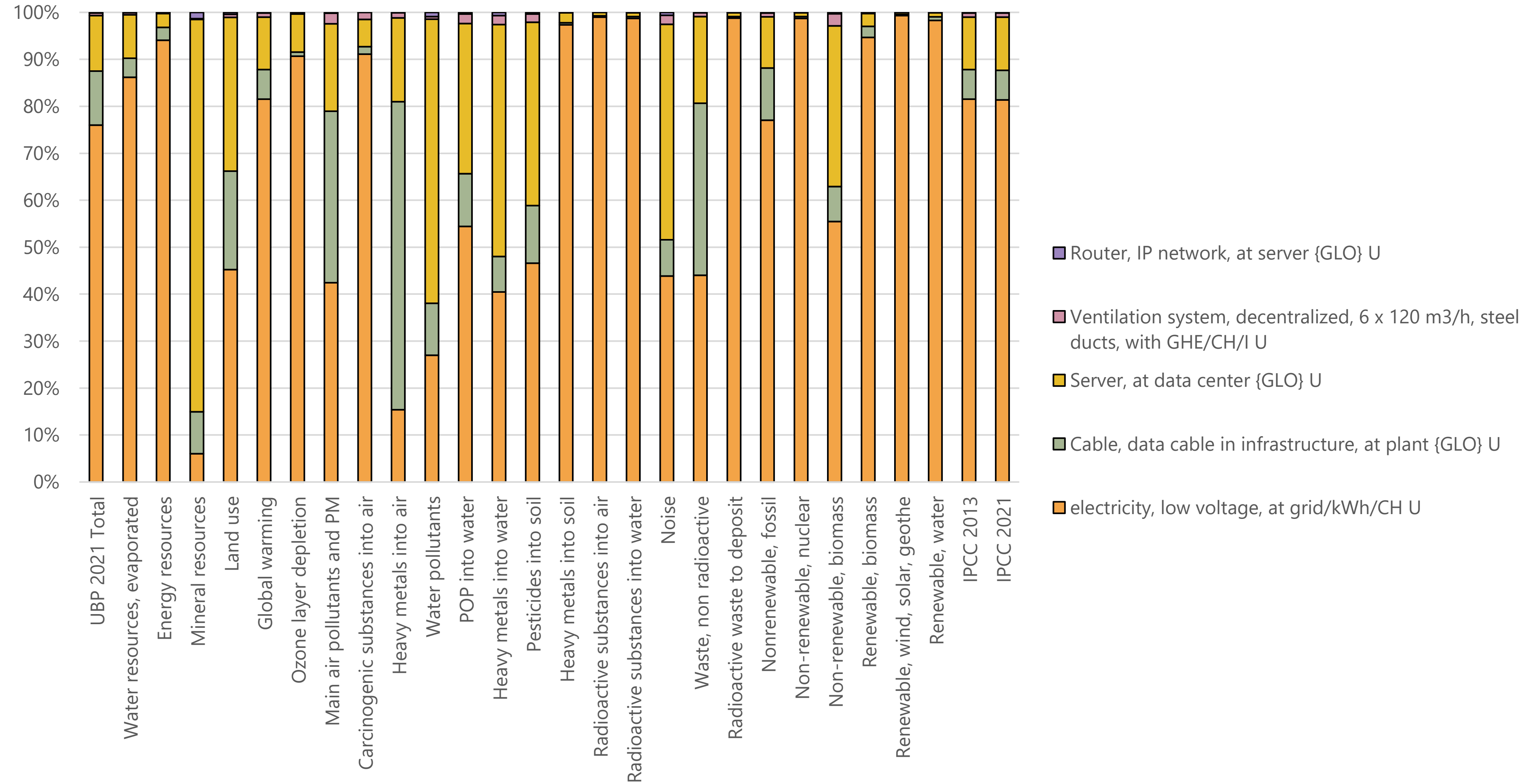

Figure 9.6-10. Contribution analysis presented in bar chart for: Use of optic fibre, fixed IP access network. FU = 1 GB

Table 9.6-20. Contribution analysis presented in table for: Use of optic fibre, fixed IP access network. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	76%	77%	82%	81%
Cable, data cable in infrastructure, at plant/m/GLO U	12%	11%	6%	6%
Server, in data center/p/GLO U	12%	11%	11%	11%
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	1%	1%	1%	1%
Router, IP network, at server/p/GLO/I U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**9.38E+00**	**2.52E-02**	**2.13E-03**	**2.10E-03**

C. Use of xDSL, fixed IP access network per GB

The dataset represents the use of the xDSL network in Switzerland. The reference year for network traffic is 2014. The equipment is based on information from 2010 but is deemed the most actual. A lifetime of 12 years is assumed (Müller et al., 2013). The amount of electricity consumed is assumed to be the same as cable since the main source used does not distinguish between copper and xDSL (Müller et al., 2013). Indeed, both are referred to as "copper network".

Table 9.6-21. Life cycle inventory for Use of xDSL, fixed IP access network per GB

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of xDSL, fixed IP access network/GB/CH U	1	unit				Unit = GB
Input						
Network access devices, internet, at user/p/GLO/I U	4.08E-04	p		Lognormal	1.32	(2,3,4,2,2,5)
Router, IP network, at server/p/GLO/I U	4.10E-07	p		Lognormal	1.32	(2,3,4,2,2,5)
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	4.22E-10	p		Lognormal	1.32	(2,3,4,2,2,5)
Cable, data cable in infrastructure, at plant/m/GLO U	7.65E-03	m		Lognormal	1.32	(2,3,4,2,2,5)
electricity, low voltage, at grid/kWh/CH U	2.86E-01	kWh		Lognormal	1.32	(2,3,4,2,2,5)

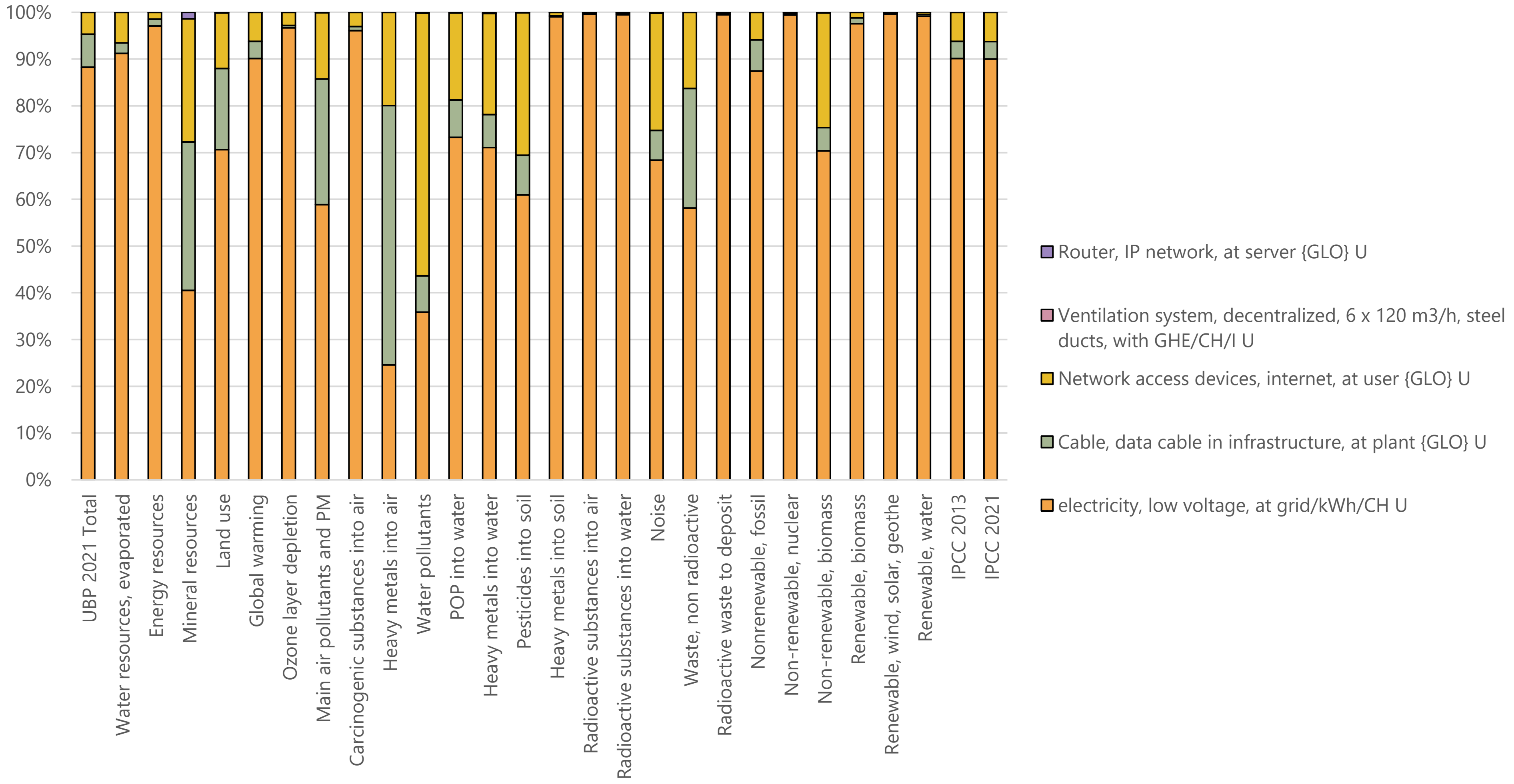

Figure 9.6-11. Contribution analysis presented in bar chart for: Use of xDSL, fixed IP access network. FU = 1 GB

Table 9.6-22. Contribution analysis presented in table for:Use of xDSL, fixed IP access network. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	88%	87%	90%	90%
Cable, data cable in infrastructure, at plant/m/GLO U	7%	7%	4%	4%
Network access devices, internet, at user/p/GLO/I U	5%	6%	6%	6%
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	>0%	>0%	>0%	>0%
Router, IP network, at server/p/GLO/I U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.66E+02**	**4.58E-01**	**3.97E-02**	**3.90E-02**

9.6.4.2 Use of the wireless IP access network (2-4G and 5G) per GB

The datasets represents the split of 2-4G and 5G use of the wireless IP access networks in Switzerland for the year 2020 based on information from Swisscom (Bieser et al., 2020).

Table 9.6-23. Life cycle inventory for Use of wireless IP access network,

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of wireless IP access network/GB/CH U	1	Unit				1 Unit = 1 GB of data transfer
Input						
Use of wireless IP access network, 5G/GB/CH U	0.009	Unit		Lognormal	1.22	(2,2,1,1,1,5)
Use of wireless IP access network, 2-4G/GB/CH U	0.991	Unit		Lognormal	1.22	(2,2,1,1,1,5)

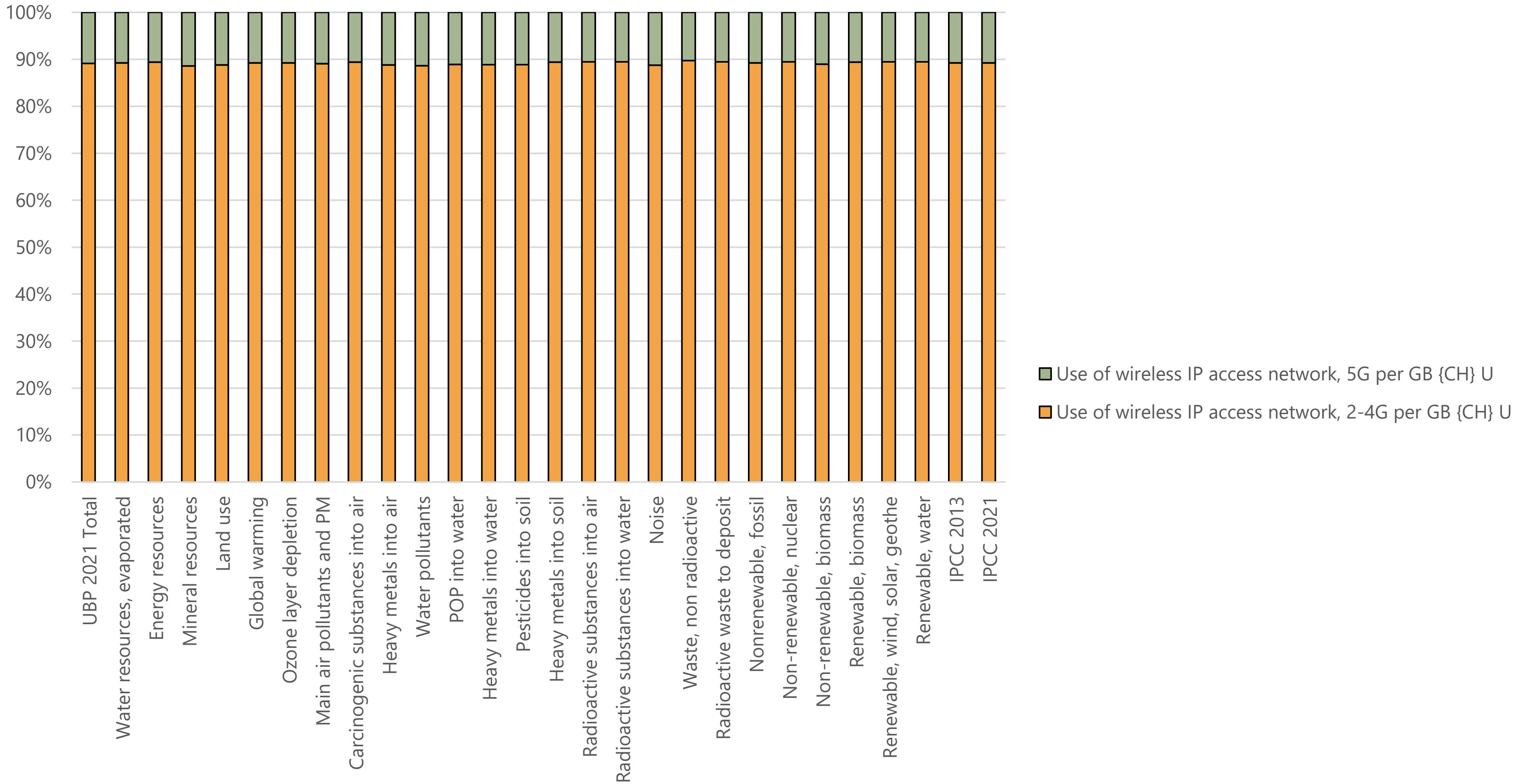

Figure 9.6-12. Contribution analysis presented in bar chart for: Use of wireless IP access network. FU = 1 GB

Table 9.6-24. Life cycle inventory for Use of wireless IP access network

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of wireless IP access network, 2-4G/GB/CH U	89%	89%	89%	89%
Use of wireless IP access network, 5G/GB/CH U	11%	11%	11%	11%
Total impact, in absolute value	**9.20E+01**	**2.31E-01**	**2.04E-02**	**2.01E-02**

A. Use of wireless IP access network, 2-4G per GB

The dataset is based on multiple Swisscom 2-4G sites. The equipment considered are antennas, baseband units, cooling units, indoor cabinets, lead acid battery, PSU indoor cabinet, radio units (Bieser et al., 2020). The amount of electricity consumed is calculated by multiplying the network energy intensity with the total network traffic. The amount of network traffic is based on the statistics of the datahub.itu.int website. It is assumed that the devices have a lifetime of 6 years, similar to the core network and based on a blade server platform (Thinkstep, 2019).

Table 9.6-25. Life cycle inventory for transmission network, access, wireless, 2-4G and the representation in the UVEK database per GB

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of wireless IP access network, 2-4G/GB/CH U	1	unit				1 Unit = 1 GBof data transfer
Input						
Aluminium alloy, AlMg3, at plant/RER U	9.02E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, aluminium/RER U	9.02E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Steel, low-alloyed, at plant/RER U	1.99E-04	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, steel/RER U	1.99E-04	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	9.41E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	9.41E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Injection moulding/RER U	1.87E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	3.22E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Copper, primary, at refinery/RER U	3.75E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Wire drawing, copper/RER U	3.75E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Chromium steel 18/8, at plant/RER U	7.20E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, chromium steel/RER U	7.20E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Cast iron, at plant/RER U	3.50E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Synthetic rubber, at plant/RER U	5.38E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polystyrene, general purpose, GPPS, at plant/RER U	5.38E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	5.38E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polypropylene, granulate, at plant/RER U	3.02E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Router, IP network, at server/CH/I U	4.27E-07	p		Lognormal	1.22	(2,2,2,2,1,5)
Power adapter, for laptop, at plant	2.92E-05	p		Lognormal	1.22	(2,2,2,2,1,5)
Cable, data cable in infrastructure, at plant/m/GLO U	6.92E-05	m		Lognormal	1.22	(2,2,2,2,1,5)
electricity, low voltage, at grid/kWh/CH U	9.27E-2	kWh		Lognormal	1.22	(2,2,2,2,1,5)

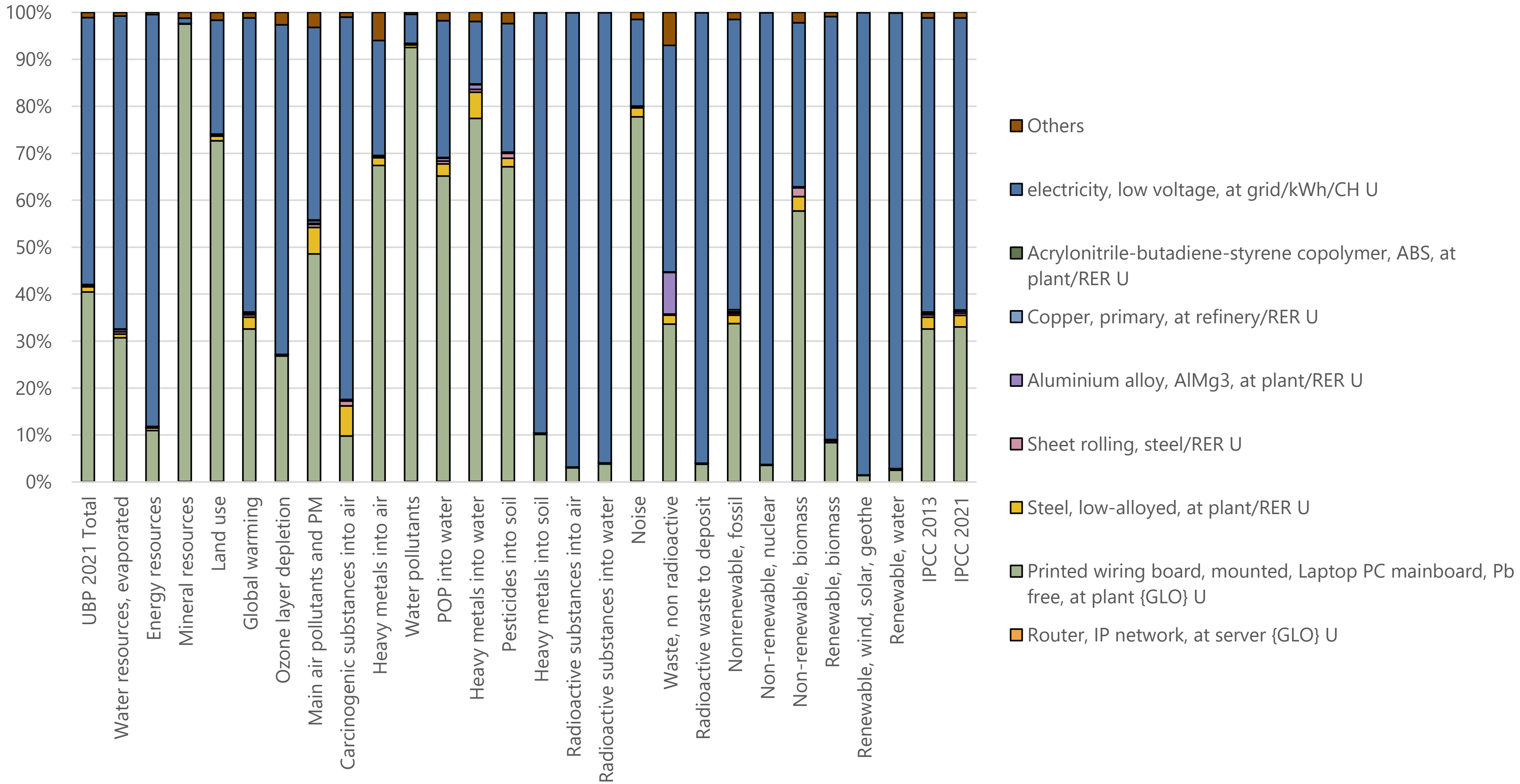

Figure 9.6-13. Contribution analysis presented in bar chart for: Use of wireless IP access network. FU = 1 GB

Table 9.6-26. Contribution analysis presented in table for: Use of wireless IP access network, 2-4G. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	57%	62%	63%	62%
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	40%	34%	33%	33%
Steel, low-alloyed, at plant/RER U	1%	2%	3%	3%
Sheet rolling, steel/RER U	>0%	>0%	>0%	>0%
Aluminium alloy, AlMg3, at plant/RER U	>0%	>0%	>0%	>0%
Copper, primary, at refinery/RER U	>0%	>0%	>0%	>0%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	>0%	>0%	>0%	>0%
Others	1%	1%	1%	1%
Total impact, in absolute value	**8.28E+01**	**2.08E-01**	**1.83E-02**	**1.81E-02**

B. Use of wireless IP access network, 5G per GB

The dataset is based on multiple Swisscom 5G sites. The equipment considered are antennas, baseband units, cooling units, indoor cabinets, lead acid battery, PSU indoor cabinet, radio units (Bieser et al., 2020). The amount of electricity consumed is calculated by multiplying the network energy intensity with the total network traffic. The amount of network traffic is based on the statistics of the datahub.itu.int website. It is assumed that the devices have a lifetime of 6 years, similar to the core network and based on a blade server platform (Thinkstep, 2019).

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Table 9.6-27. Life cycle inventory for Use of wireless IP access network, 5G per GB

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of wireless IP access network, 5G/GB/CH U	1	unit				1 Unit = 1 GB of data transfer
Input						
Aluminium alloy, AlMg3, at plant/RER U	4.98E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, aluminium/RER U	4.98E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Steel, low-alloyed, at plant/RER U	2.46E-03	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, steel/RER U	2.46E-03	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	7.40E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	7.40E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Injection moulding/RER U	1.47E-04	kg		Lognormal	1.22	(2,2,2,2,1,5)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	4.58E-04	kg		Lognormal	1.22	(2,2,2,2,1,5)
Copper, primary, at refinery/RER U	5.34E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Wire drawing, copper/RER U	5.34E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Chromium steel 18/8, at plant/RER U	1.67E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, chromium steel/RER U	1.67E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Cast iron, at plant/RER U	8.13E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Synthetic rubber, at plant/RER U	1.25E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polystyrene, general purpose, GPPS, at plant/RER U	1.25E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	1.25E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polypropylene, granulate, at plant/RER U	7.25E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Router, IP network, at server/CH/I U	1.12E-04	p		Lognormal	1.22	(2,2,2,2,1,5)
Power adapter, for laptop, at plant	6.78E-04	P		Lognormal	1.22	(2,2,2,2,1,5)
Cable, data cable in infrastructure, at plant/m/GLO U	2.15E-03	m		Lognormal	1.22	(2,2,2,2,1,5)
electricity, low voltage, at grid/kWh/CH U	1.20E+00	kWh		Lognormal	1.22	(2,2,2,2,1,5)

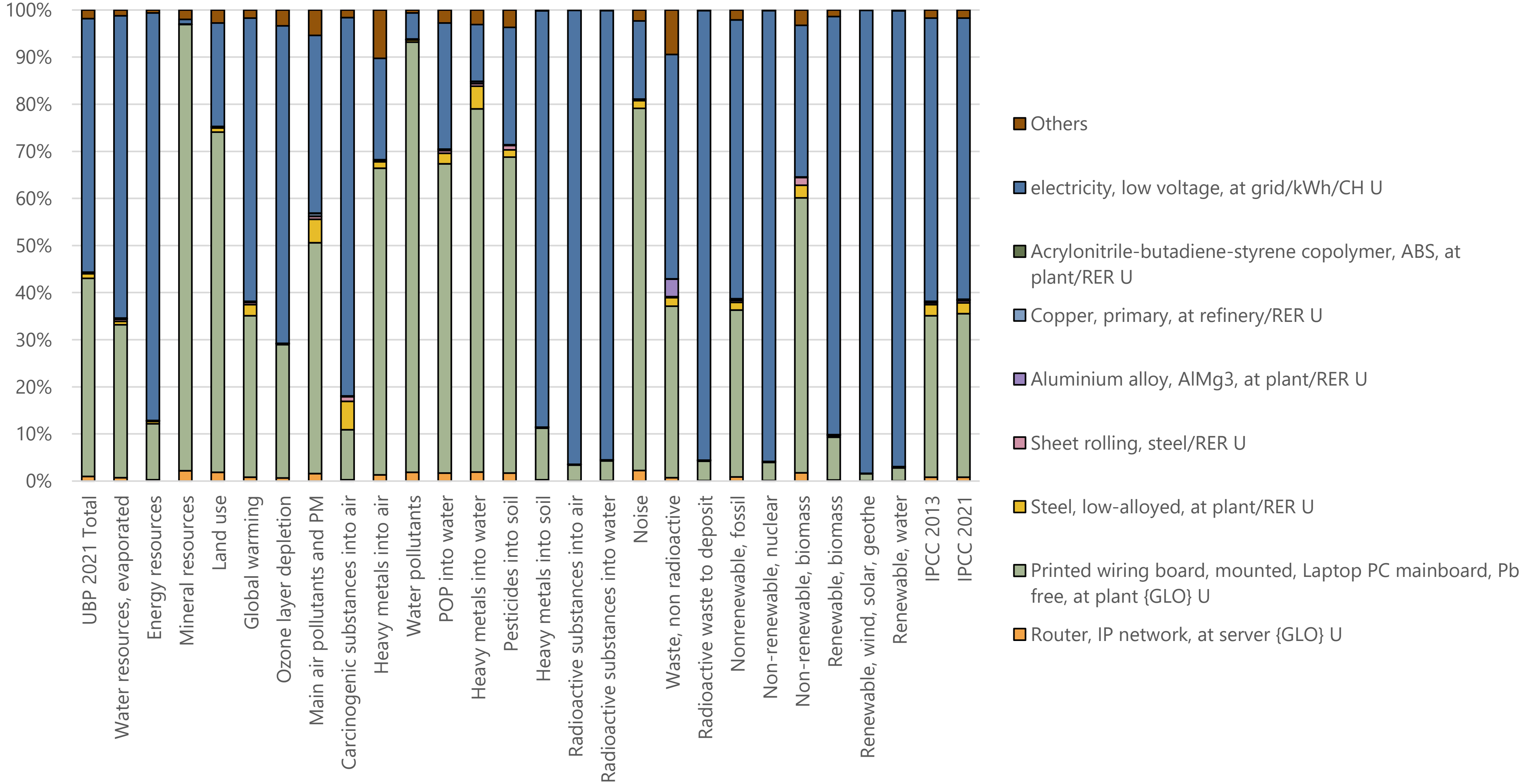

Figure 9.6-14. Contribution analysis presented in bar chart for: Use of wireless IP access network, 5G. FU = 1 GB

Table 9.6-28. Contribution analysis presented in table for: Use of wireless IP access network, 5G. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	54%	59%	60%	60%
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	42%	35%	34%	35%
Steel, low-alloyed, at plant/RER U	1%	2%	2%	2%
Sheet rolling, steel/RER U	>0%	>0%	>0%	>0%
Aluminium alloy, AlMg3, at plant/RER U	>0%	>0%	>0%	>0%
Copper, primary, at refinery/RER U	>0%	>0%	>0%	>0%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	>0%	>0%	>0%	>0%
Others	>2%	>2%	>2%	>2%
Total impact, in absolute value	**1.11E+03**	**2.76E+00**	**2.44E-01**	**2.41E-01**

9.6.5 Use of access network from internet providers per hour (IP)

The datasets represents the share of fixed and mobile data transfer on the access network of Switzerland for the year 2020. The total amount of network traffic and number of users is based on information from the ITU (ITU, 2020). The number of hours in a year is set at 8760 hours.

Table 9.6-29. Life cycle inventory for the Use of the IP access network, current shares

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of IP access network, shares/hr/CH U	1	hr				r
Input						
Use of fixed IP access network/hr/CH U	0.82876	hr		Lognormal	1.23	(2,3,1,2,2,5)
Use of wireless IP access network/hr/CH U	0.16986	hr		Lognormal	1.23	(2,3,1,2,2,5)

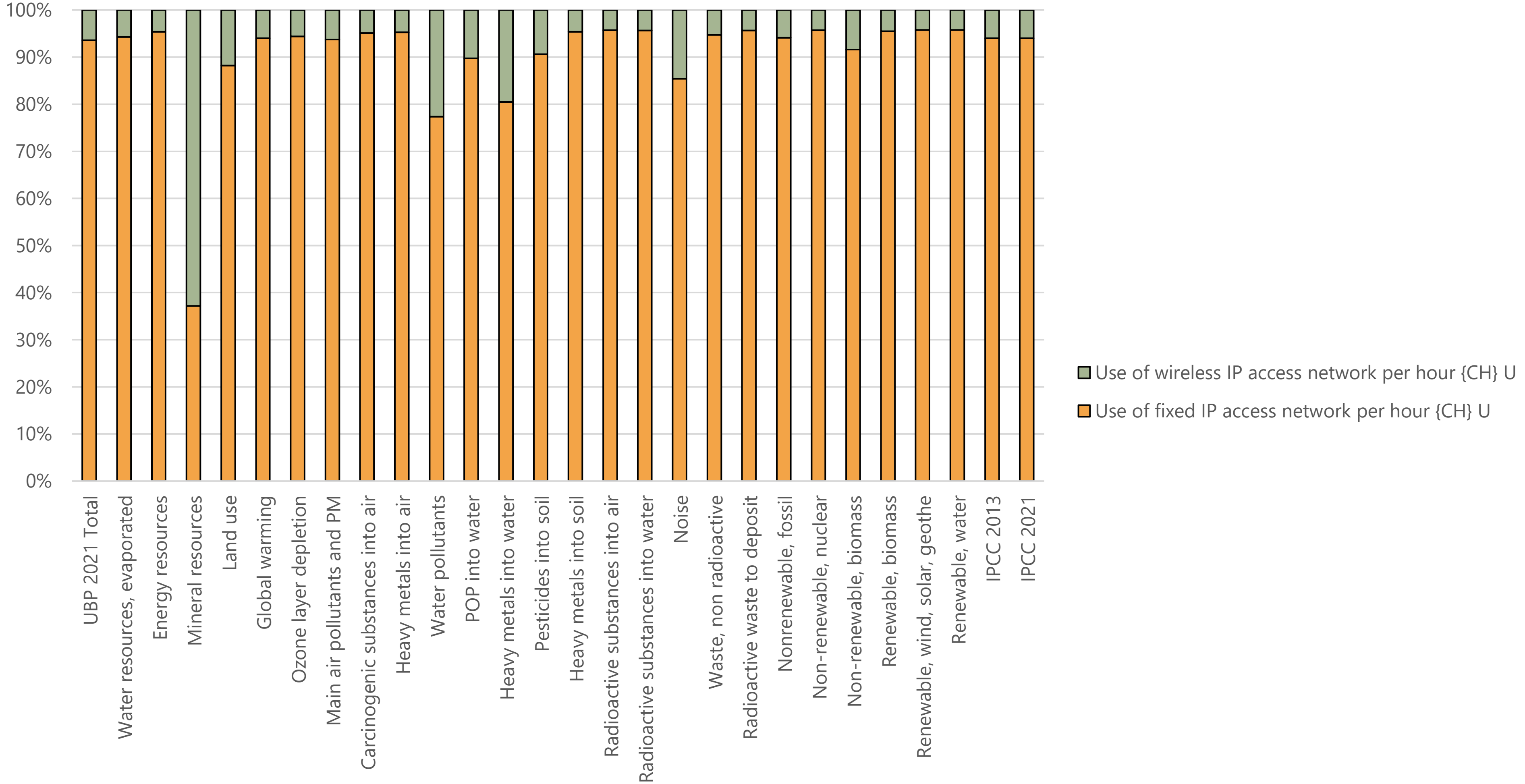

Figure 9.6-15. Contribution analysis presented in bar chart for: Use of IP access network, current shares. FU = 1 hr

Table 9.6-30. Contribution analysis presented in table for: Use of IP access network, current shares. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of fixed IP access network, CH	94%	94%	94%	94%
Use of wireless IP access network, CH	6%	6%	6%	6%
Total impact, in absolute value	**3.72E+00**	**1.02E-02**	**8.88E-04**	**8.72E-04**

9.6.5.1 Use of the fixed IP access network per hr (cable, optic fiber, and xDSL)

The datasets represents the split of fixed IP access network (cable, optic fibre, xDSL) in Switzerland for the reference year of 2014. Each transmission network type will be explained separately below. The share is based on statistics of OECD (https://www.oecd.org/digital/broadband/broadband-statistics/)

Table 9.6-31. Life cycle inventory for the Use of the fixed IP access network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of fixed IP access network/hr/CH U	1	hr				
Input						
Use of cable, fixed IP access network/hr/CH U	0.31	hr		Lognormal	1.23	(2,3,1,2,2,5)
Use of optic fibre, fixed IP access network/hr/CH U	0.09	hr		Lognormal	1.23	(2,3,1,2,2,5)
Use of xDSL, fixed IP access network/hr/CH U	0.6	hr		Lognormal	1.23	(2,3,1,2,2,5)

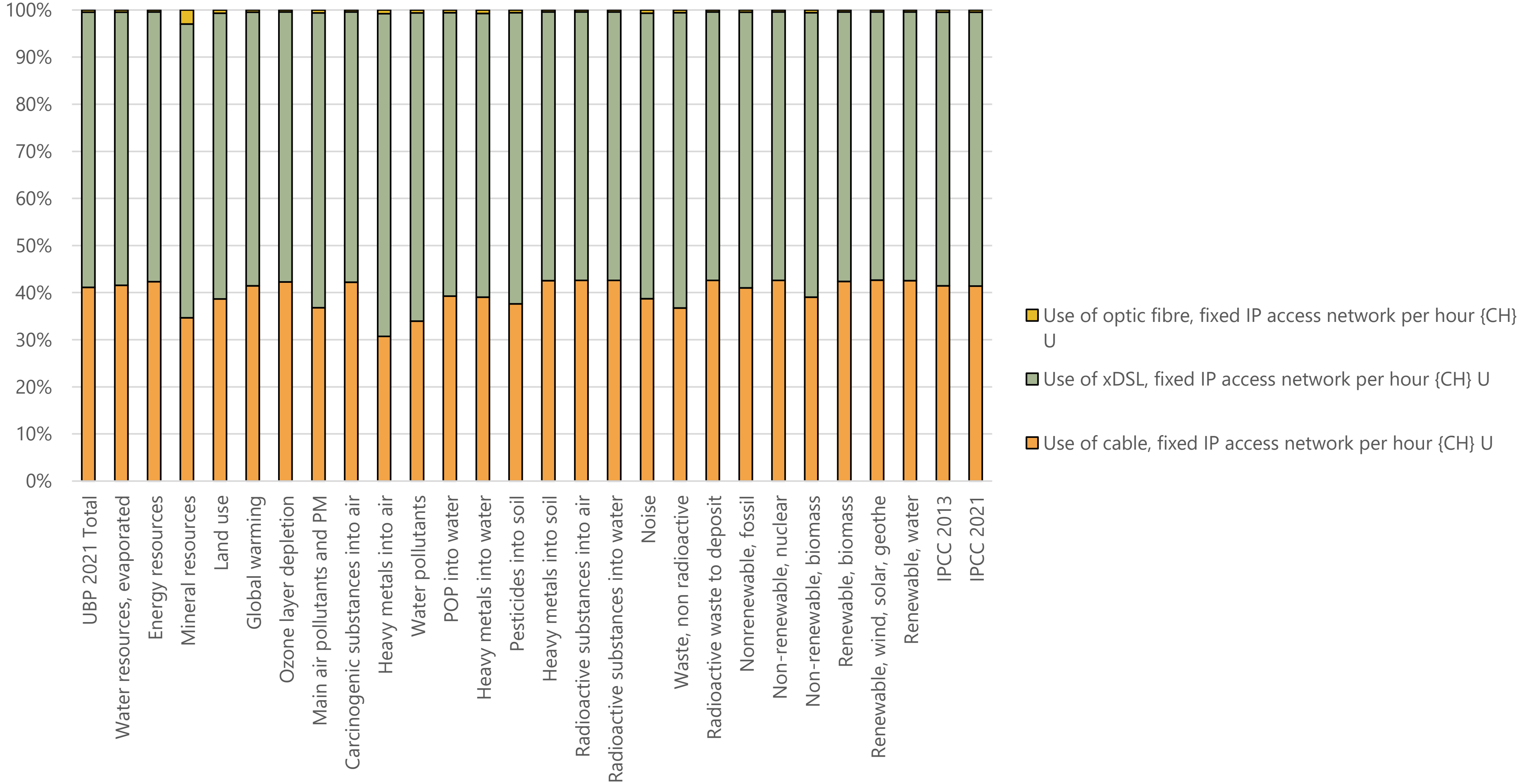

Figure 9.6-16. Contribution analysis presented in bar chart for: Use of the fixed IP access network. FU = 1 hr

Table 9.6-32. Contribution analysis presented in table for:Use of the fixed IP access network. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of xDSL, fixed IP access network/hr/CH U	58%	58%	58%	58%
Use of cable, fixed IP access network/hr/CH U	41%	41%	41%	41%
Use of optic fibre, fixed IP access network/hr/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**4.20E+00**	**1.15E-02**	**1.01E-03**	**9.90E-04**

A. Use of cable, fixed IP access network

The dataset represents the copper cable network in Switzerland. The reference year for network traffic is 2014. The equipment and electricity use is based on information from 2013, but is deemed the most recent publicly available information (SFOE, 2015). The considered number of subscribers for the entire network (~1.35 millions) is based on statistics from 2013 that are provided by the OECD interactive toolkit (https://www.oecd.org/digital/broadband/broadband-statistics/).

Table 9.6-33. Life cycle inventory for the Use of cable, fixed IP access network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of cable, fixed IP access network/hr/CH U	1	hr				
Input						
Network access devices, internet, at user/p/CH/I U	7.31E-06	p		Lognormal	1.33	(2,3,3,2,3,5)
Router, IP network, at server/p/CH/I U	6.21E-08	p		Lognormal	1.33	(2,3,3,2,3,5)
Cable, data cable in infrastructure, at plant/m/GLO U	1.20E-04	m		Lognormal	1.33	(2,3,3,2,3,5)
Points of presence (PoP), network equipment/p/GLO U	1.84E-07	p		Lognormal	1.33	(2,3,3,2,3,5)
Electricity/heat						
electricity, low voltage, at grid/kWh/CH U	1.02E-02	kWh		Lognormal	1.33	(2,3,3,2,3,5)

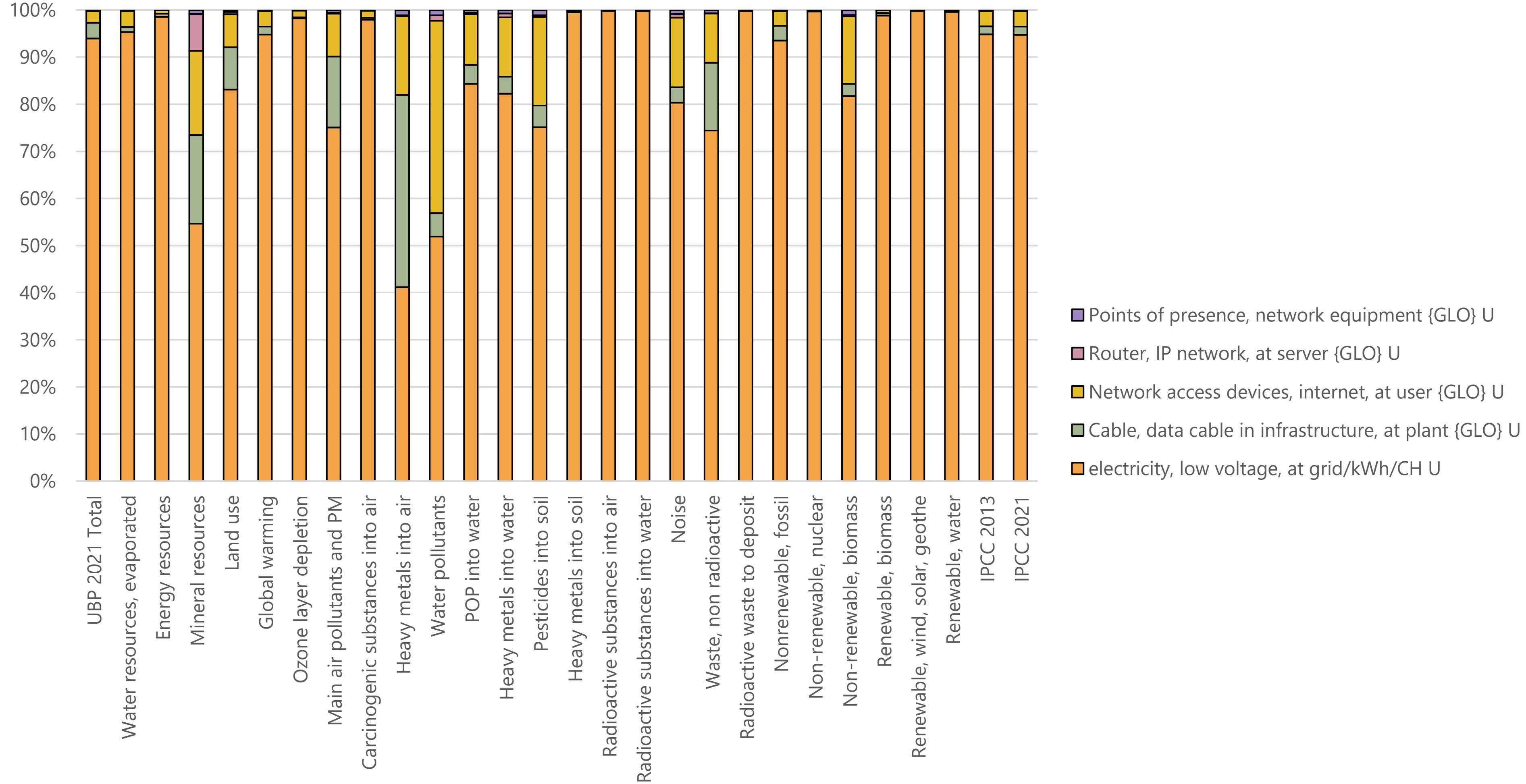

Figure 9.6-17. Contribution analysis presented in bar chart for: Use of cable, fixed IP access network. FU = 1 hr

Table 9.6-34. Contribution analysis presented in table for: Use of cable, fixed IP access network. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	94%	93%	95%	95%
Cable, data cable in infrastructure, at plant/m/GLO U	3%	3%	2%	2%
Network access devices, internet, at user/p/GLO/I U	2%	3%	3%	3%
Router, IP network, at server/p/GLO/I U	>0%	>0%	>0%	>0%
Points of presence (PoP), network equipment/kg/GLO/U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**5.57E+00**	**1.53E-02**	**1.35E-03**	**1.32E-03**

B. Use of optic fiber, fixed IP access network

The dataset represents the use of the optic fiber network in Switzerland. The reference year for network traffic is 2014. The equipment is based on information from 2010 but is deemed the most actual. A lifetime of 6 years is assumed (Müller et al., 2013). The considered number of subscribers for the entire network (~0.34 millions) is based on statistics from 2014 that are provided by the OECD interactive toolkit (https://www.oecd.org/digital/broadband/broadband-statistics/).

Table 9.6-35. Life cycle inventory for Use of optic fibre, fixed IP access network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of optic fibre, fixed IP access network/hr/CH U	1	hr				
Input						
Router, IP network, at server/p/GLO/I U	3.15E-09	p		Lognormal	1.39	(2,3,4,2,3,5)
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	3.36E-11	p		Lognormal	1.39	(2,3,4,2,3,5)
Cable, data cable in infrastructure, at plant/m/GLO U	1.68E-05	m		Lognormal	1.39	(2,3,4,2,3,5)
Server, in data center/p/GLO U	1.18E-08	p		Lognormal	1.39	(2,3,4,2,3,5)
electricity, low voltage, at grid/kWh/CH U	3.31E-04	kWh		Lognormal	1.39	(2,3,4,2,3,5)

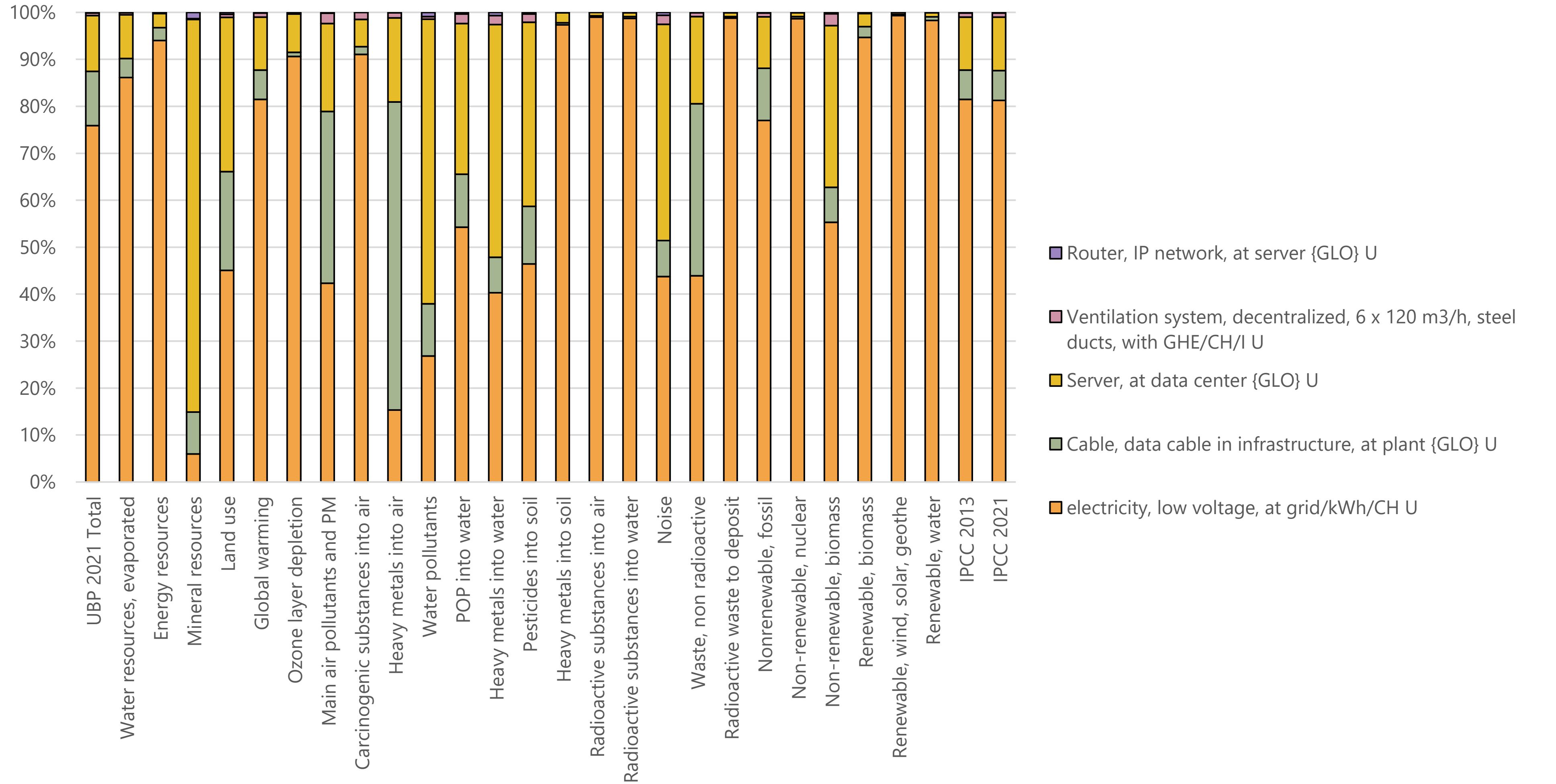

Figure 9.6-18. Contribution analysis presented in bar chart for: Use of optic fibre, fixed IP access network. FU = 1 hr

Table 9.6-36. Contribution analysis presented in table for: Use of optic fibre, fixed IP access network. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	76%	77%	81%	81%
Server, in data center/p/GLO U	12%	11%	11%	11%
Cable, data cable in infrastructure, at plant/m/GLO U	12%	11%	6%	6%
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	1%	1%	1%	1%
Router, IP network, at server/p/GLO/I U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**2.24E-01**	**6.02E-04**	**5.08E-05**	**5.00E-05**

C. Use of xDSL, fixed IP access network

The dataset represents the use of the xDSL network in Switzerland. The reference year for network traffic is 2014. The equipment is based on information from 2010 but is deemed the most actual. A lifetime of 12 years is assumed (Müller et al., 2013). The considered number of subscribers for the entire network (~2.2 millions) is based on statistics from 2014 that are provided by the OECD interactive toolkit (https://www.oecd.org/digital/broadband/broadband-statistics/).

Table 9.6-37. Life cycle inventory for Use of xDSL, fixed IP access network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of xDSL, fixed IP access network/hr/CH U	1	hr				
Input						
Network access devices, internet, at user/p/GLO/I U	1.00E-05	p		Lognormal	1.32	(2,3,4,2,2,5)
Router, IP network, at server/p/GLO/I U	1.01E-08	p		Lognormal	1.32	(2,3,4,2,2,5)
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	1.04E-11	p		Lognormal	1.32	(2,3,4,2,2,5)
Cable, data cable in infrastructure, at plant/m/GLO U	1.88E-04	m		Lognormal	1.32	(2,3,4,2,2,5)
electricity, low voltage, at grid/kWh/CH U	7.03E-03	kWh		Lognormal	1.32	(2,3,4,2,2,5)

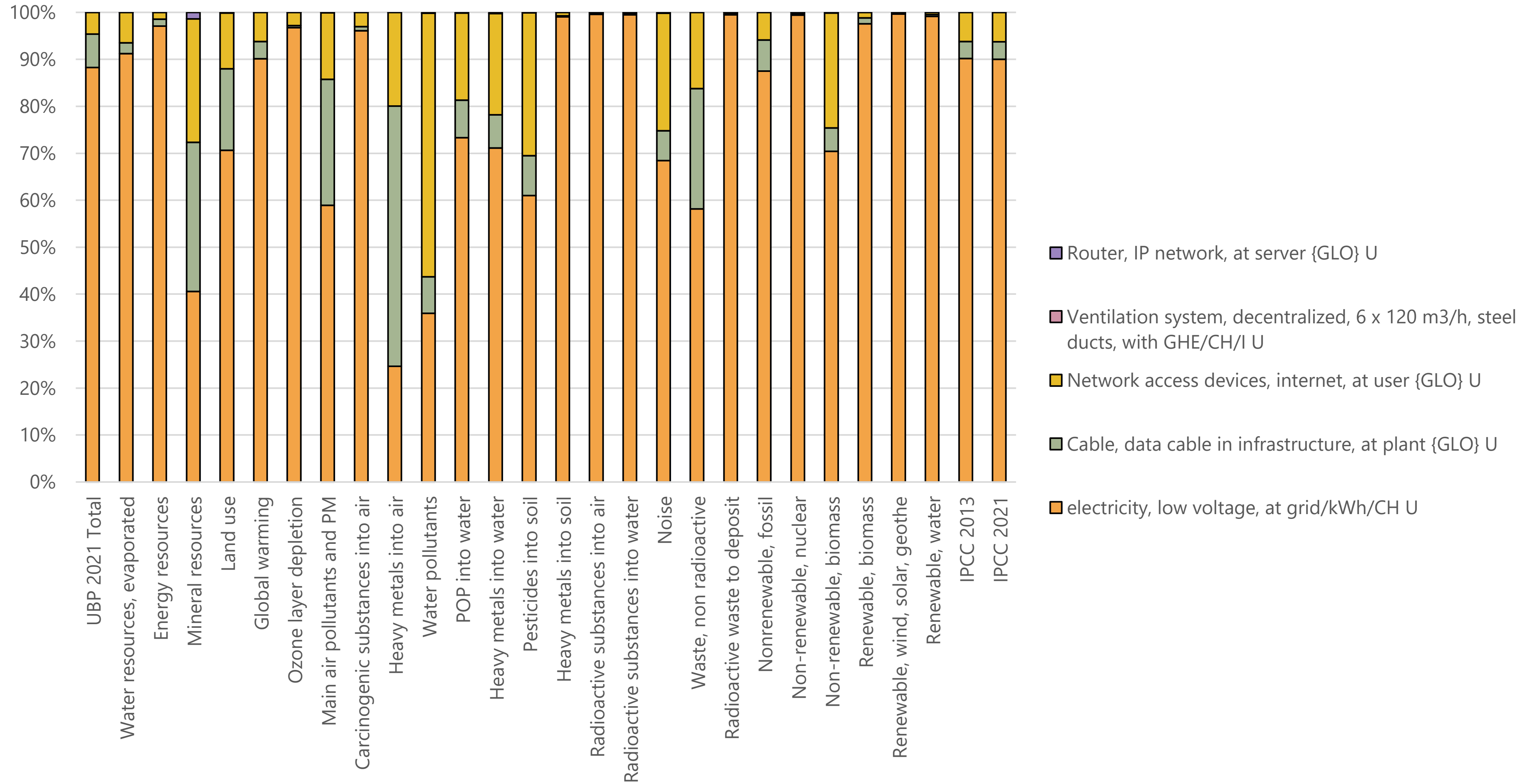

Figure 9.6-19. Contribution analysis presented in bar chart for: Use of xDSL, fixed IP access network. FU = 1 hr

Table 9.6-38. Contribution analysis presented in table for:Use of xDSL, fixed IP access network. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	88%	87%	90%	90%
Cable, data cable in infrastructure, at plant/m/GLO U	7%	7%	4%	4%
Network access devices, internet, at user/p/GLO/I U	5%	6%	6%	6%
Ventilation system, decentralized, 6 x 120 m3/h, steel ducts, with GHE/CH/I U	>0%	>0%	>0%	>0%
Router, IP network, at server/p/GLO/I U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**4.08E+00**	**1.12E-02**	**9.76E-04**	**9.59E-04**

9.6.5.2 Use of the wireless IP access network (2-4G and 5G) per hour

The datasets represents the split of 2-4G and 5G use of the wireless IP access networks in Switzerland for the year 2020 based on information from Swisscom (Bieser et al., 2020).

Table 9.6-39. Life cycle inventory for Use of wireless IP access network,

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of wireless IP access network/hr/CH U	1	hr				
Input						
Use of wireless IP access network, 5G/hr/CH U	0.009	hr		Lognormal	1.22	(2,2,1,1,1,5)
Use of wireless IP access network, 2-4G/hr/CH U	0.991	hr		Lognormal	1.22	(2,2,1,1,1,5)

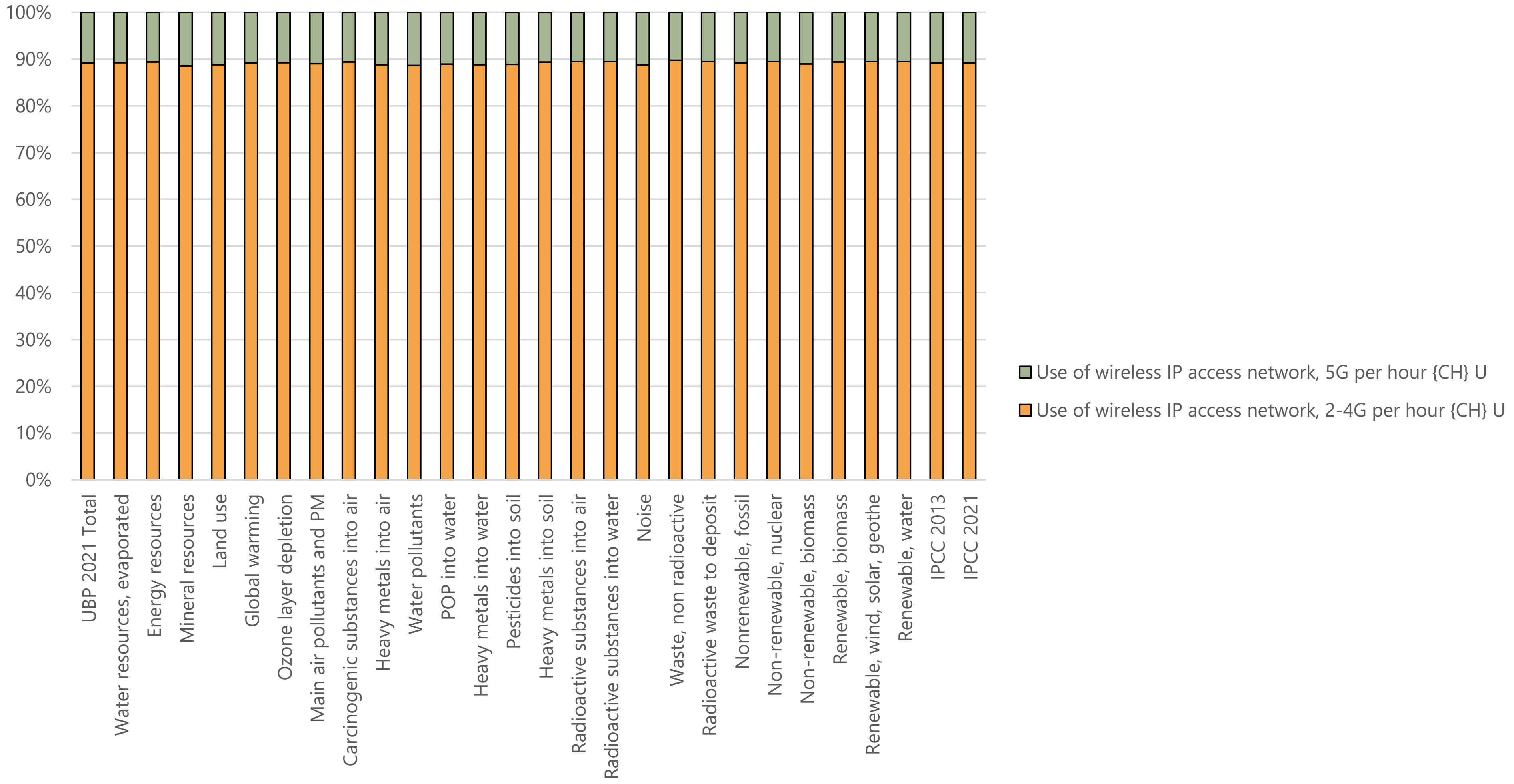

Figure 9.6-20. Contribution analysis presented in bar chart for: Use of wireless IP access network. FU = 1 hr

Table 9.6-40. Life cycle inventory for Use of wireless IP access network per hour

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of wireless IP access network, 2-4G/hr/CH U	89%	89%	89%	89%
Use of wireless IP access network, 5G/hr/CH U	11%	11%	11%	11%
Total impact, in absolute value	**1.41E+00**	**3.53E-03**	**3.12E-04**	**3.08E-04**

A. Use of wireless IP access network, 2-4G

The dataset is based on multiple Swisscom 2-4G sites. The equipment considered are antennas, baseband units, cooling units, indoor cabinets, lead acid battery, PSU indoor cabinet, radio units (Bieser et al., 2020). The amount of electricity consumed is calculated by multiplying the network energy intensity with the total network traffic. The amount of network traffic is based on the statistics of the datahub.itu.int website. It is assumed that the devices have a lifetime of 6 years, similar to the core network and based on a blade server platform (Thinkstep, 2019).

Table 9.6-41. Life cycle inventory for transmission network, access, wireless, 2-4G and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of wireless IP access network, 2-4G/hr/CH U	1	hr				
Input						
Aluminium alloy, AlMg3, at plant/RER U	1.38E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, aluminium/RER U	1.38E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Steel, low-alloyed, at plant/RER U	3.05E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, steel/RER U	3.05E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	1.44E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	1.44E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Injection moulding/RER U	2.86E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	4.92E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Copper, primary, at refinery/RER U	5.74E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Wire drawing, copper/RER U	5.74E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Chromium steel 18/8, at plant/RER U	1.10E-09	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, chromium steel/RER U	1.10E-09	kg		Lognormal	1.22	(2,2,2,2,1,5)
Cast iron, at plant/RER U	5.36E-09	kg		Lognormal	1.22	(2,2,2,2,1,5)
Synthetic rubber, at plant/RER U	8.23E-10	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polystyrene, general purpose, GPPS, at plant/RER U	8.23E-10	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	8.23E-10	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polypropylene, granulate, at plant/RER U	4.62E-09	kg		Lognormal	1.22	(2,2,2,2,1,5)
Router, IP network, at server/CH/I U	6.53E-09	p		Lognormal	1.22	(2,2,2,2,1,5)
Power adapter, for laptop, at plant	4.46E-07	p		Lognormal	1.22	(2,2,2,2,1,5)
Cable, data cable in infrastructure, at plant/m/GLO U	1.06E-06	m		Lognormal	1.22	(2,2,2,2,1,5)
electricity, low voltage, at grid/kWh/CH U	1.42E-03	kWh		Lognormal	1.22	(2,2,2,2,1,5)

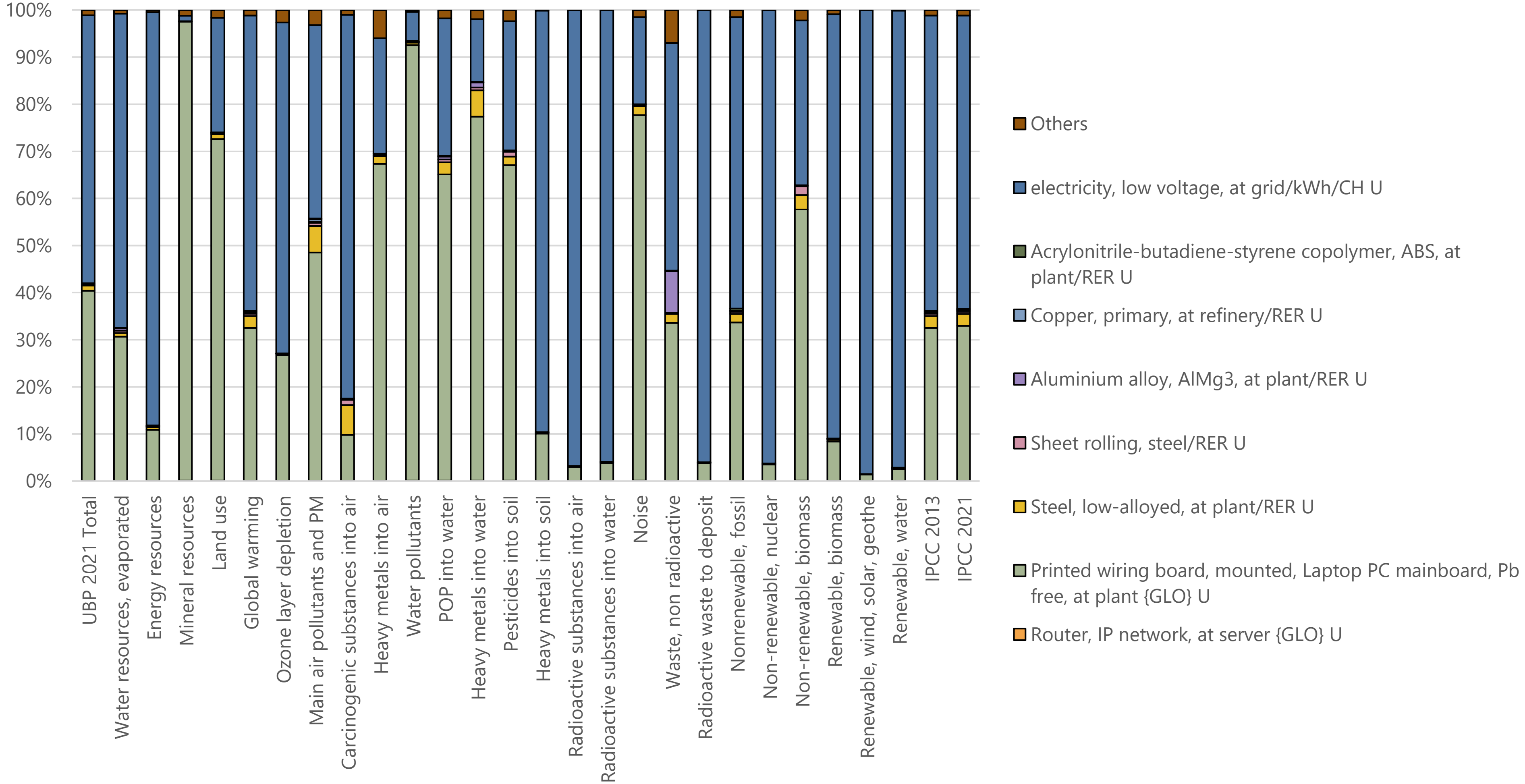

Figure 9.6-21. Contribution analysis presented in bar chart for: Use of wireless IP access network. FU = 1 hr

Table 9.6-42. Contribution analysis presented in table for: Use of wireless IP access network, 2-4G. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	57%	62%	63%	62%
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	40%	34%	32%	33%
Steel, low-alloyed, at plant/RER U	1%	2%	3%	3%
Sheet rolling, steel/RER U	>0%	>0%	>0%	>0%
Aluminium alloy, AlMg3, at plant/RER U	>0%	>0%	>0%	>0%
Copper, primary, at refinery/RER U	>0%	>0%	>0%	>0%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	>0%	>0%	>0%	>0%
Others	>1%	>1%	>1%	>1%
Total impact, in absolute value	**1.27E+00**	**3.18E-03**	**2.81E-04**	**2.77E-04**

B. Use of wireless IP access network, 5G

The dataset is based on multiple Swisscom 5G sites. The equipment considered are antennas, baseband units, cooling units, indoor cabinets, lead acid battery, PSU indoor cabinet, radio units (Bieser et al., 2020). The amount of electricity consumed is calculated by multiplying the network energy intensity with the total network traffic. The amount of network traffic is based on the statistics of the datahub.itu.int website. It is assumed that the devices have a lifetime of 6 years, similar to the core network and based on a blade server platform (Thinkstep, 2019).

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Table 9.6-43. Life cycle inventory for Use of wireless IP access network, 5G

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of wireless IP access network, 5G/hr/CH U	1	hr				
Input						
Aluminium alloy, AlMg3, at plant/RER U	7.61E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, aluminium/RER U	7.61E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Steel, low-alloyed, at plant/RER U	3.76E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, steel/RER U	3.76E-05	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene, HDPE, granulate, at plant/RER U	1.13E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	1.13E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Injection moulding/RER U	2.25E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	7.01E-06	kg		Lognormal	1.22	(2,2,2,2,1,5)
Copper, primary, at refinery/RER U	8.17E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Wire drawing, copper/RER U	8.17E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Chromium steel 18/8, at plant/RER U	2.56E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Sheet rolling, chromium steel/RER U	2.56E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Cast iron, at plant/RER U	1.24E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Synthetic rubber, at plant/RER U	1.91E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polystyrene, general purpose, GPPS, at plant/RER U	1.91E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polyethylene terephthalate, granulate, amorphous, at plant/RER U	1.91E-08	kg		Lognormal	1.22	(2,2,2,2,1,5)
Polypropylene, granulate, at plant/RER U	1.11E-07	kg		Lognormal	1.22	(2,2,2,2,1,5)
Router, IP network, at server/CH/I U	1.72E-06	p		Lognormal	1.22	(2,2,2,2,1,5)
Power adapter, for laptop, at plant	1.04E-05	p		Lognormal	1.22	(2,2,2,2,1,5)
Cable, data cable in infrastructure, at plant/m/GLO U	3.28E-05	m		Lognormal	1.22	(2,2,2,2,1,5)
electricity, low voltage, at grid/kWh/CH U	1.84E-02	kWh		Lognormal	1.22	(2,2,2,2,1,5)

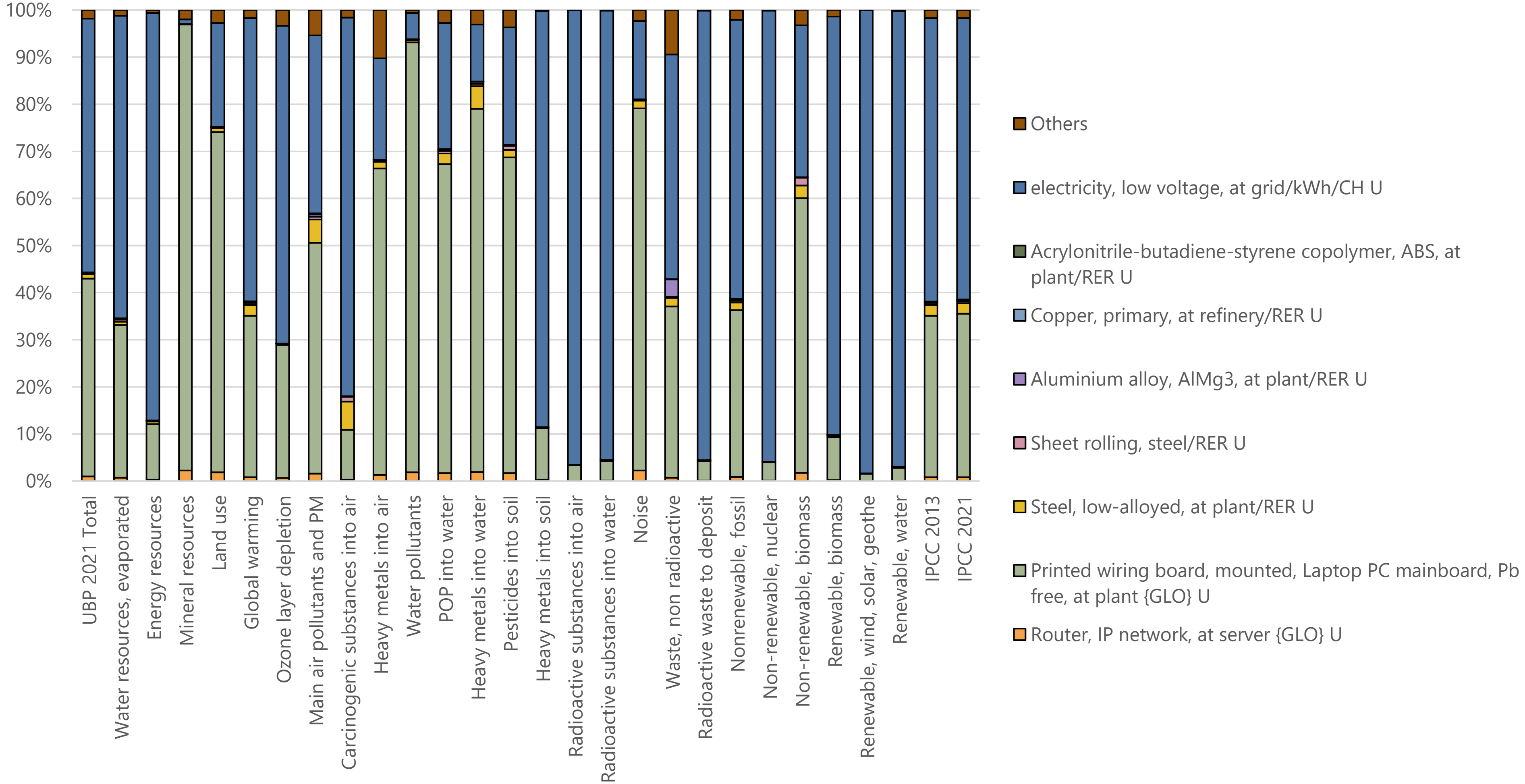

Figure 9.6-22. Contribution analysis presented in bar chart for: Use of wireless IP access network, 5G. FU = 1 hr

Table 9.6-44. Contribution analysis presented in table for: Use of wireless IP access network, 5G. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	54%	59%	60%	60%
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	42%	35%	34%	35%
Steel, low-alloyed, at plant/RER U	1%	2%	2%	2%
Sheet rolling, steel/RER U	>0%	>0%	>0%	>0%
Aluminium alloy, AlMg3, at plant/RER U	>0%	>0%	>0%	>0%
Copper, primary, at refinery/RER U	>0%	>0%	>0%	>0%
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	>0%	>0%	>0%	>0%
Others	>2%	>2%	>2%	>2%
Total impact, in absolute value	**1.70E+01**	**4.23E-02**	**3.74E-03**	**3.69E-03**

9.6.6 Use of core national IP network per GB

The dataset corresponds to the amount of equipment and electricity consumed to support a certain amount of network traffic in this specific network type. The dataset is based on the total amount of material, equipment, and components for the core network in Switzerland (Bieser et al., 2020). The information is based on Swisscom's network (Swisscom, 2021). The literature describes the amount of material, equipment, and components for an average site. This is then multiplied with the total number of sites which Swisscom has. The information however is confidential. The total amount of network traffic is based on the Swisscom network in the year 2020. The total amount of electricity consumed is based on the addition of the core network and transport network. This terminology is based on the report but corresponds to the entire core network. It is assumed that the equipment has the same lifetime as a server which is 6 years (Thinkstep, 2019). National infrastructure.

Table 9.6-45. Life cycle inventory for Use of core national IP network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of core national IP network/GB/CH U	1	unit				1 Unit = 1 GB of data transfer
Input						
Cable, data cable in infrastructure, at plant/m/GLO U	4.30E-04	m		Lognormal	1.22	(2,2,1,1,2,5)
Router, IP network, at server/p/CH/I U	3.79E-06	p		Lognormal	1.22	(2,2,1,1,2,5)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	1.91E-07	kg		Lognormal	1.22	(2,2,1,1,2,5)
Steel, low-alloyed, at plant/RER U	1.41E-07	kg		Lognormal	1.22	(2,2,1,1,2,5)
Hot rolling, steel/RER U	1.41E-07	kg		Lognormal	1.22	(2,2,1,1,2,5)
electricity, low voltage, at grid/kWh/CH U	2.21E-03	kWh		Lognormal	1.22	(2,2,1,1,2,5)

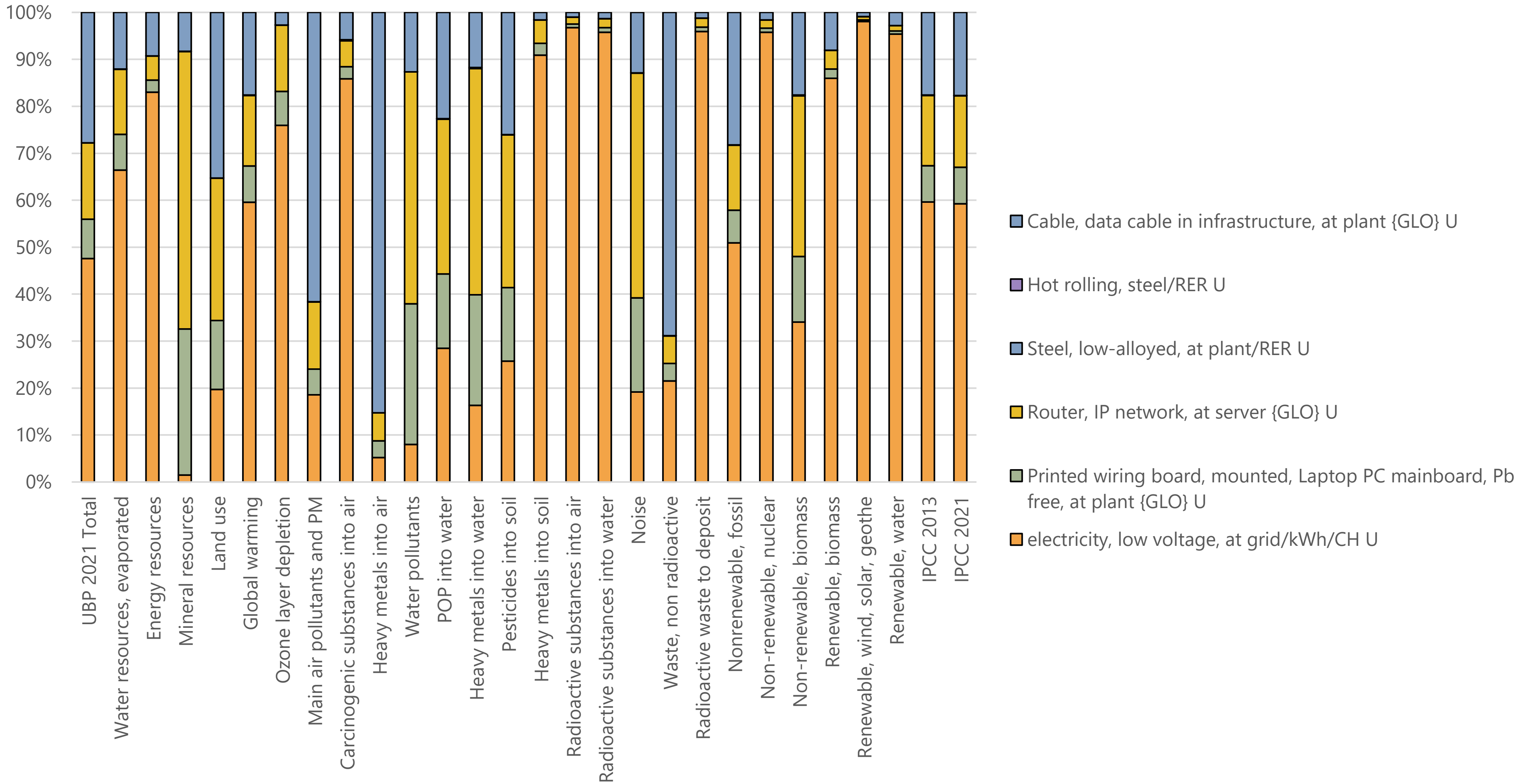

Figure 9.6-23. Contribution analysis presented in bar chart for: Use of core national IP network. FU = 1 GB

Table 9.6-46. Contribution analysis presented in table for: Use of core national IP network. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	48%	51%	60%	59%
Cable, data cable in infrastructure, at plant/m/GLO U	28%	28%	18%	18%
Router, IP network, at server/p/CH/I U	16%	14%	15%	15%
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	8%	7%	8%	8%
Steel, low-alloyed, at plant/RER U	>0%	>0%	>0%	>0%
Hot rolling, steel/RER U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**2.38E+00**	**6.07E-03**	**4.64E-04**	**4.58E-04**

9.6.7 Use of core national IP network per hour

The dataset corresponds to the amount of equipment and electricity consumed to support a certain amount of network traffic in this specific network type. The dataset is based on the total amount of material, equipment, and components for the core network in Switzerland (Bieser et al., 2020). The information is based on Swisscom's network (Swisscom, 2021). The literature describes the amount of material, equipment, and components for an average site. This is then multiplied with the total number of sites which Swisscom has. The information however is confidential. The total amount of network traffic is based on the Swisscom network in the year 2020. The total amount of electricity consumed is based on the addition of the core network and transport network. This terminology is based on the report but corresponds to the entire core network. It is assumed that the equipment has the same lifetime as a server which is 6 years (Thinkstep, 2019). National infrastructure.

Table 9.6-47. Life cycle inventory for Use of core national IP network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of core national IP network/hr/CH U	1	hr				
Input						
Cable, data cable in infrastructure, at plant/m/GLO U	3.68E-5	m		Lognormal	1.22	(2,2,1,1,2,5)
Router, IP network, at server/p/CH/I U	3.25E-07	p		Lognormal	1.22	(2,2,1,1,2,5)
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	1.64E-08	kg		Lognormal	1.22	(2,2,1,1,2,5)
Steel, low-alloyed, at plant/RER U	1.21E-08	kg		Lognormal	1.22	(2,2,1,1,2,5)
Hot rolling, steel/RER U	1.21E-08	kg		Lognormal	1.22	(2,2,1,1,2,5)
electricity, low voltage, at grid/kWh/CH U	1.89E-04	kWh		Lognormal	1.22	(2,2,1,1,2,5)

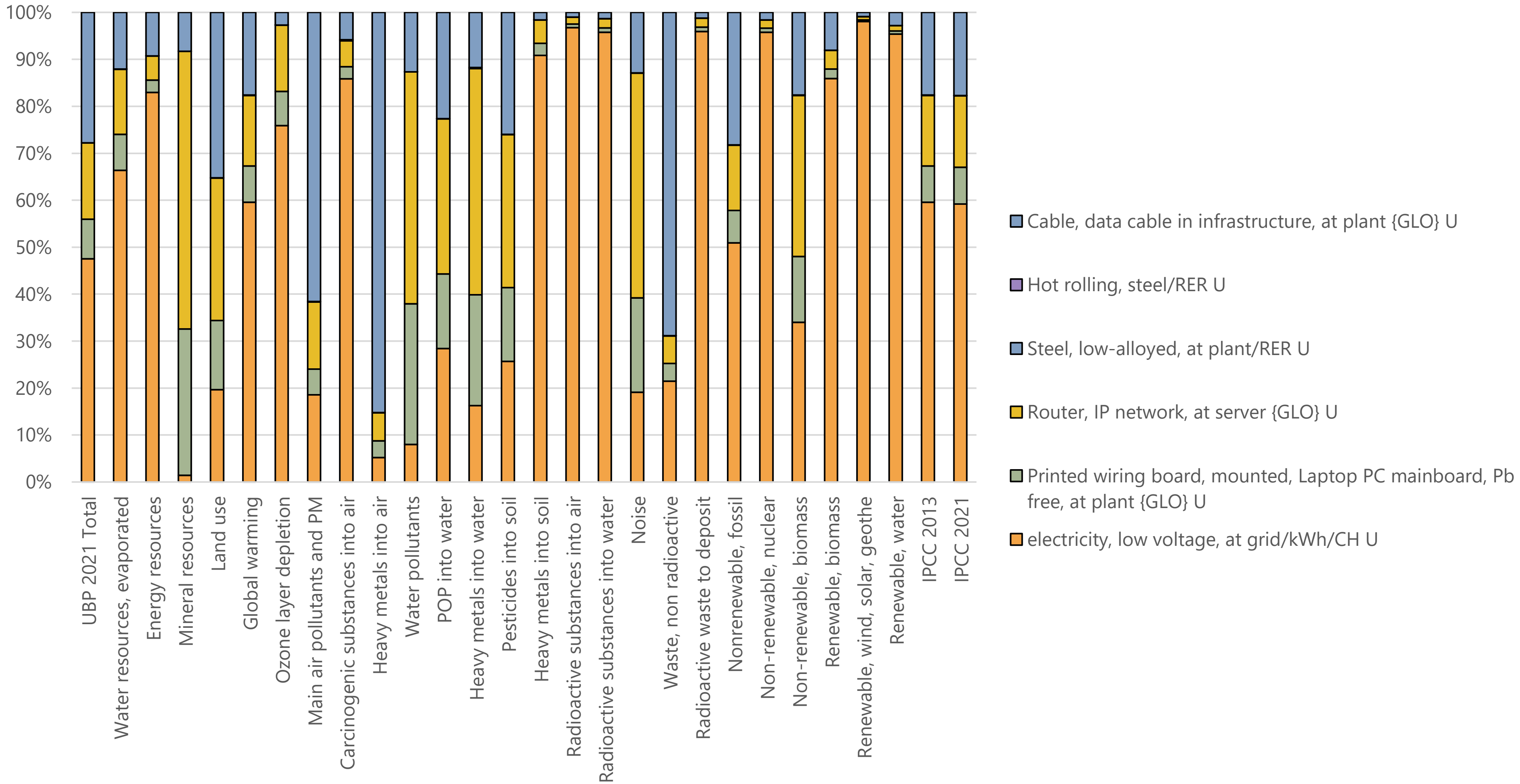

Figure 9.6-24. Contribution analysis presented in bar chart for: Use of core national IP network. FU = 1 hr

Table 9.6-48. Contribution analysis presented in table for: Use of core national IP network. FU = 1 hr

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, at grid/kWh/CH U	48%	51%	60%	59%
Cable, data cable in infrastructure, at plant/m/GLO U	28%	28%	18%	18%
Router, IP network, at server/p/CH/I U	16%	14%	15%	15%
Printed wiring board, mounted, Laptop PC mainboard, Pb free, at plant/kg/GLO U	8%	7%	8%	8%
Steel, low-alloyed, at plant/RER U	>0%	>0%	>0%	>0%
Hot rolling, steel/RER U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**2.04E-01**	**5.20E-04**	**3.97E-05**	**3.92E-05**

9.6.8 Use of global transmission network per GB

The dataset represents a global IP traffic and the amount of data centers globally. Global IP traffic is based on Cisco 2018 CGI representing 4.4 ZB in 2022(IEA, 2024). The total amount of data centers globally is based on the assumption that globally, data centers consume 340 TWh (IEA, 2023; Masanet et al., 2020). This total amount is then divided by the average electricity consumption of a single data center. The average electricity consumption of a data center assumes a 24/7 operation for 365 days and a data center power intensity of 6646 W / m2. The data center power intensity assumes a PUE of 2 and is based on the IT area per IT power from (Siddik et al., 2021), weighted based on IT area of different data center types (hyper scale, small, etc) from (Shehabi et al., 2011). The large number of data centers seems plausible since small data centers are included in the assumption. Inputs on the total number of data centers already considers the lifetime of each data center element, for example servers, network equipment, and storage equipment (HDD and SSD). Top-down perspective.

!!! It is important to mention that this model uses a conservative approach where all electricity use of data centers is linked to the tasks of data transfer. This means that we implicitly consider all electricity uses for computation to the end goal of transferring that data. If information sources were providing the split between electricity uses for computation and electricity uses for data transfer, it would be possible to make an assessment that only consider data transfer. With that being said, it seems like the end user of internet data should also have to consider the environmental impacts of the data that has been computed for his needs, so our simplification of the model still provides a useful comprehensive scope of the situation.

Table 9.6-49. Life cycle inventory for Use of global transmission network

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use of global transmission networkl/GB/GLO U	1	unit				1 Unit = 1 GB of data transfer
Input						
Data center/p/GLO U	2.15E-10	p		Lognormal	1.31	(2,2,1,3,3,5)
electricity, medium voltage, production GLO, at grid/kWh/GLO U	0.0773	kWh		Lognormal	1.31	(2,2,1,3,3,5)

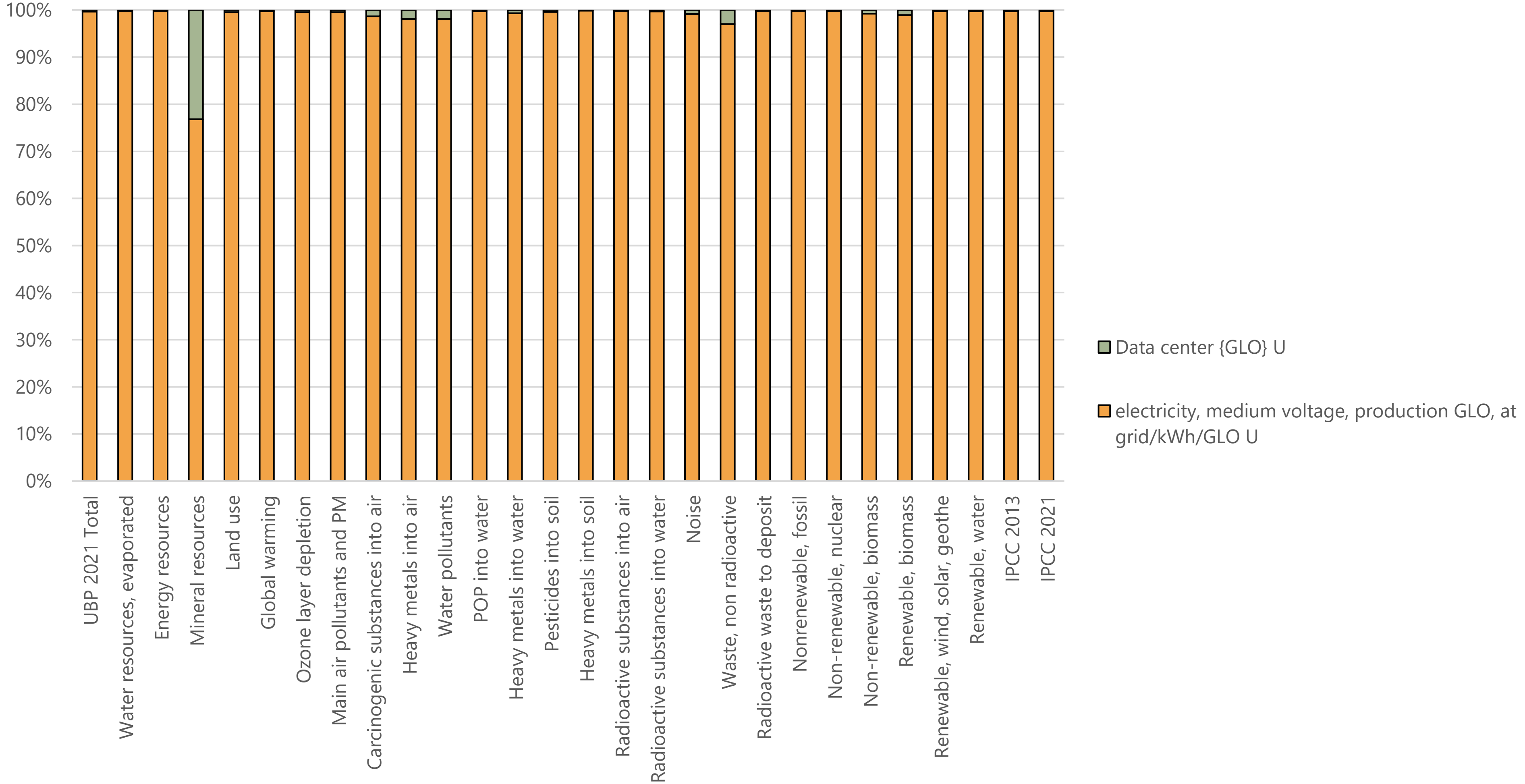

Figure 9.6-25. Contribution analysis presented in bar chart for: Use of global transmission network. FU = 1 GB

Table 9.6-50. Contribution analysis presented in table for: Use of global transmission network. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
electricity, low voltage, production GLO, at grid/kWh/GLO U	99%	99%	99%	99%
Data centre/p/GLO U	<1%	<1%	<1%	<1%
Total impact, in absolute value	**9.48E+01**	**6.63E-01**	**6.02E-02**	**6.00E-02**

9.7 Data center

The data set is based on an average of 9 data centers in Switzerland and Germany (Schödwell et al., 2018; SFOE, 2015; Umweltbundesamt, 2021). It assumes that non-infrastructure has a lifetime of 3 years while infrastructure as a lifetime of 60 years (Whitehead et al., 2015).

Table 9.7-1. Life cycle inventory for a data center and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Data center/p/GLO U	1	p				
Input						
Storage array, at data center/p/GLO U	77	p		Lognormal	1.32	(2,3,2,2,3,5)
Network equipment, at data center/p/GLO U	81.3	p		Lognormal	1.32	(2,3,2,2,3,5)
Server, at data center/p/GLO U	79.3	p		Lognormal	1.32	(2,3,2,2,3,5)
Facility of data center/p/GLO U	1	p		Lognormal	1.32	(2,3,2,2,3,5)

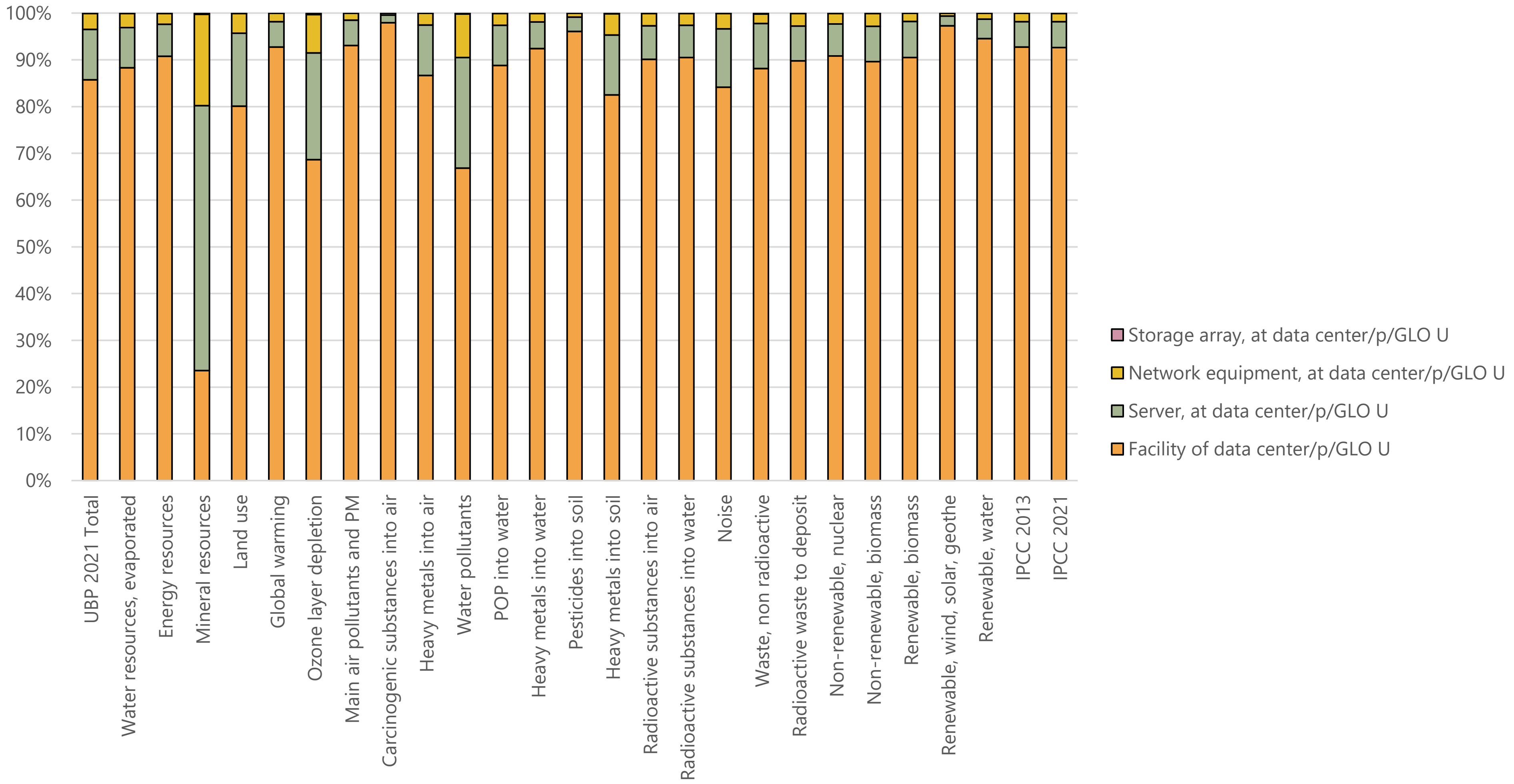

Figure 9.7-1. Contribution analysis presented in bar chart for: Data center. FU = 1 unit

Table 9.7-2. Contribution analysis presented in table for: Data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Server, at data center/p/GLO U	86%	91%	93%	93%
Network equipment, at data center/p/GLO U	11%	7%	5%	5%
Facility of data center/p/GLO U	3%	2%	2%	2%
Storage array, at data center/p/GLO U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.67E+09**	**6.56E+06**	**7.20E+05**	**7.08E+05**

9.7.1 Facility

The dataset is based on a description of a data center from a UK source (Whitehead et al., 2015). Inputs are described with the unit kg/kW/year. To obtain the total values for the facility, they need to be multiplied with the full power demand of the data center (i.e. 12895 kW) and the lifetime (i.e. 60 years). Inputs which are described with Input-Output databases are not considered. The amount of materials are based on the assumption that they would be replaced after 20 years.

Table 9.7-3. **Life cycle inventory for data center, facility and the representation in the UVEK database**

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Facility of data center/p/GLO U	1	p				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	35	kg		Lognormal	1.26	(2,3,3,3,2,5)
Alkyd paint, white, 60% in H2O, at plant/RER U	2424	kg		Lognormal	1.26	(2,3,3,3,2,5)
aluminium, production mix, wrought alloy, at plant/kg/RER U	3843	kg		Lognormal	1.26	(2,3,3,3,2,5)
Cable, network cable, category 5, without plugs, at plant/m/GLO U	472	m		Lognormal	1.26	(2,3,3,3,2,5); Assuming 0.036 kg/m (UVEK)
Cable, three-conductor cable, at plant/m/GLO U	4760	m		Lognormal	1.26	(2,3,3,3,2,5); Assuming 1.04 kg/m (UVEK)
Cathode, copper, primary copper production/GLO U	311	kg		Lognormal	1.26	(2,3,3,3,2,5)
Cement mortar, at plant/CH U	32753	kg		Lognormal	1.26	(2,3,3,3,2,5)
Concrete block, at plant/DE U	141845	kg		Lognormal	1.26	(2,3,3,3,2,5)
Concrete, normal, at plant/CH U	179	m3		Lognormal	1.26	(2,3,3,3,2,5); Assuming a density of 2300 kg/m3, including precast concrete
Natural stone plate, cut, at regional storage/CH U	13540	kg		Lognormal	1.26	(2,3,3,3,2,5)
xxx Door, inner, wood, at plant/RER U	31.1	m2		Lognormal	1.26	(2,3,3,3,2,5)
Glass wool mat, at plant/CH U	8948	kg		Lognormal	1.26	(2,3,3,3,2,5)
Gypsum plaster board, at plant/CH U	13798	kg		Lognormal	1.26	(2,3,3,3,2,5)
Cement cast plaster floor, at plant/CH U	331	kg		Lognormal	1.26	(2,3,3,3,2,5)
Polyethylene, HDPE, granulate, at plant/RER U	887	kg		Lognormal	1.26	(2,3,3,3,2,5)
Polyethylene, LDPE, granulate, at plant/RER U	565	kg		Lognormal	1.26	(2,3,3,3,2,5)
Limestone, crushed, for mill/CH U	694	kg		Lognormal	1.26	(2,3,3,3,2,5)
particleboard, average glue mix, uncoated, at plant/m3/RER	20.8	m3		Lognormal	1.26	(2,3,3,3,2,5); Assuming a density of 750 kg/m3
Plywood, hardwood veneer, UF-bonded, at plant/RER	0.353	m3		Lognormal	1.26	(2,3,3,3,2,5); Assuming a density of 750 kg/m3
Concrete, normal, at plant/CH U	4	m3		Lognormal	1.26	(2,3,3,3,2,5)
Polyvinylchloride, at regional storage/RER U	2890	kg		Lognormal	1.26	(2,3,3,3,2,5)
Rock wool, at plant/CH U	1715	kg		Lognormal	1.26	(2,3,3,3,2,5)
Sand, at mine/CH U	447	kg		Lognormal	1.26	(2,3,3,3,2,5)

Steel, low-alloyed, at plant/RER U	182080	kg	Lognormal	1.26	(2,3,3,3,2,5)
Sheet rolling, steel/RER U	182080	kg	Lognormal	1.26	(2,3,3,3,2,5)
tap water, unspecified natural origin RER, at user/RER U	11902	kg	Lognormal	1.26	(2,3,3,3,2,5)
Thermal plaster, at plant/CH U	15990	kg	Lognormal	1.26	(2,3,3,3,2,5)

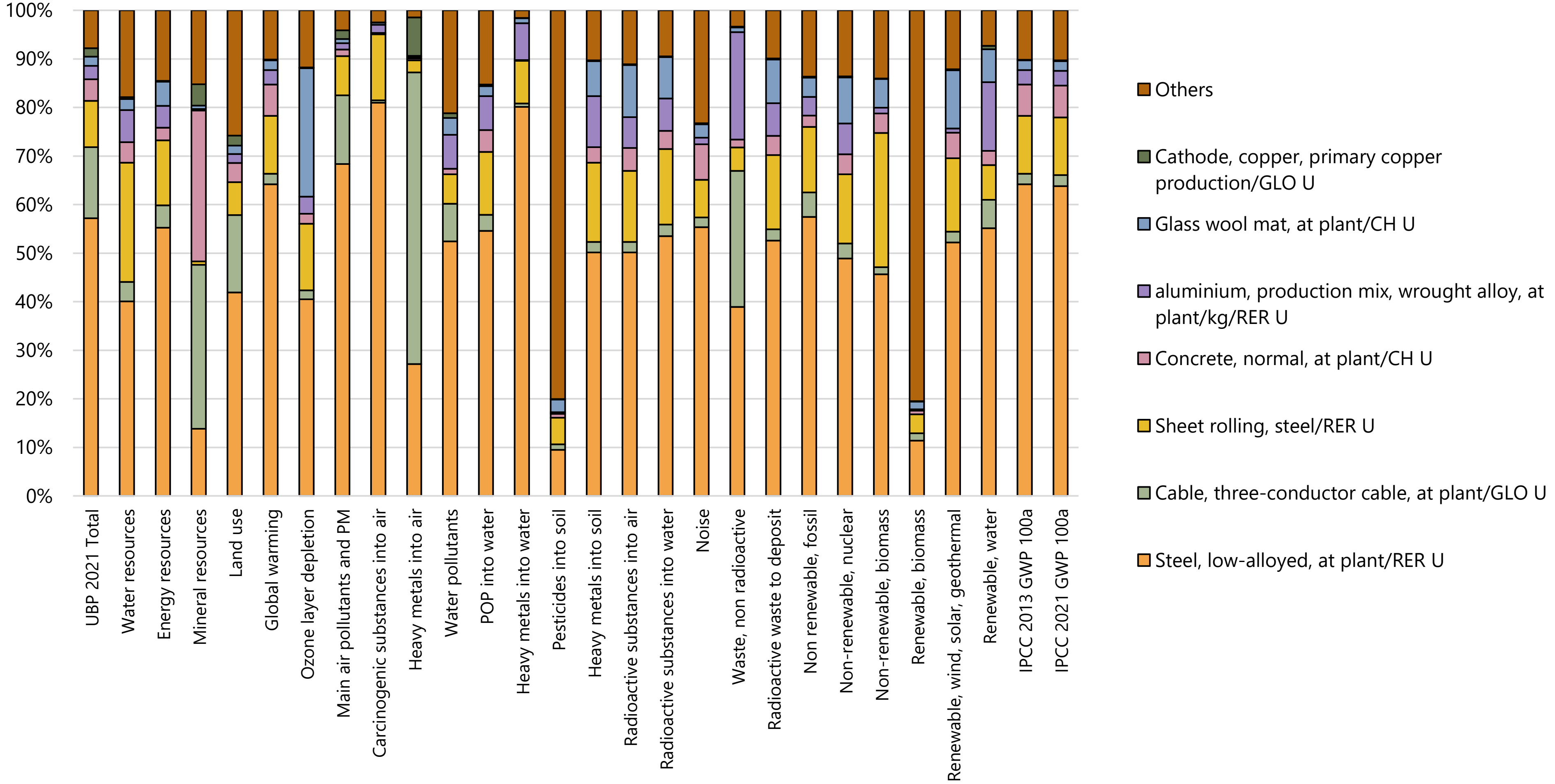

Figure 9.7-2. Contribution analysis presented in bar chart for: Facility of data center. FU = 1 unit

Table 9.7-4. Contribution analysis presented in table for: Facility of data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Steel, low-alloyed, at plant/RER U	57%	57%	64%	64%
Cable, three-conductor cable, at plant/m/GLO U	15%	5%	2%	2%
Sheet rolling, steel/RER U	10%	14%	12%	12%
Concrete, normal, at plant/CH U	4%	2%	6%	7%
aluminium, production mix, wrought alloy, at plant/kg/RER U	3%	4%	3%	3%
Glass wool mat, at plant/CH U	2%	4%	2%	2%
Cathode, copper, primary copper production/GLO U	2%	>0%	>0%	>0%
Others	8%	14%	10%	10%
Total impact, in absolute value	**1.43E+09**	**5.97E+06**	**6.68E+05**	**6.56E+05**

9.7.2 Storage array

The dataset is based on an average of two data centers in Germany (Schödwell et al., 2018). It is assumed that the ratio of HDD and SSD of a typical data center is 99:1.

Table 9.7-5. Life cycle inventory for data center, storage array and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Storage array, at data center/p/GLO U	1	p				
Input						
HDD, desktop computer, at plant/p/GLO U	0.99	p		Lognormal	1.23	(2,3,2,3,2,5)
Solide State Drive (SSD), at plant/p/GLO U	0.01	p		Lognormal	1.23	(2,3,2,3,2,5)

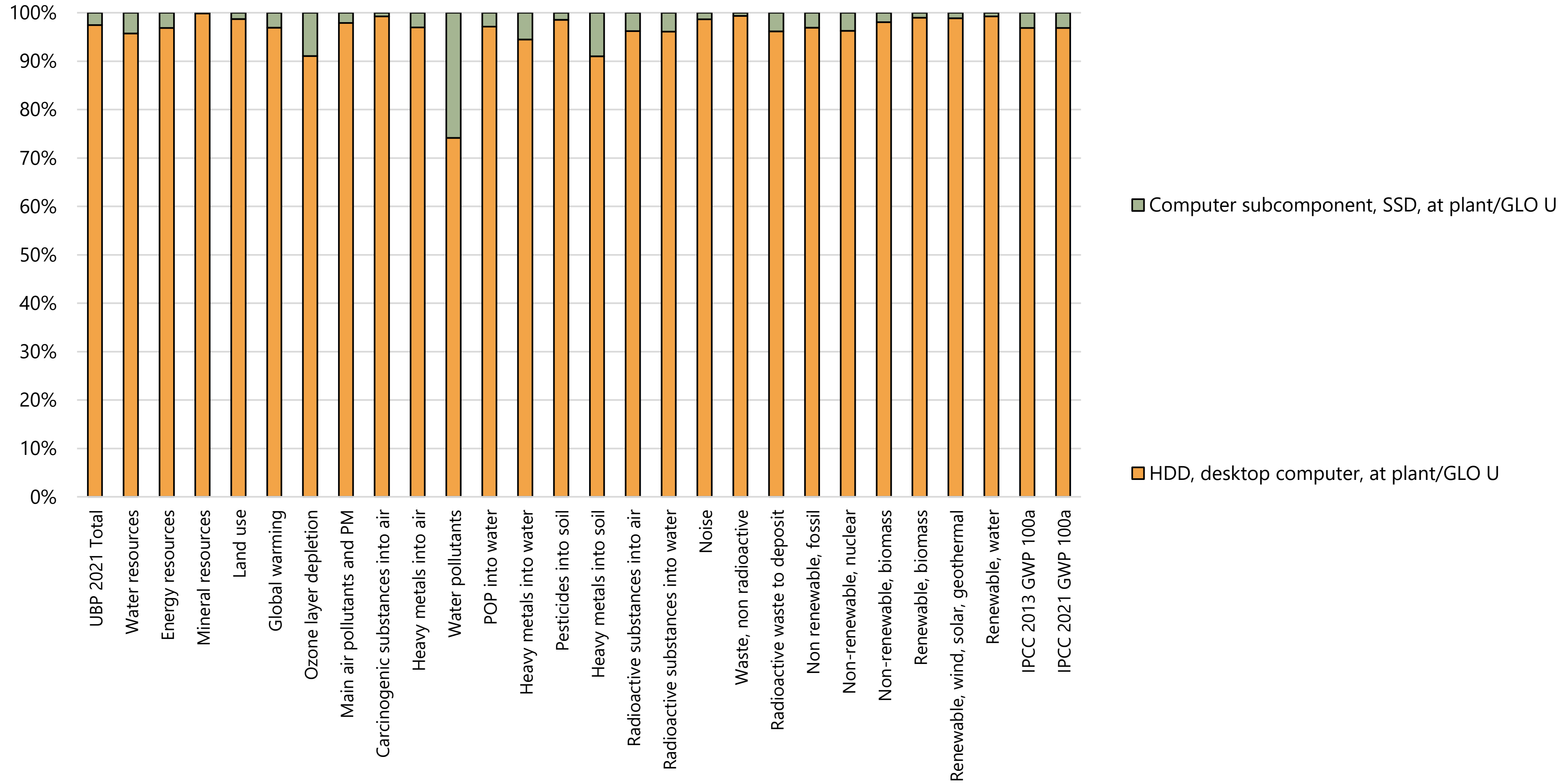

Figure 9.7-3. Contribution analysis presented in bar chart for: Storage array, at data center. FU = 1 unit

Table 9.7-6. Contribution analysis presented in table for: Storage array, at data center. FU = 1 unit

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
HDD, desktop computer, at plant/p/GLO U	97%	97%	97%	97%
Solide State Drive (SSD), at plant/p/GLO U	3%	3%	3%	3%
Total impact, in absolute value	**1.60E+04**	**6.18E+01**	**5.43E+00**	**5.42E+00**

9.7.3 Network equipment

The dataset assumes that two power supply units are needed per switch (SFOE, 2015; Umweltbundesamt, 2021). The number of switches per data center are an average of 9 data centers in Germany and Switzerland (Schödwell et al., 2018). The switches used in a typical data center is modeled individually and exists as a separate dataset. The bill of materials is taken from (Umweltbundesamt, 2021). This dataset shows that there is a 2:1 ratio between power supplies and switches in data centers.

Table 9.7-7. Life cycle inventory for data center, network equipment and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Network equipment, at data center/p/GLO U	1	p				
Input						
Power supply unit, at plant/p/GLO U	0.668	p		Lognormal	1.23	(2,2,1,3,2,5)
Switch, network component, at plant/p/GLO U	0.332	p		Lognormal	1.23	(2,2,1,3,2,5)

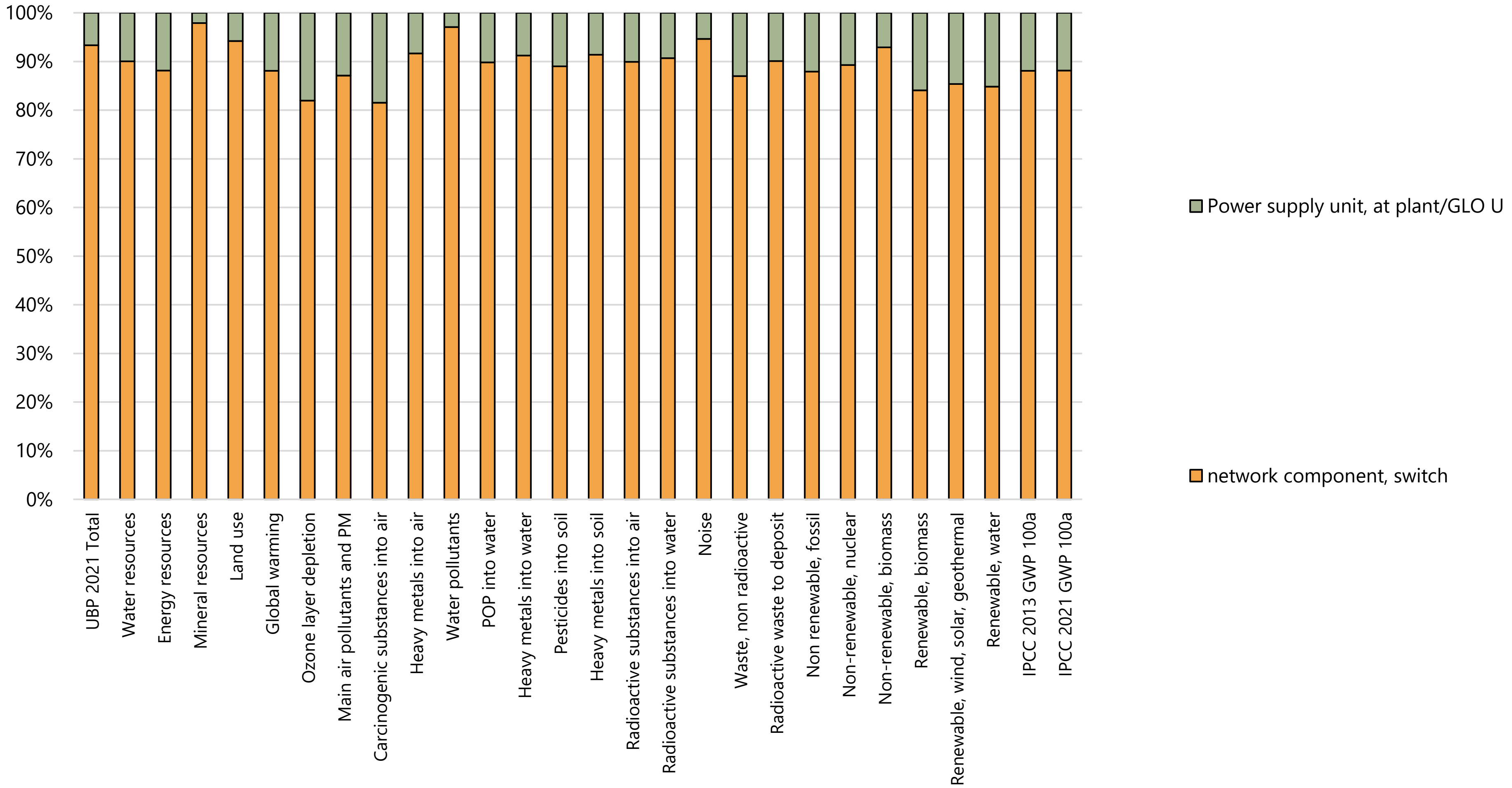

Figure 9.7-4. Contribution analysis presented in bar chart for: Network equipment, at data center. FU = 1 unit

Table 9.7-8. Contribution analysis presented in table for: Network equipment, at data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Switch, network component, at plant/p/GLO U	93%	88%	88%	88%
Power supply unit, at plant/GLO U	7%	12%	12%	12%
Total impact, in absolute value	**6.96E+05**	**1.81E+03**	**1.55E+02**	**1.55E+02**

9.7.4 Server of a data center

The dataset is an equally weighted, average of three available server types: rack, blade, and tower. It is assumed that this is a representative average share in data centers around the world, but no reference were found to validated this hypothesis. Please be aware that an increase of the share of blade server could reduce the impacts of this dataset.

Table 9.7-9. Life cycle inventory for a server in a data center and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Server, at data center/p/GLO U	1	p				
Input						
Tower server, at data center/p/GLO U	0.333	p		Lognormal	1.33	(3,3,1,3,3,5)
Rack server, at data center/p/GLO U	0.333	p		Lognormal	1.33	(3,3,1,3,3,5)
Blade server, at data center/p/GLO U	0.333	p		Lognormal	1.33	(3,3,1,3,3,5)

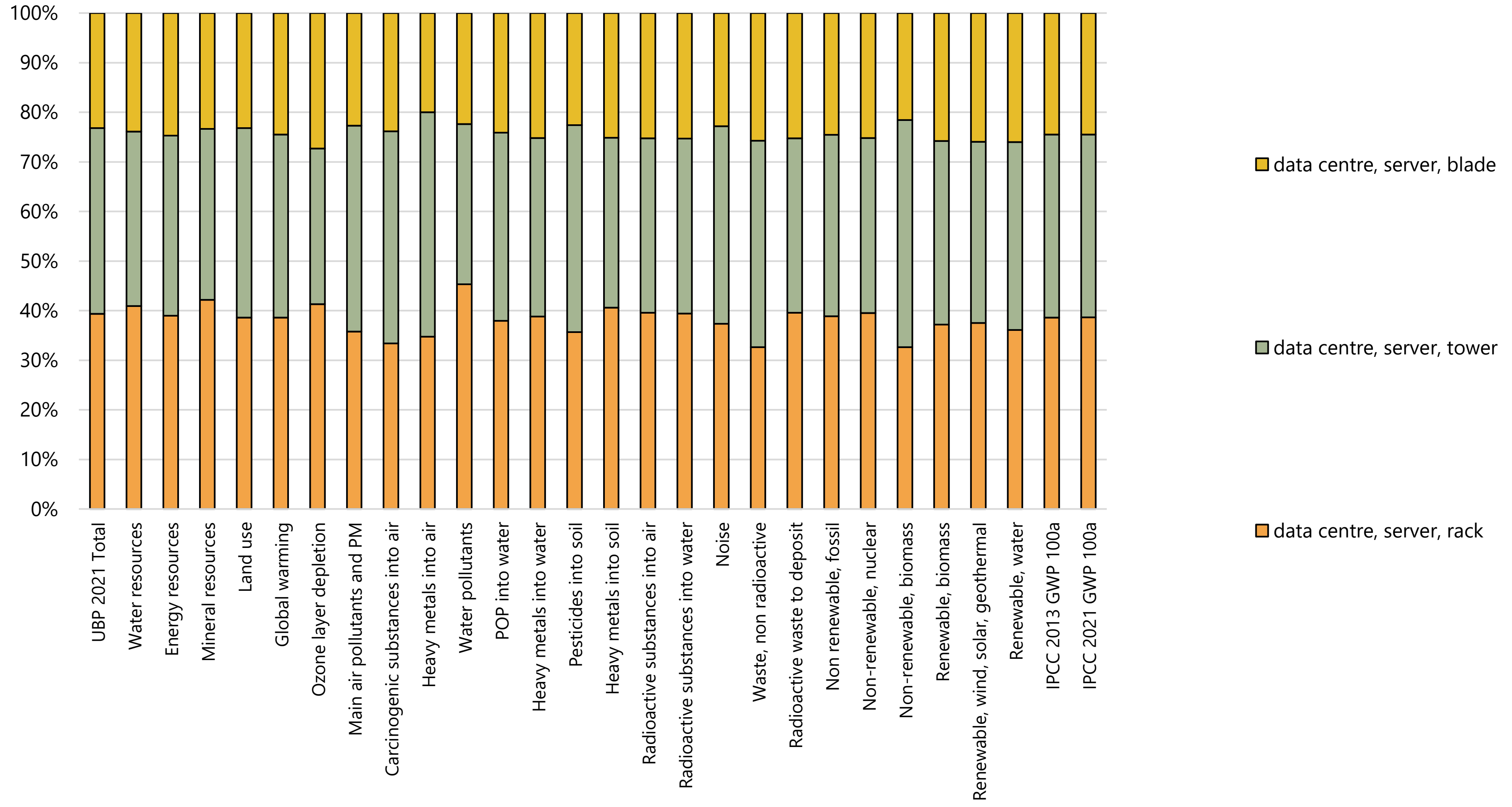

Figure 9.7-5. Contribution analysis presented in bar chart for: Server, at data center. FU = 1 unit

Table 9.7-10. Contribution analysis presented in table for: Server, at data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Rack server, at data center/p/GLO U	39%	39%	39%	39%
Tower server, at data center/p/GLO U	37%	37%	37%	37%
Blade server, at data center/p/GLO U	23%	25%	24%	25%
Total impact, in absolute value	**2.26E+06**	**5.59E+03**	**4.85E+02**	**4.84E+02**

9.7.4.1 Blade server, at data center

Dataset is an average of two blade servers in Switzerland and Germany (Deloitte & Fraunhofer IZM, 2014; SFOE, 2015). One of which is HP ProLiant BL460c Gen8.

Table 9.7-11. Life cycle inventory for blade server and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Blade server, at data center/p/GLO U	1	p				
Input						
Cable, network cable, category 5, without plugs, at plant/m/GLO U	3.61	m		Lognormal	1.26	(2,3,3,2,2,5)
Chassis, network main devices, at plant/kg/GLO U	10.63	kg		Lognormal	1.26	(2,3,3,2,2,5)
CPU, network equipment, at plant/kg/GLO U	0.23	kg		Lognormal	1.26	(2,3,3,2,2,5)
Heat sink for CPU, network equipment, at plant/kg/GLO U	0.14	kg		Lognormal	1.26	(2,3,3,2,2,5)
Fan, at plant/GLO U	0.42	kg		Lognormal	1.26	(2,3,3,2,2,5)
HDD, desktop computer, at plant/p/GLO U	9.5	p		Lognormal	1.26	(2,3,3,2,2,5)
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.11	kg		Lognormal	1.26	(2,3,3,2,2,5)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	0.9	kg		Lognormal	1.26	(2,3,3,2,2,5)
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	2	kg		Lognormal	1.26	(2,3,3,2,2,5)

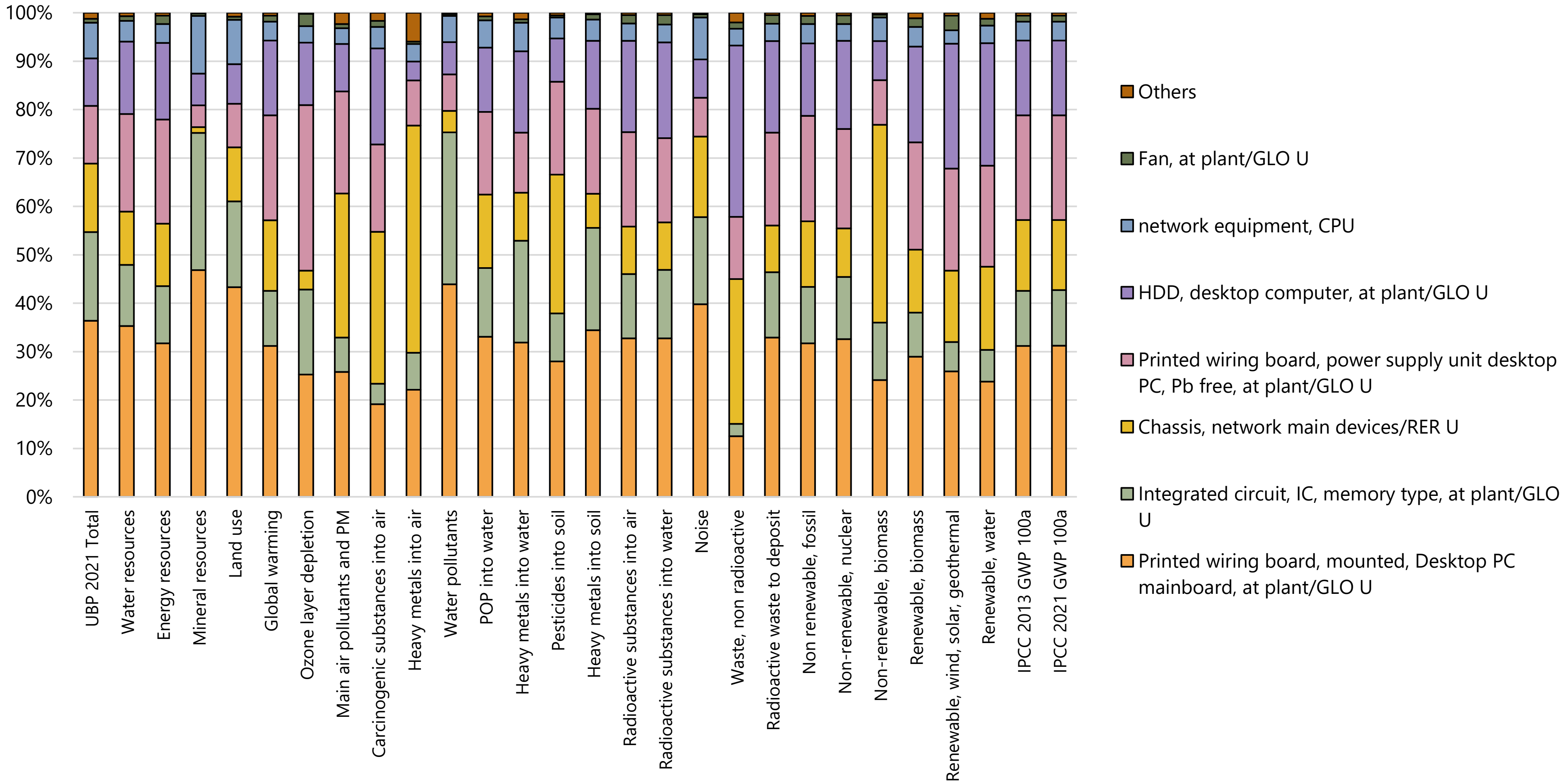

Figure 9.7-6. Contribution analysis presented in bar chart for: Blade server, at data center. FU = 1 unit

Table 9.7-12. Contribution analysis presented in table for:Blade server, at data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	36%	32%	32%	32%
Integrated circuit, IC, memory type, at plant/kg/GLO U	18%	12%	12%	12%
Chassis, network main devices, at plant/kg/GLO U	14%	14%	15%	15%
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	12%	22%	22%	22%
HDD, desktop computer, at plant/p/GLO U	10%	14%	14%	14%
CPU, network equipment, at plant	7%	4%	4%	4%
Fan, at plant/GLO U	1%	2%	1%	1%
Others	1%	1%	1%	1%
Total impact, in absolute value	**1.57E+06**	**4.09E+03**	**3.53E+02**	**3.52E+02**

9.7.4.2 Tower server, at data center

Dataset is based on one tower server (HP ProLiant ML350p Gen8) from (SFOE, 2015). Generally, public information on tower servers are quite limited when compared to other server types (rack, blade).

Table 9.7-13. Life cycle inventory for a tower server, at data center and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Tower server, at data center/p/GLO U	1	p				
Input						
Cable, network cable, category 5, without plugs, at plant/m/GLO U	7.22	m	Lognormal	1.27		(3,3,3,2,2,5)
Chassis, network main devices, at plant/kg/GLO U	35	kg	Lognormal	1.27		(3,3,3,2,2,5)
CPU, network equipment, at plant/kg/GLO U	0.43	kg	Lognormal	1.27		(3,3,3,2,2,5)
Fan, at plant/kg/GLO U	0.3	kg	Lognormal	1.27		(3,3,3,2,2,5)
HDD, desktop computer, at plant/p/GLO U	5	p	Lognormal	1.27		(3,3,3,2,2,5)
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.08	kg	Lognormal	1.27		(3,3,3,2,2,5)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	1.8	kg	Lognormal	1.27		(3,3,3,2,2,5)
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	1.36	kg	Lognormal	1.27		(3,3,3,2,2,5)

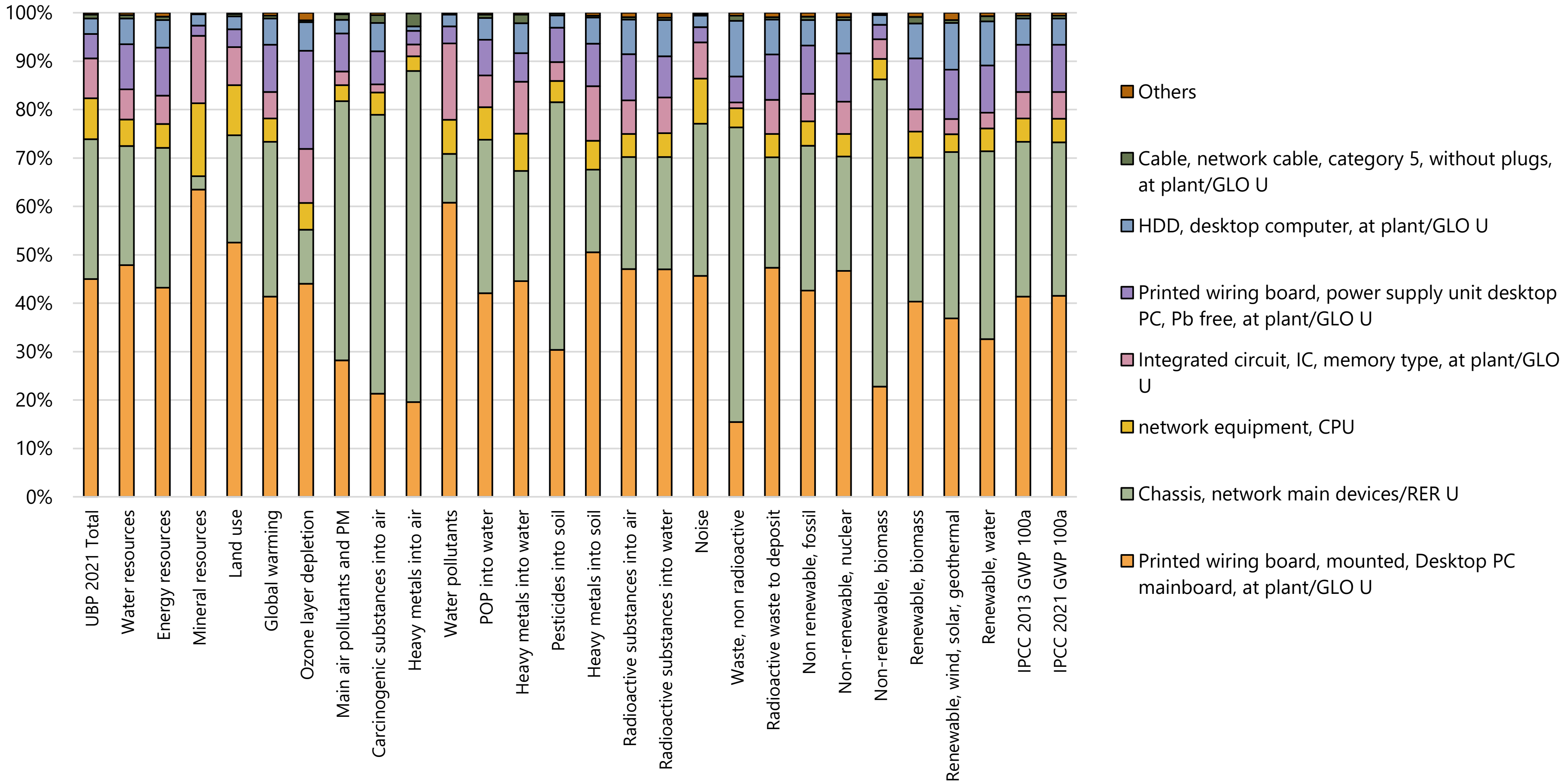

Figure 9.7-7. Contribution analysis presented in bar chart for: Tower server, at data center. FU = 1 unit

Table 9.7-14. Contribution analysis presented in table for: Tower server, at data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	45%	43%	42%	42%
Chassis, network main devices, at plant/kg/GLO U	29%	30%	32%	32%
CPU, network equipment, at plant/kg/GLO U	9%	5%	5%	5%
Integrated circuit, IC, memory type, at plant/kg/GLO U	8%	6%	6%	6%
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	5%	10%	10%	10%
HDD, desktop computer, at plant/p/GLO U	3%	5%	5%	5%
Cable, network cable, category 5, without plugs, at plant/m/GLO U	1%	1%	1%	1%
Others	>0%	1%	1%	1%
Total impact, in absolute value	**2.54E+06**	**6.16E+03**	**5.39E+02**	**5.37E+02**

9.7.4.3 Rack server, at data center

Dataset is an average of four rack servers found in Switzerland and Germany (Schödwell et al., 2018; SFOE, 2015; Talens Peiró et al., 2020; Talens Peiró & Ardente, 2015; Thinkstep, 2019). These include HP ProLiant DL360p Gen8 and Dell R740.

Table 9.7-15. Life cycle inventory for a rack server, at data center and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Rack server, at data center/p/GLO U	1	p				
Input						
single cell, lithium-ion battery, LiFePO4/CH U	0.02	kg		Lognormal	1.23	(2,3,2,3,2,5)
Cable, network cable, category 5, without plugs, at plant/m/GLO U	8.33	m		Lognormal	1.23	(2,3,2,3,2,5)
Chassis, network main devices, at plant/kg/GLO U	13.6	kg		Lognormal	1.23	(2,3,2,3,2,5)
CPU, network equipment, at plant/kg/GLO U	0.8	kg		Lognormal	1.23	(2,3,2,3,2,5)
Heat sink for CPU, network equipment, at plant/kg/GLO U	0.29	kg		Lognormal	1.23	(2,3,2,3,2,5)
Printed wiring board, surface mount, lead-free surface, at plant/m2/GLO U	0.17	m2		Lognormal	1.23	(2,3,2,3,2,5)
Fan, at plant/kg/GLO U	1.02	kg		Lognormal	1.23	(2,3,2,3,2,5)
HDD, desktop computer, at plant/p/GLO U	2.75	p		Lognormal	1.23	(2,3,2,3,2,5)
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.09	kg		Lognormal	1.23	(2,3,2,3,2,5)
CD-ROM/DVD-ROM drive, desktop computer, at plant/p/GLO U	0.05	p		Lognormal	1.23	(2,3,2,3,2,5)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	1.04	kg		Lognormal	1.23	(2,3,2,3,2,5)
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	2.25	kg		Lognormal	1.23	(2,3,2,3,2,5)
Solide State Drive (SSD), at plant/p/GLO U	0.25	p		Lognormal	1.23	(2,3,2,3,2,5)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	0.69	kg		Lognormal	1.23	(2,3,2,3,2,5)

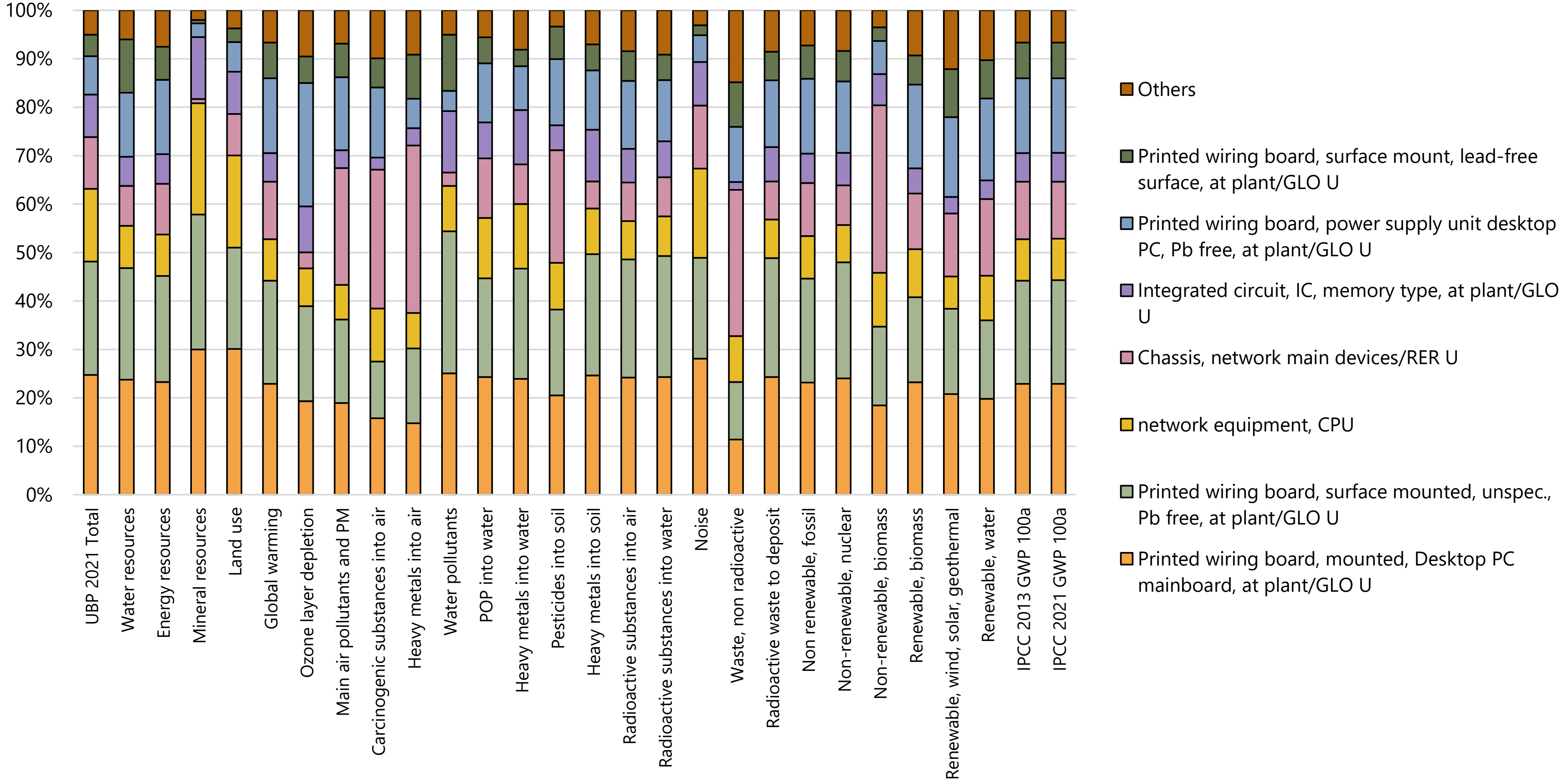

Figure 9.7-8. Contribution analysis presented in bar chart for:Rack server, at data center. FU = 1 unit

Table 9.7-16. Contribution analysis presented in table for:Rack server, at data center. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	25%	23%	23%	23%
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	23%	22%	21%	21%
CPU, network equipment, at plant/kg/GLO U	15%	9%	9%	9%
Chassis, network main devices, at plant/kg/GLO U	11%	11%	12%	12%
Integrated circuit, IC, memory type, at plant/m2/GLO U	9%	6%	6%	6%
Printed wiring board, power supply unit desktop PC, Pb free, at plant/kg/GLO U	8%	15%	15%	15%
Printed wiring board, surface mount, lead-free surface, at plant/kg/GLO U	4%	7%	7%	7%
Others	5%	7%	7%	7%
Total impact, in absolute value	**2.67E+06**	**6.55E+03**	**5.64E+02**	**5.63E+02**

9.7.5 Central Processing Unit, CPU

For the central processing unit (CPU), the dataset is based on an average 3 CPUs found in rack and blade servers (Deloitte & Fraunhofer IZM, 2014). According to literature, the logic IC type is used (Thinkstep, 2019). Here, CPU with housing is considered.

Table 9.7-17. Life cycle inventory for a CPU and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
CPU, network equipment, at plant/kg/GLO U	1	kg				
Input						
Acrylonitrile-butadiene-styrene copolymer, ABS, at plant/RER U	0.0894	kg		Lognormal	1.35	(3,3,3,3,3,5)
Aluminium alloy, AlMg3, at plant/RER U	0.465	kg		Lognormal	1.35	(3,3,3,3,3,5)
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	0.0268	kg		Lognormal	1.35	(3,3,3,3,3,5)
Cathode, copper, primary copper production/GLO U	0.0894	kg		Lognormal	1.35	(3,3,3,3,3,5)
Gold, at regional storage/RER U	0.00141	kg		Lognormal	1.35	(3,3,3,3,3,5)
Integrated circuit, IC, memory type, at plant/kg/GLO U	0.0627	kg		Lognormal	1.35	(3,3,3,3,3,5)
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	0.0676	kg		Lognormal	1.35	(3,3,3,3,3,5)
Sheet rolling, aluminium/RER U	0.465	kg		Lognormal	1.35	(3,3,3,3,3,5)
Sheet rolling, copper/RER U	0.0894	kg		Lognormal	1.35	(3,3,3,3,3,5)
Sheet rolling, steel/RER U	0.275	kg		Lognormal	1.35	(3,3,3,3,3,5)
Silicone product, at plant/RER U	0.000704	kg		Lognormal	1.35	(3,3,3,3,3,5)
Steel, low-alloyed, at plant/RER U	0.275	kg		Lognormal	1.35	(3,3,3,3,3,5)

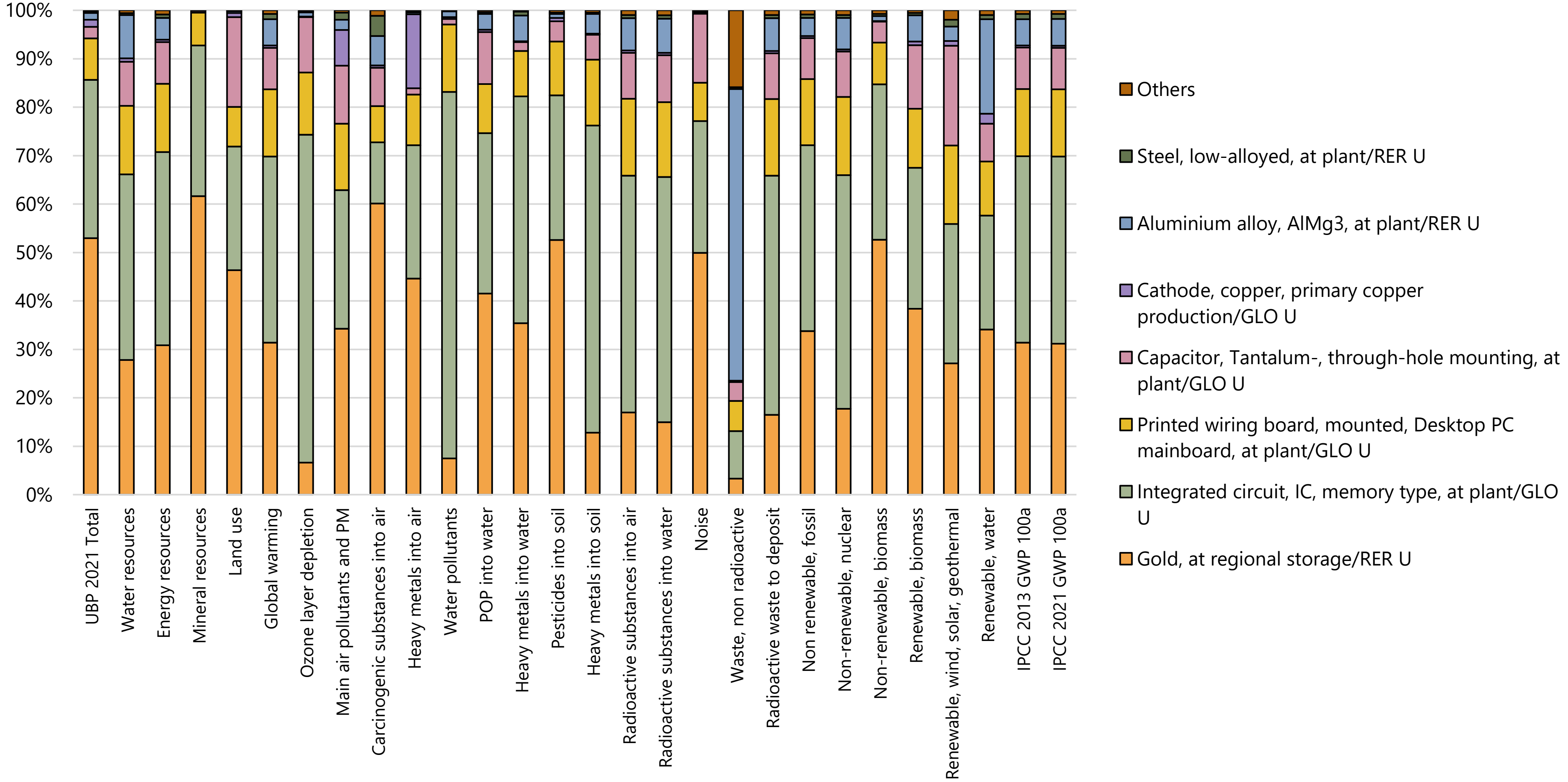

Figure 9.7-9. Contribution analysis presented in bar chart for: CPU, network component. FU = 1 kg

Table 9.7-18. Contribution analysis presented in table for: CPU, network component. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Gold, at regional storage/RER U	53%	33%	31%	31%
Integrated circuit, IC, memory type, at plant/kg/GLO U	33%	38%	38%	38%
Printed wiring board, mounted, Desktop PC mainboard, at plant/kg/GLO U	9%	14%	14%	14%
Capacitor, Tantalum-, through-hole mounting, at plant/kg/GLO U	2%	8%	9%	9%
Cathode, copper, primary copper production/GLO U	1%	>0%	>0%	>0%
Aluminium alloy, AlMg3, at plant/RER U	1%	4%	5%	6%
Steel, low-alloyed, at plant/RER U	>0%	1%	1%	1%
Others	>0%	2%	1%	1%
Total impact, in absolute value	**5.03E+05**	**7.26E+02**	**6.06E+01**	**6.07E+01**

9.7.6 Heat sink for CPU

As for the CPU heat sink, the dataset is based on average of three CPU heat sinks found in rack and blade servers (Schödwell et al., 2018; Talens Peiró et al., 2020).

Table 9.7-19. Life cycle inventory for a CPU heat sink and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Heat sink for CPU, network equipment, at plant/kg/GLO U	1	kg				
Input						
Cathode, copper, primary copper production/GLO U	0.76	kg		Lognormal	1.32	(2,3,2,3,3,5)
Sheet rolling, copper/RER U	0.76	kg		Lognormal	1.32	(2,3,2,3,3,5)
Steel, low-alloyed, at plant/RER U	0.24	kg		Lognormal	1.32	(2,3,2,3,3,5)
Sheet rolling, steel/RER U	0.24	kg		Lognormal	1.32	(2,3,2,3,3,5)

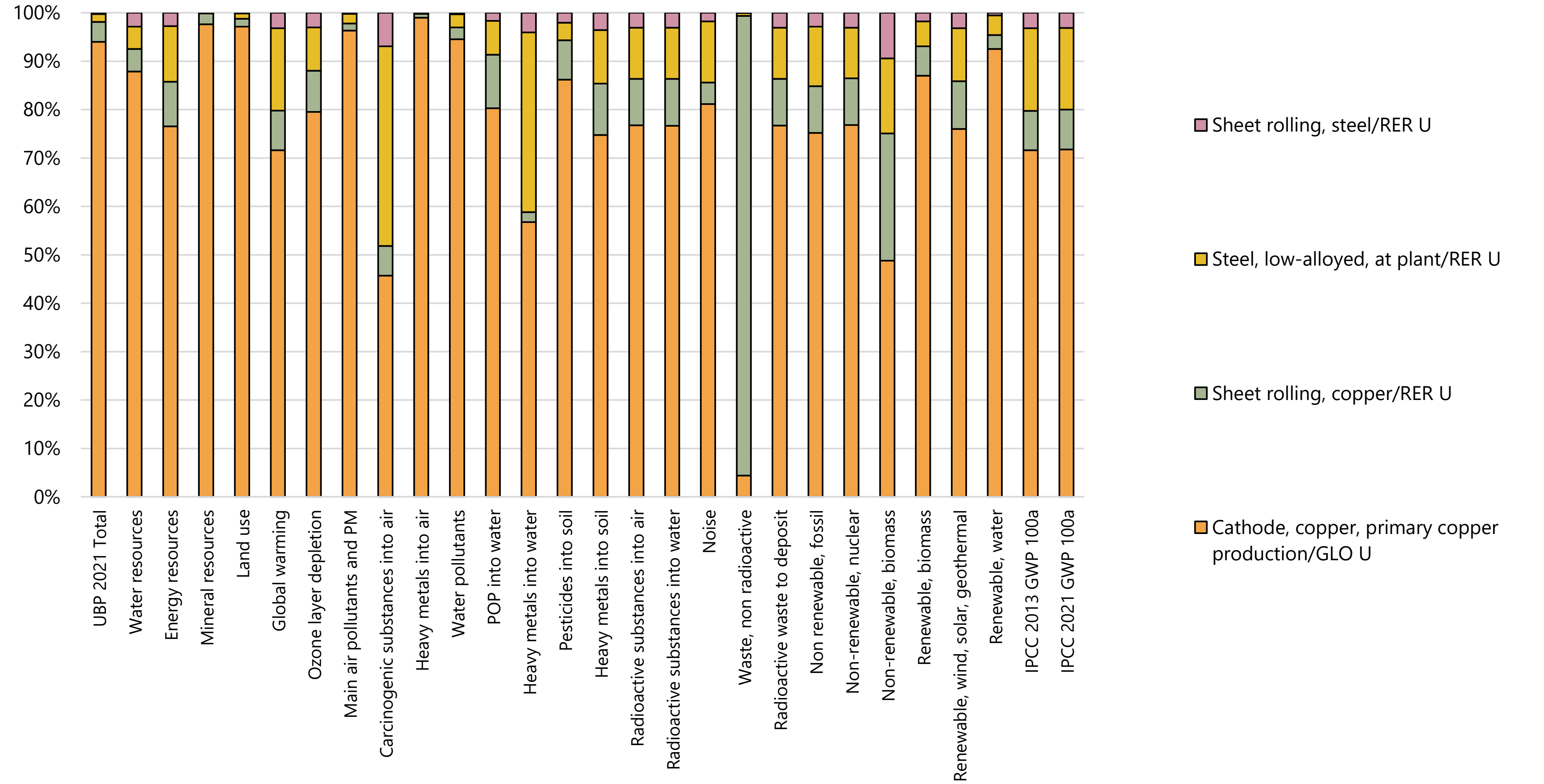

Figure 9.7-10. Contribution analysis presented in bar chart for: Heat sink for CPU. FU = 1 kg

Table 9.7-20. Contribution analysis presented in table for: Heat sink for CPU. FU = 1 kg

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Cathode, copper, primary copper production/GLO U	94%	75%	72%	72%
Sheet rolling, copper/RER U	4%	10%	8%	8%
Steel, low-alloyed, at plant/RER U	2%	12%	17%	17%
Sheet rolling, steel/RER U	>0%	3%	3%	3%
Total impact, in absolute value	**6.59E+04**	**3.68E+01**	**3.31E+00**	**3.28E+00**

9.7.7 Switch, data center devices, at manufacturer

The dataset represents typical switches used in data centers. Steel, chassis, and wiring boards are the main components. Life cycle inventory data is retrieved from (Umweltbundesamt, 2021).

Table 9.7-21. Life cycle inventory for network component, switch and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Switch, data center devices, at plant/p/GLO U	1	p				
Input						
Chassis, network main devices, at plant/kg/GLO U	5	kg		Lognormal	1.23	(2,3,1,3,2,5)
Steel, low-alloyed, at plant/RER U	0.4	kg		Lognormal	1.23	(2,3,1,3,2,5)
Hot rolling, steel/RER U	0.4	kg		Lognormal	1.23	(2,3,1,3,2,5)
Power supply unit, at plant/p/GLO U	2	p		Lognormal	1.23	(2,3,1,3,2,5)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	1.89	kg		Lognormal	1.23	(2,3,1,3,2,5)

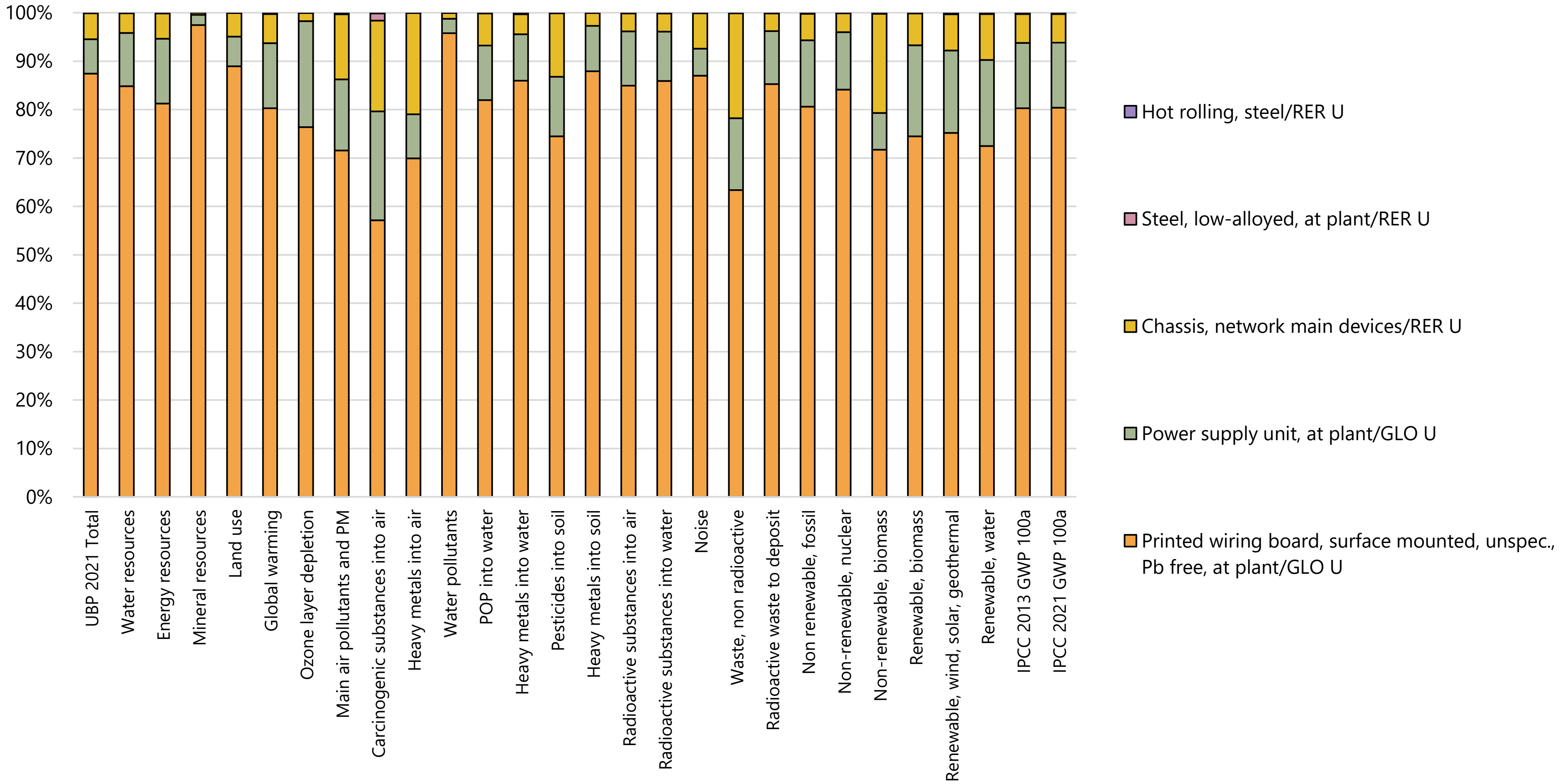

Figure 9.7-11. Contribution analysis presented in bar chart for: Switch, data center devices, at plant. FU = 1 unit

Table 9.7-22. Contribution analysis presented in table for: Switch, data center devices, at plant. FU = 1 unit

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Printed wiring board, surface mounted, unspec., Pb free, at plant/kg/GLO U	87%	81%	80%	80%
Power supply unit, at plant/p/GLO U	7%	14%	13%	13%
Chassis, network main devices, at plant/kg/GLO U	5%	6%	6%	6%
Steel, low-alloyed, at plant/RER U	>0%	>0%	>0%	>0%
Hot rolling, steel/RER U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.96E+06**	**4.78E+03**	**4.11E+02**	**4.11E+02**

9.8 Device use case scenarios per GB

For use case scenarios, six datasets are created, representing three level of use intensity for two devices: smartphone and laptop. The functional unit is defined as the use of electronic device for 1 hour. The environmental impact of device use comprises 1) embodied impact from the manufacturing of respective devices, 2) impact arising during device active use, and 3) impact arising from the use of transmission network and internet. The latter aspect is linked with the data consumption from/to the cloud and transmission network. Another difference between smartphone and laptop is that for smartphones, the data transmission occurs via the wireless network (mixed of 4G and 5G) while the laptops use Wi-Fi connections (with related fixed IP access network). The following Table 9.8-1 summarizes the key assumptions and parameters in the model.

Table 9.8-1. Dataset parameters for device use case. Functional unit = 1 hour of use.

Device	Use intensity	Device active life time	Daily usage hours	Power consumption (during use)	Total data consumption	Transmission network and internet	Reference
Smartphone	Low	2 years	4h	5 W	0.1	Transmission network, access (wireless), core, and global	Device lifetime and usage hours: (Alfieri & Spiliotopoulos, 2023; Cordella et al., 2021; Manhart et al., 2016) Power consumption: Manufacturers' sheet and other reviews (Apple, 2022; Manhart et al., 2016) Data consumption: (Obringer et al., 2021; Viana et al., 2022)
	Medium	2 years	4h	5 W	1		
	High	2 years	4h	5 * (1+15%) W	7		
Laptop	Low	4 years	5h	27 W	0.1	Transmission network use, access (fixed), core, and global	
	Medium	4 years	5h	27 W	1		
	High	4 years	5h	27 * (1+15%) W	7		

Note: 1 year = 365 days.

9.8.1 Smartphone use, low intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.8-2. Life cycle inventory for smartphone use, low intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, smartphone, low intensity/GB/CH U	1	p				1 p = 0.1 GB over an hour
Input						
Smartphone, high-tech phone/p/GLO U	0.000347	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 2 years and 1440 hours (360 days/year, 4h/day)
electricity, low voltage, at grid/kWh/CH U	0.005	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report: normal use = 5 W
Use of core national IP network/GB/CH U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
Use of global transmission network/GB/GLO U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
Use of wireless IP access network/GB/CH U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.

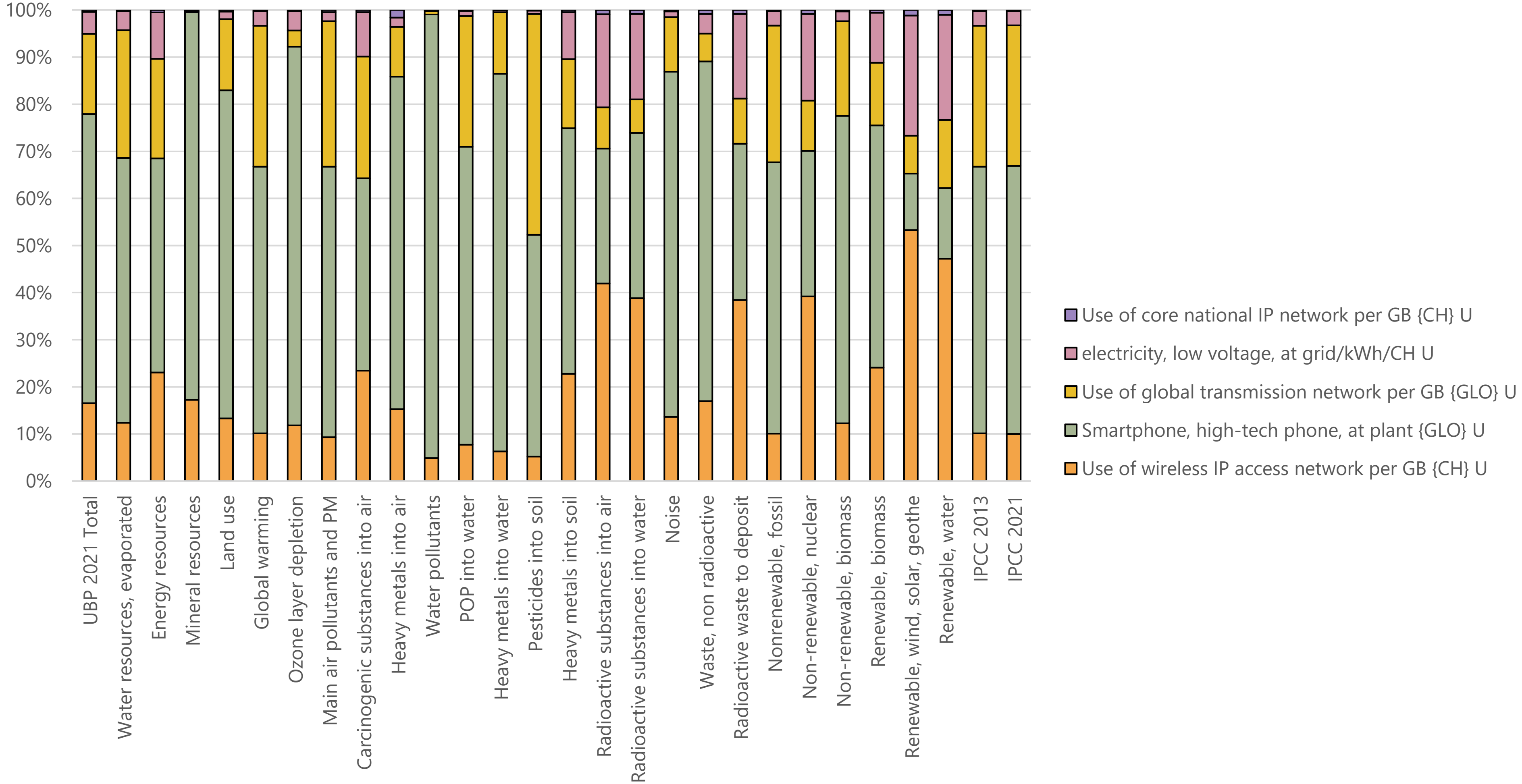

Figure 9.8-1. Contribution analysis presented in bar chart for: smartphone use, low intensity. FU = 1 h

Table 9.8-3. Contribution analysis presented in table for: smartphone use, low intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Smartphone, high-tech phone/p/GLO U	61%	58%	57%	57%
Use of global transmission network/GB/GLO U	17%	29%	30%	30%
Use of wireless IP access network/GB/CH U	17%	10%	10%	10%
electricity, low voltage, at grid/kWh/CH U	5%	3%	3%	3%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**5.57E+01**	**2.29E-01**	**2.01E-02**	**2.01E-02**

9.8.2 Smartphone use, medium intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.8-4. Life cycle inventory for smartphone use, medium intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, smartphone, medium intensity/GB/CH U	1	p				1 p = 1 GB over an hour
Input						
Smartphone, high-tech phone/p/GLO U	0.000347	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 2 years and 1440 hours (360 days/year, 4h/day)
electricity, low voltage, at grid/kWh/CH U	0.005	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report: normal use = 5 W
Use of core national IP network/GB/CH U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
Use of global transmission network/GB/GLO U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
Use of wireless IP access network/GB/CH U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.

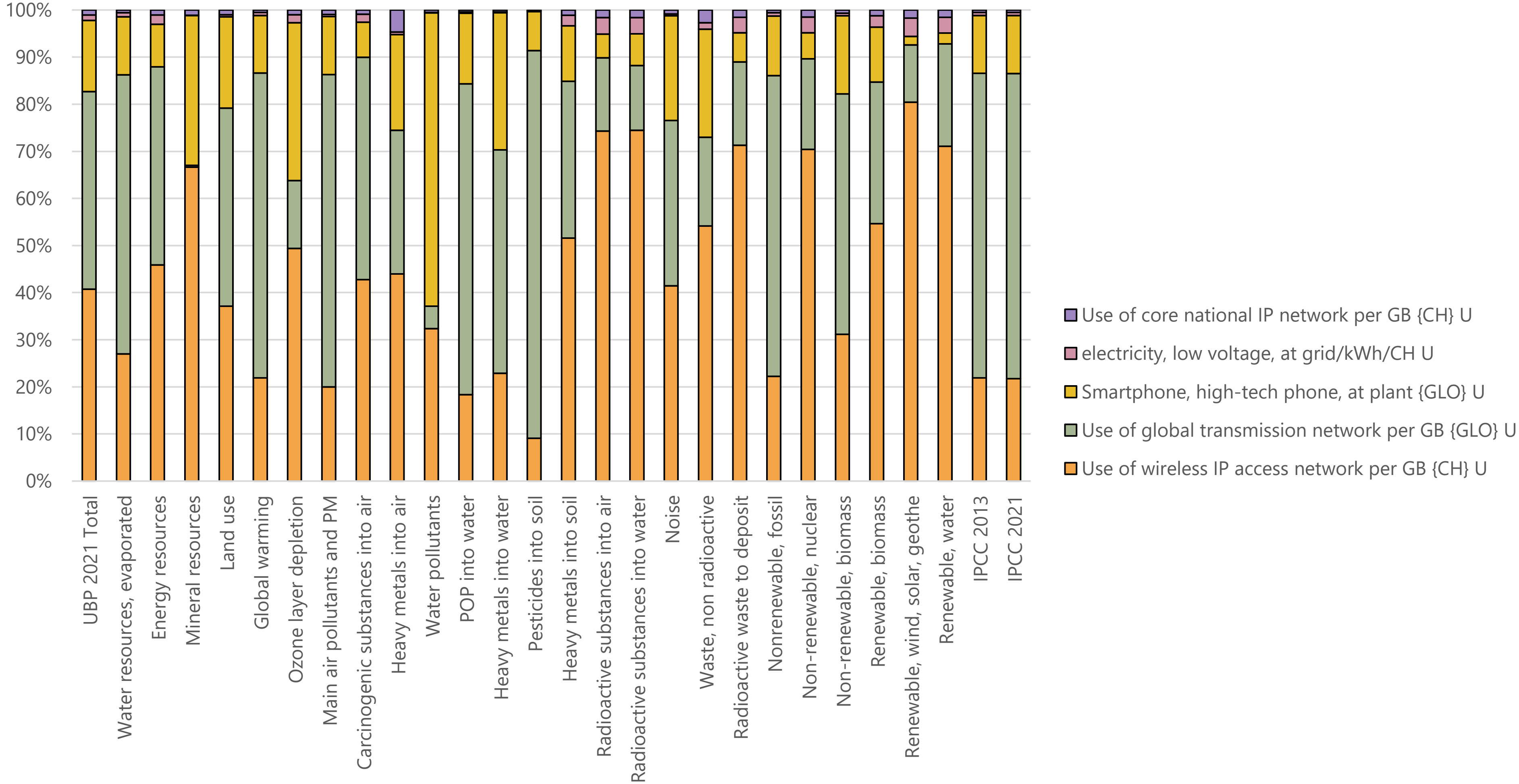

Figure 9.8-2. Contribution analysis presented in bar chart for: smartphone use, medium intensity. FU = 1 h

Table 9.8-5. Contribution analysis presented in table for: smartphone use, medium intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of global transmission network/GB/GLO U	42%	64%	65%	65%
Use of wireless IP access network/GB/CH U	41%	22%	22%	22%
Smartphone, high-tech phone/p/GLO U	15%	13%	12%	12%
electricity, low voltage, at grid/kWh/CH U	1%	1%	1%	1%
Use of core national IP network/GB/CH U	1%	1%	>0%	>0%
Total impact, in absolute value	**2.26E+02**	**1.04E+00**	**9.30E-02**	**9.26E-02**

9.8.3 Smartphone use, high intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.8-6. Life cycle inventory for smartphone use, high intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, smartphone, high intensity/GB/CH U	1	p				1 p = 7 GB over an hour
Input						
Smartphone, high-tech phone/p/GLO U	0.000347	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 2 years and 1440 hours (360 days/year, 4h/day)
electricity, low voltage, at grid/kWh/CH U	0.00575	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report: normal use = 5 W + 15% due to increased intensity
Use of core national IP network/GB/CH U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
Use of global transmission network/GB/GLO U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
Use of wireless IP access network/GB/CH U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.

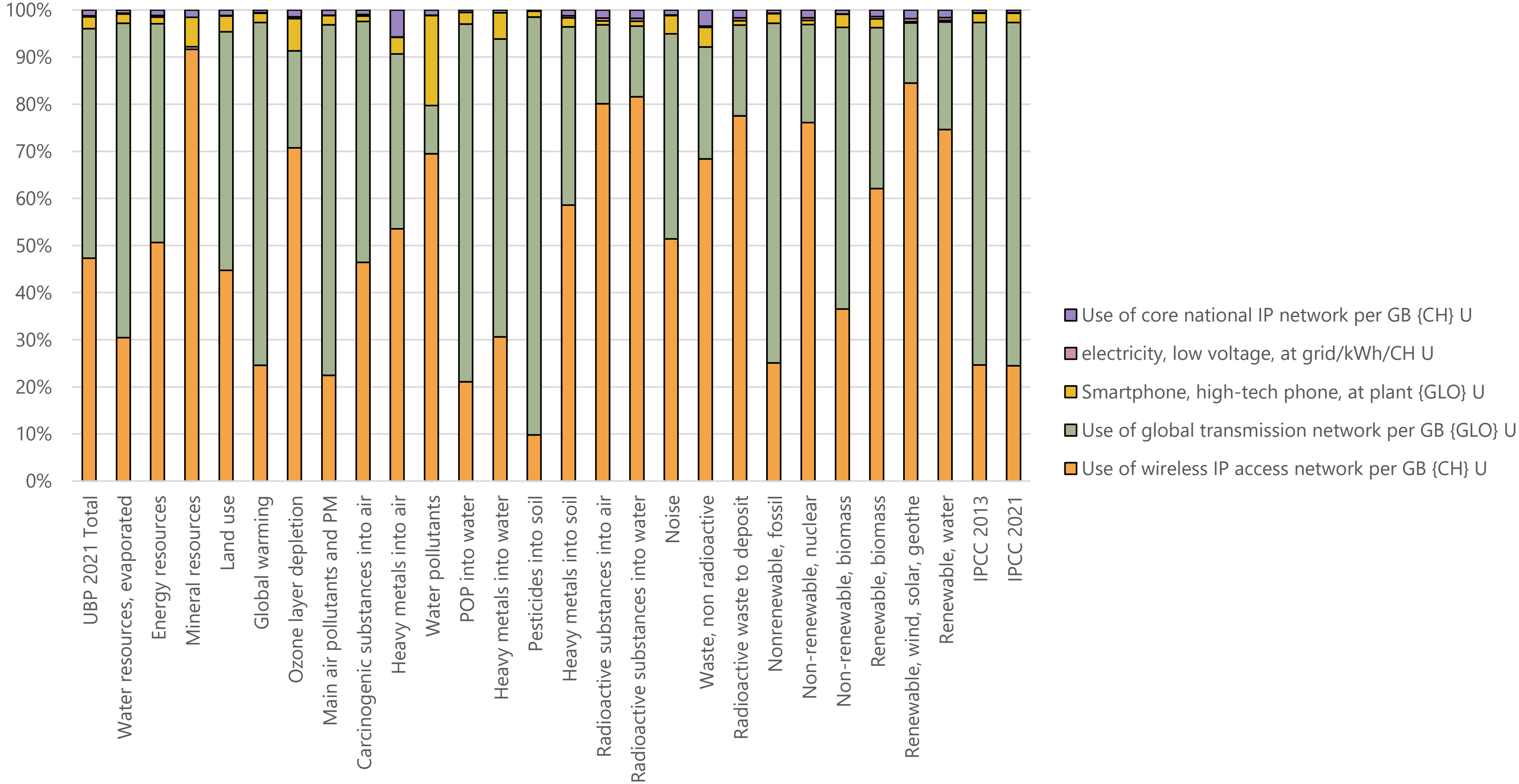

Figure 9.8-3. Contribution analysis presented in bar chart for: smartphone use, high intensity. FU = 1 h

Table 9.8-7. Contribution analysis presented in table for: smartphone use, high intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of global transmission network/GB/GLO U	48%	72%	73%	73%
Use of wireless IP access network/GB/CH U	48%	25%	25%	25%
Smartphone, high-tech phone/p/GLO U	2%	2%	2%	2%
Use of core national IP network/GB/CH U	1%	1%	1%	1%
electricity, low voltage, at grid/kWh/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.36E+03**	**6.44E+00**	**5.79E-01**	**5.76E-01**

9.8.4 Laptop use, low intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.8-8. Life cycle inventory for laptop use, low intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, laptop, low intensity/GB/CH U	1	p				1 p = 1 GB
Input						
Laptop computer, at plant/p/GLO U	0.000139	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 4 years and 1800 hours (360 days/year, 5h/day)
electricity, low voltage, at grid/kWh/CH U	0.027	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report and Viana et al 2022: normal use = 27 W
Use of core national IP network/GB/CH U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
Use of global transmission network/GB/GLO U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
Use of fixed IP access network/GB/CH U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
CPE use, for transmission network/GB/CH U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.

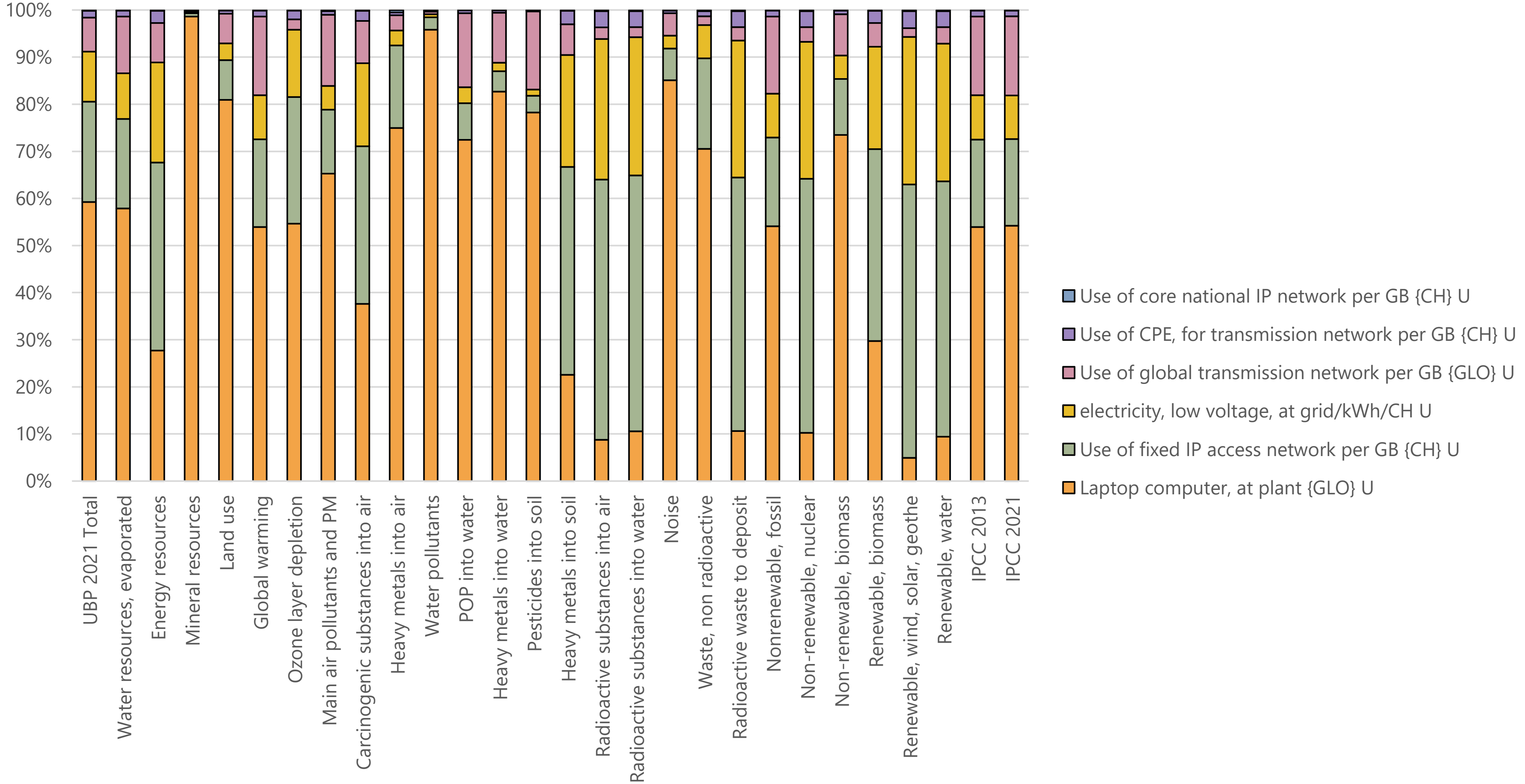

Figure 9.8-4. Contribution analysis presented in bar chart for: laptop use, low intensity. FU = 1 h

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Table 9.8-9. Contribution analysis presented in table for: laptop use, low intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Laptop computer, at plant/p/GLO U	59%	54%	54%	54%
Use of fixed IP access network/GB/CH U	21%	19%	19%	18%
electricity, low voltage, at grid/kWh/CH U	11%	9%	9%	9%
Use of global transmission network/GB/GLO U	7%	16%	17%	17%
CPE use, for transmission network/GB/CH U	1%	1%	1%	1%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.30E+02**	**4.06E-01**	**3.60E-02**	**3.58E-02**

9.8.5 Laptop use, medium intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.8-10. Life cycle inventory for laptop use, medium intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, laptop, medium intensity/GB/CH U	1	p				1 p = 1 GB
Input						
Laptop computer, at plant/p/GLO U	0.000139	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 4 years and 1800 hours (360 days/year, 5h/day)
electricity, low voltage, at grid/kWh/CH U	0.027	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report and Viana et al 2022: normal use = 27 W
Use of core national IP network/GB/CH U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
Use of global transmission network/GB/GLO U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
Use of fixed IP access network/GB/CH U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
CPE use, for transmission network/GB/CH U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.

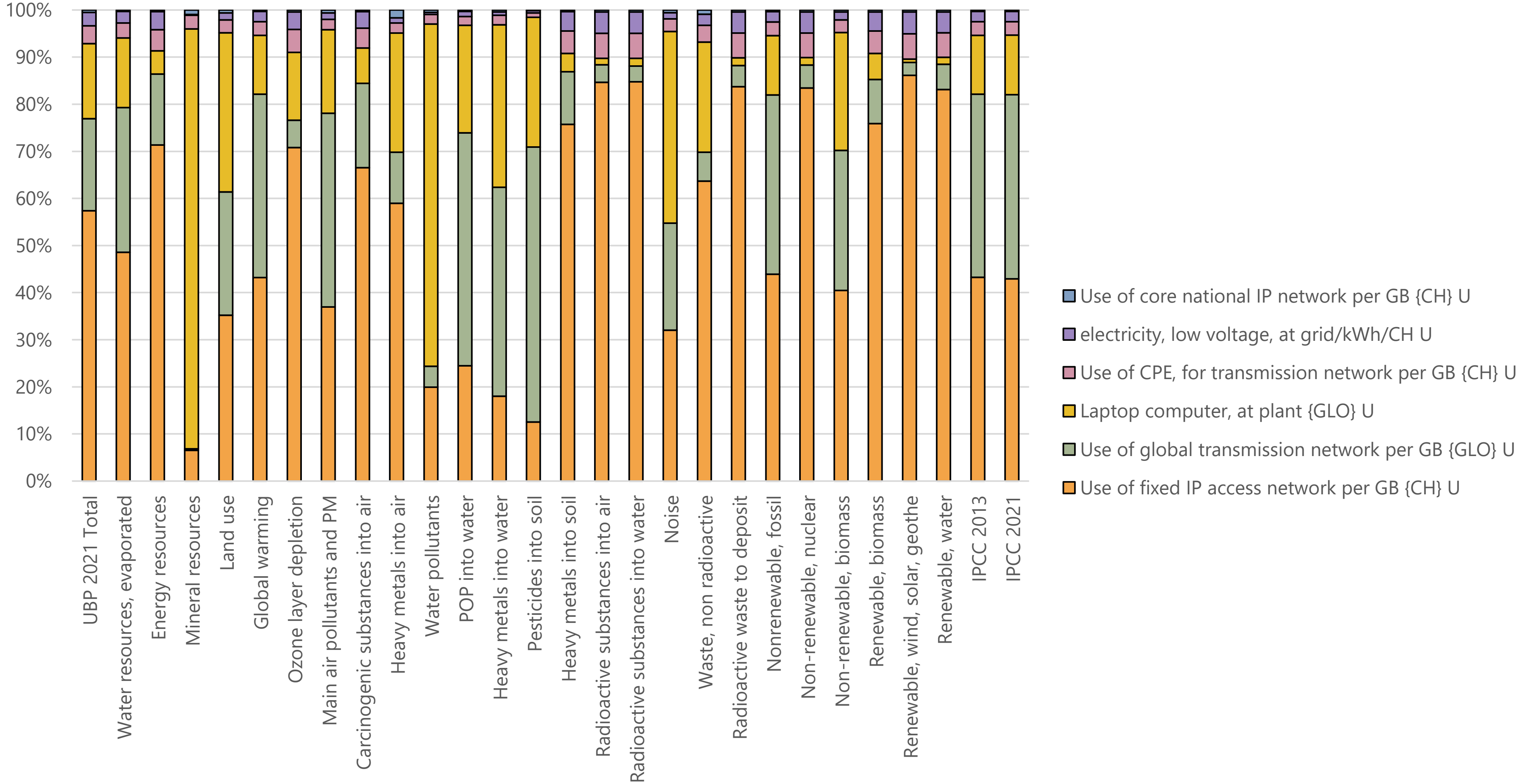

Figure 9.8-5. Contribution analysis presented in bar chart for: laptop use, medium intensity. FU = 1 GB

Table 9.8-11. Contribution analysis presented in table for: laptop use, medium intensity. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of fixed IP access network/GB/CH U	57%	44%	43%	43%
Use of global transmission network/GB/GLO U	20%	38%	39%	39%
Laptop computer, at plant/p/GLO U	16%	13%	13%	13%
CPE use, for transmission network/GB/CH U	4%	3%	3%	3%
electricity, low voltage, at grid/kWh/CH U	3%	2%	2%	2%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**4.85E+02**	**1.74E+00**	**1.55E-01**	**1.53E-01**

9.8.6 Laptop use, high intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.8-12. Life cycle inventory for laptop use, high intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, laptop, high intensity/GB/CH U	1	p				1 p = 1 GB
Input						
Laptop computer, at plant/p/GLO U	0.000139	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 4 years and 1800 hours (360 days/year, 5h/day)
electricity, low voltage, at grid/kWh/CH U	0.0311	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report and Viana et al 2022: normal use = 27 W + 15% as a function of intensity
Use of core national IP network/GB/CH U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
Use of global transmission network/GB/GLO U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
Use of fixed IP access network/GB/CH U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
CPE use, for transmission network/GB/CH U	7	unit		Lognormal	1.2	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.

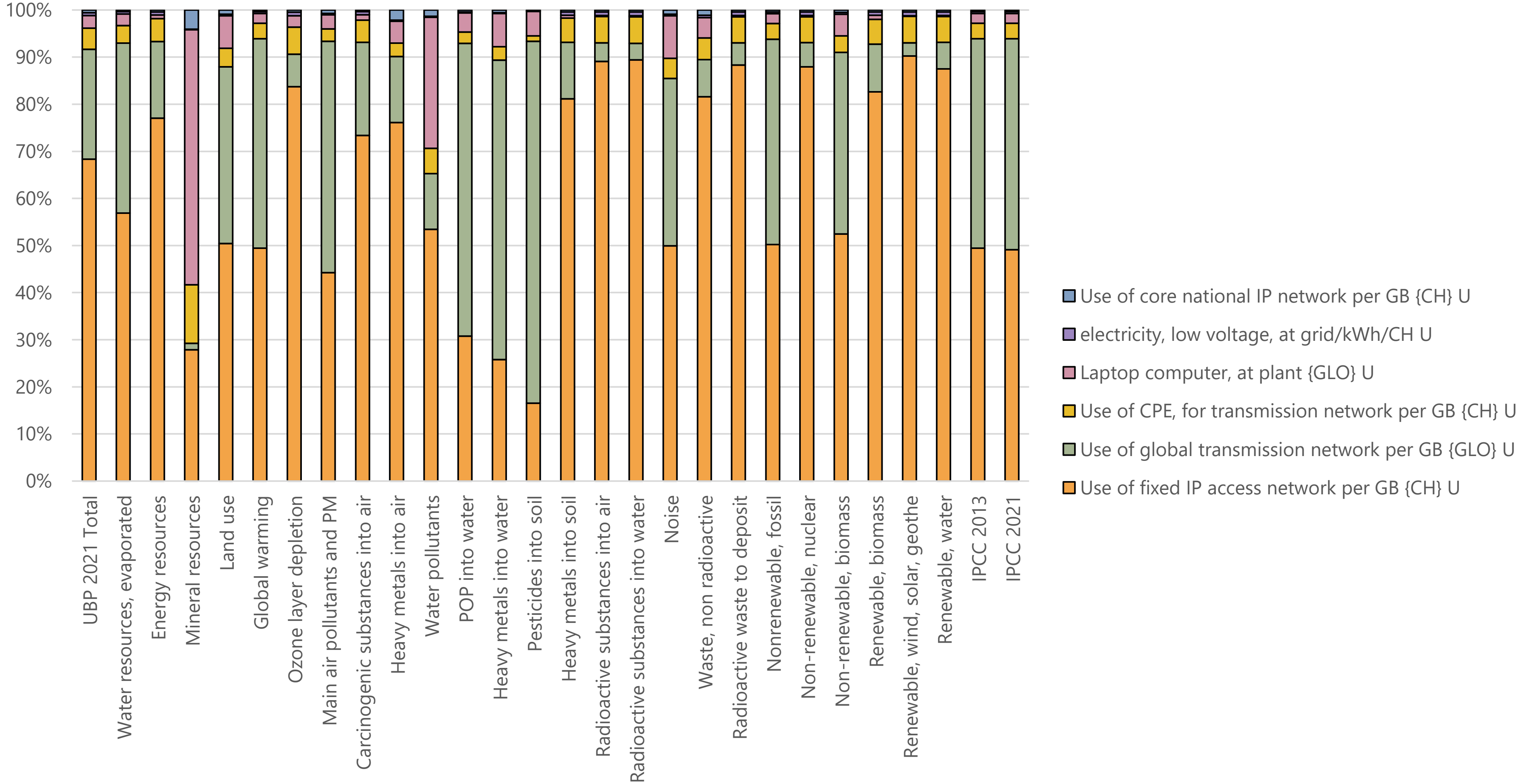

Figure 9.8-6. Contribution analysis presented in bar chart for: laptop use, high intensity. FU = 1 GB

Table 9.8-13. Contribution analysis presented in table for: laptop use, high intensity. FU = 1 GB

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of fixed IP access network/GB/CH U	68%	50%	50%	49%
Use of global transmission network/GB/GLO U	23%	44%	45%	45%
CPE use, for transmission network/GB/CH U	5%	3%	3%	3%
Laptop computer, at plant/p/GLO U	3%	2%	2%	2%
electricity, low voltage, at grid/kWh/CH U	1%	>0%	>0%	>0%
Use of core national IP network/GB/CH U	1%	>0%	>0%	>0%
Total impact, in absolute value	**2.85E+03**	**1.06E+01**	**9.48E-01**	**9.37E-01**

9.9 Device use case scenarios per hour

For use case scenarios, six datasets are created, representing three level of use intensity for two devices: smartphone and laptop. The functional unit is defined as the use of electronic device for 1 hour. The environmental impact of device use comprises 1) embodied impact from the manufacturing of respective devices, 2) impact arising during device active use, and 3) impact arising from the use of transmission network and internet. The latter aspect is linked with the data consumption from/to the cloud and transmission network. Another difference between smartphone and laptop is that for smartphones, the data transmission occurs via the wireless network (mixed of 4G and 5G) while the laptops use Wi-Fi connections (with related fixed IP access network). The following Table 9.9-1 summarizes the key assumptions and parameters in the model.

Table 9.9-1. Dataset parameters for device use case. Functional unit = 1 hour of use.

Device	Use intensity	Device active life time	Daily usage hours	Power consumption (during use)	Total data consumption	Transmission network and internet	Reference
Smartphone	Low	2 years	4h	5 W	0.1	Transmission network, access (wireless), core, and global	Device lifetime and usage hours: (Alfieri & Spiliotopoulos, 2023; Cordella et al., 2021; Manhart et al., 2016) Power consumption: Manufacturers' sheet and other reviews (Apple, 2022; Manhart et al., 2016) Data consumption: (Obringer et al., 2021; Viana et al., 2022)
	Medium	2 years	4h	5 W	1		
	High	2 years	4h	5 * (1+15%) W	7		
Laptop	Low	4 years	5h	27 W	0.1	Transmission network use, access (fixed), core, and global	
	Medium	4 years	5h	27 W	1		
	High	4 years	5h	27 * (1+15%) W	7		

Note: 1 year = 365 days.

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9.9.1 Smartphone use, low intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.9-2. Life cycle inventory for smartphone use, low intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, smartphone, low intensity/hr/CH U	1	hr				
Input						
Smartphone, high-tech phone/p/GLO U	0.000347	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 2 years and 1440 hours (360 days/year, 4h/day)
electricity, low voltage, at grid/kWh/CH U	0.005	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report: normal use = 5 W
Use of core national IP network/hr/CH U	1	hr		Lognormal	1.22	(2,2,1,2,1,5);
Use of global transmission network/GB/GLO U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
Use of wireless IP access network/hr/CH U	1	hr		Lognormal	1.22	(2,2,1,2,1,5);

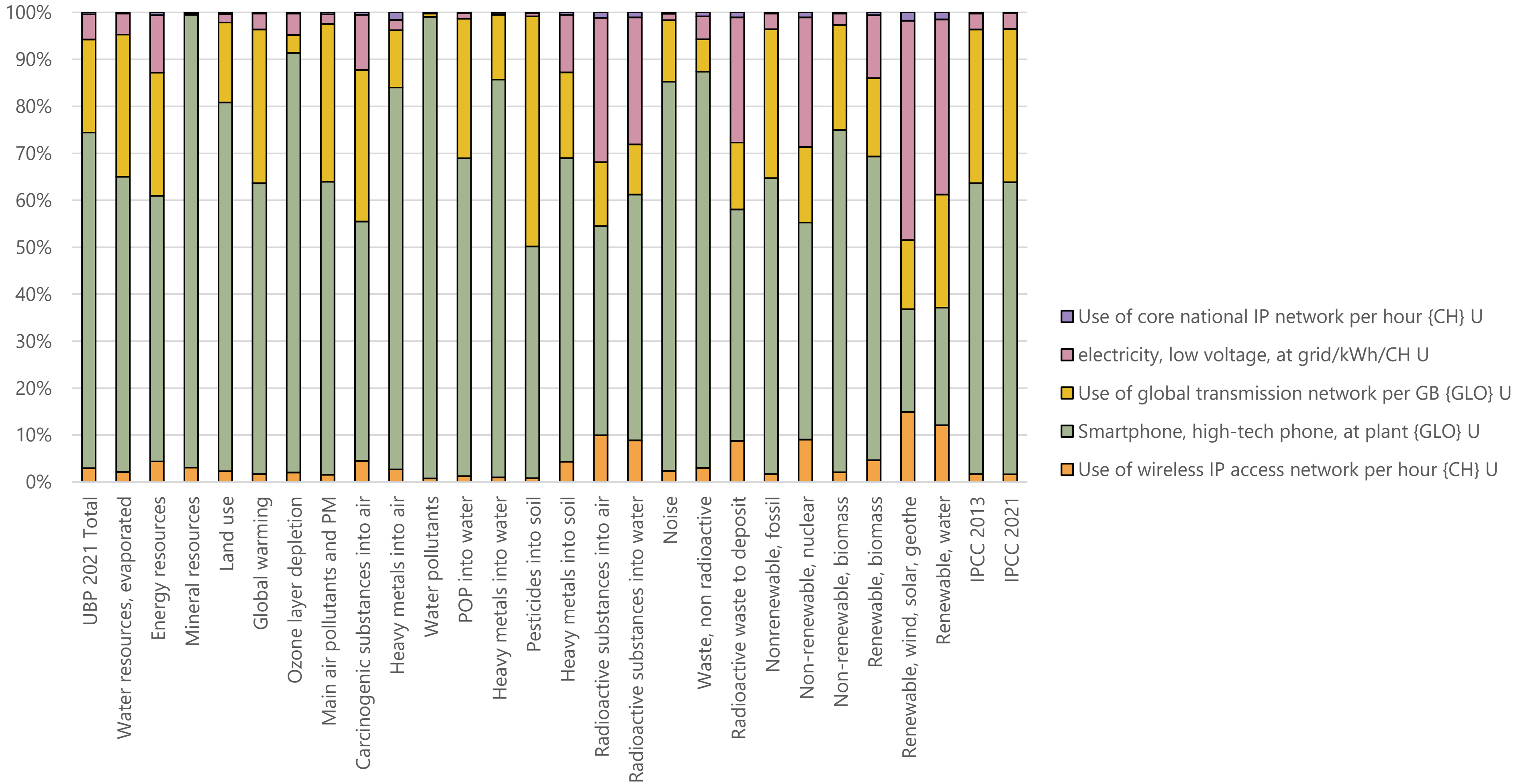

Figure 9.9-1. Contribution analysis presented in bar chart for: smartphone use, low intensity. FU = 1 h

Table 9.9-3. Contribution analysis presented in table for: smartphone use, low intensity. FU = 1 h

Contributors	**UBP 2021 Total (UBP)**	**Nonrenewable, fossil (MJ)**	**IPCC 2013 GWP 100a (kg CO_2eq.)**	**IPCC 2021 GWP 100a (kg CO_2eq.)**
Smartphone, high-tech phone/p/GLO U	71%	63%	62%	62%
Use of global transmission network/hr/GLO U	20%	32%	33%	33%
electricity, low voltage, at grid/kWh/CH U	5%	3%	3%	3%
Use of wireless IP access network/hr/	3%	2%	2%	2%
Use of core national IP network/hr/CH U	>0%	>0%	>0%	1%
Total impact, in absolute value	**4.78E+01**	**2.09E-01**	**1.84E-02**	**1.84E-02**

9.9.2 Smartphone use, medium intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.9-4. Life cycle inventory for smartphone use, medium intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, smartphone, medium intensity/hr/CH U	1	hr				
Input						
Smartphone, high-tech phone/p/GLO U	0.000347	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 2 years and 1440 hours (360 days/year, 4h/day)
electricity, low voltage, at grid/kWh/CH U	0.005	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report: normal use = 5 W
Use of core national IP network/hr/CH U	1	hr		Lognormal	1.22	(2,2,1,2,1,5);
Use of global transmission network/GB/GLO U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
Use of wireless IP access network/hr/CH U	1	hr		Lognormal	1.22	(2,2,1,2,1,5);

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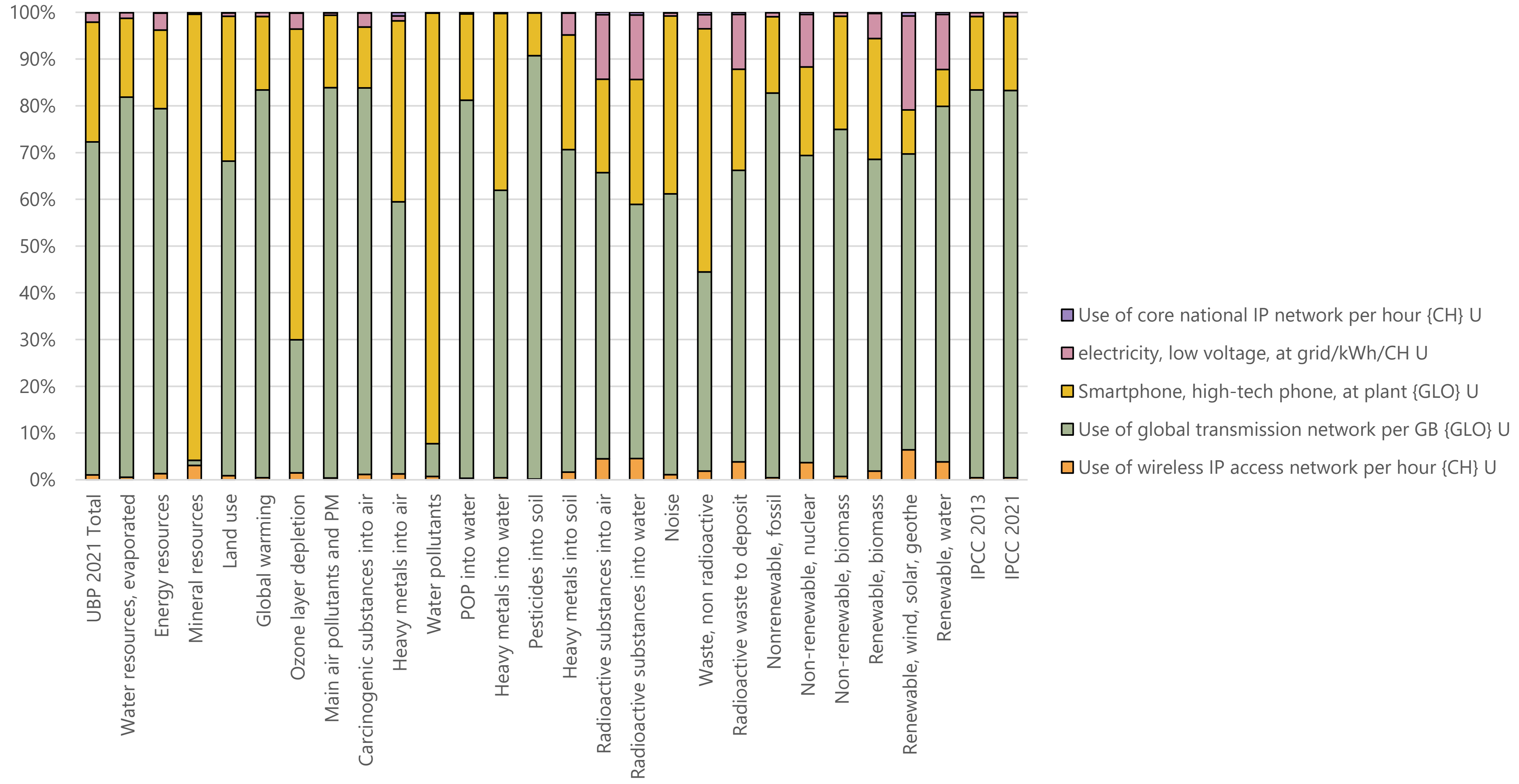

Figure 9.9-2. Contribution analysis presented in bar chart for: smartphone use, medium intensity. FU = 1 h

Table 9.9-5. Contribution analysis presented in table for: smartphone use, medium intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of global transmission network/GB/GLO U	71%	82%	83%	83%
Smartphone, high-tech phone/p/GLO U	26%	16%	16%	16%
electricity, low voltage, at grid/kWh/CH U	2%	1%	1%	1%
Use of wireless IP access network/GB/CH U	1%	>0%	>0%	>0%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.33E+02**	**8.06E-01**	**7.26E-02**	**7.24E-02**

9.9.3 Smartphone use, high intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.9-6. Life cycle inventory for smartphone use, high intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, smartphone, high intensity/hr/CH U	1	hr				
Input						
Smartphone, high-tech phone/p/GLO U	0.000347	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 2 years and 1440 hours (360 days/year, 4h/day)
electricity, low voltage, at grid/kWh/CH U	0.00575	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report: normal use = 5 W + 15% due to increased intensity
Use of core national IP network/hr/CH U	1	hr		Lognormal	1.22	(2,2,1,2,1,5);
Use of global transmission network/GB/GLO U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
Use of wireless IP access network/hr/CH U	1	hr		Lognormal	1.22	(2,2,1,2,1,5);

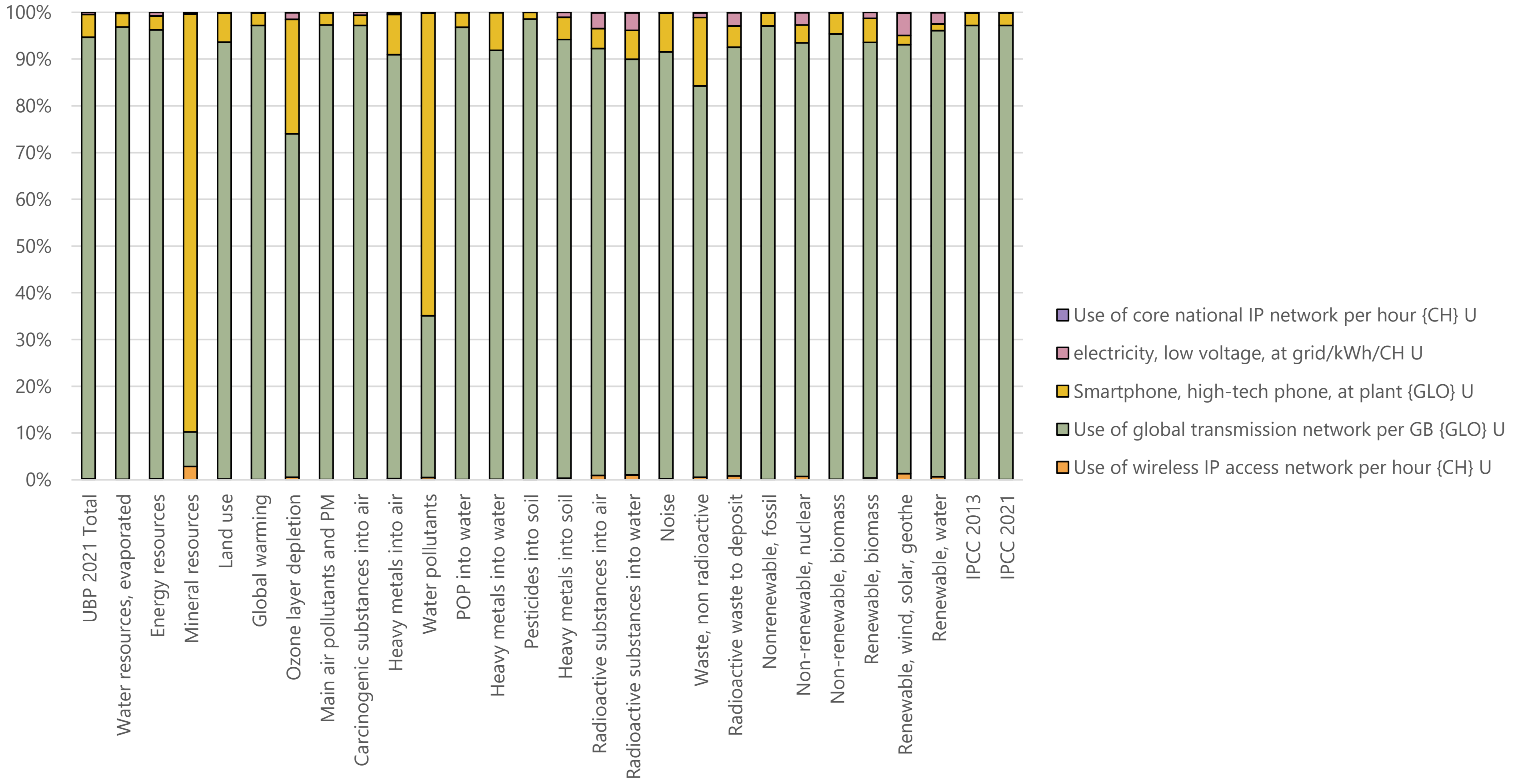

Figure 9.9-3. Contribution analysis presented in bar chart for: smartphone use, high intensity. FU = 1 h

Table 9.9-7. Contribution analysis presented in table for: smartphone use, high intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of global transmission network/GB/GLO U	94%	97%	97%	97%
Smartphone, high-tech phone/p/GLO U	5%	3%	3%	3%
Use of wireless IP access network/GB/CH U	>0%	>0%	>0%	>0%
electricity, low voltage, at grid/kWh/CH U	>0%	>0%	>0%	>0%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**7.02E+02**	**4.78E+00**	**4.34E-01**	**4.32E-01**

9.9.4 Laptop use, low intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.9-8. Life cycle inventory for laptop use, low intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, laptop, low intensity/hr/CH U	1	hr				
Input						
Laptop computer, at plant/p/GLO U	0.000139	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 4 years and 1800 hours (360 days/year, 5h/day)
electricity, low voltage, at grid/kWh/CH U	0.027	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report and Viana et al 2022: normal use = 27 W
Use of core national IP network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5)
Use of global transmission network/GB/GLO U	0.1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For low intensity = 0.1 GB data consumption/hour, according to Vianna et al 2022.
Use of fixed IP access network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);
CPE use, for transmission network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);

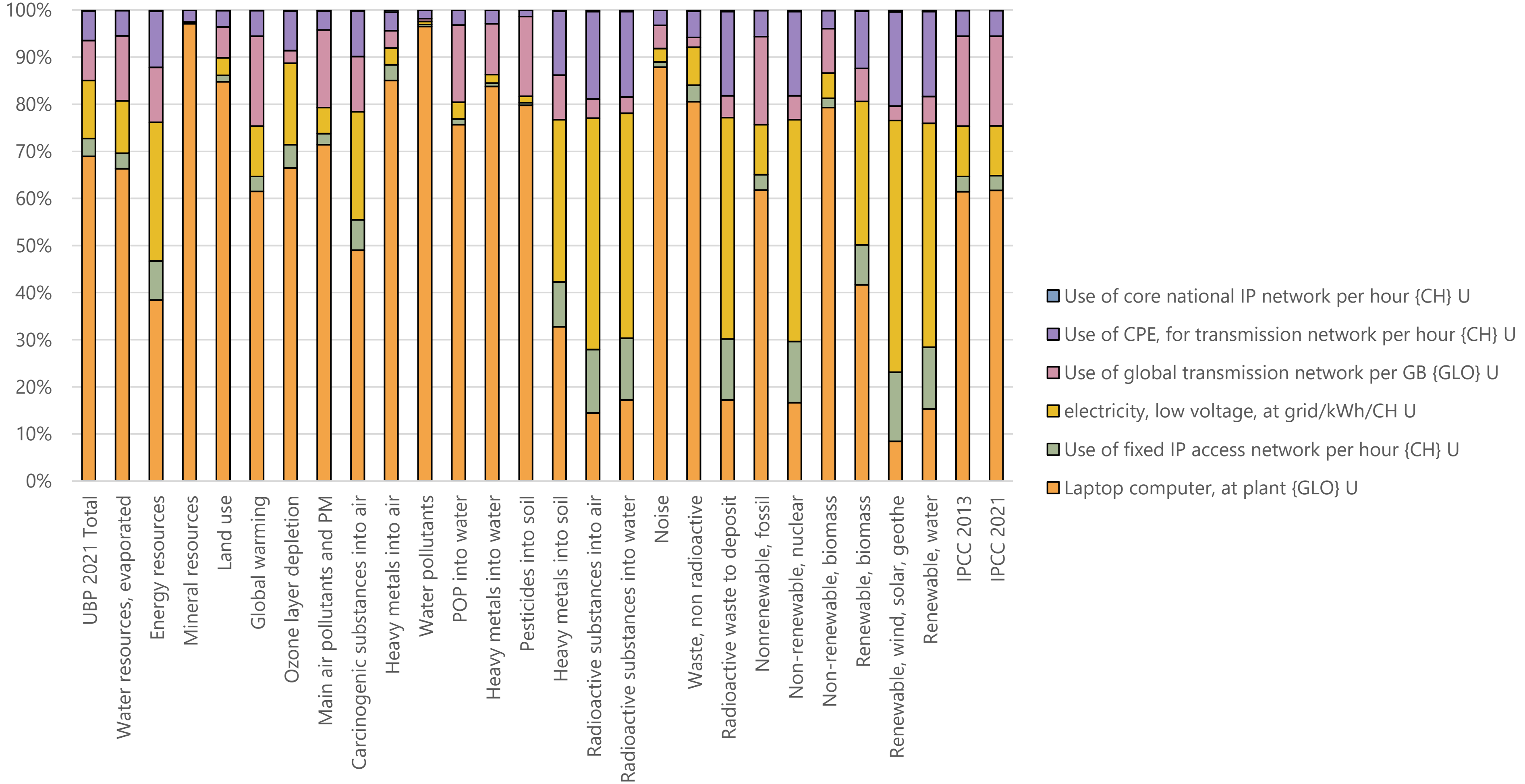

Figure 9.9-4. Contribution analysis presented in bar chart for: laptop use, low intensity. FU = 1 h

Table 9.9-9. Contribution analysis presented in table for: laptop use, low intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Laptop computer, at plant/p/GLO U	69%	62%	61%	62%
electricity, low voltage, at grid/kWh/CH U	12%	11%	11%	11%
Use of global transmission network/GB/GLO U	8%	19%	19%	19%
CPE use, for transmission network/GB/CH U	6%	6%	5%	5%
Use of fixed IP access network/GB/CH U	4%	3%	3%	3%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.12E+02**	**3.55E-01**	**3.16E-02**	**3.14E-02**

9.9.5 Laptop use, medium intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.9-10. Life cycle inventory for laptop use, medium intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, laptop, medium intensity/hr/CH U	1	hr				
Input						
Laptop computer, at plant/p/GLO U	0.000139	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 4 years and 1800 hours (360 days/year, 5h/day)
electricity, low voltage, at grid/kWh/CH U	0.027	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report and Viana et al 2022: normal use = 27 W
Use of core national IP network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);
Use of global transmission network/GB/GLO U	1	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For medium intensity = 1 GB data consumption/hour, according to Vianna et al 2022.
Use of fixed IP access network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);
CPE use, for transmission network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);

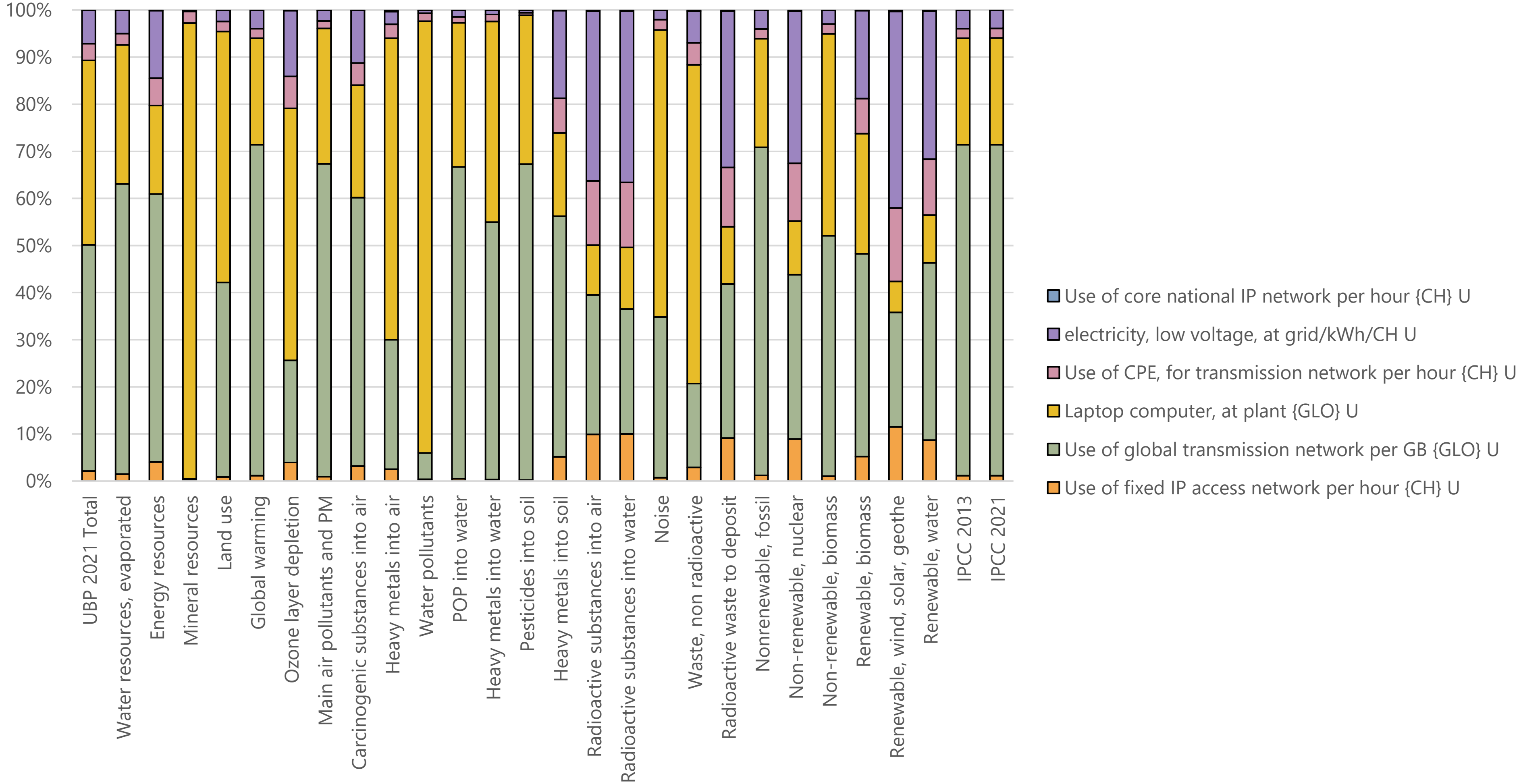

Figure 9.9-5. Contribution analysis presented in bar chart for: laptop use, medium intensity. FU = 1 h

Table 9.9-11. Contribution analysis presented in table for: laptop use, medium intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of global transmission network/GB/GLO U	48%	70%	70%	70%
Laptop computer, at plant/p/GLO U	39%	23%	23%	23%
electricity, low voltage, at grid/kWh/CH U	7%	4%	4%	4%
CPE use, for transmission network/GB/CH U	4%	2%	2%	2%
Use of fixed IP access network/GB/CH U	2%	1%	1%	1%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**1.97E+02**	**9.52E-01**	**8.57E-02**	**8.54E-02**

9.9.6 Laptop use, high intensity

- Dataset update/creation category: LCI / technical data available
- Unit process description: See section 4.8 for details.

Table 9.9-12. Life cycle inventory for laptop use, high intensity and the representation in the UVEK database

Products	Value	Unit	Sub category	Distribution	SD 95%	Comment
Use, laptop, high intensity/hr/CH U	1	hr				
Input						
Laptop computer, at plant/p/GLO U	0.000139	p		Lognormal	1.22	(2,2,1,2,1,5); life time: 4 years and 1800 hours (360 days/year, 5h/day)
electricity, low voltage, at grid/kWh/CH U	0.0311	kWh		Lognormal	1.22	(2,2,1,2,1,5); according to digisuff 2023 report and Viana et al 2022: normal use = 27 W + 15% as a function of intensity
Use of core national IP network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);
Use of global transmission network/GB/GLO U	7	unit		Lognormal	1.22	(2,2,2,2,1,5); Unit = 1GB. For high intensity = 7 GB data consumption/hour, according to Vianna et al 2022.
Use of fixed IP access network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);
CPE use, for transmission network/hr/CH U	1	hr		Lognormal	1.22	(2,2,2,2,1,5);

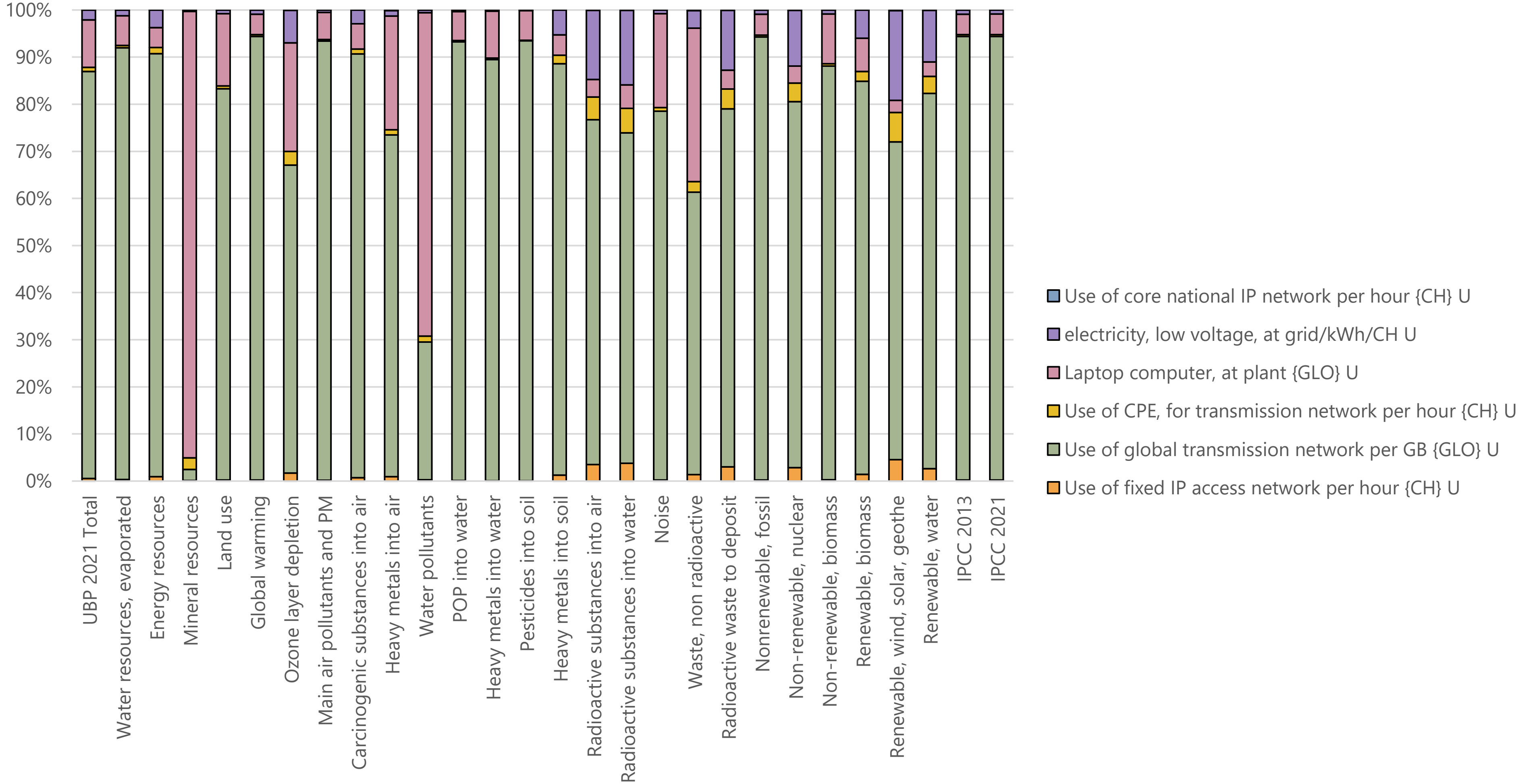

Figure 9.9-6. Contribution analysis presented in bar chart for: laptop use, high intensity. FU = 1 h

Table 9.9-13. Contribution analysis presented in table for: laptop use, high intensity. FU = 1 h

Contributors	UBP 2021 Total (UBP)	Nonrenewable, fossil (MJ)	IPCC 2013 GWP 100a (kg CO_2eq.)	IPCC 2021 GWP 100a (kg CO_2eq.)
Use of global transmission network/GB/GLO U	86%	94%	94%	94%
Laptop computer, at plant/p/GLO U	10%	4%	4%	4%
electricity, low voltage, at grid/kWh/CH U	2%	1%	1%	1%
Use of fixed IP access network/GB/CH U	1%	>0%	>0%	>0%
CPE use, for transmission network/GB/CH U	1%	>0%	>0%	>0%
Use of core national IP network/GB/CH U	>0%	>0%	>0%	>0%
Total impact, in absolute value	**7.68E+02**	**4.94E+00**	**4.47E-01**	**4.46E-01**